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DATABASE FOR IN-SERVICE INSPECTIONS' RESULTS FOR NPP STRUCTURES

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ABSTRACT

In-service inspections (ISIs) of nuclear containment and safety related structures are performed to support aging management during each phase of the life cycle including long term operation (LTO) and decommissioning. Results of ISIs are typically documented in the inspection reports. Detailed review of the reports is required to determine the dynamics of aging and to enable decisions supporting aging management of the structures.

Standards and regulatory documents contain requirements for data collection and record-keeping system to support aging management activities and to provide a basis for decisions on the type and timing of aging management actions.

An MS Access database for ISIs of structures has been developed. It has several modules to enable entering and processing the information collected during periodic ISIs. The paper contains description of the database development and explanations for the use of this tool.

INTRODUCTION

To facilitate the process and to optimize the efforts before, during, and after ISIs, it is necessary to identify the essential information to be retained and its processing. This will provide a technical basis to support the findings and the conclusions necessary to enable aging management decisions.

Organizing the information in a database would significantly reduce the costs and efforts used by the utilities before, during and after each inspection campaign, while streamlining the information, enabling visualization and quantification of aging, and thus leading to clear decision making. This in turn will further reduce the time and effort spent on review and approval of aging management decisions.

REQUIREMENTS AND STANDARDS USED IN DATABASE DEVELOPMENT

References [1] - [6] contain requirements and guidelines for managing aging of Structures, Systems, and Components (SSCs) of a Nuclear Power Plant (NPP) including requirements for record keeping and databases.

ACI 349.3R-18 [7] contains requirements for evaluation of existing nuclear safety related structures. Tier approach is used in evaluation of the structures' condition as illustrated in Figure 1. The Standard contains comprehensive list of condition indicators including cracks, spalls, signs of corrosion, etc., which has been used to set up a matrix for the database as illustrated in Figure 2. This list has been used to develop the ISI database. ACI 349.3-18[7] also provides quantitative or qualitative acceptance criteria for each condition indicator. Typically, two criteria are provided: one for tier level one and one for tier level two. This logic has been employed for development of the ISI database and is illustrated in Figure 3.

