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TANKS

CHAPTER 6.8.2.4.2 AND 6.8.3.4.6

Periodic Inspections of Tanks

Transmitted by the Government of the United Kingdom

SUMMARY	
Executive Summary:	The information paper seeks to highlight the use of Non Invasive Inspection as a replacement to the hydraulic test.

Background

Non Invasive Inspection (NII) is an assessment regime that can use a combination of Non-Destructive Testing (NDT) techniques such as ultrasonic, acoustic emission, radiography, dye penetrant, magnetic particle, electromagnetic, leak testing etc. to give an examination that, in the opinion of the United Kingdom, is at least as good as the current requirements given in Chapters 6.8.2.4.2 for a hydraulic pressure test and an internal (invasive) inspection.

The United Kingdom believes that hydraulic testing of a new tank does have many benefits and must be retained, but that periodic hydraulic testing proves nothing more than the tank did not leak on the day of the test. In the 1984 Approved Code of Practice 'Road Tanker Testing' and the Railway Group Standard for inspection and testing tanks of rail tank wagons, the United Kingdom clearly stated that periodic pressure testing is not generally required and the United Kingdom are not aware of any significant failures that can be attributed to the lack of hydraulic testing at periodic examination. The United Kingdom also recognises that hydraulic testing can lead to damage of tanks that could go undetected. The United Kingdom Institution of Mechanical Engineers at a seminar in London in December 2003 supported these findings on the subject of hydraulic testing.

The United Kingdom recognises that NII is permitted for static vessels containing dangerous substances, particularly where invasive testing is considered to be too dangerous, costly and/or damaging to the vessel.

The current chapter 6.2.1.6.1 allows the replacement of hydraulic testing by a test using acoustic emission and the ADR 2005 approved standard EN1968 *Transportable gas cylinders – Periodic inspection and testing of seamless steel gas cylinders* allows the use of ultrasonic testing to replace the hydraulic test and internal examination. It would therefore seem a logical development to extend NII to tanks covered by chapter 6.8.

The United Kingdom has carried out research into NII and the Health and Safety Executive will publish guidelines on its use. These guidelines will be available on the Internet shortly and will include a decision tree to assist the user in the identification of tanks that are suitable candidates for NII followed by detailed guidance on how the NII process should be applied and controlled. An abstract from work carried out by Mitsui Babcock UK which offers some background to NII, is attached as an annex to this paper.

Proposal

This paper is for information only. The United Kingdom will inform the September 2005 Joint Meeting of the publication of the research by the United Kingdom Health and Safety Executive into NII, and put forward a proposal for optional use of NII.

Justification

Since the introduction of the text in Chapter 6.8.2.4.2 (211 151) there have been significant developments in the field of NDT. These developments offer an opportunity to improve the defect detection rate at periodic examination. By allowing either the continuation of the hydraulic pressure test/visual internal examination or a NII process it will allow the industry to move forward and use the new technologies where they see it as cost effective and appropriate.

NII has replaced the hydraulic pressure testing of the tanks of rail tank cars as the means to periodically re-qualify tank cars for continuing service in North America. Whereas the hydraulic pressure test was a simple test of a tank's ability to hold pressure, NII is designed and intended to detect cracks and other flaws in tanks and tank structure as an aid to ensure their integrity of service. This was confirmed in a response from the Association of American Railroads to a request from the RID Tank and Vehicle Technology Working Group regarding measures to improve the safety of the transport of hazardous material by rail in North America.

Safety implications

Safety will be increased by limiting access into enclosed spaces.

The tank will be at least as safe as it is under the current requirements.

Feasibility

The decision to use NII would be taken on a case-by-case basis. Where hydraulic testing and entry into the tank are relatively straight forward there would be little benefit from a NII regime but in cases, for example UN1017 chlorine, where water contamination inside the shell of a tank could give rise to severe problems then an NII approach could be justified. This would also be the case for petroleum liquids where there is also the environmental problem of disposing of large amounts of contaminated water, an NII approach would therefore be more appropriate.

Enforceability

No problems foreseen.

