Welding

For fabrication with quench and tempered steels a low hydrogen practice should be employed to avoid hydrogen cracking. There are a great many factors to take into consideration prior to commencement of welding of a fabrication. These could include the degree of restraint or the type of welding consumable used. As a consequence these tables should only be used as guidance in the development of a qualified welding procedure. Welding procedures and welder qualifications to appropriate standards such as EN 288-3: 1992 and EN287-1: 1992 should always be adhered to prior to and during any work. When using high preheats advice should be sought from the consumables manufacturers regarding the suitability of different welding consumables.

To avoid cold cracking during the cooling of welded structures it is advisable to preheat the welded area. The preheating temperature is largely dependent on factors such as (a) steel composition i.e. CEV, (b) combined plate thickness (c) the heat input and (d) the hydrogen content of the weld consumable. The tables below show the minimum recommended pre-heat levels for the RQT series of steels, for a range of combined thicknesses and 1.5kJ/mm heat input at 5ml H/100g (Table 1) and 10ml H/100g (Table 2).

Guidance on preheat levels for welding at an arc energy of 1.5 kJ/mm for hydrogen scales 'D' and 'C', from EN1011:2

Table 1: Hydrogen scale D < 5ml H/100g

IIW CEV	Combined thickness (mm) $t_1 + t_2 + t_3$											
	20	30	40	50	60	70	80	90	100	110	120	130
0.39%	Room temperature											
0.49%	50°C						75°C	100°C				
0.53%	50°C				75°C		100°C	125°C				
0.57%	75°C				100°C	125°C						

Table 2: Hydrogen scale C > 5ml < 10ml H/100g

IIW CEV	Combined thickness (mm) $t_1 + t_2 + t_3$									
	20	30	40	50	60	70	80	90	100	110
0.39%	Room temperature									
0.49%	50°C				75°C	100°C	125°C			150°C
0.53%	50°C		75°C	100°C	125°C	150°C				200°C
0.57%	50°C		100°C	125°C	150°C	175°C			200°C	

Interpass temperature control

To prevent the possibility of reductions in weld metal and heat affect zone strength levels, the following maximum interpass temperatures are recommended.

Plate gauge mm	Max interpass temperature °C
6< t ≤16	125
16< t ≤30	150
30< t ≤100	175

* The figures in this table are for guidance only. For more accurate figures we recommend that further testing is undertaken.

