QUALIFICATION AND CERTIFICATION OF PERSONNEL IN BRAZIL – PETROBRAS EXPERIENCE

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Abstract: To increase the reliability of the installations and to assure their continuous operation, PETROBRAS, the largest Brazilian oil company decided, in 1978, to implement a centralized scheme for qualification and certification of inspectors. This successful action led to the creation of the Brazilian Qualification and Certification Scheme for NDT Personnel and of the Brazilian Qualification and Certification Scheme of Welding Inspectors. Their experience developing these schemes and the more recent improvements adopted to optimize the qualification tasks and to reduce costs, including the use of computerized programs are reported here. The specimens used for qualification practical examinations are detailed. It was formulated a proposal of minimum requirements concerning to specimens for mutual qualification systems recognition, in addition to those requirements stated on ISO 9712 standard.

Introduction: The qualification and certification of personnel in Brazil has experienced a significant development since 1978, when PETROBRAS, the largest Brazilian oil company and one of the 20 largest companies in the oil industry worldwide decided to implement a centralized scheme of qualification and certification of nondestructive testing inspectors. Till then, the qualification was carried out by contractors based on their own self-certification systems and on the recommended practice ASNT SNT-TC-1A. This qualification was separately assessed by PETROBRAS as a part of their customer inspection activity for each Job, resulting in distortions related to the depth of the evaluation of the various professionals. Furthermore, all the work of evidencing qualification had to be repeated each time the job site was changed, entailing test specimen design and examination administering costs which could be avoided if centralized system of information about qualified personnel was in place. An additional advantage of this centralized system was that it enabled an early assessment of competence and the preparation and qualification of test procedures, eliminating some of the factors that led to the delay of the works.

The qualification scheme was established based on PETROBRAS standard N-1590, which took into account ICNDT recommendations in force, and established as basic premises for eligibility for qualification Education, Experience, Training and Visual Acuity. Once these basic requirements were met, candidates were subject to a theoretical examination followed by practical examinations aimed at checking the knowledge and abilities of candidates.

The adequacy of enforced parameters, and of the use of a centralized 2nd Party system, to evaluate personnel was soon felt when the low standards of qualification of personnel already approved by contractors under self-certification systems was evidenced. Table 1 illustrates candidates low pass rates.

Based on the success achieved in the quality of industrial facilities, a reflex, among other measures, of improved inspector qualification, PETROBRAS decided to implement centralized qualification systems for qualification in other modalities that were deemed to be critical for the significant number of non conformities evidenced or for the critical role they played in the control of manufacturing, construction and assembly processes and of the products resulting therefrom.

The implementation of these new modalities was step by step, according to the following sequence:

1979 – Nondestructive Testing (A Brazilian System of Qualification and Certification is in place since 1987, and qualification started in 1992)
1983 – Welding Inspection (A Brazilian System of Qualification and Certification is in place since 1987, and qualification started in 1992)
1984 – Underwater Inspection
1985 –Concrete Inspection
1987 – Dimensional Control
1988 – Industrial Painting Inspection
1992 – Manufacturing Inspection
1993 – Instrumentation Inspection
1995 – Pipeline Inspection

1999 – Electricity Inspection
To provide a better view of the work that has been developed some statistical data are presented below:
37,300 examinations
15,000 professionals tested
680 companies served
9,700 questions prepared to constitute a large question database
600 specimens with simulated discontinuities and real inspection possibilities
The photographs presented in Annex 1 illustrate SEQUI – PETROBRAS Qualification, Certification and Inspection Division .

Results: 1. NDT – Structure of Qualification Examinations based on PETROBRAS Standard N-1590

1.1 Theoretical Examinations

Multiple choice questions were used for theoretical examinations.
To prevent information about theoretical examinations from leaking, there were no similar examinations, and all were computer generated and selected from a large question database comprising, to start the process in 1979, approximately 2000 questions.

