Non Destructive Testing Of Materials Subject To Atmospheric Stress Corrosion Cracking

**Martin VAN DALEN ¹, Craig WICKER ²,
Graham .J. WILSON ²**

¹ Southern African Institute of Welding, Johannesburg, South Africa

Phone: +27 11 836 4121, Fax: +27 11 836 4132, E-mail: vandalenm@saiw.co.za

Web: <http://www.saiw.co.za>

² Eskom, Cape town, South Africa

E-mail: Craig.Wicker@eskom.co.za, GrahamJ.Wilson@eskom.co.za

Abstract

In-service inspection revealed atmospheric stress corrosion cracking (ASCC), on 304L stainless steel piping. The method requiring inspection qualification was a surface method, namely Penetrant Testing as physical dimensions of the smallest flaw requiring detection by PT was ill defined for both pitting and cracking defects. Qualification was considered in terms of flaw volume together with absolute flaw linear dimensions. Inspection qualification would therefore determine the adequacy of the applied technique by both physical reasoning and by empirical measurement to determine the largest flaw that could escape detection.

Keywords: Atmospheric Stress Corrosion Cracking, Detection by Liquid Penetrant Inspection

Introduction

During the life of any industrial plant it may be necessary to perform routine In-service inspection on critical systems. In-service inspection in the context of this paper is considered to be “Examinations and tests conducted periodically to demonstrate structural integrity and/or operability of components important to safety”.

In one such example, In-service inspection revealed atmospheric stress corrosion cracking (ASCC), on 304L stainless steel piping that forms part of a very important safety system and resulted in a very intensive investigative program and a major repair and replacement project.

Certain aspects of the piping degradation required that the inspection system be assessed for effectiveness. This measurement of inspection effectiveness is commonly called “Performance Demonstration” in North America and “Inspection Qualification” in Europe. Unusually, however, the method requiring inspection qualification was a surface method, namely Penetrant Testing

What is Atmospheric Stress Corrosion Cracking (ASCC)?

Stainless steel was discovered in the early 20th century. It was found that iron, when alloyed with chromium was resistant to some acids. The effect of variations in the concentration of chromium in an iron matrix was studied. It was found that chromium at a concentration of at least 10, 5% is required to make the iron matrix corrosion resistant or ‘stainless’^[1].

One of the difficulties associated with the production of low concentration chromium stainless steel was the level of carbon in the steel. The carbon needed to be lower than 0.15%, however, there were difficulties in reducing it to below this level.

Only in the early 20th century when low carbon ferrochrome could be produced, did industrial stainless steel production begin. One of the first commercially produced stainless steel products was cutlery, which was manufactured from grade 430, which is still used today.

Stainless steel is however, not 'stainless' or corrosion resistant in all applications. It was found that stainless steel could experience a number of forms of corrosion, e.g., crevice corrosion, pitting or stress corrosion cracking (SCC). SCC could occur when three conditions are met ^[2];

Susceptible material,

Application of a tensile stress,

Introduction of a contaminant in an electrolyte.

These three conditions are extremely broad, in that a material that may ordinarily be non-susceptible to SCC may in fact degrade if either the tensile stress or the contaminants are increased to significantly high levels.

Elevated temperature has often been considered to be a pre-requisite for SCC, but this not generally the case.

Of the stainless steel family of materials, it is the austenitic grades that are susceptible to SCC in the standard range of industrial applications^[3]. The austenitic stainless steels have a nominal chemical composition of 18% chromium, 8% nickel with the balance being iron. The carbon content is usually in the range of 0,02 to 0,08% depending on the application. Alloying elements are added to improve the corrosion resistance of the steel, i.e., molybdenum, titanium or nitrogen.

Molybdenum is added to increase the pitting and crevice corrosion resistance and titanium is added to improve SCC resistance.

