



ONR GUIDE			
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OFFICIAL**1. INTRODUCTION**

- 1.1 ONR has established Safety Assessment Principles (SAPs) [Ref 2] considered during assessment by specialist inspectors of safety cases for nuclear facilities that may be operated by potential licensees, existing licensees, or other duty-holders. The SAPs are supported by a suite of supporting technical assessment guides to further assist assessment work, making regulatory judgements and determining appropriate assessment decisions. This technical assessment guide supports the mechanical engineering specialism group and includes a collection of topical areas developed through time reflecting developments in recognised good practices.

2. PURPOSE AND SCOPE

- 2.1 Useful information for inspectors is collected on a frequent basis within ONR; however this information often does not fit into the scope of existing guidance. This guide has been produced to capture such miscellaneous guidance and relevant good practice that does not fit within the scope of any other technical assessment guide (TAG).
- 2.2 This general TAG is to be used to collate guidance originating from the Mechanical Engineering Specialism Group (MESG). It may however be useful for other inspectors outside the specialism wishing to gain an overview of the appropriate topic areas.
- 2.3 This TAG identifies guidance and relevant good practice, by topic, in the attached appendices. Each individual appendix states the specific purpose and scope of the guidance, outlines the relevant legislation, good practice guides and internal ONR guidance. All guidance applies to the areas stated within each appendix. It is expected that appendices will be added (or potentially removed) over time.
- 2.4 The current version of this TAG should be confirmed prior to use.
- 2.5 This TAG contains guidance to advise and inform ONR staff in making their regulatory judgement.

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3. RELATIONSHIP TO LICENCE AND OTHER RELEVANT LEGISLATION

- 3.1 Each piece of guidance presented in the attached appendices has relevance to different site licence conditions and legislative requirements. Table 1 within the appendix section presents a summary of the relevant Licence Conditions [Ref 1]
- 3.2 The Energy Act 2013 includes the nuclear safety sections of the Nuclear Installations Act 1965 as Relevant Statutory Provisions. Other relevant regulations also place legal obligations on licences for examination, inspection, maintenance and testing (EIMT), some of these being:
- the Ionising Radiation Regulations 2017,
 - the Management of Health and Safety at Work Regulations 1999,
 - the Lifting Operations and Lifting Equipment Regulations 1998,
 - the Provisions and Use of Work Equipment Regulations 1998, and
 - the Pressure Systems Regulations 2000.
- 3.3 Such legislation applies to nuclear installations and should be considered by Nuclear Inspectors in addition to the specific requirements of the Licence Conditions.

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

- 4.1 As with the Licence Conditions, the various appendices apply to a number of different SAPs (2014 Edition Revision 0) [Ref 2]. Table 2 within the appendix section details the relevant SAPs for each appendix. This is not intended to be a complete list, and other requirements may also influence an inspectors approach.
- 4.2 WENRA Reference Levels and IAEA Safety Standards Guidance
- This revision of the TAG has no references to either the WENRA Reference Levels [Ref 3] or any additional IAEA Safety Standards Guidance
 - It is recognised that in future revisions of this document such references may be included, therefore this section has been included for completeness.
- 4.3 The attached appendices will also include reference to additional guidance such as ISO or BS standards where appropriate within the text of each appendix where applicable.

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5. ADVICE TO INSPECTORS

- 5.1 Advice to inspectors for this TAG is presented independently within each appendix.
- 5.2 Inspectors who wish to add additional guidance to this document should consult the process owner on HOW2 for submission.

6. REFERENCES

- 1. Licence condition handbook. Office for Nuclear Regulation. February 2017.
<http://www.onr.org.uk/documents/licence-condition-handbook.pdf>
- 2. Safety Assessment Principles for Nuclear Facilities, 2014 Edition Revision 0, November 2014
www.hse.gov.uk/nuclear/saps/
- 3. Western European Nuclear Regulators' Association. Reactor Harmonization Group. WENRA Reactor Reference Safety Levels. WENRA. September 2014.
www.wenra.org.

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ALARP	As low as reasonably practicable
BSL	Basic Safety Level
CCF	Common Cause Failure
CNS	Civil Nuclear Security (Office for Nuclear Regulation)
EIMT	Examination, Inspection, Maintenance and Testing
FM	Foreign Material
FME	Foreign material Exclusion
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
LFE	Learning From Experience
PSR	Periodic Safety Review
MESG	Mechanical Engineering Specialist Group
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
QA	Quality Assurance
RCA	Radiologically Controlled Area
SAP	Safety Assessment Principle(s)
SFAIRP	So Far As Is Reasonably Practicable
SM	Safety Mechanism
SQEP	Suitably Qualified or Experienced Person
SSC	Structure, System and Component
TAG	Technical Assessment Guide(s)
WENRA	Western European Nuclear Regulators' Association

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8. APPENDICES

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OFFICIAL**Appendix - Table 1: Licence Conditions**

