



CERTIFICATION SCHEME FOR WELDING AND INSPECTION PERSONNEL

DOCUMENT No. CSWIP-WI-6-92

Requirements for the Certification of Visual Welding Inspectors, Welding Inspectors and Senior Welding Inspectors (fusion welding)

These requirements supersede the previous issue and shall be effective from 1 June 2000

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CSWIP is administered by TWI Certification Ltd
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Accreditation Certificate No 25

FOREWORD

The Certification Scheme for Welding and Inspection Personnel (CSWIP) is a comprehensive scheme which provides for the examination and certification of individuals seeking to demonstrate their knowledge and/or competence in their field of operation. The scope of CSWIP includes, all levels of Welding Inspectors, Welding Supervisors, Welding Instructors and Underwater Inspection personnel.

CSWIP is managed by the Certification Management Board, which acts as the Governing Board for Certification, in keeping with the requirements of the industries served by the scheme. The Certification Management Board, in turn, appoints specialist Management Committees to oversee specific parts of the scheme. All CSWIP Boards and Committees comprise member representatives of relevant industrial and other interests.

The requirements governing Registration of Visual Welding Inspectors, Welding Inspectors and Senior Welding Inspectors are detailed in a separate document: CSWIP-WI-1-91. Success in the appropriate CSWIP examination is one of the prerequisites of Registration.

Registration is strongly recommended as it helps to satisfy the CSWIP certificate renewal requirements, see Clause 4.5.1

ACCESS TO CERTIFICATION

Access to certification schemes is not improperly restricted. The sole criteria for certification are given in the document (and any subsequent amendments) and no other criteria will be applied. Certification is not conditional on the candidate applying for other services or membership from TWI Certification Ltd, its parent, or any other groups or associations.

1 GENERAL

1.1 Scope

This document prescribes procedures by which personnel may be examined, and, if successful, certificated for the duties of Visual Welding Inspector, Welding Inspector or Senior Welding Inspector, as defined in Clause 1.2. This document does not purport to cover personnel who do not have the responsibilities defined in Clause 1.2. The examinations are primarily intended for fusion welded steel construction, but endorsements are available for other material groups.

There are recognition arrangements between TWI Certification Ltd and two other Welding Inspector Certification Schemes: The American Welding Society - Certificated Welding Inspector and the Southern African Institute of Welding - Welding Fabrication Inspector. Persons possessing qualification(s) in these schemes may be allowed exemptions from part of the CSWIP examination(s).

This Scheme is not normally intended to apply to engineers or engineering surveyors concerned with the total certification of the plant.

1.2 Responsibilities of personnel

Typical areas of work activity of personnel for whom CSWIP welding inspector qualifications would be suitable are given below:

1.2.1 Visual Welding Inspectors (under the supervision of a Welding Inspector or Senior Welding Inspector)

- a) Codes and standards
Application of the requirements of codes and standards.
- b) Parent material identity
Verification against documentation and markings of correctness of parent material.
- c) Welding consumables identity
Verification of correctness of welding consumables (electrodes, filler wires, consumable inserts, gases, fluxes etc).
- d) Pre-weld inspection
Verification that dimensions, fitup and weld preparations are in accordance with the engineering drawings.
- e) Preheating
Verification that preheat (where required) is in accordance with specified procedures.
- f) Post weld visual inspection
Visual inspection and dimensional check of completed weldment against specification requirements and drawings.
- g) In-process welding surveillance
Surveillance during welding to verify compliance with specified procedure including any preheat, interpass temperature control and post heat requirements.

1.2.2 Welding Inspectors

Those given above plus:

- h) Supervision of Visual Welding Inspectors in the conduct of activities (a) to (g) above.
- i) Welding procedures
Establishing that a procedure is available, has been approved as required by the appropriate authority and is being employed in production.

- j) Witnessing of welder and procedure approval tests
Witnessing the preparation of test pieces and destructive tests, and verifying compliance with appropriate standards and specifications.
- k) Welder approvals
Verification that adequate and valid welder approvals are available, and that only approved welders as required are used in production.
- l) Post weld heat treatment
Verification that post weld heat treatment has been conducted in accordance with specification requirements.
- m) NDT reports
The study and understanding of NDT results on any welding work for which the welding inspector is responsible.
- n) Reports
Preparation of inspection reports.

