

<b>NUCLEAR SAFETY DIRECTORATE - BUSINESS MANAGEMENT SYSTEM</b>		
<b>TECHNICAL ASSESSMENT GUIDE MAINTENANCE, INSPECTION AND TESTING OF SAFETY SYSTEMS, SAFETY RELATED STRUCTURES, AND COMPONENTS</b>		<b>T/AST/009</b>
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## 1. Purpose and scope

1.1 The NII Safety Assessment Principles (SAPs) <sup>[1]</sup> contain a chapter devoted to defining the engineering principles which should be applied by NII when assessing plant and equipment across the whole range of reactor and chemical plant installations subject to the NII Act. These engineering principles have been structured such that they comprise three separate groups, namely "Key", "General" and "Plant Specific" principles.

1.2 This Technical Assessment Guide (TAG) addresses SAPs P76 and P329 which deal with in-service and throughout plant life maintenance, inspection

and testing. These SAPs are supported by other general and plant specific SAPs.

1.3 The TAG contains *guidance* to advise and inform NSD inspectors in the exercise of their professional regulatory judgement. Comments on this guide, and suggestions for future revisions, should be recorded on the appropriate registry file.

1.4 Additional guidance is available in the IAEA Safety Series [2,3,4,5,6]. Assessors should ensure that the recommendations of these documents have been considered. While they are directed at Nuclear Power Plants much of their content is applicable to other nuclear installations.

1.5 Nuclear processes are designed on the premise that the plant and equipment in use will retain the reliability claimed in the safety case (SC), thus ensuring that the risk associated with the process is kept at an acceptably low level. The reliability of this plant will only be maintained through the plant's full lifecycle by a process of maintenance including replacement, based upon a sound understanding of the plant and equipment's ageing mechanisms supported by a programme of inspection and testing.

1.6 The SAPs and this TAG address the need to ensure adequate arrangements are (or will be) in place for the maintenance, inspection and testing of the safety systems, safety related structures, and components identified in the SC. These arrangements should address the need to plan, specify, implement, monitor and review the maintenance, inspection and testing activities. It is a further intention that where changes are made to either the plant and equipment or the maintenance, inspection and testing regime, they do not unacceptably degrade the overall SC.

## **2. SAPs addressed**

### 2.1 Key principles

There is only one Key principle that deals with this topic, P76. It is however supported by a "Life Cycle" principle, P329.

### 2.2 Supporting principles

The Key principles are supported by a number of general and plant specific principles. These are:

- 1) P66 - Novel designs .. monitored during service.

- 2) P82, P83 and P145 Use of best practicable standards of maintenance and inspection commensurate with the safety categorisation.
- 3) P97 - Initial test and qualification for establishing datums.
- 4) P98 - Testing etc. to maintain continuing quality and reliability.
- 5) P99 - The design and layout to facilitate inspection, testing, maintenance etc.
- 6) P100 - Provisions for in-service functional testing of all safety systems and other safety-related equipment.
- 7) P101 - Periodic measurement to reflect time degradation.
- 8) P116 - Lifetime environmental influence.
- 9) P146 - Existence of defects can be established by inspection throughout the operational life.
- 10) P148 - Product form of metal components and their parts should assist inspectability.
- 11) P154 - Materials suitable to enable inspection and maintenance.
- 12) P156/P164 - In-process inspection and proof testing before service.
- 13) P162 - Provisions for inspection.
- 14) P163 - Inspection techniques, redundancy and diversity.
- 15) P194 - Restrictions on reconfiguration of a safety system.
- 16) P198 - Allowances for unavailability of plant.
- 17) P199 - Potential to initiate a fault sequence within safety-related plant.
- 18) P200 - Minimising vetoing and taking out of service of any safety system function.

19) P269 - Fuel assemblies designed to permit adequate inspection.

2.3 In addition to the SAPs listed above there are further related SAPs to be considered, namely:

1) P22 and P33 - Accident condition SAPs that take account of component outages due to maintenance.

2) P41 - PSA provision of information relevant to maintenance and testing.

3) P54 and P55 - Review of fault analysis and collection of data throughout the operating life (e.g. data collected on failure rates and unavailabilities).

4) P323 - Construction.

5) P324 - Commissioning tests and inspections.

2.4 This guide deals with the specific area of maintenance, inspection and testing of safety systems, safety related structures, and components. It is likely that assessments may also need to take into account original safety categorisation and equipment qualification, reliability, and ageing which are the subject of other assessment guides.