Licence Condition	Relevant Appendices	
	Appendix 1	Appendix 2
LC6 – Documents, records, authorities and certificates	✓	
LC15 - Periodic Review	✓	
LC17 - Management Systems	✓	
LC19 - Construction or installation of new plant	✓	
LC20 - Modification to design of plant under construction	✓	
LC21 - Commissioning	✓	
LC22 - Modification or experiment on existing plant	✓	
LC25 – Operational records	✓	✓
LC27 - Safety mechanisms		✓
LC28 - Examination, inspection, maintenance and testing	✓	✓
LC29 - Duty to carry out test, inspections and examinations	✓	

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OFFICIAL**Appendix - Table 2: Safety Assessment Principles**

Safety Assessment Principles (SAPs)	Relevant Appendices	
	Appendix 1	Appendix 2
ECS. 3: Codes and Standards	✓	✓
ECS. 4: Absence of established codes and standards	✓	✓
ECS.5: Use of experience, tests or analysis	✓	
EQU.1: Qualification procedures	✓	
EMC.3: Evidence	✓	✓
EMC.13: Materials	✓	
EMC.20: Records	✓	
MS.4: Learning	✓	✓
ELO.1: Access		✓

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APPENDIX 1: QUALITY ASSURED BOLTING IN SAFETY CRITICAL APPLICATIONS

A1.1. INTRODUCTION

- A2.1.1.1 For the purpose of interpretation relating to “fasteners”, BS EN ISO 16426:2002 lists and BS EN ISO 3269:2001 states that these include: bolts, screws, studs, nuts, pins, washers, blind rivets and other related fasteners.
- A2.1.1.2 Mechanical Engineering inspection activities have issued challenge regarding the use of fasteners within safety critical structures, systems and components (SSCs) e.g. load-path components or structural fastenings, and whether there was evidence of the quality assurance (QA) documentation available for review.
- A2.1.1.3 Previous inspections have shown that robust QA evidence of fasteners meeting their design requirements is inconsistent. A lack of QA evidence leads to further questions regarding claimed reliability of safety critical SSCs.
- A2.1.1.4 This guidance sets regulatory expectations for such applications. This provides a set of high-level requirements concerning quality assurance measures that should be in place as part of good practice in quality management procedures of safety critical SSCs. Guidance on how examination, inspection, maintenance, and testing (EIMT) should be used to ensure the integrity of mechanical joints throughout the lifetime of the plant is also identified (see Section A1.2.4).

A1.2. RELEVANT GOOD PRACTICE

A1.2.1. Specifications

- A2.1.1.5 The QA requirements placed on fasteners in safety critical applications should be proportionate to the application and the conditions such fasteners are designed to be subject to (a graded approach). As such, where it is shown that the application is not critical to safety i.e. the fastener does not form part of the safety feature, or failure of the fastener will not weaken or cause the safety function to fail, then the requirements of EN ISO 16426:2002 should be applied and managed by the licensee as a minimum.
- A2.1.1.6 Relevant standards, EN ISO 16426:2002 and ASME B18.18:2011, both state that the purchaser must request documentation i.e. it is not (normally) supplied as standard. Where relevant, the licensee should ensure that all appropriate documentation is requested from the manufacturer / supplier. The licensee should also specifically request that results of tests be provided to them.
- A2.1.1.7 Bolts should be supplied in individual “lots” (as per EN ISO 16426:2002) and stored at site in “lots” to ensure no commingling. In this regard, suitable documentation in regards to test results and mechanical properties of “lots” shall be held by the licensee for the lifetime of fasteners (as “lots”).
- A2.1.1.8 Where bolts are to be used for safety critical applications, applying the standard EN ISO 16426:2002 may not be sufficient and as such, this should be identified within the licensee’s technical specification along with suitable reference to standards for testing and QA management. Equally, a plan for auditing of suppliers should be put in place and executed where deemed appropriate given the safety significance of components, along with suitable evidence and records of audits.
- A2.1.1.9 EN ISO 16426:2002 provides a minimal level of QA for fasteners. An adequate specification must be written and provided to the manufacturer. As part of this, a

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defined set of performance characteristics for the fastener(s) must be provided. Additionally, it is suggested that the licensee undertakes audit(s) of the manufacturer's QA and technical procedures to assure itself that the manufacturing, testing and QA practices meet its requirements.

- A2.1.1.10 It may also be deemed appropriate (depending on fastener safety significance) to require testing to be done during manufacture to ensure quality. For example, in a "lot" of 1000 bolts, a representative sample for in-manufacture testing may be 10 bolts.
- A2.1.1.11 Where testing during manufacture is not possible, it may well be acceptable to the licensee for testing to be carried out post manufacture. BS EN ISO 3269:2000 suggests no more than 5%¹, however with larger "lots" at least 1% may be a more suitable figure.
- A2.1.1.12 Fastener "lots" used for non-safety critical applications should not be used for safety critical applications unless sufficient evidence that the fasteners meet the design requirements can be provided and are held by the licensee.
- A2.1.1.13 Certificates of Conformity have been accepted by licensees as sufficient, however this is seldom sufficient to assure quality of supplied fasteners and as such, documented evidence of material properties should be expected.

