EUROPEAN NETWORK OF RISK-INFORMED IN SERVICE INSPECTION
EURIS

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INTRODUCTION

Inspection planning for passive components is currently controlled by prescriptive codified practices backed up by stringent regulatory requirements. These codes specify the location frequency and methods of inspection on the basis of the type and safe category of the components. However, due to an increasing knowledge of plant degradation mechanisms and improvements in the probabilistic safety assessment methods, plant operators are recognising the benefit in setting the inspection priorities on the basis of risk. This process has already begun in several countries, but a common understanding at EU level of risk informed in service inspection (RI-ISI) and its practical implementation has not been reached yet.

The main objective of the European Network on RI-ISI (EURIS) is to develop a European methodology for RI-ISI relevant for the needs of plant operators. The proposed methodology should be able to identify safety-significant components, and to optimise the targeting of costly inspections. It will include feedback from plant operation and must indicate the specific components and the locations to be inspected, the defect to be detected, and the performance in detection and sizing to be achieved. The methodology will integrate actions or mitigation methods other than inspection, in order to manage the risk. As a consequence, RI-ISI should, by this optimisation of the ISI programme, reduce the cost and effort required whilst maintaining safety at its currently high level or above

WORK PROGRAMME

The work to be performed has been subdivided into the following work packages.

WP 1: Definition of the 'Situation'

The purpose of this work package is to identify the necessary information for the correct definition of the 'situation' for a RI-ISI assessment. It should be emphasised that only 'passive failures' as in different to 'active failures'*.

WP 2: Estimation of the failure probability of the component

Under this work package, the possible approaches to calculate failure probabilities will be treated. This will include 'Structural Integrity' (SI) analysis whereby the failure mechanisms are modelled. The use of fracture statistics coming from feedback of operation (either plant specific or obtained at a more general level) as input data. The use of expert judgement to arrive at a final conclusions on failure probability.

WP 3: Analysis of failure consequences

Failure consequences both for the safety and the plant availability (economical aspects) will be considered.

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* An active risk is from a valve or pump that fails to operate whilst a passive risk comes from a structural failure such as a pipe weld failure

WP 4: Gathering feedback from the operation of plants

Feedback from operation of plants is relevant for both the failure probability assessment and the failure consequences estimation. However, the subject or situations of the feed back must be correctly described and limited to allow the establishment of homogeneous samples.

WP 5: Consideration of the unknown

To discuss how the unknown is or could be considered within a risk based ISI program

WP 6: Definition of effective ISI programme, and qualification strategies based upon risk based assessment

The objective of this work package is to analyse how the risk based approach can be used to target in a more efficient way the ISI whilst maintaining or even increasing the safety. The analysis performed in the previous work packages should identify and rank the passive components according to risk. The role of risk based assessments to define the level of inspection qualification required will also be covered.

WP 7: European frame for RI ISI

The outcome of the previous work packages should be summarised under Work Package 7 in a final report that describes the 'European Methodology' for RI-ISI'

DEFINITION AND MEASURE OF RISK

Within the EURIS project the definition of risk is taken as the product of a measure of the (undesirable) consequence resulting from an initiating event and the probability of that event occurring within a given period of time. This is in line with the accepted definition within the engineering/scientific community although in other contexts the term risk is sometimes used with a slightly different definition.

The probability of structural failure is a function of plant operations and degradations that occur during a period of time and is therefore expressed as a probability per unit time (yr^{-1}). The consequences of structural failure may be measured in terms of the health and safety of employees and the public, damage to the environment or financial loss resulting from lost production, replacement of equipment etc. The measure of risk from a given failure is therefore the probability of a certain consequential damage per unit time.

Despite this strict definition, risk is often assessed qualitatively without this formal factoring. In this situation, the risk is the combination of the qualitatively assessed likelihood and the consequences of failure and is often presented as an element within a likelihood-consequence matrix.

CAUSES OF STRUCTURAL FAILURES

Commonly, structural failure results from the component being in a physically deficient state as a result of material defects, damage, or degradation. Component deficiencies may be the result of inadequate design, manufacture and welding, and the degrading effects of normal service conditions. They can also be the result of initiating events that lie outside the design basis such as leaking valves or loss of environmental control.

