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REPORT

OF THE

OPERATIONAL SAFETY REVIEW TEAM
(OSART)
MISSION

TO THE

MUHLEBERG
NUCLEAR POWER PLANT
(SWITZERLAND)

8-25 OCTOBER 2012

DIVISION OF NUCLEAR INSTALLATION SAFETY
OPERATIONAL SAFETY REVIEW MISSION
IAEA-NSNI/OSART/012/170

PREAMBLE

This report presents the results of the IAEA Operational Safety Review Team (OSART) review of Mühleberg Nuclear Power Plant, Switzerland. It includes recommendations for improvements affecting operational safety for consideration by the responsible Switzerland 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 Switzerland 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 Switzerland, an IAEA Operational Safety Review Team (OSART) of international experts visited Mühleberg Nuclear Power Plant from 8 to 25 October 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 feedback, Radiation protection; Chemistry, Emergency planning and preparedness, Severe accident management and Long term operation. 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.

The Mühleberg OSART mission was the 170 in the programme, which began in 1982. The team was composed of experts from Belgium, Czech Republic, Finland, Germany, Hungary, Slovakia, Sweden, UK and USA together with the IAEA staff members and an observer from Finland. The collective nuclear power experience of the team was approximately 340 years.

Mühleberg nuclear power plant (KKM) is a single unit General Electric (GE) boiling water reactor plant with Mark 1 containment. Its licensed thermal power output is 1097 MW. The two turbine generator sets produce an electrical net output of 373 MW. Commercial operation started on 6 November 1972. The plant is situated on the left bank of the river Aare and forms part of the community of Mühleberg in the Canton of Berne. The plant is located about 14 km west of the city of Berne. The plant employs approximately 330 permanent staff.

The plant (KKM) is owned and operated by the utility BKW FMB Energie AG (BKW), Berne. BKW is the owner of eight hydropower stations and is part-owner of 18 other non-nuclear power generation installations. The total energy generated annually by BKW amounts to more than 8500 GWh, with KKM's share amounting to 2700 GWh.

Before visiting the plant, the team studied information provided by the IAEA and the Muhleberg 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 good international practices.

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

- A comprehensive strategy to manage the core shroud cracking issue and allow long term operation includes chemical treatment of the reactor water, improved ultrasonic inspection tooling, analytical modelling, and the future optimization of the tie-rod design;
- Preserving and transferring knowledge has been implemented at the plant so that running the plant safely, reliably, efficiently and with care for the environment is achieved;
- Fast and thorough response to recent significant external operating experience events, including important plant modifications and communication;
- Support for industry efforts to improve fuel design and monitoring practices; resulting in good fuel performance and fewer fuel assemblies discharged from the reactor.

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

- The plant should provide all reasonable protection for the persons on the site in an emergency with radioactive release to avoid any unjustified health risks;
- The plant should embrace and promote the operating experience program and methods throughout the plant, to ensure corrective actions are timely and OE is used throughout the plant in day-to-day activities;
- The plant should reinforce its work control and risk assessment system with the use of radiation work permits to ensure adequate, written radiological work controls are provided consistently at all times;
- The utility should consider improving its means for an independent nuclear oversight with a continuous review of safety performance at the nuclear power plant.

Mühleberg 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 operating license for the KKM nuclear power plant is held by the utility, BKW. The utility provisions for an independent nuclear oversight are not robust enough to provide the utility chief executive with an ongoing review of safety performance at the nuclear power plant. The team developed a suggestion in this area.

There is an internal safety committee, ISA, with subgroups for Nuclear safety (ISA-N), Industrial safety (ISA-A), IT-security (ISA-IT) and Human factors (ISA-H). There is a backlog in the ISA-N committee treatment of safety related events and analyses. Some items on the committees follow-up list are more than five years old without a final decision. The team encourages the plant to remedy this situation.

1.2 MANAGEMENT ACTIVITIES

The managements directions and expectations are declared in a document, entitled "Our Standards" ("Unsere Standards") which states, on an overview level, the managements objectives and expectations. However, it was noted that managers do not spend enough time in the field to observe work places and plant status, to coach plant personnel and to communicate and enforce the management expectations. The team developed a suggestion in this area.

The plant has a concept for fast and broad communication to the entire plant staff. The plant also has an on-going improvement process of this concept. It provides plant personnel with up to date information on relevant topics and safety related issues and there are several ways for information and communication that can be accessed and used by all plant staff. This is considered as a good practice by the team.

1.3 MANAGEMENT OF SAFETY

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 characteristics, attitudes and practices that are characteristics of the safety culture at the plant. The team made a number of observations 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 during observations, interviews and discussions confirmed that safety culture is of high priority for the plant management and personnel. It is reflected in their strong motivation and a will to strive for safety improvements. In the vein of continuous improvements a number of safety enhancements have been implemented, with further measures underway. The plant personnel constantly demonstrated open and cooperative behavior.

There are other attributes that the team believes could be strengthened to improve the overall safety culture. The team recognized that there is a lack the plant managers' presence in the field to observe the personnel performance and enforce standards and expectations. The plant organization and management often applies an informal approach to operating practices and do not always apply administrative controls.

The team encourages the plant to increase the use of formal criteria and procedures, to increase the use of international benchmarking on performance criteria and to increase the use of performance indicators to follow-up actual performance.

1.5 INDUSTRIAL SAFETY PROGRAMME

There is a full time industrial safety officer that reports to the plant manager and and a staff of three assigned to work with industrial safety in addition to their ordinary tasks. On top of that, during outages four external specialists have the task to continuously observe and correct the behaviour of the workers. The industrial safety officer performs risk assessments together with the person responsible for work and an external specialist. The internal safety committee, ISA, has a subgroup for industrial safety (ISA-A) and the utility has an industrial safety committee as well. There is also an industrial safety group common for the Swiss NPPs.

The accident rates and number of lost work days are higher than what is considered to be good performance, compared with the WANO performance indicators. The team noted examples in the field where safety rules, procedures and instructions were not strictly adhered to. The team developed a recommendation in this area.

1.6 DOCUMENT AND RECORDS MANAGEMENT

There is a project going on to standardize and digitalize all documentation. As for technical documentation (drawings, etc.), the responsibility is delegated to the departments which may have their own system for document control and archiving. The project also has the task to centralize and improve the system for document control. For administrative documents, a validity check and revision are to be done every five years. However, the author of the document can change this five year limit to a larger figure. The team encourages the plant to exclude this possibility.

DETAILED MANAGEMENT, ORGANIZATION AND ADMINISTRATION FINDINGS

1.1 ORGANIZATION AND ADMINISTRATION

1.1(1) Issue: The utility provisions for an independent nuclear oversight are not robust enough to provide the chief executive officer of the operating organization with an ongoing review of safety performance at the nuclear power plant utilizing independent expertise.

The operating license for the KKM nuclear power plant is held by the utility, BKW. KKM belongs to the BKW business unit Energy Switzerland (ES). There is a Management Board of KKM, chaired by the head of ES and board member of BKW, which is comprised of the KKM plant manager and management representatives from BKW organizations external to KKM, including the former KKM plant manager. The Management Board of KKM has a declared function to assess the safety and economic viability of actions and investments for the future operation beyond 2012. The Management Board of KKM periodically also reviews topics related to the safety of operations of KKM, and evaluates world-wide events rated 2 or higher on the INES scale.

Annual joint senior management meetings are held by BKW and ENSI (Direktoriumssitzung, DISI) where various aspects of safety are dealt with, e.g. organizational changes, safety culture and important projects.

- However there is no independent, systematic review and reporting of the on-going safety performance from the plant manager to the utility CEO and review of these reports by Management Board of KKM.
- The KKM plant manager reports to the board relatively freely and at his own discretion. There is no specific structure or indicators to be evaluated.
- The function of the Management Board of KKM concerning the safety review of plant operation on a continuing basis with formal reports resulting from this activity is not a formally established requirement.

This deviation from accepted nuclear safety standards may not constitute a problem for the time being, given the safety focus and a set of clear management objectives to ensure safety at KKM. However without a critical nuclear oversight independent from the constant pressures of plant operation a potential decrease in operational safety might go unnoticed or might not be given sufficient priority by the management of the operating organization.

Suggestion: The utility should consider improving its means for an independent nuclear oversight with a continuous review of safety performance at the nuclear power plant.

IAEA basis:

SSR-2/2

3.1 The prime responsibility for safety shall be assigned to the operating organization of the nuclear power plant. … It includes the responsibility for … operation of nuclear power plant(s) by the operating organization itself. The operating organization shall discharge this responsibility in accordance with its management system.

3.2 The management system … shall include the following activities:

(e) Review activities, which include monitoring and assessing the performance of the operating functions and supporting functions on a regular basis. The purpose of monitoring is to verify compliance with the objectives for safe operation of the plant, to reveal deviations, deficiencies and equipment failures, and to provide information for the purpose of taking timely corrective actions and making improvements. Reviewing functions shall also include review of the overall safety performance of the organization to assess the effectiveness of management for safety and to identify opportunities for improvement.

NS-G-2.4

3.4 … However, the assignment of tasks among organizations should not reduce or divide the prime responsibility for safety, which lies with the management of the operating organization. As a result, the operating organization remains in a supervisory position for delegated tasks.

5.17 The safety performance of the operating organization should be routinely monitored in order to ensure that safety standards are maintained and improved. An adequate audit and review system should be established to provide assurance that the safety policy of the operating organization is being implemented effectively and lessons are being learned from its own experience and from others to improve safety performance. The features of the organizational structure and management aspects should be taken into consideration when monitoring and assessing the safety performance of the operating organization or of an individual nuclear power plant.

5.18 The operating organization should provide a means for independent safety review. The key to this process is the establishment of an objective internal self-evaluation programme supported by periodic external reviews conducted by experienced industry peers using well established and proven processes. The principal objective is to ensure that, in those matters that are important to safety, safety accountability is supported by arrangements that are independent of the pressures of plant operation. The safety review should be independent of plant operation, and should be conducted on a continuing basis to verify that plant management establishes verified and authorized practices and implements changes as required. The reports resulting from this activity should be formal and should be provided directly to the top management of the operating organization.

GS-G-3.5

Appendix I, I.1.

(5) SAFETY IS LEARNING DRIVEN

(c) Internal and external assessments, including self-assessments, are used:

- Various oversight forums and processes, including self-assessment, should be used to review, evaluate and enhance the safety performance of the organization.
- The number and types of oversight mechanisms should be periodically reviewed and adjusted.
- Oversight should be viewed positively and constructive use should be made of external or independent opinions.

1.2 MANAGEMENT ACTIVITIES

1.2(a) Good Practice: Communication concept and means used to inform plant personnel.

The plant has a concept for fast and broad communication to the entire plant staff. The plant also has an on-going development of this concept. Quarterly assessments by the plant management ensure that these communication tools are implemented in the best way**.**

- The management holds monthly Staff information meetings "Pinf" where senior plant management addresses different topics. Examples are: Follow up on plant operation, follow up on plant goals and targets, information on outage activities, information on external events and other topics that might be of general interest or which might affect the plant. The meetings are organized in the plant restaurant and are attended by most plant staff, although presence is not mandatory. Extra meetings are held to inform if there are upcoming issues of general interest. Procedures are in place to enable a short-notice assembly. All Pinf presentations, including an audio recording, are uploaded onto the plant's intranet within 24 hours.
- Every Monday, following the operations meeting where plant management and all departments and groups are represented, there is a lecture series dedicated to safety "Five minutes for safety". The purpose is to have an effective way of internal experience exchange on safety. Topics may concern nuclear safety, safety culture or industrial safety. There are guidelines and personal support available to help prepare the presentations. Afterwards, these presentations are posted onto the KKM-Intranet for all staff to see.
- The plant intranet is used for different types of information to and communication with plant personnel, for example: Quarterly follow up on plant targets, a Q&A (questions and answers) section were plant personnel can get feedback on questions and an open discussion forum.
- There is an "anonymous mailbox" for all plant staff to anonymously report their concerns to plant management.
- For urgent issues, the plant manager sends an e-mail to all personnel.
- Up to date safety information is presented on screens in the plant.
- A senior management blog has been used on some occasions, for example during the outage.
- A black board with all relevant and up-to-date plant information is maintained next to the entrance of the plant. All employees have to pass by this board on their way to work.

<u>Benefit:</u>

Plant personnel has up to date information on relevant topics and safety related issues and there are, in addition to the communication within the responsibility lines, several ways for information and communication that can be accessed and used by all plant staff.

1.2(1) issue: Managers do not spend enough time in the field to observe work places and plant status, to coach plant personnel and to communicate and enforce management expectations.

A procedure was introduced in 2008 to improve the mutual understanding between managers and plant staff basically stating that they have to meet on a regular basis to exchange ideas and opinions. This is to be accomplished by means of the so called Manager in the field–process, which gives managers a structured tool for action.

The procedure is valid for the following manager categories: Plant manager, heads of departments, sections and technical function groups, picket engineers, shift supervisors, deputies and certain other persons.

It is stated that the results of this process shall be used to monitor the implementation of KKM standards and ensure their further development which is in line with the philosophy of self-assessment and constant improvement.

- However, there has been a decreasing trend in the use of this process between 2008 and 2011.
- The set minimum requirement to complete 20 Manager in the field-observations per manager per year has not been reached.
- The power plant management has a set of objectives including focus on nuclear safety and an overview of the management expectations is described in a document entitled “Our standards” ("Unsere Standards"). However, it is not common practice by management to explain what this means in concrete terms and to coach the individual.
- There are gaps in setting management standards and communicating them to the staff to report minor problems on equipment and near misses.
- Plant management has recognized that internal goals are not reached but has not yet been able to mitigate the situation.

Without communicating management expectations in concrete terms, observing actual work practices, coaching and enforcing management expectations, safety performance might be degraded. Management procedures that are not adhered to might give the impression that procedures are not important. The plant may miss opportunities to take full use of self-assessment.

Suggestion: The plant management should consider spending more time in the field to observe work places and plant status, coach plant personnel and to communicate and enforce management expectations.

IAEA basis:

GS-R-3

6.2 Senior management and management at all other levels in the organization shall carry out self-assessment to evaluate the performance of work and the improvement of the safety culture.

GS-G-3.1

2.16 The actions of managers and supervisors or team leaders have a strong influence on the safety culture within the organization. These actions should promote good work practices and eliminate poor practices. Managers and supervisors or team leaders should maintain a presence in the workplace by carrying out tours, walk-downs of the facility and periodic observations of tasks with particular safety significance.

2.18 Managers and supervisors should encourage and welcome the reporting by other individuals of potential safety concerns, near-misses, and accident precursors, and should respond to valid concerns promptly and in a positive manner. Where appropriate, contractors should give the same high priority to safety, especially when they are working at a facility.

3.2 The senior management is responsible and accountable for the planning and implementation of a management system that is appropriate to the organization. It is the role of senior management to establish and cultivate principles that integrate all requirements into daily work with the necessary information, tools, support and encouragement to perform their assigned work properly.

3.3 Visible and active support, strong leadership and the commitment of senior management are fundamental to the success of the management system. Senior managers should communicate the beliefs that underlie the organization's policies through their own behaviour and management practices. The whole organization should share the management's perception and beliefs about the importance of the management system and the need to achieve the policies and objectives of the organization.

1.5 INDUSTRIAL SAFETY PROGRAMME

1.5(1) issue: The industrial safety programme is not in line with good industry standards.

The accident rates and number of lost work days are higher than what is considered to be good performance. The targets for accident rates are not in line with good industry standards, compared with the WANO performance indicators.

Statistics of lost workdays include leisure time accidents. Accidents with up to three lost working days are called minor. Even though this in line with national guidelines it is not consistent with minimizing accidents at the plant.

The accident reporting threshold is not low enough to capture minor industrial safety accidents and near-misses.

- Industrial safety near-miss reporting is low compared to accident statistics. During the outage 2012 there were one accident with lost work days, 29 instances where minor treatment was necessary but at the same time no near-miss report was prepared. There is no evidence that line managers expect and enforce near-miss reporting.

The team noted examples of inappropriate performance such as:

- Person standing on a pipe while taking pictures.
- Workers not wearing ear protection in the turbine building even though signs of mandatory ear protection were in place.
- Cable drums not fixed.
- Use of helmets is not mandatory in some buildings (pumping station, SUSAN building) all the time.
- An unlabeled liquid container with a hose was in the decontamination area.
- In the decontamination area a hot bath with a mixture of water and “Ibel Ex”(a caustic detergent) was not equipped with any warning signs.
- In the hot workshop two bottles were found not only insufficiently labeled but also not closed, so that the fluid inside could run out if the bottle was dropped.
- Levoxin injection station is not provided with the correct warning sign.

Lack of line organization encouragement of industrial safety near-miss reporting, comprehensive use of accident data and strict adherence to rules may expose personnel to unnecessary industrial safety risks.

Recommendation: The plant should improve the industrial safety programme to further decrease the industrial safety accident rate.

