


**TECHNICAL
INFORMATION**
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BULLETIN

WELDING OF NKK EHSP

Super Abrasion Resistant Steel Wear Plate

1.0 INTRODUCTION

NKK has been manufacturing and marketing abrasion-resistant steel plates since 1955. Nowadays, NKK EVER-HARD steel plates have found a place in a broad range of fields, such as civil and architectural engineering, mining, agricultural machinery and other types of industrial machinery.

NKK has been investigating the effect of alloying elements and manufacturing conditions on abrasion-resistance, weldability and formability. This pursuit has led to the development of NKK EHSP super abrasion-resistant steel, a new type based on a technique that improves the abrasion resistance without increasing the hardness. This new approach to the alloy-design of NKK EHSP has been achieved by a uniform dispersion of a lot of high hardness precipitates in steel.

2.0 NKK EHSP SPECIFICATION

Table 1. Manufacturing Process and Available Thickness

Grade	Thickness	Heat treatment
NKK EHSP	6-65 mm	Controlled heat treatment

Table 2. Chemical Composition (mass %)

C	Si	Mn	P	S	Cr	Others	CE**
≤0.35	≤0.55	≤1.6	≤0.03	≤0.03	0.5-1.5	*	0.62

*Other alloying elements are added for enhancing the abrasion resistant property;

**Carbon Equivalent $CE=C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15$

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Table 3. Tensile, Charpy Impact and Brinell Hardness Tests

Plate thickness t mm	Specimen	Position	Direction	0.2% Proof Stress MPa	Tensile strength MPa	Elongation %	Charpy Impact Absorbed Energy J@0°C*	Brinell Hardness (surface)
9.5	JIS No.5	Full	T	1298	1401	13.3	15** (1/2t)	409
12	JIS No.5	Full	L	1270	1489	13.2	24 (1/2t)	461
			T	1274	1476	15.6		
25.4	JIS No.5	Full	T	1279	1471	16.6	18** (1/4t)	448
35	JIS No.5	Full	L	1098	1349	11.3	18 (1/4t)	455
			T	1104	1352	10.7		
50.8	JIS No.4	1/4t	T	1037	1204	10.4	15** (1/4t)	434
		1/2t	T	903	1145	10.7	16** (1/2t)	
63.5	JIS No.4	1/4t	T	867	1070	11.6	13** (1/4t)	442
		1/2t	T	677	951	13.8	15** (1/2t)	

*JIS No.4; **Longitudinal direction

3.0 WELDING

3.1 General Rules for good welds in NKK EHSP steel

- Use controlled hydrogen process.
- Select consumables per Table 6, 7 or 8.
- Consumables must be correctly stored in order to maintain their controlled hydrogen properties. See current editions of Lincoln Customer Application Bulletins 5, 55, 58 and 60 for information on storage and redrying of welding consumables.
- Clean joint area and up to approximately 12 mm on either side to remove oil, grease, paint, rust and scale before welding.
- Remove 1-2 mm from flame cut or gouged surfaces by grinding.
- Ensure that preheat and interpass temperatures, and heat input limitations specified in Tables 4 and 5 are followed closely.
- Position job for downhand welding where possible.
- Always use stringer beads, never wide weave beads.
- Deposit root runs with Jetweld LH-70, Jetweld LH-75 MR or Easyarc 18MR (E4818). These will have the least likelihood of hot tearing in joints in thicker and more highly restrained sections, due to the high ductility of the weld metal.
- Tempering beads with low hydrogen consumables such as Jetweld LH-70, LH-75 MR, or Easyarc 18MR may be deposited as extra weld reinforcement or to refine the final passes of full strength welds and heat affected zones at the top of the joint. These are normally deposited partially over the final full strength runs and partially on the plate surface adjacent to the weld.

- When required, back gouge using the air-arc process and remove scale by grinding. Do not use oxy-acetylene for back gouging.
- Arc strikes outside the weld zone can result in cracks, particularly in dynamically loaded structures. All arc strikes should therefore be made within the joint preparation.
- Grinding toes of fillet welds is particularly important in fatigue applications.
- When preheating, follow the guidelines illustrated in Figure 1.

