RISK MANAGEMENT OF KNOWLEDGE LOSS IN NUCLEAR INDUSTRY ORGANIZATIONS

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FOREWORD

Maintaining nuclear competencies in the nuclear industry and nuclear regulatory authorities will be one of the most critical challenges in the near future. As many nuclear experts around the world are retiring, they are taking with them a substantial amount of knowledge and corporate memory. The loss of such employees who hold knowledge critical to either operations or safety poses a clear internal threat to the safe and reliable operation of nuclear facilities.

This publication is intended for senior and middle level managers of nuclear industry operating organizations and provides practical information on knowledge loss risk management. The information provided in this it is based upon the actual experiences of Member State operating organizations and is intended to increase awareness of the need to: develop a strategic approach and action plans to address the potential loss of critical knowledge and skills; provide processes and in conducting risk assessments to determine the potential for loss of critical knowledge caused by the loss of experienced workers; and enable nuclear organizations to utilize this knowledge to improve the skill and competence of new and existing workers

In 2004, the IAEA published a report entitled The Nuclear Power Industry's Ageing Workforce: Transfer of Knowledge to the Next Generation (IAEA-TECDOC-1399). That report highlighted some of the knowledge management issues in Member States resulting from the large number of retiring nuclear power plant personnel who had been involved with the commissioning and initial operation of nuclear power plants. This publication complements that report by providing a practical methodology on knowledge loss risk management as one element of an overall strategic approach to workforce management which includes work force planning, recruitment, training, leadership development and knowledge retention.

Appreciation is expressed to all the participants who contributed to the development of this publication. Particular thanks are due to J.E. Boyles (United States of America) for his assistance in the preparation of the final manuscript.

The IAEA officers responsible for this publication were A. Kosilov, T. Mazour and Y. Yanev of the Department of Nuclear Energy.

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

It is well established that many nuclear power plant operators face a challenge resulting from the loss of experienced workers and the knowledge and skills they possess. Often this knowledge is undocumented and the skills require years of training and experience to acquire. This loss may be caused by a variety of factors including retirement of long term employees, internal transfers and promotions, or resignation where employees leave the nuclear industry. The following examples demonstrate three different situations where business, demographic and political decisions influence the industry and create the need to manage nuclear knowledge.

1.1.1. Expanding nuclear capacity in China

In China, rapid economic development has led to very strong growth in electricity demand and this situation seems likely to continue. The present plan is to increase capacity by 40 000 MW through the use of safe, reliable and environmentally sound nuclear power by 2020. This will require strong support in maintaining excellence in safe and reliable operations, minimizing the project costs and maximizing the value of nuclear energy assets. The plan will also require the development of the necessary infrastructure and qualified human resources to meet the future needs of the nuclear energy industry.

In order to meet Guangdong's electricity demand and fuel diversity programme, the China Guangdong Nuclear Power Holdings Company (CGNPC), which is based in Guangdong Province, has a plan to build at least one 1000 MW unit per year, adding 20 units to its fleet by 2020. This will require that a workforce of 12 000 be established to operate these new plants. Before the first plant is commissioned at its new location outside the existing Daya Bay site, the responsibility for on the job training and 'shadow' training of these new workers will rest solely with the Daya Bay Nuclear Power Operations and Management Company (DNMC). The DNMC is an O&M organization entrusted by its two owners to operate four units at the Daya Bay site (two units have been in operation for 11 years and two units for 3 years). Current staffing at the site is approximately 1860 employees. The DNMC has a relatively young workforce with an average age of 34 years. However, significant attrition of experienced staff is anticipated as employees are moved to the new site to support establishment of the operating organizations in preparation for the handover from commissioning.

The senior managements of both CGNPC and DNMC have initiated anticipatory action (including knowledge loss prevention and retention measures) to address the expected experience dilution resulting from retirement and staff turnover at the new plants over the next five years.

1.1.2. Talent loss and recruitment challenge in Germany

In Germany, the political decision to phase out nuclear power has gradually had an impact on the current and future nuclear workforce. The decision has led to a strong decline in enrolment in academic programmes related to nuclear engineering. In addition, there is a continuing trend for the current nuclear power plant workforce to seek opportunities in other regions or industries where there is greater political and public appreciation and expected future stability.

These factors, combined with the retirement of long term employees, are creating a shortage of qualified nuclear power plant workers in anticipation of the national schedule for decommissioning. In particular, this shortage of qualified workers jeopardizes the option of prolonging nuclear power plant operating permits, which could be problematic, considering that viable alternatives to nuclear power are not yet in place. The situation in the German nuclear industry is quite different from that in China but results in similar nuclear knowledge management challenges.

1.1.3. Ageing workforce and pending growth in the United States of America

In the USA, the general consensus concerning nuclear power appears clear; it is no longer a question of whether new plants will be built but when and where. Recently, at the winter 2005 meeting of the American Nuclear Society, Patrick Moore, founder of Greenpeace and keynote speaker at the conference, noted that "nuclear power is the only viable source of clean, non-carbon generating and efficient energy that can adequately sustain current and future economic growth without significant impact to the environment." This is a significant shift in the general attitude in the USA concerning the use, advancement and growth of nuclear science and technology in support of energy generation. This positive attitude towards nuclear power is also becoming the norm based on increasing public agreement that, in fact, greenhouse gas production is having an impact on the global climate. Additionally, events such as the power blackout in the eastern USA and the financial impact of Hurricane Katrina resulting from damage to the oil

production facilities in the Gulf of Mexico underscore the need for the active pursuit of alternative energy sources.

