Education and Culture

Leonardo da Vinci

Course: 141 - TIG WELDING OF STAINLESS STEEL

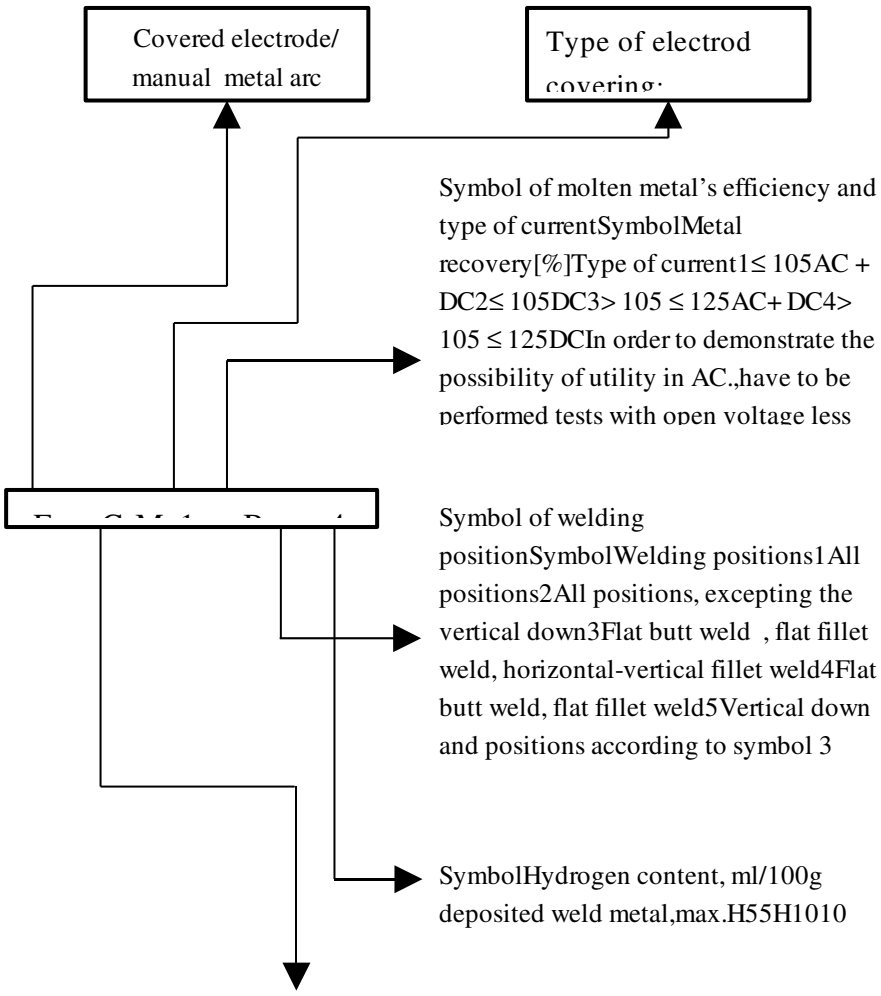
Module 5

List of content

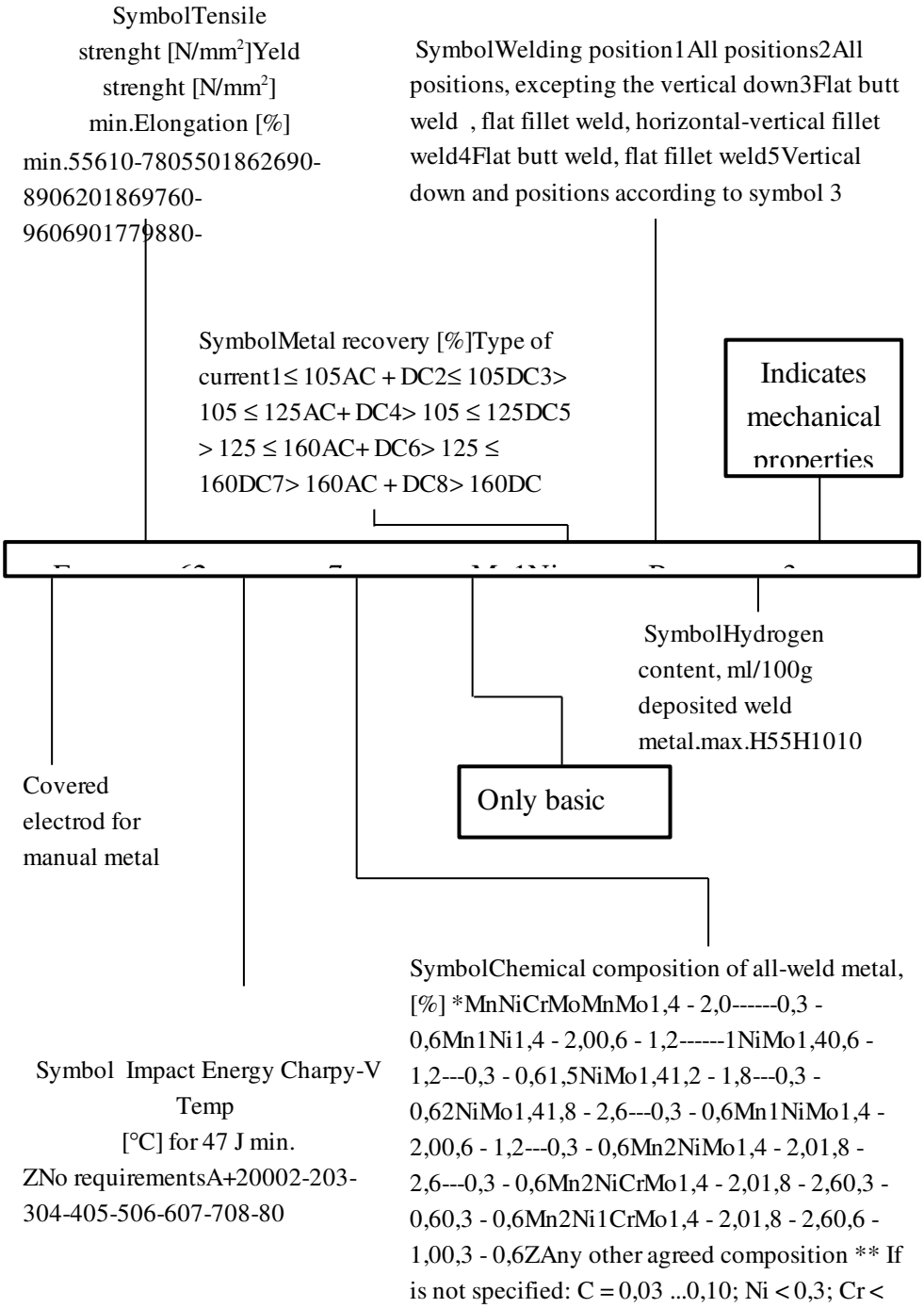
MODULE 5

Principle of welding consumables and functions of each type of welding consumable (A5)

The welding consumables are presented in the tables below:



Alloy SymbolChemical composition of all-weld metal, [%]CSiMn*PSCrMoVOther elementsMo0,100,800,40...1,50*0,0300,025---0,40...0,70------
MoV0,03...0,120,800,40...1,500,0300,0250,30...0,600,80...1,200,25...0,60---
CrMo0,50,05...0,120,800,40...1,500,0300,0250,40...0,650,40...0,65------
CrMo10,05...0,120,800,40...1,50*0,0300,0250,90...1,400,45...0,70------
CrMo1L0,050,800,40...1,50*0,0300,0250,90...1,400,45...0,70------
CrMoV10,05...0,150,800,70...1,500,0300,0250,90...1,300,45...0,700,10...0,35---
CrMo20,05...0,120,800,40...1,300,0300,0252,0...2,60,90...1,30------
CrMo2L0,050,800,40...1,300,0300,0252,0...2,60,90...1,30------
CrMo50,03...0,120,800,40...1,500,0250,0254,0...6,00,40...0,70------
CrMo90,03...0,120,800,40...1,300,0250,0258,0...10,00,90...1,200,15Ni = 1,0CrMo910,06...0,120,600,40...1,500,0250,0258,0...10,50,80...1,200,15...0,30 Ni = 0,40...1,0
