NUCLEAR SIG
Chartered Quality Institute

NUCLEAR QUALITY KNOWLEDGE

(NQK)

Version 2 – 2013

Nuclear Quality Knowledge (NQK)

Initial Version September 2011 **Version 2** May 2013

NQK has been produced by the CQI Nuclear Special Interest Group. Significant effort has been made to ensure that the contents are correct and will be valuable to the reader, nevertheless, CQI accept no responsibility for negative consequences resulting from the use of NQK.

NQK is published by: The Chartered Quality Institute (CQI), 2nd Floor North, Chancery Exchange, 10 Furnival Street, London, EC4A 1AB Tel: +44 (0)20 7245 6722 Fax: +44 (0)20 7245 6788 Email info@thecqi.org

Chartered Quality Institute©

CONTENTS

Chartered Quality Institute©

Chartered Quality Institute©

Preface

The Nuclear Quality Knowledge (NQK) is a nuclear industry guidance document that has been written by members of the CQI Nuclear Special Interest Group (NucSIG) to complement the Chartered Quality Institute (CQI) Body of Quality Knowledge (BoQK). NQK aims to highlight the differences or nuances that a quality professional will experience on joining or supplying the nuclear sector, and which are a consequence of the special hazards and regulatory requirements that apply. This is a significant part of what is sometimes called the "Nuclear Delta".

It is not expected that you read this document from cover to cover, rather that you will use it in two ways:

1. As text for a structured course.
2. As a source for revision on a specific aspect or to dip into as you come across topics or issues during your career.

This second version has been substantially rewritten; NQK is now set out in a number of Chapters, containing related topic Sections. In this way it is hoped that it provides an easier logic, and correlates more easily with International standards. In response to comments references and web links have been added in line and as endnotes to each Chapter. A single consolidated Glossary is provided as Appendix 1 to NQK.

The primary format of the NQK 2013 will be as a series of PDFs, one per Chapter or other major content heading, held on the NucSIG web page. Periodically individual Chapters will be reviewed and revisions will be made; thus readers should regularly check for updates though it is anticipated that members will be advised of them through NucSIG newsletters.

It is still the aim that the NQK will develop with time and use, and those of you using it are encouraged to comment with either corrections or opportunities for enhancement. In using the NQK , as with all documents referencing out to web-based information sources, we are conscious that organisations change their webs and thus you may have to use 'search machines' to locate such changes; please let NucSIG know of any such developments you identify.

NucSIG

If you are drawn to read NQK and are not a member of the CQI's NucSIG then we would encourage you to join the group, as networking with professionals with the same or similar challenges may be found to be of even greater value than reading and self-tuition, although these are useful.

Correlation of the NucSIG Past-Events with NQK Chapters is provided at Appendix 2 to NQK.

Details on how to join NucSIG are to be found on the NucSIG web page

Acknowledgements

Thanks are given to the many members who have contributed to this document. The names of Chapter Editors and Contributors are shown on each Chapter cover sheet and listed at the end of this preface. Especial thanks are given to Iain McNair, Mike Underwood, Richard Hibbert and Susan J M Shaw who oversaw the overall document.

We are grateful to many International, Governmental and industry bodies for extracts from their publications which are provided as identified and accredited in the document. Contains UK public sector information published by MOD, DECC, DEFRA, HSE/ONR, NDA and licensed under the Open Government Licence. Photographic images are reproduced by kind permission of the NDA.

Comments by external bodies

Nuclear Institute
The Nuclear Institute welcomes the second edition of the Nuclear Quality Knowledge publication. This document, compiled by experts from across the industry, enables knowledge and learning to be shared with all nuclear professionals.

Office for Nuclear Regulation
The ONR welcomes the CQI NucSIG's achievement in gathering the collective experience and knowledge of its membership and publishing the Nuclear Quality Knowledge. We believe this document will help quality professionals to understand the unique requirements of the nuclear sector and how quality management principles and standards can contribute to safety in nuclear facilities.

Nuclear Industries Association
The Nuclear Industry Association Quality Working Group fully supports and welcomes this publication. The quality arena is growing, improving and gaining status. The high level Nuclear Industry Council, co-chaired by ministers and Lord Hutton, has a new Quality Working Group, giving greater prominence to all aspects of quality in construction, maintenance and decommissioning work. With the creation of tens of thousands of new jobs through the planned new nuclear programme it is essential that quality remains at the heart of our growing industry.

Contributors

Stuart Allen	Sellafield
Gavin Avery	BAM Nuttall
Alex Boughey	BAe Systems
Tony Colyer	Sellafield
John Day	Sellafield
Bob Dixon	EDF
Mark Harbor	RSRL
Richard Hibbert	RSRL
Michael Jones	DSRL
Michael Kelleher	DNV
Mark Lyons	L2 Business Consulting
Bob McGeary	L2 Business Consulting
Iain McNair	Retired, formerly NII
David Morgan	ONR
Andrew Mullinder	Sellafield
Vaughan Rees	RSRL
Phil Shaw	UKAS
Susan J M Shaw	RSRL
Mike Underwood	Welsummer Quality Management
Graham Watson	EDF

Chartered Quality Institute©

Chapter 1

Introduction

CONTENTS

Editor **Iain McNair**
Contributors **Alex Boughey, Bob Dixon, Mike Underwood**

1.1 Tiers in the Supply Chain

In writing this revision we have tried to recognise differing levels of knowledge, of each component subject, that is required at varying levels (tiers) of the supply chain. A key to understanding the supply chain requirements is to understand the terminology used in the UK nuclear sector, which may be subtly different from that used elsewhere, such as the defence or aerospace industries. This is generally referred to in relation to Tier 1/2/3/4 suppliers.

For the New Build sector the following are examples of the hierarchy:

- **Licensees**
- **Tier 1** – Technology Suppliers/ Architect Engineers*
- **Tier 2** – Large companies with nuclear experience* – Civil Enabling Works / Main Civil Contractors / Marine Works / Infrastructure Works / Mechanical equipment suppliers / Electrical equipment suppliers / EC&IF Installation Companies / Mechanical installation Companies
- **Tier 3** - Smaller Mechanical or Electrical Equipment Suppliers / Niche Service providers
- **Tier 4** – *Not specified but assume to be component suppliers*

Note * *Subsequent discussion with EDF during drafting identified these main contractors are perceived by them as Tier 1, and the Architect Engineer although within EDf can also be perceived as such.*

For the decommissioning sector the following apply [1];

- **The NDA Estate** comprises the Nuclear Decommissioning Authority (NDA) - A Non Departmental Public Body (NDPB) set up in 2005 to oversee the decommissioning and clean-up of the UK's designated civil nuclear legacy - and its Site Licence Companies (SLCs), the Tier 1 Contractors to the NDA.
- **The SLCs (Tier 1)** are the entities that hold the nuclear site licence and carries out the daily management and operations of the site under contract to the NDA.
- **Tier 2 companies** have the main interface with the SLCs (Tier 1) - holding a direct contract with the SLCs (Tier 1) for works, services and supplies.
- **Tier 3/4 companies** are often SMEs who contract with Tier 2 contractors or their sub-contractors in support of the Tier 2 contract with an SLC (Tier 1). SMEs are defined as an individual company (ie not a subsidiary of a larger parent organisation) having 250 or less employees and a turnover of less than 50 million euros, or a balance sheet total of less than 43 million euros.

For the defence sector the terminology is apparently not defined [2] but the following general description has been produced [3]:

- **Customer** – Ministry of Defence (UK MoD). The customer performs a number of roles in the procurement of Nuclear related defence equipment and systems (submarines to weapons). As the MoD in new build situations is the Client they are responsible for delivering capability to the end user. They are also the technical and acceptance authority, hold budget responsibilities, indemnify the prime contractor and also hold safety regulatory responsibilities.
- **Prime Contractor** – This is usually the organisation responsible for delivering the product. They are responsible for designing, manufacturing and integrating systems that will deliver the product to time cost and performance requirements.
- **Tier 1 suppliers** provide sub systems and may be the delegated design authority for those systems e.g. the Nuclear Steam Raising Plant. This can also cover more minor systems.
  - **Tier 2 suppliers** provide individual equipment to other higher level systems such as pipework system valves etc.

Future structures include changes where the customer will be the design authority partnering with a number of prime contractors who will all hold technical authority status. The difference being that the design authority is the ultimate decider. Lower levels e.g. at tier 1 and below may not change.

Regardless of sector, the overriding principle is that it is the responsibility of the Licensee/Prospective Licensee to ensure that products or services are of a satisfactory quality, particularly those potentially impacting on nuclear safety. That degree of importance will almost certainly be defined by both Safety Function Classification and Quality Grading. The Licensee/Prospective Licensee will specify their requirements under formal contractual arrangements and oversee the delivery of the finished products or services. This will cascade down, as required, through the tiers.

In the execution of their work the lower tier contractors must work to the quality, health & safety and other project delivery requirements as specified by the Licensee/higher tier contractors, and ensure that their contract review, communications, notification processes are effective. This will ensure that they fully understand the goods and services that they are producing in terms of their functional and technical role and characteristics throughout the life of the plant. A significant issue is that the Nuclear Safety Culture (See Chapters 3 and 6) has to reach down throughout the supply chain.

---

[1] NDA Enquiries email to NQK editor- 20 August 2012
[2] G Fice DQA-Policy, MOD email to NQK editor
[3] A Boughey BAe email to NQK editor

1.2 UK Nuclear – A summary

The aim of this chapter is to outline the way in which the UK nuclear industry was formed and has since transformed to reach where it is today, and to indicate known changes due to occur in the near future. Fuller details can be found in Chapter 10. The following map shows site locations as at May 2013.

ONR Map of Regulated Nuclear Sites

The UK Nuclear Sector Principal Organisations

	Generation	Defence	Other uses eg Medical & Industrial Isotopes, Research Reactors
Designers	**Existing Reactors** Originally Consortia *see Section 10.* Now Operators as Design Auth. **New Build - Generic designs** EDF/AREVA UK EPR, Westinghouse AP1000, *Hitachi BWR,* *AECL CANDU.* *Note 1*	MoD DES Nuclear Weapons : AWE Submarine propulsion: Rolls Royce Submarines: BAe	xxx
Fuel **Enrichment & Manufacture**	Urenco Springfields Fuel	Rolls Royce	xxx
Operators	**Existing:** EDF Energy Nuclear Generation - *AGR & PWR* Magnox - *Magnox* **New Build:** EDF NNB GenCo - *UK EPR* Horizon Nuc Power NuGen *Note 2*	Royal Navy Devonport CSB Faslane & Coulport	GE Healthcare
Decommissioning	Sellafield Magnox RSRL DSRL		Imperial College Ascot
Spent fuels / Waste Management	Sellafield Magnox RSRL DSRL LLWR Studvik NDA WMDR	Devonport Sellafield Rosyth	Sellafield (HASS)
Notes:	1 Hitachi / AECL withdrew from original round of GDA		2 Horizon & NuGen have not yet (11/12)declared their choices of reactor types; Horizon is likely to be BWR

Historic Perspective

The UK nuclear story can be split into six time periods; these are:

1940s to 60s – Research and magnox [1]
This era started with the atomic weapons programme. After World War II, a breakdown of exchanges with the United States led to the establishment of the UK's own programme through AWRE; the forebears of the UKAEA.
The programme had a number of separate strands: weapons development and production; research into nuclear sciences and various types of fission reactors (SGHWR, DPFR, magnox); development of civil nuclear reactors for electricity generation (the magnox programme), associated fuel cycle activities; associated medical and industrial isotope production.

Mid-1960s – Review of the industry
When the generating companies (CEGB and SSEB) wanted to move from magnox reactors to AGRs, the House of Commons Select Committee on Science and Technology undertook a major review of the whole civil programme. Their wide-ranging recommendations resulted in a major organisational break up of UKAEA and the way in which design and construction was organised.
In 1959, following the *Windscale* fire, licensing was introduced in the UK.

1960s to 1990s – AGR and PWR plus fuel cycle
CEGB and SSEB operated the fleet of magnox reactors and built seven AGRs and one PWR. Further PWR stations were planned but never built.
BNFL was created to oversee the fuel cycle activities. Isotope facilities became Amersham international. NRPB was formed.

1960s to the present – Defence programme
Over the last 50 years, development has covered aerially delivered weapons through to nuclear powered submarines with the current Trident missiles carried by submarines. Future systems are in early stages of design. Key organisations are MoD, AWE and Rolls Royce Marine, with various shipbuilding and dockyard organisations. MoD has evolved its own internal nuclear regulator DNSR.

1990s to the present – Civil programme
Major changes in Government policy towards the UK electricity industry saw separation and privatisation of the nuclear operators into what become 'Magnox' and 'EDF-Energy Nuclear Generation Limited (EDF-E NGL)'.

Research reactors were either decommissioned and delicensed or placed ready for decommissioning. Many of the magnox reactors came to end of operating life and were defueled / started decommissioning. Production of magnox fuel ceased.

In 2005 the NDA was established to oversee the decommissioning of the older plants and manage the back-end fuel cycle activities such as storage and reprocessing. NDA was also given responsibility for development of disposal facilities.

The future - 2013 to 2020, Future Systems and Fusion

Magnox close down *Oldbury & Wylfa*, whilst EDF-E NGL seek life extensions for and continue to run the fleet of AGRs and *Sizewell B* PWR,
NDA and its SLCs continue with decommissioning and clean-up, which for Sellafield goes out on programme to 2120.

[1] magnox – first generation UK reactors called such because of the non-oxidising magnesium alloy cladding to the uranium fuel rods. The SLC 'Magnox' later came into being to run magnox fuelled stations

A programme of new build reactor design and pre-construction; this has started for *Hinkley Point C* EPR, along with siting selection and planning aspects. Initial consultations have commenced for *Sizewell 'C'* EPR. Other potential licensees and sites are being discussed.

In relation to waste the government has accepted, for England and Wales, that:

a. the UK's higher activity waste should be managed in the long term through geological disposal for which , NDA RWMD is developing the details; and
b. the continuing need for safe and secure interim storage until geological disposal is available.

The Scottish Government / Executive is progressing long-term storage rather than disposal.
DECC has responsibility for considering how the UK energy system might evolve in the future and the roles that different types of energy generation may play in it. Currently this is focussed on Uranium and Thorium fuel cycles and comparison with modern PWRs.

Since the 1950s the UK has been involved in Fusion research. This is now focussed on the *Culham* Centre for Fusion Energy (CCFE) which hosts JET and MAST. UK is a partner in ITER being built at *Cadarache* in France.

Chapter 2

Background

CONTENTS

Editor **Iain McNair**
Contributors **Mark Lyons, Bob McGeary, Mike Underwood**

2.1 Fundamentals

Overview

The need to assure the safety of workers and the public from ionising radiation is the dominant requirement for integrated management systems / quality assurance in the nuclear industry. Article 6 paragraph 4 of the European Council directive 2009/71/EURATOM, requires licensees to establish and implement management systems which give due priority to safety; and is transposed into UK law by revised Licence Condition 17 – "Management systems". International Atomic Energy Agency (IAEA) Requirements set out in GS-R-3, which are identified as 'expectations' in UK's Office for Nuclear Regulation (ONR) Inspection guidance, state that these should be Integrated Management Systems which prioritise Safety. Therefore, it is vitally important to understand what is meant by safety.

Application

Tier 1 and 2 contractors need to have very strong understanding of the nuclear nuances, whilst Tier 3 and 4 contractors need to fully understand why requirements are likely to be placed via contractual requirements, and the implications of their products, including services, on safety.

Key Definitions

IAEA provide a full glossary of definitions applicable to the nuclear industry which, to ensure commonality of understanding by everyone, should form the basis of industry usage. A general glossary is to be found at the end of this document in Appendix 1. The following definitions are so key to all understanding of integrated management systems / quality assurance that they deserve special repeating:

> ***'nuclear safety***
>
> "The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards."
>
> "Often abbreviated to 'safety' in IAEA publications on nuclear safety. 'Safety 'should be taken to mean 'nuclear safety' unless otherwise stated, in particular when other types of safety (e.g. fire safety, conventional industrial safety) are also being discussed."
>
> ***'protection and safety***
>
> "The protection of people against exposure to ionising radiation or radioactive materials and the safety of radiation sources, including the means for achieving this, and the means for preventing accidents and for mitigating the consequences of accidents should they occur."
>
> "Safety is primarily concerned with maintaining control over sources, whereas (radiation) protection is primarily concerned with controlling exposure to radiation and its effects. Clearly the two are closely connected: radiation protection (or radiological protection) is very much simpler if the source in question is under control, so safety necessarily contributes towards protection."
>
> Comment: *Whilst not disagreeing with these definitions the reader new to the subject needs to be aware that:*
>
> 1. *To achieve Safety requires understanding the source term and maintaining control in a proportionate manner. The 'source' can range from a small amount of radioactive material used for medical or industrial purposes, through to the large irradiated fuel inventory of a nuclear power station.*

2. *Radiological protection is about the appropriate use of time distance and shielding in an ALARP (As Low As Reasonably Practicable) environment.*

Comment: *'Safety' is sometimes further described by prefixes e.g. nuclear safety, radiation safety, radioactive waste safety or transport safety; care has to be taken to recognise these adjectives relate to activities and forms of material and are thus not mutually exclusive. However, 'protection' is primarily concerned with protecting humans against exposure, whatever the source, and so is always radiation protection."*

radiation protection (also radiological protection). The protection of people from the effects of exposure to ionizing radiation, and the means for achieving this.

Comment: *Pre-2000 principles for nuclear safety and radiation protection had been technically compatible but expressed differently; as such a unified set of principles was developed which became that set out in IAEA Safety Fundamentals (SF-1) (see below).*

The ONR Safety Assessment Principles (SAPs) provide the following definition: 'safety' refers to the safety of persons in relation to radiological hazards

management system. A set of interrelated or interacting elements (system) for establishing policies and objectives and enabling the objectives to be achieved in an efficient and effective manner.

- The component parts of the *management system* include the organizational structure, resources and organizational *processes*. Management is defined (in ISO 9000) as coordinated *activities* to direct and *control* an organization.
- The *management system* integrates all elements of an organization into one coherent system to enable all of the organization's objectives to be achieved.
  These elements include the organizational structure, resources and *processes*. Personnel, equipment and organizational culture as well as the documented policies and *processes* are parts of the *management system*. The organization's *processes have* to address the totality of the *requirements* on the organization as established in, for example, IAEA *safety standards* and other international codes and standards.

Comment *In IAEA GS-R-3 the following statement is made at the outset: "A management system designed to fulfil these requirements integrates safety, health, environmental, security [1] , quality [2] and economic [3] elements. Safety is the fundamental principle upon which the management system is based. These requirements must be met to ensure the protection of people and the environment and they are governed by the objectives, concepts and principles of the IAEA Safety Fundamentals publication".*

IAEA GS-R-3 uses the term 'management system' rather than 'quality assurance'.

Standards

Safety Fundamentals

IAEA Safety Fundamentals state: 'The fundamental safety objective is to protect people and the environment from harmful effects of ionising radiation.' This is met by implementing ten safety principles:'Responsibility for safety – The prime responsibility for safety must rest with the person or organisation responsible facilities and activities that give rise to radiation risks.

[1] Security measures for physical protection are essential to safety and the failure of such measures has consequences for safety.
[2] Quality refers to the degree to which a product, process or service satisfies specified requirements
[3] Economic decisions and actions may introduce or may mitigate potential risks.

1. 'Role of government – An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.
2. 'Leadership and management for safety – Effective leadership and management for safety must be established and sustained in organisations concerned with, and facilities and activities that give rise to, radiation risks.
3. 'Justification of facilities and activities – Facilities and activities that give rise to radiation risks must yield an overall benefit.
4. 'Optimisation of protection – Protection must be optimised to provide the highest level of safety that can reasonably be achieved.
5. 'Limitation of risks to individuals – Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.
6. 'Protection of present and future generations – People and the environment, present and future, must be protected against radiation risks.
7. 'Prevention of accidents – All practicable efforts must be made to prevent and mitigate nuclear or radiation accidents.
8. 'Emergency preparedness and response – Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.
   Comment: *In considering incidents the arrangements should be proportionate to the potential consequences. UK terminology used for licensed sites refers to Incidents and On-Site or Off-site Emergencies.*
9. 'Protective actions to reduce existing or unregulated radiation risks – Protective actions to reduce existing or unregulated radiation risks must be justified and optimised.'

For each principle, further guidance is provided, which when considered requires the implementation of effective management systems.

Basic Safety Standards (BSS)

IAEA

The IAEA published the first 'basic safety standards' in 1962, and subsequently it has been revised; in processes that involved many international bodies.

In November 2011 the revised BSS was published as General Safety Requirements Part 3 - Interim in the IAEA Safety Standards Series. Following approval by other potential sponsoring organizations, it will be issued as a jointly sponsored standard.

The BSS introduces five Requirements for Protection and Safety; the fifth of which is 'Management for protection and safety': "The principal parties shall ensure that protection and safety is effectively integrated into the overall management system of the organizations for which they are responsible". Because they are so underlying all that we are about in nuclear quality, the full text of Requirement 5 is reproduced at Annex A to this Section

EU

The European Union (EU) under the EURATOM treaty has also laid down basic standards. In parallel with the IAEA revision, a 'Draft EURATOM Basic Safety Standards Directive' was produced and adopted by the European Council in September 2011. The Directive was expected to come into effect during 2012 giving EU Member States until 2014 to transpose the new requirements and update national law.

Comment : *Within the Directive both quality assurance and quality control are defined. 'Quality assurance' is called up within the scope of responsibilities of the Radiation Protection Expert (Article 19), and the Medical Physical Expert (Article 20). It is also required to be addressed in control of medical equipment, and licence authorisation. Additionally there are defined a number of activities which would normally fall within a quality regime e.g. procedures, local rules, calibration of equipment, monitoring and records.*

Safety

Nuclear safety

Within the UK, nuclear activity (other than in means of transport) can only be undertaken on a licensed, permitted or authorised site.

As part of the ONR licensing a series of Licence Conditions (LCs) are prescribed. One of these is LC17 - Management Systems (prior to July 2011 titled Quality Assurance).

Defence sites which do not fall within licensing are 'authorised' by the Defence Nuclear Safety Regulator (DNSR) using conditions closely linked to the ONR LCs

Whilst accumulation and storage of nuclear materials are Licensable/ Authorised activities, nuclear waste can only be disposed of by means 'authorised' by the EA or SEPA. EA's regulatory guidance refers to "Management and Leadership for the Environment"

Radiological safety

Within the UK the principal legislation, applying generally, not just to nuclear licensed sites, is the Ionising Radiation Regulations (IRRs).

Note: *Further details of the UK regulatory system and applicable safety legislation can be found in Section 2.3*

Hazard and risk (definitions taken from ONR SAPs)

Understanding of the definitions and relationship of these two terms lies behind all regulatory approaches to safety.

Hazard	The potential for harm arising from an intrinsic property or disposition of something to cause detriment. See also external hazards.
Hazard potential	The propensity for the harm from a hazard to be realised.
External hazard	External hazards are those natural or man-made hazards to a site and facilities that originate externally to both the site and the process, i.e. the dutyholder may have very little or no control over the initiating event.
Internal hazard	Internal hazards are those hazards to plant and structures that originate within the site boundary and over which the dutyholder has control over the initiating event in some form.
Risk	Risk is the chance that someone or something is adversely affected in a particular manner by a hazard.

Note *The UK Court of Appeal* [1] *held that the term 'risk' in s.3, HSWA, means the possibility of danger rather than actual danger.*

Link to safety case

The safety case is a fundamental suite of documentation (see ONR LCs 14 & 23 +TAG 051) which sets out the justification for nuclear safety. As such it inherently has to link to the management systems that have a prime function of delivering safety. This emphasises the issue that quality and management systems are about more than standard compliance but are about 'product' outcome.

Annex A- Text of IAEA GSR Part 3 (Interim) Requirement 5

Requirement 5: Management for protection and safety

The principal parties shall ensure that protection and safety is effectively integrated into the overall management system of the organizations for which they are responsible.

Protection and safety elements of the management system

2.47. The principal parties shall demonstrate commitment to protection and safety at the highest levels within the organizations for which they are responsible.

2.48. The principal parties shall ensure that the management system is designed and implemented to enhance protection and safety by:

(a) Applying the requirements for protection and safety coherently with other requirements, including requirements for operational performance, and coherently with guidelines for security;

(b) Describing the planned and systematic actions necessary to provide adequate confidence that the requirements for protection and safety are fulfilled;

(c) Ensuring that protection and safety is not compromised by other requirements;

(d) Providing for the regular assessment of performance for protection and safety and the application of lessons learned from experience;

(e) Promoting safety culture.

2.49. The principal parties shall ensure that protection and safety elements of the management system are commensurate with the complexity of and the radiation risks associated with the activity.

2.50. The principal parties shall be able to demonstrate the effective fulfilment of the requirements for the protection and safety in the management system.

Safety culture

2.51. The principal parties shall promote and maintain a safety culture by:

(a) Promoting individual and collective commitment to protection and safety at all levels of the organization;

(b) Ensuring a common understanding of the key aspects of safety culture within the organization;

(c) Providing the means by which the organization supports individuals and teams in carrying out their tasks safely and successfully, with account taken of the interactions between individuals, technology and the organization;

(d) Encouraging the participation of workers and their representatives and other relevant persons in the development and implementation of policies, rules and procedures dealing with protection and safety;

(e) Ensuring accountability of the organization and of individuals at all levels for protection and safety;

(f) Encouraging open communication with regard to protection and safety within the organization and with relevant parties, as appropriate;

(g) Encouraging a questioning and learning attitude and discouraging complacency with regard to protection and safety;

(h) Providing means by which the organization continually seeks to develop and strengthen its safety culture.

Human factors

2.52. The principal parties and other parties having specified responsibilities in relation to protection and safety, as appropriate, shall take into account human factors and shall support good performance and good practices to prevent human and organizational failures, by ensuring among other things that:

(a) Sound ergonomic principles are followed in the design of equipment and the development of operating procedures, so as to facilitate the safe operation and use of equipment, to minimize the possibility that operator errors will lead to accidents, and to reduce the possibility that indications of normal conditions and abnormal conditions will be misinterpreted;

(b) Appropriate equipment, safety systems and procedural requirements are provided and other necessary provisions are made:

> (i) To reduce, as far as practicable, the possibility that human error or inadvertent action could give rise to accidents or other incidents leading to the exposure of any person;
>
> (ii) To provide means for detecting human errors and for correcting them or compensating for them;
>
> (iii) To facilitate protective actions and corrective actions in the event of failures of safety systems or failures of protective measures.

[1] Court of Appeal – R v Board of Trustees of the Science Museum [1993] 3 All ER 853

2.2 International and National Infrastructure

Scope and approach

The aim of this Section is to set out how international practices, commitments and in some cases law interact with the ways in which the UK nuclear industry is organised and the expectations that result. Details of the regulatory aspects are described in Chapter 3. Also provided are outlines of various international organisations operating in the nuclear arena which may be encountered; where these organisations have published quality/management systems related publications these are referred to.

Application
Tier 1 and 2 contractors need to have strong understanding of the international and UK industry picture, particularly regarding regulatory approaches and standard setting; whilst Tier 3 and 4 contractors should be aware of why requirements are likely to be placed via contractual requirements.

Introduction to International/National relationships

As described by the UK Department for Energy and Climate Change (DECC) [1] "The potential human, environmental and economic consequences of a serious release of radioactive material could be greater by orders of magnitude than those of an accident in another high hazard sector. Furthermore, the impact could extend far beyond national borders." Because of such widespread significance International organisations and agreements have been formed.

Between 1955 and 1959 the USA concluded agreements with 42 countries, whilst by 1968 the USSR had concluded nuclear co-operation agreements with 26 countries. In doing so, both major powers encouraged the establishment of regional / international organisations of their agreement states, in parallel to the overarching body which became the International Atomic Energy Agency (IAEA).

In December 2010 (prior to the Fukushima Daiichi NPP/tsunami event of March 2011) there were 441 nuclear power stations in operation worldwide with 67 reactors under construction, across 30 countries [2]; some 60 countries were indicating interest in considering the introduction of nuclear power.

IAEA is the principal international organisation publishing standards; these are followed by many but not necessarily all states having nuclear industries. The IAEA produce a tiered set of publications related to Safety (incl Transport), Security and Safeguards. IAEA Fundamental Safety Principles (See Section 2.1 for detail) No 5 'Leadership and management for safety' states – "Effective leadership and management for safety must be established and sustained in organisations concerned with, and facilities and activities that give rise to, radiation risks". The current IAEA Standard for Management systems is GS-R-3 published in 2006 (redraft started Jan 2011) which is applicable at Regulatory / Operator – Licensee level; some States still mandate in their legal system the previous version 50-C/SG-Q 1996 or their own requirements (See Chapter 11 International approaches).

Information on the UK civil nuclear industry, excluding Northern Ireland which has no nuclear facilities, can be found from the DECC website. DECC has the main Government lead on Generation and Waste Treatment/Storage whilst the Department for Environment, Food and Rural Affairs (DEFRA)/Welsh Assembly/Scottish Executive lead on Disposal aspects. A useful mapping of involved organisations, with commentary, is produced by the Nuclear Industry Association (NIA).

International Atomic Energy Agency (IAEA)

History
The international aspect of the nuclear industry was to some extent a consequence of the history of the industry (see Chapter 10) and concerns about weapons non-proliferation. These expanded with recognition that there was scope for civil nuclear power, the knowledge for which the original nuclear powers (USA, UK, Canada, USSR,) held and restricted control. Consequently various bodies developed, acting in parallel but also often in concert, to both promote nuclear matters and also determine how that can be done safely and securely.

In November 1945, President Truman and Prime Ministers Attlee of the United Kingdom and Mackenzie King of Canada, meeting in Washington, issued a "Three Nation Agreed Declaration on Atomic Energy" in which they said that they would be willing "to proceed with the exchange of fundamental scientific literature for peaceful ends with any nation that will fully reciprocate" but only when "it is possible to devise effective reciprocal and enforceable safeguards acceptable to all nations" against its use for destructive purposes. They suggested that the new-born United Nations should promptly tackle the nuclear issue. Soon afterwards, in December 1945, at a meeting in Moscow of the Council of Foreign Ministers, the USA and the United Kingdom proposed, and the USSR agreed, that a United Nations Atomic Energy Commission (UNAEC) should be created "to consider problems arising from the discovery of atomic energy and related matters." From 1945 until 1949, when the UNAEC concluded that its work had ceased to be meaningful, the proclaimed aim of the USA and the USSR and their allies was not to prevent the spread of nuclear weapons but to do away with them altogether.

On 8 December 1953 US President Eisenhower made his "Atoms for Peace" speech to the General Assembly; which a year later unanimously endorsed the creation of the new agency - the International Atomic Energy Agency (IAEA).

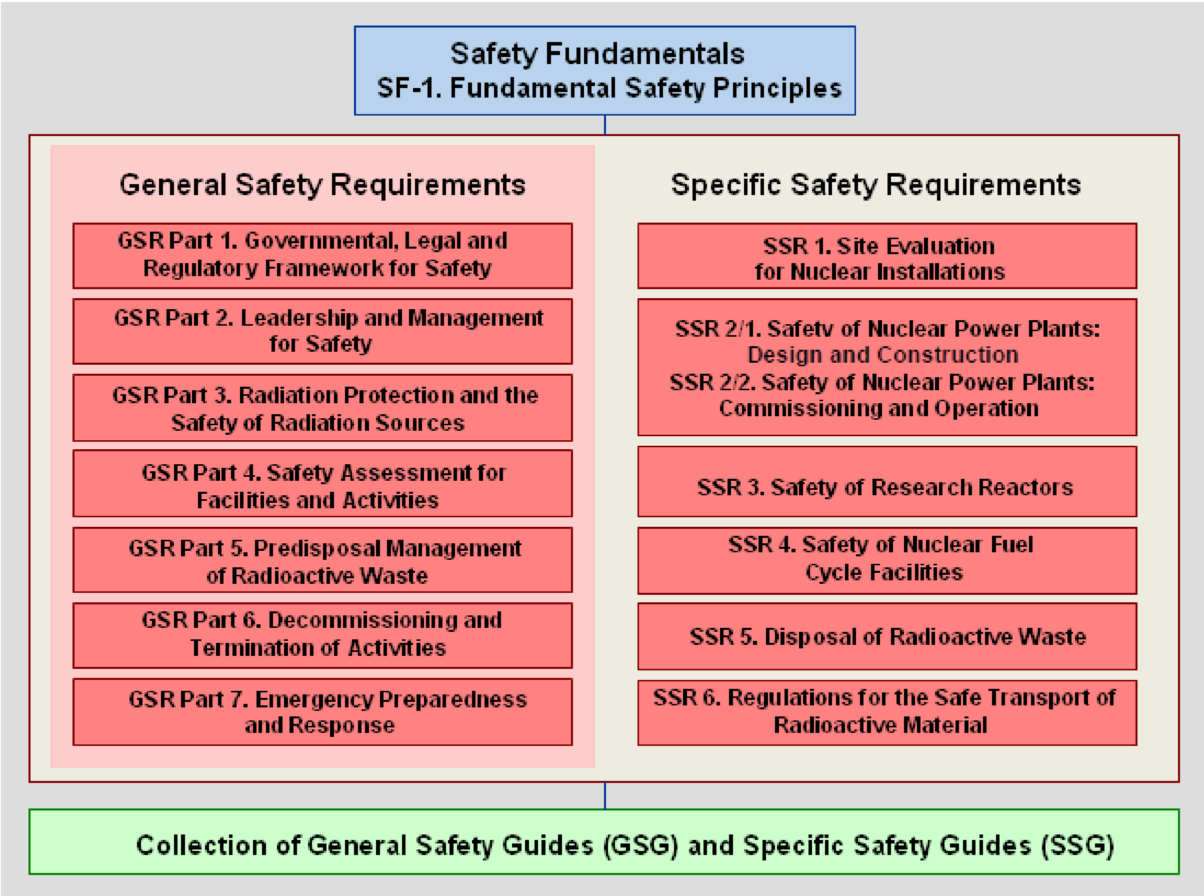
In August 1955 "The First Geneva Conference" was held with some 1500 scientist and engineer delegates and more than 1000 scientific papers being presented. Soon the only nuclear technology remaining a closely guarded secret, other than construction of the bomb itself, was that of enriching uranium; in 1956 the IAEA Statute was approved, which empowered it. The IAEA was given seven functions: (1) Research into atomic energy for peaceful purposes; (2) provision of materials etc to enable research, (3) considering the under-developed areas of the world;, (4) fostering information exchange; (5) encouraging training; (6) establishing and administering safeguards; (7) establishing standards of safety; where necessary acquiring facilities etc to undertake the first six functions. The first IAEA General Conference was held in Vienna in October 1957, with by the end of it a membership of 59 Member States; by 2011 the membership had risen to 151 States.

In 2011 the IAEA was set up in five departments: Nuclear Applications; Nuclear Energy; Nuclear Safety & Security; Safeguards; and Technical Cooperation. Details of their activities are available through the Agency's web site.

Safety (incl Transport)
In 1974, the IAEA launched the Nuclear Safety Standards (NUSS) programme. This was a comprehensive series of Codes and Safety Guides intended to ensure the safe design, siting and operation of the current generation of nuclear power reactors, and enhance their reliability.
The IAEA agreed that a series of five NUSS Codes and 47 Safety Guides should be prepared between 1975 and 1980. In 1974, the Board decided NUSS documents would be recommendations.

IAEA Safety Standards Series
In 2008 a new, long-term structure (see figure below) for the safety standards was adopted such that users may easily identify those safety standards that are applicable to the specific facility or activity they are dealing with.

The Safety Fundamentals (SF-1), the General Safety Requirements (GSR) in seven parts and the General Safety Guides (GSG) are applicable to all facilities and activities. These are complemented by Specific Safety Requirements (SSR) and Specific Safety Guides (SSG), which are applicable to specified facilities and activities. The transition to this new structure is ongoing:



Fundamental Safety Principles establishes the fundamental safety objective and principles of protection and safety. The Fundamental Safety Principles (See Section 2.1) are drafted in language to be understandable to the non-specialist reader, and convey the basis and rationale for the safety standards for those persons at senior levels in government and regulatory bodies.

Safety Requirements publications establish the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. The format and style of the requirements facilitate their use by Member States for the establishment, in a harmonized manner, of their national regulatory framework. and safety guides.

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus on the measures recommended. The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. for ensuring safety. They reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation.

Safety standards are applicable throughout the entire lifetime of facilities and activities – existing and new – utilized for peaceful purposes, and to protective actions to reduce existing radiation risks. They are developed by means of an open and transparent process for gathering, synthesizing and integrating the knowledge and experience gained from the actual use of nuclear energy technologies and from the application of the safety standards, including knowledge of emerging trends and issues of regulatory importance.

The IAEA Safety Glossary defines and explains technical terms used in the IAEA safety standards and other safety related IAEA publications, and provides information on their usage.

The whole range of safety standards can be accessed via the web, along with safety standards under development and draft standards available for comment. (Note *the formal route for UK comments is via the Office for Nuclear Regulation (ONR)*). A frequently updated status listing of all standards is maintained and published by IAEA.

GSR Part 2 Leadership and Management of Safety is currently being drafted (DS456: Leadership and Management for Safety, revision of GS-R-3). The declared contents indicate it should have the existing GS-R-3 Management for Safety content in section 4 with new sections on (2) Responsibility for safety, (3) Leadership for safety and (5) Safety Culture. *A drafting meeting was held in January 2012, on a schedule which indicated a target publication date of 12/2013*.

Transport
In 1961, the IAEA published its first regulations for the safe transport of radioactive material. These regulations have been reviewed and updated regularly over the last 50 years, and form the basis of international modal regulations established by other United Nations bodies, such as the International Maritime Organization and the International Civil Aviation Organization. The IAEA requirements are in turn adopted by national regulatory authorities creating a strong global regulatory framework.

Regulations for the Safe Transport of Radioactive Materials (TS-R-1) are revised frequently (latest version 2012 Edition (SSR-6)) and supported by additional guidance such as TS-G-1.1 "Advisory Material for the Regulations for the Safe Transport of Radioactive Material", TS-G-1.4 "The Management System for the Safe Transport of Radioactive Material" , TS-G-1.5 "Compliance Assurance for the Safe Transport of Radioactive Material".

The Regulations address all categories of radioactive material ranging from very low activity, including such materials as ores and concentrates of ores, to very high activity such as spent fuel and high-level waste. The material to be transported must be categorized on the basis of its activity concentration, total activity, fissile characteristics (if any) and other relevant subsidiary characteristics. Packaging and package requirements are then specified on the basis of the hazard of the contents and range from normal commercial packaging (for low hazard contents) to strict design and performance requirements (for higher hazard contents). Specific requirements are also established for marking, labelling, placarding of conveyances, documentation, external radiation limits, operational controls, quality assurance and notification and approval of certain shipments and package types.

Security
Nuclear security issues relate to the prevention and detection of, and response to, theft, sabotage, unauthorized access and illegal transfer or other malicious acts involving nuclear material and other radioactive substances and their associated facilities. These are addressed by international nuclear security instruments such as the Convention on the Physical Protection of Nuclear Material and its Amendment, the Code of Conduct on the Safety and Security of Radioactive Sources, the Supplementary Guidance on the Import and Export of Radioactive Sources, the United Nations Security Council resolutions 1373 and 1540 and the International Convention for the Suppression of Acts of Nuclear Terrorism. The fundamental documents and Security Series guides have their own web pages.

Convention on the Physical Protection of Nuclear Material: 1979 (as amended)
The Convention establishes measures related to the prevention, detection and punishment of offenses relating to nuclear material. The 2005 amended Convention makes it legally binding for States Parties to protect nuclear facilities and material in peaceful domestic use, storage as well as transport. It also provides for expanded cooperation between and among States regarding rapid

measures to locate and recover stolen or smuggled nuclear material, mitigate any radiological consequences of sabotage, and prevent and combat related offences.

Publications in the IAEA Nuclear Security Guidelines series are issued in the following categories:

- *Nuclear Security Fundamentals* contain objectives, concepts and principles of nuclear security and provide the basis for security recommendations.
- *Recommendations* present best practices that should be adopted by Member States in the application of the Nuclear Security Fundamentals.
- *Implementing Guides* provide further elaboration of the Recommendations in broad areas and suggest measures for their implementation.
- *Technical Guidance* publications comprise: *Reference Manuals*, with detailed measures and/or guidance on how to apply the Implementing Guides in specific fields or activities.

Safeguards
The safeguards system comprises measures by which the IAEA independently verifies the declarations made by States about their nuclear material and activities. These measures are implemented under various types of agreements and protocols.
A significant basis of safeguards has traditionally been material accountancy, containment and surveillance. Inventory information is maintained by facility operators / licensees and reported via national authorities to IAEA. IAEA Inspectors undertake independent verification.

IAEA Reports
Each year IAEA publishes an Annual Report, a Nuclear Safety Review, a Safeguards Implementation Report, a Nuclear Technology Review, and a Technical Cooperation Report.

IAEA Treaties, Conventions and Agreements
A full list is available on the IAEA web site; the following are some of the most commonly referred to:
Treaty on the Non-Proliferation of Nuclear Weapons (NPT): 1968 + additional protocols
The NPT objective is to prevent the spread of nuclear weapons and weapons technology, to promote cooperation in the peaceful uses of nuclear energy and to further the goal of achieving nuclear disarmament and general and complete disarmament. Conferences to review the operation of the Treaty have been held at five-year intervals since the Treaty went into effect in 1970. Each conference has sought to find agreement on a final declaration that would assess the implementation of the Treaty's provisions and make recommendations on measures to further strengthen it.

Convention on Early Notification of a Nuclear Accident: 1986
Adopted following the Chernobyl nuclear plant accident, this Convention establishes a notification system for nuclear accidents which have the potential for international trans-boundary release that could be of radiological safety significance for another State. It requires States to report the accident's time, location, radiation releases, and other data essential for assessing the situation.

The five nuclear-weapon States (China, France, Russia, the United Kingdom, and United States) have all declared their intent also to report accidents involving nuclear weapons and nuclear weapons tests.

Convention on Nuclear Safety: 1994
The aim is to commit participating States operating land-based nuclear power plants to maintain a high level of safety by setting international benchmarks to which States would subscribe.

The obligations of the Parties are based to a large extent on the principles contained in the IAEA Safety Fundamentals document "The Safety of Nuclear Installations". These obligations cover for instance, siting, design, construction, operation, the availability of adequate financial and human resources, the assessment and verification of safety, quality assurance and emergency preparedness.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management: 1997

The Joint Convention applies to spent fuel and radioactive waste resulting from civilian nuclear reactors and applications and to spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes, or when declared as spent fuel or radioactive waste for the purpose of the Convention by the Contracting Party. The Convention also applies to planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities.

Vienna Convention on Civil Liability for Nuclear Damage: 1963 amended 1997

In 1963 IAEA members agreed the "Vienna Convention on Civil Liability for Nuclear Damage". Following the Chernobyl accident, the IAEA initiated work on all aspects of nuclear liability with a view to improving the basic Conventions and establishing a comprehensive liability regime. In 1988, as a result of joint efforts by the IAEA and OECD NEA, the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (see NEA below) was adopted. The Joint Protocol established a link between the Conventions combining them into one expanded liability regime. Parties to the Joint Protocol are treated as though they were Parties to both Conventions and a choice of law rule is provided to determine which of the two Conventions should apply to the exclusion of the other in respect of the same incident.

Code of Conduct on safety of Research Reactors: 2006

Relationship Agreements with Specialized Agencies and Intergovernmental organisations

These relate to interactions with UNESCO, ILO, WHO, WMO, ICAO, FAO, EEC(ENEA), I-ANEA

Organisation for Economic Co-operation and Development Nuclear Energy Agency (OECD NEA)

Background

In 1948 the Organization for European Economic Cooperation (OEEC) was established to channel US aid to 16 Western European nations; in February 1958 the OEEC set up the European Nuclear Energy Agency (ENEA). OECC became the OECD and the Agency's name was changed in 1972, to the Nuclear Energy Agency (NEA), reflecting growing membership beyond Europe's boundaries. The first phase of the NEA's programme mainly consisted of laying the foundations for nuclear co-operation, and focused on launching several joint R&D undertakings such as the Halden and Dragon reactor projects, and the prototype Eurochemic plant for the reprocessing of spent nuclear fuels. This period came to a natural end during the late 1960s.

By the early 1970s the Agency's role had changed to one where major emphasis was placed on providing a forum for co-ordinating the national nuclear programmes of member countries, particularly in the health, safety and regulatory areas. As nuclear energy gathered momentum in the 1970s, governments came under increasing pressure from their constituents to give greater priority to the environmental aspects of nuclear energy and to the safety and regulation of nuclear power plants.

In the early 1990s, in the wake of the dissolution of the Soviet Bloc, the Agency followed the lead of the OECD and initiated a limited programme of outreach, focusing primarily on the countries of Central and Eastern Europe and the former Soviet Europe. Some of the activities in the outreach programme have increasingly become an integral part of the core programme of the Agency as additional countries with reactors of Soviet design have become members.

Mission

The NEAs mission is:

- "To assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes.
- To provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development."

In order to achieve this, the NEA works as a forum for sharing information and experience and promoting international co-operation; a centre of excellence which helps member countries to pool and maintain their technical expertise and a vehicle for facilitating policy analyses and developing consensus based on its technical work. About 85% of the worlds installed capacity is found in the member countries in Europe, North America and the Asia-Pacific region.

Organisation and Activities

The NEA is a semi-autonomous body of the OECD, comprising (April 2013) 31 nations. It is governed by the Steering Committee for Nuclear Energy, made up of senior officials from national atomic energy authorities and associated ministries, with the work mandated to the seven standing technical committees: Committee on the Safety of Nuclear Installations (CSNI); Committee on Nuclear Regulatory Activities (CNRA); Radioactive Waste Management Committee (RWMC); Committee on Radiation Protection and Public Health (CRPPH); Nuclear Science Committee (NSC); Committee for Technical and Economic Studies on Nuclear Energy Developments; and the Fuel Cycle (NDC) and Nuclear Law Committee (NLC). Detail of subordinate working groups/parties can be found on the organisation diagram on the NEA web site.

In 2010 CNRA held a workshop on 'Experience from Inspecting Safety Culture, Inspection of Licensee Safety Management Systems and Effectiveness of Regulator Inspection Process'. The workshop proceedings (Report 5) and national pre-question reports (Report 6) are on the web site. Pages 32 to 36 of Report 5 record the discussion groups on Licensee Safety Management Systems and provide a useful insight into international regulatory expectations and thinking. Issues raised include

- the need for grading according to safety significance;
- certification to ISO9001 should not automatically lead to attention / inspection;
- senior management has a prominent role in implementation and continuous improvement of the management system;
- need to consider both programmes/processes and outcomes/findings;
- overly complicated processes are cumbersome for effective implantation of the management system and understanding it;
- management systems failures do lead to major events (eg Davis Besse vessel head corrosion);
- a focus on root causes of problems is necessary rather than fixing individual problems.

Multinational Design Evaluation Programme (MDEP)

The NEA performs the Technical Secretariat functions for MDEP. MDEP is a multinational initiative taken by national safety authorities to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities who are currently or will be tasked with the review of new reactor power plant designs. Activities include a working group on Codes and Standards and the Vendor Inspection Co-operation Working Group (VICWG).

VICWG-02 Technical report "Survey on Quality Assurance Program Requirements" provides responses by Canada, China, Finland, France, Japan, Russian Federation, South Korea, South Africa, UK and USA on their national requirements match against US 10-CFR-50 Appx B.

The VICWG Programme Plan 2012-13 indicates that it has long term goals in harmonising QA/Management requirements and standards, and they refer to 10-CFR-50, ISO 9001 and IAEA GS-

R-3. VICWG refer to a role in commenting on behalf of members on the draft of IAEA GSR Part 2/ GS-R-3 revision.
The MDEP 2010 report Appendix C VICWG-01 provides the MDEP Protocol for Witnessed and Joint Vendor Inspection. The UK regulatory report for EPR under New Civil Reactor Build - GDA refers to MDEP input.

Conventions on Civil Liability
There are two basic international regimes for nuclear third party liability in force: the Convention on Third Party Liability in the Field of Nuclear Energy ("the Paris Convention") was established in 1960 under the auspices of the NEA and covers most West European countries, while the Convention on Civil Liability for Nuclear Damage ("the Vienna Convention") was established in 1963 under the auspices of the International Atomic Energy Agency (IAEA) and is worldwide in character.
UK is a signatory to the Paris convention.

Coverage under the Paris Convention is extended by the Supplementary Convention on Third Party Liability in the Field of Nuclear Energy of 1963 ("the Brussels Supplementary Convention").
The Paris Convention and the Brussels Supplementary Convention have both been amended three times: by Additional Protocols adopted in 1964, 1982 & 2004. Furthermore, the Paris and Vienna Conventions have been linked by the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention of 1988 ("the Joint Protocol") which entered into force in 1992.
The Paris and the Vienna Conventions are supplemented, in relation to maritime transport, by the Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material of 1971 ("the 1971 Brussels Convention").

EU/EURATOM

European activities in nuclear matters have been undertaken since 1957 through the EURATOM treaty that established the European Atomic Energy Community, with an aim of assisting the development of a civil nuclear industry in Europe. Article 2 of the treaty requires the community to:

- Promote research and ensure the dissemination of technical information
- Establish uniform safety standards to protect the health of workers and the general public and ensure they are applied
- Facilitate investment particularly by ventures to establish basic development installations
- Ensure all users in the Community obtain an equitable supply of ores and nuclear fuels
- Make certain, by supervision, that nuclear materials are not diverted to non-intended purposes
- Exercise the right of ownership in respect of special fissile materials
- Create a common market in specialised materials and equipment
- Establish relations to foster progress in the peaceful use of nuclear energy

Other sections of the treaty expand on these requirements. Falling out from the EURATOM treaty requirements are the following directives:

- Council directive 96/29/EURATOM: 13 May 1996: Basic Safety Standards for the Protection of the Health of Workers and the General Public Against the Dangers Arising from Ionising Radiation: OJ L 159, 29.6.1996, p.1.

  Note: A Revision Draft EURATOM Basic Safety Standards Directive' was produced and adopted by the European Council in September 2011 - COM(2011)593 adopted 29 Sept 2011.
  Note: In the UK the BSS are largely, but not completely, met by the Ionising Radiations Regulations. The Environmental Permitting (England and Wales) Regulations also directly apply.

- Council directive 87/600/EURATOM of 14 December 1987: Community Arrangements for the Early Exchange of Information in the Event of a Radiological Emergency: OJ L 371, 30.12.1987, p.31.

- Council directive 89/618/EURATOM of 27 November 1989: Informing the General Public about Health Protection Measures to be Applied and Steps to be Taken in the Event of a Radiological Emergency: OJ L 357,7.12.1989,p.31.
- Note In the UK the directive is implemented by the Radiation (Emergency Preparedness and Public Information) Regulations (REPPIR).
- Council directive 2003/122/EURATOM on the Control of High-activity Sealed Radioactive Sources and Orphan Sources; OJ No L 346, 31.12.2003, p57.
- Council Directive 2009/71/EURATOM on Establishing a Community Framework for the Nuclear Safety of Nuclear Installations: OJ L 172, 2.7.2009, p18.

International Organisations

European Nuclear Safety Regulators Group (ENSREG)
ENSREG was established in 2007, by the European Commission, as a High Level Advisory Group on Nuclear Safety and Waste Management. It comprises top regulators and civil servants from all 27 EU Member states plus the Commission, working on a consensus basis.

Western European Nuclear Regulator's Association (WENRA)
WENRA formed in 1999, is a network of Chief Regulators of EU countries with nuclear power plants and Switzerland as well as of other interested European countries which have been granted observer status.

The main objectives of WENRA are to develop a common approach to nuclear safety, to provide an independent capability to examine nuclear safety in applicant countries and to be a network of chief nuclear safety regulators in Europe exchanging experience and discussing significant safety issues.

WENRA have produced "Safety Reference Levels" for Reactors, Decommissioning, Waste and Spent Fuel Storage. These are clear statements of requirements, grouped by topics including Management of Safety, cross referencing to IAEA Requirements. (Note having been developed over several years the separate topic SRLs are worded differently.) They have also undertaken benchmarking, which is reported in the SRL reports.

World Institute for Nuclear Safety (WINS)
WINS was established to provide an international forum for those accountable for nuclear security to share and promote the implementation of best security practices. It has both individual and corporate members, and is based in Vienna. It is working closely with IAEA and WANO and as of August 2012 had produced some 25 'Best Practice Guides' available to members via their web site.

The Institute of Nuclear Power Operations (INPO)
INPO was established by the nuclear power industry in December 1979 as a not-for-profit organization headquartered in Atlanta USA, charged with a mission to promote the highest levels of safety and reliability – to promote excellence – in the operation of commercial nuclear power plants. INPO was established in response to The Kemeny Commission – set up by President Jimmy Carter to investigate the March 1979 accident at the Three Mile Island nuclear power plant – which had recommended that:

- The (nuclear power) industry should establish a program that specified appropriate safety standards including those for management, quality assurance, and operating procedures and practices, and that conducts independent evaluations.
- There must be a systematic gathering, review, and analysis of operating experience at all nuclear power plants coupled with an industry-wide international communications network to facilitate the speedy flow of this information to affected parties.

