GUIDE ON SELECTION OF WELDING ELECTRODES

STEEL AUTHORITY OF INDIA LTD.

CET, IPSS SECRETARIAT

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MESSAGE

I am happy to note that a **"Guide on Selection of Welding Electrodes"** is being published by IPSS Secretariat.

Undoubtedly, there is a progressively increasing role of welding and joining metal parts not only for fabrication, but also for repair, rebuilding and various others applications. Considerable economy in welding can be achieved by understanding and applying the correct welding technology. In this context, **selection** of welding electrodes of appropriate quality and brand plays a very important role.

I am glad to note that this Guide is entirely based on the experiences with the usage of welding electrodes at various steel plants and I am sure that this will be helpful in their proper selection and thus improving welding efficiency, reliability and inventory control.

I thank all those who have contributed in preparation of this Guide.

RKchopra

(R K Chopra)
Executive Director (Oprns)

FOREWORD

Construction and maintenance activities in steel plants have one major component, viz. Welding. Welding electrodes qualify as the main welding consumable in the process of welding. Various National Standards cover most of the grades of such electrodes, barring a few categorized as special electrodes for maintenance. There are several manufacturers of welding electrodes supplying under different brand names.

The proliferation of variety has left the user confused as to which brand are applicable for what application, with each manufacturers claiming superiority over the other. This has necessitated the publication of this Guide in order to fulfill the objectives of standardizing the welding electrodes by pooling in the knowledge and experience of users in the various steel plants.

The Publication is entirely based on experience with welding consumables at different steel plants and suggest equivalent brands based on the application. Corelation has been drawn on the basis of actual tests and trials, painfully conducted over the years. The National Standards have been referred for guidance.

It is, however, to be clearly understood while using the guide that the equivalents are based on

collective experience of the steel plants and do not purport to be standards equivalent chart. It may be noted that the contents are for internal circulation within steel plants and it is entirely upto the user agency to accept the text in whole or in part.

The Standards Committee on Paints and Portable Maintenance Equipment, IPSS 1:7, under whose aegis the Guide has been prepared, wishes to acknowledge its deep indebtedness to the five members expert committee consisting of Mr H Singh, AGM (Engg Shops), BSL; Mr A Dutta Roy, ADM, & Mr M K Sarkar, ADM of TATA STEEL; Mr S N Singh, SM (Foundries), BSP; Mr R N Bhattacharya, SM (MTB), DSP without whose help and support this guide would not have materialized.

IPSS 1:7 Committee, and the undersigned in particular, are thankful to the experts for sparing their valuable time in poring over volumes of data, sifting, analyzing and collating the information so as to present them in an organized and user-friendly manner.

SUGGESTIONS ARE WELCOME FOR IMPROVING THIS WORK.

(S. KRISHNAMURTHY)
CHAIRMAN, IPSS 1:7

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1.0 MILD STEEL ELECTRODE

1.1 Electrodes for general purpose welding
(AWS E6013, IS 814/ER4211X)

Electrodes of this group are medium coated rutile type with coating factor below 1.3.

Application

These are suitable for all position welding of structurals not subjected to dynamic loading.

Mechanical Properties

U.T.S.	-	47 kgf/mm^2, min.
Y.S.	-	39 kgf/mm^2, min
% Elongation	-	17, min.

Recommended Brands

FERROSPEED PLUS	Esab India Ltd
OVERCORD	Advani Oerlikon
NORMA	D & H Secheron
ELECTRA-6	Fusion Engg
SHARP 40	Sharp Electrode

Sizes

Gauge	Size
4	6.3 mm x 450 mm
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 450 mm
12	2.5 mm x 350 mm

1.2 Electrodes for structural joints subjected to dynamic loading (AWS A 5.1 E6013, IS 814/ER 4212X)

Electrod[illegible] this group are medium heavy coated rutile[illegible] good penetration properties. Coating factor is [illegible]1.3 . It is possible to achieve radiograp[illegible]lity weld joints in all positions with these el[illegible]

Applicati[illegible]

The elect[illegible]re suitable for critical structural joints sub[illegible]to dynamic loading.

However[illegible] the presence of high amount of diffusible [illegible]n in the weld metal, the application of these [illegible]es should be restricted to 40 mm combined [illegible] of plates or in case of pressure pipings, [illegible] mm wall thickness and 10 kg/cm^2 working pr[illegible]

Mechanical [illegible]

U.T.S.	–	47 kgf/mm^2, min.
Y.S.	–	39 kgf/mm^2, min
% Elonga[illegible]	–	17, min.

Recommended [illegible]

VORDIAN [illegible]	Esab India Ltd
OVERCORD[illegible]	Advani Oerlikon
MEDIO [illegible]	D & H Secheron
ELECTRA-[illegible]	Fusion

Sizes

Gauge [illegible]	Size
04 x [illegible]	6.3 mm x 450 mm
6[illegible]	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 450 mm
12	[illegible].5 mm x 350 mm

2.0 HYDROGEN CONTROLLED ELECTRODES

2.1 Hydrogen controlled medium carbon steel electrodes (AWS E7016, IS 814 EB 5424 H_3X)

Electrodes of this group are hydrogen controlled all position steel electrodes without iron powder in the coating.

Welding Precautions :

Re-dry the electrodes at 200°C for atleast 2 hrs. before use. Clean the weldable area completely from all contaminants like oil, grease, rust, paint, etc. For welding heavier sections, preheat the parent metal to 100°C and above. Use short arc and do not whip. The width of weaving should be limited to 2/3 times the core wire dia. Use D.C. welding power source with reverse polarity.

Application

These are suitable for welding of medium carbon steels, cast steel, and for buffer layer before hardfacing.