The stress component is the effective tensile stress inherent in the material and applied as a result of service or installation. The cumulative tensile stress is the sum of the tensile stresses that exist as a result of residual stress from:

The material forming operations,

Welding,

The system or component internal pressure,

The dead weight of the component.

The residual tensile stresses are a significant proportion of the total stress, and where the material has not received a suitable stress relieving (solution annealing) heat treatment, the material becomes significantly susceptible to SCC.

The susceptibility of a stainless steel to SCC is primarily a function of its threshold stress intensity factor, K_{ISCC} . Below the threshold, SCC will not initiate^[4]. The stress intensity factor of a material is a measure of the effect of a flaw on the propensity for a crack to initiate and propagate. The K_{ISCC} for austenitic stainless steels such as the basic 304L (18Cr-8Ni) is small and as such SCC can initiate from very small flaws. The high residual tensile stresses exacerbate the stress intensity factor resulting in the small defects initiating SCC.

These defects can be as small as the surface roughness of the 'as-delivered' rough surface of wrought plate or pipe, or superficial scratches, or corrosion pits.

The susceptible material and the tensile stress in combination with a contaminant result in SCC. Contaminants can accumulate in the surface discontinuities (scratches, excessive surface roughness) and in combination with an electrolyte, can acidify. The acidification results in a rapid reduction in pH which causes a highly corrosive solution which initiates pitting. Pitting propagates through the material, but since the stress intensity factor for alloys like AISI 304L is low, only small, shallow pits are required to initiate SCC. The SCC then propagates multi axially, but typically perpendicular to the principal tensile stresses. This crack propagation may not result in the appearance of surface breaking defects, however, there may be significant sub-surface cracking which penetrates the internal surface of the material. The cracks may continue to propagate until the external surface is also breached and a through wall leak may occur^[5].

In the 1970s, SCC of austenitic stainless steels in immersed conditions was considered to be temperature dependant with a threshold or critical temperature of 80° to 100°C^[6].

In the 1990s, this threshold was lowered to 50°C. However, in more recent years, SCC has been detected at even lower temperatures and in environments that could be considered to be dry. It must however be noted that dryness is a term relative to experience of SCC in immersed conditions (RH of 100%). In this case, the SCC is a function of the relative humidity (RH) of the environment, where SCC has been shown to occur at RHs as low as 40%.

SCC occurs as a result of the interaction of susceptible material, tensile stress and electrolyte. Temperature does not play a role in the susceptibility of a material to SCC, but rather the kinetics and hence the rate of propagation. In this case, high concentrations of chlorides and a high relative humidity initiated pitting that, combined with high residual tensile stresses in the austenitic stainless steel, resulted in the initiation of trans-granular stress corrosion cracking (TGSCC). TGSCC occurs where halides above threshold concentrations contaminate a material and initiate at surface anomalies, e.g. pits, mechanical damage, rough manufacturing surface finish. TGSCC can occur at a range of temperatures, but propagation is generally governed by an Arrhenius temperature relationship where increasing temperatures lead to significant increases in propagation rates.

As such, TGSCC is a form of SCC, but there is no true distinction between SCC and ASCC. ASCC is a term that has been used to describe a phenomenon associated with SCC that has initiated at temperatures that are lower than expected. Furthermore, it has occurred as a result of exposure to the external atmosphere and not a service or process fluid.

Inspection Back ground

During construction and during the first few years after being placed into service, the 304 L stainless steel piping considered in this paper was generally exposed to a humid coastal air atmosphere.

In addition to the piping being exposed to the costal atmosphere, the piping concerned was manufactured from cold rolled $\approx 5\text{mm}$ to $\approx 8\text{mm}$ plate having one continuous longitudinal seam weld. As the piping was not annealed high residual stresses were present in the piping.

After several years in-service a general discoloring and light pitting was noted on the pipe-work although routine Penetrant Testing (PT) of the pipe circumferential welds revealed no significant anomalies. Routine in-service inspection of these relatively thin-wall austenitic piping butt welds being restricted to PT on the external surfaces of the circumferential butt weld and approximately 20mm of the intersecting longitudinal seam welds.