INPO aim to achieve their mission by:

- Establishing performance objectives, criteria and guidelines for the nuclear power industry
- Conducting regular detailed evaluations of nuclear power plants
- Providing assistance to help nuclear power plants continually improve their performance

The four cornerstones of INPO are claimed as:

- Plant evaluations
- Training and accreditation
- Events analysis and information exchange
- Assistance

World Association of Nuclear Operators (WANO)
WANO's declared mission is to maximise the safety and reliability of nuclear power plants worldwide by working together to assess, benchmark and improve performance through mutual support, exchange of information and emulation of best practices.

Operating from London, Atlanta, Moscow, Paris and Tokyo; WANO exists to help its members accomplish the highest levels of operational safety and reliability achieved through a series of programmes which include peer reviews, technical support and access to a global library of operating experience. UK members in 2011 included EDF, Magnox and Sellafield.

WANO produce Performance Objectives and Criteria which are available (*on registration*).

Nuclear Energy Institute (NEI)
NEI is a US based organisation which, with member participation, develops policy on key legislative and regulatory issues affecting the industry. It has over 350 members in 15 countries spanning the range of commercial nuclear technologies.

Electric Power Research Institute (EPRI)
EPRI is a US based organisation, operating beyond nuclear but having two areas of nuclear activity – Advanced Nuclear Technology and Risk and Reliability.

The European Atomic Forum (FORATOM)
FORATOM is a Brussels-based trade association for the nuclear energy industry in Europe. Its main purpose is to promote the use of nuclear energy in Europe by representing the interests of this important and multi-faceted industrial sector in energy policy discussions involving the EU institutions and provide a "bridge" between the industry and the institutions (Members of the European Parliament and key policy-makers in the European Commission). The membership is made up of 17 national nuclear associations and also represents nearly 800 firms.

2.3 UK Government, Regulatory Organisation and Nuclear Industry

UK government involvement in nuclear matters is divided between several departments, depending on the aspects covered.

Fundamentally DECC is responsible for the safe and secure operation of the civil nuclear programme, the Ministry of Defence (MoD) for the defence programme, with the Department for Environment, Food and Rural Affairs (DEFRA) and Devolved Governments for waste discharges and disposal. The Foreign and Commonwealth Office (FCO) take the overview on non-proliferation of nuclear weapons and represents the UK in formal linkages with foreign governments and international organisations such as the IAEA.

Regulatory aspects lie around safety, security, safeguards, transport and environment. Historically these were undertaken by separate organisations, but in 2007 security (Office for Civil Nuclear Security (OCNS)) and UK Safeguards both transferred to join safety in HSE's Nuclear Directorate (which included the Nuclear Installations Inspectorate (NII)). In February 2011 the Government announced that an independent statutory body, known as the Office for Nuclear Regulation (ONR) was to be set up with the Radioactive Materials Transport Team (RMTT) transferring from the Department for Transport (DfT). Pending enactment of legislation The Health and Safety Executive (HSE), through its Agency the Office for Nuclear Regulation (ONR), has statutory responsibility for ensuring that there is an adequate framework for regulating nuclear sites in the UK. The ONR is accountable to the Secretary of State for Energy and Climate Change for its activities.

The Environment Agency (EA) in England, Natural Resources Wales and the Scottish Environment Protection Agency (SEPA) regulate the routine discharge and disposal of nuclear waste and other radioactive material. (There are *no licensed nuclear sites in Northern Ireland, although there are non-licensable applications which are regulated by the Northern Ireland Environment Agency (NIEA))*. EA is accountable to the Secretary of State for the Environment, Food and Rural Affairs for its work in England, Natural Resources Wales to the National Assembly for Wales, and_SEPA is accountable to the Scottish Government (previously titled Scottish Executive).

The Health Protection Agency (HPA) predominantly through it's 'Centre for Radiation, Chemical and Environmental Hazards' carries out the HPA's work on ionising and non-ionising radiations (until 2005 merger was known as National Radiation Protection Board (NRPB)).
HPA provide the Secretariat for two national committees:

- The Administration of Radioactive Substances Advisory Committee (ARSAC), which advises the Department of Health (DH) on matters relating to the granting of certificates to practice nuclear medicine in the UK, and other related scientific and radiological safety issues.
- The Committee on Medical Aspects of Radiation in the Environment (COMARE) is an independent expert advisory committee with members chosen for their medical and scientific expertise and recruited from Universities, Research and Medical Institutes. The Committee offers independent advice to all Government Departments and Devolved Authorities, not just the Health Departments, and is responsible for assessing and advising them on the health effects of natural and man-made radiation. It is also asked to assess the adequacy of the available data and advise on the need for further research.

HPA provide advice across government in radiation emergencies and also co-ordinates the National Arrangements for Incidents involving Radioactivity (NAIR)

The Food Standards Agency (FSA) has responsibility for radioactivity in food, naturally occurring, deliberate treatment and post-accident controls. It works largely in conjunction with EA/SEPA and HPA.

Fig 1 shows the main overall relationships**.**

UK Civil nuclear industry
The UK has many organisations interested in civil nuclear, split into the following sectors,

- Government
- Regulators
- Industry Companies
- Existing Decommissioning, Reprocessing and Waste Management Contracts and Work streams
- New Build
- Existing Generation
- Trade Unions
- Professional Bodies
- Research & Development
- Industry Supporting Bodies
- Skills Development Bodies

Other areas involving ionising radiation uses such as medical are not so easily identified.

UK Defence Nuclear
Whilst the Ministry of Defence (MoD) is responsible for defence nuclear matters, the detailed parts of the organisation are harder to identify.

- Royal Navy - Fleet Commander & Deputy Chief of Naval Staff's purpose is to provide ships, submarines and aircraft ready for any operations that the Government requires. The Fleet

includes Astute (Fleet) and Vanguard (Ballistic) submarines, all of which have nuclear propulsion systems.
- MoD Defence Equipment & Support (DE&S) includes the Chief of Materiel (Fleet) whose organisation includes Directorate Submarines which encompasses In-Service Submarines, Submarine Production, Nuclear Propulsion, Future Systems, and Strategic Weapons and Strategic Systems Executive, as well as Naval Bases with their Base Safety, Weapons and Nuclear Works organisations.
- Defence Safety & Environment Authority (DSEA) and its Defence Nuclear Safety Regulator (DNSR) are the internal MoD regulatory authorities, working to
    - JSP518 – Regulation of the Naval Nuclear Propulsion Programme
    - JSP538 - Regulation of the Nuclear Weapons Programme

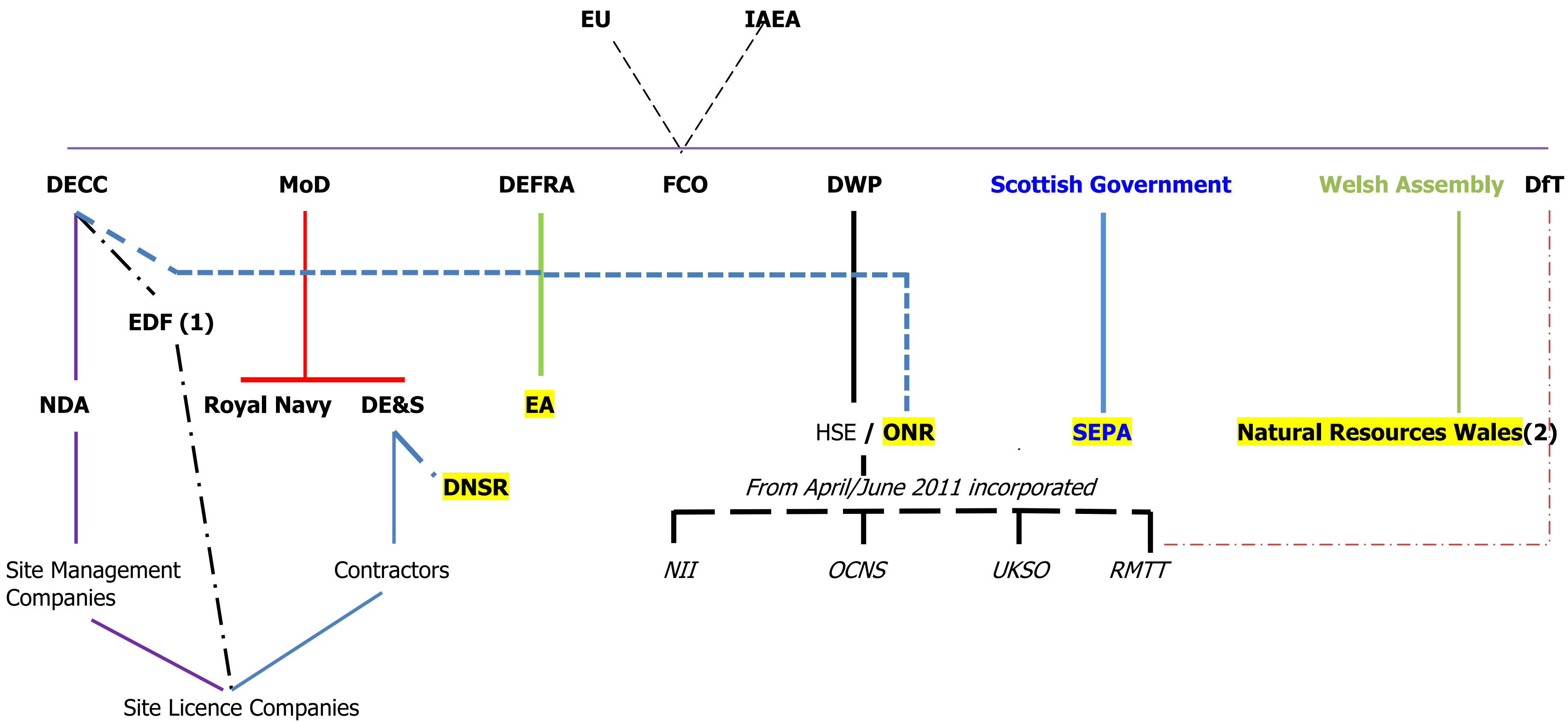
Design and manufacture of naval propulsion systems are undertaken by Rolls Royce, whilst design and construction of submarines is undertaken by BAe Systems Marine. The bases at Devonport and Rosyth are owned and operated, whilst Clyde is operated, by Babcock Marine.

Naval sites are not all licensed and the term Authorised sites may be found which is the equivalent under regulation by DNSR. Where Nuclear Powered Warships are berthed in locations outside Authorised sites, these locations are termed Operational Berths.

[1] DECC – ONR legislative reform order explanatory section 12 – March 2010 -

[2] IAEA Power Reactor Information System / Table A-1 of IAEA Nuclear technology Review 2011

Figure 1: UK government organisation



Notes

(1) EDF is used here as the example of an Operator. It would relate to both EDF-E NGL, in relation to Generation, or to NNB Gen Co for Nuclear New Build.
(2) From 1 April 2013 - New Welsh organisation includes environmental aspects.

2.4 UK Legal and Regulatory Requirements

Scope and approach

The aim of this Section is to set out how the nuclear industry in the UK is regulated and the resulting nuclear specific legislation. In doing so it should be recognised that Government policy on nuclear matters is the responsibility of the departments/devolved bodies identified in Section 2 – for civil nuclear, Department of Energy and Climate Change (DECC) lead with New Nuclear Policy, Nuclear & Radioactive Waste Policy, and National Policy Statements for Energy Infrastructure. In the area of Decommissioning and Radioactive Waste the Nuclear Decommissioning Authority (NDA) undertake much of the detailed development and establish the arrangements for the management of the implementation.

The nature of nuclear regulation is different from that of other high hazard industries because the potential human, environmental and economic consequences of a serious release of radioactive material could be greater by orders of magnitude than those of an accident in another sector; furthermore, the impact could extend far beyond national borders. Nuclear regulation is uniquely intrusive and intensive, and takes account of risks broader than simply those of health and safety at work, as is reflected in the security and safeguards regimes.

Application

Tier 1 and 2 contractors need to have strong understanding of the UK nuclear law application; whilst Tier 3 and 4 contractors should be aware of both normal legal duties and why requirements are likely to be placed via contractual requirements.

Undertaking of activities

General & Safety.

Since 1959 [1] civil nuclear activities can only be undertaken on licensed sites and the licence contains licence conditions 'necessary or desirable in the interests of safety'. Licences are issued by the Office for Nuclear Regulation (ONR) – formerly the Health and Safety Executive - Nuclear Installations Inspectorate (HSE NII). Additionally any activity involving the extraction of plutonium or uranium, or any treatment of uranium such as to increase the proportion of the isotope 235, requires a permit in writing from the Minister.

The Nuclear Installations Act also addresses issues of liability / insurance which are handled by DECC.

Activities that are licensable additional to installing / operating nuclear reactors are prescribed in the Nuclear Installation Regulations as those used for:

- manufacturing fuel elements from enriched uranium or plutonium;
- producing alloys or chemical compounds from enriched uranium or plutonium;
- processing irradiated nuclear fuel except where this is just for assay or similar purposes;
- the storage of:
  - fuel elements containing enriched uranium or plutonium;
  - irradiated nuclear fuel;
  - bulk quantities of radioactive material which has been produced or irradiated in the course of the production or use of nuclear fuel;
  - the extraction of plutonium or uranium from irradiated materials, or for enriching uranium;
  - the production of isotopes from irradiated material for industrial, chemical and other purposes;

[1] Nuclear Installations Act ; 1959 was consolidated into Nuclear Installations Act 1965 (1965 Chap 57), amended by the Nuclear Installations Act 1969 (1969 Chap 18).

- manufacturing rigs incorporating enriched uranium or plutonium for subsequent irradiation in a reactor; and
- installing a subcritical nuclear assembly in which a neutron chain reaction can be maintained.

A fuller list of applicable UK legislation can be found via National Archives index search on nuclear radioactive and atomic. The following regulations in particular will be applied frequently:

- Ionising Radiations Regulations 1999 (IRR99)
- Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 (EIADR 99)
- Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR)

Conventional health and safety regulation (for example construction work, electrical safety, machinery-guarding, work at heights and storage and use of chemicals) is regulated at nuclear and all other relevant sites by HSE's Field Operations Directorate, whilst certain specialised activities (for example, involving explosives and other hazardous non-radioactive substances) are regulated by HSE's Hazardous Installations Directorate. Responsibility for conventional health and safety will pass to ONR when legislation is enacted (Draft Energy Bill Nov 2012).

Security

Security on major civil sites is addressed by the Nuclear Industries Security Regulations 2003 which addresses Premises, Transport and Information, handling Cat I/ II and III materials (materials as defined in the Schedule of the Regulations). The application goes beyond licensed sites to a few major industrial facilities. Only premises having approved security plans, and approved carriers can be used. Regulation is undertaken by ONR. Regulation of hospitals, universities and other smaller scale facilities is undertaken by the police, whilst security of military sites is undertaken by MoD.

Transport

Three international agreements relate to the carriage of dangerous goods, to which the UK is a party). These agreements, cover road, rail and inland waterway and known in short as ADR/RID/ADN, are as follows:

- "ADR": the European Agreement concerning the International Carriage of Dangerous Goods by Road (signed at Geneva on 30 September 1957);
- "RID": the Convention concerning International Carriage by Rail (signed at Berne on 9 May 1980) (the Regulation concerning the International Carriage of Dangerous Goods by Rail).
- "ADN": the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterway (signed at Geneva on 26 May 2000);

Regulation of each is addressed in the UK by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations but a common thread leads back to the IAEA Transport Safety Requirements and Safety Guides. Regulation is undertaken by ONR .

Topics addressed include international radioactive packaging, labelling, handling and storage in transit and recordkeeping or supply of information. The lead source is IAEA "Regulations for the Safe Transport of Radioactive Material, now SSR-6 2012; section 306 and 307 specifically address Management System and Compliance Assurance, while section VII relates to test procedures.

Additional guidance can be found in the IAEA guides TS-G-1.4 and TS-G-1.5; the latter includes model checklists for inspections; and in ONR Transport guidance.

Safeguards

Nuclear safeguards are measures to verify that States comply with their international obligations not to use nuclear materials (plutonium, uranium and thorium) from their civil nuclear programmes to manufacture nuclear weapons. The need for such verification is reflected in the requirements of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) for the application of safeguards by the International Atomic Energy Agency (IAEA). Also, the Treaty Establishing the European Atomic Energy Community (the Euratom Treaty) includes requirements for the application of safeguards by the

European Commission. The primary safeguards 'regulators' are, therefore, the safeguards inspectorates of IAEA and Euratom.

Within the UK, the Foreign and Commonwealth Office (FCO) provides the UK perspective on the Non Proliferation Treaty (NPT) and Nuclear Cooperation Agreements (NCAs), whilst DECC Nuclear Non-Proliferation Policy Unit leads on non-proliferation aspects of DECC's policy interest. ONR -UK Safeguards Office (UKSO) undertake the detailed regulatory activities and interactions with IAEA/EURATOM inspectorates.

Key UK legislation includes:

- Nuclear Explosions (Prohibition and Inspections) Act 1998.
- Nuclear Safeguards Act 2000.
- The Uranium Enrichment Technology (Prohibition of Disclosure) Regulations 2004.
- The Nuclear Safeguards (Notification) Regulations 2004:

Environment
Environmental regulation depends on the location of the facility and thus discharge/ disposal authorisation is required. For England and Wales, regulation is by the EA whilst for Scotland it is by SEP. Further information on Radioactive waste (with links to Scottish Government, Welsh Assembly and Northern Ireland Department of the Environment web sites) is published on the DECC website. EA publish information via two web pages, one for radioactive substances users, such as hospitals, research organisations, radiographers and process industries, and one for civil or defence related nuclear sites.

Until 2010 the principal legislation was the Radioactive Substances Act (RSA) 1993. In England and Wales, RSA has been replaced by The Environmental Permitting (England and Wales) Regulations 2010 (with amending regulations). These regulations are not only related to 'radioactive substances activities' which are specifically addressed in Schedule 23. But Part 3 addresses The Basic Safety Standards Directive; while Part 4 addresses the high-activity sealed radioactive sources and orphan sources (HASS) Directive.

EA has published guidance on Radioactive Substances Regulation including RSR 1, Environmental Principles (2010) and Management Arrangements at Nuclear Sites (2010).

RSA still applies in Scotland – for guidance on the law as applied in Scotland see the SEPA Radioactive Substances website.

Licensing

In relation to all civil and privately managed defence sites, the ONR's Chief Nuclear Inspector grants nuclear site licences under the NI Act. The ONR ensures compliance with licences and their conditions and takes enforcement action where appropriate. Other defence nuclear sites that are Crown sites (ie MoD-controlled) are exempt from the licensing requirements of the NI Act. Aspects of these sites are regulated by the ONR under the provisions of Health and Safety at Work Act (HSWA) and associated regulations, working in conjunction with the Defence Nuclear Safety Regulator (DNSR).

The nuclear site licence is a legal document, issued before the start of construction and remaining in place throughout the life of the facility, until it can be shown that there has ceased to be any danger from ionising radiations from anything on the site. It contains site-specific information, such as the licensee's address and the location of the site, and defines the number and type of installations permitted. Licence Conditions, covering design, construction, operation, and decommissioning, are attached to each licence. These conditions require licensees to implement adequate arrangements to ensure compliance. Since 1990 there have been standardised LCs (currently 36); of particular note in relation to 'quality' is LC17 – 'Management Systems' (until 2011 entitled Quality Assurance).

Where a new site is to be licensed, or where an existing site is to be relicensed to accommodate the introduction of an additional class of prescribed activity, ONR will scrutinise the developing design safety case to assess whether the operations at the site will be adequately safe [as undertaken in relation to Nuclear New Build Generic Design Assessment (GDA) activity]

NIA65 also states that a licence can be granted only to a corporate body and is not transferable. It follows that the licensee must be a company which is also a user of the site.

NIA65 places the responsibility for the safety of a nuclear installation on the licensee. Before granting a licence, therefore, ONR must be satisfied that the applicant will be using the site for licensable activities and will have an adequate management structure, capability and resources to discharge the obligations and liabilities connected with holding that licence. The type of organisation and level of resource will need to be commensurate with the risk posed by the operations on the site.

ONR expects an applicant to develop and submit a safety management prospectus (SMP) demonstrating its commitment to health and safety. The SMP will form part of the licensee's safety case, and should provide a clear statement about the company, its structure and how it proposes to operate. ONR envisages that SMP will cover the following items:

- the corporate safety policy statement;
- a review of the licence applicant's proposals against the HSE SAPs for Leadership and Management for Safety;
- a demonstration that the licence applicant's organisational structure, resources and competencies are suitable to manage nuclear safety (the organisational 'baseline');
- precise definition and documentation of duties;
- integration of health and safety responsibilities into job functions;
- arrangements for maintaining the availability of adequate staff resources;
- arrangements for the provision of appropriately trained, experienced staff to ensure adequate inhouse expertise;
- arrangements for, and anticipated extent of, the use of contractors;
- details of the applicant's relationship with associated corporate bodies, such as its parent company and the Nuclear Decommissioning Authority. Among other things, the licence applicant will need to demonstrate that it will have unfettered day to day control of safety related activities on the site;
- lines of authority leading to adequate control of activities, whether those activities are to be undertaken by the licensee's own staff or contractors;
- the basis for corporate health and safety standards;
- the way in which the licensee will meet its regulatory responsibilities under the appropriate legislation, eg NIA65, IRR99 etc;
- arrangements for providing key functions important to health and safety including: safety case production (including modifications); independent assessment of safety cases; independent advice to line management, eg Nuclear Safety Committee, Board advisory groups; internal safety audit, inspection and review; effective challenge in decision making processes;
- details of performance indicators to monitor health and safety effectively;
- details of any incentive arrangements related to health and safety performance; and
- leasing arrangements for land and/or facilities.

Further detailed information is published by ONR.

Application of LCs
ONR's safety activities are defined in generic aspects of permissioning which includes assessment and issue of licence instruments, and compliance that includes issue of licences and intervention (inspection). Further details on these and the regulatory expectations set out in guidance to inspectors are published on the ONR website, along with links to safety assessment principles (SAPs), technical inspection guides (TIGs) and technical assessment guides (TAGs). Guides will cross-refer to applicable IAEA safety publications. Guidance on ALARP and comparisons to WENRA Reference Levels can be found via the SAPs page.

New reactor (generic design) assessment guidance can be found via links on the ONR website and geological disposal guidance via a joint EA/ONR website.

It should be noted that conventional H&S legislation, which applies regardless of nuclear regulation, in the Management of Health and Safety at Work Regulations 1999, Regulation 5 Health and Safety Arrangements, (1) requires "Every employer shall make and give effect to such arrangements as are appropriate, having regard to the nature of his activities and the size of his undertaking, for the effective planning, organisation, control, monitoring and review of the preventive and protective measures."

Environmental authorisations

Environmental authorisations are required over and above licensing. Guidance is provided by the respective national environment agencies.

Chapter 3

Leadership and Management

CONTENTS

Editor **Iain McNair**
Contributors **Richard Hibbert, Mark Lyons, Bob McGeary**

Introduction

Quality in the nuclear industry has developed into what is now referred to as Leadership and Management for Safety, with the prime objective being Safety. To achieve that objective the following key principles have to be achieved:

1. Leadership for Safety must be established and sustained in organisations that govern nuclear facilities and activities.
2. Management for Safety has to be achieved by
   a. a strong safety culture; and
   b. an effective integrated management system.

This thinking recognises that all activities undertaken by nuclear organisations have the potential to impact on nuclear safety, be it engineering, operations, finance, security, health, environmental or stakeholder relations. Strong leadership will establish clear objectives, whilst the integrated management system, will define all the actions needed to achieve the required outcomes. A strong safety culture will then effectively implement the requirements.

Nuclear quality professionals can be expected to be involved in establishing and maintaining leadership, the management system, and the culture. It is important to recognise that their roles are generally supporting rather than directing, otherwise the Leadership and Culture elements will be flawed. Potential areas of involvement could be:

1. Assisting the directors and senior management in establishing the policies of the organisation, and the goals, strategies, plans and objectives.
2. Assisting the directors and senior management in establishing the organisational structure.
3. Developing with responsible management the integrated management system needed to deliver all the policies, goals, strategies, plans and objectives. That can apply internally within the organisation or externally through the supply chain.
4. Assessing the effectiveness of the management system, identifying issues and seeking improvements. This can relate to a range of activities from supplier capability and product quality at component through to system level, process control, document systems and cultural / compliance aspects.

3.1 Leadership and Culture

Understanding

The topics of Leadership and Culture are closely integrated and need to be understood. In considering Leadership and Culture it is also important to differentiate between Management/Managers and Leadership/Leaders. Management ensures that work is completed in accordance with requirements, plans and resources. It is through leadership that individuals may be influenced and motivated, and organizations changed. Managers may also act as leaders.

A study published by NEA in 2012 looking at various events, has grouped findings as follows:

Key Issues

1. Leadership issues.
2. Operational attitudes and behaviours.
3. Business environment
4. Competence.
5. Risk assessment and management.
6. Oversight and scrutiny.
7. Organisational learning.
8. External regulation

Annex A of the study provides more detailed bullet point findings for each of the issues, which are summarised below:

Leadership

Senior managers should be the leading advocates of safety and should demonstrate in both words and actions their commitment to safety. The 'message' on safety should be communicated frequently and consistently.

Leaders develop and influence cultures by their actions (and inactions) and by the values and assumptions that they communicate. A leader is a person who has an influence on the thoughts, attitudes and behaviour of others. Leaders cannot completely control safety culture, but they may influence it. Being "role models" and "actions matching words" are necessary traits in leaders.

Managers and leaders throughout an organization should set an example for safety, for example, through their direct involvement in training and in oversight in the field of important activities. Individuals in an organization generally seem to emulate the behaviours and values that their leaders personally demonstrate. Strong involvement in the following all send the right sort of messages:

- Organisational reviews and **involvement in establishing/maintaining the integrated management system** needed to deliver all the policies, goals, strategies, plans and objectives. That can include review and authorisation of sub-tier publications. One of the issues that should fall out of this is a culture of **conservative decision making**.
- **Clear communications** regarding underpinning issues, setting **clear priorities** and **definition of responsibilities**.
- Participation in Training and Development to set appropriate levels of qualification and experience (ie **ensure the organisation has current nuclear experience** and that there is a **common understanding of what is important to ensure safety**.)
- Utilising Staff feedback , reporting and comment systems to ensure that there is **open-reporting**, the system makes it easy to **do the right things right,** and **encourage a questioning and learning attitude**. Leaders need to strongly **encourage open and honest, prompt reporting of issues** – a good-news culture must be strongly avoided.
- **Active participation** in **s**afety walk downs (including security and environmental aspects) and in safety committees. These should foster a **no-blame culture** whilst **discouraging complacency with regards to safety**.
- Working with Quality and Technical professionals to ensure the implementation of a **strong programme of management system assessment and effective management review**.

Operational attitudes and behaviours

In setting guidance for nuclear management systems, IAEA's GS-G-3.5 Appendix 1 'Achieving the attributes of a strong safety culture' identifies that there are five contributory attributes that contribute to the desired characteristics:

- Accountability for safety is clear
- Leadership for safety is clear
- Safety is integrated into all activities
- Safety is a clearly recognized value
- Safety is learning driven

A statement by the former US NRC Chairman is worth noting "If we want to continue to improve on safety, we must look beyond just engineered controls. It is possible that bad decisions or a lack of a sufficient focus on safety, not technological failures, will ultimately cause problems in the future. Perhaps the greatest additional safety benefits are to be found in a renewed and deeper focus on the safety culture of licensees."

Nearly all the following aspects that can affect operational attitudes and behaviours have been identified in discussing Leadership, but the difference is that whilst leaders set the directions it is the organisations that actually have to be engaged to ensure the outcomes.

- Procedures that work, are used, respected, and fit-for-purpose – with associated risks understood.
- Questioning attitude/constructive challenge – risks not "normalised".
- Conservative decision making clearly and visibly supported by management.
- Recognition of danger of "organisational drift"/complacency.
- Communication between teams (e.g. shifts, technical/operators).
- Involvement of all in improvement and challenge – leading to "trust" and a feeling that things get done and people listen.

Business environment
Attention needs to be paid to manage, and preferably avoid, pressures that lead the business to lose the safety/production "balance".

History has shown that the following associated with catastrophic effects:

- Impact of poorly considered change.
- "Initiative overload".
- Continuous resource reduction – "salami slicing" –until too far!
- Outsourcing/contractorisation with poor control.
- "Perverse" incentives.

The need is for careful "review' of policy / business decisions in terms of their potential impact on safety.

Competence
Nuclear organisations need to address a multitude of disciplines and often have limited directly employed resources, requiring them to procure services and products. As such they have to be aware of lack of, or loss of, capability – often without realising it! The terms "Intelligent Customer" along with "Baseline" and "Organisational Capability" have been introduced in considering this aspect.

Issues have included:

- Gradual erosion/loss of key skills and knowledge (and corporate memory).
- Leaders not always understanding risks – they themselves need to be SQEP and need to be involved in Risk Informed Decision Making programmes!
- Competence in abnormal conditions. Training needs to actively prepare for the beyond-design/accidental scenarios.
- Avoidance of 'tick box" training. Whilst book-learning is often necessary, experience is also essential in most roles. That then leads to a need for systemic review of competence with standards and appraisal.
- The need for development of non-technical skills (e.g. team working).

Risk assessment and management
Discussions have already identified "conservative decision making", "doing things the right way", "understanding of what is important to ensure safety" and "Risk Informed Decision Making". All of these invoke consideration of risk and managing optimal ways to control it.

Issues have identified;

- Failure to "stand back" and assess the emerging risks , rather focussing on" normal" states. Managers/leaders need to comprehend the big picture – understanding/awareness of the real risks (clear view of the radar screen and systems thinking).
- Complacency/overconfidence – "the gambler's dilemma". This can be offset by rigour in addressing safety cases, inspection findings, etc – prioritising and checking the

actions and seeing these as "symptoms" of wider issues. Addressing alarms/data trends and "unclear" findings (being alert to weak indicators) is also needed.
- There is always a need for SMART Enhancement Plans – getting clear priorities, and "buy-in" to make improvement work.

Need to recognise the dangers of "orphan plant or processes". Because something is not showing problems or is not actually being used does not mean that it is working safely or that it is available when needed.

Oversight and scrutiny (equates to assessment)
Experience has shown that the opportunity to use a "third eye", ie an independent assessment, is highly beneficial. Such efforts have identified issues such as:
- Safety Departments have authority and "teeth".
- The need for a hierarchical layered system – seek to look at "reality" not just paper trail – plant and people provide safety not paperwork.
- Avoiding the "good news culture" – it is important that leaders get true pictures and have sufficient knowledge to make judgements.
    - "Integration" of sources of information to give big picture (e.g. events reports, KPIs, independent reviews etc.).
    - Hierarchical safety metrics – proactive and reactive with effective monitoring.
- Remedial actions must be prioritised and seen to be timely completed.

Organisational Learning
Nearly all events have antecedents – "free lessons". Issues include:
- Avoiding denial – "it can't happen to us" – maintaining a sense of vulnerability – keep the boat rocking enough!
- Reporting encouraged within a "just" culture.
- Investigations address real root causes and findings shared.
- Minimising loss of corporate memory – keeping learning alive.
- Avoiding "organisational silos" – blocks to the transfer of learning.
- Learning from outside (with an open mind and not just "lip service").

External regulation
Regulators have often been seen as a necessary evil who only stepped in relating to significant breaches; ie after everything had gone wrong. However they often are in a position to stand back and in doing so identify precursor signs. If there is open assessment by regulators with full communication between regulator and licensee then that information can be a significant opportunity for improvement. In MoD's Nimrod Report, Wherwell (HSE) is quoted saying that "an organisation with a compliance culture is not a safe culture".

Safety Culture History

The term 'Safety Culture' was first commonly used in relation to the Bhopal chemical accident and in 1986 introduced in the International Nuclear Safety Advisory Group [1] (INSAG) *Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident* [2]; then in 1988 further expanded in *Basic Safety Principles for Nuclear Power Plants* [3]. Since then the term Safety Culture has been used increasingly in connection with nuclear plant safety; however, the meaning of the term was left open to interpretation, and guidance was lacking on how Safety Culture could be assessed. INSAG-4 therefore established the following definition: *"Safety Culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receives the attention warranted by their significance".*

The principal publication on strengthening safety culture is INSAG-15: which identifies the Key Issues as:
- Commitment
- Use of procedures
- Conservative decision making

- A reporting culture
- Challenging unsafe acts and conditions
- The learning organisation
- Underpinning issues: communication, clear priorities and organization.

Link to Management System

The topic of safety culture is closely reflected in IAEA GS-R-3 and its related management systems guides:

"The management system shall be used to ***promote and support a strong safety culture*** *by:*

• Ensuring a ***common understanding*** *of the key aspects of safety culture within the organization;*

• ***Providing the means*** *by which the organization supports individuals and teams in carrying out their tasks safely and successfully, taking into account the interaction between* ***individuals, technology and the organization****;*

• Reinforcing a ***learning and questioning attitude*** *at all levels of the organization;*

• Providing the means by which the organization continually seeks to ***develop and improve*** *its safety culture."*

Assessment of Safety Culture

Safety Culture, because it has been recognised as such a significant element in establishing and maintaining nuclear safety, has been the subject of many publications. Many 'experts' have set out their thinking, and tried to provide guidance on both what is defined in good culture and what to look for to seek improvement; most have produced forms of check point assessments' however these have to be carefully considered:

1. Periodic survey against set questions is useful in two ways:
    - Identifies progress
    - Identifies areas of focus

   But ---- it isn't always a predictive tool [4]
2. Using the same (limited number of questions) every year or so can indicate direction but too frequent surveys with perceived inaction can lead to misinformation [5].

IAEA

The lead document is INSAG – 15 whose Appendix contains question sets aimed at each of:

- Board of Directors;
- Chief Nuclear Officers and Executive Officers;
- Station Director and Senior Managers;
- Middle Managers;
- First Line Supervisors;
- Shop Floor.

WINS

WINS's Security Best Practice Guide on Nuclear Security Culture [6] includes:

1. As a main element of the text; a Culture Survey which asks the various levels of the organisation to assess where they think the organisation is (**Strongly Agree**, **Agree**, **No Comment**, **Disagree**, **Strongly Disagree**) against a a number of simple character related questions.
2. Appendix A : questions to the various levels of the organisation to assess the personal contributions to enhancing the effectiveness of nuclear security culture.
3. Appendix B : Defining different levels of organisational security culture (correlates with the Culture Survey against various characteristics).

INPO

INPO's Principles for a Strong Nuclear Safety Culture 2004 are based on 8 headings

1. Everyone is personally responsible for nuclear safety.
2. Leaders demonstrate commitment to safety.
3. Trust permeates the organization.
4. Decision-making reflects safety first.
5. Nuclear technology is recognized as special and unique.
6. A questioning attitude is cultivated.
7. Organizational learning is embraced.
8. Nuclear safety undergoes constant examination

UK

The following ONR (and previous NII) statements have been made;

- Safety Assessment Principles 2006 section on Leadership and Management
- ONR Nuclear Safety Technical Inspection Guide on LC 17 'Management systems'
- HSE Human Factors Briefing Note 07 - Safety culture
- NII Approach to Leadership and Management for Safety & Safety Culture
- ONR Technical assessment guide - T/AST/039 Management for safety (in revision)
- ONR Technical assessment guide - T/AST/072 Function and content of a safety management prospectus
- ONR Technical assessment guide - T/AST/080 Nuclear safety advice and challenge

In relation to reactor New Build, the Royal Academy of Engineering (RAEng) led in the production of several documents entitled *Nuclear Construction Lessons Learned – Guidance on best practice*, the lead one of which is on safety culture; it recognised that "successfully translating the development of a nuclear safety culture into the construction of a new nuclear power station will be a key challenge" . Building on an INPO report *Principles for Excellence in Nuclear Project Construction* , the RAEng document considers how the nine INPO key principles -

1. *Demonstration by leaders of alignment on a commitment to excellence*
2. *Focused front-line supervision is key to success*
3. *People are competent to carry out their jobs*
4. *Schedules are realistic and understood*
5. *Construction of a nuclear plant has special requirements*
6. *Personnel safety is highly valued*
7. *The plant is built as designed*
8. *Deviations and concerns are identified, communicated*
9. *The transition to plant operation is started early*

- can be applied; using a series of bullet points are set out which demonstrate elements of best practice that will support the development of a robust nuclear safety culture. Where considered relevant, recommendations are proposed that can either be applied in the delivery of a project or can support effective delivery of a fleet.

Taylor [7] provides a UK perspective and a general review of the history and concepts as well as discussing means of changing safety culture, using examples ranging from the loss of the Titanic, to Bhopal, and the Tokaimura criticality event.

Europe

Reporting has been found in :

- NKS report - Nuclear Safety Culture in Finland and Sweden [8]
- Reason : Achieving a safe culture [9]

US

Corcoran [10] provides a US nuclear view.

The NRC web on safety culture provides a trail through their, and US nuclear industry, thinking between 2005 (after the Davis Besse incident) and the present day, resulting in an aligned Safety

Policy Culture Statement (June 2011). In parallel, NRC have developed Safety Culture Case Studies, also accessible through their web site.

Further information on US Safety Culture issues are to be found in published reports and presentations, such as:

- Safety Culture Evaluation of the Davis Besse NPS - 2003
- Safety Culture (& ISM) – DFNSB – 2007
- USDOE Hanford WT&IP Independent Oversight Assessment of Nuclear Safety Culture and Management of Nuclear Safety Concerns Jan 2012
- USDOE Los Alamos Oversight LANL CMRR Safety Culture Review Apr 2012
- USDOE Office of Health, Safety and Security to Chair DNFSB – Reports on Safety Culture Reviews at Los Alamos, Y12, Idaho, OEM HQ, Pantex- Dec 2012

Fukushima Daiichi 2011

The Japanese parliamentary panel report (July 2012) found gaping holes in safety standards and emergency procedures. The chairman said *"For all the extensive detail it provides, what this report cannot fully convey - especially to a global audience - is the mindset that supported the negligence behind this disaster. What must be admitted - very painfully - is that this was a disaster "Made in Japan*."
Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the program'; our groupism; and our insularity."

The UK report by Dr M Weightman in September 2011 looks to implications for the UK and introduction of the European Council 'Stress Tests related to both reactor and non-reactor sites'.

---

[1] The International Nuclear Safety Advisory Group (INSAG) is an advisory group to the Director General of the International Atomic Energy Agency

[2] *Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident,* 75-INSAG-l : 1986 revised as INSAG-7 : 1992

[3] *Basic Safety Principles for Nuclear Power Plants* 75-INSAG-3 :1988, revised as INSAG-12 : 1999

[4] Comment on Nuclear Safety Culture Surveys - Treasure EDF @ NEA Chester 2012

[5] Discussion thread by Linkedin Nuclear Safety Culture group 2012-13.

[6] Accessible to WINS members via the webpage https://www.wins.org

[7] Taylor J.B. - Safety Culture : Assessing and Changing the Behaviour of Organisations; Nov 2010; publ Gower ISBN: 978-1-4094-0127-8

[8] Nuclear Safety Culture in Finland and Sweden –Developments and Challenges :Feb 2011; NKS-239 :

[9] Reason J, Manchester Univ; May 09: Achieving a safe culture: theory and practice

[10] Corcoran W.R. - Safety Culture — Back to the Basics; 2008: NSRCCorpn

3.2 Management systems

Overview

Many standards may apply but the following are ones that have been identified as applicable in March2013:

- IAEA Safety Standard GS-R-3, *The Management System for Facilities and Activities*. (Under review since 2012)
- ISO 9001:2008, *Quality Management Systems – Requirements*.
    - ISO 9000:2005 "*Quality management systems. Fundamentals and vocabulary*"
    - ISO 9004:2009 "*Managing for the sustained success of an organization. A quality management approach*"
- ISO 14001:2004, *Environmental Management Systems– Requirements with Guidance for Use*. (Under review at 2012)
- OHSAS 18001:2007, *Occupational Health and Safety*.
    - OHSAS 18002:2008 - *Occupational health and safety management systems. Guidelines for the implementation of OHSAS 18001:2007*
- NSQ-100,*Network Safety and Quality Management System – Requirements*.
- PAS 55 *Optimal management of physical assets :*
    - *Part 1 :2008 - Specification for the optimised management of physical infrastructure assets*
    - *Part 2 : 2008 - Guidelines for the application of PAS 55-1*
- PAS 99:2012 *Specification of common management system requirements as a framework for integration*
- ISO 22301 *Societal security -- Business continuity management systems --- Requirements*
- ISO/IEC 27001:2005 *Information technology -- Security techniques -- Information security management systems – Requirements*

Various comparisons between codes have been produced by IAEA
Comparison GS-R-3 to ISO 9001-2009
Comparison GS-R-3 to ASME NQA-1-2008 and NQA-1a-2009 addenda
Comparison 50-C.SG-Q 1996 to ISO 9001-1994

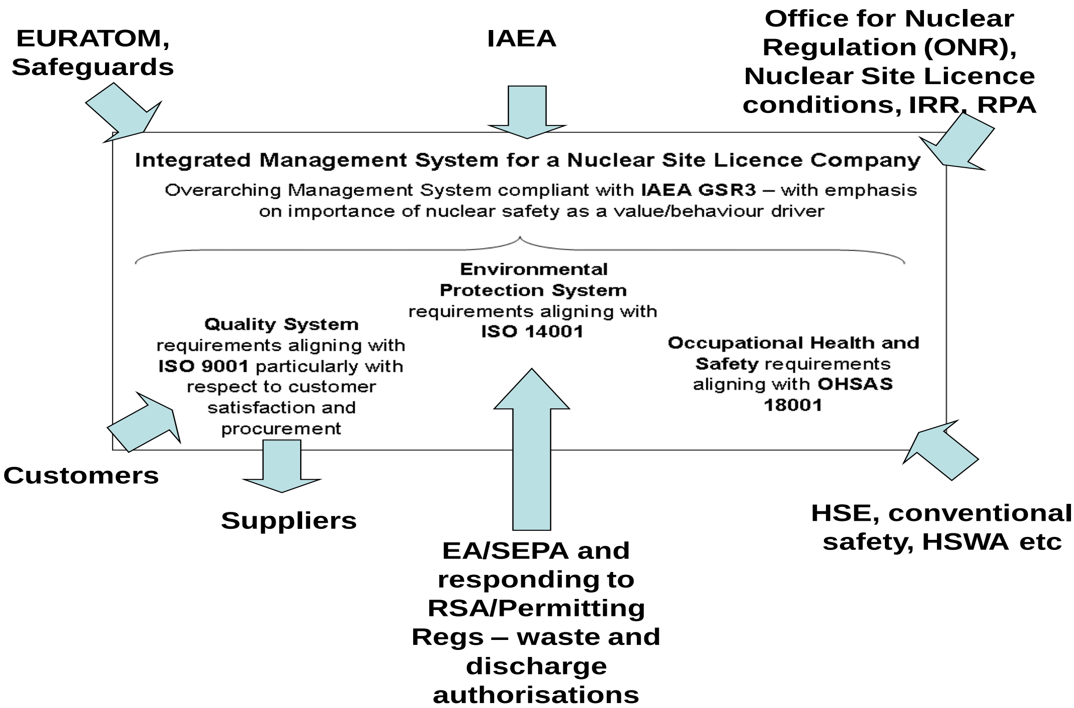
The adoption of formal management systems compliant with defined standards has been the norm in the nuclear industry since before the emergence of BS5750 [11] in the 1980s; with early practice closely linked to defence standards. Since the 1980s/90s, in the UK, nuclear site operators [1] have been required through Licence Conditions to comply with management system standards which recognise the paramount importance of nuclear safety; this was first manifested in BS 5882 [12], then IAEA 50-C/SG-Q [13] and now IAEA GS-R-3.

GS-R-3 reflects the structure of ISO 9001 [14] specifying a process approach but goes beyond it in requiring an integrated management system focussed on safety. IAEA GS-G-3.1 and IAEA GS-G-3.5 provide in-depth guidance on the requirements set out in GS-R-3.

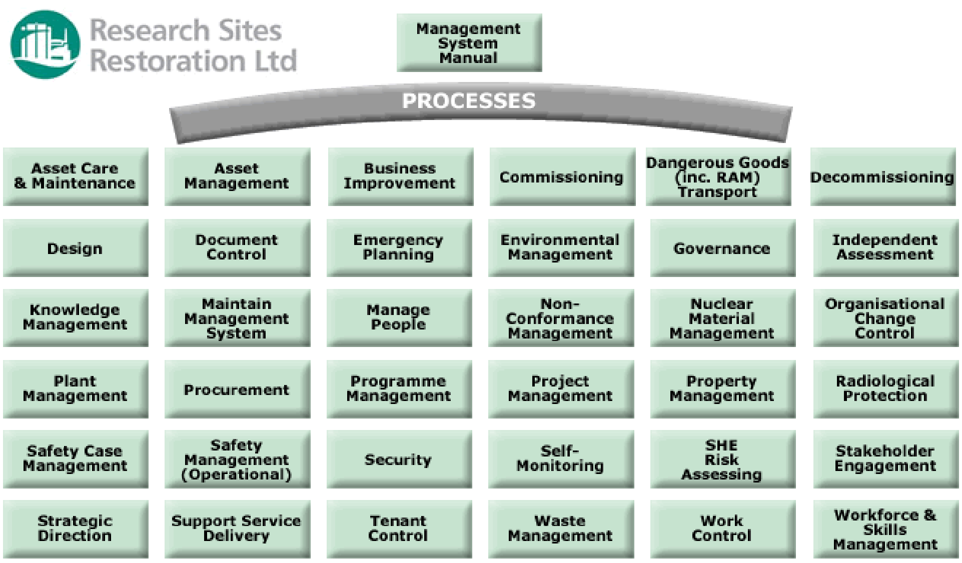
Figure 1 portrays the various applications for a nuclear site.

[1] Note: The direct application of the nuclear installation management system standards for control of the supply chain is not appropriate, although in the past their erroneous use was quite common.

Figure 1: A system conforming to GS-R-3 for a nuclear site



For any Licensee the management System therefore has to address numerous topics; as seen in this top level structure of RSRL's Management System [2].



Most site licence companies expect ISO 9001 as a minimum to be adopted by their suppliers and for particularly critical supplies call up special inspection, traceability and other requirements but this depends on the duty of the item (See Chapter 6 Supply Chain)

For nuclear new build contracts the reactor designers/constructors Westinghouse and EDF/AREVA base their requirements on ASME NQA-1 [15] and RCC [16] respectively, the standards used in their parent countries, the US and France (See Chapter 11 International).

[2] From presentation at the NucSIG event in October 2012

There is a developing initiative to derive a set of agreed common requirements beyond ISO 9001 that the nuclear industry uses for specifying requirements to suppliers which could apply across the nuclear lifecycle from new build to decommissioning but this still has to come to fruition. NQSA have produced NSQ-100 which was launched in April 2011; their NSQ-110 provides a correspondence matrix between GS-R-3 and NSQ-100. Guidelines have been published (Preamble and Sections A to H) [17]

Management systems in the nuclear industry

The current situation

Management systems in the nuclear industry are under considerable scrutiny from regulators, customers and internal assurance groups. The maturity of the systems, and familiarity that staff has with the systems, is good but it is often conceived as bureaucratic and hindering the opportunity to adopt more advanced approaches, exploiting the use of process mapping and electronic document approval systems. The other downside is that existing site management systems are sometimes not founds easy for newcomers and outsiders to the organisation to use, and each licensee, and sometimes sub-parts, has their own stylised approach.

LC 17 leaves the SLCs with a lot of freedom and they have thus established quite different arrangements tailoring to their corporate cultures, however the ONR is giving strong guidance on its commitment to IAEA GS-R-3 in their LC17 Inspection Guidance. There is certainly an opportunity, especially for new SLCs and in major corporate reviews, to develop advanced process-driven management systems that are user-friendly and easier to keep up to date.

IAEA revision thinking

The revision document [18] for GS-R-3 under the new title 'Leadership and Management for Safety' defines –

- the first objective as being the application of the safety fundamentals, to establish requirements for effective Leadership for Safety as well as requirements for Management for Safety.
- The second objective as being to capture the concept, which is embedded in the IAEA's Fundamental Principle 3, that it is Leadership and Management **for** Safety**, not of** Safety. *Safety is not something that is tagged on to an organization or is in competition with organisational success (commercially, in its status or in delivering policy objectives). It is one of the outcomes of excellence in leadership and management of an organisation.*
- The third objective of the publication is to ensure that safety is not compromised, by considering the implications of all actions not within separate management systems but with regard to safety as a whole, integrated into a single management system. The management system designed to fulfil these requirements shall typically integrate safety, health, environmental, security, quality and economic elements.

Approach to third-party certification and review

Generally nuclear establishments have third-party certification for their management systems, although this is not a requirement and IAEA GS-R-3 is not a certification standard; compliance monitoring against it is left to internal and external regulators. Third-party certification is generally aimed at ISO 9001, ISO 14001, OHSAS 18001 and PAS 55, which may be by site, or in combination across the whole organisation, as shown in EDF – Energy NGL's presentation at the NucSIG event July 2012.

Benchmarking between sites and organisations is common good practice that is internationally encouraged; examples include such as WANO / INPO and IAEA OSART missions.

Document control, periodic review and key documents that affect the management system

Generally nuclear operators have good control over documents with dedicated staff who often also manage site records. Periodic review periods vary from typically two to five years

Similarly, for SLCs, organisational changes are controlled by a formal process usually known as 'management of change' or MoC where the nature of the change is reviewed for the effect on nuclear safety.

Nuclear safety cases and associated plant engineering modification documents, Nuclear security and emergency plans, Radioactive discharge authorisations, and Nuclear transport package approvals are types of key documents that constrain other parts of the management system.

Management system roles

Quality professionals' involvement with the management system on a nuclear site or supplier to the nuclear supply chain will be a combination of:

- Owner of all or part of the management system responsible for ensuring that the management system is defined, controlled, in a fit state and available to the organisation. This involves liaison with senior and middle management who are the authors and approvers of the content.
- Working to the management system within a function or project on a nuclear site with responsibility for quality and records management. For instance, as a Quality Engineer assigned to a specific engineering project.
- Working to own company management system supplying product or services while interpreting the requirements of the supply contract and associated specifications
- Overseeing or auditing arrangements and monitoring compliance with the management systems.

Expectation of Safety Case (Safety Analysis Report) content

The Management System of a facility is a significant contributor to the safety justification for it. As such it is to be expected that it would be defined within the safety documentation – In UK the term Safety Case is used whilst elsewhere such as IAEA Safety Analysis Report is used.

UK Regulatory requirements

Relevant nuclear site licence conditions (LCs):

- 6:Documents, records, authorities and certificates
- 9: Instructions to persons on the site
- 24: Operating instructions
- 17:Management Systems (renamed from Quality Assurance - July 2011)
- 36:Organisational Capability (renamed from Control of organisational change - July 2011).

Guidance:

ONR Safety Assessment Principles (SAPs)

ONR Nuclear Safety Technical Inspection Guide on LC 17 'Management systems'

Other sources of information

IAEA Education & Training have published (December 2007) 6 on-line presentations from a training course on management systems in line with GS-R-3. The objective of this training course is to help high level managers understand:

- The structure and content of the IAEA Safety Standards, guides and safety publications
- Why it is beneficial to have a coherent management system that addresses all requirements in a structured way using processes
- The appropriateness of the management system standards to a nuclear utility
- The roles and responsibilities of senior managers and how leadership supports the development and implementation of the management system
- How to align the management system to the goals and objectives of the utility and transition the current management system to the IAEA Safety Standard GS-R–3.

Management Systems have been addressed at various NucSIG events, (See matrix at Appendix 2 of NQK)

Reports published by HSE/ NII regarding major inspections which include management systems give an insight into what can go wrong (Case studies); the following are highlights – fuller detail is available in the individual reports as are later reports on actions taken and outcomes:

AWE [19] 1997 - relating to licensing of the Aldermaston and Burghfield sites - In HSE's summary words;

> "The review in 1993-94 of health and safety management at AWE sites had identified some shortcomings both in management arrangements and in physical controls. Subsequently AWE worked to develop health and safety arrangements not only to close out the recommendations of HSE's report, but to satisfy the requirements for nuclear site licensing. Many of the HSE review recommendations provided a basis for the development of management systems into arrangements that would ensure nuclear safety and satisfy the standard licence condition requirements. The Safety Management System has continued to be improved upon and can now be considered to be well developed and mature."

Dounreay [20] 1998 - In HSE's words

- "Our main finding is that organisational changes made within UKAEA over the last four years have so weakened the management and technical base at Dounreay that it is not in a good position to tackle its principal mission, which is the decommissioning of the site.
- We now find that UKAEA is over-dependent on contractors for the delivery of many of the key functions which we would expect to see under the clear control of UKAEA as the licensee for the site.
- We find that UKAEA has not yet developed a comprehensive strategy for dealing with the various forms of radioactive waste already at Dounreay, or those which will arise in future.
- We are concerned at the lack of progress which has been made with decommissioning.
- The decommissioning and radioactive waste strategies should be integrated together, for the site as a whole.
- Early action should be taken to develop waste treatment plants.

- Conditions in the Fuel Cycle Area range from the good to the very bad. We suspect that UKAEA has been operating plants without clear knowledge of some of the risks.
- We recommend that UKAEA should broaden the scope of its rapid reporting of incidents to regulators.
- It is evident to us that UKAEA still needs to invest considerable effort, time, and resource into bringing itself up to the standards we expect of a modern nuclear licensee."

British Energy [21] 2000 - in HSE's words relating to the privitisation and subsequent staffing changes within the two component companies of BE:

"The key issues are as follows.