Mechanical Properties

U.T.S.	-	51 kgf/mm^2, min.
Y.S.	-	43 kgf/mm^2, min
% Elongation	-	22, min.
Impact	-	27 Joules, min, at -29°C

Recommended Brands

INDOTHERME	D & H Secheron
UNIVERSE	Advani Oerlikon
ESAB 56	Esab India Ltd.

Sizes

Gauge	Size
4	6.3 mm x 450 mm
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15mm x 450 mm

2.2 Hydrogen controlled electrodes for critical structure under dynamic loading (AWS E7018, IS E614/E514-HJ)

Electrodes of this group are having coating factor 1.3 - 1.5 .

Welding precautions - Same as **2.1**

Application

Suitable for radiographic quality joints subjected to dynamic loading. Can be applied in all thickness and working pressure range.

Mechanical Properties

U.T.S.	-	51 kgf/mm^2, min.
Y.S	-	43 kgf/mm^2, min.
Impact	-	27 Joules, min, at $-29^{\circ}C$
% elongation	-	22 min

Recommended Brands

SUPRATHERME	D & H Secheron
SUPERCITO	Advani Oerlikon
ESAB 36 H	Esab India Ltd
BASICOTE 6	Fusion Engg
MAXIDURE	Weldcraft

Sizes

Gauge	Size
4	6.3 mm x 450 mm
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 350 mm
12	2.5 mm x 350 mm

2.3 Low hydrogen high deposition contact type electrodes (AWS E7028, IS 814 E 5446H_3 L_x)

Application

Suitable for butt welding in G1 position and fillet welding in F1 position-Deposition efficiency is over 130 %

Recommended Brands

ESAB C6	-	Esab India Ltd
SUPERCITO 180	-	Advani Oerlikon

Sizes

Gauge	Size
4	6.3 mm x 450 mm
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 350 mm
12	2.5 mm x 350 mm

2.4 Low heat input electrodes for maintenance welding of medium carbon steels

Electrodes of this group render ferritic deposit suitable for steels sensitive to cracking when welded with conventional electrodes. The weld deposit has good ductility and impact resistance at normal and sub-zero temperatures.

Welding Precautions :

Same as indicated in item 2.1 . **However,** the electrode can be used with both A.C and D.C. power sources.

Application

These are also suitable for steel having comparatively high sulphur/phosphorus contents like free cutting steels.

Mechanical Properties

	As per AWS 5.1	Typical Value+
U.T.S.	51 kgf/mm^2, min.	52 kgf/mm^2
Y.S.	43 kgf/mm^2, min.	45 kgf/mm^2
% Elongation	22, minimum	22 minimum

+**NOTE:** The electrodes are manufactured for maintenance applications and the manufacturers do not claim conformance to any established standard. As such, it is desirable that during initial approval and periodic testing, the electrodes comply with the typical properties indicated above.

Recommended Brands

XUPER 660 NH	Larsen & Toubro
E 104	Cosmic fontech
DIFFUSALLOY 800 ELH	Diffusion Engg
LOTHERME 352	D & H Secheron
KOLDWELD CST 12	Weldcraft

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm

3.0 LOW ALLOY STEEL ELECTRODES

3.1 Electrodes for 1.25% Cr-0.5% Mo creep resisting steel (AWS A5.5 E8015-B, IS 1395 E55BB-2L20)

These are Basic coated hydrogen controlled all position electrodes. The welding can be of radiographic quality with operating temperature of 490°C, max.

Application

Electrodes of this group are suitable for welding of low alloy creep resisting steel of similar composition.

Mechanical Properties

U.T.S.	-	56 kgf/mm^2, min.
Y.S.	-	47 kgf/mm^2, min.
% Elongation	-	19, min.

Weld Metal Chemistry

% C	-	NS	% Mo	-	0.45-0.65
% Mn	-	0.90, max.	% P	-	0.03, max.
% Si	-	1.0, max.	% S	-	0.04, max.
% Cr	-	1.0-1.5			

Recommended Brands

ESAB KV5	Esab India Ltd
CROMOTHERME # 1	D & H Secheron
CROMOCORD	Advani Oerlikon

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 450 mm
12	2.5 mm x 350 mm

3.2 Low alloy high tensile electrodes (AWS E10016G)

These are basic coated hydrogen controlled electrodes for all position welding, resistant to hot and cold cracking.

Application

Electrodes of this group are applicable for joining high tensile steels.

Mechanical Properties

U.T.S.	-	78 kgf/mm^2, min.
Y.S.	-	69 kgf/mm^2, min.
% Elongation	-	15, min.
Impact	-	27 Joules, at -51^{o}C.

Weld Metal Chemistry

% C	-	0.10	% Cr	-	0.40, min.
% Mn	-	1.3-1.8	% Mo	-	0.25-0.50
% Si	-	0.60, min.	% V	-	0.05, min.
% Ni	-	1.25-2.50	%S, %P	-	0.03, max.

Recommended Brands

TENACITO 80	Advani Oerlikon
ULTRATHERME-H	D & H Secheron

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 350 mm
12	2.50 mm x 350 mm

3.3 Low heat input high tensile electrodes for critical maintenance applications

The weld metal is of 29% Cr-9% Ni austenitic type (Type AISI 312) with approx. 15% ferrite in the matrix. This, together with grain refining agents, imparts extremely high resistance to hot cracking in the weld which makes the electrode suitable for almost all types of steels except corrosion resistance grades.

Precautions :

The electrode should not be used when carbon content in the parent metal exceeds 0.5% or when the component is subjected to elevated temperature wear in service. Remove all surface contaminants before welding.

Application

For high strength, wear and impact resistance in maintenance welding, these electrodes are used.

