Chapter 8

Knowledge and Information Management

Revision Date	Description
February 2019	Hypertext links checked and updated. Text updated to reflect GS-R-3 superseded by IAEA GSR Part 2 and updates to ISO and other standards

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8.1 Knowledge Management

Knowledge Management Overview

All nuclear operators have obligations under their site licence to maintain safe operation of their plant and facilities. Safe, reliable and predictable operations rely on access to and the maintenance of a body of specialist nuclear knowledge. This knowledge is held not only in documented information systems, it is also built in to the design of plants and processes and embodied in the experienced and qualified people who are responsible for their operation. The totality of this system for maintaining and integrating knowledge in all its forms and manifestations is sometimes referred to as organisational competence and it is regularly assessed by regulators in judging if the Site Licensee is fit to operate.

An integrated and systematic approach needs to be applied to all stages of the knowledge cycle, including its identification, sharing, protection, dissemination, preservation and transfer. A number of features are necessary to ensure the effective management of knowledge, in particular:

- A strategic approach;
- Due attention to people and people interactions;
- Suitable processes and technology; and
- The commitment of senior management.

All the separate departments involved need to work together and recognise the interconnectivity of activities, including human resource management, information and communication technology, document management systems, and corporate and national strategies.

There is a growing awareness among Quality Professionals of the importance of managing knowledge as an asset and relevant knowledge management (KM) issues and practices. KM is a broad topic area and is addressed in a number of ways in nuclear industry management systems. Knowledge requirements are particularly important in relation to strategic workforce planning, competency management, process management, error prevention, learning and continuous improvement. Some organisations treat KM as a process in its own right while others embed relevant practices in other processes.

Standards and Guides

An international standard, ISO 30401:2018 Knowledge management systems – Requirements, has been produced to help organisations develop a management system that promotes and enables value-creation through knowledge.

IAEA GSR part 2 Leadership and Management for Safety requires knowledge and information to be managed as a resource. There is, therefore, an obligation on senior management to determine knowledge and information requirements and ensure that these needs are met.

ISO 9001:2015 requires that organisations determine and provide the knowledge needed for both the operation of processes and the delivery of product and services.

There is a great deal of opinion and guidance available, including more than two dozen maturity models. However, the special nature of nuclear knowledge, which is discussed below, requires a different approach that is not always reflected in much of the literature. The publications produced by the International Atomic Energy Agency (IAEA) are the primary source for guidance and good practice. The most comprehensive document is IAEA TECDOC 1510 Knowledge Management for Nuclear Industry Operating Organizations that was published in 2006. There are other IAEA guides available that provide more detailed advice and case studies. Lessons learned from IAEA KM assist visits carried out in the period 2005–2013 are summarised in the 2016 publication IAEA NG-T-6.10 Knowledge Management and Its Implementation in Nuclear Organizations. The 2017 publication IAEA NG-T-6.11 Knowledge Loss Risk Management in Nuclear Organizations covers the topic of knowledge loss management.

There are a number of useful Government documents on knowledge and information management such as "Information matters: building government's capability in managing knowledge and information" produced in 2008. This publication has a non-nuclear bias and discusses the requirements for managing and sharing knowledge within publicly funded programmes. The Nuclear Decommissioning Authority's (NDA) approach to knowledge and information management is aligned with Government requirements and guidance.

Knowledge

There is generally a clear distinction between data and information. However, the difference between information and knowledge is less well articulated or understood. Unfortunately, the two concepts are often conflated in everyday use and even sometimes in written guidance and procedures.

In normal conversation we use the word "knowledge" to describe "knowing facts" and also to describe "knowing how" to do something. In the nuclear industry we need to "know why" things happen so that we can design and engineer safe systems, identify risks and prevent unwanted events. It is also often useful to "know who" we should go to seek expert advice and share learning.

Our knowledge is held in our minds from things we have learned over a lifetime. It comes from experience in the workplace, what we remember from our childhood and what we picked up in formal education and training. Knowledge enables us to make better decisions to create new, useful information and take action.

It is useful to identify three types of knowledge: Explicit, Implicit and Tacit. Each requires different approaches to its management (see figure 1).