- The staff reduction programme in both Licensees had been predicated on the assumption that, in a privatised environment, they could reduce the amount of work (eg on plant modifications). In BEGL, staff reductions have in fact taken place even though there has not been the expected reduction in work load. The shortfall in resource has been met by placing greater reliance on contractors, some of whom are actually Licensee staff recently released under the downsizing programmes. In BEGL, the supervision of contractors is adding to the work load on the remaining in-house staff and in some areas we judge the staff reductions have gone too far. In BEG(UK)L, staff levels have been reduced in line with a reduction in the planned work load, but emergent work is at a much higher level than anticipated. BEG(UK)L has an even greater reliance upon contractors for technical support and, in some areas, its own staffing levels need to be increased.

- In BEGL, we found no formal process by which the minimum skills base had been established (ie that which must be retained within the Licensee to enable it to discharge its duties under the licence). Thus the downsizing exercise was taking place without knowing the minimum resource requirements, or having a process to ensure they can be sustained over time. This has resulted in specialist expertise in several key areas (specific to the nuclear industry) being vested in single experts. Staff leaving to pursue their careers elsewhere have exacerbated this position since BEGL cannot easily find replacements with the requisite expertise and experience.

- BEG(UK)L has developed a definition of its skills base by means of a register of posts which require suitably qualified and experienced people (SQEP) to fill them. The register identifies people who have the necessary qualifications and experience against the various posts. This approach to defining the skills base is welcomed, but it needs further development. For example, we found there are no formal criteria for judging whether qualifications and experience are adequate nor are there procedures to ensure removal of a person from the register if a skill is no longer being practised. In addition, BEG(UK)L does not have staff who can discharge the full range of identified skills and is reliant on external support to fulfil some SQEP roles. BEG(UK)L is thus unable, in all areas, to make decisions on safety matters based on the expertise of its own staff.

- Neither Licensee has policies on the use of contractors to define, for example, the circumstances under which they should be employed and on what type of work, the level of responsibility that could be delegated to contractors, and the level of monitoring required to maintain Licensee ownership of the work. A variety of contractual arrangements exists. The closest relationships - namely partnerships in BEGL and satellite offices for BEG(UK)L - pose challenges with respect to loss of Licensee control, ownership of work and decisions derived therefrom, and loss of corporate memory.

- In both BEGL and BEG(UK)L, the records show that some staff are working significant amounts of overtime. There is also under reporting of overtime so that the true situation must be worse than shown. Taking everything discussed above into account our judgement is that in some key safety areas in both BEGL and BEG(UK)L staff levels are at, and in a limited number of areas, below that required to sustain the work load and discharge the requirements of Licensees.
- Our review of the application of the management of change process in BEGL and BEG(UK)L revealed flaws in both the processes and in their application. The way in which the processes

have been applied has allowed preconditions (enablers), which should have been met before staff were released, to be relaxed to ongoing commitments. For example, a requirement to provide a trained replacement before someone leaves becomes simply 'provide training', which is open-ended. This has allowed staff to leave without having a ready replacement. We found examples of misapplication of the management of change process, including retrospective sign-off to justify release of staff who had already left (without completion of all the enablers) and examples where ongoing commitments had yet to be signed off long after someone had left.

- We require BEGL and BEG(UK)L to address the recommendations arising from the audit. The Licensees need to provide an action plan within four weeks of receipt of this report, with proposals and timescales for resolving the recommendations. The key areas for action by the Licensees are as follows:
    - BEGL and BEG(UK)L to stop the planned reduction of in-house staff numbers until they can demonstrate their forward work predictions are reliable, and demonstrate that the Management of Change processes will not adversely affect the safety of nuclear plants. BEGL and BEG(UK)L to ensure that business plans are matched to the in-house staff capability and perceived work load. BEGL and BEG(UK)L to formalise, record and resource the skills base that each requires to underpin the duties of a Licensee to retain ownership and control of its operations. BEGL and BEG(UK)L to develop and promulgate policies to identify the key considerations and to guide decision making on why, when and how to utilise contractor resource - including their 'intelligent customer' requirements. BEGL and BEG(UK)L to investigate the reasons for the high level of overtime worked in certain areas (including estimates of that not reported), and take steps to prevent excessive hours being worked by staff handling nuclear safety related work. BEGL and BEG(UK)L, as a matter of urgency, to critically review their Management of Change processes in order to ensure they will incorporate the lessons learned from the change process (including the findings of this audit).

- As part of the audit, we also explored the potential impact of integration. To ensure there is a seamless transition into the integrated organisation with no diminution of standards of work or loss of control of the Licensees' operations, all staff require a clear understanding of revised responsibilities, changes in methods of work, and additions to their workload before integration goes ahead. We found that, although the proposed structure of the integrated organisation has been defined and the managers for the joint team have been selected, few of the staff below senior level seem to know what additional responsibilities they might have to undertake following integration. We were also told that there is no explicit allowance within most work programmes to cater for the extra demands of integration - which will include additional travel between the two central offices at Barnwood (Gloucester) and Peel Park (East Kilbride). These demands will be over and above the normal workload, which is already high in many areas. We wish to be reassured that the two Licensees are ready to integrate. BEGL and BEG(UK)L therefore need to clearly define their state of readiness for integration and demonstrate that adequate control of operations can be maintained in both Licensees.

- The integration proposals put forward by British Energy (maintaining two separate Licensees for the foreseeable future) are novel and raise a potential problem which we had not previously considered in detail. The crux of the issue is the question of the acceptability, in nuclear licensing terms, of individuals in the central (integrated) team who work for one Licensee providing advice to the operating stations in the other Licensee. Each Licensee is expected to maintain control of its own operations and have its own intelligent customer capability. The arrangement proposed by British Energy could violate these principles. Resolution of these issues will be necessary before our agreement to the deferred integration proposals can be considered. The simplest way to overcome the problem would be to form BEGL and BEG(UK)L into a single Licensee."

<u>Sellafield</u> [22] 2000 - The summary findings included the following statement:

> "The inspection confirmed NII's original concerns about control and supervision. BNFL had already recognised a number of the shortcomings identified during the course of this HSE

team inspection. In particular, it has recognised the need to bring about greater integration of the Sellafield site under the management of a team with authority to manage operations on the site and has begun to take steps to address this. It has also put in place a programme of initiatives intended to improve safety in a number of areas. Unless there are proactive systems for checking that the required standards are being maintained, non-compliances are likely either to go undetected, or to have caused significant problems by the time they are detected.

There are three key conclusions from this inspection. The first is that there is a lack of a high quality safety management system across the site which is compounded by an overly complex management structure. The second is that there are insufficient resources to implement even the existing safety management system. The third is a lack of an effective independent inspection, auditing and review system within BNFL. Without a vigorous independent inspection, auditing and review system, HSE does not see how BNFL can make acceptable and timely progress in delivering a high quality safety management system across the site."

---

[11] BS 5750 *Quality Systems* Various parts - Withdrawn

[12] BS 5882 *Specification for a Total Quality Assurance Programme for Nuclear Installations* – Withdrawn

[13] IAEA 50-C-C/SG-Q *Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations - Code and Safety Guides;*1996 - Superseded

[14] ISO 9001:2009 *Quality management systems - Requirements*

[15] ASME NQA-1 *Quality Assurance Requirements for Nuclear Facility Applications (QA)* 2008 (due reissue 2011)

[16] AFCEN RCC *Design and construction rules for nuclear reactors* – separate codes as follows:

RCC-C	*Nuclear Fuel*
RCC-E	*Electrical Equipment*
RCC-M	*Mechanical components of LWR*
RCC-MR	*Mechanical components of FBR*
ETC-C	*Civil Works (Note replaced RCC-G)*
RSE-M	*In-service surveillance of mechanical components*

[17] NSGA100 Guidelines index

- Preamble
- Section A – General
- Section B – Safety Culture
- Section C – Classification
- Section D – Planning
- Section E – Design
- Section F – Purchasing
- Section G – Production & Inspection
- Section H - Audits & NCR

[18] IAEA - DS456 - GSR Part 2: Leadership and Management for safety DPP456

[19] Inspections of AWE :

- The Management of Health and Safety at Atomic Weapons Establishment Premises Part 1 (ISBN 0 7176 0864 6) and Part 2 (ISBN 0 7176 0863 8); HSE Books 1994
- "Licensing of AWE - Report on the work by the Health and Safety Executive to grant nuclear site licences for the AWE sites at Aldermaston and Burghfield" - 1997: NUC 11, HSE Books
- Report on the work by the Health and Safety Executive to grant nuclear site licences for the AWE sites at Aldermaston and Burghfield, : May 2000 : http://www.hse.gov.uk/nuclear/awe/awe00.htm

[20] Inspections at Dounreay

- Safety Audit of Dounreay 1998, HSE Books C30 8/98 : http://www.hse.gov.uk/nuclear/dounreay.pdf

- Safety Audit of Dounreay 1998, Final Report 2001, HSE Books C25 01/02 : http://www.hse.gov.uk/nuclear/auditfin.pdf

[21] Inspection of British energy

- An Audit by the HSE on British Energy Generation Limited and British Energy Generation (UK) Limited 1999- Jan 2000 : http://www.hse.gov.uk/nuclear/beaudit/beaudit.htm
- Progress report on NII's Safety Management Audit of BEGL and BEG(UK)L - June 2001 : http://www.hse.gov.uk/nuclear/beguk.pdf

[22] Inspections of Sellafield

- HSE team inspection of the control and supervision of operations at BNFL's Sellafield Site, 2000 ; http://www.hse.gov.uk/nuclear/team/team.htm
- HSE Report of the investigation into the leak of dissolver product liquor at the Thermal Oxide reprocessing plant (THORP), Sellafield, notified to HSE on 20 April 2005: http://www.hse.gov.uk/nuclear/thorpreport.pdf

3.3 Key Concepts

QA Grading

Overview

To avoid inappropriately applying overly prescriptive controls to non-nuclear safety significant tasks, a grading approach is used. This allows due rigour to be applied to those activities that truly are safety significant and lesser control to those that are less significant. The outcome of such grading is integral to almost everything that occurs related to the plant and operators.

To ensure appropriate grading there is need first of all to appropriately classify/categorise all aspects of plant structures, systems and components (SSCs). Guidance has been published by IAEA [23] and ONR [24].

The following legislation needs to be considered when grading requirements:

- LCs
- RSA 1993
- Environmental Permitting Regulations 2010
- Statutory plant legislation issued under HSWA 1974 such as pressure systems, COMAH, COSHH and CDM. All such legislation is risk-based with action criteria depending on the levels of hazard.

The following Quality standard references consider grading:

- IAEA Safety Standard GS-R-3, *The Management System for Facilities and Activities*, Section 2 Paras 2.6-2.7.
- IAEA Safety Guide GS-G-3.1, *Application of the Management System for Facilities and Activities*, Section 2 Paras 2.37-2.44.
- ISO 9001:2008 *Quality management systems - Requirements*, Section 4.1 *General requirements*

Additionally, readers should be aware of previous useful detailed guidance to be found in IAEA 50-C/SG-Q (preceded GS-R-3).

Graded application

Requirements

Like any other business, resources on a nuclear facility are limited. They must be deployed selectively in a manner that ensures:

a) Nuclear safety
b) Conventional safety
c) Environmental compliance and performance
d) Security
e) Programme, Commercial and Financial performance.

The LCs have always required a graded approach based on safety significance, for instance:

- Safety Cases and Modifications (LC 14 and LC 22).
- Control of Organisational Change (LC 36).
- Incidents on Site (LC 7).

These ensure that issues, proposals, activities, items and occurrences that have a potentially greater impact on nuclear safety (safety significance) receive greater management attention and control.

The schedules associated with nuclear waste and discharge authorisations, issued by the EA and SEPA, similarly require a graded approach to be applied to activities required for achieving and demonstrating compliance.

The requirements of plant safety-related legislation issued under HSWA 1994 are all risk-based and set various criteria and levels which prescribe the extent of controls to be applied to mitigate risks, eg pressure systems, COMAH, COSHH, fire certificates and CDM.

The IAEA management system standard GS-R-3, which sites have adopted in compliance with LC 17, explicitly requires that nuclear facility management systems requirements be graded so as to deploy appropriate resources based on:

- Significance and complexity
- The hazard and the magnitude of the potential risk
- The likelihood and potential of failure of the item or task.

ISO 9001 implies a graded approach to be applied throughout.

Graded application and process design

On nuclear sites, grading requirements are written into the process control arrangements. These arrangements set out the criteria for grading the various issues, proposals, activities, items and occurrences. The grading often considers criteria such as the likely impact on nuclear safety, conventional safety, environment, security, quality and financial and economic impact.

The following detailed topics all reflect grading some which are not at first obviously QA related, but which if inadequately applied via management systems can significantly impact the safety outcomes. As such they should be considered as examples of topics which may influence QA grading:

Design verification – the extent and level of design verification is often graded on the complexity or novelty of the design and on the potential safety and environmental impact implications.

Safety categorisation and classification. IAEA's Safety Requirements for Design require that "All items important to safety shall be identified and shall be classified on the basis of their function and their safety significance".

ONR SAPs Section ECS addresses 'Safety Classification and Standards';

- Plant modifications and organisational change –These configuration and change control processes require that the proposed changes be categorised in terms of their potential impact on nuclear and general safety, environmental performance, security and business performance. related review and approval of plant instructions may depend on the nuclear safety classification category of the plant;
- Plant events are graded on the IAEA's International Nuclear Event Scale where their potential integrated into emergency planning management activities;
- On NDA sites, project financial sanction is based on a priority assessment tool matrix integrating various safety – measured in hazard and risk, environment, finance etc to derive a programme risk score;
- Radioactive waste is graded based on activity and heat production and management activities are related to the level;

The level of grading dictates the extent of process controls to be applied to comply with legislation and to reasonably ensure that satisfactory process outcomes are achieved. Process controls may include:

- The level of authority needed to approve process activities and outputs;
- The level of supervision, checking and inspection required;
- The level of competency of workers e.g. training and competency grades or levels;
- The detail and extent and of process control documents. Documentation control –the review and approval of various site management system documents is graded in so far as higher level documents will usually require higher level review and approval;
- Hazardous material handling and transport arrangements;
- Validation by use of process arrangements/procedures/instructions;

- Validation of special processes, such as welding, heat treatment, cementation and vitrification
- Instructions carried to the job or available as reference
- Records requirements such as their retention time and storage arrangements
- Use of approved suppliers.

It can be seen from these examples that the grading and the associated controls applied to activities and items are not always common or similar. It is therefore not advisable to try to use a single grading criteria but rather tailor the criteria and grading to the requirements (product) of each process and incorporate these requirements within the process documentation.

Continuous improvement

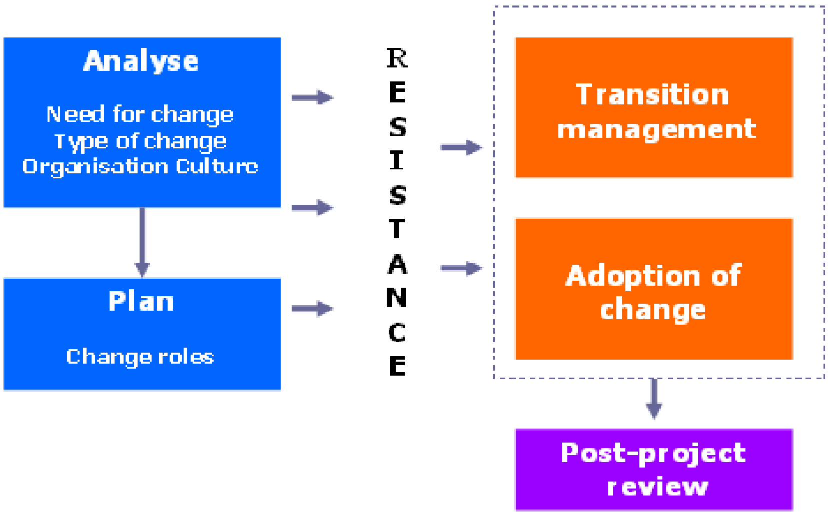
Background and definitions
The IAEA along with nearly all the world nuclear organisations express the aim of continuous improvement in almost every aspect of nuclear activity. At its highest level IAEA's INSAG [25] said "The safety management system has two general aims: the first of which is to improve the safety performance of the organization."
For that to happen the following are necessary:

- The operating organization needs to demonstrate a commitment to achieving improvements in safety wherever it is reasonably practicable to do so as part of a continuing commitment to the achievement of excellence.
- The safety performance of the organization should be routinely monitored in order to ensure that safety standards are maintained and improved.
- There will be a well-defined process to support a commitment to continuous improvement. Such a commitment is an essential feature of an effective safety management system.
  - It provides a clear demonstration of the organization's commitment to safety.
  - However, in the drive for improvement, consideration should be given to the cost effectiveness of possible improvement options.
  - The improvement process should make use of the findings from audits and reviews to identify priorities for improvement.
  - To promote ownership of the process throughout the organization, staff should be involved in generating ideas for improvements.
  - An improvement programme should be drawn up to integrate and co-ordinate the various improvement initiatives and to identify the appropriate priorities and resource requirements.
- Improvement programmes need to be routinely monitored against specified objectives and supporting targets.
  - Senior managers should be involved in this process to demonstrate their commitment.
  - As part of the monitoring process, targets and timescales should be reviewed and revised as appropriate..
- Forward looking indicators (sometimes referred to as 'input' or 'proactive' indicators) which measure positive efforts to improve safety are particularly valuable, although they are recognized as being more difficult to develop and measure objectively.
- Improvement measures usually take a substantial time to be reflected in performance data, particularly when data are analysed on a rolling basis (e.g. monthly data analysed on a 12 month rolling average).

Specific studies and general experience have shown that frequently occurring underlying conditions at those plants which have had significant problems include:

  - acceptance of low standards of plant condition/housekeeping;
  - failure to recognize that performance is declining and to restore higher levels of
  - performance in specific areas at an early enough stage;
  - a lack of accountability among line management and workers;

- ineffective management monitoring and trending of performance;
  - deficient performance in the control room;
  - an increasing human error rate;
  - inadequate and/or poorly used procedures;
  - insufficient and/or ineffective training;
  - insufficient use of operational experience feedback and root cause analysis programmes in the analysis of events and 'near misses';
  - an inadequate control of design configuration;
  - failure to benchmark against those with better safety performance;
  - a lack of awareness among the top managers about the principal deficiencies and associated corrective actions often reinforced by a 'good news' culture;
  - inadequate or insufficient self-assessments being carried out on issues relating to safety culture;
  - inadequate capability for supervising and monitoring contractors.

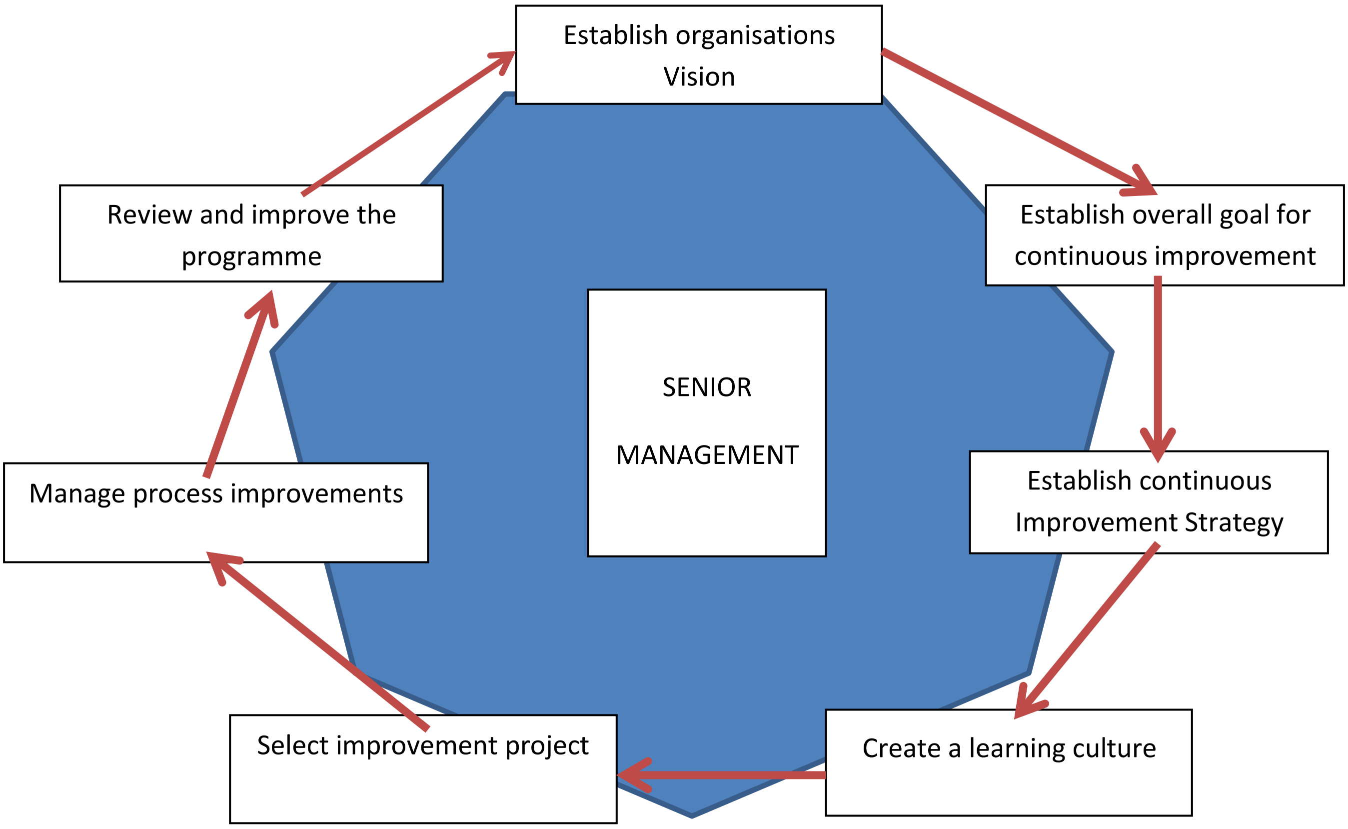


While weakness in a few areas can exist at even top performing plants, experience has indicated as a rough 'rule of thumb' that when weaknesses are apparent in more than a few of these conditions, there is a danger that a significant decline in plant performance is occurring.

Guidance
IAEA has produced guidance on management of continual improvement which states that "The following fundamental principles are considered essential to the effective introduction of structured continual improvement:

- Long term commitment from senior management throughout the entire organization;
- The implementation in the organization of a process management approach such as that advocated by IAEA Safety Standards, ISO 9001, Malcolm Baldridge National Quality Award and European Foundation for Quality Management Business Excellence model;
- The alignment of the processes with the objectives of the organization through the organization's business plan;
- The utilization by Management of the process information as an input to managing the organization;
- The employment of the information derived from the process performance to identify and prioritize the processes that require improvement;
- The active participation of all staff of the organization to using its processes in order to contribute to continual process improvement (CPI)."

IAEA's TECDOC 1491's Fig 1: *A structured approach to a continual improvement programme* sets out a management driven 7 step cyclic approach:



[23] The IAEA Safety Guide on Safety Functions and Component Classification for BWR, PWR and PTR Plants (Safety Series No. 50-SG-D1) issued in 1979 was withdrawn in 2000 ; Being rewritten under DS367-Proposed Title: Safety Classification of Structures, Systems and Components in Nuclear Power Plants – scheduled publication Q4 2008, understood at Oct 2012 that 2nd draft is being reviewed by the Safety Committees.

[24] ONR SAPs 2006 – 148 to 165 incl ECS 1-5 and EQU 1.

[25] IAEA INSAG 13 Management of Operational Safety in NPP:1999

Organisational Management

Overview

Poor organisational management has been a significant contributory factor in major industrial accidents such as Chernobyl, the Texas City Oil Refinery, Piper Alpha, the Nimrod crash and Deepwater Horizon.

The lifecycle of a nuclear plant, from design, construction and operation through to decommissioning and demolition, stretches into decades and for some facilities even centuries. During this time the configuration of the organisational (sometimes referred to by academics as configuration) and managerial arrangements will change extensively. ONR found this a significant issue in relation to AWE, Dounreay, Sellafield and British Energy in the late 1990s/ 2000 (see summaries in Section 3.2); leading to the introduction of an additional standard Licence Condition (36 - Control of Organisational Change). However, before change can be assessed a "baseline" needs to be established which quantifies all tasks that need to be undertaken e.g. in normal operations this could include shutdown/ fire watch personnel, emergency response teams, security guards, health physics attendants as well as the management required to oversee them.

Changes must be controlled throughout the lifecycle of the plant to ensure the on-going safety of the public, workers and the environment. This requires effective organisational management. Organisational management requirements and arrangements will vary from one situation to another – but the objective is the same: to enable the maintenance and consistency of systems that ensure performance and operation.

Effective organisational management ensures that:

- The management arrangements required to operate the site safely are adequately defined and understood (the "baseline"), which will inevitably include licensee HQ and Supply Chain inputs.
- Organizational changes are controlled (often referred to as Management of Change (MoC) process)

Regulatory requirements

The nuclear site licence and other legislation require that adequate organisational management processes and arrangements be established at each site. It should be noted that the site quality function will be heavily involved with the development, deployment and, in some instances, management of these arrangements.

The following legislation requires organisational management as part of the compliance arrangements.

- Licence Conditions (LC):
    - 17: Management Systems (in 2011 renamed from Quality Assurance)
    - 36: Organisational Capability (in 2011 renamed from Control of Organizational Change)
- RSA 1993 / Environmental Permitting Regulations 2010
- Environmental protection legislation
- Nuclear Industries Security Regulations 2003 and supporting ONR security requirements

Quality Standard References

IAEA GS-R-3, *The Management System for Facilities and Activities*:

- Responsibility and authority for the management system
- Managing Organisational change.

ISO 9001:2008, *Quality management systems - Requirements*:

- 5.4.2, 'Quality Management System Planning'

ISO10007, *Guidelines for Configuration Management*.

General organisational management arrangements

Organisational management planning is a fundamental aspect of good organisational management for all applications. An organisational management plan should capture responsibilities and authorities and should provide a focus on customer and other stakeholder (regulatory) requirements for plant, project or activity.

The general approach for ensuring effective organisational management would consider the following points:

- A description justification and record of the change
- A categorisation of the change identifying level of complexity, resources and impact to programmes and scheduling
- An evaluation of the consequences of the change, this is particularly important in terms of its impact.

General aspects need to be considered such as:

- Documentation of the change itself and resulting procedural changes;
- Human factors aspects of safety assessment – what training needs to be undertaken and capability of individuals / teams to undertake both the change and outcome.
- Authorisation to implement at a point in time.
- Periodic review of the organisation to see that it remains 'fit for role'.

Other sources of information

There are many publications on the general (non-nuclear) subject of organisational design.
The UK Safety Directors Forum has produced a Nuclear Industry Code of Practice on Nuclear Baseline and Management of Change.

A useful UK example can be found in NNB GenCo's application for a nuclear site licence for Hinkley Point C- July 2011 which includes their Management prospectus and Nuclear Baseline documents (Part A and Part B)These should be read with ONRs Assessment reports which include one on "NNB GenCo Organisational Capability Arrangements".

Risk informed decision making

Safety Analysis

The topic of risk is fundamental in nuclear safety considerations. (See Fundamentals Chapter 2 Section 1) and has been addressed alongside hazards since the outset of the nuclear industry.

Initially the safety cases for nuclear facilities were based on engineering standards and scientific understanding – the deterministic approach, in what became known as Design Basis Analysis (DBA), this was then developed by incorporation of fault studies. UK terminology and practice was set out in NII (now ONR) guidance - TAG 006 based on the 1992 SAPs.

Probabilistic Safety Assessment (PSA) (referred to in US as Probabilistic Risk Assessment (PRA)) was developed through the late 1970s/80s as a means of gaining insights into relative contribution to risk of identifiable initiating faults, generally utilising the high analytical power of computer systems.
Reactor PSA studies are typically undertaken at three different levels:

- A Level 1 PSA provides information on reactor core damage frequency;
- A Level 2 PSA provides insights on radioactive releases to the environment; and
- A Level 3 PSA estimates the radiological risks to the public and the environment around the facility.

At each level the PSA provides estimates of the probabilities (frequencies) of adverse consequences and information on the dependence of these values on various factors, such as technical design features, potential human errors, or weather conditions.

Expectations

Current UK regulatory expectations set out in TAG 005 (ALARP) state "SAPs expect that a safety case should provide an analysis of normal operation, fault analysis covering Design Basis Analysis, Severe Accident Analysis and a Probabilistic Safety Analysis (PSA), and analysis of the engineering design and operations". UK terminology and practice on PSA is set out in ONR guidance TAG 030 based on the 2006 SAPs. IAEA have published guidance on Deterministic safety analysis for nuclear power plants.

Use of safety analysis

One of the earliest complete studies using PSA on a commercial nuclear plant was the WASH-1400 study prepared for NRC, also known as the Reactor Safety Study or the Rasmussen Report .

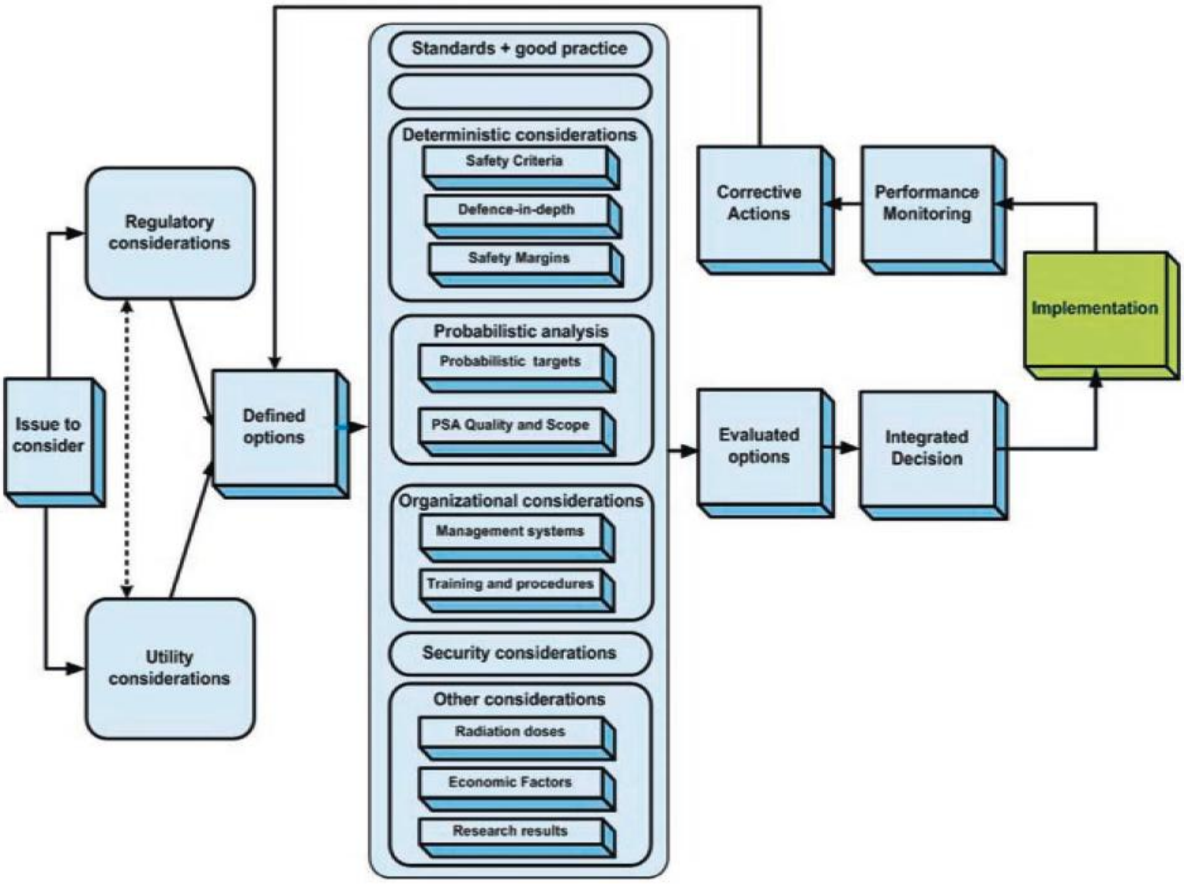
It has been understood for some time that Level 1 and Level 2 PSAs can provide useful information for decisions influencing the safety of the nuclear power plant, while a Level 3 PSA is particularly useful in decisions relating to the siting of nuclear power plants and to emergency planning. The IAEA's Safety Standards highlight the need for integrated assessment for decision making. In particular, GSR Part 4, on Safety Assessment for Facilities and Activities, states in para. 5.8:

"The results of the safety assessment have to be used to make decisions in an integrated, risk informed approach, by means of which the results and insights from the deterministic and probabilistic assessments and any other requirements are combined in making decisions on safety matters in relation to the facility or activity."

INSAG 25 (IAEA 2011) addresses the use of those results under the title "integrated risk informed decision making".

Integrated Risk Informed Decision Making (IRIDM)

INSAG argue that " IRIDM is a systematic process aimed at the integration of the major considerations influencing nuclear power plant safety. The main goal of IRIDM is to ensure that any decision affecting nuclear safety is optimized without unduly limiting the conduct of operation of the nuclear power plant." The key elements of the IRIDM process are depicted in INSAG 25 Fig. 1.



> "Depending on the nature and purpose of the decision, and the timescale in which the decision has to be taken, some or all of these elements should be evaluated. Clearly, the more information that is taken into account, the better the decision is likely to be in meeting the overall objectives."

INSAG recognise the relationship of IRIDM with Management for Safety (aka quality) and Security and address it in relation to those headings, making a number of fundamental points.

Other Sources of Information

Paper on IRIDM and IAEA's approach [26]

USNRC's Japan Task Force Report (page 17) and discussions and presentations at the USNRC Regulatory Information Conference (RIC) 2012.

NEA CSNI papers 7 and 8 (2005) addressing Living PSA and Risk Monitors

[26] Advances in Risk Informed Decision Making – IAEA's Approach - Artur Lyubarskiy, Irina Kuzmina, Mamdouh El-Shanawany -

3.4 Expectations of Supply Chain

Overview

Few if any licensees these days have themselves the capabilities to undertake all the nuclear safety-related work. From concept design through to decommissioning, the use of specialist support can vary from R&D through design and manufacture to activities such as inspection and test, records storage and third- party auditing.

The use of the supply chain is common to most organisations, regardless of activities or sector. Indeed, reports indicate that between 50% and 80% of licensees' annual site budget is with the supply chain. As such Supply Chain Management is addressed specifically in Chapter 7. Differing definitions of Tiering addressing suppliers is set out in Chapter 1.

Before an organisation attempts to become part of the supply chain it has to understand what is expected of it and what is different from their day-to-day ways of working. Expectations apply both ways and so one needs to recognise that Supply Chain companies also have expectations of the Operators / Main Contractors.

Operators/Main Contractors. The top tier organisations need to:

1. have a clear understanding of what it is they want from their suppliers (See quote by CEO EDF Vincent de Rivaz below),
2. ensure their suppliers should meet the needs (pre-qualification)
3. communicate that need clearly,
4. confirm that it is understood,
5. verify that it is being / has been delivered.

Supply Chain. The supply chain contractors need to:

1. understand the significance of the role and culture in nuclear work,
2. ensure that they understand exactly what is wanted of them,
3. meet the requirements placed upon them,
4. question any aspects where they have concerns about their understandings.
5. pass on the appropriate requirements to their own sub-tier suppliers (same criteria as above for top tier organisations now apply to them).

Within larger organisations, procurement systems should also address internal / inter-department / multi-site supply.

The NIA SC@nuclear publication "The Essential Guide to the new build nuclear supply chain" sections 'Roles & Requirements' and 'Quality Arrangements – For the design and construction of new nuclear plant', to which CQI NucSIG originally contributed, provides useful thinking on expectations.

Evidence by Vincent de Rivaz (CEO EDF) to House of Commons Energy and Climate Change Committee, 23 Oct 2012: Qs195 / 197 / 201

"There are two aspects to the construction risk. The first and most important one is to reduce those risks from the start, and that is the job that we have to do as the leader of the construction of these nuclear power plants. It is a job we do by having put in place a world class team, which is very clear about what it means to reduce the construction risk: to have a stabilised design before starting; to carry out detailed engineering studies before we start construction; and to have robust project management organisation with the role for engineering, the role for construction planning, the role for project managers, the role for commercial directors, the role for quality assurance, and the role for safety control.

We also need to have a one team approach with all the main contractors civil, conventional island, nuclear island-working as one team with the same goal and the same purpose. We need to be clear that we will not start before we are ready, but when we start we will not stop. That is in a context where, I repeat, the key issue is to have a stabilised design before we start the construction, and it is all that we are doing. So the first response to the question of construction risks is to reduce them, to mitigate them, to control them as a competent and efficient company."

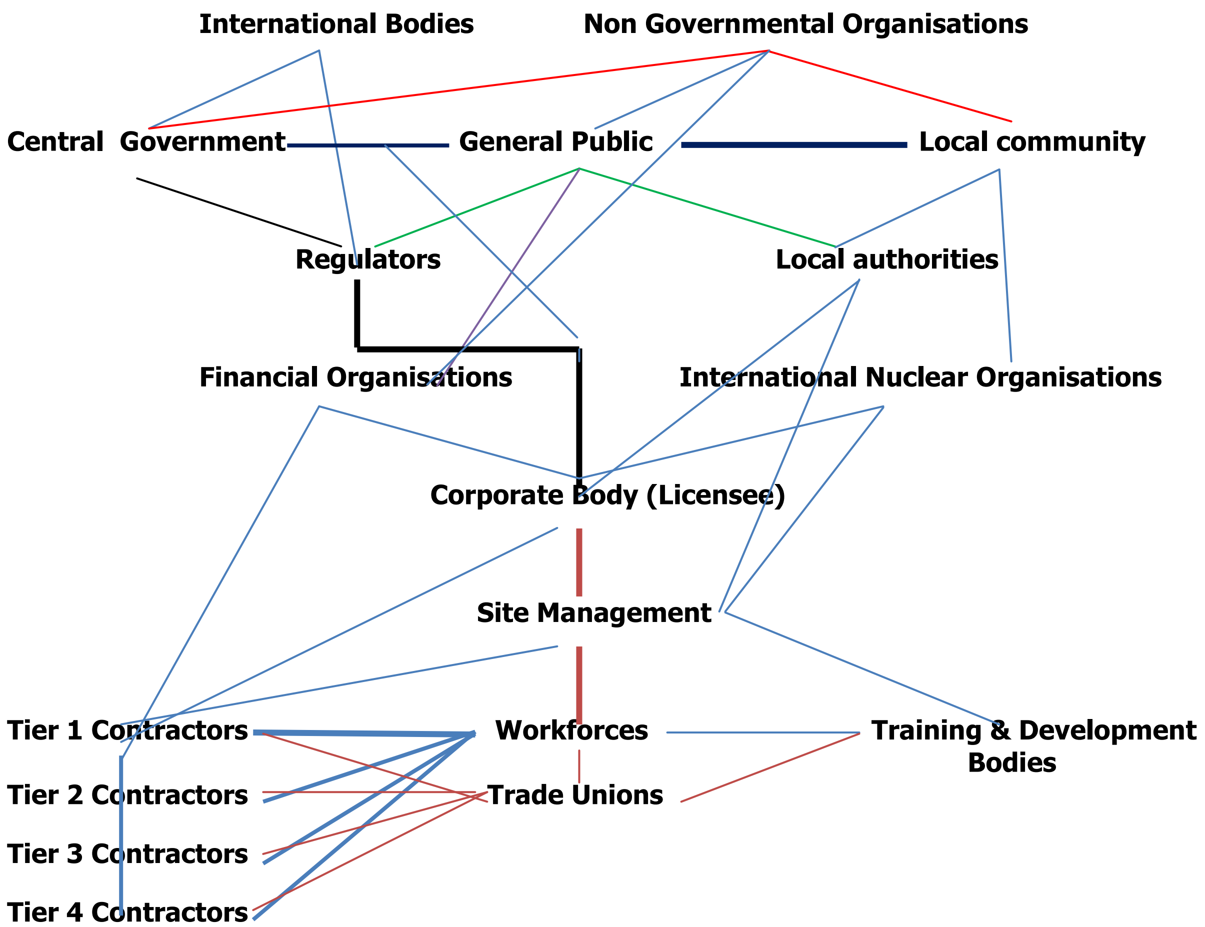
"It is a matter of great importance for us because we cannot succeed in delivering this project or in operating it for 60 years without a strong, competent, dedicated supply chain. That is why over the last three years we have organised a series of events to inform, to engage and to mobilise the UK supply chain, in the view that they take a significant role in the delivery of our project. I am confident that it will be the case. It is probably not appropriate to give any specific number, but our ambition is clearly that more than half the value of our project will be sourced from the UK. We will create through this project, something that has great importance for UK supply chain. This will be the first English speaking supply chain able not only to deliver in Britain, but to deliver projects of this kind in other parts of the world. That is our ambition,"

"Part of the supply chain point you are raising is how we are going to engage with the productive workforce during the construction of our project. I am pleased to say, without entering into too many details, that this new covenant we want to have is now making significant progress. We are involving the unions and we expect to be able, in the next few weeks, to have this framework agreement in place-a tripartite agreement, with us as the client, the main contractors would be the civil works companies, the provider of the equipment for the conventional or the nuclear island, and the unions. That is part of the vision, we cannot engage in such a project without having clear vision of all the key factors to make it a success, and that is what we are doing."

Full transcript: **Evidence**

3.5 Stakeholder engagement

The following generalised diagram attempts to identify nuclear related stakeholders and some of their relative interactions; these will vary depending on Licensees, activities and localities



Each of these will have differing expectations and levels of influence. As such it is necessary to consider each interaction. Table 1 attached is the authors attempt to summarise these. The IAEA has what is known as the Nuclear Communicators Toolbox which contains links to many IAEA publications and papers on the subject – although it has to be said much is about how to convince the wider public about benefits of nuclear power and acceptability of decommissioning/disposal. The latest IAEA Technical Meeting on 'Stakeholders Involvement in Nuclear Power' was held in Vienna in October 2012.

High level interactions (e.g. Government/Regulator/International/NGOs) will determine and express the policies that apply to the nuclear industry and the aims / objectives that have to be met by the industry including safety. These are most likely to be found in the annals of the various organisations. In the UK the Government department web sites contain, or direct to, most of the relevant information; major UK policies being contained in White Papers/Acts of Parliament/Regulations. At international level such as the IAEA any interested party can comment on draft documents via their national authorities; for UK this is via ONR. At UK government level DECC and NDA, MoD, DEFRA, ONR, EA and SEPA have undertaken public consultation on many aspects of UK policy and regulation; whilst Parliamentary Select Committees have heavily scrutinised many of their resultant proposals

Operators at corporate level interact to diverse organisations in obtaining policies, finance and public acceptance of their business. That is often a long and confused story, but now will nearly always involve "Stakeholder" meetings and presentations, often drawing in NGOs, Regulators and both national and local politicians. Without the right combination of "Stakeholder" support operators will not find the business justifiable.

At site level the local public will inevitably seek information about the plant(s); many of them will themselves be workforce or their relatives and some will have high levels of technical understanding whilst others little in-depth knowledge of what is involved. Outwardly looking this will focus through Local Liaison Committees – details of these, including report papers and minutes, can be found via NDA, SLC and ONR web sites. More detailed regulatory reports such as inspections and technical assessments can be found on ONR web site; ONR inspectors also regularly meet with site safety representatives who are statutorily established . On site management interactions with workforce will include staff tool-box briefings, events to champion nuclear safety, newsletters. More recently, in the spirit of openness and no-blame culture, processes for whistle-blowing have developed.

Annex A – Stakeholder groups individual expectations (a perspective)

Grouping	Expectations	Comment
International bodies	Here we are considering the likes of IAEA, NEA, and the EU which are linked via UK national membership, or ENSREG and WENRA which ONR interact with. These organisations will expect that activities, be they nuclear power, fuel cycle, defence or medical/ industrial usage will be conducted safely and securely, and without proliferation. As such they will expect "best practices" to be followed with desires for "continuous improvement". Additionally Defence interests will have strong US interfaces.	The UK actively participates in these organisations. This involves Government, Regulators and Industry. Interests include ensuring that UK approaches organisationally, technically and legally are accommodated.
Non Governmental Organisations	These will depend very much on the aims of the NGO, and can be pro- or anti-nuclear. Pro-nuclear In this group we can include WANO, INPO, WNA, WINS, FORATOM Anti-nuclear Friends of the Earth (FoE), Greenpeace and CND are probably amongst the best known and world wide, but there are also more regional / community ones like CANE [27], CORE [28], NFLA [29], PAWB [30] , SCRAM [31] and WISE [32], plus individuals such as John Large and Peter Wilkinson. Some organisations have limited life dependent on individual participants or duration of local activity. The following is an outline of the position expressed by some of the key organisations – **FOE** work by lobbying internationally, nationally and locally, online and by setting up local groups. A significant activity is centrally producing 'campaign' material – such as 'climate change' and 'clean British energy', amongst which advocating that nuclear power is not a solution. **Greenpeace**'s stated vision and approach to making change happen are: "Our vision is to transform the world by fundamentally changing the way people think about it." "Greenpeace stands for positive change through **action**. This action takes many forms - from investigating and exposing environmental abuse and lobbying governments and decision makers to championing environmentally responsible and socially just solutions and taking nonviolent direct action.". Greenpeace proudly state their first campaign led to The Comprehensive Nuclear Test Ban Treaty.	NGOs are difficult to define and classify, and the term 'NGO' is not used consistently. As a result, there are many different classifications in use. The most common use a framework that includes orientation and level of operation. An NGO's orientation refers to the type of activities it takes on. These activities might include human rights, environmental, or development work. An NGO's level of operation indicates the scale at which an organization works, such as local, international or national. NGOs vary in their methods. Some act primarily as lobbyists, while others primarily conduct programs and activities. Campaigning NGOs seek to "achieve large scale change promoted indirectly through influence of the political system." Campaigning NGOs need an efficient and effective group of professional members who are able to keep supporters informed, and motivated. They must plan and host demonstrations and events that will keep their cause in the media. They must maintain a large informed network of supporters who can be mobilized for events to garner media attention and influence policy changes. The primary purpose of an

Grouping	Expectations	Comment
	After the Nov 2012 publication of the NAO report on NDA and Sellafield, Greenpeace said "There are several reasons why Greenpeace opposes nuclear power and the problem of nuclear waste is one of the hardest to resolve." 'Greenpeace is known for its direct actions and has been described as the most visible environmental organization in the world. Greenpeace has raised environmental issues to public knowledge, and influenced both the private and the public sector. '(Wikipedia) Greenpeace has also been a source of controversy;[its motives and methods have received criticism and the organization's direct actions have sparked legal actions against Greenpeace activists. **CND**'s stated objectives are: ☐ Elimination of British nuclear weapons and global abolition of nuclear weapons ☐ Abolition of other threats of mass destruction or indiscriminate effect ☐ Nuclear-free, less militarised and more secure Europe ☐ The closure of the nuclear power industry	Advocacy NGO is to defend or promote a specific cause. As opposed to operational project management, these organizations typically try to raise awareness, acceptance and knowledge by lobbying, press work and activist event. (Wikipedia) Details of NGO Forums held by DECC, NDA and ONR are on their websites.
Central Government	Government departments have defined policies, frequently reviewed and updated as Political Policy follows elected parties. At the end of 2012 the main policies were those of : **DECC** – Four key priorities: 1. Save energy with the Green Deal and support vulnerable consumers 2. Deliver secure energy on the way to a low carbon energy future 3. Drive ambitious action on climate change at home and abroad 4. Manage our energy legacy responsibly and cost-effectively For No 2 the 2012-15 business plan shows that DECC has an Action to complete by Dec 2013 - Facilitate the world's first new nuclear development without public subsidy by 2019. For No 4 the business plan shows that DECC has no specific actions, although it is "still a high priority", with indicators and key data identifiers related to NDA budget and reduction in the nuclear provision through decommissioning and clean-up. Details show this to be achieved through sponsoring the NDAs delivery of its mission cost-effectively; developing/ implementing solutions for long term management of higher activity radioactive waste	Parliament, including its bodies such as Select Committees, is discussed under General Public. A cynic may argue that Government want to ensure their energy supply, waste disposal and nuclear deterrent programmes run safely, to time and definitely within costs. They will seek to meet these aims with minimal opposition and desirably without extended discussion. Select Committee evidence has questioned whether DECC and HM treasury have the same approaches.

Grouping	Expectations	Comment
	and civil plutonium; and improving the security of civil nuclear sites and materials. **DEFRA** – 3 priorities 1. Support and develop British farming and encourage sustainable food production 2. Enhance the environment and biodiversity to improve quality of life 3. Support a strong and sustainable green economy, including thriving rural communities, resilient to climate change There are no specific actions identified relating to radiation / nuclear aspects. These are most likely to come under the Area of Climate Change, Waste and Atmosphere **MoD** – "Strategy for Defence – Oct 2011" defines 7 'Military Tasks'. MT2 is "Providing nuclear deterrence"; which in the 7 Priorities is reflected in 2- "To continue to fulfil our standing commitments"	
General Public	These are the 63 million people (England - 53m, Wales – 3m, Scotland – 5 m, NI – 2m), not just the 46m electors, of the UK(England - 38m, Wales – 2m, Scotland – 4 m, NI – 1m) . The primary focus of public representation is MPs in parliament.	The level of understanding will be very varied and in many cases informed by media or ONGs.
Local community	Each Licensed site has a Local Liaison Committee / Site Stakeholder Group run by the licensee that includes local authorities, trade unions, interested local groups and members of the public. Regulators and operators provide reports to each LLC/SSG meeting (usually quarterly).	NDA SSG websites can be linked to through their web page whilst EDF NuGen Site pages include links to their LLCs. ONR publish their reports to the LLC/SSG meetings and include links to the various websites.
Regulators	The regulators prime interest is to undertake activities defined in legislation. Their primary focus is ensuring safety (even security is there to ensure safety) on behalf of the wider public, reporting through government ministers to parliament. ONR in defining what it does states "Our mission is Securing the protection of people and society from the hazards of the nuclear industry. To do this, we must achieve three key outcomes: • A nuclear industry that has a culture of continuous improvement and sustained excellence in operations. • All of our stakeholders value our work. • A nuclear industry that controls its	

Grouping	Expectations	Comment
	hazards effectively"	
Local authorities	Local authorities have their own statutory roles in regulating aspects of sites, such as, local planning issues. They also are required by REPPIR to prepare and exercise Emergency Arrangements. They are members of the various SLCs / SSGs.	
Financial Organisations (incl Shareholders)	The City / HM Treasury / shareholders are key providers for the nuclear industry; without the provision of funding it would not operate. As such they need to see 'value for money' and will critically examine management, organisational and programme/ project efficiency.	Example of perspective - FTSE 4 Good Nuclear Power Criteria
International Nuclear Organisations	The main objectives of each vary IAEA – "Three main pillars - or areas of work - underpin the IAEA's mission: Safety and Security; Science and Technology; and Safeguards and Verification" NEA – The mission statement is "To assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes." EU – The EU Strategy to 2020 states " A common EU energy policy has evolved around the common objective to ensure the uninterrupted physical availability of energy products and services on the market, at a price which is affordable for all consumers (private and industrial), while contributing to the EU's wider social and climate goals. The central goals for energy policy (security of supply, competitiveness, and sustainability) are now laid down in the Lisbon Treaty." "Through the Euratom Treaty, the EU aims to ensure safe and sustainable use of nuclear energy by developing and implementing a common EU legal framework that meets the highest standards of safety, security and non-proliferation. It also helps countries outside the bloc to meet these standards."	UK government, Regulators and Industry representatives make significant input to many of the activities. A clear aim is to ensure best practices across nations are reflected in conventions, standards and guidance, without imposing anything inappropriate to UK industry or legal practices.
Corporate Body (Licensee)	The corporate body has to meet the requirements of corporate law, regulators and financial markets. In doing so they have to (in EDF Groups 2012 words) " turn in an outstanding industrial, economic and financial performance". To operate efficiently they need to work in	One day loss of generating on a UK nuclear reactor can cost in the order of £1m. (2010 values)

Grouping	Expectations	Comment
	partnership with many suppliers and set clear expectations of the whole supply chain.	
Site Management	The site management has the prime day to day issues of operating / maintaining the plant. As such it has to operate within the corporate and site procedures / processes yet optimise the work of operators and plant. They will have significant input into the supply chain affecting the site. They will be a prime focus for local communities and authorities as well as regulators.	
Tier 1 Contractors	As Licensee but may depending on role have different approaches that need to be reconciled eg New Build reactor designers working to French / US standards and matching into UK approaches / Licensee requirements. For NDA and Defence will also need to meet their contract requirements and specifications.	
Tier 2 Contractors	Need to understand the Tier 1 requirements but also meet specific Licensee requirements applied via clear contract requirements and specifications.	
Tier 3 Contractors	Need to meet specific License, Tier 1 and Tier 2 Contractor requirements applied via clear contract requirements and specifications.	
Tier 4 Contractors	Need to meet specific License, Tier 1, 2 and 3 Contractor requirements applied via clear contract requirements and specifications.	
Workforces	Anyone working in the nuclear industry, at whatever level in the chain, is already a member of the General Public and in the minority a member of the Local Community. Regardless of their location they need to be made clearly aware of their role, the nuclear cultural implications, the requirements expected of them in terms of technical skills, and any unusual contractual requirements.	The majority of the workforce is likely to be found in the supply chain, and a significant number may not be in UK based organisations. Probably the majority will work off-site and thus not be employed in radioactive environments.
Trade Unions	TUs have a significant role in looking after the employment conditions including health and safety of their members. They are also likely to be involved in definition and supply of skills training to give those members employability advantages.	
Training & Development Bodies	The following extract from the DECC Nuclear website gives an overview of the T&D requirements and key players: "We need skilled people in all these areas. However, due to past peaks in recruitment, the workforce age profile is skewed, and retirement will take an increasing toll through the 2010s. This	CQI and NucSIG are developing contacts with DECC and NESA/ NSAN etc as well as looking at what is needed and how to deliver "Nuclear Quality Management" training based on NQK.