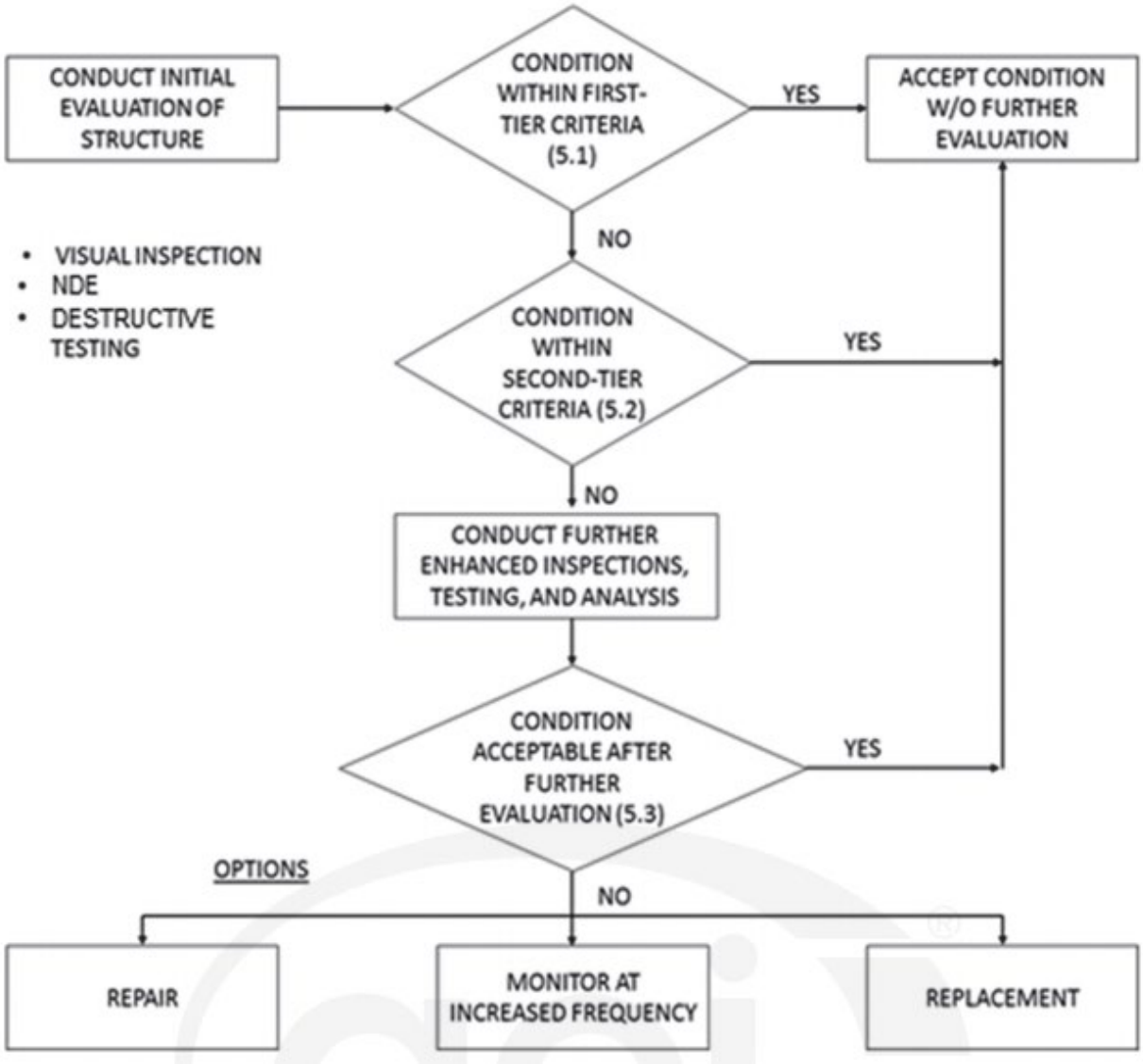

Figure 1 Tiered Approach as per ACI 349.3[7]

	Structure	
	Environmental Conditions during Inspection	
	Element / Specific Area Inspected	
	Signs of leaching, chemical attack	Concrete
	Abrasion, erosion, cavitation	
	Drummy areas	
	Popouts and voids	
	Scalining	
	Spalling	
	Signs of corrosion of steel reinforcement / embedments	
	Cracks	
	Deflection, settlement	
	Signs of indication of AAR or DEF such as map cracking, staining, expansion	
	Signs of corrosion of exposed embedded metal, corrosion stains around embedded metal	Concrete around Embedments and Supports
	Signs of leaching	
	Signs of buckling	
	Detached embedments / loose bolts or nuts	
	Signs of degradation due to vibratory loads	
	Missing or cracked grout pad	
	Signs of corrosion	Structural Steel
	Cracks	
	Signs of fatigue	
	Deformations, deflections	
	Signs of damage, degradation of bolted connections	
	Signs of damage, degradation of welded connections	
	Bulges or depressions in liner, coating, joint sealant	Liners / Coatings / Joint Sealants
	Signs of damage to the liner / coating / joint sealant	
	Cracking of the liner / coating / joint sealant	
	Signs of separation, peeling, delamination of the liner / coating / joint sealant	
	Signs of water leakage	
	Loss or degradation of the liner / coating / joint sealant	
	Signs of degradation of waterproofing membrane / coating	
	Non-structural elements do not fulfill their design functions	
	Presence of grease or corrosion-inhibiting wax on exposed concrete or steel surface	Prestressing Steel Systems
	Presence of corrosion on exposed grease cans, bearing plates, anchorages, etc.	
	Configuration of anchorage components does not conform to structural drawings	
	Signs of corroded, broken, or failed prestressing elements	
	Prestressing forces measured in ungrouted tendons are below the acceptance criteria	

Figure 2 Condition Indicators adapted from ACI 349.3-18[7]

