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ISI PERFORMANCE DEMONSTRATION DESIGNED USING THE PISC KNOW HOW

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ABSTRACT

This articles summarises aspects of the PISC Round Robin Tests, Parametric Studies and Actions related to performance demonstration of NDT techniques and procedures in view of their qualificaiton.

PERFORMANCE DEMONSTRATION

There are two main types of engineering codes and standards, those which detail the methods and procedures to be used (prescriptive) and those that define the results which must be achieved (performance standards).
The former describe in detail the means to be used by which it is hoped to ensure that the required characteristics are actually attained. Generally they describe in detail the manufacturing process or testing procedures to be followed and all the technical properties of the materials and components to be verified.
The latter type of standards limit their contents to a precise description of the characteristics which are required without describing the means that have to be used to achieve the desired result.
International organisations concerned with standardisation and codification now tend to prefer the performance type of standard to the prescriptive types of standard for several reasons. First, the standard prescribing the means may put up technical barriers to trade; secondly it may impede later technological progress by freezing technology at a given level. On the other hand performance standards avoid the problems that can arise of a prescriptive standard which in actuality does not prescribe a methodology which will, with certainty, achieve the required performance.[1]
It is therefore believed that the standards concerning results (performance standards), will grow in importance; they allow competition between companies which use their well established technologies. They will render easy harmonization at the international level.

1.The CEC/OECD Programme on the Inspection of Steel Components

The topic of performance demonstration for the qualification of inspection procedures based on NDT has already been under active study for several years [1]. Interest in it came to the fore in the early 1980's when several organisations and institutions started to propose the use of realistic training full scale assemblies and later the formal approach of Validation Centres. These steps were justified for example by the results of the PISC II [2] exercises which concluded that there was a need for performance demonstration starting with capability assessment of techniques and procedures as they were routinely applied.

General Principles of Performance Demonstration developed in PISC.

A important question is whether one can propose appropriate and affordable test pieces to be used in the procedure demonstration of the inspection techniques. Such test pieces have to contain flaws which simulate both those flaws that may commonly occur in real structures as well as those similar to limiting cases that could be imagined during actual plant inspections. One solution, which has been attempted several times [3], is to accumulate samples removed from actual structures containing real flaws; the objection to these however is that they always represent particular cases which are possibly not the worst nor the most difficult that could arise in reality. An alternative approach is to design and manufacture in realistic assemblies artificial flaws which produce the same physical phenomena as those from conservative real flaws [4]. Some advantages of this latter approach are:

- the possibility of more certain characterisation;
- the possible parametrization of the tests, including the provision of limiting cases;
- the possibility of providing guidance to experimenters for better understanding;
- the provision of non contaminated assemblies which can more easily be used for effectiveness assessment and wich can cover of more relevant selection of structural geometry and material.

To be convincing, however, this second approach must be supported by a demonstration that there is a good correlation between the artificial "realistic flaws" and a large number of real situations.
The PISC II methodology has led to considerable development in this second approach and its results have throughout been associated with this approach. The experience of PISC II showed that the introduction of these artificial "realistic flaws" in blocks and structures provides affordable and reproducible demonstration test samples (Figures 1 and 2). Mathematical models, involving a better understanding of the physical phenomena, indicate which artificial flaws can be used to replace natural ones for the validation of NDT technique and the training of inspection teams.
The concept of performance demonstration was supported by the PISC results and by the demonstration through this programme of the validity of validation assemblies.