Mechanical Properties

	AWS A5.4 Type E312-16	Typical Values
U.T.S	65 kgf/mm^2, min.	75 kgf/mm^2
Y.S	55 kgf/mm^2, min.	60 kgf/mm^2
% Elongation	22 min.	24
Impact	27 Joules, at $-51^{\circ}C$	

Weld Metal Chemistry

			Typical Values
% C	-	0.10 max.	0.10
% Mn	-	2.5 max.	1.00
% Si	-	0.90 max.	0.65
% Cr	-	28 to 32	28
% Ni	-	8 to 10.5	8

NOTE: The electrodes are manufactured for maintenance and application and the manufacturers do not claim conformance to any established standard. As such it is desirable that during initial approval and periodic testing, the electrode should comply with the typical values indicated above.

Recommended Brands

a) *For highly critical applications*

XUPER 680 CGS	Larsen & Toubro
E 106	Cosmic Fontech

b) *For critical applications*

LOTHERME 468	D & H Secheron
DUROCHROME	Esab India Ltd
KOLDWELD ST 14	Weldcraft

Sizes

Gauge	Size
6	5.00 mm x 350 mm
8	4.00 mm x 350 mm
10	3.15 mm x 350 mm
12	2.50 mm x 350 mm

4.0 ELECTRODES FOR HIGH STRENGTH LOW ALLOY STEELS

4.1 Electrodes for Tisten 52/SAILMA 300

(AWS E7018-1, IS 814 EB5626 H_3JX)

Electrodes of this group are medium coated hydrogen controlled, designed for welding in all positions. Suitable for X-ray quality welds.

Weld Metal Chemistry

% C	-	NS	* % Ni	-	0.30
* % Mn	-	1.6	* % Mo	-	0.30
% Si	-	0.75	* % Cr	-	0.20
% V	-	0.08			

* Total of all elements shall not exceed 1.75%

Mechanical Properties

U.T.S	-	51 kgf/mm^2, min.
Y.S.	-	43 kgf/mm^2, min.
% Elongation	-	22 min.
Impact	-	27 Joules, at -46^{o}C

Recommended Brands

ESAB 36 H (Spl)	-	Esab India Ltd.
SUPRATHERME (SPL)	-	D & H Secheron
TENACITO Z Plus	-	ADVANI OERELIKON

Sizes

Gauge	Size
4	6.3 mm x 450 mm
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 450 mm
12	2.50 mm x 350 mm

4.2 Electrodes for Tisten 55/SAILMA 300 HI (AWS E7018G, IS E610515 HJ)

Electrodes of this group produce a tough and ductile weld metal suitable for joining heavy and rigid structures subjected to dynamic loading and impact. The weld metal is of radiographic quality.

It is recommended that plates of thickness of 32 mm and over should be preheated before welding.

Mechanical Properties

U.T.S.	-	56 kgf/mm^2, min.
Y.S.	-	47 kgf/mm^2, min.
% Elongation	-	19, min.
Impact	-	27 Joules, at -40^{o}C

Weld Metal Chemistry

% C	-	NS	% Cr	-	0.3 min.
% Si	-	0.80 max.	% Mo	-	0.20 min.
% Ni	-	0.50 min.	% V	-	0.10 min.
% Mn	-	1.0 min.			

Recommended Brands

SUPRATHERME (Ni) SPL.	-	D & H Secheron
TENACITO 60	-	Advani Oerlikon

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 450 mm
12	2.50 mm x 350 mm

4.3 Electrodes for Tisten 60/SAILMA 350
(AWS E9018-M, IS 1395 E63BM126Fe)

A medium heavy coated, hydrogen controlled, iron powder type, all position electrode for welding high tensile structural steels, heavy sections and restrained joints in high-tensile steels. It gives a very smooth arc, medium penetration and low spatter characterised by ease of operation in all positions. Gives radiographic welds in all positions.

It is recommended that plates of thickness 25 mm and over should be preheated before welding.

Mechanical Properties

U.T.S	-	63 kgf/mm^2, min.
Y.S.	-	54 kgf/mm^2, min.
% Elongation	-	17, min.
Impact	-	27 Joules, at -51^{o}C

Weld Metal Chemistry

% C	-	0.10
% Si	-	0.8 min.
% Mn	-	0.60 - 1.25
% Ni	-	1.4 - 1.8
% Mo	-	0.35 min.
% Cr	-	0.15 min.
% V	-	0.05 min.

Recommended Brands

TENACITO 65	Advani Oerlikon
ESAB 98	Esab India Ltd

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 450 mm

5.0 WEAR RESISTANT ELECTRODES

5.1 Wear Resistant Electrodes - *Ambient Temperature conditions*

5.1.1 Air Hardening electrodes - 350 BHN hardness

Electrodes of this group are medium coated rutile type. Hardness of the deposit is 350-400 BHN, in as welded condition.

Weld Metal Chemistry (optional)

% Carbon	-	0.20
% Manganese	-	0.50
% Chromium	-	2.50 - 3.0

Hardness 350 to 400 BHN

In case of discrepancy in chemistry, hardness will be considered for acceptance.

Recommended Brands

CITORAIL-II	-	Advani Oerlikon
BOR B	-	D & H Secheron
DUROID 350	-	Indian Oxygen

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm

5.1.2 Low heat input air hardening alloys for machinable weld deposit

Electrodes of this group are basic coated all position type with deposit hardness of + 300 BHN, suitable for hardfacing ferrous components subjected to heavy shock loading and bending in service.

Thick layers can be deposited without the risk of cracking.