Second tier criteria	First tier criteria	Structure Environmental Conditions during Inspection Element / Specific Area Inspected	
Y but ≤ than during previous ISI	N or N/A	Signs of leaching, chemical attack	Concrete
Y but ≤ than during previous ISI	N or N/A	Abrasion, erosion, cavitation	
Y but ≤ than during previous ISI	N or N/A	Drummy areas	
Diameter or equivalent surface area < 50 mm; or ≤	N, N/A or Diameter or equivalent surface area < 20 mm	Popouts and voids	
Depth of scaling < 30 mm; or ≤ than during previous ISI	N, N/A or Depth of scaling < 5 mm	Scalining	
Depth of spalling <20 mm and / or any other	N, N/A or Depth of spalling <10 mm and / or any other dimension	Spalling	
Y but ≤ than during previous ISI	N or N/A	Signs of corrosion of steel reinforcement / embedments	
Passive cracks , maximum width < 1 mm; or ≤ than	N, N/A or Passive cracks, maximum width of crack < 0.4	Cracks	
Y but ≤ than during previous ISI	N or N/A	Deflection, settlement	
Y but ≤ than during previous ISI	N or N/A	Signs of indication of AAR or DEF such as map cracking, staining, expansion	
Y but ≤ than during previous ISI	N or N/A	Signs of corrosion of exposed embedded metal, corrosion stains around embedded metal	Concrete around Embedments and Supports
Y but ≤ than during previous ISI	N or N/A	Signs of leaching	
Y but ≤ than during previous ISI	N or N/A	Signs of buckling	
Y but ≤ than during previous ISI	N or N/A	Detached embedments / loose bolts or nuts	
Y but ≤ than during previous ISI	N or N/A	Signs of degradation due to vibratory loads	
Y but ≤ than during previous ISI	N or N/A	Missing or cracked grout pad	
Y but ≤ than during previous ISI	N or N/A	Signs of corrosion	Structural Steel
Y but ≤ than during previous ISI	N or N/A	Cracks	
Y but ≤ than during previous ISI	N or N/A	Signs of fatigue	
Y but ≤ than during previous ISI	N or N/A	Deformations, deflections	
Y but ≤ than during previous ISI	N or N/A	Signs of damage, degradation of bolted connections	
Y but ≤ than during previous ISI	N or N/A	Signs of damage, degradation of welded connections	
Y but ≤ than during previous ISI	N or N/A	Bulges or depressions in liner, coating, joint sealant	Liners / Coatings / Joint Sealants
Y but ≤ than during previous ISI	N or N/A	Signs of damage to the liner / coating / joint sealant	
Y but ≤ than during previous ISI	N or N/A	Cracking of the liner / coating / joint sealant	
Y but ≤ than during previous ISI	N or N/A	Signs of separation, peeling, delamination of the liner / coating / joint sealant	
Y but ≤ than during previous ISI	N or N/A	Signs of water leakage	
For local area < 4,000 mm^2, for gross	N, N/A or For local area of liner/ coating < 4,000 mm^2, for gross	Loss or degradation of the liner / coating / joint sealant	
Y but ≤ than during previous ISI	N or N/A	Signs of degradation of waterproofing membrane / coating	
Y but ≤ than during previous ISI	N or N/A	Non-structural elements do not fulfill their design functions	
Y but ≤ than during previous ISI	N or N/A	Presence of grease or corrosion-inhibiting wax on exposed concrete or steel surface	Prestressing Steel Systems
Y but ≤ than during previous ISI	N or N/A	Presence of corrosion on exposed grease cans, bearing plates, anchorages, etc.	
Y but ≤ than during previous ISI	N or N/A	Configuration of anchorage components does not conform to structural drawings	
Y but ≤ than during previous ISI	N or N/A	Signs of corroded, broken, or failed prestressing elements	
Y but ≤ than during previous ISI	N or N/A	Prestressing forces measured in ungrouted tendons are below the acceptance criteria	

Figure 3 First and Second Tier Acceptance Criteria adapted from ACI 349.3-18[7]

SOFTWARE INFORMATION

MS Access 2013 is used for both the front-end and the back end. The software can run on an Intel based PC running Windows as follows:

- Operating System: Windows 7 or higher
- Display Resolution: 1920 x 1080 (recommended)
- Microsoft Office Suite 2013, including Microsoft Access.

GENERAL STRUCTURE OF DATABASE

The database contains the 'Main Menu' ribbon with the Module / drop down lists shown in Table 1.

