BEST PRACTICE IN THE APPLICATION OF NDT – AN UPDATE

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Abstract: An update is provided on the developments of the global NDT quality infrastructure used in the power, petrochemical, oil, gas and energy sectors. Particular attention is paid to international developments in the systems designed with the intention of achieving and assuring quality in NDT. These include developments in standards, certification of personnel, accreditation of NDT organisations, qualification/performance demonstration and in the planning and management of inspections.
Suggestions are made on what is the best practice, and where further developments are needed.

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.

To achieve these objectives there is a need to manage NDT operations to ensure that they can be relied upon by the designers and engineers who call for their use. 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, 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 be in place. They are nowhere near so complete in the newer applications of NDT or in-service inspection but are being developed.

As world trade rapidly becomes more liberalised, the NDT infrastructures which were originally national in their coverage, need to become international. For example, national standards for NDT in individual European countries are being superseded by European (CEN) standards and International Standards.

NDT Quality Chain: Quality in execution of NDT operations demands attention to a series of interlinked aspects extending from research and development, codes and standards, equipment, personnel training and certification to the effects of human reliability and the influence of auditing and surveillance. These aspects can be represented as links in a 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.

NDT Infrastructure: Figure 1 attempts to represent the infrastructure. In this figure the heavy boxes indicate the "doing activities" that make up NDT operation, 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.

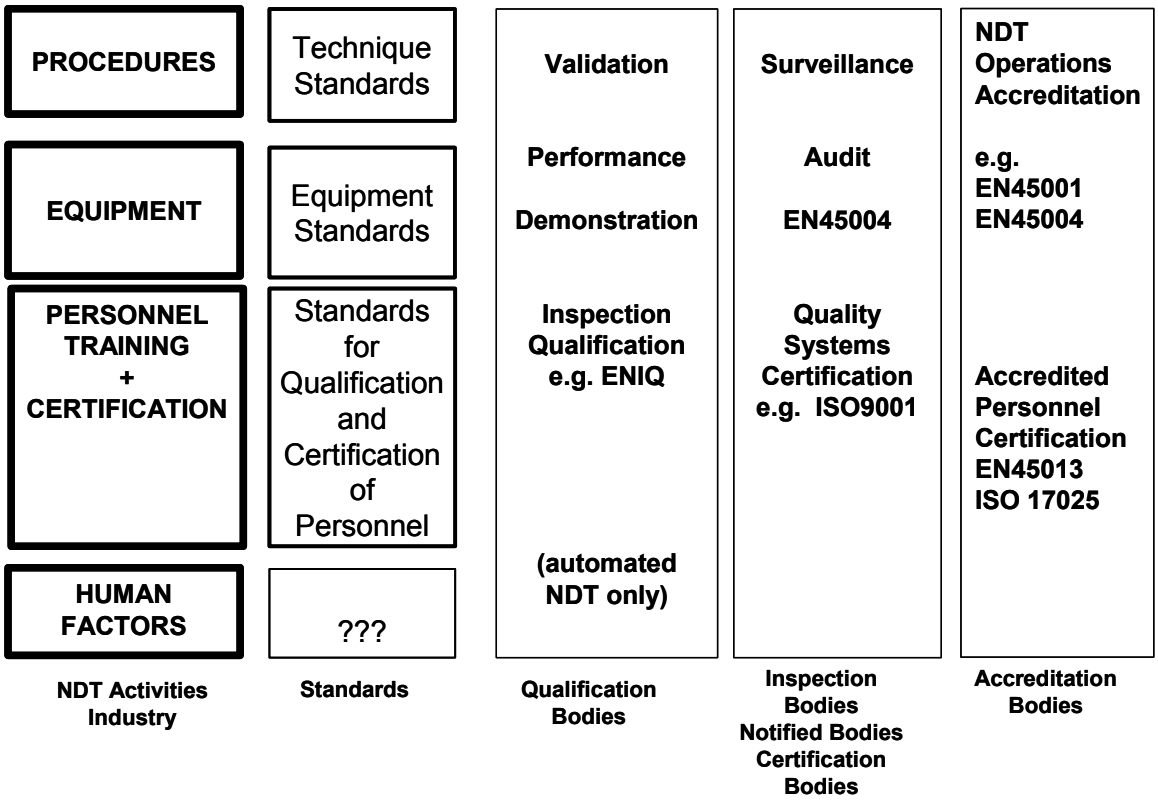

Figure 1: The NDT Quality Infrastructure

Current Status of European infrastructure and global developments:

Codes and Standards: Codes and Standards have an important role to play in achieving quality and reliability. There are International, European and national standards and codes for NDT techniques, equipment and personnel. American standards (ASME, ASTM, AINSI etc.) are widely used around the world.

Most Codes and Standards focus on manufacturing inspections and in some cases in-service inspections may be outside the intended scope.

Personnel Training and Certification: The training of NDT personnel is very important - both before and subsequent to certification 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.