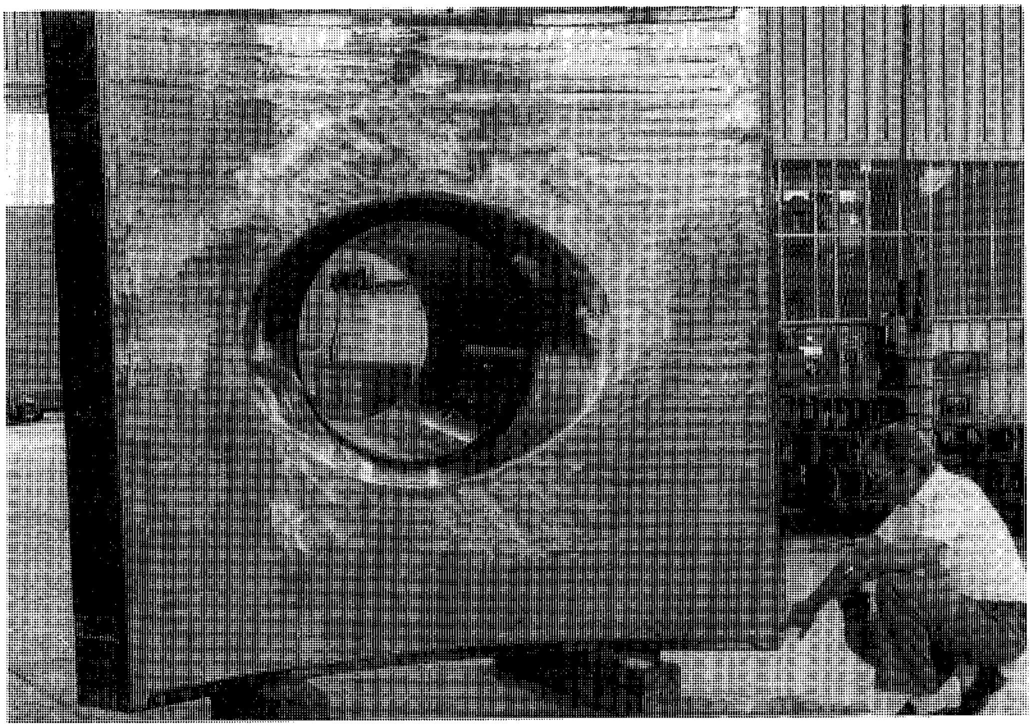


Figure 1 PISC II Assembly No. 3, PWR inlet nozzle which circulated in 14 OECD countries. This assembly, still used for inspection procedures capability assessment, contains realistic flaws simulating smooth cracks, volumetric flaws and combined flaws.

