HAYNES® HR-235® alloy

Welding

HAYNES® HR-235® alloy is readily weldable by Gas Tungsten Arc (GTAW) and Gas Metal Arc (GMAW) welding processes. For sheet welds and plate root passes, GTAW is suggested. For plate welds, GMAW is preferred. For GMAW, the pulsed spray transfer mode (GMAW-P) is highly suggested. The GMAW-P transfer mode is a stable, low spatter spray transfer at average current levels significantly below that for conventional spray transfer. This results in low-to-moderate weld heat input, which is important to maintain the material properties of Ni-base alloys. Submerged arc welding (SAW) is not recommended as this process is characterized by high heat input to the base metal and slow cooling of the weld. The welding characteristics of HR-235® alloy are comparable to the highly weldable "C-type" alloys and the same general welding guidelines apply. Compared to other metal dusting resistant Ni-base alloys, HR-235® alloy exhibits excellent weldability. For further welding details, please click here for the Welding and Fabrication guide, which contains general welding guidelines applicable to HR-235® alloy.

Heat Treatment

Wrought forms of HR-235® alloy are furnished in the solution annealed condition, unless otherwise specified, and should be welded in this condition. Welding of cold-worked materials is strongly discouraged, since it accelerates precipitation of secondary phases and induces residual stresses. As such, a full solution anneal in the range of 2100-2150°F (1149-1177°C), depending on specific requirements, followed by rapid air cool or water quench is suggested. Water quenching is recommended when annealing heavy section components and cold-worked structures prior to welding.

Base Metal Preparation

The joint surface and adjacent area should be thoroughly cleaned before welding. All grease, oil, crayon marks, sulfur compounds, and other foreign matter should be removed. Contact with copper or copper-bearing materials in the joint area should be avoided. It is preferable, but not necessary, that the alloy be in the solution-annealed condition when welded.

Filler Metal Selection

For GTAW and GMAW, HR-235® bare filler wire is suggested. For dissimilar metal welds involving HR-235® alloy, please consult with Haynes International for suggested filler metals.

Preheating, Interpass Temperatures, and Postweld Heat Treatment

Preheat is not required and is generally specified as room temperature. Preheat should not be used if the base metal to be welded is above 32°F (0°C). To minimize the precipitation of second phases in regions affected by the heat of welding, a maximum interpass temperature of 200°F (93°C) is recommended for HR-235® alloy. Auxiliary cooling methods may be used between weld passes, as needed, providing that such methods do not introduce contaminants. Post-weld heat treatment is not normally required or suggested for HR-235® alloy. Heat treatment of welded fabrications may be required for other reasons, such as stress relief.

Tensile Properties of Welded Material

Transverse Tensile – GTAW Welded Sheet

Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
RT	RT	88.1	607	105.3	726	30
200	93	43.6	300	94.0	648	43
400	204	43.1	297	99.5	686	42
600	316	38.8	268	82.6	570	26
800	427	35.3	243	76.5	527	27
1000	538	37.6	259	86.1	594	38
1200	649	32.8	226	65.1	449	25
1400	760	28.2	194	54.3	374	22
1600	871	22.1	152	29.6	204	31
1800	982	11.0	76	15.9	110	34
2000	1093	5.3	37	7.7	53	37

Transverse Tensile – GTAW Welded Plate

Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
RT	RT	65.3	450	112.3	774	51
200	93	56.2	387	89.8	619	19
400	204	48.2	332	96.4	665	41
600	316	45.6	314	90.0	621	40
800	427	42.3	292	89.1	614	44
1000	538	44.1	304	74.2	512	23
1200	649	38.1	263	73.5	507	30
1400	760	37.1	256	60.8	419	13
1600	871	23.9	165	33.1	228	25
1800	982	12.3	85	17.9	123	17
2000	1093	7.2	50	9.8	68	19

AWM (All Weld Metal) Tensile – GTAW

Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation	Reduction of Area
°F	°C	ksi	MPa	ksi	MPa	%	%
RT	RT	80.0	552	115.3	795	26	30
200	93	69.2	477	101.2	698	31	32
400	204	66.7	460	98.3	678	27	27
600	316	67.0	462	94.4	651	26	35
800	427	63.0	434	89.9	620	30	30
1000	538	58.9	406	82.5	569	29	37
1200	649	52.0	359	71.6	494	22	31
1400	760	48.3	333	64.8	447	16	24
1600	871	26.3	181	36.3	250	21	23
1800	982	15.3	105	20.7	143	15	10
2000	1093	9.1	63	12.0	83	20	15