Grouping	**Expectations**	**Comment**
	is not unique to nuclear; the workforce is ageing across the energy sector, in the UK and throughout the developed world. To address this the National Skills Academy for Nuclear was set up in January 2008, to work with existing training providers across the UK to develop training and qualifications in this area. In its first three years, it intends to provide 1,200 apprenticeships and 150 foundation degrees, as well as work-based training to help 4,000 employees move from operations to decommissioning. To identify possible future skills gaps and develop mitigating actions, the Nuclear Development Forum and OND requested that Cogent (the Sector Skills Council covering nuclear) look at this issue alongside other reports that they have published on the civil nuclear workforce. In March 2010, they published Next Generation: Skills for New Build Nuclear which identified future possible skills gaps and high risk skills (if current industry plans are realised), and suggested a series of mitigating actions to minimise the risk of key skill shortages. The Nuclear Energy Skills Alliance is made up of key stakeholders continues to meet on a quarterly basis to review progress against the mitigating actions and ensure that they are kept up to date. Also, to make sure that nuclear skills continue to be developed and be available as we move towards building the UK's new power stations the creation of the National Nuclear Laboratory in Cumbria was announced on 23 July 2008."	

[27] CANE (Communities Against Nuclear Expansion) -
[28] CORE (Cumbria Opposed to a Radioactive Environment) - http://www.corecumbria.co.uk/
[29] NFLA (Nuclear Free Local Authorities) - http://www.nuclearpolicy.info/about/index.php
[30] PAWB (People Against Wylfa B) - http://stop-wylfa.org/pawb_english.html
[31] SCRAM (Scottish Campaign to Resist the Atomic Menace) - set up 1976, focused against Torness, developing in the 1980s to focus on Dounreay, discontinued mid 1990s. Papers etc in the National library of Scotland Manuscript Collections (Acc 11607)
[32] World Information Service on Energy - http://www10.antenna.nl/wise/
WISE – Paris - http://www.wise-paris.org/index.html

Chapter 4

Project Management

CONTENTS

Editor: Andrew Mullinder
Contributors: Richard Hibbert, Mike Underwood, Iain McNair, Stuart Allen

4.1 Introduction

Nuclear Sector engineering project delivery managers need to take into account that the industry works in a highly regulated environment and it is necessary to involve throughout the evolution and delivery of their projects a wide circle of experts. Indeed a key to success is understanding and responding to the many stakeholders that will be involved including those with regulatory, fund holding, environmental, safety and security responsibilities (to name but a few). This requires the use of Project Managers and team members of high calibre , both in project management and nuclear understanding, with a disciplined systematic approach to the role to cope with the many logistic and technical issues that will require addressing.

In particular close co-operation is needed between the engineering functions involved (often drawing on many contractors) and those charged with documenting and justifying the nuclear safety case for the plant. Compilation and approval of the Safety Case is a critical output and is usually on the critical path and often cannot be completed until late in the project when it is supported by confirmatory commissioning data. For this reason the regulators generally expect it to be produced to align with key stages in the overall programme e.g. before construction, commissioning, move into routine operations and decommissioning.

However the Safety Case is only one of a myriad of substantiating records (known as the Lifetime Records) that are required to be compiled and "delivered" as well as the hardware.

A key Licensee group that contractors contributing to a nuclear project will interface with are "Intelligent Customers" (or IC's, an expression which derives from Licence Condition 36 requiring the Licensee to retain enough experience within the company whilst being able to contract out work). Intelligent Customers are individuals who are often independent of the project and work on behalf of the Licensee as an expert in a particular field that is relevant to the project so they may be for example the "Shielding Expert" or the "Remote Inspection" expert.

The nuclear industry has developed a set of nuclear specific engineering and material standards and codes which address the safety case related challenges posed by irradiated materials and averting major structural or functional failure. These will be identified in functional or contractual specifications and contractors that are in any doubt about the requirements should seek the assistance of an IC to assist in their understanding.

It almost seems unnecessary to say that given the serious issue of nuclear safety and the complexity and cost of these type of projects that a "Right First Time" culture must prevail and all project team members and supporting contractors need to have a disciplined and rigorous approach to Quality Management. For this reason larger projects will employ a dedicated Project Quality Engineer or team of engineers to support the project in achieving the high standards required.

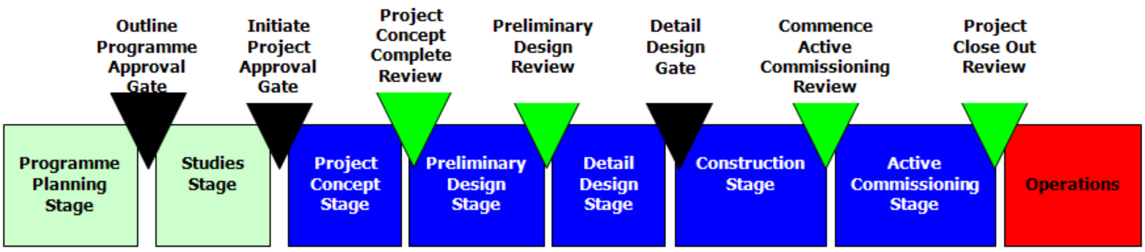
This chapter leans in its focus to larger projects which use a gated process for project validation and sanction. It is perhaps fair to say that one of the challenges for the industry is to establish and demonstrate the use of truly scalable gated project delivery processes so that work which is essentially minor in nature does not get over-burdened with unnecessary bureaucracy. For smaller, low cost projects, particularly for a site nearing the completion of its' decommissioning phase a less onerous approach can be tolerated, tailored to the risks involved.

4.2 The Gated Process for Project Management

The objective of a Project Gated Process, as typically depicted below, is to provide a streamlined sanction and validation process that can be tailored to suit the needs of differing project types.

Projects delivered within the Project Gated Process should significantly reduce non-value added activities and enjoy the following benefits:

- Good business governance ensuring projects of value
- Improved planning and alignment with business/technical requirements
- Earlier and more secure engagement of the supply chain
- Reduced project delays/abortive work
- Improved predictability of project performance



In the model shown, work activities are split between "Programmes" and "Projects". Programmes confirm the need for work and coordinate any studies required to select a single option to meet the functional specification. Projects then take the single option through design, procurement, construction, and commissioning.

Once the Project Team demonstrates that the deliverables meet the functional specification they are handed over to Operations.

The Project Gated Process separates validation from sanction, enabling effective governance. Validation reviews should be led at a seniority level such that they hold the project manager accountable for successful and compliant delivery of the project overall. The format and content of validation reviews should be tailored to a level which is appropriate given the complexity and cost of the project. Sanction (approval) gates should take account of validation reviews.

The programme phase shown has two stages: *programme planning* and *studies*. In the programme planning stage, Programme Owners identify strongly interdependent work at a very high level and group that work into programmes. After approval by an appropriate executive group at the Outline Programme Approval Gate, the Programmes team prioritise and develop work activities through the studies stage.

The *studies stage* should result in the development of a project business case and functional specification, which allows the team to select a single high level option that will be further defined after approval at the Initiate Project Approval Gate.

For major projects, project delivery has five stages: project concept, preliminary design, detail design, construction, and active commissioning.

During the *project concept stage*, the single option should be developed into a fit-for-purpose, cost effective scheme, which can be validated at the Project Concept Review.

In *preliminary design*, the engineering design should be optimised to deliver the performance requirements per the functional specification and should be validated at the Preliminary Design Review.

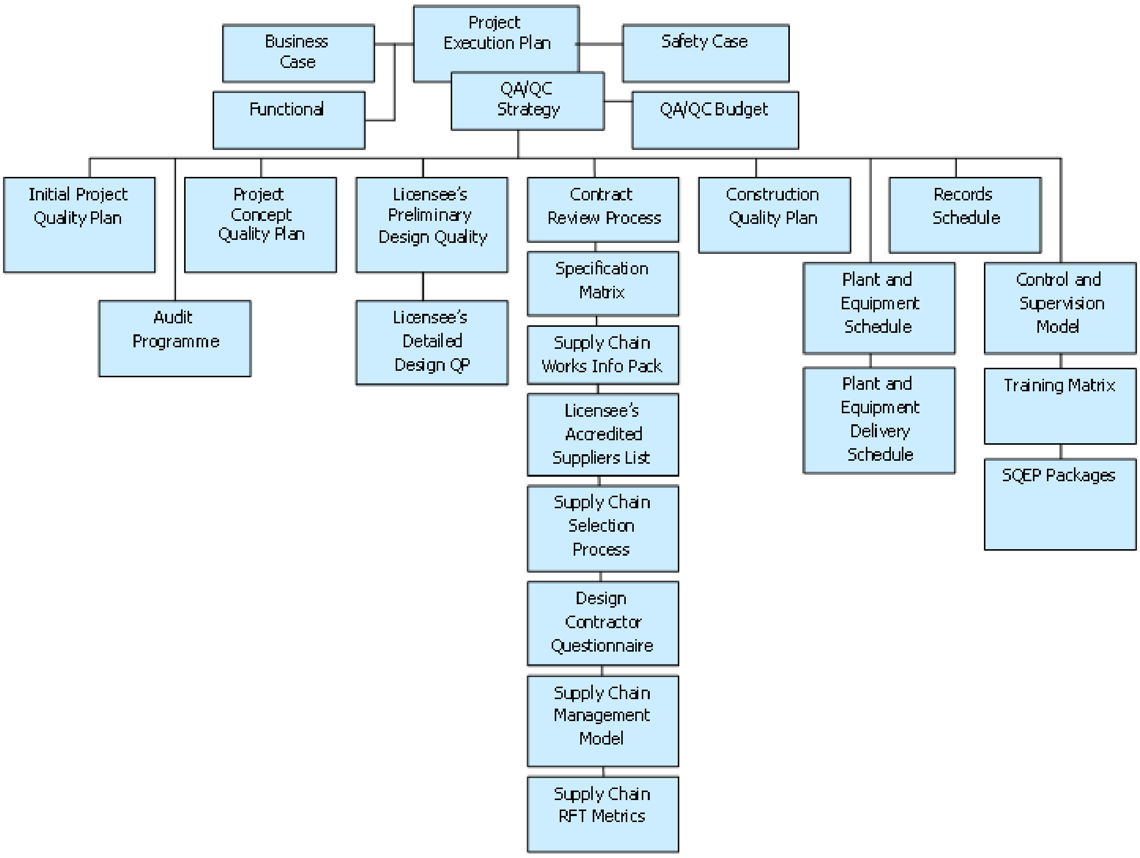
For *detail design*, design should be completed to a point where the project can allow engineering procurement to be completed and to begin major procurement, manufacture, and construction activities. The Detail Design Gate should be a sanction and validation gate, as well as a Customer hold point; this should allow the final design to be reviewed internally and by the Customers engineering validation team if required.

During *construction* all procurement, manufacture, construction, and inactive commissioning activities should be completed prior to the Commence Active Commissioning Review.

The *project close* out review and post investment appraisal should occur once the project meets the functional specification requirements and the project has been formally transferred to operations. It is important that lessons learned are captured and available to future similar projects to consider at their planning stage.

4.3 Typical Project Quality Arrangements/Quality Standards

This section of NQK identifies the quality arrangements and deliverables that would be typically expected of a nuclear project, these arrangements have been derived from best practice and experience within the nuclear industry.



The purpose of these quality arrangements are to:

- Ensure that Nuclear Safety requirements and implications are understood and appropriately managed, using the foundation that "Quality = Nuclear Safety"
- Establish and maintain consistent project management arrangements
- Ensure that all projects comply with the site licence.
- Provide effective management arrangements built on risk, size and complexity
- Deliver projects to specified requirements.
- Better define Licensee requirements to the supply chain
- Drive up Right First Time delivery in the supply chain
- Achieve maximum value from the supply chain
- Improve project cost and schedule performance

Key project documentation and controls are discussed. The extent that these are required depends on the complexity of the project and many of these documents develop during the progress of the project. The expression "Delivery Organisation" refers to the organisation taking prime responsibility for delivery of the project this may be the Licensee or for a turnkey project the Prime Contractor.

Business Case

The key to success of a business is to understand where investment should be made in order to maximise the achievement of targets and objectives in the most efficient and effective manner possible.

It is essential that proposals for investment are presented in a clear and concise manner, while providing enough relevant information to enable sound decision making. The purpose of a business case is to detail the problem, identify a solution and define the benefits which will be delivered.

For Licensees that are government funded HM Treasury's The Green Book gives a format for the business case based on the Five Case Model. The business case should '*involve close scrutiny of all relevant financial and non-financial aspects of a proposed project to ensure that the best possible solution is selected for a given set of circumstances'*.

The Five Case Model aims to minimise the chance of the project failing to meet its objectives due to inadequate scoping, planning and the consideration of associated risks. The 'five cases' require a level of detail and definition which will assure both stakeholders and members of the project team themselves that the following factors have been considered:

- Is the business case supported by a robust case for change that provides strategic synergy? (The Strategic Case)
- Does the scope and schedule optimise value for money? (The Economic Case)
- Are the scope and schedule commercially viable? (The Commercial Case)
- Is the business case financially affordable? (The Financial Case)
- Is the scope as outlined in the business case achievable? Are appropriate governance arrangements in place? (The Management Case)

Prior to the business case being submitted to the sanctioning body, it should be examined by an independent review panel in order to ensure that the content satisfies the above criteria. The business case is a management tool which develops, from first inception as an initial business case, through to the final business case. Various governance review points are required through the project's lifecycle (Gated Process), at which point funding can be requested for the next stage of the project.

Whilst striving to execute project delivery as efficiently and effectively as possible, history has shown that driving the completion of scope as quickly and cheaply as possible can lead to the project working to a schedule which is unachievable and results in cost overspend. The independent review of a business should seek to ensure that the schedule is not overly optimistic, the risk profile is commensurate with the scope of work, and that value for money is achieved at each stage of the project's lifecycle.

Project Functional Specification

The Project Functional Specification is effectively the commitment made by the project to the business and ultimately the Customer on the capability that will be delivered for the funding requested. As such it is key to managing project scope and its governance, defining the overall bounded scope of the 'to be delivered' asset. Furthermore it is a key form of communication and vehicle for agreement between the project and its stakeholders. It also provides the necessary data to allow the project team to define what work is required to deliver the asset.

The Project Functional Specification is the internal specification for the project at the Initiate Project Delivery Gate and is not to be confused with a specification to be used for procurement via the supply chain. A functional specification or performance specification is defined within BS 7373-1 as *"A document that specifies requirements in terms of features, characteristics, process conditions, limits and exclusions defining the performance of the product'.*

The Project Functional Specification typically included the following: Background; Scope; Requirements; Inputs/Feeds; Outputs/Products; Functional Performance; End State; Assumptions; Constraints; Dependencies; Exclusions; Annexes; References

Project Execution Plan (PXP or PEP)
The PXP must explain **how** the delivery organisation intends to deliver the specific scope within the agreed timescale, cost and to the appropriate specified requirements.

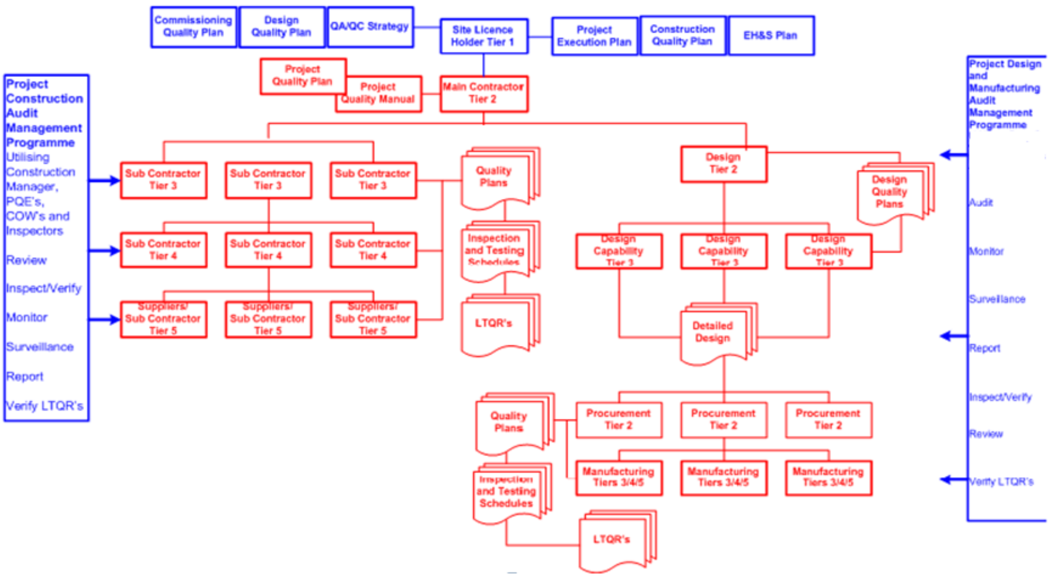
The PXP should accurately depict all the required management system arrangements that the delivery organisation intends to deploy in order to deliver the project.

Key focus should be the competence of the organisation and the methodology to be deployed in effectively managing the Supply Chain, the PXP should be periodically reviewed to ensure compliance to specified requirements. Note: For a contractor the PXP may take the form of a Quality Manual.

Quality Assurance/Quality Control Strategy
The Project QA/QC Strategy must explain clearly **how** the Delivery Organisation will deploy their quality assurance and control processes to deliver the project to specified requirements. The Strategy should be detailed in relation to the structure of the Delivery Organisation's quality arrangements, with especial focus on Supply Chain management.

In addition it is essential that the Strategy defines the SQEP requirements for all Quality personnel and **how** the Licensee will disseminate the Project Quality requirements into their supply chain.

Finally the Strategy needs to align or contain a concise QA/QC resource profile for the project.



Safety Case
The safety case is developed to demonstrate that the proposed activity fulfils all relevant legal requirements and minimises risk to as low as reasonably practicable (ALARP), whilst achieving:

- The strategic business drivers – the right job at the right time
- The optimum method of implementation – in the right way
- The use of relevant good practice

The justification that the risk associated with a proposal is ALARP should be rational, equitable and defensible and requires that either;

- There is a net reduction in risk, from all types of harm, as a result of carrying out the proposal, and that the risk could not be reduced further except at a disproportionate cost or
- Any net increase in risk is justified by the overall benefit, and that the risk could not be reduced except at a disproportionate cost.

The ALARP justification should recognise the overall risk impact across the facility and site and not just the risk associated with the proposal in isolation. The duration of the risks associated with the proposal should also be considered as part of the justification.

The safety case needs to show that the proposal is the right thing to do. For a plant in decommissioning, the safety case will need to show that the proposal will be effective in reducing risk while not introducing unnecessary further risks.

A new plant with no risk reduction role will need to demonstrate that risks are ALARP recognising that the benefits of the activity arise largely from the strategic commercial drivers.

In both cases, the safety case should show that the proposal is being done the right way, that is, that various options have been considered and no reasonably practicable way could be found to reduce risk further.

The most straightforward way to show that risk is ALARP is to use approaches which have already been accepted elsewhere, if relevant, that could include good practice from outside the nuclear industry. For new plants, relevant good practice usually means selecting appropriate design standards.

Focussed Audits and Metrics
Key learning from nuclear projects is related to the importance of establishing appropriate assurance arrangements including a focussed audit programme that cover all phases of the project.

Many nuclear projects fail to invest sufficient time and effort in planning assurance activities at the front end of their projects. This can result in significant impacts on cost and schedule as organisations have made incorrect assumptions or have overlooked key activities.

It is highly recommended that delivery organisations engaged on nuclear projects establish an appropriate risk informed assurance plan so that adherence to the safety case and design intent is maintained.

Examples of Focussed Audits**:** Safety Case Process; Design Review Process; Design Change Process; Design Verification Process; Intelligent Customer Oversight process; Supply Chain Assessment Process; Supply Chain Management Process.

Examples of Focussed Reviews: Safety Case Reviews; Design Reviews; Design Change Reviews; Supply Chain Assessments.

Examples of Focussed Metrics: Right First Time Design deliverables; Right First Time Product Quality; Right First Time Life Time Records; Health and Safety Performance; Delivery against Schedule; Delivery against Cost Estimate; Cost of Failure.

These are not definitive lists, however experience points to the importance of using metrics, focussed audits and reviews to ensure that projects remain on track. It is essential that the nuclear industry grasps the importance of investing in assurance planning at the front end as opposed to relying on increased quality control at the end.

Contract Review Procedure
The Delivery Organisation's Contract Review Process, must clearly define how Contract reviews are managed, the review must include all required Subject Matter Experts, including Design, Project Management, Commercial, Health and Safety, Quality, Project Controls, Risk, Engineering, Construction and Commissioning personnel. All Contract reviews should be recorded. Of especial focus for Contract reviews is the currency of the Contract Specifications and Standards, the Delivery Organisations proposed Tender Questions related to Contract Selection and Award and the quality of the proposed Supply Chain Works Information Package. Additionally the review should identify if there is any missing information within the supplied Delivery Organisations Works Information Pack.

Specification Matrix
It is the responsibility of the Delivery Organisation to clearly define the relevant Contract Specifications and Standards that are to be applied within the Project/Contract structure or Project Portfolio, the relevant Specifications and Standards should be identified on a matrix and as a minimum contain the title of the Specification or Standard, the current issue and any related or underpinning Specifications or Standards. The Specification Matrix should be managed as a live document and updated as required.

Works Information Package
The Delivery Organisation is responsible for compiling and issuing an accurate Works Information Package, to each of their suppliers, the pack must contain all relevant Licensee supplied requirements such as Specifications, Standards, Contract Quality Requirements, drawings if available and any specific forms or templates.

Accredited Suppliers List
The Delivery Organisation's Contracts and Commercial officer representing the Project/Contractor is responsible for compiling and maintaining a Quality Accredited Suppliers List, it is essential that the Delivery Organisation can provide documented evidence that all suppliers contained on the list have been subject to a robust selection process, have a proven track record that is underpinned by Supplier performance metrics (a process that frequently reviews and themes supply chain performance).

Supply Chain Selection Procedure
The Delivery Organisation's Supply Chain Selection Process should be applied using a Risk based approach, it is essential that the Delivery Organisation can demonstrate that a thorough review has been conducted against the supplied Works Information Pack issued to the potential suppliers. The process must identify all aspects of the potential supplier's capability that will be reviewed, including H&S performance, Quality Performance, Financial stability, appropriate facilities and tooling in accordance with the relevant specification, SQEP and most importantly the Suppliers specific supply chain management arrangements.

Design Contractor Questionnaire
As part of the Vendor Selection Process it is recommended that the Delivery Organisation utilises a Design Contractor Questionnaire, this should be available in the Works information Package.

Supply Chain Management Model
All Delivery Organisations working on Major Projects or Project Portfolios should generate a Supply Chain Model, the model should be risk based and depict the totality of the supply chain and also identify the levels of audit, surveillance, inspection and test that will be carried out against each supplier.

Supply Chain Right First Time (RFT) Metrics
The Delivery Organisation working on Standalone Major Projects and Project Portfolios should utilise Supply Chain RFT Metrics. Reports should be produced regularly and any trends identified. It is good practice that RFT Metrics commence from the contract let date in order to measure suppliers performance in relation to the submission of required contract documents, such as

Quality Plans, Inspection and Test Plans, Procedures, Qualifications and any other documents required by the contract.

Plant and Equipment Schedule
The Delivery Organisation's Plant and Equipment Schedule should include a full listing of the Contract Plant and Equipment, the related Quality Grading, individual PUWER assessment, and the Safety Function class, Safety Function Class data can be acquired from the Licensee.

Plant and Equipment Delivery Schedule
The Delivery Organisation's Plant and Equipment Delivery Schedule should depict the full list of required plant and equipment and the scheduled delivery dates. It is essential that this schedule is both accurate and well maintained so that the Delivery Organisations Resource plan, budget and the overall Inspection and Test Plan can be accurately developed. For Contracts that are in the Design Phase, regardless if the Design is being delivered in house or is Design sub-contracted, a Design Deliverable Schedule is an essential tool; again this enables the Delivery Organisation to manage the Engineering Resource and budget plan.

Project Records Schedule
Major Projects should utilise a specific Records Schedule, whilst a portfolio of projects would utilise a joint Records Schedule, the Records Schedule should identify as a minimum:

- All types of documents and records to be utilised on the project.
- The Retention Period required for particular records.
- Document and Record Titles and individual document/record reference numbers
- Document and Record Owners.
- Document and Record Approvers.
- The media in which the Document is to be supplied i.e. Original or Verified Copy.

Project Plant and Equipment Inspection Test Plan
The Delivery Organisation's Master Inspection and Test Plan should be written in accordance with the Plant and Equipment Delivery Schedule and identify specific resource requirements and inspection and test requirements allocated to individual items of Plant and Equipment, including Factory Acceptance and Functional test requirements. The Master Inspection and Test plan should be used to capture the Plant and Equipment Schedule and Delivery Schedule.

Site Licence Control and Supervision Model
All Delivery Organisation Appointments should be listed on the Site Licence Condition Control and Supervision Model; other required details are contact details, relevant qualifications and Training requirements

Project Training Matrix
The Delivery Organisation is responsible for developing, implementing and maintaining a Project Specific Training Matrix, the matrix should identify all Contract personnel and the level of training required for individuals against defined roles. A Major Project will require a standalone matrix, where a portfolio of projects will require an overall matrix.

Suitably Qualified and Experienced Personnel (SQEP) Packages
The Delivery Organisation is responsible for developing, implementing and maintaining an agreed suite of SQEP Packages, for each member of the team, as a minimum the pack should contain the incumbents CV, training records, professional qualifications and associated Role Specification.

Quality Plans (Design, Construction, Procurement and Quality Control, Project Controls and Commissioning)
The Quality Plan should contain the set of sequential activities related to managing the Delivery Organisation activities for each project discipline. The activities need to depict a link to the relevant procedures; the person responsible for delivery and the documented evidence that demonstrates satisfactory completion and the appropriate hold points, the Plan should also contain sign off boxes for Delivery Organisation against each activity.

Risk Management Plan and Framework
The Risk Plan should contain set of sequential activities related to managing the Delivery Organisation Risk activities. The activities need to depict a link to the relevant procedures; the person responsible for delivery and the documented evidence that demonstrates satisfactory completion and the appropriate hold points, the Plan should also contain sign off boxes for Delivery Organisation against each activity. In addition the Delivery Organisation need to develop and maintain a Project Risk Register, the register should identify all relevant risks and grade them in order of significance. The register should be reviewed and maintained on a frequent basis in order to track progress and establish appropriate risk mitigation.

Manufacturing/Construction contractor Questionnaire
As part of the Supply Chain Selection Process it is recommended that the Delivery Organisation utilises a Manufacturing contractor Questionnaire, this questionnaire should contain questions that are focussed upon defining the capabilities of manufacturing, fabrication and construction contractors.

Supply Chain Specification Dissemination Strategy
The Delivery Organisation has the responsibility to ensure that specified requirements are accurately disseminated throughout the supply chain. Therefore it is a necessity that the Delivery Organisation has a clear written Dissemination Strategy, this may be a section of the QA/QC Strategy.

The strategy should include Nuclear Safety and Specification awareness briefings as a minimum. A Specification Awareness briefing requirement must be risk based, if the sub-contractor is a new to nuclear or has not been involved in nuclear work in the last three years, a specification awareness brief is required. The brief should take the contractor through each clause of the specification to ensure they have full understanding of the requirements.

In addition the Delivery Organisation should adopt the use of Opening up meetings with all key suppliers. Surveillances should be carried out to ensure that specified requirements are successfully disseminated. In addition all Licensee and contractor Project induction courses should include the appropriate level of Nuclear Safety and Specification Awareness material.

Specification Awareness material that is included in the Project and Contractor inductions must be relevant to the scope of work being undertaken on the project.

Plant and Equipment/Product Release Procedure
The Delivery Organisation is responsible for releasing Plant and Equipment or products from a manufacturer's works, the Delivery organisation should utilise their QC Inspection Group to manage this process. The process should utilise an in process approach where the plant, equipment and associated Life Time Records are inspected and reviewed in accordance with the action codes within the relevant Inspection and Test Plan. Release of Plant, Equipment or Products should only be carried out by SQEP personnel, Plant and Equipment should not be released without a set of verified Life Time Records and a Release Certificate.

Goods Inward Inspection Procedure
The Goods Inward Inspection Procedure should be established on the Delivery Organisation's site or facility to receive Plant, Equipment and Consumables, the process must ensure that all Goods are received with a copy of the relevant Release Certificate, if there are any reservations against the delivered goods, this should be annotated onto the Release Certificate. In addition Goods should be accompanied by a manufacturer's Delivery note and should be checked for quantities and transport damage. Goods and associated certification should be booked into an approved storage or lay down area and allocated with a unique identification number. Any goods that are found to be damaged or considered to be outside of specified requirements should be immediately quarantined.

Project Quality Metrics
In order to demonstrate the effectiveness of project performance it is essential that the project implements a suite of appropriate measures/metrics. Looking to learn from best practice the supply chain metrics should focus on Right First Time performance, this metric is based upon the number of inspections carried out versus the number of issues identified, very simple maths divide the number of recorded issues by the number of recorded inspections and multiply by 100, will deliver a Right First Time Average.

Typically the key Right First Time metrics are:

Failed to meet specification	Electrical and Instrumentation	Civils
HVAC	Painting and Coating	Welding, Visual and NDT
Dimensional/Tolerance	Incorrect material	Damage
Surface finish	Contamination	Storage and handling
Traceability	Supplier integrity	Certification
Process	Unapproved Quality Plans	Procedural shortfalls
Qualification shortfalls	Life Time Record issues	Drawing discrepancy
Design discrepancy	People and Equipment	Dissemination of requirement issues
Resource shortfalls	Equipment shortfalls	SQEP issues

This not an exhaustive list, however learning has shown that this is a very useful suite of measures because they:
- tell projects what and where their issues are
- help the projects to focus their efforts on problem areas
- identify where there is a long history of high performance
- show how well contractors are managing their supply chain

If managed correctly the metrics and associated learning can be used to significantly enhance project and supply chain performance.

In addition to the above metrics projects should be measuring other key areas:
- Delivery to Cost Estimate.
- Delivery to Programme/Schedule.
- Health and Safety Delivery.
- Design outputs.
- Quality of Handover packages from Construction to Commissioning.
- Number of Outstanding Construction and Commissioning reservations and tests.
- Audit Management performance.

The amount and level of metrics applied on projects can be many, however it is essential that these metrics are based on risk and that they bring real value to the project. There is one thing for certain if you are not measuring you do not know where you are and you cannot improve.

Non conformance procedure
The Delivery Organisation is responsible for ensuring that a Non conformance procedure is implemented and maintained both in the supply chain and on the Licensed site, the process must describe the arrangements for managing non conformances including:
- Non –conformance documentation i.e. Defect Notes and Concessions
- Quarantine arrangements
- Corrective Action, Rework, Re-grade or Scrapping arrangements

Calibration process
The Delivery Organisation is responsible for establishing and maintaining an appropriate Calibration process, all tools and equipment that require calibration should be uniquely marked

and registered and be accompanied with the relevant calibration certification. Contractor Calibration arrangements must be assessed and accepted by the Licensee.

Life Time Record Strategy
A standalone Major Project should utilise a separate Life Time Record Strategy, where a portfolio of projects could utilise a single strategy. It is essential that Life Time Record requirements are developed in accordance with the relevant Manufacturing specifications and to the associated contract specified requirements. The strategy needs to define the levels of Life Time Records required for each contract discipline and how the Life Time Records are to be presented as complete.

Efficiency needs to be a key focus point, the use of Life Time Record Indexes within the individual Life Time Record is the most efficient method, this relates to indexes identifying materials, consumables, Weld Procedures, NDT procedures, Test procedures, Welder Qualifications, NDT Qualifications and Calibration certificates, whilst the original certification is held in a Master File. This practice can deliver major cost and schedule benefits.

Standard Life Time Record Indexes
The Delivery Organisation should clearly identify the Life Time Record requirements for each Project and contract or Purchase Order, the use of Standard Life Time Record Indexes is essential so that the requirements are effectively disseminated into the supply chain, additionally certain documents that are not required in a Life Time Record pack can be identified on the front standard index page by marking a cross in the adjacent column.

Verification procedure
The Delivery Organisation is responsible for ensuring that a Verification process is implemented and maintained in relation to Design outputs, releasing and installing Plant and Equipment, Life Time Records and Commissioning. The process should define a clear set of deliverables in relation to the levels of Site Licence Holder and supply chain verification associated to specific work packages and identify the level of certification that will accompany the design outputs, plant and equipment, product or commissioning output.

Document Control and Records Management Procedure
The Delivery Organisation is responsible for ensuring that a Document Control and Records Management Procedure is implemented and maintained. As a minimum the Delivery organisation will implement and maintain a Records Schedule that identifies:

- All types of documents and records to be utilised on the project.
- The Retention Period required for particular records.
- Document and Record Titles and individual document/record reference number.
- Document and Record Owners.
- Document and Record Approvers.
- The media in which the Document is to be supplied i.e. Original or Verified Copy.

Inspection and Test Plans (ITP's)
Inspection and Test Plans, should be discipline specific and relate to the build and associated Inspection and Test hold points to deliver the scope to the specified requirements. The benefit of using this system is to break the work down into manageable packages and to encourage concurrent Life Time Record compilation and completion to individual work packs.

Internally generated Life Time Records
The Delivery Organisation's internal Life Time Record should be generated in accordance with the associated Specifications, Quality Plan and or Inspection and Test Plan, Life Time records must be generated concurrent with design, manufacture, fabrication, construction and commissioning.

Purchase Orders or specific Sub-contracts
The Delivery Organisation's Purchase Orders or specific sub-contracts, are the general contract documents generated by the Delivery Organisation to their supply chain, it is essential that the

Purchase Orders contain the relevant information in order to accurately define the specified Quality requirements, as a minimum the PO or specific Sub-contract should contain:

- Quality Grade
- Specification
- Drawings
- Material Type
- Quantity
- Certification requirements
- Inspection requirements, at vendor and or on delivery
- Functional testing requirements, at vendor and or on delivery
- Any special requirements such as packing, extra testing etc.

Supply Chain Inspection and Test Plans
The Delivery Organisation should ensure that all suppliers generate Inspection and Test Plans, that define the inspection and test activities and associated hold points to deliver a specified work scope. The benefit of using this system is to break the work down into manageable packages and to encourage concurrent LTR compilation and completion to individual work packs. ITP's should be discipline specific.

Inspection Reports
The Delivery Organisation is responsible for generating accurate inspection reports to capture all inspection results, including civil, electrical and instrumentation, mechanical build and fabrication. The gathered data can then be utilised to deliver Right First Time metrics and associated trends.

Specified Storage Area
The Delivery Organisation is responsible for establishing a specified storage area, on the Licensed site. The storage area should satisfy the relevant requirements of the associated Licensee's Specifications and must be maintained to agreed standards. The specified storage area should contain a secure quarantine area.

4.4 Nuclear Safety Focus in Projects

Introduction
The purpose of this section is to make all levels of Licensee and Supply Chain organisations aware of their responsibilities related to maintaining Nuclear Safety within Projects. The various disciplines within projects influence Nuclear Safety in their daily activities.

What is Nuclear Safety?
Nuclear Safety in operations is about keeping nuclear materials controlled and contained at all times, the consequences of a Nuclear Safety event are so devastating that we must ensure that it is virtually impossible for an event to occur. Within Decommissioning Nuclear Projects there may be a need to deal with legacy nuclear waste/materials, all planning and associated arrangements must make the appropriate considerations to safeguard the project, the plant, the business and the community.

Nuclear Safety = Realising the Design Intent through the Quality of Workmanship.

A lot of new build projects are adjacent to active facilities, so the bottom line is, each phase of a project must recognise and establish the appropriate Nuclear Safety arrangements such that nuclear safety is preserved and project activities do not prejudicially affect the safety of ongoing operations.

WANO/INPO member sites utilise Nuclear Safety arrangements in order to minimise the potential of a Nuclear Safety event, these arrangements focus upon the 4 C's:

Chemistry Cooling Criticality Containment

All activities carried out in Design, Construction, Manufacturing, Fabrication, Commissioning, Operations and Decommissioning phases are all focussed on safeguarding the 4 C's.

Top Down Commitment
The number one objective of any Licensee has to be to establish a suite of robust Nuclear Safety arrangements within the organisation and their Supply Chain. The Licensee's Executive has to be 100% committed to delivering this objective and the Licensee must be able to demonstrate how the Nuclear Safety Thread has been both recognised and established in each phase of their project arrangements.

Nuclear Safety in Design = Getting it Right from the start by creating a positive Nuclear Safety Culture

Nuclear Safety within the Licensee's organisation and the Supply Chain is about understanding and adhering to existing procedures and related technical standards and specifications as they are focussed on safeguarding the 4C's, in short:

Nuclear Safety in Manufacturing = Realising the Design intent through the Quality of Workmanship. In plain English this is about designing and manufacturing all plant and equipment to the agreed specified requirements.

It is about realising the **Design Intent** in **all phases of the Project**.

The Challenge of balancing the demands of Quality, Cost and Schedule
It is at this point that we must clearly understand the interaction between Quality, Cost and Schedule. This interaction will vary, dependant upon the complexity and Quality Grade of the plant and equipment. If we fail to recognise this interaction in design, the pressure **will always** come in the construction, manufacturing or installation phase, and the focus will invariably shift to Cost and Schedule at the expense of Quality. This is not acceptable because **Quality = Nuclear Safety**.

The key to avoiding this dilemma is to provide **Clear Specification and Acceptance Criteria** not wishy-washy statements like "Workmanlike finish" or "Testing to be agreed with the contractor"

Typical areas that designers can improve are providing a structured Engineering Schedule, including Safety Function Class, Quality Grade, Licensee Design inputs and Long Lead Item requirements. Technical Specifications should include clear acceptance criteria, clear NDT requirements and clear inspection and test requirements.

So whether you are a Tier 1 Licensee employee or part of the Tier 2 or 3 supply chain you should be challenging when considering your own organisation and your supply chain:

- Do we all really understand the functional specification?
- Are the Design, Engineering Schedule and Technical Specifications absolutely clear?
- Do you have a clear dissemination strategy?
- What oversight arrangements have you established?
- How many reviews do you need to get involved in?
- What do you need to focus on in manufacturing and construction?

...to ensure that the nuclear safety objectives are achieved.

Nuclear Safety in Construction and Manufacturing
Nuclear Safety in construction is all about realising the design intent and the key to that is the Quality of Workmanship to the specified requirements. *'It is important for the assumptions made by the designer, incorporated within the justification of the design within a safety case, to be properly carried through the construction phase. The final construction of the works is thus as much a part of the safety case as the design'* – from ONR Technical Assessment Guide 76, Construction Assurance

Intelligent Customer (IC) role and Contractor assessment
"As an intelligent customer, in the context of nuclear safety, the management of the facility should know what is required, should fully understand the need for a Contractor's services, should specify requirements, should supervise the work and should technically review the output before, during and after implementation. The concept of intelligent customer relates to the attributes of an organisation rather than the capabilities of individual post holders"

"should fully understand the need for a Contractor's services" from ONR Technical Assessment Guide 49 Licensee use of contractors and intelligent customer capability

The Delivery organisation should ascertain contractor's actual capability, go out and see it with your own eyes. Assure their comprehension of requirements. Ask for samples. Benefit – we focus on known capability at the time of tender.

The IC needs to consider how to **supervise** the contractor. Use the contract review process regularly to ensure initial and ongoing understanding by contractors of the requirements. On which items, how many, how often, on which items? Include this detail up-front in Quality Plans. Use pre-job briefs. Go out and talk to the operatives, make sure those involved understand. Keep an eye on the compilation of the Life Time Records, it's too late when the items are delivered to find that they are inadequate. The deliverables are the kit and the Life Time Records, a 50/50 split, so focus 50% of the effort on delivering the Life Time Records.

Project Nuclear Safety Culture
This isn't a specification, this is about culture and how everyone, Project Manager and the whole project team must behave as nuclear professionals. The responsibility and authority for Nuclear Safety must be well defined and clearly understood and the Project Lead Team must reinforce Nuclear Safety on a regular basis.

Supervisor selection must consider candidates ability needed to build a strong Nuclear Safety culture. Supervisors lead in the field via coaching, mentoring & reinforcing standards to get the best out of the workforce. Supervisors recognise that production goals if not properly communicated can send mixed signals. Supervisors must support and encourage conservative questioning and decision making.

The culture should allow individuals to raise concerns without fear and demonstrate a questioning attitude by challenging assumptions, investigating anomalies and considering adverse consequences. The job does not proceed in the face of uncertainty.

4.5 Independent Nuclear Safety Assessment (INSA)

INSA is an assurance function whose remit is to provide an independent professional opinion on the adequacy of plant and process to safely deliver the design intent in line with relevant nuclear industry standards and safety case methodologies.

INSA is normally undertaken on higher consequence safety case documentation prior to submission for acceptance at internal reviews at a Management Safety Committee or Nuclear Safety Committee. The expectation is that INSA comments will be adequately addressed by the project during the course of the INSA review. ONR take considered account of the demonstration of satisfactory INSA in undertaking their own assessments. References are found in their Technical Assessment Guides eg 005 ALARP, 050 Periodic Safety Review and 080 Nuclear Safety Advice and Challenge.

The specification will target key aspects aimed at confirming the adequacy of the design to be fault tolerant in relation to the intended process. The review should aim to identify any circumstances where there is a fault condition that could lead to a dangerous situation occurring (for example the design has not recognised the potential for flammable gases in a vessel ullage and the potential for an explosion to occur).

It is important that an INSA assessor is suitably qualified and experienced (SQEP) and **independent** - they must not be involved in the design or production of the safety case or have any ownership of the final output.

INSA focuses on issues that could undermine the successful achievement of the design intent whether that be inadequate safety assessment or in the hardware itself (pipes vessels shielding etc). There is one consistent element, that is, potential for failures can lie in any aspect of design/manufacture/operation so vigilance is needed at all stages and INSA provide one of the reassurances of adequate defence in depth.

4.6 Nuclear Safety Committees (NSC)

It is a requirement of the Site Licence Condition 3 that nuclear sites have a Nuclear Safety Committee which includes independent members. One of the key roles of the committee is to understand and challenge safety proposals to ensure that they are sound before they are referred for ONR or other regulatory approval.

Safety proposals are categorised as to their potential impact, only those with high impact are routinely considered by the Nuclear Safety Committee, major projects will be in this category so the NSC provides independent advice to ensure the technical soundness of the project. INSA reviews are made available to the NSC.

4.7 Integrated Planning

In order to maximise the integrated planning process it is advisable to start with an Interactive Planning Workshop (IPW). The IPW should stress the importance of a collaborative effort which is good industry practice. The IPW process should be initiated with a 'Project Kick-off Meeting' conducted by the Project Manager. The objective of this meeting should be to confirm the scope of work, objectives, strategies, order of costs and key project milestones; along with any potential 'unique contractual requirements'. The date and location for the IPW should be set during the Project kick-off meeting.

The timing of the IPW will vary depending on the type and complexity of the project but the workshop should bring the Integrated Project Team together to contribute in the Programme and Project Execution Plan development process. This can be done by utilising for example a 'wall schedule and note-stickers' to identify key activity logic and constraints (not necessarily against a timescale at this stage).

The Project Control Manager and/or Planner should lead the discussion on the Programme, its logic, activities, indicative durations, interface points and external constraints e.g. ONR approvals etc. Interaction of all Integrated Project Team members is the key element of success for the IPW process. A Key Milestone Programme will help to drive to achieve identified dates within the Project Lifetime. The meeting encourages participation and 'buy-in' by the Integrated Project Team. It also establishes communication channels that lead to a better understanding of the project's scope of work, key project milestones, overall project goals, execution strategies, and objectives. The IPW forms the foundation for subsequent development of the detailed timescale Critical Path Method Schedule and ultimately establishes the critical path of the project.

The above process describes how to bring the integrated working approach within the SLH Project team. On many Major Build Nuclear Projects the same approach can be used once the tier two contractors have been engaged. There is without doubt a national shortage of experienced Nuclear Project personnel, both within the Licensee and Supply Chain communities, therefore sharing the risk and the deliverables as an integrated team makes sense. This approach without doubt enhances overall understanding of requirements and project deliverables and if properly structured removes the man to man marking element that was prevalent on past Major Build Nuclear Projects. For this approach to work, the "mutual trust" element of contracts has to be embedded and underpinned by clear roles and responsibilities.

4.8 Key Learning from Nuclear Projects – why they fail

Nuclear projects can be complex, expensive and take several years from the original business case being made through to handover to operations or for decommissioning projects site clearance. Experience has shown that the more rigorous the up-front planning the more likely that the project will succeed. The common pitfalls are:

- Unrealistic Programmes
- Lack of front end investment into assessing supplier's capabilities
- Out of date Licensee Specifications
- Inaccurate of Works Information
- Incomplete design/design amendments
- Contractors failing to understand the extent of and manage their own supply chain
- Failure to clearly disseminate Specified Requirements through multiple tiers of the supply chain
- Lack of contractor competent resources, Work Package Managers, Project Management, Quality Control Inspectors and Subject Matter Experts in relation to welding and Non Destructive Testing
- Focus on cost and schedule at the expense of Product Quality
- Main contractors failing to understand the complexity of the fabrication processes.
- Unreasonable pressure placed on sub-contractors as a result of unrealistic programmes and lack of understanding in relation to complexity of build and specified requirements
- Supply chain failure to deliver Nuclear Grade materials which are much more difficult to produce, test and certify
- Failure to hold the contractor to account for poor performance

Chapter 5

Operational Management

CONTENTS

Editor: **Mike Underwood**
Contributors: **Michael Jones, Alec Boughey, Iain McNair, Richard Hibbert, Vaughan Rees**

5.1 Introduction

The "operational" phase is the period from the receipt into a plant or onto a site of bulk quantities of nuclear materials, through many years of operations during which it is fulfilling its primary function (nuclear fuel fabrication; electricity generation; reprocessing fuel; propulsion of a submarine etc) through to Post –Operational Clear Out (POCO) when all bulk quantities of nuclear materials are removed.

The key objective during the operations phase is the preservation of Nuclear Safety and this is achieved by striving for stability of configuration and control of activities so as to remain bounded by the defined requirements drawn from the safety case. A conservative questioning culture is actively encouraged. Any engineering or configuration changes are subject to great scrutiny by consideration through a Modifications (or "Mods") process which is sometimes perceived as bureaucratic but essentially exists to ensure that Safety is not negatively affected by the change.

Sites in their operational phase have well developed Management Systems which are clearly owned by the various functional groups on site with oversight and often document control responsibilities residing with the Quality Team. The Quality Team which normally comprises a Team Leader and a small number of Quality Engineers will typically audit all functions including key contractors; manage the document control and records function; advise project teams on the preparation of Quality Plans; endorse documents at key process stages; facilitate the Management of Change process and liaise with external auditors from regulatory bodies and customers. Often the Quality Team reports to a site leadership member who has responsibility also for Health, Safety, Environment and sometimes Security. On larger sites these roles may be more differentiated e.g. a team of external facing Supplier Surveillance Quality Engineers may exist reporting to the Projects or Commercial functions.

Operating NPPs and their operating companies are generally members of WANO or INPO (US sites); these organisations were set up post-Chernobyl and Three-Mile Island. Members share learning and undertake Peer Reviews to maintain and improve operational performance. The WANO Performance Objectives and Criteria (known in the industry as the as "WANO POs and Cs") are available to download from the WANO website. The first tranche of POs and Cs correspond to nuclear station organisational departments: Organisational Effectiveness Functions; Operations Functions; Maintenance Functions; Engineering Support Functions; etc. The second tranche address cross functional characteristics of an organisation: Safety Culture; Human Performance; Self-Evaluation (Learning Organisation); Industrial Safety; Plant Status and Configuration Control; Work Management; Equipment Performance and Condition.

Those working in the quality function at an operating nuclear site need to be familiar in detail with their own operational arrangements but will benefit greatly from familiarizing themselves with the WANO expectations as expressed in these POs and Cs. Another key role for Quality professionals is the management of the supply chain particularly during engineering projects and outages (when the facility shuts down for typically 2 or 3 months and maintenance which is not possible whilst operating is undertaken) and also for the supply and acceptability of consumables ranging from fuel to chemicals. Supply Chain management is dealt with in NQK Chapter 6.

5.2 People Issues, SQEP, DAP, Control and Supervision

Competence

When a plant enters its operational phase the "engineering" is essentially complete with the plant designed and built to specification with appropriate monitoring systems, interlocks, safety warning systems etc. in place and all these corresponding to the requirements of the safety case. The key challenge before entering the operational phase is the establishment of a compliment of competent staff to run and maintain the plant efficiently and effectively within the requirements coming from the safety case.

The issue of staff competence is not of course unique to the operational phase of a nuclear plant it is arguably more important during the conception, design and development but during these phases there is ample time for reflection, formal decision review etc. From a regulatory standpoint more focus is placed on this issue in the operational phase particularly in the context of those individuals involved in nuclear operations command and control and with hands on roles such as Shift Managers and Control Room desk operators.

Training and competence management is subject to LC10 and should be subject to a systematic approach with a structured process for job analysis; training program development and implementation; formal assessment and competence evaluation and for this to be refreshed and re-evaluated periodically. In short from a quality management perspective it is expected that Site Licence Companies (SLCs) apply the Plan-do-check-act cycle to its people systems and have a robust competency management process in place which is integral with the overall management system. It may be argued that this is no different from the general ISO 9000 expectation but for some more critical roles a more detailed, in depth response is required:

Nuclear safety culture

The topic of nuclear safety culture is covered in more detail in Chapter 3 Leadership and Management as it is only by the example and attitudes of top level nuclear executives and their management teams that the environment exists for those at the supervisor, plant operator, clerical and all the support functions to behave in a professional, conservative, "ask if unsure", nuclear safety compliant way.

Most sites have a document or set of training slides which address the topic of "Standards and Expectations" which address the discipline needed around nuclear safety, radiological controls, plant access, compliance, risk assessment, permit gaining etc. "Standards and Expectations" are used to underpin Induction Courses which indoctrinate staff when they join the organization and contractors when they come on site.

Quality professionals will be among the first to detect that the wrong attitudes are present and must not hesitate to flag this up however unpopular it may be. Signs of a potential problem may in themselves appear unrelated to nuclear safely, for example evidence of graffiti is unacceptable and indicative of the presence of individuals who have the wrong attitude. Much worse is evidence of bullying by managers or peer pressure to cut corners. The staff in nuclear installations are all human and normal failings exist, it is very important that aberrant behaviour is clearly known to be unacceptable and outside the expected norms.

In recent years a nuclear industry Senior Manager was sacked from his post for chewing gum. Why? Because he was observed chewing in a contaminated area where eating and drinking is prohibited due to the possibility of ingesting radioactive contamination. In itself the chewing of gum in a prohibited area may seem innocuous and in truth it was probably low risk of being injurious to the Manager – **the issue is the poor example set by a Leader to his staff.**

DAPs, SQEPs and other appointments

Newcomers to nuclear will hear use of words and expressions such as SQEPness, "Are you fully SQEPed?" SQEP requirements, etc. **SQEP – Suitably Qualified and Experienced Person** derives from LC12 (Duly authorised and other suitably qualified and experienced persons) and simply means that someone's role could have an impact on nuclear safety and they must be judged to be competent to undertake their assigned tasks. Similarly from LC12 **DAP – Duly Authorised Person** apples to those with supervisory

or managerial control of operational staff who could affect safety. DAPs and SQEPs receive specific documented formal training. SLC's maintain a register of DAPs, who are usually evaluated by a DAP Board and receive a certificate of appointment.

It varies from SLC to SLC but other appointed roles are usually created specifically to address nuclear safety issues such as Intelligent Customer roles; Design Authority roles; and other Expert roles. The benefit of doing this is to ring-fence "critical" roles for which special additional competency arrangements are applied.

Human Factors
The recent Japanese investigation into the Fukushima accident established that Human Factors contributed substantially to the problems resulting from the event which of course was initiated by a natural disaster. The most damning human factor was the inertia between the site operators and the regulators leading to failure to implement a response to a recognized level of natural event.

Human Factors, including ergonomics is a huge topic and a specialist subject in its own right (often employing specialist psychologists), it should be integrated with the plant design process so that the expectations on humans i.e. the machine: operator interfaces and the human response to faults and emergency situations etc are all considered in advance. ONR's T/AST/058 concentrates on this aspect of HF and its importance in establishing a comprehensive Safety Case including a "Concept of Operation" which includes issues such as normal and fault conditions; command and control regime; working environment and staffing levels.

