



ONR GUIDE			
LC34: LEAKAGE AND ESCAPE OF RADIOACTIVE MATERIAL AND RADIOACTIVE WASTE			
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1. INTRODUCTION

- 1.1. Many of the licence conditions attached to the standard nuclear Site Licence require, or imply, that licensees should make arrangements to comply with obligations under the conditions. ONR inspects licensee's compliance with licence conditions, and also with the arrangements made under them, to judge the suitability of the arrangements made and the adequacy of their implementation. Most of the standard licence conditions are goal-setting, and do not prescribe in detail what the licensees' arrangements should contain; this is the responsibility of the duty-holder who remains responsible for safety. To support Inspectors undertaking compliance inspection, ONR produces a suite of guides to assist Inspectors to make regulatory judgements and decisions in relation to the adequacy of compliance, and the safety of activities on the site. This inspection guide is one of the suite of documents provided by ONR for this purpose.

2. PURPOSE AND SCOPE

- 2.1. This Technical Inspection Guide (TIG) has 3 main purposes:

- To assist Inspectors in carrying out their duties relating to Licence Condition 34 (LC34);
 - To facilitate a consistent approach to LC34 compliance inspection, benchmarked against IAEA safety standards;
- and;
- To identify sources of further guidance that Inspectors may choose to reference prior to inspecting particular aspects of a licensee's compliance with LC34.

- 2.2. This TIG is advisory rather than mandatory. Inspectors should apply this guidance in a targeted and proportionate manner. Inspectors should judge the frequency and extent of inspections relating to LC34 that should take place on a nuclear licensed site as part of an overall Integrated Intervention Plan and noting that LC34 is a licence condition that should be included in a programme of systems-based inspections. Relevant factors in making this judgment include:

- The characteristics, hazards and timescales associated with the management of radioactive materials and radioactive wastes on the site and the magnitude of the risks that would manifest if those materials or wastes were to leak or escape;
 - The state of maturity and complexity of the licensee's arrangements relevant to compliance with LC34,
- and;
- ONR's level of confidence in the licensee's track-record of compliance with LC34, based on evidence from previous inspections and assessments.

- 2.3. Inspectors should note that ONR has provided 3 Technical Assessment Guides that provide further guidance on ONR's expectations regarding containment and are relevant to the requirements of LC34:

- NS-TAST-GD-019 Containment: Essential Services
(www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-019.pdf)
- NS-TAST-GD-020 Containment for Reactor Plant

- (www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-020.pdf) and
- NS-TAST-GD-021 Containment: Chemical Plant
(www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-021.pdf)
- 2.4. LC34 concerns the control and containment of radioactive materials and radioactive wastes so far as is reasonably practicable to prevent their leakage or escape, and the detection, notification, recording, investigation and reporting of any leakage or escape that occurs. By virtue of the definitions used in ONR's Licence Conditions for "radioactive material" and "radioactive waste", the requirements of LC34 and ONR vires therein apply not only to accumulations of solid radioactive materials (including spent nuclear fuel) and solid radioactive wastes upon licensed sites, but also the accumulation of liquid and gaseous radioactive materials and wastes upon licensed sites.
- 2.5. On matters regarding the management of radioactive materials and wastes on nuclear licensed sites, ONR takes account of the interests of the relevant environmental regulator – either the Environment Agency (EA) in England, the Scottish Environment Protection Agency (SEPA) in Scotland, or Natural Resources Wales (collectively referred to as "the environment agencies" in the remainder of this TIG). Inspectors should familiarise themselves with ONR's Memoranda of Understanding (MoU) with the EA, SEPA and Natural Resources Wales (NRW), as the MoUs provide further guidance on the responsibilities and lead roles for each regulator.
- 2.6. The environmental legislation most pertinent to the disposal of radioactive materials and radioactive wastes – i.e. the Radioactive Substances Act 1993 (RSA93) in Scotland and the Environmental Permitting (England and Wales) Regulations 2010 (EPR2010) - require nuclear site licensees to obtain a permit or authorisation from the relevant environment agency prior to carrying out any of the following activities:
- Disposal of radioactive wastes;
 - Receipt of radioactive wastes for the purposes of disposing of that waste (eg by burial);
 - Keeping or using mobile radioactive apparatus;
- or
- Intrusive investigation work or other excavation, construction or building work: (a) to determine the suitability of any premises; or (b) to enable the use of any premises; as a place that may be used wholly or substantially for underground disposal.
- 2.7. For the purposes of RSA93 and EPR2010, "disposal" of radioactive waste includes; discharge of radioactive gas into the atmosphere; discharge of radioactive liquid into the environment; transfer of radioactive waste to a disposal site, and; transfer of a radioactive waste to another site.
- 2.8. LC34 is explicit that where discharges or releases of radioactive waste take place in accordance with an approved operating rule or environmental permit or authorisation, the licence condition requirements do not apply. In essence, the environmental legislation is concerned with controlling discharges or disposals of radioactive wastes on or from the nuclear licensed sites, whereas LC34 is concerned with the potential for unplanned leakage or escape of the radioactive materials and wastes that are accumulated upon the nuclear licensed sites.

- 2.9. In addition to radioactive materials, the requirements of LC34 apply to all the established categories of radioactive wastes. ONR has worked with the environment agencies to develop Joint Guidance on the management of Higher Activity Radioactive Waste (HAW) to enable relevant proposals from licensees to be assessed by all applicable regulators in a coherent manner. This TIG contains key information from the Joint Guidance that is relevant to LC34, without repeating that guidance in its entirety.
- 2.10. There are several possible causes of leakage and escape of radioactive materials and wastes, which include inadequate design or modifications of containment systems, mal-operation of plant, inadequately controlled experiments, operator error and degradation of plant over time leading to failure of the containment. Examination, Inspection, Monitoring and Testing (EIMT) of containment systems is a key activity in the prevention of leakage and escape. Engineered means should be adopted wherever it is reasonably practicable to do so, in order to reduce the likelihood and consequence of mal-operation or human error. Where engineered means are not reasonably practicable, a licensee may need to rely upon a system of managerial controls and operator actions to meet the requirements of LC34.

