Welding Technology Institute of Australia ABN 69 003 696 526	**Weld Procedure Variables Comparison Sheet for Structural Steel Codes**	**TGN-M-04** **Rev: 0** **Date: 31 May 2006** **Pages: 2**

1. INTRODUCTION

This guidance note is intended to compare the **Welding Procedure** essential variables for the two most widely used structural steel codes, AWS D1.1 – 2004 and AS/NZS1554.1 – 2004. This comparison sheet does not include requirements for welders.

ABBREVIATIONS USED IN COMPARISON SHEET

ac – Alternating Current
AS – Australian Standard
AWS – American Welding Society
CJP – Complete Joint Penetration
CVN – Charpy V-Notch
dc – Direct Current
E – Essential variable
Elec – Electrode
FCAW – Flux Cored Arc Welding
GMAW – Gas Metal Arc Welding
GTAW – Gas Tungsten Arc Welding
HI – Heat Input
MAG – Metal Active Gas Welding
MIG – Metal Inert Gas Welding
MMAW – Manual Metal Arc Welding
N – Non essential variables
SAW – Submerged Arc Welding
SMAW – Shielded Metal Arc Welding
t – Weld Metal Thickness
T – Base Metal Thickness
TIG – Tungsten Inert Gas Welding
Vert – Vertical
WPS – Welding Procedure Specification
M – Requalify by macro test

2. DEFINITIONS

Essential Variable: A change in a welding condition which will affect the mechanical and/or metallurgical properties of the weldment (e.g. change in material, welding process, filler metal, electrode, preheat or post weld heat treatment, etc.) and, if changed, requires re-qualification of the welding procedure.

Non-Essential Variables: A change in a welding condition which will **not** affect the mechanical and/or metallurgical properties of a weldment (such as method of preparation, method of back gouging or cleaning, etc.). These variables may be altered without re-qualification of the procedure, but must be stated on the WPS.

3. SYMBOLS USED IN COMPARISON SHEET:

(+) Addition; (>) Increase / Greater than; (↑) Uphill; (↓) Downhill; (Ø) Change in; (-) Deletion/Omission; (<) Decrease / Less than

4. HOW TO USE THE COMPARISON SHEET

The comparison between the structural codes does not include welding where Charpy V-notch testing is a requirement. The welding processes covered in the comparison are the commonly used fusion processes and are designated by a number 1 to 5 as follows:

1 - SMAW/MMAW;
2 – GTAW/TIG;
3 – GMAW/MIG/MAG;
4 – FCAW;
5 – SAW

The comparison sheet consists of three main Columns:
Welding Variables (Columns a and b),
AWS D1.1 (Columns c to k), and
AS/NZS 1554.1 (Columns l to t)

The Variables section covers the welding variables normally considered in a welding procedure in column a, with a description of the variable in column b.

The AWS D1.1 and AS/NZS 1554.1 sections are similar in order to ensure that an accurate comparison can be made. Columns c and l indicates a symbol which indicates a change or an increase, etc., as specified above. Columns d, e, m and n give the reference as specified in the code or Standard.

In columns d and m, if a P is present before a number (e.g. P4.7), it indicates that the information was obtained from that paragraph in the Standard (e.g. P4.7 - the relevant information was obtained from paragraph 4.7). No pre-script indicates that the information is from a table with the number indicated.

Columns e and n indicates whereabouts in the table, referenced in the columns d and m, the information can be found.
Columns f to j and o to s indicates the essential variables per process. An E indicates that the variable is an essential variable and any change beyond the range will require re-qualification of the procedure. An N indicates a non-essential variable (see definitions). An open space indicates that no specific requirement for that variable for that code / specification is listed and that engineering judgement and a good practice approach should be used. Columns k and t gives notes or exceptions relevant to the specific variable.

The guidance note matrix attached compares variables between the two structural steel standards for qualifying welding procedures and also verifies compliance to a specific Standard for procedures already qualified.

Example to use comparison:

What is the difference in preheat requirements between the two specifications when using the GMAW process?

From the comparison sheet go to preheat in column a. The first row under preheat (row 28) is the only row which addresses preheat, so this is the only line that will be considered. From the welding process number above, number 3 is GMAW. If you move vertical down from columns h and q and horizontal along row 28, you will find that preheat is an essential variable for both Standards. Move along row 28 to columns k and t to find the specific requirements from the Standard.

For AWS D1.1 the preheat requirements can be found in Table 4.5, number 34 and this reference will indicate a decrease of more than 15°C will require re-qualification of the procedure. The requirements for preheat in AS1554.1 can be found in Table 4.11A, number m and this reference will indicate a decrease of more than 20°C will require re-qualification of the procedure. To satisfy the requirements of both specifications, the range of preheat should be decreased by ≤15°C.

