Office for
Nuclear Regulation

ONR Guidance for Nuclear Material Accountancy, Control and Safeguards

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OFFICIAL

ONR GUIDE			
ONR Guidance for Nuclear Material Accountancy, Control and Safeguards			
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Version Control

The development of the first draft of the ONR Guidance for the Assessment of Nuclear Material Accountancy, Control and Safeguards (ONMACS) was completed in January 2019.

In response to stakeholder engagement, and following ONR Safeguards Inspector use the ONMACS document was updated in March 2020.

ONMACS was again reviewed along with the consideration of stakeholder and inspector feedback in August 2020.

For this reason, the website version is the only authorised version.

Revision History

No.	Date	Change Summary
0	January 2019	First draft produced
1	March 2019	Formatted for publication for stakeholder comments and use internally to ONR
2	March 2020	Amended following stakeholder comments and to ensure consistency of language with other guidance documents – Approved by Technical Acceptance Panel and Safeguards Professional Lead
3	August 2020	Updated following further stakeholder feedback and use in trial inspection and assessment activities
4	January 2021	Updated to reflect ONR Safeguards as a regulatory purpose

FOREWORD

The Office for Nuclear Regulation (ONR) is the independent regulator of nuclear safety and conventional health and safety on and around nuclear sites, civil nuclear security safe transport of civil radioactive material transport and nuclear safeguards across the United Kingdom.

This document together with supporting Technical Assessment Guides (TAGs) and Technical Inspection Guides (TIGs) will be used by inspectors to assist in making regulatory judgements and decisions. The guidance covers both assessment of the operators Nuclear Material Accountancy Control and Safeguards (NMACS) arrangements and inspection of the implementation of these arrangements.

These arrangements are made both to comply with the UK's international obligations under the Non-proliferation Treaty and the legal duties placed on operators by The Nuclear Safeguards (EU Exit) Regulations 2019 (NSR19) [1].

Parts of NSR19 are prescriptive and often related to enabling the UK to fulfil its international nuclear safeguards obligations, and parts are outcome focused in line with the extant regulatory approach applied within the UK across most industries, including nuclear.

The implementation of ONMACS is anticipated to take some time before it becomes mature. ONR recognises that learning from the implementation of a new regulatory regime and approach may require ONMACS to be refined and intends to review this guidance after 12 months of use.

INTRODUCTION

1.1 PURPOSE AND APPLICATION OF THE ONR GUIDANCE FOR NUCLEAR MATERIAL ACCOUNTANCY CONTROL AND SAFEGUARDS (ONMACS)

1. The purpose of the ONMACS is to provide ONR with a framework for making consistent and proportionate regulatory judgements, via assessment and inspection, on the adequacy of the operator's compliance with NSR19.

2. The principles contained in the ONMACS and the associated Technical Assessment Guides (TAGs), Technical Inspection Guides (TIGs) and other guidance should promote a consistent and proportionate ONR regulatory approach, taking into account the requirements of NSR19 and relevant good practice.

3. The requirements of NSR19 relate to NMACS for nuclear material and facilities used only for civil purposes. Nuclear material not used for civil purposes is excluded from the UK nuclear safeguards regime.

4. The ONMACS are published and may be used by operators to provide advice and guidance on ONR expectations. However, the ONMACS are not sufficient on their own to be used as design or an operational standard.

1.2 REGULATORY CONTEXT

1.2.1 UK REGULATIONS AND LEGISLATION

5. Part 3, Chapter 1 of The Energy Act (TEA) 2013 [2] defines ONR's purposes and appoints it as an independent regulator within the United Kingdom for:

   (a) the nuclear safety purpose (see section 68);

   (b) the nuclear site health and safety purposes (see section 69);

   (c) the nuclear security purposes (see section 70);

   (d) the nuclear safeguards purposes (see section 71); and,

   (e) the transport purposes (see section 73).

6. For the purposes of TEA, Relevant Statutory Provisions (RSPs) are:

   (a) Part 3 of TEA;

   (b) Nuclear Regulations (including The Nuclear Safeguards (EU Exit) Regulations 2019 ('NSR19') [1] and the Nuclear Safeguards (Fissionable Material and Relevant International Agreements) (EU Exit) Regulations 2019 [3], The Nuclear Industries Security Regulations (NISR) [4], and 'Class 7' aspects of the Carriage of Dangerous Goods & Use of Transportable Pressure Equipment Regulations) [5];

   (c) Sections 1, 3-6, 22 & 24A of the Nuclear Installations Act 1965 [6]; and,

   (d) The Nuclear Safeguards Act 2000 [7].

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Although The Nuclear Safeguards Act 2018 and The Nuclear Safeguards and Electricity (Finance) Act 1978 are not RSPs of TEA, they are part of the legislative framework for safeguards implementation in the UK. In accordance with Section 72 of TEA as amended by The Nuclear Safeguards Act 2018, ONR's safeguards purposes are to; ensure compliance with the NSR19 and compliance by the UK or, as the case may be, enabling or facilitating compliance by a Minister of the Crown, with a relevant international agreement, and the development of any future obligations relating to nuclear safeguards.

1.2.2 INTERNATIONAL FRAMEWORK AND CONTEXT

1.2.2.1 Relevant International Agreements

7. The UK has concluded a number of agreements with international stakeholders, which are relevant to this document. These include agreements with the IAEA and Nuclear Cooperation Agreements (NCAs). The relevant international agreements are defined in the Nuclear Safeguards (Fissionable Material and Relevant International Agreements) (EU Exit) Regulations 2019 and listed in references [11, 12] and [21-24] of this document.

1.2.2.2 Responsibilities of the State

8. The UK is a member of the International Atomic Energy Agency (IAEA) and is a Depositary State for the Non Proliferation Treaty (NPT) [10]. To fulfil commitments related to it the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) the UK has concluded as a safeguards agreement with the IAEA in connection with the NPT, known as the UK Voluntary Offer Agreement (VOA) [11]. The VOA provides for the application of IAEA safeguards in the UK *'on all source or special fissionable material in facilities or parts thereof within the United Kingdom, subject to exclusions for national security reasons only'*.

9. Under the VOA, the UK has a responsibility to establish, implement and maintain a State System of Accountancy for and Control (SSAC) of civil nuclear material subject to the agreements with the IAEA. Furthermore, the SSAC must also have arrangements to provide NMACS reports to the IAEA and measures to provide assurance that accountancy systems related to UK civil nuclear facilities function correctly.

10. The UK has concluded an Additional Protocol (AP) [12] with the IAEA, which contains measures additional to the UK VOA. Under the AP, the UK has a responsibility to provide declarations on any nuclear fuel cycle related research and the manufacture or export of specified nuclear equipment to non-nuclear weapons states (NNWS). In addition, it allows the IAEA access to any relevant information in connection with these activities.

1.2.2.3 State System of Accounting for and Control of Nuclear Material

11. The ONR's safeguards purpose includes ensuring compliance by the UK with the relevant international agreements detailed above. This includes provision of nuclear materials accountancy and other safeguards declarations required of the UK under such agreements.

12. Consequently, the UK has put in place a new domestic framework for the regulation of nuclear safeguards. This framework sets out arrangements to enable the timely and comprehensive reporting of NMACS declarations to the IAEA by ONR, it provides for international safeguards inspection and assurance of the effectiveness of both. Furthermore, the regulatory system provides ONR with the authority to enforce the legal duties placed on the operators. This is represented in broad terms diagrammatically in Figure 1.

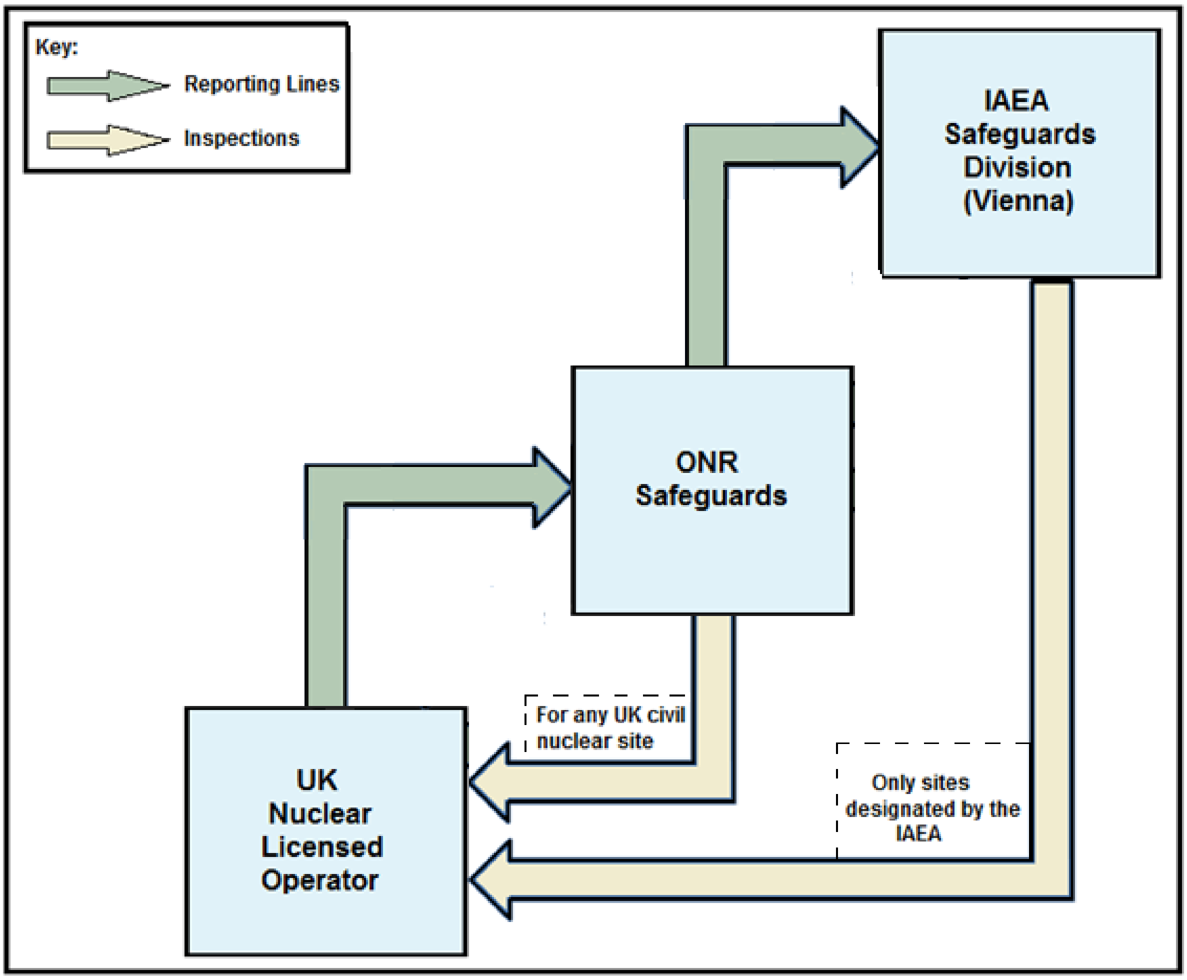

Figure 1: High Level Overview of UK SSAC Framework.

1.2.2.4 Responsibilities of operators

13. Throughout this document, the term operator, as defined in NSR19, is used to refer to all persons or organisations that have legal obligations placed on them by NSR19.
14. NSR19 places requirements on operators to establish, implement and maintain a system of accountancy and control of qualifying nuclear material in each qualifying nuclear facility. Operators must also ensure arrangements are in place to provide the NMACS declarations required by NSR19.

1.3 REGULATORY CONTEXT

1.3.1.1 General

15. The ONMACS contains regulatory expectations and associated guidance. The expectations form the underlying basis for regulatory judgements made by ONR Safeguards Inspectors and constitute safeguards relevant good practice.

16. The expectations apply to all qualifying nuclear facilities that are used for the production, processing, storage, handling, disposal or other use of qualifying nuclear material including qualifying nuclear facilities with limited operation as defined in Regulation 31 of NSR19.

17. ONR will adopt a consistent, targeted and proportionate approach to its regulation as set out in our existing enforcement policy statement, considering the:

    I. Sensitivity and quantity of nuclear material
    II. Strategic importance and configuration of the facility
    III. The quality of the operators NMACS system
    IV. The operators programme of activities
    V. NMACS regulatory performance.

1.3.1.2 Lifecycle

18. ONMACS supports regulatory activities throughout the lifecycle of nuclear facilities. It is important to note that where different areas of a nuclear facility are in different lifecycle phases it is expected that proportionate and appropriate arrangements and procedures for NMACS would be in place for each area and regulatory attention would be proportionate to the nuclear material, activities and arrangements concerned.

19. Facilities identified for decommissioning or closure remain subject to safeguards requirements and expectations until ONR has confirmed that:

    - all nuclear material has been removed
    - The physical inventory is recorded as zero, and any remaining difference from the book inventory recorded as an inventory difference (ID) and, where considered necessary,
    - all structures and equipment essential for its use have been removed or rendered inoperable such that it can no longer be used to store, produce, handle, process, dispose of or utilise qualifying nuclear material.

    The status of the facility is then amended to 'decommissioned' for safeguards purposes.

1.3.1.3 New Facilities

20. ONMACS support the regulatory NMACS assessment of new (and proposed) nuclear facilities. They represent the ONR's view of relevant good practice and it is an expectation that modern facilities satisfy their overall intent.

1.3.1.4 Facilities Built to Earlier Standards

21. ONR safeguards inspectors should assess the operator's NMACS arrangements against the relevant expectations when judging if an operator has demonstrated that NMACS requirements and regulatory outcomes are met. The expectations should take into account the age of the facility or plant, the standards when it was constructed and the extent to which practicable improvements could be made to meet current good practice.

1.3.1.5 Nuclear Safety, Security and Safeguards Assessments

22. Nuclear safety, security and safeguards legislation impose separate, specific duties on licensees, operators and duty holders. Sometimes duties to overlap, for example, in the event of a loss of nuclear material control and suspected theft or diversion of nuclear material, operators have a duty to submit a special report to the ONR under

safety and security legislation as soon as they become aware of any such occurrence. There would also be a requirement to report such incidents for nuclear safeguards purposes.

23. Operators should aim, where possible, to integrate their NMACS responsibilities with those for both safety and security. The aims of nuclear safety, security and safeguards legislation are complementary in that measures that address the requirements of one set of legislation may satisfy the requirements of another, which can lead to improved effectiveness and efficiency. However, it should be recognised that an operator sets up arrangements that enable it to demonstrate compliance to all legislation, and integration might not be the most satisfactory method for them.

24. Detailed information on safety aspects can be found in the Safety Assessment Principles 2014 Revision 1 (January 2020) document [13] and for security aspects in the Security Assessment Principles for the Civil Nuclear Industry 2017 [14].

1.3.1.6 Alternative Approaches

25. The ONMACS sets out ONR's view of good practice NMACS that meet its expectations and deliver a system that complies with the regulations. However, designers and/or operators may wish to put forward alternative practices that deliver the same expectations and a compliant NMACS system.

26. Where alternative approaches are in place, it is for the operator to present evidence to the ONR that provides assurance the alternative approach delivers the same or improved objectives.