3. LICENCE CONDITION 34: LEAKAGE AND ESCAPE OF RADIOACTIVE MATERIALS AND RADIOACTIVE WASTES

- 34(1) The licensee shall ensure, so far as is reasonably practicable, that radioactive material and radioactive waste on the site is at all times adequately controlled or contained so that it cannot leak or otherwise escape from such control or containment.
- 34(2) Notwithstanding paragraph 1 of this condition the licensee shall ensure, so far as is reasonably practicable, that no such leak or escape of radioactive material or radioactive waste can occur without being detected, and that any such leak or escape is then notified, recorded, investigated and reported in accordance with arrangements made under Condition 7.
- 3.1. The wording of 34(3) is different for licensed nuclear sites in England/Wales and Scotland to reflect the different environmental legislation that applies in each country (explained in section 9).
- 3.2. On licensed nuclear sites in England and Wales, LC34(3) is worded as follows:
- 34(3) Nothing in this condition shall apply to discharges or releases of radioactive waste in accordance with an approved operating rule or **environmental permit**, or an existing **permit** which has become an **environmental permit**, granted under the **Environmental Permitting (England and Wales) Regulations 2010 (as amended)**.
- 3.2. On licensed nuclear sites in Scotland, LC34(3) is worded as follows:
- 34(3) Nothing in this condition shall apply to discharges or releases of radioactive waste in accordance with an approved operating rule or, **disposal authorisations** granted under the **Radioactive Substances Act 1960** or, as the case may be, the **Radioactive Substances Act 1993**.

4. PURPOSE OF LICENCE CONDITION 34

- 4.1. The key purpose of LC34 is to ensure that control and containment of radioactive materials and radioactive wastes on nuclear licensed sites is not lost due to their

leakage or escape, and to ensure that any leak or escape that does take place will be detected.

- 4.2. Section 4(2) of the Nuclear Installations Act 65 (NIA65) grants ONR the power to attach such conditions to a site licence it thinks fit with respect to the handling, treatment and disposal of nuclear matter. The term ‘nuclear matter’ includes most fissile materials and any radioactive material produced in, or made radioactive by, exposure to the radiation incidental to the process of producing or utilising any such fissile material. Inspectors should note that the requirements of licence conditions such as LC34 apply even where there is no immediate impact on the safety of workers and the public (e.g.; leakage into a shielded secondary containment within the confines of a licensed site).
- 4.3. Inspectors should note that treatment, processing, keeping, storage accumulation or carriage of any radioactive material or radioactive waste fall within the definition of “operations” in LC1(1). The totality of a licensee’s arrangements to manage radioactive materials and radioactive wastes should therefore include evidence to demonstrate compliance with all relevant licence conditions such as LC4 (Control of Nuclear Matter), LC6 (Documents, Records, Authorities and Certificates), LC14 (Safety Documentation), LC25 (Operational Records) and LC28 (Examination, Inspection, Maintenance and Testing). Facilities whose main function is to store or process radioactive materials and radioactive wastes are subject to the full suite of regulatory requirements applied to “operational” facilities. Licensees need to adopt a holistic approach that meets the requirements of LC34 in addition to satisfying the requirements of all the other relevant licence conditions.
- 4.4. Analysis of data collected to satisfy the requirements of International Safeguards can provide reassurance that radioactive materials and radioactive wastes are not being inadvertently diverted as a result of leakage or escape. In such situations the licensee should clearly identify any reliance it places on such analyses as part of its demonstration that the requirements of LC34 are being satisfied. Any licensee adopting this approach should ensure that the importance of the analyses in the context of nuclear safety and environmental protection is not overlooked.
- 4.5. Inspectors are reminded that some of the requirements of the Ionising Radiations Regulations 1999 (IRR99) bear a close relationship to the requirements of LC34. Inspectors may consider including some relevant requirements of IRR99 within the scope of compliance inspections whose main focus is on LC34; HSE has produced an Approved Code of Practice and more detailed guidance on the IRR99 which Inspectors may wish to consult. Some examples include:
- IRR99 Regulation 8 Restriction of exposure
 - IRR99 Regulation 10 Maintenance and examination of engineering controls etc and personal protective equipment
 - IRR99 Regulation 27 Sealed sources and articles containing or embodying radioactive substances
 - IRR99 Regulation 28 Accounting for radioactive substances
 - IRR99 Regulation 29 Keeping and moving of radioactive substances
 - IRR99 Regulation 30 Notification of certain occurrences
- 4.6. Inspectors should note that IRR99 Regulation 30 requires radiation employers to notify HSE in the event of an uncontrolled leakage or escape of a radioactive substance that exceeds the values on quantity and concentration specified in IRR99 Schedule 8. Any

such notification from a nuclear licensee would trigger an investigation by ONR, which should include a consultation of the Enforcement Management Model (EMM). Licensees' procedures should include reporting arrangements to ONR compatible with the requirements of both IRR99 Regulation 30 and LC7 and demonstrate how the amount of any uncontrolled leakage or escape will be assessed. Licensees may sometimes be reluctant to report immediately a leakage or escape that may breach the levels stated in IRR99 Schedule 8, especially where an accurate determination of the scale of the leakage or escape may require time consuming sampling and analysis. It is preferable for licensees to take a precautionary approach in such circumstances and give early notification to ONR, even if there are some initial uncertainties, as this will enable ONR to have a more timely engagement. Inspectors may choose to consult ONR-OPEX-GD-001 which contains further guidance on incident reporting including the anticipated timescales.

