Chapter 5

Operational Management

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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 number of Quality Engineers will audit all functions including key contractors; manage the document control and records function; lead 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 (USA); these organisations were set up after the incidents at-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 for members 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 has in the past been 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 Licence Condition 10 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 9001 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 documented system 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.

A few years ago, a very Senior Manager was sacked after being observed 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 to the culprit – the issue was the poor example set by the 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 Licence Condition 12 (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. ONR's NS-TAST-GD-027 Training and Assuring Personnel Competence gives more background in this area.

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 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 NS-TAST-GD-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 Place-keeping
- 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
- ONR's NS-TAST-GD-048 gives more background.

Reference Material:

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

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. The 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 ONR are detailed in the ACOP: Work with ionising radiation: Ionising Radiations Regulations 2017 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 faeces 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 or her 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 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 Exemption: 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, however some nuclear utilities and public bodies (for example EDF and NDA) began using the management system standard, PAS 55, this is a risk based standard which leads to holistic management of an organisation's assets. PAS 55 has since been developed by ISO resulting in three standards:
- ISO 55000:2018 Asset management – Overview, principles and terminology
- ISO 55001:2018 Asset management – Management Systems – Requirements
- ISO 55002:2018 Guidelines for the application of ISO 55001

Plant maintenance
Licence Condition 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". 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 of "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 and possibly Ministers and IAEA(INES).

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. This cumulative effect should also be specifically considered during Annual and Periodic Reviews of Safety.

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 number/percentage of mods left open by category is often used as a KPI to determine the adequacy of management control.'

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 generally 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 and at and at Chernobyl reactor No 4.

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 undertaken. Commissioning is often fragmented into stages: 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 general oversight, inspection and 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
T/INS/021	Licence condition 21 – Commissioning
T/INS/027	Licence condition 27 - Safety mechanisms, devices and circuits
T/INS/028	Licence condition 28 - Examination, inspection maintenance and testing (EMIT)
T/INS/029	License condition 29 - Duty to carry out tests, inspections and examinations
T/AST/009	Maintenance, inspection, testing of safety systems, safety related structures etc
T/AST/050	Periodic safety reviews (PSRs)

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; the effect on adjacent work/areas etc. 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 and Control of Major Accident Hazards (COMAH).

ONR Guidance:

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

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 regulated by ONR 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.

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 categorised 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 operated by LLWR Ltd 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 RWM for ILW/HLW packages. Appropriate QA needs to be applied. Waste packages, for example, require quality plans/inspection and test plans to ensure rigorous control of waste drum manufacture, and similar controls for designs requiring encapsulation materials and processes see NDA management of radioactive 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.

Further Guidance:

1. ONR/SEPA Joint regulatory guidance on radioactive waste managment
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 Radioactive Waste from Nuclear Power Plants and Research Reactors, SSG-40
5. Predisposal Management of Radioactive Waste from Nuclear Fuel Cycle Facilities, SSG-41
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. Sophistication of 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, armed police armed 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

ONR Guidance:

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 (revision expected during 2019) 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.

ONR Guidance: T/INS/011 Licence condition 11 – Emergency arrangements