Can Non-Destructive Testing (NDT) do the job?

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1. Introduction:

This paper is not a technical one but where the principles and philosophies, as outlined, are applied, it can have a major improving technical impact on the outputs that can be achieved from NDT.

The intent is to detail the evolution of NDT within a major industry (Eskom power generation) in a fast developing previous third world ranked country (Republic of South Africa) at a stage when the assured supply of electricity has played an essential role, and still does, in this development. To date the author is not aware of any major incident/loss being ascribed to failure of NDT when the NDT is applied in this framework. However, there are a number of incidents, with quite substantial financial and supply losses, where incorrect, ineffective NDT has failed to help avoid the catastrophic failure, when it should have done so. This does not imply that the process is a guarantee, but that circumstantial evidence seems to validate the approach used.

2. Can NDT do the job?

To try and answer the title question it is imperative to define what the job description for NDT is. There have been a variety of descriptions including,

- crack testing,
- flaw finding,
- code acceptance etc

all of which could be used within strictly defined limits, which are usually omitted or not mentioned, which then provides a clear negative answer to the titled question.

This state of affairs has been verified by a myriad of trials, which have demonstrated a success rate as low as 6% defect detection. These results are factual, despite the howls of protestations about unfair samples and configurations etc from the NDT industry when presented with the condemning evidence.

These results were achieved by erstwhile highly skilled and experienced NDT personnel and companies with respected personal qualification, including CSWIP, PCN, SAQCC, DGZFP, and Cofrend. However it is interesting to note that discussions around these complaints have noted that if the industry had cared to fully report their data and evaluation process they would undoubtedly have had much greater success. Their crass ignorance of the impacts of limitations and often pomposity in not considering and declaring these limitations were their biggest errors.

Towards this end Eskom have come up with a definition of the job of NDT after many years of discussion and frustration. These are now standardized in an Eskom Standard and are grouped in the following categories:

i. Code specified NDT
ii. Non code specified non specific NDT application
iii. Specific NDT application.

Each of these has different qualification parameters as briefly described below.

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2.1 Code specified NDT

Code specified NDT relates to NDYT performed as part of normal construction to for examples codes like ASME V111, BS EN 5500, AD Merckblatt. Here an Eskom approved NDT Company, with an NDT level 111 as a prerequisite, using approved NDT procedures and personnel, simply applies the code and some additional Eskom (Client) requirements. Normal ISO 9000 quality control and assurance should provide adequate quality levels.

At this stage Eskom accepts that the code NDT requirements have been qualified by performance of the plant constructed to these codes to date. There is reasonable circumstantial evidence that this is valid. Arguments regarding the amount of risk involved include such factors as

- the use of professional designers,
- the use of professional original equipment manufacturers (OEM),
- the use of qualified welding processes applied by qualified welders,
- adequate quality control during welding and
- the use of an ISO 9000 Quality Assurance system

are all used to reach this conclusion. There however is a plan to check this validity in the future overall concept of qualified NDT.

One very important Eskom requirement, which has proved to be invaluable, is the logging of all NDT data from indications (flaws) at +/-50% reject level rather than the old completely useless format of "no defects found at time of test". NDT operators/technicians do not make a call on accept/reject on the job although they are expected to give their opinion/recommendation.

Within this framework a 70+% delectability of "defects" is expected and should not cause concern, unless the designers have been irresponsible with safety margins and Quality Assurance has failed. Each extra 5% NDT delectability required will probably double the NDT costs and would swiftly render NDT cost ineffective. The missing margins are made up through the quality assurance of the items.

2.2 Non code specified non specific application of NDT:

This category applies to e.g. generator retaining rings (CRR), turbine shafts and general condition monitoring. Currently pipe work in Eskom, which was designed to original code criteria, is inspected to these criteria with the 50% recording level and some specialization and focussing of staff and concentration on areas of highest engineering concern.

The off site review of all the NDT data also plays a significant role in having a overall picture of what the NDT is telling Eskom about the plant rather than an individual focus on one small item.

Thus far this has not fared too badly, but has had some scares where the vigilance and quality assurance measures have been ignored and/or relaxed.

The other items have all been supplied by OEM's but there are no relevant NDT standards and criteria. These items are being inspected for overall current condition without any proof that there is any major degradation actually present.

Due to the fact that Eskom is now entering a region of using plant past its original design life, this aspect of NDT is becoming more and more relevant and very important. If there is an OEM technique - note that these are often light years behind current technology - this is assessed as to the likelihood of detecting flaw dimensions that could be problematic to the continued safe use. Here fracture mechanics, metallurgy etc is integrally involved in determining what dimension, location, and mechanisms are essential to be avoided. If the original technique is still valid it will generally be applied and where no changes are noted the item is generally given a limited safe use periodicity until next intervention (inspection, scrap or repair). If not then a new technique is assessed and applied, with the NDT expected to provide an 80% + flaw size probability of detection, and with additional safety factors added to compensate for the probable misses. This can be increased with exponentially increased cost and has to be catered for prior to NDT becoming cost ineffective and should be mitigated by more engineering knowledge regarding likelihood of existence of the flaw. This approach is necessary due to the unknowns involved in using this plant beyond original design life.

It is extremely important that the OEM and other utitilities using this plant correspond regularly on the findings. This is not always evident as some OEM's take this as interference and unwarranted querying of their abilities but evidence to date suggests it is vital that this process is followed as their use of NDT is often well short of the engineering expectations. Here high level NDT and other engineering disciplines must work together. The actual NDT process will use fairly general good practice principles with some specifics added.