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	a	B	c	d	e	f	g	h	i	j	K	l	m	n	o	p	q	r	s	t
1	**VARIABLES**		**AWS D 1.1 – 2004**									**AS/NZS 1554.1 – 2004**								
2						*PROCESS									* PROCESS					
3				Reference		1	2	3	4	5	Notes / Exceptions		Reference		1	2	3	4	5	Notes / Exceptions
4	PROCESS	One process to another	Ø	P4.7	4.7.1	E	E	E	E	E	Changes beyond essential variables limits in Table 4.5	Ø	4.11 A	a	E	E	E	E	E	
5	JOINTS	Groove design / joint preparation	Ø	4.5	30	E	E	E	E	E	Qualification of any CJP qualifies section 3.12 & 3.13	Ø	4.11 C	d	M	M	M	M	M	From V-shape to U-shape
6		Type of groove	Ø	4.5	31	E	E	E	E	E	To a square groove and vice versa	Ø	P4.1.2	c,d	N	N	N	N	N	To 2 sided & double prep. for 1 sided for V&U
7		Tolerances (< groove angle, < root opening, > root face)	Ø	4.5	32	E	E	E	E	E	Exceeding the tolerances of 3.12, 3.13, etc.	Ø	4.11 C	e i-iii	M	M	M	M	M	See Clause 5.2 for values & ranges
8		Pre-qualified joints	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	P4.1.2	b	E	E	E	E	E	Qualifies all positions for that joint
9		One sided welding on single V or Single U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	P4.1.2	a	E	E	E	E	E	Qualifies single sided welds on plate & pipe
10		Backing or back gouging	-	4.5	33	E	E	E	E	E	Omission, but not inclusion of backing or gouging	-	4.11 C	e iv	M	M	M	M	M	Omission, but not inclusion of backing
11												Ø	P2.2	N/A	E	E	E	E	E	See P2.2 for temporary & permanent backing
12	BASE METAL	Material type	Ø	4.5	28	E	E	E	E	E	Material or comb. not listed on PQR or qual. By Table 4.8	Ø	P2.1	All	E	E	E	E	E	Carbon Steels – See P2.1 & Table 4.6.1 B
13		Diameter	Ø	4.5	27	E	E	E	E	E	See Table 4.2 for range	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14		Material thickness	Ø	4.5	27	E	E	E	E	E	See Table 4.2 for range	Ø	4.11 A	o	E	E	E	E	E	Outside 0.75T to 1.5T, See Clause 4.1.2(g)
15	FILLER METAL	Number of electrodes	Ø	4.5	11	N/A	N/A	E	E	E	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16		Electrode Diameter	Ø	4.5	10	E	E	E	E	E	Any change – see Table 4.5 (10)	>	4.11 C	a,b	M	M*	M	M	N/A	Any Increase, *More than 1 step in sequence
17		Wire Diameter	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 C	c	N/A	M	N/A	N/A	M	of more than 1 step in diameter sequence
18		Electrode / filler metal classification	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 A	b	E	E	E	E	E	< in strength (Table 4.6.1(A))
19		Filler metal strength	>	4.5	1	E	N/A	E	E	N/A	None	>	4.11 A	c	E	E	E	E	E	N/A
20		H_2 controlled to non h_2 controlled	Ø	4.5	2	E	N/A	N/A	N/A	N/A	or any > in H_2 classification	Ø	4.11 A	d	E	N/A	N/A	E	E	or any > in H_2 classification
21		Addition or deletion of filler metal	±	4.5	5	N/A	E	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22		Supplemental powdered or granular filler metal	±	4.5	7, 8	N/A	N/A	N/A	N/A	E	Or cut wire or increase in amount	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23		Change of wire heat	Ø	4.5	6	N/A	E	N/A	N/A	N/A	From cold wire feed to hot wire feed or vice versa	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24		Chemical composition of weld metal	Ø	4.5	9	N/A	E	N/A	N/A	N/A	Must meet WPS requirements. See Table 4.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25		Electrode, consumable or flux type	Ø	4.5	3	N/A	E	N/A	E	E	Electrode or Flux Electrode combination	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
26		Electrode or Flux Electrode Classification not in AWS	Ø	4.5	4	E	E	E	E	E	Not covered in AWS spec. – See Table 4.5 (4)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
27	POSITION	Butt Weld position	Ø	4.5	26	E	E	E	E	E	Any position not qualified by Table 4.1	Ø	4.11 A	k	E	E	E	E	E	Position in which welding is done, See 4.1.4
