Skills Compétences Canada
Winnipeg2023

ADDENDUM A

Welding

SECONDARY & POST-SECONDARY

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1 DESCRIPTION OF THE SKILL COMPETITION

1.1 The name of the skill competition is Welding

1.1.1 Description of the associated work role(s) or occupations

Welding is a critical process that is controlled by both national and international standards and specifications to regulate the quality of the deposited weld metal and the skill of the welder.

A welder prepares and joins a range of metals and metallic alloys using mainly processes where an electric arc is the heat source. Electric arc processes utilize a gas shield or a flux to protect the molten weld area from contamination by the surrounding atmosphere. A welder needs to be able to interpret engineering drawings, standards and symbols and correctly translate these requirements into accurate structures and fabrications.

Welders need to have a thorough knowledge and understanding of safe working practices, personal protection equipment and the hazards and practices associated with the welding and fabrication industries. They need to gain specific knowledge of a wide range of welding equipment and processes as well as an understanding of how welding will affect the structure of the material being welded. They need to be familiar with electricity and how it is utilized for welding.

A welder prepares, assembles and joins a wide range of metals and metal alloys using various welding processes including manual metal arc welding, shielded metal arc welding, metal arc gas shielded welding, gas metal arc welding, tungsten arc gas shielded welding, gas tungsten arc welding, and flux cored arc welding. A welder will use mainly processes where the heat utilized for welding will be an electric arc to join a range of materials including the commonly joined and fabricated materials – carbon steel, stainless steels, aluminium and copper and their associated alloys. They must be able to select the correct equipment, process variables, and welding technique, depending upon the material being joined.

Welders may use thermal cutting processes and should be able to identify the correct preparation for joining as applied to the type, thickness and intended use of the joint. They use grinding and cutting equipment to prepare welded joints. Modern methods of joining, as well as those noted above, include mechanized processes such as submerged arc, plasma arc, stud welding, and laser welding.

Welders join sections, pipe and plate and fabricate large and small pressure vessels. A welder can work in a unit or factory which produces fabrications and/or structures for industries as diverse as civil engineering, mechanical engineering,

transport, marine engineering, construction, service, and leisure industries. Welders also work on site preparation, construction, and the repair and maintenance of structures. A welder can work in many locations and situations, ranging from a bench in a factory, to shipyards, power stations and off-shore structures. Welders also work in engineering, construction, power generating, and petro-chemical plants. The working environment may include hazards such as being off shore, with extreme weather conditions and also in confined spaces where access to the joint to be welded is restricted.

The modern welder may specialize in one or a number of welding processes and environments. They may also be asked to work on exotic alloys such as duplex and super duplex stainless steels and cupronickels. Welders are required to carry out the finest work where faults and failure may have the most serious consequences in terms of cost, safety and environmental damage

2 ASSOCIATED DOCUMENTS

- ISO 5817-Welding—Fusion-welded joints in steel, nickel, titanium and their alloys.
- ISO 9606-Qualification testing of welders Part 1: steels.
- ISO 10042-Welding—Arc-welded joints in Aluminium and it's alloys.
- ISO 9017-Destructive tests on welds in metallic materials- fracture tests.
- ISO 15608-Welding – Guidelines for metallic materials grouping system.
- ISO 17635- Non-destructive testing of welds – General rules for metallic materials.
- ISO 10025- Hot rolled products of structural steels. General Technical delivery conditions.
- ISO 2553-Welding and allied processes – Symbolic representation on drawings – Welded joints.
- ISO 9606-2- Qualification testing of welders Part 2: Qualification Test of Welders—Fusion Welding-Part 2: Aluminium and Aluminium Alloys.
- AWS A2.4-Standard Symbols for welding Brazing, and Non-Destructive Examination.
- AWS A3.0-Standard Welding Terms and Definitions.
- Note: Where a conflict arises, the ISO standards shall have precedence. If no ISO standard is applicable, then the relevant AWS standard shall be used.

3 SKILL ASSESSMENT STRATEGY

The skill assessment criteria are clear concise aspect specifications which explain exactly how and why a particular mark is awarded. The following table is a guide to the visual assessment of weld seams.