The anticipated growth in nuclear generating capacity coupled with recent and continuing life extension of existing plants create an unprecedented demand for a unique workforce resource: the individual qualified in all of the traditional nuclear power support disciplines. However, in sustaining and advancing the nuclear industry, emphasis and attention are also being placed on the research and development of next generation reactor types and fuel cycle management options and technologies. These efforts will further draw on the same workforce needed to operate and maintain current plants. To complicate an already challenging workforce picture, the construction and licensing of new nuclear energy production facilities will further negatively affect the available workforce. Also within the USA, other industry sectors will be competing for the same college and technical graduates. There are two other complicating factors. The USA faces the issue of a 'greying' workforce where literally half the current workers will be eligible to retire within the next five years. Secondly, the lead time required to produce an individual capable of safely operating the complex nuclear systems and technologies may exceed the time-frame available until substantial retirement of the existing workforce begins.

There are global dynamics affecting this workforce picture, as well. The USA has for many years been able to bring in workers from other countries attracted by the technical opportunities available. However, as other countries develop their own high technology infrastructure (not just in the energy sector), opportunities abound for those potential migrants to remain and work in their own country. This is having a significant impact on the USA's capacity to attract technical talent to the nuclear industry. As new facilities are constructed and other necessary nuclear infrastructure and technology begin to emerge, the capability to attract new talent and have the requisite knowledge resources to train them will impact the capability to bring new facilities and support activities into operation in a timely manner to keep pace with energy demand.

In light of such diverse workforce challenges outlined in these examples, the nuclear industry has taken a more formal approach in recent years to managing its human assets, including developing strategies and programmes to capture, retain and transfer nuclear knowledge and skills.

1.2. OBJECTIVES

The objectives of this publication are to:

(a) Increase awareness among senior and middle nuclear power plant management of the need to develop a strategic approach and action plans to address the potential loss of nuclear knowledge and skills;
(b) Provide processes and tools for senior and middle nuclear power plant management to use in conducting risk assessments to determine the potential for loss of nuclear knowledge (especially undocumented knowledge) caused by the loss of experienced workers;
(c) Enable nuclear power plants to utilize this knowledge to improve the skills and competences of new and existing workers.

1.3. SCOPE

Several recent meetings sponsored by the IAEA and others have focused on nuclear knowledge management. These include technical meetings in November 2003 and June 2004 held in Vienna, a September 2004 International Conference on Knowledge Management: Strategies, Information Management and Human Resource Development held in Saclay, France, and an August 2005 workshop on Nuclear Knowledge Management held in Trieste, Italy.

In addition, recent 'assist' visits (to Krško and Kozloduy nuclear power plants) by the World Association of Nuclear Operators and the IAEA have addressed the facilities' needs to develop effective knowledge management strategies and programmes. During these assist visits, management identified the need for specific guidance and tools to help in the development and implementation of nuclear knowledge management programmes. Nuclear power plants often need to know how to begin the development of effective programmes. Assist visits and technical meetings are helpful but may address nuclear knowledge management from too broad a perspective. Therefore, this publication is focused on providing specific processes and tools with which to conduct risk assessments aimed at determining the potential for knowledge loss to the nuclear power plant and to identify steps to manage this loss. The processes and tools can be adapted or modified for use by a wide variety of organizations.

While this publication focuses on managing the risk of knowledge loss among nuclear power plants, the broader challenge posed by current nuclear workforce issues should be recognized. Section 2 briefly addresses this challenge.

1.4. KNOWLEDGE MANAGEMENT TERMINOLOGY

Knowledge management can be a broad and complex area of study and subject to wide interpretation. For the purposes of this publication the following definitions are used:

Knowledge management: The integrated, systematic approach to the identification, acquisition, transformation, development, dissemination, use, sharing and preservation of knowledge relevant to achievement of specified objectives. Knowledge management helps an organization to gain insight and understanding from its own experience. Specific activities in knowledge management help the organization to acquire, store and utilize knowledge.
Attrition: A decrease in the number of employees in an organization as a result of retirement, other termination, or transfer to other organizations.
Critical knowledge: The knowledge established in the context of a particular position that is deemed imperative for incumbents of the said position to possess before being allowed to perform associated duties and tasks independently.
Human assets: The knowledge, skills and competencies of the people in an organization.
Institutional knowledge: The collective knowledge of all the employees working in an organization or institution.
Knowledge: The acquisition, understanding and interpretation of information. Knowledge is often used to refer to a body of facts and principles accumulated by humankind over the course of time. Explicit knowledge is knowledge that can be easily expressed in documents. Implicit knowledge and tacit knowledge represent knowledge or know-how that individuals hold in their memory. Explicit knowledge is contained in documents, drawings, calculations, designs, databases, procedures and manuals. Implicit knowledge and tacit knowledge are held in a person's mind and have typically not been captured or transferred in any form (if they had, they would then become explicit knowledge). Compared with explicit knowledge, such knowledge is more difficult to articulate or to write down and so it tends to be shared between people through discussion and personal interaction. It includes skills, experiences, insight, intuition and judgement.

1.5. APPLICATION

Nuclear power plant managers should use the information provided here to develop a strategic approach which addresses the issues associated with the

potential for loss of nuclear knowledge and skills. Managers should further assess the situation in their organization and adapt or modify the concepts, processes and tools outlined here to meet their specific needs.

2. STRATEGIC APPROACH TO MANAGEMENT OF WORKFORCE ISSUES

Many nuclear power plants recognize that a strategic approach is most effective in addressing the broad array of workforce issues which many organizations face. While the focus here is on managing the risk associated with the potential loss of nuclear knowledge, the interactions between knowledge management and other, people centered programmes should be considered. These programmes may include the following:

(a) Workforce planning;
(b) Recruitment initiatives;
(c) Training programmes;
(d) Succession planning and leadership development;
(e) Knowledge management.

For example, if a potential for knowledge loss involving a plant expert on auxiliary power is identified, solutions may involve a recruitment initiative and/or development of a formal training module. The pending retirement of an experienced component engineer may require recruitment, training and succession planning. There are numerous other examples where an integrated, strategic approach must be taken to ensure the overall effectiveness of these related programmes.

