A Holtec International Company

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Record Title:

Preliminary Safeguards Report

Proprietary Classification

This record does not contain commercial or business sensitive information.

Export Control Status

Export Control restrictions do not apply to this record.

Revision Log

0	Initial Issue.
1	Updated to reflect work conducted during GDA Step 2
2	Updated following ONR review of R1

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1.0 INTRODUCTION

1.1 Background

Holtec International (Holtec) is planning to deploy its 300 MWe Small Modular Reactor (SMR-300) in the United Kingdom (UK). As the first step, Holtec (via its UK Division, Holtec Britain) is submitting its SMR-300 design for Steps 1 and 2 of the Generic Design Assessment (GDA) process by the UK nuclear regulators, namely the Office for Nuclear Regulation (ONR), the Environment Agency and Natural Resources Wales.

To complete Steps 1 and 2 of the GDA, Holtec is required to submit safety, security, safeguards, and environmental documentation for assessment by the regulators during both steps of the GDA. The Preliminary Safeguards Report (PSgR) is the safeguards submission to ONR.

Revision 0 of the PSgR was issued to ONR during Step 1. Revision 1 was issued during Step 2. This document is Revision 2 reflecting minor amendments following discussion with ONR.

1.2 Aim and Objectives of the GDA Step 2 Preliminary Safeguards Report

ONR provides technical guidance on the expected GDA safety, security, and safeguards submissions [1]. On safeguards, this ONR guidance states that '*During GDA, it is expected that the documentation submitted by the RP (Requesting Party) will need to demonstrate their understanding of safeguards requirements at the generic (international/national) level and how they will be accommodated in the generic design*'. However, no specific guidance is given as to what is expected to be submitted on safeguards for each step of the GDA.

The SMR-300 GDA Step 2 safeguards submission is an evolution of the Step 1 PSgR to reflect the developments in the design and layout of the SMR-300 and the associated safeguards arrangements. In particular, it presents:

- Holtec's understanding of the safeguards requirements at the generic (international and UK domestic) level and Relevant Good Practice (RGP).
- An outline at a high level of the SMR-300 safeguards programme, i.e. how the safeguards requirements will be delivered for the SMR-300 through all phases of its lifecycle, and progress in its implementation during Step 2.
- An outline of the SMR-300 safeguards case and the main safeguards claims, showing how these claims integrate with the SMR-300 Safety, Security and Environmental Case (SSEC), and progress on the development of the safeguards case.
- The basis for the accommodation of the safeguards requirement in the generic SMR-300 design, including information on the development of the safeguards design objective and safeguards design principles, and progress in the implementation of Safeguards by Design (SgBD).
- Progress on the development of conceptual safeguards arrangements, including Qualifying Nuclear Material (QNM) Flow and potential Material Balance Areas/Key Measurement Points (MBA/KMP).
- An outline of the evolution from GDA Step 2 to site licensing in the safeguards area, in accordance with the SMR-300 safeguards programme.

The overall aim of this Step 2 PSgR is to contribute positively to the ONR Step 2 public statement that there are no fundamental safeguards shortfalls that could prevent ONR permissioning the construction of a power station based on the generic SMR-300 design information provided for GDA.

1.3 Structure of Step 2 PSgR

This GDA Step 2 PSgR delivers the above objectives as follows:

Table 1: Structure of PSgR

Section	Presents:
3.0	Holtec's understanding of the International and UK safeguards framework.
4.0	RGP relevant to the deployment of an SMR-300 in the UK.
5.0	Outline of the SMR-300 safeguards programme.
6.0	Outline of conceptual SMR-300 nuclear material flow and storage.
7.0	Outline of the SMR-300 safeguards case.
8.0	Development of the safeguard design objective and safeguard principles, and incorporation of SgBD.
9.0	Outline of conceptual SMR-300 nuclear material accountancy and control.
10.0	Compliance with the ONR Nuclear Material Accounting Control and Safeguards (ONMACS) principles
11.0	The evolution from this document to the safeguards submission for nuclear site licensing.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Project Definitions and Abbreviations

Term	Definition
ACP	Accountancy and Control Plan
ALARP	As Low As Reasonably Practicable
AP	Additional Protocol
BTC	Basic Technical Characteristic
CNSC	Canadian Nuclear Safety Commission
c/s	Containment and Surveillance
CS	Containment Structure
CSA	Comprehensive Safeguards Agreement
DIQ	Design Information Questionnaire
DIV	Design Information Verification
EU	European Union
FHA	Fuel Handling Area
FSE	Fundamental Safeguards Expectations
GDA	Generic Design Assessment
IAEA	International Atomic Energy Agency
ID	Inventory Differences
IMSR400	Integral Molten Salt Reactor 400 MWe
ISFSI	Independent Spent Fuel Storage Installation
KMP	Key Measurement Point
LII	List of Inventory Items
MACE	Nuclear Material Accounting and Control Expectations
MBA	Material Balance Area
MBE	Material Balance Evaluation
MPC	Multi-Purpose Cask
MUF	Material Unaccounted For
MWe	Mega Watt electrical
NCA	Nuclear Cooperation Agreement
NFS	New Fuel Store
NFV	New Fuel Vault
NMAC	Nuclear Material Accounting and Control
NMACS	Nuclear Material Accounting, Control and Safeguards
NPT	Non-Proliferation of Nuclear Weapons Treaty
NSR19	Nuclear Safeguards Regulations 2019
ONR	Office for Nuclear Regulation
ONMACS	ONR Nuclear Material Accounting, Control and Safeguards
PIT	Physical Inventory Taking
PIV	Physical Inventory Verification
PSgR	Preliminary Safeguards Report
QNF	Qualifying Nuclear Facility

Term	Definition
QNM	Qualifying Nuclear Material
RAB	Reactor Auxiliary Building
RGP	Relevant Good Practice
RP	Requesting Party
RR SMR	Rolls-Royce Small Modular Reactor
SFP	Spent Fuel Pool
SFSR	Spent Fuel Storage Racks
SgBD	Safeguards by Design
SgC	Safeguards Claim
SgDP	Safeguards Design Principles
SMR-160	160 MWe Small Modular Reactor
SMR-300	300 MWe Small Modular Reactor
SQ	Significant Quantity
SQEP	Suitably Qualified and Experienced Personnel
SRA	State Regulatory Authority
SSAC	State System of Accounting for Control of Nuclear Material
SSEC	Safety, Security and Environmental Case
SSC	Structures, Systems and Components
TAG	Technical Assessment Guide
TIG	Technical Inspection Guide
USNRC	United States Nuclear Regulatory Commission
UK	United Kingdom of Great Britain and Northern Ireland
VCT	Vertical Cask Transporter
VDR	Vendor Design Review
VOA	Voluntary Offer Agreement
VVM	Vertical Ventilated Module

3.0 INTERNATIONAL AND NATIONAL SAFEGUARDS FRAMEWORK

3.1 International Framework

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) [2] places a responsibility on the International Atomic Energy Agency (IAEA) to independently verify that non-nuclear-weapon signatory States fulfil their obligations to not divert nuclear material from peaceful uses to nuclear weapons or other nuclear explosive devices. IAEA delivers this independent verification responsibility via a set of technical measures, collectively known as 'Safeguards'.

Non-nuclear-weapon signatory States are required by the NPT to sign a Comprehensive Safeguards Agreement (CSA) with IAEA to enable IAEA to verify that the State has fulfilled its obligation under the treaty. The five nuclear-weapon signatory States are not required to sign a CSA by the NPT but have all signed a Voluntary Offer Agreement (VOA) with IAEA. The basis for the CSAs and VOAs is a system of reporting/declaration (by the State) and independent verification (by IAEA).

Each State which is a signatory to the NPT develops a domestic safeguards framework to deliver its international safeguards obligations under the CSA or VOA. The international and domestic safeguards framework as it applies to the UK is illustrated at a high level in Figure 1. The remainder of this section provides an overview of the UK domestic framework together with the UK regulatory guidance and expectations.