Table 4. Recommended preheat and interpass temperature for welding NKK EHSP

Combined joint thickness (mm) *	≤40	50	60	70	80	90	100	≥110
Preheat Temperature °C**	110	130	150	160	175	185	195	200
Maximum Interpass Temp.°C	150	170	190	200	215	225	235	240

* Combined joint thickness t1+t2+t3 see Figure 1.; **Calculation based on heat input [Heat Input (kJ/mm)=(Volts × Amps × 0.06)/Travel Speed (mm/min)] of 1.7kJ/mm and maximum hydrogen level of 5ml/100g.

Table 5. Permissible heat input (kJ/mm*) for welding of NKK EHSP

Welding Process	Plate thickness			
	3-10 (mm)	12-20 (mm)	25-32 (mm)	40-100 (mm)
MMAW	1.25-2.5	1.25-3.5	1.25-4.5	1.5-5.0
GMAW	1.0-2.5	1.0-3.5	1.25-4.5	1.5-5.0
FCAW	0.8-2.5	0.8-3.5	1.5-4.5	1.5-5.0
SAW	1.0-2.5	1.0-3.5	1.5-4.5	1.5-5.0

*Heat Input (kJ/mm)=(Volts × Amps × 0.06)/Travel Speed (mm/min)

3.2 Welding NKK EHSP to mild, stainless and manganese steels

Welding NKK EHSP to mild steel is straightforward. It is usual to employ similar consumables to those materials recommended for fillet welding (Tables 6 and 7). Higher strength consumables may be used but admixture from the mild steel will lower the deposit strength to something between that of the NKK EHSP being welded and the mild steel, and the mild steel fusion zone will still be the weakest part of the joint. It is most important to observe all the precautions regarding process, arc energy input and preheat of the NKK EHSP.

When welding NKK EHSP to austenitic stainless steel, the "25 Cr-12 Ni" E309 electrode type (and "25 Cr-20 Ni" E310 electrode type for joint configurations involving high levels of admixture of mild steel) are recommended to ensure an austenitic weld metal microstructure. Again any necessary preheat/arc energy input requirements for the NKK EHSP grade must be observed.

E309 and E310 electrodes are also suitable for welding NKK EHSP to austenitic manganese steels, with the correct preheat and arc energy input for both steel types. The manganese steel requires a maximum interpass temperature of 250°C (controlled as per Figure 1.) and fast cooling from welding temperature to avoid cracking of the manganese steel component.

