

## Appendix 2

### **Ageing Plant: Site Operator Self-Assessment Question Set**

1. This appendix contains a question set to help operators assess compliance against 'Managing Ageing Plant: A Summary Guide'.
2. In the question set, each high-level question is provided with benchmarks to indicate what would typically be expected to manage the issue. It should be noted that the way these arrangements or systems are developed, provided and implemented will vary greatly depending on the nature and ways of working of the operator, and the hazards, size and complexity of the plant being managed.
3. Some supplementary questions are also provided which address the key underlying issues relevant to each high-level question.

**Key Questions on Ageing Plant**

**Question 1. Plant and Equipment on Site**

What plant and equipment is involved at the site?

*Rationale: It is important to know what plant and equipment is present on site, how important it is to safety, and whether it may be subject to ageing mechanisms, so it can be managed effectively.*

**Benchmark**

There should be an asset register that lists important plant and equipment and its location.

There should also be information on relevant hazardous fluids present within plant and equipment, together with their hazardous properties i.e. Material Safety Data Sheets (MSDSs).

Most sites will have both computer and hard copy records containing this information but often it will be kept in different formats, and records may be fragmented. The format is not critical providing that information on hazardous fluids and the hazardous fluids operating envelope is easy to access and use.

It is also important that the Asset Register is kept up-to-date and mirrored by accurate up-to-date process and instrumentation diagrams, P&IDs, and other plant or process documentation.

The Asset Register should clearly identify all primary containment safety-critical mechanical equipment (tanks, vessels, pumps, piping etc) which if they failed could give rise to a major accident. There should also be a register of safety-related electrical, control and instrumentation and prevention/control/mitigation safeguards equipment for major hazard plant.

There should be some form of prioritisation or risk ranking system within the asset register or maintenance management system to highlight safety-critical plant and equipment associated with major hazard plant.

There should be arrangements for identifying and highlighting equipment found to be subject to significant ageing, either through inspection reports, written schemes of examination or integrity reviews, so these can be monitored and managed effectively.

**Underlying Key Issues**

- Do you have an Asset Register?
- How is the Asset Register kept up-to-date?
- Does it include electrical, control and instrumentation, EC&I, prevention, control and mitigation safeguards, and structures (this can be particularly important where the safety of the plant relies on instrumented protective systems e.g. Safety Integrity Level (SIL) 1 or higher rated systems)?
- Are safety-critical items highlighted together with all the relevant assets that comprise this, support it, or are necessary for it to function?
- Are items found to be suffering from ageing identified, highlighted and given specific attention e.g. in risk-based inspection, RBI, reports, inspection reports or written schemes of examination?

**Key Questions on Ageing Plant**

**Question 2. Plant and Equipment Exhibiting Signs of Ageing**

Are arrangements in place to identify and assess the condition of plant and equipment that may be showing signs of ageing, or which may be approaching or beyond its original design life or calculated remnant life, and to justify continued operation or down-rate/decommission this?

*Rationale: Plant and equipment exhibiting signs of ageing, such as corrosion, erosion, fatigue, creep, obsolescence, etc should be identified so it can be monitored/assessed to check it is still fit for purpose. If the deterioration is significant, then plant and equipment may have to be down-rated, removed from service, or other measures introduced so it can continue operation.*

**Benchmark**

Reviews of documented information about the plant, including reassessments of design in relation to operating history, is a useful way to identify the potential for ageing after a period of service. An appraisal of operations, maintenance, inspection, and test and repair records could reveal trends in ageing.

There should be processes to identify plant that is either showing degradation or malfunctioning (e.g. inspection regimes or maintenance and test routines). Where plant is showing significant degradation or approaching its design life, there should be clear justification for continued operation.

In the first instance, this may be based on a calculation of the remaining life. This process is described in published guidance on inspection and should be carried out by a competent person and recorded. Where calculated remnant life extends beyond design life, then there should be a formal mechanism for approving this life extension (most likely by a senior manager within the organisation). This applies wherever it is intended to use equipment beyond its originally specified design life.

