



CERTIFICATION SCHEME FOR WELDING AND INSPECTION PERSONNEL

DOCUMENT NO. CSWIP-PW-6-96

Requirements for the Certification of Plastics Welders, Entry Level (Level 2) and Standard Level (Level 1)

8th Edition, March 2021

**Hot gas and extrusion welding
Butt, socket and electrofusion welding of pipe
Geomembrane welding**

Issued under the authority of the Governing Board for Certification
All correspondence should be addressed to:

TWI Certification Ltd
Granta Park
Great Abington
Cambridge CB21 6AL
United Kingdom

Tel: +44 (0) 1223 899000
Fax: +44 (0) 1223 894219
E: [mail:twicertification@twi.co.uk](mailto:twicertification@twi.co.uk).
Web: www.cswip.com

CSWIP is administered by TWI Certification Ltd
The use of the UKAS Accreditation Mark indicates accreditation in respect of those activities covered by
Accreditation Certificate No 25

FOREWORD

The Certification Scheme for 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 Welding Inspectors, Welding Supervisors, Welding Instructors, Welding Examiners, Welding Quality Control Coordinators, Heat Treatment Operatives, Cathodic Inspection personnel, Plant Inspectors, Underwater Inspection personnel, Plastics Welding Inspection and NDT 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. TWI Certification Ltd is accredited by UKAS to BS EN ISO/IEC 17024 for certification of personnel.

TWI Certification Ltd understands the importance of impartiality in carrying out its certification activities, managing conflict of interest and ensuring the objectivity of all its certification activities, in accordance with BS EN ISO/IEC 17024.

This document describes the requirements of a scheme for the testing and certification of personnel engaged in plastics welding.

ACCESS TO CERTIFICATION

Access to certification schemes is not improperly restricted. The sole criteria for certification are given in this 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 specifies the method of testing the knowledge and skill of a welder who is required to carry out welds on thermoplastics in new constructions and repair work. The skill examination of a welder is an essential condition for the assurance of the quality of the welding work. The application of this document guarantees that the examination is carried out according to a uniform procedure.

Qualification testing and certification is available in accordance with the current issues of the standards listed below:

BS EN 13067: Plastics welding personnel – Qualification testing of welders – Thermoplastics welded assemblies.

AWS B2.4: Specification for welding procedure and performance qualification for thermoplastics.

Details of training and examination are contained in Appendices 1, 2 and 3.

Certification in accordance with the above standards shall be denoted Standard Level (Level 1) certification. The requirements for Entry Level (Level 2) certification, which does not require evidence of training or experience prior to taking the test and compliance is only based on this specification document, are specified in Appendix 4.

1.2 Requirements prior to taking an qualification test

Only welders whose training and/or whose previous activities show that they are likely to pass the planned test may be admitted. The admission requirements shall be in accordance with the conditions specified in the above standards.

2 TEST PROCEDURE

The test procedure consists of both theoretical and practical tests all of which must be supervised by either a Plastics Welding Examiner (PWE) (see Appendix 1) or an authorised Invigilator.

2.1 Theoretical tests

The welder's knowledge of the practical working rules for skilful and safe working shall be established in the theoretical test.

The theoretical written test is a multiple-choice paper (specific to the category of certification sought). The candidate shall answer 20 questions for one welding process. If the candidate is being tested in more than one welding process (see Table 1), the number of multiple-choice questions shall be increased by five per welding process up to a maximum of 45.

Table 1 Welding processes for the theoretical test

Welding process	Sub-processes
Hot gas welding	Hot gas round nozzle, hot gas speed, hot gas manual, hot gas manual with V-preparation
Extrusion welding	Extrusion continuous, extrusion manual
Heated wedge welding	Heated wedge by hot gas, hot gas by machine
Heated tool welding	Butt fusion, socket fusion
Electrofusion welding	Electrofusion socket, electrofusion saddle
Solvent welding	

The questions shall cover the following general and welding process specific subjects:

General subjects:

- rules for welding of thermoplastics to which the test is designed to apply, meaning of the welding signs and symbols of the range of work;
- knowledge concerning on-site welding;
- knowledge concerning the characteristics of thermoplastics within the sub-groups;
- knowledge of the welding procedure specification (WPS) and welding record sheet;
- knowledge of non-destructive examinations and destructive tests necessary for the applied welding process(es);
- awareness of health and safety requirements for the above work.

Subjects specific to each welding process:

- operation, control and monitoring of the welding equipment;
- welding processes;
- correct preparation of the work pieces for welding;
- preventing and correcting faults when making welds;
- knowledge concerning the types of imperfections for the applied welding process(es);
- awareness of the consequences of misapplying welding parameters and/or procedures

Completion of the theoretical test shall be continuous without access to teaching aids.

The pass mark is 80%.

2.2 Practical tests

The welder shall complete the test piece specified by the required welding technique and material group, in accordance with the relevant WPS.

All welding equipment, materials and documents necessary to complete the test piece shall be available to the welder except for tests involving the welding of lining membranes, where the equipment and materials shall be provided by the welder.

The time taken by the welder to complete the test piece shall be specified in the Examination Declaration Form and shall correspond to that taken under production conditions.

The test piece may be examined visually by the PWE or Invigilator at any time during the practical test, and the test terminated at any stage if the necessary skills are not exhibited. The completed test piece shall be examined visually without magnification and shall meet the acceptance criteria specified in Evaluation Group I of the current issue of AWS G1.10M.