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 (1) and its European equivalent EN473 (2) is increasingly being accepted internationally, including in the United States. For in-house certification the American ASNT document SNT-TC-1A is widely used in place of a standard (3).

In many countries (including most European, China, India, Canada, Japan, Australia, South America, Korea, USA) there is a 'national' Certification Body which provides NDT personnel certification to the EN473 or ISO 9712 standard or similar in each main NDT method at three levels (Level 1, 2 and 3). Many of these bodies have gained independent accreditation to EN45013 by a recognised Accreditation Body and around twenty participate in the EFNDT Mutual Recognition Agreement. An international version of EN45013 has now been published (ISO 17024:2003) and will be the basis of accreditation from April 2005. The International Accreditation Forum (IAF) has published a draft guidance on the application of ISO/IEC

17024:2003. A key issue arising from these publications is the requirement for practical examinations as part of the re-certification (ten years after initial certification).
The International Committee for NDT (ICNDT) and the IAEA continue to promote ISO9712 as a basis for global harmonisation of central certification. ICNDT has initiated the revision and update of the Training Syllabi ('body of knowledge') for each method and it is hoped that a common ISO/CEN syllabus will be published. Under the Vienna Agreement ISO and CEN are committed to converging ISO9712 and EN473 into a common standard. The next version of ISO9712 currently at the voting stage, will be much closer to EN473. ICNDT is publishing Recommended Guidelines on Personnel Certification to ISO 9712.
Users of central certification schemes need to be aware due to the lack of detail in the standards there is some considerable variation between different Schemes, in depth and breadth of certification and thus in the need for in-house job-specific training and assessment. This should be addressed in a company's quality system or NDT Written Practice.
In the USA, and countries using American standards, there continues to be widespread reliance on in-house certification in accordance with ASNT document SNT-TC-1A (3), albeit with increasing reliance on independently certified Level 3s. SNT-TC-1A allows NDT procedures to tailor training and certification more closely to the specific company needs but lacks the benefits of independent examinations by a central body.
In the author's view there should be a gradual coming together of the central independent and in-company approaches. The former 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 standards for in-house certification are bringing in requirements for external assessment e.g. independently certified Level 3s.
Following a number of Code Case inquiries ASME is accepting the use of third party certification providing this is properly referenced in the company's Written Practice.
To facilitate global trade ISO9712/EN473 certification needs to be more widely accepted by users of all American codes including ASME. Companies supplying goods and NDT services into the USA are therefore seeking acceptance of their EN473 and/or ISO9712 certification by ASME. Broader acceptance of ISO9712/EN473 certification by ASME Codes following the recent Code Case Inquiries will facilitate acceptance of goods designed and manufactured to these codes in the European Union which in some cases through the Pressure Equipment Directive requires inspections to be carried out by personnel with EN473 certification.
Within the Pressure Equipment Directive, Pressure Equipment is categorised at four levels (I to IV) according to degree of hazard. Categories III and IV equipment with potentially the greatest hazard will require conformity assessment by 'notified bodies' and 'recognised third party organisations'. The responsibilities of these bodies include approval of NDT personnel. In the UK the British Institute of NDT has gained recognition as a Recognised Third-Party Organisation under Regulation 20 of the European Pressure Equipment Regulations (1999). In many cases the applicable standards reference EN473 and PCN qualification examinations satisfying EN473 criteria meet the approval requirements. When "harmonised standards" such as EN473 are not invoked the BInstNDT offers an alternative approval service. Details are given in reference (4).
Certification/Accreditation/Approval of NDT Operations: Certification Bodies have a role to play in certifying quality systems to ISO9001. Many manufacturing companies which carry out NDT will have their NDT operations covered by the assessment by a certifying body, but NDT will be unlikely to receive very detailed attention.
In a growing number of countries in Europe (including FSU countries such as Russia and Belorussia) NDT Service company operations are being accredited by Accreditation Bodies. For critical inspections of nuclear power plant in Sweden such accreditation by SWEDAC is mandatory.
Initially such accreditation referenced the European Standard EN45001 "General criteria for the operation of testing laboratories" but this is now superseded by the ISO/IEC Standard 17025

"General requirements for the competence of testing and calibration laboratories". When the NDT company's operations extend to those of an Inspection Body the reference standard is EN45004 " General criteria for the operation of various types of bodies performing inspection". UKAS has published guidelines for accreditation of NDT operations to each of these standards in the form of a document entitled RG07 "Accreditation for Inspection Bodies Performing Non-Destructive Testing" (5). These guidelines explain the UKAS view of the difference between NDT Laboratory Accreditation and Inspection Body accreditation, the latter including "determination of significance of defects found, based on test results".

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.

There are other forms of Approval for NDT operations. For example some Aerospace manufacturing companies use a scheme known as NADCAP.

Qualification of NDT procedures, equipment and personnel: The process of Qualification, previously known as Validation or Performance Demonstration was first developed as a result of the need to assure the quality of inspections of nuclear power plant.

