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CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR

MALAYSIA FRANCE INSTITUTE

FINAL EXAMINATION

SEPTEMBER 2014 SESSION

SUBJECT CODE	:	**FTB32303**
SUBJECT TITLE	:	**WELDING METALLURGY 2**
LEVEL	:	**BACHELOR**
DURATION	:	**9.00 AM – 11.30 AM (2.5 HOURS)**
DATE / TIME	:	**7 JANUARY 2015**

INSTRUCTIONS TO CANDIDATES

1. **Please read the instructions given in the question paper CAREFULLY.**
2. **This question paper is printed on both sides of the paper.**
3. **Please write your answers on the answer booklet provided.**
4. **Answer should be written in blue or black ink except for sketching, graphic and illustration.**
5. **This question paper consists of TWO (2) sections. Section A and B. Answer ALL questions in Section A. For Section B, answer TWO (2) questions only.**
6. **Answer all questions in English.**

THERE ARE 5 PRINTED PAGES OF QUESTIONS, AND 4 PAGE OF APPENDIX EXCLUDING THIS PAGE.

SECTION A (Total: 60 marks)

Please use the answer booklet provided.

INSTRUCTION: Answer ALL questions only.

Question 1

(a) State **TWO (2)** methods of weld preheating.

(4 Marks)

(b) Post heating is recommended for highly hardenable steel material or carbon equivalents more than 0.6, explain the purposes of post heating.

(4 Marks)

(c) Your task is to weld a 100 mm thickness low alloy steel plate without risk of cracking by GMAW process. Material compositions were given as below;

Carbon	= 0.20%	Phosphorus	= 0.03%
Manganese	= 0.60%	Sulfur	= 0.03%
Silicon	= 0.6%	Chromium	= 0.5%
Nickel	= 0.2%	Balance is Fe	

Determine the preheating temperature by susceptibility grouping. Assume the welding joint under medium constrain.

(6 Marks)

(d) Due to weld preheating process involves higher costs, analyze your task in question 1(c) is it possible to avoid preheating.

(6 Marks)

Question 2

(a) Permanent furnace is one of PWHT method. Discuss the advantages and disadvantages.

(6 Marks)

(b) Refer to welding parameter and condition were given as below, predict the percentage of entrapped hydrogen that able to remove from weldment by using diagram in appendix 4.

Plate Thikness	= 20 mm
Joint Design	= Tee
Preheating and Interpass Temperature	= 150°C
Preheating and Interpass Duration	= 2 hours

(6 Marks)

(c) The amount of hydrogen entrapped in weldment is 10ml. If 5ml is the maximum allowable hydrogen entrapped in weldment for prevention of weld cracking. Determine the suitable soaking temperature and soaking time for PWHT process. Soaking time should not be more than 5 hours. Assume welding parameter as below;

Welding Process	= GMAW
Plate Thickness	= 40mm
Joint Design	= Tee joint

(8 Marks)

(Note: Select suitable diagram in appendix 5)

Question 3

(a) Discuss the important of ferrite number (FN) in DeLong.

(4 Marks)

(b) State the different between DeLong and WRC1992 diagrams

(4 Marks)

(c) By aided of DeLong diagram given in appendix 3, select the most suitable filler metal for welding plate SS320 and SS 308L. Assume 30% dilution was occurred.

(12 Marks)

Table 1: Base and filler metal compositions

	Base metal (%)		Filler Metal (%)	
	SS308L	**SS320**	**ER309L**	**ER2209**
Carbon	0.03	0.02	0.3	0.03
Manganese	2.0	2.0	2.00	1.5
Chromium	18.00	20	23.5	22.5
Silicon	0.75	0.7	1.5	1.0
Nickel	10.0	34	13.5	9
Molybdenum	-	2.5	0.2	-
Nobium	-	0.3	-	-
Nitrogen	0.02	0.02	0.08	0.15
Sulphur	0.030	0.035	0.030	-
Phosphorus	0.045	0.035	0.030	-

SECTION B (Total: 40 marks)

INSTRUCTION: Answer TWO (2) questions only.

Question 1

Welding austenitic stainless steel containing carbon 0.05 wt% and above may cause to formation of chromium carbide that promote to susceptible weld decay.