Penetrant Testing General Principles^[7].

The PT technique for the inspection of the stainless pipe-work welds considered was developed in accordance with The American Society of Mechanical Engineers Section V “Non Destructive Examination” Article 6 “Liquid Penetrant Examination” The code allows for PT to be undertaken by, visible or fluorescent solvent and water-washable methods or by post emulsifiable methods.

A common industrial PT application, with medium to high sensitivity to discontinuities, is the visible (colour contrast) solvent method and was the one adopted for routine inspection. The inspection technique considered amongst other things:

1) Surface preparations

- i) In general, satisfactory results may be obtained when the surface of the part is in the as-welded, as-rolled, as-cast, or as forged condition. Surface preparation by grinding, machining, or other methods may be necessary where surface irregularities could mask indications.
- ii) Prior to each liquid penetrant examination, the surface to be examined and all adjacent areas within at least 1 in. (25mm) shall be dry and free of all dirt, grease, lint, scale, welding flux, paint, oil, and other extraneous matter that could obscure surface openings or otherwise interfere with the examination.
- iii) Typical cleaning agents, which may be used are detergents, organic solvents, descaling solutions and paint removers. Degreasing and ultrasonic cleaning methods may also be used.
- iv) PT consumables shall meet specific requirements for the control of contaminants for liquid penetrant examinations on austenitic stainless steels e.g. chlorine and fluorine contents.

- v) When examining austenitic stainless steel all PT materials shall be analyzed individually for chlorine and fluorine contents. The fluorine and chlorine contents shall not exceed 1% of residue by weight.

2) Drying after preparation

After cleaning drying of the surfaces to be examined shall be by normal evaporation or with forced hot or cold air. A minimum period of time shall be established to ensure that the cleaning solution has evaporated prior to the application of the penetrant.

3) Standard temperatures

When using the standard liquid penetrant technique the surface temperature of the penetrant and the surface of the part to be process shall not be below 60° F (16° C) nor above 125° F (52° C) throughout the inspection period. Local Heating or cooling is permitted provided the part temperature remains in the range of 60° F to 125° F (16° C to 52° C) during the examination. The examination at lower or higher temperature range requires specific qualification.

4) Penetrant application

The liquid penetrant may be applied by any suitable means such as dipping, brushing or spraying. Brushing in this instance was the preferred method.

5) Penetration dwell times

Penetration dwell time is critical. The minimum required penetration time for austenitic stainless steel welds when inspecting for lack of fusion, porosity and all forms of cracks is 5 minutes. The minimum required penetration time for austenitic stainless steel extrusions, forgings and plate when inspecting for all forms of cracks is 10 minutes, or as qualified by demonstration for a specific application.

6) Excess penetrant removal

After the specified penetration time has elapsed, any penetrant on the surface is removed taking care to minimize removal of penetrant from discontinuities. Excess solvent removable penetrant shall be removed by wiping with a cloth or absorbent paper, repeating the operation until most visible traces of penetrant have been removed. The remaining traces shall be removed by lightly wiping the surface with cloth or absorbent paper moistened with solvent. To minimize removal of penetrant from discontinuities, care shall be taken to avoid the use of excess solvent. Flushing the surface with solvent following the application of the penetrant and prior to developing is prohibited.

7) Drying after excess penetrant removal

For solvent removable technique, the surface may be dried by normal evaporation, blotting, wiping or forced air. In this instance normal evaporation was the preferred method.

8) Developing

The developer is applied as soon as possible after penetrant removal. The minimum required development time for austenitic stainless steel welds, extrusions, forgings and plate to detect lack of fusion, porosity and all forms of cracks is 10 minutes. Insufficient developer coating thickness may not draw the penetrant out of discontinuities, whilst conversely excessive coating thickness may mask indications. With colour contrast penetrant only a wet developer shall be used.

