CP25 – ANNEX A - GENERAL SPECIFICATION FOR VISUAL TESTING

This document is intended for use during PCN Visual Testing training and examination for the Level 2 Sector Specific Practical instruction writing and Level 3, Part C written procedure, until such time as a national, European or international standard giving guidance in this area is published.

1.0 SCOPE

This specification contains methods and minimum requirements for visual testing of cast, wrought or fabricated items, including metallic and non-metallic materials for use in general engineering or aerospace applications. Visual testing in accordance with this specification may be carried out during manufacture, on final inspection or in-service to detect undesirable discontinuities. Stage of inspection shall be subject to agreement by contracting parties.

2.0 DEFINITIONS

Terms and definitions shall be as defined in Section 12 of the Non-Destructive Testing Handbook - Second Edition, Volume 8 entitled “Visual and Optical Testing”.

3.0 RESPONSIBILITY

The responsibility for conducting visual tests shall be that of the owner. The owner being the manufacturer until the said item is sold.

The owner shall ensure safe working environments for visual testing personnel to conduct examinations. Areas of hazard shall be strictly legislated by safe working codes and maximum exposure limits.

Hazardous areas may constitute employment of remote inspection techniques.

4.0 QUALIFICATIONS

Personnel working in accordance with the minimum requirements of this specification shall be currently certified to an internationally recognised scheme in the specific discipline related to product form and industrial sector.

Visual acuity shall be a minimum of Snellen 20/30 for general testing and Snellen 20/20 for critical testing.

5.0 PROCEDURE

A written procedure shall be prepared by the NDT Level 3 to include at least the following:-

I. Stage of testing
II. Type of surface condition
III. Cleaning instructions
IV. How the test is to be performed
V. Illumination technique and measurement of illumination
VI. Sequence of performing the test
VII. Data to be tabulated
VIII. Check list for testing
IX. Report forms
X. Permanent records - if any
XI. Specialised equipment if required for hazardous areas
The written procedure shall define scope of coverage and may be limited to specific tasks.

The procedure shall contain a reference report form and a check list to prompt inspectors during surveillance of the test area. The checklist shall include all facets related to the specific surface examination and may be used to verify that the required observations were performed.

6.0 PROCEDURE QUALIFICATION

The written procedure shall be proven by demonstration that a fine artificial flaw of 0.7mm wide or less can be detected utilising the techniques stated therein.

The artificial flaw shall be included into a sample with representative surface texture and accessibility constraints of that requiring examination during production or in-service.

Information as to the location of artificial flaws shall not be divulged to personnel conducting procedure qualifications tests.

Failure to locate artificial flaw locations may constitute revision of techniques outlined in the procedure.

A fully documented report of procedure qualification shall be maintained for verification by third parties.

7.0 DIRECT VISUAL TESTING

Direct visual testing may usually be made when access is sufficient to place the eye within 600mm of the surface to be examined. The visual angle between plane of vision and surface being tested shall not be less than 30°. Mirrors may be utilised to improve the angle of vision.

Magnification aids may be employed for critical work between 2X and 10X magnification. General purpose testing should not be conducted with magnification levels above 5X.

Illumination of the test surface shall be 500 lux minimum for general examinations and 1000 lux minimum for critical work. Illumination shall be verified by a calibrated photometer. Positioning of a light source determines illumination levels. With increase in distance from source to test surface the intensity is decreased obeying the inverse square law. Calculation of expected illumination levels can therefore be determined by:

\[ E = \frac{I}{d^2} \]

where:

- \( E \) = Illumination in lux
- \( I \) = Luminous intensity of source
- \( d \) = Distance between source and point

Angulation of the light source to the test surface decreases intensity of illumination.

Illumination at the surface for an inclined source can be calculated using the Lambert Cosine Law.

\[ E = \frac{I}{d^2} \cos \theta \]

8.0 REMOTE VISUAL TESTING

Remote visual testing personnel shall demonstrate Snellen 20/20 vision or better. Use of remote visual testing equipment is often dictated by environmental factors and restricted access. Procedures that adopt remote vision techniques shall prove suitability by simulated trials. Records shall be maintained for third party scrutiny from all performance trials.

Illumination levels may be reduced for orthicon tube cameras. Chip cameras require higher illumination levels. Remote testing in very high radiation fields shall be conducted with Vidicon tube cameras.

Data storage on video tape using conventional VCR machines is prohibited. High resolution VCR machines with a minimum of 500 line horizontal resolution may be used.
9.0 TRANSLUCENT VISUAL TESTING

Translucent visual testing is a supplement of direct visual testing. The method is based upon back lighting of a translucent material to aid examination of such material for internal and surface flaws. Light sources used shall be sufficiently diffused as to prevent glare obscuring fine detail. Light sources should have adjustable intensity for adaptation to changing sessions or material structures.

10.0 NON-METALLIC MATERIALS TESTING

Ceramics, laminates, polymers and composites require specific attention to observe impact damage. Surface deformation may not always be evident and use of alcohol or dye being swabbed across the test surface to aid visual detection will be mandatory. Caution must be taken to ensure such chemicals do not degrade the test item. Specialist advice is recommended prior to application.