2. Fundamental Safeguards Expectations (FSE) for Nuclear Material Accountancy Control and Safeguards

The Fundamental Safeguards Expectations (FSEs) are founded in UK law through NSR19, in the requirements of relevant international agreements and in international good practice. The FSEs underpin all activities that contribute to sustain high standards of NMACS. They fall into two categories:

1) Strategic Enablers – FSEs 1-5 are expectations focussed on creation of the right conditions to support effective NMACS Strategy
2) Material Controls – FSEs 6-10 are expectations focussed on implementation and maintenance of effective and robust NMACS arrangements.

Strategic Enablers align with other ONR regulatory purposes (e.g. SyAPs) and Material Controls, focus specifically on the implementation and maintenance of NMACS arrangements.[1]

Each FSE is supported by one or more nuclear Material Accountancy and Control Expectation(s) (MACE). It is against these expectations that inspectors should judge the adequacy of operators' arrangements and their implementation. Further context to the FSE and the subsequent MACEs is provided below each expectation in section 3.

Strategic Enablers		Material Controls	
FSE 1	Leadership and Management for Nuclear Material Accountancy and Control	FSE 6	Measurement programme and control
FSE 2	Organisational Culture	FSE 7	Nuclear material tracking
FSE 3	Competence Management	FSE 8	Data processing and control
FSE 4	Reporting, Anomalies and Investigations	FSE 9	Material balance
FSE 5	Reliability, Resilience and Sustainability	FSE 10	Quality Assurance and Control for Nuclear Material Accountancy and Control

Table 1: SSAC Fundamental Safeguards Expectations for Nuclear Material Accountancy and Control.

[1] Material Accountancy and Control Expectations also align with domestic and international good practice, such as European Commission recommendation of 11 February 2009 [15] (on the implementation of a nuclear material accountancy and control system by operators of nuclear installations) and guidance including that published by the IAEA and ESARDA and previously in the UK by the UK Safeguards Office (UKSO) (ref. http://www.onr.org.uk/safeguards/accountancy.pdf)

3. Nuclear Material Accountancy, Control and Safeguards Expectations

The expectations in this section enable the effective delivery of NMACS. Inspectors should use these expectations proportionately, including by consideration of the factors summarised at paragraph 18 above.

Each FSE has a number of inter-related MACEs, which provide detail and set the outcomes to be achieved for that FSE. As the MACEs are inter-connected around a FSE, there is some overlap between the expectations. Therefore, it is necessary for them to be considered as a whole and delivered via an integrated approach.

3.1. FSE 1 – Leadership and Management for Nuclear Material Accountancy, Control & Safeguards

Fundamental Safeguards Expectation	Leadership and Management for NMACS	FSE 1
Operators should implement and maintain organisational capability for NMACS underpinned by strong leadership, robust governance, adequate management and accountability of NMACS arrangements incorporating internal and independent evidence-based assurance processes.		

27. FSE 1 contains five inter-related MACE's:

    1) Governance & Leadership,
    2) Capable Organisation,
    3) Decision Making,
    4) Organisational Learning
    5) Assurance

28. In combining the key features of leadership and management for NMACS from a range of sources, the expectations reflect:

    (a) the importance given to leadership and management for NMACS, the role of the Board, directors and worker involvement;
    (b) the impact of good and effective leadership, people management and processes; and
    (c) the need to consider the management of NMACS at all levels throughout the whole organisation in building and sustaining a positive NMACS culture.

3.1.1. **MACE 1.1 – Governance and Leadership**

FSE 1 – Leadership and Management for NMACS	Governance and Leadership	MACE 1.1
Governance and leadership at all levels should focus the organisation on achieving and sustaining high standards of NMACS and on delivering the characteristics of a high reliability organisation.		

29. Robust governance includes clear roles and responsibilities that ensure a coherent, direct chain of accountability for NMACS from workface through to the Board member responsible for NMACS oversight. Reporting structures should be clearly understood, with well-defined responsibilities and delegated personal authorities.

30. An effective management system incorporating NMACS should:

(a) be based on national or international standards or equivalent requirements
(b) be integrated such that the potential for conflicts between the organisation's goals and responsibilities is minimised
(c) ensure NMACS staff contribute to the definition and achievement of the goals of the organisation
(d) give due regard to NMACS and support a positive NMACS culture
(e) be subject to regular review, seeking continual improvement
(f) explicitly consider NMACS when developing and implementing any new arrangements for managing the organisation.

31. Strong leadership is key to establishing, and sustaining a positive NMACS culture. The behaviour and activities of directors, managers and other leaders should include:

(a) establishing standards and providing direction, governance and oversight to establish and foster an organisational culture that underpins NMACS
(b) recognising and resolving conflict between NMACS and other goals (e.g. safety, security, production and commercial pressures)
(c) ensuring that NMACS is participative, actively drawing on the knowledge and experience of all staff
(d) ensuring that performance management tools promote the identification and management of risk, encourage positive NMACS behaviours and discourage poor behaviours or complacency.

3.1.2. MACE 1.2 – Capable Organisation

FSE 1 – Leadership and Management for NMACS	Capable Organisation	MACE 1.2
The organisation should have the capability to implement and maintain the NMACS arrangements for its undertakings.		

32. The organisation should have adequate arrangements in place to ensure that the necessary competencies, experience and knowledge is maintained across a sufficient number of personnel to provide resilience and maintain the capability to govern, lead and manage NMACS at all times.

33. A properly resourced NMACS governance / management structure might typically include (but is not limited to) the following roles:

- Board member responsible for NMACS
- Director or Chief NMACS Officer
- NMACS Manager
- Analytical Measurement Management
- Other specialists relevant and specific to the organisation's needs

34. The structure should have an individual appointed who is responsible for NMACS, with sufficient authority, autonomy and resources to implement and oversee all NMACS activities.

35. The staffing requirements (structure, staffing, resources or competencies) for the NMACS structure should be:

(a) established, controlled and reviewed regularly through robust, auditable processes
(b) robust against organisational change or be adaptable for organisational change following systematic review.
(c) robust against staffing changes via the use of succession planning (especially where there is limited or singleton expertise) for expected (e.g. retirement) and unexpected (e.g. resignation) events.

36. The organisational structure, roles and responsibilities and performance standards should ensure that in a proportionate way:

(a) governance and supervision of NMACS at all levels is achieved.
(b) those with responsibilities for NMACS have authority and access to resources to discharge those responsibilities effectively.
(c) conflict with other business roles, responsibilities, accountabilities and objectives is managed.
(d) co-ordination and collaboration is effective between all those involved, including contractors.
(e) jobs, processes and procedures are designed to avoid impairing the reliable performance of the organisation.
(f) technical and behavioural competencies related to NMACS are acquired and maintained by all staff with related roles and responsibilities.
(g) the knowledge of NMACS requirements within all activities is understood and controlled, both from an internal perspective and those external perspectives within the supply chain (intelligent customer) including the management of contractors, such that the organisation is able to manage NMACS effectively.

37. The knowledge management requirements of the organisation should also be proportionate with:

(a) a capability that includes suitable and sufficient experts with a detailed and up-to-date understanding of the site, its facilities and their design, operation and associated NMACS arrangements.
(b) an adequate corporate memory and baseline of the knowledge of the intended design performance of NMACS equipment, processes and systems.
(c) a robust effective process to manage expected and unexpected staffing changes.
(d) an effective knowledge capture and learning from experience system.
(e) provision for identifying, updating and preserving documents and records relevant to NMACS. Such documents and records should be stored securely and should be retrievable and readable throughout their anticipated useful life (including statutory retention periods). Documents and records relevant to NMACS should include those:
   I. of value throughout the whole life of a facility;
   II. that would assist during an incident or circumstances of NMACS significance (e.g. LFE);
   III. relevant to making future modifications; or,
   IV. that could contribute to improvements in NMACS.

3.1.3. MACE 1.3 – Decision Making

FSE 1 – Leadership and Management for NMACS	**Decision Making**	**MACE 1.3**
Decisions made at all levels in the organisation affecting NMACS should be informed, rational, objective and prudent.		

38. The decision-making processes should proportionately include NMACS aspects where they will affect the NMACS systems. These would be expected to ensure that:

(a) all relevant data and opinions are collected, recorded and considered.
(b) there are the means for setting NMACS priorities to aid decision making at all levels.
(c) NMACS decisions are not delayed unnecessarily.
(d) personnel are empowered to take timely decisions in the interests of NMACS requirements.

39. Decisions affecting NMACS should consider in a proportionate way the following factors (where relevant):

(a) the quality, accuracy and sufficiency of the information.
(b) the significance of uncertainties.
(c) the questioning of assumptions.
(d) exploration of all relevant scenarios that may threaten NMACS.
(e) the range of options to appropriately manage risk, error and uncertainty in the short and long term.
(f) the criteria and standards that should be applied.
(g) the impact on regulatory compliance.

and ensure that for NMACS decisions:

(h) conflicts between NMACS and other business goals are recognised and appropriately resolved.
(i) they are documented and traceable.
(j) they cater for the potential for error, uncertainty and the unexpected.
(k) an appropriately conservative approach is demonstrated.

3.1.4. MACE 1.4 – Organisational Learning

FSE 1 – Leadership and Management for NMACS	Organisational Learning	MACE 1.4
Lessons should be learned from internal and external sources to continually improve leadership, organisational capability, the management system, NMACS decision-making and performance.		

40. A learning organisation should seek out, analyse and act upon lessons learned from a wide range of sources both within itself and externally. It is therefore important for an operator to demonstrate that they are open to capturing learning from NMACS events and near misses and that they use that learning to improve their accounting for and controlling qualifying nuclear material (QNM). Learning should extend from operations through to organisational, management and cultural issues.

41. Information should be collected from a range of sources inside the organisation, including from:

(a) workers (e.g. about strengths, weaknesses, deviations and errors, or concerns in relation to NMACS procedures and processes).
(b) operational feedback and audits on processes.
(c) plant monitoring of NMAC relevant equipment and processes including trending where feasible and relevant.
(d) regulatory reports (e.g. ONR Intervention Records from and IAEA inspection statements).
(e) investigations of NMACS issues, events, discrepancies or anomalies.
(f) external or self-assessment.

42. External learning from experience and good practice should be considered from both the nuclear and relevant non-nuclear industries that are involved in accounting for and controlling nuclear and other sensitive materials. Including:

(a) international standards and practices
(b) investigation of events in other organisations from both within and outside the nuclear industry.
(c) benchmarking NMACS from both within and outside the nuclear industry (e.g. ESARDA and the UK's National Physical Laboratory for the process of measurement).
(d) published feedback from ONR and the IAEA on accountancy and control.

3.1.5. MACE 1.5 – Assurance Processes

FSE 1 – Leadership and Management for NMACS	Assurance Processes	MACE 1.5
There should be evidence-based assurance processes in place to inform strategy through the governance process, which welcomes challenge from across the organisation.		

43. A primary aim of assurance should be to provide ongoing confirmation that the NMACS regime is delivering the required outcome. This assurance should be achieved at all management levels including the Board. It is important that assurance be maintained throughout all stages of the life of the undertaking.

44. Confidence that the NMACS, quality policies, strategies, plans, goals, standards, systems and procedures are being implemented through the application of an effective management system and are compliant with the regulations may be achieved by means of suitable governance, monitoring and auditing processes.

45. Good practice assurance processes utilise evidence-based methodology (e.g. analysis and interpretation of data) and incorporate meaningful metrics and performance indicators, which can be used to influence strategy and drive continuous improvement. Such indicators can be both lead and lag and should balance the use of qualitative and quantitative information.

46. Metrics and performance indicators should be chosen that are suitable for underpinning an operator's assurance. They should be:

(a) appropriate to the audience.
(b) clear, defined, understood, informative up to, and including Board level.
(c) useable to impact on the operations being assured.
(d) aligned with other relevant business metrics as appropriate.
(e) adequately defined to both trend and measure performance

3.2. FSE 2 – Organisational Culture

Fundamental Safeguards Expectation	Organisational Culture	FSE 2
Operators should encourage and embed an organisational culture that recognises and promotes the importance of NMACS.		

47. Organisational culture encompasses the values and behaviours that contribute towards the social and psychological environment within a company. Safety and security culture are often cited in the nuclear industry as having a positive influence on the wider organisational culture. More generally, the workforce should also be aware of the importance of NMACS.

48. NMACS culture is identified by ONR as ‘The assembly of characteristics, attitudes and behaviour of individuals, organisations and institutions which serves as a means to support and enhance NMACS, including as a crucial part of the international regime to prevent the proliferation of nuclear weapons’.

49. Where it is embedded, NMACS culture brings significant benefits including providing greater assurance that appropriate QNM control is being applied and that effective and efficient safeguards compliance is being achieved.

50. NMACS, safety and security cultures co-exist and need to reinforce each other to ensure the required outcomes are achieved. Therefore, successful organisational cultures foster an approach that integrates NMACS, safety and security in a mutually supporting manner however assurance of good safety and security culture cannot be considered to provide full assurance of good NMACS culture and vice versa.

3.2.1. MACE 2.1 – Maintenance of a Robust NMACS Culture

FSE 2 – Organisational Culture	Maintenance of a Robust NMACS Culture	MACE 2.1
Operators should ensure that the Board gives due priority to the development and maintenance of a NMACS culture necessary to ensure all staff involved in NMACS and who may come into contact with ONR and IAEA Safeguards Inspectors have appropriate awareness that NMACS is important and the role of the individual in maintaining it is key.		

51. It is good practice to have:

(a) processes and arrangements in place to create and sustain a strong NMACS culture. This includes:

I. maintaining and communicating NMACS expectations and standards to all staff involved in NMACS and all parts of the organisation that may encounter ONR and IAEA Safeguards Inspectors.
II. ensuring these are understood.
III. defining roles, responsibilities and accountability for each level of the organisation and interrelations between them.
IV. supporting business and NMACS priorities whilst being cognisant of the UK’s international obligations and responsibilities.

(b) an appropriate, independent governance regime led by the Board to ensure that an adequate NMACS culture is in place and is maintained by the use of appropriate management systems/ structures.
(c) effective leadership that supports and demonstrates a commitment to NMACS culture and is inclusive of staff concerns, knowledge and resource needs.
(d) assurance related to the NMACS culture delivered through SQEP staff.
(e) assurance processes include systems to deal with both inappropriate behaviour and encouraging the sharing of relevant good practice.

3.3. FSE 3 – Competence Management

Fundamental Safeguards Expectation	Competence Management	FSE 3
Operators should implement and maintain effective arrangements to manage the competence of those with assigned NMACS roles and responsibilities.		

52. It is essential that all personnel, whose activities have the potential to impact on NMACS, are demonstrably competent (i.e. SQEP to carry out their work and responsibilities in respect of the NMACS system). This includes both those who directly carry out operations and those whose roles, if inadequately conceived or executed, may affect NMACS in less visible ways. SQEP and competence are often interchangeable terms.

53. It is good practice to have robust, proportionate arrangements for identifying competence needs and assuring these are met. The process for identifying and delivering competence can be split into these phases:

    (a) analysing NMACS roles and competencies.
    (b) identifying learning objectives and training needs.
    (c) measuring competence.
    (d) organising support and training.