1.2.3 Senior Welding Inspectors

Those given above plus:

- o) Supervision of Welding Inspectors and Visual Welding Inspectors in the conduct of activities (a) to (n) above as appropriate.
- p) Certification of compliance
Final acceptance and certification that the requirements of the specification have been met.
- q) Weld drawings
Interpretation of weld drawings and weld symbols.
- r) Interpretation of weld radiographs
Interpretation of weld radiographs is often the responsibility of the Senior Welding Inspector although interpretation itself may be undertaken by other suitably qualified personnel.
- s) Records
Maintenance of comprehensive inspection records.
- t) Weld defects
Appreciation of the factors influencing the formation of weld defects and their acceptability in relation to the written specification.
- u) NDT results
Assessment of NDT reports on welding work for which the senior welding inspector is responsible.

- v) **Quality assurance**
Ensuring that quality assurance standards and procedures are maintained.

1.3 Requirements prior to taking a certification test

Job responsibilities and experience criteria for examination eligibility as given below are strictly adhered to and enforced.

1.3.1 Visual Welding Inspector

Candidates are expected to have an engineering background and to have successfully completed an approved course of training on visual inspection of welds.

Mature candidates who satisfy the criteria given in the second paragraph of 1.3.4 may also be accepted.

1.3.2 Welding Inspector

Welding Inspector for a minimum of 3 years with experience related to the duties and responsibilities listed in Clause 1.2.2 under qualified supervision, independently verified.

or

Certificated Visual Welding Inspector for a minimum of 2 years with job responsibilities in the areas listed in 1.2.1 and 1.2.2 above.

or

Welding Instructor or Welding Foreman/Supervisor for a minimum of 5 years.

1.3.3 Senior Welding Inspector

Certificated Welding Inspector for a minimum of 2 years with job responsibilities in the areas listed in 1.2.1, 1.2.2 and 1.2.3 above.

or

5 years' authenticated experience related to the duties and responsibilities listed in Clause 1.2.3, independently verified.

1.3.4 Training

All candidates (with the exception of 'mature candidates,' see below) must attend a CSWIP approved course of training at the appropriate level prior to examination. Details of such courses are available on request.

A mature candidate route offering exemption from formal training is available for candidates for Visual and Welding Inspector who are able to demonstrate at least five years' recent continuous experience in welding inspection duties as indicated in Clauses 1.2.1 and 1.2.2.

If a mature candidate is unsuccessful in the examination, it will be necessary to undertake an approved course of training before retaking it (also see Clause 4.3).

1.3.5 Health/eyesight

Candidates need to be in satisfactory physical condition and the person completing the application form will be required to signify that the candidate's health and eyesight are adequate to enable him/her to carry out his/her duties.* An eyesight test certificate must be submitted with the application form.

2 EXAMINATION PROCEDURE

2.1 Visual Welding Inspector and Welding Inspector Certification

The examination procedure for the Visual Welding Inspector consists of only a practical examination and candidates must satisfy the examiner in all parts (see 2.1.3a). Details of the examination format and syllabus are given in Appendix 1.

The examination procedure for the Welding Inspector consists of written, oral and practical examinations. Please refer to Appendices 1 and 2 respectively for details of the examination format, syllabus and specimen questions.

2.1.1 Written examination

The written examination consists of both multiple choice and narrative questions and is designed to test the candidate's knowledge of the syllabus.

2.1.2 Oral examination

The oral examination will be used to supplement the written examination and will cover the same subject matter. It will normally consist of a discussion with the examiner during the practical tests.

2.1.3 Practical examination

Candidates will be required to inspect and report on the following:

- a) At least two completed welds for compliance with stated requirements and, in addition, for the Welding Inspector grade only

*Unaided or corrected near visual acuity in at least one eye shall be such that the candidate is capable of reading N4 Times Roman type at a distance of not less than 30cm on a standard reading test chart.

- b) A set of destructive tests (macros, bend or fractured fillet) for a welder or procedure approval test intended to comply with a stated specification.

2.2 Senior Welding Inspector Certification

Candidates who do not already hold a Welding Inspector certificate must also complete the full Welding Inspector examination in addition to the procedure outlined below.

2.2.1 Written examination

This consists of a series of narrative questions covering the syllabus.

2.2.2 Oral examination

The oral examination will be used to supplement the written examination and will be of the same form as in 2.1.2 above but will concentrate more on QA, health and safety and man management aspects.