A1.2.2. Receipt of QA documentation

- A2.1.1.14 The Licensee shall ensure that where safety critical bolting is identified via the safety case, the documentation required to ensure traceability, mechanical and chemical properties of supplied fasteners is requested within the technical specification(s) or contract documentation.
- A2.1.1.15 As part of the above, the licensee should identify whether they have specified the need for type testing to be carried out by a UKAS registered body to ensure quality of deliverables.
- A2.1.1.16 Receipt of such documentation should be recorded within the licensee's own management system(s).
- A2.1.1.17 A check of the test reports should indicate whether the fasteners meet the design requirements. Acceptance on this basis should be indicated.

A1.2.3. Pre-operational considerations

- A2.1.1.18 The licensee should consider their own requirements in regards to confirmation of mechanical properties for safety critical fasteners where deemed appropriate e.g. for Safety Function Category A or B [Ref. 2] applications where the fasteners form part of the load path or which failure may result in a radiological incident or compromise nuclear safety.
- A2.1.1.19 Previously, checks on Certificates of Conformity and bolt head stamping have been considered sufficient to guarantee mechanical properties for safety critical bolting. Fastener failures have raised concerns that this is inadequate for some applications and should be questioned on an application-by-application basis. It is not expected that all fasteners are tested, however there should be an expectation that where fasteners ensure safety case compliance, a higher degree of evidence should support safety case claims.

¹ Fasteners not intended for high volume machine assembly, special-purpose applications or specially engineered applications requiring greater in-process control and lot traceability – acceptance testing would be specified by the purchaser in these cases

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- A2.1.1.20 Prior to the installation of fasteners used in safety critical applications, check(s) to ensure the supplied fasteners meet the minimum design requirements should be undertaken.
- A2.1.1.21 This should be expected as part of the QA system. Inspection of the test reports against design requirements will verify this. Acceptance of the fasteners should not take place if they do not meet design requirements.
- A2.1.1.22 The licensee should have adequate installation processes that indicate suitable pre-operational checks for all safety critical SSCs. A confirmation that safety critical bolting has also undergone checks should be part of this.
- A2.1.1.23 The licensee should also consider whether a process is required in order to “track” where safety critical fasteners are installed, so that these can be audited back to the received “lot” and to the test results and manufacturer.
- A2.1.1.24 A visual confirmation of adequate condition of bolts prior to start-up of safety critical equipment (where start-up is manual or in-situ) should be part of the pre-operational checks to reduce the likelihood of “missed” inspection.

A1.2.4. In-service inspection

- A2.1.1.25 The licensee should, where necessary to support safety case requirements, have in place an inspection regime to confirm that safety critical fasteners remain capable of providing their intended function. This may include checks for signs of corrosion and checks to ensure that fasteners have been tightened sufficiently.
- A2.1.1.26 Regular in-service inspection of fasteners should be part of the plant’s planned activities. The licensee’s EIMT schedule(s) should at least inspect for:
- surface corrosion on bolts and corrosion of the surrounding parent material(s);
 - signs of fatigue e.g. bolts identified as “loose” when previously they should have been tightened appropriately;
 - signs of gapping or “nicks” in threads and equally, checks to determine if bolts have yielded;
 - where safety critical bolts are used in structural applications, a suitable methodology for in-service inspection or planned replacement strategy should be provided by the licensee; and
 - where fasteners have “failed” or have been replaced due to signs of yielding or fatigue, then the licensee should have in place a process whereby the faster(s) are tested to identify the failure mode. This information should be used to determine whether “lots” are failing or whether failures are one-offs. The investigation should include an assessment of potential causes and contributory factors to ensure LFE is collated and where appropriate passed on to other plants.

A1.2.5. Records management

- A2.1.1.27 The licensee should be able to provide evidence of an appropriately robust record management system in regards to all safety critical components, in accordance with Licence Conditions 6 (Documents, records, authorities and certificates), 17 (Management systems) and 25 (Operational records). Safety critical fasteners should be a part of this.
- A2.1.1.28 The records should be retrievable and provide an auditable trail from specification to use on site and consideration of “location” on-site should be made. An adequate case for not implementing such a requirement in safety related application would need to be made.

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- A2.1.1.29 Suitable and sufficient training is essential to establish, maintain and develop SQEP resource. Appropriate training for those involved in the design, specification, quality assurance, receipt, storage and use of safety significant fasteners should include a focus on safety critical tasks and address the possible consequences of failing to follow procedures.
- A2.1.1.30 Steps to ensure that knowledge is captured and shared and procedures are subjected to periodic review should form part of the training arrangements.
- A2.1.1.31 Although the mechanical engineering inspector may not conduct detailed inspection of the training arrangements, the inspector should sample those areas where quality assurance tasks are covered, with a view to identifying where appropriate relevant good practice is referenced, for example the standards referenced in this Appendix, and where licensee's own arrangements are covered.

A1.2.7. Long established licensees

- A2.1.1.32 It is recognised that application of all of the above elements will prove challenging to long-established licensee's where such requirements are new. In such cases, a proportionate approach should be taken to provide confidence that the safety critical application of fasteners has been carried out in a manner that reduces the risk of failure to as low as reasonably practicable (ALARP) levels.
- A2.1.1.33 Inspectors may be presented with less evidence, but undertake a more detailed discussion with a number of personnel in order to satisfy themselves, or inspectors may require the licensee to provide a report identifying why their arrangements have met RGP. The argument "they haven't failed yet" is not sufficient, however, evidence to show that the fasteners used are sufficiently robust, are inspected on a regular basis and samples have been tested to show that they meet the design intent may satisfy the inspector.
- A2.1.1.34 The inspector should seek to advise the licensee that for future supply of safety critical fasteners, a more up-to-date and robust system for specification, auditing, receipt, storage and use should be applied. Such changes should not overly affect the established practices of the licensee; however, necessary changes may take time to implement.