IAEA basis:

SSR-2/2

Requirement 23: Non-radiation-related safety

The operating organization shall establish and implement a programme to ensure that safety related risks associated with non-radiation-related hazards to personnel involved in activities at the plant are kept as low as reasonably achievable.

NS-G-2.4

6.56 An industrial safety programme should be established and implemented to ensure that all risks to personnel involved in plant activities, in particular, those activities that are safety related, are kept ALARA. An industrial safety programme should be established for all personnel, suppliers and visitors, and should refer to the industrial safety rules and practices that are to be adopted. The programme should include arrangements for the planning, organization, monitoring and review of the preventive and protective measures. The operating organization should provide support, guidance and assistance for plant personnel in the area of industrial safety.

GS-G-3.1

2.18 Managers and supervisors should encourage and welcome the reporting by other individuals of potential safety concerns, near-misses, and accident precursors, and should respond to valid concerns promptly and in a positive manner. Where appropriate, contractors should give the same high priority to safety, especially when they are working at a facility.

GS-G-3.5

5.73 A process that reflects the national industrial safety regulations should be established for all individuals, suppliers and visitors, and the process should refer to the rules and practices for industrial safety that are to be adopted. The process should include arrangements for the effective planning, organization, monitoring and review of the preventive and protective measures for industrial safety.

5.75 Data on industrial safety at the installation should be monitored. Examples of items to be monitored include working time lost owing to industrial accidents (sometimes referred to as “lost time accidents”), other accidents leading to individuals needing medical attention, industrial safety non- conformances, near misses and modifications resulting from concerns about industrial safety.

5.76 The underlying causes of industrial accidents and problems relating to industrial safety should be identified and corrected. Results of cause analyses should be used to identify opportunities for improving industrial safety. Lessons learned from investigations and from operational experience in the nuclear industry and sometimes from other industries should be used to improve performance.

2. TRAINING AND QUALIFICATIONS

2.1 TRAINING POLICY AND ORGANIZATION

Plant procedures set forth goal-oriented initial and continuing training as the basis for reliable and safe operation. Training responsibilities are assigned to all departments separately. Department heads are responsible for their staff's competence. The department heads have appointed training delegates to evaluate performance and plan for upcoming training needs. The training delegates hold an annual meeting chaired by the training manager, during which they draft the training plan for the coming year. Departments at the plant have developed their own methods and processes for initial and continuing training. The team encourages the plant to standardise its practices.

Succession planning at the plant is done well in advance according to a ten year HR plan. Development discussions are open and the staff is aware of their long term development goals and opportunities. Exit times in employment contracts are long – up to two years. Methods are in place to ensure know-how is retained from leaving personnel, a one year overlap is common in the changeover process. The team recognised the wide array of methods in use for knowledge retention as a good practice.

2.3 QUALITY OF THE TRAINING PROGRAMMES

Both external and internal BKW courses are provided at the plant. BKW encourages personnel to continue their education and depending on the value of the training courses is willing to pay up to 100 % of the fees and to cover the costs for working time spent on these courses.

The operator training programme includes a practical training course on thermo hydraulics held by an external training company. In their laboratory, participants gain practical insight in the phenomena of evaporation and cavitation on a technical scale. According to the team's evaluation, external training companies contracted by KKM provide high standard training courses. Apart from the positive impact on the personal skills of individual employees, the cooperation across departments is also promoted as employees meet other BKW employees during common courses. The team considered BKW's support for personal development as a good performance.

On the job training (OJT) instructors are not given training in adult education. Neither is it a requirement in policies or programmes. OJT instructors receive adult learning and evaluation skills only occasionally based on their own initiative or availability of courses. Operator trainees have been assigned to other shifts to promote more effective training. The team suggested the plant to consider ensuring that modern adult education skills are developed among OJT instructors.

2.10 GENERAL EMPLOYEE TRAINING

The General Employee Training (GET) consists of instructional videos and a written test. The requirements in the test are only 60% on each of the sections. After that contractor personnel undergo a short introductory training held by their respective manager from the plant. The mechanical maintenance manager holds individual performance evaluation discussions with all of his contractors. Constant feedback is gained and needs for improvement in the training are identified. The team encourages the plant to include more practical training in health physics into the GET.

DETAILED TRAINING AND QUALIFICATION FINDINGS

2.1 TRAINING POLICY AND ORGANIZATION

2.1(a) Good Practice: At the plant a method for preserving and transferring knowledge has been implemented so that operating the plant safely, reliably, efficiently and with care for the environment is achieved.

Not all knowledge and experience is documented, but it exists as tacit knowledge of each individual employee. Preserving this know-how and handing it down constitutes a major challenge. The plant has developed a procedure for the retention of organisational knowledge including several methods e.g. exit reviews, technical seminars, senior consultancy and overlapping periods, travelling and course reports.

BKW actively reinforces and supports the plant in its succession planning.

In the last 10 years, the responsibility was handed over early to seven managerial successors, so that the previous holder of the position was available in an advisory role as Senior Consultant for at least two years. In the case of a more technical role detailed exit reports have been produced and know-how handed down to wider audiences at various technical meetings.

The early succession planning with the associated transfer of knowledge has proven successful. As a result, safety and plant availability were maintained at a high level in spite of long-standing managers changing their position or leaving the company.

2.3 QUALITY OF THE TRAINING PROGRAMMES

2.3(1) Issue: The plant has not set requirements for training and qualification of on the job training (OJT) instructors to ensure they obtain suitable teaching skills.

During the review the team identified:

- Training in pedagogy for OJT instructors is not a requirement in policies and programmes
- OJT instructors at the plant receive adult learning and evaluation skills only occasionally based on their own initiative or availability of courses
- In order to promote more effective training operator trainees have been assigned from one shift to another by line managers

Without appropriate competences of OJT instructors, the facility fails to take advantage of the best performance of trainees.

Suggestion: The plant should consider enhancing its training policies and programmes to ensure appropriate training and qualification of OJT instructors.

IAEA basis:

GS-R-3:

4.4 Individuals shall have received appropriate education and training, and shall have acquired suitable skills, knowledge and experience to ensure their competence.

NS-G-2.8:

4.15 On the job training should be conducted in accordance with prescribed guidelines provided by incumbent staff who have been trained to deliver this form of training.

5.2 Training programmes for most positions at a nuclear power plant should include on the job training, to ensure that trainees obtain the necessary job related knowledge and skills in their actual working environment. Formal on the job training provides hands-on experience and allows the trainee to become familiar with plant routines. However, on the job training does not simply mean working in a job and/or position under the supervision of a qualified individual; it also involves the use of training objectives, qualification guidelines and trainee assessment. This training should be conducted and evaluated in the working environment by qualified, designated individuals.

3. OPERATIONS

3.1 ORGANIZATION AND FUNCTIONS

The Operations department has a good succession plan in place. Although the 6 shift teams are currently well staffed for the normal daily operations, a limited number of people in Operations have a lot of overtime hours, mainly due to the yearly outage. The team encourages the plant to investigate how overtime hours can be avoided or reduced in the future.

The Operations department sets yearly goals, however these are not specific enough. The team encourages the plant to set clear measurable goals and to organise a follow-up of these goals by setting performance indicators.

A first version of a shift manual intends to give a comprehensive overview of information that the Operations personnel should know. It also integrates the Operations management expectations. However, these management expectations are too general and could give room for interpretation. Without setting clear standards and monitoring the application of these standards, conflicting situations affecting safety may occur. The team developed a suggestion to increase the efforts in setting clear standards and monitoring and assessing them.

3.2 OPERATIONS FACILITIES AND OPERATOR AIDS

The plant has a powerful Plant Visualisation System (PVS) in place that allows remote trending of more than 2000 parameters. Also a very ergonomic Safety Parameter Display System (SPDS) is in place to give a good overview of the main safety parameters at all times. The on-site simulator training facility can be switched to a mode to display the same plant parameters as in the control room. Also the PVS screens can be consulted from the SUSAN emergency control room. This is considered a good performance.

During the OSART mission, the team noticed in the Main Control Room (MCR) that there were very few disturbances that could distract the reactor operators: there were no lit annunciators at all, very few temporary instructions, very limited number of tag-outs, very few new deficiencies a day. In general, the control room personnel encounters no operation burdens during normal operations. This has led to very few scrams in the last few years and a high availability of the plant. Also the MCR of the plant has been upgraded some years ago using the advice of an external consultant. Different zones in the MCR have been marked with a different colour in the carpet. Certain zones have limited access during surveillance tests. The team appreciated the quiet and friendly atmosphere in the control room and considers this a good performance as few distractions of the MCR operators lead to fewer mistakes.

The cleanliness of the plant and the level of housekeeping is very good. In the last few years, all the labelling in the plant has been replaced by new labels. Unambiguous identification of components in the plant leads to fewer mistakes and less radiation exposure. The team considers this initiative as a good practice.

Each member of staff in the plant has his own internal mobile phone and can stay in contact with the Main Control Room at any time. This is considered a good performance.

3.3 OPERATING RULES AND PROCEDURES

The Technical Specifications (TS) of the plant are in a clear format. No manual changes are allowed, and all adaptations have to be approved by the regulator ENSI. In case the TS requirements are challenged, the Shift Technical Advisor does an independent check. This is considered as a good performance.

There is no written comprehensive policy on the surveillance programme. The programme is mainly based on the TS requirements. The team encourages to develop this policy.

There are no clear expectations on what to do in case of deviations found in the installation while performing activities such as executing checklists. The team encourages the plant to make clear that any unexpected alarm or unexpected configuration should be analysed more in depth and that it is important that the managers are informed of these deviations in a formal way.

The person in charge of Probabilistic Safety Analysis (PSA) keeps track of all Limiting Conditions of Operations (LCO) entries and their implication on the PSA of the plant. A yearly evaluative report is produced giving an overview of all LCO entries over the last five years based on the last PSA model approved by ENSI. This is considered as a good performance.

Management expectations don’t indicate which procedures have to be followed step by step and which are to be considered as guidance only. An enhancement project has been started to improve the existing checklists to include initial conditions, independent review, etc. The team encourages the plant to clarify expectations about place keeping and procedure adherence and has developed a suggestion on this subject.

Procedures have to be revised every five years, but up to now there hasn’t been any formal follow-up of this expectation. The introduction of a Document Management System (DMS) module in 2008 will allow a more formal follow-up in the future. The team encourages the plant to reinforce this expectation.

3.4 CONDUCT OF OPERATIONS

The Operators perform functional tests and execute valve line-ups using checklists. These surveillance tests are triggered by the work management system IBFS. The team encourages the plant to implement a periodic assessment of the effectiveness of the surveillance programme.

The registered process and system parameters collected while executing checklists are input into a database for trending. The availability of this database to the plant staff, and the fact that it is used by operators during the performance of surveillance tests to trend important parameters, is considered by the team to be a good performance.

3.5 WORK AUTHORISATIONS

Interfaces with other plant divisions are managed using the effective work authorisation tool IBFS. This is considered as a good performance.

During the daily morning meeting, all departments inform each other of the activities they have planned for the day and the coming week. Safety issues are a special focus on Mondays. The team encourages the plant to discuss safety issues systematically as the first point of the agenda every day.

A specific Gantt chart indicates when safety systems have to be available during the outage. The Pickett engineer in his role of Shift Technical Advisor daily checks the availability of the safety systems during the outages to guarantee that the unavailability is as planned. The team considers this a good performance.

When equipment deficiencies are reported by the staff, they are registered in the work authorisation system IBFS but are not marked locally. As a result, it is difficult to check if local deficiencies have already been reported. The team encourages the plant to consider introducing a system to mark reported deficiencies in the plant to increase attentiveness of plant staff.

3.6 FIRE PREVENTION AND PROTECTION PROGRAMME

The existing fire prevention and protection programme is approved by the Regulatory Authority. At least two trained qualified operators are to be available at all times to perform firemen’s duties as a primary response to a fire. The team noted that this has not been the case on some occasions and made a suggestion to ensure that at any time a qualified on site fire brigade is available as required.

The plant does very limited self-assessment of the fire prevention and protection programme. Performance indicators are not defined and systematically used to review status and effectiveness of the plant fire protection programme. A first self-assessment will be performed end of 2012. The team encourages the plant to perform regular self-assessments of the fire protection programme.

DETAILED OPERATIONS FINDINGS

3.1 ORGANIZATION AND FUNCTIONS

3.1(1) Issue: The plant's management expectations in operation are not defined clearly enough, and subsequent monitoring and assessment of the performance of operators in fulfilling the management's expectations are not sufficient to ensure that these expectations are well understood and applied correctly at all times.

Despite the fact that in 2012 the Operations department has finalized a first version of a shift manual, gathering the individual shift instructions and expectations for the operators of the shift which were scattered in different procedures and notes, the team identified the following:

- The shift manual is written in a general manner and lacks some details to clarify the expectations: eg:
  - The shift manual describes the alarm management in very generic terms but doesn't contain detailed expectations to define the response and communication in case of expected or unexpected alarms, unimportant (white) or important (orange) alarms, alarms during outages, during accident situations or during normal operations.
  - The shift manual refers to specific procedures for more detail around the use of 6 error reduction techniques. Expectations about several other error reduction tools, like place keeping, time out and peer checking are however not described.
  - A procedure for start-up and shut down operations is used in combination with checklists and a " operation program" that is written specifically for each expected transient. In the shift manual, the expectations how to use these procedures are missing.
  - The shift manual does not give sufficient guidance in different areas for the field operators such as reporting leaks, use of torque amplifying devices, potential configuration management problems or dealing with graffiti.
  - The shift manual contains lists of periodic test checklists that are part of the plant surveillance programme. However expectations how to use these surveillance test documents are not described.
- Some years ago, the plant started implementing the "management in the field" programme. The expectations are written down in a specific procedure. This procedure is still valid and requires that each manager has to make 5 written observations a quarter. In 2011 however there were only 33 observations filled in by the entire Operations department.
- The Shift Manual describes that the field operators have to use a checklist during their shift turnover. However, it was observed that this checklist is not always used during shift turnover.
- The Shift Manual asks that all local instructions in the plant are to be checked regularly to see if they are still valid. If valid, the documents receive a stamp with the check date. However, the validation is missing on some local documents
- Internal performance indicators are not used to measure progress in fulfilling the goals and management expectations of Operations.

Without setting clear standards and expectations and monitoring the application of these standards, conflicting situations affecting safety may occur.

Suggestion: The plant should consider clearly identifying and reinforcing its management expectations, its monitoring and assessment practices in operation to ensure that these expectations are well understood and applied correctly by operators at all times.

IAEA basis:

SSR-2/2

4.35 Monitoring of safety performance shall include the monitoring of personnel performance, attitudes to safety ... The monitoring of plant conditions, activities and attitudes of personnel shall be supported by systematic walkdowns of the plant by the plant managers.

NS-G-2.14

2.3 ... The following tasks, functions and responsibilities should be taken into consideration in determining the structure for the operations department:

- Supervision of shift operations by the shift supervisor and periodic evaluation of shift operations by the operations management (i.e. the management of the operations department);

2.16 ... High standards of performance and the expectations of management should be reflected in the operating policy and procedures.

2.18 The management of the operations department should be explicitly committed to safety and to established performance standards in plant operations. This commitment should be clearly communicated to the operations personnel and should be supported by the frequent presence of managers at the workplaces of personnel. Safety performance should be improved through leadership and coaching.

4.29 The management’s expectations with regard to performance in the control room should be established and operators should be trained to meet these expectations. These expectations should be made clear and managers should ensure that all operators understand them. Managers should continuously monitor the performance of operators in fulfilling the management’s expectations.

5.26 … Unexpected alarms should be clearly announced and should be logged. All alarms should be treated as correct and valid unless proven otherwise on the basis of the assessment of other plant indications. Alarms that are spurious or that occur frequently should be discussed and reported to the operations management for timely corrective action.

4.39 … In addition, supervisors should coach operations crews and individual operators in achieving a consistent standard in identifying and reporting plant deficiencies.

4.13 Shift turnover should be carried out in accordance with a formal procedure. … The procedure should provide for a clear declaration of acceptance of duty from the incoming operator before the outgoing operator is released. (Shift turnover)

3.2 OPERATIONS FACILITIES AND OPERATOR AIDS

3.2(a) Good Practice: Effective improvement project on component labelling system

During the OSART mission less than one month after the outage, very few labels were found missing in the plant by the team.

Four years ago a plant operator took an initiative to improve plant labeling. A new effective system was introduced. The number of labels which have to be replaced after annual outage significantly decreased from 441 labels in 2009 to 70 labels in 2012. Besides cost-effectiveness the system has also contributed to lower occupational doses, because there is a high dose rate at some places.

The improved system uses a new design of labels and new attachment technique so that labels don't need to be fixed directly to the components. The labels are attached in such a way that components can be replaced or maintained without the labels getting lost. Also the way to engrave the labels was re-examined to make them well readable and an engraving machine is used.