Non-aqueous developer shall be applied only to a dry surface and is applied by spraying except where safety or restricted access precludes it. Under such conditions, developer may be applied by brushing. Drying shall be by normal evaporation. Developing time for final interpretation starts as soon as the wet developer coating has dried. In this instance the developer was sprayed on with the use of aerosol spray cans.

9) Interpretation

The Final interpretation shall be made within 7 to 30 min after the requirements as mentioned above are satisfied. If the penetrant bleed-out does not alter the examination results, longer periods are permitted. If the surface is large enough to preclude complete examination within the prescribed or established time, the examination shall be performed in increments.

With a colour contrast penetrant, the developer forms a reasonably uniform white coating. Surface discontinuities are indicated by bleed-out which is normally a deep red colour that stains the developer. Indications with a light pink colour may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult. Adequate illumination is required to ensure adequate sensitivity during the examination and evaluation of indications, typically 1000 Lux.

10) Post examination cleaning

Post examination cleaning of the penetrant material is required and is conducted as soon as practical after evaluation and documentation of the examination results using a process that does not adversely affect the part (e.g. solvent remover/cleaner). Normal practice is to undertake post examination cleaning by flushing the test item with solvent removers in the case of solvent penetrants.

11) Documentation

ASME V requires documentation/ records to be in accordance with the referencing code section. Whilst ASME V article 6 1992 has no specific requirements the following information would need to be recorded as per company procedure requirements which is also reflected in ASME V Article 6 2001 edition.

- Type of indication i.e. rounded or linear
- Location and extent i.e. length, diameter or aligned
- Procedure reference
- Penetrant consumables identification
- Operator identity and level of qualification
- Map or record of indications
- Materials and thickness
- Lighting equipment
- Date and time of examination

Note: In the case under consideration given the area and numbers of flaws detected it would have been impractical to have measured and dimensioned each flaw, therefore, clear acetate sheets were placed over the item during the interpretation period and all flaws were drawn directly onto the acetate sheets with a 'permanent' marker.

Inspection Investigation

Over time a series of small pinhole leaks were observed on the subject piping, and although a large sample of pipe-work was re-inspected, including lengths of the piping base material, nothing untoward was revealed other than the presence of general “surface pitting”.

Photograph 1a Pinhole leak detected

As initial and subsequent PT failed to detect any major discontinuities subsequent investigation was undertaken and this revealed that immediately beneath the pitted surface of the pipe-work an extensive network of ASCC existed.

Photograph 1b ASCC originating from the bottom of pitting

Photograph 1c ASCC detected by PT

The following observations were made:

- 1) During replication, the linear indications generated by the ASCC were noted beneath the pitted surface, starting at a depth of $\approx 250\mu\text{m}$ and extending extensively into the pipe wall.
- 2) From this discovery, it was concluded that the ASCC flaws initiated at the base of the pits without readily propagating to the outer (inspection) surface. From this discovery, it was concluded that all affected pipe-work should be polished to remove a surface layer of $250\mu\text{m}$.
- 3) Further investigative work in the form of inspection qualification would be undertaken so that optimum PT results could be obtained.

Inspection Qualification (Performance Demonstration)

As physical dimensions of the smallest sought flaw requiring detection by PT was ill defined for both pitting and cracking, qualification was considered in terms of flaw volume (pitting) together with absolute flaw linear dimensions (cracking). Inspection qualification would therefore determine the adequacy of the applied technique by both physical reasoning and by empirical measurement (experimental practical trials) to determine the largest flaw that could escape detection.

1) Flaw Description

Pitting is confined to the external surfaces of the pipe-work and can be observed visually without the aid of penetrant inspection. Pitting may occur at any location on the pipe-work (including welds), with varying degrees of severity and distribution.