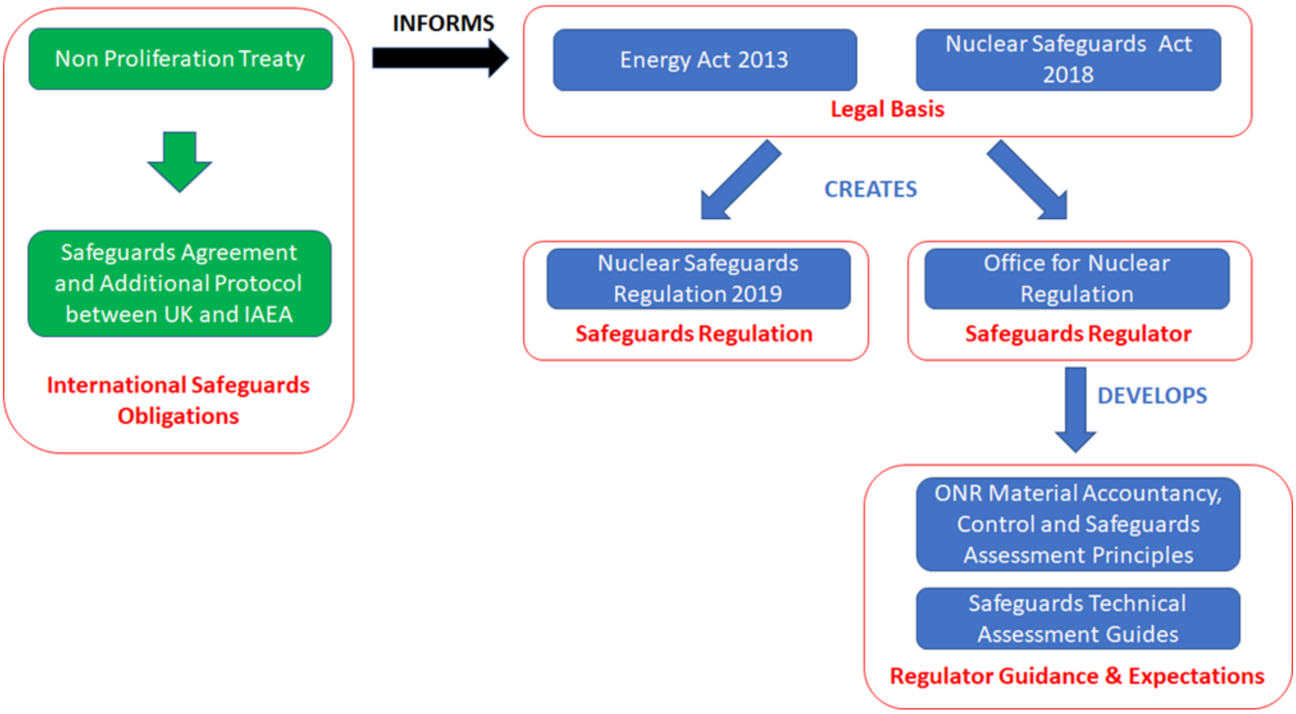

Figure 1: International and UK Safeguards Framework

3.2 UK International Safeguards Obligations

As a nuclear-weapon State, the UK's international safeguards obligations originate from the signing of the VOA [3] with IAEA. The common objective of this VOA is *'the timely detection of withdrawal from civil activities, except as provided for in this Agreement, of significant* *quantities of nuclear material which is being safeguarded in facilities'.* The VOA prescribes a safeguards regime of reporting (by the UK) and independent verification (by IAEA).

Additionally, the UK has signed an Additional Protocol (AP) to the VOA [4]. The AP extends the UK reporting to provide IAEA with additional verification measures aimed at strengthening and improving the efficiency of IAEA safeguards processes.

The UK has also entered into Nuclear Cooperation Agreements (NCAs) with several states which can also affect safeguarding requirements, guidance on these is given in [5].

3.3 UK Safeguards Legal Basis and Regulatory Framework

The Energy Act 2013 [6] and the Nuclear Safeguards Act 2018 [7] provide the legal basis for the delivery of the UK's international safeguards obligations. Under the powers contained within these Acts:

- The Nuclear Safeguards Regulations (European Union (EU) Exit) 2019 (NSR19) [8] were made to define the domestic safeguards regime for delivery of the UK's international safeguards obligations. Parts of the regulations are prescriptive, while others are outcome-focused in line with the extant UK regulatory approach for the nuclear industry.
- ONR was established as the UK safeguards regulator, responsible for the implementation of the domestic safeguards regime to enable the UK to meet its international safeguards obligations.

It is noted that while the VOA is focused on the withdrawal of significant quantities of nuclear material for non-proliferation purposes, NSR19 covers any facility[1] holding nuclear material.

As the UK's State Regulatory Authority (SRA) for safeguards under NSR19, ONR is the focal point of contact between the UK and IAEA on safeguards and is responsible for:

- Establishing, implementing, and maintaining the UK State System of Accounting for and Control of Nuclear Material (SSAC) within the civil nuclear programme. A high-level overview of the UK SSAC framework is illustrated in Figure 2 below.
- The provision of an annual safeguards report to the UK government and the publication of prescribed UK nuclear material inventory information on the ONR website.

[1] NSR19 uses the term 'Qualifying Nuclear Facility' (QNF), see Footnote 9 for full definition.

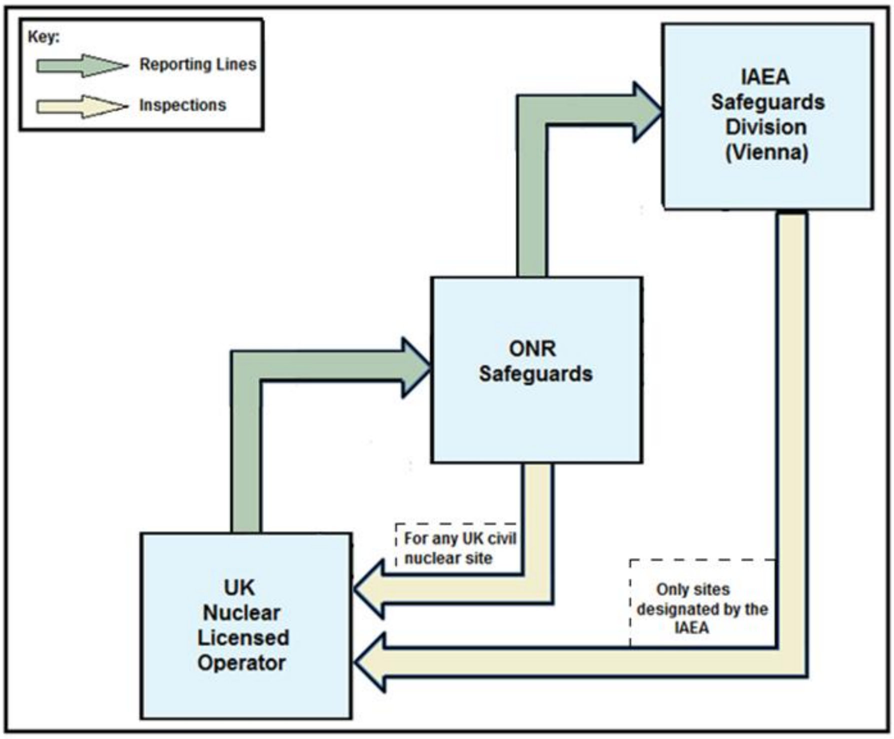

Figure 2: High Level Overview of the UK SSAC Framework
(Reproduced from [9] [2, 3])

Referring to Figure 2, ONR's responsibilities include the following:

- Provision of Nuclear Material Accounting and Control (NMAC) reports and safeguards declarations to the IAEA required under the VOA.
- Provision of additional safeguards reports to the IAEA required under the AP.
- Provision of assurance that the UK SSAC is functioning correctly.
- Facilitation of IAEA's safeguards verification activities at sites designated by the IAEA from a Facilities List of civil nuclear sites.

To deliver these responsibilities, ONR maintain and provide to IAEA a Facilities List of UK civil nuclear facilities subject to safeguards (referred to as a Qualifying Nuclear Facility[4] (QNF)) and carry out a range of activities associated with these QNF, which include:

- Ensuring compliance with NSR19 at the QNF via reviews and compliance inspections.

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[2] Note that Figure 2 refers specifically to facilities on the SSAC framework.

[3] As noted earlier in this section NSR 19 covers all sites with nuclear material, not just civil nuclear sites as implied by this figure.

[4] 'Qualifying Nuclear Facility' is the term used in UK regulatory documents. The equivalent term used in IAEA documents is 'facility' which is defined 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".

- Review of the Basic Technical Characteristics (BTCs) for QNF and, if considered necessary, ONR may impose 'particular safeguards provisions'[5] on the QNF operator[6].
- Inspections of QNF to ensure that their NMAC system is functioning correctly, and that the operator is submitting accurate and up to date NMAC reports to ONR. This may include the use of seals and other tamper-indicating devices to ensure continuity of knowledge.
- If designated by IAEA as a Facility for independent verification, arranging for the installation by the Facility operator of IAEA safeguards verification equipment and arranging IAEA access to facilitate their independent verification activities[7].

A summary of the safeguarding activities carried out by ONR as the SRA for safeguards is reported in the ONR Safeguards Annual Report [10].

3.4 UK Regulatory Guidance and Expectations

The ONR publish guidance and expectations to QNF operators to facilitate the delivery of its responsibilities as SRA. Some of this guidance is necessarily prescriptive to facilitate ONR's own reporting to the IAEA.

Most of the guidance relates to QNF during, or close to commencing, the operational phase of the facility lifecycle. However, the guidance provides invaluable information to inform design developments as part of SgBD. This guidance includes the following key documents set out in Table 2:

Table 2: Key ONR Safeguards Regulatory Guidance

ONR Document	Description
ONR Nuclear Material Accountancy, Control, and Safeguards (ONMACS) Assessment Principles [9]	This document details the regulatory expectations for compliance with NSR19 for new or existing QNF throughout the facility lifecycle. More specifically it presents the Fundamental Safeguards Expectations (FSE) for the operator's NMAC system and reporting. It details the outcomes to be achieved for each FSE via one or more Nuclear Material Accountancy and Control Expectations (MACE). There are ten FSE covering both Nuclear Material Accountancy, Control, and Safeguards (NMACS) strategic enablers and nuclear material control: <u>Strategic Enablers</u> FSE 1 NMACS Leadership and Management FSE 2 Organisational Culture FSE 3 Competence Management FSE 4 Reporting, Anomalies, and Investigations FSE 5 Reliability, Resilience, and Sustainability <u>Nuclear Material Control</u> FSE 6 Measurement Programme and Control FSE 7 Nuclear Material Tracking FSE 8 Data Processing and Control FSE 9 Material Balance FSE 10 NMACS Quality Assurance and Control

[5] 'Particular safeguards provisions' are particular safeguards provisions that may be imposed by ONR under regulation 5 of NSR19.
[6] Operator is defined in 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'.
[7] Under the UK VOA, IAEA designates Facilities for independent verification from a Facilities List provided by ONR to IAEA.