1.2 Practical Examinations

The practical examinations were prepared using test specimens and real case studies on the use of test procedures.
For practical tests, the selection of test specimens and case studies was random, and they were also selected from a large collection available.
The follow-up of examinations and examination evaluation/grading criteria were standardized since the qualification system initial operation and was recorded in Check-Lists.
The evaluation was carried out by way of micro-tasks to enable evaluating also candidate knowledge and operating capabilities, besides his/her competence in detecting discontinuities and issuing reports. All test specimens and case studies used for the practical examinations targeted the effective evidence of the required qualification level/sub-level. Thus, for example, welded test specimens were used to assess proficiency in inspection of welds by magnetic particles; collections of radiographs of welds were used to qualify level 2 inspectors for radiographic testing of welds ; for ultrasonic inspection of nozzles were used real nozzles to simulate the difficulties inherent to this type of geometric configuration. In this aspect, the established system is comparable to several national systems existing currently in France, England and Canada. Yet, it is more strict than the system enforced in a certain country, where the inspection of simple geometry test specimens - inspection of plates and butt welded joints – are deemed to be enough to qualify inspectors who will inspect more complex geometry components, as, for example, nodes of tubular structure, Tee and "Y" joints.
The statistical data of the values assessed in the qualification examinations evidence the appropriateness of the subdivision of qualification levels consistently with the complexity of the tasks to be performed.
Table 1 shows the rates of approval for each qualification level and sub-level.
For ultrasonic testing, please note that, to apply for sub-level US-N2-S2 the candidate has passed sub-level US-N2-S1, and the rate approval for US-N2-S2 was of only 41.1% which proves that testing the candidate for a lower complexity sub-level and assuming that this candidate masters test methods for all situations is definitely not a correct assumption.
Therefore, as can be evidenced, premises were established according to the requirements later issued on ISO 9712 standard, item 3.13: "examination, qualification – examination administered by a certification body or by an authorized qualifying body, which assesses the knowledge and capabilities of the candidate."
That is, the examinations met the requirement of assessing knowledge and competence and not just the objective of assessing the potential to perform a given task.

2. The Establishment of a Brazilian System of Qualification and Certification System in NDT

The use of a company certification system for a large number of years was necessary because in Brazil there was not an independent certification system in line with the requirements established by ISO 9712. Yet, since the beginning, PETROBRAS understood that the best solution was the existence of a national system, and has always provided assistance to make this solution feasible. Thus, in 1987 the National (Brazilian) System of Qualification

and Certification of Personnel for Nondestructive Testing was established by ABENDE – Brazilian Society for Nondestructive Testing and Inspection, and system operation started in 1992. As PETROBRAS qualification system had taken into account most of the international qualification requirements, the transfer to the ABENDE (Brazilian) System was quick and smooth and no problems were faced to perform the necessary adaptation.

3. Basis for the objective assessment of knowledge and abilities

For each test method, three parameters must be taken into account to assess knowledge and competence/ability to perform a given task:

a) Type of apparatus/equipment and materials/consumables used for inspection;

b) Type of material to be inspected (welded, cast, wrought);

c) Geometrical complexity of the material to be inspected.

Thus, in order to establish consistent sets of qualification for frequent inspection situations, qualification sub-levels were established, taking all these parameters into account. For candidates who applied for a broad qualification, without restrictions, the system also foresaw this condition but considering that generally it was not very common and, therefore, should be seen as a sum of qualification sub-levels.

The current composition of qualification sub-levels established in the ABENDE (Brazilian) System and the list of test specimens used for the examinations for Ultrasonic Testing are presented on Table 2.

Please note that, for Penetrant Testing there are not many sub-levels because, for this type of testing the geometric complexity of the component to be inspected is less important as a factor of test difficulty.

As can be evidenced, for some tests, like ultrasonic testing, it is impossible to enforce a general level of qualification because of the large number of test specimens required for an effective evaluation of candidates. Furthermore, there is no reason to qualify an inspector for an activity he/she will not be performing. The advantage of this structure is to allow a gradual improvement of personnel skills, always acting within the scope of their qualification, without adversely affecting service reliability and, consequently providing for uninterrupted operation and the safety of industrial facilities.

Discussion: 4. Proposal to render mutual recognition of qualification systems easier

We are proposing the development by ICNDT of a table with qualification sub-levels, similar to the one developed by ABENDE (Brazilian) System, establishing, for each sub-level, the minimum quantity and complexity of each test specimen to be used for qualification examinations. The parameters to be taken into account to prepare the table, for each test method, are those listed above, namely:

a) Type of apparatus/equipment and materials/consumables used for inspection;

b) Type of material to be inspected (welded, cast, wrought);

c) Geometric complexity of the material to be inspected.

