European Federation for Non-Destructive Testing

EFNDT

EFNDT GUIDELINES

Overall NDT Quality System

Issue 2 – October 2014

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Foreword by President and Vice President of EFNDT

These EFNDT Guidelines 'OVERALL NDT QUALITY SYSTEM' summarise the infrastructure which has grown up to assist in the achievement of safety and reliability, identifying gaps and pointing out where users can either directly, or through their national societies or the European Federation for NDT (EFNDT), assist in achieving high quality in NDT.

The first issue of these Guidelines was published in 2008. The huge interest of colleagues and all stakeholders in Europe and all over the world made this document the most successful one EFNDT has ever published.

Now, almost a decade later, many things have been changed. The EN ISO 9712 'Non-destructive testing – Qualification and certification of NDT personnel' has replaced the EN 473 and the EN ISO/IEC 17024 'Conformity assessment – General requirements for bodies operating certification of persons' have rearranged the scene, but without changing the basic ideas of an 'Overall NDT Quality system'. Both standards were published in 2012.

In particular, the replacement of the EN 473 by EN ISO 9712: 2012 constitutes a tremendous achievement for the global NDT community. It is the first time that the minimum requirements for qualification and certification of NDT personnel are identical all over the world.

Therefore, the Board of Directors of EFNDT feel that it is time for an updated second edition of the EFNDT Guidelines 'OVERALL NDT QUALITY SYSTEM' covering the newly-defined requirements.

The President and Vice President of the EFNDT want to express their gratitude to all colleagues of the Board, Committees and Working Groups who have contributed to make this second edition a similar success like the first edition.

M Purschke
President EFNDT

P Trampus
Vice President EFNDT

1. Objective

This document has been prepared by European specialists to provide guidance on systems for achieving quality in NDT. The objective is to develop a better understanding, by users and purchasers of NDT services, of the various measures available for NDT during manufacture and in-service. Additionally, some principles of condition monitoring approaches will be introduced. Condition monitoring (CM) is the process of monitoring a parameter of condition in machinery (vibration, temperature, etc), in order to identify a significant change, which is indicative of a developing fault. It is a major component of predictive maintenance.

The document will be posted on the EFNDT website (www.efndt.org) and periodically updated. Users are advised to check the website for the latest version.

2. Background

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 decades with increasingly important in-service inspections 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.

Non-destructive testing and inspection are vital functions in achieving the goals of efficiency and quality at an acceptable cost. In many cases, these functions are highly critical: painstaking procedures are adopted to provide the necessary degree of quality assurance. The consequences of failure of engineering materials, components and structures are well known and can be disastrous.

It is a 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 provides the last line of defence before the product enters service, whilst once a product or structure enters service, in-service NDT often provides an even more crucial line of defence against failure.

The use of condition monitoring (CM) additionally allows maintenance to be scheduled, or other actions to be taken to prevent failure and avoid its consequences. Condition monitoring has a unique benefit in that conditions that would shorten the normal lifespan can be addressed before they develop into a major failure. Condition monitoring techniques are normally used on rotating equipment and other machinery, while periodic inspection using non-destructive testing techniques and fit-for-service evaluation are used for stationary plant equipment, such as steam boilers, piping and heat exchangers.

3. Achievement of quality in NDT

There are three important factors to achieve the necessary quality and reliability of inspection:

1. 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).
2. The NDT methods, equipment and personnel must be capable of the purpose for which they are being employed.
3. 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. 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. For the newer applications of NDT or in-service inspection, some of the infrastructure is being developed. As world trade rapidly becomes more liberalised, and equipment is sourced more widely, the NDT infrastructures that were originally national in their coverage need to become international.

Quality in the 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, 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 systems to control all activities that 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, which provides some of the foundation stones and frameworks with which NDT quality systems can be constructed. A plethora of interested organisations exist, each of which concentrates on its own elements of the infrastructure. Some are specific to NDT, others have a much wider remit. These organisations include codes and standards organisations, qualification bodies, inspection bodies, notified bodies, certification bodies, accreditation bodies as well as national, regional and international NDT societies.
Figure 2 attempts to represent the infrastructure. In this Figure, the heavy boxes indicate the 'doing activities' that make up NDT operations, *ie* Procedures, Equipment, Training and Certification and Human Factors, whilst the lighter boxes represent the various measures designed to achieve quality. Individual users and suppliers of NDT services are able to influence the development of the NDT quality infrastructure through participation in advisory committees, for example, of notifying and accreditation bodies, management committees and national, European and international standards organisations. National NDT societies are in a position to take an overview of NDT quality and the more active seek to influence the whole quality chain. It is clear from the experience gained in recent years that much greater influence can be achieved by the societies working together in their regional groups (for example EFNDT) and the International Committee (ICNDT). See Appendix I.

NDT system	Standards	Procedures	Qualification	Inspection, Certification, Notified Bodies	Accreditation Bodies
PROCEDURES	Techniques	Job Specific Procedures Capability Trials	Validation	Surveillance Audit	Accredited laboratories acc. EN ISO/IEC 17025
EQUIPMENT	Equipment Accessories Calibration	Proficiency Tests	Performance Demonstration	Certification, e.g. EN ISO/IEC 17020	Accredited Inspection Bodies acc. EN ISO/IEC 17020
PERSONNEL	Training Qualification Certification	Job Specific Training and Qualification	Inspection Qualification e.g. ENIQ, ASME	Quality System Certification, e.g. ISO 9001	Accredited Personnel Certification Bodies acc. EN ISO/IEC 17024
HUMAN FACTORS	Code of Ethics Code of Practice	Management and Planning (Risk-based)			

Figure 2. The NDT quality infrastructure

Standards for NDT are discussed in Section 5, with further details in Appendix 2. Such standards generally cover a reasonably wide range of applications and for any particular inspection it is usually necessary to prepare a specific inspection procedure. Such procedures should be consistent with the standards on which they are based but are more prescriptive about component geometry, inspection technique, reporting criteria etc. Inspection procedures may be prepared by personnel certificated to Level 2 but must be approved by a certificated Level 3. NDT equipment and accessories should be specified in detail in the procedures together with the equipment standards applicable. Further details of typical arrangements for controlling inspection procedures are given in the exemplars of good practice in Appendix 6.

Certification arrangements are described in Section 6 and training syllabuses and guidelines are covered in Section 7.

Section 8 covers the overall assessment of inspection capability, which is variously referred to as inspection qualification, performance demonstration or validation.

Section 9 describes the accreditation of NDT organisations.

Human factors can have a major impact on NDT quality and this is discussed in Section 10, whilst Section 11 provides guidance on the overall management for NDT.

Finally, Section 12 and Appendix 7 give examples of good practice in control of NDT quality from a variety of industries.

5. Standards

5.1 European and international NDT standards

In Appendix 2, an overview on European and international NDT standards is given. They are grouped according to product sectors as defined in EN ISO 9712 *'Non-destructive testing – Qualification and certification of NDT personnel'* (Annex A 'Sectors'), which are:

- 'c' casting
- 'f' forging
- 'w' welded product
- 't' tubes and pipes
- 'wp' wrought products
- 'p' composite materials.

Furthermore, comprehensive industrial sectors:

- Manufacturing
- Pre and in-service testing, which includes manufacturing
- Railway maintenance sector
- Aerospace sector.

When creating an industrial sector, the certification body shall precisely define, in its published documentation, the scope of the new sector concerned in terms of product, object or item.
General standards which apply for all product sectors are listed in the first Table.

Finally, the last Table shows NDT standards that define terms used in non-destructive testing, within the different NDT methods or generally.

Standards which cover personnel qualification and certification and define the minimum requirements for related bodies are not listed in Appendix 2 as Chapter 6 deals with them.

Normative references in standards

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 basis of the NDT quality chain, consisting of NDT procedures, NDT personnel, NDT equipment and the human factors (see Figure 2 above).

Example:

The general standard EN ISO 5579 for RT (radiographic testing): *'Non-destructive testing of metallic materials using film and X-rays and gamma-rays'* (see Table App 2.1) refers to:

- EN ISO 19232 *'Non-destructive testing – Image quality of radiographs'* (parts 1-5), which are also listed in Table 5.1 under 'others';
- EN ISO 9712 *'Non-destructive testing – Qualification and certification of NDT personnel'* (see Chapter 6 below);
- EN ISO 11699-1 *'Non-destructive testing – Industrial radiographic film – Part 1: Classification of film systems for industrial radiography'*, which is listed in Table App 2.1 under 'equipment, materials';
- EN ISO 25580 *'Non-destructive testing – Industrial radiographic illuminators: minimum requirements'*, which is listed in Table App 2.1 under 'equipment, materials'.

Standards organisations

More information about standards can be found on the webpages

- for European standards

  Committee for European Standardisation (CEN) www.cen.eu
- for international standards

  International Organization for Standardization (ISO) www.iso.org

or on the webpage of national standards organisations (especially those that are members of the above mentioned organisations).

See Chapter 6.7 for details on the processes of preparing standards.

Information platform on standardisation

The information platform for standardisation is accessible for members of EFNDT on the EFNDT webpage: www.efndt.org

This platform offers various information on technical committees of national, European and international standards institutes with respect to non-destructive testing and related areas (for example welding, destructive testing).

It presents results of actual European and international standards work. All new standards or revisions of existing standards are listed on the first page of the information platform to provide a quick overview. Information about the committee responsible for the standards and a summary of the content is given.

Withdrawn standards are kept within the database to show the history of standards development. They are marked to show the withdrawn status.

5.2 Explanation of ISO processes

The process for development and revision of International standards follows the Directives of the International Organization for Standardization (ISO). The Technical Management Board is responsible for the establishment of Technical Committees (TCs), including TC-135 Non-Destructive Testing.

A Technical Committee can establish and dissolve Subcommittees (SCs). Thus, TC-135 established SC-7, Non-Destructive Testing – Personnel Certification. The parent Subcommittee can establish and dissolve Working Groups (WGs). Thus, SC-7 established a joint WG of CEN and ISO, responsible for the development and revision of ISO 9712:2012. A Working Group comprises a restricted number of technical experts.

All national bodies (member bodies of ISO) have the right to participate in the work of Technical Committees and Subcommittees. A national body may be a P-member with an obligation to vote on all questions within a Technical or Subcommittee and to participate in meetings. A national body may be an O-member with the right to submit comments and to attend meetings. A national body may be neither a P-member nor an O-member but still has the right to vote on draft international standards (DIS) and on final draft international standards (FDIS).

An ISO standard is developed through several project stages:

Stage	Work	Time Line
Preliminary	New work items are developed against no time deadlines	
Proposal	New work item proposal is submitted to the TC or SC	0 months
Preparatory	Work to prepare a working draft (WD)	6 months
Committee	Work to prepare a committee draft (CD)	12 months
Enquiry	Work to prepare a draft international standard (DIS)	24 months
Approval	Work to prepare final draft international standard (FDIS)	33 months
Publication	Work to prepare a published standard	36 months

Thus, development of a new standard may take far more than 36 months, since the time clock does not begin until a new work item proposal is submitted. A major revision of an existing standard, starting at the Preparatory Stage, could require 36 months.

5.3 Explanation of CEN processes for European standards

The processes for preparation and approval of European standards are explained in Appendix 3.

A European standard (EN) is a normative document made available by the European standards organisations CEN/CENELEC in the three official languages. The elaboration of a European standard includes a public enquiry (five months), followed by an approval by weighted vote of CEN/CENELEC national members (two months) and final ratification. The European standard is announced at national level, published or endorsed as an identical national standard and every conflicting national standard is withdrawn. The content of a European standard does not conflict with the content of any other EN. A European standard is periodically reviewed.

Standards may be prepared by adoption of international standards or when necessary by Technical Committees. Voting and approval procedures are described in Appendix 3.

When a consensus has been reached, the text agreed by the technical body is forwarded by the Technical Committee secretariat to the Central Secretariat, to be allocated a prEN number and distributed to the CEN/CENELEC national members for public comment. This procedure is called the 'CEN/CENELEC enquiry'. The period allowed for the CEN/CENELEC enquiry shall normally be five months.

NDT standards are prepared both by the CEN Technical Committee TC-138 Non-Destructive Testing (which prepares general methods standards, including certification of personnel) and by product-related Technical Committees (for example TC-121 NDT of Welds).

5.4 Agreement on technical co-operation between ISO and CEN (Vienna Agreement)

5.4.1 Background

In January 1989, the CEN Administrative Board approved an agreement on the exchange of technical information between ISO and CEN (called the Lisbon Agreement) as a response to the ISO Council resolution 11/1987.

Subsequently, an agreement on technical co-operation between ISO and CEN was approved by the ISO Council resolution 18/1990 and the CEN General Assembly resolution 3/1990. This agreement (called the Vienna Agreement) was published in June 1991. It is accompanied by common ISO-CEN 'Guidelines for the TC/SC Chairmen and Secretariats for implementation', approved in 1992 and revised in September 1998.

After a decade of experience, the need for the Agreement was confirmed by ISO and CEN and the recent edition was confirmed by the ISO Council resolution 35/2001 and the CEN Administrative Board resolution 2/2001.

This version is a simplified agreement, setting out the principles of its previous version. All relevant and updated operational and process specifications are grouped into a new edition of the 'Guidelines for implementation of the agreement on technical co-operation between ISO and CEN (Vienna Agreement)', referred to hereafter as the 'implementation guidelines'.

5.4.2 Rationale and objectives

Essentially, the agreement recognises the primacy of international standards (stipulated notably in the WTO Code of Conduct). But the agreement also recognises that particular needs (of the single European market for example) might require the development of standards for which a need has not been recognised at the international level. The prioritisation of ISO work is also such that in some instances CEN needs to undertake work which is urgent in the European context, but less so in the international one.

As a result, the agreement sets out two essential modes for collaborative development of standards: the mode under ISO lead and the mode under CEN lead, in which documents developed within one body are notified for the simultaneous approval by the other.

The benefits expected from the use of this agreement in accordance with the 'implementation guidelines' include:

- increasing transparency of work ongoing in CEN to ISO members, and their possibility to influence the content of CEN standards;
- avoidance of duplication of work and structures, thus allowing expertise to be focused and used in an efficient way to the benefit of international standardisation;
- increasing the speed of elaboration, availability and maintenance of standards through a need to establish consensus only once.

5.4.3 Basic principles

- This technical co-operation is operated within the current rules, policies and procedures of either ISO or CEN, as relevant for their respective activities;
- ISO recognises and respects that CEN operates within and must respect a political environment set both in the EEA and through a co-operation of the European standards organisations;
- ISO and CEN are committed to values such as transparency, openness, coherence, impartiality and relevancy. CEN supports coherence through withdrawal of conflicting national standards upon publication of a European standard;
- The transfer of work from CEN to ISO is the preferred route but is not automatic;
- When expected results are not attained, the party which is not satisfied can decide to proceed separately;
- CEN accepts that the ISO interest in CEN work, through this agreement, has some consequences for the CEN processes and visibility;
- Standards development is done in either ISO or CEN but both bodies ensure that the processes of consensus confirmation and approval are synchronised to achieve the objective of simultaneous publication.
- CEN commits to respond adequately to comments from non-CEN ISO members.

5.4.4 Modes of co-operation

Technical co-operation is possible at various levels:

- By regular exchange of information at the level of the CEN Management Centre (CMC) and the ISO Central Secretariat (ISO/CS), such as catalogue, work programme, resolutions, (draft) standards;
- By the adoption of existing international standards as European standards;
- Through working by correspondence;
- Through (mutual) representation at meetings of technical entities;
- When ISO and CEN agree to submit relevant and approved work items within the same scope to parallel procedures, with agreement on leadership (ISO-lead decided by CEN, CEN-lead decided by ISO).

5.4.5 Monitoring and co-ordination

The monitoring of the application of this agreement is entrusted to a Joint Co-ordination Group (JCG) of the ISO Technical Management Board (ISO/TMB) and the CEN Technical Board (CEN/BT). Monitoring includes reporting to these respective boards on progress or specific issues of concern and, where necessary, the review of existing mechanisms with proposals for improvement.