Human Performance
Human Performance Tools and Techniques are used to remind operations staff of their fallibility and instill the use of good practice. These tools and techniques seek to re-enforce quality practices and processes so the Human Performance co-coordinator role sometimes may be taken by a quality professional. Human Performance Tools and Techniques typically include the following:

- Pre job briefings
- Post job reviews
- Self checking and STAR (Stop, think, act, review)
- Peer-checking
- Independent verification
- Procedure use, Adherence and Placekeeping
- Task Observation and Coaching
- Questioning Attitude – STOP WHEN UNSURE
- Use of Operating Experience
- Communication Techniques

Organisational Capability, Baselines and Management of Change (MoC)
Following some issues with sites changing their organizational structure and not retaining sufficient competency to adequately manage their sites, the NII in the 1990s introduced LC36. This requires SLC's to carefully consider organizational change to ensure that the change is not prejudicial to Nuclear Safety. Often the process is facilitated by the Quality function. Typically the basis of the process is:

- Establish a Baseline statement of the organizational structure for a given operational state and justify it
- Have a system for reviewing changes to the organizational structure to consider the impact on safety and approve them before the change occurs. Usually called the Management of Change (MoC) process.

- Periodically (usually incorporated in the Management Review process) review the totality of changes to confirm no cumulative impact

Reference Material:
T/INS/026 LC 26 - Control and supervision of operations PDF
T/AST/027 Training and assuring personnel competence PDF – includes DAPs and SQEPs
T/AST/058 Human factors integration PDF
T/AST/061 Staffing levels and task organisation PDF
T/AST/048 Organisational capability PDF

5.3 Radiological Control and Criticality Safety

Radiological Control
Clearly one of the major differences between the nuclear industry and others is the potential for the exposure of workers or the general public to ionising radiation and this is subject to the Ionising Radiations Regulations. Ionising radiation occurs as electromagnetic rays (e.g. X-rays and gamma rays) or particles (e.g. alpha and beta particles). People can be exposed externally to radiation or internally, by inhaling or ingesting radioactive substances. Wounds that become contaminated by radioactive material can also cause radioactive exposure.

The Radiological Control function (commonly called Health Physics) designs the processes and procedures used to ensure that radiation exposure is minimized (ALARP "as low as reasonably practicable") and meets regulatory limits and expectations. There are three principle methods of controlling exposure to radiation are by optimising the duration or **time** of exposure; controlling the **distance** between the source of the radiation and people (inverse-square law); the introduction of **shielding** which absorbs or reflects the radiation.

The main legal requirements enforced by HSE are detailed in the ACOP: Work with ionising radiation: Ionising Radiations Regulations 1999 Approved code of practice and guidance.

Within Health Physics there is a specific authorised role known as "Radiation Protection Adviser" or RPA which has the responsibility for providing site management with appropriate radiological advice. See HSE Guidance on RPA core competence.

Methods of categorising areas of a site for exposure levels to radiation or contamination vary between SLCs. For example areas are sometimes categorised C1, C2, C3, C4 or R1, R2, R3 or R4. C standing for Contamination i.e. there is the potential for workers to be exposed to radioactive dust or other contamination which could gather on clothing or exposed skin or be ingested to the body. R stands for Radiation i.e. an area giving a level of exposure to radiation. The number 1 to 4 indicates the degree - 1 low, 4 high. Workers whilst in such areas and when entering or exiting are required to be very disciplined and follow procedures to ensure their safety and others, avoiding unnecessary radiation exposure and preventing carry-over of contamination into clean areas.

Areas are demarcated by signage and often by physical barriers (for example 24 inch high step over barriers or electronically activated gates on entry and full body monitors on exit) for which there are strict protocols (known as "Local Rules") as to the means of entrance and exit including any change of clothing, showering, hand washing etc as required either side of the barrier.

In "C" areas protective measures may include the wearing of coveralls, hats, overshoes, sometimes complete changes of clothing, the wearing of dust masks or in the extreme breathing of line-fed or cylinder air supplies.

Workers in "C" zones may be required to give urine or feces samples to assess levels of ingested material. Air quality in C areas is often sampled by air monitors to ensure contamination levels remain at acceptable levels.

All "C" areas are also "R" areas however there are clean "R" areas where there may be potential for radiation exposure but all nuclear materials are contained so that no contamination can happen but there is still exposure to radiation. Protection in "R" areas is by such measures as shielding, protective clothing and gloves and by engineered workstations such as Glove Boxes.

Levels of radiation exposure are recorded on a personally issued dosimeter, common types are a "Film Badge" held and used for a period of time by the individual or Electronic Personal Dosimeter (EPD) which are used and read for each plant visit. Staff who regularly work in "C" or "R" areas are "Classified Radiation Workers" with a requirement for a Dose Record to be maintained and regular medical surveillance.

Supervisors managing staff working in "C" or "R" areas have special responsibilities with respect to radiological protection (they are known as Radiation Protection Supervisors, RPS). An RPS will receive feedback as to his staff's radiation exposure.

Special arrangements are usually established for visitors which due to the fact that they will be on site for a shorter period and will not normally be directly contacting nuclear materials are relaxed. However contractors whose work is intrusive will be subject to a "Scheme of Work", approved by an RPA and containing specific controls. Companies that manage Classified Radiation Workers who regularly work on different nuclear sites will need to supply a Pass Book on which doses collected during each period of exposure are recorded.

Health Physics establish routine area and personnel monitoring systems for radiation and contamination to track exposure levels. Sites establish their own local action limits which are considerably in board of those set by the HSE: HSE Dose exposure limits

As well as worker protection from radiation Health Physics are involved in the release of materials that may have become activated or contaminated between areas on site or for release from the site to another location. UK guidance is provided in a Nuclear Industry Code of Practice (NiCOP) Clearance and Radiological Sentencing: Principles, Processes and Practices.

Criticality Safety

The term "Criticality Safety" essentially refers to those arrangements that are in place to avoid an unplanned criticality event (when there is enough mass of fissile material with the correct conditions to start a nuclear chain reaction). Clearly a reactor relies on "going critical" and thereafter controlling this reaction to harness heat and generate electricity. However in uranium and plutonium processing plants (or whilst handling or transporting nuclear fuel assemblies) the concern is inadvertently establishing these conditions. A criticality or "blue flash" incident gives a fatal radiation dose to anyone nearby. Typical controls that exist to prevent a criticality incident are:

- Designing plant and equipment so that their geometry is such that a critical mass of material or solutions isn't possible
- Inclusion of neutron absorbing materials into plant and equipment

And less desirable as they require Operating Rules to be in place and strict plant operator compliance:

- Limiting the presence of moderating materials (such as water and carbon)
- Limiting the allowed mass or concentration of solutions

Plants in which a Criticality Incident is conceivable have a Criticality Incident Detection and Alarm System (CIDAS) installed that continually clicks to indicate that it is energized and screeches at very high volume if a criticality event occurs, prompting staff to evacuate at speed.

Reference Material
T/AST/018 Criticality Warning Systems PDF
T/AST/041 Criticality Safety

5.4 Asset Management

This chapter describes Asset Management as it is normally found to exist in nuclear sites driven predominantly by licence conditions. In recent years utilities and public bodies have begun to adopt a management system standard, PAS 55, this is a risk based standard which leads to holistic management of an organisation's assets. EDF Nuclear Generation have adopted use of the standard and reported benefits recently: EDF PAS implementation. The Nuclear Decommissioning Authority(NDA) have also utilised PAS 55 to allow the SLC's to benchmark themselves in promoting good business practice in identifying asset related risks which have an impact on the overall organizational strategic plan. The use of PAS 55 helps to integrate the safety and engineering aspects of Asset Management with its business, investment and strategic objectives and allows the business to have a fully integrated asset management system which promotes a top down/bottom up approach to how its key objectives and milestones align to the strategic plan.

Asset Management is defined as:

"systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan" – PAS 55

A new ISO 55000 series is due to launched next year which will supersede PAS 55: 2008 Issue 2

Plant maintenance

LC 28 requires the preparation of a "Plant Maintenance Schedule" which specifically identifies the examination, inspection, maintenance and testing necessary to meet the requirement of the Safety case. This Maintenance Schedule is the hub of the maintenance programme and subject to regular scrutiny to ensure continual compliance.

On operating nuclear sites there are established Maintenance Teams usually working 24/7 on shifts. The Maintenance function makes extensive use of the Supply Chain to deliver specialist support. Maintenance workload is controlled and planned using a maintenance database. For example the database used by former Nuclear Electric sites is called "Passport" (which should not be confused with the recently created "UK Nuclear Passport" system which is planned to manage nuclear worker competency). Passport is principally used for maintenance planning but has additional functionality such as Permit and Document Control.

The maintenance database will control all maintenance activity which is required for regulatory (nuclear, radiological, environmental, industrial safety) or efficiency reasons. However the subset of plant and equipment directly related to nuclear safety is given special attention. Some pieces of kit are given a special nuclear safety status as "Safety Mechanism" or "Safety Related Item" (ref LC 27). They are mentioned in the Safety Case and breech of their maintenance conditions is very serious and would be considered to be a "Nuclear incident" which would have to be reported to ONR.

Quality staff are involved in the design and establishment of systems to support maintenance as well as auditing work practices and records.

Modification management
LC 22 entitled "Modification or experiment on existing plant" requires that the licensee *"shall make and implement adequate arrangements to control any modification or experiment carried out on any part of the existing plant or processes which may affect safety."*

A Modification, often shortened to "Mod", "*covers any alteration to buildings, plants, operations processes or safety cases and includes any replacement, refurbishment or repairs to existing buildings, plants or processes" (ref LC1(1))* .
Mods are closely controlled to ensure that the nuclear safety case is not compromised by the change. They are usually "proposed" by a member of the site engineering or operations team and subject to a detailed approval process which extends beyond the nuclear safety issue to include reviews by environmentalists, health physicists; industrial safety engineers; fire officers; security managers etc. and culminates in the final approval to proceed with the modification by the designated authority.

Modifications are categorised as to their potential impact on nuclear safety, usually from 1 to 4 and/or A to D also categorised as to their environmental impact. Higher category mods are required to be referred to the Site's Nuclear Safety Committee and the Office for Nuclear Regulation. However the vast majority of modifications will be of a low category and subject to local management approval or could have no significant nuclear consequences and could be addressed through an engineering change rather than a full modification. It is important that those assessing or approving modifications are watchful for a series of mods that interact or cumulate to become more significant when considered together.

The modification remains open until the engineering is completed and all necessary changes have been made to associated paperwork. A common problem is a delay between the physical change to the equipment and closing out the paperwork and record set leaving modifications unnecessarily and potentially compromisingly "open".

The process described above is for what are sometimes called "Minor Modifications" i.e. a change to configuration which is relatively simple to enact by an SLC's Operations or Maintenance team possibly using established contactors. A more significant change will require a completely new safety case (as opposed to a modification to an established case) and will be the subject of a "Project" and the expectations described in Section 4 (Project Management).

LC 22 also controls "experiments", these are far less common than engineering changes, however the importance of their control is clearly evidenced by the criticality incident at Tokai Mura in a research facility.

Commissioning and Qualification
Commissioning is particularly significant for major projects and is discussed in Chapter 4, however commissioning is appropriate after all modifications to confirm that the safety case requirements have been achieved and to confirm operability, the extent of commissioning/testing is dependent on the extent of work undertake. Commissioning is often fragmented into stages: at factory works; after installation before contamination (usually called inactive commissioning) and with nuclear material feeds (active commissioning). The outcome of commissioning is a Commissioning or Test Report which is key evidence to support the case for handover to Operations and may require regulatory agreement.

In nuclear processing plants as well as commissioning which has confirmed functionality and safety it is also common for this to be followed by a Qualification phase during which process feeds and operating parameters are adjusted to establish the range of operating conditions that are optimized for process efficiency.

Data and learning from commissioning and qualification contribute to the production of operating instructions.

Shutdowns and Outages

LC 30 deals with the provision of the periodic shutdown of plant so that maintenance work and inspections are possible. All Nuclear Power Plants have scheduled shutdowns, typically every 2 or 3 years, due to the need to access the pressure vessel. At NPPs a shutdown is normally referred to as an "Outage". For PWR type reactors this is also when the reactor is re-fuelled. Scheduled shutdowns are not always required for other nuclear processing plant; it depends on the nature and accessibility of the plant. During an outage that may last 2 or 3 months the NPP essentially goes into a "project delivery" mode with all internal and contracted resources focusing on the outage deliverables. Outages are an expensive requirement possibly costing as much as £1m per day in lost generating revenue in addition to the cost of the work to be undertaken.

The key to a successful outage is in depth planning to ensure that contracted personnel (could be as many as 1000 additional staff involved) and required materials and equipment are available for the outage. The sites Quality Team assist the dedicated Outage Manager during the planning period and during the outage are involved in auditing the work undertaken. Prior to the outage there will be an independent safety review of the plans and prior to reactor start-up a Reactor Start Up Report is prepared and submitted to the ONR detailing inspection findings and work undertaken.

Periodic Safety Reviews (PSR)

Nuclear Plants are generally long in their existence, expected lives of 30 years are typical and these are often extended for 10 or 20 years beyond that. These lifetimes bring with them the issue of equipment and buildings aging and becoming obsolete, replacement components becoming hard to source or difficult to repair or expected standards becoming more onerous. For this reason LC15 requires a Periodic (usually every 10 years) Safety Review or PSR.

The review is a systematic assessment of the current safety case and the buildings and equipment concerned. The review team will undertake plant walkdowns to familiarise themselves with the plant directly; their remit is to assess the plant against modern standards and if these are not met establish reasonably practicable improvements to mitigate risks. While doing this they are not only reviewing any degradation over the preceding 10 years but also anticipating what can be predicted to happen in the next 10 year period and considering the time after identification of any issues needed to make safe/POCO the plant. The review extends beyond just installed plant and also considers softer areas such as the state of the management system, the organizational structure etc.

The outcome of the PSR is a Submission to the ONR, which captures the findings and lists all planned improvements.

Reference Material

T/INS/022 Licence condition 22 – Modification or experiment on existing plant PDF
T/INS/021 Licence condition 21 – Commissioning PDF
T/INS/027 Licence condition 27 - Safety mechanisms, devices and circuits PDF
T/INS/028 licence condition 28 - Examination, inspection maintenance and testing (EMIT) PDF
T/INS/029 license condition 29 - Duty to carry out tests, inspections and examinations PDF

T/AST/009 Maintenance, inspection, testing of safety systems, safety related structures etc PDF
T/AST/050 Periodic safety reviews (PSRs) PDF

5.5 Operational Information and documentation

Operating Rules are established in the Safety Case and are significant and generally few in number, these are promulgated through the Operating Instruction set and control nuclear safety issues such as Criticality Control, availability of Safety Mechanisms etc. Breaching an Operating Rule is a major issue.

Operating (or sometimes Operator) Instructions and Maintenance Instructions
Associated with the Operations phase are usually a large set of Operating and Maintenance Instructions, these dominate the management system in terms of their numbers and volume and again are driven by nuclear site Licence Conditions - LCs 9,10,23,24 and 25 all have an influence. Instructions vary in their style and expected use. For example reactor start-up and shut-down instructions will be open on the control room desk during these operations and followed step by step as these operations are complex and less often undertaken. Other instructions for more routine maintenance work may be used during training and a checklist is carried to the job which doubles up as an aide memoire and ultimately becomes the maintenance record when completed by the operator.

The role of Operating and Maintenance Instructions is to ensure safe working and correct functioning of important safety related plant note:

- Instructions must adequately address safety case and risk assessment requirements including specific regulatory requirements for equipment, etc.
- Instructions must be accurate, up to date and easy to use, user involvement in preparation and verification is important
- Instructions need to address human factors and human performance error prevention and a culture of use and adherence promoted
- Users need to be encouraged to carry out post-job reviews and feedback any problems with instruction use

Some nuclear sites categorise their Operating Instructions according to the potential nuclear safety impact of the work being controlled. In the early 1990's BNFL worked through its entire Operating Instruction set categorising them A,B or C. Category A being reserved for the small percentage of operations that if incorrectly undertaken could have an impact off the site.

The control of instruction preparation, approval and promulgation and periodic review is undertaken by operational staff but is an area that quality professionals become involved as this document set is obviously an important part of the overall management system.

Operating Experience Feedback (OEF) aka Learning from Experience (LFE)
In the 1980s/90s most SLCs instituted Operating Experience Feedback (OEF, the terminology used generally by NPPs) or Learning from Experience (LFE) programmes. The idea is that events, incidents and non-compliances in general experienced by a plant are widely shared internally and externally with similar organizations or plants with the objective of preventing repetition. It is common practice to have a small team of OEF Engineers, sometimes within the Quality Team or as part of the Operations Team who are the focal point for gathering and sharing such experience. OEF Engineers may participate or lead in Root Cause Analysis and categorise incidents and events for the purposes of trending. Much effort with the workforce is made to encourage the reporting of issues on the basis that none are too small to report and even if no further action is required the recording of the issue contributes to the overall "picture" available to site management.

It is important that such data is considered during and review and summary of future improvement action incorporated into the Management Review process.

The scope of OEF extends from local plant issues to national and internationally shared databases of issues. For example all NPP's will have reviewed the Fukushima Event and for most this would have been a formal requirement by their regulators (ONR required this of all UK SLCs). Examples of international collaboration can be seen at the recently established European OEF Clearing House and the IAEA's Incident Reporting System (IRS).

Permits to work

All intrusive engineering or maintenance work is subject to a Permitting system to ensure that all those involved are aware of the safety issues. The work will also be supported by other paperwork such as a "mod" or a maintenance instruction and possibly a separate risk assessment. The Permit, which is similar to those which are commonplace in facilities management arrangements, is a time based centrally issued approval to set a team to work. Permits will detail radiological protection (this may be a separate document sometimes known as a [radiological] System of Work) and nuclear safety issues, alongside industrial safety aspects such as working at height; electrical and other system isolations; hot work; affect on adjacent work/areas. Permits are issued by an area controller or in the case of generating stations senior operations staff (sometimes known as a Senior Appointed Person or SAP). See HSE guidance on Permit to Work.

T/INS/009 Licence condition 9 – Instructions to persons on site PDF
T/INS/023 Licence condition 23 - Operating rules PDF
T/INS/024 Licence condition 24 - Operating instructions PDF
T/INS/025 Licence condition 25 - Operating records PDF

5.6 Nuclear Materials and Radioactive Waste

When considering the operational phase we can now picture a well designed and maintained plant fully manned with competent staff undertaking its primary objective. In achieving its primary objective it is processing nuclear material in some way. The fuel fabrication plant processes uranium ore through to uranium fuel, the reactor processes uranium fuel through to spent fuel whilst generating electricity etc.

These nuclear material inputs and outputs require significant control and their management and containment are essentially the subject of the nuclear safety case. Issues associated with nuclear material management include spent fuel and waste management, radioactive material transport and security controls. The handling and movement of nuclear materials requires the interaction between different organizational parties and is subject to national and international scrutiny so as to prevent nuclear proliferation, this is known as Nuclear Safeguards.

Nuclear Safeguards and NMAC

Nuclear Safeguards, with requirements placed by International Treaty and policed by Euratom and the IAEA is the driver for Nuclear Materials Accounting and Control (NMAC). Essentially it is the discipline of having good accountancy of uranium and the fissile products of uranium so that it can be demonstrated that none has been misused (by misused meaning used for military purposes when intended for civil use).

This is an issue which is a considerable challenge for nuclear material processing plants but is comparatively simple for NPPs. At a NPP Fuel Assemblies are received from the manufacturer, burnt in the reactor, stored for a period as spent fuel and then (in the UK) dispatched to Sellafield or a dry store. Unless a fuel assembly is badly damaged the challenge is simply one of "counting them in" and "counting them out".

At processing plants such as Springfields, Capenhurst and Sellafield the challenge is much greater with receipt and dispatch of materials internationally, expected efficiency losses and unexpected small losses (known as Material Unaccounted For or MUFs), material changing state, being enriched etc. To accommodate this such sites have a dedicated resource of Nuclear Material Accountants and clerical support working closely with operational plant staff using detailed databases to track the movement of the nuclear material inventory around the site. See IAEA's Nuclear Material Accounting Handbook and Euratom website

Radioactive Material Transport

Nuclear sites generally establish a focal role such as a Site Movement Liaison Officer (SMLO) or Radioactive Materials Transport Officer (RMTRO), who is the principle representative of the consigning site (the consignor) and organizes the shipment of radioactive material with the carrier and consignee. This is a key role in ensuring compliance with the appropriate regulations for the proposed route: road, rail, air of sea. Essentially the requirement is to establish a QA Programme which inter alia:

- Details the use of approved packages or transport containers – package approval being given by the ONR's Radioactive Materials Transport Team
- Secures any necessary route approvals including foreign government approval
- Clarifies the responsibilities of the consignor, carriers involved and the consignee
- Ensures that the correct markings and warnings are applied to the vehicle and the packages
- Ensures that the packages are safely and securely stowed during transportation
- Assesses the external surface radiation dose prior to shipment
- Establishes Emergency response arrangements

See ONR Radioactive Material Transport Guidance

Radioactive Waste Management

The generation of radioactive liquid, solid and gaseous waste should be minimized. For example packaging is removed from consumable items before they are taken into contaminated areas or bulk decommissioning materials should if possible be re-used or recycled before classified as waste.

The control process for radioactive waste should ensure that waste generated is within authorised limits and conditions and typically includes: identification of the waste source; defining the waste streams; segregating the waste; waste characterisation; treatment and conditioning; use of appropriate packaging and transport; storage and disposal; waste inventory management; security; record keeping e.g. waste package specifications and waste package data sheets; transporting waste packages that meet "waste acceptance criteria for disposal" to a licensed repository.

Note: Compared with experience in many other industries a radioactive Waste Package is considered with the same attention as is a product being delivered to a customer.

Radioactive waste is categorized according to the level of radiation emitted:

- High Level Waste (HLW) comprises mainly spent fuel elements and their arisings when reprocessed such as Sellafield's vitrified waste, HLW requires substantial shielding and cooling to remove decay heat

- Intermediate Level Waste (ILW) which comprises activated and contaminated material such as fuel cladding, ILW requires shielding but no cooling
- Low Level Waste (LLW) such as contaminated coveralls, gloves and other operation consumables as well as bulk materials for disposal during decommissioning and
- Very Low Level Waste (VLLW) which subject to conditions and approval can be disposed of to regular landfill sites.

For operational sites there are well established and long standing arrangements to send Spent Fuel to Sellafield for reprocessing, LLW waste to the LLW Repository at Drigg in Cumbria for storage and local arrangements with landfill sites for VLLW. ILW is not such a common arising at operational power stations but more significant during decommissioning when waste holding vaults and components in the reactor vessel or cooling circuits are dismantled.

Consignments need to meet the conditions for acceptance set by the disposal site or NDA RWMD for ILW packages. Appropriate QA needs to be applied. ILW packages, for example, require quality plans and rigorous control of waste drum manufacture, and some package designs require encapsulation materials and processes used to encapsulate waste. The management of records is also very important to support future disposal operations, refer to section 8 Records and Knowledge Management.

The final future disposal route for HLW and ILW in England and Wales is currently planned to be a Geological Disposal Facility (GDF), although the site for this is controversial and subject to government consultations to find an acceptable location. Scotland prefers surface ILW stores.

Waste Characterisation, involving the sampling and analysis of waste for radiochemical analysis and direct radiation assessment to an approved Sampling and Analysis Plan (SAP) is the process resulting in a Characterisation Report which underpins the waste category. The Characterisation Report supports approval to dispose via the designated route and demonstrate that the waste meets the requirements of the storage facilities Waste Acceptance Criteria (WAC). The data is also used by sites to add details of their waste inventory to the national Radwaste Inventory.

1. ONR's Fundamentals of the management of radioactive waste
2. Low level Waste Repository Waste Acceptance Criteria
3. IAEA, Predisposal Management of Radioactive Waste, No.GSR Part 5, IAEA, Vienna (2009).
4. IAEA, Predisposal Management of Low and Intermediate Level Radioactive Waste, IAEA Safety Standards,Series No. WS-G-2.5, IAEA, Vienna (2003).
5. IAEA, Predisposal Management of High Level Radioactive Waste, IAEA Safety Standards Series No. WS-G-2.6, IAEA, Vienna (2003).
6. IAEA, Management of Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research and Education, IAEA Safety Standards Series No. WS-G-2.7, IAEA, Vienna (2005).

Security

Initially, in the 1950's and 1960's site security was principally concerned with keeping the technology secret. Nowadays security on a nuclear licensed site is predominantly about keeping the inventory of nuclear material and the vast amount of operational plant and equipment secure. The types of threats that must be protected against include disruptive or violent demonstrations, espionage, sabotage of

equipment, theft of nuclear material, physical attack with weapons and explosives, and cyber attack on control and communication systems. Similar to most functional areas security systems are proportional to the risk being protected. High risk facilities are extremely heavily protected with typically double fenced perimeters, inner security areas, modern surveillance systems, guard dogs, perimeter patrols, police armed with sub-machine guns and support from military services. The actual arrangements for a site are set out in a Security Plan which is shared with ONR Security Team and local security agencies.

Nuclear security professionals are usually members of the World Institute for Nuclear Security (WINS) which provides best practice advice and guidance.

Contractors need to be aware that time should be allowed to gain security clearance in advance for their staff and gain entry to site on a daily basis.

Also see ONR Civil Nuclear security website

T/INS/034 Licence condition 34 – Leakage and escape of radioactive material &radioactive waste
T/AST/023 Control of processes involving nuclear matter
T/AST/024 Management of radioactive materials and radioactive waste on nuclear licensed sites

5.7 Emergency arrangements and preparedness

Considerable effort is spent on operational plants planning and rehearsing the arrangements to deal with emergencies and accidents this responds to the Radiation (Emergency Preparedness and Public Information) Regulations 2001 and LC11. ONR takes great interest in the rigour of emergency planning and exercising and typically for an operational site will annually witness a Demonstration Exercise, sometimes specifying to the Operator the emergency scenario usually involving some loss of radiological control or nuclear safety.

The heart of the arrangements is the Emergency Plan which considers potential accident scenarios and will involve establishing Emergency Roles, training staff to fulfill them, working out how the site may impact with the surrounding area and how it will interface with the Emergency services and local population. As well as an Emergency Control Centre (ECC) on the site, there are agreements between sites and SLCs which have established remote emergency control centers.

Typically an individual, the Emergency Planning Manager will be employed solely to prepare the Emergency Plan and manage the arrangements as a whole. The principle responsibility of Site Shift Managers is to be the leader on the ground taking control of any emergency. Arrangements exist, with rotas in place, to have a local senior manager (sometimes called a Duty Manager) ready to take a phone call and to attend the Emergency Control Centre to take executive charge or do so from offsite during "silent" hours. Duty Managers are given emergency command and control training and the site must be able to demonstrate their participation in Emergency Exercises.

A consideration for a site's Quality Team is the availability of site plans and drawings and other key information to those involved in managing the emergency given the disruption there may be to electronic document management systems etc.

Nuclear sites have a number of different alarm systems to alert staff of the need to take emergency action which differs with the nature of the event. The site alarms include Fire Alarms (evacuate to pre-defined Fire Assembly Point); Toxic Release Alarm (stay inside with windows and doors closed); Criticality Incident Alarms (evacuate at a running pace following a pre-established route to an Assembly Point). Familiarity with these arrangements is given as a part of induction training; this is reinforced by exercise drill practice.
T/INS/011 Licence condition 11 – Site inspection, planning and enforcement – LC 11 – Emergency arrangements

CHAPTER 6

Supply Chain Management

CONTENTS

Editor: **Stuart Allen**
Contributors **Bob Dixon, Gavin Avery, Mark Sweeney, Phil Shaw, Tony Colyer, Richard Hibbert**

6.1 Introduction

This chapter will provide an overview of Supply Chain Management within the UK Nuclear Industry highlighting key activities, specific legislation, standards and factors impacting a Licensee's Supply Chain Management System.

Few Licensees have the capabilities to undertake all their operation and support requirements from within their own organisation so they seek support for non-core activities (ie Construction, Consultancy Services) from specialist supply chain organisations.

Operators of nuclear facilities aim to deliver their objectives safely, securely, reliably and predictably. As such, they require their supply chain to deliver products and services safely, to schedule, of the correct quality and to the agreed cost. Supply Chain Management is required to ensure effective delivery to the Licensees specified intent.

Supply Chain Management is often perceived as supplier management, when in fact it refers to much more. The management of the 'end to end' supply chain from specification of Licensee requirement through to delivery of service or installation of product in line with the specified intent.

Supply Chain Management in the nuclear industry requires effective arrangements to ensure control of the full acquisition cycle from specification of requirement, sourcing of supplier, manufacture, delivery and installation or storage as appropriate. It will also include post contract management arrangements to oversee or assure delivery.

A significant issue in the nuclear industry is the Licensees absolute responsibility under the Nuclear Installations Act and the Licensee Conditions. This responsibility is often referred to as the Licensee's 'Intelligent Customer' Capability. In relation to effective Supply Chain Management the Licensee should fully understand the need for a contractor's services; should be able to specify requirements; should supervise the work and technically review the output before, during and after implementation.

The implication of this requirement is that the Licensee should not solely rely on the specialist supply chain to deliver their requirements without oversight. They need to maintain sufficient capability to ensure that they can manage the supply chain, specifying and overseeing delivery in line with intent. The Wylfa Prosecution Judgment [1] provides an example of events that led to the concept of 'Intelligent Customer' and outlines expectations through the supply chain.

Standards and Guides
ISO 9001:2008 is the most commonly specified management system standard in the procurement of significant products and services. Major nuclear industry suppliers are normally certificated to ISO 9001. The limitations of ISO 9001 for important nuclear related procurements are recognised by the UK nuclear industry. There is continuing discussion over the production of a nuclear industry specific standard. Many licensees and major industry suppliers have developed their own specifications based on ISO 9001 but with additional requirements. The additional requirements reflect nuclear safety issues and the need for very high standards of safety, environmental and security management when working on licensed sites. Additional requirements are normally specified on a graded basis with nuclear safety significance of the product or service being the major concern. The additional quality management requirements typically address topics such as:

- Arrangements for qualifying key personnel involved in important safety and quality related activities;
- The production and submission of contract specific quality plans;
- Document submission and approval requirements for important activities such as design, construction, manufacture, installation, commissioning and decommissioning;

- Inspection, surveillance and audit requirements; and
- Records to be provided, stored and preserved by the supplier.

The Nuclear Industry Association (NIA) has produced a helpful introductory guide called "Essential Guide for the Nuclear New Build Supply Chain." The NIA guide includes sections on "Quality Arrangements" and "Codes and Standards". IAEA guide GS-G-3.1 "Application of the Management System for Facilities and Activities" includes general guidance on nuclear industry procurement practices. There is some additional guidance in IAEA GS-G-3.5 "The Management System for Nuclear Installations". There are two helpful ONR technical assessment guides relating to procurement:

- T/AST/049 on Licensee use of contractors and intelligent customer capability;
- T/AST/077 on the procurement of nuclear safety related items and services.

Role of Quality Professionals in Procurement Activities
Quality professionals undertake a number of important activities in relation to procurement, such as:

- Ensuring that licensees and suppliers establish and implement robust procurement processes;
- Assisting with the preparation and review of specifications particularly in relation quality and quality management requirements;
- Helping to establish suitable criteria for the assessment and selection of suppliers;
- Carrying out pre-contract supplier assessments;
- Producing quality plans and monitoring their implementation;
- Reviewing document and records submissions;
- Carrying out on-site and off-site inspections, surveillance visits and audits;
- Assisting with the management of non-conforming items and products; and
- Document and records management including long-term preservation

6.2 Globalisation

The globalisation of supply chains provides significant value opportunities as more companies compete for work in the global nuclear market. While globalisation provides value opportunities it also has associated risks as vendors with little or no experience of the nuclear industry or its standards and requirements enter the markets to compete for work in the lucrative new build, operations and decommissioning sectors.

Supply chain management professionals in the nuclear industry need to be aware of both the opportunities available and associated risks to enable effective decision making and implementation of appropriate risk mitigation measures.

One of the most significant risks of globalisation related to nuclear supply chain management is the opportunity for suspect or counterfeit items entering nuclear facilities. The risks can be increased as pressure is applied to the prime contractor to reduce costs influencing the contractor to source cheaper suppliers, potentially without the required levels of controls or assurance arrangements that could be considered an unnecessary overhead by some suppliers.

> *'There is nothing in the world that some man cannot make a little worse and sell a little cheaper, and he who considers price only is that man's lawful prey.'*
>
> *John Ruskin, 1819-1900*

Nuclear Operators should have arrangements in place to effectively procure goods and services and will grade procurements to deploy appropriate levels of controls to assure delivery to specified intent. This deployed assurance has traditionally been designed to identify substandard product but now plays a key part in the mitigation measures to prevent the procurement of suspect or counterfeit items. Suspect or counterfeit product can be challenging to detect and may require more intrusive testing and controls such as material identification, product testing and traceability to original source.

The most important mitigation measure is to ensure that those involved in the acquisition process from specification of requirement through to receipt of products and services are trained and competent to perform their role.

They should be aware of the need to utilise suppliers with a proven track record of delivery or if utilising a new supplier, that appropriate analysis is completed in advance of contract placement to ensure that they have the relevant management systems in place, including controls for their own subcontract or supplier management. Supply chain assurance arrangements (ie performance measures, inspection, surveillance and audits) need to be designed to not only test for substandard product but to examine the potential for suspect or counterfeit goods.

Most individuals can recall examples of counterfeit goods; in the fashion industry (ie T-shirts/watches) or the food industry (ie horse meat substitution for beef products and false certification). The implications of counterfeit products being installed in nuclear applications and failing to meet design and safety case intent could have more significant implications to nuclear safety. IAEA have published TECDOC 1169 on the subject whilst US NRC web pages identify their presentations at an NEA meeting in December 2012; these suggest this is not an new issue (NRC have been raising it as an issue since about 1987), the examples quoted are safety significant items, and they suggest the practice is growing.

6.3 Specification

Effective specification of requirement is probably the most important aspect of the acquisition process. An ineffective specification will mean that the supply chain will find it difficult to deliver the Licensee's requirement right first time leading to delays, wastes and inevitable cost escalation.

Given the importance of the specification it is key that those writing a specification are trained and competent to perform the task. Specification authors will range from professional engineers required to design complex construction projects, whose work could be subject to independent verification and validation, through to the procurement of replacement plant and equipment as part of operational maintenance. In the latter case, it is important that the person creating the demand ensures that requirements are effectively specified by consulting with competent professionals who understand the design and safety case requirements of the plant, equipment or service.

Specifications can be considered into two major categories:

Technical Specifications
Describes the features, characteristics and properties of a product and gives all the information that is required to create it. Typically, procurement of physical assets will require a technical specification. Such a document would contain the defined functional requirements (performance, safety etc.) and the physical definition of the product within design documents, drawings and standards.

Functional Specifications
Details the requirements in terms of features, characteristics, process conditions, limits and exclusions, defining the performance of the product. Typically, a functional specification will be used to specify work to deliver a study, design or project. A functional specification may be used for the supply of an asset where performance is the prime objective and its physical attributes are not.

For further information on specification types see BS 7373–1:2001 (Product Specifications – Part 1: Guide to Preparation)

Quality Grading

Nuclear Licensees and their supply chain are encouraged to apply a graded approach to procurement of goods and services. The graded approach ensures that the appropriate levels of assurance are deployed, commensurate with the level of risk associated with failure of a procured item in use or service.

Higher levels of assurance (ie prequalification, auditing, inspection prior to product release) will be deployed on the higher level quality grades as a result of the product or service risk assessment. Lower levels of assurance will be deployed on activities with a lower measured risk (ie receipt inspection of product and records).

Activities or product with little perceived risk or only minor commercial consequence if inadequately supplied may result in no deployed assurance other than for normal commercial transactions or receipt of stock.

When applying a quality grade the Licensees would typically consider the following:

- The magnitude of the potential consequences if a product fails or an activity is carried out incorrectly
- The significance and complexity of each product or activity
- The hazards and the magnitude of the potential impact (risks) associated with the safety, health, environment, security, quality and economic elements of each product or activity.

For further information on Quality Grading, see Chapter 3

6.4 Sourcing

The sourcing of suitable suppliers or contractors in the nuclear industry follows common key principles but could be subject to certain legal constraints.

All suppliers, whether competing for significant contracts for nuclear facility maintenance, decommissioning or new build components or less financially significant products and services will be assessed on their ability to deliver against predefined criteria. The criteria will test the supplier's ability to meet the specified intent and may include the provision of information from the supplier that provides objective evidence of their capability to deliver the required product or service.

Any supplier evaluation would examine a series of factors, in addition to cost, relevant to the specific procurement. It would include a review of the potential supplier's management systems controlling their safety, environmental and security systems, quality performance and technical capability to deliver the specified work. The evaluation may also examine the potential supplier's nuclear safety culture. Ensuring that the organisation and its leaders understand the importance of nuclear safety and the contribution of any product or service they would supply to maintaining the correct nuclear safety standards when provided to the Licensee.

The supplier's past achievements could be considered together with the provision of references supporting works carried out which is similar to the intended scope. Also relevant is the supplier's financial status particularly if they are undertaking a substantial package of work that may dominate their output and impact their cash flow. Independent financial reports may be requested to confirm if the supplier has the financial viability to deliver the intended work-scope.

The Initial assessment of a supplier should be a desktop exercise which focuses on the needs of the particular project package and be proportionate to the risks, size and complexity of the work.

This initial 'risk assessment' should assist in determining the extent of any further evaluation required. The likelihood of a potential supplier failing to fulfill requirements is dependent not only on the nature of the product or service to be provided but also on the circumstances under which they are expected to provide them. The risks to the purchaser of suppliers failing to meet requirements will depend on the criticality of the requirements. It may be necessary to identify the potential for things to go wrong, the likelihood of them doing so and the impact of the failure.

The options available for evaluation might be one or a combination of the following:

- Questionnaire/feedback data
- External references
- Interview with buyer/project team
- Technical appraisal
- Commercial appraisal
- Full systems and capability audit

Many companies will maintain relationship with a group of suppliers with which they routinely do business. The suppliers would be subject to ongoing performance review after initial selection and evaluation to ensure they continue to deliver in line with the customer's success criteria. This grouping of suppliers is often referred to as a 'Preferred Suppliers' listing. Many suppliers will inquire with potential customers as to how they can be evaluated to become a preferred supplier.

Maintaining a preferred supplier listing is an effective way of managing a restricted group of suppliers for future procurements. However, it is not an option available to all UK Licensees in the Nuclear Sector as many will have to compete contracts above a certain value, in line with the requirements of the Public Contract Regulations (PCRs).

Public Contract Regulations

Many nuclear operations (ie those governed by the Nuclear Decommissioning Authority(NDA) or MoD) will fall under the remit of the PCRs and thus having the general objectives of:

- Competing the single market by removing barriers to competition within the public and utilities sector (ie water, energy, telecommunications and transport) across the European Union (EU) in order to improve supplier opportunities in the procurement of goods, services and works.
- Enacting the requirement that member states should not impose restrictions on trade within the EU
- Demonstrating transparency, objectivity and non-discrimination in the procurement process

The PCRs apply when four main conditions are met:

- The procuring body is a 'contracting authority' as defined in the rules
- The contract is a public works, services or supplies contract
- The estimated value of the contract equals or exceeds the relevant financial threshold
- No relevant exclusions apply.

When a contract satisfies the four main conditions outlined above, it must be advertised by publishing a contract notice in the Official Journal of the European Union (also referred to as an OJEU notice). The contracting authority must indicate in the notice the competition method it intends to follow and will utilise the method to assess potential suppliers ability to deliver against selected criteria.

For further information see ' Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts' .

6.5 Post Contract Management

The level of post contract management deployed by the Licensee or supplier should be commensurate with the quality grade and risk if the procurement failed to meet the intent. The higher the identified risk the more intrusive or more frequent the methods of post contract management or oversight.

Post contract management of the supply chain will also be impacted by the performance of the supplier or supply chain. If a supplier can demonstrate delivery to requirements right first time, every time then the Licensee or sub-supplier may adjust the level of assurance as appropriate. This can often be the case with manufacturing suppliers who may make large volumes of key components or equipment and have good control of their processes demonstrating compliance using statistical techniques. In such instances the purchaser may rely on records to demonstrate compliance and resort to sampling methods to monitor effective delivery of requirements rather than deploying intrusive audit and inspection at the manufacturer's facilities.

'Being convinced one knows the whole story is the surest way to fail.'
Philip B Crosby, 1926-2001

The Licensee has the responsibility for defining the overall supply chain quality arrangements. A key challenge is to ensure that the arrangements for the higher risk products and services flow down in a transparent manner through the supply chain.

At the top of the supply chain it is the Principal contractor or Licensee who will define the quality arrangements in their contracts and embed them into the contracts they let to the Tier 2 suppliers. It then becomes the responsibility of the Tier 2s and below to ensure that they flow these arrangements, as appropriate, down the supply chain. Each tier within the supply chain should be made aware of, and understand, the nuclear safety significance of the work they are performing or the product and service they are delivering. The Licensee will deploy appropriate oversight to ensure this happens effectively.

Methods of Oversight
There are many methods of performing supply chain oversight and assurance when the contract has been placed and during delivery or manufacture of the product or service. Organisations are likely to deploy a combination of approaches dependent on the scope of supply that could include:

- **Contract Review** - Meetings between the supplier and purchaser that would review quality, cost and schedule issues specific to the contract. They could consider technical matters such as: specification changes; approvals of design and engineering outputs or approval of manufacturing and test requirements; discussions on deviations and concessions; performance against key performance indicators etc.
- **Supplier Relationship Management**–Used to ensure effective relationship between the supplier and purchaser throughout any contract period. Many large suppliers provide multiple products and services to Licensees and often discussions only take place on a contract by contract basis.

Relationship management is often deployed at a more strategic level to ensure the both supplier and purchaser are aware of each other's organizational issues(ie capacity, expansion, profitability etc.) and work in a collaborative way throughout the lifetime of multiple contracts to ensure that potential issues are resolved prior to creating any impact on product or service delivery.

- **Quality Plans** – May be used to control manufacture, design, fabrication or service delivery stages requiring the identification and agreement of hold points that the supplier may not progress beyond without independent or purchaser witnessing, inspection or approval.
  Quality plans allow the purchaser to check in advance that the supplier has fully understood the detailed requirements of the specification, and that the supplier has in place the necessary assurance activities to deliver items that will meet the specification.
- **Assessment/Audit**–An organisation's management system may have been subject to review during the sourcing phase. The ongoing effective deployment of these arrangements may be subject to routine assessment by the Licensee, purchaser or by independent third party organisations performing audits on the purchaser's behalf. The audits would assess compliance with best practice management system standards and / or contract specific requirements.
  Suppliers working on Nuclear Licensed sites would expect to be subject to increased scrutiny, audit and assessment to ensure compliance with specific health and safety requirements associated with working within the Licensee's facility.
- **Vendor Analysis–**Throughout the contract period performance data can be collated on suppliers against contract success criteria, often dominated by delivery to the correct quality, on schedule and at the correct cost. Qualitative and quantitative data is utilised to demonstrate the required performance or when remedial measures are required. Vendor analysis is often used to rank and rate suppliers and maintain preferred status if applicable.

6.6 Product & Service Completion

Inspection and Test of Supplied Product
The level of inspection and test deployed on product or service completion will be dependent on the nuclear safety significance of the product or services being provided. The safety significance will relate to the quality grade of the product or service.

For products with a high impact on nuclear safety this final review may include verification or independent assessment by the Licensee, customer or a third party assessor.

For the product or service release process to be managed effectively, it is essential that suppliers carry out their activities in a controlled manner utilising quality plans as appropriate and verify that all specified procurement requirements or technical characteristics have been satisfied before offering an item or service for acceptance and release. It is important to ensure that the purchaser states clearly the intended verification requirements and method of product release in the purchasing information to ensure that the supplier and purchaser are appropriately prepared.

The supplier and purchaser must ensure that those involved in the release of products and services are trained and competent to perform their role and have available training records to demonstrate the currency of their qualifications (eg non-destructive testing qualifications).

Concession and Open Reporting of Failure
It is important to develop a culture where suppliers are encouraged to identify non-conformance or failures. The alternative, the hiding of errors and uncontrolled repairs, could have an impact on nuclear safety. While the objective of the purchaser and supplier needs to be on right first time delivery it is important to recognise that people can make mistakes and when this happens, appropriate corrective action takes place.

The identification, reporting and resolution of deviations should not be seen as negative but as an indication that the achievement of the purchaser's requirements is of prime importance. The control of any deviation from the technical specification is fundamental to the achievement of quality and therefore the integrity of the item.

All organisations within the supply chain should, as part of their quality management arrangements, operate consistent processes for the categorisation and disposition of deviations.

Purchasers at each level of the supply chain should ensure that their suppliers have adequate arrangements for the identification, categorisation and disposition of deviations for items or services. These should include obtaining the approval of the purchaser for the deviation in the form of a concession, technical query or procedure for re-work, and informing the ultimate Licensee / Regulator for deviations that are significant to nuclear safety.

An effective method of recording concessions and technical queries is essential to ensure that any deviations to specified intent are captured and traceable back to the specification and competent authority who can give permission to proceed.

Storage of Supplied Product

For many new nuclear facilities the period from procurement to operation can be several years. Despite efforts to build off site, many components will need to be stored and assembled on site and therefore items should be controlled from receipt to storage, handling and use preventing their abuse, misuse, damage, deterioration or loss of identification.

Where possible, items that arrive at the purchaser facility should be visually inspected before unloading to verify that there is no damage.

Clean conditions are required and is often a term used to define locations or activities where rigorous material controls are necessary. It can vary from inter-material compatibility eg storage of stainless steel piping on carbon steel shelving requiring a segregation layer of inert material; through storage in controlled or inert atmospheres; to avoidance of in-core debris by control of what goes in and out of the reactor housing eg 100% component inventory, including assay of fixings such as nuts, bolts and consumables thus avoiding unplanned materials being left in.

Storage should be provided to segregate and protect items prior to their installation and use. The methods and conditions of storage to prevent corrosion, contamination, deterioration and physical damage should be established and controlled, with account taken of aspects such as:

- Access
- Cleanliness and housekeeping practices
- Requirements for fire protection
- Identification and marking of items
- Protective requirements relating to coatings, preservatives, covers and sleeves
- Prevention of physical damage
- Removal from and return to storage
- Environmental control(such as temperature and humidity)
- Preventive maintenance
- Security
- Items that have limited shelf life or service life
- Physical and chemical characteristics of items
- Safety grades
- Segregation

Further information on storage requirements can be found in IAEA GS-G-3.5 Section 5.

Records Associated With Supplied Product
Manufacturers of safety related plant and equipment will be required to provide adequate records to demonstrate compliance to specified intent. This requirement is not unique to the Nuclear Industry, however the industry does have specific record requirements related to products that require enhanced focus. Many products, particularly associated with radioactive wastes will not be subject to any future handling when subject to long term disposal. As such, the record forms the only part of the plant or equipment that will be available throughout the lifetime of the product. It is therefore important to ensure that product records are supplied in the correct state and effectively controlled by the Licensee to ensure that the information is available as required during storage, to support disposal of the product or decommissioning of the facility at the end of its design life.

Records form part of the demonstration that plant and equipment meet the design intent and safety requirements and therefore the identification, generation, completion and retention of records associated with the supply of products or services should form part of the contractual arrangements between purchaser and supplier at all levels of the supply chain. Particular attention should be given to material traceability and inspection, test and surveillance activities.

Pressure often exists, particularly in project activities, for products to be delivered in advance of their associated records. While there are exceptional circumstances where this risk may be considered acceptable (ie to meet a shipping window) as a general rule it is important to ensure that all lifetime records, including those generated by subcontractors are compiled concurrently with the activity to which they relate. This minimises the risks of failure and prevents the use or installation of products that may prove to be substandard on record review and requiring considerable rework, if feasible. To prevent any poor practice, clear instructions should be given to suppliers regarding the times when the necessary documents and records should be submitted prior to the planned use or installation of the product or service.

Requirements on records and on material samples should be made clear to the supplier prior to commencing the contract. This could best be achieved by providing or requiring a record schedule that details all record requirements to be submitted by the supplier. Instructions for the retention by, or transfer of records from the supplier and subcontractors should be specified. These should include the records that are requested by the organisation to ensure that the products or services have met or will meet the requirements. Retention periods and responsibilities for the maintenance of records by the supplier should also be specified.

For more general guidance on the importance of record keeping in the nuclear industry see Chapter 8.

6.7 Further Information

NSAN – National Skills Academy Nuclear – For competency issues
NAMRC – Nuclear Advanced Manufacturing Research Center – Supply Chain assessment against 'Fit for Nuclear'
DECC – Department of Energy and Climate Change'– Nuclear Supply Chain Action Plan
Licensee/New Build Web Sites – Supply Chain Sections for Quality Requirements

[1] Wylfa Judgement - *Regina v Nuclear Electric plc: The Crown Court Mold*, before Mr Justice Morland, Transcript of the Verbatim Record, Ref. No T95/0026; 12, 13 and 14 September 1995

Chapter 7

Product Quality

CONTENTS

Editor: Bob Dixon
Contributors: Richard Hibbert, Mike Underwood, Iain McNair

7.1 Introduction

Product quality is not only vital for ensuring nuclear safety but they can almost be considered to be synonymous. Establishing world class product quality as mentioned throughout NQK is about planning from the design phase onwards to establish clear specified requirements. During manufacturing and construction Inspection & Test plans are key to provide the means to verify compliance combined with good systems for identification of the status of items and means of recording & dealing with all non-conformances. In particular for many items in the nuclear sector there are onerous requirements for traceability to parent metal melt data which suppliers may be caught out by.

Product Quality is the collection of features and characteristics of a product that contribute to its ability to meet given requirements. In the nuclear industry product quality is a key factor for ensuring nuclear safety. As we saw at Fukushima the catastrophic failure of a Reactor Pressure Vessel (RPV) of a large power plant can lead to devastating radiological consequences with wholesale and long term evacuation of the local area, and hence the highest standards are required at each stage of the life of such a vessel. In order to demonstrate that structures meet their safety functional requirements it is necessary to establish that sound design concepts, rules, standards, methodologies and proven design features have been used, and that the design is robust.

All structures, systems and components are specified and designed to provide a required engineering functionality. This functionality will have an influence on safety and so requires an appropriate safety classification to be assigned. This classification (or grading) will affect the design methods and standards, material selection, procurement process, fabrication and installation inspections as well as maintenance requirements and in service inspections.

The design concept should incorporate appropriate protection systems and monitoring systems to enable the component or structure to be maintained within its safe operating envelope for the duration of the life of the installation. For pressure boundary components, these would typically include overpressure protection systems; thermocouples for monitoring temperatures, safety relief valves, leak detection systems, loss of coolant feed trip systems. For other load bearing structures the emphasis would probably be more on monitoring systems. Adequate arrangements need to be in place for maintenance, inspection, and testing of the monitoring systems to ensure that the safety functional requirements continue to be met.
It is important to verify that safety significant components and structures are constructed from materials with well-established materials properties and behaviour,

The potential degradation mechanisms that could occur should be established at the design stage and appropriate materials chosen. Material properties used in analyses should be demonstrably conservative e.g. lower bounds of either generic databases or specific data that represent the component manufacturing and fabrication conditions. In general the steels specified in the design of pressure boundary components and other structures have a well- established history of usage. However if any unforeseen behavior change or degradation mechanism is identified the licensee should review and if necessary update the relevant safety case.

The material composition, manufacturing process, operational history, pressure, temperature, irradiation, creep, fatigue, and corrosion mechanisms may result in degradation in the material properties assumed at the design stage. Appropriate provision should be made for the measurement of relevant properties of fully representative materials across the full range of environmental conditions expected throughout the identified lifetime of the plant.

Civil structures, typically constructed from structural steel or concrete, uses idealized stress models to determine characteristic "stresses" that can be used to select the size of structural elements and/or the disposition of reinforcement. This process is known as structural analysis and certain classes of civil engineering structures can benefit from a detailed stress analysis, e.g. concrete vessels and containment. However, reinforced concrete presents particular difficulties for the stress analyst because it does not behave elastically. In structural analysis due consideration is given to uncertainties in material properties and that the methodology and loading data have been verified to ensure that the analysis is demonstrably conservative.

Reference
ONR Technical Assessment Guide T/AST/016 Integrity of Metal Components and Structures
ONR Technical Assessment Guide T/AST/057 Design safety Assurance

7.2 Product Quality Planning

In quality planning the purchaser should make clear in the contract the extent to which quality plans will be used. The use of quality plans, developed by the supplier and agreed with the supply chain purchasers. Quality plans allow the purchaser, second party (supplier), independent third party inspection personnel and, in some instances, the ONR, to insert witness points, review points or hold points into the manufacturing sequence. This is essential to ensure that items are fabricated/manufactured/tested and inspected in a planned and controlled manner and that the required levels of integrity are achieved.

Quality Plans

Quality plans also allow the purchaser to check in advance that the supplier has fully understood the detailed requirements of the technical specification, and that the supplier has in place the necessary assurance activities to deliver items that will meet the technical specification.
Quality plans should show the entire sequence of steps to realize the item or service and details of hold point release. These need to be available for review by involved parties, before work commences and in sufficient time to allow these parties to review and annotate them with hold, witness and review points and to question the sequence or referenced documents.