A1.2.8. Re-use of fasteners in Safety Critical applications

- A2.1.1.35 It is a commonly accepted practice across many industries that following replacement or maintenance related activities, fasteners are re-used. In the case of safety critical bolts being re-used, the licensee must have sufficient evidence that:
- A2.1.1.36 the same "lot" of fasteners has been tested and the licensee is satisfied that they comply with the design intent;
- A2.1.1.37 the licensee can provide a clear set of instructions used by operators to inspect the fasteners for signs of corrosion, wear, fatigue or any other life limiting factors and a record made of such inspections, together with procedures for cleaning, lubrication, tightening etc; and
- A2.1.1.38 there is a record of the duration for which such fasteners have been in place and there is an up-to-date record of cyclic loading that such fasteners have undergone (where this is a risk to failure).
- A2.1.1.39 The intent is not to prevent licensees from re-using fasteners in applications where this is not necessary, however, proportionate control in regards to the inspection

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(and testing if necessary) techniques undertaken prior to re-use should be an expectation for these safety critical fasteners.

A1.2.9. Additional information

- A2.1.1.40 Reference BS EN ISO 16426:2002 is not for specialised applications of fasteners. ASME B18.18 - 2011 identifies that a specific Quality Assurance regime should be put in place for fasteners intended for specialised applications – for example safety critical bolting. Within the ASME standard, these are indicated as Category 3 requirements, and utilise documented and verifiable in-process controls. It states that the producer shall have an independently registered quality management system and that final inspection shall be performed to the requirements of ISO/IEC 17025. Sample sizes are indicated for all categories of application within the ASME standard and may be useful for determining what would be deemed as appropriate.
- A2.1.1.41 For metric fasteners used in structural applications, ASME B18.2.6M - 2012 specifically refers to ASME B18.18 in regards to QA requirements, indicating that this ASME standard covers all key applications.

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OFFICIAL**APPENDIX 2: GUIDE TO INSPECTION OF MAINTENANCE FACILITIES****A2.2. INTRODUCTION****A2.2.1 Scope of this Guidance**

- A2.2.1.1 Keeping nuclear risk at an acceptably low level requires equipment to retain the reliability claimed in the facility safety case. Retaining this reliability also helps ensure that plants operate at optimum efficiency. Reliability can be assured by appropriate care of the asset through effective maintenance which may include refurbishment or replacement of Structures, Systems and Components (SSCs).
- A2.2.1.2 Asset management has been identified by ONR as a key strategic factor to the safe and secure management of the UK's new and existing nuclear infrastructure. However, ONR has seen examples where plant condition falls short of expected standards despite adequate written arrangements under LC28 - Examination, Inspection, Maintenance and Testing. The root cause can be attributed to a combination of not properly carrying out EIMT in accordance with the written arrangements, not using suitably qualified persons, not adhering to correct intervals and not having appropriate organisational factors including management and supervision.
- A2.2.1.3 Guidance on EIMT is often limited to preparing the written arrangements with little information about how to properly carry them out. The aim of this appendix is to address this shortfall by presenting examples of relevant good practice for EIMT implementation that will help ensure that the licensee satisfies their duty to carry out EIMT in accordance with their arrangements.
- A2.2.1.4 The guidance may assist ONR inspectors or others responsible for judging a duty holder's ability to adequately carry out EIMT in accordance with their written arrangements. The principles in this appendix are relevant to a number of disciplines where implementation of EIMT is of interest.

A2.2.2 Statement of the Problem

- A2.2.2.1 Intelligence from ONR inspections indicates that shortfalls can be categorised into one of the following types:
- Foreign materials remaining inside critical plant after maintenance activities.
 - Foreign materials dropped into open plant during maintenance
 - Incorrectly specified, damaged, un-traceable or incompatible components used during maintenance activities.
 - Non serviceable parts inadvertently fitted during maintenance.
 - Incorrect parts fitted during maintenance.
 - Poor quality assurance and quality control arrangements leading to fitting spare parts that do not meet original design specification.
 - Incorrect maintenance procedure selected, or correct procedure selected but not properly implemented.
 - Use of equipment or tools that are out of calibration or inappropriate for the intended purpose.
 - The wrong plant inspected, tested or maintained.