Joint co-ordination meetings of relevant ISO and CEN committees may be held, where necessary, to allocate work and/or to deal with comments received upon parallel enquiry or parallel voting.

Both the ISO Central Secretariat (ISO/CS) and the CEN Management Centre (CMC) shall handle the day-to-day processing and management.

5.4.6 Implementation of the agreement

In the event of difficulties arising in the implementation and functioning of this agreement and 'implementation guidelines', the ISO committees, the CEN committees and the CEN reporting secretariats shall report to their respective Secretaries General, who shall decide on the necessary actions.

5.4.7 Duration

This agreement shall remain in force until such time that ISO or CEN request its revision or its termination giving one year's notice.

6. Personnel qualification and certification

6.1 Background

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 provides 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.

The training, experience, qualification and certification of NDT personnel are therefore 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 that may be outside the scope of his certificate. Section 6 focuses on qualification and certification whilst Section 7 covers training.

Internationally there are many different NDT certification schemes and these can broadly be classified as employer-based second-party or centrally-certified third-party schemes.

The employer-based certification schemes are created specifically for the employers' requirements in accordance with employer-based standards or recommended practice and can entail the employer training and examining their own staff or using external providers. The Company Written Practice specifies what is required. The employer can, with proof of qualification, issue a certificate or equivalent; this certificate is typically only valid whilst the employee works for the company that issued the certificate.

Centrally-certified schemes are typically based on ISO 9712:2012 (known in Europe as EN ISO 9712:2012) requirements, which states the requirements for minimum training hours and experience periods for the methods. There is further guidance on numbers of questions and samples required and sectors covered. The candidate must meet the pre-examination requirements prior to attempting the third-party examinations and providing all the requirements are met, including post examination experience where applicable, the certification body will issue certification in accordance with their scheme requirements. It is still the employer's responsibility to certify/authorise the holder to perform NDT tasks on their behalf.

6.2 Central independent certification

In most European countries there is a 'national certification scheme', which provides NDT personnel certification to the EN ISO 9712:2012 standard in each main NDT method at three levels (Levels 1, 2 and 3). The majority of these bodies have gained independent accreditation to EN ISO/IEC 17024:2012 by national accreditation bodies (such as the United Kingdom Accreditation Service – UKAS). This 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 previous ISO 9712 standard, but not the current version (EN ISO 9712:2012) which is significantly different, has been adopted in a large number of countries (including China, India, Canada, Japan, Australia, South America and Korea) and certification bodies are providing independent third-party certification accordingly. A group of certification bodies in the Asia-Pacific region is developing a multilateral recognition agreement based on the EFNDT model. In the USA, standard ANSI/ASNT CP-106:2008 has been developed. The international standard ISO 9712:2012 is being considered for adoption with national modifications as an American national standard. The national foreword describes the method for making modifications and how they are identified in the text. By using the guide 21 option, the USA and other non-European countries will be offering the previous ISO 9712-compliant certification, which is significantly different to EN ISO 9712:2012-compliant-schemes.

The International Committee for NDT (ICNDT) and the International Atomic Energy Agency (IAEA) continue to promote ISO 9712:2012 as a basis for global harmonisation of central certification.

Under the Vienna Agreement, ISO and CEN are committed to the adoption of common standards to serve the needs of the European and wider international communities and, where EN ISO 9712:2012 has been adopted without deviation, this has been achieved.

Although there has been a steady increase in the level of detail in EN ISO 9712:2012 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).

6.3 Company-based approvals/certification

In the USA, and countries using American standards, there continues to be widespread reliance on in-house certification in accordance with SNT-TC-1A, 'Recommended Practice No SNT-TC-1A, Personnel Qualification and Certification in Non-Destructive Testing (2011)' (available from www.asnt.org), albeit with increasing reliance on independently-certified Level IIIs. 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 lead to a number of schemes, which combine in-house training and approvals with external third-party controls, notably in the aerospace sector:

- In the European civil aerospace maintenance sector, SNT-TC-1A is increasingly being rejected because it allows the employer too much latitude, and the typical national or regional regulatory requirement for maintenance organisations (in Europe, European Aviation Safety Agency (EASA) regulation part 145) is to implement EN 4179. This standard refers to bodies – National Aerospace NDT Boards (NANDTB) – that control NDT personnel qualification examinations at the national level. The examinations may be provided centrally or by outside agencies or employer-administered examinations.
- In the civil aerospace manufacturing sector, controlled in Europe by EASA Regulations part 21, there is no specific requirement to apply a specific certification standard but, again, EN 4179 is the predominantly applied standard. This is further emphasised by the NUCAP programme (which evolved from the North American Defence Contractors Accreditation Programme – known as NADCAP), in which the whole NDT process, including qualification of personnel, is audited and accredited under arrangements controlled and agreed by the major prime contractors (for example Boeing, Airbus, etc).

6.4 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 ISO 9712:2012 and gives guidance on how the employer should fulfil these. The requirements of EN 4179 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.

The responsibilities of the employer are:

a. to accept overall responsibility for the results of NDT operations;
b. for uncertificated employees, to introduce the candidate to the certification body or the authorised qualifying body and endorse the validity of the personal information provided, including the declaration of education, training and experience needed to establish the eligibility of the candidate;
c. to accept full responsibility for the authorisation to operate, including checking that NDT tasks to be carried out are within the scope of the individual's scope of certification and, if they are not, organise additional job-specific training and/or qualification examinations;
d. to ensure annually that employees meet the visual acuity requirements and all other conditions of validity of certification as defined in the standard;
e. to maintain records of work experience necessary as a basis for confirming continuity of satisfactory work activity (to support renewal/recertification).

To fulfil these responsibilities, the employer must prepare a quality procedure (or written practice) and maintain adequate records.

The quality procedure should cover all aspects of employing NDT technicians, including general induction training, health and safety, familiarity with the company's equipment and procedures, familiarity with the products to be tested and the applicable acceptance standards; in short, the correct administration and control of NDT personnel in order to meet the quality requirements of the company, its customers and relevant national or international regulations.

It will also include reference to:

a. applicable codes and standards;
b. general responsibilities of Levels 1, 2 and 3;
c. scope of certification required (method, level, sector…);
d. persons designated by the employer to be responsible for issuing the authorisation to operate;
e. control of in-house training and examination supplementary to that carried out during the EN ISO 9712:2012 qualification and certification process. This will include job-specific training for tasks outside the scope of the individual's certification and updating with respect to new equipment or techniques;
f. responsibility for maintenance of records.

The employer must arrange to maintain records for each of his NDT personnel including records of:

- education;
- externally and internally provided training;
- work experience;
- vision tests;
- qualification examination results.

If these are complete and acceptable, then the employer issues the necessary authorisation to discharge the duties of Levels 1, 2 or 3 in a defined area of competence.

The best way for this to be done is through a 'Certificate of Authority to Work' and this should be signed by an appropriately designated person on behalf of the employer. EN ISO 9712 provides guidance of such an authorisation.

6.5 Best practice in certification

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, for example independently-certified Level 3s.

6.6 Standards for central/third-party certification (EN ISO 9712:2012)

The current edition of the referenced standard is:

EN ISO 9712:2012 Non-destructive testing –
Qualification and certification of personnel

There are significant differences within the 2012 edition against previous editions and some countries are able to apply national deviations to the requirements using the guide 21 option.

6.6.1 EN ISO 9712:2012 – Background

Work began in 1987 to produce an international standard covering the criteria for education, training, experience and certification of NDT personnel, and the draft ISO 9712:2012 was based upon guidelines produced by ICNDT and published in 1985 as a series of documents with the WH85 prefix. The demand for such a standard arose primarily from a lack of confidence in employer-based certification systems, necessitating regular and expensive audits of suppliers' in-house certification procedures, which were subject to abuse arising from commercial pressures. After more than three years of meetings, amendments and numerous drafts, made necessary in order to satisfy the diverse interests of the nations involved, the standard was given approval and published in 1991 (but designated ISO 9712:1992). It specified independent central certification at all three levels of qualification, and a certificate validity of five years. This first edition lacked detail and substance, but it was nevertheless a good beginning that provided the opportunity for global harmonisation that had not previously existed. The current version dated 2012 is much improved and has fully superseded EN 473:2008 and provides a transition agreement until the next renewal or recertification process is required.

6.7 EFNDT Certification Executive Committee activities

Beginning in 1990, EFNDT (previously ECNDT) considered several ways to harmonise qualification and certification of NDT personnel in Europe with the help of the newly-published European Standard EN 473 (Non-Destructive Testing – Qualification and Certification of NDT Personnel – General Principles). This EFNDT project, originally known as 'ECP' (European Certification Process) aimed at a full and detailed description of the qualification provisions adding to EN 473 to provide interpretation of, for instance: conduct of examination, examination questions and test-pieces.

Successive revisions of EN 473 and the development of accreditation of certification bodies by accreditors who are members of EA (European co-operation for Accreditation) and IAF (International Accreditation Forum) implementing harmonised international standards (EN 45013, ISO 17024) reduced the initial scope of ECP.

In order to administer all issues associated with qualification and certification processes, the Certification Executive Committee was created by the EFNDT Board.

The main objectives of the Certification Executive Committee are:

- EFNDT approval of NDT personnel certification bodies
- Administration of EFNDT Multilateral Recognition Agreement (MRA)
- EFNDT Question Bank.

- **EFNDT approval of NDT personnel certification bodies (see Section 6.9):**

  EN ISO 9712:2012 requires compliance to EN ISO/IEC 17024, which provides general requirements for bodies providing certification of personnel.

  It has been agreed by the International Accreditation Forum (IAF) that the transition period will be three years. As the second edition of EN ISO/IEC 17024 was published on 1 July 2012 this means that all personnel certification bodies will need to have successfully transferred to the EN ISO/IEC 17024:2012 by 1 July 2015.

  In Europe, compliance with EN ISO/IEC 17024 is usually assessed by national accreditors. But certain certification bodies may not easily have access to the service of accreditors (an absence of such a service in their country or countries outside Europe).

  To resolve this issue, EFNDT has acted by setting up a complete professional documented system of approval, which may be used by certification bodies when appropriate accreditation is not available.

- **EFNDT Multilateral Recognition Agreement (MRA) (see Section 6.8)**

  The Agreement shall be administered by the EFNDT Certification Executive Committee (CEC), which has assigned the practical responsibility for reviewing applications for registration to the Secretary of the Committee. Having reviewed and confirmed that an application is in compliance with the terms of the Agreement, the Secretary will present it to the next meeting of the CEC with recommendations regarding acceptance and registration

Any complaints or appeals received will be referred to the EFNDT CEC for resolution.

- EFNDT Question Bank (see Section 7.4)

  The bank was developed by founders of EFNDT and brought together more than 8000 multiple choice examination questions. In 2013, the EFNDT Question Bank was handed over to ICNDT. The rules for purchasing and using the question bank are available on the ICNDT website at http://www.icndt.org/

6.8 Mutual recognition of certification to EN ISO 9712:2012

6.8.1 Background

The publication ICNDT WH 85 included a model agreement (WH 23 - 85), adopted 7th November 1985, on the mutual recognition of qualification and certification schemes for NDT personnel.

It was envisaged that what was initially a model bilateral agreement for use by two certification bodies might, due to the extension of such agreements between parties, effectively develop into a multilateral agreement between several bodies

6.8.2 Bi-lateral agreements

A number of bilateral recognition agreements, based upon the model in WH 23-85, emerged in the late 1980s and early 1990s. Some of these are still in force and those known at the point of publication are listed in the register of agreements below.

6.8.3 EFNDT Multilateral Recognition Agreement (MRA)

In early 1993, an *ad hoc* meeting was arranged in Brussels with the intent of harmonising the implementation of the European standard EN 473 (Non-Destructive Testing – Qualification and Certification of NDT Personnel – General Principles) through three CEC funded projects:

- establishing a European bank of multiple choice questions
- documentation of a system for administering examinations
- interpretation of EN 473.

At a subsequent meeting in Berlin on 21 October 1993, the European Committee on NDT (ECNDT) established a Working Group of European Union national NDT societies and their associated certification bodies. This was given a remit to establish a European-wide multilateral agreement on mutual recognition of certification. The group involved in this meeting became known as the European Working Group on Qualification and Certification.

At a meeting in Paris on 27 April 1994, the first draft of the European Multilateral Agreement was tabled. It was subsequently amended and ratified at the 6th European Conference on NDT in Nice, France, in October 1994. On this auspicious occasion, the first 20 or so of the eventual 30 plus ECNDT members signed the very first truly multilateral agreement to recognise mutually certificates issued by certification bodies registered under the agreement.

Members signing this agreement recognise mutually certificates issued by certification bodies registered under the agreement.

Participation in the MRA is open to schemes outside Europe providing EN ISO 9712:2012 certification.

A copy of the Agreement, the list of signatories and the list of recognised certification bodies is published on the EFNDT website (www.efndt.org).

Obligations

Each party to the Agreement shall:

- commit itself to the pursuance of the objectives of the Agreement;
- recognise those personnel certification schemes which have been accepted and registered by the European Federation for NDT as meeting criteria set out in the agreement;
- assist other parties in their efforts to give a clear overview of the certification activities in its own country;
- provide other parties with non-confidential information on the operation of its certification scheme(s); and
- consult with the governing boards and/or management committees of their nominated certification bodies.

Administration of the agreement

The Agreement shall be administered by the EFNDT Certification Executive Committee (CEC).
The EFNDT BoD will have final responsibility for approving the MRA, and will be presented at each of its meetings with a brief report on registrations approved by the CEC.

Procedure for recognition

Criteria for recognition by EFNDT;

A certification body seeking recognition of its certification scheme under this Agreement shall meet the following criteria:

- managed or nominated by a national NDT society, in current full or associate membership of EFNDT, which is a party to this Agreement

or

- managed or nominated by the ICNDT member national NDT society of the country in which the certification body is based

and

- be in compliance with ISO/IEC 17024 (Conformity Assessment – General requirements for bodies operating certification of persons) and issuing certification in conformance with EN ISO 9712:2012 (Non-Destructive Testing – Qualification and Certification of NDT Personnel).
- has signed an undertaking to comply with requirements of the Code of Practice for certification bodies (doc EFNDT/CEC/C/05-002)

and

- be acceptable to a quorate meeting of the Certification Executive Committee.

Compliance with the above criteria shall be demonstrated by:

- accreditation by a body in membership of European co-operation for Accreditation (EA) and which is signatory to the EA Multilateral Recognition Agreement for personnel certification, or
- accreditation by a body which is an Associate Member of the EA and is signatory to a bilateral Mutual Recognition Agreement with EA on personnel certification, or
- certification of conformance issued by a government department, body or other agency accepted by the EFNDT as adequately fulfilling the function of ensuring compliance by the certification body with the ISO/IEC 17024 criteria, or
- approval of NDT personnel certification bodies by EFNDT through the assessment for compliance with ISO/IEC 17024, and the ability to deliver certification in conformance with EN ISO 9712 carried out by an EFNDT constituted audit team (exceptionally, if there is a *bona fide* reason, as judged by the CEC, why it is not reasonably possible for the applicant certification body to demonstrate compliance as described above).

6.9 Accreditation/approval of NDT certification bodies providing certification to EN ISO/IEC 17024:2012

The standard requires that the certification system should be controlled and administered by a certification body that conforms to the requirements of the EN ISO/IEC 17024:2012 (Conformity assessment – General requirements for bodies operating certification of persons). This standard is designed to ensure that a certification body is adequately qualified for its role and is independent of any single interest. In many countries of the world, certification bodies demonstrated their compliance with this requirement by obtaining accreditation by independent agencies – many of which are government sponsored – generally known as accreditation bodies.

There are associations of accreditation bodies at international and European levels, the International Accreditation Forum (IAF) and the European co-operation for Accreditation of Certification (EAC) group. Some accreditation bodies operate outside their national boundaries.