2.2.3 Practical examination

In addition to the requirements of Clause 2.1.3 above, candidates will be required to:

- a) Scrutinise and comment on three inspection related documents.
- b) Examine and report on two separate weld failures associated with defects
- c) Scrutinise and interpret a fabrication drawing
- d) Interpret at least 6 weld radiographs (candidates already possessing a valid CSWIP or PCN Radiographic Interpreter (Welds) certificate will be exempted from this part). Different metal Groups can be selected, see Appendix 1 and Appendix 3.

2.3 Endorsement examinations

Holders of the Welding Inspector or Senior Welding Inspector certificate may take endorsement examinations at any time during the validity of their certificate.

The Endorsement examinations are available for two groups of materials:

- Aluminium and its alloys
- Stainless and high alloy steels
- Nickel alloys
- Reactive metals

For each group, the Endorsement examination is of the multiple choice type and is intended to test the candidate's knowledge of the materials, their weldability and causes and types of defect, see Appendix 1. These Endorsements are not related to the different metal Groups which may be selected for radiographic interpretation.

There is no specific training requirement prior to taking an Endorsement examination but potential candidates are strongly encouraged to undergo refresher training if they have doubts about their knowledge of the appropriate syllabus, see Appendix 1.

2.4 Application for examination and fees

Candidates will be required to submit an application form and a CV. All the information requested must be on these forms. No applications can be considered confirmed until receipt of correctly completed documents. Application forms ask for specific details of experience and training and must be signed to the effect that these details are correct.

In the event of a false statement being discovered on forms or on CVs any examination undertaken will be declared null and void. A certificate is automatically invalidated if there are any outstanding examination fees in respect of that certificate.

Examinations may be taken at any one of a number of Test Centres in the UK and overseas. Lists are available on request.

3 CATEGORIES OF CERTIFICATION

Candidates may apply for one of the three following certification categories:

- 3.0 Visual Welding Inspector
- 3.1 Welding Inspector
- 3.2 Senior Welding Inspector

For the 3.1 and 3.2 grades, endorsements are available for aluminium and its alloys, stainless steels, nickel alloys and reactive metals.

4 CERTIFICATION

4.1 Results Notices

All candidates will be sent a results notice. This notice will also be sent to the organisation paying the examination fee, if not paid by the candidate.

4.2 Successful candidates

Two copies of a certificate of proficiency will be issued to the organisation or person that pays the examination fees. Duplicate certificates to replace those lost or destroyed will be issued only after extensive enquiries.

4.3 **Unsuccessful candidates**

Candidates who fail to obtain a certificate may attempt one retest on those parts of the examination in which success was not achieved. **The retest must be completed within one year of the initial examination**, otherwise candidates will have to repeat the complete examination.

The retest, (or complete re-examination) may not be taken within 30 days of the previous examination.

4.4 **Period of validity**

The certificate is valid for five years from the date of completion of the initial test and may be renewed for a further five years on application, provided evidence is produced in accordance with Clause 4.5.1. Certificates are only valid provided:

- a) they are within date.
- b) they are on standard cream CSWIP paper bearing the CSWIP logo in black on gold signed by an officer of CSWIP and embossed with the CSWIP stamp.
- c) they have been signed by the individual to whom the certificate is awarded.
- d) they are accompanied by a valid official CSWIP identity card.

Success in endorsement examination(s) does not affect the period of validity of the certificate.

Photocopies are unauthorised by CSWIP and should only be used for internal administrative purposes.

4.5 **Renewal**

4.5.1 **Five year renewal**

In order for the certificate to be renewed after five years, the holder has to demonstrate that he/she has maintained his/her competence by:

- i) providing evidence of continuous work activity in welding inspection
- ii) providing evidence that the holder has kept up to date in welding technology.

If the certificate contains Endorsement(s), work experience covering the material group(s) concerned will be required.

One way of satisfying Part (ii) is by Registration (see document CSWIP-WI-1-91). Part (i) can be satisfied by submitting a log sheet of relevant work activity covering the period of validity of the certificate. Requests for the appropriate documentation should be made to TWI Certification Ltd at Granta Park, Great Abington, Cambridge only.

The certificate will not be renewed without further test if an authenticated complaint is received by the Governing Board during the period of its validity. Further instruction and retest may then be required.

Renewal must take place not later than 21 days after the date of expiry. It is the certificate holder's responsibility to ensure that renewal takes place at the appropriate time. Only under extreme circumstances will certificates be renewed up to a maximum of six calendar months from the date of expiry shown on the certificate and late renewal will be subject to a special fee.