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- A2.2.2.2 The expectation is that adequate implementation of EIMT is achieved when good practice is evident in the following areas:
- I. Foreign material exclusion
 - II. Control of spares
 - III. Housekeeping
 - IV. Appropriate maintenance facilities
 - V. Suitably Qualified, Experienced and Skilled Persons (SQEP)
 - VI. Appropriate written instructions
 - VII. Appropriate work standards
 - VIII. Appropriate control and supervision of EIMT activities

A2.2.3 Source material for this Appendix

- A2.2.3.1 Industries requiring a higher degree of reliability including, nuclear, oil and gas, chemical and aviation, all require higher standards of implementation for maintenance arrangements. The consequences of plant failures due to poor EIMT can be mitigated by having diverse and redundant plant. However, diversity and redundancy should not be relied upon, instead of good EIMT, to ensure plants will remain safe and reliable.
- A2.2.3.2 To ensure adequate implementation of EIMT it is necessary to adhere to strict arrangements that ensure EIMT is adequate for the plant in question. For example, the aviation industry follows implementation principles based on Civil Aviation Authority guidance [CAA guidance document B-150]. ONR inspectors visited the aircraft maintenance and servicing facility of a major passenger airline to observe the implementation of such standards. The same ONR inspectors also visited several nuclear power generation sites and areas of good practice from both these sources have been referred to in this appendix.

A2.3. GUIDE FOR INSPECTION OF MAINTENANCE FACILITIES AND MAINTENANCE PRACTICE**A2.3.1 Organisational Factors**

- A2.3.1.1 Maintenance should be well planned allowing sufficient time to complete tasks safely. Managers should ensure staff are not subjected to pressures that might lead to them taking shortcuts. Planning should be supported by an open and transparent process where operatives are able to report concerns to management without recrimination.
- A2.3.1.2 A continuous improvement culture should be evident. For example management should continually review performance, reinforce and share good practice and correct deficiencies. Maintenance professionals should be capable of reviewing the effectiveness of maintenance programmes and suggesting corrective action if appropriate.

A2.3.2 Documentation Requirements**OFFICIAL**

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- A2.3.2.1 Valid up to date maintenance manuals should specify each task with sufficient detail and these manuals should be referenced on the work instructions. The level of detail in the manual may vary but must be sufficient to ensure appropriate standards and ensure consistency. Maintenance manuals can also assist with knowledge management by capturing sufficient written knowledge and experience from senior technicians for use by those with less experience. Suitable contingency arrangements should be in place to ensure key maintenance documents are available in emergency situations.
- A2.3.2.2 Maintenance documentation should be followed at all times and even experienced technicians should avoid making seemingly obvious decisions outside of procedures. Any deviation from procedure should follow internal arrangements for change. If deviations from procedure are foreseeable due to the nature of the plant, it may be beneficial to nominate authorities who can decide to deviate from procedure. Amended (red penned/lined) documents should be submitted through the official review process. However, this should be a rare occurrence used only to drive up standards and levels of consistency.
- A2.3.2.3 Manuals should be readily available in a clear, organised and structured manner. Colour coding is a useful way to distinguish between similar tasks or for highlighting safety critical tasks. Photographs, drawings, and diagrams all help with consistency.
- A2.3.2.4 Upon completion of work it is important that the maintenance operative signs relevant paperwork to record that the work has been carried out. A responsible person or multiple persons such as supervisors or managers should verify the work and countersign the records. This paper trail is important to:
- demonstrate that maintenance was properly completed
 - provide records for input into asset management systems
 - identify any trends in system performance and reliability which can assist with predictive maintenance
 - provide management with a mechanism to supervise maintenance
 - Provides a mechanism to gather Operational Experience
- A2.3.2.5 When exiting a Radiologically Controlled Area (RCA), there is sometimes a requirement to manually copy information onto 'clean' paper to control the spread of contamination. To avoid the potential for copying errors, consideration should be given to providing facilities in the RCA for electronically scanning documents. Similarly, portable electronic devices or local display screens can be used to reduce the amount of paper taken into radioactively controlled areas. These electronic devices can also provide greater flexibility for handling, storing and presenting information.

A2.3.3 Training

- A2.3.3.1 Suitable training is essential to establish, maintain and develop SQEP resource. Training programmes for maintenance technicians should include a focus on safety critical tasks and address the possible consequences of failing to follow the associated maintenance procedures. Training programmes should endeavour to capture knowledge from experienced maintenance staff and experts.
- A2.3.3.2 Arrangements should be in place for staff, at every level to capture the knowledge necessary for those doing the job. For example, having procedures to enable technicians to suggest improvements to the way in which maintenance is undertaken not only boosts quality improvements but also encourages ownership

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of challenges. Successful arrangements require willingness of management to take all suggestions seriously, commit to any necessary investment and be prepared to give reasonable deadlines for a response. Positive and negative responses may be offered although management should justify a negative response in an open and transparent manner.

A2.3.4 Maintenance of Safety Mechanisms

- A2.3.4.1 Maintenance standards may not be consistent across all plant categories. Maintenance of Safety Mechanisms (SM's) or essential systems are likely to require additional organisational considerations. The determination of SM's is beyond the scope of this appendix and is likely to involve a combination of probabilistic and deterministic assessments. Maintenance schedules should provide sufficient information to ensure the identification of critical tasks, critical durations and critical functional requirements. This can be linked with LC 27 (safety mechanism, devices and circuits) providing the licensee has adequate arrangement under LC27.
- A2.3.4.2 For maintenance of SM's or essential systems, individuals should not be permitted to work on more than one system at once or to allow several similar components to be dis-assembled in close proximity. This approach improves diversity by avoiding repeated mistakes and avoiding mixing up parts.
- A2.3.4.3 Alternating maintenance schedules can help avoid multiple units being maintained in a similar time frame. This avoids common cause errors, e.g. if several rogue parts are fitted together on multiple units they are likely to fail together whereas an alternating pattern could identify the rogue parts prior to multiple failures. Similarly, consideration should be given to having independent teams of technicians performing maintenance on duplicated plant to avoid duplication of human error or poor practice. Where more than one similar unit needs to be worked on, separate supervisory processes may be necessary to eliminate the risk of information crossover or quality control related issues.
- A2.3.4.4 Safety critical maintenance tasks require a degree of independent validation, either by a third party or a separate team, covering different stages of the maintenance with actual checking of different components or activities. The aim is to confirm each stage is undertaken consistently to the same standards. Persons undertaking functional checks or validation after maintenance operations should be SQEP.