The new labelling system was first tested and evaluated on a sprinkler system, and following comprehensive inspections and improvements, the decision was taken to apply the new labelling system in the entire plant. The chemistry department was involved in approving the adhesives used to fix the labels. Step by step, the new labels were attached to all systems. An independent review was organized to validate the new labels using a valve checklist. To date, 95% of all labels have been replaced by the new labels.

Unambiguous identification of components in the plant leads to fewer mistakes and reduces doses and saves time during outages.

3.6 FIRE PREVENTION AND PROTECTION PROGRAMME

3.6(1) Issue: Adequately qualified on-site fire brigade is not available at all times at the plant to fulfil the task of primary response to fire.

The plant expects that primary response to a fire is ensured by an on-site fire brigade and an off-site fire brigade performs a supplementary response. The on-site fire brigade duties during late and night shift are to be performed by two operators. An external fire brigade will arrive to plant within a time limit of 15 minutes. The limit is set by the fire protection authority.

During the review the team identified:

- Two qualified fire-fighters may not be present on the shift at all times because of age limitations. (Operators above 52 years are not qualified to perform firemen duties.)
- In 8 out of 1045 shifts in 2012 two trained operators qualified to perform firemen duties were not available.
- Compensatory plant measures to call plant fire brigade staff do not ensure that they can arrive at the plant earlier than the external fire brigade. Test of mustering of the plant fire brigade in non-working hours has not been performed.

Without ensuring that the qualified on-site fire brigade is available at all times at the site to intervene in case of fire, primary response to fire cannot be ensured.

Suggestion: Consideration should be given to ensuring that the qualified on-site fire brigade is available at the site at all times to intervene as a primary response in case of a fire.

IAEA basis:

SSR-2/2

5.21. The arrangements for ensuring fire safety made by the operating organization shall cover the following:

(d) Establishment of a manual firefighting capability;

NS-G-2.1

8.3 Appropriate plant staff should be designated even in situations in which the off-site response is supplementary to a primary response by a qualified on-site fire brigade.

NS-G-2.1

8.6 Members of the on-site fire brigade should be physically capable of performing fire fighting duties and should attend a formal programme of fire fighting training prior to assignment to the plant fire brigade.

4. MAINTENANCE

4.1 ORGANIZATION AND FUNCTIONS

The team noted a comprehensive set of maintenance performance indicators spanning all levels in the maintenance organization. However the team identified some non-closed discrepancy reports at the moment of this mission, a few of them dated from before 2011. 2 discrepancy reports from 2011 were related to safety-related equipment. Because the plant policy demands to follow the status of the indicators, this example shows that the plant maintenance staff does not always follow it properly. The team recommended improvements associated with meeting plant maintenance requirements.

Plant maintenance is divided into separate electrical and mechanical sections. This organizational structure benefits the plant in its regulatory communications, but can cause problems with inconsistencies in maintenance processes. For example, the mechanical maintenance section requires an entrance protocol after receipt inspection of safety related spare parts. The electrical maintenance section does not require this to be performed. The team encourages plant maintenance managers from different sections to discuss common maintenance policy tasks and drive toward common expectations.

In some cases unclear responsibilities were identified. For example, the motor system owner and the lubrication technician did not know clearly who was supposed to define the frequency of lubricating the main coolant pump motor bearings after modification and exchange. The team encourages the plant to have a clearly defined and understood maintenance organizational structure.

The team noted good performance and a positive interface between the electrical maintenance section and Operations in the area of isolation of significant electrical equipment. In order for the operator to be able to trace the steps more easily, the electrical maintenance section has developed an overview plan that helps to trace and check each step using illustrations. Based on this overview plan, the operator carrying out the isolation is able to obtain a precise picture of the isolation status of the electrical system in connection with the isolation checklists.

4.2 MAINTENANCE FACILITIES AND EQUIPMENT

Good performance was recognized in the area of calibration of instrumentation of SUSAN and the reactor protection system. Specifically, the plant uses different instrumentation teams to calibrate different divisions, avoiding common human errors during the calibration process.

Plant policy requires calibration of local instrumentation only on demand on both safety and non-safety equipment. Local instrumentation is used for plausibility only by operational staff. The team encourages the plant to identify local instruments that should be calibrated and visualize this .

4.3 MAINTANCE PROGRAMS

Preventive maintenance planning is generally performed using different data bases. The plant is encouraged to improve preventive maintenance planning to prevent any inconsistencies between maintenance sections.

Plant practice is for system owners to request additional performance data and to check and record data taken by maintenance personnel into the work management system IBFS. These data can be used for analysis in maintenance. This was recognized by the team as a good performance.

The team recognized detailed testing on the dynamic response of approximately 400 measuring circuits as a good practice.

Good performance was identified by the team in the area of qualification of the plant in non-destructive testing. Specifically, the qualification process is ENIQ (European Network for Inspection and Qualification) based, which results in a qualified in-service testing program for class 1-4 components. Additional degradation processes were added to the database.

4.8 SPARE PARTS AND MATERIALS

The team recognised the following good performances in the plant warehousing system:

- Each item kept on stock (each item has an identification number) is backed up with the number of the component in which this item can be installed.
- Prior to the outage the system engineers are able to check on the basis of a system list which spare parts are available for the various components.
- The entire system list is also available as printout in the warehouse. This list is printed out prior to each annual outage.
- In order to leverage synergies, each warehouse identification number may comprise several component numbers. Also, a minimum notification quantity is defined for each item. The relevant section is notified as soon as this quantity is reached.

The team encourages the plant to define a prescribed list of motors to be inspected during routine preventative maintenance performed on in-stock electric motors.

4.9 OUTAGE MANAGEMENT

The team identified the following good performance associated with outage management:

- Outage risks are managed to exceed Technical Specification requirements and generally the plant has an additional system available.
- Outage scheduling includes one day a month as a free day to assist with stress relief.
- If an activity is completed early, the outage plan is not modified and other tasks are not shuffled. This results in reduced stress for the outage staff.

DETAILED MAINTENANCE FINDINGS

4.1 ORGANIZATION AND FUNCTIONS

4.1(1) Issue: The plant maintenance staff does not always meet plant requirements and there are areas where expectations are not specified in enough detail.

Although the plant has a high level of maintenance performance, the team identified during the review:

- Status of maintenance discrepancy reports on safety-related quipment is not followed and acted upon in a timely manner properly by maintenance personnel (two maintenance discrepancy reports from 2011 were still open and not closed)
- Even though the plant has general instructions for document development there are no detailed requirements for the development of maintenance procedures (like specific FME precautions, specific industrial safety requirements, specific tools requirements etc.)
- Textile lifting slings with expired/missing check sign were found in storage and turbine hall buildings
- Expired calibration period for some electrical instrumentation in electrical laboratory as a recurring issue used for calibration of non-safety-related instrumentation
- Some equipment under repair and not in operation as well as some maintenance material are not clearly tagged (such as material on the floor in pumping station).
- Maintenance procedure of reactor pressure relief valve developed by OEM supplier not verifiably reviewed and approved by the plant
- The plant does not monitor properly inconsistencies in the foreign material exclusion programme which can occur during operation and outage. The following facts were found:
  - Damaged plastic cap
  - glove used as FME cover
  - plastic cap filled with liquid
  - cardboard covers used in active workshop
  - lowered plastic cover fixed with grey adhesive tape in horizontal direction instead of vertically

Failure to comply with plant maintenance policies can lead to equipment damage in the field and failures during operation on safety-related equipment.

Recommendation: The plant should ensure that sufficiently detailed expectations are provided and proper adherence to plant requirements is demonstrated in maintenance area by plant maintenance staff.

IAEA basis:

NS-G-2.6

5.2 The operating organization should require the plant management to prepare procedures that provide the detailed instructions and controls necessary for carrying out MS&I activities. The plant management should delegate responsibility for preparing these procedures to the MS&I group. The procedures should normally be prepared in co-operation with the designers, the suppliers of plant and equipment, and the personnel conducting activities for quality assurance, radiation protection and technical support. If persons outside the plant organization prepare procedures for routine activities, these procedures should be submitted to the maintenance manager for approval. The plant management should ensure that the procedures are correctly implemented and that special provisions are included where particular hazards are envisaged.

10.23 All items of equipment together with their accessories should be calibrated before they are used. All equipment should be properly identified in the calibration records, and the validity of the calibration should be regularly verified by the operating organization in accordance with the quality assurance programme. All items should be calibrated against standards recognized by the regulatory body.

ILO Safety and health in construction

5.6.2 Lifting ropes should be installed, maintained and inspected in accordance with manufacturers' instructions and national laws or regulations.

4.3 MAINTENANCE PROGRAMMES

4.3(a) Good Practice: Long-term comparison of dynamic measuring circuit performance

The first research projects in the USA began in the 1980s to investigate the noise characteristics of various measuring transducers used in nuclear power stations. Noise characteristics maps the authentic performance of physical factors with slight variations (and is not merely interference in this context). It investigates the dynamic behaviour of transducers or measuring circuits. This dynamic behaviour can also be used to generate additional important information about measuring transducers or circuits. Any deviations can be identified earlier, whereas conventional calibration based on static behaviour would not show up any difference. The method is thus of great value for nuclear power plant safety systems.

At the plant neutron noise analyses were done in 1992/93. Using the same set of analysis tools, the first noise analyses from instrumentation signals were carried out in the reactor protection system. The same analysis instrumentation was used for the first time to carry out noise analyses of the reaction protection system's signal instrumentation as sensor tests. Since 1994, these tests have been conducted regularly as part of the annual KKM periodic testing programme. At present, approx. 400 instrumentation signals are recorded, analysed and evaluated every year.

After recording the data, they are sent to a contractor for evaluation. The evaluated data is recorded in a report and saved in the Sensbase data base which was specifically developed by the contractor for KKM. Analyses have been saved in the Sensbase database since 1996 where they are available for trending. This data base, for example, allows for a comparison of certain measuring circuits over a number of years which are preventively checked for dynamic out-of-tolerance deviations. Measuring circuits can then be corrected in advance.The plant presented examples of problems detected with pressure transmitters, electronic filters and partial flow blockage or cracking in an instrument sensing line.

5. TECHNICAL SUPPORT

5.2 SURVEILLANCE PROGRAMME

The surveillance program tasks and dates are effectively scheduled using the integrated plant management system (IBFS). However, trending and monitoring of surveillance test results (Technical Specification and other) is informal unless a tested parameter exceeds a minimum or maximum value in the checklist. In this case, a deviation report is written and the problem reviewed and corrected. Trending and monitoring is occurring within engineering, and in some cases this is performed very well (ref. Maintenance Programme Good Practice on dynamic measuring circuit performance). However, the team encourages the plant to consider adding rigor to surveillance trending and monitoring.

5.3 PLANT MODIFICATION SYSTEM

The plant uses the modification module of IBFS to process and store information on the modifications. Procedures and guidelines describe the modification process, and site personnel work as a team with high accountability. However, there is no central design authority on site for modifications, and the team has made a recommendation on modification tracking.

The team also encourages the plant to consider having more formal input from the safety analysis or probabilistic risk assessment, even for cases where a modification does not impact deterministic or probabilistic safety analysis.

Temporary modifications were few in number, and do not burden operations. Blue tags on the command center boards were used where applicable to remind operators a temporary instruction or modification exists, and the team noted this as a good performance. The team encourages the plant to consider having a single list of temporary modifications for tracking purposes. This will allow management to review open temporary modifications, and ensure they are closed in a timely manner.

5.4 REACTOR CORE MANAGEMENT (REACTOR ENGINEERING)

The Physics group provides core monitoring functions for the plant. The group works closely with the fuel vendor who designs the cores and manages the qualification of the approved steady state and transient methods. Core management and monitoring functions are specified in administrative procedures and performed well. The plant has not had a leaking fuel assembly since 2002, and the fuel pool currently contains only a single leaking irradiated fuel rod. Plant personnel cooperate with fuel vendors to improve fuel design and inspection techniques, and this was recognized as a good practice.

The plant does not have a failed fuel action plan. Eventhough there have been no leaking fuel assemblies for ten years, it is important to plan for this contingency. If a leak does occur, actions such as performing flux tilt testing and suppressing local power can be beneficial in minimizing the impact if performed expeditiously. The team encourages the plant to develop a failed fuel action plan.

5.5 HANDLING OF FUEL AND CORE COMPONENTS

The plant is a part owner in a waste processing and storage plant. The facility unloads and reloads spent fuel storage canisters, and provides monitored and retrievable storage for the spent fuel. Storage areas for high level waste (spent fuel) and intermediate level waste (core components) were adequate and specifically designed to provide needed storage capacity through the life of the plant and decommissioning. Good performance was recognized with radiation protection provisions, with equipment and a large hot cell designed specifically for moving irradiated fuel and fuel canisters.

The fuel pool contains both high density spent fuel storage racks and some older racks. The plant loads and ships enough irradiated fuel offsite to the interim storage facility to maintain at least one full core offload capability within the fuel pool. The team noted the fuel pool contained only a single leaking fuel rod stored in an approved skeleton bundle. Irradiated components were stored safely, but the team noted a large number of discharged control blades, fuel assembly channels and baskets in the pool. The team encourages the plant to consider keeping the fuel pool as free from irradiated hardware as is reasonable to facilitate refueling operations and foreign material control.

5.6 COMPUTER BASED SYSTEMS IMPORTANT TO SAFETY

Controls are established for software modification, and procedures exist for emergency recovery and backup. Adequate vendor contracts are established for servers, router, data acquisition system, and software. The team recognized good performance and noted plant personnel were very satisfied with the process visualization system (PVS) module of the plant process computer. The PVS allows users to easy view many key plant parameters from their desktops and while out of the office. This facilitates system owner trending and monitoring.

DETAILED TECHNICAL SUPPORT FINDINGS

5.3 PLANT MODIFICATION SYSTEM

5.3(1) Issue: The plant modification programme is not tracked in sufficient detail to ensure modifications are identified and closed in a timely manner.

The following observations were made:

– A backlog exists on closing modifications and there is no tracking indicator on implemented modifications remaining open. Forty-four modifications implemented since 2009 and turned over to Operations, have not been closed. Final closure requires affected documentation be updated.
– Outage modifications are not always identified in a timely manner, and there is no formal outage planning milestone to track identification.
– In October, 2012, only two modifications were identified for the August 2013 outage and one was postponed from the last outage due to unavailability of parts.
– The plant implemented over 60 modifications during the last two outages combined, with 10-15 being significant in scope. It is likely other modifications will be identified at a later date.
– Minor errors and issues during modification development and implementation are not tracked and used to improve the modification programme process. Lessons learned are shared with individuals who worked on the project, but not formally shared with other departments involved with modifications.

The modification programme process is cross functional and impacts many departments at the plant. Without tracking and reviewing key process elements, improvements in modification process and timeliness are difficult to identify and the plant safety can suffer.

Recommendation: The modifications process should be enhanced to ensure changes to the plant are identified and closed in a timely manner.

IAEA basis:

SSR-2/2; 4.39: A modification programme shall be established and implemented to ensure that all modifications are properly identified, specified, screened, designed, evaluated, authorized, implemented and recorded.

NS-G-2-4; 3.21: Where it is reasonable, the goals and objectives of all management levels should be measurable and stated in terms that allow measurement of progress and clear determination of achievement. They should be challenging, realistic and focused on specific improvements in performance, and should be limited in number to prevent dilution of efforts in key areas.

GS-G-3.5; 6.3 a): Line management monitoring necessitates that managers… should examine trends in performance indicators.

5.4 REACTOR CORE MANAGEMENT (REACTOR ENGINEERING)

5.4(a) Good Practice: Support for industry efforts to improve fuel design and monitoring practices has resulted in good fuel performance and fewer fuel assemblies discharged from the reactor.

The plant has supported industry efforts to improve fuel design and monitoring practices.

This practice aids the industry and improves performance at the plant. Examples include:

- The plant installed a limited number of fuel assemblies with an improved design and closely monitored the fuel performance over several years. The fuel assemblies performed well, up to peak pellet exposure of 80 MDT/MT. Many other plants similar to KKM have drawn on this operating experience success and installed the same design in their plants. The improved design allows fewer required fresh fuel assemblies to be loaded into the reactor and correspondingly reduces the number of fuel assemblies discharged from the reactor.
- New inspection tools were developed in close coordination with the vendor and other industry experts to improve the safe inspection of the improved fuel design. Examples include a tool for improved inspections of fuel channels and a special guide block to aid re-insertion of fuel rods back in the fuel bundle after inspection.
- Plant personnel perform reactor core and fuel criticality tests at both the beginning and end of the operating cycle. This practice allows a realistic measurement of the available shutdown margin for the reactor core. It also provides reliable data for computer code verification and more accurate predictions of margin over the operating cycle.

The practice of cooperating with fuel vendors to test improved fuel designs, combined with thorough fuel inspection, monitoring and testing activities, allows for good fuel performance at the plant.

