Terms and Definitions

Recrystallization Temperature

The approximate minimum temperature at which complete recrystallization of a cold worked metal within a specified time.

Soaking

Prolonged holding at a selected temperature.

Solution Annealing

Annealing to dissolve precipitatted constituents in solid solution, e.g. in an austenite matrix.

Solution Heat Treatment

Heating an alloy to a suitable temperature, holding at that temperature long enough to cause one or more constituents to enter into solid solution, and then cooling rapidly enough to hold these constituents in solution.

Stabilizing Treatment

A treatment applied for the purpose of stabilizing the dimensions of a workpiece or the structure of a material such as (1) before finishing to final dimensions, heating a workpiece to or somewhat beyond its operating temperature and then cooling to room temperature a sufficient number of times to insure stability of dimensions in service, (2) transforming retained austenite in those materials which retain substantial amounts when quench hardened (see cold treatment). (3) heating a solution treated austenitic stainless steel that contains controlled amounts of titanium or columbium plus tantalum to a temperature below the solution heat treating temperature to cause precipitation of finely divided, uniformly distributed carbides of those elements, thereby substantially reducing the amount of carbon available for the formation of chromium carbides in the grain boundaries upon subsequent exposure to temperatures in the sensitizing range.

Stress Relieving

Heating to a suitable temperature, holding long enough to reduce residual stresses and then cooling slowly enough to minimize the development of new residual stresses.

Surface Hardening

A generic term covering several processes applicable to a suitable ferrous alloy that produces by quench hardening only a surface layer that is harder or more wear resistant than the core. There is no significant alteration of the chemical composition of the surface layer. The processes commonly used are Induction Hardening, Flame Hardening, and Shell Hardening. Use of the applicable specific process name is preferred.

Temper Brittleness

Brittleness that results when certain steels are held within, or are cooled slowly through, a certain range of temperature below the transformation range. The brittleness is revealed by notched bar impact tests at or below room temperature.

Tempering

(1) Reheating a quench hardened or normalized ferrous alloy to a temperature below the transformation range and then cooling at any desired rate.

(2) A term used in conjunction with a qualifying adjective to designate the relative properties of a particular metal or alloy induced by cold work or heat treatment, or both.

Transformation Ranges

Those ranges of temperature within which austenitic forms during heating and transforms during cooling. The two ranges are distinct, sometimes overlapping but never coinciding. The limiting temperatures of the ranges depend on the composition of the alloy and on the rate of change of temperature, particularly during cooling.

Foreword

This booklet has been designed to make it easier for the welding professionals to select the best possible welding electrodes for the job at hand, regardless of the metal or combination of metals involved. Apart from a wealth of technical data, this booklets contains recommendation on the uses and applications of all EKNOWELD products, together with proven welding techniques which will enable you to do a better job more economically. Our R & D have constantly aimed at improvements in order to meet increasing demands for diverse requirements of electrodes tailor made for the base metal and possessing consistent properties. The electrodes manufactured by us is as per BIS, AWS, BS and DIN. We also manufacture special electrodes to meet the specific requirements of customers.

We hope that you will come to regard this new 'EKNOWELD' welding guide a useful aid in your job.

K.N. DESAI

Approvals, Registrations and Major Customers :

- Bureau of Indian Standards (ISI)
- Bharat Heavy Electricals Ltd. - Trichi (BHEL)
- Research Designs & Standards Organisation (RDSO)
- M. N. Dastur & Co. (P) Ltd.
- Indian Boiler Regulations (IBR)
- Ministry of Defence (DGQA)
- Durgapur Steel Plant
- Visvesvaraya Iron & Steel Plant
- Visakhapatnam Steel Plant
- Bokaro Steel Plant
- NTPC Ltd.
- Bokaro Power Supply Co. (P) Ltd
- Delhi Transport Corporation
- Madras Cements Ltd.
- Malabar Cements
- Indian Rare Earths Ltd.
- Bharat Earth Movers Ltd.
- Kudremukh Iron Ore Co. Ltd.
- Jindal Aluminium Ltd.
- HMT Ltd.
- Tamilnadu State Tran. Cor. (Madurai) Ltd.
- Larsen &Toubro Ltd. (Heavy Engineering Division)
- Hindustan Machine Development Corporation Ltd.
- National Mineral Development Corporation Ltd.
- Alloy Steels Plant
- Rourkela Steel Plant
- IISCO Steel Plant
- Salem Steel Plant
- JSW Steel Plant
- Central Coalfields Ltd.
- Eastern Coalfields Ltd.
- Northern Coalfields Ltd.
- Bharat Coking Coal Ltd.
- Neyveli Lignite Cor. Ltd..
- Tata Power
- Koradi Thermal Power
- Hindalo Industries Ltd.
- ACC Limited
- JSW Cement Ltd.
- Heavy Engineering Co. Ltd.
- Kinetic Engineering Ltd.
- Bharat Alluminium Co. Ltd.
- The Hutti Gold Mines Co. Ltd.
- GKW Ltd.
- JCB India Ltd.
- Burn Standard Co. Ltd:
- Paradip Port Trust
- U. P. Co-ope. Sugar Fact. Fed. Ltd.

Contents

Terms and Definitions

Pre - Heat

In view to avoid hardenable structure in the weldment (weld + HAZ + Parent Metal), it may be necessary to employ pre-heat to control cooling rates. The extent of pre-heat required can be determined by studying the metallurgical changes that result from thermal cycle with the aid of cooling transformation diagram. However, in practice, it is generally predicted by calculating the carbon equivalent.

$$\text{Carbon equivalent} = \%C + \%\frac{Mn}{6} + \%\frac{Ni}{15} + \%\frac{Cr}{5} + \%\frac{Mo}{4}$$

$$\text{Pre-Heat (°F)} : T = 350 \sqrt{C.E. (1 + 0.005s) - 0.25}$$

Where C. E. is carbon equivalent and Sis thickness, (inm.m)

The interpass temperature during welding is always the same as that of pre-heat temperature.

Heat input

The strength and toughness of the weld metal is greatly influenced by the heat - input into the joint at any one time during welding. This is because the heat input is inversely proportionate to the deposition rate and hence final structure in the weld HAZ & grain size of the weld are direct function of heat input. Based on the final application, it becomes advantageous to either increase or decrease the heat input.

The heat input in welding is generally defined as the Linear Energy input Es.

This is expressed in Kilo Joules/cm and is calculated with the following formula:

$$E_s = \frac{VI}{V_s} \times \frac{60}{100} \text{ KJ/cm}$$

Arc Voltage in V (volts)

Welding amperage in 1 (amperes)

Welding speed in V_s (cm/min.)

Post weld heat treatment

The terminology, the post weld heat treatment is generally applicable to stress relief heat treatment. The welding and other fabrication processes induces a built-in stress in the material. It may be advantageous in certain cases to thermalloy heat-treat, so that the stress distribution becomes uniform. This is particularly so with completely welded construction, where weld seam form a highly localised stress concentration points. The localised stresses may result in premature failure of pressure parts or stress corrosion may set in due to potential difference in between the stressed component and adjacent stress pronearea. Hence, stress relief is recommended for weldments that must retain dimentional stability during machining or weldments subject to stress corrosion or weldments designed for low temperature service eventhough, for weldment of the alloy steel, post weld heat treatment is mandatory in certain special condition, the post weld heat-treatment is avoided to obtain better service life.

Martensite Range

The Temperature interval between Ms and Mf.

Mf - Defined under Transformation Temperature.

Ms - Defined under Transformation Temperature.

Natural Aging

Spontaneous aging of a supersaturated solid solution at room temperature.

Postheating

Heating weldments immediately after welding, for tempering, for stress relieving, or for providing a controlled rate of cooling to prevent formation of a hard or brittle structure.

Protective Atmosphere

Gaseous medium preventing or limiting chemical reaction with workpiece. Quenching

Rapid cooling, when applicable, the following more specific terms should be used : Direct Quenching, Fog Quenching, Hot Quenching, Interrupted Quenching, Selective Quenching, Spray Quenching and Time Quenching.

Recrystallization

1) The change from one crystal structure to another, as occurs on heating or cooling through a transformation temperature.

2) The formation of a new, strain-free grain structure from that existing in cole worked metal, usually accomplished by heating.

Terms and Definitions

Aging

A change in the properties of certain metals and alloys that occurs at ambient or moderately elevated temperatures after hot working or a heat treatment (quench aging in ferrous alloys natural or artificial aging in ferrous and non-frerrous alloys) or after a cold working operation (strain aging). The change in properties is often, but not always, due to a phase change (precipitation), but never involves a change in chemical composition of the metal or alloys.

Annealing

A generic term denoting a treatment, consisting of heating to and holding at a suitable temperature followed by cooling at a suitable rate, used primarily to soften metallic materials, but also to simultaneously produce desired changes in other properties or in micro-structure. The purpose of such changes may be, but is not confined to, one or more of the following: Improvement of mechanical or electrical properties or increase in stability of dimensions.

Annealing - Ferrous

The time-temperature cycles used vary widely in both maximum temperature attained and in cooling rate employed, depending on the composition of the material, its condition and the results desired. When applicable, the following more specific commercial process names should be used Black Annealing, Box Annealing, Bright Annealing, Cycle Annealing, Flame Annealing, Full Annealing, Graphitizing, In-Process Annealing, Isothermal Annealing. Mallrabilizing, Orientation Annealing, Process Annealing, Quench Annealing, Spheroidizing. When the term is used without qualification full annealing is implied. When applied only for the relief of stress the process is properly called stress relieving.

Austenitizing

Forming austenite by heating a ferrous alloy into the transformation range (partial austenitizing or above the transformation range (complete austenitizing). When used without qualification, the term implies complete austenitizing.

Baking

Heating to a low temperature in order to remove gases. Controlled Atmosphere

Gaseous medium, in which concentration, temperature and pressure of individual constituents is held within given limits, in order to bring about, lessen or avoid certain reactions between the constituents and the workpiece being treated (reduction, oxidation, carburization, decarburization etc).

Critical Cooling Rate

The minimum rate of continuous cooling to prevent undesirable transformations. For steel it is the minimum rate at which austenite must be continuously cooled to suppress transformations above the Ms. temperature

Decarburization

The loss of carbon from the surface of a ferrous alloy as a result of heating in a medium that react with the carbon.

Grain Growth

An increase in the average size of the grains (See Notes 1 and 2) in polycrystalline metal, usually as a result of heating at elevated temperature.

Notes: (1) A grain is an individual crystal in a polycrystalline metal and includes twinned regions and subgrains when present.

(2) Grain size is a measure of the mean diameter, area, or volume of all individual grains observed in a polycrystalline metal. In metals containing two or more phases, the grain size refers to that of the matrix unless otherwise specified.

Hardenability

In a ferrous alloy, the property that determines the depth and distribution of hardness induced by quenching. Hardening

Increasing the hardness by suitable treatment., usually involving heating and cooling. When applicable, the following more specific terms should be used. Age Hardening, Case Hardening, Precipitation Hardening, Quench Hardening, Surface Hardening.

Hardening and Tempering

Hardening and subsequent tempering to improve tensile strength or-in some cases-hardness without loss in toughness.

Heat Affected Zone :(HAZ)

This is a zone adjacent to weld which extends 2 to 5 mm depending on the total heat input during welding. During fusion welding, the weld metal temperature is above melting temperature of the base metal, but adjacent area is at various temperature depending on its location with reference to weld metal Hence, we find various metallurgical structure based on the temperature reached in this particular zone. Thus, in the narrow zone of 3-5 mm, we find normalized stress relieved and tempered structure along with a zone having large grain size known as over heated zone. The extent these structure will have effect on weldability will again depend on the composition of the material, the pre-heat and heat input which determines the cooling rate.

EKNOWELD - Product Range

AWS CLASSIFICATION	BRAND NAME	AWS CLASSIFICATION	BRAND NAME
MILD STEEL ELECTRODES - RUTILE COATED			
E6012	EKNOWELD 12	E6013	EKNOWELD - XX
E6013	EKNOWELD		
E6013	EKNOWELD- X		
HIGH EFFICIEINCY ELECTRODES - RUTILE AND LOW HYDROGEN			
E7014	EKNOWELD 7014-10		
E7014	EKNOWELD 7014-15		
E7024	EKNOWELD 7024-40		
LOW-HYDROGEN ELECTRODES FOR MILD STEEL AND MEDIUM TENSILE STEEL			
E7016	EKNOWELD 7016		
E7018	EKNOWELD 7018		
E 7018-1	EKNOWELD 7018-1		
HIGH-TENSILE ELECTRODES (LOW-HYDROGEN)			
E 8016-G	EKNOWELD 8016-G	E 10016-G	EKNOWELD 10016-G
E 8018-G	EKNOWELD 8018-G	E 10018-G	EKNOWELD 10018-G
E 9018-G	EKNOWELD 9018-G	E 10018-M	EKNOWELD 10018-M
E 9018-M	EKNOWELD 9018-M	E 11018-M	EKNOWELD 11018-M
ELECTRODES FOR CRYOGENIC APPLICATIONS			**METAL PREPARATION**
E 8018 CI	EKNOWELD 8018-C1		EKNOCUT
E 8018 C2	EKNOWELD 8018-C2		EKNO GOUGE
CREEP-RESISTANT STEEL ELECTRODES (RUTILE AND BASIC)			
E 8018 CI	EKNOWELD 8018-C1		EKNOCUT
E 8018 C2	EKNOWELD 8018-C2		EKNO GOUGE
HARD-SURFACING ELECTRODES			
	EKNOWELD 25 R	EKNOWELD 35 G	EKNOWELD 7
	EKNOWELD 25 B	EKNOWELD 60 B	EKNOWELD Mn
	EKNOWELD 35 R	EKNOWELD 60 R	EKNOWELD 410 S
	EKNOWELD 35 B	EKNOWELD 30 Cr	
CAST IRON ELECTRODES - MACHINABLE AND NON-MACHINABLE			
E 7018 AI	EKNOWELD FN	ESt	EKNOWELD NM
E 8018 B2	EKNOWELD M		EKNOCAST FN
	EKNOWELD Ni		
STAINLESS STEEL ELECTRODES			
E 308-16	EKNOALLOY SS	E 318-16	EKNOWELD 318-16
E 308L-16	EKNOWELD 308L-16	E 347-16	EKNOWELD 347-16
E 309-16	EKNOWELD 309-16	E 410-16	EKNOWELD 410-16
E 309 Mo-16	EKNOWELD 309 Mo-16	E 430-16	EKNOWELD 430-16
E 309 Cb-16	EKNOWELD 309 Cb-16	E 307-16*	EKNOWELD 18/8/6
E 310-16	EKNOWELD 310-16	E 307-16*	EKNOWELD 18/8/6(5)
E 312-16	EKNOWELD 312-16	E NICU-7	EKNOMONEL
E 316 -16	EKNOWELD 316-16	E 2209-16	EKNOWELD DSS
E 316L -16	EKNOWELD 316L-16		

NOTE : In lieu of our continuous R & D efforts we reserve the right to update the product data provided in this booklet.

WELDING SYMBOLS

~	= +

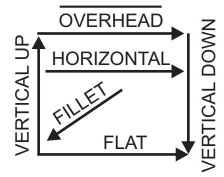
DC with Electrode Positive.

~	= +

AC or DC with Electrode Positive.

~	= +

AC or DC with Electrode Negative.