ONR Document	Description
Safeguards Technical Assessment Guide (TAG) [11]	This document presents the regulatory expectations for the following NMAC reporting and safeguards declarations by the QNF operator, as required by NSR19: QNF BTC. Annual Outline Programme of Activities. Accountancy and Control Plan (ACP).
Nuclear Material Accountancy TAG [12]	This document presents the regulatory expectations for the detailed nuclear material inventory reporting and special reports by the QNF operator, as required by NSR19.
Safeguards Technical Inspection Guide (TIG) [13]	This document provides guidance and a framework for ONR inspectors assessing the compliance with NSR19, inspecting NMAC systems, and the facilitation of IAEA verification activities on designated sites.
Reporting under the AP [14]	This document provides guidance for the reporting under the AP. This includes declarations on nuclear fuel cycle-related research and development activities with a non-nuclear weapon State, approved plans relevant to the development of the civil nuclear fuel cycle and specific exports and imports to non-nuclear weapon States.

4.0 RELEVANT GOOD PRACTICE

4.1 UK RGP

The ONR safeguards guidance documents identified in Table 2 represent RGP for the delivery of the safeguards requirements in the UK. Specific safeguards RGP for design development, licensing and GDA of new reactors in the UK is currently limited.

RGP on safeguards during the design development and licensing of a new reactor plant in the UK can be inferred from publicly available ONR safeguards assessment reports [19], [20], [21], [22], [23] related to the licensing for the Hinkley Point C and Sizewell C nuclear power plants. Although some of these ONR assessments were performed prior to the issue of NSR19, the RGP remains applicable. These ONR reports identify the importance of early and regular proactive interaction with ONR during the licensing process[8] to demonstrate the operator's commitment, discuss the BTC, and exchange information with the view of agreeing efficient and effective NMAC and safeguards arrangements as part of the SgBD process. The GDA presents an early opportunity to commence the interactions with ONR (and IAEA if requested by the RP) in these areas and demonstrate Holtec's commitment to safeguards.

The first GDA which included safeguards is the GDA of the Rolls-Royce Small Modular Reactor (RR SMR). The RR SMR Step 2 safeguards submission is publicly available [24] and has therefore helped to form the basis of RGP for this PSgR.

4.2 International RGP

The ONR safeguards guidance has been informed by the IAEA safeguards guidance and associated documentation which, themselves, provide a broader source of RGP. During the design development for a new reactor plant, licensing and the GDA, the following IAEA publications provide relevant RGP information:

1. NP-T-2.8 International Safeguards in Nuclear Facility Design and Construction [16].
2. NP-T-2.9 International Safeguards in the Design of Nuclear Reactors [17].
3. Safety Reports Series No. 123, Applicability of IAEA Safety Standards to non-water cooled reactors and small modular reactors [18].

Informed by IAEA documentation and their own CSA (or VOA), SRA around the world publish guidance for use in the delivery of the nation's safeguards obligations. This guidance is an additional source of RGP, but the guidance needs to be considered with care for UK purposes as it will have been tailored to the nation's individual agreement with IAEA and their nuclear regulatory approach, both of which may be different to the UK. However, the principles of safeguards and SgBD remain the same.

Noting the above, a relevant source of RGP for the development of the NMACS arrangements and SgBD for the Holtec SMR-300 is the United States Nuclear Regulatory Commission (USNRC). This is because the generic SMR-300 Reactor is being designed in the US in accordance with USNRC regulatory requirements, including SgBD.

Additionally, and specifically to the GDA, Canada has a pre-licensing process with similar aims to the GDA in which vendors can submit their generic reactor design for the assessment by the Canadian Nuclear Safety Commission (CNSC) as part of their Vendor Design Review (VDR) process [26]. One of the CNSC VDR Focus Areas (Focus Area 15) covers safeguards

[8] It is noted that ONR highlights the importance of early engagement in their licensing guide [25], in which they state that '*Early engagement with us is both a requirement under NSR19 (for example, preliminary information on new facilities must be provided to ONR before construction starts) and key to defining effective and efficient arrangements for safeguards verification and inspection activities*'.

[27]. Although the Canadian safeguards obligations differ from the UK in that Canada has a CSA with IAEA (and not a VOA) and the detailed reporting requirements differ, the safeguards objectives and principles remain the same. Hence the Canadian safeguards VDR experience can be considered relevant, in particular for SgBD during design development. .The experience gained supporting the safeguards elements of the VDR for the Terrestrial Energy Integral Molten Salt Reactor 400 MWe (IMSR400) [28] and the development of and discussions with CNSC/IAEA on the SgBD Design Information Questionnaire (DIQ) which is the equivalent of the BTC has informed this PSgR.

5.0 OVERVIEW OF SMR-300 SAFEGUARDS PROGRAM

5.1 Introduction

The SMR-300 will be a QNF subject to the full extent of the NSR19 requirements because it is a reactor plant and will contain sufficient quantity of QNM[9]. As a QNF, any SMR-300 deployed in the UK will be included in the UK Facilities List issued by ONR to IAEA for safeguards purposes and hence may be subject to independent verification by the IAEA.

Holtec is fully committed to supporting ONR in the delivery of the UK's international obligations under the UK VOA and AP. Equally, Holtec is committed to SgBD during the design development process. To this end, Holtec has developed and is implementing a holistic through-life safeguards programme for the SMR-300, starting during the design development phase.

[9] Under NSR19, a QNF is a facility that is used for the production, processing, storage, handling, disposal, or other use of QNM (i.e. plutonium, high enriched uranium (20% enrichment or above), low enriched uranium, natural uranium, depleted uranium, and thorium). A QNF is subjected to the full extent of the NSR19 requirements unless it is:

- A 'qualifying nuclear facility with limited operations' in accordance Regulation 2 of NSR19 because of the type of facility and quantity of QNM within it, in which case the operator may apply to ONR for the facility to be subjected to a safeguards 'regime with limited operation' as defined in Part 7 of NSR19.
- Exempted in accordance with Regulation 32 of NSR19 because it is an educational establishment with a small holding of QNM or it holds 'only end products which are used for non-nuclear purposes and which incorporate qualifying nuclear material that is, in practice, irrecoverable'.

5.2 SMR-300 Safeguards Programme

An illustration of the key elements of the SMR-300 safeguards programme and the associated regulatory interface is given in Figure 3 and an overview is provided below in this section, concentrating on the earlier stages of the programme which are directly relevant to the GDA.

[REDACTED]

Figure 3: SMR-300 Safeguards Programme

5.2.1 Safeguards Programme Enablers

The SMR-300 safeguards programme recognises that while SgBD is a key enabler to the delivery of the UK's international obligations and is the focus of the programme during design development, a robust safeguards management system and supportive culture are required during all stages of the project lifecycle (see Figure 4) to ensure a successful cost-effective and efficient delivery.

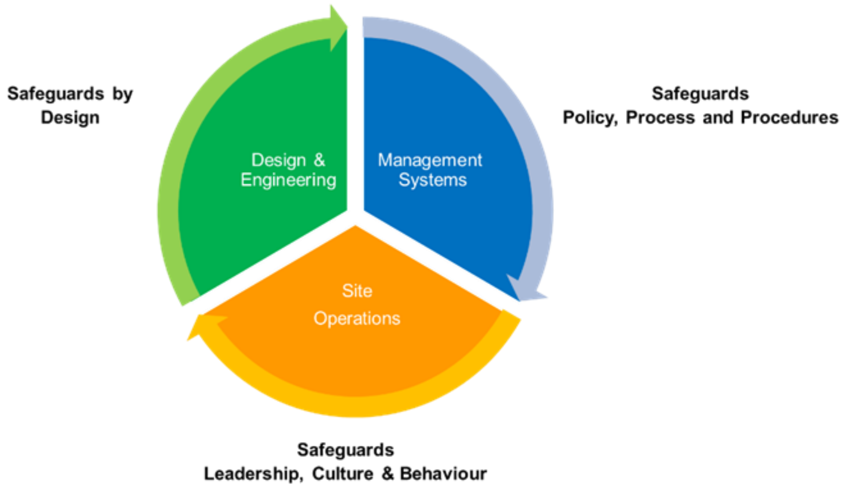


Figure 4: SMR-300 Safeguards Programme Enablers

5.2.2 Design Development and GDA

The SMR-300 safeguards programme starts during design development, as illustrated in Figure 3. International safeguards experience shows that considering safeguards as an integral part of the design process rather than retrospectively offers many benefits to all stakeholders (designer, site-specific operator, SRA, and IAEA) and so this is promoted by IAEA as part of SgBD [16].

SgBD is the focus of the SMR-300 safeguards programme during design development/GDA and the main activities during this period are to:

(a) Include safeguards in the Holtec SMR-300 design processes (e.g. design principles, design review processes). The Holtec SMR-160 Safeguards design standards have been adopted for the design of the SMR-300 [29].

(b) Set safeguards within the overall company organisational structure and governance, detailing roles and responsibilities. Holtec Britain has a Safeguards Manager reporting to the Project Director, see Section 10.0.

(c) Build inherent proliferation resistance in the design of the SMR-300 by, for example:

- Reducing the attractiveness of the nuclear material.
- Minimising withdrawal paths.
- Minimising the possibility of misuse of the plant[10].

[10] IAEA refers to misuse as the 'misuse of a safeguarded facility for undeclared activities or the undeclared production of weapons usable material' [17].

(d) Facilitate the development of a cost-effective NMACS approach by:

- Identifying and minimising MBA[11] and KMP[12]. A preliminary MBA/KMP structure has been developed during the GDA and is reported in Section 9.0.
- Identifying potential NMACS equipment for the SMR-300.

