



ONR GUIDE			
<b>CONTROL OF PROCESSES INVOLVING NUCLEAR MATTER (SAP – ENM. 1 TO 8)</b>			
<b>Document Type:</b>	Nuclear Safety Technical Assessment Guide		
<b>Unique Document ID and Revision No:</b>	NS-TAST-GD-023 Revision 4		
<b>Date Issued:</b>	August 2016	<b>Review Date:</b>	August 2019
<b>Approved by:</b>	David Senior	Director Regulatory Standards	
<b>Record Reference:</b>	TRIM Folder 1.1.3.776. (2016/392834)		
<b>Revision commentary:</b>	Routine update		

### 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 .....	3
5. ADVICE TO INSPECTORS .....	4
6. REFERENCES .....	9
7. GLOSSARY AND ABBREVIATIONS .....	10
8. APPENDICES.....	11

## 1. INTRODUCTION

- 1.1 ONR has established its Safety Assessment Principles (SAPs) 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 This Technical Assessment Guide (TAG) provides guidance on ONR's approach to the control of nuclear matter and on the relevant engineering in the SAPs [\[1\]](#), as described in [section 4.1 below](#).

- 2.2 Nuclear matter must be controlled to protect people from harm and to protect the environment, safeguard fissile material and to secure hazardous installations and materials. Harm may result from the radioactive properties of nuclear matter, or by combination of its radioactive properties with toxic, explosive or other hazardous properties. Recognition of the impact of nuclear matter is implicit throughout the SAPs.

- 2.3 The principal definition of nuclear matter used by ONR is that given in the glossary to the SAPs, based on the definition used in the Nuclear Installations Act (NIA):

*“nuclear matter” means , subject to any exceptions which may be prescribed—*

- (a) *any fissile material in the form of uranium metal, alloy or chemical compound(including natural uranium), or of plutonium metal, alloy or chemical compound, and any other fissile material which may be prescribed;*  
*and;*  
 (b) *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 as aforesaid;*

- 2.4 This guidance applies to all types of nuclear matter, including excepted matter (see the Appendix) unless the wording makes it clear that limited application was intended, or unless it can be shown that the total amount of nuclear matter concerned is sufficiently small or is in such a chemical or physical form as to make it unnecessary to apply to any one or more of the principles. The SAPs require the identification of:

*“ ...all initiating faults having the potential to lead to any person receiving a significant dose of radiation, or to a significant quantity of radioactive material escaping from its designated place of residence or confinement.” (SAP FA.2).*

- 2.5 Interpretation of “control” should not be restricted to the need for control and instrumentation (C&I) systems. In this context, control relates to the ability to manage a hazardous material. However, the legislation does not define fully the type of control required, for instance, Licence Condition (LC) 4 states only that “adequate arrangements” should exist for nuclear matter brought onto site.

- 2.6 The nature of the control required can be determined from a number of sources, including (not in order):

- Legislation, the licence conditions and other regulations.
- Published standards.
- ONR's Safety Assessment Principles and Technical Assessment Guides.
- Comparison with relevant good practice in the UK and abroad.

- Good design and analysis of appropriate systems and equipment.
- Guidance from ONR's solicitors.

- 2.7 This guidance covers the key concepts of inventory control. In this context, control should be applied proportionately and according to the meanings of relevant ONR guidance, for example on limits and conditions [\[2\]](#) and functional safety systems [\[3\]](#).
- 2.8 Nuclear matter has to be managed through most stages in the life-cycle of a facility and most of the rest of the SAPs will apply to nuclear matter at some stage. Many specific principles in other sub-sections are particularly relevant, e.g. containment and ventilation [SAPs-ECV.1 to 10] and other guidance should be consulted for the assessment of equipment designs or specific operations.
- 2.9 On civilian sites, responsibilities for ensuring the security of nuclear material are regulated by ONR's Civil Nuclear Security (CNS) and responsibilities for ensuring the safeguarding of nuclear material are regulated by ONR Safeguards. The introduction and Annex 1 to the SAPs outline their functions within the ONR.