Quality plans, in identifying the sequence of activities required to satisfy the requirements of the contract, should reference process/fabrication instructions, tests, inspections and clearly identify the records required to be generated and provided to the purchaser. They should provide the facility for signatures to be entered on stage/final completion of the work covered at each element of the plan.
Generally, a quality plan should identify/reference all those documents which form the purchaser's document package and include such aspects as qualification of personnel, fabrication procedures, material certification and traceability, consumable specification, concessions and rework, manufacture, fabrication instructions, heat treatment records.
A completed quality plan should provide the demonstration that all appropriate steps have been taken to deliver the product to purchaser requirements, including details of the organisations involved and references to control documents and appropriate records. It is important that all records that are required need to be delivered before items are released onto site or for further use. If not then quarantine/storage will need to be enforced.
For complex items that are fabricated/manufactured in stages, there may be several quality plans which support a top level quality plan.

Reference
EDF UK EPR General Quality Assurance Specification ECUK100053
BS ISO 10005:2005 QMS Guidelines for Quality Plans
ONR Technical Inspection Guide NS-INSP-GD-017 LC17 Management Systems

7.3 Specifications, Codes & Standards

Specifications and requirements for products, including any subsequent changes, are expected to be in accordance with established standards and are expected to incorporate applicable requirements. Whenever codes and standards are specified the version should be defined; in that way there should be no ambiguity as to the requirements.

It is customary in the UK nuclear industry for designers to utilise other international or USA codes as part of the design process. These may also be supplemented or replaced entirely by the licensees own standards. Differences in dimensional or other units may emanate from foreign designs and this aspect may well require further consideration e.g. for Sizewell B, US design standards led to the production of specific UK manufacturing and construction specifications to replace US product standards.

It is therefore important to recognize that codes may set standards and requirements for construction details, workmanship, concrete mix design, reinforcement and fixing details, material specifications and in the case of the EN codes, options for control of construction which may be unfamiliar to a UK construction work force.

For the UK EDF EPR projects the Design and Construction Rules for Mechanical & Electrical Components of Nuclear Islands are detailed in the RCC-M & RCC-E codes which are part of the collection of design and construction rules for nuclear power plants.

The contract drawings, schedules and construction specification should include all design, workmanship, inspection and testing requirements to be fulfilled during the construction process. However, it would also be expected that the designer highlights areas to the contractor that might not represent 'normal' practice in order to establish the practicality of the proposal and ensure the contractor understands the full requirements.

International/USA codes such as American Institute of Steel Construction (ANSI/AISC 360) Specification for structural steel buildings or American Concrete Institute (ACI 349) Code requirements for nuclear safety related concrete structures, may base the design on differing forms of test results and requirements. For example, the use of cylinder compressive strengths instead of cube compressive strengths.

The principal contractor/contractor should be fully conversant with the relevant codes used and further that suitably qualified and experienced personnel (SQEP) are employed in the relevant site supervisory roles. An Inspection and Test Plan (ITP) should be agreed with the licensee.

International codes tend to base design on the materials available within the country of origin. These materials may not be the standard; readily accepted or readily available norms in the UK, for example reinforcing bar yield strengths.

Useful information may be obtained from the relevant industry bodies such as CARES for rebar, BCSA for steel construction, and IMS for masonry.

The designer needs to specify materials (for instance reinforcement bars) that will meet the relevant structural requirements in a manner that is acceptable to the contractor. Failure to communicate and agree with the contractor these requirements will lead to formal design change requests later. Changes in materials subsequent to the completion of the design should be kept to a minimum as determining the implications for the design can require multi disciplinary specialist knowledge and if there are numerous design changes there is a risk that the specialists may not be aware of all the changes when making a decision.

Reference :

ASME Boiler & Pressure Vessel Code
EDF EPR RCC-M and RCC-E codes

7.4 QA Grading

In deciding on the levels of assurance, the purchaser should consider the safety significance of the item or service, the level of assurance normally applied to the item or service for its intended use, the code/standard requirements (for agreed and justified departures) and the difficulty of inspection and testing post manufacture or installation. It is important that the ONR has access to all parties that are carrying out quality related activities if required. Access will normally be arranged via the Licensee or purchaser.

In order to know how the UK Pressure Equipment Regulations (PER) will apply to specific items of pressure equipment; the manufacturer will need to classify the equipment according to its perceived level of hazard. Equipment of a relatively low hazard will be required to be manufactured according to 'sound engineering practice' (SEP). Equipment that is classified as a higher hazard than SEP is required to meet the relevant essential safety requirements of the PER and, on that account, to be CE marked. It is allocated, in ascending order of that hazard, to one of Categories I, II, III, or IV.

Reference
UK EPR Pre-Construction Safety Report UKEPR-0002-XZ

7.5 Special Processes

Processes for production and service provision where the resulting output cannot be fully verified by subsequent monitoring or measurement. This includes any processes where deficiencies become apparent only after the product is in use or the service has been delivered. Measures need to be established to assure that special processes, including welding, heat treating, and non-destructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

Special processes are so called, due to their nature; there is no way to determine if deficiencies exist prior to use or delivery. For such processes, we are unable to verify the characteristics of the product during processing without destroying the product as part of our evaluation.

While not an all-inclusive list, processes that fall under this category include welding, non destructive examination (NDE), heat treatment, as well as casting, forging, bending, forming, bonding, protective coatings and other processes. While infrequent, disagreement can arise over what is a special process, but needless to say, if the characteristics of a product can't be 100% verified without destroying the product, this classification applies. In all cases, it is up to organization to define these processes as part of their Quality Management System and to address these processes as appropriate.

For these processes, the only alternative to destroying useable product is to ensure that the process is controlled to the degree that it is capable of producing only conforming product. To achieve this outcome, the ISO 9001 standard addresses the control of these processes by requiring the using organization to establish arrangements for the control and verification of procedures, personnel, equipment and other factors that may impact the process under consideration.

Processes which generate that product or service are considered special processes. Example of special process: welding. Because of structural transformation during welding, it's quite hard to determine if the welding is continuous, mixture of base material and welding material was done properly, no internal holes exist, no cracks exist, etc. Although non-destructive testing methods exist, they cannot confirm 100% that the weld is adequate. A test for proving that weld is OK would be a destructive one; destroying the weld destroys the product, so there is no end of the process. Therefore, welding process must be validated. Validation of processes must demonstrate their ability to achieve desired results. Criteria for approval and review of such processes have to be determined.

Welder certification is based on specially designed tests to determine a welder's skill and ability to deposit sound weld metal. The welder's tests consist of many variables, including the specific welding process, type of metal, thickness, joint design, position, and others. Most often, the test is conducted in accordance with a particular code. The tests can be administered under the auspices of a national or international organization, such as the American Welding Society (AWS), or American Society of Mechanical Engineers (ASME), but manufacturers may specify their own standards and requirements as well. Welders can also be certified in specific welding related professions: for example, American Welding Society certifies welding inspectors and welding instructors, and the American Society of Mechanical Engineers certifies high capacity fossil fuel fired plant operators and several other professions. Most certifications expire after a certain time limit, and have different requirements for renewal or extension of the certification.

In the USA, welder qualification is performed according to AWS, ASME and API standards, which are also used in some other countries.

In Europe, the European Committee for Standardization (CEN) has adopted the ISO standards on welder qualification (ISO 9606), with the exception of qualification for steel welders, where a new version of the old European EN 287-1 standard still applies. In Europe welders are usually certified by third party Inspection Bodies or Personnel Certification Bodies. Welders involved in the manufacture of equipment that falls within the scope of the Pressure Equipment Directive must be approved by a competent third party which may be either a notified body or a third-party organization recognized by a Member State.

Once a welder passes a test (or a series of tests), their employer or third party involved will certify the ability to pass the test, and the limitations or extent they are qualified to weld, as a written document (welder qualification test record, or WQTR). This document is valid for a limited period (usually for two years), after which the welder must be retested.

7.6 Inspection & Test

Whilst quality cannot be inspected into the construction process; it is an ONR expectation that the licensee's arrangements should include additional supervision and management systems to control the construction activity of nuclear related construction and reduce risks to nuclear safety.

Activities for inspection, testing, verification and validation need to be completed before the acceptance, implementation or operational use of products. The tools and equipment used for these activities need to be of the proper range, type, accuracy and precision.

The following recommendations have been developed to provide a means of meeting these requirements for nuclear installations.

Inspection & Test Plans

The following types of information should be included in the inspection and testing plans:

(a) General information, such as the name of the installation, the product or system reference, the procurement document reference, the document reference number and status, associated procedures and drawings.

(b) Identification of special process requirements such that it can be shown that only qualified operatives undertake the work.

(c) A sequential listing of all inspection and testing activities; all products to be inspected and tested should be identified and referenced in the plan.

(d) The procedure, work instruction, specification or standard (or the specific section, if appropriate) that should be followed in respect of each operation, inspection or test.

(e) Reference to the relevant acceptance criteria.

(f) Specification of who is to perform each inspection and test and provision for recording that each inspection and test has been performed satisfactorily.

(g) Specification of hold points beyond which work may not proceed without the recorded approval of designated individuals or organizations.

(h) Specification of witness points where an assigned individual or organization can check activities but where the work need not be stopped if the inspector is not present.

(i) Specification of hold points for inspection and testing by an external organization that is independent of the installation, e.g. the regulatory body or a third party inspector.

(j) The type of record to be prepared for each inspection or test.

(k) The number of products to be inspected or tested when multiple products or repeat operations are involved.

(l) The individuals or organizations that have authority for the final acceptance of the product.

Test Requirements

Test requirements, including testing frequency and acceptance criteria, should be specified. Unless otherwise stated, the test requirements should be subject to the approval of the organization responsible for the specification of the product or system to be tested. Required tests should be controlled. Tests may include:

(a) Prototype qualification tests
(b) Production tests
(c) Proof tests prior to installation or handover of equipment in the installation
(d) Construction tests
(e) Pre-operational or commissioning tests
(f) Operational tests

The acceptance criteria should be based on the design documents or other pertinent documents. Testing should verify that the safety function of a product has been maintained. Appropriate testing of computer software should be completed before reliance is placed upon the software for operations.

Testing instructions should specify the test objectives and should make provision for ensuring that prerequisites for the given test have been met, that adequate equipment is available and is being used, that necessary monitoring is performed and that suitable environmental conditions are maintained.

Test results should be documented and evaluated to ensure that testing requirements have been satisfied.

7.7 Metrology & Calibration

Measuring & Test Equipment

Where measuring or test equipment is used for any inspection, testing, verification and validation activity which may affect safety, the equipment should be of the proper range, type, accuracy and precision.

Tools, gauges, installed instrumentation and other measuring, inspection and testing equipment (including testing software and devices) should be of the proper range, type, accuracy and measuring precision.

It is possible for instruments to be damaged during handling and it is also possible for the readings given by the instrument to drift with usage of the instrument or with age. If measurements are carried out by a faulty instrument, then the conformity of the product to the specifications also becomes questionable. The instruments should therefore be calibrated at the time of purchase and thereafter at regular intervals, depending upon their use. Some instruments need to be calibrated before every use.

Calibration Process

A process should ensure the measuring and test equipment is calibrated and traceable to national standards. The calibration process is applied to all measuring equipment which may affect safety (e.g. radiological measuring equipment, operational process measuring equipment and measuring equipment used for maintenance).

The calibration process should include:

(a) Specification of the measurements to be made and the accuracy required, and the specific measuring and testing equipment to be used.
(b) Identification, calibration and adjustment of all measuring and testing equipment and devices that could affect product quality, at prescribed intervals or prior to use, against certified equipment having a known and valid relationship to nationally or internationally recognized standards. If no such standards exist, the basis used for calibration should be documented.
(c) Establishment, documentation and maintenance of calibration procedures, including details of the type of equipment, its unique identification number, its location, the frequency of checks, the check method, the acceptance criteria and the actions to be taken when results are unsatisfactory.
(d) Verification that the measuring and testing equipment has the required accuracy and precision.
(e) Identification of measuring and testing equipment with a suitable indicator or approved identification record to show its calibration status.
(f) Maintenance of calibration records for measuring and testing equipment.
(g) Equipment is such that its accuracy and fitness for use are maintained.
(h) Protection of measuring and testing equipment from adjustments that may invalidate its accuracy.
(i) Methods for adding measuring and testing equipment to, and removing it from, the calibration programme, including the means to ensure that new or repaired products are calibrated prior to their use.
(j) A process to control the issue of measuring and testing equipment to qualified and authorized individuals.

A process should be established for the control of equipment that is out of calibration, including its segregation to prevent its further use and the identification and evaluation of any consequences of its use for previous measurements made since the last calibration date.

Testing hardware, such as jigs, fixtures, templates or patterns, and testing software used for inspections should be checked prior to their use in production and in the installation. They should be rechecked at prescribed intervals and account should be taken of any recommendations of the manufacturer/supplier. The extent and frequency of these checks should be established and records should be maintained as evidence of control. Such testing hardware that has been approved for use should be properly identified.

Where the test results for a product are required to be submitted to a regulatory authority for approval, it is necessary for the authorities to recognize the laboratory that has performed the tests.

7.8 Certification

"Certification" is defined by international standard ISO/IEC 17000 (Conformity assessment; Vocabulary and general principles) as "third-party attestation related to products, processes, systems or persons". Product certification involves the issuance of a mark by a third party to demonstrate that a specific product meets a defined set of requirements, such as safety, fitness for use and/or interchangeability characteristics for that product, usually specified in a standard.

Product certification carried out by third-party certification bodies, that is, independently of the consumer, seller or buyer, is most acceptable to purchasers, importers and regulatory authorities. Many national standards bodies provide third-party product certification services, which include placing their certification mark on the product, along with the reference number of the standards used as the criterion for testing the product. In some countries, product certification is also carried out by trade or industry associations, government institutions or private certification bodies.

The product certification authorities usually permit the use of a mark on the product to demonstrate that the product meets a defined set of requirements, such as safety, fitness for use and/or specific interchangeability characteristics that are usually specified in a standard. The mark is normally found on the product or its packaging; it also carries a reference to the number of the relevant product standard against which the product is certified. Ideally, a product certification mark should demonstrate to the consumer that a product meets the generally accepted standard for that product.

"CE" is the abbreviation for "conformité européenne", French for "European conformity". CE marking is not a quality mark. Firstly, it refers to the safety rather than to the quality of a product. Secondly, CE marking is mandatory for the product it applies to, whereas most quality marking is voluntary.

Directives relating to the above products can be found on the website of the European Union (www.europa.eu.int). Each directive includes the conformity assessment procedure to be followed.

Conformity Assessment

A manufacturer must follow a conformity assessment procedure in order to place CE-marked products on the market. The company may select from among the modules listed below, depending on the modules that are permitted or required by a particular European Union directive and the product's perceived risk level. Some products may require a combination of these modules:

- Internal control of production (module A)
- European Union-type examination (module B)
- Conformity to type (module C)
- Production quality assurance (module D)
- Product quality assurance (module E)
- Product verification (module F)
- Unit verification (module G)
- Full quality assurance (module H)

Notified bodies are designated by European Union member States to carry out conformity assessment tasks according to the directives. A list of them is published in the Official Journal of the European Union. The notified body could be a third-party organization, such as an International Standards Organization (ISO) 9000 certification body or testing body, or a product certification body accredited by the national accreditation bodies of member States of the European Union.

Quality Assessment System for Electronic Components

The IEC Quality Assessment System for Electronic Components (IECQ- CECC) is a comprehensive, worldwide approval and certification programme that assesses electronic components according to quality requirements. The supplier's declaration of conformity under third-party supervision is an essential element of the system. The IEC mark can be used for components certified under this scheme, which can provide assurance that electronic components and related materials and processes meet the conformity requirements of buyer/seller specifications. Details of the scheme can be obtained at www.iecq-cecc.org.

Conformity assessment generally consists of the following activities:

- Inspection
- Testing and calibration
- Product certification
- System certification
- Accreditation

While each of the above activities is a distinct operation, they are closely interrelated. The reliability of the results of any of the activities depends on many factors, such as the competence of the assessment body, methods followed and the appropriateness of the standard against which the product is evaluated.

The certification of structural nuclear safety related work should thus only be entrusted to appropriately qualified and experienced people.

Accreditation of a conformity assessment body

Accreditation is an internationally accepted system that recognizes that a conformity assessment body (laboratory, inspection body, product certification body or system certification body) is able to provide its services in a professional, reliable and efficient manner.

In order to demonstrate that the essential safety requirements are satisfied, equipment will be subject to conformity assessment based on EC Decision 93/465/EEC of 22 July 1993 which set down a framework of conformity assessment 'modules' intended for use in New Approach Directives. The higher the category and therefore the greater the hazard, the more demanding are the requirements.

- Equipment in Category I will be subject to the manufacturer's own internal production control.
- The modules for products in Categories II, III & IV will require the involvement of 'notified bodies', appointed by Member States, either in the approval and monitoring of the manufacturers' quality assurance system or in direct product inspection.

In addition to notified bodies, 'Recognised third-party organisations' may also be appointed by Member States specifically to carry out the approval of welding procedures and personnel and non-destructive testing personnel as required for pressure equipment and assemblies in Categories II, III and IV . 'User inspectorates' may also be appointed by Member States to carry out the tasks of notified bodies within their own organisations

Reference

97/23/EC Pressure Equipment Directive

Dti URN/05/1074 Product Standards – Pressure Equipment Guidance Note

7.9 Traceability

As-constructed records should provide a fully referenced account of the work actually constructed and should be produced in a timely manner as the information becomes available throughout the contract.

For the purposes of verification of construction detail, particularly areas which cannot be readily inspected, will become inaccessible, concealed or covered once complete, detailed referenced photographs should be retained and used as part of the as-constructed records. As- constructed records are an important aspect of future verification and maintenance and as such suitable and adequate provision should be made for their retention, see chapter 8.

Note: As-constructed records have in the past received various levels of attention at the end of a project. Records management and retention is often found to be an area for poor practice or sometimes records not available due to the time delays in their production.

7.10 Storage, Handling, Packaging & Delivery

Provision should be made for preventing damage, deterioration or loss of items. For this purpose, items should be stored in a manner that provides for their ready retrieval and protection. Storage should be controlled to prevent the deterioration of degradable material, such as elastomer seals, O-rings and instrument diaphragms.

Storage practices should be adopted to ensure that:

(a) Corrosive chemicals are well segregated from equipment and metal stock;
(b) Flammables are properly stored;
(c) Radioactive material is properly controlled;
(d) Stainless steel components are protected from halogens, sulphur and direct contact with other metals, in particular carbon steel;
(e) Relief valves, motors and other equipment are stored on their bases;
(f) Containers (boxes, barrels and crates) are stacked to reasonable heights and in accordance with instructions of the vendor and storage instructions;
(g) Parts, materials and equipment are repackaged or protective caps are reinstalled to seal items on which previous packaging or protective caps have deteriorated or been damaged or lost while in storage;
(h) Elastomers and polypropylene parts are stored in areas where they are not exposed to light;
(i) Machined surfaces are protected;
(j) Equipment internals are protected from the ingress of foreign material;
(k) Material, equipment and storage facilities are properly protected from rodents;
(l) There is suitable segregation of safety related and non-safety-related components.

Physical means of identification should be used to the extent possible and the identification should be transferred to each part of an item that is to be subdivided.

The handling and storage process should include arrangements for shelf life management. For example, an item whose shelf life has expired should be discarded unless an engineering evaluation is conducted and engineering approval is obtained prior to use of the item.

For critical, sensitive, perishable or high value items, special arrangements, such as the provision of protective enclosures, an inert gas atmosphere and moisture and temperature control, should be specified and put in place. These measures may also be applied to installed items that are subject to extended out-of-service conditions.
The handling and storage process should also cover field storage of consumables such as lubricants and solvents to ensure that they are properly stored and identified.

Items removed from storage should be protected. In the handling of items, factors such as weight, size, certification and regular inspection of hoisting or lifting equipment, chemical reactivity, radioactivity, susceptibility to physical shock or damage, electrostatic sensitivity, sling location, balance points and method of attachment should be considered. Special handling tools and equipment should be provided, controlled and inspected periodically as necessary, to ensure safe and adequate handling. Procedures should be in place to ensure that when put into operation all packaging/preservatives and tools are accounted as removed.

Items removed from or placed into storage, including surplus material returned to storage, should be promptly documented so that the store inventory is kept accurate. The store record system should indicate the locations of materials and parts in all designated storage areas. Access to storage areas should be controlled.

Maintenance should be performed on certain items held in storage, such as large pumps and motors. Such maintenance should include periodically checking energized heaters, periodically changing desiccants, rotating shafts on pumps and motors, and changing oil on rotating equipment, and other maintenance requirements as specified by the vendor.

7.11 Non Conforming Product & Concessions

The arrangements should enable the identification, segregation, control, recording and reporting of non-conformances against processes, procedures or specifications. The impact on safety should be evaluated and corrective action taken to eliminate the cause of non-conformances. All decisions even scrapping should be recorded for future reference and trending. Decisions involving repair or concession should be made at appropriate levels of design authority and for significant items mat even need regulatory agreement. The arrangements should also include preventative actions to eliminate the cause of potential non-conformances. During the construction process non-conformances may occur. It is important that there are appropriate procedures and processes within the project team to record non-conformances and confirm the actions taken through the design team to address any issues resulting from a non-conformance. A site culture should be engendered, such that contractors are positively encouraged to report openly any potential non-conformances no matter how they have arisen. Generally, a 'questioning attitude' should be fostered within the construction team.

Deviations (non-conformances) are unplanned departures from the purchaser's requirements and can be identified through a number of devices including inspection, audit or technical query. They can occur at any level within the supply chain.

The identification, reporting and resolution of deviations should not be seen as negative but as an indication that the achievement of the purchaser's requirements is of prime importance. The control of any deviation from the technical specification is fundamental to the achievement of quality and therefore the integrity of the item.

All organizations within the supply chain should, as part of their quality management arrangements, operate consistent arrangements (policed by the purchaser) for the categorisation and disposition of deviations.

Purchasers at each level of the supply chain should ensure that their suppliers have adequate arrangements for the identification, categorization and disposition of deviations for items or services. These should include obtaining the approval of the purchaser for the deviation in the form of a concession or procedure for re-work, and informing the ultimate purchaser and the ONR (via the purchaser at the head of the supply chain) for deviations that are significant to nuclear safety.

7.12 UK Nuclear New Build EPR

Design
The design management for a nuclear power plant must ensure that the structures, systems and components important to safety have the appropriate characteristics, specifications and material composition so that the safety functions can be performed and the plant can operate safely with the necessary reliability for the full duration of its design life, with accident prevention and protection of site personnel, the public and the environment as prime objectives.

The design management needs to ensure that the requirements of the operating organization are met and that due account is taken of the human capabilities and limitations of personnel. The design organization needs to supply adequate safety design information to ensure safe operation and maintenance of the plant and to allow subsequent plant modifications to be made, and recommended practices for incorporation into the plant administrative and operational procedures (i.e. operational limits and conditions).

Wherever possible, structures, systems and components important to safety should be designed according to the latest or currently applicable approved standards; shall be of a design proven in previous equivalent applications; and should be selected to be consistent with the plant reliability goals necessary for safety. Where codes and standards are used as design rules, they need to be identified and evaluated to determine their applicability, adequacy and sufficiency and should be supplemented or modified as necessary to ensure that the final quality is commensurate with the necessary safety function.

Reference
IAEA NS-R-1 Safety of Nuclear Power Plants – superseded by SSR-2/1

IAEA Safety of Nuclear Power Plants: Design SSR-2/1
HSE Safety Assurance Principles for Nuclear Facilities

General Quality Assurance Specification & Quality Related Activities
For the UK EPR Project, requirements pertaining to Quality are expressed in contractual terms in the *"General Quality Assurance Specification"(GQAS), Reference* ECUK100053, This specification is based on ISO 9001:2008, and includes additional requirements placed on the contractor to meet the needs of the nuclear industry.
In particular to the following activities and requirements:

- identification of Quality Related Activities (QRAs),
- qualification of staff and technical equipment/processes,
- technical inspection,
- the QRA Performance Report.

A QRA is defined in the GQAS as *"an activity, the failure of which can lead to a product non-compliance with the nuclear safety requirements".*
Examinations and tests are carried out to check that a QRA has obtained the required result, and these examinations and tests form part of the *"technical inspection".* Examinations and tests are not considered to be QRAs except when justified by safety considerations.

QRAs designed to ensure metallurgical quality are required to be distinguished from those guaranteeing equipment functionality. Depending on the safety considerations involved, an overall QRA may be broken down into several basic QRAs, which are subject to individual technical inspections.
The method by which the requirements of the various clauses of the GQAS are implemented will depend on the safety considerations involved.

The manufacture of materials which are for use in level N1 nuclear pressure equipment and are subject to technical qualification comprises the following QRAs:

- melting process,
- forming by hot or cold working,
- forming by casting,
- specified heat treatments,
- Non destructive Testing

Reference

EDF UK EPR EDEEM100177 Guidance for applying GQAS Mechanical Equipment
EDF UK EPR EDESFR124021 Guidance for applying GQAS Electrical Equipment

Qualification of manufacturing processes

Some manufacturing processes are to be qualified, such as procedures for manufacturing of certain parts and the operating procedures for permanent assemblies. It should also be noted that only staff possessing the required skills may be assigned to a QRA. Other staff requiring qualification include:

- welders,
- welding operators,
- tube to tubeplate expansion operators,
- NDT operators.

Qualification operations for staff and procedures are not QRAs.

Books of technical Rules & specifications

Books of Technical Specifications and Books of Technical Rules have been drawn up by EDF with reference either to design and manufacturing codes, or to European standards.

Compliance with the requirements of the Book of Technical Rules is deemed to comply with BS EN ISO 9001, the requirements from IAEA safety standard GS-R-3, and the EDF GQAS.

7.13 Regulatory Issues at Olkiluoto 3

During 2006, STUK (the Finnish regulator) appointed an investigation team after having noticed that the management of those participating in the construction of Olkiluoto 3 –unit (the first ever EPR) did not fully comply with their expectations concerning good safety culture, hampering the progress and giving increased pressures on the schedule of the subsequent construction phases. In its report the investigation team states that the major problems involve project management, in particular with regard to construction work, but not nuclear safety. Insufficient guidance of subcontractors' work in Olkiluoto 3 nuclear power plant project. Key findings were:

- major problems with project management, in particular with regard to construction work, but not nuclear safety, the project should be provided with a strong safety culture
- the large number of subcontractors had insufficient guidance and supervision to ensure smooth progress of their work, a particular problem was the supervision of subcontractors' performance level and the guidance provided for them.
- recommendations both to the buyer Teollisuuden Voima Oy (TVO) and the vendor company Consortium FANP-Siemens (CFS) and also room for improvement in the practices of the regulatory body (STUK)
- Design took longer than planned confusing the work schedules of sub-contractors
- CFS did not understand the Finnish requirement for the design to be accepted by TVO and STUK before manufacturing commenced
- Communication of requirements on quality and quality control, from CFS to subcontractors, had occasionally been deficient - essential quality requirements and any possible extra costs arising had not been clearly specified at the stage of the invitation to tender
- Issues were found with the construction of the reactor island base slab and the reactor containment steel liner and in a later report with the emergency diesel generators (EDG) emergency diesel generators (EDG) . The EDG issues were mainly related to traceability and quality of the many components involved.

However

- The required standards have been maintained and, on the basis of tests and inspections conducted, they have been met, although in some cases only after corrective measures. The observed difficulties at the construction stage have therefore not influenced the safety of the power plant when it will be ready to operate.
- Corrective measure were subsequently agreed with TVO and CFS and within STUK

Claims that welding issues have occurred during construction are refuted by STUK.

7.14 Regulatory Issues at Flamanville 3

The table below show the issues that have arisen and been reported by the French nuclear regulator ASN at [ASN's supervision of Flamanville-3-reactor]

Topic	Issue	EDF / ASN Response	NQK Comment
IN 1 Apr 2008			
1. Safe system of Work	Inadequate consideration of crane fall on adjacent existing reactor safety structure	Design in safety structure to prevent fall.	
2. Concreting	Cracking to foundation block concrete – shrinkage – poured early Dec 2007.	Repair by resin injection.	
3. Concreting & Management supervision	Rebar not fixed as drawings. Inadequate technical supervision by contractors and monitoring by EDF	EDF corrective actions (not defined) in place before concrete poured.	Correction time not defined
4. Overview	Subcontractors technical skills and safety culture	ANS believe EDF need to reinforce lead and monitoring of activities till shown satisfactory.	
IN 2 June 2008			
1. Concreting & Management supervision	Rebar not fixed as drawings. Inadequate technical supervision by contractors and monitoring by EDF	Repeated issue – EDF to • suspend concreting of safety related structures • analyse malfunctions and corrective action required • Improve service provider technical control • Improve own monitoring activities • Improve own discrepancy management procedures	See IN 1 Topic 3 Led to ASN Regional Head being questioned in press conference
IN 3 June 2008			
1. Concreting & Quality Management System	Authorise resumption of concreting after: • Improved technical control by service providers • Closer monitoring by EDF • Introduction of 3rd party supplementary tech inspection of concrete reinforcement operations • Clearer management of deviations • Training of all on site – improve safety culture • Strengthening Bouygues (principal civil and structural construction contractor) quality team	EDF to submit monthly report on implementation of action plan.	See IN 2 Topic 1 IN 4 shows work had been suspended for 23 days
IN 4 Nov 2008			
1. Liner plate welding	Use of different welding method from those defined in technical specification	EDF • submit technical justification, • Propose additional weld testing • ASN review and accept proposals	5 June to 28 Aug ie +12 weeks disruption

Topic	Issue	EDF / ASN Response	NQK Comment
IN 5 Feb 2009			
1. Liner plate welding & Management supervision	1 Deviations from technical specification requirements • Use of different welding method from those defined • Climatic conditions during welding • Welding data package available to welders 2 Inadequacies against Order of 10 Aug 1984 • Qualification of the pre-manufacturing shop on site • Monitoring of welding operations and NDT of welds • Quality management system of company responsible for welding 3 High rate of weld repairs	ASN asked EDF to suspend irreversible operations that would be incompatible with additional weld inspections. ASN after two month examination of case asked for existing welds – • additional data particularly on representative weld tests • 100% inspection of certain weld types • For new welds – • Action plan to improve weld quality • Monthly report on implementation of plan • 6 month report on effectiveness • 100% inspection of welds till confirmed significantly improved	See IN 4 Over 9 week loss on programme before allowing for additional activities
2. Safe system of Work	Changed methods in excavation of sea outfall tunnel – consideration of effects on existing reactor	ASN ask EDF to undertake safety analysis	
3. Supplied items	Pipes for essential service water system not to production standard	EDF undertake additional investigations and resultant scrapping of pipes	
IN 6 July 2009			
1. Liner plate welding & Management supervision	Radiography shows weld repairs now <10%.	EDF suspend radiography tests but maintain monitoring operations	See IN 4 & 5 (Issue 1)
2. Civil engineering operations	• Inspectors/tech support agency alert to EDF that Reactor Building foundation raft required significant number of tasks before going ahead with concreting. • Subsequently non-conformances identified in insufficient concrete poured, modifications to formwork during operations.	ASN consider major programme pressures having negative impact on quality of works. EDF asked to take measures to avoid repeat .	See IN 3
IN 7 Feb 2010			
1. Concreting -	Inadequate roughness and use of chemical not designed for construction joints	ASN asked EDF to • stop use of the product • make an inventory of all methods used to treat construction joints on site • analyse the consequence of the chemical usage • produce a comprehensive qualification procedure for methods of treating construction joints.	SEE IN 10 – (Feb 2011) regarding report.
2. Control of deviations from civil engineering standards	Many deviations from Standard ETC-C design and construction rules noted.	ASN asked EDF to • More rigorously identify and justify all such deviations • Check all deviations (to date) have been correctly identified.	

Topic	Issue	EDF / ASN Response	NQK Comment
3. Cooling system manufacturing & supplier control	Reactor coolant system and secondary system components.: • Deviations identified, cases examined and additional tests inspections led to defective steam generator component being replaced by alternate already manufactured but differing characteristics. • Tasks of those responsible for quality needed clarified.	ASN asked AREVA NP to improve • decision making procedures, • supplier approval and monitoring, • move forward in area of regulatory documentation	
IN 8 June 2010			
1. Installation of concrete prestressing sheaths	After ASN requested EDF ensured procedures for installing prestressing complied with requirements, EDF reported prestressing sheath in the inner containment wall positioned outside tolerances.	• ASN studying EDF report justifying acceptability of non-conformances. • EDF must now advise ASN of all subsequent concreting lifts in the inner containment wall.	
2. Mechanical assembly installation – housekeeping	Cleanliness requirements not being complied with on site.		
3. Cooling system manufacturing	Joint inspection with STUK – detection of deviations in manufacture of coolant pipes for Olkiluoto 3 EPR project – same manufacturer for Flamanville 3.	ANS determined that AREVA NP action plan was inadequate to allow manufacture of equipment for Flamanville to begin. Required information on ; • Quality of risk analysis • System of internal inspections • Formalisation of quality related actions • Detailed quality / manufacturing plan	Refs to IN 6. for further details
IN 9 Aug 2010			
1. Liner manufacture - welding	• Ergonomic of welding position causing new problems • Radiographic testing not keeping up with welding	EDF had already temporarily suspended new welding, reminded of 2009 action plan and begun radiography of all questionable welds. Repairs had been completed. ASN determined 2008/2009 response not adequate and EDF to apply operating feedback to all welding activities on site.	See IN 4,5 & 6
2. Safe System of Work – underground cabling to Flamanville 2	Worker on Flamanville 3 site drilled through 400kV underground cabling to Reactor 2 @ Flamanville 2 (shut down at the time for refuelling). EDF inquiry identified lack of information to construction workers + poor cable identification	ASN to take more actions to control major risks prior to construction	

Topic	**Issue**	**EDF / ASN Response**	**NQK Comment**
3. Component suppliers & supervision	Identified room for improvement in EDF project organisation related to • Monitoring by EDF • Validation of list of activities concerned by quality		
IN 10 Feb 2011			
Feedback on construction joint issues report	Report by EDF assessed by ASN/IRSN	ASN conclusion need further take account of situations on site eg difficulty of application & cleaning.	See IN 7 Topic 1
IN 11 Sep 2011			
1. Installation of concrete prestressing sheaths	EDF notified new non-conformance issues	ASN requested suspension of installation. Concerns at: • Increase training and awareness of safety culture • Increase monitoring by EDF • Impact analysis of anomalies incl cumulative account. EDf to produce Action Plan	See IN 8 Delay approx. 1 week ASN released hold on concreting
2. Concreting	EDF identified "rock pockets" in some walls. Result of • Difficulty of pouring in complex shapes with dense reinforcement • Cleaning prior to pouring incorrectly performed and inspected.	ASN require EDF • Produce report on quality of affected walls, after repairs completed • Identify if complex concreting could have led to defects for which visual inspections are not possible • Define appropriate preventative measures • Present operating experience feedback / lessons learnt prior to next complex concrete operations	This appears what in UK would be called honeycombing. See IN 13 Topic 2 Appears recurring theme in civil and mechanical welding constructability in design.
IN 12 Mar 2012			
1. Installation of concrete prestressing ducts – corrective actions	Action plan presented by EDF to ASN.	ASN inspections show adequate implementation of the various technical and management measures to ensure proper construction.	See IN 8 Topic 1 & IN 11 Topic 1
2. Polar crane brackets Manufacture	Welding defects identified in factory prior to painting and again during additional on-site inspections	ASN has requested additional inspections of other brackets EDF undertaking inspections and developing.	Delay to concreting of lift in inner containment wall
3. Concreting	EDF additional information on "rock pockets".	Accepted by ASN	See IN 11 Topic 2
4. Tank. Pool and liner welding operations	EDF must pay careful attention to: • stainless steel sheet metal contamination risks • to ensuring adequate control of sheet metal welding operations, particularly during repair work.	ASN continuing to monitor execution of these and proper implementation of tank lining procedures for spent fuel pool tanks.	

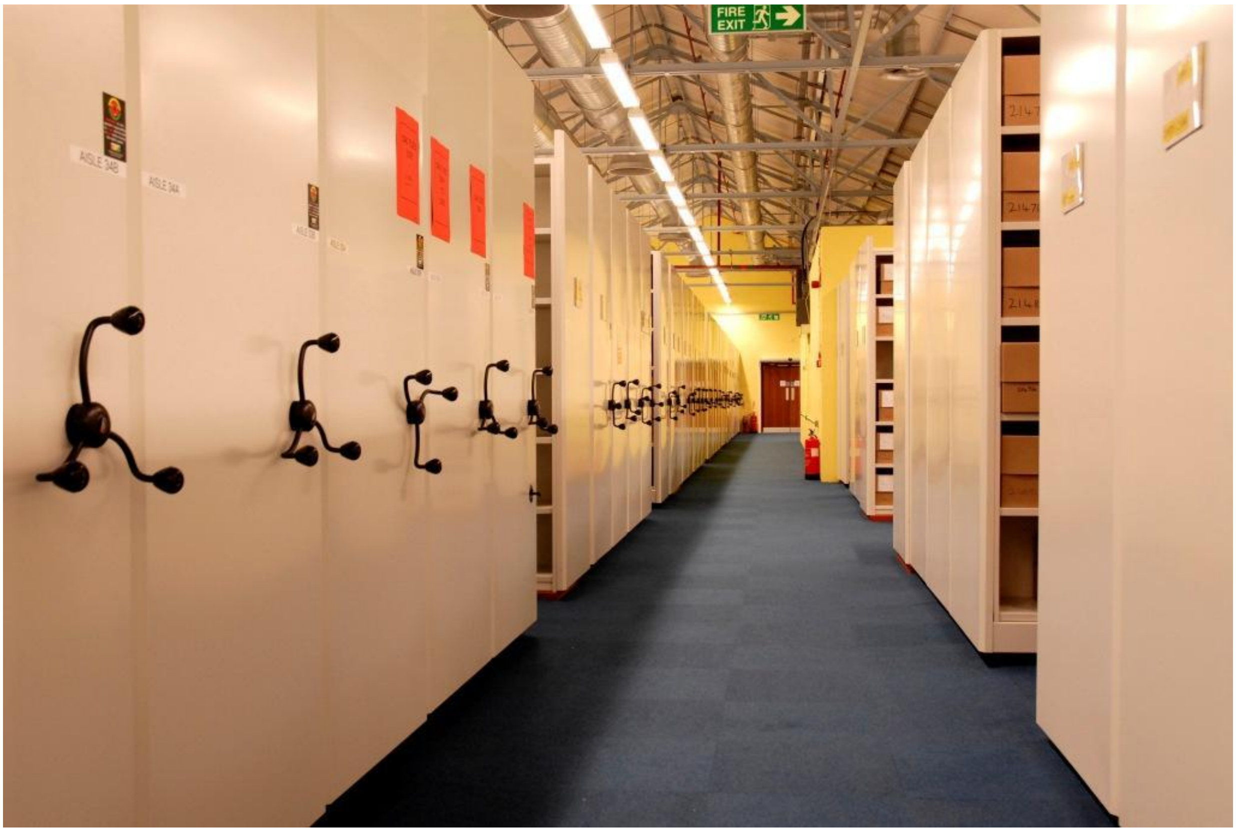
Topic	Issue	EDF / ASN Response	NQK Comment
5. Reactor vessel head repair	AREVA NP informed detection of two significant quality non-conformances during manufacture of reactor vessel head. Relate to • Initial detection of welding defects • Subsequent detection during subsequent repair operations. Proposed solution consisted of reworking several manufacturing steps	ASN asked AREVA NP to • Conduct detailed assessment of the potential impact on construction quality of the head. • To propose specific measures to ensure quality of repairs. After assessment ASN allowed AREVA to proceed with repairs. Operations being undertaken under direct supervision of ASN & inspection authority appointed by ASN. ASN will assess acceptability of reactor vessel head after completion of all repair and manufacturing operations	About 9 months between two issues. Continued work at manufacturing risk.
6. Pipe manufacturing Procurement and Product quality	During manufacturing inspection (Mar 11), AREVA NP detected small metal tears and scratches on the internal surface of certain auxiliary pipes. AREVA NP proceeded with repairs. • (Sep 11) ASN ordered suspension of repair operations due to non-consideration of requirements to improve radiation protection performance of future reactor. • (Nov 11) repairs resume dafter AREVA NP proposed measures. • (Nov 11) EDF inspectorate informed ASN of inadequacy of weld repair operations performed by AREVA NP sub-contractor. Related to tools used and inspections conducted . • (Dec 11) ASN inspection / suspended pipe manufacturing operations. (Feb 12) resumed manufacturing	ASN consider these non-conformances illustrate essential for manufacturers to stipulate specific requirements to suppliers and ensure they are met .	
IN 13 Oct 2012			
1. Polar crane supports Manufacture	EDF advise dASN of decision to have all polar crane supports remanufactured	Manufacturing in progress	See IN 12 Topic 2
2. Concreting	• EDF previous reports of localised honeycombing issues. • EDF report of “empty spaces” behind recesses accommodating gates of reactor building pools – arose from activities prior to implementation of additional measures. Identified following experience feedback from Okiluoto. EDF have undertaken repairs, inspected by ASN.	ASN attentive to final construction quality, after inspection and repair, of reactor pools	See IN 11 Topic 2

Topic	Issue	EDF / ASN Response	NQK Comment
3. Reactor vessel head repair	As first step, AREVA NP proposed large scale repair solutions, including eliminating all welds of 50 out of 105 adaptors.	After inspections and feedback, ASN approved continuation on remaining 55 adaptors. At end of second phase, AREVA NP to undertake complete inspection of closure head base metal under removed welds.	See IN 12 Topic 5 Continued work at manufacturing risk.
4. Steam Supply System components. Care & Maintenance during Transport and Site installation	ANS asked AREVA NP to carry out risk analysis of Transport and Site installation phases. Inspection showed Improvements needed in : • Identification of documents drafted by manufacturers, defining precautions needed. • Definition and compliance with conservation conditions in buildings between installation and commissioning; notably related to temperature and relative humidity.	After review, by ASN and Pressure equipment assessors, of AREVA NP's measures ASN will state its position regarding continuation of on-site assemble operations	

Chapter 8

Knowledge and Information Management

CONTENTS



Editor: Richard Hibbert
Contributors: John Day; Mike Kelleher; Mark Harbor

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 SLC 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 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

Knowledge management (KM) has only been recognised as a distinct discipline in recent years and there is no international standard for KM. IAEA GS-R-3 has the following basic requirements in relation to knowledge:

- Information and knowledge be managed as a resource;
- Individuals acquire suitable knowledge to ensure their competence; and
- Knowledge sharing takes place to aid the identification of potential non-conformances.

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 principle document is IAEA TECDOC1510 which, although now 7 years old, provides a good introduction and overview of the subject. The other IAEA guides available provide more detailed advice and case studies in an ever expanding suite of integrated documents.

Another important source of guidance appears is the the Government document "Information matters: building government's capability in managing knowledge and information". This publication has a non-nuclear bias and discusses the requirements for managing and sharing knowledge within publicly funded programmes. The NDA's approach to knowledge and information management is aligned with this document.

Knowledge
We readily distinguish between data and information and yet 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" in a number of different ways: to describe "knowing facts" and also to describe "knowing how" to do something. When deciding if we should jump into a swimming pool we need to understand the difference between "knowing facts" about swimming, "knowing how" to swim and knowing why jumping is a good decision. In the nuclear industry we also need to "know why" things happen so that we can design and engineer safe systems identify risks and prevent unwanted events and it is often useful to "know-who" we should go to seek expert advice and share learning.

Our knowledge is lodged in our heads; things we have learned over a lifetime, 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.

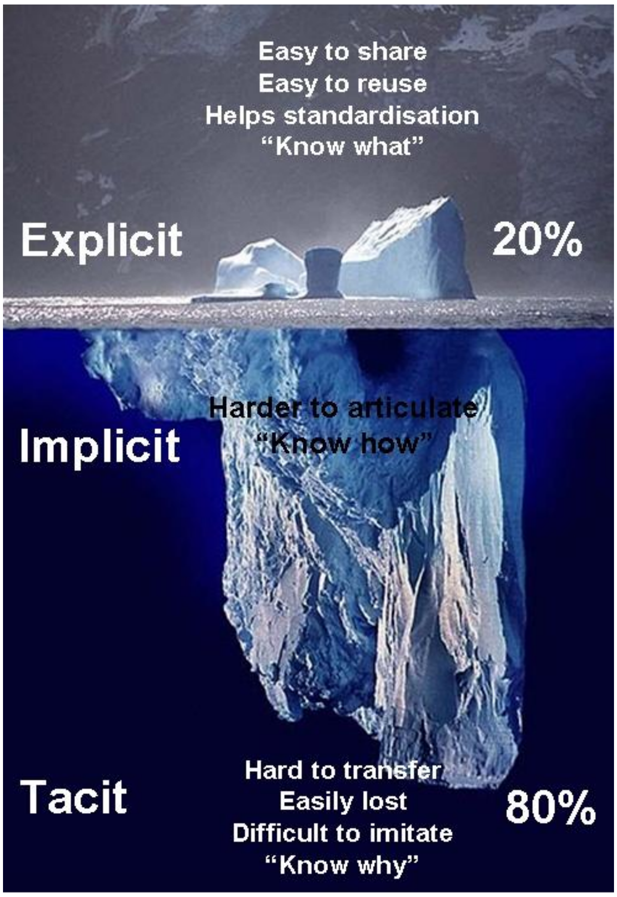


Figure 1 Explicit, Implicit and Tacit knowledge
Background based on an original image by Uwe Kils reproduced under the Creative Commons Attribution – Share Alike 3.0 Unsupported licence

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 1 or 2 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 organisations.

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 life-cycle 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 to competence for nuclear workers is relatively long compared to other industries. With the requirement for long periods of training, higher qualifications and continuous learning and development, nuclear expertise can take decades to develop. When combined with the relatively old age profile of the workforce this demands 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 their re-use.
- Implicit knowledge can also, with sufficient effort, be captured in artefacts such as files, personal network naps, 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 and 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 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 are 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 organisation, 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.

Many knowledge management activities are scoped to be effective within the boundaries of a single organisation. In contrast, the nuclear industry requires intra-organisational, national and international approaches to knowledge management. Integrated national strategies are required linking energy policy, higher education, human resource planning, capital investment, supply chain capability, research and development, information libraries and archives and the growth and maintenance of an experienced and qualified workforce.

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 Nuclear Decommissioning Authority is demonstrating its commitment to knowledge management in its recent KM Policy (IMP05) and knowledge management roadmap for the Estate it is overseeing. The NDA's KM programme was launched in March 2013 and opportunities to contribute to an integrated UK national strategy on NKM will emerge during the implementation of the programme.

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;
- 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 records 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 Nuclear Decommissioning Authority (NDA) is planning to build a National Nuclear Archive (NNA) at Wick in Scotland. The NNA will hold records from nuclear sites in the NDA estate including records relating to the early history of the UK nuclear industry. A purpose built facility will be constructed that is expected to be operational in early 2016.

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 1996, Environmental Permitting Regulations 2010 (replacing Radioactive Substances Act in England and Wales), the Radioactive Substances Act 1993 (still in force in Scotland) and the Ionising Radiation Regulations 1999. HSE, EA and 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.

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 Licensee Management of Records and 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 GS-R-3 include basic requirements relating to records. IAEA safety guide GS-G-3.1 includes a significant amount of guidance on records management practices. The older superseded IAEA publication 50-C/SG-Q 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.

Useful international and British standards are:

- BS ISO 30301:2011 is an auditable standard for a records management system. This standard is aimed at management rather records management professionals. It fits well with a process approach and can be readily used with other management system standards such as ISO 9001.
- ISO 15489:2001 is the foundation standard that codifies best practice for records management operations. It is aimed at records management professionals rather than management.
- BS 10008:2008 can be used to identify controls to ensure authenticity when converting physical records to electronic format.
- BS ISO/IEC 27001:2005 can be applied to the information security aspects of records management and can be applied more generally to the management of all information assets.
- PD 5454:2012 covers requirements for long term storage of records for an archive facility.

General Records Management
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 ISO 15489; 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 it is a requirement if ISO 30301 or ISO 15489 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 is 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 PD 5454. There are a number of specialist suppliers who can provide records archiving services.

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 ISO 27001. 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 defines the controls to be applied when scanning paper documents to help ensure that authenticity is preserved.

Chapter 9

Assessment and Improvement

CONTENTS

Editor: **David Morgan**
Contributors: **Richard Hibbert, Graham Watson**

9.1 Assessment

Overview

Because of the importance of providing adequate assurance of safety, internal audit alone is not considered sufficient to assess management systems for organisations in the nuclear sector. Organisations are legally obliged and encouraged to adopt a strength-in-depth approach in providing assurance of safety. This approach extends to assessing the adequacy, implementation and effectiveness of its arrangements and to strive for continual improvement and good practice.

This section sets out, for someone who is familiar with auditing a quality management system against the requirements of ISO 9001[1] and the auditing guidance in ISO 19011[2], additional information on the assessment techniques used in the nuclear sector.

Assessment of the management system

The IAEA Safety Standard GS-R-3 *The Management System for Facilities and Activities* is widely applied to the management of nuclear activities and in the UK is used by most licensees as the basis of their arrangements under Licence Condition (LC) 17 – Management Systems. The requirements of GS-R-3 therefore condition licensees' approaches to assessing their management systems. GS-R-3 does not simply include requirements for audits, as is common with most management system standards, but requires self-assessment and independent assessment.

The purpose of self-assessment is for managers at all levels in the organisation

- To evaluate the performance of the work for which they are responsible, and
- To assess improvement of the safety culture.

The purpose of independent assessment is for an independent unit

- To evaluate the effectiveness of processes in satisfying declared plans and objectives
- To determine the adequacy of work performance and leadership
- To evaluate safety culture, to monitor product quality, and
- To identify opportunities for improvement.

GS-R-3 requires senior management to evaluate the results of independent assessments, take any necessary actions, and to record and communicate their decisions and the reasons for them.

ISO 9001, on the other hand, requires audits to be carried out with the purpose of determining whether the quality management system conforms to the planned arrangements and the requirements of ISO 9001 and the extent to which it is effectively implemented and maintained. There is no equivalent requirement for self-assessment by managers.

The purpose of assessing the management system in the nuclear sector is broader and audit alone is not considered sufficient. This is appropriate because getting it wrong can have far-reaching consequences. Managers have a greater role in ensuring the adequacy and effectiveness of the arrangements and processes for which they are responsible.

Various approaches to self-assessment and independent assessment used by UK licensees are described below.

Self-assessment

GS-R-3 requires senior management and management at all other levels in the organisation to carry out self-assessment to evaluate the performance of work and the improvement of the safety culture.

Self-assessment enables management to periodically compare its performance with management expectations, worldwide industry standards of excellence and regulatory requirements so that deficiencies and opportunities for improvement can be identified. Self- assessment should promote continual improvement in safety performance and in the management system.

Assessments are carried out by all levels of management and include the processes and activities for which the manager or their unit is responsible. To ensure the assessments are effective managers may consider including supervisors and operators when carrying out assessments.

Many organisations find it is difficult to carry out self-assessment effectively and this may often be attributed to a high workload on the management team and to reactive styles of management. It is therefore important that the management system contains a simple self-assessment process which provides guidance to managers and a framework for the administration of self-assessments and the associated corrective actions.

Continual improvement and self-assessment should be seen as a normal part of routine work and therefore the frequency of self-assessment and the topics covered should be chosen carefully. Smaller and more frequent self-assessments help to make the task less onerous and part of the normal management routine. Self-assessments should also be undertaken where poor performance is identified and there is a need for a closer review.

To ensure that all deficiencies and areas of weakness are identified during self-assessment a variety of different methods and techniques are used. These may include:

- Workplace inspections or visits and informal communications with operators and other personnel
- Analysis and review of key performance indicators
- Analysis and review of non-conformity reports and event reports
- Analysis and review of process performance data
- Benchmarking.

GS-R-3 also requires management to evaluate the improvement of the safety culture (see Chapter 3). Identifying the methods and indicators for measuring the many intangible aspects of safety culture such as beliefs, attitudes and behaviours can be challenging. IAEA and others publish comprehensive guidance on this subject.

While an effective manager will be in tune with the culture within their area of responsibility, methods such as interviews, questionnaires, observations and reviews of documentation can also be used to gauge the safety culture of the organisation. It is impossible to use a single measure to judge the safety culture and management should use a number of methods to develop an overall picture.

Senior management plays an important role in developing a successful self-assessment culture and it is essential that senior managers support and encourage the self-assessment process. Senior managers reinforce a questioning attitude and encourage the identification and reporting of non-conformities and areas for improvement. To enable self-assessment to identify deficiencies and areas for improvement senior management foster a blame-free reporting culture where individuals are not punished or blamed for unintentional errors.

Independent assessment

Independent assessment is carried out on behalf of senior management to assess the effectiveness of the management system and to make sure that safety is not compromised by financial, commercial or other pressures. Independent assessment also identifies improvement opportunities and helps drive continual improvement in the management system.

Independent assessment is carried out by an independent unit within the licensee's organisation which has a reporting line directly to senior management. People do not assess their own work or work carried out by their management unit. GS-R-3 requires senior management to evaluate the results from independent assessment. To do this effectively the assessment unit must summarisethe output from its assessment activities and present them in a logical and comprehensible format which allows senior management to understand the information and take strategic decisions to improve leadership, safety culture and the management system.

Below is a brief description of activities that can be included in an independent assessment programme.

- **Internal audit**

  Internal audits carried out in the nuclear sector are usually carried out in accordance with a process based on ISO 19011. Audits determine if the management system conforms to the planned arrangements, conforms to quality management system requirements and is effectively implemented and maintained. Audits also identify opportunities for improving the management system and operational performance. Audits within the nuclear sector will be focused on both safety-related activities, such as site licence compliance processes and on product realisation processes. Audits are less effective in assessing safety culture and leadership performance so other methods of assessment are more effective in the assessment of these topics.