A2.3.5 Expected Standards in Maintenance Facilities

- A2.3.5.1 The term 'maintenance facility' is applicable to any area where maintenance and repair takes place and should not just be limited to permanent maintenance workshops. It is acknowledged that maintaining components outside of a workshop environment is often more difficult to control especially when routine plant operations are still taking place or if the area is outdoors. Good housekeeping, control of tools, control of parts and exclusion of foreign material are all essential regardless of where the work takes place.
- A2.3.5.2 The following sections provide examples of relevant good practice when implementing good standards for maintenance facilities.

A2.3.6 Tool Storage

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- A2.3.6.1 Photograph 1a below shows a poor example of tool storage. In this all too common example there is a high risk that the technician could leave a hand tool inside a critical plant item because he has no easy way of knowing that the tool is missing. In contrast, photograph 1b indicates good practice with all tools having a designated storage position making it obvious when tools are missing. Regular assessment of the tool stock holding, together with a check of anticipated future requirements, is encouraged. Individual tool identification also aids control. The storage and condition of the tools should reflect the importance of the tasks they perform.

Photograph 1a –Poor Practice for storing tools in a cabinet



Photograph 1B – Good practice where each tool has designated storage locations.



A2.3.7 Work Environment

- A2.3.7.1 Even minor deterioration of the building fabric can lead to foreign material ingress. For example, photograph 2a and 2b show examples where there is a risk of paint flakes entering components due to minor deterioration of the building fabric. The condition can also be a sign of water leakage into the room leading to further component degradation. Furthermore, poor quality facilities can present the wrong corporate message leading to a culture of poor workmanship. Photograph 2c shows the same facility after basic repairs bringing it back to the expected standard and demonstration of relevant good practice.

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Photograph 2a – Examples of poor building standards leading to foreign material generation.



Photograph 2b - Poor building standards leading to foreign material generation.



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Photograph 2c – Expected workshop standards reducing the risk of foreign material generation and promoting good safety culture.



A2.3.8 Housekeeping

A2.3.8.1 Good housekeeping requires that everything has a suitable location including work in progress. Appropriate racks, shelves, cabinets and bespoke storage units avoid an accumulation of redundant items and also make it easier to identify poor housekeeping. Strict policies of parts disposal should prevent a culture of hoarding. Photograph 3a, 3b and 3c show examples of poorly thought out storage with little or no control of components presenting a risk that items can become foreign material or to lead to faulty components being fitted. In contrast, photograph 3d and 3e show examples of relevant good practice.

Photograph 3a - Poorly stored items with no traceability and no segregation of different plant items.



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Photograph 3b – Poorly stored items that are not easily retrievable



Photograph 3c – Some attempt to store components but with little or no traceability and a mixture of different plant items.



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OFFICIAL**Photograph 3d – Good use of dedicated spares and tool cabinets****Photograph 3e – Properly designed lay down areas for storage with good access.****A2.3.9 Parts Control**

- A2.3.9.1 Stores are vital for control of quality assured spare parts, foreign material exclusion and serve to remove some of the errors that technicians can make if parts are not properly controlled. Duty holders should consider having a main stores and satellite stores to ensure that only essential parts are held at the work face. Furthermore, large stores can assist with removing the need to house large items that can clutter up small workshops.
- A2.3.9.2 All spares and tools in stores should be properly managed making use of shadow boards or tool cabinets to assist with tool control. The use of maintenance specific vending machines, operated via personal identification numbers, facilitates traceability. Vending systems can be programmed to specific jobs such that they will only dispense the correct type and quantity of materials or consumables.
- A2.3.9.3 Dedicated tooling and parts kits offer better control for specific tasks. For example, technicians can be presented with all the tools and parts they need to do the particular task and nothing else. This is particularly useful for spare parts as it enables the removed part to be placed back into the empty position in the parts container making it easy to count parts in and out. It also enables OEM suppliers to provide spares kits which further assist to ensure that the correct parts are fitted. Photograph 4a and 4b shows an example of good practice for dedicated tools and spares kits respectively.

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Photograph 4a - Dedicated tool kit



Photograph 4b – Dedicated Spares Kit



- A2.3.9.4 For general purpose tools, duty holders should decide whether each technician needs their own or whether dedicated tool kits can be held in a central store. Where each technician needs their own tools they should be supplied by the duty holder so that the quality and quantity of tools in the facility can be controlled. Similarly, special purpose tools and those that need calibration should be managed appropriately, deciding whether it is better to hold certain tools centrally (as shown in Photograph 6a & b).