1. **Explicit knowledge** is knowledge that has been articulated or codified. In other words, it can be documented in useful forms such as operating manuals, files, reports, drawings, etc.
2. **Implicit knowledge** is knowledge held by individuals that has the potential to be codified but has not yet been articulated or documented.
3. **Tacit knowledge**, in contrast, is held in the mind of individuals and is often unspoken and difficult to articulate and share. It includes skills, insight, intuition and judgement. The consensus amongst knowledge management professionals is that most of the knowledge in any organisations is tacit.

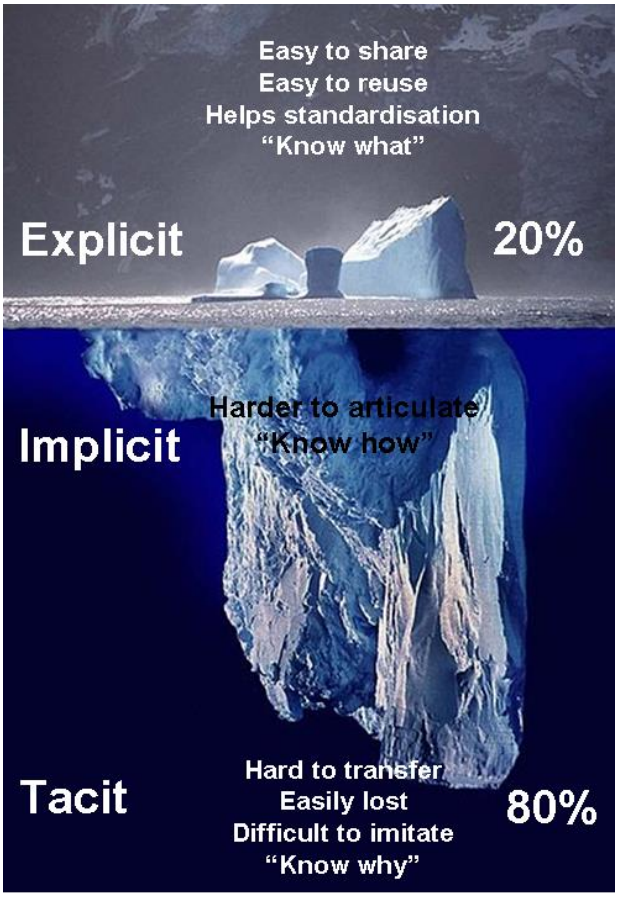

Figure 1 Explicit, Implicit and Tacit knowledge

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Knowledge Management

Knowledge management (KM) is a relatively recent term, however it means nothing more complex than managing knowledge intelligently and systematically so that we might have the right knowledge in the right place at the right time and with the right people. There are many ways of achieving this and the emphasis one organisation chooses will depend on the precise nature of its current and future plans. The IAEA's definition of Nuclear Knowledge Management (NKM) is:

> "identifying, acquiring, transforming, developing, disseminating, using, sharing, and preserving knowledge."

It can be inferred from the IAEA definition that developing new knowledge, learning from successes and failures, sharing knowledge with fellow employees, recording knowledge in a written and reusable form will result in an improved performance. However, for many reasons, these sharing and learning processes might not function automatically in organisations that do not give them sufficient attention or management support. Competing instead of collaborating divisions, differences in culture, pressure of the daily challenges, lack of communication tools and places to meet, poor discipline and counter-productive incentives within the organisation might also get in the way. These issues result in a variety of undesirable consequences that can all be mitigated by managing our collective knowledge better such as:

- Mistakes can be repeated because earlier ones were not recorded or analysed;
- Work is redone because people are not aware of past activities or their outcomes;
- Customer relationships are poor because knowledge is not available at the point of action;

- Costs are raised because good ideas and best practices are not shared;
- Critical knowledge is lost because one or two key employees move or leave;
- Opportunities are missed because the company learns too slowly;
- Employees are frustrated because knowledge and information is not available or difficult to find.

Nuclear Knowledge Management

There are more similarities than differences between the nuclear industry and other industries in the KM challenges and best practices they adopt. However, there is some consensus that the nuclear industry in the UK presents a unique combination of factors that demands a more systematic, organised, well-funded, co-ordinated and long-term approach than that adopted by other industries.