6. OPERATING EXPERIENCE FEEDBACK

6.1 MANAGEMENT, ORGANIZATION AND FUNCTIONS OF THE OE PROGRAM

A programme is in place in the plant and is briefly explained in plant procedures. Links to aspects like QA, ALARA, training, maintenance rule, were not always clearly defined. The OE manager reports to the Operations manager. Contacts in the other plant departments have organically evolved over time and seem to work in an informal way. The plant is encouraged to formalize the process.

The plant policy on Operating Experience (clear goals, objectives and management expectations) is not mentioned in procedures, nor is it visible in the plant (posters / written communication). Operating experience is not always formally used for work activities by personal to remind themselves of lessons learned and to take precautions to enhance their alertness and to reduce risks. There is a recommendation developed in this area.

6.2 REPORTING OF OPERATING EXPERIENCE

A large threshold appears to exist among approximately 90% of plant staff to report events via the different reporting tools. This was observed by the OSART team in different departments and on different occasions. Writing reports is not sufficiently reinforced by line management. A suggestion was made by the OSART team.

6.3 SOURCES OF OPERATING EXPERIENCE

The plant participates actively in a platform on safety management, which includes other Swiss high reliability organizations. The team recognises this as a good performance.

6.4 SCREENING OF OPERATING EXPERIENCE INFORMATION

First, all screened external OE documents are kept in a list, however in this list, no feedback is kept why an external report was not selected for short commentary or analysis. Second, no external reports are distributed in the plant for information and trending. The plant is encouraged to add comments to screened external OE information and distribute these for information.

Screening of new industry events, posted on the WANO website is performed every 9 weeks. Compared to other Western European countries this is a low frequency of screening. The plant is encouraged to increase the screening frequency.

6.5 ANALYSIS

Analysis of internal and external operating experience reports is not always performed in a timely manner and with sufficient level of detail, including root causes and human factors, and corrective actions are not always defined in a specific and measurable way and do not show clear links to defined causes. The team made a recommendation on this subject.

6.6 CORRECTIVE ACTIONS

At the Monday morning deviation reports screening meeting, no Pikett engineer or other representative with an Operator's licence is present to check the plant for operability after the reported deviation. The plant is encouraged to include a more formal operability check in the deviation report process.

6.7 USE OF OPERATING EXPERIENCE

The plant reacts to significant external events in a flexible yet fast and thorough way. The team recognized this as a Good Practice.

6.8 DATABASE AND TRENDING OF OPERATING EXPERIENCE

Approximately 15% of the deviation reports are put into different trending categories. The OSART team encourages the plant to fine-tune the number of trending categories and trend all reported deviation reports.

The plant uses an expert in work- and organizational psychology from the university of Bern to look for trends in the events, selected by the ISA-H group. The OSART team recognized this as a good performance.

6.9 ASSESSMENT AND INDICATORS OF OPERATING EXPERIENCE

Self-assessment of OE is performed, but timeliness and the quality of the analysis are not systematically incorporated into the review. The plant is encouraged to include all different sub-processes of OE in the self-assessment.

DETAILED OPERATING EXPERIENCE FEEDBACK FINDINGS

6.1 MANAGEMENT, ORGANIZATION AND FUNCTIONS OF THE OE PROGRAM

6.1(1) Issue: Plant management does not always embrace and promote the operating experience program and methods throughout the plant, to ensure corrective actions are taken timely and OE is used throughout the plant.

The following observations were made:

Expectations for timeliness in analyzing internal and external OE and for timeliness and completion of corrective actions are not always clearly defined. The plant has not defined criteria for what they see as a timely analysis of an external event (EXT) or an internal event (IEB). There are no clear management expectations on how to use OE information.

1. OE program:
   - At this moment, the plant is editing a new set of procedures. At the time of the review draft versions were available.
   - At the current stage, procedures of OE are being developed, however, little evidence of procedures on methodology of analysis (e.g. root cause / apparent cause / trend analysis) was found.
2. Line management does not use the OE databases to track open corrective actions.
3. Management shows no clear expectations on how to encourage the use of the OE process in day-to-day activities and the promotion of writing condition reports with their staff.
4. Effectiveness review of closed corrective actions is not performed.
5. Recurring events are neither identified nor tracked.
6. Corrective actions (CA):
   - Closed corrective actions took on average of nearly 3 years to complete;
   - At the time of the OSART review, the plant had a total of 19 overdue CA from deviation reports.
7. Indicators and trend analysis
   - Indicators on OE do not include an average time for initial screening of OE documents, number and age of reports awaiting evaluation, number and age of corrective actions awaiting implementation, recurrent events, ratio of events detected through surveillance and quality programmes versus operational failures or degradation in service.

Without a strong management focus on the OE program, the risk exists that the OE program does not receive sufficient attention and the plant may miss an opportunity to learn from in house and external operating experience.

Recommendation: The plant should embrace and promote the operating experience program and methods throughout the plant, to ensure corrective actions are timely and OE is used throughout the plant in day-to-day activities.

IAEA basis:

SSR-2/2

5.30 As a result of the investigation of events, clear recommendations shall be developed for the responsible managers, who shall take appropriate corrective actions in due time to avoid any recurrence of the events. Corrective actions shall be prioritized, scheduled and effectively implemented and shall be reviewed for their effectiveness. Operating personnel shall be briefed on events of relevance and shall take the necessary corrective actions to make their recurrence less likely.

NS-G-2.11

7.2 Managers of nuclear installations should clearly define their expectations regarding the systematic reporting, screening and use of internal and external operating experience. Information on operating experience should be made readily accessible to plant personnel…

2.12 A detailed procedure should be developed by the operating organization on the basis of the requirements for a national system established by the regulatory body. …

5.2 The development of recommended corrective actions following an event investigation should be directed towards the root causes and the contributory causes, and should be aimed at strengthening the weakened or breached barriers that failed to prevent the event. Personnel at nuclear installations are responsible for implementing corrective actions promptly and effectively. …

8.2 The operating organization or licensee should periodically review the effectiveness of the process for the feedback of experience. …Indicators of the effectiveness of the process should be developed. …

GS-G-3.1

6.71 Senior management should ensure that corrective actions are subject to approval, prioritized and completed in a timely manner, on the basis of their significance. Managers should be held accountable for meeting due dates for corrective actions…

6.74 Corrective actions designed to prevent any recurrence of significant non conformances should be reviewed for effectiveness…

6.75 Senior management should monitor the status of corrective actions …

NS-G-2.4

6.67 The responsibilities, qualification criteria and training requirements of personnel performing activities to review operating experience should be clearly defined. Personnel who conduct investigations of abnormal events should be provided with training in investigative root cause analysis techniques such as accident investigation, human factor analysis (including organizational factors), management oversight and risk tree analysis, change analysis and barrier analysis. …

6.69 Where applicable, lessons learned from industry and in-house experience should be transmitted to the training department as soon as possible for determination

6.2 REPORTING OF OPERATING EXPERIENCE

6.2(1) Issue: Not all departments fully engage with identifying and reporting internal events and not all events that meet internal reporting criteria are reported in order to facilitate learning from events.

The following observations were made:

Reporting numbers appear to depend on individuals:

- For 2012, up until October 10th, the departments Services (DM) and Surveillance (UM) wrote 68 and 59 low-level event reports, respectively. On the other hand, the departments Operations (BM) (excl. the OE manager) and Mechanical Engineering (MM) only participated with 19 and 11 deviation reports, respectively. Department Electrical Engineering (EM) has not reported any deviation reports for 2012.
- In the Mechanical Engineering department “MM”, only one of the five sections entered 11 deviation reports in 2012. The other four reported none.
- Events entered in the low-level event reporting system / deviation reporting system amount for 2008 to 744 reports, for 2009 to 592 reports, for 2010 to 247 reports, for 2011 to 106 reports and for 2012 (> 9 months) to 184 reports.

Reporting criteria:

- Reporting criteria are not clearly specified.
- There are no expectations for timeliness of reporting.
- The threshold for reporting contamination events was found to be high; although many contamination events were recorded in the RP database, only 3 were reported in recent history.

Reporting database:

- The database of the deviation reports does not allow to retrieve information by role.
- Quality Assurance audit reports, Operational Decision Making (ODM) reports and information from pre- and post-job briefs are currently not put into any database

Contractors reporting:

- No internal event reports (IEB) from the last two and a half years were reported by contractors.
- Reporting rate by contractors: 8 in 2008, 1 in 2009, none in 2010, 1 in 2011 and 9 so far in 2012.

Without a strong reporting culture, not all learning opportunities are identified and opportunities for continuous learning could be missed.

Suggestion: The plant should consider to encourage and reinforce reporting of identified problems at all levels and all departments, inside and outside the organization, according to well established criteria.

IAEA basis:

SSR-2/2

5.31 The operating organization shall be responsible for installing an attitude among plant personnel that encourages the reporting of all events, including low level events and near misses, potential problems relating to equipment failures, shortcomings in human performance, procedural deficiencies or inconsistencies in documentation that are relevant to safety.

NS-G-2.4

6.68 All plant personnel should be encouraged to report all events and near misses relevant to the safety of the plant. All plant personnel should be given the opportunity to report all events and near misses. It is the responsibility of plant management to review and respond to these submissions in a timely and confidential manner.

NS-G-2.11

10.2 Operating organizations should develop documents specifying appropriate reporting criteria specific to the type of plant being operated and consistent with national regulatory requirements. These criteria should specify the types of events and incidents…

10.4 Operating experience should be reported in a timely manner to facilitate learning from events. …

6.5 ANALYSIS

6.5(1) Issue: Analysis of events is not performed in a timely manner and with sufficient level of detail. Root causes, human factor and corrective actions are not always defined in a specific and measurable way.

The following observations were made:

Methodology and training and qualification of investigator:

– No root causes or causal factors are defined in ISA-H report examples.

– Human factors, although referred to in some reports, were not always analysed with sufficient level of detail, although a separate subcommittee looks at human performance issues.

– Search for recurrence of events and causes and for precursors was not always performed in a traceable way.

– No clear screening criteria for ISA-H or ISA-N exist.

– Authors of the analysis reports were, in all observed cases, knowledgeable on the technical subject, but had not received training on operating experience analysis methods. There is no formal assessment of completed analysis reports. Quality indicators for completed analysis reports are neither defined, nor measured.

Timeliness, cause analysis and link between cause and corrective action.

- Excluding reportable events to the regulator, on average, the time to start and / or to complete an analysis is relatively long.
- Since 2008 no formal Root Cause Analysis has been performed.
- In the middle of October 2012, the plant had not completely finished the analysis of WANO SOER 2008-1 on Lifting and Rigging, issued in April 2008, nor the WANO SOER 2010-1 on Shutdown safety, issued in May 2010 nor the WANO SOER 2011-1 on large power transformer reliability, issued in January 2011.

Corrective actions

- Several examples were found where corrective actions were not defined in a specific, measurable, achievable, realistic and timely way. They are treated more likesuggestions, which can be accepted or rejected by the head of department.

Although the plant has a high level of performance, without a thorough and detailed analysis of events in a timely way, resulting in specific, measurable and achievable corrective actions, the plant might miss learning opportunities, with a risk of events repeating themselves.

Recommendation: The plant should review its policies and procedures to ensure that event investigations are completed in a timely manner and with sufficient level of detail, including root causes and human factors and that corrective actions are defined in a specific and measurable way.

IAEA basis:

SSR-2/2

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

4.7 Event analysis should be conducted on a timescale consistent with the safety significance of the event. The main phases of event analysis can be summarized as follows:

- …
- Cause analysis:
    - Direct cause (why it happened);
    - Root cause (why it was possible);
- …

II.9. Causes. The direct causes, root causes and causal factors of the event should be clearly described. … The reasons for equipment malfunctions, problems of human performance, organizational weaknesses, design and manufacturing deficiencies and other relevant facts should be included under causes. Whenever appropriate the method used for cause analysis should be referenced in the report.

III.3. Training (both initial and refresher) should be provided for the staff who might take part in an investigation. This should include training in investigation techniques, documentation needs, witness interviews, conflict resolution and dealing with confidentiality issues. …

II.8. The safety assessment should be focused on the safety consequences and implications of the event. …. The safety significance of the event should be indicated.

IV.3. Factors that should be considered in the formulation of corrective actions include the following:

- Whether the proposed corrective action addresses the fundamental problem;
- What adverse consequences may result from the implementation of the corrective action;

NS-G-2.4

6.64 … Low level events and near misses should be reported and reviewed thoroughly as potential precursors to degraded safety performance. Abnormal events important to safety should be investigated in depth to establish their direct and root causes. Methods of human performance analysis should be used to investigate human performance related events. The investigation should result in clear recommendations to plant management, which should take appropriate corrective action without undue delay to prevent recurrence.

6.7 USE OF OPERATING EXPERIENCE

6.7(a) Good Practice: Fast and thorough response to recent significant external OE events, including important plant modifications and communication.

The plant organises itself in a flexible, yet effective way, to cope with important external events, outside of the normal OE process. Necessary resources (in terms of staff and budget) are made available in a short time to organize this.

The response of the plant includes discussions with the regulator, immediate corrective actions, plant modifications and internal communication.

Events that receive international or national press attention, are followed by a special group, communication of this group happens on a regular basis in order to inform the staff on on-going incidents.

The group that is set up during an important event, screens the available information from different sources and tries to understand what happened in the last 24h. They provide technical insight and explanation on different relevant topics. In one case they discussed such topics as reactor building venting / different reactor types / some calculations on dispersion of radioactivity, a technical comparison (reactor type, containment) to KKM, what is written in the press, what other countries and utilities are doing, what actions can be / are envisaged by the KKM plant, …
At a later stage, topics might move on to what the impact of the event is on the KKM plant and its staff, including the long term.

In recent history, the plant has shown this during two of such events:

1. Fukushima Daiichi

The response of the plant to the Fukushima Daiichi accident, that took place in March 2011, included the following items:

Immediate corrective actions: 800 kVA emergency power aggregates that could be transported to site by helicopter, were rented, as well as mobile pumps. Measures were taken to assure fuel supply to the site. Additional tools were bought for maintenance and connections for the external emergency equipment were made. Different storage locations for this equipment were evaluated and arranged.

Later corrective actions included important modifications to the main heat sink, the spent fuel pool cooling and the upgrading of the SUSAN intake. All realisations were performed within a very short period of time. Further actions are in the process of being implemented.

In this case, a special team was set up to collect all the available information (e.g. WANO, regulators, press). They prepared a presentation for the plant manager to be given at additional PinF meetings. The frequency of the presentation depends on the amount of available information and the need to communicate urgently, but was typically several times a week. Meetings to inform plant staff, were held on 14 March 2011, 16 March, two on 17 March, 22 March, two on 25 March.

It was the plant manager who presented the information / messages to the plant personnel. In some occasions, he was assisted by his manager, the BKW Energy Switzerland manager.

2. Doel reactor vessel inspections

After anomalies had been detected in the Doel 3 PWR reactor vessel in July 2012, the plant, although the outage had already started, adapted its outage plan to include a detailed ultrasonic inspection of a representative sector of its reactor vessel and the subject was discussed during the outage meeting with plant staff, for the total duration of the outage.

Benefit:

The plant’s prompt and thorough response results in fast modifications, that avoid a similar event occuring at this site. The entire plant staff is informed, they can give answers to family and friends. The staff can understand what they read in the papers or watch on TV, get a better idea of the risks / threats. The plant staff know what measures will be taken in the KKM plant and might even suggest items.

7. RADIATION PROTECTION

7.1 ORGANISATION AND FUNCTIONS

Responsibility for Radiation Protection (RP) rests fully with the RP group on this plant. They are all well trained, experienced, skilled and attentive to the safety of the plant. They display a great deal of commitment to control of work at all levels and take pride in their work, which is performed to high standards and well supported by the plant. RP regularly attend the plant meetings to ensure that RP issues are addressed. It is considered however by the team that there can be a tendency for over reliance on the RP group for all controls and therefore other departments on the plant may not be aware of their risks and responsibilities for RP, which can lead to events when RP are not (or cannot be) present. The team encourages the plant to review this reliance.

The RP programme is set with clear goals for dose performance, however there are not sufficient performance indicators in use to enable an effective management review of the RP programme overall. Improvement within the RP programme could be enhanced, and the team encourages the plant to do this by using some of the tools of self-assessment, internal audit, benchmarking and independent assessment.

The management is encouraged to consider how workers are set to work to ensure that they are fit for work within the Radiological Controlled Area (RCA) each day.

7.2 RADIATION WORK CONTROL

At the work level, the departments work closely together to ensure radiological work control and there is a comprehensive cleaning and survey programme. The dose assessment process for external doses is comprehensive and the plant participates in external blind QA tests. There is evidence of good performance in the use of effective ALARA practices including good dose contour maps and use of a 3D camera to support training, planning and preparation of high doserate work sites.

The team has identified an issue with radiological work control and has made a recommendation.

In general, the plant worker doses are high, compared to other BWR reactors.There are some high individual doses, for which dose optimisation and justification methods are not tangible and the plant is encouraged to review these activities.