- 4.7. Also of particular relevance to LC34 is IRR99 Regulation 27, paragraphs (2) and (3), which state:

“(2) The radiation employer shall ensure that the design, construction and maintenance of any article containing or embodying a radioactive substance, including its bonding, immediate container or other mechanical protection, is such as to prevent the leakage of any radioactive substance -

(a) in the case of a sealed source, so far as is practicable; or

(b) in the case of any other article, so far as is reasonably practicable.

(3) Where appropriate, the radiation employer shall ensure that suitable tests are carried out at suitable intervals to detect leakage of radioactive substances from any article to which paragraph (2) applies and the employer shall make a suitable record of each such test and shall retain that record for at least 2 years after the article is disposed of or until a further record is made following a subsequent test to that article.”

5. GUIDANCE ON ARRANGEMENTS FOR LICENCE CONDITION 34

- 5.1. The list below identifies some aspects that ONR might expect a licensee to address in order to demonstrate compliance with the requirements of LC34.

- **Safety cases** including justified **limits and conditions** and **suitable operating instructions** should be in place for all activities involving containment of radioactive materials and radioactive wastes, including waste stores. The safety case should identify the reasonably foreseeable routes for leakage or escape that should be protected against. Wherever the level of radiological challenge dictates, these safety cases should assign safety functions to all Systems, Structures and Components (SSCs) that contribute to the prevention of leakage or escape. Where the management of radioactive materials or radioactive wastes is subject to significant uncertainties (examples may include uncertain details of a stored inventory, or uncertain status of relevant SSCs), the potential implications for safety should be made clear and approached conservatively – HSE’s decision-making process in such circumstances is outlined in its publication “Reducing Risks, Protecting People”.
- Wherever the radiological hazard is sufficiently high, **the provision of all process vessels, storage ponds, piping, ducting, tanks, drains, flasks and storage vessels used in activities with radioactive material or radioactive wastes should incorporate multiple containment barriers**, such that the largest reasonably foreseeable leakage from the primary containment for any

design basis fault will be safely captured. A leak detection system and supporting procedures should be in place, where appropriate the procedures should allow normal operations to be stopped in the event that a leak is discovered and potential exists for the situation to worsen. The procedures should also ensure that operators take appropriate action to minimise the risk to personnel in the vicinity. Containment safety functions should be ascribed to all SSCs that make a contribution to any of the multiple-barriers in place, including the SSCs used in leak detection.

- The licensee's approach to design, operation, maintenance and decommissioning of nuclear plant should ensure **effective management oversight** of the status of all SSCs that play a role in the prevention of leakage or escape of radioactive materials and radioactive wastes, including leak detection systems.
- Systems should be provided to **detect, locate, quantify and monitor any leakage or escape** of radioactive materials and/or radioactive wastes that may occur from any primary containment boundary during normal and accident conditions. All reasonably practicable methods of detection and monitoring should be considered, which may include; regular plant walk-downs; CCTV; visual inspections and radiation monitors.
- So far as reasonably practicable, the licensee should minimise the potential for human error to give rise to a leak or escape of radioactive material or radioactive waste. In addition to having suitable design criteria, the licensee should have in place **a programme of training** for all operational personnel who play a role in preventing leakage and escape of radioactive material and radioactive wastes, especially staff who carry out Examination, Inspection, Maintenance and Testing (EIMT) of relevant SSCs and operators of mobile apparatus for use in cross-site transport. A licensee should ensure the arrangements it makes to comply with the requirements of LC28 are compatible with meeting the requirements of LC34.
- Wherever a **ventilation system** contributes to the containment of radioactive materials and/or radioactive wastes, this should be clearly identified and the ventilation system should be ascribed a suitable safety function. Operational procedures should identify the actions that should be taken if a fault with the ventilation system were to occur. This is particularly important for activities involving alpha-emitting airborne contamination, typically carried out in glove boxes; such ventilation systems should ensure a pressure differential sufficient to protect workers from a leak or escape in the event of a reasonably foreseeable breach of the glove box containment (e.g. from a glove tear).
- A licensee's arrangements made under LC22 should be compatible with meeting the requirements of LC34 by ensuring no **modification to plant or process parameters** can adversely effect the ability of SSCs to prevent leakage or escape of radioactive material or radioactive waste (eg storing a different type of liquor than the original design intent).
- The licensee should identify the systems by which all required **records** will be generated and retained, with suitable cross references to the arrangements for LC4, LC6, LC7, LC25 and LC32. These should include the means of identifying radioactive materials and wastes, the nature of contents, location, main radionuclides present and an indication of the activity/dose rate and the date of recording. This is necessary to determine the possible radiological consequences of leakage and escape and inform clean-up efforts.