There has been 60 plus years of public funded investment in the development of nuclear knowledge through research and development and operation of nuclear facilities, which, if lost, would require substantial reinvestment to ensure the UK maintains a strategic capability to deploy a nuclear energy programme.

The complexity and inter-dependency of this knowledge has required a unique effort in combining technical disciplines to provide the national competence to build, operate and decommission hundreds of inter-dependent nuclear facilities.

On top of the sunken costs, there is still a huge investment to be made in nuclear knowledge. For example, there is a remaining cost to the public of £74 Billion in the UK for the decommissioning and waste management of the civil nuclear liabilities alone, excluding the additional investment required for a nuclear renaissance.

Unlike some other industries, nuclear power has a long timescale associated with it. At Sellafield, for instance, there is still a further 120 years of work planned simply to address the existing liabilities. Knowledge will need to be transferred from generation to generation of nuclear operators and specialists. New plant can take decades to design and build and the full lifecycle of a given facility usually exceeds any one individual's career.

The industry in the UK has moved from one that is centrally directed to one that is now relatively fragmented. Consequently, the essential knowledge lies in many different organisations that need to work closely together and share what they know. A successful national programme requires the cooperation and collaboration of a large number of independent organisations through such mechanisms as supply chain alliances, R&D contracts with universities and the involvement of numerous other national agencies. This presents a logistical and cultural challenge to maintaining the critical national core skills.

The time required for nuclear workers to meet the competence requirements for a particular job or task is relatively long compared to other industries. Long periods of training, higher qualifications and continuous learning and development may be required. Nuclear expertise can take decades to develop and the age profile of the workforce is relatively mature compared to other industries. There is, therefore, the need for a concerted effort to transfer specialist knowledge from one generation to the next.

Consequences for the different types of Knowledge

All of the above confirm the need for nuclear organisations to adopt a broad-based and integrative systemic approach to the challenges of maintaining knowledge and developing new knowledge. With reference to figure 1 above:

- Explicit knowledge in any given domain of knowledge, as manifested in documents, images, reports, drawings, etc., should be consolidated in one location, organised in structures recognisable and accessible by users and be easily retrievable to support its re-use.
- Implicit knowledge can also, with sufficient effort, be captured in artefacts such as files, personal network maps, concept maps, etc. These can be added to the library of explicit knowledge and also stored and found via 'expert pages' centred on individuals.
- Tacit knowledge requires a focus on peer-to-peer approaches, ensuring that the donor transfers his or her knowledge to colleagues; this is most frequently undertaken via 'communities of practice'. The latter are sometimes organic, emerging through a shared interest in a topic, but also sponsored by the organisation. These communities enable members to collaborate and share and validate best practices, to learn together and join forces to develop new knowledge. They facilitate rapid diffusion of new ideas and useful experiences across the organisation.

In caring for their intellectual assets, organisations need to include and balance three main approaches:

1. Raise proficiency by developing organisational and individual competencies through training, recruitment, partnerships, research and development. These activities strongly relate to the Human Resources (HR) function in the company and should ensure that the workforce holds the right competencies to meet its strategic agenda.
2. Codify personal experiences and skills into information that is accessible and reusable for all employees that need to know or need to have access. This codified body of knowledge ensures continuity and uniformity in operations and provides the foundation for improving business excellence based upon a well-organised corporate memory.
3. Diffuse knowledge through the creation of networks across organisational boundaries and beyond, to partners outside the organisation.

Therefore through proficiency enhancement, codification and diffusion, tacit knowledge can be developed and shared, implicit knowledge can be codified and explicit knowledge consolidated. Each of these approaches is more powerful when combined in to a coordinated approach to managing knowledge.

Knowledge management programmes

Management of nuclear knowledge requires inter-related KM programmes at organisational, intra-organisational and national level that take note of international guidance.