Atmospheric stress corrosion cracking has been revealed on the external surfaces of the pipe-work, however this flaw has also been detected 'subsurface'. Atmospheric stress corrosion cracking may occur at any location (including welds) and may adopt any orientation. Atmospheric stress corrosion cracks may be individually discrete or occur as part of a 'network' of cracks.

Photograph 2a A network of ASSC after replication

As penetrant inspection is a surface inspection technique all indications detected will be considered to be relevant discontinuities, until proved otherwise.

Photograph 2b ASSC detected on weld toe and in parent material

2) Qualitative Detection Capability

The ability (ease) with which a penetrant fluid will enter a surface discontinuity is aided, or resisted, by several combined properties. Generally, the most important properties affecting the ability of a penetrant fluid to enter a surface flaw are surface tension (cohesiveness) and wetting ability (flow resistance) ^[8-9].

i) Surface Tension

Fluids have the ability to move, flow or change shape and will readily assume the shape of their 'container'. Broadly, liquid penetrant molecules are free to move (flow) relative to one another, however they are also held in close proximity to each other by the cohesive forces in the liquid.

The tendency for the surface area of a liquid to 'contract' to minimum values is a measure of the surface tension (cohesiveness) of the liquid penetrant and this resists the attractive capillary forces drawing the liquid penetrant into a surface flaw.

ii) Wetting Ability

Wetting ability (flow resistance) can be measured in terms of 'contact angle'. Fluids with a high surface tension and low wetting ability contract to produce droplets with high contact angles.

Typically, water has a high surface tension together with a poor wetting ability, which hence produces a high contact angle between the fluid droplet and a typical solid surface. With the addition of a wetting agent, the contact angle is reduced, producing a satisfactory penetrant material, ie a fluid with a high surface tension but with a low contact angle.

Figure 1 Penetrant Properties

Therefore, in a general sense, the measure of any fluids contact angle is the best indication of the potential penetrability of a liquid probing medium. Typically, inspection penetrant fluids have contact angles $<10^\circ$, (and very close to 0°).

Note: Strictly, the measurement of contact angle is not restricted solely to the fluid medium, as the material, surface, surface finish etc are also influential.

iii) Interaction At The Triple Point Interface

One further important consideration affecting the ability of a penetrant fluid to enter a surface flaw are the interactions at the triple interface region (liquid, gas and solid) within the flaw itself.

As the penetrant fluid infiltrates the volume of the flaw, the air within the flaw cannot escape through the surface layer of the liquid penetrant, and the entrapped gas is subsequently compressed into a smaller region (near a crack tip for instance).

Further penetrant ingress continues until the surface energies reach equilibrium, where the net capillary and surface wetting forces are counter balanced by the entrapped gas pressure.

This can be expressed simply thus:

$$P = 2S \cos \theta / W$$

Where

P = Capillary pressure

S = Surface tension

θ = Equilibrium contact angle of the liquid penetrant

W = Crack width

With long duration penetrant dwell time it is possible that the entrapped gas may dissolve into the penetrant fluid and diffuse out to the surface and thus escape.

Equally, the above formula indicates that for a flaw with varying 'widths', the forces generated will be greater at narrower sections driving the gas towards the wider sections. Such actions may explain the ability of penetrant liquids to enter almost any flaw.

iv) Visibility of Penetrant Indications

Provided flaws are open to the inspection surface and are not filled with contaminants, or other extraneous soils, which block the passage of the penetrant liquid, there is no physical reason why penetrant should not enter a flaw. It is reported in literature that flaws with openings smaller than 1µm are sufficiently wide enough to allow for the ingress of penetrant.

An important aspect affecting reliability of detection is the visibility of penetrant indications.

The penetrant developer serves two functions; firstly as a medium to facilitate reverse capillary of the penetrant, and secondly to provide a high contrast background against which the red penetrant stain is viewed. Contrast ratios for colour contrast visible penetrant are estimated to be in the order of 10:1 to 20:1, (which is the theoretical maximum contrast obtainable).