- The licensee's arrangements made under LC28 should include **a programme of regular EIMT** for all the SSCs that play a role in leak detection, to ensure all such equipment is kept in effective working order.
- The licensee's arrangements made under LC28 should include **a programme of regular EIMT** of all process vessels, ponds, piping, pipe bridges, ducting, tanks, drains, flasks and storage vessels used in activities with radioactive material and/or radioactive wastes, to underwrite the ability of all applicable SSCs to prevent the leakage or escape of radioactive materials or radioactive wastes on an ongoing basis.
- The arrangements should identify all the **storage locations** for radioactive materials and radioactive wastes on the site and the amounts, durations and form of storage. Storage should always be demonstrably safe and secure for the anticipated storage period.
- Wherever radioactive waste is held in long-term storage on a licensed nuclear site, so far as reasonably practicable the **waste should be held in an immobilised form, within a suitable containment** in order to restrict its ability to leak or escape. It is good practice to provide a summary of the safety case elements relevant to the management of any HAW in a Radioactive Waste Management Case (RWMC), prepared in accordance with the Joint EA, SEPA, NRW and ONR Guidance on the Management of HAW.
- The licensee should have in place a means of **inventory control**, such that the licensee is at all times aware of the amount, type and location of radioactive materials and radioactive wastes present on the site. The licensee should also clearly identify the barriers to leakage and escape, the means of detecting any failure of those barriers and the associated maintenance, inspection and testing schedule. Regular review of data may provide assurance that radioactive material is not being unwittingly diverted, or subject to leak or escape. This aspect should take cognisance of compliance with LC4 and LC25.
- As LC34(2) contains a requirement for any leakage or escape of radioactive material or radioactive waste to be notified in accordance with the arrangements made under LC7, the licensee should have a clear **process for notification, investigation and reporting of any significant leakage or escape, or any other significant non-compliances** with the licence condition requirements. These systems should recognise the relevant requirements of the IRR99 for formal notification to ONR of any leak or escape of a radioactive substance that exceeds the levels stated in Schedule 8 of the IRR99.

6. GUIDANCE ON INSPECTION OF ARRANGEMENTS AND THEIR IMPLEMENTATION

- 6.1. LC34 may be carried out as routine inspections that are part of a programme of System-Based Inspections (ONR-INSP-GD-059) or may be conducted to investigate specific issues or events. During the planning stage of an LC34 compliance inspection, Inspectors should consider the scope and depth of the inspection including co-operation and information sharing with the relevant environment agency (and the Defence Nuclear Safety Regulator (DNSR) on licensed sites that contribute to the MoD's Defence Nuclear Programme). An inspection may take a cross-site overview, focus on a particular facility, or look in depth at a particular aspect of LC34 compliance (e.g.; EIMT of vessels and pipe-work). Aspects that may influence the scope and objectives of an LC34 compliance inspection may include:

- Recent events or near-misses associated with leakage or escape of radioactive materials or radioactive wastes, such as breaches of a safety case, breaches of an environmental permit or authorisation, transport criteria or other legal limit;
 - An identified need to assess the licensee's delivery against extant regulatory issues, agreements or enforcement action;
 - Recently implemented or impending modifications to the licensee's processes, plans, safety cases, plant or personnel of relevance to leakage or escape of radioactive materials or radioactive wastes;
 - Any need to consider the practical impacts of outcomes from assessment of the licensee's submissions to ONR such as; safety cases, modification proposals, the site's Integrated Waste Strategy (IWS), decommissioning strategy, periodic reviews of safety or Radioactive Waste Management Cases;
 - Identified benefits from carrying out a joint intervention with the relevant environment agency or DNSR;
 - Periodic checks to underpin regulatory confidence in selected aspects of the licensee's compliance with LC34 that have significance with respect to nuclear safety;
- or;
- Any other emergent regulatory concern at the licensee's performance in complying with the requirements of LC34.
- 6.2. Inspectors should consider whether the licensee's approach to complying with the requirements of LC34 is sufficiently comprehensive, using Section 5 of this TIG and supporting references as a guide.
- 6.3. Licensees should recognise that the level of harm likely to result from any leakage or escape of radioactive material or radioactive waste depends upon the biological and environmental pathways the material or waste may enter, if adequate control over the material or waste were to be lost. In certain circumstances an escape of even a small amount of radioactive material or waste could be significantly harmful to personnel (e.g.; if alpha-emitting material in the form of a fine dust was ingested). Leakage or escape may also give rise to long-term cumulative impacts, such as an escape of radioactive liquid into the ground that could threaten water courses. Consequently the physical form and nature of the radioactive materials or wastes being worked upon, in addition to their radiological and chemical properties, are key factors in the design of effective containment systems.
- 6.4. Licensees should recognise that some aspects of risk associated with a leakage or escape of liquid radioactive materials or wastes can escalate if the liquid concerned is allowed to dry out through evaporation, as this may give rise to airborne contamination with the potential to provide an internal dose.
- 6.5. Nuclear licensees make arrangements under LC11 (and to satisfy the requirements of the Radiation Emergency Preparedness and Public Information Regulations, REPPiR) to mitigate the large-scale leakage or escape of radioactive materials or radioactive wastes beyond the licensed site that may result from postulated accident scenarios that are outside the normal design basis. Such mitigative measures are therefore not normally considered to be a matter of compliance with LC34.