3. RISK ASSESSMENT PROCESS AND TOOLS

The following processes and tools can be used by nuclear power plants to identify and mitigate knowledge loss threats. Management can adapt or modify these processes and tools to meet the specific needs of their organization.

3.1. ATTRITION RELATED KNOWLEDGE LOSS RISK ASSESSMENT

Attrition related knowledge loss threats can be identified, prioritized and addressed using the following process to determine a total risk factor for each employee in the organization. This total risk factor is based on a projected attrition date, which could be retirement, transfer, or other attrition (attrition risk factor), and criticality of knowledge and skill (position risk factor). This three step process has been succesfully implemented by the Tennessee Valley Authority (TVA) in the USA. Figure 1 is a flow diagram of the critical knowledge retention process. Knowledge retention roles and responsibilities are outlined in Annex I.

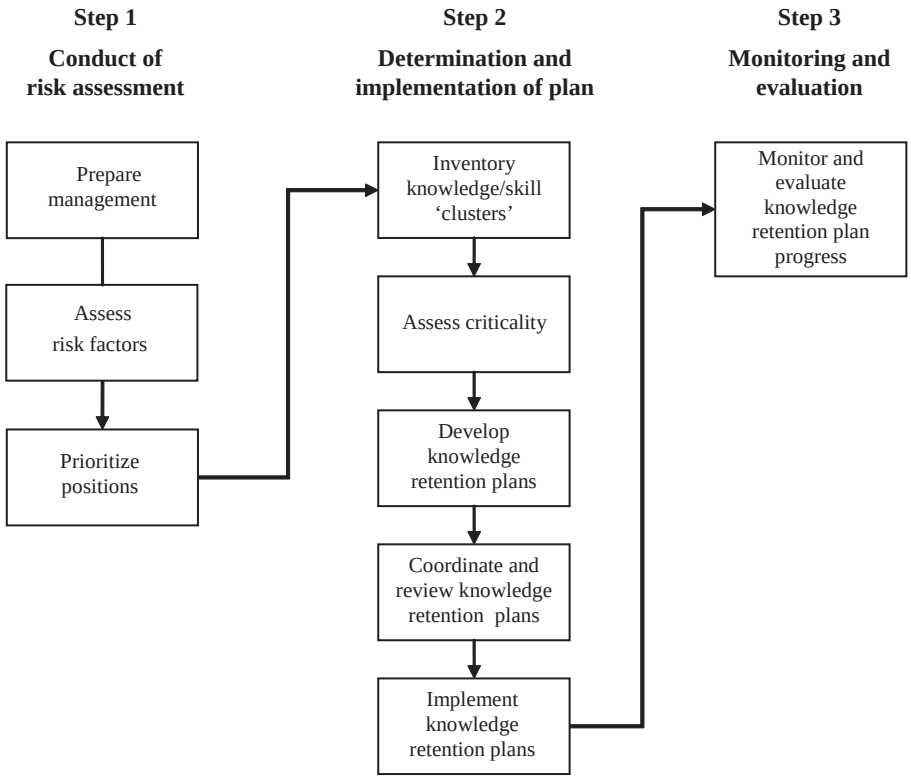

FIG. 1. Critical knowledge retention flow chart.

3.1.1. The three step process

3.1.1.1. Step 1: Conduct of a knowledge loss risk assessment

The knowledge loss risk assessment is designed to identify positions/individuals where the potential for knowledge loss is greatest and most imminent.

The attrition risk factor is based on the expected retirement or other attrition date. The date can be provided by the employee or calculated according to age and tenure data. Table 1 lists the criteria used to assign an attrition risk factor.

The position risk factor is initially assigned by the department level manager using criteria listed in Table 2. The position risk factor criteria are based on the unique/critical knowledge and skills possessed by the employee and an estimate of the difficulty or level of effort required to refill the position. In assigning the factor the manager should consider each employee's responsibilities and background, formal and informal roles, collateral duties, recurrent assignments (e.g. outage related duties, problem solving or trouble shooting assignments) and other factors suggesting that the employee may have unique/critical knowledge and skills. Department managers may want to consult other work group members, key plant customers, or interested parties when determining ratings.

The total risk factor of an employee is determined on the basis of the guidelines provided in Table 3. The total risk factor provides an overall assessment of attrition related risk for knowledge loss. The total risk factor is computed by multiplying the attrition risk factor by the position risk factor (see Table 4).

Each nuclear power plant management team should collectively review the results of the risk assessment. Experience has shown that a critical review of

TABLE 1. ATTRITION RISK FACTOR CRITERIA

Retirement factor	Criteria
5	Projected attrition date within current fiscal year or next fiscal year
4	Projected attrition date within third fiscal year
3	Projected attrition date within fourth fiscal year
2	Projected attrition date within fifth fiscal year
1	Projected attrition date within (or later than) sixth fiscal year

TABLE 2. POSITION RISK FACTOR CRITERIA

Position risk factor	Criteria
5	Critical and unique knowledge or skills. Mission critical knowledge/skills with the potential for significant reliability or safety impacts. Organization or site specific knowledge. Knowledge undocumented. Requires 3–5 years of training and experience. No ready replacements available.
4	Critical knowledge and skills. Mission critical knowledge/skills. Some limited duplication exists at other plants/sites and/or some documentation exists. Requires 2–4 years of focused training and experience.
3	Important, systematized knowledge and skills. Documentation exists and/or other personnel on-site possess the knowledge/skills. Recruits generally available and can be trained in 1–2 years.
2	Procedural or non-mission critical knowledge and skills. Clear, up-to-date procedures exist. Training programmes are current and effective and can be completed in less than a year.
1	Common knowledge and skills. External hires possessing the knowledge/skills are readily available and require little additional training.