28		Direction of welding (Vert. up or Vert. Down)	Ø	4.5	29	E	E	E	E	N/A	From uphill to downhill and vice versa	Ø	4.11 A	k	E	E	E	E	E	See clauses 4.1.2(b) & 4.1.3 (c)
29		Fillet weld position	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 A	s	E	E	E	E	E	See Clause 4.5.4
30	PREHEAT	Specified preheat temperature	<	4.5	34	E*	E**	E*	E*	E*	Decrease by more than: *15°C, **55°C	<	4.11 A	m	E	E	E	E	E	Of more than 20°C
31		Specified inter-run (pass) temperature (Decrease)	<	4.5	36	E*	E**	E*	E*	E*	Decrease by more than: *15°C, **55°C	<	4.11 A	m	E	E	E	E	E	Of more than 20°C
32		Specified inter-run (pass) temperature Increase > 56°C	>	4.5	35	N/A	E	N/A	N/A	N/A	Increase > 55°C if CVN tests are required	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
33	PWHT	PWHT	Ø	4.5	37	E	E	E	E	E	Addition or deletion of PWHT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
34	GAS	Shielding gas classification	Ø	4.5	20	N/A	N/A	E	E	N/A	GMAW-A5.18 or 5.28, FAW-A5.20 or 5.29	Ø	4.11 A	e	N/A	E	E	E	N/A	Outside the limits of AS 4882
35		Single, mixture or % of mixture	Ø	4.5	18	N/A	E	E	E	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36		Flow rate	Ø	4.5	19	N/A	E	E	E	N/A	Increase > 50% or Decrease > 20%	Ø	4.11 A	j	N/A	E	E	E	N/A	**≥ 25% or ≤ 10%**
37	ELECTRICAL CHARAC-TERISTICS	Specified mean arc voltage	Ø	4.5	14	E***	E**	E*	E*	E*	A Ø for each dia. used, *±7%, **±25%, ⌂**See table**	Ø	4.11 A	f	E	E	E	E	E	±7% for 3,4,5 & ±15% for 1,2
38		Specified mean welding current	Ø	4.5	12	E	E	E	E	E	Ø in the Amps for each diameter used	Ø	4.11 A	g	E	E	E	E	E	±10% for 3,4,5 & ±15% for 1,2
39		Specified mean speed of travel (No HI control req.)	Ø	4.5	16	N/A	E*	E**	E**	E***	(> or <) *50%, **25%, ***15%	Ø	4.11 A	h	N/A	E	E	E	E	More than ±15%
40		Type of current or polarity or metal transfer mode	Ø	4.5	13	N/A	N/A	E	E	E*	*Only when using an alloy flux or Q&T materials	Ø	4.11 A	I	E	E	E	E	E	ac to dc, dc polarity or transfer across arc
41		Heat Input	>	4.5	17	E	E*	E	E	E	Increase > 10%, *Any when CVN tests are required	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
42		Pulse parameters	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 A	q	N/A	E	E	E	N/A	See clause 4.11
43		Wire feed speed for each electrode diameter	Ø	4.5	15	N/A	N/A	E	E	E	(> or <) > 10%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
44	TECHNIQUE	Spacing of the arc in multi arc processes	Ø	4.5	21,22	N/A	N/A	N/A	N/A	E	Longitudinal or lateral spacing >10% or 3mm	Ø	4.11 C	f i,ii	N/A	N/A	N/A	N/A	M	Long.(Lat.) space > of ±10% & ±4mm(±1.5mm)
45		No. of runs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 A	i	E	E	E	E	E	> ±25% in no of runs, allow > in area
46		No. of electrodes in multiple wire application	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 A	n	N/A	E	E	E	E	N/A
47		Electrode stick-out	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 A	p	N/A	N/A	E	E	E	> 20%
48		Single pass to multi pass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ø	4.11 A	r	E	E	E	E	E	For fillet welds, see clause 4.1.3
49		Leg length size	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	>	4.11 A	t	E	E	E	E	E	For single pass fillets over size on WPAR
50		Angular orientation of any parallel electrode	Ø	4.5	23	N/A	N/A	N/A	N/A	E	An increase or decrease of more than 10°	Ø	4.11 C	f iii	N/A	N/A	N/A	N/A	M	A ±10% change in angular rotation
51		Electrode angle (For machine or automatic SAW)	Ø	4.5	24	N/A	N/A	N/A	N/A	E	An increase or decrease of more than 3°	Ø	4.11 C	f ivA	N/A	N/A	N/A	N/A	M	A ±3° change in direction of travel
52		Orientation normal to direction of travel (machine/auto)	Ø	4.5	25	N/A	N/A	N/A	N/A	E	An increase or decrease of more than 5°	Ø	4.11 C	f ivB	N/A	N/A	N/A	N/A	M	A ±5° change normal to direction of travel