(a) Explain in detail how weld decay occurs.

(10 Marks)

(b) Sketch the location of weld decay for double V butt joint.

(4 Marks)

(c) Distinguish the weld decay in austenitic and ferritic stainless steels.

(6 Marks)

Question 2

(a) State **THREE (3)** common problems associated with welding heat treated aluminum alloy such as 2014, 6061 and 7075.

(6 Marks)

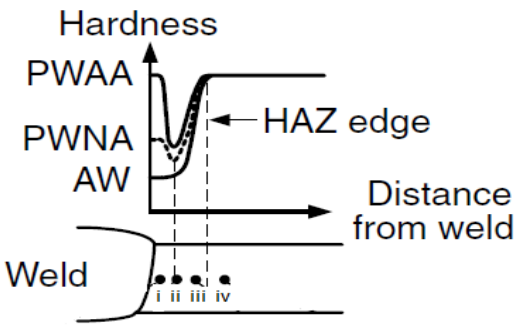


Figure 1: HAZ profile in an Al-Cu aluminum alloy

(b) Refer to Figure 1 above;

i. Sketch the microstructure for location (ii), (iii) and (iv).

(6 Marks)

ii. Explain why hardness profile as welded condition (AW) is lower at location (i) and (ii).

(4 Marks)

iii. Explain why hardness profile for post weld artificial ageing (PWAA) at location (ii) is not increase significantly as other locations.

(4 Marks)

Question 3

Heat treatable nickel base alloys are often post weld heat treatment (PWHT) after welded to relieve stress and develop the maximum strength, however cracking can occur during PWHT.

(a) Explain how reheat cracking occurs in nickel alloys during PWHT.

(6 Marks)

(b) Discuss **TWO (2)** methods to prevent reheat cracking.

(6 Marks)

(c) Sketch the hardness profile of heat treatable nickel alloy after weld.

(4 Marks)

(d) State **TWO (2)** criteria than nickel base alloy are chosen for applications.

(4 Marks)

END OF QUESTIONS

Appendix1

$$CE = C\% + \frac{Mn\%}{6} + \frac{Cr\% + Mo\% + V\%}{5} + \frac{Cu\% + Ni\%}{15}$$

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

Table 1: Susceptibility Index grouping

Hydrogen Level (H)	***Pcm***				
	< 0.18	**< 0.23**	**< 0.28**	**< 0.33**	**< 0.38**
H_1	**A**	**B**	**C**	**D**	**E**
H_2	**B**	**C**	**D**	**E**	**F**
H_3	**C**	**D**	**E**	**F**	**G**

Where, **H_1 = 5 ml/100g of weld metal**
H_2 = 10 ml/100g of weld metal
H_3 = 30 ml/100g of weld metal

Table 2 Minimum Preheat and Interpass Temperatures (Above the Ambient) for Fillet and Butt Welds for Three Levels of Restraint (°C)

Level of Restraint	*Thickness* (mm)*	*Susceptibility Index Grouping*						
		A	*B*	*C*	*D*	*E*	*F*	*G*
Low	10	< 20	< 20	< 20	< 20	60	140	150
	10–19	< 20	< 20	20	60	100	140	150
	19–38	< 20	< 20	20	80	110	140	150
	38–75	20	20	40	95	120	140	150
	> 75	20	20	40	95	120	140	150
Medium	10	< 20	< 20	< 20	< 20	70	140	160
	10–19	< 20	< 20	20	80	115	145	160
	19–38	< 20	20	75	110	140	150	160
	38–75	20	80	110	130	150	150	160
	> 75	95	120	140	150	160	160	160
High	10	< 20	< 20	< 20	40	110	150	160
	10–19	< 20	20	65	105	140	160	160
	19–38	20	85	115	140	150	160	160
	38–75	115	130	150	150	160	160	160
	> 75	115	130	150	150	160	160	160

* Thickness refers to thicker part.