EAC have a Multilateral Agreement (MLA) covering accreditation of personnel certification bodies, as does the IAF. The accreditation process is intended to increase the confidence of users in the status of a certification body and its certificates.

Accreditation reduces risk for business and its customers by assuring them that accredited bodies are competent to carry out the work they undertake within their scope of accreditation. Accreditation bodies that are members of the International Accreditation Forum, Inc (IAF) are required to operate at the highest standard and to require the bodies they accredit to comply with appropriate international standards, and IAF Guidance to the application of those standards (in 2003, the IAF drafted guideline G24 for the application of the standard by accreditation and certification bodies since updated).

Recognising that the lack of availability of accreditation in some countries/regions makes it difficult for certification bodies in those countries/regions to participate in its Multilateral Recognition Agreement (MRA), the European Federation for NDT has developed and implemented a system for assessment and EFNDT approval of NDT personnel certification bodies. This system is described in EFNDT document CEC/P/05-001 RO2, the introductory text from which is replicated below for information.

EFNDT assessment and approval of certification bodies

Introduction

The EFNDT provides a system for the assessment and approval of bodies engaged in the certification of competence of NDT personnel in accordance with third-party qualification and certification standard EN ISO 9712:2012.

Management

The EFNDT approval process is managed by a Certification Executive Committee (CEC) constituted by the EFNDT Board of Directors. The CEC is responsible to the EFNDT for setting, maintaining and reviewing criteria for applicant and approved certification bodies and, if requested, will advise the EFNDT BoD on the justification for approval of any particular body.

Purpose and eligibility

The purpose of the assessment and approval service is to provide for international recognition of NDT personnel certification bodies where there is presently no national system of accreditation or to otherwise satisfy the EFNDT requirements for registration under its Multilateral Recognition Agreement (MRA).

To be eligible for assessment and approval, the applicant certification body shall be nominated by an NDT society in Full or Associate Membership of the EFNDT, and will remit to EFNDT the current application and pre-assessment fees, and undertake to comply with the EFNDT Code of Practice for certification bodies (doc EFNDT/CEC/C/05-002).

Applications for assessment and approval

The applicant certification body will indicate an intention to comply with the applicable standard(s) by returning to the EFNDT Certification Executive Committee (CEC), c/o COFREND, the completed application form with the current application fee, together with a quality management system and procedures in the English language.

Applicants should note that EN ISO 9712:2012 and ISO/IEC 17024 require, between them, that the certification body has a documented quality management system and procedures describing how it deals with:

- document and change control
- control and maintenance of records, including security thereof
- internal audit
- corrective and preventive actions
- management review
- continual improvement
- development and validation of examination questions, including model answers, relevant to the adopted training syllabus
- the compilation and authorisation for use of examination scripts
- the assessment and mastering of examination specimens
- candidate eligibility (*ie* training, vision, experience) for examination and certification
- development and conduct of qualification examinations, including the marking and grading of such
- control of NDT equipment used in examinations, including maintenance and calibration
- process control, for example assessing and recording checks on penetrant and magnetic particle systems or on radiographic film development process facilities
- control of substances used in examinations that may be hazardous to health Ref. EFNDT CEC_P_05_001 R02 (EFNDT Assessment and Approval of Certification Bodies) Page 3 of 7, 2009, available to download from www.efndt.org
- granting, maintaining, renewing, expanding and reducing the scope of certification
- suspending or withdrawing certification
- appeals and complaints received from applicants, candidates, certified persons and their employers and other parties about the certification process and criteria

- re-affirming, at least annually, the fairness, validity, reliability and general performance of each examination (such as collecting and maintaining statistical data)
- assessment, authorisation and monitoring of the performance of its examiners and subcontractors
- regulatory requirements for the maintenance and release of information and data
- the use of its mark, and the procedures it is to follow in case of misuse, including false claims as to certification and false use of its marks.

A desktop review of the certification body's system documentation will be conducted prior to any on-site assessment to confirm the availability of procedures covering all of the above, and any deficiencies identified during this review shall be corrected prior to the conduct of an on-site assessment.

Scope of approval

Approval may cover the qualification and certification activities of any particular certification scheme in whole or in part. The certificate of EFNDT approval will clearly state the scope and limitations of the approval granted.

Conditions of approval

The EFNDT approved certification body shall:

- Conduct qualification examinations in conformity with the current edition of the applicable standard EN ISO 9712:2012;
- Pay in full, prior to the publication of the decision regarding EFNDT approval, all relevant published EFNDT application fees, audit charges and direct expenses anticipated during the assessment process;
- Comply with the EFNDT Code of Practice for approved certification bodies (doc EFNDT/CEC/C/05-002).

Validity of approval

The EFNDT approval is valid for a period of three years, with a surveillance visit taking place within 12 months of initial approval. Re-approval requires the same process as the initial approval.

Extensions to approved scope

Existing EFNDT approved certification bodies wishing to extend the scope of their authorisation should use the same application form and procedure to provide evidence of satisfying the applicable standard(s) for the additional scope.

6.10 European Pressure Equipment Directive

Introduction

The Pressure Equipment Directive – 97/23/EC – was formally adopted by the European Parliament and Council on 29 May 1997, and was published in the official journal of the European Communities No L181 of 9 July (ISBN 011 916 0927). It entered into force on 29 November 1999 and compliance with its requirements has been mandatory since 29 May 2002.

The purpose of the Directive is to harmonise national laws regarding the 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 above atmospheric.

Equipment is categorised within four levels (I to IV) according to the degree of hazard: category III and IV equipment will require conformity assessment by 'notified bodies' and 'recognised third-party organisations'.

Non-destructive testing

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' recognised by a member state pursuant to Article 13.

Certificates of competence in compliance with EN ISO 9712:2012 and covering the testing of permanent joints (in effect, welds) are presumed to satisfy the requirements of the Directive because EN ISO 9712:2012 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.

References

97/23/EC: The Pressure Equipment Directive

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

Documents are available at www.efndt.org under the section 'Pressure Equipment'.

6.11 European Aviation Safety Agency (EASA)

Introduction

European standard EN 4179:2009 (Aerospace series: Qualification and approval of personnel – Non-destructive testing) defines, at clause 3.17, a National Aerospace NDT Board (NANDTB) as an "an independent national aerospace organisation representing a nation's aerospace industry that is chartered by the participating prime contractors and recognised by the nation's regulatory agencies to provide or support NDT qualification, examination and/or certification services in accordance with this standard".

The responsibilities of such a Board are briefly described in the standard as follows:

- … may include participation in certification (3.17)
- When used, the NANDTB shall administer procedures for qualification and certification of NDT personnel according to the requirements of this standard. It is entitled, in conjunction with the employer, to recognise equivalencies of qualification and certification and may be requested to provide general guidelines in accordance with this standard regarding facilities for NDT training, course outlines, examination questions and exam procedures. For countries where no NANDTB exists, the employer may use the services of other NANDTBs (4.5.2)
- … training shall be conducted in accordance with a detailed course outline approved by the responsible Level 3 or NANDTB (6.1.1)

There are further references, throughout the standard (as above), to the activities of the Responsible Level 3 or the NANDTB.

6.12 Forum for National Aerospace NDT Boards

A proposal to establish a Forum for NANDTBs was presented and 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 Appendix 6 along with the Forum's current action plan.

The Forum has its own web pages at (www.efndt.org).

7. Training syllabuses/guidelines

7.1 Introduction

Historically, there has been concern to develop syllabuses that collect the appropriate theoretical and practical knowledge to carry out training courses and certification schemes. The earliest version was produced by ASNT (1966) as Recommended Practice SNT TC 1A, which included recommendations on training syllabuses; it has been revised and extended at the same time that the new issue of Recommended Practice SNT TC 1A.

In 1985, the International Committee for Non-Destructive Testing (ICNDT) published a collection of separate documents as ICNDT WH 85. These documents cover the following methods at Levels 1, 2 and 3:

Number	*Document*	*Adopted*
15-85	Basic requirements for national personnel qualification and certification schemes	3 November 1985
16-85	UT	26 August 1982
17-85	RT	18 March 1983
18-85	ET	7 November 1985
19-85	MT	7 November 1985
20-85	PT	7 November 1985
21-85	LT	7 November 1985
22-85	Guidelines for training times	3 November 1985
23-85	Model agreement on the mutual recognition of qualification and certification schemes for NDT personnel	7 November 1985
24-85	VT	October 2000
25-00	AE	October 2000

The International Atomic Energy Agency initiated, in the late 1970's, the compilation of syllabuses for the more common NDT methods prepared by experts involved in a Working Group under a project in Latin America; it was first issued in 1987 as IAEA-TECDOC 407 Training Guidelines in Non-Destructive Testing. This document has been reviewed at different times; the current version is IAEA-TECDOC-628/rev2 Training Guidelines in Non-Destructive Testing Techniques 2008 Edition.

ANSI/ASNT CP 105 ASNT Standard Topical Outlines for Qualification of Non-Destructive Testing Personnel

This standard provides training outlines for Level 1 and Level 2 personnel and topical outlines for the qualification of Level III NDT personnel and details the minimum training course content for those personnel. CP-105 is the compilation and updated revision of the Recommended Training Course Outlines formerly appended to both ASNT Recommended Practice No SNT-TC-1A and ANSI/ASNT CP-189.

CEN ISO/TR 25107 and CEN ISO/TR 25108 IN

As part of the efforts to streamline and harmonise the training and certification of NDT personnel, a joint working group of CEN TC 138/AHG8 and ISO TC 135/WG2 after two years of work has produced, in 2006, two documents: CEN ISO/TR 25107 and CEN ISO/TR 25108 IN. These documents are intended to serve those involved in training and to be useful in achieving a uniform level of training material and consequently in the competence of personnel

The Technical Report CEN ISO/TR 25107 presents the recommendations for the minimum technical knowledge to be required to NDT personnel. These recommendations provide means to evaluate and document the competence of personnel whose duties demand the appropriate theoretical and practical knowledge.

This document covers the following methods at Levels 1, 2 and 3:

- Acoustic emission
- Eddy current
- Leak testing
- Magnetic particle
- Penetrant
- Radiographic
- Ultrasonic
- Visual.

The Technical Report CEN ISO/TR 25108 IN gives guidelines for NDT training organisations and establishes the minimum requirements for effective structured training of NDT to ensure eligibility for qualification examinations leading to third-party certification according to recognised standards.

This document covers the following topics:

- Training organisation management
- Quality management system
- Induction of candidates
- Candidate assessment
- Training syllabuses and course notes
- Facilities
- Training specimens
- NDT equipment
- Technical library
- Training staff
- Training records.

Currently both documents are being reviewed.

7.2 Normative status of guidelines on training syllabuses

As a result of the defining training syllabuses being published out of synchronisation with the standards for certification of personnel, there is a discrepancy between normative status and best practice.

EN ISO 9712:2012 references both documents CEN ISO/TR 25107 and CEN ISO/TR 25108 IN, but includes minimum training hours that are somewhat less than the recommendation contained in CEN ISO/TR 25107.

CP 105-2011 is referenced in ASNT documents including SNT TC 1A: 2011 and ANSI/ASNT CP 189 (2011).

7.3 IAEA TECDOC-628 (2008)

The International Atomic Energy Agency (IAEA) has been actively involved in developing training materials for some considerable time. These serve as guides to the IAEA experts involved in training programmes to achieve an uniform level of training materials and competence of personnel.

This process was initiated in the late 1970s with the compilation of syllabuses for the more common NDT methods prepared by a Working Group under a project in the Latin American and Caribbean Region. Later, these syllabuses were also accepted for use in the Asia and Pacific Region.

Recognising their need and usefulness, an IAEA consultants meeting in May 1986 recommended that the IAEA publish these guidelines. Consequently, they were first issued as IAEA TECDOC-407, Training Guidelines in Non-Destructive Testing, in1987.

A revised and enlarged version was issued as IAEA TECDOC-628 in 1991, in both Spanish and English. This latter version included the development work carried out by the International Committee for Non-Destructive Testing (ICNDT) and many national NDT societies. It has been one of the documents referred to in ISO Standard 9712, which is an internationally accepted standard for the qualification and certification of NDT personnel. To date, this publication has been used by many countries supported by the IAEA in formulating their national NDT training programmes. The industrial sectors benefiting from these programmes include steel making, power generation, oil & gas, aviation, chemical, petrochemical and many others.

Since the publication of IAEA-TECDOC-628 in 1991, NDT and product technology has undergone numerous changes. Advancements in materials science have led to changes in the applicable NDT codes, standards and specifications. In addition, new NDT techniques and equipment have been developed, which are widely accepted by the engineering community.

To accommodate the latest developments, a revision of the 1991 version of IAEA TECDOC-628 was considered essential to meet the demands of end-user industries. Modifications were made during an Advisory Group Meeting, held in Vienna from 25-29 June 2001, revision 1 dated 2002, is an updated version of IAEA TECDOC-628. The details of the topics on each subject have been expanded to include the latest developments in the technology of NDT and materials.

The present publication is an updated version of IAEA-TECDOC-628/Rev. 1. The modifications were made during a consultants meeting held in Vienna from 30 October to 2 November 2006. The participating experts at the meeting were from well-known international bodies active in the qualification and certification of NDT personnel.

The content of IAEA TECDOC-628/Rev 1 has been revised, based on the experiences of the experts, as well as comments of the end-user industries. The details of the topics on each subject have been expanded to include the latest developments in the respective method.

The incorporated help the end user industries to update their NDT qualification and certification schemes, and training changes will house materials. This publication, like the previous version, will continue to play an important role towards international harmonisation in the field of NDT.

Reference:

IAEA TECDOC-628 Revision 2 (2008 edition): Training Guidelines in Non-Destructive Testing Techniques. International Atomic Energy Agency, Wagrammerstrasse 5, PO Box 100, A-1400 Vienna, Austria, Tel: +43 1 20601; Telex: 112645 Atom A; Fax +43 1 20607; Email: official.mail@iaea.org

7.4 Question banks

7.4.1 Introduction

Banks of questions are available from several sources, for user either students, trainers or examiners. Questions may be classified by NDT method, by level (1, 2 or 3) and sector. They may be validated or not.

Users should check if the questions being used are designed to match the requirements of a particular training syllabus and should select questions accordingly.

7.4.2 ASNT specimen question bank

ASNT publishes question & answer books as supplements to recommended practice SNT TC 1A. 13 books are available for Levels 1, 2 and 3, providing focused study for individuals preparing for NDT certification examinations. This is a good way to review vital NDT material and prepare for testing situations.

7.4.3 EFNDT question bank

BINDT, DGZfP and COFREND have developed a confidential question bank, containing around 7000 questions (three levels, five methods). This is used by the certification bodies of BINDT, DGZfP and COFREND and several other certification bodies that participate in the EFNDT MRA (see Section 6.9.3).

7.4.4 Others

Several European NDT societies, for instance BINDT, DGZfP, COFREND, AEND and others, all of them accredited by each corresponding national accreditation body, maintain databases of general, specific and practical questions for each NDT method and level. The databases are updated and reviewed regularly by technical committees, which have been established for this purpose. Members of these technical committees are experienced NDT experts from industry, science and research.

7.5 Leonardo project

The training, experience and visual acuity requirements have been established, and a big interest exists on the development of syllabuses for every method and every level. Furthermore, for the time being, international standards have been published devoted to the certification of NDT technique personnel.

However, didactic materials for teachers and students, comprising the knowledge according with the syllabuses, have not yet been developed; they have to acquire the knowledge regarding the qualification level foreseen.

From 2004-2006, the National Centre of Vocational Training of Cartagena (Spain) promoted the project PROQUALINDT 'European Training Programme for the Qualification of NDT Personnel', funded by the European Programme Leonardo da Vinci II.

The project objective is the preparation of a European programme for the training of professionals that perform NDT at Levels 1, 2 and 3 in five methods (PT, MT, ET, RT, UT) and that accomplishes the requirements demanded in the certification.