The level of imperfection assessment to be no less than that expected for the qualification of a welder to ISO 9606 Qualification of welders – fusion welding part 1: Steels and part 2: Aluminium and Aluminium alloys. The level of imperfection no less than level “B” of ISO 5817 Welding – Fusion welded joints in steel, nickel titanium and their alloys (beam welding excluded) – Quality levels. For RT inspections of the test plates and pipe, digital RT shall be used where possible, but if not possible, double loaded film practices shall be used. Both practices to be performed IAW ISO 17635.

ISO 10042 Arc – welded joints in Aluminium and its weldable alloys – Guidance on Quality levels for imperfections

Imperfection Description	Explanation	limits for imperfections
1. Cracks	Is the weld surface free of all cracks?	Not permitted
2. Weld starts and craters	Are weld bead craters and starts completely filled? (From crown to crater bottom, or crown of stop and crown of restart)	Task two (PV) ≤ 1.5 mm
3. Stray Arc Strikes and stray grinding	Arc projects free of arc strikes? Is stray grinding present?	Not permitted (Projects shall be free from stray grinding for the intent to remove arc strikes.)
4. Slag and Spatter Removed	Is all surface slag and spatter removed from the joint and surrounding area?	Greater than 99% of all slag and spatter to be removed
5. Grinding Marks	Is the weld surface free from grinding or other metal removal on the cap pass (es) and penetration, for the purpose of enhancing the finished weld?	No metal removal permitted from the finished weld
6. Visual Inclusions	Is the weld metal free of short, solid imperfections? (slag, flux, oxide or metallic inclusions)	Task two (PV) Incremental marking max. two defects
7. Surface or internal Porosity and Gas Pores	Is the weld metal free of porosity? Excessive root concavity <suck back>.	Task one (Coupon X-Ray) - See International Standard IS0 5817 Task one (Coupon destructive testing) - Incremental marking. Two defects Task two (PV) Incremental marking max. two defects

		Task three (AL) - Incremental marking max. two defects Task four (SS) - Incremental marking max. two defects
8. Undercut	Is the weld joint free from undercut?	≤ 0.5mm
9. Overlap (Over roll)	Is the weld joint completely free of overlap (over roll)?	Not permitted
Imperfection Description	**Explanation**	**limits for imperfections**
10. Lack of Penetration	Is the joint free from lack of penetration or root fusion?	Task one (Coupon X-Ray) See International Standard IS0 5817 Task one (Coupon Visual) – Not permitted. Task three (AL) – Incremental marking Task four (SS) - Incremental marking
11. Excessive root concavity (shrinkage groove)	Is the weld penetration free of excessive root concavity “suck back”?	Task one - See International Standard IS0 5817
12. Excessive Penetration	Is the joint free of excessive penetration?	Task one (Coupon) - ≤ 2.0 mm Task two (PV)– N/A Task three (AL) - ≤ 3.0 mm Task four (SS) - ≤ 2.5 mm
13. Excessive Face Reinforcement (height)	Is the weld joint free of excessive face reinforcement?	Task one (Butt) - ≤ 2.5 mm Task two (PV) - ≤ 2.5 mm Task three (AL) - ≤ 1.5 mm Task four (SS) - ≤ 1.5 mm
14. Incompletely filled groove	Is the butt weld groove completely filled?	Not Permitted
15. Linear Misalignment (high/low)	Is the joint free from linear (high/low) misalignment?	Task one - See International Standard IS0 5817 Task two (PV) - ≤ 1.0 mm Task three (AL) - ≤ 1.0 mm Task four (SS) - ≤ 1.0 mm
16. Fillet Weld Sizes	Are fillet sizes in accordance with specifications? (Measurement leg length)	Task one (Coupon) -0/+2 mm Task two (PV) -0/+2 mm Task three (AL) -0/+2 mm Task four (SS) -0/+1 mm
17. Full Radius Contour	Does the joint exhibit a full radius contour = to plate thickness?	Full radius contour (To be assessed by judgement marking)
18. Excessive Width variation of Butt Weld Face	Are bead widths uniform and regular? (Measure narrowest portion vs. widest portion)	Task one (Coupon) - ≤ 2.0 mm Task two (PV) - ≤ 2.0 mm Task three (AL) - ≤ 1.5 mm

