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ONR GUIDE			
CONTAINMENT: CHEMICAL PLANTS			
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TABLE OF CONTENTS

1. INTRODUCTION	2
2. PURPOSE AND SCOPE	2
3. RELATIONSHIP TO LICENCE AND OTHER RELEVANT LEGISLATION	3
4. RELATIONSHIP TO SAPS, WENRA REFERENCE LEVELS AND IAEA SAFETY STANDARDS ADDRESSED	4
5. ADVICE TO INSPECTORS	5
6. REFERENCES	8
7. GLOSSARY AND ABBREVIATIONS	8

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NOT PROTECTIVELY MARKED**1. INTRODUCTION**

- 1.1 ONR has established its Safety Assessment Principles (SAPs) [1] which apply to the assessment by ONR specialist inspectors of safety cases for nuclear facilities that may be operated by potential licensees, existing licensees or other duty-holders. The principles presented in the SAPs are supported by a suite of guides to further assist ONR's inspectors in their technical assessment work in support of making regulatory judgements and decisions. This technical assessment guide is one of these guides.

2. PURPOSE AND SCOPE

- 2.1 Containment is provided to retain nuclear material and prevent its uncontrolled spread from the process plant into other parts of the facility and potentially into the environment, both in normal operation and fault conditions. The term 'containment' encompasses a wide range of Structures, Systems or Components (SSC's) from large civil structures surrounding reactors to glove boxes handling small quantities of nuclear material. This Assessment Guide has been prepared to consider the factors which are relevant to non-reactor facilities and which are generally known as chemical plants. In some cases containment is a physical barrier which is robust enough to prevent the spread of radioactive material. In others there may be engineered SSC's designed to prevent the release of radioactive material i.e. filtration, scrubbing or ventilation systems providing dynamic containment. Specific guidance on the latter is set out in ONR Technical Assessment Guide (TAG) NS-TAST-GD022 - Ventilation.
- 2.2 Where SSC's forming part of containment provide a safety function, general engineering and safety principles should be applied.
- 2.3 Containment may consist of a number of different barriers. The "primary" containment on a chemical plant invariably refers to the boundary immediately in contact with the nuclear material and additional layers of protection may be incorporated in the design dependent on the significance of process risk. Secondary containment is generally the barrier which is incorporated to contain spills resulting from failure of the primary containment. The term containment may be used differently in the context of nuclear reactors. Specific guidance on containment for reactor plant is set out in ONR TAG NS-TAST-GD-020. In general nuclear material in chemical plants is not in such an energetic state as fuel in a reactor. However the nuclear material in chemical plants is likely to be in a more easily dispersible form such that the number of containment barriers may be equal to or higher than those on reactors. Some dispersal mechanisms generally considered are impact, fire, explosion, pressure release, boiling of liquors and entrainment in ventilation systems. However, other failures, for example failure of a glove, seal or window in a glovebox will also represent a loss of containment.
- 2.4 Depending on the functional requirement of the containment system the licensee may need to consider the means by which material or equipment can be safely imported or exported from the containment. For example for processing, sampling, maintenance or test. Facilities provided for such purposes may be at variance with the requirement for permanent containment and shielding but may be necessary to ensure safe operation of the facility.
- 2.5 This TAG contains guidance to advise and inform ONR staff in the exercise of their professional regulatory judgement. Other relevant TAGs that may be consulted are;
- NS-TAST-GD-005 – Guidance on the demonstration of ALARP;

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- NS-TAST-GD-009 - Examination, Inspection, Maintenance and Testing of Items Important to Safety;
 - NS-TAST-GD-016 – Integrity of Metal Components and Structures;
 - NS-TAST-GD-020 – Containment for Reactor Plant;
 - NS-TAST-GD-022 – Ventilation;
 - NS-TAST-GD-098 – Asset Management.
- 2.6 Comments on this guide, and suggestions for future revisions, should be recorded in accordance with ONR’s standard procedures.

3. RELATIONSHIP TO LICENCE AND OTHER RELEVANT LEGISLATION

3.1 The following Licence Conditions (LCs) [2] are of particular relevance:

LC28 Examination, inspection, maintenance and testing

The licensee shall;

- Make and implement adequate arrangements for the regular and systematic EIMT of all containment structures or facilities;
- ensure in the interests of nuclear safety that EIMT is carried out by and under the control and supervision of suitably qualified and experienced persons in accordance with written schemes and within the intervals specified in the plant maintenance schedule;
- take appropriate action should EIMT reveal any matter indicating that a containment structure or facility may be affected.