7.3 CONTROL OF OCCUPATIONAL EXPOSURE

The team has identified two issues in the control of occupational exposure and has therefore made two suggestions. The first is that the controls in place on the plant for radiation hazards do not always minimise the radiation doses to workers. The site generally uses the limitation principle and dose sharing (not a recognised dose reduction principle), but there is little written evidence to support the use of justification (for doses) nor optimisation in planning. The second issue is that investigation and processes in place are not always effective for the prevention of contamination occurring in contamination zones above the levels expected for the zone.

7.4 RADIATION PROTECTION INSTRUMENTATION, PROTECTIVE CLOTHING, AND FACILITIES

There is good performance in radiation protection instrumentation, including a good supply of new and modern instrumentation in use, particularly for body contamination measurements and gamma monitoring. A schedule is established for periodic checks and some excellent facilities exist for the calibration and testing of the instrumentation. The frequency of source checks on both installed and portable radiation protection equipment is remarkably low and the plant is encouraged to review whether this will adequately detect poor instrument performance. The control of the alarm and parameter settings, testing and functional testing of the plant's installed radiological instrumentation is under the control of the electrical maintenance department and this gives rise to the risk that Radiological Protection staff don't necessarily fully have control of the results given by the instrumentation that they rely on. The plant is encouraged to consider this arrangement and make improvement.

The plant has good performance with many excellent, well stocked and well planned facilities for the controlled area exit, change facilities, laundry, workshops and storage areas within the controlled area.

7.5 RADIOACTIVE WASTE MANAGEMENT AND DISCHARGES

The team has identified a good practice in this area which is the use of a special shielded transport container for high dose rate waste, reducing operator and public doses.

There is a radioactive waste management programme and good interaction with the intermediate and final repositories. Clearance, minimisation, segregation, decontamination and isolation of contamination are all employed effectively to reduce the amount of waste generated on the site and good facilities are provided for this work. There is a tangible link between radioactive waste management and minimisation, which ensures that the radioactive waste section are engaged as stakeholders in the modifications process. The plant is encouraged to review their contingency arrangements for incidents and accidents when handling radioactive waste on the site.

In the effluent systems there is an opportunity for improvement in the treatment of effluent from the plant and when the torus is drained. The current system does not optimise these radioactive discharges. The plant is aware of this and has taken steps to segregate the discharge routes, reduce the volume and activity of these discharges. There is further work in progress and the plant is encouraged to pursue these improvements, to ensure that activity and volume reduction systems are put into place as soon as possible.

DETAILED RADIATION PROTECTION FINDINGS

7.2 RADIATION WORK CONTROL

7.2(1) Issue: The plant is not using written radiological work controls (Radiation Work Permit, RWP) to support work control and risk assessment.

Although the plant performs a risk assessment and considers the radiological controls that are needed for work tasks, the team made the following observations:

- There is no written radiological work permit to give controls for radiological work, including work area conditions expected, permission to undertake the work, precautions to be taken, radiological monitoring to be carried out, equipment to be used.
- Dose rate and dose alarm on the EPD are not set to task specific levels in normal operation (not currently based on risk assessment for the task)
- Work instructions (Arbeitsschein) do not always give the exact details of the full extent of the intended work, which means that the RP assessment and surveillance cannot always be based on the full scope, particularly relevant if decontamination work is to take place after the main task.
- Work groups undertaking work rely on the advice of the radiation protection staff who are available at the point of work. If they are not there or forget something then there is a possibility for the working group or the supervisor to not know what they should do.
- When there is a lack of communication between maintenance and RP to know when a task is to start, appropriate support cannot be provided.
- Appropriate written instructions are not provided to radiation workers to ensure their safety.
- Events have occurred in the past when inappropriate actions were undertaken which have led to internal contamination events and spreads of contamination.

Without written radiological work controls (called a Radiation Work Permit), there is a risk that inadequate controls will be in place for work which can lead to a spread of contamination or unplanned exposure.

Recommendation: The plant should reinforce its work control and risk assessment system with the use of an RWP to ensure adequate, written radiological work controls are provided consistently at all times.

IAEA basis:

GSR part 3

3.90 "Registrants and licensees:… … Shall restrict access to controlled areas by means of administrative procedures such as the use of work permits."

NS-G-2.7;

3.2 "The RPP (Radiological Protection Programme) should be based on a prior risk assessment in which the locations and magnitudes of all radiation hazards have been taken into account, and should cover: …

(d) work planning and work permits;"

3.40 "…work planning should include the provision of written procedures as appropriate. Matters that should be considered in the planning of work include:

(a) information on similar work completed previously;
(b) The intended starting time, the expected duration and the personnel resources necessary;
(c) the plant’s operational state (cold or hot shutdown, operation at full power or decreased power);
(d) other activities in the same area or in a remote area of the plant that may interfere with the work or may require the work to be conducted in a particular manner;
(e) the need for preparation for and assistance in operations (such as isolation of the process, construction of scaffolding or insulation work);
(f) the need for protective clothing and a listing of tools to be used;
(g) communication procedures for ensuring supervisory control and co-ordination;
(h) the handling of waste arising;
(i) requirements and recommendations for industrial safety in general."

3.44 For tasks necessitating radiological precautions, a radiation work permit (RWP) should normally be prepared. A copy of the RWP should be submitted to the supervisor of the work and it should be retained with the work team throughout the performance of the work. Information and instructions that may be given in the RWP in addition to a description of the work would include for instance:

(a) details of average dose rates and possible areas of elevated activity in the working area on the basis of a survey made prior to the work or otherwise estimated;
(b) estimates of contamination levels and how they might change in the course of the work;
(c) additional dosimeters to be used by the workers;
(d) protective equipment to be used in different phases of the work;
(e) possible restrictions on working time and doses;
(f) instructions on when to contact members of the radiation protection group.

3.45 An authorized person of the operations group and a member of the radiation protection group should sign the RWP to confirm that if the specified precautions are taken the work described can be performed safely.

3.46 The person in charge of planning the operations should issue the RWP to the person who is to supervise or carry out the work. The person in charge of operations should sign the RWP to confirm that the workplace is in the condition specified in the permit. The RWP should be amended if necessary to take into account changing conditions as the work proceeds.

3.47 On completion of the task, the person who supervises or carries out the work should return the RWP to the person in charge of operations, thereby certifying that the work has been finished, that all personnel employed on the task have been withdrawn and that the workplace may safely be returned to its normal operating conditions.

7.3 CONTROL OF OCCUPATIONAL EXPOSURE

7.3(1) Issue: The controls in place at the plant for radiation hazards do not always fully minimise the radiation doses to workers.

Although the plant has suitable limits and limitation activities in place for legal compliance, makes good use of shielding and undertakes relevant surveillance activities, the team made the following observations:

- There is no systematic approach to hot spot control i.e. registering, flushing or removing
- There is no dose rate limit (general area nor hot spot) defined above which access restrictions for high dose rate areas should be implemented.
- There are high doserate areas and transient high doserate areas/rooms on the plant which are not and cannot be locked, and where no gamma interlock devices or installed gamma monitoring is in use.
- The keys controlling access to high doserate and controlled areas are held by over 200 people on the plant and they are not unique locks.
- Electronic Personal Dosimeter (EPD) settings are high for routine, low risk work
- For normal workers (not shift), the dose alarm is 0.3 mSv/day and on one day sampled during the review, 100% of these workers had doses <0.06 mSv/day.
- Specific room hazard information e.g. location and magnitude of hotspots, general area doserates and low-doserate waiting areas are not posted at the entries to rooms.
- There is no simple indication (e.g. colour code) displayed at the doors of the rooms to give immediate recognition of the magnitude of the hazard.

Without adequate controls in place on the plant for radiation hazards, doses to workers may not be minimised.

Suggestion: The plant should consider enhancing controls for radiation hazards in place to ensure radiation doses to workers are always minimised.

IAEA basis:

SSR-2/2;

5.11 The radiation protection programme shall ensure that for all operational states, doses due to exposure to ionizing radiation in the plant … … are as low as reasonably achievable.

NS-G-2.7;

2.14 The optimization of protection and safety measures, or the application of the ALARA principle (to keep doses as low as reasonably achievable, economic and social factors being taken into account), should be carried out at all stages during the lifetime of the equipment and installations.

3.2 The RPP should be based on a prior risk assessment in which the locations and magnitudes of all radiation hazards have been taken into account, and should cover:

(a) the classification of working areas and access control;

3.67 For the control of radiation exposure of personnel, consideration of the optimization of radiation protection is required in the design and operation of a nuclear power plant [1, 21] (see paras 2.14–2.33) in order to keep doses as low as reasonably achievable, economic and social factors being taken into account. In line with this requirement, in examining working procedures and activities, the reduction of doses should be given the highest priority. A hierarchy of control measures should be taken into account in optimization. Firstly, removal or reduction in intensity of the source of radiation should be considered. Only after this has been done should the use of engineering means to reduce doses be considered. The use of systems of work should then be considered and, lastly, the use of personal protective equipment.

Annex I: CLASSIFICATION OF ZONES IN A CONTROLLED AREA FOR NUCLEAR POWER PLANTS

I-1. The following is an example of how zones in a controlled area may be classified:

(a) Radiation zone 1: access is normally prohibited because of high levels of radiation or contamination, but may be permitted under certain conditions (such as reactor shutdown) as specified in the operating procedures.
(b) Radiation zone 2: compliance with the applicable dose limit for external exposure can be ensured only by restricting working time.
(c) Radiation zone 3: all other areas within the controlled area.

7.3(2) Issue: Investigation and processes in place are not always effective for the prevention of contamination occurring in contamination zones above the levels expected for the zone.

Although the plant has good instrumentation, software and facilities for exit from the controlled area and Radiation Protection staff take actions to control problems when they identify them, the team made the following observations with regard to contamination zones:

- During the month prior to the visit, 39 contamination events were recorded on the final exit monitors and 1 on the pre-monitor.
- Workers outside the RP department who work directly on and in the plant (operations, chemistry, maintenance & contractors), do not always receive timely practical training to ensure that they can minimize their doses and control the contamination when working with contaminated equipment (This training is usually within 6 months – 1year of starting for staff during which time they remain accompanied).
- There is no practical training element in the initial first day (film only) training for staff and contractors.
- There are several instances of finding contamination, which are not investigated, reported or trended fully to enable common or root cause analysis and ensure prevention of reoccurrence. For example, the coveralls are not routinely examined when an individual is contaminated on their skin or undergarments. Contamination events are not always reported if the contamination is not found on the third re-monitoring after washing, even though a person was contaminated. The details of what a person was working on cannot always be obtained.
- The procedure to be taken on receiving a whole body contamination alarm can give rise to further contamination events, due to potential for spreading contamination by using a different exit monitor and walking around near the barrier.
- The chain which is used for work sites is at times the same whether or not there is a radiological hazard.
- Contaminated items, equipment and waste are not consistently labelled with the doserate and contamination levels.
- Items awaiting decontamination and items which have already undergone decontamination are stored at the decontamination facility without labelling or signage
- Personnel contamination monitoring is only carried out at the controlled area exit (premonitor and final monitor) and not within the plant at contaminated zones. This can lead to large undetected spread of contamination and this means that detection at source is not possible and large areas have to be checked when contamination is discovered at the final barrier.
- Skin and personal clothing contamination is not treated as significant unless on the chest or head.
- Due to the allowance and standard practice of an individual to wash before and after alarm when contamination is discovered, there is no measurement opportunity and therefore there are no skin dose assessments made when an individual has skin contamination.
- One instance of contamination was found at 4x and 20x greater than the expected level in a clean area and there is no written evidence of follow-up investigation for root cause analysis.

- There is no evidence of written investigations into contamination spreads, personal or equipment contaminations, except for in circumstances when a regulator report was required.
- Working practices while undertaking sorting of laundry can give rise to contamination spread.
- Items are found contaminated at the RCA exit (final barrier) on a routine basis and investigation is not always carried out.

Without investigation into contamination events and without contamination control processes in place, contamination can be spread beyond the designated zones within the plant. This can cause inadvertent personnel skin contamination or internal exposures and cause challenge to the final controlled area boundary.

Suggestion: The plant should consider improving investigation and processes to prevent contamination occurring in contamination zones above the levels expected for the zone.

IAEA basis:

SSR-2/2;

5.16 The radiation protection programme shall ensure control over radiation dose rates for exposures due to activities in areas where there is radiation … as well as exposures due to radioactivity… The programme shall make arrangements to maintain these doses as low as reasonably achievable.

NS-G-2.7 2.26 Investigation levels should be seen as important tools for use by management in optimization of the protection of workers and the public, and should therefore be defined at the planning stage of activities. They may be revised on the basis of operational experience. Regulatory bodies may also wish to establish generic investigation levels. An investigation level is defined as "the value of a quantity such as effective dose, intake or contamination per unit area or volume at or above which an investigation should be conducted". Investigation levels should be used in a retrospective sense and should not be confused with dose limits or dose constraints.

NS-G-2.7 2.27 The exceeding of an investigation level should prompt a review of its circumstances to determine the causes. Appropriate lessons for future operations should be derived and any necessary additional measures should be taken to improve the current arrangements for protection.

NS-G-2.7 3.13 Before items are removed from any contamination zone, and in any case before they are removed from controlled areas, they are required to be monitored as appropriate (Ref. [2], para. I.23) and suitable measures should be taken to avoid undue radiation hazards.

NS-G-2.7 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;

7.5 RADIOACTIVE WASTE MANAGEMENT AND DISCHARGES

7.5(a) Good Practice: Special shielded transport container for high doserate waste, reducing operator and public doses.

In order to reduce doses to the public and to workers at the plant, a specialised shielded container has been designed and produced to transport 200 ltr waste drums from the plant to the waste facility on the public roads. The plant has developed a container based on industrial standards, made modifications and added steel shielding to ensure that the drums cannot move in transport, cannot be damaged and therefore will contain the radioactive material in the event of a transport incident and that the doserates on the outside of the package meet the transport regulations (Type A). Additionally minimal handling at the site is ensured, using remote controls, so that personnel doses are minimised. The initial doserates of the drums are on average 6mSv/h, but can rise to 100 mSv/h. This container reduces these doserates to 1.5 mSv/h on the outside of the container. This results in reduction of the doses to the workers loading the container and the public during transport. The plant's estimated dose saving relative to using the traditional industrial containers is 0.5 man.Sv.

This proactive approach and this equipment specifically demonstrates a commitment to continuous improvement by the plant.

8. CHEMISTRY

8.1 ORGANIZATION AND FUNCTIONS

Chemistry personnel are well qualified to perform their functions. The chemistry performs job rotation in a two-week routine which is scheduled six month in advance. The team identified this practice as good performance.

The chemistry team holds daily and weekly meetings, but the meeting results are not documented. The team encourages the plant to document key results from these meetings for tracking purposes.

8.2 CHEMISTRY CONTROL IN PLANT SYSTEMS

The qualification of chemicals in the plant is not always performed consistently. Beginning in 2007, the process began and was applied for new chemicals but not chemicals currently in use. In addition, chemicals in the plant do not designate clearly the areas approved for use. The team encourages the plant to consider implementing a program to evaluate chemicals and clearly designate areas of the plant they can be used.

Condensate filter demineralizers are removed from service periodically to refresh resin material on the filters. The plant practice is not to rinse the freshly coated filter elements and remove the rinse water to a separate tank prior to putting the filter demineralizer back in service. This can result in impurities from the resins being added to the feedwater. The team encourages the plant to consider flushing the resins before use.

A periodic sampling of diesel fuel, oil and cooling water for the diesel engines is not organized by chemistry but by the secondary systems department. This change was implemented recently, and the team encourages the plant to continue analyses consistently and completely.

8.3 CHEMICAL SURVEILLANCE PROGRAMME

The Chemistry section participates in proficiency tests, both nationally and internationally. The team noted this as good performance.

Common industry practice involves graphical presentation as part of the chemistry control cards. This ensures the quality of analyses, and the team encourages plant personnel transform the data into graphics.

8.5 LABORATORIES, EQUIPMENT, AND INSTRUMENTS

The team noted some electrical equipment in the hot lab which was not controlled by the electrical maintenance section. The team encourages the plant to take ownership for the laboratory hardware.

8.6 QUALITY CONTROL OF OPERATIONAL CHEMICALS AND OTHER SUBSTANCES

The control, handling and labeling of chemicals in the plant is not always performed in a way that ensures safe and efficient application and the team has recommended changes.

DETAILED CHEMISTRY FINDINGS

8.6 QUALITY CONTROL OF OPERATIONAL CHEMICALS AND OTHER SUBSTANCES

8.6(1) Issue: The control, handling and labeling of chemicals in the plant is not always performed in a way that ensures safe and efficient application.