Photograph 6a – Secure area for dedicated tool storage cabinets.



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Photograph 6b Good use of storage for specialist tooling

- A2.3.9.5 Component shelf life should be carefully monitored so that perished components or consumables are not inadvertently used and manufacturers may specify specific storage conditions. Quality assurance arrangements for through life management of such components require a heightened level of management attention to ensure suitable controls are in place and effective.
- A2.3.9.6 The storage of used parts or part used consumables should be avoided if possible as they can lead to quality issues and can become a source of foreign material. Parts that can safely be re-used must be adequately labelled and appropriately stored with a traceable history to verify their quality. Bulk storage of new spares should be avoided to assist with foreign material exclusion. Any unwanted removed parts should be discarded through an appropriate waste route. The use of dedicated spares kits with the correct amount of parts for a particular task, as mentioned above, helps reduce parts inventory. This is particularly applicable for small items such as fasteners, washers, etc. Effective use of a central stores facility should be adopted providing it is well controlled.
- A2.3.9.7 Larger items of equipment required to undertake certain tasks should be stored with care in a designated 'set down' area as shown in photograph 7. This set down area ensures that only those tools necessary for the task are out on the workshop floor.

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Photograph 7 – Typical example of designated storage area for larger items of maintenance equipment.



A2.3.9.8 Workshop consumables (nuts, bolts, washers, seals, adhesives, etc.) may be used in routine maintenance tasks which are not safety critical, but are often stored and available in the same facilities used to maintain safety critical equipment. In such cases, management control is necessary to prevent inadvertent deployment to safety critical applications.

A2.3.10 Foreign Material - Identification, Assessment and Mitigation

- A2.3.10.1 Whenever maintenance activity involves opening a system or component, Foreign Material Exclusion (FME) becomes a consideration. Foreign Material (FM) includes any rogue material that is not intended to be inside the equipment and is particularly significant where it can threaten reliability. Insufficient covering of open equipment can lead to inadvertent FM entering the item such as metal shavings, rags, grinding dust, etc although inadvertently installing the wrong component or fastener can also be considered as FM.
- A2.3.10.2 The sections above provide examples of good practice for cleanliness and storage to improve FME but handling and transportation of items prior to installation can also improve FME.
- A2.3.10.3 The cleanliness standards expected when undertaking maintenance is commensurate with the safety significance of the equipment being worked on. Good practice includes the deployment of temporary clean surfaces in working areas and covering of dirty workshop surfaces. Such covering can also assist in controlling the potential spread of contamination.
- A2.3.10.4 HSE Guide HSG129 – Health and Safety in Engineering Workshops; provides guidance for small individual workshops. Expectations for the oversight applied by duty holders undertaking maintenance tasks are provided in Nuclear Energy Agency, Nuclear Regulation NEA/CNRA/R [2011]4 – The Nuclear Regulator’s Role in Assessing Licensee Oversight of Vendor and Other Contracted Services.

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A2.3.10.5 FM needs to be minimised and any requirements need to be defined and included in the work package. Consideration should also be given as to whether there is a risk that other systems or plant, voids, ponds or personnel may be affected by the FM. Table 1 sets out some of FME considerations and solutions to be considered.

Table 1 – FME considerations and solutions

FME Consideration	FME Possible Solutions
Should the area surrounding the work be in an exclusion zone? If yes, define the work area.	<ul style="list-style-type: none"> • Warning Signs • Barriers • Controlled access • Access/egress arrangements including those used in emergencies • Protecting of other areas
Can parts, tools or other items that could be dropped into open systems be retrieved? Consideration should be given to implement the following:	<ul style="list-style-type: none"> • Appointment of personnel (Guardians) to control and monitor anything taken into or removed from the exclusion area. • Securing items such as tools, security passes, film badges, dosimeters, spectacles, etc, using lanyards to ensure items are retrievable if dropped. • Removing non-essential items or materials from the area. • Ensuring tools are in good condition and do not have loose or missing parts (record missing parts to avoid confusion later). • Use the correct tool and materials, fail safe tools if required • Comply with material control as required. • Account for all tools, equipment & materials prior to system/component closure.
Is there any dirt and debris in the area adjacent to the work area that could be introduced into the open system? If yes then the following should be taken into account;	<ul style="list-style-type: none"> • Cleaning of adjacent area prior to starting the work activity. • Removing non-essential materials from the work area. • Cleaning overhead areas and gratings. • Install temporary covers when work is not in progress • Maintain appropriate/effective housekeeping conditions. • Ensure removal of harmful contaminants. • Using only approved cleaning materials, solvents and chemicals. • Minimize re-contamination of cleaned surfaces and minimise the cleaning required after installation, repair or modification. • Stopping work and notifying Team Leader/task Supervisor if FME control is lost.
Is the system or component difficult to clean once the activities are complete? If yes, then consideration should be given to the following:	<ul style="list-style-type: none"> • Clean enclosures, vacuum cleaning systems, special clothing or any other method to reduce the possibility of FM intrusion into a system or component. These considerations are particularly important during maintenance activities that create dust and swarf. • Verify system cleanliness requirements at

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	<p>specified stages of the task and following the maintenance activity.</p> <ul style="list-style-type: none"> Control other unrelated work activities in in the area that could introduce dirt and debris into the system or component, such as the removal of floor plugs that connect two different work areas?
Could the system or component be safely left open and unattended for extended periods?	<ul style="list-style-type: none"> Install temporary covers when work is not in progress?