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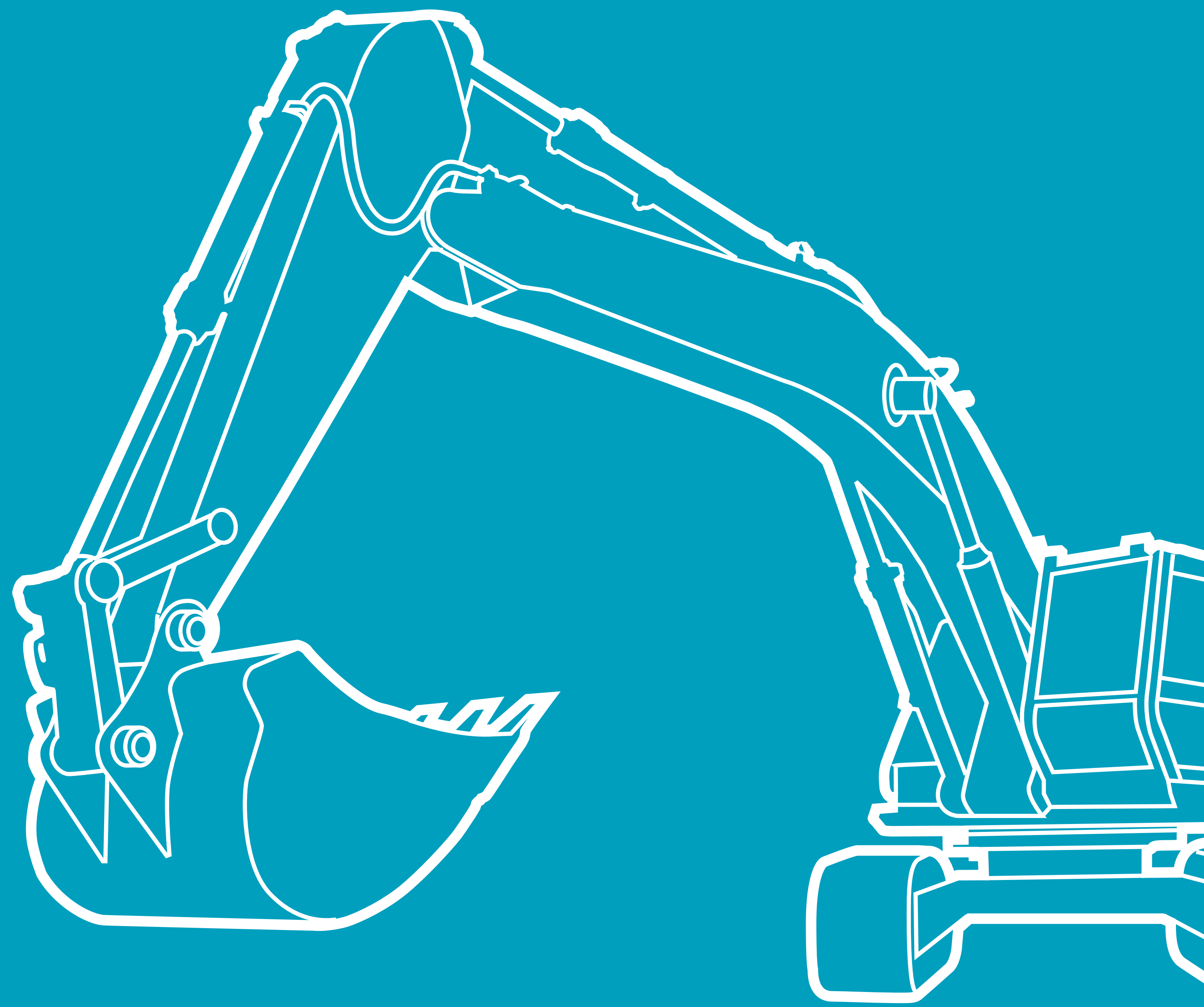
RQT 701 Quenched and Tempered Plate



RQT 701 Quenched and Tempered Plate

Chemical composition limits (maximum and typical ladle analysis)

Thickness range (mm)		C (%)	Si (%)	Mn (%)	S (%)	P (%)	Cr (%)	Mo (%)	Nb (%)	Ti (%)	V (%)	Ni (%)	Cu (%)	B (%)	Al (%)	CEV (%)
6≤ t ≤25	max.	0.20	0.50	1.50	0.005	0.020	(1)	(2)	0.06	0.04	0.08	(3)	(4)	0.003	0.06	
	typical	0.14	0.40	1.40	0.003	0.012	0.01	0.01	0.035	0.025	0.06	0.01	0.01	0.002	0.04	0.39
25< t ≤40	max.	0.20	0.50	1.50	0.005	0.020	0.25	0.20	0.06	0.04	0.08	0.70	0.20	0.003	0.06	
	typical	0.17	0.40	1.40	0.003	0.012	0.15	0.15	0.035	0.025	0.01	0.25	0.15	0.002	0.04	0.49
40< t ≤100	max.	0.14	0.35	1.00	0.005	0.020	0.65	0.60	–	–	0.08	1.00	0.40	0.003	0.085	
	typical	0.11	0.30	0.90	0.003	0.012	0.50	0.45	0.003	0.004	0.04	0.85	0.25	0.002	0.07	0.53

( ) Not normally used but may be added when considered necessary up to (1) 0.25% % max (2) 0.20%max, (3) 0.70% max, (4) 0.20%max.