The consortium created for this first project was composed by AEND (Spain), COFREND (France), BINDT (United Kingdom) and DGZfP (Germany).

The didactic material for students and trainers is unique for participating countries, written in each of their languages (English, French, German and Spanish).

The didactic material was composed of the following documents:

- Training study of state-of-the-art in the partners countries
- Style guide
- Didactic guidelines
- Study manuals
- Teacher guide.

The TRANSFER PROQUALINDT 'Transferring European Training Programme for the Qualification of NDT Personnel' project 2011-2013 is devoted to the review, update and translation to the languages of the partners' countries (Czech Republic, Hungary, Croatia and Portugal) of, the documents coming from the first project. This project was funded by the European Lifelong Learning Programme Leonardo da Vinci.

The consortium created for this second project was composed by CNFPO (Spain) as promoter and the partners AEND (Spain), CNDT (Czech Republic), MAROVISZ (Hungary), CrSNDT (Croatia) and RELACRE (Portugal).

Those projects provide common documents for training and studying, reinforcing the harmonisation in Europe.

7.6 Need for integration of training guidelines, standards, training materials and question banks

There is arguably a need for a 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, handouts, sample questions) and to the examinations (questions, practical samples). Employers must 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 whether additional job specific training is necessary.

8. Inspection qualification

Performance demonstration of Non-Destructive Evaluation (NDE) procedures and personnel has always been a requirement in many countries (often limited to demonstration of calibration) and international studies have shown a poor capability and large scatter of results (the result is that rigorous performance demonstration methodologies have emerged to show reliability). The objective is to provide a level of confidence appropriate to the safety significance of the component in question and to the role played by inspection in assuring safety by a systematic and independent assessment that the NDE system is capable of meeting the inspection requirements in real circumstances. The process covers the whole inspection activity, including the procedure, equipment and personnel. Hence, it is quite distinct from the personnel qualification referred to in Section 6.1.

8.1 History

In the early 1990s, the PISC programme had revealed significant shortcomings in the prescriptive code-based approach to producing inspection procedures. Previously, the practice had been to design inspections against the requirements of a code or standard, which specified how the inspection was to be done but without reference to any particular defects. The code had specified the detail of the inspections themselves in terms of the probe angles to be used, sensitivity for a scanning and recording data.

The need for an independent assessment of the capability of the NDE became evident and various approaches emerged. Notably, in the United Kingdom, a process called 'Validation' was introduced. In France, within RSE-M, EDF has described a formal process for qualifying the NDE implemented for in-service inspection of primary and secondary systems of French PWR nuclear power plants, whereas in the USA, the term 'Performance Demonstration Initiative' (PDI) was used to describe the ASME approach. In Europe, the term qualification was adopted based on ENIQ recommendations, which are more or less influenced by national qualification practices. Today, processes have been developed in the USA through ASME and others, and in Europe through ENIQ and CEN. An ISO standard is in preparation. The International Atomic Energy Agency published a VVER-specific qualification guidance, which is a pragmatic synthesis of both ENIQ and ASME methodologies and seems quite close to ENIQ, but not in contradiction to the PDI practice.

Generally speaking, there are many variants of the process and, today, 'Inspection Qualification' is the term currently used to describe an independent assessment of a specific non-destructive test to ensure that is capable of meeting its objectives.

8.2 ENIQ (European Network for Inspection and Qualification)

ENIQ started in 1992 and its first milestone was the publication of the first issue of the 'European Methodology for Qualification of Non-Destructive Testing' in 1995. It contains guidelines for the qualification of NDT systems and is often referred to as the 'European Qualification Methodology Document (EQMD)'. In contrast to the qualification guidelines laid down in the ASME codes and standards, which are based mainly on practical trials on mock-ups and real tests, EQM assembles theoretical (physical reasoning, technical justification (TJ), numerical simulation) and experimental evidence (past ISI experience, open practical trials). All this evidence has to be presented to an independent qualification body. When first published, the EQMD contained a number of innovative proposals, such as the use of technical justifications (TJ), the separation between procedure/equipment and personnel qualification and the use of open trials for procedure and equipment qualification. The EQMD was updated twice to account for the rapid progress of ISI qualification in Europe and the ENIQ Recommended Practices (RPs) that have been published in the meantime. The latest version of the EQMD, Issue 3, was published in 2007. One of the major features of the ENIQ qualification process is that in 2010 the TGQ published a short version of the EQMD for the non-specialist. In practice, inspection qualification can be performed with varying degrees of complexity and cost, depending among others on the structural integrity significance of the NPP component involved, the difficulty of the ISI involved and the national requirements. The aim of this RP is to provide guidance on how inspection qualification might be applied according to the purpose and nature of the inspection.

See http://capture.jrc.ec.europa.eu/capture/eniq-pubs

Since 2013 ENIQ has been integrated into NUGENIA, which is an European-based R&D association on Gen II and III reactors founded in November 2011.

8.3 ASME BPVC X1 Appendix VIII – Performance Demonstration Initiative

In the USA, following analysis of the results of the PISC II round-robin trials, the ASME Section XI committee adopted, in 1991, the principles of performance demonstration and introduced Appendix VIII to Section XI of the ASME code to define how performance demonstration trials should be conducted. The requirements of Appendix VIII have developed steadily since its introduction and a number of important changes have been made. Many of the requirements contained in Appendix VIII arise from the need to provide a pragmatic approach for qualifying inspections carried out on the widely different types and designs of nuclear power reactors mainly for ultrasonic techniques.

However, for those inspections which are included in BPVC Section XI, Appendix VIII, the primary need is to demonstrate, through practical trials, that the NDE system can meet certain performance targets. Appendix VIII contains a list of parameters which must be specified in the inspection procedure but does not give the values that such parameters must assume.

The approach in ASME XI, Appendix VIII is often a generic qualification. It is not specific to any particular plant or, in general, to any specific defect type. The one exception is that where IGSCC has occurred, there is a requirement to include this defect type amongst the ones in the test-pieces. Otherwise, flaw types are specified as mechanical fatigue, thermal fatigue and cracks of unspecified type, machined notches or manufacturing flaws such as slag or lack of fusion, depending on the particular supplement applicable.

In essence, the qualifications obtained through Appendix VIII are valid only for the range of components represented by the test-pieces and the defect types used to carry out the practical trials. The relevance of these to a particular inspection task or a particular component is the responsibility of the user. Those unfamiliar with the consensus approach used to develop ASME may have difficulty in understanding a connection to the defect types and sizes specified for the practical trials. In Appendix VIII, procedure qualification is arrived at in conjunction with personnel qualifications. About the implementation, how this is done is not clear and when a failure in personnel qualification occurs it may not be clear whether this has arisen from a fault in the procedure or equipment.

Performance demonstrations to these code requirements are now being implemented through the Performance Demonstration Initiative (PDI) managed by the Electrical Power Research Institute (EPRI).

For eddy current steam generator tube inspection, the rules are defined by the EPRI-MRP and the personnel qualification by the QDA instance.

8.4 ASME Section V

ASME V includes non-destructive examination methods that are applicable to most component geometries and materials that are encountered in fabrication and on-site repairs under normal conditions. Where conditions dictate that modifications are required to the standard methods and techniques, special procedures are to be produced. These special procedures are required to be proved by demonstration.

Article 14 of ASME V gives the provisions for qualifying NDE systems, which are mandatory when specifically invoked by the referencing code section. The qualification process uses three levels of rigour, involving the use of a technical justification (low rigour and no trials are needed) and, when required, blind or non-blind performance demonstration (high rigour). Section T-1425 contains a list of the steps for planning and implementing a qualification. These resemble the corresponding steps which are defined in the ENIQ Methodology Document (EQMD). The two approaches differ in the detail of how the qualification is carried out as discussed further below. Essentially, the approach in ASME V, Article 14 is based on practical trials carried out in sufficient number to generate probability of detection (POD) and false call probability (FCP) curves.

In addition there are differences between the requirements of Appendix VIII and those of Article 14. These include principally:

- The absence of requirements in Appendix VIII to define the flaws that are the subject of the inspection and its qualification in terms of their types and essential parameters.
- There is no requirement to produce a TJ in Appendix VIII. Such a requirement does exist in Article 14, even though the precise purpose of the TJ and its manner of assessment are unclear.

At present, Article 14 is not a standard requirement called up by other parts of the ASME Code as is Appendix VIII. To be used, it must be referenced by a code case for a specific inspection.

8.5 CEN Technical Report TR 14748:2005

CEN Technical Committee TC 138 established a working group to draft a general standard for qualification of inspection procedures of metallic components. This has been published as FD CEN/TR14748:2005, Non-destructive testing – Methodology for qualification of non-destructive tests to confer its open mind (non-mandatory) character. It was developed beside the ENIQ guidelines – which was specific to nuclear applications – to provide a more general methodology applicable to a wide range of industries, on any type of either materials or NDE methods. Where there is a lack of standard or norm for inspection, it drafts what to do. It enables the clear definition of the test programme as well as contractual relationships between partners, and to define the skill of the operators.

8.6 Nadcap aerospace NDT approvals

Many aerospace manufacturing companies use an international scheme known as NADCAP (National Aerospace and Defence Contractors Accreditation Program) (see http://www.pri-network.org/Nadcap/aboutNadcap/), in which the whole NDT process, including qualification of personnel, is audited and 'accredited' under arrangements controlled and agreed by the major prime contractors (for example Boeing, Airbus, Rolls-Royce, etc).

The Prerequisites for an NDT Nadcap audit in Europe:

- The company must be certified EN9100 or ISO 17025 (lab)
- The staff must be certified EN 4179/NAS 410

The Aeronautic NDT standards specify the requirements relating directly to the process concerned. They are originally based on ASTM standards, but can reflect some ISO/EN standards.

A Nadcap audit is conducted in two parts:

- Part 1: Documentary (1 day): Environment quality system around method(s) using questionnaires AC7114 A and AC7114S ('extras' clients) plus general part of the specific questionnaire on method(s) concerned and AC7114/1-/2-/3-/4 AC7114/1S-/2S-/3S-/4S
- Part 2: Job audit (1 day / method): Audit process / product with 'compliance' part of the specific questionnaire on method(s) concerned and 'extras' customers AC7114/1- / 2-/3-/4 and AC7114/1S-/2S-/3S-/4S. Invigilation of the implementation of three NDT systems from three different clients made by three different inspectors (to the extent possible) to verify that the base lines and Nadcap 'supplements' of customers are taken into account in carrying out the process. This survey is completed by three (paper audit) / method of three additional clients.

Furthermore, every year each practitioner must be audited in the purpose to verify these capabilities to apply the NDT system in a real environment.

Note: In France, at a given moment, Nadcap would have also been interested by other industries sectors (for example: automobile, nuclear industries field) for all special processes.

8.7 ISO/TS 11774 Non-destructive testing – Performance-based qualification

This standard technical specification provides a method for qualification of non-destructive testing personnel, procedures and equipment for specific non-destructive tests conducted in accordance with documented procedures established within a performance-based qualification programme.

The main drawbacks of the ISO 11774 TS are:

- It covers performance demonstration and includes the concept of a qualification body, so there is a clear overlap in scope with ENIQ or ISO 14748 for the capability assessment of the NDT system and EN ISO 9712 for the certification of personnel
- ENIQ allows considerable flexibility in tailoring qualification requirements to a particular inspection. ISO 11774 seems more formal: there is mention of Industry Sector Committees and the performance-based qualification programmes established by these Committees.
- Difficulties for recognition, mutual agreement between the different sectors' committees
- Personnel qualification saddle the QB with the responsibility of the quality of inspection.

9. Accreditation of NDT organisations

9.1 Background

In a growing number of countries in Europe (including former Soviet Union countries such as Russia and Belarus) NDT service company operations are being accredited by accreditation bodies.

Accreditation is defined in the international standard ISO/IEC 17011 'Conformity assessment' – General requirements for accreditation bodies accrediting conformity assessment bodies as follows: third-party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks.

In the EU, there is a regulation dealing with accreditation: Regulation (EC) No 765/2008 of the European parliament and the Council of July 2008 setting out the requirements for accreditation and market surveillance related to the marketing of products and repealing Regulation (EEC) No 339/93.

The definition for accreditation in this regulation is more detailed than in ISO/IEC 17011 and reads as follows: Accreditation shall mean an attestation by a national accreditation body that a conformity assessment body meets the requirements set by harmonised standards and, where applicable, any additional requirements set out in relevant sectorial schemes, to carry out a specific conformity assessment activity.

Regulation 765/2008 also requires that only one accreditation body per member country is acceptable and accreditation bodies must not be profit oriented.

The importance of accreditation as a proof of competence has increased during the last two decades, mainly because of the globalisation. Accreditation is in many cases mandatory.

Initially, such accreditation referenced the European Standard EN 45001 '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 (see below), the reference standard is EN 45004 'General criteria for the operation of various types of bodies performing inspection', now superseded by ISO/IEC Standard 17020. EA, the European co-operation for Accreditation, published a guidance paper EA-4/15 G (rev00) in 2003 with the title 'Accreditation for Bodies Performing Non-Destructive Testing', which differs from the application document IAF/ILAC A4 'Guidance on the application of ISO/IEC 17020'.

Accreditation assessments are much more comprehensive and searching than a 'quality systems' audit to ISO 9001, with greater emphasis on the inherent technical capability of the organisation.

9.2 Laboratories

A distinct way to prove the competence of a laboratory to perform testing and/or calibration procedures according to referenced European and/or international standards or defined working procedures is accreditation of the laboratory according to EN ISO/IEC 17025 'General requirements for the competence of testing and calibration laboratories'. This international standard describes the requirements that are to be fulfilled by a laboratory. In the case of an accreditation according to EN ISO/IEC 17025, the laboratory has to fulfil all requirements of this standard but no additional requirements, according to the rule 'No less no more'.

The standard was developed by ISO/CASCO 'Committee on Conformity Assessment' and taken over by CEN/CENELEC TC1 'Criteria for Conformity Assessment Bodies' in a parallel voting procedure. The customer often asks for a certified ISO 9001 'Quality management systems'. In order to prove compliance with the requirements of ISO 9001, ILAC-IAF and ISO/CASCO published a document saying that all requirements of ISO 9000 are covered by the requirements laid down in EN ISO/IEC 17025 and EN ISO/IEC 17020. So, if laboratories comply with the requirements of ISO/IEC 17025, "they will operate a quality management system for their testing and calibration activities that also meets the principles of ISO 9001" (ISO/IEC 17025, chapter 1.6; cross-reference list to ISO 9001), respective EN ISO/IEC 17020

As the scope of laboratories is quite broad and test-specific details cannot be covered by the standard, which states requirement in a more general sense, accreditation bodies sometimes provide additional guidance, for example ILAC, IAF, EA or national accreditation bodies. In most cases, national accreditation bodies implement guidance papers from ILAC, IAF or EA in their national system in order to have the same level of requirements all over the world.

At the European level, an organisation exists named 'EUROLAB aisbl', which was created in Brussels on 27 April, 1990 on the basis of a memorandum of understanding, signed by delegations representing the private and public laboratories of 17 out of the 19 countries of the EEC and EFTA.

EUROLAB is, since October 1998, a legal entity setting it as the European Federation of National Associations of Measurement, Testing and Analytical Laboratories.

The European Federation for NDT (EFNDT) has been a member (International Affiliate) of EUROLAB since 2002. Other members are national EUROLAB associations and international organisations.

EUROLAB supports its member's interests – interfacing with accreditors – and helps them in technical, regulatory and quality management matters, aiming at simplification and international harmonisation of regulations concerning competence and performance of laboratories. For more information refer to www.eurolab.org

9.3 Inspection bodies

Requirements for inspection bodies are laid down in the international standard EN ISO/IEC 17020 'General criteria for the operation of various types of bodies performing inspection'. In 1998, this standard replaced ISO/IEC Guide 39 'General requirements for the acceptance of inspection bodies' and, five years later, the European standard EN 45004, without any alteration, was taken over by ISO/CASCO 'Committee on Conformity Assessment' in a fast-track procedure and published as IDSO/IEC 17020. Later, ISO/IEC was revised and accepted by CEN/CENELEC TC1 'Criteria for Conformity Assessment Bodies' in a parallel voting as a European standard. It takes into account requirements and recommendations of the ISO 9000 (see above).