Table 1 Database Modules

Module	Description
Define Facility	Define facility ID and facility name.
Define BSI/Structure	Define BSI and BSI description. Associate structure and date of in-service examination to the BSI.
Inspection Data	Define inspection data
Report	Access to inspection report generation

ASSESSMENT INFORMATION TABS

The inspection information is detailed in the nine (9) assessment information tabs. Each tab highlights a different element of the inspection.

For data input, each of these tabs is comprised of some combination of text fields; memo fields; text lists; drop-down lists; and/or checkboxes. The user (i.e. inspector) is responsible for entering inspection data in the appropriate fields. For example, as part of the element / inspection checklist tab, the concrete tab utilizes pre-defined concrete checklist populated in the database. Checkboxes are utilized the criteria pertaining to condition of concrete (see Figure 4).

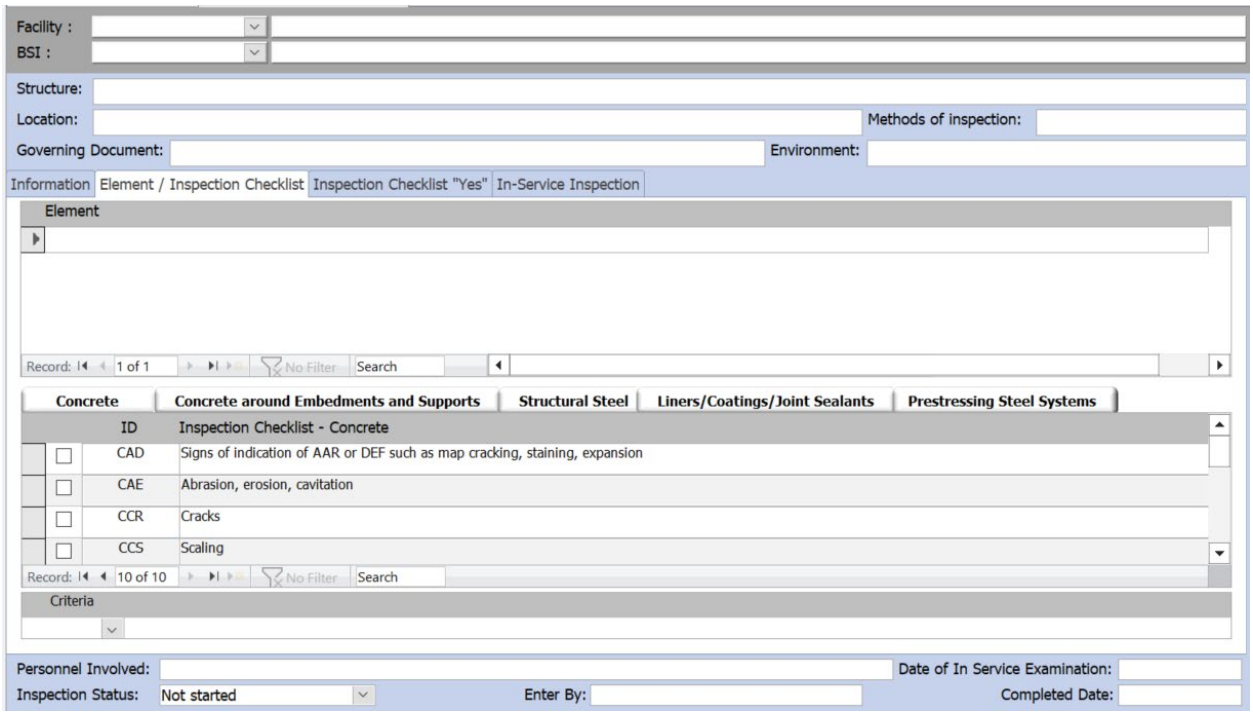

Figure 4 Inspection Checklist - Concrete

ISI RESULTS EVALUATION AND INFORMATION PROCESSING

After the observed condition is compared with the first and second tier acceptance criteria as identified in Figure 3, a series of questions need to be answered if the first and second tier criteria are not met. The questions include the following:

- Does observed condition adversely affect ability of the structure to meet its requirements?
- Can observed condition adversely affect ability of the structure to meet its requirements prior to next ISI?
- If no action is taken, can observed condition facilitate degradation of the structure?