In any proposal for mutual recognition, a correlation must be established between the test specimens used by interested organizations and the ICNDT table. Thus, once the similarities and the differences between the systems and the ICNDT table are established, it will be possible to determine up to what point systems are comparable and choose, or reject, mutual recognition.

Clearly, practical tests represent just part of the issue and other attributes must be considered, like, for example, the existence of a quality system in conformity with EN 45013/ISO 17024, duly certified by the National Accreditation Body of the country to which the system belongs and conformity with all other ISO 9712 requirements.

5. Recent improvements to optimize qualification activities

Aimed at optimizing qualification activities, maintaining respective reliability and reducing costs, studies strongly supported by information technologies have been developed to follow-up and monitor NDT Personnel Qualification and Certification Examinations conducted by the ABENDE (Brazilian) System according to ISO 9712 and EN 45013.

The application foresees not just the qualification per se, but also the full related process, from receiving applications, to the agenda/program, preparation of the examinations (theoretical), examination grading/evaluation, consolidation of results, preparation of next stage (where applicable), ultimately generating statistical data on the examinations and a summary for receiving the fees.

The SSO Program – SEQUI (PETROBRAS) Operations System was developed using a methodology based on advanced techniques and technological resources involving a Relational Database and Clustered Servers.
The following modules were foreseen:
. Grading of theoretical examinations by an optical reading system
. Automatic grading of practical tests by the SSO, using previously registered master sheet;
. Partial grading of tests during the examination, recording information on every follow-up made by the examiner
. Automatic completion of Examiner and Candidate Check Lists;
. Automatic setting of Re-examinations, types and quantities of Test Specimens to be used for each candidate;
. Online examination statistics;
. Conducting and grading of examinations in external units;
. Control of test specimen use, enabling recycling of the relevant test specimen as required;
. Automatic determination by the SSO of the number of conducted examinations to be audited by Level 3 examiners;
. Follow-up statistics for the whole process of Qualification and Certification;
. Monitoring the individual performance of each examiner in the process of conducting Qualification and Certification examinations;
. Automatic scheduling and program of Qualification Examinations;
Once implemented, the SSO – SEQUI Operations System, proved to be a critical tool in the process of Qualification, Certification. With system implementation SEQUI was able to minister examinations and disclose results faster, and the reliability of the process of Qualification and certification was significantly increased.
Among main achieved results are:
. Relevant productivity increase;
. Facility to evidence the reliability and safety of the information pertaining to the process of Qualification and Certification;
. Less time required to provide examination results to clients;
. Less men-hour required by the process of Qualification and Certification;
. More examinations with the same number of examiners
. Streamlined retrieval of candidate information;
. Lower examination costs;
. Traceability of examinations and of the use of Test Specimens;
. No rework required from Examiners to complete the Check Lists;
. Increased rate of client satisfaction with the services provided by SEQUI.

Conclusions: 6.1 In any proposal for mutual recognition a correlation must be made between the test specimens used by interested organizations and a single table, prepared by an internationally recognized organization, like the ICNDT. Thus, once the similarities and differences between the systems and the ICNDT Table are established, we will be able to determine up to what point the systems are comparable and choose, or reject, mutual recognition.
Clearly, practical examinations represent just part of the issue and other attributes must be considered, like, for example, the existence of a quality system in conformity with EN 45013/ISO 17024, duly certified by the National Accreditation Body of the country to which the system belongs and conformity with all other ISO 9712 requirements.
6.2 Centralized qualification and certification systems offer significant advantages over the self-certification systems, and should be established to ensure the reliability of industrial facilities, and consequently, their safety and uninterrupted operation.
6.3 The use of information technology enables the optimization of qualification activities, maintaining the required trust and lower costs, enabling the implementation of national systems and the integration of the various centers of qualification examinations with their respective Certification Bodies.