TABLE 3. TOTAL RISK FACTOR

Total risk factor	Priority
20–25	High priority — immediate action needed. Specific replacement action plans with due dates will be developed to include: knowledge retention plan, knowledge management assessment, specific training, on-the-job training/shadowing of incumbents.
16–19	Priority — staffing plans should be established to address method and timing of replacement, recruitment efforts, training and shadowing of current incumbent.
10–15	High importance — consideration given to how the position will be filled and the work accomplished. College recruitment, training programmes, process improvements, reinvestment.
1–9	Important — recognition of the functions of the positions and determination of the replacement need.

TABLE 4. EXAMPLE OF COMPUTING OF TOTAL RISK FACTOR

Overall assessment	Risk factor		
Projected attrition within one year	Attrition factor	=	5
Critical/unique knowledge/skills	Position risk factor	=	5
Total risk factor = 5 × 5 = 25			

the position risk factor assigned by the department manager is important in ensuring accurate ratings. Often there is a tendency to rate high performing employees as having unique and critical knowledge and skills. A high level of performance is not the basis for a high position risk factor (5 rating) and such ratings should be changed. After completing the collective review, the management team identifies where a knowledge retention plan is needed and assigns responsibility for plan development (typically, to the employee's supervisor or manager).

3.1.1.2. Step 2: Determination of the approach needed to capture critical knowledge

Once the risk assessment is complete, the next step is to address the potential knowledge loss for each high priority (20–25 total risk factor) employee. In many cases this will involve an interview with the employee (the elicitation process) utilizing a trained elicitor. The knowledge and skills in question may be of many different types — task and equipment related knowledge and skills; facts or information about specific people, vendors, projects and locations; and unique pattern recognition knowledge and problem solving skills. The interviews employ questionnaires designed to assist the elicitor and employee in identifying the specific areas where critical/unique knowledge may exist. Guidelines for conducting interviews and suggested questions are contained in Annex II.

On the basis of the results of the interviews, knowledge retention plans (Annexes III and IV) are developed and implemented. The process for determining and implementing the most appropriate method(s) for addressing this potential loss involves:

(a) Inventory of the specific knowledge and skills of the identified employee;
(b) Assessment of the importance to the organization (criticality);
(c) Assessment the consequences of loss (e.g. operational, financial);

(d) Review of the mitigation options (e.g. codification, alternative resources, re-engineering);
(e) Development of knowledge retention plans as needed;
(f) Implementation of knowledge retention plans;
(g) Coordination and review of knowledge retention plans.

The first priority is to identify, capture and retain critical knowledge held by employees nearing retirement. However, it is also important to develop and implement a knowledge retention plan for any employee with a position risk factor of five. These employees may be promoted, transferred, or may leave the organization for other reasons, resulting in the loss of critical knowledge.

3.1.1.3. Step 3: Monitoring and evaluation

Periodic reviews should be conducted to monitor the status of implementation of the knowledge retention process. Specifically, this step should:

(a) Review previous knowledge retention plans and progress.
(b) Identify any positions/incumbents requiring reassessment or knowledge retention plan development.
(c) Identify related emerging issues or points of coordination.
(d) Review knowledge retention metrics, including:
    (i) Future attrition projections;
    (ii) Number of high priority positions;
    (iii) Number of positions targeted for knowledge retention plan development;
    (iv) Status of knowledge retention plans (complete, on-track, etc.);
    (v) Knowledge related organization metrics (human performance, safety, etc.);
    (vi) Consideration of the impact of other activities on the risk assessment (e.g. emerging work).
(e) Evaluate the success of knowledge retention plans in accomplishing stated goals.

Additional information about the TVA knowledge retention process is available on the TVA web site: http://www.tva.gov/knowledgeretention/

3.2. EMPLOYEE SELF-ASSESSMENT–KNOWLEDGE RETENTION PROCESS

Often the expert employee who has undocumented knowledge is critical to day-to-day operations of the plant and therefore their time is valuable and limited. Processes such as the one outlined in Section 3.1 are effective, but may require significant resources and time. The following process (detailed in Annex V) can be much less time consuming when utilized by nuclear power plants to allow for self-assessments in order to identify specific 'at risk' knowledge. This approach can be used to address potential knowledge loss when employees are being terminated, transferred, promoted, etc. The process can facilitate the gathering of additional information pertinent to the individual's knowledge, skills and duties to support the continued safe and efficient operation of the plant.

The self-assessment consists of two steps — the employee self-assessment and the employee task assessment. The employee self-assessment is geared to obtaining general information from the employee on their current job tasks as well as information regarding meetings they attend, emergency positions they hold, etc. The employee task assessment provides more specific information about 1–5 *major* tasks performed by the employee. These major tasks may include activities they perform as part of their everyday job or they may be collateral duties such as outage assignments.

The critical knowledge held can either be apparent, where the individual is recognized as 'the' expert in a task or area, or it may be deep seated, where critical steps are so ingrained in the individual that they may or may not recognize them as critical. This method of knowledge retention is a self-elicitation method that may need to be followed up with a more detailed review of the employee's information (e.g. the process outlined in Section 3.1.1.2).

Once the employee has completed both the employee self-assessment and the employee task assessment, department managers and supervisors should review the tasks performed by the individual and make a decision as to whether additional assessments are needed. The completed self-assessment is retained by the manager and is used to address challenges created by the pending personnel changes as well as the potential knowledge loss.

3.3. RISK MANAGEMENT OF INSTITUTIONAL KNOWLEDGE LOSS

Institutional knowledge is defined as the collective knowledge of all the employees working in an organization or institution. Sections 3.1 and 3.2 provide processes and tools to address specific knowledge loss associated with

individual expert workers nearing retirement or employees transferring, receiving promotions or leaving the organization (or industry) for other reasons. This section will consider the impact of knowledge loss on the organization and the resulting impact on organizational competency, in other words, the ability to function safely and efficiently.