Recommended Brands

EUTECTRODE 2 B	-	Larsen & Toubro
E-710	-	Cosmic Fontech
KOLDWELD SF 30	-	Weldcraft
TUF ALLOY 320	-	Diffusion Engg

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm

5.1.3 Air hardening electrodes - 550 BHN hardness

These are basic coated and the weld deposit is non-machinable.

The electrode should be used in combination with a buffer layer of medium carbon weld deposit, particularly while hardfacing steel castings.

Application

Electrodes of this group are suitable for building up surfaces subjected to high abrasion and moderate impact.

Weld Metal Chemistry (optional)

% Carbon	-	0.45 - 0.55
% Chromium	-	4.0 - 6.5
% Molybdenum	-	0.40 - 0.50
% Vanadium	-	0.40 - 0.50

Hardness

As welded hardness should be in the range of 500 to 600 BHN

NOTE: In case of discrepancy in chemistry, hardness should be considered for acceptance.

Recommended Brands

ESAB 600 B	-	Esab India Ltd
BOR-C	-	D & H Secheron
SUPER ALLOY 550	-	Diffusion Engg

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 350 mm

5.1.4 Air hardening alloys - 550 and above BHN hardness

The deposit is alloyed and modified white cast iron type which is hard and extremely resistant to abrasion with low impact.

Welding Procedure

Re-dry the electrodes at 250°C for 30 minutes before use. Grind all surfaces to free them from oxides and other contaminants. Remove fatigued or damaged metal with gouging electrodes, prior to deposition of overlay.

Applications

Used for fan blades, exhaust blades, scraper bars, excavator buckets, sand washing installations, conveyor parts, coal crushing hammers, etc.

Recommended Brands

CCR 20	-	D & H Secheron
E 720	-	Cosmic Fontech
LOTHERME 604	-	D & H Secheron
ABROCARB 84	-	Diffusion Engg

Sizes

Gauge	Size
6	5.0 mm x 450 m

5.1.5 Electrode for tough, machinable and high yield strength deposit

These are medium heavy, basic coated all position electrodes. The weld deposit is extremely tough, and resists wear due to high impact without any resultant brittleness of the overlay.

Precaution :

Components should be tempered/stress relieved after welding.

Application

Suitable for rebuilding of coupling bores, keyways, forging dies, etc.

Weld Metal Chemistry

% C	-	0.07/0.09	% Ni	-	1.8/2.2
% Mn	-	1.2/1.7	% Mo	-	1.0/1.5
% Si	-	0.15/0.25	% V	-	0.1/0.2
% Cr	-	2.5/3.0	% S & P	-	0.03 Max

Mechanical Properties

U.T.S	-	96 to 110 kgf/mm^2
Y.S.	-	88 to 100 kgf/mm^2
% Elongation	-	16, min.
Hardness	-	260 to 330 BHN

Recommended Brands

NICROMOLYCORD 535	-	Advani Oerlikon

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm

5.2 Wear Resistant Electrodes - *Elevated Temperature Electrodes*

5.2.1(a) Air hardening machinable weld deposit for resistance against abrasive wear with moderate impact

A basic coated electrode, depositing molybdenum nickel alloy steel deposit, which is both impact and abrasion-resistant. The deposit consists of highly alloyed martensite with a considerable amount of retained austenite. The high molybdenum content gives rise to secondary hardening, which is responsible for its strength and hardness at elevated temperatures.

Applications

Seat area of blast furnace bells and hoppers, where resistance to high abrasion and to moderate impact upto 400°C, is required. It is recommended that the bell be preheated to around 150-200°C before depositing.

Weld Metal Chemistry

% C	-	0.25
% Mo	-	5.0
% Ni	-	5.0

Hardness

500 Hv (49 Rc) at 400°C
475 Hv (47 Rc) at 450°C
460 Hv (46 Rc) at 500°C
415 Hv (42 Rc) at 560°C

The deposit also work-hardens, increasing its abrasion resistance, and is machinable.

Recommended Brands

DUROBELL - Esab India

Sizes

Gauge	Size
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm

5.2.1(b) Air hardening non-machinable weld deposit for resistance against abrasive wear

Hardness

52 RC at 400°C
48 RC at 600°C

Recommended Brands

TERROWELD SHR(SS)	-	Esab India

5.2.2 **Work-hardening machinable deposits**

These electrodes are suitable for resistance against moderate abrasion and high impact upto 700°C.

Weld Metal Chemistry

% C	-	0.10 - 0.15
% Cr	-	16.0 - 19.0
% Mn	-	3.5 - 4.5

Hardness

As-welded	-	200 - 250 BHN
After work-hardening	-	450 - 500 BHN

Recommended Brands

CROMA	-	D & H Secheron

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

5.2.3(a) Air hardening impact and abrasion resistant electrodes

The electrode is applicable for hardfacing at elevated temperatures. Deposit is machinable with special tools.

Application

Suitable for building up hot shear blades, tong pins, etc, where tungsten bearing hot die steels are required.

Weld Metal Chemistry

% C	-	0.35
% Cr	-	1.8
% W	-	8.0
% Co	-	2.0
% V	-	0.4

Mechanical Properties

Hardness - 550 - 700 Hv at 500^{o}C

Recommended Brands

Esab 550 - Esab India Ltd

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm

5.2.3(b) Air hardening high impact and high abrasion electrodes

Recommended Brands

EUTEC 700 - L & T

5.2.4 Hastalloy "C" type work hardening weld deposits

Nickel-molydenum-chromium-tungsten alloy used for protecting hot-working equipment, specially for facing hot-forging dies. Ideally suited for withstanding combinations of heat and heavy impact. It wears evenly, won't crack or spall and resists corrosion, oxidation and thermal shock. The alloy has low frictional characteristics, takes high polish and retains its hardness upto 650°C.