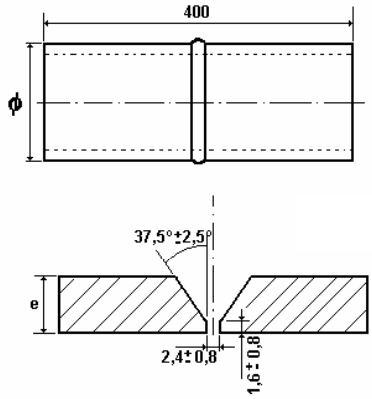
TABLE 1 – Approval Rates Of Candidates, Already Qualified By Self-Certification Systems

Nondestructive Testing		% Approval, 1979 to 1989
Penetrant Testing	Level 1	37.7
	Level 2	43.8
Magnetic Particle Testing	Level 2	25,3
Radiographic Testing– Gamma-Ray	Level 1	39.2
	Level 2	21.5
- X-Ray	Level 1	34.9
	Level 2	29.5
Spot Testing	Level 2	48.9
Ultrasonic Testing– Thickness Measurement	Level 1	64.5
- Inspection of Plates	Level 1	61.0
- Inspection of Welds	Level 2/Sub-level S1	23.7
	Level 2/Sub-level S2	41.1
	Level 2/Sub-level S4	36.0
	Level 2/Sub-level AE1	32.2

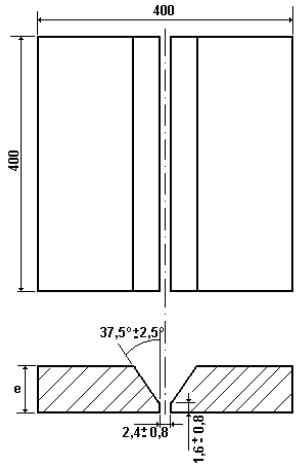
TABLE 2 – Ultrasonic Testing - Test Specimens

Level/ Sub-Level	Attributions And Capabilities	Specimens and quantity inspected( )	Examination Duration (hour)
US-N1-ME	Performing thickness measurement test in metallic materials, with evaluation of results.	US-08 (8) US-09 (2)	1
US-N1-CL	Comprises US-N1-ME + performing test in plates with normal and double crystal transducers, with evaluation of results.	US-01 (2)	2
US-N2-FF	Comprises US-N1-CL + inspection of cast and wrought materials.	not implemented	
US-N2-S1	Comprises US-N1-CL + inspection of butt welds in plates with $t \geq 15mm$ + circumferential butt welds in pipes with $t \geq 15mm$ and ∅ext $\geq 220mm$ (∅ nominal ≥ 8") + longitudinal butt welds in pipes $t \geq 15$ mm and ∅ext $\geq 508mm$ (∅ nominal ≥ 20").	US-22 (1) US-07 (1)	6.5
US-N2-S2	Comprises US-N2-S1 + inspection of butt welds in plates with $6mm \leq t < 15mm$ + circumferential butt welds in pipes with $6mm \leq t < 15mm$ and ∅ext $\geq 220mm$ (∅ nominal ≥ 8") + longitudinal butt welds in pipes with $6mm \leq t < 15mm$ and ∅ext $\geq 508mm$ (∅ nominal ≥ 20").	US-22 (2) US-07 (2)	13
US-N2-S2.1	Comprises US-N2-S2 + inspection of butt welds in plates with $4,8mm \leq t < 6mm$ + inspection of circumferential butt welds in pipes with $t \geq 4,8mm$ and $60mm \leq$ ∅ext < 220 mm (2" ≤ ∅ nominal < 8").	US-22 (4) US-07(2)	17
US-N2-S3	Comprises US-N2-S2 + inspection of welds in T, Y and K joints.	US-22 (2) US-07 (1) US-10 (1) US 50/51 (1)	18
US-N2-S4	Comprises US-N2-S3 + inspection of welds in joints with	US-22 (2)	16

	variable geometry cross-section (nozzles of equipment).	US-07 (1) US-17 (1)	
US-N2-S4.1	Comprises US-N2-S4 + accurate sizing and recording length and height of discontinuities (for fracture mechanics analysis purpose).	not implemented	
US-N2-G	Level 2 General, to be defined for each industrial sector.		
US-N2-AE	Comprises detailed sector specific applications.	See below	
US-N3	Those defined for Level 3 inspectors, related to Ultrasonic method. If a Level 3 inspector is required to perform activities of evaluation, interpretation of results and issue of respective reports in production activities, said inspector must be qualified as a Level 2 inspector for the intended set method/level/sub-level.		
Specific Applications of the Oil/Petrochemical and Electromechanical Industries			
US-N2-AE1	Comprises US-N2-S4 + inspection of welds in nodes of platform tubular structures.	US-22 (2) US-07 (1) US-17 (1) US-70 (1)	22
US-N2-AE2	Automated ultrasonic inspection of butt-welded straight-seam and spiral-seam pipe in the manufacture.	US-11 (1) Shop fabricated tube ∅≥12” t. ≥1/2”.	4.5



