1. Purpose and scope

1.1 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 and plant items, from the massive buildings surrounding power 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 a number of process steps which are designed to prevent the release of radioactive material i.e. filtration, scrubbing.

1.2 Ventilation systems are also important in limiting the spread of radioactive contamination but specific guidance on such systems is given in **T/AST/022**.

1.3 Where equipment forming part of containment serves as part of a safety system the general principles applicable to engineering and safety systems should also be applied.

1.4 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 risk the process presents to workers and others. 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. The appropriate TAG should be consulted if clarification for nuclear reactors is required.

1.5 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 levels of containment require that the numbers of barriers may be the same or higher than those on reactors. The main dispersal mechanisms are generally considered to be fire, explosion, liquid releases from pressurised systems, boiling of liquors, and entrainment in ventilation systems but other failures, for example failure of a glove on a glovebox may represent a significant hazard to workers in the immediate vicinity.

1.6 Not withstanding the Safety Assessment Principle aimed at avoiding breaks in containment, consideration will have to be given by the licensee as to the most appropriate methods of allowing for the movement of material and equipment into and out of containment for maintenance, sampling, experiments and product export. Facilities provided for such purposes may be at variance with the need to maintain containment and shielding but may be necessary to ensure the safe operation of the facility.

1.7 This TAG contains *guidance* to advise and inform NSD inspectors in the exercise of their professional regulatory judgement. Comments on this guide, and suggestions for future revisions, should be recorded on the appropriate registry file and also copied to the Business System Manager for recording on the Index database.

2. SAPs addressed

2.1 The Engineering Principles have a number of Key Principles which may have a major influence on for example the cost of the plant; are seen as a fundamental engineering requirement; or require the plant to be based on sound concepts. Two of these Key Principles make a direct reference to containment or barriers and are P64 and P65

2.2 These two Key Engineering Principles state the basic requirements which must be met by any containment boundary for it to be acceptable. As with all the Principles, the basic requirement applies to new plant and the assessor will have to consider if it is reasonably practicable for an existing facility to meet this requirement.

2.3 Many of the other Key Engineering Principles are relevant to the provision of suitable and adequate containment and should be used as appropriate.

2.4 There are a number of plant specific SAPs relating to the general principles of containment. These are considered not to be as significant as the Key Principles but have a wide application in the assessment of plant. These specific principles are P222 to P238.

2.5 The Key Principles make statements as to the standards that should be met by new plant and/or facilities. The aim of the safety case should be to demonstrate that such Principles have been met and that suitable and adequate 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.

2.6 The main objective of these SAPs is to ensure there is a clear identification of the barriers which are necessary 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.

2.7 The Principles relating to containment do not specify quantitative standards but state goals that a particular facility should achieve. However the safety case should demonstrate that the containment barriers are capable of reducing risks to workers and others to at least below the Basic Safety Limit (BSL) and to as low as reasonably practicable. The detailed hazard and risk assessments carried out by the licensee should justify the number and form of the barriers to give the necessary levels of protection .

2.8 These SAPs rely on the judgement of the assessor to determine if the adequacy of the justification by the licensee meets the necessary requirements. 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.

3. Relationship to licence and other relevant legislation

Not applicable directly to licence or legislation.

4. Advice to assessors

4.1 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 as low as reasonably practicable. The barriers may perform more than one duty i.e. to contain nuclear material and also to reduce doses. In such circumstances the assessor must be satisfied that there has been no reduction of standards to allow this dual function.

4.2 The main thrust of these Principles is to ensure that in normal operation and following certain fault conditions adequate provisions are made to ensure that separation is maintained between personnel, both workers and others, and the nuclear material in process. The barriers should be engineered to ensure their physical integrity is maintained at all times to meet the design and specified 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.

4.3 In the case of nuclear chemical plants the processing equipment in contact with the nuclear material is normally taken as the primary containment with additional barriers being provided dependent on the assessed hazard, potential consequences and risk.

4.4 The 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 accepted practice in the industry. In these circumstances it may only be necessary to confirm the appropriate application of such codes/standards rather than a fundamental assessment of the criteria.

4.5 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 an assessment against the Basic Safety Objective (BSO) and ALARP considerations have been addressed.

4.6 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 use of shielded, ventilated pipebridges is equivalent to use of the “ventilated parts of a building” for tertiary containment.

4.7 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.

4.8 Specific matters which the assessor should consider are:

1) 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;

2) the numbers of containment barriers proposed in the safety case relative to the hazard and perceived risk should be clearly argued in the safety case. The justification for each barrier should be clearly stated;

3) 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;

4) 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

5) 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 HAZOP;

6) 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;

7) 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. The sealant or sealing system used must be capable of withstanding changes due to process, environment and fault conditions including fire and seismic events;

8) 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;

9) 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;

10) some consideration should be given to the provision of sparage as a result of faults. Such sparage must have the same levels of safety as the original process plant. Sparage should not be used to accommodate the expansion of process fluids as a result of routine processing. Adequate provisions to cater for such material should be

covered by the plant design;

11) ventilation may form part of the containment strategy adopted for a particular process. In such circumstances **T/AST/022** should be consulted.

12) 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.

References

1. OECD-NEA, The Safety of the Nuclear Fuel Cycle 1993. (This reference has been used only in preparing this assessment guide, no specific references within the text are warranted).