Mechanical properties

Steel grade	Thickness range (mm)*	Minimum yield stress (MPa)	Tensile strength (MPa)	Minimum elongation % (50mm GL)	Minimum impact energy (Average)	Minimum impact energy (Individual)	Maximum ladle CEV %**
RQT 501	8 to 15	470	560 – 710	21	41J @ -40°C	29J @ -40°C	0.41
	15.01 to 50	470	560 – 710	21	41J @ -40°C	29J @ -40°C	0.41
	50.01 to 80	430	530 – 700	21	41J @ -40°C	29J @ -40°C	0.41
	80.01 to 100	415	530 – 700	21	41J @ -40°C	29J @ -40°C	0.41
RQT 601	8 to 25	620	690 – 850	19	27J @ -45°C	20J @ -45°C	0.43
	25.01 to 40	620	690 – 850	19	27J @ -45°C	20J @ -45°C	0.47
RQT 701	**8 to 20**	**690**	**790 – 930**	**18**	**27J @ -45°C**	**20J @ -45°C**	**0.43**
	20.01 to 40	**690**	**790 – 930**	**18**	**27J @ -45°C**	**20J @ -45°C**	**0.52**
	40.01 to 70	**690**	**790 – 930**	**18**	**27J @ -45°C**	**20J @ -45°C**	**0.57**
	70.01 to 100	**630**	**690 – 930**	**18**	**27J @ -45°C**	**20J @ -45°C**	**0.57**
RQT 901	8 to 50	890	940 – 1100	11	27J @ -40°C	20J @ -40°C	0.57
	50.01 to 65	830	880 – 1100	11	27J @ -40°C	20J @ -40°C	0.57
RQT 960	8 to 25	960	980 – 1150	10	40J @ -20°C	30J @ -20°C	0.57

* Plates with thickness less than 8mm may be available on request, for further information please contact our Technical Advisory Line at Scunthorpe on 01724 402106.

** Maximum CEV available by agreement.

Fabrication

Shearing

RQT 701 steels can be cold sheared. The maximum gauge which can be handled will depend on the power available in the shear unit and the material used in the shear blades. For smaller shears the maximum gauge is reduced by 35% relative to mild steel.

The quality of the sheared edge can be heavily influenced by machine set up and therefore cutting blades should be well maintained. Any new cut edges should be dressed prior to performing any bending operation.

Flame cutting

RQT 701 steels can be cut satisfactorily using conventional oxy-fuel gas practices, in many cases without the need for preheat, provided cutting procedures are selected with consideration of the plate thickness and CEV. Other cutting techniques such as abrasive water jet, where no heat is generated, or plasma cutting techniques, which gives a smaller HAZ than oxy-fuel gas, can be used. Care should be taken when cutting underwater as the quenching effect could result in a high hardness edge forming. With all thermal cutting processes care should be taken that cut edges are free from sharp notches.

Prior to cold forming, if there are any cut edges in regions which will be bent then these should be ground back. Application standards commonly stipulate that unless all the cut edge is to be incorporated into a weld then it should be ground back. In multiple cutting head situations, as with all steels, care is required to achieve a balanced arrangement of cutting torches to minimise the possibility of distortion.

Cold bending

RQT 701 steels can be readily cold formed. The power required for forming will be appreciably higher (70%) than that for mild steel of the same thickness. It is recommended that the largest possible bending radius should be used, and generally the inside radius should not be less than 3x the plate thickness.

Bend axis vs. rolling direction	Minimum inside bending radius	Minimum die opening
Perpendicular	3t	8.5t
Parallel	4t	10t

Hot forming

It is recommended that the RQT 701 series of steels are NOT hot formed. Where this is absolutely necessary, by design codes, the steels should be heated to a maximum temperature of 550°C and at least 50°C below the tempering temperature stated on the test certificate. When temperatures approaching 500°C are used the soaking time should be minimised as far as possible to prevent deterioration in mechanical properties.

Stress relief

In cases where stress relief is considered necessary after welding, the stress relieving temperature should be generally within the range 550-600°C and at least 20°C below the tempering temperature stated on the test certificate. Stress relaxation tests have indicated that adequate stress relief can be obtained from a soaking time of 60min at 550°C. Prolonged time at temperature in excess of 550°C is not generally recommended since it can cause some deterioration in mechanical properties.

Machining

The RQT 701 series of plates can be machined and drilled using high speed steel (HSS) or cemented carbide (CC) tools. The approximate hardness of RQT 701 can be obtained from the Ultimate Tensile Strength (UTS) and is within the range 240-280 HBN.