54. Relevant good practice can be found in the National Occupational Standards (NOS) for Nuclear Material Accountancy and Safeguards https://www.ukstandards.org.uk/ The NOS describe the standard expected of individuals who are responsible for activities to meet NMACS requirements, together with specifications of the underpinning knowledge and understanding.

3.3.1. MACE 3.1 – Analysis of NMACS Roles and Associated Competencies

FSE 3 – Competence Management	Analysis of NMACS Roles and Associated Competencies	MACE 3.1
Analysis should be carried out of all tasks important to NMACS and used to justify the effective delivery of the NMACS functions to which they contribute.		

55. It is good practice to carry out and review the following for all members of the workforce who have responsibility for any operations which may affect NMACS:

    (a) develop training requirements at all responsibility levels based on a task analysis of NMACS operations.
    (b) ensure that the task analysis applies to all actions and controls required to maintain effective and robust NMACS.
    (c) ensure all tasks are designed to be feasible and within achievable timescales so that there is high confidence of successful completion.
    (d) use the task analysis to provide the basis for establishing required staffing levels for normal operations and reasonably foreseeable deviations from the norm.
    (e) once defined, ensure competencies and staffing levels are kept under periodic review.
    (f) routinely train and assure the competence and capability of all.

56. The analysis of NMACS roles and associated competencies may result in the identification and appointment of SQEP personnel with direct operational responsibility for nuclear material in a particular facility (e.g. facility operators), to control and supervise operations critical for NMACS; and arrangements to ensure that only SQEP personnel perform any duties which may affect NMACS.

3.3.2. MACE 3.2 – Identification of Learning Objectives and Training Needs

FSE 3 – Competence Management	Identification of Learning Objectives and Training Needs	MACE 3.2
An analysis of roles, tasks and competencies should be used to generate learning objectives, which inform the development of a set of training needs and are used to derive the criteria, or standards, against which the trainee is assessed during and/or after training.		

57. It is good practice to proportionately define from the analysis of the roles and tasks:

(a) competencies needed of each role and the training to achieve an adequate level of competence. The competencies should include both technical and other areas such as decision-making, leadership and management.
(b) learning objectives (LO) to inform the design and implementation of appropriate training arrangements and measures to determine monitor and sustain competence of all personnel with NMACS responsibilities.
(c) the training programme required to develop and maintain the competence of all personnel with NMACS responsibilities. The programme should set out the LOs and how they are to be achieved.

3.3.3. MACE 3.3 – Measurement of Competence

FSE 3 – Competence Management	Measurement of Competence	MACE 3.3
Operators should implement and maintain a process of assessment, which provides confidence that all personnel whose actions have the potential to impact upon NMACS meet defined competence expectations.		

58. In measuring competence it is good practice to:

(a) assess and periodically re-assess the competence of workforce personnel who have NMACS responsibilities in order to establish and maintain SQEP. Assessment methods can include written, oral or practical demonstrations of learning competence
(b) select and employ the most effective competence assessment methodologies based upon their validity, objectivity, reliability and frequency for the NMACS role being assessed.
(c) implement a well-defined system for monitoring the effectiveness of training, and for identifying areas where training may need to be augmented or revised. The evaluation should involve intelligence gathering in order to confirm that training has been specified properly, and that it is comprehensive, effective and up to date.

3.3.4 MACE 3.4 - Organisation of and Support to the Training Function

FSE 3 – Competence Management	Organisation of and Support to the Training Function	MACE 3.4
Training and competence assurance of personnel with NMACS roles should be given due priority by operators.		

59. Competence delivery functions should be supported by commitment from senior levels in the organisation and by an appropriate management structure.

60. Good practice includes:

(a) a defined commitment in policy and arrangements recognising the need to develop and maintain the competence of staff in order to meet NMACS requirements.
(b) ensuring there are adequate resources to maintain a training system to support the implementation of the NMACS policy.
(c) defining responsibilities for training.
(d) management demonstrating an awareness of the purpose and significance of training, the need to monitor staff performance and to facilitate the maintenance of competence.
(e) active identification of training needs and willingness to release staff for training.
(f) ensuring trainers maintain and develop their own capability.
(g) maintaining appropriate training records.

3.4 FSE 4 – Reporting, Anomalies and Investigations

Fundamental Safeguards Expectation	Reporting, Anomalies and Investigations	FSE 4
Operators must implement and maintain arrangements for the timely and accurate reporting of information required by NSR19. Arrangements for the investigation, resolution and reporting of discrepancies and anomalies must be in place.		

61. NSR19 has a number of regulations requiring the regular reporting of information in a number of forms at set times from operators to the ONR which must be complied with. Arrangements must be in place to comply with Regulation 12 of NSR19 and to ensure that the reports contain up to date and correct information.

62. In addition, there are other reports required from the operator in the event of a deviation from normal operations.

63. A discrepancy is defined for the purposes of this guidance as any inconsistency between two or more pieces of NMAC information (e.g. source data, records, reports etc.) where this inconsistency cannot be justified after taking account of legitimate measurement variation or uncertainty estimation. Discrepancies include measurement discrepancies, material balance discrepancies (Inventory Differences (ID) and Shipper Receiver Differences (SRD)) and nuclear material control discrepancies where there is a non-conformance in the identification or location of nuclear material.

64. An anomaly is defined for the purposes of this guidance as any NMAC-related issue that significantly affects the ability to draw safeguards conclusions or assess compliance with safeguards regulations, including a discrepancy or series of discrepancies that is consistent with the absence or gain of a significant amount of nuclear material. An anomaly can be identified during an investigation of discrepancies of whatever kind.

65. An ONR NMACS regulatory issue is defined as any NMACS matter that has the potential to degrade NMACS; challenge regulatory compliance; challenge regulatory strategy; or impugn ONR's reputation. A discrepancy or anomaly will usually be considered an ONR NMACS Regulatory Issue.

66. ONR uses a graded approach to the management of regulatory issues and the issue level is assigned to indicate its significance and to assign an appropriate level of management scrutiny

67. Operators should have a detection capability for nuclear material lost during normal operations and should not rely solely on an annual physical inventory take (PIT). Such a capability should include detection of abrupt and protracted loss.

68. Operators must have an approach in place that corresponds to the reporting requirements under Regulation 16 (Special Reports) of NSR19.

69. Operators must recognise, investigate and document the treatment of NMACS discrepancies and anomalies corresponding to Regulation 17 (a) (Unusual Occurrences) of NSR19.

70. Operators should notify and report NMACS discrepancies, anomalies, incidents or events to ONR corresponding to ONR Guidance: Notifying and Reporting Incidents and Events to ONR [26].

3.4.1 MACE 4.1. – Reporting

FSE 4 – Reporting, Anomalies and Investigations	Reporting	MACE 4.1
Operators should implement and maintain arrangements for the monitoring, reporting and review of NMACS performance, which includes the effectiveness of meeting NMACS requirements and identifying trends. (see also MACE 7.3)		

71. In addition to arrangements and procedures for regular reporting, there should be reasonably practicable arrangements and procedures for detecting, reporting, and responding to NMACS discrepancies and anomalies.

72. Operators should monitor and review NMACS performance, which should include effectiveness of meeting NMACS requirements and identifying trends. Performance metrics will be tailored to local conditions but should include information on:

    (a) nuclear material control of movements, measurements and inventory.
    (b) nuclear material accountancy accuracy and timeliness.
    (c) discrepancies, anomalies; their investigation, corrective action and Learning From Experience (LFE).
    (d) human performance in conduct of operations to reduce intrinsic risk of human errors.
    (e) safeguards compliance, assurance and responsiveness.
    (f) NMACS competence, culture and regulatory confidence.

73. Personnel should be identified to act as points of contact for the following:

    (a) regular reporting of NSR19 information.
    (b) NMACS performance.
    (c) relevant information regarding the investigation, identification and elimination of the cause of NMACS discrepancies and anomalies.
    (d) NMACS performance and learning.
    (e) actions under Regulation 17 (a) or (b) of NSR19 on ‘unusual occurrences’ to report internally and to ONR.
    (f) responding to ONR requests for ‘further details or explanations’ in connection with a special report under Regulation 16 of NSR19.

3.4.2 MACE 4.2. – Anomalies and Investigations

FSE 4 – Reporting, Anomalies and Investigations	Anomalies and Investigations	MACE 4.2
Operators should have an approach that recognises, investigates and manages NMACS discrepancies and anomalies in a timely manner and documents their treatment. Such investigations should aim to establish in a timely manner the accountancy evidence that all material is properly accounted for and under control.		

74. Operators should have arrangements and procedures in place for investigation, identification and elimination of the cause of NMACS discrepancies and anomalies. Such investigations should aim to establish in a timely manner the evidence that all material is properly accounted for and under control.

75. Where applicable, operators should develop, implement and maintain NMACS related response procedures for:

    (a) Inventory Differences (ID) or Shipper Receiver Differences (SRD) that exceed action levels (The loss of a discrete item shall be considered a breach of action level).
    (b) unexpected changes in the control of nuclear material, to a point where unauthorised removal of nuclear material has become possible.
    (c) discrepancies and anomalies that are deemed significant by the operator including items that cannot be found at their recorded location.

76. The procedures where appropriate should ensure:

    (a) any abnormal ID or SRD is recorded immediately when it is identified (e.g. once an ID is calculated after a PIT or when an abnormal SRD is measured). It is not appropriate to wait for the results of investigatory work before documenting and reporting the ID and the ID should be reported in the MBR declaration within 15 days of a PIT.
    (b) the facility operator or Nuclear Material Accountant ensures the investigating offices issues an initial report as soon as reasonably practicable
    (c) the investigation remains open until a final report on the incident is issued and this is accepted by the NMACS manager.

77. Wherever possible, nuclear material for which significant SRDs have been identified should not be further processed or converted into other batches until approved by the NMACS manager. Normally, this would only be after the NMACS manager is satisfied that adequate measures have been taken to understand and resolve the SRD.

3.4.3 MACE 4.3. – Corrective Actions

FSE 4 – Reporting, Anomalies and Investigations	Corrective Actions	MACE 4.3
Operators should have arrangements and procedures in place to deal with NMACS incidents, events, anomalies and discrepancies, which include escalation, investigation and corrective action arrangements to resolve incidents. Procedures should aim to prevent reoccurrence of NMACS incidents, events, anomalies and discrepancies and ensure wider dissemination of learning from experience.		

78. Corrective actions are defined for safeguards purposes as an action to eliminate the cause of a detected NMACS discrepancy, anomaly (as defined in FSE 4 above) or other undesirable situation. Corrective action is taken to prevent recurrence. There is a

distinction between correction and corrective action, i.e. a correction is to put the issue right, a corrective action is to make sure it should not happen again.

79. Operators should have practicable and proportionate arrangements and procedures in place to deal with NMACS incidents including escalation, investigation and corrective action arrangements. These should include escalation procedures for suspected loss of nuclear material control and/or suspected theft or diversion of nuclear material.

80. Escalation arrangements and procedures should cover conditions including:

(a) the suspension of movements/operations
(b) the taking of a physical inventory at short notice (an Emergency Physical Inventory Taking – EPIT)
(c) reporting to ONR.

81. Incidents classed as NMACS-related include those which:

(a) are a potential loss of control of nuclear material (e.g. discrepancies and anomalies exceeding operator defined action levels, unexpected changes in control, items which cannot be found and unauthorised movements).
(b) undermine the integrity of nuclear material accountancy information.
(c) are non-compliant with NMACS-related requirements.
(d) negatively affect ONR or IAEA safeguards implementation (e.g. denial of access to ONR or IAEA inspectors or tampering with IAEA measurement equipment.).
(e) impact on obligation code and pool accountancy management and reporting (obligation codes and pool accountancy are described in the glossary).

82. Operators should develop, implement and maintain graded corrective action arrangements to aim to prevent recurrence of NMACS discrepancies, anomalies and incidents and ensure wider dissemination for learning from experience (LFE). Such arrangements should include a review of similar incidents or LFE at other nuclear sites where available.

83. The Management System (QMS) should assign responsibility for managing corrective actions and the criteria for recognising when practicable corrections are identified.

3.5 FSE 5 – Reliability, Resilience and Sustainability

Fundamental Safeguards Expectation	Reliability, Resilience and Sustainability	FSE 5
Operators should design and support their NMACS regime to ensure it is reliable, resilient, sustained and remains relevant and proportionate throughout the entire lifecycle of the facility.		

84. NMACS structures, systems and components should be designed to deliver their required NMACS functions with appropriate reliability and so provide confidence in the robustness of the overall design of the NMACS system.

85. For NMACS purposes, the life cycle of a qualifying nuclear facility can be sub-divided into eight phases:

(a) Pre-Construction
(b) Construction
(c) Commissioning
(d) Operating
(e) Maintenance/Modification

(f) Shut-down
(g) Closed-down
(h) Decommissioned (for safeguards purposes)

Each phase is associated with specific NMACS requirements; it is important to keep in mind that different areas of the same nuclear facility may be in different life cycle phases.

86. Sustainability is defined by the set of objectives and implementing actions incorporated into the NMACS system to support its continuing effectiveness. If the NMACS system is to remain effective, its constituent parts must be maintained and supported over time to ensure it continues to achieve the required outcomes. It should also remain relevant and proportionate throughout the entire lifecycle of the qualifying nuclear facility.

3.5.1 MACE 5.1. – Reliability and Resilience

FSE 5 – Reliability, Resilience and Sustainability	Reliability and Resilience	MACE 5.1
Operators should incorporate reliability and resilience into the design of systems for the purposes of NMACS.		

87. Operators should make every effort to ensure availability of a sufficient number of resources to maintain continuity of NMACS provision. Continuity arrangements, aligned to appropriate standards should be developed in order to maintain an effective and robust NMACS system.

88. Redundancy should be incorporated as appropriate within the designs of NMACS systems and the operators arrangements should demonstrate that the required level of redundancy for the intended NMACS function has been achieved.

89. Source data and operating records to substantiate accounting records and accounting reports and if necessary enable reconstruction of the accounts (e.g. if any part of the system is destroyed or rendered ineffective). These recorded shall be maintained for 5 years[2] from the date on which they were generated. All nuclear material accountancy information is to be readily traceable from its generation as source data through to final production of accounting reports.

90. The measures whereby the claimed reliability of NMACS systems and components will be achieved in practice should be stated in the arrangements. Evidence should be provided to demonstrate the adequacy of these measures. This should include a reliability analysis of both random and systematic failures. Assumptions made in the course of the reliability analysis should be justified.

91. Where reliability data is insufficient to support a claim, appropriate measures should be taken to ensure that the onset of failures will be detected, and that the consequences of failure are minimised. Such measures may, for example, include planned replacement after a fixed lifetime, or be achieved through a programme of examination, maintenance, and inspection and/or testing.

[2] Note however that Nuclear Site Licence Condition 6 requires that 'Without prejudice to any other requirements of the conditions attached to this licence the licensee shall make and implement adequate arrangements to ensure that every document required, every record made, every authority, consent or approval granted and every direction or certificate issued in pursuance of the conditions attached to this licence is preserved for 30 years or such other periods as ONR may approve.'