BIS Classification 814-2004

A PREFIX LETTER & FOUR DIGIT CODING
PREFIX LETTER :E: DENOTES EXTRUSION (SOLID)

E X X X X X X X X

LETTER TYPE OF COVERING

- A : Acid
- B : Basic
- C : Cellulosic
- R : Rutile
- RR : Rutile (heavy coated)
- SB : Semi Basic

THIRD DIGIT

WELDING POSITION

1. All position
2. All position except vert, down
3. Flat butt and Fillet weld & Horiz/vert. fillet weld
4. Flat butt and Fillet weld
5. Vert, down Flat butt and fillet & Horiz/vert. fillet weld
6. Any other position not classified above

FOURTH DIGIT CURRENT CONDITION

0. D(+)
1. D(±)A50
2. D(-)A50
3. D(+)A50
4. D(±)A70
5. D(-)A70
6. D(+)A70
7. D(±)A90
8. D(-) A90
9. D(+)A90

SUFFIX LETTERS

- H : Hydrogen Controlled
- H_1 : Upto 15ml. diffusable hydrogen
- H_2 : Upto 10ml. diffusable hydrogen
- H_3 : Upto 5ml. diffusable hydrogen
- J : Metal recovery 110-129%
- K : Metal recovery 130-149%
- L : Metal recovery 150% & above
- X : Radiographic quality

FIRST & SECOND DIGITS — **MECHANICAL PROPERTIES**

Combination of Percentage Elongation and Impact Value

Electrode Classification	Range of Tensile Strength N/mm²	Minimum Yield Stress N/mm²	Minimum Elongation on a Gauge length of 5.65 So Percent	Temperature and minimum Impact Value
EX-40XX	410-540	330	16	No impact requirement
EX-41XX	410-540	330	20	+27°C,47J
EX-42XX	410-540	330	22	0°C, 47 J
EX-43XX	410-540	330	24	-20°C, 47 J
EX-44XX	410-540	330	24	-30°C, 27 J
EX-50XX	510-610	400	16	No impact requirement
EX-51XX	510-610	400	18	+ 27°C,47J
EX-52XX	510-610	400	18	0°C, 47 J
EX-53XX	510-610	400	20	-20°C, 47 J
EX-54XX	510-610	400	20	-30°C, 27 J
EX-55XX	510-610	400	20	-40°C, 27 J
EX-56XX	510-610	400	20	-46°C, 27 J

Eknoweld Range of Products for castings

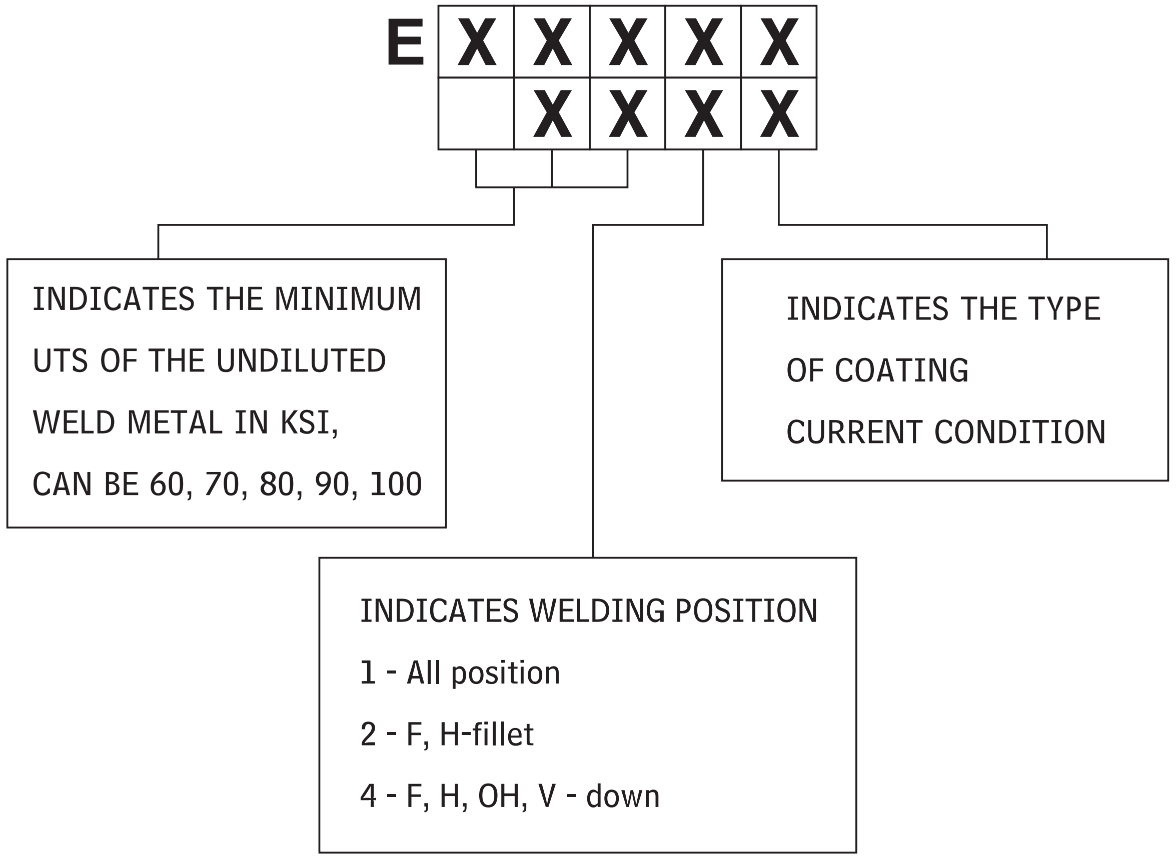
Spec No.	Type of grade	UNS No.	P. No.	Nominal Composition	Minm. Specified UTS, MPa	Minm. Specified CVN Impacts	Similar Wrought Alloy	EKNOWELD Products
SA 487	4-D			0.5Ni-0.5Cr-0.25Mo	690	HRC < 22		Eknoweld 11018 M
SA 487	8-C	J22091	5C	2.25Cr-1Mo	690	HRC < 22		Eknoweld 9018 B3
SA 487	9-D			1Cr-1/4Mo	690	HRC < 22		Eknoweld 8018 B2
SA 487	CA15-D	J91171	6	13Cr	690			Eknoweld 410
SA 487	CA6NM-B	J91540	6	13Cr-4Ni	690			Eknoweld 410 (M)
SA 352	LC2-1	J42215	11A	3Ni-I.5Cr-0.5Mo	725	41J@-73C		Eknoweld 11018 M (Spl)
SA 487	4-B	J13047	11A	0.5Ni-0.5Cr-0.25Mo	725			Eknoweld 11018 M(Spl)
SA 487	8-B	J22091	5C	2.25Cr-IMo	725			Eknoweld 9018 B3
SA 487	9-B			ICr-I/4Mo	725			Eknoweld 8018 B2
SA 487	11-B			1Ni-0.75Cr-1Mo	725			Eknoweld 10016 G
SA 487	12-B			0.75Ni-0.75Cr-1Mo	725			Eknoweld 10016 G
SA 487	CA6NM	J91540	6	13Cr-4Ni	760	27J@-73C		Eknoweld 410 M
SA 487	CA6NM-A	J91540	6	13Cr-4Ni	760			Eknoweld 410 M
SA 487	9-E			1Cr-1/4Mo	795			Eknoweld 8018 B2
SA 487	CB7CU-1			16Cr-4Ni-3Cu-0.25Cb	860		17-4PH	Eknoweld 430 (Mod)
SA 487	CB7CU-2			15Cr-5Ni-3Mo-0.25Cb	860			Eknoweld 430 (Mod)
SA 487	CA15-A			13Cr	965			Eknoweld 410
SA 216	WCA	J02502	1	C-Si	415			Eknoweld X
SA 216	WCC	J02503	1	C-Mn-Si	485			Eknoweld 7018
SA 216	WCB	J03002	1	C-Si	485			Eknoweld 7018
SA 217	WC6	J12072	4	1.25Cr-0.5Mo	485			Eknoweld 8018 B2
SA 217	WC4	J12082	4	1Ni-O, 5Cr-0.5Mo	485			Eknoweld 9018
SA 217	WC1	J12524	3	C-O-SMo	450			Eknoweld 7018 AI
SA 217	WC9	J21890	5A	2.25Cr-1Mo	485			Eknoweld 9018 B3
SA 217	WC5	J22000	4	0.75Ni-1Mo-0.75Cr	485			Eknoweld 9018 M
SA 217	C5	J42045	5B	5Cr-0.5Mo	620			Eknoweld 502
SA 217	C12	J82090	5B	9Cr-1Mo	620			Eknoweld 505
SA 217	C12A	J84090		9Cr-IMo-Cb-V-N	585			Eknoweld 505 (mod)
SA 217	CA15	J91150	6	13Cr	620		410	Eknoweld 410
SA 217	WC11			1.25Cr-0.5Mo	550			Eknoweld 8018 B2
SA 351	CF3	J92500	8	18Cr-8Ni	485		304L	Eknoweld 308 L
SA 351	CF3A	J92500	8	18Cr-8Ni	530		304L	Eknoweld 308 L
SA 351	CF8	J92600	8	18Cr-8Ni	485			Eknoweld 308
SA 351	CF8A	J92600	8	18Cr-8Ni	530			Eknoweld 308
SA 351	CF8C	J92710	8	18Cr-10Ni-2Cb	530		347	Eknoweld 347
SA 351	CF3M	J92800	8	18Cr-12Ni-2Mo	485		316L	Eknoweld 316 L

Eknoweld Range of Products of castings

Spec No.	Type of grade	UNS No.	P. No.	Nominal Composition	Minm. Specified UTS, MPa	Minm. Specified CVN Impacts	Similar Wrought Alloy	EKNOWELD Products
SA 351	CF3MA	J92800	8	18Cr-12Ni-2Mo	550		316L	Eknoweld 316 L
SA 351	CF8M	J92900	8	18Cr-12Ni-2Mo	485		316	Eknoweld 316
SA 351	CG3M	J92999	8	19Cr-10Ni-3Mo	515			Eknoweld 317 L
SA 351	CG8M	J93000	8	19Cr-10Ni-3Mo	515		317	Eknoweld 317 L
SA 351	CK3MCuN	J93254	8	20Cr-18Ni-6Mo	550		354 SMO	Eknoweld 25/20/5 Cu
SA 351	CE8MN	J93345	10H	24Cr-10Ni-Mo-N	655			Eknoweld 309 Mo
SA 351	CHS	J93400	8	25Cr-12Ni	450			Eknoweld 309 Mo
SA 351	CH10	J93401	8	25Cr-12Ni	485			Eknoweld 309 Mo
SA 351	CH20	J93402	8	25Cr-12Ni	485		309	Eknoweld 309 Mo
SA 351	CG6MMN	J93790	8	22Cr-12Ni-5Mn	585			Eknoweld 18/8/6
SA 351	CK20	J94202	8	25Cr-20Ni	450		310	Eknoweld 310
SA 351	HK30	J94203		25Cr-20Ni-0.5Mo	450			Eknoweld 310
SA 352	LCA	J02504	1	C-Si	415	18J@-32C		Eknoweld 7018
SA 352	LCB	J03003	1	C-Si	450	18J@-46C		Eknoweld 7018-1
SA 352	LCC	J02505	1	C-Mn-Si	485	20J@-46C		Eknoweld 7018-1
SA 352	LC2	J22500	9A	2.5Ni	485	20J@-73C		Eknoweld 8018-C1
SA 352	LC3	J31550	9B	3.5Ni	485	20J@-101C		Eknoweld 9018 G
SA 487	11-A			1Ni-0.75Cr-0.5Mo	485			Eknoweld 9018 M
SA 487	12-A			0.75Ni-0.75Cr-IMo	485			Eknoweld 9018 M
SA 487	16-A			2Mn-1.25Ni	485			Eknoweld 8018 Cl
SA 487	1-A	J13002	10A	Mn-V	485			Eknoweld 9018 M
SA487	2-A	J13005	3	Mn-0.25Mo	585			Eknoweld 9018 M
SA487	8-A	J22091	5C	2.25Cr-IMo	585			Eknoweld 9018 B3
SA487	1-B	J13002	IDA	Mn-V	620			Eknoweld 9018 M
SA487	1-C	Mn-V	620	HRC,22				Eknoweld 9018 G
SA487	2-B	J13005	3	Mn-0.25Mo	620			Eknoweld 9018 G
SA487	2-C			Mn-0.25Mo	620	HRC,22		Eknoweld 9018 G
SA487	4-A	J13047	3	0.5Ni-0.5Cr-0.25Mo	620			Eknoweld 9018 M
SA487	4-C			0.5Ni-0.5Cr-0.25Mo	620	HRC,22		Eknoweld 9018 M
SA487	9-A			1Cr-I/4Mo	620			Eknoweld 8018 B2
SA487	9-C			1Cr-I/4Mo	620	HRC,22		Eknoweld 8018 B2
SA487	13-A			1.5Ni-0.25Mo	620			Eknoweld 9018 G
SA487	CA15-B	J91171	6	13Cr	620			Eknoweld 410
SA487	CA15-C	J91150	6	13Cr	620			Eknoweld 410

A FOUR OR A FIVE DIGIT CODING

AWS Classification SFA 5.1



AWS Classification	Type of covering	Type of current
E6010	High cellulose sodium	DC(+)
E6011	High cellulose potassium	AC/DC (+)
E6012	High titania sodium	AC/DC (-)
E6013	High titania potassium	AC/DC(-) or DC(+)
E6020 } E6022	High iron oxide	AC/DC (-) { AC/DC (-)
E6027	High iron oxide iron powder	AC/DC (-)
E7014	Iron powder, titania	AC/DC
E7015	Low hydrogen sodium	DC(+)
E7016	Low hydrogen potassium	AC/DC (+)
E7018	Low hydrogen potassium iron powder	AC/DC(+)
E7024	Iron powder, titania	AC/DC
E7027	High iron oxide, iron powder	AC/DC (-)
E7048	Low hydrogen potassium iron powder	AC/DC (+)

Mild & Alloy Steels

Steel is an alloy of iron and carbon. Ordinary mild steel, containing about 0.2% of carbon presents very few problems in welding. If the carbon and/or alloying elements such as chromium, molybdenum, nickel and vanadium are present it becomes more difficult to produce a sound weld. Intelligent application of welding requires a knowledge of the effect of welding upon such steel.

Carbon is an extremely important element in ferrous metals imparting both strength and hardness by the formation of carbides.

2 Mild steel with a carbon content of 0.15-0.25% and a U.T.S. of around 386-494 N/mm is a tough alloy, readily weldable and with little hardening response by heat treatment. From a welding standpoint an increase of carbon above about 0.3% will begin to present increasing problems of wedability as the carbon content increases. The base metal heated to a high temperature and then coole: suddenly by mass-quench effect of the surrounding metal, may produce a zone having dangerously low ductility. These zones are prone to cracking. The hardness and brittleness of these zones depend on the composition of the steel being welded and the rate at which it is cooled. A further factor to be considered when using conventional electrodes is the presence of hydrogen in the arc atmosphere. During welding the ionised hydrogen diffuses into the zone around the weld. The capacity of steel to absorb hydrogen is dependent on its physical condition and at high temperature it is converted to the austenitic condition in which it is able to absorb large quantities o' hydrogen. As the weld zone cools it transforms to a condition in which it cannot hold so much hydrogen, and molecular hydrogen is precipitated out of solution, creating a condition of strain in the hardened zone, which if sufficiently brittle may crack.

It is characteristic of this type of crack that it may not appear on the surface of the metal, hence it is known as underbead cracking. As steel in the austenitic condition is able to absorb hydrogen, weld material that remains in the austenitic condition at room temperature will act as a sink for the hydrogen, holding it harmlessly in solution and the use of austenitic electrodes is a method of welding steel that would otherwise crack.

An alternative method of welding the more difficult steels is in the use of electrodes with low hydrogen coatings. By eliminating combined hydrogen from the coatings, relief from cracking can be obtained. It is important that the coatings should not be damp when the electrodes are used, and drying before use is recommended.

The welding of high-tensile fine-grained steels

Industries producing boilers, pressure vessels, storage tanks and similar items, increasingly rely on fine-grained quality steels, In developing this material, steel producers employ various methods, with the common aim of combining high yield strength, consistently high impact strength, and optimum weldability. Those steels are generally used in the normalised or quenched and tempered condition and may vary considerably in composition from grade to grade. As a matter of course, suitable electrodes had to be designed for welding this type of material.

The vast number of high-tensile steel grades renders classification difficult. As a practical approach, various tensile ranges have been established, where materials are grouped according to their yield and tensile strengths.

Additional distinctions are made by steel producers with a view to ageing resistance and low-temperature usability, a group to be considered separately comprises steels with ultra-high yield and tensile strength levels, some of which are supplied in the quenched and tempered condition.

Welding of steels for cryogenic applications

The expansion of cryogenic engineering, mainly for the storage and transportation of liquefied gases in welded tanks, means wider usage of suitable welding products.

It is a well-known fact that with decreasing temperature, steels gain tensile strength and lose elongation and impact strength. Therefore, the most important consideration for subzero and cryogenic applications is that the material must still possess the requisite impact strength at the lowest service temperature anticipated. The leading Classification Societies generally specify a minimum notched bar impact strength of 27 Joule (ISO V at service temperature).