The necessity to maintain organizational competency for nuclear power plants has been widely recognized by Member States, given the nature of the business (high hazard low risk) and the life cycle of 100 years or more. They recognize the importance of continuing the safe and efficient operation of existing facilities, supporting research and development and educational institutions, and supporting the expansion of nuclear power.

The three examples of China, Germany and the USA (covered in Section 1.1) demonstrate that different situations or life cycle stages exist that may contribute to the potential loss of knowledge and skill in the nuclear industry. However, all three share the common challenge of managing nuclear knowledge to maintain and enhance institutional knowledge.

As with specific knowledge loss threats, addressed in Sections 3.1 and 3.2, organizations should periodically assess the risk of institutional knowledge loss. This assessment should consider both internal (e.g. loss of experienced workers) and external (business and political) factors. Other considerations include:

(a) *Current work load*: Provision of an assessment of the current workload in the organization or department. Consideration of current work backlogs, amount of overtime (paid and unpaid) and levels of stress in the workforce. Identification of core and non-core functions performed and the impact of non-performance. Identification of options to address any potential knowledge loss issues (e.g. process improvements, reorganization and elimination of non-core activities).

(b) *Future work load*: Evaluation of future staffing needs based on an assessment of future workload (expanded capacity, decommissioning, restart, major modifications, etc.). Consideration of lag time in recruitment, training and time until full competency is achieved.

(c) *Areas where critical knowledge and skills are at risk*: On the basis of current information, identification of any areas that exist where critical knowledge and skills are at risk of being lost to the organization. These areas may be general areas (e.g. system engineering) or specific to individual experts (turbine specialist). Each area or individual should be listed and details of what is at risk included. The cause of the threat should be included (e.g. retirement, transfer).

(d) *Risk and impact*: On the basis of workload assessments, an evaluation should be made of the risk that exists and its likely impact on organizational performance. Consideration should be given regarding what work can proceed and what will be deferred. Where possible, the impact on safety, performance and cost should be quanitified.

(e) *Current programmes or proposed initiatives that support knowledge management*: Recognition of existing programmes and processes and their contribution to the retention and enhancement of institutional knowledge. These may include corrective action programmes, configuration control processes, or change management tools. It is important to be as specific as possible and to identify gaps where programmes or processes need to be improved.

On the basis of the assessment results, a strategic plan to address institutional knowledge loss should be developed (see Section 2).

4. SUMMARY AND CONCLUSIONS

The knowledge management tools and processes presented in this publication are intended for use by nuclear power plant operators to assist in managing the risk of knowledge loss caused by the departure of experienced personnel. Sections 3.1 and 3.2 address the risk of knowledge loss with regard to individual workers. Section 3.3 deals with the institutional knowledge of an organization. The processes and tools are easily adaptable and can be modified to meet the needs of a wide range of organizations (e.g. chemical, aerospace, govenmental).

The attrition related knowledge loss risk assessment process (Section 3.1) has been successfully utilized by the TVA's nuclear organization. This includes all three nuclear power plants (Browns Ferry, Sequoyah and Watts Bar) and the corporate office in Chattanooga, Tennessee. In addition, the process has been benchmarked by numerous other organizations and agencies (e.g. Entergy, Bruce Power, Ontario Power Generation, the Nuclear Regulatory Commission and the Institute of Nuclear Power Operations). As with most management processes, implementation is often the weak link, necessitating periodic monitoring and follow up. It is important to restate that these tools and processes are not stand alone initiatives. Knowledge management is *not* intended to replace existing systems, processes or programmes but rather to increase the overall benefit by providing an integrated approach to the management of knowledge loss.

Annex I

KNOWLEDGE RETENTION ROLES AND RESPONSIBILITIES

THE THREE STEP PROCESS

	Line organization			Human resources	
	Employee	Manager/supervisor	Senior leadership	Human resources consultant	Workforce planning
STEP 1: Conduct of knowledge loss risk assessment					
Preparation of management team and appropriate managers and supervisors		Reviews process and roles	Reviews process and roles Involves appropriate staff	Briefs and consults	
Assessment of the total risk factor for each position	Communicates anticipated retirement date to human resources and/or manager	Notifies human resources of known plans or changes in employee's anticipated retirement Assesses position risk factor	Reviews and approves factors	Consults as needed Facilitates timely review Notifies workforce planning of revised factors	Maintains attrition projections and factor ratings Computes total risk factor Provides reports
Prioritization of positions		Identifies targeted positions and notifies human resources/ workforce planning	Reviews and approves	Consults as needed Notifies workforce planning of targeted positions	Records targeted positions Provides reports

THE THREE STEP PROCESS (cont.)

	Line organization			Human resources	
	Employee	Manager/supervisor	Senior leadership	Human resources consultant	Workforce planning
STEP 2: Determination and implementation of plans to capture critical knowledge or adapt to its loss					
Inventory knowledge and skills 'clusters' of the identified employee	Participates in inventory as requested	Conducts inventory Requests support as needed		Consults as needed May provide/broker support for interviews and initial inventory	
Assessment of the criticality of each of these knowledge/ skill clusters	Supports assessment as requested	Assesses criticality Requests support as needed		Consults as needed May provide/broker support for initial assessment of criticality	
Development of knowledge retention plans	Supports plan development as requested	Develops knowledge retention plans Requests support as needed		Consults as needed Provides support for initial knowledge plan development	

THE THREE STEP PROCESS (cont.)