### **3. RELATIONSHIP TO LICENCE AND OTHER RELEVANT LEGISLATION**

- 3.1 Explicit reference to nuclear matter is found in LC 4 and 5.
- 3.2 LC 4 is concerned with the necessity of "*adequate arrangements*" for bringing nuclear matter onto a licensed site and for its storage there. Safety cases covering issues addressed by the relevant SAPs and this guidance should be consistent with such arrangements, and the advice herein will be useful in addressing such arrangements as well as relevant aspects of safety cases.
- 3.3 LC 5 is concerned with the regulatory control of consignments from a licensed site and the records required to be kept. Its main purpose is to ensure that ONR can identify destination sites for which a new licence might be needed.
- 3.4 Other laws and regulations affecting nuclear installations define the materials within their scope in slightly different ways. The Appendix to this guide expands on the definitions. Since all the legislation requires some control over radioactive/nuclear material, this guidance is relevant to all nuclear legislation in varying degrees.
- 3.5 LC 34 requires that licensees ensure, so far as is reasonably practicable, that radioactive material and radioactive waste on the site is at all times controlled or contained so that it cannot leak or otherwise escape. Assessment of arrangements to comply with this licence condition should therefore also take account of this guidance. Arrangements made under LCs 23 and 27 on operating rules and safety mechanisms may also be relevant in this respect. Arrangements for the periodic review of safety cases under LC 15 will also be relevant as such reviews should address aspects of control and containment, shortfalls against modern standards and the relevant overall site strategies for the control of nuclear matter.

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

#### **SAPS**

- 4.1 This TAG provides guidance on SAPs ENM.1 to ENM.8 and their relationship with other parts of the SAPs. The SAPs in the ENM section specify control at increasing level of detail, starting at ENM.1 (highest level) with planning and the management strategy for the site. ENM.2 then covers facilities and their safety cases, ENM.3 covers the design, implementation and operation of those facilities and ENM.4 the administration of those operations. Desirable attributes of material in facilities are

defined in principles ENM.5 and 6. Finally, principles ENM.7 and ENM.8 are concerned with identification and accountancy of nuclear material.

- 4.2 Additional applications of this guidance include: fuel handling on research reactors, waste handling on power reactors and reprocessing activities. Nuclear matter is subject to specific controls whilst in the core of a reactor [SAPs-ERC1 to 4]. Reactor coolant must also be controlled to prevent damage to the core [SAPs-EHT1 to 5 and ERC.3]. SAPs ENM.2-8 also apply to radioactive waste and contaminated land where they present an equivalent hazard. For these materials, principles in the sections on radioactive waste management [RW.1 to 7] & contaminated land also apply [RL.1 to 8].

#### **Western European Nuclear Regulators Association (WENRA) Reference levels**

- 4.3 There are no *specific* WENRA reference levels relevant to this TAG, although those under Appendix E of the report of the Reactor Harmonisation Working Group on the Design Basis Envelope for Existing Reactors are relevant to the associated engineering design provisions. The reference levels for Waste and Spent Fuel Storage are explicitly addressed in other TAGs but the advice given in this TAG is consistent.

#### **IAEA Standards**

- 4.4 The concept of control in IAEA safety standards & guides, covers all regulated radioactive material and not just nuclear material, but in general the control of materials necessary for safety is not made explicitly in most IAEA documents. The Requirements Document on the Safety of Fuel Cycle Facilities [6] sets out relevant engineering design requirements and the Safety Guide which covers fire protection [7], provides relevant guidance where a failure to control may lead to a fire or explosion hazard.