CP- US-22



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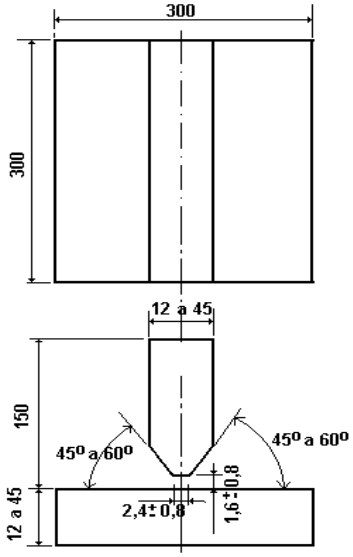

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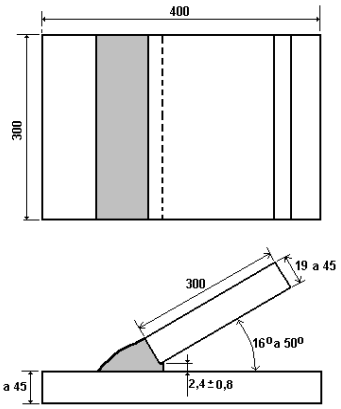
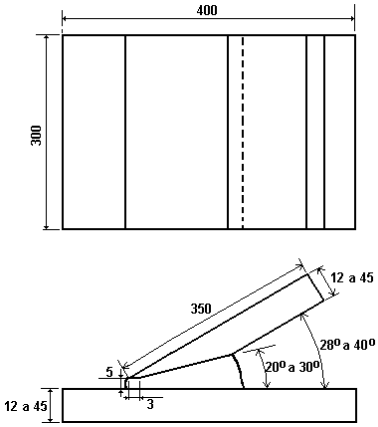


CP-US-50



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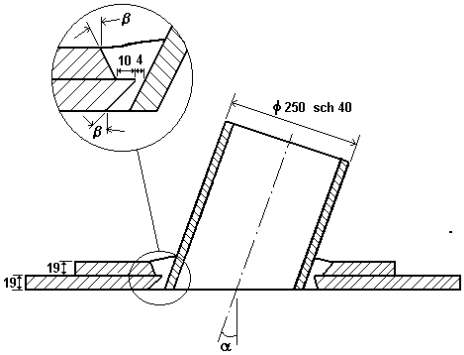
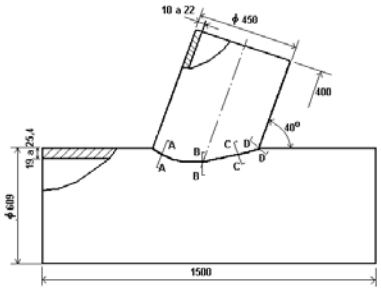
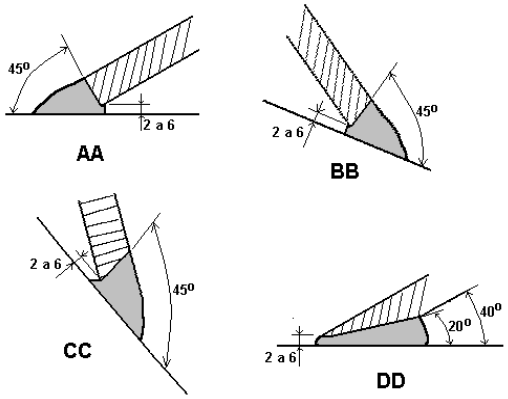


CP-US-17



CP-US-70



PETROBRAS/SEQUI Facilities - Examination Center - São José dos Campos, Brazil

PT Specimens

UT Specimens

UT Specimens - Nodes

Underwater Inspection

Dimensional Control

Visual Testing Examination

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