Appendix 2

Table **3.1** Maximum thicknesses for welding mild steel without preheat (suitable for a maximum CE of 0.38)

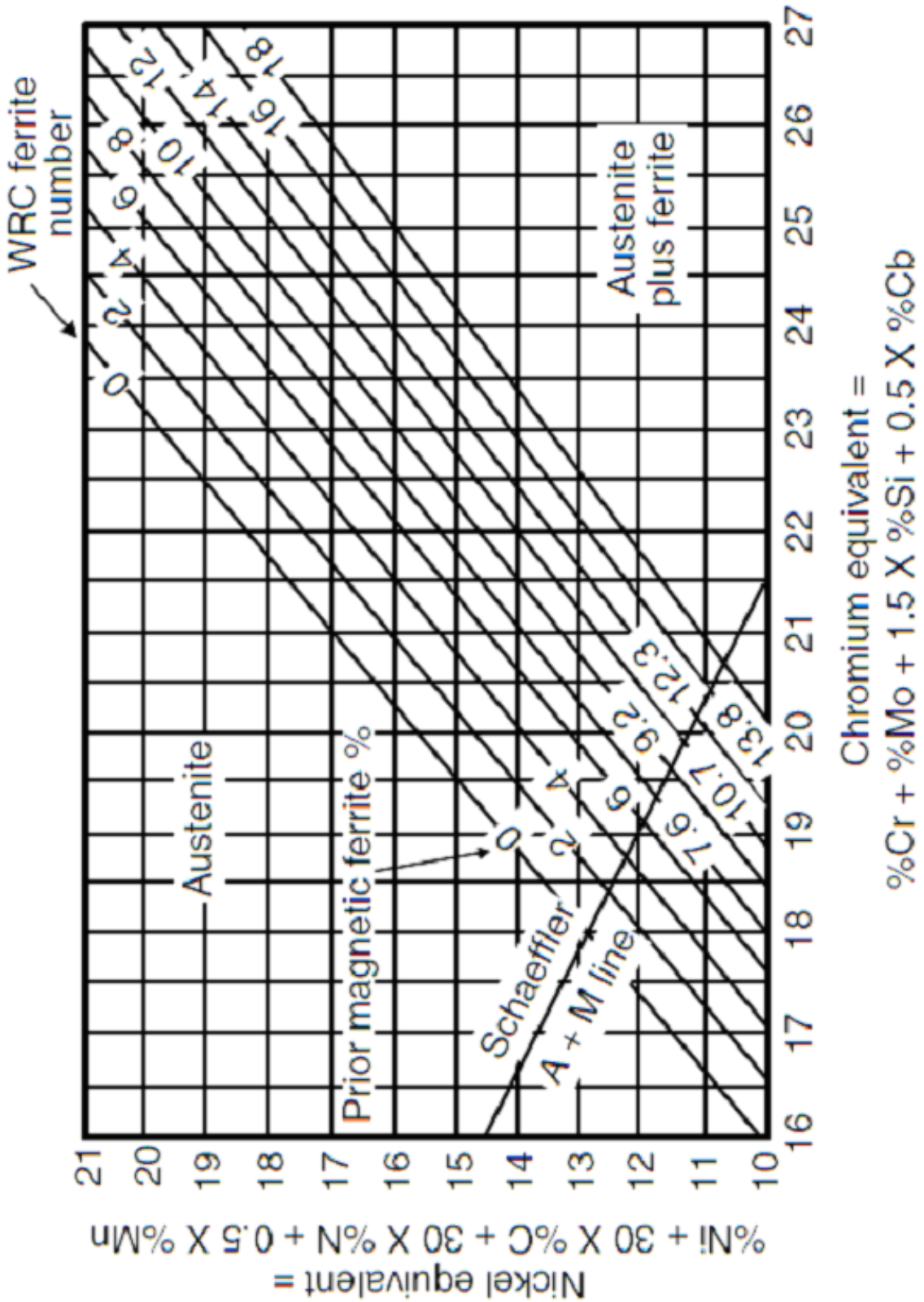
Heat input, kJ/mm	Maximum combined thickness, mm							
	Manual metal arc, gas-shielded metal arc with hydrogen potential:				Submerged-arc with hydrogen potential:			
	High (A)	Medium (B)	Low (C)	Very low (D)	High (A)	Medium (B)	Low (C)	Very low (D)
0.6	22	27	35	—	27	35	42	—
1.0	38	45	60	—	47	57	72	—
1.4	52	63	80	—	66	80	—	—
1.8	66	80	—	—	—	—	—	—
⩾2.2	80	—	—	—	—	—	—	—

Notes: 1 A dash indicates no limit.
2 Lower values of combined thickness may be required for highly restrained joints.