Symbols: + Addition, > Increase / Greater than, ↑ Uphill, ← Forehand, → Backhand, ↓ Downhill, Ø Change in, - Deletion/Omission, < Decrease / Less than

Disclaimer applies

***Welding Processes: 1 - SMAW/MMAW/Stick, 2 – GTAW/TIG/ARGON, 3 – GMAW/MIG/MAG/CO_2, 4 – FCAW, 5 – SAW**

Variables: E – Essential variable, N – Non Essential Variable, N/A – Not applicable or no specific code / specification requirement (Use engineering judgement and good practice approach), M – Re-qualification by Macro Test.

Notes: In the reference section above, P = Paragraph and no pre-script indicate that the information is from a Table with number indicated. The comparison does not include welding where Charpy V-notch testing is a requirement

Abbreviations: T – Base Metal Thickness, t – Weld Metal Thickness, HI – Heat Input, CVN – Charpy V-Notch, CJP – Complete Joint Penetration, MMAW – Manual Metal Arc Welding, SMAW – Shielded Metal Arc Welding, GTAW – Gas Tungsten Arc Welding, TIG – Tungsten Inert Gas Welding, GMAW – Gas Metal Arc Welding, MIG – Metal Inert Gas Welding, MAG – Metal Active Gas Welding, FCAW – Flux Cored Arc Welding, SAW – Submerged Arc Welding, Vert – Vertical, ac – Alternating Current, dc – Direct Current,

NDNP TECHNOLOGY DIFFUSION ACTIVITY # 27	WTIA Welding Technology Institute of Australia ABN 69 003 696 526 **NATIONAL DIFFUSION NETWORKS PROJECT** **TECHNOLOGY QUESTIONNAIRE** **Mining Industry Group (TGN-M-03)** **"WELD PROCEDURE VARIABLES COMPARISON SHEET FOR STRUCTURAL STEEL CODES"**	**Document No:** 9.4.6QR-0001 **Revision No:** Rev 0 **Page 1 of 2** **Date: 3**1/05/2006

As part of the WTIA National Diffusion Networks Project, the Mining Industry Sector has identified the need to compare the American and Australian structural steel Standards (AWS D1.1 and AS/NZS 1554.1) to determine the commonalities and differences in the essential variables. The WTIA has prepared a comparison matrix that includes the essential variables of the two common welding Standards used in structural steel applications in the mining and processing industries. This comparison matrix will allow users to optimise procedure qualification by ensuring conformance to both Standards. The comparison matrix can be used to establish whether welding procedures qualified to one of the Standards also conforms to the other Standard. Information in the matrix enables the development of a list of the essential variables that could require procedures to be re-qualified. As a valued technology expert in this area we would like you to be part of the Technology Expert Group to review this matrix. Please complete this questionnaire so that we can gauge the success of meeting this need.

Objective 1: Identify the need for a simple and readily available matrix to compare the essential variables of Australian and American structural steel welding Standards

Fabrication and maintenance workshops need an easy guide to verify the essential variables of structural steel welding Standards and a quick comparison guide to determine the differences between the different structural steel Standards. How well does the matrix achieve these aims?

poor ☐ average ☐ good ☐ very good ☐

Comments: _____

Objective 2: Identify appropriate technology receptors

This document was written for Welding Engineers, Quality Managers, Inspectors, Welding Supervisors, Welders and Welding Coordinators involved in Fabrication and Repairs for the mining Industry. Are these people the appropriate individuals we should be targeting?

yes ☐ no ☐

What other types of companies and/or personnel do you suggest we target? _____

_____

Objective 3: Identify current best practice for repair & maintenance welding

The matrix was developed to reflect current best practice for fabrication, repair and maintenance of structural steel welded components. Do you envisage opportunities for the use of this practice in industry?

yes ☐ no ☐

If yes, what and where, if no why not? _____

_____

Objective 4: Is the information provided clear, concise and accurate?

yes ☐ no ☐

If not, why? _____

Objective 5: Broad dissemination of technology to the Mining Industry

Please indicate how best to disseminate this matrix to the appropriate Industry Recipients

Free Website Download ☐ Hard Copy Matrix ☐

If hardcopy Matrix, what size? A3 ☐ A4 ☐ Laminated ☐ What selling price? $ _____

Objective 6: Continuous Improvement

Please Identify areas where the document can be improved or return the document with your recommended additions/amendments. Alternatively, please use the area below to provide any additional comments.

*Respondents Name:*_____ *Company:* _____ *Phone:* _____

Fax: _____ *Email:* _____ *Date:* _____

Please Fax (02 9748 2858) or E-mail (info@wtia.com.au) your response.

The WTIA has joined forces with industry and government to create a 3.5 million dollar Technology Support Centres Network. This network will assist industry to identify and exploit world's best technology and manufacturing methods to establish a vibrant Australian industry beyond 2006. Together we will be implementing a step by step process which will lead to ongoing viability and greater profitability for all concerned:

(1) Determine your technological and manufacturing needs;
(2) Identify world's best practice;
(3) Draw upon the network to implement world's best practice at your site