4.5.2 **Ten year renewal**

Certificates are renewed beyond ten years from the initial examination (or from a previous ten year renewal) by the holder successfully completing a renewal examination prior to the expiry of the certificate in addition to the renewal procedure given in Clause 4.5.1. Requests for the appropriate documentation should be made to TWI Certification Ltd at Granta Park, Great Abington, Cambridge only.

The 10 year examination will consist of the following:

Multi choice written paper and, if appropriate, additional papers relating to any endorsement(s) held.

Practical visual inspection of a plate or pipe butt weld

Note: A **Senior Welding Inspector** will in addition be required to take Interpretation Group A (ferritic steels) or an alternative metal group of his/her choice, see Appendix 1 and Appendix 3, unless a separate, recognised, qualification is held by the candidate. Interpreter certification in other material groups is also available, see Appendix 1.

One retest, within 4 months of the 10 year renewal examination, will be allowed.

Failure by a **Welding Inspector** at the retest point will mean that the candidate **must** take the full course and initial examination again to regain the qualification.

A **Senior Welding Inspector** who fails at the retest point:

- a) multi-choice paper and/or plate/pipe will be required to take the full 3.1 and 3.2 courses and Initial examinations to regain the qualification.
- b) Interpretation Group A: can be awarded a Grade 3.1 certificate. To regain the 3.2 certification it would be necessary to take the Interpretation course followed by the interpretation part of the 3.2 examination within four (4) months of the retest. After this point no retest is allowed.

4.6 Complaints and appeals

An aggrieved party in a dispute which considers itself to have reasonable grounds for questioning the competency of a CSWIP qualified person may petition the Governing Board for non-renewal of the certificate. Such a petition must be accompanied by all relevant facts, and if in the opinion of the Board an adequate case has been presented, a full investigation of the circumstances under dispute will be initiated. If the petition is substantiated to the satisfaction of the Board, the certificate will not be renewed without further test.

Appeals against failure to certify or against non-renewal of the certificate may be made by the inspector or the employer upon application in writing to the Governing Board.

4.7 Supplementary tests

4.7.1 3.1 Welding Inspector

Candidates for Welding Inspector who already possess a valid Visual Welding Inspector certificate will be required to undertake the full Welding Inspector examination, with the exception of the plate inspection.

Certificates issued as a result of successful completion of the examination will supersede any previous Visual Welding Inspector certificate. Such certificates will be valid for five years from the date of the examination.

4.7.2 3.2 Senior Welding Inspector

Candidates for Senior Welding Inspector who already possess a valid Welding Inspector certificate and/or a valid CSWIP or PCN Radiographic Interpreter certificate for any metal group will be required to undertake a supplementary test.

Certificates issued as a result of successful completion of the supplementary test will incorporate any previous Welding Inspector certificate but any previous Radiographic Interpreter certificate will still be separately held.

5 RECORDS

TWI Certification Ltd maintains records of successful and unsuccessful candidates. These records are accessible to the Governing Board or its nominees at all reasonable times.

ADDRESSES

For further general information contact:

TWI Certification Ltd
Granta Park
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Cambridge CB1 6AL

Phone: +44 (0) 1223 891162
Fax: +44 (0) 1223 894219
E:mail: twicertification@twi.co.uk

For specific information on examinations and tests and arranging for them to be carried out, contact the approved Examining Body:

TWI Training and Examinations
Granta Park
Great Abington
Cambridge CB1 6AL

Phone: +44 (0) 1223 891162
Fax: +44 (0) 1223 89163
E:mail: trainexam@twi.co.uk

TWI on the WWW: <http://www.twi.co.uk>

CERTIFICATION SCHEME FOR WELDING AND INSPECTION PERSONNEL

**CERTIFICATION OF
VISUAL WELDING INSPECTORS,
WELDING INSPECTORS AND
SENIOR WELDING INSPECTORS**

APPENDICES TO DOCUMENT NO CSWIP-WI-6-92

Appendix 1:	Examination Syllabus
Appendix 2:	Specimen Written Examination Questions
Appendix 3:	Radiographic Interpreter (Welds) Syllabus

APPENDIX 1: EXAMINATION SYLLABUS

1 Visual Welding Inspector

1.1 Examination format

Practical Part A1: Inspection of a plate or pipe butt weld to a code provided by the Test Centre. Time allowed 1hr 45 minutes.