Besides composition - Ni essentially improves low-temperature strength-the degree of purity and the condition of materials as heat treated are governing factors. Ferritic steels yield optimum results with the finely crystalline structure developed by quenching and tempering, whereas austenitic CrNi grades offer adequate impact strength without having been heat treated.

For selection of electrodes the first consideration is that they should be analogous or similar to the base metal in composition. This requirement can be met down to - 80°C, using our electrode Eknoweld 8018-C2 for temperatures not surpassing - 80°C, and Eknoweld 8018-C1 for the-60°C range.

Welding of high temperature and creep resisting steels

The application of high temperatures and pressures in power and heat generation, in petroleum refineries and in steam turbine plant improves thermal efficiency and accelerate chemical reactions, As a consequence, the steel grades used in these fields, and even more so the welds made in them, must be fully resistant to elevated temperatures, Welding consumables offered have to equal base in high temperature strength.

Unalloyed constructional steels show a serious decrease in tensile properties at higher temperatures. By adding certain elements, such as chromium, molybdenum, tungsten, or vanadium, one obtains steels of substantially higher hot strength. For elevated temperature application there is more to be considered than just mechanical properties. Under the combination of heat and load, the phenomena of creep and flow occur and make safe working stress dependent on time.

Steel grades are classified as to their composition and, consequently, their operating temperature range. The alloying elements are Cr, Mo, T, V, Ni, Co, Nb-Ta, Ti and Al, their effect being due to their action on the matrix and to carbide formation.

For service upto about 550°C, small additions of Mo, V and Cr will suffice, with Mo Yielding the most significant increase in hot strength. Above 550°C the additional requirement of scaling resistance must be met.

Here, the appropriate choice is a 12% Cr steel with additions of Mo, V and Nb-Ta. In the range above 600°C, heat treatable steels lose so much of their creep rupture strength that austenitic Cr-Ni grades have to be used instead, whose basic type contains 16% Cr and !3% Ni, additions of Mo and Nb-Ta (particularly the latter) improve creep rupture strength. At ultra-high temperatures those above 700°C - only special Cr-Ni-Co base alloys with additions of Mo, Ta and Nb-Ta will offer adequate creep resistance. Stabilized austenitic steels develop superior properties of elevated temperatures when welded in the solution treated condition. This type of material shows susceptibility to hot cracking, so temperature should be kept low over the entire welding operation The poor thermal conductivity of these steels easily leads to local overheating, so welding heat must not be allowed to accumulate. Therefore only electrodes with diameters upto 4mm should be employed, keeping a short arc, and applying electrodes at an angle between 80 and 90°C, making rather narrow weave beads is a good practice, if employed oscillation must not exceed three times the core wire diameter, Welds are usually executed without preheating.

EKNO WELD

Standard Casting Specification & Eknoweld Range Electrode Suitability

Sl. No.	Designation	Grade	C	Mn	Chemical Composition					
					Si	Ni	Cr	Mo	Others	EKNOWELD Products
1	A217	WC-i	0.25	0.5-0.8	0.60	-	-	0.45-0.65	-	Eknoweld 7018 Al
	Martensitic Stainless	WC-6	0.20	0.5-0.8	1.0-1.5	-		0.45-0.65	-	Eknoweld8018B2
	Steel and alloy	WC-9	0.18	0.4-0.7	0.5-0.8	-	2.0-2.75	0.90-1.20	-	Eknoweld 9018 B3
	Castings for pressure	C5	0.20	0.4-0.7	0.75	-	4.0-6.50	0.45-0.65	-	Eknoweld 502
	parts, suitable for	C12	0.15	1.0	1.50	-	8.0-10.0	0.90-1.20	-	Eknoweld 505
	HT Service	C15	0.15	1.0	1.50	-	11.5-14	0.5	-	Eknoweld 410 M
2	A296	CF8	0.08	1.50	2.00	8.0-11.0	18.0-21	-	-	Eknoweld 308
	Corrosion resistant	CG12	0.12	1.50	2.0	10-13	2-23	-	-	Eknoweld 309
	Fe-Cr, Fe-Cr, Ni & Ni	CF20	0.20	1.50	2.0	9-12	18-21	-	-	Eknoweld 308
	base alloys	CF8M	0.08	1.50	2.0	9-12	18-21	2-3	-	Eknoweld 316
		CF8C	0.08	1.50	2.0	9-12	18-21	Cb Stabilize	-	Eknoweld 347
3	Castings for General	CH-20	0.20	1.50	2.0	12-15	22-26	-	-	Eknoweld 309
	Applications	CK-20	0.20	2.00	2.1	19-22	23-27	-	-	Eknoweld 310
		CE-30	0.30	1.50	2.2	8-11	26-30	-	-	Eknoweld 312
		CA-15M	0.15	1.00	2.3			0.15-1.0	-	Eknoweld 410 M
		CF-3	0.03	1.50	2.3	8-12	17-21	-	-	Eknoweld 308 L
		CF-3M	0.03	1.50	2.5	9-13	17-21	2.0-30	-	Eknoweld 316 L
		CG-8M	0.08	1.50	2.6	9-13	18-21	3.0-4.0	-	Eknoweld 316
		CN-7M	0.07	1.50	2.7	29.5-30.5	19-22	2.0-3.0	Co 3-4	Eknoweld 310
		CN-6NM	0.06	1.0'	2.8	3.5-4.5	11.5-14	0.4-1.0	-	Eknoweld 410 M
4	A 297	HF	0.20-0.4	2.0	2.0	8-12	18-23	0.5	-	Eknoweld 316
	Heat resistant Fe-Cr,	HH	0.20-0.5	2.0	2.0	11-14	24-28	0.5	-	Eknoweld 309
	Fe-Cr, Ni alloy	HK	0.20-0.60	2.0	2.0	18-22	24-28	0.5	-	Eknoweld Ni Cr Fe2
	castings for	HT	0.35-0.75	2.0	2.5	33-37	13-17	0.5	-	Eknoweld NiCrFe2
	General Applications	HX	0.35-0.75	2.0	2.5	64-68	15-19	0.5	-	Eknoweld Ni Cr Fe2
5	A 352	LCA	0.25	0.70	0.60	-	-	-	-32°C	Eknoweld 7018
	Ferritic steel casting	LCB	0.30	1.00	0.60	-	-	-	-46°C	Eknoweld 7018-1
	for pressure parts	LCC	0.25	1.20	0.60	-	-	-	-	Eknoweld 7018
		LC2	0.25	0.5-0.80	0.60	2.0-3.0	-	-	-	Eknoweld 8018 G
		LC3	0.15	0.5-0.80	0.60	3.0-4.0	-	-	-101°C	Eknoweld 8018 C3

EKNO WELD

P. No.	Alloy Type	Plates	Pipes	Tubes	Forgings	Castings	EKNOWELD Products
3	C-½MO	SA204Gr. A/B/C SA302Gr.A/B	SA335Gr.Pl SA369 Gr.FPl SA426 Gr.CPl	SA209Gr. Tl/Tla/Tlb	SA182Gr.F1 SA336 Gr.F1	SA217Gr.WCl	Eknoweld 7018 Al
3	½Cr - ½Mo	SA387Gr.2	SA335Gr.P2 SA369Gr.FP2 SA426Gr.CP2	SA213Gr.T2	SA182Gr.F2	-	Eknoweld8018Spl conforms E 7018 B2 L
4	I Cr - ½Mo	SA387Gr.I2	SA335Gr.P12 SA369Gr.FP12 SA426Gr.CP12	SA213 Gr.T12	SA182 Gr. F12 SA336 Gr. F12	-	Eknoweld 8018 B2
4	1¼Cr - ½Mo	SA387Gr.II	SA335 Gr.PII SA369Gr.FPII SA426Gr.CPII	SA199 Gr.TII SA213 Gr.TII	SA182Gr. F11 SA336Gr. F11 SA541Gr.11	SA217Gr.WC6	Eknoweld 8018 B2
5A	2 ¼Cr - ½Mo			SA199 Gr. T4		-	Eknoweld 9018 B3
5A 5C	2¼Cr - 1Mo	SA387Gr.22 SA542Gr.A&B	SA335 Gr.P22 SA369Gr.FP22 SA426 Gr.CP22	SA199 Gr. T22 SA213Gr.T22	SA182 Gr. F22 SA336 Gr. F22 SA508 Gr.22 SA541Gr.22	SA217 Gr. WC9 SA487 Gr.8	Eknoweld 9018 B3
5A	3Cr - 1Mo	SA387Gr.21	SA335 Gr.P21 SA369 Gr.FP21 SA426 Gr.CP21	SA199Gr. 21 SA213 Gr. T21	SA182 Gr. F21 SA336 Gr. F21	-	Eknoweld 9018 B3
5B	5Cr - 1Mo	SA387Gr.5	SA335Gr.P5/5b/5c SA369Gr.FP5- SA426 Gr.CPS	SA199 Gr. T5 SA213 Gr. T5/5b/5c	SA182 Gr. F5/F5A	SA217 Gr.CS	Eknoweld 502
5B	9Cr - 1Mo	SA387Gr.9	SA335Gr.P9 SA369 Gr.FP9 SA426 Gr.CP9	SA199 Gr.T9 SA213 Gr.T9	SA182 Gr. F9 SA336 Gr. F9	SA217Gr.C12	Eknoweld 505
5B	9Cr - 1Mo(Mod)	SA387 Gr.91	SA335Gr.P91 SA369 Gr.FP91	SA199Gr.T91 SA213 Gr.T91	SA182 Gr. F91 SA336Gr. F91		Eknoweld 505 (mod)

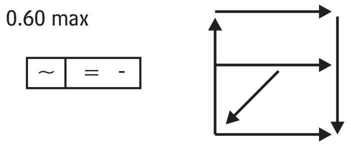
NOTE:

1. Cr-Mo, electrodes chart provides the details for welding of various ASTM steel Material specifications Ref: ASTM Boiler and Pressure vessels code sections - IIA-2001 specs and P. nos - ix 2001 specs
2. Recommendations are based on the steel compositions. Due to welding variables, beyond the control of NWIPL, the users are requested to consult the equipment designers to ensure service conditions and additional requirements (eg. Impact properties, extended PWHT etc.,). The product listed above from NWIPL standard product range. Customised special products are also available. Please contact our central marketing office atekno.customerservice(5)gmail.com

EKNOWELD - 12

Characteristics and Applications : A Rutile coated, thin general purpose electrode for sheet metal and light guage work. It is distinguished by its excellent operating characteristics under identical current conditions in all positions. Good weldability on difficult sheet metal constructions. For materials ST 34 - St 52; ship building steels; boiler plates HI - HII

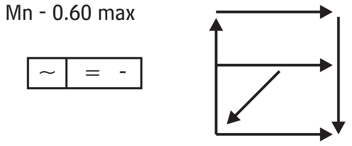
Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	330	AWS A 5.1/	C - 0.10 max
Tensile Strength	N/mm²	410-540	ASME SFA 5.1: E 6012	Si - 0.30 max
Elongation %	(L=5d)	20-24	IS 814 : 2004 ER 4114X	Mn - 0.60 max
Reduction in area %		50-75		
Impact value	CVN at 27°C	50J		



EKNOWELD

Characteristics and Applications : General Purpose all positional rutile coated electrode for mild steel. An ideal and versatile electrode for all types of fabrications and general engineering works. It also finds suitability in areas such as ship building, wagon building, tanks etc. Excellent deposition rate with good mechanical properties. Slag is self-releasing. Electrode has good restriking qualities. Can be used with both AC and DC supply. Works well on low O.C.V. transformer. For base metals such as ST 34-ST 52; boiler plates HI - H III, 17 Mn 4. Weld metal is of radiagraphic quality.

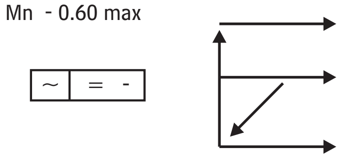
Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	370-470	AWS A 5.1/	C - 0.10 max
Tensile Strength	N/mm²	460-540	ASME SFA 5.1 : E 6013	Si - 0.30 max
Elongation %	(L=5d)	22-25	IS 814 : 2004 ER 4212X	Mn - 0.60 max
Reduction in area %		50-70		
Impact value	CVNatO°C	50J	**Approvals : BIS, CIB, MND BHEL**	



EKNOWELD - X

Characteristics and Applications : A medium heavy coated electrode for radiographic quality welds for boilers, structural, piping and storage tanks. The composition of flux enable vertical up and overhead welding to be carried out with considerable ease. There is very little spatter and the semi-inflated slag is easily removable. The electrode is suitable for the welding of medium-high tensile steels. For material ST 34 - ST 52; boiler plates HI - H III, 17 Mn 4; ST E 315 and ST E 355.

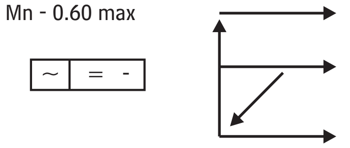
Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	370-480	AWS A 5.1/	C - 0.10 max
Tensile Strength	N/mm²	460-550	ASME SFA 5.1 : E 6013	Si - 0.30 max
Elongation %	(L=5d)	22-27	IS 814 : 2004 ER 4222X	Mn - 0.60 max
Reduction in area%		50-70	BS 639 E 4333 R 22	
Impact value	CVN at 0°C	50J	DIN 1913 4333 R 22	



EKNOWELD - XX

Characteristics and Applications : A paramount in the Eknoweld series, this is a heavy rutile coated all positional electrode for achieving welds of superior finish and radiographic quality. Produces smooth and finely rippled welds. Suitable for welding thin sheet metal grades due to its fine droplet transfer. Also used in Coach, Wagon Building, Locomotive Fabrications, Auto Components.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	360-480	AWS A 5.1/	C - 0.10 max
Tensile Strength	N/mm²	460-550	ASME SFA 5.1: E 6013	Si - 0.30 max
Elongation %	(L=5d)	24-30	IS 814 : 2004 ERR 4222X	Mn - 0.60 max
Reduction in area %		50-70	BS 639 E 4333 R 22	
Impact value	CVN at 0°C	50-100	DIN 1913 4333 R 22	



Low Hydrogen Electrodes

EKNOWELD - 7016

Characteristics and Applications: A basic coated low hydrogen type electrode for mild steel, medium high tensile and low alloy steel welding. Smooth finely rippled weld seams. Clean, notch-free weld interfaces. Extremely tough, ductile and radiographic quality. Good impact strength at room as well as sub-zero temperatures. Smooth stable arc with low spatter loss and easy striking arid restriking characteristics. Good weldability with both AC and DC and on low O.C.V. transformers. Good, clean fully penetrated crack free, non-porous root welds.

For materials: Finds application in unknown and medium carbon steel and cast iron (non-machinable), high sulphur steels, rail and auto bodies, roller and pulleys. For St 50, St 60, C 45, C 60, GS 45, GS 52, GS 60,17 Mn 4,19 Mn 5, St 35, St 35.8, St 45.8, boiler plates HI - H III, fine grained structural steels upto St E 355.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm^2	440-550	AWS A 5.1/	C - 0.06-0.10
Tensile Strength	N/mm^2	510-630	ASME SFA 5.1: E 7016	Si - 0.75 Max
Elongation %	(L=5d)	24-30	IS 814 : 2004 EB5426H3X	Mn - 0.8 - 1.5
Reduction in area %		45Min		
Impact value	CVN at 27°C	140-200J		
	at -29°C	50-80J		

~ = -

Store in a dry place; redry for 2 hours at 250°C prior to use

EKNOWELD - 7018

Characteristics and Applications : An Extra low hydrogen, radiographic quality, medium heavy coated, iron powder type electrode that is highly resistant to hydrogen - induced embrittlement. Specially recommended for high strength welds on mild steels, medium carbon and low alloy high strength steels. Deposition efficiency above 110%. Used on a variety of steels providing unique hydrogen - free deposits with superior impact resistance at normal and sub-zero temperatures. Recommended applications include critical pressure vessels, high-pressure piping, blast furnace steel work, heavy welded fabrication as replacement for castings, penstocks, bridges, atomic reactor shell, overhead cranes, steel gears, loco frames, etc.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm^2	450-560	AWS A 5.1/	C - 0.05-0.10
Tensile Strength	N/mm^2	500-640	ASME SFA 5.1: E 7018	Si - 0.75 Max.
Elongation %	(L=4d)	24-30	IS 814 : 2004 EB5426H JX	Mn - 0.80 - 1.50
Reduction in area %	60-75		BS 639 514 4B1202 4 (H)	
Impact value	CVN at 27°C+2	140J	DIN 1913 E 5144 B 1026	
	0°C	100J		
	-30°C	50J	**Approvals : BIS, CIB, MND**	

~ = +

Store in a dry place; redry for 2 hours at 250°C prior to use

EKNOWELD 7018-1

Characteristics and Applications : A basic coated all positional, low hydrogen, iron powder electrode depositing radiographic quality welds, with exceptionally good mechanicall properties including good impact strength down to -46°C. Specially designed for use in boilers, pressure vessels, penstocks, oil storage tanks, offshore platforms, oil rigs and plant and equipment for service at subzero temperatures.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm^2	450-560	AWS A 5.1/	C - 0.05 - 0.09
Tensile Strength	N/mm^2	510-620	ASME SFA 5.1: E 7018-1	Si - 0.2 - 0.6
Elongation %	(L=4d)	24-30	IS 814: 2004 EB5426H$_3$JX	Mn - 1.2 - 1.6
Reduction in area %	CVN at 27°C	60-80		
Impact value	0°C	180J		
	-30°C	140J	**Approvals : CIB**	
	-45°C	100J		
		50J		

~ = +

Store in a dry place; redry for 2 hours at 250°C prior to use

Branch Connections

Figs. 1 and 3 have been extracted from BS 2633 :1973 : Class I arc welding of ferritic steel pipework for carrying fluids. Fig. 2 extracted from BS 2971:1977 : Class II arc welding of carbon steel pipework for carrying fluids.