- 6.6. Inspectors should note that where a multi-barrier containment system has been provided, it is generally inappropriate, unless appropriately justified, for a licensee to allow the effectiveness of any single barrier to degrade such that reliance on the other barriers is increased. Such an approach will lessen the inherent level of protection by removing the overall system's strength-in-depth. During normal operations, the principal means of controlling the location of radioactive material and wastes should be the primary containment. A licensee should provide sufficient evidence to demonstrate that all reasonably practicable steps have been taken to prevent any leakage or escape from the primary containment in the first instance. Secondary containment systems are mitigative measures that it is sensible to provide if the licensee judges that, despite taking all reasonably practicable steps to avoid leakage or escape from the primary containment, it is still reasonably foreseeable that some leakage or escape from the primary containment may still occur (e.g.; tanks and valves do sometimes fail, and a secondary containment system can restrict the impact of such failures).
- 6.7. Wherever the level of radiological challenge is sufficiently high, the licensee should be able to demonstrate a multi-barrier approach to the containment of radioactive materials and wastes, with the number and type of barriers being commensurate with the level of hazard of the radioactive material or waste being managed. In addition to engineered measures, the barriers may include operational controls. In order for a secondary containment system to function in an effective manner, it should be provided with:
- A leak detection system, such that if a leak into the secondary containment were to occur the licensee would be aware of the leak and able to enact an appropriate remedy;
 - A means of isolating the secondary containment and recovering the leaked material;
 - A programme of EIMT to ensure all the required containment functions are adequately delivered by all relevant SSCs on an ongoing basis.
- 6.8. Established good practice is for all tanks, mobile bowlers and bulk storage containers used to hold potentially mobile radioactive materials and wastes to be provided with secondary containment. It is also good practice for licensees to provide a means of secondary containment (most commonly a bund arrangement) around storage areas for radioactive materials and wastes and operational areas where work may involve potentially mobile radioactive materials and wastes (e.g. decontamination processes or decanting of radioactive fluids between containers). Particular attention should be paid to temporary arrangements, which tend to be used for one-off tasks or in plant decommissioning. Features that an Inspector may choose to look for include:
- Whether secondary containment has been provided to all appropriate tanks, vessels, radioactive waste stores and operational areas that may give rise to the leak or escape of radioactive materials or wastes;
 - Whether the secondary containment provided to tanks also serve any neighbouring areas that feature temporary connections, as these may be vulnerable to spillages;
 - Whether secondary containments are being regularly inspected and maintained in a quality assured manner, to enable the responsible manager to have an effective oversight of the true status of all associated SSCs (such as level alarms) within his/her remit;
 - Whether secondary containments are provided with an appropriate geometry, good access and a smooth surface finish to allow easy decontamination in the event of a leak;

- Whether secondary containments are constructed from appropriate materials (e.g. water retaining concrete).
 - Whether the secondary containments provided to tanks have sufficient capacity (good practice based upon the requirements of the Oil Storage Regulations being at least 110% of the capacity of any vessel they serve);
 - Storage tanks for radioactive liquids are often linked to similar neighbouring tanks by pipe-work. In the event of a leak, any hydrostatic links between tanks may provide a leak path via which the contents from more than one tank could be lost. In such circumstances the secondary containments should be sufficiently sized to accept 110% of the maximum possible leak volume from all the linked vessels;
 - Whether the licensee has taken all reasonable steps to prevent liquid accumulating into secondary containments from sources other than the primary containment (e.g. weather proofing to combat any ingress of rain water);
 - Whether the secondary containments are adequately water-tight and do not feature any possible leak paths that may allow mobile radioactive material or waste to overcome them (e.g. by capillary action);
 - Whether the secondary containment height and mechanical strength is sufficient to contain a reasonably foreseeable sudden large-scale failure of the vessel or its connections (which may result in a wave effect);
 - When a secondary containment system is located in an area that is out of day-to-day view, whether the licensee would be aware in a timely manner should a leak into it take place;
 - Whether the licensee has a fit-for-purpose means of recovering any reasonably foreseeable leak that may take place into the secondary containment.
- 6.9. SSCs that provide a leak detection and monitoring capability, such as level indicators and alarms, play an integral role in an effective overall system to prevent the leakage or escape of radioactive materials and radioactive wastes. Particular aspects an Inspector may wish to consider include:
- Whether there is sufficient coverage of alarms and level indicators across the licensed site, such that the licensee can be confident it has an accurate state of knowledge on all the plant areas where the leak or escape of radioactive material or radioactive waste is reasonably foreseeable;
 - Whether the contribution alarms and level indicators make to the prevention of leakage and escape of radioactive materials and radioactive waste is appropriately recognised in the plant safety case;
 - Whether all SSCs that provide the leak detection and monitoring capability are duly recognised as safety related equipment and ascribed an appropriate safety function;
 - Whether alarms and level indications are routed to staffed areas, such that appropriate Suitably Qualified and Experienced Personnel (SQEP) would be informed of any leak that takes place in a timely manner;
 - In the event that it is not reasonably practicable for a licensee to provide alarms and level indications to an area that is potentially vulnerable to leakage or escape, inspectors should consider whether the licensee is carrying out plant walk downs with an appropriate scope and periodicity in order to give assurance that leakage or escape is not occurring;