3.5.2 MACE 5.2 – Examination, Inspection, Maintenance and Testing

FSE 5 – Reliability, Resilience and Sustainability	**Examination, Inspection, Maintenance and Testing**	**MACE 5.2**
Systems and components for the purposes of nuclear material accountancy and control should receive regular and systematic Examination, Inspection, Maintenance and Testing (EIMT).		

92. A process for in-service testing, inspection and other maintenance procedures of NMACS systems and components should be identified in the operators' arrangements.

93. The EIMT should be commensurate with the reliability required of each element and carried out in a manner, governed by arrangements and procedures, and applying codes and standards appropriate to the NMACS system or component. Such inspection should be of sufficient extent and frequency to give adequate confidence that degradation will be detected before loss of the NMACS function to ensure continuing quality and reliability. Accordingly, EIMT should prove the outcome of the complete system and the NMACS function of each functional group.

94. Where test equipment, or other engineered means, is used for EIMT (e.g. for measurement equipment), the extent to which they reveal failures affecting NMACS functions should be justified. The test equipment, or other engineered means, should itself be tested at intervals sufficient to uphold the reliability claims of the equipment under test.

95. EIMT is part of normal operation and it should be possible to carry out these tests without any loss of any NMACS function. In other cases, the operators arrangements should justify that there will be sufficient compensatory measures in place at all times to ensure any risk of system/component failure is adequately mitigated.

96. Where complete functional testing is claimed not to be appropriate, an equivalent means of functional proving should be adopted. In circumstances where this cannot be done, additional design measures should be incorporated to compensate for the deficiency, or it should be demonstrated that adequate long-term performance would be achieved without additional measures.

97. The continuing validity of such equipment qualification for NMACS structures, systems and components should not be unacceptably degraded by any modification or by the carrying out of any maintenance, inspection or testing activity. Furthermore, NMACS systems and components should be subject to extraordinary EIMT and/or re-validation after any event that might have challenged their reliability.

3.5.3 MACE 5.3 – Sustainability

FSE 5 – Reliability, Resilience and Sustainability	**Sustainability**	**MACE 5.3**
Operators should ensure that the constituent parts of its NMACS regime are sustained and supported over time to ensure it continues to achieve the required outcomes.		

98. Senior managers within operator organisations should set priorities and identify the long-term financial resources needed (e.g. for asset replacement) in addition to on-

going operational expenditure related to issues such as training, configuration management, asset care and maintenance.

99. Operators should ensure effective management and planning in order to sustain the NMACS regime through reviewing resources allocated for effective design, implementation, operation and maintenance.

3.6 FSE 6 – Measurement Programme and Control

Fundamental Safeguards Expectation	Measurement Programme and Control	FSE 6
Where measurements are performed, operators must implement and maintain robust arrangements to ensure the appropriate performance of measurement systems that provide data for the purposes of NMACS.		

100. Where facilities handle bulk quantities of nuclear material the measurement and accountancy system should comply with relevant good practice such as those set out in ISO standards e.g. ISO/IEC 17025:2017 [16] and ISO 10012:2003 [17]. Facilities where the material is identifiable, as discrete items e.g. nuclear fuel elements should only apply the criteria where accounting reports are based on calculations (i.e. burn-up declarations and nuclear production and loss in power reactors); this applies for the whole section 3.6.

101. The quality of measurements from which nuclear material accountancy records are based must meet the International Target Values 2010 for Measurement Uncertainties in Safeguarding Nuclear Materials [18].

102. The implementation of an effective measurement system and an associated measurement control programme are crucial for achieving accurate and robust NMACS. Aspects of the measurement system, and control programme that are likely to be important for achieving and maintaining accurate and robust NMACS are highlighted in individual sections of these expectations. These have not been written to be exhaustive.

103. Operators should, where practicable and proportionate, ensure SQEP personnel are in place for the management of the measurement control programme who are ideally organisationally independent of those performing measurements and either directly responsible for or have oversight of:

(a) measurement quality and authenticity
(b) measurement equipment performance, including that used during the PIT
(c) the planning, development, coordination, and administration of a measurement control program
(d) the appropriate use of and traceability to reference standards
(e) the measurement resources (equipment, instruments and procedures used in performing a measurement)
(f) hold up modelling and statistical handling of measurement errors
(g) improvements to eliminate/minimise significant source of bias or improve measurement capability
(h) measurement disputes.

3.6.1. MACE 6.1 – Measurement Control Programme

FSE 6 Measurement Programme and Control	Measurement Control Programme	MACE 6.1
A system must be implemented for accountancy areas where nuclear material is processed, to ensure the effectiveness of measurement and analytical systems and the quality of resulting data that is generated for NMACS purposes.		

104. The operator must have arrangements and procedures in place for monitoring the validity of the measurement results to be used for nuclear material accountancy. The criteria to assess the results must be predetermined and statistical tools should be used where relevant and possible. The programme should include the regular use of certified reference material to demonstrate analytical and measurement performance, participation in inter-comparisons, replicate tests and retesting. The programme should be subject to periodic review and improvement.

105. Operators must ensure the arrangements that comprise the measurement control programme (MCP) include a calibration and verification plan for instruments used in measurements for NMACS purposes. Verifications and calibrations should be performed according to arrangements and procedures in place to ensure metrological traceability. Calibration uncertainty should be estimated according to established methods, further considerations are outlined below:

(a) verification and calibration parameters should be stipulated in advance
(b) routine checks should be also planned when needed
(c) actions to resolve non-conformities should be included in the arrangements
(d) follow-up and history of every relevant instrument should be ensured by means of a records system.

106. The MCP should provide assurance that accountancy mass values are free from any significant measurement bias and that the measurement uncertainty is appropriately estimated. The MCP should include measures to ensure that factors influencing measurements are under control, considerations should include:

(a) instrumentation and equipment
(b) external conditions
(c) human factors
(d) measurement methods.

107. Estimation methods to quantify measurement uncertainties should be documented. They should include every component, which are of importance in a given situation and should guarantee metrological traceability of measurements and calibrations.

108. Provision should be made for the record keeping of all measurement activities performed. Operators should ensure that the implementation of a records management system enables the maintenance of a comprehensive record of measurement data.

109. Measurement procedures should be in place for each of the measurement methods in use and should be known and understood by those performing measurements.

110. A suitably qualified and experienced person (SQEP) should be nominated as responsible for approving measurement results.

111. Where nuclear material sampling is performed for NMACS purposes, a sampling plan should be in place and appropriate sampling procedures should be identified based

on statistical considerations. Sampling and the sampling technique should be recorded appropriately.

112. In cases where data provided for the purposes of NMACS is based on calculations that are not direct measurements, the values provided should be validated, traceable and approved. Similar requirements apply to item counting. The calculation method applied should be documented, technically justified and validated with real data where possible. A nominated SQEP person should approve the results and every activity should be recorded.

3.6.2. MACE 6.2 – Traceability and Validation

FSE 6 Measurement Programme and Control	Traceability and Validation	MACE 6.2
Measurements performed for the purposes of NMACS must be conducted to have traceability and should be validated appropriately.		

113. Records of every measurement related activity should show exactly how, whom by, when, the equipment used, and under what conditions the measurement was made. Templates for records should consider this criterion and a system to archive records should be documented and implemented.

114. Measurement results must be traceable to units of the international system when possible, by means of traceable calibrations. For the purposes of this document, traceability should be read as metrological traceability as it is defined in International Vocabulary of Metrology (VIM) [19] ‘*property of a measurement result whereby the result can be related to a stated reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty*’.

115. The measurement methods and techniques used for NMACS purposes should be subject to appropriate validation. Measurement methods completely covered by recognised international standards or normative documents (International Organization for Standardization (ISO) standards, European standards (EN), International Organization of Legal Metrology (OIML) Recommendations) do not need to be validated (this does not imply that metrological validation should not be performed). Any other method should be validated according to predetermined performance criteria. Operators should document and record each validation study. In the case of nuclear power reactors, the calculation codes for the burn-up and nuclear production/loss are considered as validated by the provider. It should be ensured that the code is used under the conditions allowed by the validation and using the correct data.

116. Measurement techniques employed for the purposes of the NMACS system should:

(a) be appropriately identified, in NMACS arrangements and procedures; and
(b) be calibrated, maintained and used to provide accurate data in line with the prevailing measurement standards.

3.6.3. MACE 6.3 – Precision and Accuracy

FSE 6 Measurement Programme and Control	Precision and Accuracy	MACE 6.3
Where measurements are performed for the purposes of NMACS, a programme must be established for providing sufficiently accurate and precise quantification and characterisation of the material subject to measurement.		

117. This should, where appropriate be done according to the Guide to the expression of uncertainty in measurement (GUM) (ISO, OIML, BIPM,) [20]. Limits on uncertainty should be pre-stated, and should be assessed not only during validation etc. but also on a regular basis for every measurement based on regular validation/calibration of the measurement system involved.

3.7 FSE 7 – Nuclear Material Tracking

Fundamental Safeguards Expectation	Nuclear Material Tracking	FSE 7
Operators must implement and maintain an NMACS system that is able to provide identification, quantity, characteristics and track any nuclear material in their facilities at any time.		

118. For the purposes of these expectations, control of internal (on-site) movements is as follows:

(a) document the expected nuclear material flow and locations in each MBA, the accountancy points at which transfer of nuclear material custody occurs, and methods for determining the quantity of nuclear material transferred
(b) retain custodial control with the issuing MBA until the accountancy point at which transfer of nuclear material custody occurs (including for transfers of nuclear material in 'waste' as defined in NSR19).
(c) record and verify all movements of nuclear material between different MBAs and transfer the nuclear material accountancy data to the Nuclear Material Accountant as soon as is reasonably practicable with an aim of doing so within one working day to ensure nuclear material accounts are as up to date as possible at any given time
(d) prove the integrity of the reporting system for fully automated systems of movement control during commissioning
(e) ensure that any interventions or corrections to source data are documented and traceable to the personnel involved
(f) agree NMACS arrangements for new flows of nuclear material in an existing MBA before the first movement takes place.

3.7.1. MACE 7.1 – Inventory Control

FSE 7 Nuclear Material Tracking	Inventory Control	MACE 7.1
Operators must ensure that procedures and arrangements are established and implemented to ensure any processing and/or transfers of nuclear material are controlled, recorded and verified appropriately. (See also MACE 8.3 and MACE 9.2)		

119. Inventory control requires the operator to ensure that all nuclear material transfers into and out of the MBA and material changes (e.g. in material description code or

form) are recorded. Operators must have arrangements in place and implemented to ensure that all transfers of nuclear material are correctly recorded. This must include transfers of material to or from 'waste' as defined in NSR19.

120. Timeliness is a key aspect of the capability of a nuclear material accountancy and control system to provide an up-to-date statement of nuclear material inventories. Where the required accountancy records rely on results from sampling and analysis, provisional estimated data should be entered, and identified as such.

121. Operators must have inventory control arrangements and procedures in place to comply with Regulation 19 of NSR19 to identify and report separately by obligation code the qualifying nuclear material subject to the relevant international agreements [21-24]. More information on obligation codes and obligation code accountancy is provided in the glossary and the joint BEIS/ONR implementation guidelines for implementing Nuclear Cooperation Agreements between the United Kingdom and International Partners [25].

122. A regular interval for records matching should be defined and procedures and arrangements in place, to ensure that accounting records correspond with key measurement points (KMP) flow records, operating records and source data. .

123. Where appropriate, the NMACS system should take into account any inventory control measures that ensure continuity of knowledge of the nuclear material contents of items (e.g. items under seal).

124. Operators' inventory control arrangements should, in a proportionate manner include physical checks of inventory in addition to the PIT. This requirement should be proportionate to the material type, material form, the type, complexity and size of the installation in addition to its operational status.

125. The NMACS system must be able to provide location, identification, quantity and the characteristics of all nuclear material in the MBA at any time, irrespective of custodial transfer and pending receipt documentation.

126. Nuclear material accountancy data authentication must include a full audit trail to original source documents. The accounting records may be updated based on an electronically authorised source document, providing this is secured, retained and protected from unauthorised correction. Source data for nuclear material movements should never be amended without endorsement by a suitably authorised or SQEP person and amendments should be traceable.

127. Where blending and mixing of a variety of nuclear material is not aimed at producing a target product batch (e.g. within an analytical laboratory), then a SQEP person should ensure that details of the nuclear materials being blended in the batch are provided to the Nuclear Material Accountant.

3.7.2. MACE 7.2 – Identification of Nuclear Material

FSE 7 Nuclear Material Tracking	Identification of Nuclear Material	MACE 7.2
Operators must ensure that arrangements and procedures are in place to enable the unique identification of all nuclear material within the MBA.		

128. Nuclear material should, where practical, be in containers having a recorded unique identity. When nuclear material is not in a transportable container (e.g. in process vessels), a well-defined process location can be considered both as identity of the 'container' and as the location of the material.

129. Identities of the containers must be permanent and readily legible for inventory checking. If the identity of the item needs to be changed, the link between the old and new identities should be recorded.

130. If nuclear material is within multiple layers of containment, the NMACS system should be able to provide the characteristics and quantity of the nuclear material by means of the container's unique identity.

131. The locations in which nuclear material can be held should be defined and identified on the NMACS documentation and used as the basis for recording the location and transfers of material.

132. Where appropriate, specific positions within storage areas should be part of the information provided by the NMACS system for the location of nuclear material (e.g. drum coordinates or can position within storage facilities).

133. For nuclear material storage, the NMACS system should be able to provide identification, quantity and characteristics of nuclear material present in every specific location of the facility. Records of nuclear material transfers into and out of the facility and between different positions within the MBA should be kept. This includes nuclear material in 'waste' as defined in NSR19 and described in the glossary.

134. When nuclear material enters a process or is subject to repacking, the operating records should enable identification of the items from which the material has been fed into the process (or into new containers).

135. Operating records should specify the amount of material fed into the process or repackaged and provide traceability of the characteristics and quantity of the nuclear material.

136. When new items or batches of material arise because of processing or repackaging, mass values and identities must be established for these items. The identity of the new items should be linked to the relevant mass results and measurement history. The rebatching process should be suitably transparent in nuclear material accounting declarations (e.g. ICRs).

137. In the event of a transfer of nuclear material, that is not a transfer of a contained item, the amount of the transferred material should be measured. It should be documented which methods and instruments are used for this purpose, all the requirements of FSE 6 apply.

138. The records associated with nuclear material movements should include information on the protective marking; on what nuclear material was moved, how and when it was transported, where it was moved from, and the 'handshake' and confirmation sign offs. Data should include locations, batch and container identification, quantity and form, the actual date of movement, and authorisations and confirmations of those accountable.

139. Operators should ensure that the records associated with blending or mixing of nuclear material with different isotopic compositions include a unique blend identity,

where and when the blend took place, the nuclear material identity, quantity, form, and isotopic composition of the blend inputs and outputs.