Practical Part B1: Inspection of a T-joint fillet weld (not fractured) to a code provided by the test centre. Time allowed 1 hour 15 minutes.

Passmark for all parts is 70%.

1.2 Subjects

Candidates will need to demonstrate their knowledge of:

- a) **Codes and Standards**
The make-up of typical application standards.
- b) **Terminology**
Welds, joints, weld face, toe, root, throat, leg length, HAZ, fusion boundary.
Terminology for defects.
- c) **Materials** – Inspection points
 - Size: thicknesses, lengths, diameters
 - Type: grade, composition against documentation
 - Condition: cleanliness and surface for welding
 - Heat treatment condition and distortion
- d) **Welding processes**
Basic features of manual and mechanised flux shielded and gas shielded arc processes, gas welding and electroslag welding.

The identification of weld defects due to misuse or malfunction of processes.
- e) **Consumables**
The identification of consumables to British, European, ISO and American standards.

Coating types and fluxes. Shielding gas compositions. Electrode and filler wire compositions.

The storage and drying of electrodes and fluxes, matching consumables (electrodes with shielding gases, electrodes with fluxes).

- f) **Visual examination and dimensional checking before and after welding**
Weld preparations and fit-up. Dimensions and shape of finished welds.
Defects. Code requirements.
- g) **Identification of pre-heat**
Application and control
- h) **Safety**
Health and safety requirements and practices.

2 **Welding Inspector**

2.1 **Examination format**

- | | |
|--------------------|--|
| Theory Part A2: | General Welding Theory and Product Technology
30 multiple choice questions. Time allowed 30 minutes. |
| Theory Part B2: | Specific Welding Technology.
4 questions from 6. Time allowed 1hr 15 mins. |
| Oral: | Specific oral based on the candidate's nominated code* plus
general welding questions. |
| Practical Part A2: | Inspection of a plate butt weld to a code provided by the Test
Centre. Time allowed 1hr 15 mins. |
| Practical Part B2: | Inspection of a pipe butt weld to the candidate's nominated
code.* Time allowed 1hr 45 mins. |
| Practical Part C2: | Inspection of a set of destructive test samples, two of which
will be a macro and the other a fractured fillet weld or a bend
test to ISO5817/BSEN25817. |

*The candidate's nominated code requires prior approval of the Chief Examiner, see Application Standards.

Passmark for all parts is 70%.

2.2 **Subjects**

Candidates will need to demonstrate a knowledge of the Visual Welding Inspector syllabus plus:

- i) **Materials**
 - Size: thicknesses, lengths, diameters
 - Type: grade composition against documentation
 - Condition: cleanliness and surface for welding
 - Heat treatment: Condition and distortion

The effect of composition, thickness and hydrogen on welding of certain grades of steel. The techniques and control used to avoid hydrogen induced cracking and lamellar tearing.

Post weld heat treatment, its conduct and control.

j) **Welding processes**

The effect of variations in welding parameters. The influence of process on appearance and penetration, and centreline cracking. British, American and ISO symbols on drawings.

k) **Welding procedures and welder approvals and their control**

The essential features of a procedure.

British, European, American and other systems of procedure and welder approval and appropriate documentation.

l) **Quality control of welding**

The implementation of quality controls and in-process inspection. Organisation and records.

m) **Destructive tests**

The selection and purpose of all destructive tests specified in standards. Assessment of results.

n) **Non-destructive testing**

The methods, capabilities and limitations of penetrant, magnetic particle, radiographic and ultrasonic testing of parent materials and welded joints.

o) **Weld defects**

Identification of defects. Reasons for their occurrence and acceptance.

p) **Distortion**

The influence of welding techniques on distortion. The control of distortion. The influence of heat treatment and machining.

q) **Reporting**

The preparation of technical reports on all aspects of inspection referred to above.

3 **Senior Welding Inspector**

3.1 **Examination format**

Candidates who do not already hold a Welding Inspection certificate must also complete the full Welding Inspector examination in addition to the procedures outlined below:

Theory Part C3:	Specific Welding Technology (including audit question). 4 questions from 6. Time allowed 1 hour 15 minutes.
Theory Part D3:	Basic Radiographic Theory, Interpretation and Basic Radiation Safety 20 multi-choice questions. Time allowed 30 minutes.
Oral:	Man management, quality control, etc.
Practical Part A3:	Scrutinise and comment on three inspection related documents Time allowed 1 hour.
Practical Part B3:	Examination of weld failures. Time allowed 1 hour.
Practical Part C3:	Scrutiny and interpretation of a fabrication drawing. Time allowed 1 hour.
Practical Part D3:	<p>Radiographic interpretation – Certification is awarded in a number of combinations of metal groups:</p> <p>Group A: Ferritic steels including clad steels: manual metal-arc, MIG, TIG and mechanised fusion welding, oxy-acetylene welding.</p> <p>Group B: Austenitic steels and high nickel alloys (excluding Monel): manual metal arc, MIG, TIG and mechanised fusion welding. Titanium alloys: inert gas welding.</p> <p>Group C: Aluminium and its alloys: MIG and TIG welding. Magnesium and its alloys: TIG welding.</p> <p>Group D: Copper and its alloys and Monel: manual metal-arc, MIG and TIG welding.</p> <p>The possible combinations are:</p> <p>Group A (one group) Group C (one group) Group A and B (or C and D) (two groups) Group A, B and C (or D) (three groups) Group A, B, C and D (four groups)</p> <p>In each case six radiographs must be interpreted for the first Group (A or C) plus three radiographs each of any additional groups. Time allowed is fifteen minutes per radiograph.</p> <p>Candidates are also required to conduct 5 density readings and answer 5 sensitometry questions.</p>

Additional examinations may be taken at any time to expand the number of Groups held.

Passmark for all parts is 70%.

3.2 Subjects

Candidates will need to demonstrate a knowledge of the Visual Welding Inspector and Welding Inspector Syllabuses given above plus:

- r) **Interpretation of weld radiographs**
In accordance with the Radiographic Interpreter (Welds) Syllabus, see Appendix 3.
- s) **Supervision of welding inspectors and record keeping**
Supervisory techniques and the duties of a supervisor including comprehensive record keeping.
- t) **Certification of compliance**
Requirements of typical contracts, codes and specifications.
- u) **NDT**
Reports of NDT results and their assessment for both volumetric and surface methods. Certification systems for NDT personnel.
- v) **Weld defects**
Factors influencing the formation of weld defects and their avoidance. Acceptability of defects in relation to written specification requirements.
- w) **Weld drawings**
The understanding and interpretation of weld drawings.
- x) **Quality assurance**
Quality assurance and quality control procedures and their implementation.

4 Endorsements

Endorsement examinations for additional material groups are available to holders of Welding Inspector and Senior Welding Inspector certificates only. The examination for each material group consists of 20 multiple-choice questions and the time allowed is 30 minutes.

The subjects for each material group are given below:

- a) Production of the alloys concerned
- b) Properties
- c) Weldability aspects of the alloy concerned by fusion welding processes
- d) Types of defects encountered in different alloys and their cause
- e) Typical applications and weld quality acceptance standards

Such endorsements are available for:

- Aluminium and its alloys
- Stainless and high alloy steels
- Nickel alloys
- Reactive metals

APPLICATION STANDARDS

The following is a list of codes, standards and specifications to which candidates for the above examinations may refer. They may be selected by the candidate or the candidate's employer.

The candidate is required to have a good working knowledge in areas relating to the welding inspector's duties of his/her chosen code, standard or specification. In addition, he/she should also be aware and in possession of any such specifications that may be cross referenced by their main application code/standard, relating to materials, consumables, welding procedure/welder qualifications, destructive and non-destructive testing, etc.

It is the responsibility of the candidate to ensure that the selected code, standard or specification is up to date, and wherever possible contains the latest amendments.

The use of any document not listed, may be permitted by contacting the Examiner responsible. In certain circumstances a copy for scrutinising may be requested before permission is given.

British

BS 1113:	Specification for design and manufacture of water-tube steam generating plant (including superheaters, reheaters and steel tube economisers).
BS 2633:	Specification for Class 1 arc welding of ferritic steel pipework for carrying fluids.
BS 2654:	Specification for manufacture of vertical steel welded non-refrigerated storage tanks with butt-welded shells for the petroleum industry.
BS 2971:	Specification for Class 11 arc welding of carbon steel pipework for carrying fluids.
BS 4515:	Specification for process of welding of steel pipelines on land and offshore.
BS 4677:	Specification for arc welding of austenitic stainless steel pipework for carrying fluids.
BS 5500:	Specification for unfired fusion welded pressure vessels.

American

ANSI/ASME B31-3 Chemical plant and petroleum refinery piping.

API 1104: Welding of pipelines and related facilities.