The IAF/ILAC A4:2004 guide titled: 'Guidance on the application of ISO/IEC 17020' supports the implementation of the standard through further explanations. This guidance document was taken over by EA.

The guide describes three different categories of inspection bodies, which reflect the level of their independence. Whereas a type A inspection body is completely separated from design, manufacture, supply, installing, purchasing, ownership, usage or maintenance, a type B inspection body is separated from design, manufacture, supply, installing, purchasing, ownership, usage or maintenance by a fire wall and a type C inspection body may be involved in design, manufacture, supply, installing, purchasing, ownership, usage or maintenance.

By this means, the guide supports the requirement of the European Pressure Equipment Directive (see Chapter 11.3.1 of the standard).

The non-profit organisation 'CEOC International' represents independent inspection and certification organisations in 20 countries. CEOC promotes safety, quality and the environment through independent inspection and certification. CEOC contributes to better regulation through participation in the work of EU institutions and bodies such as EA and EUROLAB. Further, it contributes to the standardisation work of CEN, ISO and ISO-CASCO – the ISO policy development committee on conformity assessment.

CEOC International has 31 members from 20 countries, which are accredited by public authorities to provide inspection and other conformity assessment services for a large variety of equipment. See also www.ceoc.org

A representative from EFNDT is a member of the Joint Technical Committee (of CEOC and EUROLAB) on Product Testing and Certification.

9.4 Certification bodies

Certification of NDT personnel is normally carried out by accredited certification bodies. These certification bodies can prove their competence by accreditation against ISO/IEC 17024 'Conformity assessment – General requirements for bodies operating certification of persons'. The requirements for the competence of NDT personnel are laid down in EN ISO 9712.

10. Human factors

Human factors is the study of how humans behave physically and psychologically in relation to particular situations. There are three main factors which influence behaviour at work: the job or task; the organisation; and the individual.

The 'job' covers the nature of the work, including the physical characteristics, the workplace and working environment. The individual includes personal attitude, skills, habits and personalities. The organisation includes such things as planning, safety, communication, management and culture (see Section 11).

These 'human factors', which influence the reliability of the 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.

It should be noted that research has shown that the factors which motivate staff are different to those that provide de-motivation. So, it is necessary to take steps to avoid de-motivating staff as well as implementing actions to provide motivation.

The concept of motivation is very complex. Several models try to explain the motives of each individual. One of the famous is Maslow's hierarchy of needs. Maslow used the terms physiological, safety, belongingness and love, esteem, self-actualisation and self-transcendence needs to describe the pattern that human motivations generally move through.

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, *ie* 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, and more recently in Sweden. The PISC project illustrated how an operator's performance can vary over the duration of a day. It also showed how a poor scanning technique can be improved by targeted training.

The problem with human factors is that what would appear to be a logical cause and effect is often turned on its head. Enkvist *et al* attempt to explain some of the results obtained by reference to a model of human performance in which "the attention 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 time this effect reverses. Boredom equates to a lack of arousal and can have a very negative impact on performance.

The UK's PANI (Programme for the Assessment for NDT in Industry) projects have shown the variability in performance between ultrasonic operators of similar experience and qualification. PANI 2 showed that improvements in reliability can be obtained by the use of targeted procedures, job specific training and independent repeat inspections. PANI 3, which is due to be published, has found a correlation between good ultrasonic performance and operators with good mechanical comprehension. There is also a correlation between good ultrasonic performance and operators with an average level of cautiousness and lower levels of original thinking. This project has also highlighted the importance of ensuring that the inspection procedure is written in a way that assists the operator in the task and that the operator follows the procedure.

Marija Bertovic, Christina Müller and Uwe Ewert, of the BAM Federal Institute for Materials Research and Testing, Berlin, Germany, and others presented an interesting paper on the occasion of the 18th World Conference on Non-Destructive Testing, 16-20 April 2012, Durban, South Africa:

"Human factors approach to the acquisition and evaluation of NDT data'.

This paper gives an introduction to the field of human factors, with the focus on their influence on the reliability of NDT in the nuclear energy production (in-service inspections) and final storage of highly radioactive nuclear waste.

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 and environment) for personnel engaged on quality critical activities.

11. Overall management of NDT to achieve quality

11.1 Overall management

It is clear from the results of various round-robin exercises and trials that there is often an over-reliance on the use of standards and personnel certification as a guarantee of quality in NDT. All too often, purchasers and suppliers of NDT services may fail 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 all 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 an accredited 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' to operate under the purchaser's quality system 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.

11.2 Guidance on best practice

In Section 4, the various elements of the quality infrastructure have been summarised. The question arises: 'Which elements of the infrastructure should be used when?' or 'What constitutes best practice?'.

As a disappointing result of a project investigating the reliability of manual ultrasonic inspection for in-service inspection on component geometries relevant to pipework, oil, gas and petrochemical plant, the detection rates varied between 26% and 98%. The wide spread of the detection rate occurred even though the inspections were carried out to current practice in manual ultrasonic testing, *ie* relevant standards were used, procedures were written and approved by a Level 3 and operators certificated to EN ISO 9712 (EN 473) conducted the inspection.

It is obvious that the specifications for inspection were inappropriate and the operators were not adequately trained on the specific geometries or types of defect.

These problems were considered faults in the way inspection is normally managed rather than solely the fault of the operators and could be equally applicable to other methods as well as ultrasonic testing.

It is important to ensure that the procedure is written appropriately to assist the operator and that the inspection is planned and managed in a way that the operator is able to concentrate on the inspection task. NDT vendors identified the biggest risk to the quality of an inspection as the lack of information from the plant owner.

As a result, a short summary of recommendations:

- Use an organisation accredited for NDT operations with necessary technical management, *ie* 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, NDT-method and geometry
- Carry out capability trials when necessary
- Use certified operators
- Carry out job specific training – when inspection is not within the 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.

As an example for best practice find a number of documents of the Health and Safety Executive (UK) entitled 'Best Practice for the Procurement and Conduct of Non-Destructive Testing' for manual ultrasonic inspection, magnetic particle and dye penetrant inspection, radiographic inspection, as well as ultrasonic sizing errors and their implication for defect assessment.

(www.hse.gov.uk/comah/sragtech/ndt1.pdf and .../ndt2.pdf, ndt3.pdf, ndt4.pdf)

The Best Practice guidelines recommend the use of the entire 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.

12. Exemplars of good practice

The intention is to encourage NDT experts from a range of European industries to present some aspects of their strategy for good practice of NDT in their specific technical fields. These experts are encouraged to demonstrate the extent to which use is made of the various elements of the NDT quality infrastructure. RWE NPower plc, UK, has produced an 'Exemplar of Good Practice' for the non-nuclear power generation industry. The non-nuclear exemplar and other contributions will be published in Appendix 7. It is likely that other exemplars will be added from time to time and therefore the most up-to-date version of this Guide will always appear on the EFNDT website (www.efndt.org).

Appendix I – EFNDT and ICNDT

A1.1 European Federation for NDT (EFNDT)

To increase their influence at the European level where, increasingly, decisions are taken, the national NDT societies have combined to form the European Federation for NDT (EFNDT). EFNDT is a non-profit legal entity registered in Brussels. National NDT societies within the United Nations definition of Europe are eligible for membership. Each is represented on the General Assembly, which elects a President and Board of Directors. A secretariat is provided by one of the member national societies. EFNDT has established a series of working groups and committees covering topics such as:

- European certification
- NDT for public security and safety
- Forum for National Aerospace NDT Boards, Railway Maintenance and Marine

These groups seek to support and complement (rather than compete with) the European committees/working groups of EA (European co-operation for Accreditation), CEN, ISO etc and support national societies in their work at local level. Details and news of the EFNDT can be found on its website (www.efndt.org).

EFNDT mission statement:

"A Europe-wide partnership to promote NDT and related fields for the benefit of industry, the professions, users and the wider community".

The overall mission of EFNDT is to bring together the resources of the national societies and organisations involved in NDT and related topics in Europe to create a more effective and more valuable voice for industry, the professions, the users and the wider community.

EFNDT values and principles:

- Members adopt a Code of Ethics as a common basis.
- Members are dedicated to public safety in a technological world.
- Members maintain a high level of quality with respect to their activities.
- Members promote the value of NDT and related topics, in particular the certification of NDT personnel, in society and in industry.
- Members shall promote, as a valuable instrument, the assurance of competence through accreditation, training and certification.
- Members consider that knowledge about NDT and related topics will be strengthened, harmonised and disseminated by means of conferences, symposia, publications and other media.
- Members shall, where appropriate, support research and development.
- Members shall, where appropriate, be actively involved in standardisation.
- Members will strive to make certification processes equivalent throughout Europe.
- The Federation represents European interests in the relevant fields at the international level.

A1.2 International Committee for NDT (ICNDT)

The International Committee for NDT was formed in 1960. For most of its existence, ICNDT's main role has been to organise the World Conference. Since the mid 1990s, the more active members of ICNDT have been seeking to strengthen the organisation and make it more active. The national societies each nominate two representatives to the ICNDT Committee. The committee then elects a Chairman, General Secretary and a Treasurer, each for four years. It also elects Honorary Members. These people along with nominees by each of the regional groups (Europe, Asia-Pacific, Americas) form the Policy and General Purposes Committee. A secretarial service is provided by an NDT society. Separately, the ICNDT chooses the society to hold the next World Conference and that society nominates the World Conference President. The next World Conference will be held in Munich in 2016. Details and news of the ICNDT can be found on the ICNDT website (www.icndt.org).

Appendix 2 – European and International NDT standards

Table App 2.1: General standards for different NDT methods

NDT method	*General principles*		*Equipment, Materials*		*Others*	
	EN	*ISO*	*EN*	*ISO*	*EN*	*ISO*
General					CEN/TS 15053 Non-destructive testing – Recommendations for discontinuities-types in test specimens for examination CEN/TR 14748 Non-destructive testing – Methodology for qualification of non-destructive testing	
ET	EN ISO 15549 Non-destructive testing – Eddy current testing – General principles and basic guidelines	ISO/DIS 15549 Non-destructive testing – Eddy current examination – General principles	EN ISO 15548-1 Non-destructive testing – Eddy current examination; Equipment characteristics and verification – Part 1: Instrument characteristics and verification EN ISO 15548-2 Non-destructive testing – Eddy current examination; Equipment characteristics and verification – Part 2: Probe characteristics and verification EN ISO 15548-3 Non-destructive testing – Eddy current examination – Equipment characteristics and verification – Part 3: System characteristics and verification	EN ISO 15548-1 Non-destructive testing – Eddy current examination – Equipment characteristics and verification – Part 1: Instrument characteristics and verification EN ISO 15548-2 Non-destructive testing – Eddy current examination; Equipment characteristics and verification – Part 2: Probe characteristics and verification EN ISO 15548-3 Non-destructive testing – Eddy current examination – Equipment characteristics and verification – Part 3: System characteristics and verification		
MT	EN ISO 9934-1 Non-destructive testing – Magnetic particle testing – Part 1: General principles	ISO 17638 Non-destructive testing of welds – Magnetic particle testing	EN ISO 9934-3 Non-destructive testing – Magnetic particle testing – Part 3: Equipment EN ISO 9934-2 Non-destructive testing – Magnetic particle testing – Part 2: Detection media		EN ISO 3059 Non-destructive testing – Penetrant testing and magnetic particle testing – Viewing conditions	
PT	EN ISO 3452-1 Non-destructive testing – Penetrant testing – Part 1: General principles	EN ISO 3452-5 Non-destructive testing – Penetrant testing – Part 5: Penetrant testing at temperatures higher than 50°C		EN ISO 3452-2 Non-destructive testing – Penetrant testing – Part 2: Testing of penetrant materials		EN ISO 3059 Non-destructive testing – Penetrant testing and magnetic particle testing – Viewing conditions

NDT method	*General principles*		*Equipment, Materials*		*Others*	
	EN	*ISO*	*EN*	*ISO*	*EN*	*ISO*
PT *continued*		**EN ISO 3452-6** Non-destructive testing – Penetrant testing – Part 6: Penetrant testing at temperatures lower than 10°C		**EN ISO 3452-3** Non-destructive testing – Penetrant testing – Part 3: Reference test blocks **EN ISO 3452-4** Non-destructive testing – Penetrant testing – Part 4: Equipment		
RT	**EN ISO 5579** Non-destructive testing – General principles for the radiographic examination of metallic materials using X-rays and gamma rays	**ISO 5579** Non-destructive testing – Radiographic examination of metallic materials by X- and gamma-rays – Basic rules **ISO 11533** Non-destructive testing – Thermal neutron radiographic testing – General principles and basic rules	**EN 25580** Non-destructive testing – Industrial radiographic illuminators – Minimum requirements **EN 12679** Non-destructive testing – Determination of the size of industrial radiographic sources – Radiographic method **EN 13068-1** Non-destructive testing – Radioscopic testing – Part 1: Quantitative measurement of imaging properties **EN 13068-2** Non-destructive testing – Radioscopic testing – Part 2: Check of long-term stability of imaging devices **EN 13068-3** Non-destructive testing – Radioscopic testing – Part 3: General principles for the radioscopic testing of metallic materials by X- and gamma rays	**EN ISO 11699-1** Non-destructive testing – Industrial radiographic film – Part 1: Classification of film systems for industrial radiography **EN ISO 11699-2** Non-destructive testing – Industrial radiographic film – Part 2: Control of film processing by means of reference values **ISO 11699-1** Non-destructive testing – Industrial radiographic films – Part 1: Classification of film systems for industrial radiography **ISO 11699-2** Non-destructive testing – Industrial radiographic films – Part 2: Control of film processing by means of reference values	**EN ISO 19232-1** Non-destructive testing – Image quality of radiographs – Part 1: Image quality indicators (wire type); determination of image quality values **EN ISO 19232-2** Non-destructive testing – Image quality of radiographs – Part 2: Image quality indicators (step/hole type) – Determination of image quality value **EN ISO 19232-3** Non-destructive testing – Image quality of radiogrammes – Part 3: Image quality classes for ferrous metals **EN ISO 19232-4** Non-destructive testing – Image quality of radiographs – Part 4: Experimental evaluation of image quality values and image quality tables **EN ISO 19232-5** Non-destructive testing – Image quality of radiographs – Part 5: Image quality of indicators (duplex wire type), determination of image unsharpness value	**ISO 10675-1** Non-destructive testing of welds – Acceptance levels for radiographic testing – Part 1: Steel, nickel, titanium and their alloys **ISO 19232-1** Non-destructive testing – Image quality of radiographs – Part 1: Image quality indicators (wire type) – Determination of image quality value **ISO 19232-2** Non-destructive testing – Image quality of radiographs – Part 2: Image quality indicators (step/hole type) – Determination of image quality value **ISO 19232-3** Non-destructive testing – Image quality of radiographs – Part 3: Image quality classes for ferrous metals **ISO 19232-4** Non-destructive testing – Image quality of radiographs – Part 4: Experimental evaluation of image quality values and image quality tables **ISO 19232-5** Non-destructive testing – Image quality of radiographs – Part 5: Image quality indicators (duplex wire type) – Determination of image unsharpness value