140. NSR19 requirements for submission of certain accounting reports to ONR do not apply to nuclear material contained in waste, but operator NMZCS systems must include accounting records for nuclear material in waste as specified in Regulation 29 of NSR19.

3.7.3. MACE 7.3 – NMACS Discrepancies

FSE 7 Nuclear Material Tracking	NMACS Discrepancies	MACE 7.3
Operators should ensure that arrangements are in place that recognise and investigate NMACS discrepancies whilst recording their management. (See also MACE 4.2 and MACE 8.3)		

141. A discrepancy is defined for the purposes of this guidance as any inconsistency between two or more pieces of NMACS information (e.g. source data, records, reports etc.) where this inconsistency cannot be justified after taking account of legitimate measurement variation or uncertainty estimation. Discrepancies include measurement discrepancies, material balance discrepancies (IDs and SRDs) and nuclear material control discrepancies where there is a non-conformance in the identification or location of nuclear material.

142. The nuclear material accountancy and control system should include procedures and arrangements to minimise NMACS discrepancies resulting from misreading or incorrect data transmission or calculation, with checking mechanisms employed to provide timely detection of errors, discrepancies or omissions in records.

143. Investigations into NMACS discrepancies should indicate the actions to be taken and the conditions that are required to resolve the discrepancy. Actions to be taken should include identifying the responsible person and the additional data to be utilised. Operators should have arrangements and procedures in place for resolving and reporting discrepancies, which fulfil the requirements of relevant good practice [reference 17].

144. Operators should make the appropriate correction of records and accounting reports when a discrepancy has been resolved.

145. Operators should record when a discrepancy remains unresolved the action taken in attempting to resolve it and arrangements to mitigate the unresolved discrepancy

146. Operators should have arrangements and procedures in place to resolve and report discrepancies and reconciliation with other MBA accounts.

3.8 FSE 8 – Data Processing and Control

Fundamental Safeguards Expectation	Data Processing and Control	FSE 8
Operators must implement and maintain data processing systems that are capable of producing the NMACS reports and records required under NSR19 that incorporate technical and procedural controls to protect the confidentiality, integrity and availability of sensitive nuclear information.		

147. Data processing systems and components need to be designed to deliver their required NMACS functions whilst maintaining an appropriate level of control of the documentation and data they handle. Data processing systems can be computerised or non-computerised systems. This fundamental expectation for NMACS describes ONR's expectations of how operators will implement effective data processing and control to ensure the NMACS system can function effectively and efficiently.

148. The MACE's below do not specify particular processes but describe what good data processing and control will look like. It should be noted that the ONR's security assessment expectations [14] outline the ONR's expectations of how organisations within the civil nuclear industry and third parties handling sensitive nuclear information (SNI) and other assets will apply protective security to ensure the civil nuclear industry can function effectively, efficiently and securely.

3.8.1. MACE 8.1 – Data Processing Capabilities

FSE 8 Data Processing and Control	Data Processing Capabilities	MACE 8.1
Operators must have the appropriate capabilities in place to ensure that the reports and records required under NSR19 can be produced in the correct format, within the required timescales.		

149. Operators must implement a data processing system, which is capable of producing the accounting reports required under NSR19 in a safe and secure manner. An NMACS data processing system should include, as appropriate:

(a) material balance standard deviation for material balance tests (i.e. for bulk material forms)
(b) various types of documents linked to inventory change (IC) declarations such as shipping documentation and source documents
(c) working documents for routine inventory control (e.g. List of Inventory Items)
(d) working documents for the PIT
(e) a list of inventory items (LII) resulting from PIT and used during PIV or other verification
(f) data processing procedures should be in place to correct records and generate correction declarations as appropriate, for any situation where a discrepancy has been detected. Traceability should be maintained during such correction processes. Quality control and quality assurance should ensure the completeness and correctness of the data-processing system.

150. NMACS data processing capabilities may also include:

(a) provision of inventory lists permitting inventory checking by the operator
(b) inventory lists providing any information necessary for identifying discrepancies between the locations described in the records and the real physical location
(c) support of regular reconciliation of operating records and accounting records, when the accountancy of nuclear material in process involves separate storage of these records
(d) arrangements and procedures in place to describe how to deal with discrepancies, which guarantee traceability of corrections
(e) documentation of the results of inventory checking and database reconciliation, including documentation of discrepancies encountered (for the purpose of performance indicators).

151. The arrangements and procedures in place for data-processing activities should provide the NMACS system manager with supervisory information. This should include the staff member initiating each software execution, identify the application program(s) involved as well as identify the location of the data inputs used and location of the data outputs created. It should also be possible to identify any execution of application software or access to records and data, which do not conform to the authorized data processing policy (ISO 17799:2017 [16]).

152. Source data, operating records and accounting records to substantiate accounting reports to ONR Safeguards and if necessary reconstruct the accounts (e.g. if any part of the system is destroyed or rendered ineffective) are required to be maintained for 5 years[3] from the date on which they were generated. All accountancy information is to be readily traceable from its generation as source data through to final production of NMACS reports. Accounting records must also be available for nuclear material in 'waste' as defined in NSR19.

153. Timeliness is a key aspect of the capability of an accountancy and control system to provide an up-to-date statement of nuclear material inventories, and so the system aim should be to record transactions within one working day of them taking place where practicable. The nuclear material accountancy and control system should show both the date the transaction took place and the date it was entered into the records, and include means of monitoring any delay. Where the required accountancy data relies on results from sampling and analysis, provisional estimated data should be entered, and identified as such.

154. The accountancy and control system should include procedures to minimise data errors resulting from misreading or incorrect data transmission or calculation, with checking mechanisms employed to provide timely detection of errors, discrepancies or omissions in records.

3.8.2. MACE 8.2 – Compilation of Nuclear Material Accounts

FSE 8 Data Processing and Control	Compilation of Nuclear Material Accounts	MACE 8.2
Operators should ensure that the appropriate arrangements and procedures are in place to ensure the effective management of their nuclear material accounts.		

155. Accounting records for each MBA are finalised when PIT data becomes available, the MBA balance has been calculated, and the inventory difference (ID) derived and reported on the MBR declaration. The PIL and MBR must be submitted to ONR Safeguards within 15 days of the PIT. Subsequent corrections will then apply to the accounts for the period in which the correction is made.

156. Units of accountancy for nuclear material;

(a) quantities of nuclear material are required to be expressed in grams for reporting to ONR Safeguards, therefore accounting records and reports should be expressed in units of grams, or smaller if additional precision is necessary
(b) uranium accounting records and reports are required for each nuclear material category (natural, depleted or enriched) in terms of total uranium. A single

[3] Note however that Nuclear Site Licence Condition 6 requires 'the licensee shall make and implement adequate arrangements to ensure that every document required, every record made, every authority, consent or approval granted and every direction or certificate issued in pursuance of the conditions attached to this licence is preserved for 30 years or such other periods as ONR may approve.

(unified) category may be agreed with ONR Safeguards for bulk processes (e.g. enrichment) which involve more than one category

(c) uranium accounting records and reports are required to record the fissile component for low and high enriched uranium stocks
(d) plutonium accounting records and reports are required to be kept in terms of total plutonium (and may also record fissile content, if agreed with ONR Safeguards)
(e) where nuclear material is present as discrete items, then the accounting records and reports should also be balanced by number of items

157. Good practice is to:

(a) account for sub gram items held in discrete containers and which have higher concentrations of nuclear material (e.g. metallic uranium or plutonium), especially if there are large number of such items. In this case, such items can be aggregated and reported as a single batch with a number of items
(b) record all item nuclear material weights to the same level of significance (as determined by the sensitivity or capability of the measurement) for aggregating.

158. All accounting or recording conventions used in deriving nuclear material quantities from source data should be contained within the accounting arrangements and approved.

159. Corrections:

(a) to NMACS transactions must be in a form that indicates the record that that has been changed along with both the old and new values
(b) to transactions that have not already been reported formally to ONR Safeguards should be recorded, but only the corrected transaction need be included in the accounting report
(c) to transactions that have already been reported formally to ONR Safeguards should be recorded, with that correction also included in the next accounting report submitted
(d) in formal reports to ONR Safeguards must be by means of deletion and addition of the reporting lines concerned, or use of the New Measurement (NM) inventory change code, as agreed with ONR Safeguards
(e) all corrections should show the date of the correction and the identity of the person making the correction.

160. Category changes:

(a) where blending or mixing of batches of nuclear material with different isotopic compositions leads to a change of nuclear material category (e.g. from high enriched uranium to low enriched uranium), the change is reported in the MBA in which the blending occurred and should record the uranium quantity, the U235/233 quantity and the obligation codes involved
(b) if a category change is required because of a new analytical result, it is reported in the MBA where the nuclear material originated and any subsequent transactions already declared to ONR Safeguards are treated in accordance with the procedure for corrections.

161. Re-batching:

(a) where a batch or batches of nuclear material are re-batched into new discrete batches, then a full audit trail is maintained between the original and new batch(es)
(b) re-batching takes place entirely within one MBA and one category and should not give rise to any discrepancies other than rounding

(c) any rebatching of nuclear material should be suitably transparent in nuclear material accounting declarations (e.g. ICRs).

162. Nuclear productions: the generation of nuclear material because of irradiation (e.g. in a reactor) is required to be recorded. Such production in irradiated fuel is declared to ONR Safeguards in the accounting reports when the fuel is transferred from the reactor MBA or as otherwise agreed with ONR Safeguards. Elsewhere, nuclear production should be accounted for and reported as specified in PSPs or otherwise agreed with ONR Safeguards.

163. Nuclear loss information on the conversion of uranium and plutonium and on decay isotopes for plutonium and reference dates for their calculation must (if recorded for operational reasons) be provided to ONR Safeguards on request.

164. Reported quantities of QNM may be rounded down when the first decimal is 0 to 4 and rounded up when the first decimal is 5 to 9. Individual nuclear material accounting records may be rounded in such a manner as to ensure they remain meaningful -in particular to enable their summation to provide reports accurate to the nearest gram.

165. Change of safeguards status (i.e. nuclear material withdrawn from or brought under safeguards), nuclear material can only be withdrawn from safeguards following ONR Safeguards approval of a request made in advance (Regulation 33 of NSR19). UK Government policy is that withdrawals are limited to small quantities of nuclear materials not suitable for weapons purposes, the details of which are made public. Non-safeguarded nuclear material can only be brought under safeguards from the UK military cycle following approval from the MoD. Separate notification should be provided to ONR Safeguards.

166. Obligation Accountancy:

a) obligation account stocks need to reconcile with total site stocks and total customer account stocks.
b) methods of allocating obligations (e.g. the principles of fungibility, proportionality and equivalence) should be fully documented.
c) prior authorisation for obligation exchanges must be sought by contacting ONR Safeguards. Information on swaps that are approved should be part of the accounting records

167. Further information on obligation codes and obligation code accountancy is provided in the glossary at Section 6 below and in the joint BEIS/ONR implementation guidelines for implementing Nuclear Cooperation Agreements between the United Kingdom and International Partners [25].

168. Operator arrangements and procedures must also be in place to ensure effective management of accounts for nuclear material contained in waste – including for accounting records as specified in Regulation 29 of NSR19.

3.8.3. MACE 8.3 – Records Management

FSE 8 Data Processing and Control	Records Management	MACE 8.3
Operators should ensure that the appropriate arrangements are in place to effectively manage the control of NMACS documentation and data. (See also MACE 7.1 and MACE 7.3)		

169. NMACS documentation and data;

(a) all nuclear material accountancy data, whether for safeguards, commercial or other purposes, need to be derived from and readily reconcilable with a single set of source data. The same nuclear material is not to be the subject of parallel accountancy systems /arrangements.
(b) all documentation and data associated with the nuclear material accountancy system requires appropriate protective marking in accordance with the classification policy issued by ONR CNSS. It is held, handled and transmitted in accordance with current security policy for government protectively marked information and, where appropriate, procedures for the control of commercial information. Personnel require appropriate security clearance for the information or IT systems to which they have access
(c) Nuclear material accountancy data needs to be readily retrievable for independent audit/verification. The data should reflect the quantity of nuclear material on inventory for each MBA, including details of nuclear material transferred into and out of the MBA and other inventory changes and information on obligation codes. The accountancy and control system should be capable of being updated on a daily basis or on-demand for all nuclear material transactions, and of producing book inventory figures for MBAs within one working day
(d) all records used for nuclear material accountancy are to be traceable to authenticated source data and kept in a manner that guarantees traceability. In particular, all mass values for effluents, discards, wastes and accidental losses require a traceable history.

170. Disaster recovery processes need to include the reconstruction or reconstitution of the nuclear material accounts for any MBA , if any part of the accountancy system for that area is destroyed or rendered ineffective. The source data and accompanying operator and accounting records necessary to reconstruct the accounts are required to be maintained for a period of at least 5 years[4] following the end of the accountancy period in which they were created.

171. IT management systems should:

(a) assure the authenticity and security of data. This includes protection from training and program testing activities
(b) have a configuration controlled environment for quality assurance and provide a full audit trail of data and programme changes, to enable independent confirmation
(c) provide a description to ONR Safeguards of the computerised nuclear material accountancy system at least to a level, which documents the data handling procedures

[4] Note however that Nuclear Site Licence Condition 6 requires 'the licensee shall make and implement adequate arrangements to ensure that every document required, every record made, every authority, consent or approval granted and every direction or certificate issued in pursuance of the conditions attached to this licence is preserved for 30 years or such other periods as ONR may approve.'.

(d) ensure the computer system has the appropriate ONR CNSS accreditation
(e) ensure that any migration/upgrade strategy includes suitable arrangements for maintenance of data integrity during migration and provision of long-term record storage and retrieval capability of historic data not migrated.

3.9 FSE 9 – Material Balance

Fundamental Safeguards Expectation	Material Balance	FSE 9
Operators must have arrangements in place to ensure that material shipped, received, processed and stored within facilities is subject to robust NMACS arrangements that guarantee traceability, include arrangements for physical inventory taking and, where appropriate, material balance evaluation.		

172. NMACS requires an authoritative breakdown of all nuclear materials, which reflects physical reality. This breakdown needs to be localised enough to maintain appropriate nuclear material control and enable effective and efficient safeguards verification. The level of localisation needed is determined by ONR Safeguards in consultation with the operator (and the IAEA for selected sites), including defining the facility as comprising one or more Material Balance Areas (MBAs). The operator may decide to subdivide an MBA into smaller accountancy areas for their own nuclear material control purposes.

173. General guidelines for constructing accountancy areas are that physical boundaries and Key Measurement Points (KMPs) are identified to maximise the control of nuclear material flow and physical inventories (which contribute to the mass balance of each category of nuclear material held in the accountancy area) and that an accountancy area does not span more than one MBA.

174. Ongoing accountability and control is exercised over an MBA by: documenting the area; assigning a facility operator[5] to control the area; conducting a regular physical inventory of locations which can hold nuclear materials; controlling measurements; deploying performance monitoring criteria; and controlling the authenticity and technical provenance of all nuclear material accountancy related data.