The test piece shall then be tested destructively, as defined in the relevant standard. Details of the practical tests specified in BS EN 13067, together with the range of qualification, for each category are given in Table 2 for information. Examples of mechanical test acceptance criteria for examination test specimens are given in Table 3.

2.3 Application for tests and fees

Candidates for testing are required to submit an application form and experience checklist and, if appropriate, evidence of successful completion of a recognised course of training. Applications will not be considered confirmed until correctly completed and authenticated documents are received. In the event of a false statement being discovered in the application documentation, any testing will be declared null and void. A certificate is automatically invalidated if there are any outstanding fees in respect of that certificate.

Candidates proved to have cheated, or found to have attempted to remove or found to have removed examination material in a CSWIP examination will not be accepted as a candidate for any CSWIP examination for a minimum period of five years from the date of the examination where cheating, attempt to remove or removal of examination material, was established to have taken place.

Arrangements may be made for testing to be carried out on the employer's premises.

3 CERTIFICATION

3.1 Successful candidates

Two copies of a certificate of proficiency demonstrating success in the relevant qualification test will be issued to the sponsoring organisation or person. Duplicate certificates to replace those lost or destroyed will be issued only after extensive enquiries.

3.2 Unsuccessful candidates

A standard results notice will be issued to all candidates and their sponsoring organisation. If applicable it will indicate those parts of the tests in which success has not been achieved.

Candidates who fail to obtain a certificate shall undertake further training before taking a new qualification test. One retest in the part of the examination that was failed can be undertaken, providing this is done within four months from the date of the original examination. After this time, or if the retest is failed, a new qualification test, comprising both theoretical and practical parts, shall be undertaken.

3.3 Initial qualification

The validity of the welder's qualification begins from the date when the overall assessment pass is awarded and is related to the date of expiry on the certificate. This date is different to the date of issue marked on the certificate.

A welder's qualification shall remain valid for a period as defined in the relevant standard, providing all the following conditions are fulfilled:

- a) the welder shall be engaged with reasonable continuity on welding work within the range of qualification corresponding to the qualification test certificate. An interruption period for longer than six months is not permitted.
- b) the welder's work shall be in general accordance with the technical conditions under which the qualification test certificate is awarded.
- c) there shall be no specific reason to question the welder's skill and knowledge.

The sponsoring organisation shall advise TWI Certification Ltd at twelve monthly intervals on each welder's activity and the welder's quality performance.

If any of these conditions are not fulfilled, the qualification shall be cancelled.

3.4 Prolongation

Prolongation is only allowed when TWI Certification Ltd is advised before expiry of the period of initial qualification.

Prolongation is only allowed when proof of welding quality is available to TWI Certification Ltd, who accepts that this is the case. This can be provided by:

- Test results from TWI Ltd or an independent, nationally-accredited test house on specimens taken from a test piece appropriate to the category or categories being submitted for prolongation;

or

- A signed letter on headed paper from a customer, dated within 12 months from the expiry date of the initial qualification, stating that welding work carried out by the certificate holder and appropriate to the category or categories being submitted for prolongation, was of acceptable quality.

The validity within the range of approval is extended under the original approval for a further period of time, as specified in the relevant standard, provided the conditions according to 3.3 are fulfilled.

3.5 Period of validity of certificate

Approval test certificates have a period of validity of one year. A new certificate shall be awarded annually, provided that the approval is maintained in accordance with 3.3 and 3.4.

3.6 Approval test recertification

An approval recertification test taken within three months before the expiry of the period of validity shall commence from that date of expiry.

3.7 Exemptions

Certificate holders who wish to take an examination on a different material/pipe size but on the same welding technique for which they hold a valid certificate, can be exempt from sitting the theoretical test again. In this case, the validity of qualification for the new category shall be from the date of the original qualification.

If a certificate holder wishes to take an examination on a different welding technique to that which they hold a valid certificate, they must take both the theoretical and practical examinations for that category. In this case, the validity of qualification for the new category shall be from the date when the overall assessment pass for this category is awarded.

3.8 Validity of certificates

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 PWE;
- d) they have been signed by the individual to whom the certificate is awarded;
- e) they are accompanied by a valid official CSWIP identity card.

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

3.9 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 welder or the employer upon application in writing to the Governing Board.

4 RECORDS

TWI Certification Ltd maintain records of successful and unsuccessful candidates. These records are accessible to the Governing Board or its nominees at all reasonable times. Full records are only held for a period of eight months from the date of the test, only outline details of the test and the results are maintained on file.

5 REFERENCES

ASTM D6392-12(2018): 'Standard test method for determining the integrity of non-reinforced geomembrane seams produced using thermo-fusion methods.'

AWS B2.4: 2012: 'Specification for welding procedure and performance qualification for thermoplastics.'

AWS G1.10M: 2016: 'Guide for the evaluation of hot gas, hot gas extrusion, and heated tool butt thermoplastic welds.'

BS EN 12814-1:2000 'Testing of welded joints of thermoplastic semi-finished products – Part 1 bend tests.'

BS EN 12814-2: 2000 'Testing of welded joints of thermoplastic semi-finished products – Part 2: tensile tests.'

BS EN 12814-2:2000 'Testing of welded joints of thermoplastic semi-finished products –Part 2 tensile tests.' Annex B: 'Notched tensile test specimen.'

BS EN 12814-4:2018 'Testing of welded joints of thermoplastic semi-finished products –Part 4: peel tests.'

BS EN 12814-8:2001 'Testing of welded joints of thermoplastic semi-finished products – Part 8: requirements.'