Penetrant experiments on glass plates clamped together have shown that penetrant can enter openings of 130nm, however whether flaws with such a small volumetric area contain sufficient entrapped penetrant to be visible later (by reverse capillary action) is a determinant of the reliability of detection

3) Empirical Detection Capability

Studies performed have empirically derived the minimum simulated flaw size that can be detected with the applied penetrant technique. Simulated flaws were either “rounded” (pitting) or “linear” (cracks).

i) Rounded Flaws (1)

A $100\text{mm}^2 \times 5\text{mm}$ thick ASTM 304L plate was prepared, containing six $0.8\text{mm} \varnothing$ drilled holes at varying depths of 0.3mm, 0.6mm, 0.9mm and through wall (see figure 2).

The drilled holes are an approximation of pitting flaws, the diameter being fixed at 0.8mm as this is the smallest drill size obtainable at time of the experiment.

The $0.8\text{mm} \varnothing$ through wall holes were countersunk by a $1\text{mm} \varnothing \times 1\text{mm}$ deep hole as an approximation of a pit connected to a crack.

Figure 2 Test Piece 1 Simulated Rounded Flaw Details

ii) Rounded Flaws (2)

A second $100\text{mm}^2 \times 5\text{mm}$ thick ASTM 304L plate was prepared, containing three $1.0\text{mm} \varnothing$ and three $1.5\text{mm} \varnothing$ drilled holes at varying depths of 0.3mm, 0.6mm, 0.9mm and through wall (see figure 3).

Figure 3 Test Piece 2 Simulated Rounded Flaw Details

iii) Linear Flaws

A series of similar stainless blocks containing continuous 0.1mm wide EDM notches at varying depths of 0.2mm, 0.4mm, 0.6mm, 0.8mm, 1.0mm and 1.2mm were prepared so that flaw lengths of 2mm, 4mm and 6mm could be studied (see figure 4).

The desired flaw length was achieved by sealing the continuous notch with mastic.

Figure 3 Test Piece Simulated Linear Flaw Details

4) Detection Capability Results

The fabricated samples were inspected in accordance with ASME V, Article 6 1992 All inspection parameters were kept similar to those during site inspections (i.e. dwell times, temperatures, etc).

i) Rounded Flaws

The detection capability for rounded flaws is given in Table 1 (see photographs 3a and 3b).

Rounded Flaw Detection Results			
Diameter	Depth	Volume	Inspection Result
0.8mm Ø	0.3mm	0.150mm ³	Not Detected
	0.6mm	0.301mm ³	Not Detected
	0.9mm	0.452mm ³	Detected
1.0mm Ø	0.3mm	0.235mm ³	Detected
	0.6mm	0.471mm ³	Detected
	0.9mm	0.706mm ³	Detected
1.5mm Ø	0.3mm	0.530mm ³	Detected
	0.6mm	1.06mm ³	Detected
	0.9mm	1.59mm ³	Detected

Table 1 Detection Results

Photograph 3a 0.8mm Ø Detection

Photograph 3b 1.0mm & 1.5mm Ø Detection

ii) Linear Flaws

The detection capability for linear flaws is given in Table 2a to 2c (see photographs 4a to 4c).

Linear Flaw Detection Results			
Length	Depth (W width x D Depth)	Volume	Inspection Result
2mm	0.1mm W x 0.2mm D	0.040mm ³	Not Detected
4mm	0.1mm W x 0.2mm D	0.080mm ³	Not Detected
6mm	0.1mm W x 0.2mm D	0.120mm ³	Not Detected

Table 2a Detection Results 0.2mm Depth

Photograph 4a 0.2mm TTD

Linear Flaw Detection Results			
Length	Depth (W width x D Depth)	Volume	Inspection Result
2mm	0.1mm W x 0.4mm D	0.080mm ³	Detected
4mm	0.1mm W x 0.4mm D	0.160mm ³	Detected
6mm	0.1mm W x 0.4mm D	0.240mm ³	Detected