Managing the organisation's intellectual assets in the context of maintaining a national capability requires a comprehensive and integrated KM programme consisting of the following components:

- A KM strategy: that sets out the business case, the value proposition and a high-level plan for direction;
- Knowledge mapping: the identification of the knowledge, the characterisation of its nature and when it is needed to deliver the organisation's mission;
- Knowledge risk assessment: the introduction of both a *collective risk* approach that focuses on knowledge at risk in departments, teams, projects, etc. and an *individual risk* approach that identifies individuals who hold knowledge and the potential vulnerability of the organisation to lost knowledge in the absence of that person;
- Knowledge sharing: support for communities of practice, peer-to-peer collaboration and the recognition that time taken to share knowledge and to learn from others is legitimate and beneficial;

- KM enablers: roles, skills and behaviours required to successfully deploy KM processes and tools;
- IT: supportive information technology can enable KM to be more effective across all dimensions of knowledge;
- Knowledge and learning culture: promoting a culture where knowledge is valued, treated as an asset, maintained and developed accordingly.

The UK nuclear industry is increasingly aware of the importance of the management of its knowledge and is taking co-ordinating action to further align the various KM processes and tools. The NDA produced a KM Policy (IMP05) and launched a KM programme in March 2013. The NDA's knowledge management approach includes;

- Ensuring that required knowledge is available to support safe and efficient decommissioning;
- Avoiding duplication of effort;
- Promoting a learning culture; and
- Promoting knowledge sharing across the NDA estate.

8.2 Records Management

Records Management Overview

The nuclear industry has a number of generic obligations relating to records that it shares with other industries. There are also a number of specific issues that make records management particularly important in the UK nuclear industry:

- Nuclear site licensees are required to maintain records to demonstrate compliance with the conditions of their nuclear site licences. This requirement is reflected in the records component of procurement specifications placed on key suppliers.
- Atmospheric and liquid radioactive discharges and transfers of solid radioactive waste are regulated under the environmental permitting regulations. Records need to be maintained to demonstrate compliance with permit conditions.
- Manufacturers of safety related plant and equipment need to provide adequate records to demonstrate conformance to design requirements. These records can include material samples.
- Nuclear safety related plant and equipment needs to undergo appropriate active and inactive commissioning. Suitable records of commissioning activities need to be generated to confirm that the design intent has been met.
- Accurate records of construction, plant configuration, contamination levels, operational history and accidents are very important in the planning of decommissioning and land remediation.
- Records relating to radioactive wastes are very important in relation to on-site storage, transport and future disposal.
- Records are required to demonstrate that a suitable end state has been achieved to enable de-licensing of a site.

In summary, the UK nuclear industry faces the challenge of generating and maintaining extensive, accurate and authentic records for prolonged periods of time.

Nuclear industry organisations need to establish effective records management arrangements as an integral part of their Quality management systems. Such arrangements typically have the following key features:

- A strong commitment from senior management and staff at all levels to disciplined records management practices.
- A clear indication of records ownership with owners aware of their responsibilities – Information Asset Owners (IAOs).
- An adequate infrastructure and adequate resources including trained and competent staff. Infrastructure requirements include appropriate storage facilities and equipment.

- A clear definition of records keeping responsibilities and requirements. This is normally done through the production and implementation of one or more procedures.
- The clear specification of the records to be kept, their retention period and form. This is normally done through the production of a records retention schedule.
- Defined controls to ensure that the integrity and authenticity of records is maintained during organisational and technology changes. These controls are normally defined in procedures and project plans.
- Appropriate security arrangements to prevent inappropriate access and loss. This is particularly important in relation to sensitive nuclear information.

The NDA has built a National Nuclear Archive at Wick in Scotland. The facility is called Nucleus (the Nuclear and Caithness Archives) and opened in February 2017. Nuclear records from across the NDA's estate will be progressively transferred to the facility. The transfer will take several years to complete. The kinds of records to be stored at Nucleus are described in the NDA Archive Acquisition Policy (IMP09).

Regulatory Requirements and Guides

The legal framework relating to management of records is made up of numerous pieces of legislation. The principal nuclear legislation is the Nuclear Installations Act 1965, Environmental Permitting Regulations 2016 (replacing Radioactive Substances Act in England and Wales), the Radioactive Substances Act 1993 (still in force in Scotland) and the Ionising Radiation Regulations 2017. The Health and Safety Executive (HSE), Environment Agency (EA) and Scottish Environment Protection Agency (SEPA) have published joint guidance on managing information and records relating to radioactive waste.