BS EN 13067:2020 'Plastics Welding Personnel – qualification testing of welders – thermoplastic welded assemblies.'

ISO 17024: 2012 'Conformity Assessment - Criteria for Certification Bodies Operating Certification of Personnel.'

ADDRESSES

For further general information contact:

TWI Certification Ltd
Granta Park
Great Abington
Cambridge
CB21 6AL
UK

Phone: +44 (0) 1223 899000
Fax: +44 (0) 1223 894219
Email: twicertification@twi.co.uk

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

TWI Technology and Training Centre - North East
Ferrous Road
Riverside Park
Middlesbrough
Cleveland

TS2 1DJ

Phone: +44(0)1642 216320
Fax: +44(0)1642 252218
E-mail: twinorth@twi-global.com

Table 2 Details of practical tests

Material Group	Test Category	Examination test piece (Note 1)		Welding process	Weld form (Note 2)	Type of examination test (Note 1)	Range of qualification	
							Dimensions	Type of joint
1 PVC	1.1	S	$e_n = 5$	Hot gas - round nozzle	V	V/B_{f+r}	All e_n	V, <u>V</u> , X, \perp
	1.2	S	$e_n = 5$	Hot gas - high speed nozzle	V	V/B_{f+r}	All e_n	V, <u>V</u> , X, \perp
	1.4	P	$d_n = 40$ and $d_n = 110$ SDR ≤ 21	Solvent welding	Socket	V/V_{ls}	$d_n < 160$	Socket
	1.5	P	$d_n \geq 160$, SDR ≤ 21	Solvent welding	Socket	V/V_{ls}	$d_n \geq 160$	Socket
2 PP	2.1	S	$e_n = 9$ or 10	Hot gas - high speed nozzle	X	V/B_{f+r}	All e_n	V, <u>V</u> , X, \perp
	2.2	S	$e_n = 9$ or 10	Extrusion - continuous	<u>V</u>	V/B_{f+r}	$e_n \geq 3$	<u>V</u> , X, \perp
	2.4	P	$d_n = 110$, SDR ≤ 17.6	Heated Tool	]]	V/B_r	$e_n \geq 3$, $d_n \leq 315$]]
	2.5	P	$d_n \geq 400$, SDR ≤ 17.6	Heated Tool	]]	V/B_s	$d_n > 315$]]
	2.6	P	$d_n = 63$, SDR ≤ 17.6	Heated Tool	Socket	V/P_c	All d_n	Socket
	2.7	P	$d_n = 63$, SDR ≤ 17.6	Electrofusion	Socket	V/P_c	All d_n	Socket
3 PE	3.1	S	$e_n = 10$	Hot gas - high speed nozzle	X	V/B_{f+r}	All e_n	V, <u>V</u> , X, \perp
	3.2	S	$e_n = 10$	Extrusion - continuous	<u>V</u>	V/B_{f+r}	$e_n \geq 3$	<u>V</u> , X, \perp
	3.4	P	$110 \leq d_n \leq 180$ SDR ≤ 17.6	Heated Tool	]]	V/T_w	$d_n \leq 315$]]
	3.5	P	$d_n \geq 400$, SDR ≤ 17.6	Heated Tool	]]	V/T_w	$d_n > 315$]]
	3.6	P	$90 \leq d_n \leq 125$ SDR ≤ 17.6	Electrofusion	Socket	V/P_c	$d_n \leq 315$	Socket
	3.7	P	$d_n \geq 355$, SDR ≤ 17.6	Electrofusion	Socket	V/P_d	$d_n > 315$	Socket
	3.8	P	$d_n \leq 63$ on $90 \leq d_n \leq 125$ SDR ≤ 17.6	Electrofusion	Saddle	V/P_c	All d_n	Saddle
	3.9	P	$d_n = 63$, SDR = 11	Heated Tool	Socket	V/P_c	All d_n	Socket
	3.10	P	$d_n = 32$ on $d_n = 90$ SDR = 11	Heated Tool	Saddle	V/P_c	All d_n	Saddle