A2.3.10.6 Where it is deemed necessary to use temporary covers for FME, the covers should satisfy certain requirements as follows:

- Non brittle, non-splitting, non-tearing, non-melting.
- Thick enough to avoid damage to underlying surfaces.
- Made from cheap/compatible but non porous materials.
- Unable to damage system or component.
- Will not deteriorate or decompose over time
- Will not cause any chemical reaction
- Easily detectable and retrievable

A2.3.10.7 Each cover should carry an identifier that is clearly visible. For example a caution notice and/or be coloured to contrast the plant (e.g. fluorescent colours if appropriate).

A2.3.10.8 Temporary covers should not be used for extended periods. Once work is complete, then verification of system cleanliness may be required. Verifications may range from simple visual inspection to system flushes with rigid acceptance criteria and independent verification by appointed personnel.

A2.3.10.9 FME requirements, when identified, should be included into maintenance instructions. Reference should also be made within the job history section when completing maintenance history. FME requirements and FME control logs if used should be retained and included in the work package for future work planning.

A2.3.10.10 In the unfortunate event that FM ingress has occurred and cannot be safely and easily retrieved, the task should be stopped and the job made safe. A team that includes SQEP's should then consider the situation before any further action is taken which could possibly make the situation worse. Although it is best if foreign matter is retrieved it is inevitable that in some cases the foreign matter will be located in such a way as to prevent retrieval. In these cases design authority assistance may be necessary to determine the effects of leaving the FM inside the system and to consider alternative retrieval methods.

A2.3.10.11 In all cases when foreign matter has been allowed to ingress into a system or component even if it was retrieved, an effective corrective action process, possibly including root cause analysis, should be performed to prevent recurrence.

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A2.4. CHECKLIST

A2.4.1.1 Inspectors may find the following checklist helpful as a brief summary of the guidance contained in this appendix.

Checklist	✓
1. Maintenance professionals actively involved in continual reviewing of performance, reinforcing and sharing relevant good practice and correcting deficiencies	
2. Arrangements in place for staff at all levels to offer suggested improvements	
3. Planning arrangements appropriate to implement maintenance tasks.	
4. Essential maintenance appropriately staggered to retain redundancy.	
5. Arrangements in place to protect technicians from conflicting commercial pressures.	
6. Arrangements in place for independent functional checking.	
7. Arrangements in place for independent teams of technicians employed on duplicate plant.	
8. Adequate procedures to identify safety critical tasks.	
9. Readily available manuals, drawings and other necessary information sheets in a convenient location for those undertaking the work. Availability of key maintenance documents for emergency situations.	
10. Evidence that training adequately addresses safety critical tasks and the possible consequences if technicians fail to follow procedures.	
11. Evidence that training reflects feedback from those with appropriate maintenance experience and, where appropriate involves subject matter experts.	
12. Procedures to ensure that workplace check sheets are accurately copied across into final records.	
13. Arrangements in place for introducing alternative procedures when a deviation from standard procedure is necessary. Submission of any amended (red lined/penned) maintenance documentation through official review process.	
14. Job cards should accurately identify the appropriate maintenance manual or other key documentation.	
15. Arrangements in place for safety critical maintenance tasks to be inspected by supervisors and independently verified at completion.	
16. Arrangements in place to prevent technicians from working on two (or more) similar systems at once.	
17. Arrangements in place to achieve appropriate standards in temporary maintenance facilities.	
18. Appropriate storage, control and identification of tooling and specialist equipment.	
19. Evidence that redundant items are disposed of, especially old parts, consumables, and items that do not belong in the facility.	
20. Arrangements in place for ensuring that parts are adequately labelled, stored and documented. Unwanted components discarded through appropriate waste route.	

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Checklist	✓
21. Maintenance facility building or area is in a condition that is appropriate for maintaining nuclear safety critical plant.	
22. Housekeeping standards are appropriate.	
23. Equipment is safely and appropriately stored in a designated storage location.	
24. The facility is equipped with appropriate storage locations, shelving, containers, cabinets, etc.	
25. Hand tools are adequately controlled and maintained.	
26. Evidence that storage of consumables and spares is appropriately controlled to minimise inventory.	
27. Evidence that shelf life of spare parts and consumables is adequately controlled.	
28. Adequate lay down areas are provided for work in progress particularly large plant items and large specialist tools, jigs frames etc.	
29. Adequate consideration of FME and its potential effects on the plant.	
30. Adequate exclusion zones if necessary to control FM.	
31. Use of personnel to control and account for materials	
32. Adequate control of tooling and personal belongings to control FM, use of lanyards if applicable.	
33. Cleanliness, sterile working conditions during maintenance.	
34. Appropriate FME covers provided and in use.	
35. Are FME requirements included into maintenance instructions	
36. Procedures in place for dealing with FM if found inside a plant item.	

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