The total risk from structural failure is made up from the likelihood of all of these causes. Component inspection by non-destructive examination (NDE) provides information about the existence of defects (e.g. flaws and cracking), damage (e.g. denting, gouging) or degradation (corrosion, erosion) but does not address other causes of failure. Inspection is therefore only one of the package of measures needed to manage the total risk from structural failure.

DEFINITION OF RISK INFORMED IN SERVICE INSPECTION (RI-ISI)

RI-ISI is the development of a scheme of inspection on the basis of the information obtained from an assessment of the risk of failure of the equipment being considered within the scope of the scheme. On its own, risk ranking is insufficient to define an inspection programme. Information about the degradation processes and the threat to integrity is also required in order to fully implement an appropriate programme of inspections. The resulting inspection plan can not only target the high risk components, but can also be specifically designed to detect the potential degradation processes identified at a level and a time when fitness to service could be threatened.

In order for the inspection to meet its objectives to provide quality information about the condition of the plant, the combination of the inspection techniques, procedures and operators must have sufficient reliability. An unreliable inspection is of little value. RI-ISI, therefore has a strong link with inspection reliability and the processes of qualification that can be used to provide assurance concerning the probability of detecting defects, damage or degradation of concern.

EFFECT OF INSPECTION ON THE PROBABILITY OF FAILURE

The information gained from inspection increases the knowledge base about the condition the components inspected and reduces prior uncertainty. This may change the estimate of probability of failure and hence the estimated risk. If the component is found in better condition than previously expected, then the estimated probability of failure and hence the risk, is reduced; if more damage, defects or degradation are detected than previously considered, then the estimated failure probability and again the risk, is increased.

Since inspection can affect the estimated risk, a prior assessment of the risk can be used to define the inspection plan such that the information obtained has the maximum impact on the plant risk. Feedback of the results of inspection into the risk assessment is an essential part of the process. Components found by inspection to be free from deficiencies increase confidence in the total process of integrity management

ELEMENTS OF A RI-ISI PROGRAMME

A RI-ISI programme is defined by asking the following questions:

- What are the plant boundaries/components of the inspection planning?
- How is the probability of failure distributed about the components inspection sites?
- How is the consequence of failure for each of these sites to be evaluated?

- What criteria are to be used to select the locations?
- Which and how many locations are to be inspected?
- When should these locations be inspected and with what frequency?
- What information is it necessary to obtain from the inspection?
- What methods of inspection are appropriate?
- What is the reliability of the methods to be employed?

A final subsequent question, certainly within the European context, is:

- What value is added by inspection qualification?

In a risk informed approach the answers to these questions are determined from the information generated from the risk assessment process.

THE PLANNING OF A RI-ISI PROGRAMME

The key steps in the process of risk informed inspection planning given below.

- Formation of a risk informed inspection team (RIIT)
- Definition of the boundary of the equipment considered by the inspection planning
- Determination of the applicability of risk based inspection
- Identification of the information necessary to carry out the risk assessment
- Establishing the availability and gathering the information required
- Identification of credible types and causes of failure for each unit/component
- Assessment of the rates of degradation mechanisms and the probability of failure
- Assessment of the consequences of failure in terms of safety or economic loss
- Risk ranking of each unit/component or placement in a risk matrix
- Development of the inspection plan defining the inspection scope, methods, reliability and interval in relation to risk and fitness for service
- Feedback of information from the inspection and review of RII assessment

An RIIT is a multi-disciplinary team based activity. The team needs to be able to draw on the expertise of competent individuals with knowledge of the hazards, risk assessment, materials degradation and inspection techniques, plus staff with plant specific knowledge of maintenance and inspection, plant operation and process conditions. Management of the RI-ISI activity needs to take account of its context within the overall risk assessment of the plant.

SUMMARY OF INFORMATION TO DEFINE THE SITUATION FOR RI-ISI

The planning process for a RI-ISI brings together four categories of information:

- Design specifications
- Historical plant operating data
- An assessment of consequences
- An evaluation of failure probabilities

The information (deterministic or statistical) within each category required to specify a risk-informed inspection depends on the approach adopted, but may include:

Design Specifications
- Defined boundaries of plant items to be considered for inspection planning
- Design and manufacturing records
- Deterministic design stress and fatigue analysis

Historical Plant Data
- Operational transient and condition monitoring data
- Plant failures and service experience data
- Pre-service and in-service inspection records
- Environmental conditions (temperatures, water chemistry, flow rates etc.)
- In-service degradation assessments (fatigue, SCC, erosion-corrosion etc.)