Material Group	Test Category	Examination test piece (Note 1)		Welding process	Weld form (Note 2)	Type of examination test (Note 1)	Range of qualification	
							Dimensions	Type of joint
4 PVDF	4.1	S	$e_n = 4$	Hot gas - high speed nozzle	V	V/B_{f+r}	$e_n \geq 2$	V, <u>V</u> , X, \perp
	4.3	P	$d_n = 110, e_n = 5.3$	Heated Tool	]]	V/B_r	All d_n $e_n \geq 1.9$]]
	4.4	P	$d_n = 63, e_n = 3$	Heated Tool	Socket	V/P_c	All d_n	Socket
5 ECTFE or FEP or PFA	5.1	S	$e_n = 2.3$	Hot gas - high speed nozzle	<u>V</u>	V/T	$e_n \geq 1.6$	V, <u>V</u> , X, \perp
	5.2	P	$d_n = 110, e_n = 3$	Heated Tool	]]	V/T	All d_n All e_n]]
6 PVC-P	6.1	M	$1 \leq e_n \leq 3$	Hot gas manual	Lap	V/P_t	$1 \leq e_n \leq 4$	Lap
	6.4	M	$1 \leq e_n \leq 3$	Heated wedge	Double lap	V/P_t	$1 \leq e_n \leq 4$	Lap
	6.5	M	$1 \leq e_n \leq 3$	Hot gas manual with V-preparation	<u>V</u>	V/HV	$0.5 \leq e_n \leq 4$	<u>V</u>
	6.6	M	$1 \leq e_n \leq 3$	Extrusion - manual	Lap	V/P_t	$1 \leq e_n \leq 4$	Lap
	6.7*	M	$1 \leq e_n \leq 3$	Hot gas by machine With V-preparation	<u>V</u>	V/HV	$0.5 \leq e_n \leq 4$	<u>V</u>
7 PE	7.4	M	$2 \leq e_n \leq 2.5$	Heated wedge	Double lap	V/P_t	$1 \leq e_n \leq 5$	Lap
	7.5	M	$2 \leq e_n \leq 2.5$	Extrusion - manual	Lap	V/P_t	$1 \leq e_n \leq 5$	Lap
	7.6	M	$0.75 \leq e_n \leq 1$	Hot gas manual	Lap	V/P_t	$0.3 \leq e_n \leq 1$	Lap
	7.7	M	$0.75 \leq e_n \leq 1$	Heated wedge	Double lap	V/P_t	$0.3 \leq e_n \leq 1$	Lap
	7.8	M	$0.75 \leq e_n \leq 1$	Extrusion - manual	Lap	V/P_t	$0.3 \leq e_n \leq 1$	Lap
9 PP	9.1	M	$1 \leq e_n \leq 2$	Hot gas - manual	Lap	V/P_t	$0.7 \leq e_n \leq 3$	Lap
	9.4	M	$1 \leq e_n \leq 2$	Heated wedge	Double lap	V/P_t	$0.7 \leq e_n \leq 3$	Lap
	9.5	M	$1 \leq e_n \leq 2$	Extrusion - manual	Lap	V/P_t	$0.7 \leq e_n \leq 3$	Lap
10 PA-U	10.1	P	$110 \leq d_n \leq 180$ $SDR \leq 17.6$	Heated Tool	]]	V/T_w	$d_n \leq 315$]]
	10.2	P	$d_n \geq 400, SDR \leq 17.6$	Heated Tool	]]	V/T_w	$d_n > 315$]]

Material Group	Test Category	Examination test piece (Note 1)		Welding process	Weld form (Note 2)	Type of examination test (Note 1)	Range of qualification	
							Dimensions	Type of joint
	10.3	P	$90 \leq d_n \leq 125$ $SDR \leq 17.6$	Electrofusion	Socket	V/P _c	$d_n \leq 315$	Socket
	10.4	P	$d_n \geq 355$, $SDR \leq 17.6$	Electrofusion	Socket	V/P _d	$d_n > 315$	Socket
	10.5	P	$d_n \leq 63$ on $90 \leq d_n \leq 125$ $SDR \leq 17.6$	Electrofusion	Saddle	V/P _c	All d_n	Saddle

Note 1: / = and
 B = Bend test (f: face, r: root, s: side)
 HV = High voltage test
 M = Membrane
 P = Pipe
 P_c = Peel test (crush)
 P_d = Peel test (decohesion)
 P_t = Peel test (t-peel)
 S = Sheet
 T = Tensile test (w: waisted specimen)
 V = Visual examination
 V_{ls} = Visual examination of longitudinal cross-sections

Note 2: V = Single V preparation
V = Single V preparation with backing run
 X = Double V preparation
][= Butt weld

* this is not in accordance with BS EN 13067:2020

Table 3 Examples of mechanical test acceptance criteria for examination test specimens

Material	Test Category (BS EN 13067)	Examination test piece	Welding process	Mechanical test	Mechanical test requirements	No. of specimens to be tested	Acceptance criteria
PVC	1.1	S $e_n = 5$	Hot gas - round nozzle	Bend	30° bend angle or 7mm ram displacement	6 initial (3 per side) + 2 additional	Max. of 1 failure from 6 specimens + 2 further passes
	1.2	S $e_n = 5$	Hot gas - high speed nozzle	Bend			
	1.4	P $d_n = 40$ and $d_n = 110$, $SDR \leq 21$	Solvent welding	Visual examination of longitudinal sections	$\geq 70\%$ of surface shall have a whitened texture $\leq 50\%$ unbonded length	8 (4 per side)	No failures
	1.5	P $d_n \geq 160$, $SDR \leq 21$	Solvent welding				
PP-H or PP-B	2.1	S $e_n = 9$	Hot gas - high speed nozzle	Bend	45° bend angle or 13mm ram displacement	6 initial (3 per side) + 2 additional	Max. of 1 failure from 6 specimens + 2 further passes
	2.2	S $e_n = 9$	Extrusion - continuous	Bend			
	2.4	P $d_n = 110$, $SDR = 17.6$	Heated Tool	Bend	85° bend angle or 22mm ram displacement	4 initial + 2 additional	Max. of 1 failure from 4 specimens + 2 further passes
PP-R	2.4	P $d_n = 110$, $SDR = 17.6$	Heated Tool	Bend	150° bend angle or 52mm ram displacement		
	2.5	P $d_n = 400$, $SDR = 17.6$	Heated Tool	Bend (side)	118° bend angle or 38mm ram displacement		
PP-H or PP-B	2.5	P $d_n = 400$, $SDR = 17.6$	Heated Tool	Bend (side)	70° bend angle or 19mm ram displacement		
PP-H, PP-B or PP-R	2.6	P $d_n = 63$, $SDR = 17.6$	Heated Tool	Peel (crush)	No fracture between pipe and fitting	4 (2 per side)	No failures
	2.7	P $d_n = 63$, $SDR = 17.6$	Electrofusion	Peel (crush)	Fracture length $\leq 33\%$ of fusion zone length		
PE	3.1	S $e_n = 10$	Hot gas - high speed nozzle	Bend	65° bend angle or 19mm ram displacement	6 initial (3 per side) + 2 additional	Max. of 1 failure from 6 specimens + 2 further passes
	3.2	S $e_n = 10$	Extrusion - continuous	Bend			
	3.4	P $110 \leq d_n \leq 180$ $SDR \leq 17.6$	Heated Tool	Tensile (waisted)	Ductile failure mode	4	No failures
	3.5	P $d_n \geq 400$, $SDR \leq 17.6$	Heated Tool	Tensile (waisted)			
	3.6	P $90 \leq d_n \leq 125$, $SDR \leq 17.6$	Electrofusion	Peel (crush)	Fracture length $\leq 33\%$ of fusion zone length	4 (2 per side)	No failures