Where the remnant life calculation does not justify continued operation (for example where there is no remaining corrosion allowance), then a fitness for service assessment may be used, providing that it too is carried out to a recognised standard, by a competent person, recorded and approved. In all cases the methods for continued condition assessment and monitoring of such plant should be identified.

Leading and lagging performance indicators should be set for monitoring the effectiveness of ageing plant controls. Leading indicators could include a 'cyclic' environment, information that staff responsible for equipment on a day-to-day basis are competent and aware of the tell tale signs of ageing from plant performance.

### Key Questions on Ageing Plant

Lagging indicators could include repeated service problems and unplanned shutdowns, leakage, surface damage such as blistering or corrosion, or reductions in plant efficiency or lack of process stability. The latter could indicate pipe fouling or valve pump/seizure, or excessive vibration and movement.

While fatigue (cycling), creep, cracking and corrosion are typical features of ageing they manifest themselves in different ways. Visible deterioration e.g. leakage, surface damage, blistering and corrosion are obvious enough but there are others that are equally revealing. Internal inspections/non-destructive testing, NDT techniques will show what is happening in places that cannot be seen and can measure rates of corrosion and other changes.

The stability of the process is another indicator. Repeated service problems and unplanned shutdowns all provide useful information. It is unlikely that the plant was designed to do this and there must be a reason that could be age-related for these unplanned events and excursions.

Where plant items are removed from service, there should be arrangements to ensure that they are managed and maintained so that they remain safe and do not present a hazard to people, the environment and or other equipment.

### Underlying Key Issues

- Are there arrangements to identify plant and equipment that may be showing signs of ageing?
- Are there arrangements to identify plant and equipment approaching or beyond its original design life or calculated remnant life?
- How is their condition assessed and monitored?
- What leading and/or lagging indicators are used to indicate assets that may not be performing as required or showing signs of deterioration in their integrity or performance?
- Is the remnant life calculated for items showing significant degradation?
- Where remnant life calculation suggests an extension of service beyond design life, or the design life is approaching, are formal life extension studies conducted?
- Who is responsible for conducting plant life extension studies/justifications, etc?
- Who is responsible for approving the use of such equipment or plant and determining conditions for its continued use, e.g. setting the inspection/review periods, allowable service limits, etc?
- Are there arrangements in place to manage items 'removed from service'? These still need to be managed and maintained to ensure they remain safe and do not present a hazard to people, the environment or other equipment.

**Key Questions on Ageing Plant**

**Question 3. Plant and Equipment Change Management**

How are changes to plant and equipment assessed and are ageing issues addressed as part of this?

*Rationale: new plant and equipment, changes to existing plant and equipment, or changes to the conditions under which they operate need to be identified and assessed. If these could detrimentally affect the integrity or performance, breach safe operating and design limits, introduce new ageing mechanisms or exacerbate deterioration due to existing ageing mechanisms, then suitable safeguards would need to be identified and provided to manage the situation.*

**Benchmark**

Some form of hazard studies (e.g. HAZOP) would be expected for new plant designs and modifications to assess the hazards and risks.

There should be a formal change management system and procedures for plant changes to ensure these are identified, assessed and approved at the relevant level.

A change approvals procedure should require specialist safety and mechanical engineering input/checks.

A good change management system should also capture changes to safety-related control and instrument systems including software changes.

There should be some mechanism for the changes approved by the change management system to result in an update of the asset register and to ensure drawings (P&IDs or process flow diagrams, PFDs) or plans are updated to show the changes.

**Underlying Key Issues**

- Are plant design reviews and hazard studies carried out for new plant and major modifications?
- Does the change management system address alterations, temporary changes, modifications and repairs to plant and equipment including EC&I (including software/control systems), safeguards, and structures?
- How do you check that changes proposed do not impact the original design basis/specification or the intended operating envelope of the process and plant or equipment?
- Are these changes recorded/logged, safety-assessed, and approved before the changes are implemented?
- Are specialists such as mechanical integrity, engineers, corrosion specialists, EC&I specialists and health/safety/environmental specialists consulted as part of the assessment and approvals process?
- Who can approve the changes and are they competent to do this?
- How are changes fed in to the asset register(s) to keep it up-to-date?
- How are plant drawings, data sheets, operating manuals, maintenance manuals and other key documents and procedures kept up-to-date with changes or new additions?