NDT method	*General principles*		*Equipment, Materials*		*Others*	
	EN	*ISO*	*EN*	*ISO*	*EN*	*ISO*
Neutron radiography		ISO 11537 Non-destructive testing – Thermal neutron radiographic testing – General principles and basic rules		ISO 12721 Non-destructive testing – Thermal neutron radiographic testing – Determination of beam L/D ratio		
X-ray diffraction			EN 13925-1 Non-destructive testing – X-ray diffraction from polycrystalline and amorphous material – Part 1: General principles			
Film digitisation	EN 14096-1 Non-destructive testing – Qualification of radiographic film digitisation systems – Part 1: Definitions, quantitative measurements of image quality parameters, standard reference film and qualitative control		EN 14096-2 Non-destructive testing – Qualification of radiographic film digitisation systems – Part 2: Minimum requirements			
Digital radiography	EN 14784-2 Non-destructive testing – Industrial computed radiography with storage phosphor imaging plates – Part 2: General principles for testing of metallic materials using X-rays and gamma rays EN 13068-1 Non-destructive testing – Radioscopic testing – Part 1: Quantitative measurement of imaging properties EN 13068-3 Non-destructive testing – Radioscopic testing – Part 3: General principles for the radioscopic testing of metallic materials by X- and gamma rays		EN 14784-1 Non-destructive testing – Industrial computed radiography with storage phosphor imaging plates – Part 1: Classification of systems EN 13068-2 Non-destructive testing – Radioscopic testing – Part 2: Check of long-term stability of imaging devices			
UT	EN ISO 16810 Non-destructive testing – Ultrasonic examination – Part 1: General principles EN ISO 16823 Non-destructive testing – Ultrasonic testing – Part 3: Transmission technique		EN ISO 2400 Non-destructive testing – Ultrasonic examination – Specification for calibration block no 1	ISO 7963 Non-destructive testing – Ultrasonic testing – Specification for calibration block No 2	EN ISO 16811 Non-destructive testing – Ultrasonic examination – Part 2: Sensitivity and range setting	

NDT method	*General principles*		*Equipment, Materials*		*Others*	
	EN	*ISO*	*EN*	*ISO*	*EN*	*ISO*
UT *continued*	EN ISO 16828 Non-destructive testing – Ultrasonic examination – Part 6: Time-of-flight diffraction technique as a method for detection and sizing of discontinuities		EN 12668-1 Non-destructive testing – Characterization and verification of ultrasonic examination equipment – Part 1: Instruments EN 12668-2 Non-destructive testing – Characterization and verification of ultrasonic examination equipment – Part 2: Probes EN 12668-3 Non-destructive testing – Characterization and verification of ultrasonic examination equipment – Part 3: Combined equipment	ISO 12710 Non-destructive testing – Ultrasonic inspection – Evaluation electronic characteristics of ultrasonic test instruments ISO 18175 Non-destructive testing – Evaluating performance characteristics of ultrasonic pulse-echo testing systems without the use of electronic measurement instruments	EN ISO 16826 Non-destructive testing – Ultrasonic examination – Part 4: Examination for discontinuities perpendicular to the surface EN ISO 16827 Non-destructive testing – Ultrasonic examination – Part 5: Characterization and sizing of discontinuities	
Wall thickness measurement	EN 14127 Non-destructive testing – Ultrasonic thickness measurement		EN 15317 Non-destructive testing – Ultrasonic testing – Characterization and verification of ultrasonic thickness measuring equipment			
TOFD					EN ISO 15626 Non-destructive testing of welds – Time-of-flight diffraction technique (TOFD) – Acceptance levels	
VT	EN 13018 Non-destructive testing – Visual testing – General principles		EN 13927 Non-destructive testing – Visual testing – Equipment			

Table App 2.2: NDT standards Casting Sector 'c'

NDT method	*General principles for casting*		*Discontinuities*	*Comparators*
	EN	*ISO*		
General	EN 1559-1 Founding – Technical conditions of delivery – Part 1: General EN 1559-2 Founding – Technical conditions of delivery – Part 2: Additional requirements for steel castings EN 1559-3 Founding – Technical conditions of delivery – Part 3: Additional requirements for iron castings EN 1559-4 Founding – Technical conditions of delivery – Part 4: Additional requirements for aluminium alloy castings EN 1559-5 Founding – Technical conditions of delivery – Part 3: Additional requirements for magnesium alloy castings EN 1559-6 Founding – Technical conditions of delivery – Part 3: Additional requirements for zinc alloy castings			
ET	EN ISO 15549 Non-destructive testing – Eddy current testing – General principles and basic guidelines			
MT	EN 1369 Founding – Magnetic particle inspection	ISO 4986 Steel castings – Magnetic particle inspection		
PT	EN 1371-1 Founding – Liquid penetrant inspection – Part 1: Sand, gravity die and low-pressure die castings EN 1371-2 Founding – Liquid penetrant inspection – Part 2: Investment castings	ISO 9916 *Withdrawn with no replacement* Aluminium alloy and magnesium alloy castings – Liquid penetrant inspection		EN 1370 Founding – Surface roughness inspection by visual-tactile comparators
RT	EN 12681 Founding – Radiographic examination	ISO 4993 Steel castings – Radiographic inspection		
UT	EN 12680-1 Founding – Ultrasonic examination – Part 1: Steel castings for general purposes EN 12680-2 Founding – Ultrasonic examination – Part 2: Steel castings for highly stressed components EN 12680-3 Founding – Ultrasonic examination – Part 3: Spheroidal graphite cast iron castings	ISO 4992-1 Steel castings – Ultrasonic examination – Part 1: Steel castings for general purposes ISO 4992-2 Steel castings – Ultrasonic examination – Part 2: Steel castings for highly stressed components		

VT			**BS EN 1370** Founding – Visual examination of surface discontinuities – Steel sand castings	**EN 1370** Founding – Surface roughness inspection by visual-tactile comparators **BNIF 359** Caracterisation d'Ètats de surface des pièces moulées **SCRATA** Comparators for the surface definition of surface quality of steel castings

Table App 2.3: NDT standards Forging Sector 'f'

NDT method	*General principles for forging*
ET	
MT	**EN 10228-1** Non-destructive testing of steel forgings – Part 1: Magnetic particle inspection
PT	**EN 10228-2** Non-destructive testing of steel forgings – Part 2: Penetrant testing
RT	
UT	**EN 10228-3** Non-destructive testing of steel forgings – Part 3: Ultrasonic testing of ferritic or martensitic steel forgings **EN 10228-4** Non-destructive testing of steel forgings – Part 4: Ultrasonic testing of austenitic and austenitic-ferritic stainless steel forgings
VT	

Table App 2.4: NDT standards Welding Products Sector 'w'

NDT method	*General principles for welds*		*Classification of imperfections*	*Acceptance levels*	
	EN	*ISO*		*EN*	*ISO*
General	EN ISO 17635 Non-destructive testing of welds – General rules for metallic materials		EN ISO 5817 Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections EN ISO 6520-1 Welding and allied processes – Classification of geometric imperfections in metallic materials – Part 1: Fusion welding EN ISO 6520-2 Welding and allied processes – Classification of geometric imperfections in metallic materials – Part 2: Welding with pressure		
ET	EN 1711 Non-destructive examination of welds – Eddy current examination of welds by complex plane analysis	ISO 17643 Non-destructive testing of welds – Eddy current testing of welds by complex-plane analysis			
MT	EN ISO 17638 Non-destructive testing of welds – Magnetic particle testing of welds			EN ISO 23278 Non-destructive testing of welds – Magnetic particle testing of welds – Acceptance levels	EN ISO 23278 Non-destructive testing of welds – Magnetic particle testing of welds – Acceptance levels
PT				EN ISO 23277 Non-destructive testing of welds – Penetrant testing of welds – Acceptance levels	
RT	EN ISO 17636-1 and EN ISO 17636-2 Non-destructive testing of welds – Radiographic testing of welded joints	EN ISO 17636-1 and EN ISO 17636-2 Non-destructive testing of welds – Radiographic testing of fusion-welded joints		EN ISO 10675-1 Non-destructive testing of welds – Part 1: Evaluation of welded joints in steel, nickel, titanium and their alloys by radiography – Acceptance levels EN ISO 10675-2 Non-destructive testing of welds – Part 2: Evaluation of welded joints in aluminium and its alloys by radiography – Acceptance levels	

UT	EN ISO 17640 Non-destructive testing of welds – Ultrasonic testing of welded joints EN ISO 7963 Welds in steel – Calibration block No. 2 for ultrasonic examination of welds EN ISO 22825 Non-destructive testing of welds – Ultrasonic testing – Testing of welds in austenitic steels and nickel-based alloys	EN ISO 17640 Non-destructive testing of welds – Ultrasonic testing of welded joints EN ISO 22825 Non-destructive testing of welds – Ultrasonic testing – Testing of welds in austenitic steels and nickel-based alloy		EN ISO 11666 Non-destructive testing of welds – Ultrasonic testing of welded joints – Acceptance levels	EN ISO 23279 Non-destructive testing of welds – Ultrasonic testing – Characterization of indications in welds
TOFD	EN ISO 10863 Welding – Use of time-of-flight diffraction technique (TOFD) for examination of welds				
VT	EN ISO 17637 Non-destructive examination of fusion welds – Visual examination	EN ISO 17637 Non-destructive testing of welds – Visual testing of fusion-welded joints			

Table App 2.5: NDT standards Tubes and Pipes Sector ‘t’

NDT method	*General Principles for Tubes and Pipes*	
	EN	*ISO*
General		
ET	EN1971-1 and EN 1971-2 Copper and copper alloys – Eddy current test for tubes EN ISO 10893-1 Non-destructive testing of steel tubes – Part 2: Automatic eddy current testing of seamless and welded (except submerged arc-welded) austenitic and ferritic-austenitic steel tubes for verification of hydraulic leak-tightness EN ISO 10893-2 Non-destructive testing of steel tubes – Part 3: Automatic eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections	EN ISO 10893-2 Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes – Eddy current testing for the detection of imperfections
MT	EN ISO 10893-5 Non-destructive testing of steel tubes – Part 12: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections EN ISO 10893-5 Non-destructive testing of steel tubes – Part 18: Magnetic particle inspection of the tube ends of seamless and welded ferromagnetic steel tubes for the detection of laminar imperfections EN ISO 10893-5 Seamless and welded steel tubes for pressure purposes – Magnetic particle inspection of the tube ends for the detection of laminar imperfections EN ISO 10893-5 Seamless and welded steel tubes for pressure purposes – Magnetic particle inspection of the tube body for the detection of surface imperfections	
PT	EN ISO 10893-4 Non-destructive testing of steel tubes – Part 11: Liquid penetrant testing of seamless and welded steel tubes for the detection of surface imperfections	
RT	EN ISO 10893-6 Non-destructive testing of steel tubes – Part 10: Radiographic testing of the weld seam of automatic fusion arc welded steel tubes for the detection of imperfections	EN ISO 10893-6 Submerged arc-welded steel tubes for pressure purposes – Radiographic testing of the weld seam for the detection of imperfections
UT	EN ISO 10893-10 Non-destructive testing of steel tubes – Part 6: Automatic full peripheral ultrasonic testing of seamless steel tubes for the detection of transverse imperfections EN ISO 10893-10 Non-destructive testing of steel tubes – Part 7: Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc welded) tubes for the detection of longitudinal imperfections EN ISO 10893-11 Non-destructive testing of steel tubes – Part 8: Automatic ultrasonic testing of the weld seam of electric welded steel tubes for the detection of longitudinal imperfections EN ISO 10893-11 Non-destructive testing of steel tubes – Part 9: Automatic ultrasonic testing of the weld seam of submerged arc-welded steel tubes for the detection of longitudinal and/or transverse imperfections EN ISO 10893-13 Non-destructive testing of steel tubes – Part 13: Automatic full peripheral ultrasonic thickness testing of seamless and welded (except submerged arc-welded) steel tubes EN ISO 10893-8 Non-destructive testing of steel tubes – Part 14: Automatic ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of laminar imperfections	EN ISO 10893-10 Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes – Full peripheral ultrasonic testing for the detection of longitudinal imperfections EN ISO 10893-10 Seamless steel tubes for pressure purposes – Full peripheral ultrasonic testing for the detection of transverse imperfections EN ISO 10893-11 Electric resistance and induction welded steel tubes for pressure purposes – Ultrasonic testing of the weld seam for the detection of longitudinal imperfections EN ISO 10893-11 Submerged arc-welded steel tubes for pressure purposes – Ultrasonic testing of the weld seam for the detection of longitudinal and/or transverse imperfections EN ISO 10893-8 Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes – Ultrasonic testing for the detection of laminar imperfections ISO 10332 Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes – Ultrasonic testing for verification of hydraulic leak-tightness ISO 10375 Non-destructive testing – Ultrasonic inspection – Characterization of search unit and sound field

UT *continued*	EN ISO 10893-9 Non-destructive testing of steel tubes – Part 15: Automatic ultrasonic testing of strip/plate used in the manufacture of welded steel tubes for the detection of laminar imperfections EN ISO 10893-8 Non-destructive testing of steel tubes – Part 16: Automatic ultrasonic testing of the area adjacent to the weld seam of welded steel tubes for the detection of laminar imperfections EN ISO 10893-8 Non-destructive testing of steel tubes – Part 17: Ultrasonic testing of tube ends of seamless and welded steel tubes for the detection of laminar imperfections	EN ISO 10893-12 Seamless and hot-stretch-reduced welded steel tubes for pressure purposes – Full peripheral ultrasonic thickness testing EN ISO 10893-8 Seamless and welded steel tubes for pressure purposes – Ultrasonic testing of tube ends for the detection of laminar imperfections EN ISO 10893-9 Welded steel tubes for pressure purposes – Ultrasonic testing for the detection of laminar imperfections in strips/plates used in the manufacture of welded tubes EN ISO 10893-8 Welded steel tubes for pressure purposes – Ultrasonic testing of the area adjacent to the weld seam for the detection of laminar imperfections
VT		

Table App 2.6: NDT standards Wrought Products Sector ‘wp’

NDT method	*General Principles for Wrought Products*		*Acceptance Criteria, Tolerances*	
	EN	*ISO*	*EN*	*ISO*
General				
ET				
MT				
PT				
RT				
UT	EN 10160 Ultrasonic testing of steel flat product of thickness equal to or greater than 6 mm (reflection method) EN 10306 Iron and steel – Ultrasonic testing of H beams with parallel flanges and IPE beams EN 10307 Non-destructive testing – Ultrasonic testing of austenitic and austenitic-ferritic stainless steels flat products of thickness equal to or greater than 6 mm (reflection method) EN 10308 Non-destructive testing – Ultrasonic testing of steel bars	ISO 17577 Steel – Ultrasonic testing for steel flat products of thickness equal to or greater than 6 mm		ISO 12715 Ultrasonic non-destructive testing – Reference blocks and test procedures for the characterization of contact search unit beam profiles
VT	EN 10163-1 Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections – Part 1: General requirements EN 10163-2 Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections – Part 2: Plate and wide flats EN 10163-3 Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections – Part 3: Sections		EN 10029 Hot rolled steel plates 3 mm thick or above – Tolerances on dimensions, shape and mass	

App 2.7: NDT standards Metal Manufacturing Sector

See c, f, t, w, wp

App 2.8: Pre and in-service testing of equipment, plant and structure

See c, f, t, w, wp

App 2.9: Railway maintenance sector

See also f, t and wp.

NDT method	*General application*	
	EN	*ISO*
General	EN 15085-1 + A1 Railway applications – Welding of railway vehicles and components – Part 5: Inspection, testing and documentation	
ET		
MT		
PT		
RT		
UT	EN 12080 + A1 Railway applications – Axle boxes – Rolling bearings	ISO 5948 Railway rolling stock material – Ultrasonic acceptance testing
VT		

Table App 2.10: NDT standards Aerospace Sector

See also f, t and wp.