175. Good practice is that:

(a) there are separate MBAs for: bulk handling processes; storage of discrete items of nuclear material; areas with significantly different safeguards approaches (e.g. containing nuclear material in waste); separate physical areas of the site and separate areas of management responsibility
(b) NMACS systems cater for reconfiguration of MBAs (merging or splitting) and the size of the MBA is proportionate with cost effective measurement and recording;
(c) there is a single responsibility for the correct and accurate functioning of the nuclear material measurement systems used for NMACS
(d) formal handover arrangements exist within an MBA to enable continuity of knowledge for ongoing activities (moves, physical inventories in progress, investigations etc).

[5] see paragraph 61 above, the term ‘facility operator is used in this guidance for the SQEP individual to whom specific responsibility for custody of (i.e. direct responsibility for) qualifying nuclear material in terms of operations in a particular facility area etc. is assigned by those with authority for the operational areas concerned.

3.9.1. MACE 9.1 – On/Off Site Movements of Nuclear Material

FSE 9 Material Balance	On/Off Site Movements of Nuclear Material	MACE 9.1
Operators must ensure that the appropriate arrangements are in place to ensure that nuclear material shipped from sites and external receipts of nuclear material onto sites are controlled and subject to effective and robust NMACS arrangements that guarantee traceability.		

176. Operators arrangements for the control of external receipts into and issues out of the site should include:

(a) each site has a nominated person with overall responsibility for nuclear material in transit to or from the location
(b) agreement should be obtained from the relevant Nuclear Material Custodian before delivery of the material is agreed
(c) formal agreement for the shipment of nuclear material is required from the consignee, prior to the dispatch of any nuclear material from the site
(d) information relevant to on/off site movements of nuclear material should be recorded in a way that guarantees traceability
(e) accountancy data should be transmitted to the Nuclear Material Accountant as soon as is practicable, with the aim of this being within one working day to ensure nuclear material accounts are as up to date as possible at any given time”

177. Operators arrangements for the receipt of nuclear material onto site, should include:

(a) arrangements should be in place clearly identifying those responsible and the activities required to check and enter NMACS information provided to the site upon receipt of nuclear material. These activities should include the corrective actions to be taken in the event of discrepancies
(b) nuclear material receipts are physically checked as far as practicable against accompanying source data (e.g. which should indicate or allow the derivation of nuclear material weight, isotopic composition, the safeguards obligation code and, where available, the MBA code for the shipper), including check measurements where appropriate. The nuclear material should not be released for use until these checks are complete
(c) the NMACS system uses the shipper’s data. If, after measurement, a difference is found outside the acceptance criteria and a correction is not supplied by the shipper, then the data is instead corrected to the site’s values by declaring a Shipper Receiver Difference (SRD) – see also MACE 9.3.
(d) an arrangement or escalation process should be in place to deal with receipts that have no accompanying nuclear material documentation or for nuclear material subsequently found in equipment or apparently empty containers received at the site
(e) if, on receipt, the data recorded on the shipper’s documentation is incorrect then the shipper should provide corrected documentation (the personnel at the receiving site should not amend shipper’s documentation). Until a difference is resolved, the shipment should be held under a quarantine procedure (see also MACE 4.2 and 9.3)
(f) advance notification of certain imports is required to be communicated to ONR Safeguards (as specified in Regulation 22 of NSR19). Unless otherwise stated, such notification has to reach ONR Safeguards at least four days before the nuclear material is unpacked, carry the appropriate protective marking and be submitted to ONR Safeguards via UK.SSAC@onr.gov.uk
(g) good practice is the use of suitably protected/encrypted electronic data exchange between consignor and consignee for regular and detailed consignments.

178. Operators should have arrangements in place for the shipment of material from sites, which ensure the following:
    (a) V nuclear material is appropriately measured (physically checked) and accounted for before dispatch and NMACS shipping advice notes are produced. These activities should include the check of the NMACS information to be sent to the receiver
    (b) the NMACS system is appropriately updated to reflect the dispatch of material
    (c) arrangements should be in place to manage the appropriate response and corrective actions to be taken in the event of the recipient reporting discrepancies
    (d) advance notification of certain exports is required to be communicated to ONR Safeguards (as specified in Regulation 21 of NSR19). Unless otherwise stated, such notification has to reach ONR Safeguards at least seven days before the day on which the nuclear material is to be packed for shipment, carry the appropriate protective marking and be submitted to ONR Safeguards via ukso@onr.gov.uk
    (e) an auditable system of checks should be in place to ensure that nuclear material is not shipped from the site in apparently empty containers.

179. Operator arrangements must also provide for reporting on transfers of nuclear material in conditioned waste as specified in NSR19 Regulation 30.

    (f)

3.9.2. MACE 9.2 – Physical Inventory Taking

FSE 9 Material Balance	Physical Inventory Taking	MACE 9.2
Operators must ensure that the appropriate Physical Inventory Taking (PIT) arrangements are in place to ensure that all nuclear material within an MBA is recorded accurately through measurement or derived estimates, as specified in Regulation 15 of NSR19. (See also MACE 7.1)		

180. A PIT involves measuring or deriving estimates of all nuclear material within an MBA, and is performed in order to verify the book inventory at a given date. Unless otherwise specified in a PSP, a PIT is required for each MBA every calendar year, with the period between two successive PITs not exceeding 14 months. NSR19 requires, on an annual basis, an outline programme of activities that includes provisional dates for taking a PIT, with confirmatory details of the PIT provided to ONR Safeguards at least 40 days prior to it taking place. Any subsequent changes to the intended programme require communication to ONR Safeguards without delay. Such declarations carry an appropriate protective marking and, unless agreed otherwise, are to be submitted to ONR Safeguards via ukso@onr.gov.uk

181. The operators' arrangements for PIT should take into account all relevant organisational policies, management procedures and work instructions and include clear definition of responsibilities and specific criteria for the planning, housekeeping, pre-checks, conducting, and reconciling the results of the inventory. They should ensure that nuclear material movements are halted for the duration of the PIT and that the presence of all nuclear material is recorded accurately:

    (a) nuclear material is uniquely identified
    (b) items that can be shown to have retained their integrity since last being measured do not require re-measurement but should receive some continuity check measurements to maintain confidence
    (c) the amount of nuclear material held in any process areas is minimised, and there is suitable technical justification for estimates of the nuclear material quantities involved (i.e. they are not determined by the difference between receipts and issues in a particular location)

(d) wherever necessary to determine its nuclear material content, nuclear material is converted to a measurable form and/or transferred to a suitable measurement location. Where this is not practicable then a technically justifiable estimate can be used
(e) nuclear material which is in a measurable form, and for which the nuclear material content is not accurately known, is homogenised, sampled and analysed
(f) all personnel who participate in the PIT are trained and have achieved the necessary competence for their area of responsibility
(g) instruments used for nuclear material measurements at KMPs are in calibration and records of recent calibrations and derived measurement uncertainties are available.

182. Good practice is that operators, as part of their PIT procedures, develop MBA specific standards to target at PIT, which ensure that facilities are in an optimal configuration (considering points from 181 above). This provides outage management and operational personnel with a clear target to aim for at PIT for which they can begin preparations from an early stage.

183. If it is not possible to perform a direct check of all nuclear material (e.g. in areas where it cannot be safely accessed, such as reactor cores, fuel storage ponds and waste stores), then the PIT may involve the use of a sampling plan or record check as approved by the NMACS Manager. Where the PIT relies entirely on transfer records, then quality controls on such records need to be undertaken, supported by assurance of the nuclear material integrity during presence in the area.

184. Procedures should ensure that PIT results are recorded on uniquely identified source documents that facilitate the accurate recording of data and, as a minimum, include batch and container/vessel identities, quantitative information on number of items and bulk quantity of nuclear material; location information and accountancy area; physical and chemical form; isotopic data and category of nuclear material; and sign off data of those taking/checking the inventory.

185. Any corrections to PIT data are to be authorised by or with the consent of the facility operator and the Nuclear Material Accountant. PIT results are reported to ONR Safeguards in the form of a Physical Inventory Listing (PIL), submitted along with a Material Balance Report (MBR) within 15 days of the date of the PIT.

186. Process control and/or other requirements not directly related to safeguards may mean that inventory monitoring and verification are required on a more frequent basis than an annual PIT. Such monitoring may take a number of forms, for example, process monitoring, check inventories, interim assurance or Near Real Time Material Accountancy (NRTMA).

187. Good practice is that:
(a) PIT frequency should be no greater than 12 months to allow a contingency in achieving a successful PIT/PIV within 14 months. Intervals between PITs should be of similar duration but optimising PIT intervals is risk based (taking into account the control and monitoring measures in place; the levels of inventory difference found; the accuracy of the system; plant opportunities and the degree of confidence in the system)
(b) following a PIT, a timely critique of the PIT performance and anomaly resolution should be produced and communicated to those involved/responsible and to a wider site review of PIT performance and learning
(c) stores with high turnover of items should be subject to interim stock checks (e.g. cycle counting) in order to identify items in error earlier, thus triggering investigation, identification, and elimination of the cause of the errors

(d) sites have a detection capability for nuclear material lost during normal operations and do not rely solely on an annual PIT. Such a capability includes detection of abrupt and protracted loss
(e) sites are able to carry out an EPIT to confirm or discount claims (external or internal) concerning loss of nuclear materials.

188. NSR19 requirements for the submission of MBRs and PILs to ONR do not apply to nuclear material contained in waste, but operator arrangements must include physical inventory taking and associated accounting records for nuclear material in waste as specified in Regulation 29 of NSR19.

3.9.3. MACE 9.3 – Material Balance Evaluation

FSE 9 Material Balance	Material Balance Evaluation	MACE 9.3
Operators must ensure that where appropriate, arrangements are in place to ensure that Material Balance Evaluation (MBE) is carried out to determine if any non-zero inventory differences for can be explained by measurement uncertainty or reflects other causes.		

189. **Inventory Differences** (IDs) -an ID is calculated as:

ID = closing physical inventory minus opening physical inventory minus receipts plus issues

A positive ID is therefore referred to as an apparent nuclear material ‘gain’ and a negative ID as an apparent nuclear material ‘loss’.

190. IDs in bulk handling facilities are recorded in the nuclear material accounting reports for the MBA in which they are determined. These IDs should be tested for statistical significance against the Inventory Difference Action Level (IDAL) which is derived from the measurement uncertainties identified by the measurement control plan (MCP). If, exceptionally, no IDAL has been calculated then interim action levels can be assigned using historic performance or the IAEA values for the “expected measurement uncertainty δE (relative standard deviation) associated with closing a material balance” quoted in the IAEA Safeguards Glossary.

Bulk handling facility type	Relative standard deviation, δE
Uranium enrichment	0.002
Uranium fabrication	0.003
Plutonium fabrication	0.005
Uranium reprocessing	0.008
Plutonium reprocessing	0.010
Separate scrap storage	0.04
Separate waste storage	0.25

191. These δE values are based on operating experience at the various types of bulk handing facility and are considered achievable under normal operation conditions. For calculating the international standard for the uncertainty of a material balance, the figure from the table above (expressed as a relative standard deviation) is multiplied by the throughput. The δE values can be used along with the International Target Values to determine whether a facility’s measurement system meets international standards.

192. The methodologies for calculating ID and IDAL should be part of the operators arrangements and any statistical evaluation should be technically defensible.

193. Where estimates of in-process material are based on historical information or modelling, the estimation method and method of estimating the uncertainty should be described in the operators' arrangements.

194. IDs in storage facilities may arise as a result of rounding, when batches are issued as two or more sub-batches. Such differences are recorded as rounding adjustments and not IDs. Differences can also arise from analytical results or mistakes in batch details. An amendment to the quantity associated with a package in a store should not generate an ID in that store. The difference between the original and amended quantities is instead transferred back, as a correction to the original receipt, to the area in which the package originated, or generates a shipper/receiver difference (SRD) in the case of external receipts.

195. Where it is necessary to confirm or refresh characterisation data for a batch it is normal for any sampling/re-containerisation to be conducted in a process (contact) area. Differences, which arise from such characterisation, can be recorded as new measurement in that process area and not passed back to plant of origin. Where the process performs other fuel cycle operations, then re-characterisation differences should be recorded separately from normal plant performance/ID action levels.

196. Finds of nuclear material where the presence of nuclear material is both unexpected and unusual are normally brought onto inventory using the inventory change code Accidental Gain (GA). Use of this code requires a special report to be sent to ONR Safeguards. (See also MACE 4.2). Unless there is, evidence that the nuclear material has been accounted for previously, the inventory change should not be included in consolidated figures for IDs. Additional advice on NMACS reporting in such circumstances can be obtained by contacting ONR Safeguards and advice on security reporting should be obtained from the site security manager.

197. IDs are identified as significant at the three sigma, 99.7% confidence level with operator investigation and follow-up expected at the 2-sigma level. For MBAs where nuclear material is stored in the form of discrete items, the IDAL is typically the loss of an item. The NMACS manager is responsible for specifying IDALs, records for which (and their derivation) are to be maintained for all MBAs on the site.

198. Shipper/Receiver Differences (SRDs) is calculated as:

SRD = Receiver value minus Shipper value

199. SRDs should not exist between MBAs within the same site, and there should be procedures to ensure that shipping and receiving areas use the same figure for the quantity of nuclear material transferred. Agreement should be based on measurement and not, for example, commercial or financial convention.

200. Where an operator's arrangements generate a better understanding/ measurement of nuclear material received from another site then any difference can either be recorded using SRD or by the consignee correcting the shipment documentation. . SRD is the normal reporting method for regular differences such as those arising from reprocessing spent fuel, where reactor calculations applied to the fuel at the shipping facility are typically less accurate than destructive analysis measurements made at the receiving facility once the fuel has been dissolved. Shipment documentation should however be corrected if there is reason to believe the quantities stated are incorrect.

201. Action levels for SRDs are deemed significant at the 3 sigma, 99.7% confidence level with operator investigation and follow up expected at the 2-sigma, 95% confidence level. The NMACS manager is responsible for specifying SRD action levels. In the case of reprocessing SRDs, action levels will vary depending on fuel type and burn up.

202. Where applicable, operators should develop, implement and maintain NMACS arrangements for:

(a) IDs or SRDs that exceed action levels (including any that involve the loss of discrete items)
(b) unexpected changes in the control of nuclear material, to a point where unauthorised removal of nuclear material has become possible
(c) discrepancies and anomalies that are deemed significant by the operator including items that cannot be found at their recorded location.

203. The operators arrangements and procedures should ensure that:

(a) any abnormal ID or SRD is documented immediately when it is identified (e.g. once an ID is calculates after a PIT, or when an abnormal SRD is measured)). It is not appropriate to wait for the results of investigatory work before documenting and reporting the ID and the ID should be reported in the MBR declaration within 15 days of a PIT.
(b) the facility operator or Nuclear Material Accountant ensures the investigating officer issues an initial report as soon as reasonably practicable.
(c) the investigation remains open until a final report on the incident is issued and this is accepted by the NMACS Manager.

204. Wherever possible, nuclear material for which significant SRDs have been identified should not be further processed or converted into other batches until approval has been received from the NMACS Manager. Normally, this would only be after the NMACS Manager is satisfied that adequate measures have been taken to understand and resolve the SRD.