(e) Safeguards-inform the SMR-300 design and layout to:

- Accommodate the potential SMR-300 NMACS system and equipment (e.g. space, uninterruptible power supply, cabling, penetrations), this is identified in the set of safeguards design requirements for the SMR-300 [29].
- Accommodate the potential ONR safeguards equipment required for inspection purposes and facilitate access by ONR to the equipment.
- Make provisions to accommodate IAEA safeguards equipment for their independent verification activities, should the SMR-300 be designated by IAEA for independent verification from the Facilities List.

(f) Integrate safeguards with nuclear safety, nuclear security, and operations at the SMR-300, for example to:

- Deliver an optimised design (e.g. via the common use of equipment).
- Ensure that NMACS equipment and supporting infrastructure is adequately protected against sabotage[13] by the SMR-300 security arrangements. This is reflected in the security design requirements for the SMR-300 [29] and the GDA security documentation.
- Ensure that NMACS equipment and supporting infrastructure has sufficient hazard withstand capability to remain operable during emergency conditions and nuclear security events.
- Ensure that NMACS activities can be carried out without impeding operations.

(g) Start regular engagement with the ONR Safeguards Team (e.g. via the GDA interactions) and IAEA (if requested by the RP) to:

- Familiarise the regulators with the SMR-300 safeguards programme, the safeguards case, relevant aspects of the SMR-300 design and operations (e.g. nuclear material inventory, fuel route) and preliminary NMACS arrangements.
- Ensure Holtec fully understand the ONMACS requirements and expectations.
- Discuss potential NMACS systems and equipment.
- Discuss AP reporting.

Regular regulatory engagement commenced during Step 1 of the GDA and is currently ongoing.

(h) Deliver a SgBD BTC to support engagement with ONR. The SgBD BTC will follow the format prescribed in NSR19 for '1-A Reactors' so that it can be readily updated for formal issue to ONR at a later stage in the SMR-300 safeguards programme (See Section 5.2.3 (b) below). Two revisions of the SgBD BTC have been issued to ONR

[11] An MBA is defined by 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 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 these Regulations can be established'.

[12] A KMP is defined by NSR19 as '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 discards) and storages in material balance areas'.

[13] Sabotage in this context refers to manipulation or tampering to conceal the withdrawal of nuclear material.

during the GDA [30].

A separate BTC for the Independent Spent Fuel Storage Installation (ISFSI) will be produced in line with timescales for deployment of the ISFSI.

5.2.3 Site-Specific Design to Start of Operations

The SgBD activities undertaken during design development continue during this period, as appropriate, but the focus of the SMR-300 safeguards programme changes to:

(a) The detailed design, procurement, installation, and commissioning of a proportional and appropriate NMACS system for the SMR-300 and associated equipment. This may also include the installation of safeguards equipment which will be required by:

- ONR for their inspections to gain assurance that the SMR-300 NMAC system was functioning correctly and accurate and up to date NMAC reports were being submitted by the SMR-300 operator.
- IAEA for their independent Physical Inventory Verification (PIV) activities, if the SMR-300 site is designated for inspection by IAEA.

(b) The formal provision of SMR-300 design information to ONR so that the Design Information Verification (DIV) can be carried out. This will be in the form prescribed in NSR19 for '1-A Reactors' and in accordance with the schedule prescribed in NSR19 for a new QNF as follows:

- The preliminary site-specific BTC as soon as the decision is taken to construct the SMR-300.
- The detailed BTC, not later than 200 days prior to the start of construction.
- The as-built BTC, not later than 200 days prior to the receipt of first QNM.

(c) Preparedness for the start of operations, informed by the ten ONMACS strategic enabler and material control FSE [9], see Table 2 above. This will include, in accordance with NSR19:

- The implementation of any particular safeguards provisions required by ONR following their review of the SMR-300 BTC.
- The issue to ONR of the SMR-300 ACP for approval, not later than 200 days prior to the arrival of QNM on site, and the Annual Outline Programme of Activities.
- Development of operator NMAC processes and procedures.
- Development and delivery of operator training to support and deliver NMAC processes.

An initial review of compliance with the ONMACS FSE has been carried out during the GDA and reported in Section 10.0.

At some point during this period, responsibility and leadership for the site-specific SMR-300 safeguards programme will transition from Holtec (as the designer) to the site-specific SMR-300 operator. The aim will be a seamless transition of responsibility at a date to be agreed between Holtec and the future SMR-300 operator, ensuring effective oversight of the transfer of safeguards information from the GDA to site licensing/operations.

5.2.4 Start of Operations to End of Life

The focus of the SMR-300 safeguards programme during the operational phase through to decommissioning (whilst the SMR-300 remains a QNF) is on NMACS reporting as prescribed by ONR [12], [14] and facilitating inspections by ONR and IAEA, as necessary [13]. This will require:

(a) The operator to issue to ONR a broad range of safeguards related information in accordance with NSR19, including:

- On an annual basis, the Annual Outline Programme of Activities to ONR prior to the start of each calendar year.
- Advance notification of at least 40 days prior to the taking of a physical inventory.
- NMAC operating records, accounting records and reports, and special reports.
- Notification of any changes that affect any of the above at the earliest opportunity.
- Notification of a change in the BTC for the SMR-300 at least 30 days prior to the day on which the change is completed unless advance notification to ONR of such a change is required by any particular safeguard provisions imposed on the operator by ONR following their review of the BTC.
- Advance notification of import/export of SMR-300 QNM.

(b) The maintenance and potential upgrade of SMR-300 NMACS equipment and the maintenance of a SQEP (Suitably Qualified and Experienced Personnel) resource to operate the NMAC systems and deliver the prescribed NMACS reporting.

(c) The retention of the SMR-300 NMAC records and reports for at least five years and making these available to ONR for inspection at any time.

Additionally, SgBD will continue as required, for example during the design of plant modifications.

6.0 NUCLEAR MATERIAL FLOW AND STORAGE

The QNM within the SMR-300 is divided into two groups for the purpose of this report:

1. Reactor Fuel Assemblies
2. Other QNM

The flow and storage of this QNM is discussed in the following two sections.

6.1 Reactor Fuel Assemblies

Nuclear fuel within the SMR-300 site arrives predominantly as U_{235} in the form of UO_2, delivered to site pre-assembled for use as fuel in a thermal nuclear reactor. The flow of reactor fuel assemblies through the SMR-300 site is summarised in Figure 5 below.

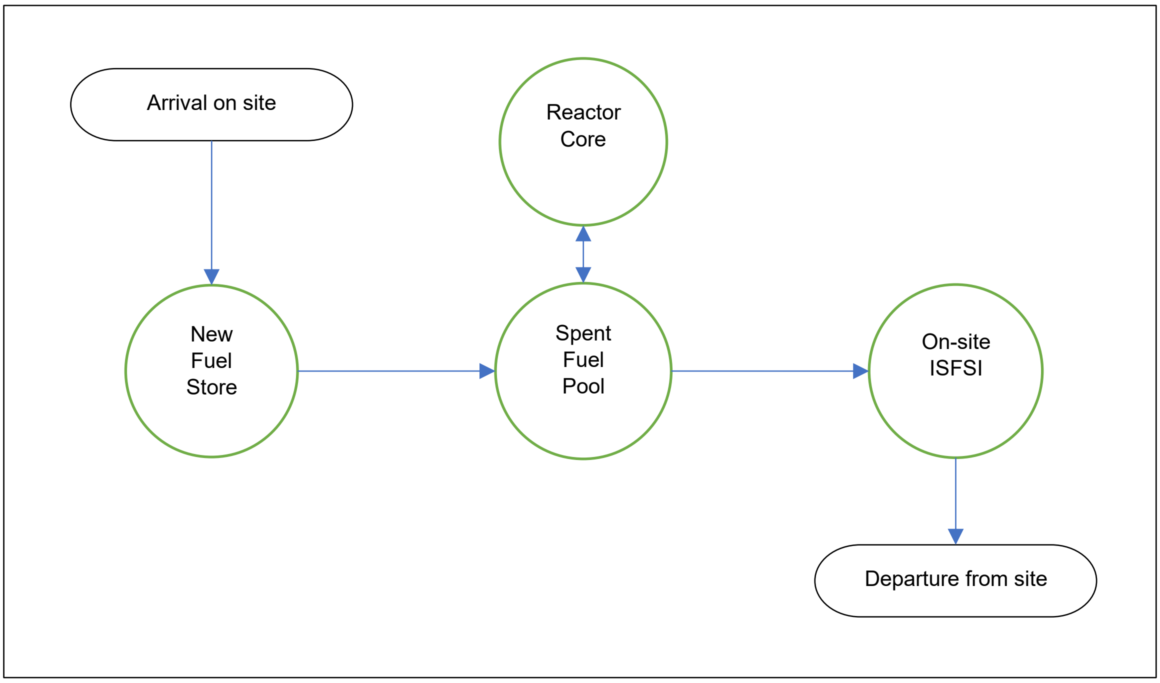


Figure 5: Flow of reactor fuel assemblies through the SMR-300 Site.

[REDACTED]

6.2 Other QNM

Other QNM is anticipated on site over the project life cycle. At the time of writing, the precise details of this other QNM, its storage and flow are still in development. Other QNM may comprise of items of similar size and form to fuel assemblies, which would progress through the site in the same manner as fuel assemblies, or of smaller items which would be stored in secure storage locations within the MBA.

7.0 OVERVIEW OF THE SMR-300 SAFEGUARDS CASE

7.1 Introduction

The fundamental objective of the SMR-300 safeguards case is to demonstrate how the SMR-300 safeguards programme will support ONR in the delivery of the UK obligations as required by NSR19, including provision of information to the IAEA in accordance with the UK VOA and AP. Following on from Section 3.2, this requires that:

1. The undeclared withdrawal of a Significant Quantity (SQ) of QNM from the SMR-300 site will be detected in a timely manner[14] in accordance with the VOA.
2. The SMR-300 designer/operator will provide the reporting required by the AP.
3. The SMR-300 designer/operator will support ONR in the delivery of its NSR 2019 obligations.

