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PROGRESS REPORT ON THE DEVELOPMENT OF EFNDT GUIDELINES FOR AN OVERALL NDT QUALITY MANAGEMENT SYSTEM

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1. ABSTRACT

This paper describes a project currently in progress under the auspices of EFNDT Task Group 3 on Quality in NDT. The project was conceived as a result of the EFNDT strategic planning exercise in 2005-6. The objective of the project is to prepare guidelines on achieving quality in NDT to help develop a better understanding by users and purchasers of NDT services of the roles of the various measures available for control of NDT quality during manufacture and in-service. Practices in different industries will be compared. Internet links will be provided to other relevant information sources. The document will be posted on the EFNDT website and periodically updated.

Keywords: NDT quality, reliability, personnel certification, accreditation.

2. INTRODUCTION

Non-Destructive testing (NDT) has a number of important roles to play in ensuring the through-life quality and reliability of many important products whose integrity is of paramount importance. The traditional role of NDT in quality control during manufacture - predominantly defect detection - has been complemented in recent years with increasingly important inspections in-service on plant and equipment at varying stages through life. The correct application of NDT can prevent accidents, save lives, protect the environment and avoid economic loss. It is an increasing requirement of quality assurance systems that a company's engineers, technicians and craftsmen are able to demonstrate that they have the required level of knowledge and skill. This is particularly so since NDT and inspection activities are very operator dependent and those in authority have to place great reliance on the skill, experience, judgement and integrity of the personnel involved. Indeed, during fabrication, NDT and inspection prides the last line of defence before the product enters service, whilst once a product or structure enters service, in-service NDT is often the only line of defence against failure.

3. ACHIEVEMENT OF QUALITY IN NDT

There are three important factors to achieve the necessary quality and reliability of inspection. Firstly, the responsible engineer must specify his requirements very clearly in terms of the regions to be inspected and the types of flaws or deterioration to be looked for (all-encompassing combinations would be prohibitively expensive). Secondly, the NDT methods, equipment and personnel must be capable of the purpose for which they are being employed and, thirdly, the selected NDT process must be implemented thoroughly.

Many of the necessary controls are available through the “NDT infrastructure” which has been established in many countries – comprising research and development, national standards, training courses, personnel certification, inspection qualification, third party inspections etc. These infrastructures are quite sophisticated and most complete in the manufacturing quality control sphere of NDT, particularly in those geographical areas where ISO 9001 certification of quality assurance demands comprehensive systems to be in place. They are nowhere near so complete for the newer applications of NDT or for in-service inspection but are being developed. As world trade rapidly becomes more liberalised, and equipment is sourced more widely, the NDT infrastructures which were originally national in their coverage, need to become international.

Quality in execution of NDT operations demands attention to a series of interlinked aspects which can be represented as links in a chain as shown in Figure 1.

Figure 1: NDT Quality Chain

The chain will only be as strong as its weakest link. Extra attention to one link in the chain cannot compensate for lack of attention to another - just as a strong link in a chain cannot compensate for a weak link. National and international standards for quality systems such as ISO 9001 require management to establish quality systems to control all activities which affect quality including NDT. The quality system must address each of the links in the NDT quality chain - to ensure that all the links are in place and properly joined. Other legislation, codes and practice, and good professional conduct all oblige users of NDT and suppliers of NDT to address how to achieve reliability.

4. OVERVIEW OF NDT INFRASTRUCTURE IN EUROPE

An NDT infrastructure has gradually grown up. Figure 2 attempts to represent the infrastructure. In this figure the heavy boxes indicate the "doing activities" that make up NDT operations, i.e. Procedures, Equipment, Training and Certification, Human Factors, whilst the lighter boxes represent the various measures designed to achieve quality, with the types of organisations generally responsible shown along the foot of the diagram. Each concentrates on its own elements of the infrastructure. None is concerned with the complete quality chain.