	Line organization			Human resources	
	Employee	Manager/supervisor	Senior leadership	Human resources consultant	Workforce planning
Coordination and review of knowledge retention plans		Coordinates planned actions Revises knowledge development plans and provides human resources/workforce planning with current plans Requests support as needed	Reviews and approves knowledge development plans Facilitates coordination as needed	Facilitates timely review and revision of plans Provides workforce planning with copies of final plans	Maintains a record of what knowledge retention plans have been developed Maintains copies of knowledge retention plans
Implementation of knowledge retention plans	Supports implementation as requested	Implements knowledge retention plans	Supports implementation as requested	Supports implementation as requested	
STEP 3: Monitoring and evaluation					
Monitoring and evaluation of action plans and priorities		Provides updates and current status of plans to management and human resources/workforce planning Identifies issues	Reviews progress Provides support, redirection and coordination as needed	Facilitates review at least semi-annually Coordinates plans, issues, etc., as needed	Updates records Reports metrics

Annex II

GUIDE TO IDENTIFICATION OF 'AT RISK' KNOWLEDGE

II–1. INSTRUCTIONS

The purpose of this publication is to help individuals identify their critical skills and knowledge, especially those unique items of knowledge and skills that might be lost when an individual leaves the organization. While managers/supervisors or others can use this guide to inventory the knowledge and skills of an employee, it is written as though the employee were being asked to respond.

Several points need to be considered when the individual works through these questions:

(a) Knowledge or skill can mean several different things. We want to use a very broad definition that could include anything that new employees would need to know to do a job like yours (except for the exclusions noted below). Consider all your responsibilities and contributions — both formal and informal roles, collateral duties and recurrent assignments (e.g. outage related duties, problem solving or trouble shooting assignments), areas where others often seek your expertise, etc.

(b) Do not include standard skills that are common to your particular job or that are assumed for a particular certification or degree (e.g. journeymen electricians are expected to be able to read a blueprint, etc.). If you are not sure if it is common, include it.

(c) Some of the questions will appear to ask the same thing in several different ways. We do this on purpose to make sure we do not miss valuable information. When the answer is something you have already discussed, simply say so rather than repeat the information again.

(d) When we ask you to describe or list things, give us a general description and not a detailed description. Do not try to tell us how to do something. We will come back and gather this level of detail later. For now we are just trying to build lists to evaluate and prioritize.

(e) For each major piece of knowledge, try to give us some sense of how important it is and how much trouble attrition may cause. Tell us if the knowledge is written down somewhere or not, who knows it besides you, what would be likely to happen if no one knew this, how long it takes someone to learn it, etc.

(f) The questions in Section II-3 will produce lists. In many cases these lists will already exist in job descriptions, training programmes, preventive maintenance procedures and/or in various databases. If so, simply refer to the appropriate source or list and tell us how to find it. In other words, there is no need to try to rewrite the list in the interview.

II–2. GENERAL QUESTIONS

(a) What kinds of knowledge or skills do you now have that the organization will miss most when you leave?
(b) If you had to leave the organization suddenly and only had one day left to brief your replacement, what would you put on your list of things to tell them?
(c) Looking back, what things do you wish you had been taught early on in your job that you eventually learned the hard way?
(d) What are the key resources (procedures, manuals, etc.) that you use to do your job?
(e) What roles do you play (or what 'hats' do you wear)? What have been frequent collateral duty areas and recurrent assignments (e.g. outage related duties, problem solving or trouble shooting assignments)? In what areas do others often seek your expertise?
(f) Are there some important types of at risk knowledge that will take a long time for someone else to learn? What are they?
(g) What pieces of knowledge are you most worried about 'slipping through the cracks' when you leave?
(h) How did you learn the things you know? What were the critical training programmes, work assignments, etc? What is unique about your background compared with the typical employee in positions like yours?

II–3. QUESTIONS ABOUT TASKS

These questions tend to produce lists. Remember, there is no need to recreate lists that already exist.

(a) *How to test and maintain equipment*: What are the types of equipment that you must know in order to test, maintain, or repair? Produce lists or logical groupings of equipment along with the tasks associated with each type (e.g. installation, assembly/disassembly, test, preventive

maintenance, diagnosis and repair). If you were training new employees who will later replace you, how would you prioritize this list?

(b) *How to use special tools*: What types of special tools must you know how to use to do your job? These would be tools that are unique to your type of work. If you were training new employees who will later replace you, how would you prioritize this list?

(c) *Operation of special equipment*: What types of special equipment must you know how to operate to do your job (e.g. lifts, bucket trucks, cranes, test devices)? If you were training new employees who will later replace you, how would you prioritize this list?

(d) *Operation of system devices*: What types of system operation task (energize, de-energize, switching, tag-out, isolation, etc.) must you master to do your job? If you were training new employees who will later replace you, how would you prioritize this list?

II–4. QUESTIONS ABOUT FACTS OR INFORMATION

(a) *Geographical information*: Describe any special geographical information you may have about where things are located and how to get to particular locations. This includes the easiest way to get to locations. Describe any such information that may be common to an experienced employee but would prove to be critical if not known by an inexperienced employee.

(b) *Inventories*: Describe any special information you may have about the location or existence of spares, materials, tools and equipment. Describe any such information that may be common to an experienced employee but would prove to be critical if not known by an inexperienced employee.

(c) *People facts*: Describe any special information you may have about key contacts for expert advice, decisions and permissions, getting something processed or expedited. Describe any such information that would prove to be critical if not known by an inexperienced employee.

(d) *System equipment facts*: Describe any special information you may have about where to locate maps, lists, drawings, vendor manuals, design data, calculations, etc. Describe any such information that would prove to be critical if not known by an inexperienced employee.

(e) *Vendor information*: Describe any special information you may have about how to order parts, materials and services, where and how to get equipment repaired, calibrated, etc. Describe any such information that would prove to be critical if not known by an inexperienced employee.