These three safeguards requirements are the high-level Safeguards Claims (SgCs) delivered by the SMR-300 safeguards case, as shown diagrammatically below.

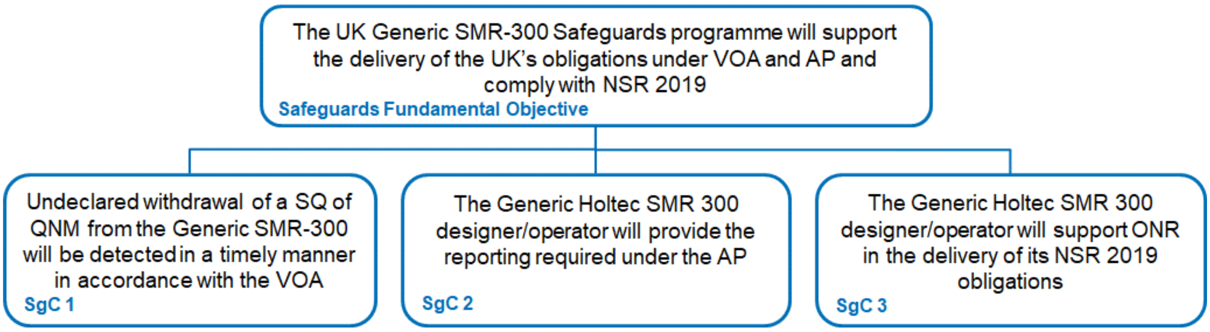


Figure 6: SMR-300 Safeguards Case Fundamental Objective and High Level SgC

This section presents an outline of the SMR-300 SgC, focusing on the main safeguards sub-claims and general arguments supporting the above high level SgC.

7.2 SgC 1 - Timely Detection of Undeclared Withdrawal of QNM

A holistic approach is used in the SMR-300 safeguards programme to deliver SgC 1, throughout the SMR-300 project lifecycle. This will involve a combination of design measures, procedural measures, deterrence, nuclear material accounting and reporting, inspection and independent verification which can be grouped into three safeguard sub-claims as shown and discussed below:

[14] The IAEA inspection goal for their verification activities at a specific facility comprises a quantity and a timeliness component. The quantity component is derived from the 'approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive device cannot be excluded', which is defined by the IAEA as a SQ [33]. The timeliness (i.e. timely detection) component is derived from the 'time required to convert different forms of nuclear material into the metallic components of a nuclear explosive device' which is defined by the IAEA as the conversion time [33]. The SQ and conversion time current used by IAEA in establishing the quantity and timeliness components are shown in Appendix A.

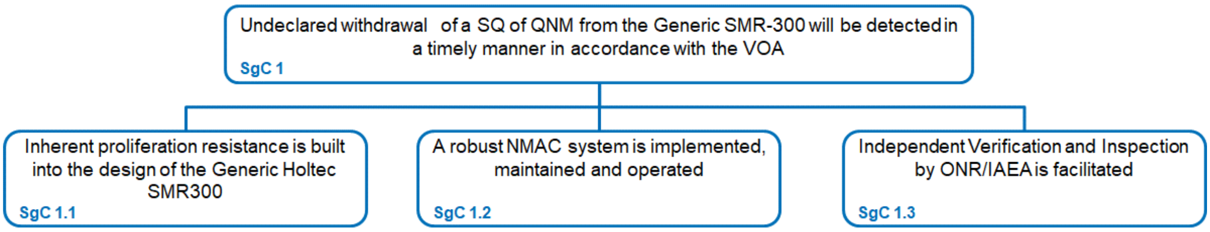


Figure 7: SMR-300 SgC 1 and Sub-claims

7.2.1 SgC 1.1 - Inherent Proliferation Resistance

[REDACTED]

However, consideration is given as part of the SgBD process during the design development phase, to design measures that reduce the attractiveness and potential for the State to covertly divert significant quantities of QNM abruptly or protractedly[15] from an SMR-300 plant for the manufacture of nuclear weapons. These include consideration of the following during design development, as appropriate:

- Attractiveness of the nuclear material within the SMR-300 site for the manufacture of nuclear weapons.
- Minimisation of QNM storage areas and accumulation of QNM within the site.
- Minimisation of paths for the abrupt or protracted withdrawal of significant quantities of QNM.
- Accessibility to potential withdrawal paths to make it difficult to covertly remove QNM.
- Optimisation of layout/space to prohibit the covert misuse of the SMR-300 site for proliferation purposes.

7.2.2 SgC 1.2 - Implementation of a Robust NMAC System

[REDACTED]

To this end, a NMAC system will be implemented, operated, and maintained at the SMR-300 site, which:

- Has been optimised as part of the SgBD process during design development, e.g. via design considerations, including:
    - [REDACTED]
    - Minimising MBA/KMP to keep the NMAC system simple to operate and facilitate reporting.
- Has been provided as part of SgBD with, for example:
    - Sufficient space in the plant layout for it to be accommodated and facilitate its operation and maintenance.

[15] IAEA considers two types of diversion which can be read across to withdrawals: abrupt and protracted. In an abrupt diversion scenario, the IAEA assumes that a large quantity of nuclear material is removed in one batch from one location. In a protracted diversion, the removal occurs over a long period, perhaps more than a year, and can be a continuous flow, intermittent or even taken from different locations [17].

    - The supporting services required for its operation (e.g. Uninterruptible Power Supply).
- Meets ONR's FSE as presented in the ONMACS principles [9] and delivers accurate accounting reports as specified by ONR [11], [12].
- Is complemented by Containment and Surveillance (c/s) to ensure continuity of knowledge, i.e. to detect undeclared movement and tampering with safeguards equipment, in order to confirm already verified information.
- Has sufficient hazard-withstand capability to remain operable during emergency conditions and nuclear security events.
- Is protected against sabotage (physical, cyber, blended) by the SMR-300 security arrangements.
- Is supported by a robust safeguards management system and operated by a SQEP team.

7.2.3 SgC 1.3 Inspection and Independent Verification

Inspection by ONR and independent verification by IAEA provide assurance that the NMAC system is functioning correctly and guards against the falsification of inventory reports obtained from the SMR-300 NMAC system in order to mask withdrawal of QNM from the site. This inspection verification will be carried out by ONR and IAEA (if designated by IAEA as a facility for inspection).

This inspection and independent verification will be facilitated via, for example, the:

- Provision of information on SMR-300 design and layout as well as the safeguards arrangements to ONR via the BTC together with regular engagement with ONR to support their DIV design verification.
- Provision of electronic NMAC reports to ONR direct from the NMAC system.
- Provision, as part of the SgBD process, of:
    - Space to accommodate, operate and maintain inspection and independent verification equipment.
    - Supporting services (e.g. Uninterruptible Power Supply) to inspection and verification equipment.
- Protection against sabotage (physical, cyber, blended) of the inspection and verification equipment by the SMR-300 security arrangements.

7.3 SgC 2 - AP Reporting

The SMR-300 safeguards programme will include reporting arrangements to meet the requirements of the AP, as prescribed by ONR [14]. This includes an annual AP declaration, which is already ongoing.

7.4 SgC 3 - Supporting ONR's delivery of its NSR19 Obligations

The SMR-300 safeguards programme will include reporting arrangements to support timely and comprehensive reporting of NMACS declarations to ONR and IAEA. The overall SMR-300 management system, as well as the safeguards programme, will be implemented with clarity of demonstration that the FSE are met in mind.

7.5 Integration with the Safety, Security and Environmental Case

The SMR-300 safeguards case integrates with the SMR-300 SSEC via the SMR-300 Fundamental Purpose [15] as illustrated below.

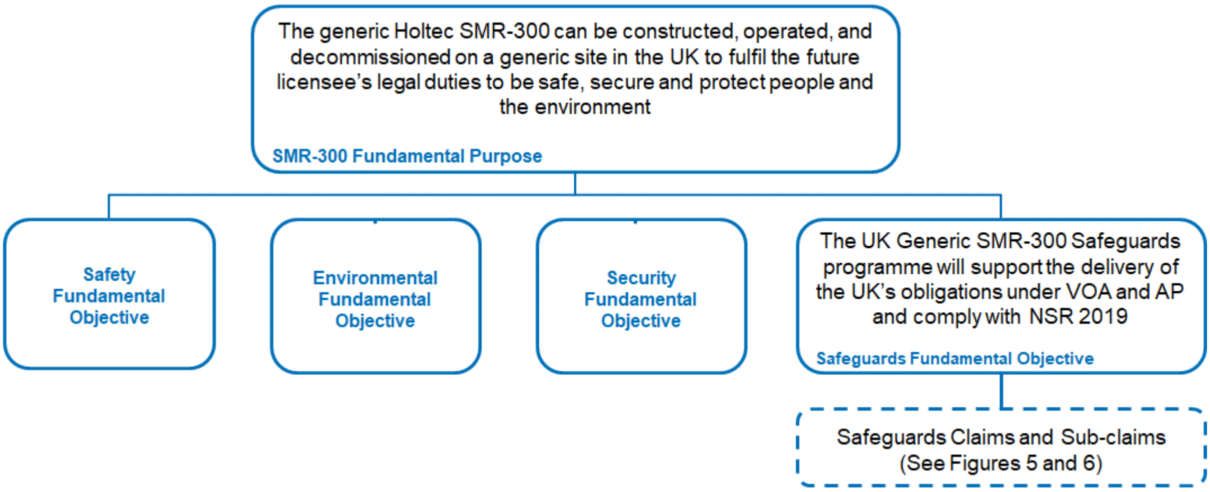


Figure 8: Integration of the Safeguards Case with the SSEC

8.0 SAFEGUARDS BY DESIGN

8.1 Introduction

The previous two sections show how the SgBD process makes a significant contribution to the SMR-300 safeguards programme and safeguards case throughout the SMR-300 project lifecycle.