### **5. ADVICE TO INSPECTORS**

#### **Overall strategy**

- 5.1 ENM.1 states that a strategy should exist, to ensure that unwanted material is not generated and that matter is controlled to prevent harm and to ensure control can be maintained. The strategy should be consistent with current Government policy (eg: Cmd. 2919) on such matters and comply with relevant legislation, including relevant Licence Conditions. The strategy should be compatible with individual safety cases and take a holistic view, especially with regard to inherent safety [EKP.1]. The strategy should identify all routes for nuclear material inwards and outbound. The latter should also comply with relevant legislation for transfers and disposals (the latter regulated by the EA and SEPA, see Annex 1 to the SAPs). The strategy should cover all nuclear material whether declared as nuclear waste or not.
- 5.2 The strategy will take account of the lifetimes of plant and requirements for control consistent with safety cases. The strategy or safety cases should demonstrate any prolonged storage is safer than disposal, where a disposal route is available. In some circumstances, the radioactive matter will present a hazard long after the current facilities have reached the end of their useful life. The strategy should deal with this possibility. Finally, strategy documents should be live documents, taking account of changes to circumstances. The following guidelines, together with other relevant SAPs [e.g.: SC.6, DC.1 to 8], can be used in assessing this strategy. Some radioactive waste is also nuclear matter and the principles in the SAPs sub-sections on Radioactive Waste and Contaminated Land could also be relevant.

#### **Management Control**

- 5.3 SAP-ENM.2 covers control at the level of organisational control over activities on a nuclear licensed site by a combination of engineered systems and managerial control procedures. The control will be justified in safety cases for all the relevant operations on the site, which define the safe operating envelope for the material.

- 5.4 All activities involving nuclear matter are included and ENM.2 is not just restricted to the processing of nuclear matter. Control must be exercised when raw nuclear materials or intermediates are stored or moved on a site, while nuclear material is being processed and after treatment, prior to transport off-site for further treatment or disposal. There is no distinction between the standards of control required for radioactive feedstock or radioactive waste. The level of control will be related to the hazard, reliability demanded and the consequences of loss of control of any such material on workers and others.
- 5.5 In order to control processes involving hazardous substances it is necessary to understand the objectives of the process, the limits and conditions required to maintain safety and the physical and chemical properties of the substances being processed.
- 5.6 The need for control should be identified early in the safety case [particularly SC.3] and the SAPs specifically demand identification of faults leading to loss of control [FA.2].
- 5.7 The safety case should review the options for process selection; to eliminate hazards by minimising the inventory [SAP-EKP.1 Para 146] or prevention (i.e. minimisation or reduction of the frequency of the fault) or by mitigation of the consequences, in order of preference. This should be clearly identified in the options studies that are carried out at the time of process selection and should form part of the safety justification, usually at the preliminary stage. The effects of scale-up from experiments or different conditions during operation of earlier plant should be allowed for. There should be adequate provision to ensure that under normal and fault conditions nuclear matter is:
- Cooled, monitored and controlled where the heat from radioactive decay or chemical reaction may be significant;
  - Managed so that chemical reactions, radiolysis, precipitation, pH etc. are kept within the specified limits;
  - Segregated appropriately [see ENM.5].
- 5.8 The safety case should be developed (see [4]) through a structured analysis [SAP-FA.2, EKP.4] including fault studies supported by probabilistic safety analysis where appropriate.
- 5.9 The safety case should clearly identify the operating parameters [SAP-SC.6] which define the operating envelope and safety significant parameters which define the (LC 23) safety envelope and how each is derived; other ONR guidance applies. Specific consideration should be given to process transients due to start-up, shutdown, maintenance and foreseeable faults [FA.6]. This is to ensure that conditions during such phases are adequately covered by the control / safety system or administrative procedures. Such consideration may indicate the requirement for additional control during these phases.
- 5.10 Although the preference would be for passive then engineered control at all times, where this is not reasonably practicable, administrative safety measures may suffice, see EKP.5.

#### **Control Features of Plant**

- 5.11 Inventories should be low enough to avoid adverse effects due to runaway reactions and buffer storage should be sufficient to eliminate process perturbations with safety implications, as recognised by ENM.2. Buffer storage that reduces sensitivity to faults should not be used for the prolonged storage of nuclear matter and its inventory of potentially harmful materials should be minimised consistent with the required functionality. There is a balance between achieving a robust process and minimising the inventory in buffer storage.