- Whether the licensee's approach to EIMT of the SSCs used in leak detection and monitoring includes a regular and thorough proof test, to ensure the overall system works as intended. ONR has previously identified a contributory factor to a major recent leak of radioactive material was a regime of EIMT that focused on testing specific component parts of an alarm system in isolation, in a manner that did not test the overall system dynamics;
 - Whether the licensee's operating philosophy includes a robust response to alarms associated with leak detection; it is not appropriate for a licensee to tolerate alarms being in an activated state as a matter of routine;
- and;
- Whether the licensee undertakes trending of key data that may highlight suspicious changes to the plant state over time and thereby indicate the leak or escape of radioactive material or radioactive waste.
- 6.10. Licensees who manage nuclear chemical plants should comply with the requirements of LC34 as part of a holistic approach that satisfies all applicable regulatory requirements including where appropriate; the Control of Major Accident Hazards Regulations 2015 (COMAH); the Pressure Equipment Regulations 1999; the Pressure Systems Safety Regulations 2000 and the Control of Substances Hazardous to Health Regulations 2002 (COSHH).
- 6.11. As leakage or escape of radioactive materials or wastes can present an immediate risk to personnel, a licensee should have in place procedures that ensure operators will take appropriate action in the event that leakage or escape is discovered. The first priority upon discovering leakage or escape should be to make the affected area safe. If necessary, operators who suspect leakage or escape should withdraw from the area, cease normal operations, arrange immediate isolation of the area and report the finding to plant management. ONR would expect the licensee to carry out further monitoring to establish the scale of any leakage or escape, investigate the cause and carry out checks of any similar circumstances or plant items across the licensed site. Once the scale and nature of any leakage or escape has been fully understood, the licensee should take all reasonably practicable steps to minimise the risks from the leaked radioactive material or waste, instigate a timely and safe clean-up and make any required amendments to its safety cases. Typically upon finding a leakage or escape a licensee may need to; change the radiological classification of the affected area; restrict personnel access; halt operations; provide temporary containment or shielding, and/or; provide Personal Protective Equipment. In the event of a significant leakage or escape having occurred, Inspectors should check that the immediate steps taken by the licensee were adequate. There should be adequate provisions for assessing the radiological consequences or accrued doses of personnel due to the leak and subsequent clean-up activities and appropriate mitigating arrangements.
- 6.12. Some historic facilities on nuclear licensed sites are currently being used to store significant quantities of potentially mobile radioactive materials and/or radioactive wastes within a single layer of containment that is of questionable integrity and sometimes located underground. In rare cases, some recognised established leakage and escape cannot be stopped as the required repairs are not technically feasible. In such circumstances the licensee's demonstration that risks are being managed ALARP should include evidence to demonstrate the reasons why an effective repair to the containment system is not reasonably practicable and the steps that are being carried out in mitigation. The plant should then be managed in a manner that reflects the hazard and risk it presents as a result of the continuing leakage and escape. Inspectors being made aware of this type of situation should raise it to the attention of ONR management and discuss any implications for protection of the environment with the relevant environment agency site inspector. In some cases, the only practicable

means of achieving modern standards is removal of the radioactive materials and/or wastes from the facility concerned, to allow a better standard of storage to be secured for the future. In such circumstances, regulatory expectations need to balance the need for waste retrievals to be achieved in a safe and timely manner alongside the need to manage current day risks to levels that are ALARP. It is important that compliance with the requirements of LC34 is given appropriate consideration during the retrieval process itself – this should be addressed in the modification proposals to enable retrievals. Further guidance can be found in ONR's Technical Assessment Guide on ALARP.

6.13. It is common for SSCs that play a role in prevention of leakage or escape of radioactive materials or radioactive wastes to provide additional functions that are important for operational purposes, or for other aspects of safety. In such circumstances, the importance of the features that ensure containment of radioactive materials and/or radioactive wastes can sometimes be overlooked or neglected. Inspectors may wish to check that the licensee has given proper recognition to maintenance of features that prevent leakage or escape of radioactive materials and wastes involved with plant such as:

- Gloveboxes, especially those that provide a pressure boundary;
- Ventilation systems;
- Fuel storage pond civil structures;
- and;
- Effluent treatment plant civil structures.

6.14. Many buildings used for activities with radioactive materials and radioactive wastes on licensed sites have basements / voids / vaults / cellars / catch pots / sumps etc in areas of restricted access that can be vulnerable to water ingress and egress, especially if construction joints are located below the level of the groundwater table. Such features can allow groundwater to enter into a building, or liquid may escape from the building into the ground and into the environment. Wherever it is reasonably practicable, radioactive materials and wastes should be segregated away from any potential leak path. These factors are particularly important for buildings where bulk volumes of radioactive liquids are routinely handled, such as fuel storage ponds, effluent treatment plants and large scale chemical processing facilities. Factors an Inspector may wish to consider in these situations include:

- Whether the licensee has comprehensive knowledge and accurate data on the extant status of all the sumps / voids / vaults / catch pots / basements etc on the site;
- Whether the licensee is taking all reasonably practicable measures to avoid the accumulation of liquids in sumps / voids / vaults / catch pots / basements and thereby minimise the potential for leakage or escape of radioactive materials and wastes, such as making civil structures fully water tight and preventing rain water ingress;
- Whether the sumps / voids / vaults / catch pots / basements etc that may be vulnerable to the accumulation of radioactive liquids and wastes and their possible leakage or escape are equipped with suitable alarms and instrumentation and regularly inspected;

- Whether operational procedures include an appropriate response should a significant leak be discovered, including the circumstances in which cessation of operations should be considered;
- Whether the licensee properly understands the source of any liquid accumulation that may have been found in sumps / voids / vaults / catch pots / basements etc. and hence whether the liquid concerned contains radioactivity,
- Whether the licensee has detailed knowledge of all potential ingress/egress routes (e.g. through access to detailed engineering/plant drawings) that may lead to leaks or spread of radioactivity.
- Whether the licensee undertakes an appropriate programme of sampling to provide reassurance that any liquid accumulated in sumps / voids / vaults / catch pots / basements etc inside buildings used for licensable activities does not contain significant levels of radioactivity.

and;

- Whether the licensee undertakes an effective programme of ground and groundwater monitoring as a indicator of potential leakage or escape of radioactive materials and/or radioactive wastes, especially when a site features concealed underground structures.