2.3 Specific Application of NDT

The third category is generally involved with recovery after failures either on own plant or on other utilities with similar plant. There will hopefully be precise definition of the flaw to be avoided and very specific techniques applied to detect this with pretty much 100% effectiveness.

Here one enters the areas of diversity (different techniques) and redundancy (independent repeats) to assure maximum delectability. As failures are hopefully rare the amount of supporting data available is somewhere between zero and completely inadequate, but following a qualified NDT process from first principles, can often come up with adequate results for engineering assessments.

At this time it is extremely important to note that NDT is a part of the engineering assessment of the item and does not/cannot stand on its own. When the latter has been tried it has always failed to perform adequately. If we want professionalism and adequacy in NDT then NDT must act professionally within the engineering umbrella.

Even where there are specified NDT criteria, as in construction codes, it is always inherently understood that these are allied to the overall engineering Quality Assurance of the item. Do not accept or reject items on NDT reports, unless you are a qualified NDT individual with engineering responsibility for the plant. If not, it is the duty to simply report findings, adding that these are acceptable or rejectable according to the code NDT criteria.

Additionally note the use of the term flaw rather than defect. Where NDT is used to find defects it is being applied much too late and will fail, whereas the term flaw allows some error inherent in the NDT process and will generally provide value and effectiveness for further accurate assessment.

Now that we have established the job of NDT how can this be achieved?

3. How can NDT do the job?

The route that has been followed within Eskom will be outlined. As above this, to date, has provided reasonable improving NDT quality. It is not yet complete, will probably never be, and is not without problems. However, it has kept Eskom running and is being transferred into other RSA industries simply because it appears to work and is the best currently available.

In the mid-80's Eskom was in a new build mode with most of the NDT under the responsibility of manufacturers. The personnel mix would have been some 50% overseas, carrying out the "important" functions with 50% local assisting these or carrying out the less "important" work. The only method that would have had a higher local content was radiography generally due to laziness and in some cases, rare due to subsequent findings, concerns on safety and health.

The NDT quality was not good nor was it assured. However, the manufacturers and their processes were fairly competent. At this time The Late Mr. H. W. Coe (Professional Quality Assurance) had been appointed as the Eskom representative on the newly formed South African Qualification and Certification Committee (SAQCC) and must be recognised by NDT for his extremely important role. Additionally Mr C. Smallbone, Director of the South African Institute for Welding (SAIW), who drove and hosted the SAQCC needs to be mentioned as a champion for quality NDT. The intent was to take all the vocational engineering disciplines to a better competency level through independent certification. On hind sight they did make one mistake in adding certification. The process should have been left at qualification. NDT along with welding and corrosion was included.

Eskom had been running an NDT approval system based on limited competency due to the variability in the American Society for Non-destructive Testing, Inc (ASNT) SNT-TC-1A-type scheme being applied at that time. Before moving on it is imperative to understand the SNT-TC-1A scheme initiated in 1966, when applied as intended, was the first, is the basis of all others, and is still the best NDT certification scheme. The intended application was within the American Society of Mechanical Engineers (ASME) code in a manufacturing scenario, where the manufacturer took full responsibility for the quality of the product until final destruction/scrapping. In the American system, faults that occur later in life are still the responsibility of the manufacturer where his work caused the problem. In this scenario there is a great likelihood that they would assure the quality of any NDT involved in this process. However, with the outsourcing of NDT to pure supply companies, the responsibility ended when the cheque was cashed. This led to greed, with the connivance of qualified but unethical NDT L111's, to an absolute disgraceful abuse of SNT-TC-1A.

The examples set by initial Certification Scheme for Weldment Inspection Personnel (CSWIP) were used by the SAQCC. Under Mr. Coe's advice Eskom scrapped their internal approval examination and used the SAQCC route. Despite some reservations and arguments this succeeded and immediately caused an improvement in the NDT quality. Within five years almost all Eskom NDT supply was provided by these SAQCC qualified personnel.

During this period these knowledgeable personnel came to realize that they were far short of assured quality due to completely inadequate documentation and the control of same. It could be argued that this should have been done first but circumstances didn't allow for this luxury and the absence did cause better awareness. If one asked for the quality control document for personnel one normally got presented with a 1984 version of SNT-TC-1A. On pointing out the only "shall" in the document i.e. the requirement for a written practice, the only response was a question of why Eskom was being awkward and information that they had ASME approval for many jobs. The personnel certification existed of a document informing that the individual had attended an NDT course of some length and had successfully completed an examination. Any queries regarding the validity of the certificate and assurance that it had covered the company's needs, as detailed in their written practice, elicited similar responses.

Fortunately the knowledge imparted in the SAQCC process had made some of the better technicians aware of the need for well controlled documentation for personnel certification and the actual application of the techniques. Eskom made these mandatory along with the personnel qualification within their NDT approval system. Many companies became more aware of this by working at Eskom's nuclear site at Koeberg which had to have these controls, as part of their licensing agreements and the need for the local industry to take up the slack caused by the departing overseas personnel.

There was also a major financial boost with the arrival of offshore gas and overseas aid incorporated in the project which funded SAQCC and the allied SAIW NDT training. This documentation process took another five years to complete but also raised awareness for the need for NDT Level 111's within the industry.

4. Conclusion:

Where companies installed and maintained control over quality documentation and practices, and where NDT is performed as part of the engineering responsibility for the operation of plant, and where the NDT technicians are clear what they are employed for and what is expected of them, and where equipment and procedures have been reviewed and approved by the engineering team, and where NDT data is recorded in line with the procedures, and where NDT reports and results are reviewed off-line to obtain an overall picture of plant condition, i.e. where all these factors together are considered and applied, then NDT can do the job!

Thank you.