2.5 Many of the general principles have been written in very broad terms to allow them to deal with a range of engineering applications and so interpretation has had to be carried out to produce this guide. To ensure that this interpretation is fully understood, the assessment will be carried out by suitably qualified assessors in the appropriate assessment Unit.

2.6 The SAPS identified above are referenced in the following sections of this TAG.

### **3. Relationship to licence and other relevant legislation**

3.1 Site Licence condition 28 - Examination, Inspection, Maintenance and Testing specifically deals with this area and calls for the licensee to make and implement adequate arrangements for the regular and systematic examination, inspection, maintenance and testing of all plant which may affect safety. Also of relevance are Licence conditions 14 and 15 (preparation and review of safety cases), 23, 24, 25, 26, and 27 (control of operations which includes maintenance), 29, 30 and 31 (Plant shut down and test requirements), 7 (investigation and reporting) and 12 (duly authorised

and other suitably qualified and experienced persons).

#### **4. Advice to assessors**

4.1 For any new plant, modification to existing plant or revision to a SC, the SC should clearly identify all safety systems, safety related structures and components on which the continuing adequately safe operation of the plant depends. Assessors should confirm that this information is presented or otherwise defined. Judgements as to the adequacy of the SC and the identification of safety systems etc. are addressed in other TAGs.

4.2 SAP P76 expects that provision will be made for the monitoring and inspection of all safety systems, safety related structures and components throughout their lives commensurate with the reliability required of each item. It is implicit that this includes maintenance necessary to ensure the plant can reliably continue to perform the function required by the SC.

4.3 The requirements for periodic maintenance, inspection and testing should be identified and recorded in a maintenance schedule or schedules (P329). This schedule or its associated documents may act as a link between the:

- i) SC requirement for maintenance, inspection and test;
- ii) procedures and instructions by which the work is carried out;
- iii) arrangements in place to confirm that it has taken place, and
- iv) reporting of outcomes or results.

#### **4.4 Safety case**

1) The SC, at an appropriate stage of development, should identify the nature (not detail) and periodicity of the maintenance, inspection and testing proposed and provide a justification for any long term performance claimed without such inspection etc. Whenever the latter claim is made, the assessor should confirm (P76) the adequacy of the additional design measures incorporated to justify the absence of monitoring and inspection or the alternative arguments cited in support of such a claim.

2) Assessors should confirm that the overall arrangements for maintenance, inspection and testing as set out in the SC are

adequate. Assessors should review the nature and periodicity of (a sample of) the inspection and testing set out in the SC. The assessor should normally concentrate on those features which make a significant contribution to safety. Where novel design features are utilised the assessor should consider the need to assess the associated monitoring provisions (P66). The assessor should also confirm (by appropriate sample) that less significant features have been addressed.

3) Assessors should confirm, guided by judgement and experience, supported as necessary by data from previous operating experience, that the periodicity and the content of the testing etc. is appropriate and sufficient to assure the continuing safety function and reliability claimed for the equipment (P98).

4) The assessor should confirm (by sample) the translation of the assumptions (e.g. component unavailabilities and outages due to maintenance) used in the accident condition SAPs P22 and P33 and the relevant PSA information (e.g. reliability requirements) P41 into the SC maintenance, inspection and test documentation. Also that these assumptions and requirements can be traced through to the implementation documentation such as the maintenance schedule and procedures (see below).

5) A number of SAPS (i.e. P82, P83 and P145) address the need for the licensee to adopt appropriate standards commensurate with the safety categorisation of the structure, system or component. This includes consideration of maintenance, inspection and test standards. The assessor should, therefore, confirm that the licensee has selected and justified appropriate standards (e.g. best practicable commensurate with the safety categorisation etc. for inspection, maintenance .. P82) for maintenance, inspection and test in the SC.

#### 4.5 Maintenance schedule

1) Assessors should confirm that any assumptions made in the SC for maintenance, inspection and testing and its periodicity are accurately and adequately translated into the schedule. For new plants or substantial modifications, this confirmation will normally be done by a review of the procedures by which the Licensee creates or modifies the schedule and confirms that the changes are comprehensive and accurate plus sampling of selected aspects. Selection of the sample should be guided mainly by safety significance but should include a range of topics and systems. For simpler modifications, a direct check that the SC assumptions have been satisfactorily translated into the

schedule may be possible.