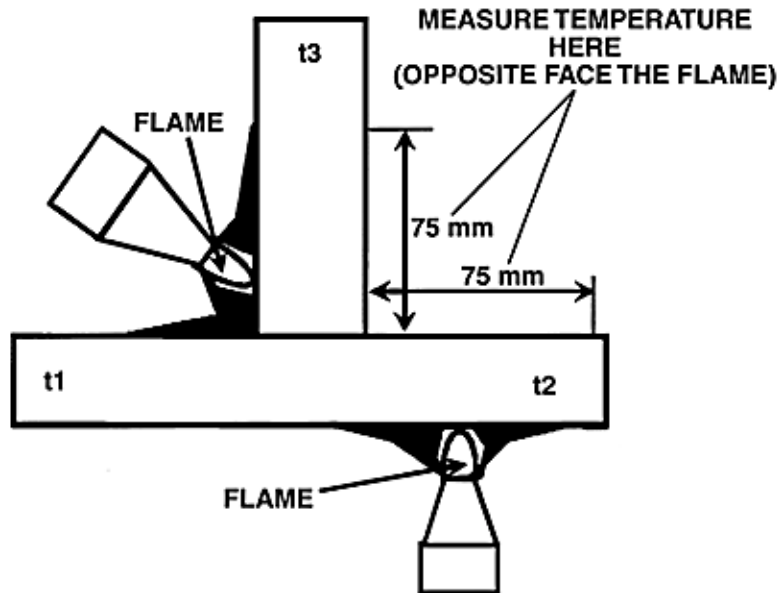


Figure 1. Recommended preheat zone and location of preheat measurement

Table 6. Lincoln consumables for welding NKK EHSP

Manual Metal Arc Welding					
Consumable	Size Range mm	Classification Per Consumables Standard	General description	Applicable Joint Types/ Positions	Evolved Hydrogen mL/100g Deposited Metal
Jetweld LH-70	2.5-5.6	E4818-4.H5 per AS/NZS 1553.1 E7018 per AWS A5.1.	Low iron powder manual electrode. Tensile Strength - 500 MPa min.; Charpy impact minimum 47 J at -40°C.	Root passes. Non critical Butts/Fillets Temper beads	≤ 5
Jetweld LH-75 MR	2.5-4.8	E4818-5.H5R per AS/NZS 1553.1 E7018-1 per AWS A5.1	Low iron powder manual electrode. Tensile Strength - 500 MPa min.; Charpy impact minimum 47 J at -50°C.	Root passes. Non critical Butts/Fillets Temper beads	≤ 5
Jetweld LH-110M MR	3.2-4.8	E7618-M per AS1553.2. E11018M per AWS A5.5.	Low iron powder manual electrode. Capable of producing 758 MPa tensile strength deposit.	All position.	≤ 5
Gas Metal Arc Welding					
L54 Ultra	0.9-1.6	ES4-GC/M-W502A.H per AS2717.1	High quality general purpose all positional mild steel solid wire. Meets Lloyd's grade 3.	Non-critical Butts/Fillets	≤ 5
L56 Ultra	0.8-1.6	ES6-GC/M-W502A.H per AS2717.1	High quality general purpose all positional mild steel solid wire with higher manganese and silicon levels.	Non-critical Butts/Fillets	≤ 5
Lincolnweld LA90	1.6	ESD2-GC/M-W559A.H (Also meets ESMG-GC/M-W629A.H) per AS2717.1 ER80S-D2 (Also meets ER90S-G) Per AWS A5.28	High strength electrode (containing 0.5% molybdenum) designed to produce weld tensile strengths in excess of 630MPa.	Non-critical Butts/Fillets	≤ 5
Gas Shielded Flux Cored Arc Welding					
Outersield 70	1.6-2.4	ETD-GCp-W502A. CM1.H10 per AS2203.1 E70T-1 per AWS A5.20.	Down hand welding with CO ₂ shielding only. Penetration increases effective fillet throat thickness. Deposition rate to appr. 13 kg/hr.	Non-critical Butts/Fillets	≤ 10
Outersield 71M	1.2-1.8	ETP-GCp/Mp-W503A. CM1.H10 per AS2203.1 E71T-1 per AWS A5.20.	Positional welding with CO ₂ or 25% CO ₂ in Argon shielding only. Deep penetration increases effective fillet throat thickness. Deposition rate to appr. 8 kg/hr.	Non-critical Butts/Fillets	≤ 10
Outersield 75-H	1.2, 1.6	ETD-GMp-W504A. CM1.H5 per AS2203.1 E70T-5 per AWS A5.20.	High deposition down hand welding with low cracking sensitivity. Use Ar-25% CO ₂ for shielding	Non-critical Butts/Fillets	≤ 5
Outersield MC710	1.2, 1.6	ETP-GMp-W503A. CM1.H10 per AS2203.1 E71T-1 per AWS A5.20	Metal cored wire designed for flat and horizontal single and multiple welding. Deposition rate to approx. 9 kg/h	Non-critical Butts/Fillets	≤ 10
Outersield 81Ni1-H	1.2, 1.6	ETP-GMp-W554A. Ni1.H5 per AS2203.1 E81T1-Ni1 per AWS A5.29	A nominal nickel content of 1.0% makes this wire desirable for critical applications requiring superior mechanical properties in as welded condition.	Non-critical Butts/Fillets	≤ 5
Outersield 91K2-H	1.2, 1.6	ETP-GMp-W629A. K2.H5 per AS2203.1 E91T1-K2 per AWS A5.29	This electrode is designed for all positional single and multiple pass welding and can produce weld tensile strengths in excess of 630MPa.	Non-critical Butts/Fillets Higher restraint	≤ 5
Outersield MC-1100	1.2, 1.6	ETD-GMp-W839A. G.H5 per AS2203.1 E110C-G per AWS A5.28	This down hand electrode is designed to provide weld tensile strengths in excess of 744 MPa, with good toughness and very low diffusible hydrogen levels.	Non-critical Butts/Fillets	≤ 5
Self Shielded Flux Cored Arc Welding					
Innersield NR232	1.7, 2.0	ETP-GNn-W503A. CM1.H15 per AS2203.1 E71T-8 per AWS A5.20	High deposition rates on out-of-position welding, for high productivity and impact properties.	Non-critical Butts/Fillets	≤ 15
Innersield NS3M	2.0-3.0	ETP-GNn-W503A. CM2.H15 per AS2203.1 E70T-4 per AWS A5.20	NS-3M has the highest deposition rates of the Innersield line. The choice when Charpy V-Notch impact properties are not required. Has low penetration which makes it particularly useful for poor fit up.	Non-critical Butts/Fillets	≤ 15
Innersield NR212	1.7, 2.0	ETP-GNn-W500A. CM2.H15 per AS2203.1 E71T-11 per AWS A5.20	The unique alloy system of NR 212 makes it suitable for a wide variety of applications. Able to handle poor fit up with. Has a low spatter level.	Non-critical Butts/Fillets	≤ 15
Innersield NR311	2.0-2.8	ETD-GNn-W500A. CM2.H15 per AS2203.1 E70T-7 per AWS A5.20	General purpose wire for high deposition rates, fast travel speeds and good penetration. Good economic choice for flat and horizontal welding where Charpy V-Notch impact properties are not required.	Non-critical Butts/Fillets	≤ 15