6.15. Many nuclear licensees store or transfer radioactive fluids in tanks, sumps or pipe-work that are concealed. Such concealment may be within the fabric of civil structures, in trenches, in conduits or underground. While concealment can provide safety benefits in terms of shielding and segregation, it may also result in SSCs that play a role in the containment of radioactive materials and/or radioactive wastes being difficult to access and away from day-to-day view. EIMT of such infrastructure may not be straightforward, or worse may be completely overlooked, particularly if the associated instrumentation/alarm provisions are lacking. Wherever such situations exist upon a nuclear licensed site, Inspectors may wish to consider the following:

- Whether the licensee's safety case requirements for the concealed SSCs have included adequate details of the duty the service has to perform throughout its design lifetime within the real-world environment to which the SSC is exposed. Integral to this will be the suitability of selected materials, devices, components, structures etc to withstand ageing and other potential degradation mechanisms such as corrosion or mechanical fatigue, noting that long-term exposure to high levels of radiation can cause embrittlement (especially to seals and water-bars).
- Several different types of services (e.g. pipe-work carrying radioactive liquids, electrical supplies, control and instrumentation connections, potable water supplies and conventional drains) may be located in close proximity to each other inside ducts / voids / trenches etc. In such circumstances it is important the licensee protects against any interactions between the different systems that may result in a leak of radioactive materials or radioactive wastes. Factors to consider include; temperature variations; mechanical vibration; corrosion; leakage from pipe-work used for non-nuclear purposes onto neighbouring SSCs; etc.
- Whether the licensee has clear records that accurately identify where any concealed services used to store, contain or transport radioactive materials

and/or radioactive wastes are located, with appropriate warning notices and instructions displayed.

- Whether the licensee's EIMT arrangements properly substantiate the performance of SSCs that perform a role in containment of radioactive materials and/or radioactive wastes but which are subject to access restrictions due to being remote, are not amenable to visual inspection and which may be exposed to a hostile environment. This may be of particular relevance when a plant is subject to lifetime extension.
- Whether the licensee provides appropriate systems to control work that enable the managers responsible for different concealed systems to communicate effectively and thus secure an effective oversight. Points to consider could include: Whether the modifications process adequately addresses potential adverse impacts on co-located services and whether due consideration is given to faults in one system affecting another, etc.
- Whether the licensee can provide a comprehensive plan during decommissioning or plant modifications that recognises the impacts of dismantling work or modifications on concealed services that may contain radioactive materials or radioactive wastes, and the potential effects from degradation of any concealed services that the licensee intends to leave in-situ.

6.16. Containment systems should be designed, operated and maintained in such a manner that they accommodate all reasonably foreseeable changes in the characteristics of the stored radioactive material and/or radioactive waste throughout the required lifetime. There may be particular challenges to be faced where a need arises to store radioactive materials or radioactive wastes on a site for an extended period. Factors an Inspector may wish to consider include the following:

- Whether the licensee's arrangements will be robust to changes in physical properties of both the stored inventory and the SSCs that secure its containment, through ageing effects such as corrosion;
- Whether the licensee has taken proper account of the long-term effects of elevated levels of radiation, such as embrittlement of materials commonly used in engineered seals such as PVC or natural rubber;

and;

- Generation of flammable gases, especially hydrogen, that can arise from radiolysis and has potential to give rise to deflagrations or explosions.

6.17. The licensee's arrangements should include a programme of EIMT to provide assurance that all SSCs that play a role in preventing the leakage or escape of radioactive materials and radioactive wastes will perform adequately for as long as they remain in service. The EIMT should include checks for:

- Fatigue failure of pipe-work and process vessels, which may occur wherever such equipment is subjected to mechanical vibration, wide variations in temperature and/or pressure, long-term effects of high radiation fields, etc.
- Corrosion failure of components such as pipe-work, process vessels, pipe bridges, especially where such equipment is subject to a harsh environment.

6.18. Wherever it is reasonably practicable, radioactive wastes needing to be held in long-term storage on a licensed site should be immobilised and kept within a container that minimises the risk of leakage or escape in accordance with the Joint HSE, EA, SEPA

and NRW Regulatory Guidance “Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites” (Parts 1 to 3 inclusive). Specific aspects to consider include:

- Whether a RWMC exists for the waste, including reference to a suitable Letter of Compliance from NDA’s Radioactive Waste Management Directorate;
 - Whether the radioactivity is fully immobilised;
 - Whether the waste form and its container are physically and chemically stable;
 - Whether a multi-barrier approach is in place to ensure containment of the waste;
 - Whether the storage environment will maximise the waste package life;
 - Whether secondary containments are provided with alarms and monitoring systems that would detect any reasonably foreseeable leakage or escape of the stored radioactive wastes and the relevant SSCs are being properly maintained in good working order;
 - Whether waste packages can be inspected on a periodicity that gives assurance that adequate containment of the wastes is being delivered on an ongoing basis;
 - Whether waste stores have contingent systems in place to facilitate an adequate response should any waste packages be discovered to be leaking;
- and,
- Whether the justified lifetime of the store and waste packages is compatible with the intended disposal route.

6.19. Inspectors may wish to examine the consistency of the arrangements used by the licensee to achieve compliance with LC34, including the period of validity of any procedures and whether any significant changes have occurred on the plant since the last periodic review. Inspectors should note whether the instructions, standards and quality assurance system claimed in the arrangements have been properly applied and whether any changes have been incorporated and validated via the applicable due process. Inspectors may wish to check evidence that monitors being used to assay radioactive materials and radioactive wastes are being adequately maintained and properly calibrated.

6.20. Inspectors may wish to examine the licensee’s design standards and whether these give adequate recognition to the need to comply with LC34 within all processes relevant to the generation, storage, processing and transfer of radioactive materials and radioactive wastes. Some particular aspects to consider are:

- Design standards should ensure that options studies and process selection give due recognition to the importance of avoiding the leakage and escape of radioactive materials and radioactive wastes;
- Methods of construction should seek to avoid unnecessary contamination spread;
- The plant layout, including the arrangements for storage of radioactive material and radioactive waste, ventilation and personnel access, should minimise the potential for spread of contamination.

6.21. Inspectors may check that the licensee has a comprehensive listing of all the areas that are being used for storage of radioactive materials and radioactive wastes, including any temporary arrangements, and that each area is covered by an adequate safety case which should identify any necessary limits and conditions. Inspectors may

check the recorded inventory for each of those storage areas then carry out plant visits and, where it is practicable, ascertain whether the actual accumulations are as expected and whether leakage or escape may be occurring. Arrangements for the custodianship and use of each storage area should be unambiguous and fully understood by all relevant personnel.