2) While in general assessors may disregard the timing as opposed to the periodicity of the maintenance, inspection and testing and leave that to the commercial judgement of the Licensee, when any (near) coincident testing of related systems etc. is proposed, attention should be paid to the following safety concerns :

i) Confirmation that any SC requirements for staggered testing are translated into the schedule.

ii) Confirmation that, in constructing the schedule, the Licensee has considered the need for, and demonstrated;

a) that the minimum configurations of operational safety systems justified in the SC (P22, P33 and P198) will be maintained for the duration of any maintenance, testing etc.

b) compliance with any requirements on plant availability derived from consideration of the Single Failure Criterion (see **T/AST/011**).

#### 4.6 Maintenance, inspection and testing implementation

1) The maintenance, inspection and test programme should be implemented in accordance with the requirements of the maintenance schedule and related procedures and instructions.

2) Assessors should review (a sample of) the maintenance, inspection and testing instructions to confirm that all the key SC requirements for the system components are addressed and that their satisfactory completion will provide confirmation that the equipment will continue to function with the necessary performance, sensitivity and reliability (P98). The testing, as set out in the procedures, should comprise a full functional test (P100) or demonstrate equivalence to it.

3) Assessors should confirm that the instructions provide for the full and accurate reporting of every maintenance, inspection and test. This should include the recording and reporting of any defects (P146) and of any properties or parameters which may need to be monitored to confirm continuing serviceability (P101). Evidence of degradation or adverse environmental conditions which may affect (P116) the

continuing satisfactory functioning of the equipment should be reported. Clear criteria for successful completion of the work should be stated and the procedures should provide for the reporting and rectification of non-conformances. Note that LC 28 requires any matter indicating that the safe operation or safe condition of the plant may be affected should be the subject of appropriate action including investigation and reporting under LC 7 arrangements.

4) The implementation arrangements should ensure that activities are performed and supervised by competent staff using equipment and tools which have been demonstrated to be adequate for the task. In certain circumstances the personnel and equipment may require validation (P163).

5) Assessors should confirm that the implementation arrangements make use of specifically engineered and adequately safeguarded facilities under strict administrative control (P194) where it is necessary and justified (P200) to alter the configuration of a safety system during maintenance, inspection and test.

#### 4.7 Maintenance, inspection and testing review

1) It should be confirmed that licensees have procedures for the periodic review of the results and reports of the maintenance, inspection and testing to ensure that adverse trends are detected and appropriate and timely remedial action may be initiated.

2) The review procedures should address the need to revisit the fault analysis carried out at the design stage in the light of any relevant information revealed by the maintenance, inspection and test activities (P54 and P55). Note that this will require the licensee to collect data throughout the operating life of the plant.

#### 4.8 Maintenance, inspection and testing changes

1) For plant modifications, assessors should confirm as in preceding sections that any relevant maintenance, inspection and testing aspects necessary to ensure adequate safety are incorporated into relevant schedules and procedures. This should include confirming that any knock-on effects on the unmodified plant's maintenance schedule(s) have been considered and appropriately implemented.

2) Proposals to change any established maintenance, inspection or testing requirement necessary to ensure adequate safety, or to delete

them, should be submitted in a SC and assessed to confirm whether or not the change is adequately justified. In particular, where the proposed change involves a reduction in the maintenance or its frequency, assessors may wish to consider the need for a review of experience after a predetermined period to demonstrate that the required reliability is being maintained.

#### 4.9 Maintenance, inspection and testing in design

1) In the assessment of the adequacy of a proposed design or modification, assessors should consider the future need to carry out maintenance, inspection and testing and confirm that, so far as is reasonably practicable the design facilitates such activities. A number of SAPs consider this aspect, namely: P66, P99, P100, P148, P154, P162, P194, P198, P199, P200 and P269.

#### 4.10 Construction and commissioning

1) It should be noted that SAPS P323 and P324 specifically address construction and commissioning. The factors noted here are those that have implications for in-service maintenance, inspection and test. Assessors should ensure that preconstruction and precommissioning safety cases for new plant define adequate arrangements for:

- i) Maintenance of installed (but unused) equipment.
- ii) Inspection of structures and components to define the as built state, and identify and characterise defects (e.g. in-process inspection P156).
- iii) Testing to prove integrity and functionality of structures, safety systems and components (e.g. type testing and commissioning reference data P97, and proof testing P164)

#### 4.11 General

1) The above guidance is set out in general terms to allow its application to a range of engineering disciplines. Detailed interpretation will be necessary by experienced assessors in the relevant engineering disciplines. The depth and scope of the assessment should be related to the safety significance of maintenance, inspection and test as defined in the SC.