LC32 Accumulation of radioactive waste

The licensee shall;

- Make and implement adequate arrangements for minimising, so far as is reasonably practicable, the rate of production and total quantity of radioactive waste accumulated on or within any containment structure or facility and maintain suitable storage arrangements and adequate records.

LC33 Disposal of radioactive waste

The licensee shall;

- If so directed by ONR, ensure that radioactive waste accumulated through a containment structure or facility is disposed of as ONR may specify and in accordance with an environmental permit.

LC34 Leakage and escape of radioactive material and radioactive waste

The licensee shall ensure so far as is reasonably practicable:

- that radioactive material is at all times adequately controlled or contained so that it cannot leak or otherwise escape from such control or containment;
- 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.

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- 3.2 Relevant Approved Codes of Practice (ACoP)
- Ionising Radiations Regulations 2017 – specific reference should be made to paragraphs 104 and 109.
- 3.3 Relevant legislation includes:
- Health and Safety at Work etc Act 1974
 - Nuclear Installations Act 1965
 - Ionising Radiations Regulations 2017

4. RELATIONSHIP TO SAPS, WENRA REFERENCE LEVELS AND IAEA SAFETY STANDARDS ADDRESSED

- 4.1 ONR's Safety Assessment Principles [1] set out Engineering Key Principles which drive for high levels of plant safety to be achieved through the application of sound engineering concepts. One of these Engineering Key Principles, EKP3, makes reference to defence in depth through containment barriers. This Key Engineering Principle states "An important aspect of the implementation of defence in depth is the provision of multiple, and as far as practicable independent, physical barriers to the release of radioactive material to the environment, and to ensure the confinement of radioactive material at specified locations. The number of barriers will depend on the magnitude of the radiological hazard and the consequences of their failure". Many of the other Engineering Key Principles are relevant to the provision of suitable and adequate containment and should also be used as appropriate.
- 4.2 Additionally, there are a number of general engineering principles which are particularly relevant to the assessment of chemical plants. Of particular note are the Engineering Containment and Ventilation (ECV) principles which are listed below;
- ECV.1 Prevention of leakage;
 - ECV.2 Minimisation of releases;
 - ECV.3 Means of confinement;
 - ECV.4 Provision of containment barriers;
 - ECV.5 Minimisation of personnel access;
 - ECV.6 Monitoring devices;
 - ECV.7 Leakage monitoring;
 - ECV.8 Minimisation of provisions for import or export of materials or equipment;
 - ECV.9 Containment and ventilation system design;
 - ECV.10 Ventilation system safety functions.
- 4.3 The main objective of these SAPs is to ensure the safe containment of nuclear material. The adequacy of such barriers should be justified by the use of engineering and quality standards consistent with the maximum potential hazard in both normal and fault conditions.
- 4.4 The Principles relating to containment do not specify quantitative standards but state goals that a particular facility should achieve. However the safety case should

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demonstrate that the containment barriers are capable of reducing risks to workers and others to at least below the Basic Safety Level (BSL) and to As Low As Reasonably Practicable (ALARP). ONR SAP's for safety cases (SC 1 - 8) set the foundation for effective safety cases. The aim of the safety case should be to demonstrate that such Principles have been met and that suitable and adequate containment barriers are in place. The right balance needs to be struck between probabilistic and deterministic safety analyses to avoid a rather narrow risk based argument being used to justify potentially lower engineering standards. The licensee's safety case should also provide justification that all SSC's providing a containment function have been adequately qualified against the full scope of environments they are expected to encounter over their intended life in accordance with ONR SAP EQU.1: Equipment Qualification.

4.5 Further applicable SAP's are:

- EAD 1 – 5 which set out the Principles for the assessment of aging and degradation of SSC's;
- EMT 1 – 8 which set out the Principles for the assessment of Examination, Inspection, Maintenance and Test of SSC's.