<table>
<tr><th>NDT system</th><th>Standards for</th><th>Procedures</th><th>Qualification</th><th>Inspection, Certification, Notified Bodies</th><th>Accreditation Bodies</th></tr>
<tr><td>PROCEDURES</td><td>Techniques</td><td rowspan="2">Job Specific Procedures;
Capability Trials
Proficiency Tests</td><td rowspan="3">Validation
Performance Demonstration
Inspection
Qualification e.g. ENIQ, ASME</td><td rowspan="2">Surveillance Audit
Certification, e.g. EN ISO/IEC 17020</td><td rowspan="2">Accredited laboratories acc. EN ISO/IEC 17025
Accredited Inspection Bodies acc. EN ISO/IEC 17020</td></tr>
<tr><td>EQUIPMENT</td><td>Equipment Accessories Calibration</td></tr>
<tr><td>PERSONNEL</td><td>Training Qualification Certification</td><td>Job Specific Training and Qualification</td><td rowspan="2">Quality System Certification, e.g. ISO 9001</td><td rowspan="2">Accredited Personnel Certification Bodies acc. EN ISO/IEC 17024</td></tr>
<tr><td>HUMAN FACTORS</td><td>Code of Ethics</td><td>Management and Planning (Riskbased)</td><td>Letter of Intent
Associations</td></tr>
</table>

Fig. 2: The NDT quality infrastructure

The EFNDT Guidelines document will have the following sections on each of the above elements of the infrastructure.

4.1 Standards

This section of the document provides a comprehensive list of European and International NDT standards, grouped according to product sectors, e.g casting, welded products, forging, tubes and pipes, and wrought products. General standards and standards on terminology are also listed. It is important when working with European or International standards to consider the normative references which are listed at the beginning of a standard. They bring together the foundations of the NDT quality chain, consisting of NDT procedures, NDT personnel, NDT equipment and the human factors (see Fig.2 above).

4.2 Personnel Qualification and Certification

<u>Background</u>
The training, qualification and certification of NDT personnel are very important. Training is necessary both before and subsequent to qualification examinations.

Attention must be given to job-specific training before an operator is asked to carry out jobs which may be outside the scope of his certificate. Section 6 focuses on Qualification and Certification whilst Section 7 covers training.

In the field of personnel certification there are two types of standards: those which cover central, independent certification and those for in-house certification. Central independent certification as defined in standards such as the International Standard ISO9712 (6) and its European equivalent EN473 is increasingly being accepted internationally, including in the United States. For in-house qualification and approval (certification, by definition, involves a third party 'certification body') the American ASNT document SNT-TC-1A is widely used in place of a standard in, for example, the pressure equipment sector, where ASME codes are often applicable. In the aerospace sector, there are sector specific standards, such as EN 4179 and AIA NAS 410 for the qualification and approval of personnel by the employer (see section 6.3).

<u>Central independent certification</u>

In most European countries there is a 'national certification scheme' which provides NDT personnel certification to the EN473 standard in each main NDT method at three levels (Level 1, 2 and 3). The majority of these bodies have gained independent accreditation to EN45013, or to EN ISO/IEC17024 (2003) which superseded EN45013 in 2005, by national accreditation bodies (such as the United Kingdom Accreditation Service), which enables them to participate in the EFNDT Multilateral Recognition Agreement (MRA). In order to extend the availability of the EFNDT MRA to certification bodies in countries where there is presently no national system for independent accreditation, the EFNDT offers assessment and approval of certification schemes against the referenced standards.

Globally, the ISO9712 standard has been adopted in a large number of countries (including China, India, Canada, Japan, Australia, South America, Korea, USA) and Certification Bodies are providing independent third party certification accordingly. A group of Certification Bodies in the Asia-Pacific region are developing a multilateral recognition agreement based on the EFNDT model. The International Committee for NDT (ICNDT) and the IAEA continue to promote ISO9712 as a basis for global harmonisation of central certification.

Although there has been a steady increase in the level of detail in ISO9712 and EN473, there are still NDT applications that are not covered under national certification schemes adopting these standards and there may be a need for additional in-house job-specific training and assessment. This should be addressed in a company's NDT personnel qualification and authorisation procedure (commonly known as a written practice).