2) In carrying out assessments relating to maintenance, inspection and

testing of safety systems, safety related structures and components as set out above, assessors may wish to draw to the attention of other specialists, or more commonly the site inspector, matters in their respective areas of responsibility. This is particularly relevant when assessing instructions.

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## **Appendix 1 - Outage Inspections**

A1.1 It is established practice and often a regulatory requirement that reactors and some nuclear chemical plant is shutdown periodically to permit the carrying out of maintenance inspection and testing which cannot be done with the plant operational. Licensees should produce in advance a programme for such work. Much of that programme will be prescribed in the maintenance schedule and its supporting documents, but it will typically include maintenance, inspection and testing discussed in this TAG. For plant which is not subject to routine shutdown, the work should be otherwise programmed but assessed broadly as in this TAG.

A1.2 Substantial, generally passive structures such as reactor pressure vessels, non-replaceable reactor internals and equivalent features on nuclear chemical plant such as process vessels, piping and storage facilities normally containing highly active material are inspected according to a more extended programme which may be less explicitly defined and subject to iterative review. Appropriate reference should be made to such work in the schedule and assessors should confirm that all relevant structures, systems and components are identified in the schedule and that the arrangements whereby programmes of work are defined and reviewed are referenced. Inspections of this nature are often (but not always) associated with periodic shutdown of facilities.

A1.3 Assessors should carry out a timely review of the programme to establish that it provides the necessary coverage of the plant (within an overall long term plan) and includes all additional work identified as necessary as a result of review of previous inspections, undertakings or safety concerns identified during operation of the plant or arising from generic concerns.

A1.4 It should be confirmed that all inspections etc. will be carried out to written procedures and that appropriate arrangements are in place for the independent checking (by sampling) of inspections to confirm that appropriate quality is maintained. Licensees' arrangements for the reporting and review of results, categorisation and sentencing of defects, including where appropriate independent assessment, and reporting the overall results should be assessed to confirm overall acceptability. Particular attention should be given to the process whereby the licensee ensures that, where there is a regulatory or procedural control over restart, all findings which are pertinent to the safety justification for the restart are provided

for timely consideration by assessors.

A1.5 Procedures should be sampled to confirm that they contain clear and adequate instructions, guidance on reporting criteria and provide adequate means of spatially identifying and recording both items inspected and any features or defects observed.

A1.6 Assessors involved in the review of a sample of inspection findings should, while guided by the need to concentrate particularly on matters of greatest safety significance, include in the sample a range of inspections to confirm the general adequacy of conformance to relevant procedures.

A1.7 Assessors should review the final outage inspection reports (traditionally the 28-day report) or any equivalent reports and urgently advise if any of the matters reported raise new concerns which should have been considered in the context of restart. They should also review the reports to confirm that the licensee has considered and adequately addressed any trends in the results of the inspection etc. programme.

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## **Appendix 2 - Definitions**

### A2.1 Maintenance

The replacement, repair or adjustment of plant, equipment or components.

### A2.2 Inspection

The examination of the plant, equipment or components by visual, electronic or other means.

### A2.3 Testing

The monitoring of the operation, actuation, condition or state of the plant, equipment or components under either normal operation or special conditions.

### A2.4 Safety System

A system which acts in response to a fault to prevent or mitigate a radiological consequence.

### A2.5 Safety Related

A plant system, other than a safety system, on which radiological safety may depend.

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## **References**

1. Safety Assessment Principles for Nuclear Plants. (HSE 1992)
2. IAEA Safety Series No 50-SG-O7 (Rev 1) - Maintenance of Nuclear Power Plants : A Safety Guide.
3. IAEA Safety Series No 50-SG-O2 - In Service Inspection of Nuclear Plants : A Safety Guide.
4. IAEA Safety Series No 50-P-2 - In-Service Inspection of Nuclear Plants - A Manual.
5. IAEA Safety Series No 50-SG-D3 - Protection System and Related Features in Nuclear Power Plants : A Safety Guide.
6. IAEA Safety Series No 50-SG-D8 - Safety-Related Instrumentation and Control Systems for Nuclear Power: A Safety Guide.