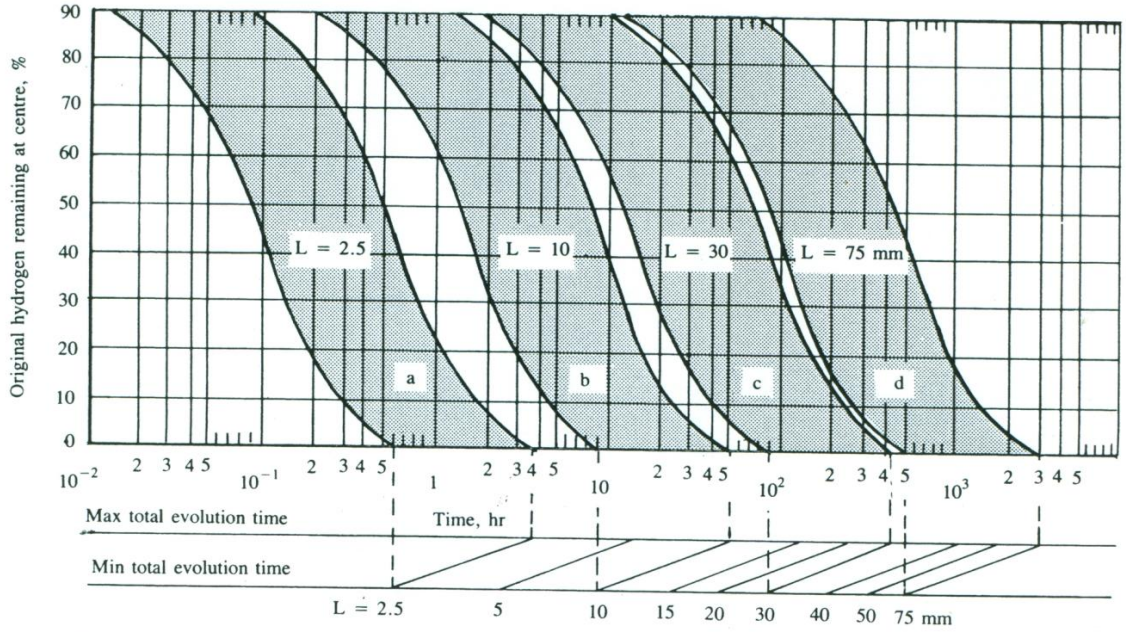
Table **3.2** Maximum thicknesses for welding mild steel with preheat (suitable for a maximum CE of 0.38)

Preheat temperature, °C	Heat input, kJ/mm	Maximum combined thickness, mm							
		Manual metal arc, gas-shielded metal arc with hydrogen potential:				Submerged-arc with hydrogen potential:			
		High (A)	Medium (B)	Low (C)	Very low (D)	High (A)	Medium (B)	Low (C)	Very low (D)
75	0.6	27	33	50	—	35	43	55	—
	1.0	45	55	—	—	58	72	—	—
	1.4	62	77	—	—	80	—	—	—
	1.8	80	—	—	—	—	—	—	—
100	0.6	35	45	—	—	42	—	—	—
	1.0	55	—	—	—	70	—	—	—
	1.4	80	—	—	—	—	—	—	—