<u>Company-based approvals/certification</u>

In the USA, and countries using American standards, there continues to be widespread reliance on in-house certification in accordance with ASNT guideline SNT-TC-1A, albeit with increasing reliance on independently certified Level 3s. SNT-TC-1A allows companies to tailor training and approval more closely to the specific needs of a company but lacks the benefits of independent certification examinations by a central body. This deficiency has led to a number of schemes which combine in-house training and approvals with external third party controls, notably in the aerospace sector**.**

Responsibilities of employer

The Employer has important responsibilities when using either company or third party qualification and certification systems. These should be reflected in the employer's quality procedure for the qualification and authorisation of NDT employees (the written practice). This Section of the Guidelines clarifies the employer's responsibilities within the framework of EN 473 and gives guidance on how the employer should fulfil these. The requirements of EN4179 in this area are clear, and employers seeking to develop a procedure for controlling the internal qualification and authorisation of their NDT employees may derive benefit from a careful review of this standard. In this context the employer (the 'responsible agency') is defined as 'the organisation for which the NDT technician works on a regular basis'. If the NDT technician is self-employed he should assume all responsibilities specified in the standard for the employer or responsible agency.

Best Practice in certification

Whereas several years ago the two approaches to approval and certification (central, independent, third party and in-company) were seen as very different, there now seems to be a gradual convergence of the two. Users of central certification are increasingly aware of the need for the central certification to be used in the correct way - as part of an organisation's quality systems for NDT or written practice - and the guidelines for in-house, company based certification are bringing in requirements for external assessment eg independently certified Level 3s.

Standards for central/third party certification (ISO9712/EN473**)**

Comprehensive explanations are given on the history, development and relationships between the two standards and on the CEN and ISO processes for their development presently undergoing revision to a third edition). The role of accreditation of NDT Certification bodies is explained, and some explanation is given of the new EFNDT process for approval of Certification Bodies providing EN473 and ISO9712 certification.

Mutual Recognition Agreement (MRA) of Certification to ISO9712/EN473

In Nice, France, in October 1994 the first 20 or so of the eventual 30 plus ECNDT members signed the very first truly multi-lateral agreement to mutually recognise certificates issued by Certification Bodies registered under the agreement. Today, the European Federation for NDT (EFNDT) MRA has 28 signatories and nearly 20 registered Certification Bodies, all of which are accredited or approved as complying with International Standard EN ISO/IEC 17024 and issuing certification in compliance with EN 473 (and/or ISO 9712). Since Version 8 of the Agreement (26 October 2002), participation is open to schemes outside Europe providing either EN473 or ISO9712 Certification. A copy of the Agreement is published on the EFNDT Website (www.efndt.org).

European Pressure Equipment Directive 97/23/EC

The purpose of the directive is to harmonise national laws regarding design, manufacture and conformity assessment of pressure equipment and assemblies (vessels, storage containers, heat exchangers, shell and water tube boilers, industrial pipework, safety devices and pressure accessories) subject to an internal pressure greater than 0.5 bar. Equipment is categorised within four levels (I to VI) according to degree of hazard: category III and IV equipment will require conformity assessment by 'notified bodies' and 'recognised third party organisations'. For pressure equipment, non-destructive tests of permanent joints must be carried out by 'suitably qualified personnel'. For pressure equipment in categories III and IV, NDT personnel must be approved by a 'Third Party Organisation' recognized by a member state pursuant to Article 13. Certificates of competence in compliance with EN 473 and covering the testing of permanent joints (in effect, welds) are presumed to satisfy the requirements of the directive because EN 473 is a harmonised standard. But, there are alternative acceptable methods of fulfilling the requirements, as detailed in the Guideline 6/13 and the CEN document referred to below:

WPG6/13 Guideline for RTPO approving NDT personnel - final version adopted 2004-03-17

CEN/TR 15589 (October 2006) Non-Destructive Testing - Code of practice for the approval of NDT personnel by Recognised Third Party Organisations under the provisions of Directive 97/23/EC

Qualification and approval of personnel against EN4179

European standard EN 4179: 2005 (Aerospace series; Qualification and approval of personnel - non-destructive testing) defines, at clause 3.17, a National Aerospace NDT Board as an "an independent national aerospace organization representing a nation's aerospace industry that is chartered by the participating prime contractors and recognized by the nation's regulatory agencies to provide or support NDT qualification and examination services in accordance with this standard". A proposal to establish a Forum for NANDTBs was agreed at the 9th European Conference on NDT, Berlin, in September 2006. The aims and objectives, constitution and method of working of the Aerospace NDT Board Forum which is supported by the European Federation of NDT are set out in the Guidelines document along with the Forum's current action plan.