The welding characteristics are smooth and uniform with a very quiet, stable arc and low spatter loss at low amperage. Slag removal is easy. The base metal should be preheated from 200°C to 350°C, and slow-cooled after welding to avoid cracking of the deposit. The deposit has low dilution on ferritic steels and can be machined with special tools.

Application

Parts requiring wear resistance at elevated temperature and metal-to-metal wear, high impact, such as hot forging and trim die rolls, entry guides and die pots, hot shear blades, billet caster shear blade.

Parts requiring resistance to heavy impact, chipping, cracking and spalling may be surfaced with this electrode.

Weld Metal Chemistry (nominal composition)

% C - 0.1
% Mo - 17
% W - 5.0
% Fe - 6.0
% Cr - 17
% Ni - Bal.

Mechanical Properties

U.T.S.	-	62 kg/mm^2
0.1% Proof stress	-	40 kg/mm^2
% Elongation	-	10 min.

Hardness

225 to 280 BHN as welded
350 BHN work hardened, 2 layers

Recommended Brands

UNIARC 273	-	Union Carbide (I) Ltd.

Sizes

Gauge	Size
6	5.0 mm x 350 mm

5.2.5 Stellite Gr. 6 type wear and shock resistant alloy

Cobalt base alloy for resistance against shock, abrasion, oxidation and corrosion at elevated temperature upto 1000°C.

The extent of deposit should be limited within 3 layers max. to eliminate cracking. Preheating and interpass temperature should be closely maintained above 200°/250°C.

Application

Suitable for hot shear blades, punches, edger rolls for Banning Press, etc.

Weld Metal Chemistry (nominal composition)

% C	-	1.0
% Cr	-	26.0
% W	-	5.0
% Co	-	Bal.

Mechanical Properties

U.T.S.*	-	92 kgf/mm^2
0.1% Proof stress*	-	56 kgf/mm^2
Hardness	-	380 to 425 BHN as welded

* For guidance only and not as a acceptable criterion

Recommended Brands

SUTECDUR 9060	-	Larsen & Toubro
UNIARC GR.6	-	Union Carbide (I) Ltd.
SUPER ALLOY 1006	-	Diffusion Engg

Sizes

Gauge	Size
6	5.0 mm x 350 mm

5.3 Manganese Steel Electrodes

5.3.1 Electrodes for Mn steel rebuilding

These are heavy coated low hydrogen type.

Application

Electrodes of this group are suitable for building up 14% Mn steel castings.

Weld Metal Chemistry

% C	-	0.75 - 1.0
% Si	-	0.30 - 0.80
% Mn	-	11.0 - 14.0
% S	-	0.05, max.
% P	-	0.05, max.

Hardness

As welded	-	250 BHN
After work hardening	-	500 - 550 BHN

Recommended Brands

ESAB MN	-	Esab India Ltd
CITOMANGAN	-	Advani-Oerlikon
SMA	-	D & H Secheron
EUS 400	-	L & T
HADMOALLOY 140	-	Diffusion Engg

Sizes

Gauge	Size
4	6.3 mm x 450 mm
6	5.0 mm x 450 mm
8	4.0 mm x 350 mm

5.3.2 Electrodes for buffer layer on Mn-Steel

Electrodes of this group are suitable for joining Mn steel with mild steel or as a buffer layer on Mn steel. These are of austenitic type and resistant to oxidation.

Weld Metal Chemistry (optional)

% C	-	0.15, max.
% Mn	-	5.0 - 7.0
% Cr	-	17.0 - 19.0
% Ni	-	8.5 - 9.5

Recommended Brands

CITOCHROMAX-N	-	Advani Oerlikon
SIA	-	D & H Secheron

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm

5.3.3 Low heat input 18/8/5 electrodes for maintenance applications

Electrodes of this group are synthetic stainless steel of 18% Cr-8% Ni-5% Mn type, having good work hardening properties. These are also resistant to cracking and deformation. The weldment has a very narrow heat affected zone (HAZ), resulting in minimum deterioration of parent metal properties.

Application

Applicable on high carbon steels like rail steel without any buffer layer and resists wear due to abrasion and impact.

The electrode is ideally suited for rebuilding of points and crossings of railway tracks and for joining of high manganese steel to mild steel.

Weld Metal Chemistry (Typical)

% C	- 0.12	% S & P	- 0.03
% Mn	- 5.09	% Ni	- 9.85
% Si	- 0.827	% Cr	- 18.08

Hardness

As welded	- 200 - 240 BHN
After work hardening	- 400 - 500 BHN

Recommended Brands

XHD 646	- L & T
E108	- Advani Oerlikon
LOMELT 206	- Modi Arc Electrodes Co.
DIFFUS ALLOY 618	- Diffusion Engg

Sizes

Guage	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm

6.0 STAINLESS STEEL ELECTRODES

6.1 General purpose stainless steel electrodes (AWS E308-16)

These electrodes are rutile coated all-position type.

Application

Suitable for general purpose stainless steel joining (materials conforming to ASTM 302, 304 and 308) and surfacing applications.

Weld Metal Chemistry

% C	- 0.08 max.	% Ni	- 9 - 11
% Cr	- 18 - 20	% Mo	- 0.5 max.
% Mn	- 0.5 - 2.5	% S,P	- 0.04, 0.03 max.
% Si	- 0.90 max.	% Cu	- 0.5 max.

Mechanical Properties

U.T.S.	-	56 kgf/mm^2, min.
% Elongation	-	25

Recommended Brands

a) *Conventional Electrodes*

OK 61.30	-	Esab India Ltd.
SUPERINOX 1A	-	Advani Oerlikon
RUTOX A	-	D & H Secheron

b) *Low Heat Input Electrodes*

E124	-	Cosmic Fontech
LOTHERME 452	-	D & H Secheron

Sizes

Guage	Size
	5.0 mm x 350 mm
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

6.2 Extra low carbon grade stainless steel electrodes (AWS E308L-16)

These are stainless steel electrodes with extra low carbon and controlled ferrite for superior resistance to hot cracking, weld decay, corrosion and pitting.