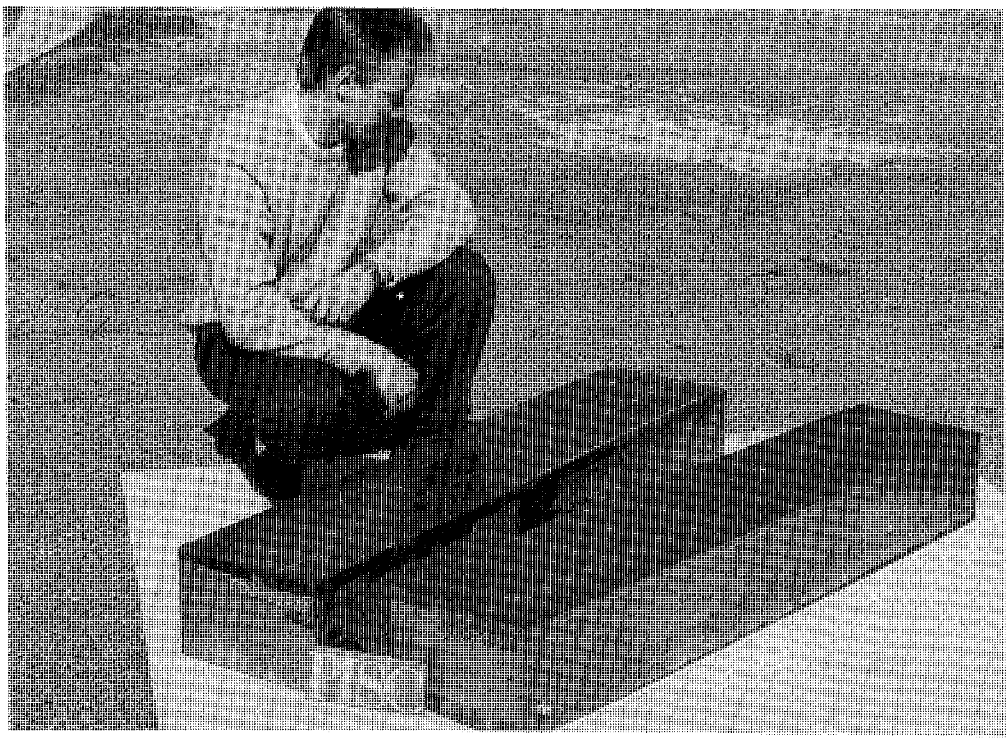


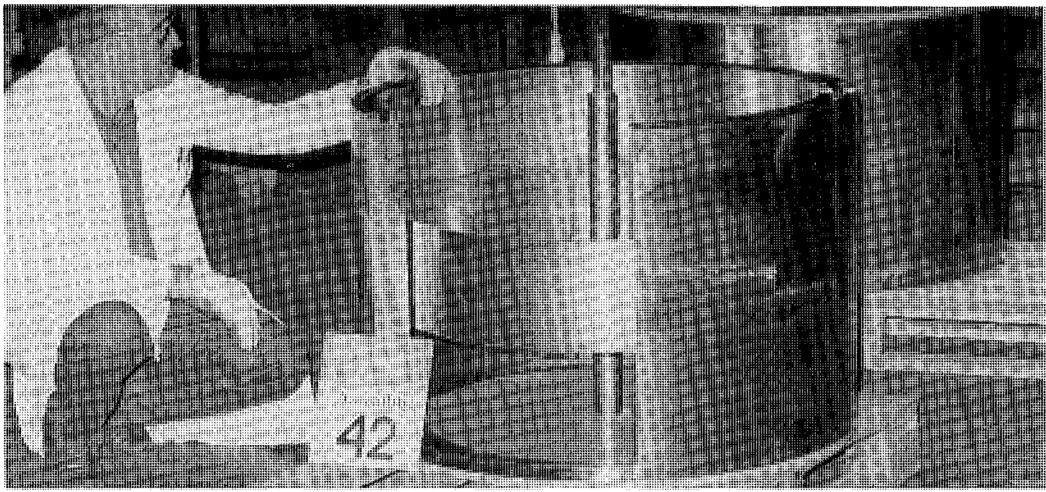
Figure 2 Parametric Studies blocks containing sharp planar flaws for NDT techniques capability evaluations.

In 1990 ASME (American Society of Mechanical Engineers) modified deeply Section XI of its Code for Pressure Vessels and Boilers, by the introduction of a new appendix "Performance demonstration for Ultrasonic Examination Systems". [5] Also in Europe, Performance Demonstration has been seen as the way to harmonize the ISI procedures without "technical dispute". JRC/IAM, Reference Laboratory of PISC, has developed, with a network of Industries and Laboratories [2] the know-how to introduce artificial realistic flaws, in preference to the real flaws that some have recommended. The advantage resulting from the PISC understanding of what has to be done for performance demonstration include the following:

- simplified performance demonstration procedures based on simple test blocks;
- large coverage of possible cases by the use of artificial realistic flaws (based on PISC knowhow) instead of only the particular cases that can be covered by real flaws;
- lower cost of assemblies by an order of magnitude;
- the possibility of using identical approaches for such performance demonstration at three levels namely; .
  . plant owner for his own verification;
  . inspection company to validate its procedure;
  licensing/regulatory authority or its agents to verify safety targets
- the possibility to develop, for example within the network of laboratories mentioned above, a long standing capability of using third parties for manufacturing blocks and flaws, combining reproducibility of repeated similar samples with confidentiality and the "double blind" approach.
- the ability to administer blind tests (e.g. how much info do you give the qualifying inspection team, how much time, what info must they provide, how to maintain confidentiality etc.) and how to interpret the results of the tests (i.e. location errors vs false calls, human errors, etc).

In several cases of performance demonstration the emphasis has to be on safety. This implies that conservative cases are important. The key to this is the ability to use "REALISTIC FLAWS" as it was shown by the Parametric Studies of PISC III [6].
The importance of the contribution of PISC to the general concepts of performance demonstration is thus not only due to capability evaluation of techniques as was done in the PISC II RRT, nor the identification of key parameters as was obtained through the PISC II parametric studies nor even to the establishment of particular values that such parameters could take. It is not only due to the reproducibility/reliability exercises as are proposed in PISC III or to the systematic comparison of particular automatic and manual techniques again being done in PISC III; it is also due to the care taken in the PISC exercises (PISC II, Round Robin Tests, PISC II Parametric Studies, PISC III Actions) to identify and to make use of the so called realistic flaws and to develop test assemblies which are simple, modular and at low cost (Figure 3) [7].