4.3 Training Syllabi/Guidelines

Introduction

There has been a progressive development of training guidelines/syllabi which attempt to define the body of knowledge needed by NDT personnel. The earliest versions were produced by ASNT (1966) and the ICNDT (1985). Later Training Guidelines were produced by the IAEA (1986, updated 2002) and more recently, a joint working group of CEN TC 138/AHG8 and ISO TC135/WG2 has produced document CEN TR 25107 Guidelines for Training Syllabi. In addition, CEN has produced TR 25108 “Guidelines for NDT personnel training organisations” which sets out the criteria to be met by training organisations and will facilitate assessment and approval of such organisations by certification bodies.

Normative Status of Guidelines on Training Syllabi

ISO 9712 (2005) references only the IAEA Training Guidelines of 2002. (It was published before TR 25107 was agreed.) CEN EN473 (2000) references several Syllabi. The revised version references both TR 25107 and 25108 and includes some further commentary on the minimum (versus recommended) training hours .

The Guidelines document discusses the need for integration of training guidelines/standards/training materials/question banks. There is arguably a need for more complete integration of the NDT quality chain in this area by better linking of the necessary body of knowledge and practical skills (ie the training syllabus) to the training materials (notes, reference books, hand-outs, sample questions) to the examinations (questions, practical sample. Employers should be able to understand the content of courses and examinations in order that they can decide if the company’s specific needs are covered and decide if additional job specific training is necessary.

4.4 Inspection Qualification / Performance Demonstration

The process of Qualification or Performance Demonstration previously known as Validation was first developed as a result of the need to assure the quality of inspections of nuclear power plant by a systematic programme of analysis and trials.

In the USA, following analysis of the results of the PISC II round-robin trials, the ASME Section XI committee adopted the principles of performance demonstration and introduced Appendix 8 to Section XI of the ASME code to define how performance demonstration trials should be conducted. Performance demonstrations to these code requirements are now being implemented through the Performance Demonstration Initiative (PDI) managed by the Electrical Power Research Institute (EPRI). In European a network of the nuclear electricity utilities and inspection companies known as ENIQ, (the “European Network for Inspection Qualification”) have co-operated to draw up a document which deals with the objectives and role of NDT qualification, including principles for the derivation of basic qualification requirements and how to organise the process of NDT qualification. Utilities and regulators in Europe are utilising the ENIQ guidelines. CEN Technical Committee TC138 has prepared a Technical Report on NDT qualification and in the USA Performance demonstration has been widely adopted for computerised imaging techniques (Code case 2235 CIT) and a new ASME Section V system, similar to ENIQ, has been developed. Although the work is incomplete at the time of writing, ISO TC135/SC7/WG7 is developing an international standard on the qualification of NDT procedures and personnel for critical applications.

4.5 Accreditation OF NDT Organisations

In some countries in Europe, NDT company operations are being accredited by Accreditation Bodies. For critical inspections of nuclear power plant in Sweden such accreditation by SWEDAC is mandatory. Accreditation assessments are much more comprehensive and searching than a ‘quality systems’ audit to ISO9001 with greater emphasis on the inherent technical capability of the organisation. Laboratories may be accredited to EN ISO/IEC 17025 “General requirements for the competence of testing and calibration laboratories” whilst requirements for Inspection Bodies are laid down in the international standard ISO/IEC 17020 “General criteria for the operation of various types of bodies performing inspection”. The IAF/ILAC A4:2004 Guide titled “Guidance of the application of ISO/IEC 17020” supports the implementation of the standard through further explanations. There are also other forms of approval for NDT operations. For example some aerospace manufacturing companies use an American scheme known as NADCAP.

4.6 Human Factors

“Human factors” which influence the reliability of implementation of NDT may, in some instances, be the weakest link in the NDT quality chain and the NDT quality infrastructure is least developed in this regard.