Application

Specially recommended for E.L.C. grade of stainless steel (ASTM 308L) and for low temperature notch toughness properties.

Weld Metal Chemistry

% C	- 0.04 max.	% Si	- 0.90 max.
% Mn	- 0.5 - 2.5	% Ni	- 9.11
% Cr	- 18 - 21	% Cu	- 0.5 max.

Mechanical Properties

U.T.S.	-	56 kgf/mm^2
% Elongation	-	35 min.

Recommended Brands

SUPERINOX 1C	-	Advani Oerlikon
RUTOX B	-	D & H Secheron

Sizes

Gauge	Size
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

6.3 Stabilised stainless steel electrodes (AWS E347-16)

Electrodes of this group are stabilised stainless steel of 18:8 type and can be used where there is a chance of picking up carbon from the parent material. It resists intergranular corrosion.

Application

Generally used for joining stainless steel material (ASTM 347 & 321) and also used for grade 302, 304 and 308.

Weld Metal Chemistry

% C	0.08 max.	% Ni	9.0-11.0
% Mn	0.5-2.5	% Nb	0.6-0.90
% Si	0.90 max.	% Cu	0.5 max.
% Cr	18.0-21.0	% Mo	0.5 max.

Mechanical Properties

U.T.S.	52 kgf/mm^2
% Elongation	30 min.

Recommended Brands

ESAB CHROMWELD B 347	ESAB India Ltd.
WELDCRAFT 321	Weldcraft
RUTOX A STAB	D & H Secheron
SUPERINOX 1B	Advani Oerlikon

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

6.4 Niobium stabilised 18 Cr - 12 Ni electrodes
(AWS E318-16)

Electrodes of this group are of 18-8-3 Mo type stabilised with Nb/Cb which can be used for resistance to stress corrosion cracking, chemical and inter-crystalline corrosion.

Application

Generally suitable for for material ASTM 318-16, 316-16 & 321.

Mechanical Properties

U.T.S.	-	56 kgf/mm^2
% Elongation	-	25% min.

Weld Metal Chemistry

% C	-	0.08
% Mn	-	0.5 - 2.5
% Si	-	0.9
% Cr	-	17 - 20
% Ni	-	11 - 14
% Mo	-	2 - 2.5
% Nb/Cb	-	6 x %c min. subject to 1.0 max.
% Cu	-	0.5% max.

Recommended Brands

a) *Conventional Electrodes*

ESAB 316 KCR	-	Esab India
RUTOX MO STAB.	-	D & H Secheron
SUPERINOX 2B	-	Advani Oerlikon

b) *Low Heat input Electrodes*

LOTHERME 455	- D & H Secheron
EUTEC STAINTRODE AMOL	- L & T

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm

6.5 Heat and Corrosion Resistant Electrodes

6.5.1 Heat and corrosion resistant electrodes upto 1000°C (AWS E309-16)

Electrodes of this group are suitable for welding heat-resisting stainless steel of 25/12 grade. They are resistant to oxidation and scaling upto 1000°C.

Application

Suitable for material grade ASTM 309

Weld Metal Chemistry

- % C - 0.08
- % Mn - 0.5-2.5
- % Si - 0.90 max.
- % Cr - 22-25
- % Ni - 12-14
- % Mo - 0.5 max.

Recommended Brands

a) *Conventional*

CHRONITHERME	-	D. & H Secheron
INOX D2	-	Advani Oerlikon
ESAB 309	-	Esab India Ltd.

b) *Mo Stabilised Grade*

309 CB	-	D & H
INOX D_2Mo	-	Advani Oerlikon

Sizes

Gauge	Size
6	5.0 mm dia.
8	4.0 mm dia.

6.5.2 Heat and corrosion resistant electrodes upto 1200°C (AWS 310-16)

Designed for elevated temperature applications upto 1200°C.

Application

These electrodes are suitable for welding of 25/20 grade of stainless steel (ASTM 310).

Also suitable for joining dissimilar steels like stainless steel to mild steel.

Weld Metal Chemistry

% C	-	0.20 max.
% Mn	-	1.0-2.5
% Si	-	0.75 max.
% Cr	-	25-28
% Ni	-	20.0-22.5
% Mo	-	0.5 max.

Mechanical Properties

U.T.S.	-	57 kgf/mm^2
% Elongation	-	30
Hardness	-	195 BHN

Recommended Brands

a) *Conventional Electrodes*

ESAB 310	-	Esab India Ltd.
INOX CW	-	Advani Oerlikon
D & H 310-16	-	D & H Secheron

b) *Low Heat Input Electrodes*

STENSTROD D	-	L & T
E126	-	Cosmic Fontech

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

6.6 Ferritic Grades Stainless Steel Electrodes (AWSE 410-60)

6.6.1 Electrodes of this group are heavy coated hydrogen controlled type for welding of ferritic /martensitic stainless steel. Weld deposit is air hardenable.

Use of pre-heat and stress releive is **strongly recommended** to avoid hardening in the weld zone.