11.0 APPLICATION

Analysis of profile and topographical features may be required. Silicone rubber replication can be used where flexibility is required. Cellulose acetate tape shall be used for fracture surface replication due to the superior resolution achieved.

12.0 ALTERNATIVE METHODS OF TESTING

Ambiguous indications may warrant supplementary test techniques. Suitability of such tests shall be determined by the NDT Level 3.

13.0 EVALUATION

All tests shall be evaluated in terms of the acceptance criteria of this specification. Where specific detail is not included in the acceptance criteria then agreement between contracting parties shall be required. All observations outside acceptable limits shall be reported with reference to location and dimensional position.

14.0 REPORTS

A written report shall be completed by the person(s) conducting the tests. The report shall include:-
   I. Component identity
   II. Stage of manufacture
   III. Surface condition as found
   IV. Illumination level
   V. Type of light source
   VI. Specialised equipment used
   VII. Flaw locations
   VIII. Datum points used
   IX. Complementary NDT methods advised
   X. Statement of compliance/non-compliance
   XI. Acceptance criteria used
   XII. Name and qualification details of person conducting test
   XIII. Date of test
   XIV. Signature of person conducting test

15.0 RECORDS

Records of tests shall be held on file for a period of five years. Access to all documentation shall be made available to contracting parties and any designated third party.

16.0 ACCEPTANCE CRITERIA

The acceptance criteria is sub-divided into the following product forms:-
   Cast components
   Wrought components
   Fabricated components including welding
   Non-metallic components
16.1 Acceptance Criteria - Cast Products
The following shall not be acceptable:-
- Cold shuts exceeding 5mm in length
- Cracks/tearing of any length
- Porosity/blow holes exceeding 1mm diameter individually or grouped exceeding 25mm² surface area
- Areas of sink/concavity exceeding 1mm deep with length exceeding 15mm
- Surface breaking shrinkage cavities
- Non-metallic inclusions exceeding 3mm in length
- Any severe condition limiting complete testing due to contamination, incomplete fettling, corrosion or heavy grinding, chisel marks, arc strikes shall be reported for remedial action prior to completion of the test.

16.2 Acceptance criteria - Wrought Components
The following shall not be acceptable:-
- Cracks of any length
- Laps exceeding 5mm in length
- Bursts of any length
- Seams, stringers or rokes exceeding 5mm in length
- Laminations exceeding 5mm in length
- Non-metallic inclusions exceeding 3mm in length
- Blisters of any length
- Exfoliation of any length shall be reported for further investigation by complementary NDT methods.

16.3 Acceptance Criteria - Fabricated Components including Welding
The following shall not be acceptable:-

16.3.1 Welded fabrications

16.3.1.1 General
- Angular distortion/misalignment exceeding 1.5mm in any 100mm length
- Undercut exceeding 0.5mm deep with length exceeding 2mm
- Concavity/underflushing of the weld reinforcement or root penetration in excess of 1mm deep x 5mm long
- Cold overlap/lack of fusion in excess of 3mm length
- Lack of penetration exceeding 3mm long
- Weld reinforcement (cap height) in excess of 3mm high x 10mm long
- Excess root penetration in plate butt welds plate exceeding 2mm height x 5mm length.

16.3.1.2 Butt welds in pipe

Penetration of root bead:

<table>
<thead>
<tr>
<th>nominal size of pipe (I/D)</th>
<th>max penetration in bore*</th>
<th>max restriction in bore*</th>
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<tbody>
<tr>
<td>mm</td>
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<td>mm</td>
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<td>&lt; 12</td>
<td>1</td>
<td>1.5</td>
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<td>1.5</td>
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<td>5</td>
</tr>
<tr>
<td>&gt;99</td>
<td>3</td>
<td>6</td>
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</table>

* Values rounded to nearest 0.5mm
Porosity: Individual pores exceeding 1mm diameter or grouped porosity in excess of 25mm² surface area.

Inclusions exceeding 3mm long
Spatter exceeding 3 pieces in any 50mm length
Detectable cracks are not permitted regardless of length

16.3.1.3 Fillet welds
Fillet weld leg length and throat thickness sizes shall be +/- 10% of the nominal contract drawing size
Any severe condition such as contamination, oxidation or heavy grinding, chisel marks, arc strikes and undressed tacks, that limits complete examination shall be reported for remedial action prior to testing.

16.3.1.4 Bolted fabrications
The following shall not be acceptable:-
Visibly loose nuts
Absence of washers under nuts
Absence of bolts from holes
Bolted joints where less than one full bolt thread protrudes through a nut
Bolts that do not seat flat for at least 75% of head area
Nuts or bolts with severe mechanical damage
Cracked nuts or bolt heads

16.3.1.5 Riveted fabrications
The following shall not be acceptable:-
Incompletely formed rivets
Lack of protrusion or through wall penetration
Visibly loose rivets
Absence of rivets
Cracked rivets
Severe mechanical damage to rivets and adjacent material
Evidence of fretting wear

16.4 Acceptable Criteria - Non-Metallic Materials
The following shall not be acceptable:-
Cracks exceeding 2mm in length
Delamination exceeding 10mm² area
Inclusions exceeding 2mm² area
Voids exceeding 2mm in length
Impact damage shall be reported regardless of length for further investigation by complimentary NDT methods