Nuclear Site Licence condition 6 requires the licensee to make adequate records to demonstrate compliance with the site licence conditions. There is a requirement to make adequate arrangements to preserve records for 30 years. Licence condition 5(3) contains a specific requirement for a retention period of 50 years in the case of any consignment of nuclear matter that is stolen, lost, jettisoned or abandoned.

Nuclear Site Licence condition 17 requires licensees to make and implement adequate Quality management arrangements. These arrangements need to cover records management including provision for long term retention of records.

Nuclear Site Licence condition 25 requires licensees to produce adequate operational records.

There are ONR guides on Duty Holder Management of Records, LC 6 Documents, Records, Authorities and Certificates and LC 25 Operational Records.

Nuclear Site Licensees may require records to be managed on their behalf by their suppliers. However, they retain responsibility for ensuring that these records continue to be properly maintained and accessible.

Standards and Guides

ISO 9001 and IAEA GSR part 2 include basic requirements relating to records. ISO 9001:2015 no longer uses the term records. The term documented information was introduced as part of the common High Level Structure (HLS) and common terms for Management System Standards. The term documented information covers both documents and records. Requirements in ISO 9001:2015 to keep documented information as evidence should be interpreted as a requirement to keep records.

IAEA safety guide GS-G-3.1 Application of the Management System for Facilities and Activities includes a significant amount of guidance on records management practices. The older superseded IAEA publication 50-C/SG-Q Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations Safety Guide Q3 still provides some useful guidance on record retention periods for different types of record. There are other IAEA publications that provide more specific guidance on records management covering topic areas such as decommissioning and waste packaging records.

The NDA has developed a records retention schedule that provides a generic framework for record retention requirements within the NDA's estate.

Useful international and British standards are:

- BS ISO 30301:2011 Information and documentation - Management systems for records - Requirements is an auditable standard for a records management system. This standard is aimed at management rather than records management professionals. It fits well with a process approach and can be readily used with other management system standards such as ISO 9001.
- BS ISO 15489:2016 Information and documentation - Records management - Concepts and principles is the foundation standard that codifies best practice for records management operations. It is aimed at records management professionals rather than management.
- BS 10008:2014 Evidential weight and legal admissibility of electronic information - Specification can be used to identify controls to ensure authenticity when converting physical records to electronic format.
- BS EN ISO/IEC 27001:2017 Information technology - Security techniques - Information security management systems - Requirements can be applied to the information security aspects of records management and can be applied more generally to the management of all information assets.
- BS 4971:2017 Conservation and care of archive and library collections specifies current best practice in managing archive collections.

General Records Management

Records are information assets and need to be subject to an appropriate level of risk assessment and treatment. Site Licensees and larger organisations normally have defined arrangements that typically include: defined information asset ownership, defined risk appetite, a risk assessment method and defined controls to ensure that risks to confidentiality, integrity and availability are managed effectively. Information Asset Ownership provides a clear line of responsibility at senior management level to ensure that risks fall within the corporate Information Risk Appetite.

Records keeping is important at all stages of the lifecycle of a nuclear plant. There are also onerous records requirements associated with radioactive waste storage and disposal. Careful consideration needs to be given to records requirements when procuring important items and services. Records requirements should be clearly specified and controls established to ensure a proper handover of records takes place. Responsibilities for maintenance of records may be assigned to specialist organisations such as a dosimetry service or archive.

It is important to manage the transition from one type of operation to another, e.g. when changing from construction to commissioning. It is often necessary to handover, review and consolidate records as part of the change. Nuclear facilities may undergo prolonged periods in care and

maintenance before final decommissioning is carried out. In these situations, the records required to aid knowledge retention require careful consideration.

A well designed records management system is essential for each organisation with records keeping responsibilities. The important components of a records management system are:

- A records management policy;
- An appropriate organisation and competent people;
- Records management procedure(s);
- Records retention schedule;
- Suitable storage facilities and equipment to retain and retrieve physical records; and
- Suitable IT infrastructure for the management of electronic records.

The elements of effective records management are discussed in more detail below.

A records management policy is valuable as an expression of senior management commitment. The policy may be discrete or integrated into other policies. Typical policy content includes:

- A high level commitment to the importance of records management;
- Records management objectives;
- Key responsibilities for records management;
- A summary of key obligations relating to records management and a commitment to comply with them;
- A statement of the standards to which the organisation subscribes such as BS ISO 15489-1:2016; and
- A summary of records management arrangements, including references to procedures and the records retention schedule.