SgBD is the process by which it is ensured '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' [9].

International safeguards experience has shown that integrating safeguards into the design process from project inception delivers a cost-effective and efficient safeguards solution. This is in contrast with the traditional approach to considering safeguards retrospectively when the design and layout has been frozen, which in some cases had 'resulted in costly redesign and project delays and had reduced the efficiency and effectiveness of safeguards implementation' [16].

8.2 SMR-300 SgBD Process

The key elements of the SMR-300 SgBD process are illustrated in Figure 9 and an overview is given below.

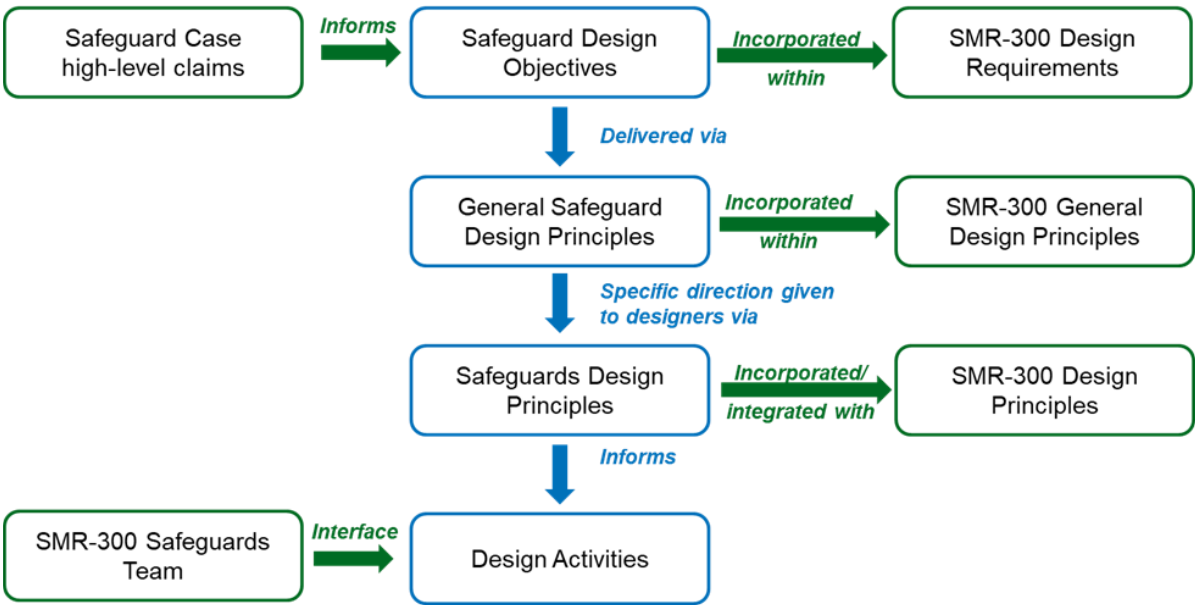


Figure 9: SMR-300 SgBD Process

8.2.1 Safeguards Design Objective

The SgBD process starts with the review of the safeguards requirements which are presented in Section 7.1 as the high-level SMR-300 SgC. Of these high-level SgC, only SgC 1 is relevant to the design of the SMR-300, namely:

'Undeclared Withdrawal of a SQ of QNM from the SMR-300 shall be detected in a timely manner'.

This high-level SgC becomes the safeguards design objective and is incorporated within the overall SMR-300 design requirements log.

8.2.2 General Safeguards Design Principles

The three sub-claims associated with SgC 1 form the basis for the SMR-300 general Safeguards Design Principles (SgDP) as tabulated in Table 3.

Similarly, these general SgDP are incorporated within the overall SMR-300 general design principles log.

Table 3: SMR-300 General SgDP

#	Design Principle
SgDP 1	Inherent proliferation resistance shall be built into the design of the SMR-300.
SgDP 2	A robust NMAC system shall be implemented, maintained, and operated.
SgDP 3	Independent Verification and Inspection by ONR/IAEA shall be facilitated.

8.2.3 Safeguards Design Principles

Detailed direction to the designers on the implementation of these three generals SgDP are provided via a set of specific SgDP. The development of these SgDP is guided by a SgBD hierarchy of control (See Section 8.3) where appropriate. Illustrative examples, based on the discussions on SgC 1 in Section 7.2 are given in Table 4.

Table 4: SMR-300 SgDP associated with General SgDP 2

General SgDP	Specific SgDP
SgDP 1	SgDP 1.1 – Storage areas for new and spent fuel within the SMR-300 site should be minimised.
	SgDP 1.2 – Potential withdrawal paths along the SMR-300 fuel route should be minimised.
SgDP 2	SgDP 2.1 – The SMR-300 plant layout shall provide sufficient space to accommodate, operate and maintain the NMAC systems.
	SgDP 2.2 – c/s equipment shall be installed within the SMR-300 plant to ensure continuity of knowledge by detecting undeclared movement of QNM and tampering with safeguards equipment along the fuel route.
SgDP 3	SgDP 3.1 – The SMR-300 plant layout shall provide the necessary services (e.g. uninterruptible power supply) to operate and maintain safeguards equipment used for independent verification.
	SgDP 3.2 – The safeguards equipment used for independent verification shall be provided with protection against sabotage (physical, cyber, blended).

It is noted that some of the specific SgDP in Table 4 are compulsory; these are identified by the use of the verb ‘shall’, e.g. SgDP 2.1 and 3.2. Other SgDP are not compulsory but are desirable to deliver an effective and efficient safeguards solution; these are identified by the use of the word ‘should’, e.g. SgDP 1.1.

The SgDP are also incorporated into the SMR-300 design principles log. This provides the opportunity to integrate design principles to deliver an optimised and cost-effective design where possible. To illustrate this, surveillance equipment required at some locations along the fuel route to comply with SgDP 2.2 could also be used for safety, security, and operational purposes.

The high-level safeguards design requirements adopted by the US team for the SMR-300 design are contained within the SMR-160 Design Standard for Security and Safeguards [29] which has been adopted for the SMR-300 project. These complement the SgDP referred to in this section.

8.2.4 Design Activities

The SgDP and SMR-160 Design Standard for Security and Safeguards [29] inform the SMR-300 designers of the safeguards requirements that need to be considered in design activities. Design activities in this context refer to a range of activities during the project lifecycle including:

- Design of the SMR-300 site and building layouts.
- Design of plant Structures, Systems, and Components (SSC).
- As Low As Reasonably Practicable (ALARP) and Optioneering studies.
- Design Reviews.
- Design Modification.
- Design of plant upgrades.

The SMR-300 Safeguards Team are involved in all these design activities, by providing advice on individual design activities, resolving conflicts between safeguards requirements and other disciplines, or participating in ALARP/Optioneering studies or design review committees.

It is noted that any potential design changes identified via SgBD is managed via the Holtec Britain GDA design change process [31] with input from the Holtec Britain safeguards team in the same way as potential Secure by Design changes [32].

8.3 SgBD Hierarchy of Control

A SgBD hierarchy of control, adapted from the ONR security hierarchy of control [34], is used to guide the development of the SMR-300 SgDPs and the subsequent design solutions, where appropriate. This SgBD hierarchy of control is illustrated in Figure 10.

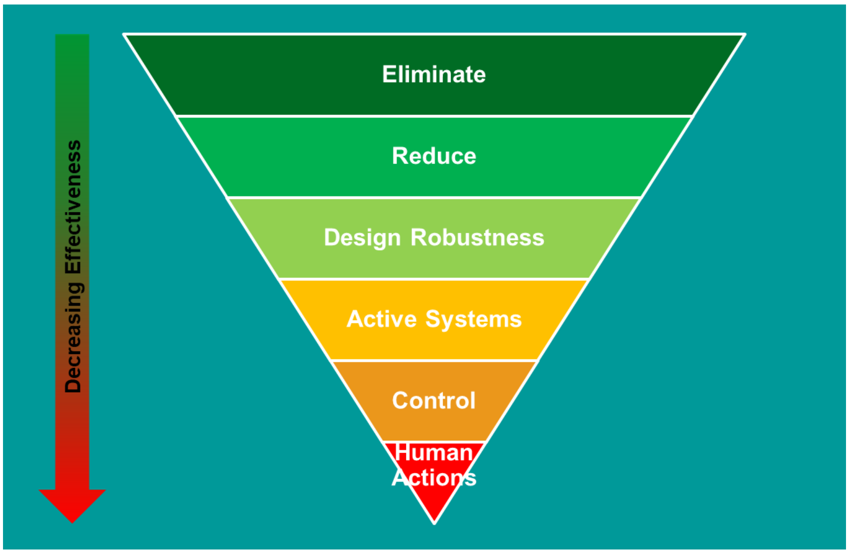


Figure 10: SgBD Hierarchy of Control

As an example to illustrate the use of the SgBD hierarchy of control, SgDP 1 requires that 'inherent proliferation resistance shall be built into the design of the SMR-300'. Inherent proliferation resistance can be built into the design via the consideration of withdrawal paths. Referring to Figure 10, the most effective control measure would be to 'eliminate' withdrawal paths, but this is not possible, except for potentially in specific parts of the fuel route (e.g. within containment). However, it may be possible and more practical to 'reduce' the number of withdrawal points along the fuel route, hence the identification of SgDP 1.2 in Table 4 above.