4.6 The above SAPs rely on the judgement of the assessor to determine if the adequacy of the justification by the licensee meets the necessary requirements. Also the standards of design and construction must be clearly identified by the licensee for the particular facility so that the assessor is able to make judgements as to whether or not such standards have been achieved.

4.7 Western European Nuclear Regulators Association (WENRA) Reference levels: There are no specific WENRA reference levels relevant to this TAG.

5. ADVICE TO INSPECTORS

5.1 Containment is provided to ensure the segregation of nuclear material from the general environment, workers and others. On chemical plants the form of the nuclear material being handled will vary dependent on the purposes of the facility but the design of such a facility should recognise the need for suitable and sufficient barriers to ensure the risks to workers and others are reduced to ALARP. The barriers may perform more than one duty i.e. to contain nuclear material and also to reduce radiation dose. In such circumstances the assessor must be satisfied that there has been no reduction of standards to allow this dual function.

5.2 The licensee must provide sufficient justification through its safety case that its containment system is engineered to ensure adequate separation between people and the nuclear material in both normal operation and in design basis fault conditions. The barriers should be capable of withstanding both internal and external hazards and retaining their duty for the life of the plant and into decommissioning. This is particularly important for the storage of material where there is currently no disposal route or whose use is not yet determined.

5.3 Design and construction standards applicable to the containment should be clearly stated and justified for the particular application. The standards of design and construction must be clearly identified by the licensee for the particular facility so that the assessor is able to make judgements as to whether or not such standards have been achieved. Licensees may have developed in-house standards for application in their own circumstances which are based on relevant good practice in the industry. In

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these circumstances it may only be necessary to confirm the appropriate application of such codes/standards rather than a fundamental assessment of the criteria.

- 5.4 The different forms, type and quantity of radioactive material being processed in nuclear chemical plants results in as equally varied type of containment being necessary to meet the specific duty. These range from the large volumes of highly active liquor in reprocessing facilities to laboratory quantities of radio-isotopes. In such cases the containment ranges from stainless steel tanks located in stainless steel lined thick-walled concrete cells to ventilated boxes located in controlled areas. In all cases the justification as to the number and type of barriers would have to be prepared by the licensee to ensure the appropriate BSLs are being met and that assessments against the Basic Safety Objective (BSO) and ALARP considerations have been addressed.
- 5.5 In the particular case of chemical plants the use of the term "primary containment" usually refers to the barrier in contact with the material being processed. In the case of liquids and gases this is usually the piping or vessels in which the material is being processed or stored. The "secondary containment" is usually that barrier provided to contain and collect spillages, escapes and leaks from the primary containment. For high hazard potential liquids and gases a third barrier may be employed using appropriately ventilated parts of the building. In the case of high hazard potential powders a similar system to the above may be appropriate. The powder is processed within a primary containment system of vessels and pipework. Secondary containment, usually in the form of a ventilated glovebox, is then provided to contain and collect spillages, escapes and leaks. Again a third barrier may be employed using appropriately ventilated parts of the building. In the case of low hazard potential solids, a licensee could submit justification for the use of sealed containers as primary containment and an unventilated building as the secondary containment. The primary and secondary containment features are well demonstrated when considering co-axial pipework, as used to transfer process material from one primary containment to another. Indeed the use of shielded, ventilated pipebridges is equivalent to use of the "ventilated parts of a building" for tertiary containment.
- 5.6 The materials of construction of the containments must be compatible with the process materials being contained. Such factors as chemical, thermal and radiological stability should be considered during the assessment. The containment must be stable under normal and fault conditions when the physical, chemical and radiological conditions of the nuclear materials may change. The containment should also retain its stability under both internal and external fault conditions for example fire and seismic events if the consequences are such that the primary function needs to be retained for safety reasons. To ensure the above requirements are met ONR SAP EQU.1 is applicable.
- 5.7 The licensee should demonstrate that it has adequate arrangements in place for managing aging and degradation of the containment system over its full lifecycle. ONR SAPs EAD 1 – 5 set out Principles for the assessment of aging and degradation of SSC's. Further guidance can be found in NS-TAST-GD-098.
- 5.8 An important aspect of managing ageing and degradation is for the licensee to have an adequate Examination, Inspection, Maintenance and Test (EIMT) regime in place. The Principles for EIMT can be found in ONR SAP EMT 1 – 8. The assessor should make judgements as to the adequacy of the licensees safety case for the containment system against these principles. Further guidance can be found in NS-TAST-GD-009.