During the review the team found the following facts:

- The chemical phenyl-xylyl-ethane (needed for analytical measurements – “scintillator”) was valid only to 01.04.2012, but it was still in use.
- The quality control program for chemicals started in 2007. All chemicals which were on site before this date were not qualified or prequalified.
- Of 800 safety data sheets only 200 valid were available, the other 600 safety data sheets have been valid but an IT error made them invalid.
- The labeling of the sample bottles near to the glove box for wastewater sampling was incomplete.
- Chemicals found in the controlled area near to the wastewater sampling system are not clearly labeled for use in this area.
- Some storage places for chemicals are not provided with respective warning signs.
- Ether (high flammable) and hydroxide peroxide (fire-promoting) were stored in a domestic non Ex-protected fridge.
- The labeling of an ethanol barrel was difficult to recognize and not labeled in according with international standard.

Without a comprehensive hazardous materials management with appropriate implementation, there is a risk of accidents and damage to the system.

Recommendation: The plant should enhance its policy, programs and procedures to ensure safe and effective application of chemicals.

IAEA basis:

SSR-2/2

7.17. The use of chemicals in the plant … shall be kept under close control.

NS-G-2-1

6.7(d) The storage of all other combustible materials should be prohibited.

For liquids:

6.7(ii) Approved containers or dispensers should be used whenever possible for the transport and use of flammable or combustible liquids. Openings in containers should be fitted with spring loaded closures. Transport of flammable or combustible liquids in open containers should be avoided.

NS-G-2-1

6.7(iv) All containers of flammable or combustible liquids should be clearly and prominently labeled to indicate their contents.

SSG-13

6.33 Industrial safety (provision of fume hoods for ventilation, appropriate storage of flammable solvents and hazardous materials, and flammable and other gases, and provision of safety showers for personnel, as well as personal protective equipment and first aid kits) and radiological safety (proper radiation shielding and contamination control facilities) should be ensured. All laboratory and work practices should be carried out in accordance with industrial safety standards and the principle of optimization of protection (and safety) [3, 14].

9.1 A policy should be established to prevent the use of chemicals or other substances that could introduce potentially harmful impurities into plant areas or circuits, thereby affecting the coolant, auxiliary and safety systems, or other external surfaces. The responsibility for coordinating the control of chemicals and other substances on-site should also be clearly established in accordance with the requirements established in Ref. [7].

9.3 The use of chemicals and other materials at the plant, including those brought to the plant by contractors, should be controlled in accordance with clearly established procedures. The intrusion of non-conforming chemicals or other substances into plant systems can result in deviations in the chemistry regime, leading to component and system damage or increase of dose rates. The use of uncontrolled materials on the surfaces of the components may also induce damage.

9.13 Management should periodically carry out walk downs of the plant to evaluate the effectiveness of the chemistry program and to check for uncontrolled storage of chemicals.

9.15 Chemicals should only be stored in an appropriate store that is fire protected and captures spillages and which is equipped with a safety shower, as required. Oxidizing and reducing chemicals, flammable solvents and concentrated acid and alkali solutions should be stored separately. Tanks containing chemicals should be appropriately labeled. Reasonably small amounts of chemicals can be stored in other controlled environments in the workshops or operational department.

9.9 Chemicals and substances should be labeled according to the area in which they are permitted to be used, so that they can be clearly identified. The label should indicate the shelf life of the material.

9. EMERGENCY PLANNING AND PREPAREDNESS

9.1 EMERGENCY PROGRAMME

The planning basis and the concept of operation for emergency preparedness in the plant does not harmonize with the IAEA safety standards. However, the planning basis and the concept of operation for emergency planning at KKM is consistent with national regulation. This issue that the threat assessment and emergency classification in the Swiss regulation on emergency planning and preparedness are not consistent with GS-R-2 was recognized by the Integrated Regulatory Review Service Mission of the IAEA in December, 2011. The corrective action at the Swiss regulatory body now are being implemented to modify the respective regulation in the country. Accordingly, the team encourages the plant to closely follow-up this process and improve its planning basis and concept of operation as soon as the new regulation comes into force.

9.2 RESPONSE FUNCTIONS

The plant has provisions for the protection of persons on the site in an emergency, but not all reasonable arrangements are in place and therefore the team developed a recommendation in this area.

9.5 EMERGENCY FACILITIES

In response to the severe reactor accident in Fukushima the Swiss nuclear power plants set up a joint protected central external storage facility (external Storage Reitnau), which the team recognizes as a good practice.

9.6 EMERGENCY EQUIPMENT AND RESOURCES

The plant communicates during emergency with the canton police via normal landlines, direct lines and radio and with the canton fire brigade also via the same systems and satellite phone. While most of the tools are regularly tested, the team encourages the plant to also ensure regular checks of the radio and satellite communication lines with the off-site organizations.

9.7 TRAINING, DRILLS AND EXERCISES

The plant has no duty system for the emergency team position, but the alerting process is organized in a way that can ensure the call in of all team members. According to the plant this process is effective, however it is exercised only once per year, which might not serve enough evidence to justify this statement. The team therefore encourages the plant to more frequently hold alerting exercises to test and demonstrate the availability of enough team members any time.

The plant has the basic expertise and arrangements for carrying out the emergency tasks at an appropriate level, however the specialist training of technical experts (RP, nuclear safety, chemistry) for emergency actions is limited, and it is not easy to verify if all the team members attend the due number and type of exercises and trainings. The team therefore encourages the plant to make arrangements that ensure that all emergency team members take part in emergency training and exercise each year and put emphasis on theory and technical aspects of emergency response actions.

DETAILED EMERGENCY PLANNING AND PREPAREDNESS FINDINGS

9.2 RESPONSE FUNCTIONS

9.2(1) Issue: The plant provisions for the protection of persons on the site during an emergency with radioactive release is not sufficient to minimize health risks to plant personal.

- KKM has several locations which can be used in emergency situations by the emergency team. However, most of the facilities are not fully protected against all emergency conditions (i.e. with protection against radioactive release, fire, flooding and seismic event). The SUSAN building is protected against external risks and is equipped with communication tools with the on and off site locations, but in its current state its long-term habitability by the emergency team is not ensured.
- While provisions are made to use decontamination facilities from the external storage facility in Reitnau or from the Fire Department at Berne, there is no designated decontamination capability/facility on the site that is designed to be used after a release.
- The plant has designated muster points for assembly of the personnel, contractors and visitors in an emergency. These muster points are not marked and not protected against any external risk. There is no protective equipment, radiation equipment or potassium-iodide stored at the muster points. There are no effective capabilities at the muster points to identify if anybody is missing. Accounting would be done by printed lists via roll-call. During outages about 800 persons needed to be identified. Automatic accounting is possible only for the defined security zones within the plant or when exiting the plant.
- There are no written procedures on how to evacuate the people from muster points and there is no written strategy for how to search for those missing.
- Most electronic dosimeters are stored in a central location outside the entrance to the radiation controlled area. For low probability emergency situations with an early release of radioactivity there is no arrangement in place to ensure the availability of electronic dosimeters for each worker involved in the emergency response. The transportation and distribution of emergency equipment from the controlled zone has never been exercised (except for exercises with off-site fire brigade). Minimum protective equipment and only limited radiation survey equipment is available at the SUSAN building (1 kit consisting of a dose-rate meter and a surface contamination control).
- The muster points have no continuous monitoring of radiation levels in place.
- The operation shift’s "scout" team has minimal access to radiological monitoring equipment.
- Radiation Protection staff in the Emergency Team are not exercised to practice decontamination of persons or setting up of control points.
- The Pickett Engineer is duly authorized to initiate the response without consultation, but his procedure does not clearly lay down the sequence and priorities of the tasks.
- The emergency plan is focused on getting the problems solved rather than providing a sequenced and prioritized list of activities that should be carried out in an emergency.
- The plant specific level 2 PSA study of 2005 includes very rare scenarios for which a large release can occur after a relatively short time delay. For such fast events on-site protective actions could be warranted.

Without providing all reasonable protection including the following items, avoidable health risks might be caused to the persons on the site in an emergency:

- an appropriately equipped and prepared emergency response centre that is habitable on a long-term basis under the assumed conditions,
- procedures and methods for timely evacuation, effective accounting for plant personnel and the identification of and searching for those missing at muster points,
- appropriate procedures to ensure that personal protective and radiation protection equipment for the emergency workers is available in a timely manner at the location where it is needed,
- appropriate training and exercise for the emergency team to use the protective, decontamination and other equipment used in an emergency.

Recommendation: The plant should provide all reasonable protection for the persons on the site in an emergency with radioactive release to avoid any unjustified health risks.

IAEA basis:

SSR-2/1

Requirement 67: Emergency control centre

An on-site emergency control centre, separate from both the plant control room and the supplementary control room, shall be provided from which an emergency response can be directed at the nuclear power plant.

6.42 Information about important plant parameters and radiological conditions at the nuclear power plant and in its immediate surroundings shall be provided in the on-site emergency control centre. The on-site emergency control centre shall provide means of communication with the control room, the supplementary control room and other important locations at the plant, and with on-site and offsite emergency response organizations. Appropriate measures shall be taken to protect the occupants of the emergency control centre for a protracted time against hazards resulting from accident conditions. The emergency control centre shall include the necessary systems and services to permit extended periods of occupation and operation by emergency response personnel.

SSR-2/2

Operational Safety Programmes

Requirement 18: Emergency preparedness

5.7 Facilities, instruments, tools, equipment, documentation and communication systems to be used in an emergency shall be kept available and shall be maintained in good operational condition in such a manner that they are unlikely to be affected by, or made unavailable by, accident conditions.

GS-R-2

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.

5.25 Adequate tools, instruments, supplies, equipment, communication systems, facilities and documentation (such as procedures, checklists, telephone numbers and manuals) shall be provided for performing the functions specified in Section 4. These items and facilities shall be selected or designed to be operational under the postulated conditions (such as the radiological, working and environmental conditions) that may be encountered in the emergency response, and to be compatible with other procedures and equipment for the response (such as the communication frequencies of other response organizations), as appropriate. These support items shall be located or provided in a manner that allows their effective use under postulated emergency conditions.

5.27 [For facilities in threat category I, an] "on-site emergency control centre, separated from the [facility] control room, shall be provided to serve as [a] meeting place for the emergency staff who will operate from there in the event of an emergency. Information about important [facility] parameters and radiological conditions in the [facility] and its immediate surroundings should be available there. The room should provide means of communication with the control room, the supplementary control room and other important points in the [facility], and with the on-site and off-site emergency response organizations. Appropriate measures shall be taken to protect the occupants for a protracted time against hazards resulting from a severe accident."

GS-G-2.1

Appendix V

Appendix VIII, Table 15

Facility/location: Emergency operations facility

Functions: Coordination of the on-site and off-site response to an emergency warranting off-site protective actions. Typically staffed by the director of the on-site response, the director of the off-site response and the incident commander. When the incident commander is present, this becomes the incident command post.

Characteristics: Access to the information required to coordinate on-site and off-site response decisions; reliable communications with on-site and offsite response centres and organizations; continuous monitoring of radiation levels; security to prevent unauthorized access. If located within the UPZ, it should be provided with sufficient protection to remain habitable during an emergency or provided with a backup. Activation time: within 1 hour of declaration of a site area or general emergency.

Facility/location: Assembly points

Functions: Locations where non-essential personnel at the facility are assembled, accounted for and sheltered or evacuated.

Characteristics: Areas (one or more) within the facility security boundary with sufficient room for on-site nonessential (non-response) staff (including construction workers or other non-permanent personnel). Easily accessible, provides some protection against a release or exposure, and is continuously monitored. Activation time: within 15 minutes of the declaration of an emergency.

9.5 EMERGENCY FACILITIES

9.5(a) Good Practice: External Emergency Storage Facility in Reitnau

Following the severe reactor accident in Fukushima, Japan, the operators of NPPs in Switzerland were requested by ENSI ordinance to make urgently available an external storage facility for severe accident scenarios. The storage facility was to be earthquake and flood proof and to contain additional means and equipment for deployment.

The operators decided to set up a joint central external storage facility (in the following referred to as "External Storage") and to store therein additional equipment for event scenarios. The equipment stored exceeds the international standards.

The External Storage constitutes a supplementary pillar for Emergency Management of CH-NPPs and has been integrated as such in the Emergency Organisation of the respective plants. The equipment stored is permanently ready for deployment. For this purpose, the systems and equipment stored are regularly maintained and used for training. In the event of an accident the emergency response unit will be set up at an early stage, i.e. predefined staff will travel from the non-affected plants to the external storage facility and start preparing material and equipment for transportation.

The External Storage accommodates emergency generators, fire brigade equipment such as pumps, hoses and other fire fighting material, radiation protection material, tools, fuels, oils & lubricants, and other auxiliary materials. There are several sets for many of the aforementioned items.

The storage facility was designed and established in cooperation with the fire brigades, army and air force. All items are packed and prepared in such a way, that they can immediately be transported by land or air (helicopter) with the help of these response forces.

11. LONG TERM OPERATION

11.1 ORGANIZATION AND FUNCTIONS FOR LTO

There are no specific regulatory requirements for long-term operation (LTO) preparation, however, for the 2010 PSR ENSI requested a feasibility study for LTO. The NPP has not implemented any specific organizational structure to manage LTO preparation. LTO activities are rather distributed in the plant. NPP employees do not have consistent information about LTO strategy, LTO targets and milestones. Plant is encouraged to define suitable organizational measures for LTO preparation within the plant and communicate them.

The feasibility study for LTO consists of several input reports as ageing management (AM) results, the study for the reactor pressure vessel, the study for reactor pressure vessel internals and the study for the turbine but there is no plant document containing a summary of the results of all those studies with conclusions, necessary actions and recommendations for the considered LTO scenarios. The team encourages the plant to produce such a summary report for similar decisions in the future.

PSR (Periodic Safety Review) is performed in accordance with HSK R-48 (ENSI Requirements). KKM performed PSR in 2000, 2005, 2010. There were no deficiencies identified by the NPP in safety factors Environmental qualification and Ageing in PSR performed in 2010 which is not in line with the team’s findings. The team encourages the plant to consider the team’s findings in those areas.

AM and TLAAs (time limited ageing analysis) revalidation is solved separately by the mechanical, electrical and civil structures departments. There is only informal communication between those departments. The team encourages the plant to coordinate those activities between departments.

Plant has not performed specific evaluation of preconditions for LTO (maintenance, equipment qualification, in-service inspection, surveillance and monitoring, monitoring of chemical regimes) as required in the IAEA SR 27, nevertheless PSR is being performed every five years. The team encourages the plant to perform this evaluation for LTO.

The suggestion is given by the team to verify the scope of Systems, Structures and Components (SSCs) for LTO, properly document it and perform the ageing management review for all SSCs within the scope.

At the initiative of the Swiss Power Plant Operator GSKL, a number of working groups were formed which are composed of representatives of the different power plants, each dealing with one specific task area. An AM Working Group is one of them.

The successful cooperation of the AM Working Group is based on a well-functioning network. Regular meetings allow direct personal contacts between the individual members and in many ways promote the close cooperation and uncomplicated direct exchange of operating experience. Thus, topical issues and tasks can be discussed within the shortest possible time.

In addition, the AM Working Group keeps international contacts through its members, i.e. to VGB (Germany), the owners' group, and to IAEA, thus enabling the extension of its scope of experience regarding operational information etc.

The enhancement of knowledge by attending courses, conferences and seminars and the subsequent dialogue is a further aspect of this cooperation. Sometimes this aspect contributes directly to the main task of the AM Working Group, i.e. development of high-level common standards which are applicable to the whole of Switzerland based on regulatory requirements. These binding standards find their expression in jointly prepared documents which reflect the state of the art of science and technology such as a GSKL guideline for the development of AM reports, a catalogue of ageing mechanisms, and a document defining boundaries between mechanical and electrical components and civil structures. This has been found a good performance.

11.2 REVIEW OF AGEING MANAGEMENT PROGRAMMES

The plant has not reviewed if AMPs contain the nine IAEA attributes of an effective AMP. The suggestion is given by the team to review ageing management programmes to ensure that the plant programmes and practices that will be used to support the management of ageing effects during long term operation are consistent with the generic attributes of an effective ageing management programme.

Monitoring of electrical and I&C components maintenance effectiveness is performed properly. Five indicators such as deviation reports, reportable incidents, internal incidents, unplanned unavailability and unavailability of safety systems are monitored and evaluated annually. Results of all tests are recorded and trended as one of the indicators for electrical and I&C maintenance. The team considered it as a good performance.

The plant has developed a comprehensive strategy to manage the core shroud cracking issue which allows long term operation. This has been found a good practice.

There is a common cable deposit for all Swiss plants placed in three NPPs to accelerate ageing of cables. There are no results from the cable deposit for the plant yet. Ageing management review of safety cables outside the containment for LTO has not been performed. The majority of important safety systems were replaced including cables. There may still be some types of safety cables which are original cables. The approach of the plant is to replace all safety systems including cables. Based on operating experience, there have been only very infrequent, if any, failures caused by cable malfunctions till now. Walk-downs are performed to check if cables are properly installed and temperature hot-spots are monitored. The team encourages the plant to perform ageing management review of cables for LTO.