2. Present major contributors of PISC assemblies: ENSA (Spain), ANSALDO (Italy); CEA (France); EDF (France); ENEL (Italy); IVC (United Kingdom); JAPEIC (Japan); MITSUBISHI (Japan); NUCLEAR ELECTRIC (United Kingdom); UNIV of STUTTGART/MPA (Germany); BATTELLE with NRC (USA)



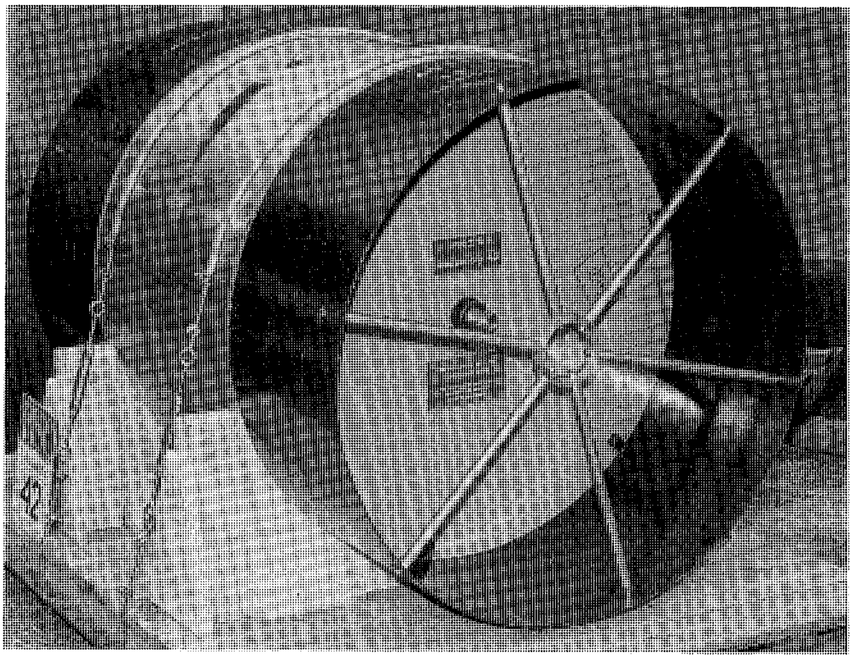


Figure 3 PISC III Assemblies 41 and 42. Modula test assemblies simulating 31" primary piping sections with welds, of different materials and containing different types of real and realistic flaws.

CONCLUSIONS

The effectiveness of NDT techniques or procedures cannot rely only on a simple performance demonstration after training on some real cases, this is partly because training on real flaws represents only particular cases and experience shows that such training does not necessarily provide the inspector with techniques of high capability.

The NDT procedure has to be validated and tested for its performance and for the reliability of its applications on structures containing flaws that, not necessarily being real ones, still induce the real physical phenomena that the inspection techniques must be able to handle.

Their reproducible introduction in blocks and structures allows affordable validation samples. Mathematical models, involving a better understanding of the physical phenomena, also indicate which artificial flaws could be used to replace natural ones for NDT techniques validation and inspection team training. It is for these reasons that PISC III has made use of real flaws to provide correlation between real and realistic flaws.
Three applications of the general principle of Performance Demonstration result from the PISC Round Robin Tests:

A. Use of thick steel section blocks containing well specified realistic flaws to verify the capability of inspection techniques for thick walled pressure vessels.
B. Certification of heat exchanger tubes inspection with eddy current testing or ultrasonic testing. The various flaws tested during the PISC RRT are suitable for the evaluation and verification of the inspection techniques capability for corrosion flaws.
C. Piping testing certification or thin walled pressure vessel inspection certification:

Application C on piping and simple vessels is very general. It would provide the industrial welding industry with a simple tool for the "Harmonization" of inspection codes and standards and thus would be a real contribution for the availability of European standards concerning the replacement of components. Similarly in many cases of piping, pipe welds, piping components like elbows, sections, penetrations, nozzles and in most cases of valve casings, simple pressure vessels, the PISC RRTs have shown how to fabricate realistic simple assemblies which would properly simulate difficult industrial inspections in view of inspection qualification.
Such assemblies containing realistic artificial flaws are also ideal samples on which inspection procedures can be optimised and personnel can be trained so as to reach the necessary performance with a reduced number of techniques and therefore a reduced inspection effort.

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