ASME Boiler and pressure vessel code.
Part VIII: Rules for construction of pressure vessels. Division 1.

ANSI/AWSD1.1 Structural welding code (Steel).

ABS Rules for building and classing steel vessels (American Bureau of Shipping)
Issued annually.

Any other national or international standard may also be included.

Reference Literature list: Doc No CSWIP-WI-6-92-SUP01

This document is available on request from TWI Certification Ltd.

APPENDIX 2: SPECIMEN WRITTEN EXAMINATION QUESTIONS

1 WELDING INSPECTOR

1.1 Part A1 and Part A2

Candidates are required to tick, or otherwise indicate, the correct answer in the section provided. There is only one correct answer for each question.

- 1 Applying preheat when welding carbon manganese steel is normally done to avoid:
 - a) Slag inclusions a. _____
 - b) Hydrogen cracking b. _____
 - c) Lack of sidewall fusion c. _____
 - d) Porosity d. _____
- 2 Which of the following mechanical properties of a weld in carbon manganese steel is most affected if the heat input per unit length of weld is excessively high?
 - a) Elongation a. _____
 - b) Tensile strength b. _____
 - c) Hardness c. _____
 - d) Toughness d. _____
- 3 You observe centreline cracking in a weld that has been made at one of five work stations each making similar components. The first action to take is:
 - a) Impound all welding consumables a. _____
 - b) Report the occurrence to a higher authority b. _____
 - c) Stop all welding c. _____
 - d) Call for full NDT checks d. _____
- 4 Which of the following defects is unlikely to be found by visual inspection?
 - a) Linear misalignment a. _____
 - b) Undercut b. _____
 - c) Overlap c. _____
 - d) Linear slag inclusions d. _____
- 5 Which of the following welding processes uses a resistive heating system to achieve weld metal deposition?
 - a) Manual metal arc welding a. _____
 - b) Submerged-arc welding b. _____
 - c) Electroslag welding c. _____
 - d) Resistance spot welding d. _____

- 6 Which of the following units could Charpy V notch energy be measured in?
- | | |
|----------------------------------|----------|
| a) Pounds per square inch | a. _____ |
| b) Joules | b. _____ |
| c) Newtons per square millimetre | c. _____ |
| d) None of the above | d. _____ |
- 7 The usual method of assessing the sensitivity of a radiograph is by means of a:
- | | |
|-----------------|----------|
| a) Dosemeter | a. _____ |
| b) Fluoroscope | b. _____ |
| c) Penetrameter | c. _____ |
| d) Clinometer | d. _____ |

1.2 Theory Part B1 and Part B2

Question 1 is a compulsory question for the Welding Inspector grade.

- 1 Describe your duties as a Welding Inspector, as applicable to your selected Application Standard or Code of Practice (approx. 300 words).
- 2 Sketch the cross section of a single 'U' butt joint and indicate the following features:

angle of bevel, included angle, root face, root gap, root radius.
- 3 Using weld symbols to BSEN 22553 show how the following would be indicated on a fabrication drawing:
 - a) A single V butt joint welded on the 'arrow side.'
 - b) Three intermittent fillet welds with a leg length of 8mm, the length of each weld being 25mm and the distance between each weld 50mm, welded on the 'other side.'
- 4 Describe the manual metal arc welding process and state two causes for each of the following defects:
 - a) Excessive penetration
 - b) Incomplete root fusion
 - c) Slag inclusions
 - d) Crater pipe
- 5 Distinguish between 'fused' and 'agglomerated' fluxes as used for submerged-arc welding.
- 6 Describe at least two different methods of applying preheat, and outline the checks you would conduct to verify that the treatment was in accordance with procedural requirements.

- 7 It has been necessary to remove part of a welded joint for macro examination, describe how you would prepare the specimen for subsequent examination.
- 8 Write a short account of the causes of hydrogen cracking in the welding of carbon manganese and low alloy steels. Sketch a cross section of a weld showing this type of cracking.

2 SENIOR WELDING INSPECTOR

2.1 Theory Part C3

Question 1 is a compulsory question.

- 1 You are required to visit a site on which your welding inspectors have been involved. The work concerns the inspection of a welded structure to a specified application standard and is now completed and ready for final approval.

What questions do you ask, what documents do you review and what inspections do you require before submitting your inspection report to the authorities concerned?

- 2 Discuss the functions of the following:

- a) Inspection
- b) Quality control
- c) Quality assurance

- 3 Discuss the four most important factors related to hydrogen induced cracking.