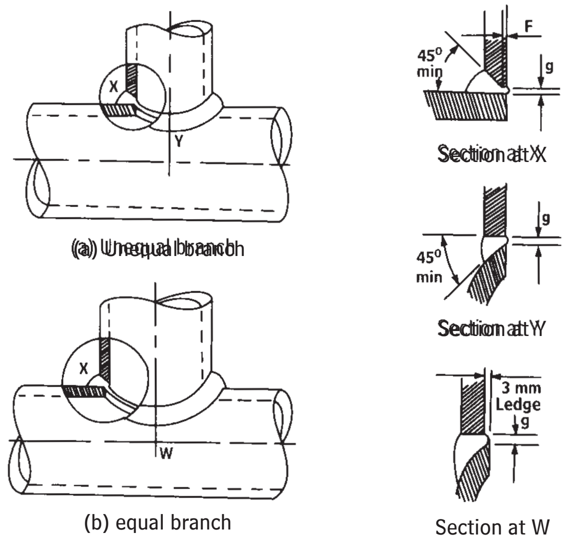
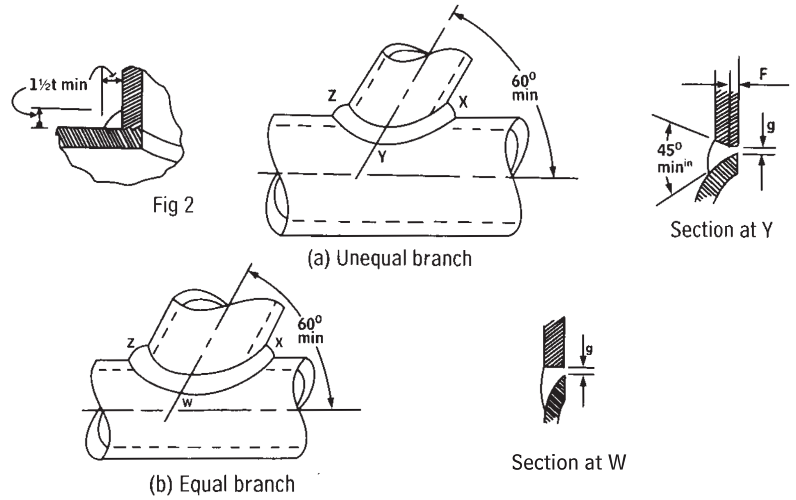
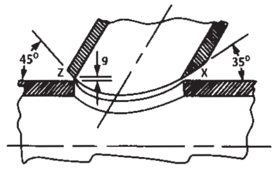


Fig. 1. Set-on right angle branch connections without backing,

f = 1.6 ± 0.8 mm g = 2.5 ± 0.8 mm

With set-on connections the branch does not enter below the surface of the main. Fig. 2 shows a form which may be used under certain conditions; for instance, at pressures not greater than about 10 bar unless an internal seal weld can be applied.





F = 1.6 ± 0.8 mm

g = 2.5 ± 0.8 mm

Fig. 3 Set-on sloping branch connections without backing.

(c) Section at x and z showing main pipe ground locally at x to improve access

It is generally recommended that sloping branches should be avoided because of the difficulty of making good welds at the crotch. For preference a sloping connection should be made with a right angle branch followed by a bend.

With set-in branch connections the branch enters below the surface of the main. If they are to be used there should be access to the inside of the main so that the root run can be dressed to clean metal, seal welded and then dressed flush. It is generally recommended that sloping branches should not be used; see the previous paragraph.

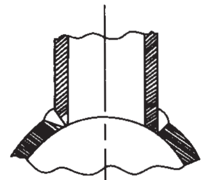


Fig. 4. Set-in right angle branch connection

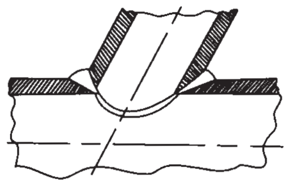
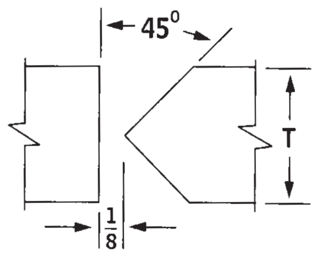
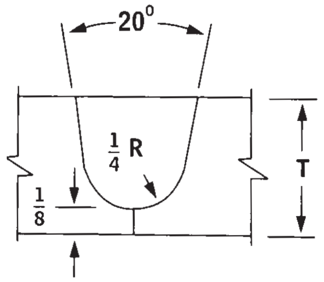
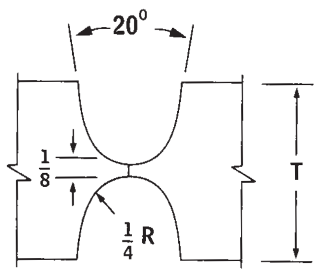
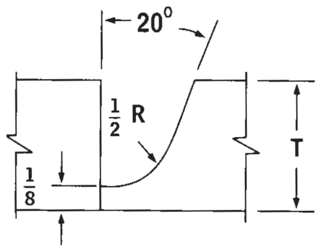
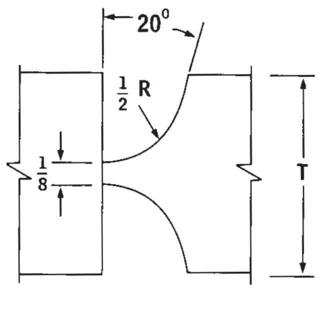


Fig. 5. Set-in sloping branch connection.

AREA AND WEIGHT OF Weld Metal Deposition

Weld	Design	T in inch	CSA Theor. in.2	Weld Deposit Theoretical lb/ft	CSA W/ref. in.^{2}	Weld Deposit W/ Reinforcement lb/ft
Double bevel		5/8	0.176	0.600	0.211	0.720
		3/4	0.234	0.798	0.281	0.958
		7/8	0.301	1.025	0.361	1.230
		1	0.375	1.279	0.450	1.535
		1-1/4	0.547	1.862	0.656	2.234
		1-1/2	0.750	2.560	0.900	3.072
		1-3/4	0.984	3.360	1.181	4.032
		2	1.250	4.260	1.500	5.112
		2-1/2	1.875	6.398	2.250	7.677
		3	2.625	8.950	3.150	10.740
Single U		1/2	0.163	0.555	0.179	0.611
		3/4	0.310	1.058	0.341	1.164
		7/8	0.392	1.338	0.431	1.472
		1	0.479	1.635	0.527	1.799
		1-1/4	0.671	2.288	0.738	2.517
		1-1/2	0.885	3.020	0.974	3.322
		1-3/4	1.120	3.820	1.232	4.202
		2	1.376	4.680	1.514	5.148
		2-1/2	1.961	6.680	2.157	7.348
		3	2.631	8.960	2.894	9.856
Double U		1	0.396	1.350	0.475	1.620
		1-1/4	0.543	1.852	0.652	2.222
		1-1/2	0.701	2.390	0.841	2.868
		1-3/4	0.870	2.968	1.044	3.562
		2	1.151	3.922	1.381	4.706
		2-1/4	1.242	4.235	1.490	5.082
		2-1/2	1.444	4.925	1.732	5.910
		2-3/4	1.658	5.650	2.000	6.780
		3	1.879	6.410	2.255	7.692
		3-1/2	2.389	8.150	2.867	9.780
		4	2.951	10.070	3.541	12.084
		4-1/2	3.495	11.790	4.151	14.148
Single J		1/2	0.180	0.614	0.198	0.675
		3/4	0.261	0.890	0.287	0.979
		1	0.409	1.395	0.450	1.535
		1-1/4	0.580	1.978	0.638	2.176
		1-1/2	0.774	2.640	0.851	2.904
		1-3/4	0.989	3.375	1.088	3.713
		2	1.229	4.190	1.352	4.609
		2-1/4	1.491	5.080	1.640	5.589
		2-1/2	1.774	6.050	1.951	6.655
Double V		1	0.360	1.228	0.432	1.474
		1-1/4	0.437	1.490	0.524	1.788
		1-1/2	0.589	2.010	0.707	2.412
		1-3/4	0.728	2.482	0.874	2.978
		2	0.875	2.983	1.050	3.580
		2-1/4	1.029	3.510	1.235	4.212
		2-1/2	1.191	4.065	1.429	4.878
		2-3/4	1.360	4.640	1.632	5.568
		3	1.535	5.235	1.842	6.282
		3-1/2	1.909	6.510	2.291	7.812
		4	2.313	7.880	2.776	9.456

High Efficiency Electrodes

EKNOWELD 7014-10, EKNOWELD 7014-15

Characteristics and Applications : A heavily covered rutile coated iron powder type high-performance electrode used in structural engineering, bridge and ship building, boiler, tank and vehicle construction. Due to its excellent current carrying capacity, weld metal recovery is over 115%. The weld metal has good elongation characteristics since the slag easily followed weld pool. Thin fillet welds with finely rippled appearance can be achieved easily.
For materials: St. 34 - St 52, boiler plates HI - H III, 17 Mn4,19Mn5, fine grained structural steels up to St 355.

Mechanical Properties of all Weld Metal

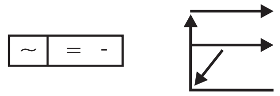
Yield strength	N/mm^2	390
Tensile Strength	N/mm^2	510-610
Elongation %	(L=5d)	22-26
Reduction in area %		50-75%
Impact value	CVN at 27°C	50J

Classifications

AWS A 5.1/
ASME SFA 5.1: E 7014
IS 814: ERR5222-XJ

Weld Metal Chemistry, Wt. %

C - ≤ 0.10
Si - 0.40 max
Mn - 0.60 max



EKNOWELD 8018 W

Characteristics and Applications : Basic coated electrode suitable for high tensile steels upto 650 N/mm^2 in all positions. Welds are radiographic nature, which can withstand heat treatment of low temperature conditions. Weld deposits possess ambient corrosion resistance due to controlled chemistry. Eminently suited for welding of weathering steels. For welding cover steel suitable for rail coaches and wagons.

Mechanical Properties of all Weld Metal

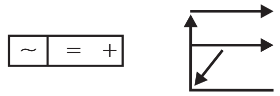
Yield strength	N/mm^2	500
Tensile Strength	N/mm^2	580-680
Elongation %	(L=5d)	20-25
Reduction in area %		50-75
Impact value	CVN at RT	150J
	-20°C	40J

Classifications

AWS A 5.57
ASME SFA 5.5 : E 8018-W
IS : EB5229H$_3$JX

Weld Metal Chemistry, Wt. %

C - ≤ 0.06
Ni - 0.5-0.8
Mn - 0.80 max
Cu - 0.3-0.75
Cr - 0.30-0.70



Store in a dry place; redry for 2 hours at 250°C prior to use

EKNOWELD 8018 W

Characteristics and Applications : Basic coated electrode suitable for high tensile steels upto 650 N/mm^2 in all positions. Welds are radiographic nature, which can withstand heat treatment of low temperature conditions. Weld deposits possess ambient corrosion resistance due to controlled chemistry. Eminently suited for welding of weathering steels. For welding cover steel suitable for rail coaches and wagons.

Mechanical Properties of all Weld Metal

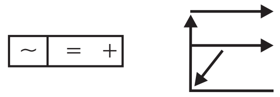
Yield strength	N/mm^2	460-570
Tensile Strength	N/mm^2	560-650
Elongation %	(L=5d)	22-25
Reduction in area %		50-80
Impact value	CVN at 27°C	120-200J
	0°C	120-180J
	-40°C	50-120J
	-50°C	30-80J

Classifications

AWS A 5.55
ASME SFA 5.5 : E 8018-G
IS 1395 : E 55 BG 129 Fe

Weld Metal Chemistry, Wt. %

C - ≤ 0.07
Ni - 1.0 max
Mn - 1.40 max
Mo - 0.5 max
Cr - 0.10 max



Store in a dry place; redry for 2 hours at 250°C prior use

High Tensile Electrodes

EKNOWELD 9018 G

Characteristics and Applications: A medium - heavy coated, low hydrogen, iron powder type, all position electrode for welding of high tensile structural steels, heavy sections and restrained joints in high tensile steels. High strength (700 N/mm2) welding of bridges and tanks, material handling equipment, boiler, power house construction and earth moving equipment.

Mechanical Properties of all Weld Metal

Yield strength	N/mm^2	530-620
Tensile Strength	N/mm^2	630-700
Elongation %	(L=5d)	20-24
Impact value	CVN at 27°C	150J

Classifications

AWS A 5.5 : E 9018 G
IS 1395 : E 63 BG 129 Fe

Weld Metal Chemistry, Wt. %

C - ≤ 0.06 Mo - 0.5 max
Ni - 1.4 max Si - 0.80 max
Mn - 1.20 max

Store in a dry place; redry tor 2 hours at 2M°L prior to use

EKNOWELD 9018 M

Characteristics and Applications : A low alloy high strength steel electrode with excellent mechanical properties for welding penstocks, spheres and heavy duty structures. Extremely crack-resistant due to particularly low hydrogen content. For materials: quenched and tempered fine grained special structural steels, such as N - A - XTRA 56, HY 80.

Mechanical Properties of all Weld Metal

Yield strength	N/mm^2	540-620
Tensile Strength	N/mm^2	630 Min.
Elongation %	(L=5d)	20-24
Impact value	CVN at -51°C	>30J

Classifications

AWS A 5.5 : E 9018 - M

Weld Metal Chemistry, Wt. %

C - 0.10 max Ni -1.8 max
Mo - 0.35 max Si - 0.80 max
Mn -1.25 max Cr - 0.15 max

Store in a dry place; redry for 2 hours at 250°C prior to use

EKNOWELD 10016 G

Characteristics and Applications: A medium coated low hydrogen type of electrode for all position welding of Ni-Cr-Mo steels. The weld metal has high tensile strength and can also retain its mechanical properties at elevated temperature. For joining and surfacing of high-tensile steel machinery parts, earth moving equipment parts, automobile parts and chemical plant equipments, steam turbine, rotors, etc.

Mechanical Properties of all Weld Metal

Yield strength	N/mm^2	600 Min.
Tensile Strength	N/mm^2	690 Min.
Elongation %	(L=5d)	22-24
Impact value	CVN at -20°C	100J

Classifications

AWS A 5.5 : E10016 -G
IS 1395 : E 68 BG 126

Weld Metal Chemistry, Wt. %

C - 0.09 max Mo - 0.5 max
Ni -3.2 max Si -0.25 max
Mn -1-50 max Cr -1.2 max

Store in a dry place; redry for 2 hours at 250°C prior to use

EKNOWELD 10018 G

Characteristics and Applications : A hydrogen controlled low alloy, high tensile steel electrode suitable for welding earth moving, mining, material handling equipment.