Attention is required to human motivation to achieve quality. In fact the motivation and commitment to quality of NDT personnel is of prime importance in the quest for total quality in NDT operations. It is most unlikely that quality can be achieved by quality system certification, standards and validation unless the individuals executing NDT are properly motivated. In some organisations the NDT staff are salaried, work regular hours and are included with other staff in personnel training schemes, staff development schemes, quality circles etc., i.e. they are fully integrated, have the means of achieving a satisfying and worthwhile career and can call upon technical and managerial support. In contrast, in other cases NDT is carried out by agency staff or by temporary personnel, often self-employed. In many cases payment is by the hour or even by the metre of weld tested. Extended shifts and long periods without a day off are common. There are no paid holidays, no sick-leave and no technical or safety support by the employer. This situation has probably arisen because of the portability of personal NDT certificates on the one hand and commercial pressures on the other. It is not conducive to high quality. There is a need for a code of practice on employment conditions for NDT staff. It is necessary to set down guidelines based on research as to what are appropriate employment conditions and working arrangements (time, pressure, noise, environment) for personnel engaged on quality critical activities.

4.7 Overall Management of NDT to Achieve Quality

It is clear from the results of various round-robin exercises and trials that there is often an over-reliance on use of standards and personnel certification as a guarantee of quality in NDT with both purchasers and suppliers of NDT services failing to recognise when they are moving outside the normal scope of standard inspections, training and certification. More emphasis should be placed on the use of <u>all</u> relevant elements of the NDT quality infrastructure.

Contractual arrangements should be clear in the definition of who takes responsibilities. Users should think in terms of employing a service company capable of accepting technical responsibilities and providing back-up rather than employing operators as individuals. Either the purchaser of the service retains the key responsibility and simply 'hires a pair of hands' or the purchaser buys a service and specifies clearly his requirements. The supplier of the service may then have to qualify his offer if the demands are more onerous than he can guarantee. The time allowed for preparation and then for execution of an inspection is crucial. Sufficient time must be allowed for both and the contractual arrangements must allow the inspection company to recover its costs. Further guidance is given in the guidebook "Non-destructive Testing: A Guidebook for Industrial Management and Quality Control Personnel" published by the IAEA in 1999 and in the HSE Best Practice (see below).

The question arises "Which elements of the infrastructure should be used when?" Or "What constitutes Best Practice?" In the UK, the Health and Safety Executive, through a joint HSE-Industry Working Group has developed a document "Best Practice for the Procurement and Conduct of NDT" which is available to the public via the HSE web-site. The HSE Best Practice has many recommendations including:-

- Use an organisation accredited for NDT operations with necessary technical management, i.e. don't hire a man, hire a competent organisation
- Define the purpose of inspection and the various responsibilities for the involved organisations clearly
- Use relevant standards
- Prepare specific procedures - specific to the material and geometry
- Carry out capability trials when necessary - if outside previous experience
- Use certificated operators, <u>of course</u>
- Carry out job specific training - when inspection is not within scope of standard certification examinations
- Carry out inspection qualification if the risks are high
- Carry out Audit and Surveillance of site operations to ensure operator performance

The Best Practice guidelines recommend the use of <u>all</u> of the infrastructure with increased emphasis on job specific procedures, job specific training and technical management of the inspection wherever high quality inspection is needed. However, the guidelines recognise that not all inspections justify the use of all the measures and guidance is given on how to select appropriate ones.

Excellent advice on the management of best practice NDT is provided in a document "Inspection/Non Destructive Testing" published by HSE under COMAH (Control of Major Hazards) available at *www.hse.gov.uk/comah/sragtech/techmeasndt.htm*

5. EXEMPLARS OF GOOD PRACTICE

It is hoped to include a group of articles summarising good practice in a wide range of industries. The task group has suggested the following targets and will be delighted if other examples are provided: European Pressure Equipment Directive, European Airbus, European Aviation Safety Agency (EASA) and the Federal Aviation Authority (FAA), British Energy, BNFL Magnox, SAFED, UK Health and Safety Executive, German power industry, European railways (UIC 960 V), Belgian Nuclear Power Industry, French Nuclear Power Industry, Dutch oil/petrochemical industry, NADCAP Aerospace scheme, German Chemical Industry, and Austrian Hydro-electric Power Industry.