- 6.22. A common contributor to loss of containment events has been a failure in management oversight of the plant concerned. Wherever a licensee undertakes a process with potentially mobile radioactive material or waste, it is important that all maintenance on SSCs playing a role in containment of the radioactive material or waste is carried out in a quality assured manner. Maintenance tasks should follow an appropriate procedure, be carried out with a periodicity that reflects the requirements of the plant safety case and completion of the required maintenance should be recorded. The plant should be returned back to service in the operating state, and with the SSCs in place, as required by the safety case. If maintenance is approached in an uncontrolled way the plant manager may be left without an auditable means of knowing the true status of the relevant SSCs.
- 6.23. The list below identifies some common areas for improvement, relevant good practice and observations associated with the requirements of LC34, drawn from ONR's operational inspection experience. The list should not be taken as fully comprehensive nor exclusive, and is advisory rather than mandatory.
- Whenever an uncontrolled leakage or escape of radioactive material or radioactive waste occurs on a nuclear licensed site it tends to generate stakeholder interest. Reputational damage to a licensee from such an event can be very significant, even if the scale of risk from the leakage or escape is relatively minor. Mitigation of this reputational risk can be a motivating factor for licensees to maintain high standards of compliance with the requirements of LC34 even where the inherent risks to personnel are relatively low.
 - Some historic nuclear facilities have suffered leakage and escape of radioactive contamination via "unusual pathways", which have typically involved access and egress of wildlife into and out of controlled areas. Licensees should take reasonably practicable steps to prevent such "unusual pathways" giving rise to contamination spread, such as maintaining buildings to be fully secure against the threat of wildlife access.
 - A relatively small-scale leakage or escape of radioactive material or radioactive waste might be a forerunner to a more serious accident. Whenever a licensee discovers that a leakage or escape has taken place, it should bear in mind any potential that may exist for the situation to escalate. If the licensee is not able to quickly develop a comprehensive understanding of the circumstances that have given rise to the leakage or escape, it should consider shutting down normal operations if this will reduce the potential for the situation to suddenly worsen.
 - A leakage or escape of mobile fissile material has the potential to give rise to a criticality event. So far as is reasonably practicable, licensees should ensure the secondary containments used for activities involving fissile material are so designed that the potential for a criticality event is minimised (e.g. by following the principle of being "safe by shape").
 - It is important that licensees recognise the need to achieve compliance with the requirements of LC34 and their environmental permits or authorisations in a balanced manner that recognises the totality of relevant regulatory expectations

from both ONR and the applicable environment agency, rather than focussing on one set of requirements to the detriment of the other;

- It is important that inspectors and licensees recognise that the requirements of LC34 apply to both radioactive materials and radioactive wastes, rather than focussing only on radioactive wastes;
- Leakage and escape of radioactive material may not be explicitly addressed in some safety cases because of the relatively low magnitude of the associated hazards in comparison with other faults. This may make it difficult to follow a “golden thread” from a safety case to the EIMT measures that prevent and detect leakage and escape.

7. FURTHER READING

- 7.1. Nuclear Site Licence Conditions; ONR; www.onr.org.uk/documents/licence-condition-handbook.pdf
- 7.2. Safety Assessment Principles for Nuclear Plant (2014 edition, Revision 0) ONR 2014; www.onr.org.uk/saps/
- 7.3. Joint regulatory guidance on the management of higher activity radioactive waste on nuclear licensed sites, Revision 2, February 2015; www.onr.org.uk/wastemanage.htm
- 7.4. Memorandum of Understanding between the Office for Nuclear Regulation and the Environment Agency, Scottish Environment Protection Agency and Natural Resources Body for Wales on matters of mutual interest, including at licensed nuclear sites; www.onr.org.uk/documents/2015/mou-onr-ea-180815.pdf, www.onr.org.uk/documents/2015/sepa-nuclear.pdf and www.onr.org.uk/documents/2015/nrw-mou.pdf, respectively
- 7.5. Waste legislation and regulations; www.gov.uk/guidance/waste-legislation-and-regulations
- 7.6. Industry Guidance on Interim Storage of Higher Activity Waste – Integrated Approach, NDA, November 2012
- 7.7. IAEA Safety Standard; Predisposal Management of Radioactive Waste; General Safety Requirements Part 5; No GSR Part 5; May 2009; STI/PUB/1368 ISBN 978 92 0 111508 9; www-pub.iaea.org/MTCD/publications/PDF/Pub1368_web.pdf
- 7.8. IAEA Safety Standard; The Management System for the Processing, Handling and Storage of Radioactive Waste; Safety Guide GS-G-3.3; June 2008; ISBN 978-92-0-102008-6; www-pub.iaea.org/MTCD/Publications/PDF/Pub1329_web.pdf
- 7.9. Regulatory Guidance Series, No RSR 1, Radioactive Substances Regulation: Environmental Principles, Version 2, Environment Agency April 2010; www.gov.uk/government/uploads/system/uploads/attachment_data/file/296388/geho0709bqsb-e-e.pdf
- 7.10. ONR Technical Assessment Guide on Land Quality Management (NS-TAST-GD-083 Revision 0); www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-083.pdf

8. DEFINITIONS

- 8.1. Definitions for all the terms commonly used in the management of radioactive wastes can be found in the joint HSE, EA,SEPA and NRW document “Joint Guidance on the

Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites” at
www.onr.org.uk/wastemanage/waste-management-joint-guidance.pdf