Appendix 3

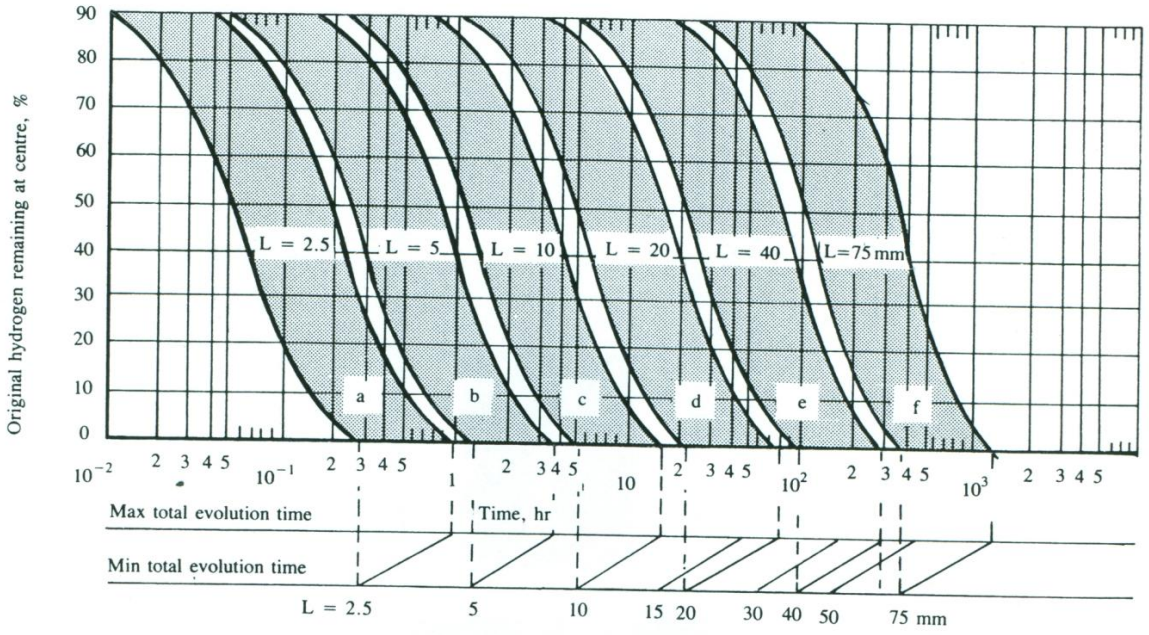

WRC ferrite number
Austenite
Austenite plus ferrite
Prior magnetic ferrite %
Schaeffler
A + M line
Nickel equivalent =
%Ni + 30 X %C + 30 X %N + 0.5 X %Mn
Chromium equivalent =
%Cr + %Mo + 1.5 X %Si + 0.5 X %Cb