Table 2b Detection Results 0.4mm Depth

Photograph 4b 0.4mm TTD

Linear Flaw Detection Results			
Length	Depth (W width x D Depth)	Volume	Inspection Result
2mm	0.1mm W x 0.6mm D	0.120mm ³	Detected
4mm	0.1mm W x 0.6mm D	0.240mm ³	Detected
6mm	0.1mm W x 0.6mm D	0.360mm ³	Detected

Table 2c Detection Results 0.6mm Depth

Photograph 4c 0.6mm TTD

5) Reliability Of Detection

Reliability studies performed during the Nordtest NDT Programme (on 133 specimens containing 635 flaws of various types) are summarised in Table 4a and 4b: ^[10].

Probability of Detection (Flaw Depth)	
POD	Depth
0.2	0.5mm
0.6	1.0mm
0.7	2.0mm
0.8	3.0mm
0.85	4.0mm
0.9	5.0mm

Table 4a POD Flaw Depth

Probability of Detection (Flaw length)	
POD	Length
0.2	2.0mm
0.56	5.0mm
0.6	7.5mm
0.62 ¹	12mm
<i>Note¹ POD does not improve with greater flaw length</i>	

Table 4b POD Flaw Length

Whilst details regarding penetrant method, samples and technique are not revealed it is apparent that POD values show a greater sensitivity to flaw depth rather than length. The round robin report concluded with; ‘coloured chemicals’ gave the most reliable results when all types of surface flaw have to be detected.

Reliability of detection is influenced largely by human performance factors, however these issues were not analysed.

6) Flaw Detection Summary

The largest rounded (pitting) flaw to escape detection by penetrant inspection is 0.8mm Ø x 0.6mm depth. This flaw has a volume of 0.301mm³.

If flaw volume alone is considered a 1.0mm Ø x 0.3mm (0.235mm³) is detectable. Therefore it is empirically derived that flaws with volumes $\geq 0.310\text{mm}^3$ will always be detected.

The largest linear (crack) flaw to escape detection was 6mm long x 0.2mm deep notch. Based upon the study, flaw length was least influential in detection capability. Flaws at 0.4mm depth, regardless of length, are always detected.

Conclusions

Theoretical Studies Conclude The Following:

- Penetrant probing fluids have the ability to enter almost any surface breaking flaw.
- Colour contrast penetrant indications are highly visible.

Practical Studies Conclude The Following:

- The largest rounded flaw escaping detection is 0.8mm Ø x 0.6mm deep.
- The largest linear flaw escaping detection is 6.0mm long x 0.1mm wide x 0.2mm deep.
- Flaws diameter was seen to be a key determinant for detection of rounded flaws.
- Flaw depth was seen to be a key determinant for linear flaws.
- International studies reveal Probability of Detection (POD) values are sensitive to flaw depth.

General conclusion

During routine In-service inspection on critical systems it is important to know, what the critical flaw sizes are, which needs to be detected. The only way to ensure that critical flaws are not going undetected is by performance demonstration. Performance demonstration is not only a measure for the detection of flaws it is also demonstrate that the inspection can provide information to show structural integrity and operability of important safety components.

Whenever any of the conditions for potential ASCC are present investigate and ensure the component integrity.

Observation

Reliability of detection is influenced by human performance factors however these issues are beyond the scope of this paper.

Abbreviations

ASCC – Atmospheric Stress Corrosion Cracking
SCC – Stress Corrosion Cracking
TGSCC – Trans-Granular Stress Corrosion Tracking
PT – Penetrant Testing
ASME – American Society of Mechanical Engineers
ASTM – American Society for Testing of Material
AISI – American Iron and Steel institute
EDM – Electrode Discharge Machining
POD – Probability of Detection.
RH – Relative humidity

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