Weld Metal Chemistry

% C	-	0.8
% Mn	-	0.7
% Si	-	0.6
% Cr	-	12.5

Mechanical Properties

Hardness	-	375 - 400 BHN (36-40 RC)

Recommended Brands

CITO CHROME 13	-	Advani Oerlikon
D & H 410	-	D & H Secheron

Sizes

Gauge	Size
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

6.6.2 Low heat input ferritic stainless steel electrodes

Application

Suitable for all position welding

Mechanical Properies

UTS	90 kgf/mm^2
Hardness	38-22 RC
% Elongation	15

Recommended Brands

Xuper Turbotec 5300	L & T
E 127	Cosmic Fontech

Sizes

Gauge	Size
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

7.0 CAST IRON ELECTRODES

7.1(a) Ferro-nickel type of electrodes (AWSE NiFeCI)

Deposit of this group is stronger than pure nickel weld metal and bond strength is comparatively higher.

Application

Electrodes of this group are suitable for welding of grey iron castings.

Weld Metal Chemistry

% C - 1.0
% Ni - 55-57
% S&P - 0.03 max.
% Fe - Bal.

Recommended Brands

ESAB 802	-	Esab India Ltd.
D & H 1111 CI	-	D & H Secheron
CPCI 026	-	L & T

Sizes

Gauge	Size
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm
12	2.5 mm x 350 mm

7.1(b) Low heat input Fe-Ni electrodes for maintenance applications

Crack-resistant nickel iron alloy electrode for grey cast iron. The deposit is ductile and machinable. Good bonding on difficult-to-weld cast iron. For oil-soaked parts, undercutting will be required.

NOTE: Ferro-nickel type electrode should not be used over Ni-free buffer layers, otherwise the weld deposit will be difficult to machine.

Applications

The electrode can be used for positional work.

Also suitable for application on S.G. Iron upto 40 kg/mm^2 tensile strength, i.e. grade 400/12 ferritic S.G. Iron.

The electrode is also suitable for high phosphorous grade of cast iron and for joining dissimilar metals like M.S., stainless steel, etc with cast iron.

Weld Metal Chemistry

Same as in 7.1.1

Mechanical Properties

U.T.S.	-	45 kgf/mm^2
Hardness	-	190 BHN
% Elongation	-	10

Recommended Brands

XYRON 224	-	L & T
E 119	-	Advani Oerlikon
LOTHERME 703	-	D & H
CINOD 160	-	Diffusion Engg
KOLDWELD CI 11Mo	-	Weldcraft

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm

7.2(a) High nickel electrodes (AWSE NiCI)

The electrode is suitable for joining and surfacing of grey iron. It is extremely ductile, although bond strength will be lower than Fe-Ni types. Weld deposit is machinable. For better bonding, use Ni-free deposit as buffer layer.

Weld Metal Chemistry

% C	-	1 - 1.2	% Cu		2.5 max
% Ni	-	95 min.	% Al		1.0 max
% Mn	-	1.5 max.	% other elements		1.0 max
% Fe	-	1.5 max.			

Mechanical Properties

U.T.S	-	38 kgf/mm^2
Y.S.	-	30 kgf/mm^2
% Elongation	-	8
Hardness	-	160 BHN

Recommended Brands

SUPERNICRON	-	Advani Oerlikon
NFM	-	D & H Secheron
FERROLOID 4	-	ESAB (I) Ltd.

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm
10	3.15 mm x 350 mm

7.2(b) Low heat input high nickel electrodes for maintenance applications

The electrode is recommended for grey cast iron, malleable iron and for joining to other metals. An all-position electrode, enabling work to be carried out in situ on machine bases, motor blocks, heavy castings, etc. without dismantling. For applications where trouble-free machinability and crack resistance is required.

Weld Metal Chemistry

Same as in **7.2 (a)**

Mechanical Properties

U.T.S	-	38 kgf/mm^2
Y.S.	-	30 kgf/mm^2
% Elongation	-	8
Hardness	-	160 BHN

Recommended Brands

XUPERXYRON 242	-	Larsen & Toubro

Sizes

Gauge	Size
8	4.0 mm x 350 mm

7.3 Cast iron non-machinable electrodes

Electrodes of this type gives very good performance on oxidized and contaminated surface.

Application

Used for all cast iron repair welding not requiring machining.

Also suitable for joining cast iron to steel.

Weld Metal Chemistry

% C	-	0.3-0.35
% Mn	-	1.5-1.8
% Si	-	0.1
% S	-	0.01 max.
% P	-	0.015 max.

Mechanical Properties

Tensile Strength	-	42-45 kgf/mm^2
Hardness	-	350 BHN min

Recommended Brands

EUTEC 27	-	L & T
E 117	-	Cosmic Fontech
LOTHERME 701	-	D & H Secheron

8.0 CUTTING ELECTRODES

8.1 Electrodes for arc cutting

Electrodes of this group are suitable for cutting stainless steel, non-ferrous metals and cast iron, without the use of compressed air. Use DC (+) power source.

Recommended Brands

CUTTRODE	-	Larsen & Toubro
E 901	-	Cosmic Fontech
LOTHERME 801	-	D & H Secheron
CITOCUT	-	Advani Oerlikon

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm

8.2 Electrodes for arc gouging

Electrodes of this group have a special exothermic coating which concentrates the force of the arc right at the point of application and yields a highly efficient metal removing tool.

Application

Suitable for gouging of crack for repair work.

Recommended Brands

CHAMFERTRODE	-	Larsen & Toubro
E 900	-	Cosmic Fontech
LOTHERME 802	-	D & H Secheron

Sizes

Gauge	Size
6	5.0 mm x 350 mm
8	4.0 mm x 350 mm

9.0 CONSUMABLES FOR CONTINOUS WELDING

9.1 Consumables for Automatic & Semi-Automatic Welding of Mild Steel

9.1.1 Submerged arc welding wire-flux for mild steel

Wire-flux combination for submerged arc welding of carbon and carbon manganese steels for joining and surfacing applications.