II–5. QUESTIONS ABOUT PATTERN RECOGNITION KNOWLEDGE

(a) *Complex trouble shooting and diagnosis*: Describe or list any non-standard (i.e. uncommon) knowledge that you possess or have developed about the diagnosis of complex problems. These often involve interaction among several pieces of system components. Name the pieces or types of equipment or describe the type of failure or fix.

(b) *Diagnostic short cuts*: Describe or list any special knowledge that you may have about specific pieces of equipment or unique pieces of equipment that would lead to rapid diagnosis of failure. Name the pieces or types of equipment or describe the type of failure or fix.

(c) *Predictive patterns*: Describe or list any special knowledge you think you may have about patterns of equipment performance deterioration that predict major system failures. In other words, these are patterns that are not obvious and would easily be missed by inexperienced personnel. Are there different patterns for particular pieces of equipment? Are there phenomena (sounds, readings, etc.) that might be thought to indicate a problem but which are actually routine?

(d) *Failure patterns*: Describe or list any special knowledge you may have about failure patterns for particular pieces of equipment that would lead you to undertake preemptive inspection or replacement. Name the pieces or types of equipment or describe the type of failure or fix. Are there any annual or seasonal patterns that are not obvious?

(e) *History of major errors*: Describe any historical knowledge (lessons learned) you have that might help avoid a repeat of a major error in the future. Describe the type of failure, related equipment and time-frame.

Annex III

KNOWLEDGE RETENTION PLAN

III–1. DIRECTIONS

Knowledge retention plans should be developed for knowledge and skills identified as most critical. Plans may include methods to retain the critical knowledge and skills and actions necessary to mitigate the negative impact of losing the knowledge and skills.

III–2. OPTIONS

A variety of alternatives can be used to address impending loss of critical knowledge and skill. These include:

(a) Staffing:
New hire or transfer;
Current employee to assume responsibilities.
(b) Documentation and codification:
New or revised procedures;
Checklists, inventories, etc.;
Performance support systems;
Shared folders, intranet, job aids;
Videotaped instructions and demonstrations;
Photographic records;
Concept maps.
(c) Education and coaching:
Classroom and simulator training;
Computer based training, video based and alternative delivery;
Directed self-study;
On the job training and qualification;
Targeted work assignments;
Coaching, shadowing and mentoring;
Apprenticeship programmes.
(d) Process re-engineering:
Process improvement;
Update equipment;

'Smart' tools and technology;
Task, product or service termination.

(e) Alternative or shared resources:
Agency/site/department expert;
Rotational or 'visiting' staff;
Multiple skills, cross-training, collateral duties;
Contractors, part-timers, retirees.

III–3. COORDINATION

Some actions included in knowledge retention plans need to be coordinated with other groups in order to be completed. In other instances, a potential knowledge loss issue at one site or within one group may suggest a more widespread threat. To complete the knowledge retention plan or to address broader issues, coordination should occur with such groups as:

(a) Site training;
(b) Other sites;
(c) Key leadership and succession planning;
(d) Peer teams;
(e) Recruitment;
(f) Employee technical training and organizational effectiveness;
(g) Process and methods;
(h) Corporate office.

This coordination should be addressed as part of the development of the knowledge retention plan. As needed, senior management addresses coordination or implementation issues, which cross major sites or divisions.

TABLE III–1. EXAMPLE

At risk knowledge or skill	Action (Steps which will be taken to retain this critical knowledge/ skill and/or minimize the impact of its loss)	Assigned to:	Target date(s) for completion	Status and issues
Mary is designer of ... and an expert on ... client database (in Microsoft Access)	Develop up-to-date documentation of database Complete Microsoft Access training Mary to cross-train Mike on database All — include these activities in performance review and development	Mary Mike Mary and Mike Mike, Mary and supervisor	30 July 30 July 30 Sept. By quarterly review	

TABLE III–2. KNOWLEDGE RETENTION PLAN

Employee _____ **Position** _____

Position risk factor _____

Summary and situation assessment:

At risk knowledge or skill	Action (Steps which will be taken to retain this critical knowledge/skill and/or minimize the impact of its loss)	Assigned to:	Target date(s) for completion	Status and issues

Plan prepared by: _____ **Date:** _____

Reviews (as needed): _____ **Date:** _____

Reviewed by: _____ **Date:** _____

Reviewed by: _____ **Date:** _____

Reviewed by: _____ **Date:** _____

Additional notes or coordination needed: _____

_____

_____

Annex IV

EXAMPLE OF KNOWLEDGE RETENTION PLAN FOR MECHANICAL ENGINEERS

Employee: John Q. Smith **Position:** Mechanical Engineer, Mechanical Design, Sequoyah NPP

Total risk factor: 20

Summary and situation assessment:
Position risk factor = 4, attrition risk factor = 5. The incumbent has detailed knowledge of piping analysis and expertise in the application of T-Pipe software. The software is unique to Sequoyah and little duplicate knowledge exists. While a graduate engineer could become proficient in approximately 6 months, it is estimated that 2 years of on the job training is needed to respond quickly to urgent questions relating to piping analysis. In addition to the T-Pipe software, the incumbent must have extensive knowledge of the class II computer system. A degree in either mechanical or civil engineering is recommended when considering a replacement.
Currently Frank Jones is being cross-trained on the T-Pipe system. In addition, Jane Franks is somewhat knowledgeable and could be considered for backup along with two employees in the corporate office (Leo Lee and Oscar Free) who have past experience with T-Pipe and extensive piping analysis experience. Since T-Pipe is unique to Sequoyah NPP, no external training is available. However, the American Society of Mechanical Engineers offers training in piping analysis.