In the USA, following analysis of the results of the PISC II 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 the countries of the European Union and Switzerland, 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 have begun to utilise the ENIQ guidelines. Under the auspices of EPERC studies are being conducted into how Inspection Qualification might be applied more widely and the CEN Technical Committee TC138 has established a working group to draft a general standard for qualification of inspections.

The ASME Board on Pressure Technology Codes and Standards has established a Section V/Post Construction Joint Task Group on NDE Performance Demonstration for the purpose of formulating standard requirements for qualification of NDE (beginning with ultrasonics), primarily in support of risk-based inspection processes being developed by the Post Construction Main Committee. The methodology being developed has similarities to both the ASME XI methodology and the ENIQ methodology. Three levels of qualification (Low rigor, Intermediate rigor and High rigor) are defined.

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.

The effect of human factors on ultrasonic testing has been researched in the course of the PISC II and III programmes (6) and more recently in Sweden (7). In both cases tiredness and motivation affected performance but there were no clear undisputable findings. Enkvist et al (7) attempt to explain some of the results by reference to a model of human performance in which "the attentional ability of a person is determined by his or her level of arousal". "The arousal level also determines the amount of attention resources that are available." In practical terms, this means that stress and pressure may initially lead to improved performance, but after a time this effect reverses. Boredom equates to lack of arousal and can have a very negative impact on performance.

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.

Management of NDT: It is clear from the results of exercises such PISC II, III, PANI etc. 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 ie.

- use of accredited NDT laboratories or service companies. (EN45001 or 45004)
- use, where necessary, of Qualification of Inspection Procedures, Equipment and Personnel
- use of third party personnel certification as a basis for establishing the competence of personnel, in the context of a company Written Practice
- use of a supervisory NDT Engineer (normally Level 3) to:
    - assess task required (inspection geometry, defect targets, proposed procedure) and time available
    - decide if "normal" certification adequate
    - decide if Job Specific training required
    - decide if development of specific procedure necessary, including use of special equipment
    - decide if qualification of Inspection Procedure necessary

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 a series of Best Practice guides published by the UK Health and Safety Executive (8).

The Best Practice guidelines are recommending 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. Figure 2 shows the NDT infrastructure with the HSE Best Practice added.

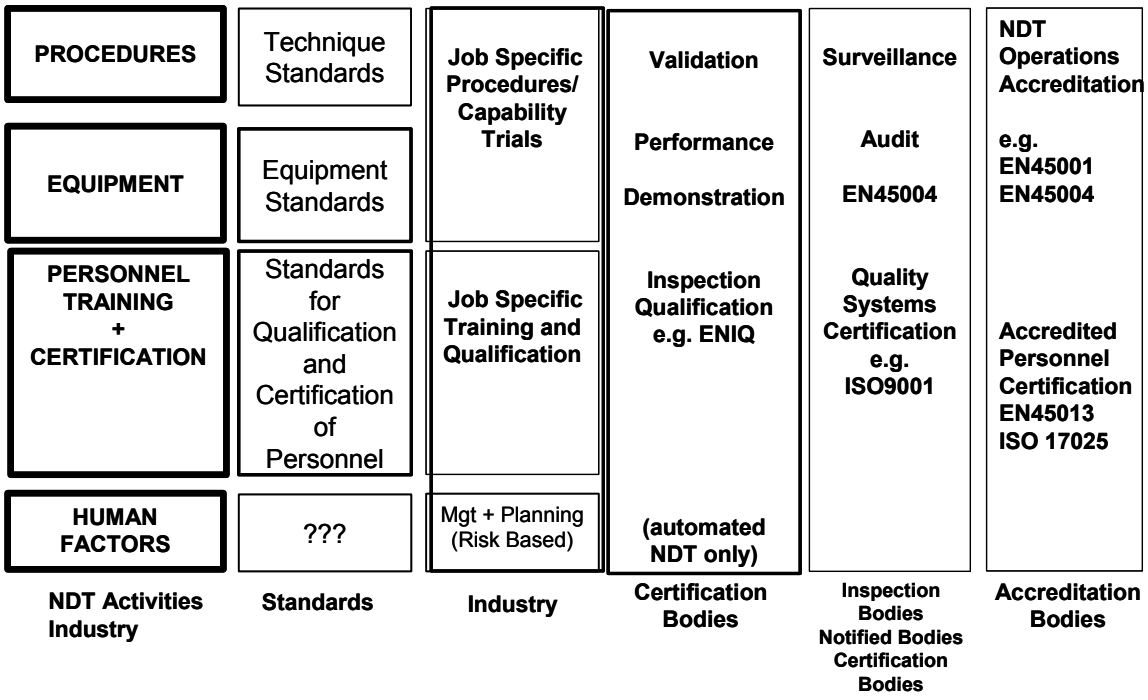

Figure 2: The NDT Quality Infrastructure

References:

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