Mechanical Properties of all Weld Metal

Yield strength	N/mm^2	600 Min.
Tensile Strength	N/mm^2	690 Min.
Elongation %	(L=5d)	20-24
Impact value	CVN at 25°C	110J

Classifications

Weld Metal Chemistry, Wt. %

C - 0.09 max Cr - 0.35 max
Mo - 0.05 max Si - 0.6 max
Mn - 1-0 max Ni - 2.10 max

Store in a dry place; redry for 2 hours at 250°C prior use

EKNOWELD 10018 M

Characteristics and Applications : Hydrogen controlled, low - alloy high tensile steel electrode suitable for welding fully killed fine grained steels. For welding of high tensile steels such as UST-1, HOAGN-A-XTRA 65, N-A-XTRA 70, BH 65, Penstocks, earthmoving equipment and other heavy steel fabrications.

Mechanical Properties of all Weld Metal

Yield strength	N/mm^2	620-690
Tensile Strength	N/mm^2	750
Elongation %	(L=4d)	20-24
Impact value	CVN at -51°C	>30J

Classifications

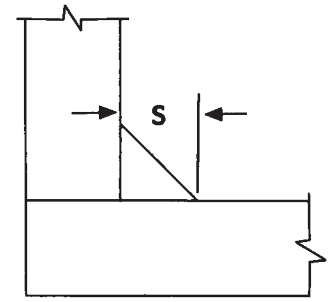
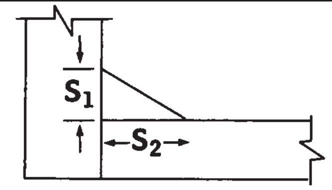
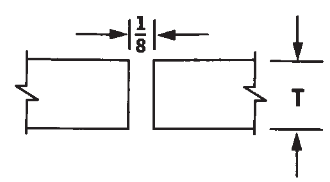
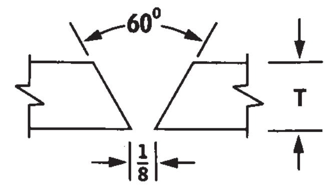
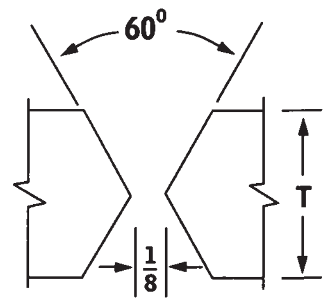
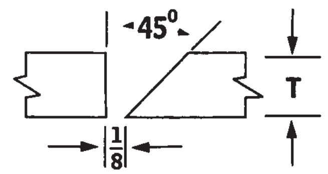
AWS A 5.5/
ASME SFA 5.5 : E 10018-M
IS 1395 : E 68 BM 22G Fe

Weld Metal Chemistry, Wt. %

C - ≤0.08 Ni - 1.5-2.0
Cr - 0.2-0.3 Si - 0.3-0.5
Mn - 1.0-1.5 Mo - 0.3-0.5

Store in a dry place; redry for 2 hours at 250°C prior use

AREA AND WEIGHT OF Weld Metal Deposition

Weld	Design	T in inch	CSA Theor. in.^{2}	Weld Deposit Theoretical Ib/ft	CSA W/ref. in.^{2}	Weld Deposit W/ Reinforcement Ib/ft
Fillet (equal legs)		1/8	0.008	0.027	0.009	0.030
		3/16	0.018	0.061	0.020	0.067
		1/4	0.031	0.106	0.034	0.117
		5/16	0.049	0.167	0.054	0.184
		3/8	0.070	0.238	0.077	0.262
		7/16	0.096	0.326	0.106	0.360
		1/2	0.125	0.425	0.138	0.468
		9/16	0.158	0.537	0.174	0.591
		5/8	0.195	0.663	0.215	0.729
		3/4	0.281	0.956	0.309	1.052
		7/8	0.383	1,503	0.421	1.653
		1	0.500	1.700	0.550	1.876
Fillet (unequal legs)		1/4x3/8	0.047	0.160	0.052	0.176
		3/8x1/2	0.094	0.319	0.103	0.351
		1/2x5/8	0.156	0.530	0.172	0.583
		5/8x3/4	0.234	0.795	0.258	0.875
		3/4x1	0.375	1.274	0.413	1.401
Square		1/8	0.016	0.054	0.019	0.065
		5/32	0.019	0.065	0.023	0.078
		3/16	0.023	0.078	0.027	0.094
		7/32	0.027	0.092	0.032	0.110
		1/4	0.031	0.105	0.037	0.126
		9/32	0.035	0.119	0.042	0.143
		5/16	0.039	0.132	0.047	0.158
Single V		1/4	0.067	0.228	0.074	0.251
		3/8	0.128	0.384	0.141	0.422
		1/2	0.206	0.702	0.227	0.772
		5/8	0.305	1.040	0.336	1.144
		3/4	0.418	1.430	0.460	1.573
		1	0.702	2.395	0.772	2.635
Double V		3/4	0.256	0.874	0.307	1.049
		1	0.414	1.420	0.497	1.704
		1-1/4	0.608	2.075	0.730	2.490
		1-1/2	0.838	2.860	1.006	3.432
		1-3/4	1.105	3.765	1.326	4.518
		2	1.405	4.780	1.686	5.736
		2-1/4	1.742	5.945	2.090	7.134
		2-1/2	2.210	7.530	2.652	9.036
		2-3/4	2.530	8.620	3.036	10.344
		3	2.978	10.150	3.574	12.180
		3-1/2	3.970	13.530	4.764	16.236
		4	5.620	19.130	6.744	22.956
Single bevel		1/4	0.063	0.215	0.069	0.237
		3/8	0.117	0.364	0.129	0.400
		1/2	0188	0.641	0.207	0.705
		5/8	0.301	1.025	0.331	1.128
		3/4	0.375	1.280	0.413	1.408
		1	0.625	2.135	0.687	2.349

Stainless Steel Electrodes

EKNOWELD 430 -16

Characteristics and Applications : A heavy coated rutile type all positional electrode specially designed for ferrite steels containing 17% Cr and above. Excellent corrosion resistance and resists scaling and oxidation of upto 900°C. Ideally suited for welding ferritic chrome steels of grade 430,442,446, etc. It is recommended for suitable preheat and post-heat treatment to obtain optimum physical properties of the weldment. For German steels 4016,4510 and 4741.

Welding Instructions : Similar to Eknoweld 312-16. Recommended pre-heat to 250°C and post-heat to 740°C and cool very slowly.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	480 - 540	AWS A 5.47	C - ≤ 0.1 max	Mn - 1.0 max
Elongation %	(L = 5d)	22-24	ASME SFA 5.4 : E 430 -16	Cr - 15 -18	Si - 0.90 max
				Ni - 0.6 max	Mo - 0.5 max

* AWS : E 430-15 also available.

EKNOWELD 18/8/6 (S)

Characteristics and Applications: A very heavy- coated basic electrodes having mild steel core wire giving 18 Cr / 8-10 Ni/ 6 Mn austenitic stainless steel deposit. A low heat input electrode that ensures ease of operation at low currents with minimal spatter loss and easy slag detachability. Weld metal has an excellent heat, corrosion and work hardening properties. Deposition efficiency of 130%. Ideally suited for repairing cracks in manganese steel castings, surfacing manganese steel rails and as buffer layers on difficult steels prior to hard facing.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	550 - 650	AWS A 5.47	C - ≤ 0.2	Mo - 0.5 max
Elongation %	(L=4d)	30 - 40	ASME SFA 5.4 : E 307 -16 (Nr.)	Cr - 17 - 20	Mn - 5 - 8
Impact value	CVN at 27°C	60 - 90J	IS : E 18.8 Mn B 26	Ni - 7 - 10	Si - 0.9 max

Store in a dry place

EKNOWELD DSS

Characteristics and Applications : All position, specially formulated stainless steel electrode used primarily to weld duplex stainless steel contains approx. 22% of chromium. Weld metal has "duplex" microstructure consisting of an austenite-ferrite matrix. Weld metal combines increased tensile strength with improved resistance to pitting corrosive attack and to stress corrosive cracking. It is most suitable for corrosion resistance in marine environments.

Instructions : Similar to EKNOWELD 312-16

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	690 - 790	AWS A 5.4/	C - < 0.04	Cr - 21.5 - 23.5
Elongation %	(L=4d)	20 - 30	ASME SFA 5.4 : E 2209-16	Mn - 0.5-2.0	Ni - 8.5 -10.5
				N - 0.08 - 0.20	Mo - 2.5 - 3.5

EKNOMONEL

Characteristics and Applications : A radiographic quality all positional medium heavy coated electrode with very low iron content that ensures maximum corrosion resistance. Weld deposit will not harden when heat-treated. To minimize dilution while surfacing carbon steels and during welding of dissimilar steels, a large weld puddle should be formed and the arc should be directed on it. The weld metal is very strong and ductile and is easily machinable in as deposited condition and after stress relieving. For welding monel to itself or to stainless or carbon steels and for overlaying on steels for corrosion resistance. Ideally suited for marine application and for cladding.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	500 - 600	AWS : A 5.11 /	C - ≤ 0.15	Ti -1.0 max
Elongation %	(L=4d)	20 - 40	ASME SFA 5.11: E NiCu - 7	Mn - 4.0 max	Ni - 62 - 69
				Fe - 2.5 max	Cu - Balance
				Si - ≤ 1.5	

EKNO WELD

Electrodes for Cryogenic Applications

EKNOWELD 8018 CI

Characteristics and Applications: A heavily covered basic type iron powder electrode, with controlled, hydrogen is specially designed for welding low temperature steels. For welding nickel alloy steels used for high ductility and resistance to embrittlement at sub-zero temperatures. This 2.5 Ni electrode gives smooth and stable arc with low spatter and easy slag. For fine grained structural steels upto STE 355,10 Ni 14,12 Ni 19, TTSt35, CG1, CG2, etc.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	470-540	AWS A 5.5/	C - 0.05-0.08
Tensile Strength	N/mm²	560-660	ASME SFA 5.5 : E 8018 - C1	Mn - 0.7 -1.1
Elongation %	(L=5d)	25-30	IS 1395: E 55 BC126 J	Ni - 2.0-2.7
Impact value	CVNat20°C	160J		Si - 0.2-0.4
	at 0°C	130J		
	-40C	100J		
	-60C	50J		

Store in a dry place; redry for 2 hours at 250°C prior to use

EKNOWELD 8018 C2

Characteristics and Applications 0: A heavily covered, low hydrogen, iron powder, type electrode designed for welding low temperature nickel alloy steels used for ductility and resistance to embrittlement at sub-zero temperatures. This 3.2-3.8% Ni electrodes gives a smooth and stable arc, minimal spatter loss and easy slag detachability. Good recovery of 120%. For materials StE 355-StE 500, FG 36-FG 51. Specially used in locomotive and truck main frames, pressure vessels, refineries, etc.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	470-540	AWSA5.5/	C - ≤ 0.08
Tensile Strength	N/mm²	560-660	ASME SFA 5.5 : E 8018 C2	Mn - 0.8-1.2
Elongation %	(L=5d)	23-26		Si - 0.15 - 0.30
Impact value	CVN at 20°C	200J		Ni - 3.2 - 3.7
	at 0°C	150J		
	-20°C	130J		
	-50°C	90J		
	-80°C	60J		

Store in a dry place; redry for 2 hours at 250°C prior to use

Metal Preparations

EKNOCUT

Characteristics and Applications : High arc force for deep penetration and cutting action. Ideal for piercing and cutting all metals by the electric arc process and for removing Runners & Risers in foundry. The electrode strikes arc easily and achieves clean cuts even on thicker materials. The arc force is excellent and operates at high currents without getting over heated.

Instructions : Set up the work piece so that molten metal can run off easily. It is advisable to execute an up and down sawing movement, pushing the molten metal away with the electrode.

EKNO GOUGE

Characteristics: A heavy coated electrode for chamfering and grooving with electric arc. No compressed air or oxygen needed. It is a highly heat resistant electrode with exothermic coating. Arc force is concentrated right at the point of application, yielding an efficient metal removing tool.

Applications: To be used for preparing V section prior to welding, for removing old fatigued and unwanted metal prior to final machine operation. Suitable for both ferrous and non-ferrous metals, wear plates, removing / cutting of flash and risers,

Approvals : RDSO (Class - N2)

EKNO WELD

Creep Resistant Steel Electrodes

EKNOWELD 7018 Al

Characteristics and Applications: A medium coated, hydrogen controlled, iron powder electrode for welding high and low alloy steels used at elevated temperature. The electrode gives ductile and creep resistant 0.5% Mo weld deposit to withstand service temperature upto 500°C. For welding creep resistant steels of 0.5% Mo and 1 Cr 0.5 Mo type high strength steels used in the manufacture of boilers, pipe lines, etc.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	420-520 (at 27°C)	AWS A 5.5/	C - 0.05 - 0.09
Yield strength	N/mm²	470 (at 300°C)	ASME SFA 5.5 : E 7018-A1	Mn - 0.5 - 0.9
Yield strength	N/mm²	415 (at 510°C)	IS 1395 : E 49 BA 126 Fe	Si - 0.20 - 0.60
Tensile Strength	N/mm²	500-600		Mo - 0.4 - 0.65
Elongation %	(L=4d)	26-30		
Impact value	CVN at 27°C	170J		

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Store in a dry place; redry for 2 hours at 250°C prior use

EKNOWELD 8018 B2

Characteristics and Applications: A basic coated hydrogen-controlled electrode designed for welding 1¼% chromium, ½% molybdenum type creep-resisting steels and depositing weld metal of high mettalurgical and radiographic quality. For welding 1 Cr 0.5Mo, ASTM A 182-F2, F11, F12; A387-2,11,12; A 213-T2, Til, T12, A335-P2, PII, 12 and german steel 13Cr Mo44, 15 CrMo5 used in boilers, power plants, oil refineries and chemical plants.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Yield strength	N/mm²	620(at 27°C)	AWS A 5.5/	C - 0.05 - 0.10
Yield strength	N/mm²	350 (at 200°C)	ASME SFA 5.5 : E 8018 B2	Cr - 1 - 1.5
Yield strength	N/mm²	270 (at 500°C)	IS 1395 : E 55 BB 226 Fe	Mn - 0.5 - 0.9
Tensile Strength	N/mm²	560-680		Mo - 0.4 - 0.65
Elongation %	(L=4d)	22-28	**Approvals: CIB**	Si - 0.2 - 0.6
Impact value	CVN at 27°C	80J		

~ = +

Recommended heat treatment:
Preheat 150°C; Interpass temp. 200°C; Post heat 650°C

EKNOWELD 9018 B3

Characteristics and Applications: A basic medium-heavy coated, hydrogen-controlled, iron powder type, all position electrode designed for welding 2¼ Cr -1 Mo type, Creep-resisting steels. Efficiency of 110% for welding German Steel IOCr Mo9 and 100 CR Si Mo V7.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Yield strength	N/m	540-670	AWS A 5.5/	C - 0.08 max	Mo - 0.9 -1.2
Tensile Strength	N/mm²	625-750	ASME SFA 5.5 : E 9018 - B3	Cr - 2.0-2.5	Si -0.6 max
Elongation %	(L=4d)	17-25	IS 1395 : E 53 BB 326 Fe	Mn - 0.9 max	

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EKNOWELD 502

Characteristics and Applications : A medium heavy-coated, low hydrogen, iron powder electrodes producing a weld deposit containing 5 Cr 0.5 Mo which has excellent creep resistance at elevated temperatures upto 550°C. Weld deposit has resistance to oxidation upto 650°C. Weld deposit air-hardens. For power house, petro-chemical and fertilizer plants where steels of similar composition are used.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Yield strength	N/mm²	460 - 520	AWS A 5.5/	C - 0.08 max	Mo - 0.4-0.6
Tensile Strength	N/mm²	550 - 650	ASME SFA 5.5 : E 8018-B6	Cr - 4.0 - 6.0	Si - 0.80 max
Elongation %	(L=5d)	20-25	IS 1395 : E 41 BB 626 Fe	Mn - 0.90max	Ni - 0.4 max
Impact value	CVN at 27°C	80 - 140 J			
Hardness		225 BHN			

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Recommended heat treatment:
Preheat 200°C; Interpass temp. 250°C; Post heat 720°C

EKNO WELD

Stainless Steel Electrodes

EKNOWELD 316L - 16

Characteristics and Applications : An all positional, radiographic quality extra low carbon 18/13 Mo stainless steel electrode with controlled ferrite content for maximum resistance to stress, chemical corrosion and hot cracking. Can withstand elevated temperature upto 850°C and has excellent creep resistance. Molybdenum enables to resist corrosive agent of reducing nature. For welding AISI316L and 317L types, stainless steel clad plates, chemical plants and dye-industries.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	510 - 600	AWS A 5.47	C - ≤ 0.04	Mn - 0.5-2.5
Elongation %	(L = 4d)	30 - 40	ASME SFA 5.4 : E 316 L -16	Cr - 17 - 20	Si - 0.9 max
			IS : E19.12.2LR26	Ni - 11 - 14	
				Mo - 2 - 2.5	

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EKNOWELD 318 -16

Characteristics and Applications : An all positional low carbon 18/13/Mo/Nb stabilized that has excellent resistance to stress, cracking and inter crystalline corrosion. It is also highly creep resistant. Excellent arc stability and low spatter loss. For paper mill and dying equipments, chemical plants, heat resisting castings etc ideally suited for welding stabilized stainless steel of AISI 318 and also for non-stabilized steels of type AISI 316, 317 and 318

Welding Instructions : Similar to EKNOWELD 309 - 16

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	560 - 670	AWS A 5.47	C - ≤ 0.08	Ni - 11-14
Elongation %	(L=4d)	25 - 35	ASME SFA 5.4 : E 318 -16	Mn - 0.5 - 2.5	Mo - 2.0-2.5
			IS : E 19.12.2 Nb R 26	Si - 0.3 - 0.9	δ-Ferrite - 4 - 8
				Cr - 17 - 20	Nb - 0.3 - 1.0

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EKNOWELD 347 -16

Characteristics and Applications : A low carbon 19 /10 /Nb stabilized stainless steel electrode with controlled ferrite content for maximum resistance to cracking corrosion and high temperatures. Niobium prevents harmful carbide precipitation. For welding AISI steels 321 and 347. Generally on 18/8 steels stabilized with titanium or niobium. Used widely in the aircraft and chemical industries.