4 SKILL ASSESSMENT PROCEDURES

4.1 Procedure for performing non-destructive testing

- Specified procedures shall be used for all non-destructive testing;
- The welded test coupons shall be radiographed in the as welded condition. (No removal of any excess weld metal.);
- Radiography of the test coupons shall be performed in accordance with ISO 5817. Welds with no recordable imperfections are an “A” category pass;

Procedure for performing fracture tests on the Fillet welded coupon;

- Each test piece shall be positioned for breaking in accordance with ISO 9017 Destructive tests on welds in metallic materials – Fracture tests;
- Each coupon shall be visually assessed after breaking for lack of fusion, inclusions, and porosity

4.2 Procedure for the hydrostatic pressure test

- The Expert, whose Competitor’s vessel is being tested, is allowed to witness the test;
- Fill the vessel with water and ensure that all air is allowed to escape;
- Plug vessel and pressurize to city pressure;
- Ensure vessel is fully dry on outside;
- If vessel exhibits a leak – Score one point and test is complete;
- If no leaks are observed at city pressure, the vessel is further pressurized in stages (minimum of FOUR stages) to the maximum pressure normally 69bar (1000 psi) dependant on pressure pump available;
- Each hold point is held for 60 seconds. If no leak is detected the pressure is increased in stages until the vessel is pressurized to the maximum pressure;
- If the vessel leaks at any stage in the hydrostatic test the marks are awarded appropriate to the last successful hold point;
- Drain all water from the vessel.

Note: If a leak is detected, it shall be highlighted with a metal marker

5 TEST PROJECT DESIGN REQUIREMENTS

5.1 General Requirements

Overall, the Test Project shall be modular which are standalone assessments of the Competitor’s skill

Materials and equipment: Welding power sources:

- 111 SMAW, MMAW, 141 GTAW, TIG: AC/DC, 300 Amps Inverter-Type with Hi-Frequency, AC- Frequency (Hz) and Pulse controls;
- 135 GMAW, MAG, 136 FCAW: DC, 350 Amps with Pulse or Synergic contr
- Welding accessories
- 111 SMAW, MMAW Welding cable and electrode holder;

- 141 GTAW, TIG gun and accessories, contact tips, diffusers, shielding gas accessories, regulator, hoses, remote variable amperage controls, foot or hand-operated, hose for purging;
- 135 GMAW, MAG gun and accessories, contact tips, diffusers, shielding gas accessories, regulator, hoses, etc.
- 136 FCAW gun and accessories, contact tips, diffusers, shielding gas accessories, regulator, hoses, etc.

During the Competition only the materials provided by the Competition Organizer may be used.

5.2 Practice plates for the Competition.

The Competition Organizer shall provide two sets (four pieces each) of material for each of the test coupons and ten pieces each (100x50 mm) of aluminium and stainless steel material in the thickness of the tasks, to be used for practice plates. These plates shall be made available to the Competitor for practice on the day set aside for testing the installations before the Competition and for adjusting the welding parameters during the Competition.

Dimensions of practice plates

The practice plates shall be the same width and thickness as the actual Test Project module pieces but they shall each be shorter by 20 mm in length

5.2.1 Basic materials

Steel groups according to CR ISO/TR 15608 (2005), group one, two, or three for low carbon steel;

Group eight for stainless steel (300 series), and aluminium in the 5000 and 6000 series. Chosen material shall be listed on the Infrastructure List with full detail of the material grouping and classification. MTR's shall be provided to the Experts to review for accuracy and to approve before cutting of the material commences.

5.2.2 Plates

- High quality low carbon steel, 2 mm to 12 mm thick to ISO 10025;
- For pressure vessel, plates are to have through-thickness tested certification;
- Austenitic stainless steel, 2 mm to 3 mm thick e.g. 18/8 types X5CrNi 18;
- Aluminium, 3 mm thick only e.g. 5000 or 6000 series.

5.2.3 Pipes

- High quality low carbon steel pipes to ISO 10025, dia. 40 mm to 150 mm, wall thickness 1.6 mm to 10 mm;

- Stainless steel and aluminium, diameter 25 mm to 50 mm, wall thickness 1.6 mm to 6 mm.

Test coupons shall be cut, milled or turned, so that they are smooth and parallel.