Not all organisations need a discrete records management policy but a policy is required if ISO 30301:2011 or ISO 15489-1:2016 is adopted.

Responsibilities for records management need to be clearly defined and an appropriate organisation established. A sufficiently senior manager should have responsibility for ensuring that an effective records management system is established. It may be appropriate to combine responsibility for the records management system with a broader responsibility such as Quality, information or knowledge management. Consideration needs to be given to the provision of specialist advice and services where records management requirements are extensive. Most staff have some involvement in records management and so require training in relevant procedures.

The content of records procedures varies depending on organisational needs. Factors that need to be considered include: organisational infrastructure, records keeping obligations, knowledge retention and information security requirements. The procedures need to be comprehensive and cover the whole lifetime of records from generation to final disposition. The receipt control of records should ensure that the records are complete, legible and in a form suitable for storage. Procedures typically need to cover:

- Responsibilities for the identification and control of records;
- The generation, receipt, storage and retention of records;
- The filing system to be used;
- Levels of security to protect from corruption, unauthorised access, loss or damage;
- The means of making corrections to records;
- Arrangements for the review, archiving and destruction of records; and
- The periodic auditing of records and records management arrangements.

A Records Retention Schedule details the type of records to be kept and their retention and review periods. The development of a comprehensive retention schedule requires a detailed consideration of:

- Legal and other obligations;
- Customer requirements and expectations;
- The need to demonstrate compliance with the requirements of applicable codes;

- Specifications and standards;
- Specific Quality management requirements, such as quality plans and competency records;
- Specific business process requirements; and
- Knowledge retention requirements, e.g. to enable future decommissioning.

Care needs to be taken to preserve all required information but also to avoid keeping unnecessary records. Schedules can take the form of simple tables but a database may be required if requirements are extensive. IAEA GS-G-3.1 Annex III recommends using the following retention times:

- Greater than 30 years;
- 30 years;
- 5 years; and
- 3 years.

IAEA 50-C/SG-Q Safety Guide Q3 Annex III continues to provide useful guidance on retention times for particular types of record, even though this publication has been superseded by GS-G-3.1.

Physical Records Management

Physical records can take a number of forms, common examples are: paper documents, microfilms, photographs and material samples. Appropriate storage facilities and systems need to be established that ensure that records are:

- Categorised according to the retention schedule;
- Registered upon receipt;
- Readily retrievable;
- Indexed and placed in designated locations appropriate to their use;
- Stored in a controlled and secure environment;
- Subject to periodic review;
- Transferred to a secure archive at the appropriate time if retention times are prolonged; and
- Destroyed in a secure manner when no longer required.

Storage facilities for physical records should be maintained to prevent damage from causes such as fire, water, air, rodents, insects, earthquakes and unauthorised access. Consideration should be given to appropriate contingency arrangements including making copies of important records.

Physical records can normally be stored under conditions of ambient temperature and humidity for periods up to five years. Long retention times may require a special facility, such as an archive that meets the temperature and humidity conditions specified in BS 4971:2017.

Electronic Records Management

Records may exist in electronic format throughout their lifecycle or originate in physical form and be converted to electronic format. Electronic formats can offer some significant advantages, but there are also challenges in maintaining the security and integrity of records.

Electronic records need to be subject to carefully defined procedural controls. This can be facilitated by the use of electronic document management system (EDMS). IAEA GS-G-3.1 Annex 1 provides guidance on the use of an EDMS. Information security risks need to be carefully considered and this can be aided by use of the international standard BS EN ISO/IEC 27001:2017. Particular care is needed to ensure that the hardware and software that is used does not become obsolete. Periodic technology reviews are, therefore, very important, particularly where records have retention times of 30 years or more. Risks can be minimised by selection of widely used software, file formats and hardware. Special care is needed when software or hardware is upgraded to ensure that records do not become corrupted or lost.

Nuclear Site Licensees need to take special care to ensure that the authenticity of records is maintained during times of change. Changes include the conversion of physical records to electronic

format and technology upgrades. BS 10008:2014 defines the controls to be applied when scanning paper documents to help ensure that authenticity is preserved.