**Key Questions on Ageing Plant**

**Question 4. Managing the Integrity of Plant and Equipment**

Is there an Integrity Management System in place and who is responsible for managing the integrity of the plant at the site?

*Rationale: Asset integrity management is a significant task that needs to be properly managed. Over the years sites may have changed, organisation and management reorganised and duties reallocated. There has also been an increase in the use of independent bodies for the management of integrity.*

*It is important to establish who has the responsibility onsite for managing the assets and what demarcation there may be between them and independent bodies or other bodies who have a role in asset integrity assurance.*

**Benchmark**

There should be a clearly defined Integrity Management System in place at the site covering policy, strategy, responsibilities and arrangements for the management of integrity of all major hazard assets.

The maintenance, inspection and testing requirements set out in the Integrity Management System should be based on appropriate information, e.g. equipment supplier advised requirements, historically developed requirements, reliability or risk-based assessments, etc.

Ownership of the process and clarity in the responsibilities should be clearly set out in the procedures or organisational arrangements.

It should be clear who is responsible for the integrity of the plant, does this include the safeguards and EC&I equipment, if not – are responsibilities clearly assigned for these?

Uncertainty in responsibilities, or gap and overlaps may indicate a defective system.

It should be clear who has the responsibility onsite and what the demarcation is between them and independent bodies or other parties who have a role in plant integrity assurance.

**Underlying Key Issues**

- Who is responsible for the maintenance management system (MMS), and keeping this up-to-date?
- Are there clear interfaces and no significant gaps/omissions between responsibilities for integrity e.g. if use third parties or contractors or if other companies/sections share assets on the site – what do they cover, is this clear?
- Are there clear interfaces and allocation or responsibility for pipelines, vehicles, transportable containers or other transport features coming on to or leaving the site?
- Are all the assets/asset types covered, including EC&I (including software/control systems), safeguards, and structures?
- Are there good lines of communication between operators, maintenance technicians and managers covering inspection, testing, maintenance, and repair activities and requirements so that everyone is clear about their role and responsibilities and so issues can be quickly identified and resolved?
- How are the requirements for maintenance, testing and inspection set?
- Some testings, e.g. functional testing, may be conducted by operators. If so, is this logged in the MMS or some other system to plan and log the tests and record the findings?

**Key Questions on Ageing Plant**

**Question 5. Changes to the Integrity Management System**

How are changes to the asset management system assessed, controlled and communicated?

*Rationale: Over the years there are likely to be many changes to the asset integrity management systems, arrangements, and procedures as requirements, ideas and practices change. There may be changes to the inspection periods, the type and scope of testing, use of different inspection bodies, or a move to a risk based inspection method or changes to Written Schemes of Examination. These changes need to be controlled, assessed and recorded to ensure the systems continue to be fit for purpose and effective.*

**Benchmark**

Changes to the Integrity Management System could involve changes in methods and scope e.g. as a result of inspection findings (day-to-day changes) or more comprehensive changes to the system e.g. organisational changes or a move to a RBI based inspection strategy (strategic changes). The standard of assessment and authorisation would be different for more strategic changes.

For day-to-day changes:

Fitness-for-service assessment, repair and revalidation need to be supported by on-going schemes of examination that address the age and condition of the plant and equipment and the risk of failure.

This process should be managed transparently. It should be clear who has the authority to revise and change written schemes of examination.

It may be useful to check when the written schemes of examination were last revised to see both what was done and who on site was responsible for it, and who approved the change or revision.

If the scheme(s) was (were) not changed in line with changes to the plant and equipment, then the extent, nature or frequencies of the inspection need to be reviewed and revised or the operator needs to justify why no change is needed.

For more strategic changes:

There should be evidence of assessments being carried out of the impact of recent organisational changes; did these check for implications for the integrity management systems, including the loss of key skills or knowledge needed to maintain integrity?

There should be evidence of changes being communicated to the workforce and relevant contractors or other external bodies, or of training, so they are aware of new arrangements, responsibilities or standards/procedures/requirements.

Changes to the integrity management systems should be identified, assessed, managed and approved through the change management systems.