- 5.12 The site arrangements, layout and plant design should aim to avoid unnecessary movements of nuclear matter [EKP.3 and ELO.3]
- 5.13 Occasions when it is necessary to temporarily re-route nuclear matter include pressure relief and sampling. Continuous monitoring instrumentation may provide necessary data but in certain circumstances samples of the actual material may have to be taken.
- 5.14 Monitoring of plant parameters should rely as far as is practicable on instrumentation that does not require nuclear matter to be diverted outside the main containment.
- 5.15 If samples are needed, adequate consideration should be given to ensuring that samples are representative of the process to allow accurate measurement, whether or not routine control depends on the on-line or the off-line instruments. Account should be taken of potential problems due to phase separation, sample line deposition, condensation from gas streams, blockages, temperature and chemical changes, which may affect the composition of the sample being taken.
- 5.16 Where material must be re-routed, provision should be made to ensure the safe handling of the material [ECV.3 and 4] and its return to safe containment by:
- 1 Return to the process after use, or
  - 2 Treatment, or
  - 3 Storage, or
  - 4 Disposal.
- 5.17 Whilst sampling should be avoided as a means for controlling dynamic systems, it may still be necessary to periodically retrieve smaller amounts of material over a longer timescale, in order to demonstrate compliance with a safety case. Whilst ENM.3 discourages sampling as a means of controlling dynamic processes, ENM.7 is a reminder that some sampling from longer-term storage may be necessary.
- 5.18 Facilities should be designed for bulk recovery of material before they reach the end of their operational or design life or earlier if required by site strategies [e.g.: ENM.1 & RW.1]. ENM.7 states that facilities should be designed and operated so that material can be retrieved within an appropriate timescale, and (para 488(c)) including intervention in the event of any changes in the characteristics of the nuclear matter, its containment or its storage environment that might occur during the storage period. This includes unexpected faults, accidents or degradation of packaging. (See also SAP-RW.5.)
- 5.19 The scope of SAP-ENM.3 is broad; including not only systems for materials accountancy but also the design and operation of the facilities that control nuclear matter. Essentially, it builds on ENM.2 by considering the systems needed to provide control.
- 5.20 In some cases, adequate control may depend on the use of robust and auditable operating instructions and procedures. Accountancy measurements may provide further support. There is ONR guidance [\[5\]](#) on centralised systems to monitor materials movements and process conditions.
- 5.21 The fundamental principles SAP-EKP.1 to 5 are relevant to design and operation of processes controlling nuclear matter. ONR expects systems providing safety functions to possess appropriate levels of redundancy, diversity and segregation from systems used for normal control [EDR.2], see ONR guidance on functional safety systems [\[3\]](#). It should be shown that safety-related components can be operated and controlled within a safe operating envelope throughout their operating life. The parameters of the

envelope should be consistent with the type of construction, potential modes of failure and operational considerations.

- 5.22 Monitoring and recording systems are necessary to detect problems that may develop in processes due to leakage, changes in temperature, chemical reaction and other effects. The ESR and ESS sections of SAPs expand on the requirements for these systems. As well as leakage, effects including segregation, deposition and condensation can cause problems, see ENM.8.
- 5.23 Where practicable, safety systems, safety-related instrumentation and engineered controls should be designed to fail-safe. Failure should be revealed to the operator by alarms or other means. There may be a requirement for high levels of redundancy and diversity dependent on the reliability of each system. The problems associated with single failure criteria should be considered [EDR.4].
- 5.24 The maintenance requirements of any monitoring and control equipment should be clearly identified [LC28] and in accordance with the arrangements made under the licence conditions. These should include calibration and ensure that the control system is always available when required.

#### **Attributes of Nuclear Material**

- 5.25 ENM.5 and 6 outline physical and chemical characteristics that nuclear material should possess, for control to be achievable. Together with the process characteristics, these determine the precautions that need to be taken to ensure adequate control arrangements are in place. These should be documented e.g.: in flowsheets, safety functional requirements and the basis of design. These documents should be identified in the safety case. Such information will help to define the safety envelope within which the process is managed.
- 5.26 In some circumstances the identification and quantification of the materials being handled may not be possible. When this is the case, the arrangements should allow for the level of uncertainty and identify additional levels of control to maintain safety margins as required by the safety analysis.
- 5.27 Arrangements should be made and implemented (which may include examination, testing and auditing) to ensure that incoming material meets the acceptance criteria. Arrangements should also be established for the safe management of any incoming material that fails to meet the acceptance criteria.
- 5.28 Segregation in paragraph 485 includes segregation both from incompatible materials and according to physical and chemical form, flammability, specific radioactivity, half-life, fissile nature and type of radiation emitted where subsequent storage, processing, conditioning and disposal would otherwise be adversely affected.