Consequence Assessment
- Design safety class categorisation
- Detailed assessment of consequences
- Failure modes and effects analysis
- Cost analysis of component failure

Failure Probability Evaluation
- Expert assessments of the failure probability
- Generic component failure rates
- Component specific failure rates
- Frequency and probability size density of defects
- Distributions of material properties and degradation rates
- Full analysis of probability of failure

The availability and accessibility of this information will vary depending on the particular circumstances.

The relationship between these categories within the process of RI-ISI is shown in Figure 1. Following inspection, the results feed back into the historical database and should be used in planning further examinations thus establishing a living process.

STATUS OF EURIS AND CONCLUSIONS

At the time of writing, the present project is finalising a discussion document. EURIS intends to continue and hopefully produce a European methodology for RI-ISI over the next year. Some of the prominent discussions/conclusions to date are as follows:

1. The risk-based philosophy is a natural progression of current in service inspection philosophy.
2. The report is seen as a whole plant management philosophy.
3. In respect of the preceding point, the fullest range of possible mitigating actions should be

considered to offset any particular risk identified.

4. Cost is considered as part of the philosophy.
5. Probability of failure estimates for structural components should be primarily based on structural reliability models (SRM's) and that world data can only serve as a general datum point or as a form of normalising.
6. In respect to the above point, work needs to be carried out to verify and, however possible, validated current SRM's.
7. That the individual plant probabilistic risk assessment (PRA) be used as the primary source to estimate the direct consequence of failure.
8. That leak before break (LBB) should be considered as a justifiable mitigation against the consequence.
9. Secondary consequences must be fully explored in arriving at a total consequence.
10. Plant feed back/experience must be formally recognised within the process.
11. How a truly unknown degradation mechanism, as different from a postulated mechanism, can be reconciled with within a risk-based philosophy which by definition can only be evaluated from a known or postulated situation.
12. A method of identifying the extent of any safety based inspection program based probably on the ALARP (As Low As Reasonably Practical) principle.

It is clear that throughout the European Community there is a significant awareness of the risk-informed methodology and its potential advantages. The working group believes that the underlying benefit/advantage of this approach is intrinsically built into its focusing on risk, be this risk defined in terms of safety or economics. It believes that expanding the concept into a full plant management methodology, covering both safety and cost, offers significant benefits to the safe and reliable management of the plant.

The working group also recognises that a risk-based methodology, being plant specific by nature, is most suited to an enabling legislative environment. However, it is recognised that within Europe there is a mixture of regulatory regimes, some being of an enabling nature, while others are more prescriptive. The group is, therefore, working to produce a European methodology that will be of value and give benefits, whichever regulatory regime is operating.

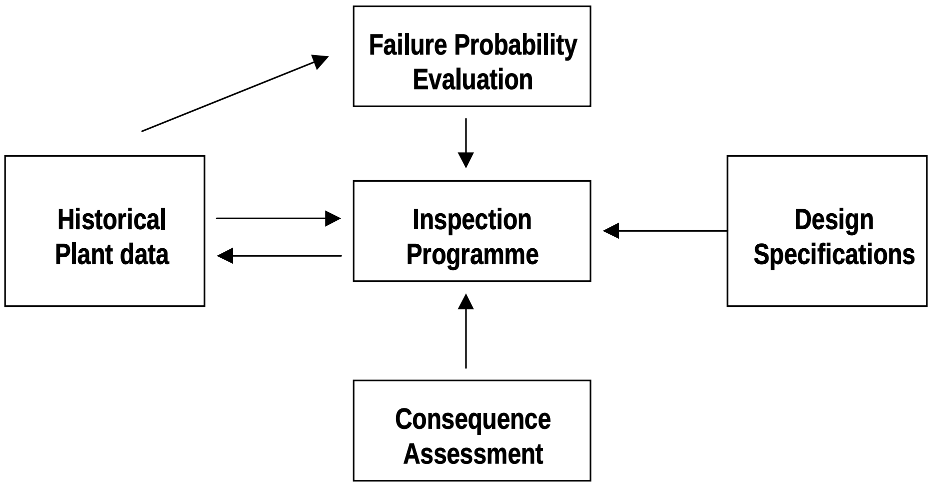

Figure 1: Definition of the Situation: General Scheme