Material	Test Category (BS EN 13067)	Examination test piece	Welding process	Mechanical test	Mechanical test requirements	No. of specimens to be tested	Acceptance criteria
	3.7	P $d_n \geq 355$, $SDR \leq 17.6$	Electrofusion	Peel (decohesion)	$\leq 33\%$ brittle failure	8	No failures
	3.8	P $d_n \leq 63$ on $90 \leq d_n \leq 125$ $SDR \leq 17.6$	Electrofusion	Peel (crush)	Fracture length $\leq 33\%$ of fusion zone length	2 (1 per side)	No failures
	3.9	P $d_n = 63$, $SDR = 11$	Heated Tool	Peel (crush)	No fracture between pipe and fitting	4 (2 per side)	No failures
	3.10	P $d_n = 32$ on $d_n = 90$ $SDR = 11$	Heated Tool	Peel (crush)		2 (1 per side)	No failures
PVDF	4.1	S $e_n = 4$	Hot gas - high speed nozzle	Bend	70° bend angle or 18mm ram displacement	6 initial (3 per side) + 2 additional	Max. of 1 failure from 6 specimens + 2 further passes
	4.3	P $d_n = 110$, $e_n = 5.3$	Heated Tool	Bend	41° bend angle or 15mm ram displacement	4 initial + 2 additional	Max. of 1 failure from 4 specimens + 2 further passes
	4.4	P $d_n = 63$, $e_n = 3$	Heated Tool	Peel (crush)	No fracture between pipe and fitting	4 (2 per side)	No failures
ECTFE, FEP or PFA	5.1	S $e_n = 2.3$	Hot gas - high speed nozzle	Tensile	Short-term tensile weld factor ≥ 0.8	3 parent and 5 initial + 2 additional	Max. of 1 failure from 5 specimens + 2 further passes
	5.2	P $d_n = 110$, $e_n = 3$	Heated Tool	Tensile		4 parent and 4 initial + 2 additional	Max. of 1 failure from 4 specimens + 2 further passes
PVC-P	6.1	M $e_n = 2$	Hot gas manual	T-peel	All failures (including yielding), except for an AD-WLD break, shall be in the parent material	7	Max. of 2 failures
	6.2	M $e_n = 2$	Hot gas by machine	T-peel			
	6.3	M $e_n = 2$	Heated wedge by hot gas	T-peel			
	6.4	M $e_n = 2$	Heated wedge - electric	T-peel			
	6.5	M $e_n = 2$	Hot gas manual with V-preparation	High voltage	No sparks	Whole test piece	No failures
	6.6	M $e_n = 2$	Extrusion - manual	T-peel	All failures (including yielding), except for an AD-WLD break, shall be in the parent material	7	Max. of 2 failures
	6.7	M $e_n = 2$	Hot gas by machine With V-preparation	High voltage	No sparks	Whole test piece	No failures
PE	7.2	M $e_n = 2$	Hot gas by machine	T-peel	315N/15mm peel load and fracture in parent sheet	7	Max. of 2 failures
	7.3	M $e_n = 2$	Heated wedge by hot gas	T-peel			
	7.4	M $e_n = 2$	Heated wedge - electric	T-peel			

Material	Test Category (BS EN 13067)	Examination test piece		Welding process	Mechanical test	Mechanical test requirements	No. of specimens to be tested	Acceptance criteria
	7.5	M	$e_n = 2$	Extrusion - manual	T-peel	273N/15mm peel load and fracture in parent sheet	7	Max. of 2 failures
	7.6	M	$e_n = 0.75$	Hot gas manual	T-peel	All failures, except for an AD-WLD break, shall be in the parent material		
	7.7	M	$e_n = 0.75$	Heated wedge	T-peel	118N/15mm peel load and all failures, except for an AD-WLD break, shall be in the parent material		
	7.8	M	$e_n = 0.75$	Extrusion - manual	T-peel	102N/15mm peel load and all failures (including yielding), except for an AD-WLD break, shall be in the parent material	7	Max. of 2 failures
PP	9.1	M	$e_n = 1$	Hot gas - manual	T-peel	66N/15mm peel load and all failures, except for an AD-WLD break, shall be in the parent material	7	Max. of 2 failures
	9.4	M	$e_n = 1$	Heated wedge - electric	T-peel		7	Max. of 2 failures
	9.5	M	$e_n = 1$	Extrusion - manual	T-peel		7	Max. of 2 failures
PA-U	10.1	P	$110 \leq d_n \leq 180$ $SDR \leq 17.6$	Heated Tool	Tensile (waisted)	Ductile failure mode	4	No failures
	10.2	P	$d_n \geq 400$, $SDR \leq 17.6$	Heated Tool	Tensile (waisted)			
	10.3	P	$90 \leq d_n \leq 125$, $SDR \leq 17.6$	Electrofusion	Peel (crush)	Fracture length $\leq 33\%$ of fusion zone length	4 (2 per side)	No failures
	10.4	P	$d_n \geq 355$, $SDR \leq 17.6$	Electrofusion	Peel (decohesion)	$\leq 33\%$ brittle failure	8	No failures
	10.5	P	$d_n \leq 63$ on $90 \leq d_n \leq 125$ $SDR \leq 17.6$	Electrofusion	Peel (crush)	Fracture length $\leq 33\%$ of fusion zone length	2 (1 per side)	No failures