#### **Passively safe conditions for storage should be used where reasonably practicable.**

- 5.29 Storage of material in a passively safe state still requires a safety case that identifies operational limits and conditions required for safety. Many of the paragraphs in SAP-RW.5 also apply to ENM.6 and 7 for nuclear material. Where fissile material is present, no external controls should be relied upon to prevent criticality, see ECR.1 and ECR.2. The safety case should demonstrate acceptable sub-criticality margins for stores taking account of the uncertainties that may exist. Relevant factors may include:
- form of the material;
  - environmental conditions, including temperature, humidity, and contaminants;
  - heat generation (from individual items and the whole store);

- gas generation (pressurisation, flammable mixtures, deformation); and
- radiological hazards, taking account of on-site storage and long term management, which may include disposal.

5.30 In some circumstances, the inherent safety characteristics of the process reduce the potential hazard such that the control arrangements can be appropriately simplified.

#### **Accountancy & Display Systems**

- 5.31 Principle ENM.4 expects records of nuclear matter to be generated and kept, as do international safeguards. ENM.8 requires this information to be processed and analysed in a timely manner in order to prevent any significant deviations from environmental, security or safety case criteria.
- 5.32 The arrangements for monitoring and relaying control and safety information to relevant staff should be clearly identified in the safety case. Thus the safety case should specify the periodicity of gathering and displaying such data. Display systems should be configured to provide an overview of the condition of the process including, where appropriate, mass and volumetric balance summaries.
- 5.33 Where plant safety must be maintained by appropriate and timely response to system alarms [EHF.7], the response should be automatic where reasonably practicable; however where it is not, proportionate robust managerial control should be exercised.
- 5.34 The actions to be taken on failure of safety systems, safety related instrumentation and engineered control equipment should be clearly identified in the safety case and in instructions to workers. This advice should be incorporated in any on-site, off-site emergency or contingency instructions. In some circumstances the safety case may have to consider the need for local field control stations for normal control and in the event that the main control centre is not tenable.



## 6. REFERENCES

1. *Safety Assessment Principles for Nuclear Facilities. 2014 Edition Revision 0. ONR November 2014* : <http://www.onr.org.uk/saps/saps2014.pdf>
2. ONR, *The Limits and Conditions for Nuclear Plant Safety*, T/AST/035.
3. ONR, *Safety Systems*, T/AST/003.
4. ONR, *Purpose and Scope of Nuclear Safety Cases*, T/AST/051.
5. ONR, *Computer Based Safety Systems*, T/AST/046.
6. IAEA *Safety of Fuel Cycle Facilities*; NS-R-5.
7. IAEA *Protection Against Internal Fires and Explosions in the Design of Nuclear Power Plants; Safety Guide Safety Standards Series; NS-G-1.7*.
8. IAEA *Derivation of Activity Concentration Values for Exclusion, Exemption and Clearance*; Safety Series 44; STI/PUB/1213.

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

## 7. GLOSSARY AND ABBREVIATIONS

BSL	Basic Safety Level
BSL(LL)	Basic Safety Level (legal limit)
BSO	Basic Safety Objective
C&I	Control and Instrumentation
EA	Environment Agency
FA	Fault Analysis
IRR99	Ionising Radiation Regulations (1999)
LC	Licence Condition
NIA	Nuclear Installations Act
ONR	Office for Nuclear Regulation
SAP	Safety Assessment Principle(s)
SEPA	Scottish Environment Protection Agency
TAG	Technical Assessment Guide(s)
WENRA	Western European Nuclear Regulators' Association

## 8. APPENDICES

### APPENDIX 1: EXCEPTED MATTER, THE NIA AND OTHER LEGISLATION

A1.1 It is a fundamental premise that terms defined in the law underpinning our regulatory framework should be used consistently within our licence conditions and our guidance.