- **Surveillance**

  Surveillance is a good technique for assessing a specific or ongoing work activity and is less formal than an audit. The timing of surveillance visits can be more flexible allowing specific work activities to be observed. It can involve periodically visiting work areas or observing management processes over a period of time. This enables the individual making the assessment to develop a closer relationship with the personnel carrying out the task and allows a much better assessment of the less tangible elements of safety culture, such as leadership, beliefs, attitudes and behaviours. In addition to observing the work or process being carried out, surveillance activities should include reviews of documentation and interviews with personnel.

  Some licensees use an internal regulator to carry out surveillance activities. The internal regulator is often based on the licensed site and has a close contact with the licensee's management team.

- **Inspection**

  The term inspection is often used by licensees, especially those with internal regulators, to describe activities that assess compliance with legal requirements, such as site licence conditions, permitting regulations or safety legislation. Inspections of legal compliance are usually carried out in addition to internal audits which have a greater focus on improving the management system.

- **Peer review**

  Licensees can invite international organisations such as the IAEA's Operational Safety Review Team (OSART), the World Association of Nuclear Operators (WANO) or the Institute of Nuclear Power Operations (INPO) to undertake peer reviews on their facilities. In the case of WANO and INPO licensees need to be members of the organisations. The reviews compare the licensee's performance with international good practice, observe plant activities and material condition, review performance data and interview operators. The assessment teams identify opportunities for improvement and offer advice.

- **Second- and third-party audits**

  Many licensees are certificated to standards such as ISO 9001, ISO14001[3] and OHSAS 18001[4] and certification or surveillance audits will be carried out by an accredited certification body. Similarly, some licensees are audited when their customers carry out second-party supplier audits. The output from such audits can provide a valuable input into the independent assessment process but, the licensee should be aware that the auditors may focus on product realisation rather than nuclear safety processes.

- **Regulatory interventions**

  On licensed sites the regulators will have an intervention programme which describes the compliance inspections, guidance, permissioning and safety case assessment work which the regulator plans to carry out. The regulators should never be seen as part of the licensee's independent assessment programme. However, the feedback from the regulator's inspections and assessments can provide an excellent source of information on the organisation's performance and on the quality of its safety cases.

- **Safety culture assessment**

  GS-R-3 requires the organisation to evaluate its safety culture. The assessment of safety culture is a specialist topic and is usually undertaken by human factors practitioners. To assess safety culture the independent assessment programme must seek to measure the beliefs attitudes and behaviours of the workforce. Various methods have been devised to achieve this including the use of questionnaires and interviews. IAEA and HSE publish extensive guidance on assessing safety culture and there are safety culture assessment tools available.

Auditor competence

This section identifies information that a management system auditor in the nuclear sector should be familiar with in order to enhance their capabilities as auditors. It is assumed that they have already received formal training as a lead auditor, i.e. an accredited course in an appropriate discipline such as quality, environment or health and safety. However, under certain circumstances, auditors are required to be qualified and formally appointed.

General requirements for auditor competence are not specific to the nuclear sector, but some standards, eg ASME NQA-1[5] impose specific requirements on auditor competence, auditing practices and audit reporting. An auditor should be aware of standards containing generic requirements for auditors and auditing and should be aware of applicable standards containing specific requirements and international/national auditor certification schemes.

They should understand the various types of audit that can be carried out (specified in audit criteria) and the differences between audit and inspection.

Many audits require specialist knowledge in order to effectively assess the extent of compliance. A skilled auditor is therefore adept at identifying appropriate technical experts to include on the audit team.

It should be noted that one auditor is unlikely to have the competence to audit all aspects of a management system in the nuclear sector. An auditor therefore needs to be aware of their own limitations and when to seek professional development.

Management system standards

Audits in the nuclear sector can be carried out against the requirements of more than one management system standard. It is therefore important to understand the requirements of each management system standard in order to assess compliance with the standard or demonstrate effective fulfilment of its requirements. This includes the aims of the various management system standards, their common features, differences and the circumstances under which they are applied.

Organisations are increasingly operating, or claiming to operate, an integrated management system. These require a joined-up approach to auditing and auditors should be equipped to undertake such audits without compromising the outcome of the audit.

Legal framework

The nuclear sector is highly regulated and much emphasis in management systems is directed to legal compliance. The auditor should understand the international/national framework of statutory and regulatory requirements applicable to the business being audited and which influence or control the management system. This generally includes safety (both nuclear and conventional), environmental and security or safeguards.

In some instances auditors may require detailed knowledge of specific legislation, such as the Nuclear Installations Act, Radioactive Substances Act and the nuclear site licence and regulations, consents and authorisations issued under enabling legislation (see chapter 2).

Regulatory regime

The auditor should understand who regulates what and how in the nuclear sector. This has a bearing on how identified nonconformities are reported and addressed. In some situations, international standards are invoked under legislation and the auditor should be aware when this applies (see chapter 2).

Graded application requirements

Standards either require a graded approach or imply one, but often auditors are unable to interpret this requirement or assess an organisation's implementation. The auditor should have sufficient understanding of requirements for grading to enable them to assess, interpret and challenge the auditee's arrangements and their application (see chapter 3).

Records

Records have an important status in the nuclear sector and are generally required to be retained for (what can be very) long periods. Auditors should be capable of assessing the auditee's retention periods and understand requirements for preservation and retrieval and issues surrounding records that are retained using electronic media (see chapter 8).

Processes

Processes form the basis of management systems based on GS-R-3 and ISO 9001. The auditor therefore should understand the requirements related to management and control of processes (as opposed to documents) and the interaction between processes as problems normally occur at the interfaces between processes. The auditor should understand the differences between processes and procedures and be capable of evaluating the effectiveness of processes in achieving their desired outputs.

Product quality requirements

The auditor should understand the sources of quality requirements relating to products. In many instances, such requirements are contained or implied in standards rather than being explicitly included in contracts or similar agreements. In many instances, the safety requirements are of equal importance to the quality requirements and evidence of conformity and traceability is essential. This knowledge is needed in order to assess the auditee's ability to produce conforming product.

The nuclear baseline

This forms the basis for the core competence in the UK and influences organisational structure and human resources. The auditor should understand the roles of the intelligent customer, subject matter expert, and how the auditee identifies and maintains core competence (see chapter 3).

Control of contractors/agency workers

Much work is now contracted or carried out by agency workers. The auditor should understand how the responsibilities of the organisation are retained and how work carried out through contracts or agency agreements is controlled by the organisation (see chapters 3, 4, 5 and 6).

Owners/parent bodies/site licence companies

The nuclear sector in the UK) has undergone significant change in recent years. This affects ownership, operation and licensing. The auditor should understand the structure and interaction of the various bodies involved and understand where the authority and responsibility for the areas being audited lie.

Structure of the organisation and management of change

The auditor should understand the nature and structure of the organisation and the management system that is the subject of the audit and how changes to it are managed. This may have significance in terms of understanding how responsibilities are properly allocated and how resources for certain activities such as safety are allocated (see chapter 3).

Safety case

The safety case underpins safety aspects of all work undertaken on or on behalf of a nuclear licensed site. The auditor should understand the basic principles of the safety case and how this influences or controls operations.

Operational processes and plant

The auditor should understand the basis of any operational processes, eg how a reactor works and factors affecting the manner in which the plant operates. This could include for example maintenance, outage and control systems. In some circumstances, this could include an understanding of the technology, reactor type or technical processes involved.

Configuration management

This is relevant to management systems (how do parts of the organisation interact, especially when multiple organisations are involved), plant configuration and process interaction (see chapters 3 and 5).

Traceability

The auditor should understand the importance of traceability to material specifications and material properties and the ability to understand how to identify counterfeit items (see chapters 4,5, 6 and 7 and IAEA guidance).

Further Information

ISO 19011:2011 Guidelines for auditing management systems

BIP 2015:2009 Process management auditing for ISO 9001:2008 (Second Edition).

9.2 Challenge

'Challenge' is not a requirement or term usually associated with management system standards but is one which is often heard on nuclear sites. It is used to describe the arrangements which satisfy the Office for Nuclear Regulation's (ONR) expectation for operators of nuclear facilities (licensees) to have an effective 'challenge function' which enhances nuclear safety by presenting additional barriers to flawed decision making and inappropriate behaviours. The challenge function is independent of the people responsible for decision making or carrying out work and its purpose is to identify poor decisions or performance and to resolve the issue before nuclear safety is adversely affected.

Examples of challenge functions within an operator's organisation are: the nuclear safety committee, independent nuclear safety assessment and internal regulation.

In addition to detecting poor decision making and resolving poor performance 'challenge' can also provide a valuable contribution to the continual improvement of the management system if an analysis and summary of the issues identified form one of the inputs into management review.

Appropriate challenge should be applied at all levels in the operator's organisation and be proportionate to the hazard involved. The arrangements for 'challenge' should be documented in the management system.

Challenge can be applied in a number of ways at all levels in the organisation and may be a formal step in a process, a result of surveillance activity or a challenge by an individual or group who is concerned that nuclear safety is being adversely affected by a poor decision or action. Examples of different methods of 'challenge' which should be incorporated into the management system are shown below:

- Appropriate structure at board level which includes an appropriate number of non-executive directors who are competent to challenge decisions affecting nuclear safety and independent representation for nuclear safety such as a safety director.
- An independent nuclear safety committee which provides advice to the operator. This is required by LC 13.
- Senior management meetings should include independent representation for nuclear safety (e.g. safety director or manager).
- Processes which involve taking decisions that may affect nuclear safety (e.g. producing safety cases, plant modifications, and management of changes) should include steps where decisions can be challenged by competent independent people. This may involve an independent person attending meetings or reviewing the decisions at another step in the process.
- Senior Managers should develop and, by their actions, actively promote, a culture that encourages people at all levels in the organisation to have a questioning attitude and challenge decisions, actions or existing conditions which may adversely affect nuclear safety. The process for raising, reporting and resolving these concerns should be documented in the management system.
- An independent 'challenge function' (e.g. internal regulation) with responsibility for the oversight of nuclear safety throughout the operators organisation is often established. This

function usually carries out a number of activities to gather intelligence and information on the operator's nuclear safety performance. Activities can include on site surveillance of management decisions and actions, independent assessment and event investigation.

To promote the continual improvement of the management system the 'challenge functions' overview of nuclear safety performance and the concerns raised by its inspectors and auditors should be an important input into management review.

Further Information

ONR publishes its guidance to inspectors on 'challenge' in Technical Assessment Guide T/AST/080 – Nuclear Safety Advice and Challenge and Technical Inspection Guide T/INS/013 – LC 13 Nuclear Safety Committee.

9.3 Operating Experience Feedback

It is better to learn from someone else's mistakes rather than your own and the nuclear industry recognises that valuable lessons can be learned from events which occur either on the operators own sites or which occur on nationally or internationally. One of the key attributes of a strong safety culture is that safety is learning driven and a questioning attitude should prevail through the organisation. The process for gathering, disseminating and using such information to improve safety performance is known in the industry as "Operating Experience" (OPEX) or "Learning from Experience" (LFE). A nuclear sites management system will usually include an operating experience process which is administered by dedicated personnel.

Leaders within the organisation must support the OPEX process and be role models for its implementation. Mechanisms for staff involvement in improvement, communication and knowledge sharing need to be in place. Industry suppliers often have their own arrangements for OPEX in place.

Typically an operating experience process starts with the operator screening on site events and operating experience information from other sources to identify learning opportunities. Where appropriate the events are investigated to identify the root causes. Root causes are often different to the immediate cause of the event and are frequently related to management issues rather than work related activities. Improvement actions can then be formulated to address the root causes and prevent the event occurring or reoccurring on the operator's site. The operating experience process is monitored to ensure the process and the corrective and preventative actions taken are effective.

Nuclear sites usually participate in national and international event reporting systems which provide participants with operational experience information from nuclear facilities around the world. IAEA and WANO both have operational experience programmes. To fulfil their obligations to these programmes operators identify the operating experience which is useful to the national and international community and report this information to the coordinating body. In return operator received operational experience feedback from the coordinating body relating to the experience of other participants.

To provide the input into the operating experience process operators may gather operating experience information from a number of sources. These may include:

Operators with more than one facility can make sure that all its facilities learn from events by gather operating experience from its facilities and ensuring this is disseminate and acted upon throughout its organisation.

The IAEA has a web based incident reporting system (WB IRS) which is international system jointly operated by the IAEA and the Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (OECD/NEA). Participating countries exchange experience to improve the safety of nuclear power plants by submitting event reports on unusual events considered important for safety. The Office of Nuclear Regulation is the national co-ordinator for the receipt and distribution of information to end users in the UK. The IAEA database is available to UK operators who therefore usually have access the information directly. Similar data bases exist for fuel related events (IAEA/NEA Fuel Incident Notification and Analysis System (FINAS) and research reactors (IAEA/NEA Incident Reporting System for Research Reactors – (IRSRR).

Members of the World Association of Nuclear Operators (WANO) can participate in its operating experience programme which relies on members reporting events and operating experience is then analysed and disseminated to members.

Learning can also be gained from studying other non-nuclear national and international events such as the Deep water Horizon accident in the USA or the Buncefield Fire in the UK.

New build and decommissioning sites may also obtain information from other parts of the construction sector.

Quality management system standards contain requirements for continual improvement and management systems should include arrangements to continually improve processes and ensure the continuing suitability and effectiveness of the management system. Clearly, to ensure that improvement activities are coordinated and prioritised appropriately the operating experience process must be aligned with and complement other improvement processes and operating experience should be an important input into management review.

Further Information

IAEA Safety Guide NS-G-2.11 – A System for the Feedback of Experience from Events in Nuclear Installations provides comprehensive guidance on operating experience and Appendix 1 of Safety Guide GS-G-3.5 – The Management System for Nuclear Installations provides further information on achieving the attributes of a strong safety culture.

The Office of Nuclear Regulation publishes its guidance to its inspectors on OPEX in Technical inspection guide T/INS/007 - LC7 "Incidents on the Site" and Other Reporting and OE Processes.

9.4 Non-conformity & Event Investigation

Licence condition 7 places a duty on licensees make and implement adequate arrangements for the notification, recording, investigation and reporting of such incidents occurring on the site. Licensees therefore have a strict legal duty to report incidents occurring on site. ONR publishes Guidance for Notifying and Reporting Incidents and Events to ONR (G/INS/007). Contractors on the nuclear site will be required to participate in the process by reporting events, cooperating in investigations and implementing improvements where appropriate.

Licence condition 7 compliance arrangements usually use a number of levels of investigation depending on the severity or potential severity of the event. The levels of investigation may include: simple trending analysis to identify precursors to declining performance, simple investigations carried out by supervisors or full root-cause analysis carried out by people who have been trained in root cause analysis techniques. The investigations identify corrective actions which address the immediate and root causes of the event and prevent a recurrence.

On nuclear facilities LC 17 requires quality management arrangements for all matters which may affect safety. This is in addition to any quality management arrangements which are in place to fulfil customer requirements. Consequently non-conformities may be nuclear safety or product related. Examples of typical non-conformities found on nuclear sites are:

- All nuclear sites will have an event reporting and investigation process because site licence condition 7 places a strict legal duty on licensees to have "adequate arrangements for the notification, recording, investigation and reporting of such incidents occurring on the site". Significant safety and environmental events must be reported to the office of Nuclear Regulation or Environment Agency respectively. Operators usually have a single event reporting process which captures all types of events and initiates corrective actions as appropriate. Events reported on site may encompass nuclear safety, industrial safety, the environment, plant defects, and any other types of abnormal events.

- Non-conformities found during internal or external audit or independent inspection activities.

- Non-conformities relating to products.

In quality management terms all these undesirable events can be considered as non-conformances and controls, as required by quality management system standards, should be in place to prevent the inadvertent use of non-conforming products or processes and to ensure that corrective action is taken. Events and other non-conformances are opportunities for improvement and will usually be inputs in to other management system improvement processes such as 'Operating Experience' and 'Management review'.

Nuclear operators recognise that the reporting of poor performance, plant defects, unsafe behaviours is very important to nuclear safety and therefore it is common practice to develop a 'no blame' or 'just reporting' culture which actively encourages people to report all unsafe conditions or defects without fear of action being taken against them.

Operators will have systems for assessing the impact of non-conformances and determining their safety significance and impact. Due priority is given to nuclear safety when developing corrective actions and such actions should always be conservative so safety is not compromised.

Quality standards require the causes of non-conformities to be determined and remedial actions taken to prevent their recurrence. The operating experience (OPEX) process usually fulfils this requirement for site events but additional systems may be needed for plant defects or product related non-conformities

Operators should have a process to monitor and report the status of corrective and preventative actions resulting from all types of events and non-conformances.

Where non-conformities relate to plant condition either during construction or in operation remedial action will usually be to replace the item like for like or to repair the item to original specification. In both cases this resolves the non-conformity by meeting the original specification and not affecting the design. If however a different item is fitted or a concession is raised to accept the item 'as is' the operator may have to produce an LC 20 – (Modification to design of plant under construction) or an LC 22 (Modification or experiment on existing Plant) submission which justifies the safety of the change to original design.

Quality management standards require the causes of nonconforming products to be eliminated and this usually involves carrying out some kind of investigation into the causes of the non-conformity. On nuclear sites the requirement to investigate events is more onerous because site licence condition 7 places a strict legal duty on licensees to make and implement adequate arrangements for the investigation of incidents occurring on the site. Also because quality non-conformities are likely to have safety implications the management of health and safety at work regulations apply and their approved code of practice states that "monitoring includes...adequately investigating the immediate and underlying causes of incidents and accidents to ensure that remedial action is taken, lessons are learnt and longer term objectives are introduced". The sites LC 7 compliance arrangements therefore usually cover the requirements for identifying and eliminating the causes of non-conformity. Additional arrangements may be needed to cover product related non-conformities.

Further Information

HSE HSG245 Investigating accidents and incidents.

The Energy Institute "Guidance on Investigating and Analysing Human and Organisational Factors Aspects of Incidents and Accidents" - May 2008

9.5 Management Review

Quality management system standards require organisations to undertake management review to ensure the continuing suitability and effectiveness of their management systems. Nuclear sites are no different in this respect but because licence condition 17 requires "adequate quality management arrangements for all matters which may affect safety" the reviews must cover nuclear safety performance and associated processes in addition to any product quality related review.

ISO 9001 and IAEA GS-R-3 standards contain similar requirements and identify a number of inputs into management reviews.

IAEA GS-R-3 requires:

- outputs from all forms of assessment;
- results delivered and objectives achieved;
- non-conformances and corrective and preventive actions;
- opportunities for improvement;
- lessons learned from other organizations to be included in the reviews (this is unique to the IAEA standard and is linked to the principle of operating experience).

On nuclear sites activities are closely monitored by performance indicators and many internal and external bodies carry out independent or regulatory assessment of the management system. The potential amount of information which can form the input into management review is huge. The range of inputs can include:

- internal audit reports and the internal regulators inspection reports;
- status of actions from past management reviews;
- reports from peer reviews, external audits and regulatory inspections;
- nuclear safety performance indicators;
- outputs from the annual review of safety presented to ONR;
- event reports and defect reports;
- opportunities for improvement from any source;
- output from the operating experience process identifying lessons which can be learned from other organisations;
- feedback on the satisfaction of interested parties (e.g. customers, owners, operators, employees, suppliers, partners, trade unions, regulators.);
- The performance of suppliers;
- The control of process and product non-conformances;

To enable managers to clearly understand what all this information is telling them about the organisations performance and the management system it is essential that careful thought is given to the information provided for management review and its presentation. With a lot of information available it is very easy to fall into the trap of discussing individual events rather than taking a wide overview of how the organisation is performing as a whole. It is often appropriate to provide a summary of the information for management review. The information provided should allow senior managers to concentrate on identifying improvement opportunities, prioritising improvement actions and deploying resources to carry them out.

An organisation may have an integrated management system which directs and controls: nuclear safety, nuclear site licence compliance, conventional safety, environmental management, commercial and financial management. If a single management review is carried out care must be taken to give due priority to nuclear safety so it is not overwhelmed by other review activities. If they are coordinated effectively a series of management reviews covering each part of the system may be more effective than a single meeting.

The output from management review includes the decisions and actions relating to improving the management system and its processes. Due consideration should be given to safety and improvement actions should be prioritised accordingly. The resources needed to realise the improvements should be identified.

Further Information

Detailed Guidance on management review in nuclear facilities is in IAEA Safety Guide GS-G-3.1 – Application of the Management System for Facilities and Activities.

9.6 Bench marking

Bench marking allows organizations to compare their performance and approach with others and identify good practices which can help the organisation improve its safety and quality performance. Bench marking can be a one off or continual process which allows an organisation to improve its processes. Standard Benchmarking techniques can be readily applied in the Nuclear Industry where an organization can find a suitable and willing benchmarking partner. However, this can be difficult as the activities carried out by UK nuclear operators are very diverse and in some cases there is little similarity in their processes.

Fortunately there are many organizations and industry groups which encourage operators to challenge their own performance and learn from the experience of others. (e.g. IAEA, WANO, INPO and Regulators). Consequently, there is a lot of information available which can be used to benchmark performance against good practice and to identify opportunities for improvement. Indeed the World Association of Nuclear Operators states its mission is "to maximise the safety and reliability of nuclear power plants worldwide by working together to assess, benchmark and improve performance through mutual support, exchange of information and emulation of best practices."

Good sources of such information are:

- IAEA Publications, including safety standards and guides.
- WANO website including the WANO performance objectives and criteria. More information will be available to organizations who are WANO members.
- ONR publishes its guidance to inspectors in the form of Technical Inspection Guides and Technical Assessment Guides which describe relevant good practice against which inspector should judge performance
- UK licensees are usually represented at the UK nuclear industry safety directors' forum which produces Nuclear Industry Codes of Practice (NICOPs). NICOPs have been produced to cover:
    - Clearance and Exemption Principles, Processes and Practices for Use by the Nuclear Industry
    - Managing Organisational Change.

9.7 Continual Improvement - Improvement Programmes

In the nuclear industry the principle of continual improvement is well understood and is encouraged by stakeholders and regulators throughout the industry. Quality improvement tools (e.g. six sigma, PDCA cycle, quality circles and TQM) can be used to improve quality and safety performance and operators must determine how such tools are best deployed within their organisations. The nuclear industry also has a number of other mechanisms which drive continual improvement and these are often used in preference to other improvement tools used in wider industry. For example:

Poor safety or quality performance in the nuclear industry can result in very serious consequences so in addition to voluntary quality improvement programmes on Nuclear sites licence condition 15 places a legal duty on the licensee to "make and implement adequate arrangements for the periodic and systematic review and reassessment of safety cases." ONRs guidance to its inspectors in T/AST/050 – Periodic Safety Reviews states the purpose of the periodic review of safety (PSR) is to determine, by assessment against modern standards whether the plants, processes, management, operations and facilities covered by a safety case are safe, and that ageing and other time-related phenomena will not render them unsafe before the next PSR. Where modern standards are not met the PSR should assess the significance of the shortfalls, and identify reasonably practicable improvements. The periodic review is usually carried out every ten years and for most facilities will initiate a significant improvement programme. Improvements may be physical improvements to the plant or improvements to the associated management arrangements including operating rules, operating instructions and the plant maintenance schedules.

Operators can invite international organisations such as the IAEA's OSART (Operational Safety Review Team) ,the World Association of Nuclear Operators (WANO)or the Institute of Nuclear Power Operations (INPO) to undertake peer reviews on their facilities. Such reviews are thorough and usually identify many opportunities for improvement. Improvement programmes are often initiated in response to such reviews in order to track and manage corrective and preventative actions.

Regulators carry out compliance inspections to confirm that operators fulfil their legal duties. If a compliance inspection identifies a significant shortfall against a legal requirement the regulator may take enforcement action and require an operator to develop and carry out an improvement programme to achieve compliance. It is always better for operators to demonstrate robust self regulation by identifying such a shortfall itself and present the improvement programme to the regulator rather than allowing the regulator to find the shortfall.

Further Information

ONR Technical Inspection Guide T/INS/015 – LC 15 Periodic Review.

---

[1] ISO 9001, *Quality Management Systems – Requirements*

[2] ISO 19011, *Guidelines for Quality and/or Environmental Management Systems Auditing*. 2011

[3] ISO 14001, *Environmental management systems. Requirements with guidance for use* 2004

[4] OHSAS 18001, *Occupational health and safety management systems. Requirements* 2007

[5] ASME NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications* 2012

Chapter 10

History of UK Nuclear

CONTENTS

Editor: **Iain McNair**

10.1 The six era of the UK nuclear industry

1940s to the 1960s – Research, weapons and magnox

The UK nuclear programme was developed by the 1940/41 Maude Committee, in a project called 'Tube Alloys'. Following the 1943 Quebec Agreement the UK cooperated with the US Manhattan Project, leading to the bombs dropped in 1945 on *Hiroshima* (uranium) and *Nagasaki* (plutonium) in Japan.

After the 1946 US McMahon Act stopped further collaboration, in 1946 the Atomic Energy Research Centre was set up at *Harwell* and within two years the first two reactors GLEEP and BEPO went critical. The UK began development of its own bomb in 1947 at *Fort Halstead* and later *Aldermaston*; leading to testing of the first Blue Danube bomb in 1952.

In parallel, production facilities at *Capenhurst, Springfields* and *Windscale* were designed and constructed to produce weapons grade plutonium.

In 1954 the AWRE sites joined with the AERE (*Harwell*) to become part of the UKAEA, which was established by the Atomic Energy Authority Act. The Authority was responsible for a series of parallel programmes and activities:

- Design and development at *Risley*, Cheshire
- Uranium enrichment at *Capenhurst*, Cheshire
- Fuel manufacture at *Springfields*, Lancashire
- Reactor programme – weapons reactors at *Calder Hall* and *Chapelcross*, followed by nine civil magnox stations in the UK , plus one each in Italy (*Latina*) and Japan (*Tokai Mura*).The UK stations were operated by the CEGB (England and Wales) and SSEB (South of Scotland). *Oldbury* and *Wylfa* were the first Pre-stressed Concrete Pressure Vessels (PCPVs), all those before having steel pressure vessels. From these UKAEA developed the *Windscale* advanced gas-cooled reactor (WAGR) prototype.
- Reactor research at *Dounreay*, Caithness - initially DFR and DMTR, later PFR.
  An adjacent site housing the Shore Test Facility also known as the *Vulcan* Naval Reactor Test Establishment.
- Reactor research at *Harwell*, Berkshire and *Winfrith*, Dorset - many small research reactors.
- Fuel storage and reprocessing at *Windscale* and *Sellafield*, Cumbria
- Isotope production at *Amersham*, Buckinghamshire.
- Fusion research at *Culham*, Oxfordshire.

A full list of UK research and power reactors and other sites is tabled at the end of this Section.

Apart from basic nuclear design of the reactor which was undertaken by UKAEA, design and construction of the CEGB/SSEB magnox stations was undertaken by a series of consortia based on boilermakers and turbine manufacturers. Originally there were five consortia but eventually these consolidated into two: TNPG and BNDC.

After the *Windscale* fire in 1957 licensing of nuclear installations and insurance arrangements were legislated for in 1959. The Inspectorate of Nuclear Installations (later renamed the Nuclear Installations Inspectorate) was established in the Department of Energy.

Mid-1960s review of the industry

In 1965, CEGB/SSEB proposed a programme of AGR stations and a Select Committee inquiry was held into the whole civil programme. The main recommendations were:

- The consortium system should be phased out
- The UKAEA should concentrate on research and development
- A single organisation or company should be responsible for design and construction
- A new fuel supply and manufacturing company should be established

- A technical assessment unit should be formed to advise government on the merits of projects proposed by UKAEA
- A study should be undertaken of a body to deal with all aspects of energy policy and provide it with adequate expert staff
- An independent study should be made of the costs of all methods of energy supply
- HTR development should be intensified
- Development of SGHWR and other water reactors should be speeded up
- Development of fast reactor should be witha view to both home and overseas markets
- Consideration should be given to marine propulsion possibilities
- Fusion research should be reviewed.

In 1971, the NRPB, BNFL, URENCO and the Radiological Centre Ltd (later Amersham International) were separated off from UKAEA. In 1973, AWE (the weapons group) transferred to MoD.

The two construction consortia amalgamated in 1973 into a shareholding NNC and working NPC – these amalgamated (NNC) around 1982.

In 1975, following the Robens Report, NII became part of the new HSE.

1960s to 1990s – AGR and PWR plus fuel cycle

Following the 1965 review, five AGR stations were constructed in England for CEGB (*Dungeness B, Hinkley Point B, Hartlepool, Heysham 1 and Heysham 2*), with a further two in Scotland for SSEB (*Hunterston B and Torness*). Plans for a SGHWR at *Stakeness* for NSHEB, and a HTR at *Bradwell* for CEGB were dropped in about 1973.

In 1971 British Nuclear Fuels (BNFL) was set up out of UKAEA to manage the fuel cycle activities located at *Risley, Springfields, Capenhurst, Sellafield* including *Calder Hall*, and *Chapelcross*. At the same time isotope activities were separated out into the Radiochemical Centre, privatised in 1982 as Amersham International. Also the National Radiological Protection Board (NRPB) was established.

In 1978 the government decided to pursue the pressurised water reactor (PWR). Assessment by NII on licensability of PWR and a public inquiry into *Sizewell B*, Suffolk (from 1983–85) preceded licensing and start of construction. Similarly for *Hinkley Point C*, with future plans for *Wylfa B* and *Sizewell C*. After 1988 privatisation policy only *Sizewell B* was built.

1960s to the present – Defence programme

Overview

Initially atomic and nuclear weapons were designed to be aerially delivered, although rocket and artillery shells, atomic demolition munitions and naval mines were developed.

In the mid- 1960s the first nuclear powered, hunter killer (SSN) and Polaris ballistic missile carrying (SSBN), submarine were commissioned. In the 1980s introduction of the SSBN carrying Trident saw the whole nuclear weapons programme becoming naval platformed. The first of a new SSN (*Astute*) class commenced sea trials in October 2009.

AWE was established in 1973 and has had weapon design and production responsibilities. Since 1997 *Aldermaston* and *Burghfield* have been licensed nuclear sites.

Rolls Royce has been a naval reactor designer and constructor since the US transfer of technology in the late 1950s and has a licensed site at *Derby*. A naval test reactor facility (*Vulcan*) operates adjacent to the *Dounreay* licensed site. Nuclear submarine construction was originally undertaken in various shipbuilding yards but has now centred at BAE *Barrow*. Submarines have operated from various dockyards but are now centred on *Clyde (Faslane and Coulport*) and *Devonport*. Laid-up and decommissioned submarines are held at *Rosyth* and *Devonport*, while the MoD has been undertaking studies (ISOLUS/ SDP) into storage or disposal routes for the resulting nuclear matter.

Current position

The naval nuclear programme can be considered in two distinct aspects;

- Operations undertaken by Royal Navy personnel from *Faslane* and *Devonport*, as well as certain facilities, formerly known as Z berths, but now called operational berths.
- Design, build and trials, refits and decommissioning are managed through the supply chain by the MoD Defence Equipment and Support Organisation (DE&S).

The atomic weapons programme is undertaken by MoD and design and supply obtained through the supply chain from AWE (*Aldermaston* and *Burghfield*).

Safety oversight is undertaken by the Defence Nuclear Safety Regulator (DNSR) within DE&S, working in close co-operation with ONR. ONR license various contractor activities relating to submarine build sites and dockyards and AWE.

Naval nuclear propulsion

Nuclear reactors have been used by the Royal Navy as a means of propulsion for submarines since the 1960s. *HMS Dreadnought* was the first SSN, with an American *Skipjack* reactor propulsion system; thereafter all RN submarines had British systems.

The SSN classes were *Valiant* (+ *Warspite*), *Churchill* (+*Conqueror* and *Courageous*), *Swiftsure* (+*Sovereign, Superb, Sceptre, Spartan and Splendid*), *Trafalgar* (+*Turbulent, Tireless, Torbay, Trenchant, Talent and Triumph*) up to the present *Astute* (+ *Ambush).,*

The SSBN classes were Polaris carrying *Resolution* (+ *Repulse, Renown and Revenge*) and Trident carrying *Vanguard* (+ *Victorious, Vigilant and Vanguard*).

Build has commenced on three further *(Artful , Audacious and Anson)* The government has announced funding for further *Astute* boats and development of the *Successor* class system

MoD DE&S have been undertaking work on decommissioning of submarines, originally under the title ISOLUS (Interim Storage of Laid-up Submarines) more recently under the title Submarine Dismantling Project (SDP), for which a post consultations report was published in July 2012. MoD's decision was announced in March 2013 to dismantle the first submarine at *Rosyth* and thereafter as priority at *Rosyth* but also considering *Devonport*. with storage of the reactor pressure Vessels pending availability of a Geological Disposal Facility.

Atomic/nuclear weapons

The UK undertook trials in 1952 at the *Monte Bello Islands* which led to the development of the Blue Danube free fall bombs carried by the RAF's V bomber force. Blue Danube (1953–63) was later replaced by Red Beard (1962–71). Tests known as Operation Grapple were undertaken in 1957–58, and following the 1958 US-UK Mutual Defence Agreement led to development of Yellow Sun (1959–1966) and Red Snow (1961–72).

WE177 became the main air delivered weapon (1966–98) before the UK nuclear deterrent was totally transferred to submarine-launched systems.

The original four SSBN (*Resolution* class) carried Polaris/Chevaline and were replaced by Trident carried on the *Vanguard* class.

Replacement of Trident is an ongoing government policy debate, though some funding has been provided for developmental infrastructure.

1990s to the present – Civil programme

During the 1990s and 2000s government policy fluctuated and the main points of note relate to the privatisation and reorganisation of the industry. CEGB and SSEB transformed in stages to become, dependent on reactor types:

- BE operating the AGR and PWR stations
- Magnox Electric, later integrated with BNFL, operating magnox stations.

Under the Energy Act 2004 the Nuclear Decommissioning Authority (NDA) was established to decommission and clean up the UK civil nuclear legacy. NDA now owns the sites previously owned by UKAEA, BNFL and Magnox Electric and via contracts manages the site licence companies (SLC).

Current position

Research reactors

At May 2013 there remains one civil research reactor in the UK: *Imperial College Consort Research Reactor* located at *Ascot*, Berkshire; which has been in post operational maintenance state, pending decommissioning since 2008.

Medical and industrial sources

GE Healthcare (formerly Amersham International, Nycomed Amersham and Amersham plc), located at *Amersham* (with a sub-site at *Cardiff*) , manufacture sources used in medical treatments.

Power generation

Magnox generation continues at *Wylfa* on one reactor until about September 2014.

EDF Energy Nuclear Generation (formerly British Energy) operate the following AGRs and PWR:

Site	Reactor Type	Commissioned	Scheduled date of decommissioning	Net capacity (MW)
Hunterston B	2 AGRs	1976	2016/2023*	890
Hinkley Point B	2 AGRs	1976	2016/2023*	870
Hartlepool	2 AGRs	1983	2019	1,180
Heysham 1	2 AGRs	1983	2019	1,160
Dungeness B	2 AGRs	1983	2018	1,040
Heysham 2 1,220	2 AGRs	1988	2023	1,220
Sizewell B	1 PWR	1995	2035	1,191

*Information from EDF-E NGL website 8 Nov 2012. * Intent for extension of 7 years announced 4 December* 2012.

Magnox manage the following defuelling or defuelled reactor sites at

Site	State	Commissioned	Ceased Generation	End defuelling
Berkeley	Care & Maintenance	1962	1989	1992
Bradwell	Defuelled	1962	2002	2005
Chapelcross	Care & Maintenance prep	1959	2004	2011
Dungeness A	Defuelling	1965	2006	Sched
Hinkley Point A	Defuelled	1965	1999	2004
Hunterston A	Care & Maintenance prep	1964	1990	1995
Oldbury	Fuelled - Ceased operation	1967	2012	Sched 2015

Sizewell A	Defuelling	1966	2006	Sched 2014
Trawsfynnydd	Care & Maintenance prep	1965	1991	1995

Information from Magnox website 8 Nov 2012.

Fuel cycle

Sellafield including *Calder Hall* and *Windscale*: The following overview indicates the scale of works over the next 100+ years:

Year	Key activities
2120	Final site clearance
2105 - 2115	Calder Hall final site clearance
2075	Transfer of stored HLW to HLW repository
2046	All ILW from the Legacy Ponds and Silos retrieved, conditioned and stored
2040	Transfer of stored ILW to Geological Disposal Facility (GDF)
2030	Windscale Pile 1 and 2 in Care and Maintenance with fuel and isotopes removed
2026	• Vitrification of liquid HLW complete • First Generation Magnox Storage Pond - start of residual retrievals
2024	Calder Hall site enters Care and Maintenance phase. During this stage the reactor is left to cool. Most of the structures are removed, and the reactor building is left in a safe state which requires minimum supervision, until final site clearance.
2021	Vitrification of liquid HLW complete
2019	Complete return of overseas customers HLW
2018	• Pile Fuel Cladding Silo - start of waste retrievals • Magnox Swarf Storage Silos - start of bulk retrievals • THORP reprocessing complete
2017	Pile Fuel Storage Pond - start of residual retrieval
2016	Magnox reprocessing completed
2015	• Highly Active Liquor (HAL) stocks reduced to "steady state" volume • First Generation Magnox Storage Pond - start of bulk retrievals
2014	Completion of defuelling at Calder Hall
2013	Complete Active commissioning of Sellafield Product and Residue Store (SPRS)

Information from the NDA's website 8 Nov 2012.

Capenhurst: The site was until December 2012 split between licensees:

- Sellafield Ltd
- URENCO UK

ONR agreed to relicensing the entire *Capenhurs*t site to Urenco UK Limited in December 2012, with much of the work undertaken by the former Sellafield Limited – Capenhurst licensee transferring to a new Urenco subsidiary company, Capenhurst Nuclear Services Limited.,

Springfields; Having been producing nuclear fuels since around 1946 [1], Springfields Fuels Limited has been run since 2010 under the management of Westinghouse Electric UK Limited. *Springfields* main activities include

- Oxide fuels for Advanced Gas-cooled and Light Water Reactors, as well as intermediate fuel products, such as powders, granules and pellets
- Manufacture of Uranium Hexafluoride
- Processing of residues
- Decommissioning and demolition of redundant plants and buildings

Studsvik has a Metals Recycling Facility (MRF) at *Lillyhall* near *Workington*.

LLWR (Low Level Waste Repository) *Drigg* is the national LLW disposal facility for the UK, though some materials are disposed of on sites such as *Clifton Marsh* near *Springfields* and under construction at *Dounreay*. Not all LLW comes from the nuclear industry; in 2009 it was identified that 877 faculties in the non-nuclear sector, in England, Scotland and Wales, held RSA 93 authorisations.

Decommissioning sites
The former nuclear research and fuel cycle sites at *Dounreay, Harwell* and *Winfrith* are in the process of being decommissioned. The end dates for restoration are currently targeted as 2025, 2064 and 2048 respectively.

The future - 2013 to 2020, Future Systems and Fusion 2013 to 2020,
The 2006 Energy Review concluded that nuclear power will have a role in the future UK generating mix, and proposed a number of initiatives to reduce the regulatory barriers for new nuclear build. In in advance of any application to build a nuclear power station at a particular location, the nuclear regulators devised a pre-authorisation process, which they called generic design assessment (GDA). Following the publication of GDA guidance, a number of design companies then requested the regulators to assess their nuclear power station designs and in August 2007 the nuclear regulators started the first stage in the assessment process for four designs (EDF/Areva's UK EPR, AECL's ACR-1000, GE's ESBWR, and Westinghouse's AP 1000). AECL subsequently withdrew from the process and GE temporarily suspended its involvement. In December 2012 ONR and EA respectively issued a Design Acceptance Confirmation (DAC) and Statement of Design Acceptability (SDA) for the UK EPR.

In May 2007 the Government published its Energy White Paper, "*Meeting the Energy Challenge"*, which covered a range of energy issues including nuclear power. At the same time, the government published a consultation document, "*The Future of Nuclear Power"* on the government's preliminary view that it is in the public interest to give private energy companies the option of investing in new nuclear power stations. In January 2008, the government issued a separate White Paper on civil nuclear power "*Meeting the Energy Challenge – A White Paper on Nuclear Power*." which set out the rationale behind the government's decision to allow energy companies to invest in new nuclear power stations.

In July 2011, the Government designated National Policy Statements (NPS) to guide planning decisions on energy:

- EN1 'Overarching' sets out generic principles regardless of type of energy source,
- EN6 'Nuclear' addresses new build reactors and identifies 10 potential sites in England and Wales.

As at March 2013, three potential operating/licensee companies had been identified:

EDF intends to build four new EPR reactors (amounting to 6.4GW) at Hinkley Point and Sizewell. The operating company is known as NNB GenCo. A Site Licence was issued by ONR in November 2012, Environmental permits by EA in March 2013, and Planning Consents by the Secretary of State DECC in March 2013 for NNB GenCo to install and operate two units at Hinkley Point,

Horizon Nuclear Power, originally a joint venture set up by E.ON UK and RWE npower, bought by Hitachi in October 2012, are planning to build between two and three new Advanced Boiling Water Reactor (ABWR) nuclear plants at Wylfa on Anglesey and the same at Oldbury in Gloucestershire, for which it has acquired land and agreed connections. Hitachi have indicated they will now work towards GDA/Licence acceptance, and have signed Memorandums of Understanding with Rolls Royce and Babcock International

NuGen, a consortium of GDF SUEZ SA and Iberdrola SA, has set out plans to build up to 3.6GW of new nuclear capacity at Moorside, immediately West of Sellafield. NuGen has not (at Aprilh 2013 selected a reactor design, focusing on EPR and AP1000, and is indicating it is not likely to make an investment decision until 2015. In November 2011 NuGen received planning consent to commence a preliminary phase of temporary site investigation and characterisation works which are expected to be complete in 2013

Future Systems

DECC's work includes considering how the UK energy system might evolve in the future and the roles that different types of energy generation may play in it. This may include new designs of nuclear reactors and new types of fuel. 2 . Particular work has been done on comparison of Uranium and Thorium fuel cycles 3, and in assessing future systems against modern LWRs 4. The types considered were –

- Gen IV - Sodium Fast Reactor (SFR); Gas Fast Reactor (GFR); Lead Fast Reactor (LFR); Very High Temperature Reactor (VHTR); Super Critical Water Reactor (SCWR) Molten Salt Reactor (MSR);
- Accelerator Driven Sub-critical Reactor (ADSR);
- Hyperion Power Module (HPM)
- Small modular Light Water Reactor (LWR).

The 2012 National Nuclear Laboratory (NNL) addendum report to DECC identified that:

- "**SFR, GFR and LFR** have identical scores under Generating cost, Proliferation, Resistance and Physical Protection (PRPP), Sustainability and Waste. Under Safety, SFR and LFR have similar scores, but with GFR scoring low on technological maturity and transient response time. Under the Strategic grouping SFR scores the highest on account of its higher technological readiness (with commercial-scale prototypes having been built and operated), with GFR lowest of the three. GFR scores highest on deployability on account of its high operating temperatures and therefore suitability for process heat applications."
- "**VHTR** is the highest scoring system in three of the groupings: PRPP, Safety and Deployability. This is a result of the uniquely robust fuel form which offers clear benefits for inherent PRPP and passive safety. VHTR is especially well suited to high temperature heat applications and this is beneficial under Deployability. VHTR also scores quite highly on Generating cost and Strategic (but with the proviso that further development is needed to ensure it is competitive compared with LWRs). However VHTR scores relative poorly on Sustainability and Waste, because it is a once-through fuel cycle. VHTR is at a relatively high stage of Technology Readiness, with commercial-scale prototypes having been built and operated, but further development is needed for it to be regarded as technologically mature."
- "**SCWR** scores for PRPP, Sustainability and Waste are equivalent to those of the LWR once-through reference. SCWR performance is slightly penalised on Generating cost and Safety and heavily penalised on Strategic because of its low technological readiness. On Deployability, SCWR shows a slight advantage over the reference LWR on account of its high operating temperature."
- "**MSR** scores highly on Deployability, Sustainability, Waste and Safety. On PRPP MSR is equivalent to once-through LWR. MSR is penalised on production costs and R&D costs, which leads to a middling rating on Generation Cost. On Strategic, MSR scores poorly because of its very low technology readiness and very long development timescale."
- "**ADSR** scores very highly on Deployability, Sustainability and Waste. However ADSR scores poorly on Generating cost (because of the additional complexity and cost of the accelerator system) and Strategic (because of its low technology readiness and long timescale to deployment). On PRPP and Safety ADSR is assessed to be equivalent to the mainstream Gen IV breeder systems."
- "**HPM** scores highly on PRPP and Safety, while on Sustainability and Waste it is ranked the same as the LWR once-through reference."
- "**Small LWR** is equivalent to the LWR once-through reference for all metrics groupings apart from Generating Cost (where there is a scaling penalty) and Strategic, where there

are small penalties on technology readiness and timescale to deployment, with no designs being commercially proven at present."

DECC published its long term nuclear energy strategy (to 2050) in March 2013. That identified a number of key priorities and enablers:

"The priorities are

1. Nuclear power making a significant contribution to secure, low carbon generation, now and through a successful Generation III programme built over the next two decades.

2. Maintaining options for nuclear making a major contribution to the longer term energy mix.

3. Development and maintenance of an effective and expanding UK-based supply chain, competing successfully for work at home and abroad, contributing positively to the UK economy.

4. Decommissioning the UK's nuclear legacy, including through safe and secure interim storage of waste and spent fuel, pending the availability of long-term disposal.

5. Planning for wastes arising from nuclear new build.

6. Achieving the long-term management of nuclear waste.

7. Effective and well-resourced regulatory bodies, to protect the environment and society from the hazards of nuclear power.

8. Management of the UK's civil plutonium.

9. Government continuing to play an effective and pro-active role in the sector.

These priorities will be supported by the following enablers:

10. Research and Development.

11. Skills development.

12. International collaboration."

Fusion

The leading designs for controlled fusion research use magnetic (tokamak design) or inertial (laser) confinement of a plasma, with heat from the fusion reactions used to operate a steam turbine which in turn drives electrical generators, similar to the process used in fossil fuel and nuclear fission power stations. The concept has been attractive to nuclear engineers since around 1946.

- In the UK ZETA at *Harwell* was the first large scale fusion machine to be built – in operation in 1957.
- US research on Stellarators in the 1950s/60s programmes at *Princeton Plasma Physics Lab* were overtaken by the Tokamak concept in the 1970s. Recent renewal in interest about Stellarators has led to some important modern experiments are *Wendelstein* 7-X, in Germany, and the Large Helical Device (LHD), in Japan.
- Soviet 1950s research developed the Tokomak. The Joint European Taurus (JET) at *Culham*, TFTR at *Princeton* USA, TEXTOR at *Julich* in Germany, and Tore Supra at *Caderache* in France are amongst many of this type around the world.

As of 2012 the UK fusion programme is centred on the innovative MAST (Mega Amp Spherical Tokamak) experiment at the *Culham* Centre for Fusion Energy (CCFE) [5].

Additionally CCFE hosts the Joint European Torus (JET) on behalf of European partners., In 1997, JET produced a peak of 16 MW of fusion power (65% of input power), with fusion power of over 10 MW sustained for over 0.5 sec. JET is the first step on a three stage routemap to fusion reactors

JET will be succeeded by the International Thermonuclear Experimental Reactor (ITER) currently being built at *Cadarache* in the south of France and granted a licence by the French government in November 2012. At December 2012 the target for first plasma was 2020 with the start of Deuterium-Tritium Operations in 2027. ITER is a joint project by EU, France, Japan, China, South Korea, USA, Russia and India

DEMO, is expected to be the first fusion plant to reliably provide electricity to the grid. In preparation, several activities are being implemented under Euratom FP7 including the establishment of a dedicated project team and implementation of the Engineering Validation and Engineering Design Activities (EVEDA). This in turn will prepare for the construction of the International Fusion Materials Irradiation Facility (IFMIF). IFMIF's goal will be to qualify materials for DEMO through irradiation testing and modelling of materials. In addition, studies of the DEMO conceptual design, as well as work on the safety, environmental and socio-economic aspects of fusion energy, must be undertaken

DEMO was foreseen as commencing construction around 2024 with operation starting around 2033 – Note these dates would overlap the operating dates given for ITER. If DEMO is fully successful in terms of systems and performance, it may be possible to use it as a commercial prototype, going for the so-called 'fast track' to fusion which could significantly bring forward the availability of fusion as an energy option.

The physics of nuclear explosions, for example, can be explored with big lasers. In the UK AWE made an early start in this field when the HELEN laser opened in 1979. A much larger laser facility, ORION, is under commissioning in 2012 and scheduled to go into operation in April 2013..

An alternative to using powerful lasers for inertial fusion is 'heavy ion fusion', where high-energy particles from an accelerator are focused using magnetic fields onto the fusion target. Heavy ion fusion experiments are planned for the NDCX-II (Neutralized Drift Compression Experiment II) accelerator, which completed construction in May 2012 at *Lawrence Berkeley National Laboratory* (LBNL) USA.

Various other Fusion reactors exist around the world, operating as research related to nuclear weapon programmes. These include the National Ignition Facility (NIF) at *Lawrence Livermore National Laboratory* (LLNL) USA and the French CEAs Laser Mégajoule (LMJ) – near *Bordeaux* both are laser facilities; whilst the Z machine operated by the *Sandia Nuclear Laboratories*, USA is believed to be the world’s largest X-ray generator.

10.2 Reactors in the UK

Listed in date order of criticality or grid connection. (Details taken from IAEA reactor databases 2010 unless shown otherwise.)