ANNEX

DEVELOPMENT OF A RECOMMENDED PRACTICE FOR NON- INVASIVE INSPECTIONS

B.W.O. Shepherd, bshepherd@mitsuibabcock.co
Mitsui Babcock, UK
M.H.Gast, m.h.gast@rtd.nl,
T.Bouma, t.bouma@rtd.nl
Röntgen Technische Dienst, The Netherlands
Corresponding Author Contact:
Email: t.bouma@rtd.nl, Internet: http://www.rtd.nl/

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Abstract

Non-invasive inspections have the potential for significant cost savings compared to the traditional approach of opening up a vessel for internal inspection. However there are no guidelines on how to perform non-invasive inspections, or when they are appropriate.

The work of a recent group sponsored project is described which has covered the development of a "Recommended Practice for Non-Invasive Inspections". It provides guidance on non-invasive inspection planning, implementation and analysis. A pilot study has been performed to demonstrate the validity of the Recommended Practice.

Introduction

Pressure and process vessels generally require periodic in-service inspection to ensure continued safe and economic operation. This usually includes a requirement to inspect for possible internal degradation, and the traditional approach has been to open the vessel and perform e.g. internal visual inspection.

For internal inspections there can be very high costs associated with shutting down a vessel (loss of production), isolating it and preparing for it for entry. These costs can be much higher than the cost of the inspection itself. The mechanical disturbances involved in preparing the vessel for internal inspection and reinstating it may also adversely affect future performance. In addition entering the vessel may be hazardous.

There can therefore be significant advantages if inspections are performed from the outside of the vessel only, i.e. non-invasively. Although experience of non-invasive inspections is increasing there are no practical guidelines to determine when non-invasive inspection is an acceptable alternative to internal inspection, and how the inspection should be performed. Non-invasive inspection methods must be tailored to the types and locations of defects of potential concern, and 100% coverage of the entire vessel using the most sensitive inspection methods may be impractical.

A Group Sponsored Project has therefore been set up to develop a “Recommended Practice for Non-Invasive Inspections” and to provide guidance on the capability and cost-effective application of non-invasive inspection methods.

Recommended Practice Document

One of the main objectives of the project has been to produce a "Recommended Practice" for non-invasive inspections. It is expected that this document will be made freely available beyond the sponsor group. (The project has also covered work on inspection method capability, optimised inspection planning, guidelines on how to optimise vessel design to facilitate non-invasive inspection, and a pilot study. Much of this other work is expected to remain confidential to the sponsor group)
The Recommended Practice document includes sections covering the following.

Objective of Non-Invasive Inspection

The objective of the non-invasive inspection should be carefully considered.

The economic savings associated with non-invasive inspection generally come from not having to isolate, open and prepare the vessel for entry, and in minimising the cost of lost production. The cost of the non-invasive inspection itself may be more expensive than the cost of the internal (e.g. visual) inspection, since non-invasive inspection is likely to require more sophisticated inspection methods. There may therefore be little advantage in performing non-invasive inspection of most of the regions of interest if the vessel has to be opened anyway due to maintenance operations, or because some features can only be inspected from the inside.

The objective may be for all future inspections to be non-invasive, or to increase the period between internal inspections by performing intermittent non-invasive inspections. The non-invasive inspection may be intended to complement internal inspection, for example if an internal inspection is planned during a shutdown, performing a preliminary non- invasive inspection before the shutdown starts could identify areas requiring repair or maintenance. The total shutdown period could then be reduced by improved preparation of repair and maintenance activities.

Although there may be major advantages if the non-invasive inspection can be performed "on-stream" without shutting down the process, off-stream non-invasive inspection may still provide significant benefits by avoiding the need to isolate, purge, and prepare the vessel for internal inspection, and by minimising mechanical disruption.

The types of NDT methods used for non-invasive inspection methods can generally provide more quantitative data on defect through-wall dimensions than visual inspections, and are therefore particularly appropriate for monitoring degradation rate.