Welding Instruction: Similar to EKNOWELD 309 -16

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	560 - 690	AWS A 5.47	C - ≤ 0.08	Nb - 0.4 -1.0
Elongation %	(L=4d)	30 - 40	ASME SFA 5.4: E 347 -16	Cr - 18 - 21	Mn - 0.5 - 2.5
			IS : E19.9NbR26	Ni - 9 - 11	Si - 0.9 Max.
				Mo - 0.5 max	

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EKNOWELD 410 -16

Characteristics and Applications: An all positional designed for welding straight chrome martensitic steels and castings. Also for antiwear coatings on a wide variety of components. Weld deposit had good corrosion, erosion and abrasion resisting properties. Also resistant to scaling and oxidation upto 600°C. Ideally suited for surfacing carbon steels, valves, low alloy steels, heat treatable steels.etc., that are subjected to wear. Designed for 13% Cr type steels. Pre-heating of this type of steel upto 350°C is recommended. For German steels 4001,4006,4008,4021,4024,4027 and 4107.

Welding Instructions: Similar to EKNOWELD 309-16

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm²	480 - 550	AWS A 5.4/	C - ≤ 0.12	Ni - 0.5 max
Elongation %	(L=4d)	20 - 25	ASME SFA 5.4 : E 410 -16	Cr - 11 - 13.5	Mn - 1 max
				Mo - 0.5 max	Si - 0.9 max

* AWS: E 410 -15 also available.

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EKNO WELD

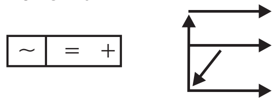
Stainless Steel Electrodes

EKNOWELD 310 -16

Characteristics and Applications: An all positional, medium -heavy coated, rutile type electrode which gives 25 Cr/20Ni weld deposits that has high oxidation resistance and can withstand elevated temperature upto 1200°C in continuous service. Welding AISI310 type steels, cladding sides of stainless steels, straight chrome steels, German steels 4762,4828,4841,4846 and 4848, dissimilar steels, gas turbine combustion chamber parts, high temperature furnace parts, hydrogenation and polymerisation plants, annealing boxes etc. Also suited for welding carbon molybdenum steels 309,410,430,520 steels.

Welding Instruction: Similar to EKNOWELD 309-16

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile Strength	N/mm^2	560 - 680	AWSA5.4/	C - 0.08 - 0.20
Elongation %	(L = 4d)	30 - 40	ASME SFA 5.4 : E 310-16	Cr - 25 - 28
Impact value	CVN at 196°C	35 - 65J	JIS 5206: E 25.20 R	Ni - 20 - 22
				Mn - 1.0 - 2.5
				Mo - 0.5 max
				Si - 0.75 max

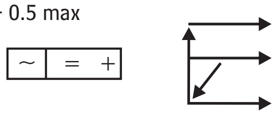


EKNOWELD 312 -16

Characteristics and Applications : A highly alloy, versatile, all positional electrode for welding dissimilar and difficult to weld steels, Balanced ferrite/ austenite structure provides resistence with very high strength. Welds are of rediographic quality and higly crack-resistent. Ideally suited for welding steels of unknown compositions. Can be used for hardfacing structural parts that are subjected to wear such as shovels teeth, crusher jaws, beating arms, guide rails, hot working tools splines, key ways of shafts, gear box main shaft, crank shafts, leaf spring, etc.

Welding Instructions : Surface to be cleaned from rust, oil, scales, paint, etc. Gouge out / grind worn, damaged and fatigued metal / cracks. Use dry electrodes. Hold short arc while welding and minimum current. Employ short stringer beads. Chips slag between passes. Peen deposit while hot.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile Strength	N/mm^2	740 - 850	AWS A 5.4/	C - ≤ 0.15
Elongation %	(L = 5d)	25 - 32	ASME SFA 5.4 :E312-16	Cr - 28 - 32
Impact value	CVN at 27°C	35J	IS 5206 :E 29.9 R 26	Ni - 8 - 10.5
Hardness	BHN 200 - 225			Mn - 0.5 - 2.5
				Si - 0.9 max
				Mo - 0.5 max

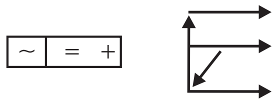


EKNOWELD 316 -16

Characteristics and Applications : An all positional radiographic quality low carbon 18/13/Mo stainless steel electrode with controlled ferrite content for maximum resistance to corrosion and cracking and can withstand elevated temperatures upto 850°C with excellent creep resistance. Easy arc striking and restriking with good arc stability and low spatter loss ensuring smooth, uniform weld beads. The deposit has increased resistance to sulphuric, hydrochloric, phosphoric, formic, acetic, citric, tartaric acids etc. and can efficiently handle bleaching solution, coal or oil smoke, pulp liquor in paper and pulp mill equipment. For welding AISI 316 and 317 types, tanks, vats, coils, chemical mixers, paint & dye industries.

Welding Instruction : Similar to EKNOWELD 309 - 16

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile Strength	N/mm^2	560 - 660	AWS A 5.4/	C - ≤ 0.08
Elongation %	(L = 4d)	30 - 40	ASME SFA 5.4: E 316 -16	Cr - 17 - 20
Impact value	CVN at 27°C	70 - 100J	IS 5206 : E 19.12.2 R 26	Ni - 11 - 14
				Mo - 2 - 2.5
				Mn - 0.5 - 2.5
			Approval : RDSO (Cl. M3)	Si - 0.90 max



Hardfacing-Welding Techniques

The term "hardfacing" is relative. The American Welding Society classifies hardfacing as a part of the overall field of "Surfacing"

Surfacing provides protection against abrasion, corrosion, impact, heat, friction and erosion.

In the selection of the proper type of hardfacing material, the question should not be "which is the hardest buildup alloy ?" but which alloy wears longest under any particular condition.

All of our experience and theory is based on the uncontested fact that the relative abrasion resistance of hardfacing alloys is due to the amount of metal carbides present.

Generally speaking, the more carbides, the greater the resistance to wear. These carbides are natural chemical compounds, formed by the union of one or more of about a dozen chemical elements such as Tungsten, Chromium, Molybdenum, etc. Such elements are known as carbide-formers, because they have a great tendency to join with the carbon in the molten metal to form crystals of definite shapes.

Because all carbides are hard and brittle, a cushioning material known as the Matrix is as important to the service life of a hardfacing alloy, as is the carbide. In most cases iron is used to form the matrix.

Where corrosion or high temperatures are encountered, nickel or cobalt may form the matrix.

Before hardfacing, it is often necessary to restore a worn part to its original size and contour. Generally, this cannot be done with hardfacing alloys, particularly on badly worn parts where a great amount of metal has been lost.

The build-up material must be strong enough to provide a rigid, sound base for the hard metal overlay.

Base metal dilution, which is seldom noticeable in gas welding, occurs in deposits made by electric arc welding. It can be kept to a minimum by proper heat control (low amperage) and is usually eliminated in the third weld-layer.

Stresses can, and do, frequently cause failures in the part to be hardfaced, particularly on hard base metals.

Pre-heating or depositing of cushioning alloys with a high elongation electrode are proven techniques. Where two parts, that come in contact with each other, are to be surfaced, it is advisable to apply alloys that have approximately 10 Rockwell C difference in hardness.

The economy of hardfacing has never been more proven than in quarrying and rock crushing operations together with the mining industries. Rebuilding and hardfacing very often save the cost of replacement parts. The chief economy lies mostly in the increased efficiency and output.

Many variable conditions determine the final selection of the best hardfacing material, whether working in granite, sandstone or limestone, or whether the application involves impact or sliding abrasion, etc. Keeping in mind that down-time is the biggest cost factor, the savings for the operator lie in the increased service life before rewelding.

Austenitic Manganese Steel has a tendency to work-harden under impact; it is non-magnetic. It is an unstable steel and will revert quickly to its normal state if subjected to "sustained" high temperatures. Therefore, it is most important that it be welded rapidly and kept below 200°C at all times.

Manganese steel is a poor heat conductor. The heat does not easily dissipate. In addition to that, it has a high rate of expansion, warps and distorts very easily. Good results have been achieved by submerging the workpiece in water, whereby only the surface to be welded protrudes.

Hammering the deposit is another method to relieve weld bead stresses, especially important when welding austenitic manganese steel.

Hardfacing with Eknoweld range is one of the simplest and best method of combating the effects of metallic wear. There are a wide variety of deposit type available, even specially designed to withstand certain forms of wear and service conditions.

For more details please contact Central Marketing Office.

Hardfacing Electrodes

EKNOWELD 25 R, EKNOWELD 25 B

Characteristics and Applications : A 25 B is a low hydrogen hardsurfacing electrode for depositing wear-resistance deposits on mild steel, carbon steel and low alloy steels. Excellent resistance to rolling and sliding friction. Weld metal is machinable. 25 R is a rutile electrode of air-hardening type and has a high resistance to wear and impact. For hardfacing and building up of shaft, scrapers hammers, gear wheels, wagon wheels, tractor sprockets, idler shafts, shovels.

Instructions: Use short arc and minimum current while welding. Keep electrode dry. Hardness increases with multilayers but limit to 2-3 layers. Before depositing on carbon steel, a buffer layer of EKNOWELD 7018 is recommended.

Mechanical Properties of all Weld Metal	Weld Metal Chemistry, Wt. %
Hardness : 250-300BHN	C - 0.20 max
After Hardening : 350-400BHN	Si - 0.40 max
	Mn - 0.60 max
	Cr - 1.25 max

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EKNOWELD 35 R, EKNOWELD 35 B, EKNOWELD 35 G

Characteristics and Applications: 35 R is a rutile coated air hardening type electrode for hardfacing application on mild steel, carbon steel and low alloy steels. The weld deposit can give hardness upto 350 BHN and is highly resistant to abrasive wear with good toughness properties. Soft and stable arc, smooth and regular weld head profile, easy slag detachability are characteristics of this electrode. Weld metal can be machined with a carbide tool.

For hardfacing and building up of shear blades, brake shoes, crane wheels, cams, gears, shafts, plough shares, coveyor parts, rail ends and crossing, pulley and axles, cog wheels, couplings, crawler parts end, pinion teeth.

Instructions: Use short arc and minimum current while welding. Keep electrode dry. Hardness increases with multilayers but limit to 2-3 layers. Before depositing on carbon steel, a buffer layer of EKNOWELD 7018 is recommended.

Mechanical Properties of all Weld Metal	Classifications	Weld Metal Chemistry, Wt. %
Hardness on 3 layer deposit : 350 BHN	EKNOWELD 35 B	C - 0.20 max
	IS : 7303 - 91	Si - 0.6 max
	EFe-B	Mn - 0.50 max
		Cr - 3.1 max

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EKNOWELD 60 B

Characteristics and Applications : A medium coated low hydrogen air hardening type specially designed for hardfacing and building up of worn out machine parts which are subjected to severe service conditions involving a combination of impact and abrasion. Soft steady arc, smooth, uniform bead profile and easy slag detachability. For surfacing / rebuilding of mill hammers for pulverising coal, disintegrator hammers in Iron Ore Mines, earth moving equipment parts, hot and cold punching dies, agricultural machinery, bamboo chipper knives, cane cutting knives, mill knives, shear blades, impellers, jaw crushers, tractor grousers, rollers rock drills, etc.

Instructions : Keep the electrode dry. use short arc and low welding speed. Employ short stringer beads. Preheating may be required for multilayer welding. A buffer layer of EKNOWELD 7018 on carbon steels and EKNOWELD -18/8/6(5) on stainless steels, is necessary for austenitic manganese steel.

Deposit can only be ground finished.

Mechanical Properties of all Weld Metal	Classifications	Weld Metal Chemistry, Wt. %	
Hardness: 500 - 600 BHN (on 2 layer deposit)	IS: 7303 - 91	C - 0.60 max	Cr - 6 max
	E Fe - 1C	Mn - 0.70 max	Mo - 0.6 max
		Si - 0.70 max	V - 0.4 max

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EKNOWELD 60 R

Characteristics and Applications : A medium coated air-hardening type of electrode for hardfacing on mild-steel, carbon and alloy steel with hardness of 600 BHN approx.

Suitable for machine parts subjected to abrasive wear.

For surfacing/rebuilding of crusher hammers, cane cutting knives, conveyor buckets, drilling bits, shears and croppers, oil expellers, mine rails, caterpillar treads, mixer blades, dipper teeth, etc.

Instructions: Keep electrode dry. Use short arc and low welding speed. Employ short stringer beads. A buffer layer of EKNOWELD - 7018 on carbon steels and EKNOWELD - 18/8/6(S) on stainless steel, is necessary for austenitic manganese steel.

Deposit can only be ground finished. Deposit not more than two layers.

Mechanical Properties of all Weld Metal	Classifications	Weld Metal Chemistry, Wt. %	
Hardness: 500 - 600 BHN (on 2 layer deposit)	IS : 7303 - 91	C - 0.60 max	Cr - 5 max
	E Fe - IC	Si - 0.70 max	Mo - 0.5 max
		Mn - 0.80 max	

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EKNO WELD

Stainless Steel Electrodes

EKNOWELD 309-16

Characteristics and Applications: An all positional radiographic quality electrode giving 25/12 deposit that has high oxidation & corrosion resistance and can withstand elevated temperatures upto 1100°C in continuous service. Low spatter & smooth weld beads with easy slag detachability. For welding AISI309 type straight chrome steels. Joining stainless steel to lower alloy and carbon steels. Building up and overlaying mild steel to increase wear resistance and worn out parts of wear resisting steels. Welding

Instructions: Keep electrode dry. Ensure good fit-up on joints and hold short arc while welding. Adopt proper sequence. Do not use excessive current. Use stainless steel wire brush for cleaning.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile strength	N /mm^2	560 - 680	AWS A 5.4/	C - ≤ 0.08
Elongation %	(L = 4d)	30 - 45	ASME SFA 5.4 : E 309 -16	Cr - 22 - 25
Impact value	CVN at 27°C	50 - 100J	IS 5206 : E 23.12 R 26	Ni - 12 -14
				Mn - 0.5 - 2.5
			Approval: RDSO (Cl. M4)	Si - 0.9 max
				Mo - 0.5 max

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* Low carbon version "**EKNOWELD 309L - 16**" also available

EKNOWELD 309 Mo -16

Characteristics and Applications: An all positional electrode giving 25/12/2.5 Mo weld deposit that has excellent resistance to chemical corrosion and heating. The addition of molybdenum increases tensile strength and corrosion resistance. Quiet stable arc and low spatter ensures smooth weld beads and easily detachable slag. For welding dissimilar metals like molybdenum containing austenitic stainless steels and carbon steels, 309 Mo steels and 316 class steels. Also suitable for welding difficult to weld steels and building up of carbon steels to increase wear resistance. For welding structural parts subjected to wear like rollers, rails and hot-working tools.