Weld Metal Chemistry

% C	-	0.07-0.15	% S	-	0.015-0.035
% Mn	-	1.15-2.25	% P	-	0.015-0.035
% Si	-	0.3-0.55			

Mechanical Properties

U.T.S.	-	42.5-56.0 kgf/mm^2
Y.S.	-	33 kgf/mm^2, min.
% Elongation	-	22 min.
Impact	-	27 Joules, at $-51^{\circ}C$

Recommended Brands

Wire	Flux	Manufacturer
SA-2	BRD-1	ESAB (I) Ltd.
AUTOMELT GR.C	Meltoflux	Advani Oerlikon

Sizes

Wire 3.15 mm x 12" spool
Wire 4.0 mm x 12" spool
Flux 8 x 35 mesh size

NOTE: Procurement should be on the basis of wire-flux combination of the same manufacturer.

9.1.2 Solid wire for MAG/CO_2 welding of mild steel

Copper-coated solid wire for CO_2 welding of carbon and carbon manganese steels for joining and surfacing applications.

Weld Metal Chemistry

% C	- 0.07-0.15	% S	- 0.035, max.
% Si	- 0.80-1.15	% P	- 0.025, max.
% Mn	- 1.40-1.85	% Cu	- 0.50, max.

Mechanical Properties

U.T.S	-	50 kgf/mm^2
Y.S.	-	42 kg/mm^2
% Elongation	-	22 min.
Impact	-	27 Joules, at $-29^{\circ}C$

Recommended Brands

CITOFIL	-	Advani Oerlikon
MW1	-	ESAB (I) Ltd.

Size

1.2 mm dia x 300 mm spool

9.1.3 Self shielded flux cored wires for Teromatec process

Open arc Flux Cored Arc Welding (FCAW) wire for structural welding of carbon steel components. The welding can be carried out on Termomatec machines without any need for gas shielding.

The wire should conform to spec AWS E70T-4.

Weld Metal Chemistry

% C	-	NS	% Mo	-	0.30 max.(optional)
% Mn	-	1.50 max.	% Cr	-	0.20 max.(optional)
% Si	-	0.90 max.	% V	-	0.08 max.(optional)
% Ni	-	0.50 max.	% Al	-	1.80 max.

Mechanical Properties

U.T.S.	-	51 kgf/mm^2
Y.S.	-	42 kgf/mm^2, min.
% Elongation	-	22 min.
Impact	-	27 Joules, at $-51^{\circ}C$

Recommended Brands

FONMATIC O-1044	-	Advani Oerlikon
TEROMATEC OA-2110	-	Larsen & Toubro

Sizes

2.4 mm/2.8 mm dia in 300 mm spool.

9.2 Self-Shielded Hardfacing Wires for FCA Welding

9.2.1 Air hardening type non-machineable deposit

Flux cored wires depositing chromium carbide type weld metal which resists high abrasion and mild impact at ambient temperature. The wire can be used without any gas shield.

Suitable for continuous welding of components requiring abrasion resistance.

Weld-Metal Chemistry

% C	-	2.5 to 3.0
% Cr	-	6 to 8

Hardness

As welded hardness should be in the range of +500 BHN (*In case of discrepancy in chemistry, hardness value will be considered for acceptance*).

Recommended Brands

FONMATIC O-7050	-	Advani Oerlikon

Size

2.4 mm/2.8 mm dia in 300 mm spool.

9.3 Gas Welding Consumables

9.3.1 Rods of this group are suitable for joining mild steel sheets, pipes, etc. The welding requires complete fusion with neutral flame. Fluxes are not required.

Mechanical Properties

U.T.S.	-	39 kgf/mm^2
Hardness	-	121 BHN

Weld Metal Chemistry

% C	-	0.10 max.
% Mn	-	0.60
% S & P	-	0.04 max.

Recommended Brands

C.C.M.S.	-	ESAB (I) Ltd
C.C.M.S. (COPPER COATED MILD STEEL)	-	Asiatic Oxygen Ltd.

Sizes

3/16" dia.
1/8" dia.

9.3.2 **Flux coated rods for copper to M.S joints**

Coated brazing rods for joining copper to mild steel. To be used for similar joints in Oxygen Lances.

Recommended Brands

EUTECROD 145 FC	-	Larsen & Toubro
SF210	-	Cosmic Fontech

Sizes

Gauge	Size
10	3.2 mm

9.3.3 Copper-2% Silver Alloys for silver brazing

The rod is suitable for welding of copper and Cu-alloys at low temperature.

Recommended Brands

SILVER BRAZING 2% Ag	-	Esab India Ltd.
EUTEC 1805	-	L & T
DIFFUS ALLOY 202	-	Diffusion Engg
A 301	-	Cosmic Fontech

Size

3/16"

9.3.4 General purpose brazing alloys

Rods of this group are suitable for brazing of copper alloys by fusion technique.

Mechanical Properties

U.T.S.	-	45 kgf/mm^2

Recommended Brands

SILICON BRONZE	-	Esab India Ltd.
- do -	-	Asiatic Oxygen Ltd.

Sizes

1/4" dia.
3/16" dia.

9.3.5 Aluminium alloy filler rods

Rods of this group are suitable for joining and surfacing of aluminium. These are applicable for both Oxy-Acetylene and TIG processes.

Recommended Brands

ALUMINIUM 5% SILICON ROD	-	Esab India Ltd.

Sizes

1/8" dia.
3/16" dia.

10.0 ARC WELDING ELECTRODES FOR BRONZE, COPPER, CAST IRON, ETC.

Recommended Brands

EUTEC 2080	-	L & T
BRONZE	-	Advani Oerlikon
BRONZOID	-	Esab India Ltd.

Sizes

4.0 mm dia.
3.15 mm dia.