**Key Questions on Ageing Plant*****Underlying Key Issues***

- Do the change management systems address changes to:
  - The organisation, responsibilities, persons and competence?
  - Inspection, testing and maintenance procedures?
  - Asset integrity or operational priorities?
  - Change in examination, inspection or testing arrangements scope and frequencies?
  - A move to a risk-based inspection regime(s)?
  - A change in the competent body(s) or their scope of work?
  - Changes in international, national, company and local codes, standards, practices or guidance?
- How do you ensure that key skills, knowledge and experience relevant to asset integrity management and ageing is not lost when people leave, retire, move to a new position in the company etc?
- Are the changes recorded/logged, assessed, and approved before the changes are implemented?



**Key Questions on Ageing Plant**

**Question 6. Resources**

Are integrity management resources monitored to ensure the required level of attention, focus, skills and knowledge are maintained?

*Rationale: Asset integrity management is a significant task that needs to be properly managed and resourced. Over the years sites may have changed, organisation and management reorganised, personnel changed and duties reallocated. There has also been an increase in the use of independent bodies for the management of integrity.*

*It is important to establish that those with responsibility for managing the assets and undertaking the maintenance, testing, inspection, are suitably competent and that the overall allocation of resources is adequate to maintain the integrity, functionality and safety of the plant and equipment.*

**Benchmark**

Those responsible for managing and undertaking maintenance, testing and inspection should be competent for this. Someone with an engineering qualification would be expected to manage the maintenance, inspection and testing systems and arrangements. Technicians should also have suitable NVQ, SVQ or similar qualifications or experience or specific training to meet the company requirements. Supervision should be in place for those not yet assessed as fully competent, newcomers, or those in training. Some companies will have recruitment, training and development competence assessment systems in place. Important attention should be paid if a new inspection body or contractor for maintenance has been appointed, or where experienced staff are due to retire, or other organisational changes may be underway. Where key people are about to leave, arrangements to retain or plug gaps in skills and knowledge should be in place.

Checks should be in place to confirm the competency of third parties involved in asset integrity management. These should include competence checks as part of the selection and monitoring processes for contractors.

Inspection bodies should be registered and certificated as such, e.g. to BS EN ISO/IEC 17020:2004 and UKAS accreditation.

The level of backlogs in the maintenance management systems may give an indication as to whether the overall levels of resources are suitable. This can be a particular issue if there has been recent downsizing of maintenance staff and managers in the company.

Changes to resources or responsibilities should be identified, assessed, managed and approved through the change management systems

### Key Questions on Ageing Plant

#### ***Underlying Key Issues***

- Who is responsible for monitoring and maintaining the maintenance, inspection and testing programme and ensuring this is delivering the required performance?
- Are those responsible suitably qualified in terms of professional qualifications, experience and skills?
- How are contractors or other bodies involved in asset integrity management or inspection and testing activities selected, and how are they assessed for competency and managed/monitored to check they are working to the required scope and standards?
- How do you ensure you retain the skills and experience to maintain, test, (re-program?) and repair unusual, novel, old or obsolete plant and equipment (include EC&I systems and equipment) still in use on site?
- How are Maintenance Management System (MMS) backlogs monitored, priorities assigned and addressed?
- Are job/skills continually addressed when changing personnel or plant and equipment?
- How is the adequacy of overall resource levels assessed? Is the completion and close out of tasks and actions and MMS backlogs used as KPIs?

**Key Questions on Ageing Plant**

**Question 7. Awareness of Ageing**

Are those responsible for ensuring asset integrity aware of ageing mechanisms, and what plant and equipment may be particularly prone to this type of deterioration?

*Rationale: It is important that those responsible for managing the integrity of the assets and conducting maintenance, inspection and testing, are aware of the potential ageing mechanisms relevant to the assets on site, the conditions under which these can occur and the types of deterioration they can cause. This is a key issue if ageing issues are to be identified early and managed effectively.*

**Benchmark**

This is vital to making decisions about ageing plant. The decisions made here are only as good as the information available and the soundness of the process used to apply it.

Those who are responsible for assessing the fitness for purpose of plant should be aware of its age, likely damage mechanisms, current condition, and rate of ageing and remaining life.

