Achieving Effective and Reliable NDT in the Context of RBI

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1. SCOPE

Plant owners/operators are now managing the integrity of their plant and planning inspection based on risk assessments.

If an accurate assessment of plant fitness-for-service is to be realised then inspection, in particular Non-Destructive Testing (NDT), is very important. In order to achieve effective and reliable NDT, many issues need to be considered.

Following an introduction to Risk-Based Inspection (RBI), this paper discusses some of the key NDT issues, in the context of RBI, and presents a list of questions with commentary that can be used as a checklist/audit tool by RBI teams and/or regulatory bodies.

2. INTRODUCTION

In-service inspection of pressure systems, storage tanks and containers of hazardous materials has traditionally been driven by prescriptive industry regulations. Statutory inspection under Health & Safety legislation has long been a requirement for boilers, pressure systems and other safety critical items of plant.

Goal-setting safety legislation for pressure systems was first introduced in the UK in 1989 (1) and retained in the Pressure Systems Safety Regulations (PSSR) 2000 (2). This has enabled a move towards inspection strategies based on the risk of failure. The legislation leaves the owner/operator, in conjunction with the Competent Person, the flexibility to determine a 'suitable' written scheme of examination on the basis of available information about the system and best engineering practice.

This trend towards a risk-based approach is being supported by extensive plant operating experience, improved understanding of material degradation mechanisms, and the availability of fitness-for-service assessment procedures. At the same time, developments in NDT have increased the scope and efficiency of examinations that can be undertaken. Inspection trials have also produced a greater appreciation of the limits of NDT performance and reliability (3).

Industry is recognising that benefit may be gained from more informed inspection (4). Certain sectors of industry, particularly the refining and petro-chemical sectors, are now setting inspection priorities on the basis of the specific risk of failure. Improved targeting and timing of inspections offers industry the potential benefits of:

- Improved management of Health & Safety and other consequences of plant failure.
- Timely identification and repair, or replacement, of deteriorating items of plant.
- Cost savings by eliminating ineffective inspection, extending inspection intervals and greater plant availability.

3. RISK BASED INSPECTION

In-service inspection is most valuable where there is uncertainty about the operating conditions, or their effect on the materials, particularly where the conditions are such as to suggest that deterioration is taking place. Even when the service conditions and effects are well understood, such as in high integrity plant, inspection can provide continuing assurance of design assumptions and operating integrity. Inspection is also a priority for plant items where the fabrication, inspection, or operating history is unknown, or where there is inadequate maintenance, or where there is a lack of the materials data required for assessing fitness-for-service.

Risk-based inspection involves the planning of an inspection on the basis of information obtained from a risk analysis. The purpose of the risk analysis is to identify the potential degradation mechanisms and threats to component integrity and to assess the consequences and risks of failure. The inspection plan can then target the high-risk plant items and be designed to detect potential degradation before fitness-for-service could be threatened.

Inspection provides new information about component condition. This may be better, or worse, or the same as previously estimated, but the effect is to reduce the prior uncertainty. New information can therefore change the estimated probability of failure.