5.3 Module 1: Test coupons general notes

- Time: allow three to four hours approximately;
- Quantity: three to five specimens, either Single V-groove butt joint welds or fillet welds;
- Welding processes: See Appendix 13.1;
- Welding positions: See Appendix 13.2;
- Drawings: See Appendix 13.2.
- For all test plates, 20mm at the start and finish will not form part of the inspection or marking process.
- The preparation for all butt weld test coupons shall be milled or turned at 30º to a featheredge. (No root face) See Appendix 13.2 for test coupon drawings

5.3.1 Fillet weld notes

The Competitor shall submit the test coupons fully assembled to the Experts for stamping prior to welding.

The fillet weld coupon/s shall consist of two pieces each 12 mm in thickness, one-piece 125 mm width and the other 100 mm width, 250 mm in length.

The fillet weld coupon shall have a leg length of 10mm, with an allowable tolerance of (+2 mm /– 0 mm). The fillet welds must be completed with a minimum of two runs and a maximum of three runs.

The weld must be MULTI RUN with a maximum of THREE runs. Single run or welds with more than three runs will NOT be allocated any marks for that coupon.

- If the hold point was not conducted, all affected assessments shall receive no marks.
- Grinding for the intent to enhance the cap pass shall not be allowed. All aspects for the assessment of an enhanced cap pass shall not be evaluated and a 0 mark awarded.
- The fillet weld coupon shall contain a stop start in the middle 75 mm of the joint. The stop start shall be located in either root or capping run to be decided by a jury vote at the Competition.
- The stop/start to be inspected and verified by stamping.

5.3.2 10 mm Test Coupon notes

- Grinding for the intent to enhance

- the root pass or cap pass shall not be allowed. All aspects for the assessment of an enhanced root pass or cap pass shall not be evaluated and a zero mark awarded.
- GMAW (MAG) is the only semi -automatic process to be used for root pass runs. FCAW (136) shall not be considered for making root passes.
- One test plate coupon shall consist of two (2) pieces, each 10 mm in thickness, 150 mm width and 250 mm in length.

5.3.3 16 mm Test Coupon notes

- If GMAW (MAG) is drawn for the root pass, a stop/start is required in the centre 75 mm of the plate;
- If any semi- automatic processes (GMAW/FCAW) are drawn for the fill and cap passes, a stop/start within the given 75 mm range documented on the drawing for the cap pass shall happen. A weave or the last pass of a multi-pass stringer bead cap is considered for the stop and restart.
- GTAW (141) shall not be used on the 16 mm test coupon.
- GMAW (135) is the only semi -automatic process to be used for root pass runs. FCAW-G (136) shall not be considered for making root passes.
- If hold points were not conducted, all affected assessments associated with the hold point shall receive no marks.
- Grinding for the intent to enhance the root pass or cap pass shall not be allowed. All aspects for the assessment of an enhanced root pass or cap pass shall not be evaluated and zero marks awarded.
- The test coupon dimension shall consist of two pieces, each 16 mm x 150 mm x 250 mm.
- Each of the two plate test coupons shall be welded with a different process. If a combination process joint is selected from the table for the 16 mm coupon as listed in Appendix 13.1 this rule shall not apply.
- The stop/start to be inspected and verified by stamping.

5.3.4 Pipe Test Coupon notes

- The pipe test coupon shall consist of two pieces of 114.3 mm dia x 8.56 mm wall (4” Sch 80) carbon steel pipe.
- The pipe coupon shall be welded with the process or processes selected from the table listed in Appendix 13.1.
- Grinding for the intent to enhance the root pass or cap pass shall not be allowed. All aspects for the assessment of an enhanced root pass or cap pass shall not be evaluated and zero marks awarded.

5.4 Module 2: Pressure vessel notes

Description: A completely enclosed plate/pipe structure, which shall encompass all four of the process listed and all weld positions as described in this Technical Description.

- Time: seven to eight hours approximately;
- Size: Overall dimensional space, approximately 350 mm x 350 mm x 400 mm;
- Plate thickness: 6.8 mm and 10 mm;
- Pipe wall thickness 3 mm to 10 mm;
- Pressure test minimum normally 1000 psi (69 bar).

The pressure vessel shall not weigh more than 35 kg in the welded condition.

The Skill Competition Manager reserves the right to amend the design test pressure of any pressure vessel prior to the start of the Competition.

5.5 Module 3: Aluminium structure

Description: A partially enclosed structure of aluminium, which shall be welded with TIG (141).