9.0 NUCLEAR MATERIAL ACCOUNTANCY AND CONTROL

9.1 Design Considerations in Support of NMAC

NMAC is the primary operational safeguards measure which is implemented by the operator of a facility subject to safeguards. NMAC forms the basis for the regular declaration of inventory of nuclear material for reporting to ONR and verification by IAEA, if the facility is selected by IAEA for independent verification.

The SMR-300 operator will use software tools of their choosing to support their nuclear material accountancy and control process.

At the design stage, the efficacy of future nuclear material accountancy and control for the SMR-300 can be influenced by:

1. Establishing MBA where flows and inventory of nuclear material can be determined.
2. Establishing KMP within those MBA where flows and inventories of nuclear material can be measured.

Establishing MBA and KMP at the design stage will enable the future operator to:

(a) Determine the quantities of nuclear material.

(b) Keep records of:

- The nuclear material inventory via a List of Inventory Items (LII).
- Physical Inventory Taking (PIT).
- ID over a material balance period.

(c) Prepare and submit accounting reports to ONR as set out in [8].

(d) Support the independent verification of the accounting information by IAEA.

(e) Report any import or export of safeguarded nuclear material in accordance with [8].

As SMR-300 fuel is delivered to site pre-assembled, it is anticipated that on-site fuel assay is limited to checking assembly weight (normally by incorporation of a load cell into lifting equipment) and identification markings. Relative proportions of specific isotopes in irradiated fuel are usually calculated based on operating power history, it is anticipated that calculational routes will continue to be the primary means of preparing these aspects of accounting reports for irradiated fuel.

To meet UK licensing requirements it is expected that SMR-300 NMAC records will be retained from initial QNM receipt, throughout the operational phase and at least until removal of all qualifying material during the decommissioning phase of the facility lifecycle.

The flow of QNM through the SMR-300 site is described in Section 6.0. Two MBA are proposed for the generic SMR-300 site; these are:

1. Inside the Reactor Auxiliary Building (RAB)/CS.
2. The on-site ISFSI.

Figure 11 shows the locations of these two MBA in a typical site plan.

[REDACTED]

Figure 11: SMR MBA and Nuclear Fuel Pathway

[REDACTED]

Two types of KMP are proposed, inventory KMP and process KMP. Inventory KMP are proposed for QNM storage areas. Process KMP are proposed for activities where there is interaction with or movement of QNM.

The two proposed SMR-300 MBA and their respective KMP are discussed in turn below.

9.2 Proposed SMR-300 MBA-1

[REDACTED]

REDACTED

Figure 12: QNM Flow with KMP through Proposed SMR-300 MBA-1

9.3 Proposed SMR-300 MBA-2

[REDACTED]

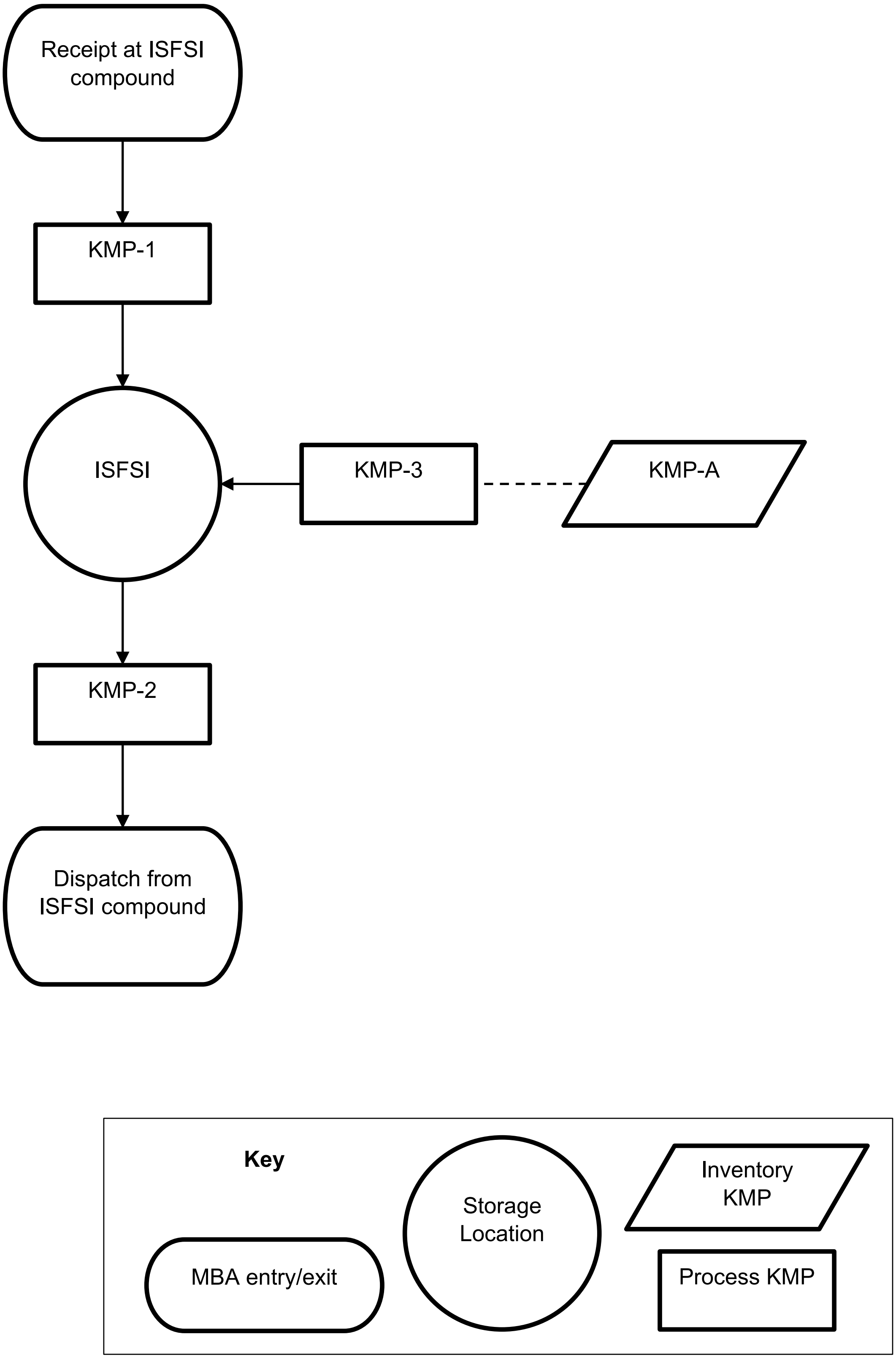


Figure 13: QNM Flow with KMP through Proposed SMR-300 MBA-2

9.4 On-site ex-MBA Activities

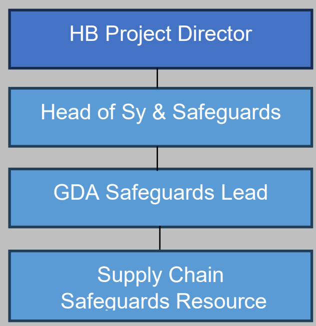
[REDACTED]

These movements and handling activities are highly amenable to safeguards measures, including seals, monitoring equipment, and continuous remote and/or in-person surveillance. All of these movements and handling activities are performed with multiple fuel assemblies contained inside a Multi-Purpose Cask (MPC) and HI-TRAC, which preclude direct interaction with their contents and therefore no site-based MBA or KMP is proposed to encompass these movements and handling activities. Material transport outside the site boundary is assumed to be subject to separate justification and arrangements.

10.0 UK SAFEGUARDS EXPECTATIONS

Holtec recognises that satisfactory implementation of Safeguards to meet UK regulatory expectations extends beyond purely design considerations. This section summarises the implementation of Safeguards within Holtec Britain in terms of meeting the ONMACS [9] FSE at the generic design stage.

Table 5: Safeguards Expectations

<table>
<tr><th>FSE</th><th colspan="2">Title</th><th>Description</th><th>GDA Compliance & Evidence</th></tr>
<tr><td rowspan="6">FSE 1</td><td colspan="2">Leadership and Management for NMACS</td><td>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.</td><td rowspan="6">Whilst this FSE is aimed at a UK SMR-300 operator, an appropriate safeguards organisation is in place within Holtec Britain (HB) to deliver the current annual safeguards reporting and GDA deliverables, as follows:


Holtec Britain's safeguards organisation operates under the Holtec Britain Management Systems, which covers the MACE associated with this FSE.
NMACS specific management arrangements and organisation will develop as the project progresses from GDA to site-specific licensing and thereafter to operations at a level commensurate with NMACS activities being undertaken.
The need for the development of the safeguards organisation and management arrangements to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report.</td></tr>
<tr><td>MACE 1.1</td><td>Governance and Leadership</td><td>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.</td></tr>
<tr><td>MACE 1.2</td><td>Capable Organisation</td><td>The organisation should have the capability to implement and maintain the NMACS arrangements for its undertakings.</td></tr>
<tr><td>MACE 1.3</td><td>Decision Making</td><td>Decisions made at all levels in the organisation affecting NMACS should be informed, rational, objective, and prudent.</td></tr>
<tr><td>MACE 1.4</td><td>Organisational Learning</td><td>Lessons should be learned from internal and external sources to continually improve leadership, organisational capability, the management system, NMACS decision-making and performance.</td></tr>
<tr><td>MACE 1.5</td><td>Assurance Processes</td><td>There should be evidence-based assurance processes in place to inform strategy through the governance process, which welcomes challenge from across the organisation.</td></tr>
<tr><td rowspan="2">FSE 2</td><td colspan="2">Organisational Culture</td><td>Operators should encourage and embed an organisational culture that recognises and promotes the importance of NMACS.</td><td rowspan="2">As for FSE 1.</td></tr>
<tr><td>MACE 2.1</td><td>Maintenance of a Robust NMACS Culture</td><td>Duty holders should ensure that the Board gives due priority to the development and maintenance of a NMACS culture necessary to ensure the entire organisation recognises NMACS is important and the role of the individual in maintaining it is key.</td></tr>
<tr><td>FSE 3</td><td colspan="2">Competence Management</td><td>Operators should implement and maintain effective arrangements to manage the competence of those with assigned NMACS roles and responsibilities.</td><td>As for FSE 1.</td></tr>
</table>