At risk knowledge or skill	Action (Steps which will be taken to retain this critical knowledge/skill and/or minimize the impact of its loss)	Assigned to:	Target date(s) for completion	Status and issues
Rigorous and alternative piping analysis, component qualification of code components and pipe rupture skills	Identify replacement candidate Replacement to attend ASME training on piping analysis and code requirements Replacement to receive on the job training on T-Pipe, code requirements and Sequoyah specific procedures/criteria	Mechanical design deputy supervisor replacement Supervisor, incumbent and replacement	Dec. 2004 Sept. 2005 Ongoing	Jones selected with Franks being trained as backup
Development plans	Supervisor assigns 'trail task' under direction of incumbent Replacement completes qualification under mentorship of supervisor	Supervisor and incumbent Replacement	Ongoing Sept. 2005	

At risk knowledge or skill	Action (Steps which will be taken to retain this critical knowledge/skill and/or minimize the impact of its loss)	Assigned to:	Target date(s) for completion	Status and issues
	Include mentor responsibilities in performance review and development of the supervisor and establish goals to complete training for replacement	Section manager and supervisor	Dec. 2004 July 2005	
	Recruit and hire individual for replacement	Section manager		
Documentation	The incumbent will develop piping analysis, component qualification and pipe rupture reference library of handbooks, procedures, criteria and processes in conjunction with the replacement	Incumbent	July 2005	

Plan prepared by: Al Bert, Mechanical Design Dept. Supervisor **Date:** 6 Nov. 2004

Reviews (as needed): _____ **Date:** _____

Reviewed by: John Q. Smith **Date:** 10 Nov. 2004

Reviewed by: Andrew Lang, Human Resources Manager **Date:** 10 Nov. 2004

Reviewed by: Site Vice President **Date:** 15 Nov. 2004

Additional notes or coordination needed: _____

Annex V

EMPLOYEE SELF-ASSESMENT–KNOWLEDGE RETENTION PROCESS

This process was developed to capture critical information on the job and tasks performed by (organization name) employees who are leaving or transferring to other organizations. These forms facilitate the gathering of additional information pertinent to the individual's skills, knowledge and duties in order to maintain knowledge critical to the safe and efficient operation of (organization name).

The assessment of an employee's critical knowledge consists of two steps: the employee self-assessment and the employee task assessment. The employee self-assessment is geared to obtaining general information from the employee on their current job tasks as well as information regarding meetings they attend, emergency positions they hold, etc. The employee task assessment provides more specific information about 1–5 *major* tasks that the employee participates in. These major tasks may include activities they perform as part of their everyday job or they may be collateral duties such as outage assignments.

Critical knowledge can either be apparent, where the individual is recognized as 'the' expert in a task or area, or it may be deep seated, where critical steps are so ingrained in the individual that they may or may not recognize them as critical. This method of knowledge retention is a self-elicitation method that may need to be followed up with more detailed review of the employee's information.

Once an employee has given his/her notice of termination or transfer, their manager should give them both the employee self-assessment form and the employee task assessment form to complete. The employee should complete the forms and return them to their manager as quickly as possible so that they can be reviewed. The employee should copy and complete the employee task assessment form for each major task they perform. Typically, no more than five tasks should be critical enough to be documented. In the event that the employee is unable to complete these forms (owing to death/disability or termination for cause), the supervisor will provide as much information as he/she is able to.

Once the employee has completed both the employee self-assessment and the employee task assessment, department managers and supervisors should review the tasks performed by the individual and make a decision as to whether additional assessment is needed.

Once all assessments are complete, the completed assessments should be forwarded to the department manager.

When asking employees to complete the self-assessment, it should be stressed to them the value they bring to the organization and how important it is to the future of (organization name) to make sure that their transition goes as smoothly as possible and that critical tasks are captured and risk analysed.

EMPLOYEE SELF-ASSESSMENT FORM

Name:		Title:	
Department:		Supervisor:	

Please return this completed assessment to your supervisor/manager

(1) List below all the meetings that you attend and the function that you perform at those meetings. Indicate the frequency of these meetings and the approximate duration of each. Indicate whether you have preparatory work to do prior to the meetings and if so, give details and time involved.

Meeting name	Frequency	Duration	Role

(2) List below any memberships you have for industry groups, associations or peer groups

Group	Role	Frequency of meeting

(3) List below any emergency response positions:

(4) List below your outage role(s):

(5) Do you support outages at other sites (shared resources)? ❒Yes ❒No

If yes, what site(s)?

What function do you perform?

(6) List below commitments you have to participate on a benchmarking trip or an assessment:

Event	Location	Date

EMPLOYEE SELF-ASSESSMENT FORM (cont.)

(7) What skills and knowledge do you possess that may be considered unique and may be difficult to replace? Please consider identifying someone that you think may be able to perform these functions with appropriate training or turnover.

(8) What open actions do you have assigned to you (e.g. problem evaluation report, corrective actions, self-assessment findings)? Consider attaching copies of open items.

(9) What functional titles (formal or informal), such as refuel floor coordinator, training coordinator, budget coordinator, technical contract manager, or other ongoing task force or team project department do you hold and how much of your time is devoted to these activities?

(10) What approval authorities do you have that must be transferred to another (e.g. timesheet approval, contracts)? Specifically identify what must be turned over.

(11) What certifications or qualifications do you possess that are derived from external or internal training or processes (e.g. professional engineer, reactor operator, senior reactor operator, shift technical advisor)?

(12) What direct interface do you have with other departments that will need to be done by someone else in the future? Training, process expertise, the 'go to' person on a certain issue.

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Maintaining nuclear competences in the nuclear industry and nuclear regulatory authorities is a critical challenge. As many nuclear experts around the world are retiring, they are taking with them a substantial amount of knowledge and corporate memory. The loss of such employees, who hold knowledge critical to both operations and safety, poses a clear threat to the safe and reliable operation of nuclear facilities. This publication is intended to increase awareness of the need to develop a strategic approach and action plans to address the potential loss of critical knowledge and skills in nuclear industry organizations and provides practical guidance for conducting risk assessments and implementing actions to improve the skills and competences of new and existing workers.

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