Are key issues, signs or symptoms being communicated to operations or maintenance personnel so they are aware of what to be alert to as indicators of ageing plant?

It is likely that only the largest and international multi-site operators will have fully developed formal systems. Smaller less complex sites should take a proportionate approach based on:

- asset management planning;
- periodic reporting on condition indicators;
- identification of key equipment performance indicators along with availability/reliability targets;
- comparative equipment performance reviews;
- reporting analysis of lost production, incidents, and failures;
- holding plant integrity review meetings;
- knowledge about industry codes and guidance through trade associations and standards bodies; and
- access to specialist skills and knowledge on ageing mechanisms and their management.

**Underlying Key Issues**

- Do those responsible for maintaining, testing and inspecting plant and equipment, and managing these activities, have an understanding of ageing issues?
- Are they aware of the key indicators to show that a plant is ageing?
- Are those responsible aware of current standards and guidance and are they applying these?
- Do they have access to mechanical engineers and corrosion/asset integrity specialists, electrical, control and instrumentation specialists, for specialist advice?
- Do they carry out reviews of the operational history to identify equipment that may have been subject to ageing-related deterioration, or prolonged service, or operated at or above its design limits?

Key Questions on Ageing Plant
<p><b>Question 8. Out-of-date or Obsolescent Plant and Equipment</b></p>
<p>How is out-of-date or obsolescent plant and equipment, particularly EC&amp;I equipment, identified and managed to ensure their integrity and performance (including equipment that may no longer be supported by the supplier or manufacturer)?</p> <p><i>Rationale: Some of the assets on site, including electrical, instrument and control systems may be very old, or essentially obsolete, or no longer supported by the manufacturer or supplier. This may not necessarily mean that they are no longer fit for purpose, but it could affect the ability to maintain, test and repair these items.</i></p>
<p><b>Benchmark</b></p>
<p>There should be a list of equipment that is obsolete or no longer supported by the manufacturer/supplier. This may be indicated in the Asset Register and maintenance procedures.</p> <p>There may be special arrangements for repairing, maintaining or replacing such equipment, for example to have access to other suppliers of parts or to access software programmes with the right experience.</p> <p>A programme of replacement may be needed where equipment is approaching the end of its useful life and/or is obsolete or no longer supported by the manufacturer/supplier.</p> <p>Where EC&amp;I equipment is to be replaced with modern digital equipment, this will need to be carried out in accordance with the requirements of IEC 61508/IEC 61511 (including change management). If the in-house specialist resources and competency in these key areas is not available, then consideration should be given to bring in specialist contractors to advise and assist.</p>
<p><b>Underlying Key Issues</b></p>
<ul style="list-style-type: none"> <li>■ How is the condition of out-of-date or obsolescent plant and equipment identified? (This can be a particularly important issue for EC&amp;I equipment and systems, which may also have a shorter design life than mechanical equipment.)</li> <li>■ How is equipment maintained, repaired and tested where there is difficulty in accessing detailed information on its design and maintenance requirements, difficulty in obtaining spares, or a lack of expertise/skills or knowledge, for example, to maintain, change/debug software etc?</li> <li>■ How do you access specialist skills or knowledge needed about these items?</li> <li>■ What is the replacement strategy for such plant and equipment?</li> <li>■ Where EC&amp;I equipment is to be replaced with modern digital equipment, is the company aware of the requirements of IEC 61508/IEC 61511, and the implications of these, particularly regarding specialist resources and competency to deal with these?</li> </ul>

**Key Questions on Ageing Plant**

**Question 9. Monitoring the Condition of Plant and Equipment**

How is the condition of plant and equipment monitored?

*Rationale: The asset integrity management system needs to include arrangements to check/assess the condition and performance of the assets on an ongoing basis to make sure they remain fit for purpose and to identify items needing non-routine maintenance, repair or replacement etc. Various methods can be used to monitor the condition of the assets depending on the circumstances. The information gathered is also important to allow the overall effectiveness of the asset integrity management system to be assessed and to identify areas for improvement.*

**Benchmark**

There should be an inspection and testing plan in place which shows what needs testing, and at what interval. This should also record the test/inspection dates and a summary of links to the conclusions (pass/fail). This plan should include all safety-critical equipment including prevention, control and mitigation safeguards and structural elements as well as the primary containment and motive equipment such as pumps, compressors, etc. Some form of documented scheme of examination should be in place for safety-critical equipment, especially where this is for major hazard plant.