(all dimensions in millimetres)

APPENDIX 1

Tasks and Responsibilities of Plastics Welding Examiners

1 Definition

A Plastics Welding Examiner (PWE) is a qualified person acceptable to the contracting parties who verifies the compliance with the CSWIP document for the qualification testing of welders of thermoplastics.

The PWE may not be the examiner for any individual that he/she has trained and shall reach his/her professional decisions independently.

2 Tasks and Responsibilities

Note: Some of the items listed below will not apply to tests conducted under Appendix 4 of this document.

- Select the questions for the theoretical tests.
- Check the eligibility and identity of the candidate. This includes attendance on a recognised course where applicable.
- Supervise the qualification test - both theoretical and practical parts including welding of the test piece(s), ensuring that normal examination conditions are maintained at all times.*
- Check test materials, welding procedure specification (WPS), machines and equipment to be used.*
- Identify the test pieces with the number or mark of the PWE and the candidate.*
- Witness the completion of the welding record sheet by the candidate.*
- Check that the completed test piece is visually acceptable before submission to the test house.*
- Ensure that the test pieces are delivered to an approved test house for the specified destructive tests.*
- Check the test house qualification and training course qualification if applicable.
- Mark the theoretical test.
- Evaluate the completed test piece, the test specimens and the results produced by the test house in accordance with prescribed procedures.
- Forward the results of both theoretical and practical tests to TWI Certification Ltd.
- Take action in the case of difficulties during the test, for example:
 - i) stop the test if the welding conditions are not in with the WPS or if it appears that the welder does not have sufficient skill to obtain a satisfactory result;
 - ii) allow the test piece on which welding has been started to be replaced if difficulties arise which have not been caused by the candidate;
 - iii) allow errors during the hot gas or extrusion welding practical test to be repaired if appropriate;
- Verify compliance with the conditions for prolongation of certificates and inform the Certification Body accordingly if the conditions are satisfied so that a new certificate can be issued.

(* these tasks can be carried out by an authorised Invigilator).

APPENDIX 2

Examination Syllabus

1 Hot Gas Welding

1.1 Health and safety

Electrical safety; fume; care and use of electrical/hand tools and lifting tackle commonly used by the welder; heat burns and fire.

1.2 Plastic materials

Molecules and polymer chains; plastic material classification; copolymers; glass transition temperature.

1.3 Common thermoplastics for fabrication

Polyethylene; polypropylene; polyvinylchloride; polyvinylidene fluoride.

1.4 Materials identification

Simple manual test; fourier transform infrared spectroscopy (FTIR).

1.5 Processing of plastics

Injection moulding; extrusion; blow moulding.

1.6 Joint types and symbols

Common joint type used in thermoplastic fabrications; symbols for welded joints.

1.7 Welding processes

Process; equipment; applications.

1.8 Welding procedure

Setting the gun; hand tools; preparation of materials; hand welding; speed welding; filling the weld; finishing the weld.

1.9 Welding procedure specification and welding record sheet

1.10 Inspection

Visual inspection; spark testing; dye penetrant test.

1.11 Destructive testing

Bend testing; tensile testing.

1.12 Certification

2 Butt and Socket Fusion Welding

2.1 Health and safety

Heat burns; fume; machine safety; pipe and fittings storage; handling of pipe and equipment.

2.2 Plastic materials

Molecules and polymer chains; plastic material classification; copolymers; glass transition temperature.

2.3 Common thermoplastic materials for plastic pipe

Polypropylene; polyethylene; polyvinylidene fluoride.

2.4 Pipe and fittings identification

Standards; identification markings – fittings, pipe; materials identification.

2.5 Processing of plastics

Injection moulding; extrusion.

2.6 Plastics pipe welding processes

Butt fusion welding; socket fusion welding.

2.7 Welding Procedures

Welding procedures and records; manual butt fusion welding; manual socket fusion welding; machine socket fusion welding.

2.8 Testing of Welded Joints

Visual inspection; non-destructive testing; destructive testing.

2.9 Certification

3 Electrofusion Welding

3.1 Health and safety

Electrical safety; use of 240V and 110V equipment; care and use of tools commonly used by the welder; pipe and fittings storage; handling of pipe, fittings and equipment.

3.2 Plastic materials

Molecules and polymer chains; plastic material classification; copolymers; glass transition temperature.

3.3 Common thermoplastic materials for plastic pipe

Polyethylene; polypropylene.

3.4 Pipe and fittings identification

Identification markings – fittings, pipe; materials identification.

3.5 Processing of plastics

Injection moulding; extrusion.

3.6 Welding process

3.7 Welding procedure

3.8 **Testing of welded joints**

Visual inspection; non-destructive testing; destructive testing.

3.9 **Certification**

4 **Geomembrane Welding**

4.1 **Health and safety**

Electrical safety; use of 240V and 110V equipment; fume; care and use of electrical/hand tools and lifting tackle commonly used by the welder; heat burns and fire.