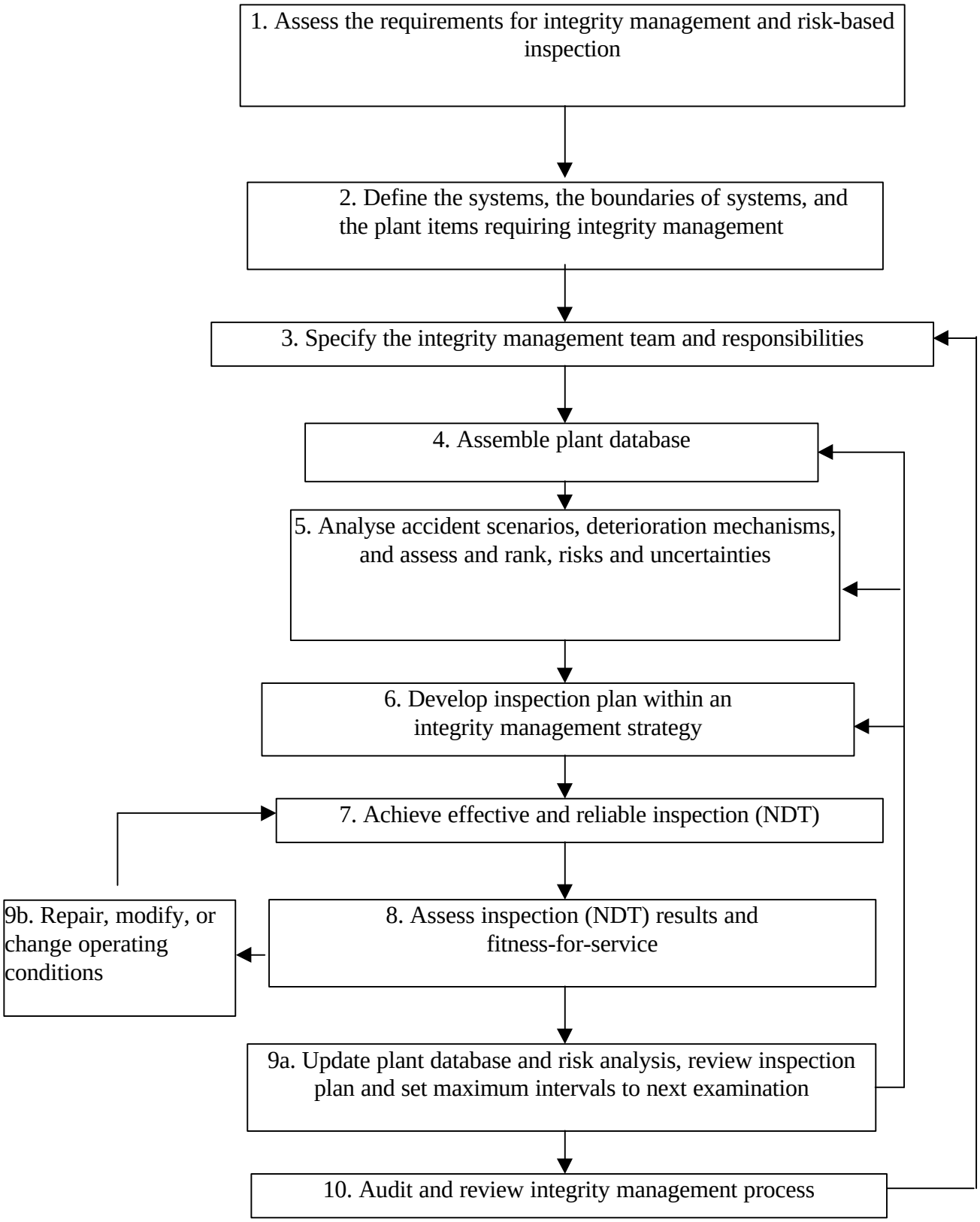
An impending failure and its consequences are not prevented, or changed, by risk-based inspection unless additional mitigating actions are taken. Inspection is an initiator for actions such as the repair or replacement of deteriorating items of plant, or a change to the operating conditions. By identifying potential problems, risk-based inspection increases the chances that mitigating actions will be taken, and thereby reduces the frequency of failure.

4. PROCESS OF RISK BASED INSPECTION

The process of risk-based inspection should form part of an integrated strategy for managing the integrity of plant. Its aim is to focus management action on prioritising resources to manage the risk from critical plant items.

Risk-based inspection is a logical and structured process of planning and evaluation. Figure 1 shows the main stages and links within the process.

Figure 1 - Process Diagram for Plant Integrity Management by RBI



5. DISCUSSION OF KEY NDT ISSUES

In the context of a risk-based approach to plant inspection, many issues need to be considered to ensure that effective and reliable NDT is achieved. Some of the key issues are now discussed.

With regard to the performance and reliability of NDT, this needs to be commensurate with the risk of failure of the component inspected. High-risk plant items require high NDT performance and reliability to be demonstrated. Items of lower risk need to be inspected by NDT that is judged to be effective for its purpose.

A strategy used to achieve high performance and reliability is to apply the principles of diversity and redundancy when selecting NDT techniques and determining inspection procedures. The use of a number of complementary NDT techniques can significantly reduce the likelihood of missing flaws.

Human errors are a significant contributor to low NDT performance and reliability. A strategy to reduce the possibility of human errors is to select automated, or semi-automated, NDT techniques. Techniques that provide a permanent record of inspection data should be favoured, since these allow the results to be independently assessed by more than one person.

When manual NDT techniques have been selected, NDT operators need to have appropriate training, qualification and experience. For high-risk situations, these aspects become critical and an independent review to demonstrate their adequacy is recommended. For particularly difficult and important inspections, it may be beneficial for more than one operator to carry out the same inspection.