Decision On Whether Invasive or Non-Invasive

Although non-invasive inspections can offer major economic benefits, it is important that they are only employed when they can provide the required information on vessel integrity, particularly when leakage or failure could have safety or environmental consequences.

Guidelines have therefore been produced on whether, for a particular vessel, non-invasive inspection is appropriate in principle. These guidelines are based on work performed by AEA Technology, who have collaborated with the group sponsored project through the HOIS2000 group.

This decision process is a three-stage process.

The first stage is designed to rapidly screen out vessels for which non-invasive inspection should not be considered and addresses issues such as lack of access to external surface, extreme surface temperature, lack of previous inspection history, vessel to be opened for other reasons, etc.

The purpose of the second stage is to determine whether sufficient information exists to plan the non-invasive inspection, and what effectiveness is required. This requires consideration of how confidently potential defect types and locations can be predicted, based on evidence from other similar vessels operating under similar conditions, the effectiveness of previous inspections, and the severity and rate of any known or predicted degradation.

The third stage determines whether non-invasive inspection methods can provide the inspection effectiveness required, taking into account aspects such as geometry, surface coating / insulation, temperature and available access.

Information Required to Plan a Non-Invasive Inspection

It can be impractical to perform non-invasive inspection over the entire vessel surface. In addition non-invasive inspection methods have different capabilities and limitations for different defects and degradation types, and can be heavily influenced by aspects such as geometry and material. Non-invasive inspections therefore require more information on potential defect types and locations than is generally the case for internal inspections.

The Recommended Practice lists the type of information which should be available when planning a non-invasive inspection. This covers a number of categories including but not limited to:

- Type of vessel and function
- Details of operation and service
- Detailed drawings
- Modifications and repairs
- Previous inspection results
- Generic experience
- Access requirements
- Inspection constraints
- Potential degradation mechanisms / locations

For each category, the document provides examples of the type of information required.

Inspection Plan

The inspection plan for a vessel involves the definition of the parts to be inspected, the types of degradation or defects to be detected and characterised, the inspection methods and in the case of sample inspections, the sample size.

A multi-disciplinary approach is required to planning a non-invasive inspection. The Recommended Practice provides competence criteria for the planning team, which should include knowledge of NDT, fabrication processes, corrosion or material technology, process conditions etc. The planning team should specify the competence and certification requirements of those who will perform the inspection.

The vessel should be divided into zones corresponding to the different combinations of geometry, material, likelihood of degradation and previous inspection results. The inspection effectiveness required, inspection method and coverage should then be determined on a zone by zone basis.

The inspection effectiveness will depend on the capability and reliability of the inspection method, the inspection coverage, and the extent to which statistical methods are used to extrapolate the results from sample inspections.

An example of a statistical method which can be useful for planning and analysing the results from sample inspections is extreme value statistical analysis. A typical application is the use of corrosion pit depth data from ultrasonic inspection of a sample within a vessel zone, to predict the maximum pit depth within the uninspected parts of that zone. An example output from extreme value statistical analysis is presented in Figure 1. In this case the sample size was 20% of a particular vessel zone, and the maximum predicted pit depth (for 95% confidence level) in the whole of the zone was 3.12 mm.