As a minimum, there should be formal records of all inspections of pressurised equipment and the testing of safety related devices such as SIL-rated instrumented safety systems, pressure relief valves etc. Pressure systems should have up-to-date written schemes of examination in place.

The maintenance management system should also contain logs of remedial work or repairs undertaken.

There should be a clear process to ensure that reviews of inspection reports and maintenance activity are carried out. As a minimum this should be undertaken by a competent engineer; more complex sites may employ a formal team-based site-wide review. There should also be a process for senior management review for key issues arising.

There should be a process in place for identifying changes in codes, standards and practices relevant to integrity management and assessing the impact of these, including adapting plant, equipment or procedures as appropriate.

There should be evidence of changes to the inspection and testing arrangements for equipment that has been found to be suffering unacceptable levels of deterioration.

### Key Questions on Ageing Plant

#### ***Underlying Key Issues***

- Are records kept of all maintenance, inspections, testing/proof testing, calibrations and repairs? [see Research Report 509 Plant ageing: Management of equipment containing hazardous fluids or pressure (4), Section 2.4 page 32].
- Are all the assets/asset types covered, including EC&I (including software/control systems), safeguards, and structures?
- What methods are used to indicate trends or issues in the condition of the assets, e.g. regular reviews of data, use of key performance indicators (KPIs) benchmarking of performance etc?
- Are reviews conducted to assess the implications of revised/new codes and standards etc, and adapt plant, equipment or procedures where appropriate?
- Are regular integrity reviews conducted by suitably qualified persons to look for trends and issues, and are significant issues referred to and given attention by senior management? For more complex high hazard sites, might expect formal integrity reviews attended by senior management.
- Has plant or equipment been identified as ageing, and if so, how was this identified/discovered and what is being done to manage this?

Key Questions on Ageing Plant
<p><b>Question 10. Feedback, Review and Continuous Improvement</b></p> <p>How are the findings of inspections, tests, maintenance and repairs used to manage and improve the integrity of the assets?</p> <p><i>Rationale: It is important that information is gathered and used to allow the overall effectiveness of the asset integrity management system to be assessed and to identify areas for improvement. Useful data could be collected from a variety of sources, not just the inspections and test records.</i></p>
<p><b>Benchmark</b></p> <p>Integrity reviews should be carried out for equipment to assess the overall adequacy of the integrity assurance arrangements.</p> <p>The findings of the tests and inspections should be used to review performance and improve the arrangements and inspection/testing periods etc. Use leading and lagging key performance indicators (KPIs) to assess the integrity of the assets with objectives/targets set and reviewed annually for these KPIs.</p> <p>Plant and equipment approaching or past its design life or calculated remnant life should be identified and given specific attention in integrity/asset reviews.</p> <p>Lessons and trends from incident, accident and near miss reporting systems should also be being used to improve the asset management systems.</p> <p>Senior managers and plant/asset managers should be aware of the status of the assets and being involved in reviews or audits of the integrity management systems.</p>
<p><b>Underlying Key Issues</b></p> <ul style="list-style-type: none"> <li>■ Are integrity reviews conducted on a regular basis using information from the maintenance, testing and inspection systems and reports?</li> <li>■ Are key performance indicators (KPIs) set for reviewing the condition of the assets and the effectiveness of the maintenance, testing and inspection regimes?</li> <li>■ Are known problems, changes in inspection, testing or maintenance regimes or changes in priorities communicated to plant/asset managers and to staff and contract personnel involved in operations, maintenance and testing/inspection?</li> <li>■ How are lessons learned from incidents/accidents and near miss reports used to improve integrity management?</li> <li>■ Are there safety suggestion schemes, plant defect reporting schemes, to encourage personnel to report problems or observations or suggest ways to improve the systems and arrangements?</li> <li>■ Is this information from integrity reviews, KPIs, incidents, fed back to senior management?</li> </ul>