FSE	Title		Description	GDA Compliance & Evidence
	MACE 3.1	Analysis of NMACS Roles and Associated Competencies	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.	
	MACE 3.2	Identification of Learning Objectives and Training Needs	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.	
	MACE 3.3	Measurement of Competence	Duty holders 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.	
	MACE 3.4	Organisation of and Support to the Training Function	Training and competence assurance of personnel with NMACS roles should be given due priority by duty holders.	
FSE 4	**Reporting, Anomalies, and Investigations**		**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.**	This NMAC reporting is not applicable at this stage of the UK SMR project. The need for a UK SMR-300 operator to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report. HB has arrangements in place to provide the annual AP reporting.
	MACE 4.1	Reporting	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.	
	MACE 4.2	Anomalies and Investigations	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.	
	MACE 4.3	Corrective Actions	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.	
FSE 5	**Reliability, Resilience and Sustainability**		**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.**	Not applicable at this stage of the UK SMR project. The need for a UK SMR-300 operator to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report.
	MACE 5.1	Reliability and Resilience	Operators should incorporate reliability and resilience into the design of systems for the purposes of NMACS.	
	MACE 5.2	Examination, Inspection, Maintenance and Testing	Systems and components for the purposes of nuclear material accountancy and control should receive regular and systematic Examination, Inspection, Maintenance and Testing (EIMT).	

FSE	Title		Description	GDA Compliance & Evidence
	MACE 5.3	Sustainability	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.	
FSE 6	**Measurement Programme and Control**		**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.**	Not applicable at this stage of the UK SMR project. The need for a UK SMR-300 operator to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report.
	MACE 6.1	Measurement Control Programme	A system must be implemented for accountancy areas where QNM is processed, to ensure the effectiveness of measurement and analytical systems and the quality of resulting data that is generated for NMACS purposes.	
	MACE 6.2	Traceability and Validation	Measurements performed for the purposes of NMACS must be conducted to have traceability and should be validated appropriately.	
	MACE 6.3	Precision and Accuracy	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 QNM subject to measurement.	
FSE 7	**Nuclear Material Tracking**		**Operators must implement and maintain an NMACS system that is able to provide identification, quantity, characteristics and track any QNM in their facilities at any time.**	Preliminary work is support of an NMACS system is being carried out during the GDA, including: ● Identification of QNM ● QNM flow ● Proposed MBA and KMP Evidencing documentation comprises: ● SMR-300 Safeguards by Design Basic Technical Characteristics, HI-2241030 ● Step 2 Preliminary Safeguards Report (this document). The need for a UK SMR-300 operator to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report.
	MACE 7.1	Inventory Control	Operators must ensure that procedures and arrangements are established and implemented to ensure any processing and/or transfers of QNM are controlled, recorded, and verified appropriately.	
	MACE 7.2	Identification of QNM	Operators must ensure that arrangements and procedures are in place to enable the unique identification of all QNM within the MBA.	
	MACE 7.3	NMACS Discrepancies	Operators should ensure that arrangements are in place that recognise and investigate NMACS discrepancies whilst recording their management.	
FSE 8	**Data Processing and Control**		**Operators must implement and maintain data processing systems that can produce 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.**	Not applicable at this stage of the UK SMR project. The need for a UK SMR-300 operator to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report.
	MACE 8.1	Data Processing Capabilities	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.	
	MACE 8.2	Compilation of Nuclear Material Accounts	Operators should ensure that the appropriate arrangements and procedures are in place to ensure the effective management of their nuclear material accounts.	

FSE	Title		Description	GDA Compliance & Evidence
	MACE 8.3	Records Management	Operators should ensure that the appropriate arrangements are in place to effectively manage the control of NMACS documentation and data.	
FSE 9	**Material Balance**		**Operators must ensure that the appropriate arrangements are in place to ensure that QNM shipped from sites and external receipts of QNM onto sites are controlled and subject to effective and robust NMACS arrangements that guarantee traceability.**	Not applicable at this stage of the UK SMR project. The need for a UK SMR-300 operator to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report.
	MACE 9.1	On/Off Site Movements of QNM	Duty holders should facilitate CNC deployment that is appropriate to achieve the required security outcome.	
	MACE 9.2	Physical Inventory Taking	Operators must ensure that the appropriate PIT arrangements are in place to ensure that all QNM within an MBA is recorded accurately through measurement or derived estimates, as specified in Regulation 15 of NSR19.	
	MACE 9.3	Material Balance Evaluation	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 IDs can be explained by measurement uncertainty or reflects other causes.	
FSE 10	**Quality Assurance and Control for NMACS**		**Operators must implement and maintain quality assurance and quality control measures for NMACS.**	Not applicable at this stage of the UK SMR project. The need for a UK SMR-300 operator to comply with this FSE and associated MACE will be reflected in the GDA documentation, specifically in this Preliminary Safeguards Report.
	MACE 10.1	NMACS Performance Measures	Operators should ensure that the appropriate arrangements are in place to ensure that NMACS performance is monitored and reviewed.	
	MACE 10.2	Quality Assurance and Control Measures	Operators should ensure that key NMACS tasks incorporate quality assurance and quality control measures.	

11.0 EVOLUTION TO NUCLEAR SITE LICENCE

The Step 2 PSgR will evolve into the overarching SMR-300 Safeguards submission for nuclear site licensing in the UK. It is expected that there will be a number of submissions of the overarching Safeguards Report to coincide with the main SSEC development phases and submissions during site-specific design and site licensing. In common with other the overarching submissions comprising the SSEC, the overarching Safeguards Reports will be referred to as the Pre-Construction Safeguards Report, Pre-Operational Safeguards Report etc. commensurate with the phase of the UK SMR-300 project.

It is expected that the structure of the Safeguards Report will be the same as that for the PSgR, but the contents will be updated, as appropriate, to reflect:

- The status of the UK SMR-300 project and developments in its design and layout.
- Developments in the UK Safeguards regulatory requirements and RGP.
- Outcome from regular engagement with ONR Safeguards.
- Progress on the implementation of SgBD.
- Progress in the development of the safeguards case.
- Progress on the development and implementation of the NMACS arrangements and NMAC system.

In parallel with the evolution of the Safeguards Reports:

- Further issues of the SMR-300 SgBD BTC will be submitted to ONR to reflect developments in the site-specific SMR-300 design and layout as well as the NMACS arrangements and NMAC system design. These will be informal issues to support the ongoing engagement with ONR and their engagement with IAEA as required. The formal BTC submissions will start with the Preliminary BTC when the decision to construct at a specific site is taken (see Figure 3) as required by NSR19.
- Regular reporting will continue as required by the AP [4].

And at the appropriate time during this period, the following documents which will be supported by the extant Safeguards Report will be developed and issued:

- Annual Outline Programme of Activities.
- Accountancy and Control Plan (ACP).

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13.0 LIST OF APPENDICES

Appendix A Significant Quantity and Conversion Times

The SQ values and conversion times used by IAEA at the time of writing to establish the quantity and timeliness components of their inspection goal for a specific QNF are reproduced below from the IAEA Safeguards Glossary [33].

TABLE 1. SIGNIFICANT QUANTITY (SQ) VALUES CURRENTLY IN USE

Material	*SQ*
Direct use nuclear material	
Plutonium[a]	8 kg *plutonium*
^{233}U	8 kg ^{233}U
High enriched uranium (HEU) (^{235}U ≥ 20%)	25 kg ^{235}U
Indirect use nuclear material	
Uranium (^{235}U < 20%)[b]	75 kg ^{235}U (or 10 t *natural uranium* or 20 t *depleted uranium*)
Thorium	20 t *thorium*

[a] For *plutonium* containing less than 80% ^{238}Pu.
[b] Including *low enriched uranium (LEU)*, *natural uranium* and *depleted uranium*.

TABLE 2. ESTIMATED MATERIAL CONVERSION TIMES FOR FINISHED PLUTONIUM OR URANIUM METAL COMPONENTS

Beginning *material form*	*Conversion time*
Plutonium, *high enriched uranium (HEU)* or ^{233}U metal	Order of days (7–10)
PuO_2, $Pu(NO_3)_4$ or other pure *plutonium* compounds; *HEU* or ^{233}U oxide or other pure *uranium* compounds; *mixed oxide (MOX)* or other unirradiated pure mixtures containing *plutonium*, *uranium* (^{233}U + ^{235}U ≥ 20%); *plutonium*, *HEU* and/or ^{233}U in *scrap* or other miscellaneous impure compounds	Order of weeks (1–3)[a]
Plutonium, *HEU* or ^{233}U in irradiated fuel	Order of months (1–3)
Uranium containing <20% ^{235}U and ^{233}U; *thorium*	Order of months (3–12)

[a] This range is not determined by any single factor, but the pure *plutonium* and *uranium* compounds will tend to be at the lower end of the range and the mixtures and *scrap* at the higher end.