4.2 **Materials technology**

Molecules and polymer chains; plastic material classification; copolymers; glass transition temperature.

4.3 **Thermoplastic geomembranes**

Geomembranes; manufacture; polyvinylchloride; polyethylene; polypropylene.

4.4 **Welded joints and terminology**

Materials; joint types; symbols.

4.5 **Thermal fusion processes**

Principles of heated wedge welding; joint preparation; welding parameters; principles of hot air welding; equipment cleaning and maintenance; welding documentation.

4.6 **Extrusion and manual hot air welding**

Joint preparation; principles of extrusion welding; welding parameters; repairs; connections to pipes and structures; welding documentation.

4.7 **Testing of welded joints**

Destructive testing; failure modes; non-destructive testing.

4.8 **Weld quality**

Types of imperfection; origins of imperfections.

4.9 **Site working**

Cleaning procedures; weather protection; handling of materials; subgrade acceptance.

4.10 **Related Geosynthetic Materials**

Geosynthetic clay liners; geotextiles; geonet; geocomposite.

4.11 **Certification**

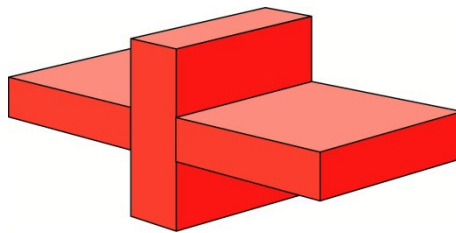
APPENDIX 3

Specimen Questions for the Theoretical Test

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

1. What does OEL stand for?

- Occupational Exposure Law
- Ozone Exposure Limits
- Occupational Exposure Limits
- Occupational Ethylene Limits

☐
☐
☒
☐

2. The above picture shows which joint type?

- Butt joint
- T joint
- Edge joint
- Cruciform joint

☐
☐
☐
☒

3. Why would you adjust the speed of an electric hot wedge-welding machine during welding?

- To get the site work finished quickly
- To compensate for ambient temperature fluctuations
- To prevent the equipment stalling
- To ensure constant speed

☐
☒
☐
☐

APPENDIX 4

Requirements for Entry Level (Level 2) Certification of Thermoplastics Welders

1 SCOPE

The categories of certification described in this appendix are classified as 'Entry Level' because they do not require evidence of training or experience prior to taking the test.

Certification in accordance with this Appendix is deemed to satisfy the 'Level 2' qualification standard of the UK Environment Agency for welding PE lining membrane.

Unless otherwise stated, the provisions of the main part of this document apply.

2 TEST PROCEDURE

2.1 Welding of pipe

The test procedure consists of both theoretical and practical tests, all of which must be supervised by an authorised PWE or Invigilator.

2.1.1 Theoretical test

The theoretical written test is a multiple choice paper (specific to the category of certification sought) consisting of 20 questions covering the following:

- operation and monitoring of equipment;
- knowledge concerning on-site welding;
- correct preparation of the pipes for welding;
- preventing and correcting faults when making welds;
- knowledge concerning the types of imperfections in pipe welds;
- knowledge of the welding procedure specification (WPS) and welding record sheet;
- awareness of the consequences of misapplying welding parameters and/or procedures;
- awareness of health and safety requirements for pipe welding processes.

Completion of the theoretical test shall be continuous without access to teaching aids.

The pass mark is 80%.

2.1.2 Practical test

The welder shall complete the test piece specified by the required sub-group, see Clause 4, and according to the relevant test piece geometries specified in Figures 2, 4 and 5 of BS EN 13067 and in Table A1, in accordance with the relevant WPS.

The test piece shall be subjected to a visual examination only and shall meeting the acceptance criteria specified in Evaluation Group I of the current issue of AWS G1.10M.

2.2 Welding of PE lining membrane

The test procedure consists of a practical test only, which must be supervised by an authorised PWE or Invigilator.

The welder shall complete the test piece specified by the required sub-group, see Clause 4, and according to the relevant test piece geometries specified in Figures 7 and 8 of BS EN 13067 and in Table A2, in accordance with the relevant WPS.

3 APPLICATION FOR TESTS

Candidates for testing are only required to submit an application form.

4 CATEGORIES OF CERTIFICATION

Successful completion of the test will lead to certification in one or more of the following categories:

Butt fusion and electrofusion welding of pipe

- 2.4 Heated tool welding of PP pipe (Diameter \leq 315mm) – Entry Level (Level 2)
- 2.5 Heated tool welding of PP pipe (Diameter $>$ 315mm) – Entry Level (Level 2)
- 2.6 Heated tool socket welding of PP pipe – Entry Level (Level 2)
- 2.7 Electrofusion welding of PP pipe – Entry Level (Level 2)
- 3.4 Heated tool welding of PE pipe (Diameter \leq 315mm) – Entry Level (Level 2)
- 3.5 Heated tool welding of PE pipe (Diameter $>$ 315mm) – Entry Level (Level 2)
- 3.6 Electrofusion welding of PE pipe (Diameter \leq 315mm) – Entry Level (Level 2)
- 3.7 Electrofusion welding of PE pipe (Diameter $>$ 315mm) – Entry Level (Level 2)
- 3.8 Electrofusion saddle welding of PE pipe – Entry Level (Level 2)
- 3.9 Heated tool socket welding of PE pipe – Entry Level (Level 2)
- 3.10 Heated tool saddle welding of PE pipe – Entry Level (Level 2)
- 4.3 Heated tool welding of PVDF pipe – Entry Level (Level 2)
- 4.4 Heated tool socket welding of PVDF pipe – Entry Level (Level 2)
- 5.2 Heated tool welding of ECTFE, FEP or PFA pipe – Entry Level (Level 2)
- 10.1 Heated tool welding of PA-U pipe (Diameter \leq 315mm) – Entry Level (Level 2)
- 10.2 Heated tool welding of PA-U pipe (Diameter $>$ 315mm) – Entry Level (Level 2)
- 10.3 Electrofusion welding of PA-U pipe (Diameter \leq 315mm) – Entry Level (Level 2)
- 10.4 Electrofusion welding of PA-U pipe (Diameter $>$ 315mm) – Entry Level (Level 2)
- 10.5 Electrofusion saddle welding of PA-U pipe – Entry Level (Level 2)