205. Cumulative ID and SRD figures should be maintained such that lifetime positions by MBAs and by facility are available. Trends should be identified and investigated.

206. Good practice is that:

(a) when IDs occur due to re-measurement the rationale for accepting the new measurement and (in cases of gross differences) assurances about batch integrity should be recorded.
(b) a trend of linked IDs of opposite sign should be investigated. This includes coupled MBAs with opposite sign inventory differences (e.g. regular pattern of gains in one in line with losses in another) and includes mixed uranium/plutonium streams (one category losses and the other gains)
(c) an MCP is used for bulk handling plants (NSR19 requires that measurements comply with relevant international standards and that a site describes its control of accuracy, statistical evaluation and determination of uncertainties and uncertainty propagation).

4.0 FSE 10 – Quality Assurance for Nuclear Material Accountancy and Control

Fundamental Safeguards Expectation	Quality Assurance for Nuclear Material Accountancy Control and Safeguards	FSE 10
Operators must implement and maintain quality assurance and quality control measures for NMACS.		

207. An operator's management system (MS) needs to ensure that all NMACS requirements are incorporated. The QMS should set-out the organisation, responsibilities, documentation, controls and operational activities of the NMACS arrangements. Arrangements for current and historic system parameters should include MBA structures; accountancy areas (where appropriate); facility operator appointments; technical justifications; action levels; performance indicators; investigations; and current and cumulative apparent losses/gains.

208. Good practice is to:

(a) standardise NMACS arrangements and procedures across the site
(b) have a clear and concise statement of how NMACS requirements are implemented
(c) pursue continuous improvement and adoption of better practice
(d) have an NMACS testing and comparison regime for important locations
(e) have an overall records management system compliant with or equivalent to ISO 15489
(f) ensure that the authoritative nuclear material inventory for the site is the NMACS inventory (i.e. all nuclear material inventory (mass) information, for whatever purpose, is derived from that held in the NMACS system).

4.0.1. MACE 10.1 – NMACS Performance Measures

FSE 10 NMACS Performance Measures	NMACS Performance Measures	MACE 10.1
Operators should ensure that the appropriate arrangements are in place to ensure that NMACS performance is monitored and reviewed.		

209. Monitoring and review of NMACS performance should include effectiveness of meeting NMACS requirements and identifying trends. Performance metrics will be tailored to local conditions but should include information on:

(a) nuclear material control of movements, measurements and inventory
(b) nuclear material accountancy accuracy and timeliness
(c) anomalies; their investigation, corrective action and Learning From Experience (LFE)
(d) human performance in conduct of operations so as to reduce intrinsic risk of human errors
(e) safeguards compliance, assurance and responsiveness
(f) NMACS competence, culture and regulatory confidence.

210. Review of the NMACS processes helps ensure performance is maintained and, where necessary, improved. Such review includes assessment of system effectiveness; mitigating weaknesses and risks; self-verification; measures of performance/quality; communication with regulators on deficiencies; and an annual statement for ONR Safeguards on nuclear material balance anomalies.

4.0.2. MACE 10.2 – Quality Assurance & Control Measures

FSE 10 NMACS Performance Measures	Quality Assurance & Control Measures	MACE 10.2
Operators should ensure that key NMACS tasks incorporate quality assurance and quality control measures.		

211. Automation of data handling should be implemented where possible and effective. Peer review and other quality control measures to ascertain the accuracy of data should be documented and implemented where needed.

212. Arrangements should be in place detailing the methodology used to calculate performance indicators along with criteria defining poor performance from the results. Operators should take action to improve poor performance and retain records of historic performance. Examples of relevant indicators may include:

(a) ID figures
(b) Number of NMACS anomalies
(c) Number of regulatory comments arising from NMACS reporting and inspections.

213. An internal assessment programme should be in place that covers key NMACS tasks. It should include a schedule, and identify the individuals responsible for carry out audits and the audit criteria to use. Records of the internal audits should be kept and issues identified during NMACS audits should be managed appropriately.

5.0. REFERENCES:

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15. European Commission recommendation on the implementation of a nuclear material accountancy and control system by operators of nuclear installations (2009/120/Euratom), 11 February 2009 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009H0120&from=EN

16. ISO/IEC 17025:2017 – General requirements for the competence of testing and calibration laboratories
https://www.iso.org/standard/66912.html
17. ISO 10012:2003 – Measurement management systems – Requirements for measurements processes and measuring equipment
https://www.iso.org/standard/26033.html
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19. International Vocabulary of Metrology
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20. Guide to the expression of uncertainty in measurement (GUM) (ISO, OIML, BIPM, …)
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https://www.gov.uk/government/publications/nuclear-cooperation-agreements-implementation-guidelines-for-operators
26. ONR Guidance: Notifying and Reporting Incidents and Events to ONR
http://www.onr.org.uk/operational/inspection/onr-opex-gd-001.pdf

6.0. Glossary of Key Terms, Abbreviations and Acronyms

6 Description of some of the terms below includes their definition as included in The Nuclear Safeguards (EU Exit) Regulations 2019 ('NSR19') [1] or international good practice (e.g. European Commission recommendation 2009/120/Euratom) [15]. and guidance published by the IAEA and ESARDA and previously in the UK by the UK Safeguards Office (UKSO) (ref. http://www.onr.org.uk/safeguards/accountancy.pdf).

6.1 ***Accountancy area*** -A uniquely identified area, wholly within a single MBA, with its own nuclear material account. The physical boundaries of an accountancy area are defined by the operator, in contrast to those of an MBA, which are defined by ONR Safeguards.

6.2 ***Anomaly*** -Defined for the purpose of this guidance as 'any NMACS related issue that significantly affects the ability to draw safeguards conclusions or asses compliance with safeguards regulations, including a discrepancy or series of discrepancies that are consistent with the absence or gain of a significant amount of nuclear material'. An anomaly can be detected during an investigation of discrepancies of whatever kind.

6.3 ***Basic Technical Characteristics*** (BTCs) - information for plants or locations where safeguarded nuclear material is stored or used as required by Regulation 3 of NSR19. BTCs include a description of the installation, the form, quantity, location and flow of nuclear material being used, the layout of the installation, containment features and procedures for nuclear material accountancy and control. The information is used, inter alia, to prepare the safeguards approach for the installation and if necessary any Particular Safeguards Provisions (PSPs). Such information known as Design Information (DI) in the IAEA safeguards system.

6.4 ***Batch*** -Defined at Regulation 2 of NSR19 as 'a portion of qualifying nuclear material handled as a unit for accounting purposes at a key measurement point and for which the composition and quantity are defined by a single set of specifications or measurements. The qualifying nuclear material may be in bulk form or contained in a number of items'. Examples of a batch therefore include one fuel assembly, one UF6 cylinder, a tray of pellets prepared for loading into one fuel rod and several drums of UO2 powder with the same specifications. The term 'batch data' is defined at Article 2 of NSR19 as 'the total weight of each category of qualifying nuclear material and, in the case of plutonium and uranium, the isotopic composition when appropriate. For reporting purposes the weights of individual items in the batch must be added together before rounding to the nearest unit'.

6.5 ***Book inventory*** -Defined at Regulation 2 of NSR19 as 'the algebraic sum of the most recent physical inventory of that material balance area, and of all inventory changes that have occurred since that physical inventory was taken.'

6.6 ***Category*** -For purposes of NMACS, nuclear material is assigned to categories. These are (defined at Regulation 2 and Schedule 1 of NSR19):

Category of qualifying nuclear material	**Code**
Plutonium	P
High enriched uranium (20% enrichment and above)	H
Low enriched uranium (higher than natural but less than 20% enrichment)	L
Natural uranium	N

Depleted uranium	D
Thorium	T

6.7 ***Conditioned waste*** -Defined at Regulation 2 of NSR19 as ‘waste, which has been conditioned in such a way (for example, in glass, cement, concrete or bitumen) that it is not suitable for further nuclear use.’

6.8 ***Containment*** -Defined in international good practice such as Section 2.1 of Recommendation 2009/120/Euratom as ‘a structural feature of a facility, container or equipment which is used to establish the physical integrity of an area or item (including safeguards equipment or data) and to maintain the continuity of knowledge of the area or item by preventing undetected access to, or movement of, nuclear or other material, or interference with the contained items. Examples are the walls of a storage room or of a storage pool, transport flasks and storage containers.’ The continuing safeguards integrity of the containment itself is usually assured by seals or surveillance measures, especially for containment penetrations such as doors, vessel lids and water surfaces.

6.9 ***Correction*** -Defined at Regulation 2 in NSR19 as ‘an entry made in an accounting record or report which rectifies an identified mistake or to reflects an improved measurement of a quantity which was previously entered in a record or report.’.

6.10 ***Corrective action*** -Defined in international good practice such as Section 2.2 of 2009/120/Euratom as ‘action to eliminate the cause of a detected NMAC discrepancy, anomaly or other undesirable situation. Corrective action is taken to prevent recurrence. There is a distinction between correction and corrective action’.

6.11 ***Data processing*** -Defined in international good practice such as section 2.3 in 2009/120/Euratom as ‘ the link between the creation of measurement results and material-tracking data and the production of a variety of regulatory reports, documents supporting … verification and internal working documents related to material tracking by the facility itself’.

6.12 ***Decommissioned*** -Defined at Regulation 2 of NSR19 as ‘a qualifying nuclear facility for which it has been confirmed to the satisfaction of ONR that residual structures and equipment essential for its use have been removed or rendered inoperable so that it is not used to store and can no longer be used to produce, handle, process, dispose of or utilise qualifying nuclear material.’ The term ‘closed-down’ is defined in Regulation 2 of NSR19 as ‘a qualifying nuclear facility which has not been decommissioned but in relation to which it has been confirmed by the ONR that operations have ceased and all the qualifying nuclear material removed.’

6.13 ***Discrepancy*** - Defined for the purpose of this guidance as ‘any inconsistency between two or more pieces of NMAC information (e.g. source data, records, reports etc) where this inconsistency cannot be justified after taking account of legitimate measurement variation or uncertainty estimation. Discrepancies include measurement discrepancies, material balance discrepancies (IDs and SRDs) and nuclear material control discrepancies where there is a non-conformance in the identification or location of nuclear material.’

6.14 ***Effective kilogram*** - is defined at Regulation 2 of NSR19 as a unit used in safeguarding qualifying nuclear material which is obtained by taking

a) for plutonium, its weight in kilograms;
b) for uranium with an enrichment of 0.01 (1%) and above, its weight in kilograms multiplied by the square of its enrichment;

c) for uranium with an enrichment below 0.01 (1%) and above 0.005 (0.5%) , its weight in kilograms multiplied by 0.0001; and
d) for depleted uranium with an enrichment of 0.005 (0.5%) or below, and for thorium, its weight in kilograms multiplied by 0.00005.'

6.15 ***Emergency Physical Inventory Taking (EPIT)*** -A rapid stock take of nuclear material in response to the suspected loss, theft, or allegation of theft, the objective of which is to confirm or rule out the suspicions/allegations.

6.16 ***Equivalence principle*** -The equivalence principle is a feature of NCAs and obligation accountancy and provides that where nuclear material of a particular obligation loses its separate identity because of process characteristics (e.g. mixing), an equivalent quantity is designated as obligated nuclear material (on the basis that atoms or molecules of a substance are indistinguishable from another). The principle of equivalence does not permit substitution by a lower quality material, e.g. enriched uranium cannot be replaced by natural or depleted uranium. See also the principles of fungibility and proportionality.

6.17 ***Facility*** -Defined for IAEA safeguards purposes at Article 90.I of the UK/IAEA Safeguards Agreement as 'a reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant or a separate storage installation; or any location where nuclear material in amounts greater than one effective kilogram is customarily used.' The term 'installation' as used in NSR19 differs by also including waste treatment and storage installations and locations with holdings of less than one Effective Kilogram of nuclear material.

6.18 ***Facility Attachment*** -A facility-specific part of the subsidiary arrangements to safeguards agreements with the IAEA, which details how the reporting and inspection provisions of the agreement are to be applied at a particular facility or group of similar facilities.

6.19 ***Find*** -The discovery of a discrete item or items of nuclear material whose existence is previously unknown or unquantified – see NSR19 reporting codes NM (New Measurement) and GA (Accidental Gain).

6.20 ***Fungibility principle*** -Uranium, in common with a number of other commodities, is 'fungible' in that, during processing, uranium from any source is identical to uranium from any other and it is not possible to differentiate, physically, the origin of the uranium. This fungibility has led to the establishment and use of the principles of equivalence and proportionality.

6.21 ***GA (Accidental Gain)*** -NSR19 reporting code – see Schedule 1 of NSR19.

6.22 ***Holdup*** -Nuclear material deposits remaining after shutdown of a plant in and about process equipment, interconnecting piping and adjacent areas. For plants in operation, the Holdup is the amount of nuclear material contained in the process, and is referred to as 'in-process inventory'.

6.23 ***Intelligent Customer* -** The capability of an organisation to understand where and when work is needed; specify what needs to be done; understand and set suitable standards; supervise and control the work; and review, evaluate and accept the work carried out on its behalf.

6.24 ***International Atomic Energy Agency (IAEA)*** -An independent intergovernmental United Nations organisation, which is, amongst other things, responsible for applying the international safeguards measures required by the Nuclear Non-Proliferation Treaty (NPT).

6.25 ***International Target Values (ITVs)*** - The International Target Values, first issued under the auspices of the IAEA as document STR-327 of April 2001 and subsequently updated and available as the International Target Values 2010 for Measurement Uncertainties in Safeguarding Nuclear Materials at https://esarda.jrc.ec.europa.eu/images//Bulletin/Files/B_2012_048.pdf . The ITVs set out expected values for random and systematic measurement uncertainty components for destructive analysis (DA) and non-destructive assay (NDA) measurements performed on nuclear material. The values reflect what is regarded as achievable in the conditions normally encountered in industrial laboratories or during safeguards inspections. They do not represent the measurement uncertainties achievable under 'ideal' research laboratory conditions.

6.26 ***Inventory Changes*** - Defined at Regulation 2 of NSR19 as 'an increase or decrease, in terms of batches of qualifying nuclear material in a material balance area;

6.27 ***Inventory change increases***:

a) Imports;
b) *Receipts within the UK* -receipts from another UK nuclear sites, or from another material balance area on site, or from an activity not subject to safeguards under this Agreement, or at the starting point of safeguards;
c) *Nuclear production* -production of special fissionable material in a reactor;
d) *Accidental gains* -finds of nuclear material in plant areas where the presence of material is both unexpected and unusual; and
e) *New measurements (+ve)* – Inventory difference and new measurements which result in an apparent gain of nuclear material.

6.28 ***Inventory Change Decreases***:

a) Exports;
b) *Shipments within the UK* -shipments to another UK nuclear site or to another material balance area on site; or to an activity not subject to safeguards under this Agreement;
c) *Nuclear loss* -loss of nuclear material due to its transformation into other element(s) or isotope(s) as a result of nuclear reactions;
d) *Measured discard* -nuclear material which has been measured, or estimated on the basis of measurements, and disposed of in such a way that it is not suitable for further nuclear use;
e) *Retained waste* -nuclear material generated from processing or from an operational accident, which is deemed to be irrecoverable for the time being but which is stored;
f) *Accidental loss* -loss that is, irretrievable and inadvertent loss of nuclear material as the result of an operational accident or theft; and
g) *New measurement (-ve)* – Inventory difference and new measurements, which result in an apparent loss of nuclear material.