- Time: two or three hours approximately;
- Size: Overall dimensional space approximately 200 mm x 200 mm x 250 mm;
- Aluminium plate/pipe material thickness 3mm.
- All seams shall be welded in one run/pass with filler metal. The deposit of second run with or without filler will result in NO marks being awarded for the entire structure.
- The Test Project module may be sawn in half, where necessary, to enable weld penetration inspection and marking to be carried out.
- During assembly and welding of the aluminium structure, there shall be no gaps in any weld seam.

5.6 Module 4: Stainless Steel structure

Description: A partially enclosed structure of stainless, which shall be welded with GTAW (141).

- Time: two or three hours approximately;
- Size: Overall dimensional space approximately 150 mm x 150 mm x 200 mm;
- Stainless steel plate/pipe material thickness 2 mm to 3 mm.
- This Test Project module may be sawn in half, where necessary, to enable weld penetration inspection and marking to be carried out.

- All seams shall be welded in one run/pass with filler metal. The deposit of a second run with or without filler will result in no marks being awarded for the entire structure.

During assembly and welding of the stainless-steel structure, there shall be no gaps in any weld seam.

6 COMPETITION SPECIFIC INSTRUCTIONS

Welding machines, tools and equipment usage

- It is a requirement that the Competition Organizer supplies welding machines that can be used in basic modes of operation;
- Welding machines may be used to their full technical potential;
- It is a requirement that the Competition Organizer makes available detailed operation manuals to all participating countries/regions at least six (6) months prior to the Competition;
- The welding machines provided shall have the capability to be operated using both standard amperage control and remote amperage control. Remote variable amperage devices shall be made available;

Remote hand-held and foot controls switching controls must be provided.

Grinding and the use of abrasive materials and equipment:

- Material removal is not permitted on any of the root penetration or cap weld surfaces. “Cap pass” shall be defined as the final layer of the weld that meets the weld size, grooves and fillets.
- Restarts may be prepared before welding over them.
- Grinding the surfaces of the fillet coupon material before welding is permitted but the machined preparation angle shall remain at 90 degrees.
- Wire brushing: • Wire brushing, manual or powered, may be used on all weld surfaces of the test plates/pipes (module one) and the pressure vessel (module two).
- Wire brushing or chemical cleaning is NOT permitted on any of the completed welds of the aluminium project (module three) or the stainless-steel project (module four).

Backing bars/plates and restraining devices

- No chill plates, ceramic backing tapes/bars or run off tabs are to be used in the Competition;
- Purging equipment may only be used with the Gas Tungsten Arc Welding process on the stainless-steel project;

- Restraining devices shall not be used during welding of the test plates Such devices include: • Clamps, jigs, fixtures or steel plates, tack welded to the test plates;
- Welding of the test plates is to be carried out without the aid of restraining devices; (except that the provided restraining material for the fillet weld coupons) this is so the Experts can assess the control of distortion;
- Only standard fixture or positioning aids (positioners), supplied by the Competition Organizer may be used when welding the test coupons. Depending on the selected projects, they shall at all times be welded and ground 100% on the workbench. Only when instructed can a Competitor grind a coupon while still located in the positioner as long as grinding does not throw sparks over the top of the weld cell. Competitor is stopped immediately if grinding is being accomplished in an unsafe manner.

Weld cleaning of GTAW (141) projects

- The weld faces on the aluminium and stainless steel GTAW (TIG) projects are to be presented in the “as welded” condition. Cleaning, grinding, steel wool, wire brushing or chemical cleaning is NOT permitted on any of the welds except for the preparation of stop starts on the stainless-steel project.

Tack welds

- Tack weld inspection is a HOLD POINT
- The maximum length of any one tack weld for any project is 15 mm.
- For pressure vessel, Stainless Steel, and Aluminium tacking, 15 mm tacks may be combined about the X, Y and Z axis;
- Tacking in module 1 and module 2, i.e. fillet welds, test pipe, test plates, and pressure vessel, the Competitor may use any of the welding processes listed in this Technical Description for tack welding in any position;
- No tack welds shall be made on the inside of any project. If found during presentation, Competitor is asked to remove them. Time are not compensated for this.
- For fillet weld coupons, only two sufficient tack welds are placed on the strong back in such a manner that they can be easily removed. Two tacks at each start and ending edge of the coupon are permitted.