Heated wedge and extrusion welding of PE lining membrane

- 6.1 Hot gas manual welding of PVC-P membrane – Entry Level (Level 2)
- 6.4 Heated wedge (electric) welding of PVC-P membrane – Entry Level (Level 2)
- 6.5 Hot gas manual welding with V-preparation of PVC-P membrane – Entry Level (Level 2)
- 6.6 Extrusion welding of PVC-P membrane – Entry Level (Level 2)
- 6.7 Hot gas by machine welding with V-preparation of PVC-P membrane – Entry Level (Level 2)
- 7.4 Heated wedge welding of PE membrane – Entry Level (Level 2)
- 7.5 Extrusion welding of PE membrane lap joint - Entry Level (Level 2)
- 7.6 Hot gas manual welding of thin PE membrane – Entry Level (Level 2)
- 7.7 Heated wedge welding of thin PE membrane – Entry Level (Level 2)
- 7.8 Extrusion welding of thin PE membrane – Entry Level (Level 2)
- 9.1 Hot gas manual welding of PP membrane – Entry Level (Level 2)
- 9.4 Heated wedge welding of PP membrane – Entry Level (Level 2)
- 9.5 Extrusion welding of PP membrane – Entry Level (Level 2)

Table A1 Entry Level (Level 2) categories for welding of pipe

Material	Test Category	Examination test piece	Welding process	Weld form
PP	2.4	$110 \leq d_n \leq 180, SDR \leq 26$	Heated tool	||
	2.5	$d_n \geq 400, SDR \leq 26$	Heated tool	||
	2.6	$d_n = 63, SDR \leq 17.6$	Heated tool	Socket
	2.7	$d_n = 63, SDR \leq 17.6$	Electrofusion	Socket
PE	3.4	$110 \leq d_n \leq 180, SDR \leq 26$	Heated tool	||
	3.5	$d_n \geq 400, SDR \leq 26$	Heated tool	||
	3.6	$90 \leq d_n \leq 125, SDR \leq 17.6$	Electrofusion	Socket
	3.7	$d_n \geq 355, SDR \leq 17.6$	Electrofusion	Socket
	3.8	$d_n \leq 63$ on $90 \leq d_n \leq 125, SDR \leq 17.6$	Electrofusion	Saddle
	3.9	$d_n = 63, SDR = 11$	Heated tool	Socket
	3.10	$d_n = 63$ on $d_n = 90, SDR = 11$	Heated tool	Saddle
PVDF	4.3	$63 \leq d_n \leq 110$	Heated tool	||
	4.4	$d_n = 63, e_n = 3$	Heated tool	Socket
ECTFE, FEP or PFA	5.2	$63 \leq d_n \leq 110$	Heated tool	||
PA-U	10.1	$110 \leq d_n \leq 180, SDR \leq 17.6$	Heated tool	||
	10.2	$d_n \geq 400, SDR \leq 26$	Heated tool	||
	10.3	$90 \leq d_n \leq 125, SDR \leq 17.6$	Electrofusion	Socket
	10.4	$d_n \geq 355, SDR \leq 17.6$	Electrofusion	Socket
	10.5	$d_n \leq 63$ on $90 \leq d_n \leq 125, SDR \leq 17.6$	Electrofusion	Saddle

(all dimensions in millimetres)

Table A2 Entry Level (Level 2) categories for welding of lining membrane

Material	Test Category	Examination test piece	Welding process	Weld form
PVC-P	6.1	$1 \leq e_n \leq 3$	Hot gas manual	Lap
	6.4	$1 \leq e_n \leq 3$	Heated wedge	Lap
	6.5	$1 \leq e_n \leq 3$	Hot gas manual with V-preparation	<u>V</u>
	6.6	$1 \leq e_n \leq 3$	Extrusion - manual	Lap
	6.7	$1 \leq e_n \leq 3$	Hot gas by machine with V-preparation	<u>V</u>
	7.4	$2 \leq e_n \leq 2.5$	Heated wedge	Lap
	7.5	$2 \leq e_n \leq 2.5$	Extrusion - manual	Lap
	7.6	$0.75 \leq e_n \leq 1$	Hot gas manual	Lap
	7.7	$0.75 \leq e_n \leq 1$	Heated wedge	Lap
	7.8	$0.75 \leq e_n \leq 1$	Extrusion - manual	Lap
PP	9.1	$1 \leq e_n \leq 2$	Hot gas - manual	Lap
	9.4	$1 \leq e_n \leq 2$	Heated wedge	Lap
	9.5	$1 \leq e_n \leq 2$	Extrusion - manual	Lap

(all dimensions in millimetres)