6.29 ***Inventory Change Report (ICR)*** -A report that describes changes in the inventory of nuclear material in an MBA, and one of the accounting reports required by NSR19 (Regulation 14).

6.30 ***Inventory Difference (ID)*** -The difference between the Physical Inventory and the inventory indicated by the nuclear material accountancy system (book inventory). Also known as 'Material Unaccounted For' (MUF) and for which it should be noted that the NSR19 convention (Physical Inventory – Book Inventory) is the opposite of the IAEA convention. Annual publication of Nuclear Material Balance figures for UK sites where civil nuclear material is processed includes information on Inventory Difference/Material Unaccounted For at the sites concerned.

6.31 ***Inventory Difference Action Level (IDAL)*** -The limit on an ID, which, if exceeded, will require a special report to be made by the operator to the safeguards inspectorates.

6.32 ***Item*** - Defined at Regulation 2 in NSR19 as 'an identifiable unit, such as a fuel assembly or a fuel pin.'

6.33 ***Key Measurement Point (KMP)*** - Defined at Regulation 2 of NSR19 'a location where qualifying nuclear material appears in such a form that it may be measured to determine material flow or inventory, including but not limited to, the inputs and outputs (including measured discharges) and storages in material balance areas'.

6.34 ***Key Performance Indicator (KPI)*** -Metrics that may be used to monitor the effectiveness of a nuclear material accountancy system and nuclear operations – see Section 6 of this guidance. International good practice such as Section 2.15 of Recommendation 2009/120/Euratom defines 'performance indicator' as 'a leading indicator of attainment achieved by an individual, team, organisation or an action.'

6.35 ***List of Inventory Items (LII)*** -See Physical Inventory.

6.36 ***Material Balance*** -The output from the process of comparing and reconciling the book inventory for a category of nuclear material and the amount of that material which is physically present. The balance for areas where material is processed may therefore include a statement of inventory difference (i.e. the amount of Material Unaccounted For, MUF). The term 'material balance test' is defined in international good practice such as Section 2.6 of Recommendation 2009/120/Euratom as 'the method for assessing the material balance value; taking into account the justified estimation of measurement uncertainty, the balance test will decide whether the balance is acceptable or not.' The term 'material balance discrepancy' is defined at Section 2.7 of the recommendation as 'a material balance value which is not accepted by the material balance test'.

6.37 ***Material Balance Area (MBA)*** -Defined at Regulation 2 of NSR19 as 'an area in a qualifying nuclear facility in respect of which - :

a) the quantity of qualifying nuclear material in each transfer into or out of the material balance area can be determined; and
b) the physical inventory of qualifying nuclear material in the area can be determined when necessary in accordance with specified procedures, in order that the quantity of qualifying nuclear material for safeguards purposes under NSR19 can be established.

6.38 ***Material Balance Report (MBR)*** -A report of the nuclear material in an MBA, facility, installation or other location where safeguarded nuclear material is stored or used, which shows aggregated transactions for the material balance period (e.g. year) in comparing the physical inventory with the book inventory and one of the accounting reports required by the NSR19 (Regulation 15).

6.39 ***Material Unaccounted For (MUF)*** -Terminology for an inventory difference (ID). The term is defined at Regulation 2 of NSR19 as 'the difference between the physical inventory for a material balance area and the book inventory for that material balance area.'

6.40 ***Measurement Control Programme (MCP)*** -A system to ensure the effectiveness of measurement and analytical systems and the quality of resulting data that is generated for nuclear material accountancy and safeguards purposes (e.g. using ITVs to judge performance).

6.41 ***Ministry of Defence*** (MoD)

6.42 ***Near Real Time Material Accountancy (NRTMA)*** -A form of material accountancy for bulk handling facilities in which verification of flow is supplemented by physical inventories at frequent intervals, e.g. weekly, using in-process instrumentation (generally operator equipment) that does not interfere with process operations.

6.43 ***New Measurement (NM)*** -NSR19 reporting code – see Schedule 1 of NSR19.

6.44 ***Non-Destructive Assay (NDA)*** -The measurement of the nuclear material content of an item without producing significant physical or chemical changes in the item. Non-Destructive Assay usually involves measurement of the radioactivity of the item for comparison with a calibration based on similar items whose nuclear material contents are very accurately known.

6.45 ***Non-Safeguarded nuclear material*** -Nuclear material that is excluded from the scope of NSR19 for reasons of national security and/or defence purposes. Accountancy requirements for such non-safeguarded nuclear material are specified by the Ministry of Defence (MoD).

6.46 ***Nuclear Material Account*** – A group of debit or credits entries brought together under a specific heading to indicate an accounting condition (MBA, Accounting Area, Customer, material Type).

6.47 ***Nuclear Material Accountancy (NMA)*** -A system to register material quantities and locations, track items and quantities through transfers and processes, record measurement data, and provide information for reporting and analysis. The term 'Nuclear Material Accountancy and Control' (NMAC) is defined in international good practice such as Section 2.10 of Recommendation 2009/120/Euratom as 'all activities in a nuclear installation concerning the accountancy and control of nuclear material, including the determination and processing of data and the reporting to the Commission.'

6.48 ***Nuclear Material Accountancy Control and Safeguards (NMACS) systems*** -The totality of operator measures for nuclear material accountancy to enable the implementation of nuclear safeguards.

6.49 ***Nuclear material control account*** – An account which controls a number of other accounts. It contains the totals of debits and credits of a number of accounts to show at any time the balance of the aggregate of these accounts (e.g. site account).

6.50 ***Nuclear safeguards*** -Measures, including nuclear material accountancy, to verify that civil nuclear materials are properly accounted for and are not diverted to undeclared uses.

6.51 ***Obligation Codes*** -.Nuclear material obligations are commitments on material use under nuclear supply or co-operation agreements (NCAs), the current relevant agreements are listed in references [21-24] of this document. Reporting on such obligations is a requirement of NSR19 (but is not a feature of IAEA Safeguards Implementation) and a responsibility of the operator. Obligations on peaceful end use (as agreed with supplier states and administered by BEIS) are to be identified and accounted for using obligation code (or 'flags') assigned by ONR Safeguards as an additional accountancy characteristic for the qualifying nuclear material concerned.

At present obligation codes fall into three main groups:

Code	Obligations
	Nuclear Cooperation Agreements (NCA)
A	All material subject to the UK-US NCA
C	All material subject to the UK-Canada NCA
D	All material subject to the UK-US NCA and UK-Canada NCA
S	All material subject to the UK-Australia NCA
T	All material subject to the UK-US NCA and UK-Australia NCA
	Peaceful Use
P	All material (other than that described by the codes above) supplied subject to a peaceful use clause
	Not subject to defined safeguarding obligations
N	All material which does not fall into one of the above groups, but which are nevertheless subject to Safeguards under NSR19

6.52 ***Obligation Accountancy –***

a) Obligation account stocks need to reconcile with total site stocks;
b) Methods of allocating obligations (e.g. the principals of fungibility, proportionality and equivalence) should be fully documented;
c) Obligation accounting for any blending of enriched uranium or different isotopic compositions is based on the uranium-235 and/or uranium-233 content, with appropriate adjustments on total uranium.
d) Obligation exchanges between different sites or owners are possible. The owners involved (or their delegated authorities) have the responsibility to seek prior authorisation from the ONR Safeguards. ONR Safeguards will seek confirmation of details by the site and reporting of the exchanges once authorisation to proceed is given.

6.53 ***Obligation Pool Accounting –*** Sites may have arrangements for the operation of an 'obligation pool'. There is no requirement to use pool accountancy, and such arrangements must be established by agreement with ONR Safeguards. Procedures need to ensure correct and traceable allocation of obligation codes to all nuclear material accountancy transactions and to action any obligation code swaps and loans. Addition of any new facilities to the pooling arrangements must be by agreement with ONR Safeguards. Obligations are allocated on qualifying nuclear material transferred to waste, but qualifying nuclear material in retained or conditioned waste is no longer considered as part of the pool and no longer under any requirements for obligation following and reporting. Operation of a pool means that once qualifying nuclear material enters the pool it assumes a pool obligation code flag, which is used for all movements within the pool. The stocks of each obligation code are accounted for at pool level and need not be tracked against specific items in the pool.

6.54 ***ONR Civil Nuclear Security and Safeguards (CNSS***) -The Security and Safeguards regulator for the UK's civil nuclear industry.

6.55 ***ONR NMACS regulatory issue*** – Defined for the purpose of this guidance as any NMACS matter that has the potential to degrade NMACS; challenges, regulatory compliance, challenge regulatory strategy; or impugn ONR's reputation. Any discrepancy or anomaly will typically be considered as an ONR NMACS regulatory issue.

6.56 ***Operator*** -The term ‘ operator’ is defined at Regulation 2 of NSR19 as ‘a person or undertaking setting up operating, closing down or decommissioning a qualifying nuclear facility for the production, processing, storage, handling, disposal or other use of qualifying nuclear material’ The term is also used to refer to the organisation ultimately responsible for NMACS compliance with NSR19 ’

6.57 ***Particular Safeguards Provisions (PSPs)*** -Specific requirements for the implementation of safeguards at a site or location within a site where safeguarded nuclear material is stored or used. These may be drawn up by ONR Safeguards from information provided in the BTCs and addressed to the operator, that take into account operational and technical constraints of application of the general provisions of NSR19. ONR’s use of PSPs is however expected to be limited.

6.58 ***Physical Inventory -Taking (PIT) -***The ***Physical Inventory*** is defined at Regulation 2 of NSR19 as ‘the sum of all the measured or derived estimates of batch quantities of qualifying nuclear material on hand at a given time within a material balance area, obtained in accordance with NSR19’. The Physical Inventory is therefore as determined by the operator by means of a physical inventory taking (PIT), and defined in international good practice such as Section 2.16 of Recommendation 2009/120/Euratom as ‘the process to produce a complete list of the nuclear material items for an MBA as a basis for allowing verification of physical inventory by inspectors’.

6.59 The results of the PIT must be reported to the safeguards inspectorates in the form of a ***Physical Inventory Listing (PIL),*** which lists all batches of nuclear material present at the time of the PIT. Requirements for provision of the PIL are as specified at Regulation 15 of NSR19. The PIL is supplemented by detailed information in the form of a ***List of Inventory Items (LII),*** defined in international good practice such as Section 2.5 of Recommendation 2009/120/Euratom as ‘a complete list of nuclear material (NM) items in a material balance area (MBA) or a specified location within an MBA produced as a result of applying an installation procedure. The list may include material that is handled as a batch. The list should include the identities and locations of the items or batches. The mass values and other characteristics of the items or batches should be traceable.’

6.60 ***Proportionality principle*** -The proportionality principle is a feature of NCAs and obligation accountancy and provides that where obligated nuclear material is mixed with other nuclear material, and is processed or irradiated, a proportion of the resulting material will be regarded as obligated nuclear material to the same proportion as was obligated nuclear material initially.

6.61 ***Retained waste*** -Defined at Regulation 2 of NSR19 as ‘waste which is generated from processing or from an operational accident, measured or estimated on the basis of measurements, which has been transferred to a specific location within the material balance area from which it can be retrieved.’

6.62 ***Safeguards agreement*** -An international agreement involving the IAEA, which specifies the application of safeguards by the IAEA. So-called ‘comprehensive’ or ‘full scope’ such agreements are required of non-nuclear-weapon states (NNWS) under the Nuclear Non-Proliferation Treaty (NPT). The states defined as nuclear-weapon states (NWS) under the NPT, including the UK, have agreed so-called ‘voluntary offer’ safeguards agreements in connection with the Treaty, which make some or all of their civil nuclear activities eligible for the application of IAEA safeguards. There are also safeguards agreements with the IAEA which predate and/or do not relate directly to the NPT, but provide for IAEA safeguards application to particular nuclear material and/or facilities (many of which are known as ‘INFCIRC/66’ type agreements).

6.63 ***Safeguards By Design (SBD)*** -to ensure that safeguards requirements are fully integrated into the design process stages (design, construction, commissioning, operation and decommissioning) and the project management structure from project inception.

6.64 ***Safeguards Inspectorate*** -International nuclear safeguards are measures to verify that countries abide by their commitments to use nuclear material for declared peaceful purposes. The necessary international confidence is based on independent verification by the international safeguards inspectorate of the International Atomic Energy Agency (IAEA).

6.65 ***Seal*** -A tamper indicating device used to join movable segments of containment in a manner such that access to its contents without opening the seal or breaking of the containment is difficult. A sealing system comprises the containment enclosing the material to be safeguarded, the means of applying the seal (e.g. a metal wire) and the seal itself. All three components must be examined in order to verify that the sealing system has fulfilled its function of ensuring continuity of knowledge of the identity and integrity of the material concerned. See also containment.

6.66 ***Shipper/Receiver Difference*** (SRD) -Defined at Regulation 2 of NSR19 as 'the difference between the quantity of qualifying nuclear material in a batch as stated by the shipping material balance area and as measured at the receiving material balance area .'

6.67 ***Small Holder of Nuclear Material (SHNM)*** -Those responsible for nuclear material which is not at a facility as defined in the UK/IAEA Safeguards Agreement but is nevertheless subject to the safeguards requirements of NSR19 (Regulation 31), for example:

a) universities, colleges and research institutes that use nuclear material for academic studies;
b) analytical laboratories that use nuclear material as reference sources;
c) manufacturers of measurement instruments that use sealed sources as standards for calibration and/or who use plutonium, enriched uranium or uranium-233 in gram quantities or less as sensing components in instruments (e.g. for fission chambers or smoke alarms); and
d) organisations that use depleted uranium, natural uranium or thorium in exclusively non-nuclear activities (e.g. as radiation shielding, including depleted uranium transport containers for medical or industrial radioisotopes, as ballast/counterweights, as high hardness alloys of the kind used in aerospace applications, as catalysts for use in the chemical industry or as pigments in glass)

6.68 ***Source data*** -Defined at Regulation 2 of NSR19 as 'those data, recorded during measurement or calibration or used to derive empirical relationships, which identify qualifying nuclear material and provide batch data, including: weight of compounds; conversion factors to determine weight of element; specific gravity; element concentration; isotopic ratios; relationship between volume and manometer readings; and relationship between plutonium produced and power generated'.

6.69 ***State) System of Accountancy and Control (SSAC)*** -Organisational arrangements to account for and control nuclear material in a state, which amongst other things provide the basis for application of IAEA safeguards – and as such are a requirement of safeguards agreements with the IAEA. The ONR CNSS operates the SSAC for the UK/IAEA voluntary offer safeguards agreement.

6.70 ***Waste*** - Defined at Regulation 2 of NSR19 as qualifying nuclear material in concentrations or chemical forms irrecoverable for practical or economic reasons and which is intended to be disposed of. See also ***Conditioned Waste*** and ***Retained Waste***.