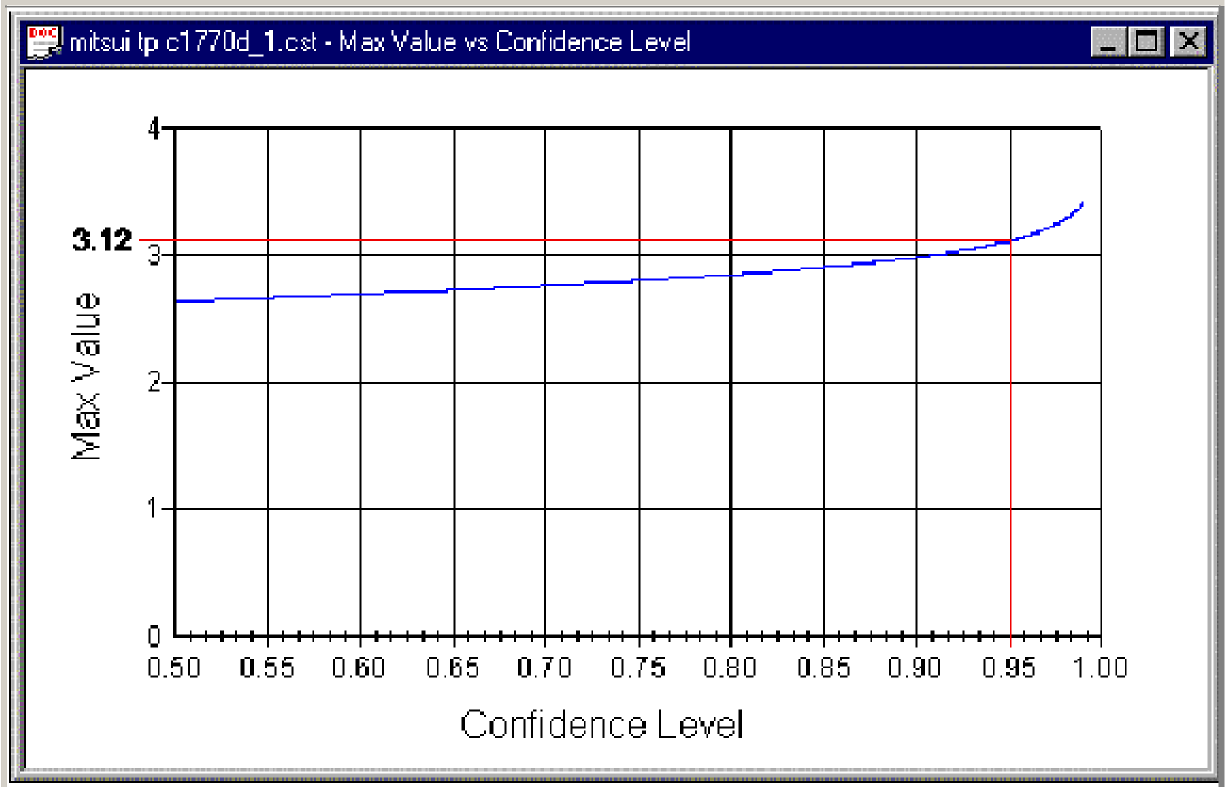

Fig 1: Extreme Value Statistical Analysis of Corrosion Pit Data.

Inspection Preparation and Implementation

Preparation for the inspection is an important step in ensuring it is performed correctly and within time and budget. Issues which need to be considered include:

- Provision of detailed instructions, procedures and drawings to inspection team
- Definition of datum and referencing system
- All appropriate parties informed of inspection
- Required access, scaffolding, power
- Local permit requirements
- Removal of insulation, surface preparation if required
- Safety restrictions and local safety inductions
- Possibility of other operations in the area
- Environmental conditions (temperature, weather)
- NDT equipment checked before mobilisation

During inspection the inspection team must follow the prepared instructions and scope of work. Any problems or restrictions should be identified as soon as possible so that the required action can be agreed and implemented. Preliminary analysis of results before demobilisation is recommended so that any anomalous results can be identified and additional inspections or measurements taken if appropriate. The inspection results should be reported in a pre-defined format.

Pilot Study

A pilot study has been performed on a large carbon steel pressure vessel at a plant owned by one of the sponsors. The vessel was approximately 8m high, 2.5m diameter and 12mm wall thickness. It was vertically mounted on a support skirt and was insulated. An internal visual inspection had been performed shortly before the pilot non-invasive inspection, but the results of this internal inspection were deliberately withheld until after the non-invasive inspection pilot study in order to allow objective comparison between the effectiveness of the internal and non-invasive inspections. All other relevant information (including previous inspection reports prior to the most recent internal inspection) was made available to the pilot study planning team.

A draft of the Recommended Practice document was used as a basis for planning, preparing, implementing, analysing and reporting the results of the pilot study. The final version of the Recommended Practice addresses lessons learnt from the pilot study.

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