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- i. Any processes carried out in containment should be thoroughly understood to ensure that releases resulting in changes of form or state are adequately addressed when specifying the containment hazards;
- ii. The numbers of containment barriers proposed relative to the hazard and perceived risk should be clearly argued in the safety case. The justification for each barrier should be clearly stated;
- iii. The standards for the design and construction of each boundary should be clearly identified and be relevant to the materials of construction, which should be compatible with the process materials and process conditions. Any computer codes should be verified and validated;
- iv. The design of the containment should be capable of withstanding the effects of external events as well as internal faults, for example most chemical processes use pressure vessels as part of the containment, these should be capable of withstanding external overpressures in addition to internal process pressures if the potential for an explosion exists;
- v. Suitable monitors should be installed to detect radioactive material following loss of containment which could be in the form of solids, liquids or gases. Consideration should be given to the possibility of a change in phase as the process material escapes for example hot liquids may solidify on escape and accumulate in the secondary containment rather than flow to a sump where the detector is located. This type of phenomena should be identified as part of the Hazard Identification and Operability study (HAZOP);
- vi. The safety case should address in detail the implications of fissile material escaping from containment, particularly the circumstances which may allow accumulations above the criticality limits. The assessor should be satisfied that the safety case adequately addresses how the containment design copes with such an event, this applies equally to dusts in addition to liquids;
- vii. Chemical plant processes are generally supported by a number of services some of which may have to enter the containment. Adequate consideration should be given to sealing, where the services enter the containment boundary. The sealant or sealing system used must be capable of withstanding changes due to process, environment and fault conditions including fire and seismic events;
- viii. Adequate consideration should be given to the possible failure of process lines within the containment and to routing of process pressure relief vents. Particular fault mechanisms may result in provisions being made to route such a system to a facility outside of the containment. The adequacy of such provisions should be clearly justified;
- ix. Adequate consideration should be given to the recovery of spills in the containment. The use of steam ejectors and resulting condensate may increase the volume of such spills to unacceptable levels such that additional treatment facilities may have to be provided. The maintenance of pumps in containment may be difficult and should be considered in the safety case;
- x. Ventilation may form part of the containment strategy adopted for a particular process. In such circumstances NS-TAST-GD-022 should be consulted.

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- xi. In general all activities involving the handling of radioactive material and contaminated items should be conducted inside suitable containment. However sampling and the handling of waste may be carried out outside of containment and appropriate engineered systems should be incorporated into the design. This should result in the package being adequately wrapped and decontaminated before removal from containment. The maintenance of equipment inside containment should be carried out remotely but in some circumstances this may not be possible and alternative engineered provisions should be provided at the design stage which reduce risk to ALARP.

7. REFERENCES

1. Safety Assessment Principles for Nuclear Facilities. 2014 Edition Revision 0. November 2014. <http://www.onr.org.uk/saps/saps2014.pdf>
2. Licence condition handbook. Office for Nuclear Regulation. January 2016. <http://www.onr.org.uk/documents/licence-condition-handbook.pdf>
3. OECD-NEA, The Safety of the Nuclear Fuel Cycle 2005. <https://www.oecd-nea.org/nsd/pubs/2005/3588-safety-nuclear-fuel-cycle.pdf>

(This reference has been used only in preparing this assessment guide, no specific references within the text are warranted).

Note: ONR staff should access the above internal ONR references via the How2 Business Management System.

8. GLOSSARY AND ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BSL	Basic Safety Limit
BSO	Basic Safety Objective
EAD	Engineering Aging and Degradation
ECV	Engineering Containment and Ventilation
EIMT	Examination, Inspection, Maintenance and Test
EKP	Engineering Key Principles
EQU	Engineering Equipment Qualification
HAZOP	Hazard Identification and Operability (study)
IAEA	International Atomic Energy Agency
NEA	Nuclear Energy Agency
ONR	Office for Nuclear Regulation
SAP	Safety Assessment Principle(s)
SSC	System, Structure or Component
TAG	Technical Assessment Guide(s)
WENRA	Western European Nuclear Regulators' Association

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