A1.2 *Nuclear Matter* and *Radioactive Material* are terms defined in law. In the standard licence, Condition 1 states:

*“nuclear matter”* has the meaning assigned thereto in the Nuclear Installations Act 1965;

A1.3 Definitions of radioactive material have appeared in UK legislation and international treaties since the Paris Convention was signed by the UK in 1960. Since then, the Nuclear Installations Act and other legislation covering radioactive waste, nuclear security and emergencies have defined radioactive materials in slightly different ways.

A1.4 The 1960 Paris Convention on nuclear liability uses the terms *“nuclear fuel”* and *“radioactive product or waste”* and seeks to identify responsibilities and liabilities damage caused by occurrences involving such material. The NIA defines its subject matter:

*“nuclear matter”* means , subject to any exceptions which may be prescribed—

(a) *any fissile material in the form of uranium metal, alloy or chemical compound(including natural uranium), or of plutonium metal, alloy or chemical compound, and any other fissile material which may be prescribed;*  
and;

(b) *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 as aforesaid;*

A1.5 In the NIA, *“excepted matter”* means nuclear matter consisting only of one or more of the following, that is to say—

(a) *isotopes prepared for use for industrial, commercial, agricultural, medical [scientific or educational] purposes;*

(b) *natural uranium;*

(c) *any uranium of which isotope 235 forms not more than 0.72 per cent.;*

(d) *nuclear matter of such other description, if any, in such circumstances as may be prescribed (or, for the purposes of the application of this Act to a relevant foreign operator, as may be excluded from the operation of the relevant international agreement by the relevant foreign law);*

A1.6 Excepted matter is nuclear matter. The Excepted Matter Regulations provide certain exemptions which apply outside of nuclear licensed sites. For definitions of terms such as *“relevant foreign operator”*, *“radiation practice”* etc, inspectors are referred to the source legislation.

A1.7 The definition of *“Radioactive Substance”* in the Ionising Radiation Regulations (1999) is a much broader term than *“Nuclear Matter”*. Radioactive substances include any substance which contains one or more radionuclides whose activity cannot be disregarded for the purposes of radiation protection.

A1.8 In IRR(1999), a substance may never be disregarded if its specific activity in Bq/gm exceeds the value in column 2 of Schedule 8 and total Bq exceeds the value in column 3 of the same Schedule. Naturally occurring radionuclides used in work (other than a practice) where their use may lead to a dose < 1 mSv / year may not be subject to the limits in Schedule 8.

- A1.9 Below these activity levels, substances may still be considered “radioactive” and the IRRs ACoP provides guidance. Naturally occurring radionuclides are included for operators of certain practices, namely:
- Production, processing, handling, use, holding, storage, transport or disposal of radioactive substances or;
  - Operation of any electrical equipment emitting ionising radiation and ... operating at a potential difference > 5kV.
- A1.10 The term “sealed source” means a source containing any radioactive substance whose structure is such as to prevent, under normal conditions of use, any dispersion of radioactive substances into the environment, but it does not include any radioactive substance inside a nuclear reactor or any nuclear fuel element.
- A1.11 The principal legislation for safeguards purposes (Euratom Article 197) defines nuclear material as ore, source material or special fissile material. Special fissile material means Pu-239, U-233 or U enriched in 235 or 233. Source material means uranium containing the mixture of isotopes occurring in nature. The IAEA exclude ore from their definition of nuclear material in Article XX of the IAEA statute. The European Commission and the IAEA council reserve the right to extend these definitions and the foregoing definitions have been abbreviated for this appendix. Natural uranium is "excepted nuclear matter" under the NIA and its associated regulations.
- A1.12 Inspectors should be able to identify situations where additional advice may be needed. The purpose of including the above definitions and exceptions is to explain how the legislation avoids obvious traps associated with materials that could cause little damage in human or environmental terms, whilst still achieving its aims.