Table 6 (continued). Lincoln consumables for welding NKK EHSP

Submerged Arc Welding					
Consumable	Size Range mm	Classification Per Consumables Standard	General description	Applicable Joint Types/ Positions	Evolved Hydrogen mL/100g Deposited Metal
LA90/880	2.4, 3.2	EA3F BL-W624A.H10 per AS1858.2 F9A6-EA3K-A3 per AWS A5.23	This electrode/flux combination is designed to provide low carbon, high manganese, high silicon, 0.5% molybdenum weld deposit in multiple pass application that require a minimum of 620 MPa Tensile Strength.	Down hand butts and fillets.	≤ 10
LAC M2/880M	2.4, 4.0	ECM2F BL-W769A/PM2.H10 per AS1858.2 F11A6/P6-ECM2-M2 per AWS A5.23	This electrode/flux combination is designed to produce weld deposit of 690 MPa min Tensile Strength in as welded and stress relieved condition	Down hand butts and fillets.	≤ 10
MC-120S-55/880M	2.4	ECG-FBL-W769AG.H5 per AS1858.2 F12A6-ECG-G per AWS A5.23	Metal cored sub arc wire/neutral flux. Extremely low H ₂ and excellent impacts. Capable of providing weld deposits of 820 MPa min. Tensile Strength.	Down hand butts and fillets	≤ 5

Table 7. LiquidArc consumables for welding NKK EHSP

Manual Metal Arc Welding					
Consumable	Size Range mm	Classification Per Consumables Standard	General description	Applicable Joint Types/ Positions	Evolved Hydrogen mL/100g Deposited Metal
Easycarc 18MR	2.5-5.6	E4818-4.H5 per AS/NZS 1553.1 E7018 per AWS A5.1.	Low iron powder manual electrode. Tensile Strength - 500 MPa min.; Charpy impact minimum 47 J at -40°C.	Root passes. Non critical Butts/Fillets Temper beads	≤ 5
Gas Metal Arc Welding					
Steelmig Super 4	0.8-1.3	ES4-GC/M-W502A.H5 per AS2717.1	High quality general purpose all positional mild steel solid wire. Meets Lloyd's grade 3.	Non-critical Butts/Fillets	≤ 5
Steelmig Super 6	0.8-1.6	ES6-GC/M-W502A.H5 per AS2717.1	High quality general purpose all positional mild steel solid wire with higher manganese and silicon levels.	Non-critical Butts/Fillets	≤ 5
Gas Shielded Flux Cored Arc Welding					
Easycore 71M	1.2-1.8	E7P-G Cp/Mp-W508A. CM1.H10 per AS2203.1 E71T-1 per AWS A5.20.	Positional welding with CO ₂ or 25% CO ₂ in Argon shielding only. Deep penetration increases effective fillet throat thickness. Deposition rate to appr. 8 kg/hr.	Non-critical Butts/Fillets	≤ 10

Table 8. Lincoln & LiquidArc hardfacing consumables with matching hardness to NKK EHSP steel

Manual Metal Arc Welding		
Consumable	Size Range mm	AS/NZ 2576 Classification
Easycarc HF 450	3.2-5.0	1445-A4
Self Shielded Flux Cored Arc Welding		
Lincore 36LS	1.6	1440-B7
Lincore 40-0	2.8	1440-B7
Submerged Arc Welding		
L50/QR8045	2.0-4.0	1440-B4
L60/H535	2.0-4.8	1435-B4
Lincore 36LS/880M	1.6	1435-B7
Lincore 40S/880M	3.2	1440-B7