Welding Instructions: Keep electrode dry. Ensure good fit-up on joints and hold short arc while welding. Adopt proper sequence. Do not use excessive current. Use stainless steel wire brush for cleaning.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile strength	N /mm^2	560 - 650	AWS A 5.4/	C - ≤ 0.12
Elongation %	(L = 4d)	30 - 45	ASME SFA 5.4 = E 309 Mo -16	Cr - 22 - 25
			IS : E 23.12.2 R26	Ni - 12 -14
				Mo - 2 - 3
				Mn - 0.5-2.5
				Si - 0.90 max

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* Low carbon version "**EKNOWELD 309 MoL-16**" also available

EKNOWELD 309 Cb -16

Characteristics and Applications: A medium heavy-coated, all-positional rutile electrode giving 25/12/1 Columbium (niobium) stabilized deposit. Colum1bium provides resistance to intergranular corrosion and also withstands elevated temperature of 1100°C in continuous service, Has excellent resistance to chemical corrosion. For welding stabilized and unstabilized steels to mild steel, AISI 309 and 309 Cb type, straight-chrome steels, joining stainless steel to lower alloys and carbon steels. Building up of mild steel to improve wear resistance.

Welding Instructions: Similar to EKNOWELD 309 -16

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile strength	N /mm^2	550 - 650	AWS A 5.4/	C - ≤0.12
Elongation %	(L = 4d)	30 - 40	ASME SFA 5.4 = E 309 Cb -16	Mn - 0.5-2.5
Impact value	CVN at 27°C	60 - 90J	IS : E 23.12 Nb R 26	Cr - 22-25
				Si - 0.9 max
				Ni - 12-14
				Mo - 0.5 max
				Nb - 0.7 - 1.0

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EKNO WELD

Stainless Steel Electrodes

EKNOWELD 18/8/6

Characteristics and Applications : Highly - alloyed, basic type, austenitic stainless steel electrode with a stainless steel core wire giving 18/8/6 Mn steel weld Deposit. Bead is smooth and shining with minimal spatter. The weld metal has excellent heat resisting properties upto 950°C and is resistant to corrosion. Ideal for tough wear-resistant hardfacings like on rail curves or parts of hydraulic engines subjected to cavitation and erosion. Excellent for first layer on difficult-to weld steels and high alloy steels. Very good for repairing cracks in austenitic manganese steels. For joining manganese steel to mild steel, stainless steel, etc.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile strength	N/mm^2	560 min.	AWS A 5.4/	C - ≤ 0.20
Elongation %	(L = 5d)	26 min.	ASME SFA 5.4 : E 307 -16 (Nr.)	Mn - 5-8
Impact value	CVN at 27°C	60-90 J	IS: E 18.8 Mn R 26	Cr - 17 - 20
				Ni - 7 -10
				Si - 0.9 max
				Mo - 0.5 max

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EKNOWELD 308 - 16

Characteristics and Applications : An all positional radiographic quality 19/10 stainless steel electrode with controlled ferrite content for maximum resistance to corrosion and cracking. Weld metal has excellent creep strength and resistant to inter-crystalline corrosion. Arc is stable and weld deposits are smooth, uniform and of excellent appearance. Slag is easily detachable. Applications: Suitable for welding ferritic steels of 13 to 17% chromium. Resistant to scaling upto 800°C for welding of AISI types: 301,302,304 and 308 for building up surfaces of pump impellers, shafts and other components used in chemical plants.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile strength	N/mm^2	550 - 650	AWS A 5.4/	C - ≤ 0.08
Elongation %	(L = 5d)	35 - 40	ASME SFA 5.4 : E 308 -16	Mn - 2.5 max
Impact value	CVN at 27°C	75 - 90J	IS 5206: E19.9.R26	Cr - 18 - 21
				Ni - 8 -11
				Si - 0.90 max
				Mo - 0.5 max

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EKNOWELD 308L - 16

Characteristics and Applications : An all positional extra low carbon electrode with controlled ferrite for maximum resistance to intergranular corrosion and cracking. Weld can withstand elevated temperature upto 850°C and highly creep-resistant. Can be used on low-temperature steels as low as - 150°C. Carbon content as low as 0.03% eliminates possibility of inter crystalline corrosion in the temperature range of 500 to 850°C. Weld beads are smooth, uniform and of excellent appearance. For welding of 18/8 stainless steels represented by AISI types 301, 302, 304L & 308L which have low carbon content and BS grades En 50, En 58A, En 58E. Used widely in dairy, chemical and food industries.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %
Tensile strength	N/mm^2	550 - 650	AWS A 5.4/	C - ≤ 0.04
Elongation %	(L = 5d)	35 - 44	ASME SFA 5.4 : E 308L-16	Mn - 0.5-2.5
Impact value	CVN at 27°C	75 - 90J	IS 5206 : E 19.9L R26	Si - 0.90 max
	CVN at - 100°C	30 - 50J		Cr - 18 - 21
				Ni - 9-11
				Mo - 0.5 max

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Hardfacing Electrodes

EKNOWELD 30 Cr

Characteristics and Applications : A very heavy coated electrode for hardfacing applications on mild steel, carbon steel and low-alloy steels where resistance ot severe abrasion is called for. Weld metal contains 35% Cr and 3.5% Carbon approx. Retains hardness even at relatively high temperatures and resistant to oxidation upto 1000°C. For grinding rings, plough shares, cultivator, shovels, coke, chutes, mining and earth moving equipment, sand blasting equipment, conveyor screws, edge-runner scrapers, etc.

Mechanical Properties of all Weld Metal	Weld Metal Chemistry, Wt. %
Hardness: 575 - 600 BHN (on 2 layer deposit)	C - 3.5 - 4
	Cr - 35 max
	Mn - 1.1 max
	Si - 0.7 max

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EKNOWELD 7

Characteristics and Applications: A medium basic coated graphitic electrode for hardfacing and build-up of worn out machine parts and components. Soft and stable arc, smooth and uniform bead profile with easy slag detachability. Weld metal is extrremely resistant to abrasion and metal to metal wear. Built-up surface does not deteriorate through furrowing, local plastic flow and micro-cracking. For concrete mixer blades, scraper blades, screw conveyors, cement die rings, oil expeller worms, muller tires, clinker mill liner plates, plough shares, dippers, excavator teeth, earth moving equipment, etc.

Instructions : Keep electrode dry. Use short arc and low welding speed. Employ short stringer beads. Usually hardfacing is done across the wear direction. Deposit not more than two layers. Deposit can only be ground finished.

Mechanical Properties of all Weld Metal	Weld Metal Chemistry, Wt. %
Hardness: 500-600 BHN	C - 2-3.5
	Si - 2.75 max
	Mn - 1 max
	Cr - 6 max

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EKNOWELD Mn

Characteristics and Applications: A medium heavy basic coated, austenitic manganese (12□Mn) steel electrode giving a smooth and shining bead with easy slag detachability. Weld metal highly resistant to wear by impact. Ideal for abrasive wear of gouging type. Hardfacing of crusher jaws and hammers, dredger bucket teeth, manganese steel rails, rail cross overs, rail frogs and switches, austenitic manganese steel castings, cement grinder rings, crusher mantles, etc.

Instructions: Clean the surface to be built up from oil, greese, dust. Remove by grinding any work hardened zone of cracked or spalled material. Use short arc and minimum current level. Avoid excessive weaving and very thick bead. Minimum heating of base metal. Peen the weld while hot. When using this electrode on plain carbon steel of low-alloy steel, give a buffer layer with stainless steel electrode such as EKNOWELD 18/8/6(5)

Mechanical Properties of all Weld Metal		Weld Metal Chemistry, Wt. %
Hardness: As deposited	200 BH	C - 0.65-1.0
After work Hardening	500 BHN	Mn - 12 -14
		Si - 0.5-0.8

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EKNOWELD 410 S

High deposition electrode, conforming to AWS E 410-26 for joining similar alloys and surfacing on steels for corrosion, erosion and abrasion resisatance. For 410 stainless steels of slightly lower or higher chromium content. For steam valves, automobile body moulding, oil burner parts, turbine components, etc.

Mechanical Properties of all Weld Metal			Weld Metal Chemistry, Wt. %
Tensile Strength	N/mm^2	500-550 C -0.08 max	C - 0.08 max
Elongation □	(L = 4d)	20-25 Mn-0.70 max	Mn - 0.70 max
Weld Metal	Hardness	> 310 BHN Si -0.55 max	Si - 0.55 max
			Cr - 12.50 max

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Cast Iron Welding Technique

Grey cast iron, due to its brittle nature, confronted welders with many problems and it is only since the development of special techniques for cold welding cast iron that these problems have been eliminated. The principal advance which made the cold welding of cast iron possible was the development of special electrode coatings (low hydrogen in character but ensuring lowest possible working temperature). This has resulted in better bonding of the weld m etal to grey cast iron, spheroidal castings, malleable iron, cast steels, etc. Often because the size of the component or when dismantling and re-assembling is too expensive, that "cold welding" of cast iron is in many cases the most economical answer.

Machinability

At 1316°C nickel can hold up to 0.65% carbon in solution. When the weld freezes, carbon, which does not form a stable compound with nickel, is rejected as graphite. This causes an increase in volume, reducing shrinkage stresses, and because graphite is soft it increases the machinability at the fusion zone.

Other factors necessary to obtain a machinable transition zone, are above all, an equal heat conduction, the observation of important minimum temperatures and of course, slow cooling.

"Cold Welding" does not imply that the workpiece has to be kept cold; if it gradually warms up during welding, all the better, provided that the heat does not build up more in one section than in another. When welding on thick-walled work pieces it is not always possible to prevent a martensitic zone. On these work pieces, it is therefore important that multi-layers of weld are deposited to re-heat the transition area and destroy the martensitic zone.

High Mechanical Properties.

When correctly used, EKNOWELD electrodes give welded joints of higher strength than the parental metal. The special electrode coating ensures a spray type metal transfer, minimizing dilution (mixing of the filler with the base metal), resulting in high joint tensile strength.

PREPARATION FOR COLD WELDING CAST IRON

There are three accepted methods of weld preparation on cast iron:

1. Gouging

The fastest and most economical method is to use the EKNOWELD gouging electrode EKNO GOUGE. We would recommend gouging only on a thick walled parent metal, burnt or chemically affected cast irons. After gouging, it is still advisable to grind the surfaces to be welded in order to remove the hard (Martensitic) zone which has been created during the gouging process.

2. Grinding

Preparation by grinding is very efficient particularly on larger work pieces. However, if a pressure tight weld is required, the ground surface should afterwards be filled in order to remove the residues of the grinding wheel.

3. Chiselling

Chiselling is advisable on smaller machine parts and especially where pressure tight welds are required. Chiselling must always be used when the first buttering layer on oily or burnt iron shows porosity. On poorer quality cast iron a repeated chiselling-off of the first bead is often necessary to obtain a perfect joint.

Whatever the method of preparation, it is important that all sharp edges are removed, in other words, preparation should take the form of a single "U" and not "V" on thin-walled parts (diag. 1) and on thick-walled parts as a double "U" and not an "X" (diag.

2) Due to the high strength of the weld deposit, it is only essential to prepare grey-cast iron work pieces to two-thirds of the wall thickness. High strength alloyed and nodular cast irons should be Veed-out completely, so that full penetration of the root face can take place.

Experience has proven that it is better to use a pure nickel electrode for the first layer, i.e. EKNOWELD Ni. On oily castings EKNOWELD FN enable a better bonding to the parent metal.

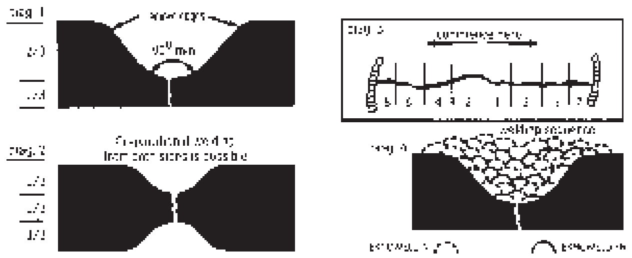
The following basic rules have to be observed:

1. On thin-and medium-walled components, prepare crack by chiselling a single "U" as wide as possible, i.e. remove all sharp edges. The depth should not be greater than two thirds of the wall thickness.
2. Locate ends of the crack and block them by bridging beads. Should the bead crack, this indicates a high stress area and the end of the new crack should be located and a further bridging bead be applied.
3. For pressure-tight welding use EKNOWELD Ni 2.5 mm with amperage of 60 amps. On very oily parts use EKNOWELD FN 2.5mm.
4. Butter sides of the "U" preparation as thinly as possible and peen the first layer thoroughly. On thin-walled parts, weld short beads, a maximum often times the core wire diameter. Peen the bead thoroughly while still hot.
5. It is especially important on pressure-tight welding, that the first joining layer is perfect and free from porosity; porosity points to an inferior quality of the parent metal and above all, to the presence of oil. Should porosity be present, we would recommend the first layer to be removed by chiselling. Regardless of the presence or otherwise of porosity, it is always advisable to test the first layer with a chisel to ensure good bonding.
6. When pressure-tight welding, it is essential that the slag is completely removed before subsequent layers are deposited.

Welding Procedures

Hold electrode veritcally - arc length 3-4mm. It is necessary to start the electrode at the edge of the hole and to weld round once so that the weld deposit follows the contour of the cavity and the slag settles in the centre of the conical cavity. After solidification it is easy to remove the slag and the next layer can be welded immediately. If a covering layer is welded over the edge of the filled hole, strike the arc again after solidification and slag removal in the centre of the deposited metal. This will help to soften the newly created transition area. Avoid weaving as this would unnecessarily heat the base metal. Generally, we can say that it is advisable, also when joining, to break the arc by taking the electrode backwards over the weld deposit and not over the parent metal.

Important: Specific tests and experience have shown that multi-layer welding contributes considerably to a softening of hard transition areas even on thick-walled material.



CHEMICAL ANALYSIS OF SOME COMMON AISI Stainless Steels

AISI Type Number	C % (Max)	Mn % (Max)	Si % (Max)	Cr %	Ni %	Other Elements %	Recommended EKNOWELD Electrodes
201	0.15	5.5/7.5	1.0	16.00/18.00	3.50/5.50	N2-0.25 Max	EKNOWELD 308-16
202	0.15	7.5/10.0	1.0	17.00/19.00	4.00/6.00	N2-0.25 Max	EKNOWELD 308-16
301	0.15	2.00	1.00	16.00/18.00	6.00/8.00	-	EKNOWELD 308-16
302	0.15	2.00	1.00	17.00/19.00	8.00/10.00	-	EKNOWELD 308-16
302 B	0.15	2.00	2.00/3.00	17.00/19.00	8.00/10.00	-	EKNOWELD 308-16
303	0.15	2.00	1.00	17.00/19.00	8.00/10.00	SO.ISMin	EKNOWELD 308-16
303 SE	0.15	2.00	1.00	17.00/19.00	8.00/10.00	Se 0.15 Min	EKNOWELD 308-16
304	0.08	2.00	1.00	18.00/20.00	8.00/12.00	-	EKNOWELD 308-16
304 L	0.03	2.00	1.00	18.00/20.00	8.00/12.00	-	EKNOWELD 308L-16
305	0.12	2.00	1.00	17.00/19.00	10./13.00	-	EKNOWELD 308-16
308	0.08	2.00	1.00	19.00/21.00	10.00/12.00	-	EKNOWELD 308-16
309	0.20	2.00	1.00	22.00/24.00	12.00/15.00	-	EKNOWELD 309-16
309 S	0.08	2.00	1.00	22.00/24.00	12.00/15.00	-	EKNOWELD 309-16
310	0.25	2.00	1.50	24.00/26.00	19.00/22.00	-	EKNOWELD 310-16
310 S	0.08	2.00	1.50	24.00/26.00	19.00/22.00	-	EKNOWELD 310-16
316	0.08	2.00	1.00	16.00/18.00	10.00/14.00	Mo 2.00/3.00	EKNOWELD 316-16
316 L	0.03	2.00	1.00	16.00/18.00	10.00/14.00	Mo 2.00/3.00	EKNOWELD 316L-16
321	0.08	2.00	1.00	17.00/19.00	9./12.00	Ti 5x C Min	EKNOWELD 347-16
347	0.08	2.00	1.00	17.00/19.00	9./12.00	Nb + Ta 10 x CMin	EKNOWELD 347-16
348	0.08	2.00	1.00	17.00/19.00	9./12.00	Nb + Ta 10 x CMin Ta 0.10 Max	EKNOWELD 347-16
403	0.15	1.00	0.50	11.5/13.0	-	-	EKNOWELD 410-16
405	0.08	1.00	1.00	11.5/13.0	-	AI 0.10/0.30	EKNOWELD 410-16
410	0.15	1.00	1.00	11.5/13.0	-	-	EKNOWELD 410-16
414	0.15	1.00	1.00	11.5/13.0	1.25/2.5		EKNOWELD 410-16
420	0.15	1.00	1.00	12.0/14.0	-	-	EKNOWELD 410-16
430	0.12	1.00	1.00	14.0/18.0	-	-	EKNOWELD 430-16
431	0.20	1.00	1.00	15.0/17.0	1.25/2.5	-	EKNOWELD 430-16
440	0.60/1.20	1.00	1.00	16.0/18.0	-	Mo 0.75 Max	EKNOWELD 430-16
501	0.10	1.00	1.00	4.0/6.0	-	Mo 0.40/0.65	EKNOWELD 502
502	0.10	1.00	1.00	4.0/6.0	-	Mo 0.40/0.65	EKNOWELD 502

NIOBIUM (COLUMBIUM) (Nb)

1. A strong carbide former. Used to stabilize austenitic stainless steels against the harmful precipitation of chromium carbides in the range 900-1500°F.
2. A strong ferrite former.
3. Added to some high strength alloys for hardening and strengthening effects.
4. Added to some martensitic straight chromium stainless steels to tie up the carbon and hence reduce the hardening tendency of the steels.