NDT method/technique selection should be based on the capability to detect and assess the deterioration types anticipated/sought in the components of interest. The plant owner/operator and/or Competent Person should have evidence of this capability, together with knowledge of any significant limitations.

For established techniques, satisfactory evidence may be available through published literature. Additional confidence is provided by inspection procedures that are produced in accordance with national codes and standards. For newer or more specialised techniques, where the only available evidence may be capability data provided by the equipment supplier, an independent assessment of the capabilities and limitations may be necessary.

An important issue is whether the magnitude of the risk justifies the need for inspection qualification. In situations where the full process of qualification (requiring pass/fail criteria) is not considered necessary, the provision of capability statement(s) should be considered as a suitable alternative. In lower risk situations, inspection qualification is not generally necessary.

Continuity of inspections and inspection data is important. A key part of the RBI process is the feedback of knowledge of plant condition into the inspection planning process. Thus, attention should be paid to how records of inspections carried out, including the results, are kept and archived.

6. SUMMARY OF KEY NDT ISSUES

A summary of the key NDT issues discussed in the preceding section is now presented in the form of a list of questions with commentary. This 'checklist/audit tool' can be used by RBI teams and/or regulatory bodies to assess whether the NDT being proposed is appropriate in terms of its overall performance and reliability.

Are the selected NDT methods/techniques appropriate for the detection and assessment of the damage mechanisms anticipated?

In selecting the NDT methods/techniques, consideration should be given to the description of the damage mechanism sought (its location, orientation etc.). Another important consideration is the size of damage that must be reliably detected; this may be based on either existing acceptance standards or fitness-for-service criteria.

Are there inspection procedures available which satisfactorily cover the range of components/weld geometries to be examined?

It is important that the inspections to be carried out are covered by a written inspection procedure. The procedure should address the following aspects: details of the inspection technique, personnel requirements, equipment details, calibration details, scanning details, sensitivity and recording levels, reporting requirements, safety considerations and any pre-requisites such as surface preparation requirements, access requirements etc.

Do the inspection personnel have the appropriate training and qualifications for the tasks to be carried out?

Details of personnel training and qualification requirements should be stated in the inspection procedure. For the main inspection and NDT methods, approved training courses and certification schemes, in accordance with EN 473, ISO 9712 or SNT-TC-1A, are available. For the specialist or remote inspection techniques, training is usually available from the manufacturers of equipment.

What checks are being carried out to ensure that the inspection equipment is functioning correctly?

It is important that inspection equipment is checked regularly. Details of the checks to be carried out should be stated in the inspection procedure. In the case of the ultrasonic method, for example, it quite common to see EN 12668-3 referenced in an inspection procedure. This standard specifies the on-site checks that are required to ensure the ultrasonic test equipment is functioning correctly.

Is inspection qualification required for high-risk items of plant?

Inspection qualification is applicable when the safety or economic consequences of inadequate inspection are severe. It is particularly necessary when the inspection methods/techniques are new and not covered by existing standards/certification. Also, when the inspection is likely to be problematic, as a result of complex geometry, difficult materials etc. inspection qualification provides additional confidence. Inspection qualification involves the formal assessment of

procedures, equipment and personnel, using a combination of technical justification and practical assessment (usually carried out on representative test pieces).

Is evidence of NDT capability available or required?

For all inspections, evidence of NDT capability should be available. For the more straightforward inspections this could be a simple document that states the capability to detect and size certain flaw types with reference to independent published data. For newer and more specialist techniques, such as the non-invasive techniques, a more comprehensive document is expected as these techniques remain largely unproven with little reference data available in the published literature. Plant owners/operators should either, in order of preference, (i) carry out their own capability evaluation or (ii) obtain equipment manufacturers capability statements.

Is compatibility with previous inspection results being maintained?

This is to facilitate assessment of component degradation from NDT results. It is important that this is addressed, particularly if the inspection technique being applied differs significantly from the technique used for previous inspections of the component.

Are inspection datums and co-ordinate systems on the component being maintained for future inspections?

This is also important when data between successive inspections is to be compared.

How are inspection results documented and archived?

Proper documentation and archiving is important to facilitate comparison of data between successive inspections. It is particularly important if there is likely to be a long period between successive inspections or when there is the possibility that personnel involved in previous inspections may no longer be available.

7. ACKNOWLEDGEMENT

The Authors would like to thank the UK Health & Safety Executive who funded the original research work (Contract Research Report 363/2001 – Best Practice for Risk-Based Inspection as a part of Plant Integrity Management).

8. REFERENCES

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