NDT method	*General Principles for Aerospace*	*Weld*	*Acceptance Criteria*
ET	**EN 2002-20** Aerospace series – Test methods for metallic materials – Part 20: Eddy current testing of circular cross-section tubes		
MT			
PT	**EN 2002-16** Aerospace series – Metallic materials – Test methods – Part 16: Non-destructive testing, penetrant testing		
RT	**EN 2002-21** Aerospace series – Metallic materials – Test methods – Part 21: Radiographic testing of castings		
UT	**EN 3718** Aerospace series – Test method for metallic materials – Ultrasonic inspection of tubes **EN 4050-1** Aerospace series – Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 1: General requirements **EN 4050-2** Aerospace series – Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 2: Performance of test	**EN 4050-3** Aerospace series – Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 3: Reference blocks	**EN 4050-4** Aerospace series – Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 4: Acceptance criteria
VT			

Table App 2.11: NDT standards Terminology

Standards which define the terms used in non-destructive testing within the different NDT methods or generally are also important:

NDT method	*Terminology*	
	EN	*ISO*
General	EN 1330-1 Non-destructive testing – Terminology – Part 1: List of general terms EN 1330-2 Non-destructive testing – Terminology – Part 2: Terms common to the non-destructive testing methods	ISO/TS 18173 Non-destructive testing – General terms and definitions
AE	EN 1330-9 Non-destructive testing – Terminology – Part 9: Terms used in acoustic emission testing	
ET	EN ISO 12718 Non-destructive testing – Terminology – Part 5: Terms used in eddy current testing	EN ISO 12718 Non-destructive testing – Terminology – Terms used in eddy current testing
LT	EN 1330-8 Non-destructive testing – Terminology – Part 8: Terms used in leak tightness testing	
MT	EN 1330-7 Non-destructive testing – Terminology – Part 7: Terms used in magnetic particle testing	
PT		EN ISO 12706 Non-destructive testing – Terminology – Terms used in penetrant testing
RT	EN 1330-3 Non-destructive testing – Terminology – Part 3: Terms used in industrial radiographic testing	
X-ray diffraction	EN 1330-11 Non-destructive testing – X-ray diffraction from polycrystalline and amorphous materials – Part 11: Terminology	
UT	EN 1330-4 Non-destructive testing – Terminology – Part 4: Terms used in ultrasonic testing	ISO 5577 Non-destructive testing – Ultrasonic inspection – Vocabulary
VT	EN 1330-10 Non-destructive testing – Terminology – Part 10: Terms used in visual testing	EN ISO 8785 Geometrical Product Specifications (GPS) – Surface imperfections – Terms, definitions and parameters

More information about standards can be found on the webpages of:

- Committee for European Standardisation (CEN) for European standards – **www.cen.eu**
- International Organisation for Standardisation (ISO) for International standards – **www.iso.org**

or on the webpage of national standard organisations (especially those that are members of the above-mentioned organisations).

Appendix 3 – Preparation of European standards

(edited extract from part 2 of the CEN Regulations)

General

A European standard (EN) is a normative document made available by CEN/CENELEC in the three official languages. The elaboration of a European standard includes a public enquiry (five months), followed by an approval by weighted vote of CEN/CENELEC national members (two months) and final ratification. The European standard is announced at national level, published or endorsed as an identical national standard and every conflicting national standard is withdrawn. The content of a European standard does not conflict with the content of any other EN. A European standard is periodically reviewed.

As the basis for the European standard, it shall first be established whether:

a) there is published international work in the field and that international work would be acceptable as a European standard;

b) the work can be developed within the framework of the international agreements that CEN and CENELEC have with ISO and IEC, respectively.

For case a), the 'Questionnaire procedure' allows a published international document to be assessed for suitability for progressing to a formal vote as a European standard.

For case b), the work may be offered to the international organisations for work to be carried out within the international organisation with parallel approval conducted by the European organisation under the terms of the Vienna Agreement (for CEN and ISO) or the Dresden Agreement (for CENELEC and IEC).

A European standard may result from the application of the ISO/CEN and IEC/CENELEC co-operation agreements, from the questionnaire procedure, from Technical Committee work or from a combination of these processes. Documents may also be processed under the Unique Acceptance Procedure.

Questionnaire procedure

The questionnaire procedure permits the Technical Board to find out:

- Whether enough interest exists in harmonisation on the subject proposed;
- The existing degree of national harmonisation with the reference document in question; and
- Whether that document would be acceptable as EN.

The questionnaire procedure serves the same purpose as the CEN/CENELEC enquiry.

The questionnaire procedure has two applications:

- For an entirely new reference document, using the Primary Questionnaire (PQ);
- For a revised reference document the previous edition of which has already been adopted as an EN, using the Updating Questionnaire (UQ).

A UQ is sent out automatically by the Central Secretariat where no Technical Committee is involved, whereas each PQ requires the authority of the Technical Board. A PQ may also be suggested to the Technical Committee where considered necessary for the progress of the Technical Committee's work. If the Technical Board decides to launch a PQ without a preceding formal proposal, the letter accompanying the PQ shall refer to the Technical Board decision.

Both PQ and UQ shall be circulated to members by the Central Secretariat, with three months as a normal time limit for replies. Members shall include in their replies the fullest information relating to proposals for common modifications, special national conditions, requests for national deviations and so on. The results of the PQ/UQ, together with any comments received, shall be circulated by the Central Secretariat without delay.

Evaluation of the replies and comments to the PQ and UQ shall result in an appropriate decision, by the Technical Committee or the Technical Board.

Technical Committee procedure

Successive working drafts shall be circulated to the responsible technical body for comments. In CEN, at least one working draft shall be circulated to the parent body for information but not for technical enquiry.

When consensus has been reached, the text agreed by the technical body is forwarded by the Technical Committee secretariat to the Central Secretariat, to be allocated a prEN number and distributed to the CEN/CENELEC national members for public comment. This procedure is called the 'CEN/CENELEC enquiry'. The period allowed for the CEN/CENELEC enquiry shall normally be five months.

The results of the CEN/CENELEC enquiry, together with any comments received, shall be circulated by the Technical Committee secretariat without delay. If the results show sufficient agreement, preferably unanimity, on the content of the draft, a final text shall be prepared by the Technical Committee secretariat for approval, subject to review by the Technical Committee of any technical comments received.

If the results of the CEN/CENELEC enquiry show that insufficient agreement has been reached, a second enquiry lasting normally two but a maximum of four months may be decided by the Technical Committee. Further enquiries shall not be allowed. The Technical Committee may also consider the possibility of publishing another CEN/CENELEC publication.

Approval

Approval of the final text of a prEN (abbreviated FprEN) shall be effected by a formal vote of members. The voting period shall be two months. A request for an extension of one month may be accepted during the two-month period.

The weighted voting procedure (as given in 6.1.4 and 6.2 of part 2 of the CEN regulations) shall be applied. All votes shall be unconditional. Editorial comments may, however, be made. All negative votes shall be accompanied by their justification.

The Central Secretariat shall prepare the voting report in consultation with the Technical Committee chairman and secretariat, if any, and circulate it to members for information and to the Technical Board for action.

If the voting result is positive and unless an appeal has been lodged, the Technical Board shall note the approval of the EN, note or establish a target date of availability (dav) and agree the dates for national implementation, *ie* date of announcement (doa) of the EN, date of publication (dop) of identical national standards or endorsements and date of withdrawal (dow) of conflicting national standards.

If the voting result is negative, the Technical Board shall decide what further action is to be taken and whether or not standstill should be released.

Before an EN can be made available, its definitive text shall have been checked in the official languages. No further alteration shall be possible except through the updating and amendment procedures.

Copies of the definitive texts in the official languages shall be circulated by the Central Secretariat.

Unique Acceptance Procedure

The Unique Acceptance Procedure (UAP) may be applied to any type of document, whatever its origin, in order to achieve rapid approval of an EN, if it is reasonable to suppose that the document is acceptable at European level. For a reference document, the UAP combines the questionnaire procedure and the formal vote. For a Technical Committee document, the UAP combines the CEN/CENELEC enquiry and the formal vote.

UAP is launched by the Central Secretariat after agreement of:

- the Technical Committee for a document related to an approved standards project; or
- the Technical Board in all other cases.

If, and only after agreement of the Technical Board or the Technical Committee responsible, the UAP is applied to a text available in only one of the official languages, the other two versions shall be available within a period of two months following the launch of the UAP, unless otherwise decided by the Technical Board.

The steps in the procedure are:

- submission of the document, by the Central Secretariat, to the CEN/CENELEC national members normally for a period of five months;
- voting by each member, before the end of the voting period, using the appropriate form provided by the Central Secretariat;
- preparation by the Central Secretariat of the voting report.

If the voting result is positive, the Central Secretariat shall inform Technical Board members by correspondence of the result and of proposed dates of availability and implementation, without circulating the texts. Acceptance of the result serves as the official ratification. Any editorial comments shall be examined by the Technical Committee or Reporting Secretariat, in order to prepare the final text of the EN for circulation on or before the due date of availability.

If the voting result is negative, the document shall be sent back to the Technical Committee responsible or to the Technical Board. With advice in the former case from the Technical Committee, the Technical Board shall decide what further action is to be taken and whether or not standstill should be released. After agreement of the Technical Board, the document may be submitted to a second UAP or to a formal vote.

A full set of CEN reference documents can be found on CEN website.

ISO, CEN and the Vienna Agreement

The objective of this paragraph is to clarify what the ISO/CEN Vienna Agreement is and its intent in coordinating work between ISO and CEN, the European Committee for Standardisation.

Where desired, CEN standards are coordinated with International Organization for Standardization (ISO) standards via the ISO/CEN Vienna Agreement. This Agreement is similar to the IEC/CENELEC Dresden Agreement. It provides the means for ISO standards to become CEN standards and *vice versa*. The Agreement is supplemented by an Implementation Guidance Document. Also available for your information and use is a very helpful ISO/CEN Vienna Agreement FAQs (frequently asked questions) document.

The latest version of the Vienna Agreement went into effect in 2001, superseding both the 1991 version of the Vienna Agreement and the earlier 1989 Lisbon Agreement. The latest version of the Vienna Agreement features the following new provisions:

- The primacy of international standardisation is more strongly reflected.
- Text has been added indicating that assignment of lead to CEN should only take place in very exceptional cases.
- ISO committees may decide to assign lead to CEN contingent on there being a CD level vote on the document in the ISO committee.
- Revisions of all Vienna Agreement documents will take place under ISO-lead, even if the current version was or is being developed under CEN-lead.
- The one to four ISO committee representatives may attend the relevant CEN committee meetings without need for issuance of special invitations and are expected to represent the breadth of comments from the ISO committee, not a consensus of the ISO committee as previously understood.
- Any ISO member may comment on a draft CEN standard even if there is no equivalent ISO activity.
- ISO and CEN considering the feasibility of eliminating CEN lead.

An ISO/CEN Joint Coordination Group, consisting of representatives of both organisations, has been established to monitor and manage the operation of the Vienna Agreement and to deal with any problems that may arise. The Group usually meets annually.

Appendix 4 – EN ISO 9712:2012

ISO 9712 was prepared by Technical Committee ISO/TC 135, Non-destructive testing, Subcommittee SC 7, Personnel qualification.

This fourth edition cancels and replaces the third edition (ISO 9712:2005), which has been technically revised.

Changes from the third edition include:

- clarification of responsibilities for the certification body, the qualification body and the examination centre;
- redrafting of the clause 'training' for clarification and change in the number of required hours;
- redrafting of the clause 'experience' for clarification;
- introduction of 'digital certificates';
- other minor technical and editorial changes.

Transition between EN 473:2008, ISO 9712:2005 and the International Standard EN ISO 9712:2012:

Certification according to EN 473:2008[4] and/or ISO 9712:2005, awarded before publication of this international standard, remains valid until the next mandatory step in the certification process, *ie* renewal or recertification, which shall be carried out according to this international standard.

Certification according to this international standard is considered as fulfilling the requirements of both EN 473:2008 and ISO 9712:2005; consequently, any requirement for certification to either of these standards is fulfilled by a certification according to this international standard.

Normative references include:

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies: EN ISO/IEC 17024:2003, Conformity assessment – General requirements for bodies operating certification of persons.

This is now the internationally specified standard for personnel certification bodies and is universally applied in accreditation systems operated by International Accreditation Forum (IAF) members.

Appendix 5 – EFNDT Forums

A Forum is set up upon the decision of the EFNDT Board of Directors (BoD) with a defined area of the scope and method of working in accordance with this Operating Procedure.

A Forum may be established for a one-off discussion or on a permanent basis to consider and make recommendations to the BoD upon a subject under consideration.

The EFNDT BoD shall elect a suitably qualified person as a Convenor. He/she shall take office for a term not exceeding two years and shall be eligible for re-election by the Forum for one further term of office.

A Secretary of the Forum is appointed by the Convenor and approved by the EFNDT BoD.

A Secretariat, if needed, is provided by the National NDT Society or EFNDT body appointed for that purpose by Convenor and approved by the EFNDT BoD.

Other NDT societies or participants may attend Forum meetings with observer status upon invitation of the Convenor of the Forum.

Any organisation wishing to apply for membership of the Forum and to nominate the representative to attend meetings is required to contact Forum officers.

Method of working

The Forums shall consider matters of policy at at least one ordinary meeting per year.

Meetings shall be announced a minimum of four weeks in advance by circulation of a Notice of Meeting and Agenda and relevant documents.

Participation in the EFNDT Forums is open to all EFNDT officers, full and associate member NDT society representatives and partners in an MoU relationship with EFNDT.

A member organisation may, at any time, nominate alternates or change their representation by informing the Secretary of the Forum.

The quorum for a meeting shall be a minimum one third of the current voting members.

If a vote is necessary, representative members shall have one vote for each country represented on a national board.

Proceedings of the Forum shall be recorded and the Forum shall report to the EFNDT BoD.

These general rules for EFNDT Forums shall be explained by means of the example of the Forum for National Aerospace NDT Boards, as follows.

Forum for National Aerospace NDT Boards

A5.1 Formation

A proposal to establish a Forum for NANDTBs was presented and 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 this Appendix along with the Forum's current action plan.

A5.2 Aims and objectives of the ANDTBF

A5.2.1 The Aerospace NDT Board Forum (hereinafter referred to as 'the ANDTBF'), has the following aims and objectives in relation to EASA regulations (*ie* part 145 and part 21 etc) and EN 4179:

- provide a forum for discussion of matters of common interest to all NANDTBs;
- harmonisation of methodology for the control of aerospace NDT training and EN 4179 qualification examinations provided at the various national levels;
- provide formal representation of the common concerns of the ANDTBF members to EASA;
- act as an advisory body for new NANDTBs, implementing applicable regulations and standards;
- agree common specifications for outside agencies providing training and qualification examinations at the various national levels;
- agree and promote a common format for company written practices in conformance with EN 4179;
- provide a mechanism for interpretation in cases of dispute regarding the implementation of applicable regulations and standards.

A5.2.2 The ANDTBF will seek multilateral recognition between its members, with organisations having similar aims, for example IAQG, and with any other pertinent body in order to benefit the aerospace industry and to minimise duplication and multiple audit.

A5.2.3 In order to obtain the widest possible representation, the ANDTBF encourages NANDTB or similar organisations outside of the European Union and Free Trade area to apply for membership or otherwise to seek involvement in its activities.

A5.2.4 Any organisation wishing to apply for membership of the ANDTBF, and to nominate a representative to attend meetings, is requested to contact the Secretary to the ANDTBF, c/o Certification Services, British Institute of NDT, Newton Building, St George's Avenue, Northampton NN2 6JB, United Kingdom. Further information on membership is available upon request

A5.3 Constitution

A5.3.1 The ANDTBF is composed of the duly nominated representatives of the NANDTB member bodies. The bodies in current membership are listed in document reference ANDTB/02. Such other bodies as the ANDTBF may determine may be invited to join on terms which the ANDTBF shall prescribe.

A5.3.2 Member organisations may at any time nominate alternates or change their representation by informing the Secretary of the ANDTBF in writing.

A5.3.3 The ANDTBF shall elect a suitably qualified person as Chairman. The Chairman shall take office for a term not exceeding two years and shall be eligible for re-election for one further term of office.

A5.3.4 The ANDTBF shall elect a suitably qualified person as Vice Chairman. The Vice Chairman shall take office for a term not exceeding two years and shall be eligible for re-election for one further term of office.