11.3 REVALIDATION OF SAFETY ANALYSES THAT USED TIME LIMITED ASSUMPTIONS

The plant has no overall list of TLAAs (only for key components). The responsibility for well-timed evaluation is delegated to each system engineer for his/her system. This means that the responsibility is very distributed. The team encourages the plant toverify whether the scope of TLAAs for LTO is complete.

Design basis information and references to DB supporting documents are contained in FSAR and are kept up-to-date. The design basis database was developed in the last 5 years. It is based on many other supporting documents. The various department maintain their DB documents. The team considered it as a good performance.

The AM report of control rod drives concludes that TLAA relevant to this component is valid for 40 years and should be revalidated even if the number of cycles is much lower than calculated in this analysis. The revalidation has not been performed until now. Control rod drives are periodically refurbished and that is why all of them were at least one cycle out of service. The revalidation of TLAA is planned to be done. The team encourages the plant to revalidate those TLAAs.

The recommendation is given by the team to take measures to revalidate environmental qualification for LTO of originally installed safety cables of class 1E.

DETAILED LONG TERM OPERATION FINDINGS

11.1 ORGANIZATION AND FUNCTIONS FOR LTO

11.1(1) Issue: Scoping of Systems, Structures and Components (SSCs) for Long Term Operation (LTO) and, consequently, ageing management review for some SSCs for LTO are not complete and documented.

The plant has developed ageing management programmes for SSCs, but nevertheless the following observations were made:

- The scoping of SSCs for LTO is based on the safety classification. Criteria from ENSI-G01 guideline were used for safety classification but the specific reason for which an SSC was allocated to a safety class is not recorded in plant documentation.
- Because the reason for the classification is not recorded it is difficult to verify whether the scope for LTO (e.g. non-safety SCs which may affect safety SCs) is complete.
- The result of scoping is described only as a part of each specific AM report prepared for safety systems. There is no overall list of SSCs in a scope for LTO in an equipment master list.
- The majority of important cables outside the containment were replaced but there are still some types of safety-related cables which were not replaced. They have been assessed generically and on the basis of operating experience. The AM Report is planned to be prepared.
- The sludge tank 20 A45 is designed for a lifetime of 40 years. It is classified as components of safety class 4. It has not been inspected since 1995. The plant has no available data about the life-time of the internal coating. It has not been assessed for the LTO period.

Without a complete and well-documented scope of SSCs for LTO, ageing management review does not cover all SSCs for LTO which may cause malfunctions or failures in the LTO period due to their ageing.

Suggestion: The plant should consider to verify that the scope of SSCs is complete for LTO and properly documented, and that the ageing management review has been performed for all SSCs within the scope.

IAEA basis:

SSR-2/2

Requirement 14: Ageing management

The operating organization shall ensure that an effective ageing management programme is implemented to ensure that required safety functions of systems, structures and components are fulfilled over the entire operating lifetime of the plant….

Requirement 16: Programme for long term operation

4.54 The comprehensive programme for long term operation shall address:

(b) Setting the scope for all structures, systems and components important to safety;

(c) Categorization of structures, systems and components with regard to degradation and ageing processes;…

NS-G-2.12

6.3 The review process should involve the following main steps:
- An appropriate screening method to ensure that structures and components important to safety will be evaluated for long term operation;
- Demonstration that the effects of ageing will continue to be identified and managed for each structure or component during the planned period of long term operation;

…..

6.5 The results of the review of ageing management for structures and components for long term operation should be documented.

6.6 Reference [SR 57] provides more detailed information on the implementation of the process described in para. 6.3.

SR 57

4.1 SCOPE SETTING PROCESS

The SSCs within the scope of LTO are those that perform the following safety functions [11]:

(a) All SSCs important to safety that ensure the integrity of the reactor coolant pressure boundary;

(b) All SSCs important to safety that ensure the capability to shut down the reactor and maintain it in a safe shutdown condition;

(c) All SSCs important to safety that ensure the capability to prevent accidents that could result in potential off-site exposure or that mitigate the consequences of such accidents.

Other SSCs within the scope of LTO are those whose failure may impact upon the safety functions specified above. All SCs within the scope of LTO and not subject to replacement based on a qualified life or specified time period are identified and included for further reviews for LTO….

…. The results of the scope setting process are documented in a manner that complies with the requirements of the quality assurance programme.

The information to be documented includes: (a) identification of the plant SSCs that meet the description above; and (b) the information sources used to accomplish the scope setting and any discussion needed to clarify their use.

11.2 REVIEW OF AGEING MANAGEMENT PROGRAMMES

11.2(1) Issue: Ageing management programmes (AMP) do not contain all generic IAEA AMP attributes.

AMPs are implemented in the plant and ageing management reports (AM reports) are prepared by the plant and plant suppliers in accordance with ENSI-B01 guidelines, nevertheless the following observations were made:

- It is not verified that AMPs contain all nine attributes.
- The majority of the attributes are present in various plant documents (AM reports provided by suppliers and other related documents) but some attributes are not always defined or missing (trending, mitigating ageing effects, acceptance criteria, corrective actions, quality management).
- AM Reports are prepared to demonstrate activities and results related to AM. They are typically suppliers` documents provided in different formats and with different contents.
- There is an ENSI requirement to revise AM Reports each 10 years at least. One report has not been revised within the period specified.
- The coincidence of critical location, material and environment which may cause degradation is not consistently documented in AM reports.
- Water is considered as a potentially harmful medium in AM reports. Other environments such as air or soil are not always considered as environmental factors contributing to degradation.
- Acceptance criteria and related corrective actions are not described in fatigue AMP. Corrective actions are decided on a case-by-case basis.
- Many pipelines have been already replaced by less susceptible materials due to Flow Accelerated Corrosion (FAC), nevertheless the FAC is still a relevant degradation mechanism. The plant plans to set a database of measurements with a precise grid of measuring points for trending in future.
- AMP of buried pipes of service water line for SUSAN equipment estimates the residual life-time of pipeline internal plastic layer till 2018. Corrective measures have not been defined in this AMP yet. There is an on-going study to decide what should be done if criteria are exceeded.

Without verifying that AMPs contain all nine AMP attributes and, if not so, adding the missing attributes, it might not be possible for the plant to demonstrate that there is an effective ageing management programme.

Suggestion: The plant should consider to review ageing management programmes to ensure that this programme contains all generic IAEA AMP attributes including evaluation against them.

IAEA basis:

SSR-2/2

Requirement 14: Ageing management

The operating organization shall ensure that an effective ageing management programme is implemented to ensure that required safety functions of systems, structures and components are fulfilled over the entire operating lifetime of the plant….

Requirement 16: Programme for long term operation

4.54 The comprehensive programme for long term operation shall address:

…(e) Review of ageing management programmes …

NS-G-2.12

4.21. The review relating to the understanding of the ageing of structures and components should address materials, stressors and the environment, ageing mechanisms of concern and sites of degradation, and available analytical models (i.e. based on theory) or empirical models (i.e. based on observation or experiment) for predicting future degradation. The results of the review relating to the understanding of ageing should be documented.

4.27 The methodology used to carry out the review of ageing management should be documented and justified.

4.34 A summary sheet for each ageing management programme may be produced. The summary sheet should provide an executive summary of the ageing management programme that highlights information useful for understanding and managing ageing, including materials, degradation sites, ageing stressors and environment, ageing mechanisms and effects, inspection and monitoring requirements and methods, mitigation methods, regulatory requirements and acceptance criteria.

6.2 The in-depth review of ageing management should ensure that plant programmes and practices that will be used to support the management of ageing effects during long term operation are reviewed and are consistent with the generic attributes of an effective ageing management programme such as that given in Table 2. *[comment: description of IAEA nine attributes]*

1. Scope of the ageing management programme based on understanding ageing
2. Preventive actions to minimize and control ageing degradation
3. Detection of ageing effects
4. Monitoring and trending of ageing effects
5. Mitigating ageing effects
6. Acceptance criteria
7. Corrective actions
8. Operating experience feedback and feedback of research and development results
9. Quality management

6.3 The review process should involve the following main steps: ….

- Demonstration that the effects of ageing will continue to be identified and managed for each structure or component during the planned period of long term operation;

…..

6.5 The results of the review of ageing management for structures and components for long term operation should be documented.

6.6 Reference [SR 57] provides more detailed information on the implementation of the process described in para. 6.3.

SR 57

5.2 IDENTIFICATION OF AGEING DEGRADATION EFFECTS

To determine the ageing effects requiring management, the operating organization considers and addresses the materials, environment and stressors that are associated with each structure, component or commodity grouping under review.

5.3 REVIEW OF EXISTING PLANT PROGRAMMES AND PROPOSED PROGRAMMES FOR AGEING MANAGEMENT

…Any existing and new plant programme that supports LTO and manages the ageing effects identified for LTO is reviewed to determine whether it includes the nine elements described below…

5.5 DOCUMENTATION OF THE EVALUATION AND DEMONSTRATION FOR MANAGEMENT OF AGEING EFFECTS

The operating organization develops and retains in an auditable and retrievable form all information and documentation required by the regulator.

11.2(a) Good Practice: The KKM plant has developed a comprehensive strategy to manage the core shroud cracking issue and allow long term operation. The strategy includes chemical treatment of the reactor water, improved ultrasonic inspection tooling, analytical modelling, and the future optimization of the tie-rod design.

- The plant is an industry leader for on-line noble metal chemical addition (OLNC).Previously, the plant added the noble metal annually and injected a low rate of hydrogen in the reactor water continuously. However, evidence suggests the on-line OLNC process, in conjunction with the same low rate of hydrogen addition, better protects the shroud and other core internals. Pool side inspections of fuel and careful monitoring of this chemical addition has confirmed there is not a detrimental impact on fuel performance. In addition, reduced injection rates of hydrogen reduce plant dose during power operation.
- Plant personnel have worked with industry experts to refine inspections on the core shroud welds. For example, while ultrasonic testing (UT) inspections on the shroud welds have been performed for years, improved tooling allows for better weld coverage and accuracy. The UT data on the crack growth in welds is very comprehensive.
- Detailed three dimensional finite element analytical models of the shroud and supporting reactor structures are used to provide a structural assessment of the cracked core shroud. The modelling, coupled with conservative input assumptions and accurate crack measurements, quantify available structural margin. The results of the assessment verify the shroud has adequate design margins, even for extremely unlikely accident scenarios.
- The utility plans to add further design margin in the future to support long term operation. In the mid-1990's, the shroud was strengthened by adding four stabilizers or "tie rods" to the original design. The new design will replace the four existing tie rods with six tie rods of an improved design.

The actions completed to date, in combination with a future design change, provide a comprehensive short and long-term strategy for the KKM core shroud. Plant personnel will continue on-line OLNC, visual and ultrasonic inspections, and detailed analytical fracture mechanics modelling. These actions ensure current operation is safe and adequate margin exists for unlikely postulated accidents. The new tie-rod design, after installation, will increase design margin further and possibly allow reductions in the scope of visual and ultrasonic inspections.

11.3 REVALIDATION OF SAFETY ANALYSES THAT USED TIME LIMITED ASSUMPTIONS

11.3(1) Issue: Environmental qualification (EQ) of originally installed safety cables of class 1E is not completely revalidated for LTO.

The plant has replaced most safety systems (e.g. SUSAN building systems, Reactor Protection System and other systems) including safety cables. They are properly qualified for LOCA conditions. Nevertheless the following observations were made:

- Several safety systems still have the originally installed class 1E cables and have their original qualification documentation files. Qualified life-time of originally installed class 1E cables has been defined for 380V power cables, but not yet for control cables.
- The replacement of these cables with qualified cables has been planned but not performed yet.
- ENSI-B01 guideline requires the plant to prepare AM (Ageing Management) reports for all 1E class components. In some AM Reports for class 1E safety cables the qualified life-time has not been defined.
- New projects (safety I&C systems) were introduced 3 years ago. Remaining safety systems including their class 1E cables were planned to be replaced within the framework of these projects. These projects were postponed due to Fukushima corrective actions beyond 2012.
- Qualification of original safety control cables was not revalidated for LTO.

Without revalidation of qualified life-time, it cannot be demonstrated that safety systems will perform their intended safety function properly during LOCA and post-LOCA conditions.

Recommendation: The plant should take measures to revalidate environmental qualification for LTO.

IAEA basis:

SSR-2/2

Requirement 13: Equipment qualification

The operating organization shall ensure that a systematic assessment is carried out to provide reliable confirmation that safety related items are capable of the required performance for all operational states and for accident conditions.

4.48 Appropriate concepts and the scope and process of equipment qualification shall be established, and effective and practicable methods shall be used to upgrade and preserve equipment qualification. A programme to establish, to confirm and to maintain required equipment qualification shall be launched from the initial phases of design, supply and installation of the equipment. The effectiveness of equipment qualification programmes shall be periodically reviewed.

4.49 The scope and details of the equipment qualification process, in terms of the required inspection area(s), method(s) of non-destructive testing, possible defects inspected for and required effectiveness of inspection, shall be documented and submitted to the regulatory body for review and approval. Relevant national and international experience shall be taken into account in accordance with national regulations.

NS-G-2.12

7.3 A demonstration of the functionality of any safety related item of equipment that performs safety functions under harsh environmental conditions is important for the equipment qualification programme. Service conditions following a postulated initiating event are significantly different from normal operational conditions, and little confidence in the continued functionality of an item of equipment can be derived from performance during normal operation, pre-operational tests and periodic surveillance tests.

7.4 The ageing of individual items of equipment is managed by using a concept either of ‘qualified life’ or of ‘qualified condition’ established by equipment qualification.

7.6 The qualified life established by equipment qualification is the period of time of normal operation for which ageing degradation would not prevent satisfactory performance of the equipment if a postulated initiating event were to occur. Before the end of the equipment’s qualified life, equipment replacement is carried out, life limiting components are renewed or a new, longer qualified life is established.

SRS – 57

3.3.2 Equipment qualification

Equipment qualification establishes that equipment, while being subject to environmental conditions, is capable of performing its intended safety functions or that it will be replaced/repaired so that its intended safety functions will not be compromised during the planned period of LTO.

Equipment qualification also demonstrates whether the environmental and seismic qualification of equipment will remain valid over the expected period of LTO. The demonstration supports the technical justification that the material degradation and ageing effects will be managed effectively. Equipment designed in accordance with earlier standards is reviewed and requalified, if necessary, under a comprehensive programme. Timely replacement of equipment that cannot be qualified for the planned period of LTO is considered. A specific programme is developed for replacement of mechanical and electrical equipment with qualified or stated lifetimes less than the planned LTO period.

NS-G-2.10

4.19 Qualification of plant equipment important to safety should be achieved through a process that includes generating, documenting and maintaining evidence that equipment can perform its safety functions during its installed service life. This should be an ongoing process, from the plant design to the end of service life, and plant ageing, modifications, repairs and refurbishment, equipment failures and replacements, and abnormal operating conditions should be taken into account. Although many parties (such as plant designers, equipment manufacturers and consultants) are involved in the equipment qualification process, the operating organization has the ultimate responsibility for the development and implementation of a plant specific equipment qualification programme that includes generating and maintaining the documentation demonstrating qualification.

4.20 The review of equipment qualification should determine (a) whether assurance of the required equipment performance capability was initially provided and (b) whether equipment performance has been preserved by ongoing application of measures such as scheduled maintenance, testing and calibration and has been clearly documented. It should be noted that a review relating to (a) above may not be necessary if a previous review has concluded that adequate initial equipment qualification was established; and a review relating to (b) above should provide assurance that equipment qualification will be satisfactorily preserved in future. A plant walkdown of installed equipment should be performed to identify for qualified equipment any differences from the qualified configuration (abnormal conditions such as missing or loose bolts and covers, exposed wiring or damaged flexible conduits).

14. SEVERE ACCIDENT MANAGEMENT

14.1 DEVELOPMENT OF SEVERE ACCIDENT MANAGEMENT STRATEGIES

Preventive & Mitigative regime

The plant-specific preventive Accident Management Measures (AMM) are a development of Mühleberg NPP (KKM) which started back in 1994. The latest AMMs are a response to the Fukushima event. Plant specific Severe Accident Management Guidance (SAMG) for full power operation events were prepared with the support by an external organisation in 2004. The OSAR team has identified as a good practice the development of (SAMG) for shut-down conditions, which were finalized at the end of 2006.

The following top level objectives are addressed by Accident Management Measures (AMMs) and SAMGs: a) prevent or stop core melt, b) retain containment integrity and c) minimize radioactive releases into the environment. In general, it seems that applying the developed AMM and SAMG provides a “scope of action” to the pikett engineer / responsible staff of the Emergency Response Organisation (ERO) during accidents for their decisions by having less detailed instructions available which accounts for flexibility for ad-hoc measures to a certain extent. So the use of non-dedicated systems, unconventional line-ups and temporary connections and the use of systems beyond their design basis is considered. In general, the approach used to write down the AMM procedures and SAM guidelines is consistent. In both guidelines the main overall information on the actions to be performed is provided, but the actions themselves are not described for all AMM and SAMG in detail. The team has made a suggestion in this regard.