Location	**Name/ Programme**	**Thermal/ Electric power**	**Criticality date/Grid Connection**	**Status at June 2011**
Harwell	GLEEP Research	50kW	1947	Decom
Harwell	BEPO Research	6.5MW	1948 [1]	Decom

[1] Select committee on Science and Technology Report – UK Nuclear Reactor Programme Appendix A

Location	**Name/ Programme**	**Thermal/ Electric power**	**Criticality date/Grid Connection**	**Status at June 2011**
Windscale	Piles Weapon materials prodn		1950/51	Shut down after 1957 fire
Harwell	ZEPHYR Pu/Fast breeder Research	Zero	1954	Decom
Harwell	ZETA Fusion Research	Zero	1954	Decom
Winfrith	ZEUS Research	100W	1955	Decom
Harwell	LIDO Research	300kW	1956	Decom
Harwell	DIDO Research	26MW	1956	Decom
Calder Hall	4x magnox Weapon materials prodn	190MW(E)	1956	Shut down 2003
Harwell	PLUTO Research	26MW	1957	Shut down
??	HAZEL Research	Zero	1957	Decom
Aldermaston	HORACE Research	10W	1958	Decom
Dounreay	DMTR Research	22.5MW	1958	Decom
Winfrith	ZENITH I Research	50W	1959	Decom
Aldermaston *AEI*	MERLIN Research	5MW	1959	Decom License revoked/ surrendered 1963
Dounreay	DFR Research	65MW (15MW(E))	1959	Shut down 1977
Chapelcross	4x Magnox Weapon materials prodn	190MW(E)	1959	Shut down 2004
Langley - Hawker Siddley	JASON Research		1960	License surrendered 1962
Royal Naval College Greenwich (relocated from Langley)	JASON Research	10kW	1961+	Decom
Aldermaston	HERALD Research	5MW	1960	Shut down
Aldermaston	VERA Research	100W	1961	Decom
Winfrith	NESTOR Research	30kW	1961	Decom
Harwell	DAPHNE Research	100W	1962	Decom

Location	**Name/ Programme**	**Thermal/ Electric power**	**Criticality date/Grid Connection**	**Status at June 2011**
Winfrith	DIMPLE Research	<100W	1962	Decom
Winfrith	ZEBRA Research	100W	1962	Shut down
Windscale	HERO Research	3	1962	Decom
Windscale	WAGR Prototype	120MW /34MW(E) Avr	1962	Shut down 1981
Berkeley	2x civil magnox	276MW(E)	1962	Shutdown 1988–89
Bradwell	2x civil magnox	300MW(E)	1962	Shut down 2002
Winfrith	HECTOR Research	100W	1963	Decom
Rolls Royce Derby	NEPTUNE Research	100W	1963	Operating
Scottish Universities East Kilbride	UTR-300 Research	100kW	1963	Decom
Hunterston A	2x civil magnox	320 MW(E)	1963	Shut down 1989–90
Winfrith	JUNO	<100W	1964	Decom
Liverpool and Manchester Universities Risley	NURR Research	100kW	1964	Decom
Winfrith OECD-NEA joint project	DRAGON HTR Research	20MW	1964	Decom
Queen Mary College London	UTR-B Research	100kW	1965	Decom
Imperial College Ascot	CONSORT II Research	100kW	1965	Shut down
Hinkley Point A	2x civil magnox	500 MW(E)	1965	Shut down 2000
Trawsfynydd	2x civil magnox	500 MW(E)	1965	Shut down 1991
Dungeness A	2x civil magnox	550 MW(E)	1965	Shut down 2006
Sizewell A	2x civil magnox	580 MW(E)	1966	Shut down 2006
Winfrith	SGHWR Prototype	100MW(E)	1967	Shut down 1990
Oldbury	2x civil magnox	600 MW(E)	1967	Shut down

Location	**Name/ Programme**	**Thermal/ Electric power**	**Criticality date/Grid Connection**	**Status at June 2011**
Wylfa	2 x civil magnox	1180 MW(E)	1971	1 Operating
Winfrith	ZENITH II Research	100W	1972	Decom
Dounreay	PFR Prototype	250 MW(E)	1975	Shut down 1994
Hinkley Point B	2x civil AGR	1250 MW(E)	1976	Operating
Hunterston B	2x civil AGR	1250 mW(E)	1976	Operating
Dungeness B	2x civil AGR	1200 MW(E)	1983	Operating
Hartlepool	2x civil AGR	1250 MW(E)	1983	Operating
Heysham I	2x civil AGR	1250 MW(E)	1983	Operating
Heysham 2	2x civil AGR	1360 MW(E)	1988	Operating
Torness	2x civil AGR	1360 MW(E)	1988	Operating
Sizewell B	Civil PWR	1250 MW(E)	1995	Operating

10.3 Other licensed sites in UK

Not all licensed sites are solely reactors, and as such the following are, or have been, licensed generally for research or fuel cycle activities:

1. *Berkeley Nuclear Laboratories, Gloucestershire*
2. *Rolls Royce Nuclear Fuel Processing, Raynesway, Derby*
3. *Marston Excelsior Nuclear Fuel Processing, Wolverhampton*
4. *Vickers Nuclear Fuel Storage, Barrow in Furness*
5. *AEI Nuclear Research Laboratories, Wythenshaw, Manchester*
6. *Parsons Nuclear Research Laboratories, Heaton, Newcastle upon Tyne*
7. *Vickers Test Rig Installations, South Marston, Swindon*
8. *IRD Nuclear Research Laboratories, Heaton, Newcastle upon Tyne (same site as 6)*
9. *Queen Mary College Critical Assembly, Stepney, London*
10. *PERA Fuel Element Plant, Melton Mowbray*
11. *Queen Mary College Nucleonics Laboratory, Newham, London*
12. *Cammell Laird's Nuclear Fuel Storage, Birkenhead*
13. *ICI Triga Research and Isotope Production, Billingham*
14. *Sellafield Sites Ltd (previously BNFL), Capenhurst*

15. *LLWR (previously BNFL),Drigg*
16. *Springfields Fuels (previously BNFL and UKAEA), Springfields, Preston*
17. *Sellafield Sites Ltd (previously BNFLand UKAEA),Sellafield (including Calder Hall and Windscale)*
18. *GE Healthcare, Amersham, Harwell and Cardiff*
19. *Urenco, Capenhurst*
20. *DML Devenport Dockyard Fuel Storage, Devonport, Plymouth*
21. *BAE Systems (previously VSEL) Devonshire Dock Complex, Barrow-in-Furness*
22. *RSRL (previously UKAEA),Harwell*
23. *RSRL (previously UKAEA),Winfrith*
24. *AWE, Aldermaston*
25. *Studsvik Metal Recycling Facility, Lillyhall, Workington*
26. *DSRL (previously UKAEA), Dounreay*

10.4 Additional sources of information

1940s to the 1960s – Research, weapons and magnox

- Arnold L and Cotterrel A *Windscale 1957: Anatomy of a Nuclear Accident*.
- Arnold L (1987) *A Very Special Relationship: British Atomic Weapon Trials in Australia*.
- Arnold L (2001) *Britain and the H Bomb*.
- Arnold L and Smith M (2006) '*Britain, Australia and the Bomb: The Nuclear Tests and Their Aftermath*' in *International Papers in Political Economy*.
- AWE history - www.awe.co.uk/aboutus/our_history_f77a4.html
- Gowing M (1964) *Britain and Atomic Energy – 1935-1945*.
- Gowing M and Arnold L (1974) *Independence and Deterrence: Britain and Atomic Energy – 1945–52 Vol1 Policy Making*.
- Gowing M and Arnold L (1974) *Independence and Deterrence: Britain and Atomic Energy – 1945–52 Vol2 Policy Execution*,
- Gowing M and Arnold L (1979) *The Atomic Bomb (SISCON)*.
- HMSO (1952) *Harwell: The British Atomic Energy Research Establishment*.
- Jay KEB (1954) *Britain's Atomic Factories: The story of Atomic Energy Production in Britain*.
- Jay KEB *Calder Hall: A Guide*
- King's College London index of Files on nuclear history held in the Public Records Office (National Archives) http://www.kcl.ac.uk/lhcma/pro/proindex.htm
- Sinclair S and Newnes (1960) *Windscale: Problems of Civil Construction and Maintenance*.
- *Symposium on Calder Works Nuclear Power Plant* from the British Nuclear Energy Conference, Vol2 No2, April 1957.
- UKAEA (1958) *The Technology of the Gas-Cooled Reactor*.
- UKAEA *Reminiscences of an Atomic Pioneer*– H G Davey Works General Manager Windscale and Calder Works 1947–1958.
- Wearne and Bird (2009) *UK Experience of Consortia Engineering for Nuclear Power Stations*. http://www.dalton.manchester.ac.uk/aboutus/reports/uk_consortia.html

Mid-1960s review of the industry

- *Report from the Select Committee on Science and Technology Session 1966–67*; United Kingdom Nuclear Reactor Programme. HMSO; October 1967; 381-XVIII.
- *Safety and health at work; report of the Committee, 1970-72.* Comd 5034 Chairman: Lord Robens London, H.M. Stationery Off., 1972. ISBN: 0101503407

1960s to 1990s – AGR and PWR plus fuel cycle

- 1988 White Paper *Privatising Electricity*,

- Layfield F (1987) *Sizewell B Public Inquiry: Report*

Note: The National Archives (Energy Group) hold the Sizewell B inquiry full transcripts and supporting information.

- HMSO (1990) *Hinkley Point Public Inquiry: Report to Secretary of State for Energy and Environment*.

1960s to the present – defence programme

- The Future of the United Kingdom's Nuclear Deterrent: Defence White Paper 2006 (Cm 6994)
- Defence Nuclear Safety Regulator (DNSR) via MoD website https://www.gov.uk/government/organisations/ministry-of-defence
- AWE: http://www.awe.co.uk/index.html
- Rolls Royce Marine Derby: http://www.rolls-royce.com/energy/nuclear/index.jsp
- BAe Systems – Barrow : http://www.baesystems.com/home
- Vulcan Naval reactor Test Establishment (NRTE) Dounreay:
- Clyde Naval Base (Faslane): http://www.royalnavy.mod.uk/The-Fleet/Naval-Bases/Clyde
- RNAD Coulport: http://www.royalnavy.mod.uk/The-Fleet/Naval-Bases/Clyde/RNAD-Coulport
- HMNB Devonport : http://www.royalnavy.mod.uk/The-Fleet/Naval-Bases/Devonport
- Devonport Royal Dockyard: http://www.babcockinternational.com/about-us/responsibilities/community/devonport-royal-dockyard/
- Submarine Dismantling Project: Consultation report October 2011 and links https://www.gov.uk/government/consultations/consultation-on-the-submarine-dismantling-project
- Rosyth Royal Dockyard: http://www.babcockinternational.com

1990s to the present – civil programme

- Wood J (2007) *Nuclear Power*.
- Nuclear Decommissioning Authority www.nda.gov.uk
- Imperial College Consort Research Reactor - Ascot : http://www3.imperial.ac.uk/reactorcentre
- GE Healthcare - Amersham, Harwell and Cardiff: http://www.gelifesciences.com/webapp/wcs/stores/servlet/catalog/en/GELifeSciences-us/brands/amersham/
- Magnox Limited : http://www.magnoxsites.co.uk/
- EDF Energy Nuclear generation: http://www.edfenergy.com/about-us/energy-generation/
- Sellafield : http://sellafieldsites.com/
- Capenhurst ; http://www.urenco.com/Content/41/Urenco-UK-Ltd-Capenhurst.aspx
- Springfields: www.nuclearsites.co.uk/ite.php?LocationID=2
- Dounreay: http://www.dounreay.com/
- Harwell and Winfrith: Research Sites Restoration Ltd: http://www.research-sites.com/
- Studsvik MRF: http://www.studsvik.com/en/Business-Areas/Waste-Treatment/Treatment-of-Metallic-Waste-in-the-UK/
- LLWR Drigg: http://www.llwrsite.com/

The future

- White Paper 2007, "*Meeting the Energy Challenge* : http://webarchive.nationalarchives.gov.uk/20100512172052/http://www.decc.gov.uk/en/content/cms/publications/white_paper_07/white_paper_07.aspx
- Consultation document 2007, "*The Future of Nuclear Power"* : http://webarchive.nationalarchives.gov.uk/20100512172052/http://www.berr.gov.uk/consultations/page39704.html
- White Paper 2008 "*Meeting the Energy Challenge – A White Paper on Nuclear Power*." : http://webarchive.nationalarchives.gov.uk/20100512172052/http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/white_paper_08/white_paper_08.aspx
- NPS EN1: http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf

- NPS EN6 Vol I; http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/2009-nps-for-nuclear-volumeI.pdf
- NPS EN6 Vol II: http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1943-nps-nuclear-power-annex-volII.pdf
- DECC New Nuclear: https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/new-nuclear-power-stations
- DECC Office for Nuclear Development: https://www.gov.uk/government/policy-teams/office-for-nuclear-development-ond
- DECC, Nuclear Development Forum : https://www.gov.uk/government/policy-advisory-groups/99
- ONR/EA GDA : http://www.hse.gov.uk/newreactors/index.htm
- EDF Energy New Nuclear: http://www.edfenergy.com/about-us/energy-generation/new-nuclear/
- Horizon Nuclear Power: http://www.horizonnuclearpower.com/
- NuGen : http://www.nugeneration.com/
- NIA Industry map : www.nuclearsupplychain.com
- European Nuclear Society -ENC2012 Transactions – Advanced Reactors http://www.euronuclear.org/events/enc/enc2012/transactions/ENC2012-Transactions-Advanced-Reactors.pdf?goback=.gde_46854_member_204408024

[1] Nuclear Fuel manufacture at Springfields – http://www.nuclearsites.co.uk/resources/upload/Brochure%20Nuclear_Leaflet_04.pdf

[2] DECC - Advanced reactors and Fuel Cycle Reports - http://www.decc.gov.uk/en/content/cms/meeting_energy/nuclear/reactor_report/reactor_report.aspx

[3] Fuel cycle comparison - http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/nuclear/6300-comparison-fuel-cycles.pdf

[4] Assessment of comparison between types - http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/nuclear/6299-assessment-reactor-systems-uk-metrics.pdf and http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/nuclear/6302-addendum-assessment-reactor-metrics.pdf.

[5] Culham Centre for Fusion Energy - http://www.ccfe.ac.uk/CCFE.aspx

Chapter 11

International Approaches

CONTENTS

Editor: **Susan J M Shaw**

Contributor: **Iain McNair**

11.1 Overview of International Approaches

This section will be viewed from the point of view of a UK based nuclear professional either working in an international environment or receiving goods from overseas. Because nuclear is a global industry with a limited number of design organisations and a large supply chain, virtually no country operates independently; yet each country has its own legal and regulatory system including codes and standards. Until a universally accepted standard is available, in the interests of safety and economy, operators need to consider how the approaches of any supplier, or sub-tier supplier, fits into the national requirements they have to satisfy; and vice-versa.

For each country, consideration may be given to the types of leadership & management, project management, design, siting and construction management, operations management, supply chain management, product quality management, knowledge and information management culture and expectations. These are not universal, and may be applied differently because of the

- Nature of the government eg degree and stability of democracy
- Type of legal system eg UK, USA & France each have distinct and different legal systems
- Speed that legislation can change eg make-up of the government majority
- Cultural expectations eg understanding of business relationships and contracts
- Regulatory systems
- Level of expectation of quality management eg the country may be using inspection, quality control, quality assurance or full quality management or any/all of these.

It is unwise to provide specific details of how each country operates because developments are continuous. Currently, UK works closely with some countries, eg USA and France, and not with others. This is subject to constant change for political and commercial reasons. Consideration of the current supply chain partners, the political status of the countries and the relationship which UK government has with those countries governments is needed. These relationships develop fast and can best be tracked from the international organisation websites and governmental organisations which are linked.

Two major organisations provide current information to assist:-

- International Atomic Energy Agency (IAEA) is the organisation which supports international governmental regulatory authorities which was set up in 1957 by the United Nations under the banner "Atoms for Peace". The Agency works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies.
- World Nuclear Association (WNA) is an association of local nuclear associations and global commercial organisations engaged in the nuclear sector

The UK's two most consistent partner countries, France and USA, and their commercial organisations are considered in this chapter in more detail, beginning with a list of the reactors being used or considered. These act not so much to inform but to illustrate the international nature of the nuclear industry and the diversity of partnerships. USA's Westinghouse's AP1000 and France's EDF/Areva NP (EPR) are important in UK. However, recently Japan has entered our marketplace in the form of Hitachi. Below shows where these reactor types are being used.

AP1000:

- USA – VC Summer & Vogtle
- China – Haiyang 1-8&Sanmen 1-6
- Czech Republic – Temelin 3&4

EPR:

- Finland – Olkilouoto 3
- France – Flamanville 3
- China – Taishan 1&2
- UK – Hinkley Point C & Sizewell C

BWR: UK GDA has seen the re-entry of Hitachi and thus a need to also consider their approaches. The WNA list of plants in the pipe-line shows:

- Japan – Shimana 3 &Ohma 1 (currently deferred post-Fukushima)
- Taiwan – Lungmen 1&2

AP1400 (developed from Westinghouse System 80+):

- KEPCO have two AP1400 in trials / construction at Shin Kori 3&4 with another 6 planned – Shin Ulchin 1-4 and Shin Kori 5&6.
- The UAE are building Barakah1-4, on the coast 300 km west of Abu Dhabi city. The consortium is led by Korea Electric Power Co. (KEPCO) and involves Samsung, Hyundai and Doosan, as well as Westinghouse.

OPR1000: KEPCO designed based on the Palo Verde System80 design by Combustion Engineering (bought by Westinghouse) and operate eight – Yonggwang 3-6 and Ulchin 3-6, whilst four more under construction/ commissioning (2010-12 targeted)- Shin Kori 1&2 and Shin Wolsong 1&2.

CAP1400 (being developed from Westinghouse AP1000): Technology transfer contracts were announced in 2010, between Westinghouse and the Chinese State National Power Technology Corporation (SNTPC).

The consideration of USA and France below acts as a guide to the type of issues to note when working and trading internationally.

11.2 USA

Governmental organisation

US Department of Energy (US DoE)

US DoE is responsible for Nuclear energy in relation to supply but a more significant amount of their effort falls under the banner of National Security and Safety, where they identify four priorities;

- Insuring the integrity and safety of the country's nuclear weapons
- Promoting international nuclear safety
- Advancing nuclear non-proliferation
- Continuing to provide safe, efficient and effective nuclear power plants for the United States Navy.

In the USA, all nuclear weapons deployed by the United States Department of Defense (DoD) are actually on loan to DoD from the National Nuclear Security Administration (DOE/NNSA), which has federal responsibility for the design, testing and production of all nuclear weapons. NNSA in turn uses contractors to carry out its responsibilities at the following government owned sites:

- Design of the nuclear components of the weapon: *Los Alamos National Laboratory* and *Lawrence Livermore National Laboratory*
- Engineering of the weapon systems: *Sandia National Laboratories*
- Manufacturing of key components: *Los Alamos National Laboratory, the Kansas City Plant, and Y-12 National Security Complex*

- Testing: *Nevada Test Site*
- Final weapon/warhead assembling/dismantling: *Pantex*

Nuclear Regulatory Commission (NRC)

NRC reviews and issues licenses for the construction and operation of commercial nuclear power plants, research reactors and other nuclear fuel cycle facilities; and it licenses the possession and use of nuclear materials for medical, industrial, educational, research and other purposes. Regulatory authority for nuclear materials licensing has been transferred to 34 states under the NRC's Agreement states program. The NRC also regulates gaseous diffusion uranium enrichment facilities which the US Enrichment Corporation (USEC) lease from DoE

NRC inspects and enforces related to nuclear plants, and provides independent expertise and information under the banner of Regulatory Research.

The NRC establishes requirements for the design and manufacture of packages for radioactive materials. The Department of Transportation regulates the shipments while they are in transit, and sets standards for labelling and smaller quantity packages (See Title 49, Transportation, of the U.S. Code of Federal Regulations).

Legislation

US Code of Federal Regulations (CFR) Part 10 relates to Energy. Title 10 of 10 CFR Part1 is 'NRC Regulatory Commission'; the parts of Title 10; the ones most commonly referred to are 10CFR50 'Domestic Licensing of Production and Utilization Facilities'; and 10CFR52 'Licenses, Certifications, and Approvals for Nuclear Power Plants'. Part 60 or 63 relate to a geologic repository for the disposal of high-level radioactive waste; and part 72 relates to an ISFSI (Independent Spent Fuel Storage Installation) for the storage of spent fuel licensed or an MRS (Monitored Retrievable Storage Installation) for the storage of spent fuel or high-level radioactive waste.

From a 'quality' perspective the main Section is Part 50 Appendix B which though promulgated in 1970 was last amended in 2007. NRC's NUREG 1.28 'Quality Assurance Program Criteria (Design and Construction)' provides guidance on what staff find acceptable for complying with provisions relating to licensing referring to 10CFR50 Appendix B. It indicates in Part C that "The Part I and Part II requirements included in NQA-1-2008 and the NQA-1a-2009 Addenda, 'Quality Assurance Requirements for Nuclear Facility Applications', for the implementation of a QA program during the design and construction phases of nuclear power plants and fuel reprocessing plants are acceptable to the NRC staff and provide an adequate basis for complying with the requirements of Appendix B to 10 CFR Part 50, subject to the additions and modifications of NQA-1-2008 and the NQA-1a-2009 Addenda identified below." It then goes into detail on the identified subjects – Quality Assurance Records and Audits. (**Note** NQA-1 has been revised and re-issued as NQA 2012; it is anticipated that NRC will produce a revised/ updated NUREG to comment on that version)

Standards & Guidance

DOE

10 CFR Part 830 – Nuclear Safety Management is the applicable set of regulations applicable to activities (including providing items and services) that affect, or may affect, the safety of DOE nuclear facilities, excluding NRC regulated , Naval nuclear propulsion, transportation nuclear waste and space activities . Sub part A Quality Assurance Requirements is addressed in Sections 830.120, 121 and 122.

DOE Order 414.1 (Rev D @ Apr 2011) establishes the Quality Assurance Program for the DOE, based on 10 criteria (1-Management/Program, 2- Management/Personnel training and Qualification, 3- Management/Quality Improvement, 4- Management/Documents and Records, 5- Performance/Work processes, 6- Performance/Design, 7- Performance/Procurement, 8- Performance/Inspection and Acceptance Testing, 9- Assessment/Management Assessment, and 10- Assessment/Independent Assessment). Specific guidance is provided on Suspect and Counterfeit Items referencing to IAEA-TECDOC-1169.

Guidance is provided in:

- DOE G 413.3.2 QA Guide for Project Management
- DOE G 414.1-2B, Quality Assurance Management System Guide for Use with 10 CFR 830.120 and DOE O 414.1 (Aug 16,2011).
- DOE G 414.1-4, Safety Software Quality Assurance Guide for Use with 10 CFR 830.120 and DOE O 414.1 (Jun 17, 2005)
- DOE O 414.1D Quality Assurance (25 Apr 2011)
- DOE O 450.2 Integrated Safety Management (25 April 2011)
- DOE G 450.4-1B Integrated Safety Management guide (1 Mar 2001)

NRC

NRC publishes a significant amount of information on its New Reactors - Regulatory Oversight - Quality Assurance web pages. 10 CFR Part 21 Reporting Defects and Non-compliance is cited by NRC in addition to 10 CFR 50 Appendix B.

Standard Review Plan (NUREG-800) addresses how the NRC looks at licensee/ manufacturer programs; Safety Evaluation Reports document the reasons for NRC approvals.

NRC undertakes a significant programme of inspection and oversight of industry vendor activities. Details from Inspection procedures, through Inspection program and Inspection reports are published and can be linked via the web page. The NRC has created a Vendor Centre of Excellence (COE). NRC periodically accompanies the Nuclear Procurement Issues Committee (NUPIC) teams on audits to evaluate suppliers furnishing safety-related components and services and commercial-grade items to nuclear utilities.

NRC lists by Criteria all applicable Quality Assurance (QA) Inspection for New Reactor Licensing and Vendor QA Inspection reports that have either a Notice of Non-conformance (NON) or Notice of Violation (NOV) within a specific criterion of 10 CFR 50 Appendix B or 10 CFR Part 21 related issue. Links lead to letters issuing the Notices and provide details of the findings.

Additionally NRC organise meetings and workshops about vendor oversight activities. Summary of meetings held, since 2007, between NRC, Licence applicants and Industry bodies are published via links on the NUPIC page. Workshops were held in 2008 and 2010. The 3rd NRC Workshop on Vendor Oversight for New Reactor Construction (June 28, 2012, *Baltimore*, Maryland) agenda and presentations have been published. In the plenary session NRC set out that

- ISO9001 does not meet the requirements of 10CFR 50 Appendix B;
- ASME NCA-4000 provides quality assurance requirements for Class 1, 2, 3, CS, MC and CC items;
- ASME Section III subsection NCA-4000 requires use of NQA-1 for code activities;
- NQA-1 and NCA-4000 work together to meet the requirements of Appendix B for component manufacturers;
- 10 CFR 50.55a requires the use of NQA-1 for ASME Section III, XI and OM code activities.

ASME (the American Society of Mechanical Engineers)

The principal standard is the recently published ASME-NQA-1-2012. This supersedes ASME NQA-1-2008, "Quality Assurance Requirements for Nuclear Facility Applications," with ASME NQA-1a-2009 Addenda. The development of these standards from American National Standards Institute (ANSI) and IEEE standards is set out in Appendix A to the USNRC Regulatory Guide Regulatory Guide 1.28, Revision 4.

IAEA published a comparison of ASME NQA-1-2008 and NQA-1a-2009 Addenda against IAEA GS-R-3 2006, identifying a number of areas where each side did not address the others requirements. These are listed in Annex C.

The following provide additional information:

- STP-NU-051 Code Comparison Report for Class 1 Nuclear Power Plant Components *Prepared for:* Multinational Design Evaluation Programme Codes and Standards Working Group January 27, 2012 addresses ASME III vs RCC-M, JSME, KEPIC and CSA. Specific sections of each comparison address Quality aspects.
- Comparison of ASME Specifications and European Standards for Mechanical testing of Steels for Pressure Equipment - December 2005.

Future Build / Licensing Status

At October 2011 NRC anticipated or had definitive information regarding license applications for:

- AP1000 – Bellefonte AL, William Lee Nuclear Station SC, Harris NC, Vogtle GA, Summer SC, Levy County FL, Turkey Point FL
- ABWR – South Texas Project TX
- EPR – Calvert Cliffs MD
- USAPWR – North Anna VA
- ESBWR – Fermi MI,

Work on 5 additional sites (1xAP1000, 2xEPR, 2xESBWR) has been suspended.

AP1000 design certification has been issued by NRC against various Design Control Document (DCD) Revisions, up to Rev 19. NRC had issued a Final Design Acceptance (FDA) against DCD Rev 15 but were subsequently asked by Westinghouse to 'retire' it. NRC's position at December 2012 was that 'Applicants or licensees intending to construct and operate a plant based on the AP1000 design should do so by referencing its DCR (design certification rule –April 2005) in lieu of the FDA'

ABWR design certification under Appendix A to 10 CFR part 52 is (generally) valid for 15 years from June 11, 1997. NRC reviewed an amendment submitted by South Texas Project Nuclear Operating Company (STPNOC) to demonstrate compliance to the requirements in 10 CFR 50.150, the Commission's new aircraft impact rule. NRC issued the Final rule in December 2011. In December 2010 GE-Hitachi applied for a renewal of the ABWR DC; Toshiba also applied for renewal of the ABWR DC in October 2010, with an application amendment in June 2012.

US EPR design certification was applied for by Areva NP in 2007. NRC is currently reviewing the application.

USAPWR design certification was applied for by Mitsibushi Heavy Industries in 2007. A target date of 2015 is given by NRC for issue of the Final Rule

ESBWR Standard Design Certification was applied for by GE-Hitachi in 2005, subsequently various revisions to the DCD have been submitted and in March 2011 NRC staff issued their final safety evaluation report and final design approval. However, 'in late 2011, while the NRC staff was preparing the final rule, issues were identified with the ESBWR steam dryer, a non-safety component. These issues called into question certain conclusions in the staff's safety review. …… The DC rulemaking process is delayed pending resolution of these issues.'

11.3 FRANCE

Safety Authority and the Licensing Process

Nuclear legislation in France has developed in successive stages in line with technological advances and growth in the atomic energy field. Many of the enactments governing nuclear activities are to be found in the general French legislation on environmental protection, water supply, atmospheric pollution, public health and labour. Although French nuclear law is characterized by its variety of sources, as in other countries where nuclear energy has developed, the original features of this legislation derive chiefly from international recommendations or regulations

The Atomic Energy Commission (CEA)

French nuclear legislation began to develop from the time the Atomic Energy Commission (CEA), the public agency set up by the State in 1945 reporting directly to the prime minister, no longer held a monopoly for nuclear activities i.e. from the time nuclear energy applications entered the industrial stage, thus requiring the involvement of new nuclear operators. This development had several landmarks:

- in 1963, a system for licensing and controlling major nuclear installations was introduced, setting government responsibility in matters of population and occupational safety. Prior to this, procedures concerning the licensing and control of industrial activities were dealt with by the *Préfet*, the Government local representative, for each *Département*. In 1973, this system was expanded to cover the development of the nuclear power programme, and better define the role of government authorities.
- in 1966 a Decree included Euratom Directives as part of the French radiation protection regulations.
- In the 1980's, the enactments setting up the CEA were amended so as to strengthen its inter-ministerial status and a tripartite Board of Administration including staff representatives was created. Governmental decisions are prepared by the Atomic Energy Committee, which acts as a restricted inter-ministerial committee on nuclear energy matters. CEA is now answerable to the Minister for Industry, to the Minister for Research and to the Minister of Defense.
- In 1992 the main task of CEA was laid down by the Government; to concentrate on developing the control of atom uses for purposes of energy, health, defence and industry, while remaining attentive to the requests made by its industrial and research partners.
- In 1999, the inter-ministerial committee more specifically requested CEA to "strengthen long-term research on future reactors capable of reducing, and even eliminate the production of long-lived radio-active waste". In addition CEA was given a particular responsibility for R&D on alternative and renewable energies.

Regulation of large nuclear installations (SCSIN-> DSIN->DGSNR->ASN)

The regulations for large nuclear installations, termed 'Base Nuclear Installation (BNI), were supplemented with regard to procedures by an Instruction of 1973 and a Decision of the same date (amended 1976), which were internal instruments issued by the Minister for Industry. The authorities primarily involved in the licensing procedure for the setting up of BNI were the Minister for Industry and the Minister for Ecology and Sustainable Development. For this purpose, the Central Service for Nuclear Installations Safety (SCSIN), set up in 1973 within the Ministry of Industry, was reorganised as the Directorate for Nuclear Installations Safety (DSIN).

In 2002, the DGSNR (General Directorate for Nuclear Safety and Radioprotection) was created as a result of the merger of DSIN and the former Central Board for Protection against Ionizing Radiations (OPRI). As a consequence, in addition to nuclear safety, DGSNR also held the responsibilities of the former OPRI regarding radioprotection; it also co-ordinated and defined controls for the radiation protection of workers and was involved in the safety plans to be put in action in case of radioactive incident. DGSNR reported to the Ministers for Industry, Health and Ecology and Sustainable Development. At the local level, DGSNR's actions were relayed through the nuclear divisions of the Regional Directorates for Industry, Research and Environment (DRIRE). These Directorates were in charge of the survey of nuclear installations and monitoring reactor shutdowns and all pressurized components, and provided technical support to the "*préfet*", in particular in case of accident.

DGSNR was assisted in decision making by the Institute for Radiation-Protection and Nuclear Safety (IRSN). The IRSN could also undertake studies or research on protection and nuclear safety problems on request of any concerned ministerial department or agency (Law n°2001-398 AFSSE of 9 May 2001).

In 2006, an Act on transparency and safety (The TSN Act) created the Authority for Nuclear Safety (ASN-Autorité de Sûreté Nucléaire); an independent administrative agency headed by 5 members designated by the President of the Republic and the Presidents of the two Parliament Assemblies. The agency is consulted before decisions concerning nuclear safety, nuclear security, and radioprotection are taken by decrees. It can also complete the legislation on technical matters but its decisions may be homologated by the Ministers in charge of these questions. The ASN also has the responsibility of:

- Organizing and directing the control of nuclear installations (designation of inspectors, delivery of permits….).
- Monitoring radioprotection over the national territory.
- Proposing and organizing public information on nuclear safety.
- Establishing the procedures for licensing large nuclear installations (licenses for setting up, commissioning, disposal, etc.).
- Helping the management of emergency situation in the event of an accident involving radioactive exposures.

In addition to Orders (Laws), DSIN/DGSNR and now ASN have issued various regulations and guides:

- General technical regulations, based the decree of 1963, covered (amongst other topics) quality organisation.
- The ministerial order and circular of August 10, 1984 stipulate the general rules for quality assurance and organisation to be followed by operators at the BNI design, construction and operating stages.

Also referred to are about 40 Basic Safety Rules describing accepted practices and which were to be found in Brochure 1606 published by the Official Gazette and the Nuclear Safety Authority under the title "The safety of nuclear installations in France - laws and regulations". (Note *not traced on web but listed in appendix 2 to the 2005 IAEA CNS report and none solely address quality*)

France’s 2001/2002 CNS submission stated that Installations have to be operated in compliance with the General Operating Rules, a regulatory document comprising ten chapters, of which Chapter 2 is titled ‘Organisation of quality’, Chapter 3 ‘Technical Operating Specifications, Chapter 8 ‘Operating procedures’ Chapter 9 ‘Surveillance tests of safety-related systems’ and Chapter 10 ‘Physical tests of reactor core’

France’s 2004/05 CNS submission identified the formulation by the manufacturers of design and construction rules, known as the RCC codes which, for the different categories of equipment involved (civil engineering, mechanical and electrical equipment, fuel, etc.) concern the design, construction and operation stages. It also ides that Volume III of the Safety Analysis Report, Chapter 1 is to be Quality in manufacturing, addressing general construction rules and Quality control.

France’s 2007/2008 CNS submission stated that “A draft revision of the quality order (10 August 1984) has been produced, aiming to bring it into line with the WENRA reference levels. This order will be replaced by one dealing with BNI safety policy and management. As part of the WENRA reference levels transcription process, five working groups have been drafting texts (order and guides) since the beginning of 2006 in the following areas: safety policy and management (all BNIs); safety approach; pressurised water reactor (PWR) design; PWR operations and emergency situations.”. *It is assumed that this refers to the published February 2012 Order*.

In response to questions raised on its 2007/2008 submission the following was stated:

- “ASN is implementing quality management system which shall comply with the IAEA standard GS-R-3 by using ISO 9001-2000 principles. This quality approach implementation should ensure consistency of its main processes across ASN and should promote continuous improvement.”
- The quality management system of EDF is not an integrated management in line with the principles of IAEA GS-R-3. But, its integrates the fundamental concepts of Excellence from the European Foundation for Quality Management

In response to the question 'How are the new IAEA Requirements GS-R-3 considered in the regulatory framework?' the following answer was provided;

- "A new regulation is under development as regards the safety management systems. This regulation will comply with the reference level established by the association WENRA from the GSR 3.
- This regulation will replace the current regulatory requirements spelling out in the order concerning the quality assurance." (*Assumed this was the basis of the February 2012 Order*)

Appendix 2 to France's 2010/2011CNS submission identifies technical texts that have been issued by ASN. These include Safety-management policy (published 22/02/10).

Commentary under Human factors in France's CNS submissions overlaps with Quality; eg in the 2010/2011 submission notes

> "One of the major objectives associated with the company's challenges is to consider quality as the driving force for success in order to reach excellent results within a context of continuous progress.
>
> That objective reflects the conviction that the largest progress margins lie at the level of the working teams through the implementation of safety-oriented actions, the improvement of operational safety and of human achievements by mobilising site managers and involving the staff. The deployment of management through quality, which is directly associated with DPN's (*EDF Nuclear Power Operations Division)* orientations, is a means of responding to that objective. Those values were reflected in eight managerial principles based on the basic principles of the European Formation for Quality Management."

Section 13.2.2 states

> "The need to guarantee safety has led EDF to develop a quality system for its nuclear activities
> Based on:
> _ personnel skills;
> _ work organisation;
> _ formalized methods.
> The quality system evolves on the basis of experience in respect of the following points:
> _ overview of all activities;
> _ analysis in advance of each stage of the process;
> _ the need to apply the requirements of the quality system in a tailored fashion to activities
> important to safety, availability, cost control and human resources management;
> _ involvement of all stakeholders in achieving quality (managers, personnel, contractors, etc.)."

Section 13.2.3 states

> "Activities of key strategic importance for the NPP fleet are identified. Each activity is subject to prior analysis with regard to the difficulties inherent in the activity and the consequences (particularly for safety) of possible failures at each stage of its execution. This highlights the essential quality characteristics of the activity, and in particular the required quality level. Appropriate quality assurance measures follow from this, in particular predefined methods and procedures which must be complied with, and which incorporate stopgap measures in respect of potential failures. The predefined measures provide a set of tools to be used by those involved. Through a questioning attitude, by performing risk assessments, and by making proposals for improvement, personnel can help perfect them."

Security

Security, is the responsibility of the Nuclear Security Authority of the Ministry of Ecology, Sustainable Development and Energy and the Ministry of Defence

Major industrial orgs

EDF

In 1946 nationalization of 1,450 French electricity and gas generation, transmission, and distribution companies led to the creation of Electricité de France (EDF). In 1974, in the wake of the oil crisis, France turned to nuclear-powered electricity generation and announced its intention to build 13 nuclear power plants within two years. This initiative marked the beginning of France's energy independence. In 2004, 70% of the electricity market was opened to competition; EDF changed corporate status to become a limited company. In 2010 EDF invested 2/3 in France and 1/3 internationally (of an €11Bn spend) with sales of €65.3Bn (421TWh generated in France, 55.8TWh in UK). France is 76% nuclear, 11% hydro and 3% other renewable generation. France has 58 nuclear reactors (all PWR) with a total capacity of over 63GWe.

CEA

The Commissariat al'Energie Atomique (CEA) set up in 1945 is the public R&D corporation responsible for all aspects of nuclear policy, including R&D. In 2009 it was re-named Commission of Atomic Energy and Alternative Energy (*still abbreviated as CEA*). It has 14 research reactors of various types and sizes in operation, all started up 1959 to 1980, the largest of these being 70 MWt. About 17 units dating from 1948 to 1982 are shut down or decommissioning. CEA since 2006 have been looking at the design of a GenIV reactor

AREVA

The overarching Group Areva SA is a public multinational company 90% owned by the French state (79% by CEA), although 34% of Areva NP is retained by Siemens of Germany.

Areva NC (formerly known as Cogema) carry out most of the fuel cycle activity Uranium conversion is undertaken at *Malvesi* and *Pierlatte* plants in the Rhone valley. Since 2003 Areva own a 50% share of Urenco's Enrichment Technology Company (ETC). Areva manufacture fuels at several plants in France and Belgium. Used fuel is sent to Areva's *La Hague* plant in Normandy for reprocessing. Recovered plutonium is sent to *Melox* near Marcoule where Areva fabricate it into MOX. ANDRA (Agence Nationale pour la gestion des Déchets Radioactifs) is responsible for the national waste disposal programme. It is undertaking research into deep geological repository, and operates the LLW disposal facility at the *Centre de l'Aube.* ANDRA also operates the *Morvilliers* facility (CSTFA) to hold VLLW. ANDRA's *Centre de la Manche* facility next to *La Hague* received LLW and short-lived ILW up to 1994, and is now capped.

Areva NP (previously known as Framatone) with inputs from Siemens and EDF are the designers of the European Pressurised Reactor (EPR),

Quality and management systems

Past and Present.

Quality was originally defined by the order of 10 August 1984 relating to "the quality of the construction and the operation of nuclear facilities of basic design". A full perspective of the application of this law can be found in the French governmental submissions to the IAEA under the Convention on Nuclear Safety, and responses to questions raised on them.(2nd Convention meeting 2002, 3rd meeting 2005, 4th meeting 2008, 5th meeting 2011). Article 13 of each report addresses "Quality assurance", under the headings:

2002 Report	**2011 report**
13.1 Regulatory requests	13.1 ASN requests
13.2 Presentation by EDF on its quality assurance policy and programme	13.2 Quality assurance policy and programme for nuclear-power reactors
13.3 Presentation by the CEA on its quality assurance policy and programme	13.3 Quality assurance policy and programme for research reactors
13.4 Regulatory analysis	13.4 ASN analysis

The text of the 1984 "quality order" was included in the 2002 report.

Future

In 2012 a new law was introduced (JORF no 0033 du 8 Fevrier 2012 page 2231). The preamble defines the purpose and scope:

> "The themes dealt with are safety management, public information, control of the risk of accident, control of the impact on health and the environment, the management of waste, emergency situations."
>
> "The order includes the essential requirements applicable to basic nuclear installations in these areas. These essential requirements will be supplemented and specified later by regulatory decisions as to technical character of the nuclear safety authority. The new provisions of this order include the monitoring of external stakeholders by nuclear operators, the extension of the principles of quality in all the activities contributing to the protection of the interests covered by the Act, taking account of situations to demonstrate nuclear security rollups, application to basic nuclear installations of some regulatory texts relating to installations classified for the protection of the environment."

The 2012 Order, which will come into force between 2013 and 2015 depending on existing authorizations, specifically addresses Integrated management system (Title 2 Chapter 4) and Continuous improvement (Title 2 Chapter 7) (both Chapters are attached at Annex B).

Meanwhile, on July 1, 2013, the Decree of 10 August 1984 relating to the quality of the construction and the operation of nuclear facilities of basic design is repealed.

Codes and standards

Areva base their requirements for EPR on AFCEN RCC *Design and construction rules for nuclear reactors* – separate codes as follows:

RCC-C	*Nuclear Fuel*
RCC-E	*Electrical Equipment*
RCC-M	*Mechanical components of LWR*
RCC-MR	*Mechanical components of FBR*
ETC-C	*EPR Technical Code for Civil works – replaces RCC-G*
RSE-M	*In-service surveillance of mechanical components*

Information on these codes has been published in:

- Proceedings of the ASME Pressure Vessels and Piping Division Conference, July 26-30 2009 in Prague:
  PVP2009-78036. AnOverview of QA/QC Requirements in Present NPP Projects: *P Malouines (AREVA).*

- PVP2009-78046. Adaption of RCC-M Design and Construction Rules to the Evolution of Projects Needs, Regulatory Evolutions and International Exchanges: *J-M Grandemange (AFCEN).*

Appendix 1

Abbreviations

Research reactor names are not listed as abbreviations below, although often they were acronyms.

A

AERE	Atomic Energy Research Establishment
AFCEN	Association for Design, Construction and In-service rules for nuclear island components (France)
AGR	Advanced Gas-Cooled Reactor
ALARP	As Low As Reasonably Practicable
AREVA	French based international nuclear company (Mining/Nuclear Fuels/Reactors and services/Waste, transportation and decommissioning) and renewable energy designer/manufacturer
ASME	American Society of Mechanical Engineers
AWE	Atomic Weapons Establishment
AWRE	Atomic Weapons Research Establishment (superseded by AWE)

B

BE	British Energy (taken over by EDF in 2009)
BEGL	British Energy Generation Limited (Component company within BE became EDF Energy Nuclear Generation Limited in 2011))
BEG(UK)L	British Energy Generation (UK) Limited (Component company within BE, formerly known as Scottish Nuclear)
BIS	Department for Business Innovation and Skills
BNDC	British Nuclear Design and Construction (design and construction consortia)
BNFL	British Nuclear Fuels Ltd (abolished circa 2010)
BoQK	CQI Body of Quality Knowledge
BS	British Standard
BSS	Basic Safety Standard
BWR	Boiling Water Reactor

C

CAA	Civil Aviation Authority
CANE	Coalition Against Nuclear Energy (NGO)
CCFE	Culham Centre for Fusion Energy
CECA	Civil Engineering Contractors Association
CEGB	Central Electricity Generating Board (England and Wales)
CEO	Chief Executive Officer
CDM	Construction Design and Management regulations
CMRR	Chemistry and Metallurgy Research Replacement facility (USDOE - LANL)
CNC	Civil Nuclear Constabulary
CND	Campaign for Nuclear Disarmament (NGO)
CNI	Chief Nuclear Inspector
CNPA	Civil Nuclear Police Authority
CNRA	Nuclear Energy Agency Committee on Nuclear Regulatory Activities
COMAH	Control of Major Accident Hazards regulations
CoPs	Communities of practice
CORE	Cumbrians Opposed to a Radioactive Environment (NGO)
CoRWM	Committee on Radioactive Waste Management (DECC)
COSHH	Control of Substances Hazardous to Health regulations
CPI	Continual Process Improvement
CRPPH	Nuclear Energy Agency Committee on Radiation Protection and Public Health
CSNI	Nuclear Energy Agency Committee on the Safety of Nuclear Installations
CV	Curriculum Vitae

D

DBA	Design Basis Analysis
DECC	Department of Energy and Climate Change
DEFRA	Department for the Environment, Food and Rural Affairs
DE&S	Defence Equipment and Support (MoD)
DFSNB	Defence Nuclear Facilities Safety Board (within USDOE)
DfT	Department for Transport
DFR	Dounreay fast reactor
DGTREN	EU Directorate General of Transport and Energy
DMTR	Dounreay materials test reactor
DNSR	Defence Nuclear Safety Regulator (within DE&S Directorate of Safety and Engineering)
DPFR	Dounreay prototype fast reactor
DSRL	Dounreay Site Restoration Limited

E

EA	Environment Agency (England and Wales)
EC&I	Electrical, Control and Instrumentation
ECO	Export Control Organisation (BIS)
EDF	EDF Energy including NNB Generation Ltd and Nuclear Energy Generating Group Ltd (part EDF Group previously known as e de France)
EDMS	Electronic document management system
ENSREG	European Nuclear Safety Regulators Group
EPR	European Pressurised Reactor
EU	European Union
EURATOM	European Atomic Energy Community (also refers to treaty of 1957 that established the Community)

F

FAO	United Nations Food and Agriculture Organisation
FBR	Fast Breeder Reactor
FCO	UK Foreign and Commonwealth Office
FOE	Friends Of the Earth (NGO)
FORATOM	European Atomic Forum
FSP	Fundamental safety principle
FTSE	International indices organisation, also produce papers and research reports

G

GDA	(i) Office for Nuclear Regulation & Environment Agency Generic Design Assessment (new build) (ii) Geological Disposal Facility
GSR	General Safety Requirements (IAEA Safety publication)

H

HASS	Highly Active Sealed Source
HMS	Her Majesty's Ship
HR	Human resources
HSE	Health and Safety Executive
HSWA	Health and Safety at Work Act
HTR	High Temperature Reactor

I

IA	Inspection agency
IAEA	International Atomic Energy Agency
IC	Intelligent customer
ILO	International Labour Organisation (UN)
IMO	International Maritime Organisation (UN)
INES	International Nuclear Event Scale (IAEA)
INPO	Institute of Nuclear Power Operators
INSAG	International Nuclear Safety Advisory Group (IAEA)
IRIDM	Integrated Risk Informed Decision Making
IRR	Ionising Radiation Regulations
IS	Information system
ISM	Integrated safety management
ISO	International Standards Organisation
IT	Information technology
ITER	International Thermonuclear Experimental Reactor (located at at Cadarache in France)

J

JET	Joint European Torus (situated at the Culham Centre for Fusion Energy)

K

KM	Knowledge Management

L

LANL	Los Alamos Nuclear laboratory (USDOE)
LC	Licence Conditions (made by Office for Nuclear Regulation under the Nuclear Installations Act)
LLC	Local Liaison Committee (see also SSG)

M

magnox	Type of fuel for first generation reactors in UK. Named because of the non-oxidising magnesium alloy cladding used to contain the uranium fuel rods.
Magnox	Name of the operating company which is the site licence company for sites on which reactors are or were fuelled by magnox
MAST	Mega Amp Spherical Tokamak (situated at the Culham Centre for Fusion Energy)
MCA	Marine and Coastguard Agency
MoC	Management of change
MoCP	Management of change procedure
MoD	Ministry of Defence
MOX	Mixed oxide fuel, based on a mix of oxides of Plutonium and Uraniums. Used as fuel in LWRs.
MRWS	Managing Radioactive Waste Safely DECC programme related to long-term management of the UK's higher activity radioactive waste)

N

ND	Health and Safety Executive Nuclear Directorate (superseded by the Office for Nuclear Regulation in April 2011)
NDA	Nuclear Decommissioning Authority
NDC	Nuclear Development Committee (NEA)
NDPB	Non Departmental Public Body

NEA	Nuclear Energy Agency (part of Organisation for Economic Co-operation and Development)
NESA	Nuclear Energy Skills Alliance
NFLA	Nuclear Free Local Authorities (NGO)
NGO	Non-Governmental Organisation
NI	Nuclear Institute (merge 2009 of British Nuclear Energy Society (BNES) and Institution of Nuclear Engineers (INucE))
NIA	(1) Nuclear Installations Act (2) Nuclear Industries Association
NIA SC	Nuclear Industries Association Supply Chain – NIA sub-group leading on UK new build
NII	Nuclear Installations Inspectorate (formerly part of the Nuclear Directorate, incorporated into the Office for Nuclear Regulation in April 2011)
NIREX	Nuclear Industries Radioactive Waste Executive(superseded by NDA RWMD)
NLC	Nuclear Energy Agency Nuclear Law Committee
NNA	National Nuclear Archive
NNC	National Nuclear Corporation
NNSA	National Nuclear Security Administration (US)
NPC	Nuclear Power Company
NPS	Nuclear power station
NPT/NPPT	The Treaty on the Non-Proliferation of Nuclear Weapons or Nuclear Non- Proliferation Treaty
NQA	Nuclear Quality Assurance (ASME Standard)
NQK	Nuclear quality knowledge
NQSA	Nuclear Quality Standard Association (formed in 2011 from an AREVA / Bureau Veritas initiative)
NRC	US Nuclear Regulatory Commission
NRPB	National Radiation Protection Board (now Health Protection Agency, Centre for Radiation, Chemical and Environmental Hazards, Radiation Protection Division)
NSAN	National Skills Academy (Nuclear)
NSC	(1) Nuclear Energy Agency Nuclear Science Committee (2) Nuclear Safety Committee (LC13)
NSD	Health and Safety Executive Nuclear Safety Directorate (renamed Nuclear Directorate on addition of Office for Civil Nuclear Security and UK Safeguards Office)
NSHEB	North of Scotland Hydro-Electric Board
NSQ	NSQ-100 standard, Nuclear Safety and Quality
NSS	International Atomic Energy Agency Nuclear Security Series
NucSIG	CQI Nuclear Special Interest Group
NuLeAF	Nuclear Legacy Advisory Forum – group established by UK Local government association to identify common local government viewpoint on nuclear clean-up issues
NuSAC	Nuclear Safety Advisory Group (former advisory group to HSE – suspended in 2008)

O

OCNS	Office of Civil Nuclear Security (formerly part of the Nuclear Directorate, incorporated into the Office for Nuclear Regulation in April 2011)
OECD	Organisation for Economic Co-operation and Development
OEM	Office of Environmental Management (USDOE - NNSA*) [The mission of the Office of Environmental Management (EM) is to complete the safe cleanup of the environmental legacy brought about from five*

	decades of nuclear weapons development and government-sponsored nuclear energy research.]
OHSAS	International Occupational Health and Safety Standard
OJ	Official Journal of the European Union
OJEC	Official Journal of the European Communities
OND	Office for Nuclear Development (DECC)
ONR	Office for Nuclear Regulation (Agency of HSE)
ORR	Office for Rail Regulation
OSART	Operational Safety Review Team (IAEA plant based mission)

P

PAHO	Pan-American Health Organisation
PAS	Publically Available Specification (BSI fast-track specification
Pantex	US nuclear weapons assembly and disassembly facility (USDOE – Amorillo Texas)
PAWB	People Against Wylfa B (NGO)
PCPV	Pre-stressed concrete pressure vessel (Wylfa and Oldbury sites plus all Advanced Gas-cooled Reactors)
PFR	Prototype fast reactor
PLC	Programmable logic controller
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Analysis
PWR	Pressurised water reactor

Q

QA	Quality Assurance (former title of LC17 – renamed management systems)
QC	Quality Control

R

RAEng	Royal Academy of Engineering
RAF	Royal Air Force
R&D	Research and development
RCC	AFCEN Rules for Design and Construction
REPPIR	The Radiation (Emergency Preparedness and Public Information) Regulations 2001
RIC	Regulatory Information Conference (run annually by NRC in Bethesda near Washington)
RMTT	Radioactive Materials Transport Team (DfT) (incorporated into the Office for Nuclear Regulation in June 2011)
RSA	Radioactive Substances Act
RSRL	Reactor Sites Restoration Limited (SLC for Harwell and Winfrith)
RWMC	Radioactive Waste Management Committee (NEA)
RWMD	Radioactive Waste Management Directorate (NDA)

S

SAPs	Health and Safety Executive/Nuclear Safety Directorate (now Office for Nuclear Regulation) Safety Assessment Principles
SCRAM	Scottish Campaign to Resist the Atomic Menace (NGO)
SDF	Safety Directors Forum (UK)
SEPA	Scottish Environment Protection Agency
SF	IAEA Safety Fundamental
SFAIRP	So Far As Is Reasonably Practicable
SGHWR	Steam Generating Heavy Water Reactor
SHE	Safety, health and environment
SIL	Safety Integrity Level

SLC	Site licence company (holder of licence under Nuclear Installations Act, issued by ONR)
SME	Small to Medium Enterprise
SSBN	Ship submersible ballistic nuclear
SSC	Structures, Systems and Components
SSEB	South of Scotland Electricity Board
SSN	Ship submersible nuclear
SQEP	Suitably Qualified and Experienced Person (LC 12)
SSG	Site Stakeholder Group (see also LLC)

T

TAG	ONR Technical Assessment Guide
TECDOC	IAEA Technical Document
THORP	Sellafield Thermal Oxide Reprocessing Plant
TIG	ONR Technical Inspection Guide
TNPG	The Nuclear Power Group (design and construction consortia)
TRANSEC	Department for Transport Security and Contingencies Directorate
TRIGA	Training, Research, Isotopes, General Atomics (light water research reactor)

U

UK	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
UKSO	United Kingdom Safeguards Office (formerly part of the Nuclear Directorate, incorporated into the Office for Nuclear Regulation in April 2011)
UNEP	United Nations Environment Programme
URENCO	Uranium Enrichment Company (UK/NL/GE tripartite company)
USA	United States of America
USDOE	Department of Energy (USA)

V

W

WAGR	Windscale prototype Advanced Gas-cooled Reactor
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association
WHO	World Health Organisation
WINS	World Institute for Nuclear Security
WISE	World Information service on Energy (NGO)
WNA	World Nuclear Association
WNTI	World Nuclear Transport Institute
WT&IP	Waste Treatment & Immobilisation Plant (USDOE Hanford)

X **----**

Y **----**

Z

Zangger Committee	Also known as the NPT Exporters Committee, essentially contributes to the interpretation of article III, paragraph 2, of the Nuclear Non-Proliferation Treaty and thereby offers guidance to all parties to the treaty

Appendix 2

NucSIG event topics correlated with NQK sections.

CQI NucSIG regularly holds events at which members and invited guests present their experience on a particular topic and members have the opportunity to discuss the topic. The material presented at these events is published on the CQI NucSIG Past events website. This matrix table identifies the linkage between NQK topics and topics discussed at these events so that readers can seek further Case Study information.

	Introduction	Background	Leadership and Management	Project ,Design and Construction Management	Operational Management	Supply Chain Management	Product Quality Management	Knowledge and Information Management	Assessment and Improvement	History of UK Nuclear	International Approaches
NQK 2013 Section **Event (Most recent at top)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
NQK 2013 Launch *Nuclear Quality Assurance, Conference 1 May 2013 London*	X	X	X	X	X	X	X	X	X	X	X
How many Business Management Systems do we need *16 Oct 2012 Hunterston*			X		X			X			
Generating Quality *25 June 12 Barnwood*			X		X	X			X		
Nuclear Quality Knowledge launch *28 Sep 11 London*	X					X					

	Introduction	Background	Leadership and Management	Project ,Design and Construction Management	Operational Management	Supply Chain Management	Product Quality Management	Knowledge and Information Management	Assessment and Improvement	History of UK Nuclear	International Approaches
NQK 2013 Section **Event (Most recent at top)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Process based Management Systems *24 June 11* *Harwell*			X	X	X	X	X	X	X		
New Build *5 Sept 10* *London*			X	X		X					
Nuclear Supplier Assurance *8 June 10* *HMNB Clyde*						X	X				
Knowledge Management *20 Jan 2010* *Berkeley*								X			
Audits, Assessment and Inspections *16 Sept 09* *Hunterston*									X		

	Introduction	Background	Leadership and Management	Project ,Design and Construction Management	Operational Management	Supply Chain Management	Product Quality Management	Knowledge and Information Management	Assessment and Improvement	History of UK Nuclear	International Approaches
NQK 2013 Section **Event (Most recent at top)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Supply Chain Quality *30 April 09* *Sellafield*						X					
NucSIG Launch *15/16/17 July08* *Sellafield / Bootle / London*	X	X	X								