A5.3.5 The ANDTBF shall appoint a suitably qualified person as secretary. The Secretary shall take office for a term not exceeding two years and shall be eligible for re-appointment.

A5.3.6 The ANDTBF shall have the power to co-opt individuals to attend meeting(s).

A5.4 Method of working

A5.4.1 The ANDTBF shall consider matters of policy at at least one ordinary meeting per year, which shall be convened on the authority of the Chairman by the Secretary with at least 30 days' notice in writing.

A5.4.2 Matters to be decided at a meeting should be supported by written documentation issued in advance of the meeting.

A5.4.3 The quorum for a meeting shall be a minimum of one third of the current voting members. In the event that a vote is necessary representative members shall have one vote for each country represented on a national board. Co-opted members shall not have a vote.

A5.4.4 Approval of changes to the constitution, terms of reference and method of working, and invitations for other bodies to be represented on the ANDTBF shall be decided by a majority of not less than three fourths of those present at an ordinary meeting. Other matters shall be decided by a simple majority.

A5.4.5 Any five voting members of the ANDTBF may request a special meeting at any time by written notification to the Secretary. Such notification must state clearly the purpose of the proposed meeting, which must be convened to take place within 28 days of receipt of the notification.

A5.4.6 The ANDTBF is empowered to set up working groups and committees, establish their terms of reference and set out the procedures whereby they report to the ANDTBF.

A5.4.7 Neither the ANDTBF, its Chairman, individual members, the bodies they represent, nor any working party or sub-committee appointed by the ANDTBF, shall carry any financial liability for any scheme operated for the ANDTBF, or be liable for any damages resulting, or claimed to have resulted, from decisions of personnel implementing the scheme, or for any consequential loss arising out of the operation of the scheme.

A5.4.8 The ANDTBF shall publish an annual report covering its activities.

A5.5 Action plan of the European Forum for National Aerospace NDT Boards

5.5.1 Introduction

The December 2006 Paris EF NANDTB meeting required the definition of an action plan, including methods of working, main objectives, qualification and certification process, planning and target dates. The following section summarises the proposals received by the Secretary, circulated to the Forum, and agreed at the 2nd meeting of the Forum in Istanbul on 29 June 2007.

5.5.2 Method of working

From the EF NANDTB constitution clause 3.6: "The ANDTBF is empowered to set up working groups and committees, establish their terms of reference and set out the procedures whereby they report to the ANDTBF". It is proposed that, for each of the agreed action plan items, the Forum:

- determines the objective(s) and timescales for achievement;
- assigns responsibility to an individual convener, who is empowered to set up a working group of experts (from within or from outside of the Forum) on the subject area; and
- reviews the report and recommendation(s) of the working group presented by the convener at an ordinary meeting.

5.5.3 Main objectives (agreed at 29 June 2007 meeting in Istanbul)

EASA regulations

Objectives:

- Establish EASA's intentions and timescales for review and update of EASA AMC 145 (which refers to EN 4179:2000).
- Request that EASA harmonise or combine EASA Regulations parts 21 and 145.
- Offer to assist with or contribute to the work involved.

Nadcap

Objectives:

- Review Nadcap activities and establish any crossover with NANDTB activities.
- Establish lines of communication with Nadcap (whilst preserving the autonomy of boards at the national level).

Harmonisation of operations of Forum members

Objectives:

- Draft ANDTBF policy document proposing harmonisation of the operations of the national boards.
- Propose outside agency audit criteria.
- Recommend policy on recognition of approvals issued under the control of other national boards.

Interpretation of standards for qualification/certification of NDT personnel

Objectives:

- Provide a mechanism for interpretation of applicable qualification standards, for example EN 4179 and EN 473, for the aerospace sector.
- Make recommendations concerning experience – reductions in duration (EN 4179, Table 2, Note a). Survey each board concerning their understanding of this note.
- Make recommendations concerning practical examination content (initial and recertification).

Conferences

Objectives:

- Offer to manage a half-day aerospace NDT personnel qualification/certification session within the next European Conference on NDT.

- Stage a one-day ANDTBF workshop during 2008, open to any interested party. Topics to include:
  - Guidance to employers of NDT personnel
  - Audit and control of qualification examinations (conducted by employers and outside agencies)
  - Acceptable alternatives to EN 4179 approval
  - Interpretation of regulations and AMC 21 and 145
  - Interpretation of standards (4179 and 473)

Appendix 6 – Exemplars of good practice (data collection form)

Authors are invited to describe how NDT quality is controlled/achieved in their sector/company, making reference to the sections of the EFNDT Guidelines document and using some or all of the following proforma headings

Industrial Sector:	*Author:*
Scope	General description of NDT activities covered
Achievement of quality in NDT	General comments on how quality is achieved/controlled
NDT infrastructure (national/European/international)	Explain geographical scope of the NDT work described
Standards	State which types (for example ISO, CEN, etc) of standards are used. Are there gaps in the available standards?
Personnel qualification and certification	Summarise what scheme(s) are used and mention any job specific training/approval
Training syllabuses and guidelines	Indicate which scheme you use and mention any job specific training/approval
Inspection qualification	Are your NDT procedures, equipment, personnel subjected to inspection qualification/ performance demonstration?
Accreditation of NDT laboratories and inspection bodies	Do you use/supply accredited NDT/inspection services?
Human factors	Do you have any human factors controls to assist reliability?
Overall management to achieve quality	Who takes management responsibility for NDT quality?

A6.1 Power Generation (Non-Nuclear)

Industrial sector: power generation (non-nuclear)	*Author: Paul Crowther MPhil, BSc, CEng, MInstNDT, Group Head, Inspection Management, RWE npower plc*
Scope	Provision of a team of NDT professionals to support RWE power generation plant in constructional, operational and developmental activities meeting ongoing challenging environments. Provision of specialist inspections using bespoke advanced inspection methodologies. Inspection of critical components on power station plant. Management, supervision and audit of NDT contractors carrying out routine NDT inspections on power station plant. NDT advice and consultancy in new build projects. External representation to promote/influence NDT-related subjects towards continual improvement in the power generation sector.
Achievement of quality in NDT *Employment of people*	RWE npower employs NDT personnel through one of the following routes: a) full-time employees; b) full-time NDT contract staff; and c) NDT contract staff for short-term projects. Full-time members of staff are chosen for their extensive knowledge of NDT, power generation experience and related engineering disciplines and are qualified to degree and/or PCN Level III. Full-time NDT contract inspectors are also chosen for their extensive knowledge of NDT with extensive experience in the power generation sector and are certificated to a minimum of PCN Level II that meets the requirements of EN ISO 9712. They are often trained in specialist NDT application and are often expected to take a supervisory role at sites on behalf of inspection management. NDT contract technicians are employed through specific contracts; NDT contract technicians are required to be certificated to a minimum of PCN Level II that meets the requirements of EN ISO 9712.
Structure	All NDT personnel working on RWE npower plant or external client plant work within a structured organisation. The organisation is split into two sections that are managed by Lead NDT Engineers; the first covers NDT applications on power generation plant, which are normally carried out by contract staff, and the second covers inspections on critical components and inspections that require specialist inspections. All NDT activities are underwritten by a Inspection Management Quality Management System accredited to ISO 9001 and actively reviewed by the senior members of the team on a monthly basis.
Apprenticeship scheme	RWE npower Inspection Management has an effective apprenticeship scheme. The Inspection Management Apprenticeship Scheme started in September 2003 and was developed in accordance with the British Institute of Non-Destructive Testing framework agreement, which allows for two or three year schemes (RWE npower elected to go for the three year scheme); on occasions, RWE npower recruited apprentices as members of staff at the end of the scheme. The reason for starting the apprenticeship scheme was a growing awareness that there was a notable shortage of skilled NDT engineers, declining by the year, that could put RWE npower at considerable risk in terms of being able to maintain its plant. The requirement to take on apprentices is driven by business need so in some years there is a multiple intake, whereas in other years there is no intake.
Training specialist	Very often, training and certification for advanced and emerging technology are not available under EN ISO 9712, particularly when applied to industry specific plant items, looking for industry specific material degradation. It is important to RWE that NDT specialists are appropriately trained in all aspects of advanced technology and have extensive knowledge of the materials they are inspecting. This advanced training and in some cases examinations are usually provided by equipment manufacturers and in some cases AQBs.
Staff CPD	Career professional development (CPD) is increasingly becoming a mandatory requirement in engineering and NDT; Engineering Registration (CEng, IEng and EngTech requires recipients to develop and maintain a CPD; RWE npower encourages its NDT staff to seek Engineering Registration. RWE npower undertakes a staff appraisal scheme that requires individuals to keep up-to-date CPDs which includes an historical record of achievements together with a forward looking development, training and certification plan.

Training & certification – PCN top-up	All personnel working on RWE npower plant or clients' plant are required to be trained and certificated to a certification scheme that meets the requirements of EN ISO 9712. Personnel Certification in NDT (PCN) is the British scheme that meets the requirements and in some cases exceeds the requirements of EN ISO 9712. Where: a) No suitable third-party scheme meeting the requirements of RWE npower exists for the relevant inspection method(s) or b) When additional training and/or qualification is deemed to be required or appropriate by RWE npower in supplementing a persons existing third-party certification in an NDT method in order to meet the requirements of a power generation component specific inspection application. An RWE npower Written Practice specifies the requirements of RWE npower in the selection, training, examination, qualification and re-qualification of personnel engaged in NDT. Training, examination syllabuses and question banks have been developed by RWE npower Inspection Management to qualify NDT personnel.
Carrying out specialist inspections	Inspections on critical components which necessitate the use of advanced technology and are so intricate that they require a high degree of scrutiny are carried out by NDT specialists. The NDT specialists are usually full-time RWE staff or carefully selected contract staff on long-term contracts.
Management, supervision and audit of NDT contractors	'Management, supervision and audit of NDT contractors' is essential if the accuracy of NDT inspections is to be assured. RWE npower manages all aspects of NDT and quality assurance at the sites they are engaged on. Supervisors are deployed to manage all NDT activities on substantial areas of plant, such as pressure systems and rotating plant. Auditors carry out 'audit by re-inspection' of a nominal 10% of inspected plant items; this percentage can vary depending on the criticality of the plant. Very often, RWE npower is required to oversee the NDT carried out on manufactured plant at manufacturer's works before the components are delivered to site.
Approval and authorisation of NDT reports	Standard NDT reports generated by NDT contract staff (usually employed through a service inspection company) are reviewed for technical content and accuracy and approved for issue by Inspection Management. Standard NDT reports produced by Inspection Management are subject to peer review and endorsed by a second signature. Specialist inspection reports are subject to peer review and approved by an appropriate PCN Level III. Power station outage management reports containing detailed subjective assessment of outage performance are subject to review, approval and authorisation by the Inspection Management Senior Engineer or the Group Head.
Membership of BINDT	Membership of BINDT is seen as an essential element of keeping up-to-date with what is happening within the NDT profession and also to support the industry. Membership of BINDT is not mandatory within RWE npower but all NDT personnel, including contract staff, are encouraged to join. Those RWE npower NDT personnel who have aspired to Engineering Registration are required to be members of the registering institute, in this case BINDT, by the Engineering Council.
Attendance at conferences and exhibitions	RWE npower personnel attend conferences and exhibitions in the UK and overseas, partly to be aware of emerging technology and partly to enhance their career professional development (CPD). In the UK, RWE npower allows a number of people to attend the BINDT annual conference and, in the years where it is appropriate, has the apprenticeship certificates presented by the President.
Support for the national society (BINDT)	RWE npower has always supported the national society. In the past it has had engineers who have held the posts of President and Vice President; currently the Group Head of Inspection Management is a Director of BINDT and others sit on the Certificate Management Committee, the Membership, Qualification and Education committee and the Industry Committee.
NDT infrastructure (national/European/international)	RWE npower actively contributes to the NDT community through close collaboration with targeted national/international NDT work streams such as RCNDE/NDEvR, group-funded NDT-related projects managed via the UK Technology Strategy Board or EEC that brings NDT interested industrial and academic parties together to exchange views/work on collaborative projects to the mutual benefit of all contributors and advancement of new NDT-related technologies.
Standards	There are over 100 'BS EN ISO' standards that mandate the activities of non-destructive testing. Where such standards exist, RWE npower uses them to underpin the drafting of RWE npower NDT procedures and technique sheets. If such standards do not exist, then NDT procedures are produced based on the general principles of European standards.

Personnel qualification and certification	There is a consensus view in the UK power generation sector that a direct correlation exists between NDT competence and the rigour of training and examination. Therefore, RWE npower is developing additional requirements to those provided by third-party certification schemes. These additional requirements are related to power plant materials degradation and NDT technician competence and detailed as: In undertaking NDT inspections of power generation plant and components, RWE npower will engage and utilise suitably experienced NDT personnel certificated to Level II in accordance with BS EN ISO 9712 in the appropriate NDT method and sector. The Personnel Certification in Non-Destructive Testing (PCN) certification scheme managed and administered by the British Institute of Non-Destructive Testing is the preferred third-party certification scheme. RWE npower has the sole responsibility of providing a declaration of qualification to Level I and II when: a) No suitable third-party certification scheme meeting the requirements of RWE npower exists for the relevant inspection method(s); b) When additional training and/or qualification is deemed to be required or appropriate by RWE npower in supplementing a persons existing third-party certification in an NDT method to meet the requirements of a power generation component specific inspection application. Authorised PCN Level III personnel employed directly by RWE npower Inspection Management have the responsibility for administering Level I and II personnel qualification examinations and their proper conduct. The pre-requisite qualification requirements in terms of visual acuity, training and experience shall be fulfilled by each candidate for eligibility for the qualification examination. These pre-requisites are verified by RWE npower and endorsed on the qualification record. This may also involve a requirement to demonstrate a level of material/plant knowledge through the successful completion of an examination on relevant product knowledge.
Training syllabuses and guidelines	RWE npower requires NDT personnel to be trained by an approved training organisation (normally BINDT approved) and certificated by an authorised qualifying body of a certification scheme that meets the requirements of EN ISO 9712 (normally PCN). In addition, RWE npower provides additional site-specific training and qualification as and when required as defined in RWE's Employers Written Practice for NDT Qualification of Personnel based on ISO 9712 and ISO 11484. RWE npower has produced a comprehensive set of Level III approved NDT procedures and numerous technique sheets; all NDT personnel working on RWE npower sites or RWE npower customer sites are required to work to these procedures and technique sheets.
Inspection qualification	In RWE npower, all NDT procedures, technique sheets and equipment are subjected to a degree of internal inspection qualification and performance demonstration. In the preparation of an NDT procedure/technique sheet, multiple inspections by multiple NDT technicians are carried out on representative samples in both open and blind trials, the results compared to the sectioning of those samples. Specific procedures require more extensive qualification incorporating reliability, repeatability and reproducibility demonstrated through auditable verification and validation processes.
Accreditation of NDT laboratories and inspection bodies	RWE npower does not use or supply accredited laboratory services. It does, however, endorse service inspection companies through a rigorous procurement process in order to develop bespoke service level contracts. The key elements of a contract include: proven historical performance, commitment to RWE, provision of multidiscipline personnel working to approved quality systems, ability to provide additional personnel at short notice, provision of certificated equipment and in some cases Engineering Registration.
Human factors	RWE npower Inspection Management considers human factors as key attributes affecting the achievement of quality. Consideration for personnel wellbeing and safety during the inspection process is of paramount importance contributing to the motivation and commitment to quality from NDT personnel. It is most unlikely that quality can be achieved by training and certification alone, therefore RWE npower has been proactive in structuring the organisation to allow individual responsibility and empowerment, work placement that facilitates job satisfaction and motivating team members by conducting annual assessments and encouraging personal development.
Overall management to achieve quality	The RWE npower Inspection Management Business Unit is accredited to ISO 9001:2008. Through a quality management system, quality performance of the group is reviewed and assessed on a monthly basis by senior members of the group, continual improvement being the driver to take the group forward. The Inspection Management QMS is subject to bi-annual reviews by independent third-party, LRQA.

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