The answers to these questions will enable selection of the outcome of inspection including the following:

- Condition is acceptable;
- Condition can be acceptable if ISI frequency is increased. Other recommendations (e,g, additional inspection/testing/analysis, repair, replacement, monitoring) can be provided; or
- Condition is not acceptable. Recommendations (e,g, additional inspection/testing/analysis, repair, replacement, monitoring) shall be provided indicating their urgency.

The flowchart demonstrating the logic for evaluation of ISI results is provided in Figure 5.

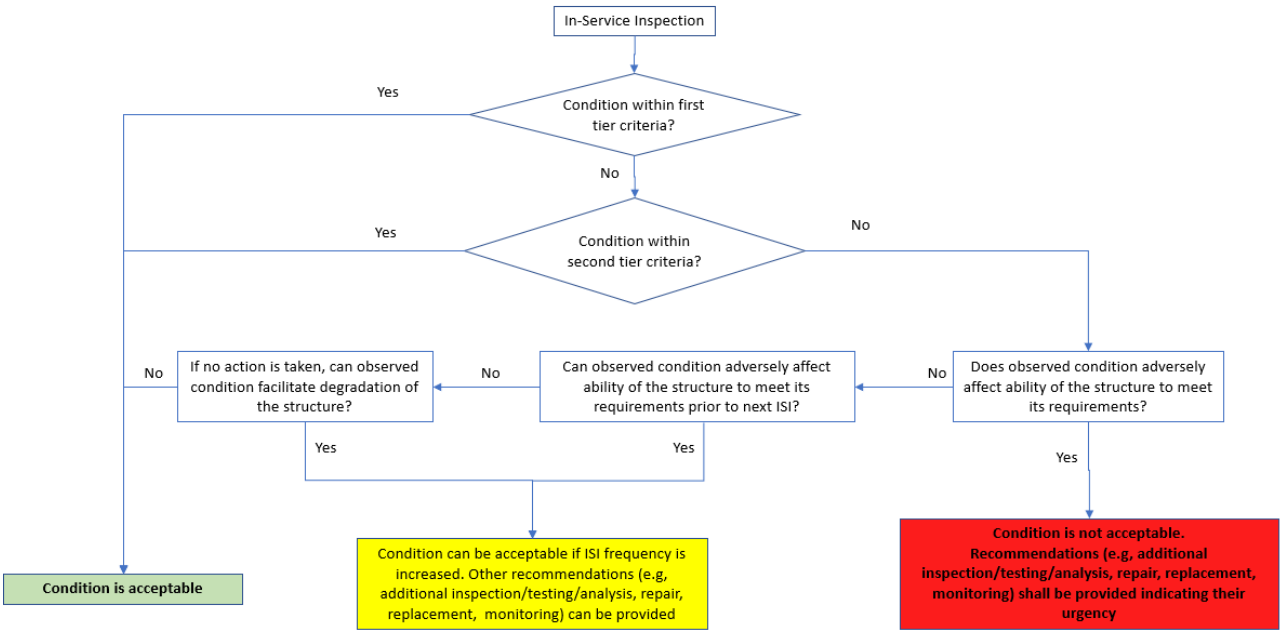

Figure 5 Flowchart for ISI Results Evaluation and Information Processing

REPORTING

In-Service Inspection results can be printed out in various reports including the following:

1) Trending Reports

Trending is necessary as it allows for visual representation of results and can enable making prognosis for future performance. Once the data from several ISIs is inputted in the database, trending tool can be used to plot the data. For example, the progression of cracks can be trended based on the data collected during several inspection campaigns. The crack width is then compared with the first and second tier acceptance criteria.

2) In-Service Inspection Reports

In-Service Inspection is generated to include all the inputs including the ISI data, evaluation results based on tier one and tier two acceptance criteria, conclusion related to the acceptability of condition of the element and the structure, and the associated recommendations.

CONCLUSIONS

Development of an MS Access database for ISIs of structures including identification of the necessary information to be retained and its processing provides a technical basis to support the findings and the conclusions necessary to support aging management decisions.

This should significantly reduce the costs and efforts used by the utilities before, during and after each inspection campaign, while streamlining the information, enabling visualization and quantification of aging, and thus leading to clear decision making; thus further reducing the time and effort spent on review and approval of aging management decisions.

ACKNOWLEDGEMENTS
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