- 4 Owing to sickness it has been necessary for you to replace a very experienced welding inspector who has been responsible for carrying out all welder approval testing. His replacement has to come from your existing staff, none of whom have had vast experience in this field.

How would you instruct the replacement in his new duties and what critical points would you emphasise?

- 5
 - a) A crack is observed along the centreline of the weld metal. Give two reasons for its formation.
 - b) Explain why depth to width ratio of a weld is important in the context of solidification cracking.
 - c) State four methods of minimising solidification cracking.

2.2 Theory Part D3

Specimen questions:

Which of the following defects is caused by entrapped gas in the MMA welding process:

- | | | |
|----|---------------------|-------|
| a) | Porosity | a)___ |
| b) | Lack of fusion | b)___ |
| c) | Lack of penetration | c)___ |
| d) | Undercut | d)___ |

Ideally, penumbral unsharpness should not exceed:

- | | | |
|----|--------|-------|
| a) | 2.0mm | a)___ |
| b) | 1.0mm | b)___ |
| c) | 0.5mm | c)___ |
| d) | 0.25mm | d)___ |

APPENDIX 3: RADIOGRAPHIC INTERPRETER (WELDS) SYLLABUS

Theory

1 Nature and properties of X and/or gamma radiation

Penetration, absorption, scatter, diffraction, transmission. Rectilinear propagation. Photographic properties.

2 Photographic aspects

- a) Dark room procedures: layout, light traps and entrance, wet and dry benches, film-pass hatches, processing units, safe-lights and ancillary equipment. Handling and processing of films, temperature control.
- b) Sensitometry: types of film and paper used in industrial radiography. Characteristic curves, speed, contrast, definition, density. Fog. Graininess. Inherent unsharpness. Latitude. Commercial films and their properties.
- c) The use of screens.
- d) Spurious indications: light (and safe-light) fogging, chemical fog, strains, air bubbles, reticulation, pressure marks, static marks, drying marks, finger marks, defective screens, incomplete fixing, film manufacturing faults.

3 Fundamental aspects of radiographic quality

- a) Quality of radiation.
- b) Optimum working densities.
- c) Radiographic contrast. Objective and subjective contrast. Methods of controlling radiographic contrast. Effects of scattered radiation. Use of filters, screens, masking and blocking media. Influence of processing conditions and viewing conditions on contrast.
- d) Radiographic definition: objective and subjective, unsharpness, geometric unsharpness, inter-relationship of dimensions of focal spot or source, focus (source) - object and focus (source) - film distances. Inherent unsharpness. Movement. Film screen contact. The summation of factors controlling definition.
- e) Control of radiographic sensitivity and its assessment by the use of image quality indicators.

4 X-ray and gamma ray equipment

A knowledge of the effects on radiographic quality in the event of equipment change.

5 Geometry of image formation

Control of focus (source) - object distance, object - film distance, focus (source) - film distance. Selection of beam angle.

6 Exposure calculations

Effect of distance on exposure. Use of exposure charts and calculators for X and gamma radiography.

7 Application to welds

- a) Interpretation of radiographs in steel plate, and circumferential butt joints in steel pipe.
- b) Welds in aluminium.
- c) Welds in copper and its alloys.
- d) Welds in small bore tubes.
- e) The determination of the depth of a flaw from one surface in a specimen by the practical use of the tube or source shift method.

8 Viewing of radiographs

Optimum viewing conditions. Checking for acceptable density, contrast and freedom from spurious indications. Analyse the loss of sensitivity in order to rectify faulty techniques.

9 Welding technology

- a) Terminology for welds, welded joints, welding procedures, weld defects, parent metal defects.
- b) Influence on techniques of geometry, size, surface condition, parent metal composition, weld metal structure. Influence of surface cladding, heat treatments and weld repairs.
- c) Basic principles of fusion welding processes.
- d) Types of defect associated with particular parent metal/welding process combinations. Types of defect in welds and parent metals detectable by ultrasonics. Defect parameters which influence detectability, eg size, geometry, distance from surface, orientation, reflectivity and opacity.

Practical

- 1 In the practical part the candidate is firstly required to carry out a number of sensitivity calculations using DIN, ASME and BS IQIs and to establish the accuracy of a densitometer using a density strip.
- 2 Secondly, the candidate is required to interpret a number of radiographs of welds. For each radiograph the candidate is required to locate and identify defects and to evaluate the correct radiographic procedure.