Welding of test plates/pipes and fillet coupons

- Once welding has commenced, the test plates may not be separated and then re-tacked. Re- tacking may only take place, if root welding has not commenced.

- There shall be no gap present in the fillet weld joint between plates after tacking. If such condition exists, Competitor is asked to reassemble the coupon to remove the gap. Time will not be compensated for this.
- HOLD POINT: A stop start must be conducted within the given 75 mm specified on the drawing for the root of the fillet weld coupon.
- HOLD POINT: A stop start must be conducted within the given 75mm specified on the drawing of the root and cap pass for the 16 mm coupon. If SMAW (111) is chosen for the root pass, no root pass hold point is conducted.
- HOLD POINT: The test pipe coupon shall be secured in the positioner provided and mark the 12 o'clock position before welding commences. This is to be confirmed by permanent marking and will also act as a reference point for any inspection or testing.
- If hold points are not conducted in the root pass or cap pass of any coupon, all aspects of the effected pass are awarded zero marks except for RT aspects. Class D RT marks will automatically be given.
- If a Competitor welds a coupon with the incorrect process or in the incorrect position, no further inspection and testing are carried out and no marks are awarded to that coupon.

Welding of the pressure vessel

If any of the joint configurations on the pressure vessel i.e. butt, fillet or outside corners are welded with the incorrect process or in the incorrect position, that joint configuration shall not be visually assessed, and no marks are awarded.

Welding of the Aluminium or stainless-steel structures

If any of the joints are welded in the incorrect position, no further inspection shall be carried out and no marks are awarded for the complete structure.

After tacking, inspection and verification by stamping there can be no further material removal, no grinding, filing, or cleaning shall be carried out on the structure.

Note: A Competitor who is seen to be carrying out an operation that compromises any of rules or guidelines of this Technical Description is notified immediately, to carry out no further work on the project until the matter is brought to a conclusion. The Competitor shall not be penalized by any time penalty during any investigation.

The standard list for test coupons will detail the position of the coupon, the process for the root pass, and the process for the fill and cap passes. The Skill Competition Manager will determine the four test coupons to be welded

ALL WELDING OF VERTICAL OR SLOPING WELDS MAY ONLY BE DONE WITH AN UPWARD PROGRESSION.

MODULES THREE AND FOUR MUST BE WELDED IN ONE PASS ONLY WITH FILLER ADDED

7 GENERAL BEST PRACTICE PROCEDURES

Topic/Task	Best Practice Procedure
Equipment Failure	• If equipment or tools which are brought by the Competitor fail there is no extra time allowed. • If equipment or tools supplied by the Competition Organizer fail extra time is allowed only if the Technician of the sponsor or supplying company specifies and proves it is not a “user error”.

8 APPENDIX A

8.1 SELECTION OF COUPONS, WELD PROCESS AND POSITION COUPON

	Root pass	Fill and capping	Position
Pipe			
1	TIG/GTAW (141)	MMA/SMAW (111)	H-LO45/6G
2	TIG/GTAW (141)	MAG/GMAW (135)	PH/5G
3	TIG/GTAW (141)	FCAW -G (136)	PC/2G
4	MMAW/SMAW (111)	MMAW/SMAW (111)	H-LO45/6G
10 mm Plate			
5	MMAW/SMAW (111)	MMAW/SMAW (111)	PE/4G
6	MMAW/SMAW (111)	MMAW/SMAW (111)	PC/2G
7	MAG/GMAW (135)	MAG/GMAW (135)	PC/2G
8	MAG/GMAW (135	MAG/GMAW (135)	PF/3G
16 mm Plate			
9	MAG/GMAW (135)	FCAW-G (136)	PA/1G
10	MAG/GMAW (135)	FCAW-G (136)	PC/2G
11	MAG/GMAW (135)	FCAW-G (136)	PF/3G
12	MAG/GMAW (135)	FCAW-G (136)	PE/4G
Fillet Weld			
13	MAG/GMAW (135)		PF/3F
14	MAG/GMAW (135)		PB/2F
15	FCAW-G (136)		PB/2F
16	FCAW-G (136)		PF/3F
17	FCAW-G (136)		PD/4F
18		MMAW/SMAW (111	

9 APPENDIX B