Identification of plant specific vulnerabilities and plant capabilities

The identification of plant specific vulnerabilities and plant capabilities in the case of accidents beyond the design basis is typically done together with the development of safety related documents, like PSA. The team found that written information on this is limited. On the other hand, the applied AMM and SAMG show a wide use of plant specific features and systems, which the team noted as a good performance.

Hardware provisions for accident management

Several systems at KKM were installed the specific purpose of mitigating challenges to containment integrity that might occur during severe (i.e. core damage) accidents, which was very seldom done at that early time and is appreciated by the team. Two important systems are:

- Drywell Spray and Flooding System (DSFS), and
- Containment Depressurization System (CDS).

Several systems are available at the plant to remove heat from the core and to depressurize the reactor; some of them were back-fitted years ago (mainly RCIC, TCS, ALPS, SUSAN, mobile pumps, high water reservoir). Others (second heat sink of diverse design) are in planning as a result of the Fukushima event. Also, back-ups for power supply are available. For more information see ENSREG stress test report.

Role of instrumentation and Control

Since the implementation of AMM/SAMG depend on the ability to estimate the magnitude of several key plant parameters, the required plant parameters have been identified. For the SAMG the availability of the instrumentation was checked during development of SAMGs. Alternative information sources are mentioned and easy to use tools to derive the needed information were developed. The team noted as a good performance that the effect of environmental conditions on the instrument reading was considered while checking the instrumentation availability.

14.2 DEVELOPMENT OF PROCEDURES AND GUIDELINES

General

The possibility of transition from AMMs to SAMGs before the ERO is operable, is considered in the development of procedures and guidelines. The pikett engineer is responsible until the ERO is operable. The ERO will get support from the SAMAG team in case of a severe accident.

Plant Specific Development

A large set of event and symptom oriented operational procedures exists including detailed flow charts related to the typical NPP safety functions of the RPV and the primary and secondary containment. Whenever the plant status escalates, exits are defined into specific preventive AMM strategies and further into SAMG. If strategies are to be implemented in parallel, it is the duty of the personnel in charge (pikett engineer, ERO) to decide what to do based on their determination of the plant status and their knowledge about the individual strategies.

A systematic assessment of the available staff resources is not contained in the SAMG procedures , but it is expected that sufficient personnel should be available as in principle all are alerted and a large number of staff would be ready for support.

The strategies used for the severe accident procedures or guidelines are representative for most severe accident phenomena at the plant. Not all relevant phenomena or system states at the time of the strategy application are covered, especially not in the deterministic analysis for DSFS and CDS use. The team made a recommendation in this respect.

Analytical Tools

The integral code MELCOR 1.8.5 was used, which was code version at the time of the development of the SAMG for both power conditions. The model application was done within the code validation range. The code was used by experienced users. From today`s perspective, a few improvements of the plant specific input deck can be encouraged, especially when in depth analyses are to be performed concerning the use of CDS and DSFS.

Plant Specific Accident Sequences

Plant specific severe accident sequences were analyzed in the PSA level 2 studies of 2000 and 2005, also used as a basis for SAMG development for full power conditions. Results of the MELCOR analyses are documented for SAMG development and as well in the PSA level 2 of 2005. The content of the information provided is too limited. The limitation does not allow an independent review. Analyses with application of accident management measures focus mainly on the use of CDS and DSFS.

Language and Clarity

User-friendliness of guidelines and procedures is adequate. German is used for operating procedures and AMMs and English for SAMGs. For a well-trained person of the shift or the ERO it should be possible to work with the documents quite efficiently.

14.3 RESPONSIBILITY AND PLANT EMERGENCY ARRANGEMENT

The ERO is well structured. No “standby system” for staff for specific functions in the ERO is foreseen. In an emergency / accident all staff is alerted to be sure to get enough staff for all topics. The lead of the individual working groups of ERO is selected / distributed between the staff arriving first at the main control room after an alert (voluntarily basis).

14.4 VERIFICATION AND VALIDATION OF PROCEDURES AND GUIDELINES

AMM procedures were developed by KKM and verified internally by plant staff. The date of the development of the procedure, of its verification and of the approval is provided on each document. SAMG procedures were developed with support from an external organisation. The team encourages the plant to use signature for verification of SAMG by KKM as well.

For the validation of the SAMG, different emergency drills were used in the last years as well. They are organized on a regular basis with different scenarios. There is a full scope simulator, which is used whenever possible. The emergency drills confirm that the actions specified in the AMM procedures and SAM guidelines can be followed by trained staff to manage emergency situations.

The verification and validation processes are documented as long as they are related to the emergency drills. There is feedback from the lessons learned from verification and validation, but its inclusion in the regular updates of the SAMG should be improved.

14.5 TRAINING NEEDS AND TRAINING PERFORMANCE

Training is a separate review area. It is not covered here in detail; just some observations are mentioned. Besides the emergency drills mentioned regular training is organized by KKM for the ERO and the SAMAG staff and provided by the SAMG developer. The detail of information provided in the SAMG trainings is appreciated.

14.6 ACCIDENT MANAGEMENT PROGRAMME UPDATING AND REVISIONS

ENSI has reviewed the full power SAMG after its completion and stated that their requirements related to SAMG and SAM organization (SAMAG as part of ERO) are met.

The latest review for full power SAMG by the external developer was done after the PSA level 2 of 2005 was finished. It resulted in a proposal of three specific areas of improvement related to a) ATWS sequences, b) preparation of DSFS in case of a very early core heat-up, and c) sequences with significant releases into the secondary containment and the operation of the ventilation systems.

In March 2007, the update of the SAMG for low power and shut down was provided to ENSI and they performed a review.

Furthermore, ENSI required a regular review and update process of the SAMG. The plant developed a work procedure to comply with this request. Information is provided in the protocols of the annual review process meetings of SAMG.

The team encourages KKM to incorporate review results of AMM/SAMG into changes and updates of these documents more regularly.

DETAILED SEVERE ACCIDENT MANAGEMENT FINDINGS

14.1 DEVELOPMENT OF SEVERE ACCIDENT MANAGEMENT STRATEGIES

14.1(a) Good Practice: Development and implementation of Severe Accident Management Guidance (SAMG) for shut-down conditions.

Extending the SAMGs from full power to shut down to provide appropriate guidance for fuel damage events that might occur during plant shutdown conditions requires an understanding of severe accident behaviour that takes into account the plant conditions and physical changes in equipment configuration during shut-down conditions. SAMG for low power and shut down were finalized at the end of 2006, again prepared with support from the same external organisation. Typically, in such an accident the time until the fuel in the core or the spent fuel pool assemblies heat up is much longer than for severe accidents in full-power operation. Several specific SAMG are prepared to deal with such situations, while others from the full power SAMG are used as well.

The Accident Management Program at KKM including Severe Accident Management Guidance for shut-down conditions is remarkably comprehensive.

14.1(1) Issue: The instructions provided by AMM / SAMG procedures, the information on priorities and on rules of usage provided for effective implementation during emergency situations, and the assessment of negative impacts are not always provided in detail.

The way in which the implemented AMM and SAMG are applied by the pikett engineer or the ERO as described and seen in the OSART review provides a “scope of action” to the responsible staff taking the decision. The SAMG are used by a special group of plant experts forming the working group SAMAG. This group will support the ERO leader by proposing actions based on the SAMG and the assessment of the plant status.

In general, the approach used to write down the AMM procedures and SAM guidelines is consistent. In both the main overall information is provided on the actions to be performed. The success and possible consequences for the AMM and SAMG have been analysed based on the boundary conditions and plant conditions defined for their development. The following observations where made:

- In the AMM the goal of the strategy and the actions themselves are not always described in detail.
- If multiple measures are described within one AMM strategy using different systems, often no prioritisation is given.
- Information is missing in the AMMs concerning the time needed or allowed to perform the individual action(s).
- The level of detail of instructions to the staff which must perform the action is coarse.
- No information is provided in the AMM check lists on how to proceed if one check fails; nor are any instructions written down to indicate, whether the check list has to be followed in hierarchical order or if parallel actions are allowed or recommended.
- Success criteria or information concerning which plant parameters are to be monitored and what to do, if one instrument fails, are limited.
- Little information is provided in detail indicating where the equipment is available which is expected to be needed to perform the action (e.g. keys, equipment, tools, protective clothes).
- Often no hand-out material is prepared to be provided to the shift personnel (or others) who are supposed to perform the action.
- To what extent potential positive and negative consequences of proposed strategies in AMM and SAMG have been analysed and considered, has often not been specified in the written documents:
- The AMM implemented to flood the containment up to a certain water level leads to a fully water submerged status of the vacuum breakers between inner torus and drywell. The consequences are not clearly described and analysed.
- The AMMs implemented to feed into the RPV and to flood the drywell until a certain water level is reached may be used simultaneously. In the event that external water sources are used, the consequences from injecting water in parallel by both measures are not fully considered, especially not for the plant status when the described drywell water level is reached.
- Potential consequences of a local RPV failure by a penetration in a severe accident have not been analysed.

- Several entry points from AMMs to the SAMG are defined in the symptom oriented flow charts. No detail is provided into which specific SAMG the entry should be made.
- AMM(s) available in the current emergency documents folder to be used by plant personnel in case of an accident, are not always linked to the symptom oriented flow chart.
- The flow charts used for the low power and shut down SAMG are not fully separated from the full power SAMG

If the guidance in the form of procedures (AMM) and guidelines (SAMG) to be used by responsible personnel in case of an accident is not provided in an appropriate way including descriptive details, priorities and clearly written rules of usage and addressing a wide spectrum of credible challenges and probable system combinations, the personnel may not apply it efficiently.

Suggestion: The plant should consider improving the descriptive details, priorities and clearly written rules of usage of the guidance given in the procedures (AMM) and guidelines (SAMG). Particular consideration should be given to strategies that have both positive and negative impacts or those with multiple measures planned in order to provide a better basis for a decision about which strategy constitutes a proper response under a given plant damage condition.

IAEA basis:

SSR-2/2

5.8: The accident management programme shall be documented and periodically reviewed and revised as necessary.

NS-G-2.15: 2.8 Appropriate guidance, in the form of procedures and guidelines, should be developed for the personnel responsible for executing the measures for accident management.

NS-G-2.15: 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 … . 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.

NS-G-2.15: 3.33 The procedures and guidelines should contain the following elements:
- Objectives and strategies;
- Initiation criteria;
- The time window within which the actions are to be applied (if relevant);
- The possible duration of actions;
- The equipment and resources (e.g. AC and DC power, water) required;
- Actions to be carried out;
- Cautions;
- Throttling and termination criteria;
- Monitoring of plant response.

NS-G-2.15: 3.24 A method for carrying out a systematic evaluation of the possible strategies that can be applied should be developed, taking into consideration the evolution of the accident. Adverse conditions that may hamper the execution of the strategy for that phase of the accident should be considered. In selecting and prioritizing strategies, it should be noted that evaluation is very important owing to the potential for multiple negative impacts of actions, and the increased levels of uncertainty about the plant status and the plant's response to actions.

NS-G-2.15: 3.25 Particular consideration should be given to strategies that have both positive and negative impacts in order to provide the basis for a decision about which strategies constitute a proper response under a given plant damage condition. …

NS-G-2.15: 3.38 Possible positive and negative consequences of proposed strategies should be specified in the guidelines, in cases where the selection of the strategies will need to be done during the evolution of the accident. The technical support centre should check whether additional negative consequences are possible, and should consider their impact.

NS-G-2.15: 3.27 Priorities should be set between strategies, because possible strategies can have a different weight and/or effect on safety, and because not all strategies can be carried out at the same time. In the preventive domain, the priority of the strategies should be reflected in the priority established for the critical safety functions. In the mitigatory domain, priority should be given to measures that mitigate large ongoing releases or challenges to important fission product barriers …

NS-G-2.15: 3.39 … Conflicts in priorities, if any, should be resolved. The priorities may change in the course of the accident and, hence, the guidelines should contain a recommendation that selection of priorities be reviewed at regular time intervals. ...

NS-G-2.15: 3.56 Rules of usage should be defined for the application of SAMGs. Such rules define what needs to be done in the actual application of the guidelines. …

NS-G-2.15: 3.125 Generally, analysis should be of a best estimate type, as it is important to retain the best available physical picture of the response of the plant. Best estimate calculations usually yield the mean or median value of a possible range of values. Hence, appropriate consideration should be given to uncertainties in the determination of the timing and severity of the phenomena.

NS-G-2.15: 3.127 Computer code results should be interpreted with consideration given to model limitations and uncertainties. … All code results should be evaluated and interpreted with due consideration given to code limitations and the associated uncertainties.

14.2 DEVELOPMENT OF PROCEDURES AND GUIDELINES

14.2(1) Issue: The use of the containment venting system CDS under all expected conditions and the link to the use of the containment spray system DSFS is not clearly described in relevant documents: operating procedure, AMM and SAMG.

Two systems – Drywell Spray and Flooding System (DSFS), and Containment Depressurization System (CDS) – were installed at KKM in the early 1990s for the specific purpose of mitigating challenges to containment integrity that might occur during accidents and severe accidents. The operation of the systems under various conditions is described in the operating procedure, AMM and SAMG. The use of the two systems is a central element in the KKM Accident Management Program.

The following observations where made:

- The relevant documents related to the operation of the CDS – the operating procedure, the AMMs and the SAMG – describe different ways of using the system under different boundary conditions or for different plant conditions, respectively. These are a) cooling of the torus by steam release through the CDS and b) use of CDS under severe accident conditions to prevent containment failure and to minimize activity releases. The content of information provided in the documents is not clearly described and separated. The supporting analyses differ and do not consider all probable plant conditions. This applies to such cases in particular, in which not all air ventilation systems connected to the stack are switched off during operation of the CDS in case of a severe accident.
- The actions to be taken in case the rupture disc in the CDS system fails are not clearly described. A detailed estimation of the possible positive and negative consequences is missing.
- No clear guidance is provided for severe accident cases with possible enhanced leakages from the primary containment (hydrogen, aerosols, noble gases) into the secondary containment at high containment pressure.
- The relevant documents related to the operation of the DSFS – the operating procedure, the AMMs and the SAMG - describe different ways of using the system under different boundary conditions assumed respectively for different plant conditions.
- An entrance into SAMG in case of containment pressure control in the symptom oriented flow chart is not considered.

If the guidance provided in the form of procedures (AMM) and guidelines (SAMG) to be used by responsible personnel in case of an accident is not clear, the staff may not apply them efficiently.

Recommendation: The plant should clearly describe in the operating procedure, the AMM and the SAMG documents the use of the containment venting system CDS under all expected conditions for the strategies a) cooling of the torus by steam release through the CDS and b) use of CDS and DSFS under severe accident conditions to prevent containment failure and to minimize activity releases.

IAEA basis:

SSR-2/2

5.8: The accident management programme shall include instructions for utilization of the available equipment and the technical and administrative measures to mitigate the consequences of an accident.

NS-G-2.15: 2.8 Appropriate guidance, in the form of procedures and guidelines, should be developed for the personnel responsible for executing the measures for accident management.

NS-G-2.15: 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 … . 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.

NS-G-2.15: 2.15 Development of accident management guidance should be based on best estimate analyses in order to capture the proper physical response of the plant. … Hence, mitigatory actions should be initiated at parameter levels and at a time that gives sufficient confidence that the protection intended by carrying out the action will be achieved. For example, venting the containment, if necessary to protect the structural integrity of this fission product barrier, should be initiated at a time and at a containment pressure level that gives confidence that the structural integrity of the containment will not be lost.

NS-G-2.15: 3.24 … Adverse conditions that may hamper the execution of the strategy for that phase of the accident should be considered. In selecting and prioritizing strategies, it should be noted that evaluation is very important owing to the potential for multiple negative impacts of actions, and the increased levels of uncertainty about the plant status and the plant's response to actions.

NS-G-2.15: 3.25 Particular consideration should be given to strategies that have both positive and negative impacts in order to provide the basis for a decision about which strategies constitute a proper response under a given plant damage condition. ...

NS-G-2.15: 3.26 Insights into the plant damage states in the evolution of the accident should be obtained wherever possible. They are helpful, as they can help to select strategies, because some strategies can be effective in one plant damage state, but may be ineffective or even detrimental in another.

NS-G-2.15: 3.125 Generally, analysis should be of a best estimate type, as it is important to retain the best available physical picture of the response of the plant. Best estimate calculations usually yield the mean or median value of a possible range of values. Hence, appropriate consideration should be given to uncertainties in the determination of the timing and severity of the phenomena.

NS-G-2.15: 3.127 Computer code results should be interpreted with consideration given to model limitations and uncertainties. … All code results should be evaluated and interpreted with due consideration given to code limitations and the associated uncertainties.

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)
- **SSG-4**; Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants (Specific Safety Guide)
- **SSG-15**; Storage of Spent Nuclear Fuel (Specific Safety Guide)
- **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

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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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