COBALT (Co)

1. Added to various alloys to impart strength and creep resistance at high temperatures.

CHROMIUM (Cr)

1. A ferrite and carbide former.
2. Primary contributor to scaling and corrosion resistance.
3. In the stainless steels, this element used with little or no effect on high temperature strength and creep strength.

COPPER (Cu)

1. Use to improve corrosion resistance of stainless steel in many liquids which are reducing rather than oxidizing.

MOLYBDENUM (Mo)

1. A ferrite and carbide former.
2. Used to improve high temperature strength and creep resistance.
3. Used to improve general corrosion resistance of steels in non-oxidizing media, and the resistance to pitting corrosion in all media.

MANGANESE (Mn)

1. Austenite former

NITROGEN (N)

1. A strong austenite former.
2. Used to minimize grain growth in high chromium straight chromium steels at high temperatures.

NICKEL (Ni)

1. An austenite former.
2. Used to improve the general corrosion resistance against non-oxidizing liquids
3. Sometimes added in small amounts to straight chromium grades to improve the mechanical properties.

PHOSPHOROUS (P) One of these two elements occasionally added to stainless steels in conjunction

SULPHUR (S) with a small amount of Molybdenum or zirconium to improve machinability of the steel.

SILICON (Si)

1. A ferrite former.
2. Used to increase the corrosion resistance of austenitic steels.
3. Used to improve high temperature scaling resistance.
4. Used to improve resistance of high temperature steels to carburization.

TITANIUM (Ti)

1. A strong carbide former. Used to stabilize austenitic stainless steels against the harmful precipitation of chromium carbides in the range 900 - 1500°F.
2. A strong ferrite former.
3. Added to some high strength heat resisting alloys for its hardening and strengthening effects.
4. Added with aluminium to some high strength heat resisting alloys for age hardening effects.

Cast Iron Electrodes

EKNOWELD FN

Characteristics and Applications : An all positional electrode depositing weld metal consisting of nickel-iron alloy. Deposits yield greater bond strength and ductility. Welds are highly crack-resistant and free from porosity. Machinability is excellent. Specially recommended for heavy work pieces and at places where stresses occur. Ideally suited for joining and repair welding of ferritic and pearlitic high-strength spheroidal-graphitic cast irons and for welding these types to other ferrous and non-ferrous materials (cast steel, alloy cast iron and dirty or oily cast iron)

Instructions : Casting skin of parent material must be removed over sufficient width. Hold vertically, short arc and minimum current. Direct arc to the weld pool, Employ short stringer beads. Peen weld while hot. Reignite on the weld metal only.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm^2	400 - 500	AWS A 5.15/	C - ≤ 20	Fe - Remainder
Yield Strength	N/mm^2	300 - 430	ASME SFA 5.15 : E Ni Fe - CI	Si - 4 max	Mn - 1.0 max
Hardness	BHN	165 - 215	IS 5511: E Ni-FeG16	Ni - 60 approx	Cu - 2.5 max
Elongation %	(L=4d)	6 -18			

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EKNOWELD M

Characteristics and Applications : A graphite based coating, monel cored electrode, with low melting point for welding cast iron without pre-heating. Arc is very smooth and deposits are non-porous having very good bond strength and is suitable for machining. Gives an extremely shallow and yet sufficient depth of fusion which ensures minimum dilution of the weld metal by the base metal. Recommended for welding fractures in heavy castings, fabricating cast-iron machine components, correcting machining errors, rebuilding wornout surfaces, joining cast iron to steel, etc.

Instructions : Clean and surface to be welded, use back-step technique depositing stringer beads not longer than 60-80mm. Hold vertically directing the arc on the weld puddle. Short arc and minimum current. Peen each bead while hot. Weld intermittently.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm^2	280 - 400	AWS A 5.15/	C - 0.35 - 0.55	Ni - 60 - 70
			ASME SFA 5.15 : E NiCu-B	Fe - 3 - 6v	Cu - 25 - 35

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EKNOWELD Ni

Characteristics and Applications: An all positional electrode depositing almost pure nickel weld metal ideally suited for repairing and joining grey cast iron. Held bead is smooth, free from cracks or porosity. Excellent machinability. Suited for cold welding. Nickel deposit does not pick up carbon from the base metal and hence remains ductile and the same time retain adequate strength.

Because of easy and intimate fusion with all grades of cast iron, the electrode is best suited for engine components as a non-corrosive surfacing on cast iron parts exposed, broken castings, gear wheels and sprockets. Joining cast iron to steel.

Instructions : Casting skin of parent material must be removed over sufficient width. Hold vertically, short arc and minimum current. Direct arc to the weld pool. Employ short stringer beads. Peen weld while hot. Reignite on the weld metal only.

Mechanical Properties of all Weld Metal			Classifications	Weld Metal Chemistry, Wt. %	
Tensile Strength	N/mm^2	280 - 440	AWS A 5.15/	C - ≤ 2	Si - 1.0 max
			ASME SFA 5.15 : E Ni - CI	Fe - ≤ 2	Mn - 1 max
				Ni - 95 min.	

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EKNOWELD NM

Characteristics and Applications : A high strength nickel-free electrode for non critical work. For all types of cast iron where machinability is not essential. For welding bases, gears, cams, cracked motor or generator housings. Deposit even on old or dry cast iron. Suitable for joining cast iron to carbon and low alloy steels also.

Mechanical Properties of all Weld Metal			Classifications
Hardness	BHN	250 - 400	AWS A 5.15
			ASME SFA 5.15 : E St
			IS 5511: Fe B26

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EKNOCAST FN

Characteristics and Applications : deposits nickel iron alloy, ideal for welding all types of weldable cast irons. Low energy combined with smooth stable arc and negligible spatter ensures deposition of crack and porous free welds which are easily machinable. Weldments have greater bond strength, ductility and crack resistance. Recommended for welding heavy work pieces, maintenance and repair welding of ferritic amd pearlitic, high strength spheroidal graphitic type cast irons etc. Also used for joining cast iron to mild steel.

Weld Metal Chemistry, Wt. %	
C - 2 max	Ni - 40 max
Si - 4 max	Fe - Balance
Mn - 2 max	

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The increasing demand by industry and especially the chemical industry for steels with high mechanical properties and physical constants under high heat, acid and corrosive conditions, brought about the development of stainless steels.

Stainless steels are iron base alloys that contain at least 11% chromium, uniformly dispersed throughout the metal.

The outstanding characteristic of stainless steels is their ability to readily form a chromium-oxide film which acts as a constant buffer against further corrosion of the underlying metal. This oxide film is transparently thin; nevertheless it is quite stable and adherent. If broken or destroyed it reforms instantly and continues its protective action. Increasing amounts of chromium in the steel provide increasing corrosion resistance since the protective surface film is thus proportionately enriched.

Under conditions of high temperature exposure (between 650 - 700°C), surface films become thicker, forming a tight impervious seal with desirable heat resisting properties.

Chromium also introduces notable physical effects. Steels containing excess amounts of chromium develop brittleness as a result of grain growth after exposure to high temperatures. For this reason, straight chromium steels impose limitations in welding. All stainless steels of the straight chromium types are magnetic under all conditions.

Nickel additions in stainless steel are always supplementary to chromium. However, such additions profoundly affect the resulting steels. Corrosion resistance is substantially improved since the protective film containing both chromium and nickel is far more corrosion resistant than in the case of the straight chromium steels whose surface films contain chromium only.

Fundamental to most types of corrosion to which stainless steels are subject is the fact that halogen salts, primarily chlorides, easily penetrate the passive film and allow corrosive attack to proceed. Additions of 2-4% Molybdenum increase the resistance to non-oxidizing acids, particularly to sulphuric acids of low concentration.

Nickel additions also impart several other important physical properties to stainless steel.

Provided the alloy contains sufficient amount of nickel, the stainless steel becomes non-magnetic, non-hardening by heat treatment and unusually tough and ductile. It retains its high degree of ductility in high temperature applications and possesses excellent welding characteristics. These valuable properties, combined with outstanding corrosion resistance render chromium nickel stainless grades useful for a wide variety of applications.

There are several other elements which are always present in smaller quantities (trace elements) or intentionally added for specific purposes. These include chiefly Manganese, Silicon, Copper and Aluminium.

Added in sufficient quantities, each introduces modifications to the major characteristics of stainless steels.

One element not mentioned yet is carbon. As a constituent, carbon is very important, While carbon increases the strength of the stainless steel and imparts hardenability by heat- treatment in the straight chromium types, it decreases the ductility, corrosion resistance and toughness, especially at low temperatures.

Because carbon has a higher affinity for chromium than it has for iron, the two combine readily and its presence is quite noticeable in welding where necessarily high heat is employed. As the steel cools down, it goes through a sensitization range which occurs between 480 - 815°C. Sensitization is caused by the precipitation of normally dissolved carbon at the metal grain boundaries in the form of chromium-rich carbides.

Such carbides in turn cause a depletion of chromium adjacent to the boundaries. Because chrome carbides are unstable alloys, they produce an undesirable brittle structure, low in strength and relatively easily destroyed by heat or corrosive attack. In effect, an excessive local depletion of the chromium content may lead to intercrystalline corrosion and eventually to physical disintegration.

For many applications, the effect of carbon is so pronounced that special protective steps are required to secure satisfactory welds.

As a rule, there are three courses to follow:

1. To apply material with a very low carbon content, not in excess of 0.04
2. To heat the fabricated assembly to 1036°C where the carbon dissolves and then quench it rapidly in water. There would not be any time for new chromium carbides to form. In most cases this procedure is impractical because of type, shape or design of the product.
3. To apply grades immune to sensitization

STABILIZED STAINLESS STEELS

Elements such as Niobium, Tantalum and Titanium bear a high affinity to carbon. These metals form harmless carbides of their own before the chromium may unite with the carbon.

In addition, these carbides are uniformly dispersed throughout the steel, They prevent the formation of harmful grain boundary carbides. Since they render the material stable in relation to carbides, regardless of thermal treatments these elements are termed " stabilizers" and stainless steels so treated are termed "stabilized" steels. Since stabilizing elements do not materially affect working, fabricating and physical properties, they solve one of the most serious problems in the application of stainless steels. As a result, stabilized grades have established themselves as indispensable in a multitude of applications. Although all of these stabilizing elements may be added to the base metal, Titanium cannot be transferred across the arc but can be contained in the coating. Niobium-Tantalum stabilized electrodes ensure perfect results where cracking and intergranular corrosion must be avoided.

For welding high heat resistant steels, 25% chromium, 20% nickel arc-welding electrodes have been developed. Their deposit resists constant temperatures of 1200°C.

These electrodes deposit an alloy which remains austenitic even if welded to non-alloyed steels, in spite of dilution with the base metal.

The austenitic (non - magnetic) stainless steels are characterized by these additional physical properties affecting welding procedures.

1. Co-efficients of expansion are 50% higher than those of mild steel, thus allowance should therefore be made for greater thermal expansion by slightly increasing the gap between plates when welding, liberal use of tack-welds to prevent warping and use of jigs and clamps wherever possible.
2. Thermal conductivity is half that of mild steel and this factor (because of the slower heat dissipation) contributes additionally to distortion through build-up of residual stresses.

Finally austenitic steels are non-air hardening and are not responsive to heat treatment.

The" straight chromium" types of stainless steel are divided into two sections, martensitic (heat treatable), and ferritic, whereby the decisive factor is the proportion of chromium to carbon. Because of their alloy balance, both steels have a tendency to become hard and brittle after welding.

Unless precautions are taken, these steels may crack.

Pre - heating to 200 - 300°C and the avoidance of unnecessary heat build-up during welding is advisable. A post treatment of 700 - 820°C is in many cases unavoidable.

The coefficient of expansion of both martensitic and ferritic stainless steels are less than those of mild steel. The incidence of warping in the weldment is thus correspondingly small.

The thermal conductivity, depending on the percentage of chromium in the alloy varies from half to one - third that of mild steel.

In many instances, the 'straight chromium types" are welded with austenitic electrodes because of the non-hardening aspects of their weld deposit. Some times the joining is done with an austenitic electrode and the top layer welded with a straight chromium type

WELDING CLAD STEELS

The term" clad steel" denotes the optimum combination of two basically different materials: the corrosion resisting cladding, and the material underneath which gives strength to the combination.

Accordingly, established joint welding practice involves two types of filler metal: first, a mild or low alloy steel electrode matching the base material and then a high alloy type of electrode analogous to the cladding material. Success of the welding operation hinges on proper joint preparation.

The first part of the welding operation is carried out in the backing material following relevant rules for heat control procedure and filler metal. You are free to choose the welding process, but it has become general practice to execute the root and the following pass with manual arc welding electrodes, preferably of the lime coated type. Filler passes can be executed with iron powder electrodes. Any root defect has to be gouged out in order to provide a perfectly sound base for the cladding metal. Incipient fusion of the high alloy material must definitely be prevented, since this would cause inter-alloying with its attendant formation of martensite hard enough to cause cracking.

The second part of the welding operation concerns the clad side and is governed by the rules applying to the corrosion resisting material. Arc welding with coated electrodes offers itself as the most appropriate process. In the case of rather infrequent straight chromium steel cladding it may be necessary to preheat the work to a temperature between 150°C and 300°C.

Particular attention must be given to the correct preparation of the clad side, where grooves should not normally cut deeper into the backing than 1 mm; otherwise the latter would be weakened. On the other hand, at least 2 layers of metal must be deposited (one upon the other) in the groove so that there will definitely be no loss of corrosion resistance caused by admixture from the ferrite side, i.e. dilution of the stainless composition. Small diameter electrodes (2.5 or 3.15 mm) low amperage, and string beads are the elements of the best procedure to retain the full chemistry and corrosion resistance of the weld metal, particularly of the first pass.

Usually one employs filler metals analogous to the cladding, but there is no point against choosing a higher alloy grade to counteract dilution of the first pass. This intermediate layer then serves as a base for the deposition of filler metal analogous in composition to the cladding. When welding with two types of electrode, care must be taken to avoid mix-up.

With straight chromium steels, too, it is recommended to use austenitic Cr-Ni type electrodes; the weld deposits so produce exhibit superior impact properties but should be examined for adequate corrosion resistance, although as a rule austenitic material resists severe corrosion far better than straight Cr steel, except in sulphurous media.

Specific Effects of Alloying Elements and Impurities in Stainless Steels and High Strength Heat Resisting Alloys

CARBON (C)

1. A strong austenite former.
2. Added to some high strength alloys for hardening and strengthening effects.