Appendix 4

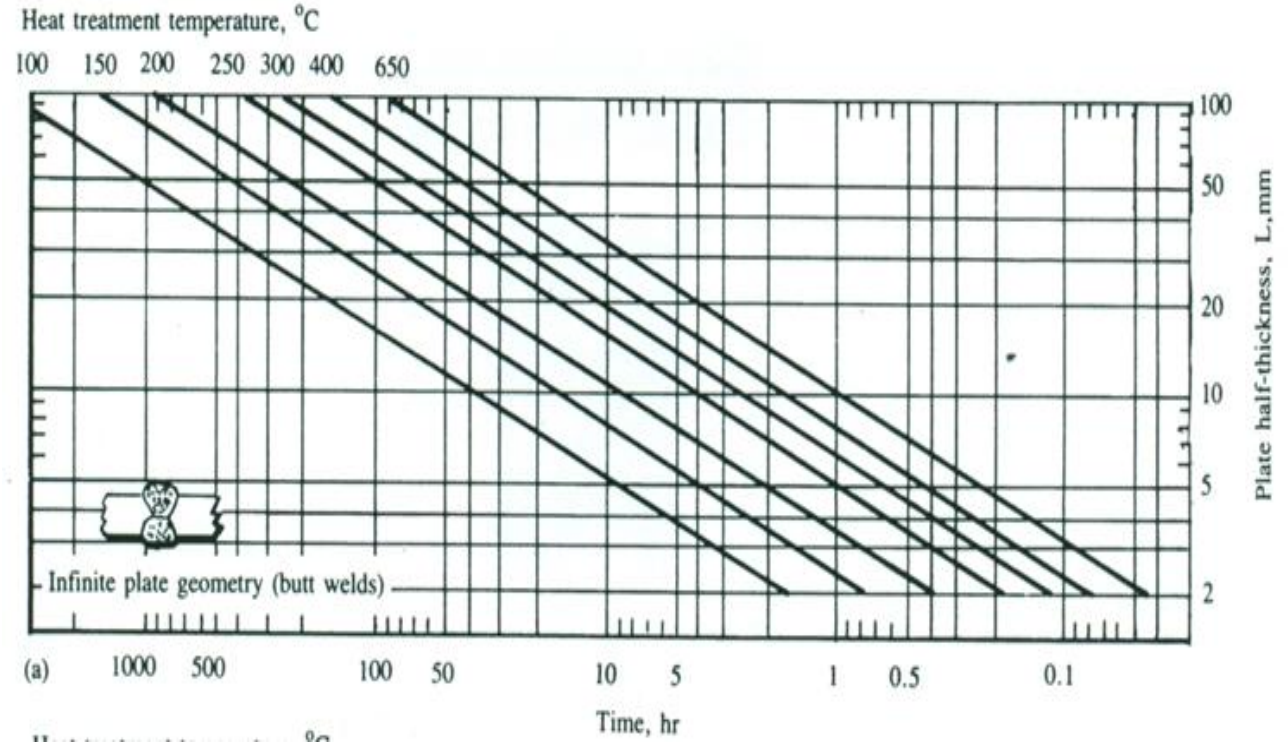


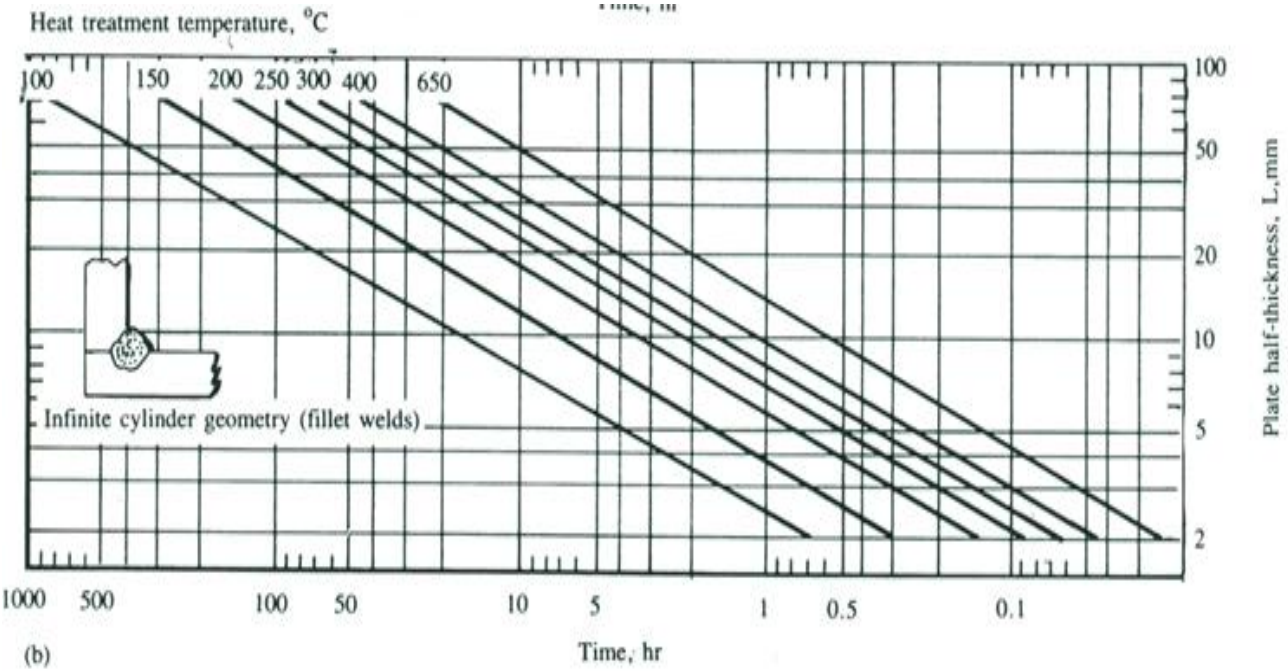
5.10 Infinite cylinder 150 °C.

5.11 Infinite cylinder 200 °C.



Appendix 5





Approximately time for removing 75% of original hydrogen for butt weld