Nb=0,03...0,10


SymbolTensile strenght [N/mm2]Yeld strenght [N/mm2] min.Elongation [%] min.55610-7805501862690-8906201869760-9606901779880-
SymbolWelding position1All positions2All positions, excepting the vertical down3Flat butt weld , flat fillet weld, horizontal-vertical fillet weld4Flat butt weld, flat fillet weld5Vertical down and positions according to symbol 3
SymbolMetal recovery [%]Type of current1≤ 105AC + DC2≤ 105DC3> 105 ≤ 125AC+ DC4> 105 ≤ 125DC5 > 125 ≤ 160AC+ DC6> 125 ≤ 160DC7> 160AC + DC8> 160DC
Indicates mechanical properties
SymbolHydrogen content, ml/100g deposited weld metal.max.H55H1010
Only basic
Covered electrod for manual metal
Symbol Impact Energy Charpy-V Temp [°C] for 47 J min. ZNo requirementsA+20002-203-304-405-506-607-708-80
SymbolChemical composition of all-weld metal, [%] *MnNiCrMoMnMo1,4 - 2,0------0,3 - 0,6Mn1Ni1,4 - 2,00,6 - 1,2------1NiMo1,40,6 - 1,2---0,3 - 0,61,5NiMo1,41,2 - 1,8---0,3 - 0,62NiMo1,41,8 - 2,6---0,3 - 0,6Mn1NiMo1,4 - 2,00,6 - 1,2---0,3 - 0,6Mn2NiMo1,4 - 2,01,8 - 2,6---0,3 - 0,6Mn2NiCrMo1,4 - 2,01,8 - 2,60,3 - 0,60,3 - 0,6Mn2Ni1CrMo1,4 - 2,01,8 - 2,60,6 - 1,00,3 - 0,6ZAny other agreed composition ** If is not specified: C = 0,03 ...0,10; Ni < 0,3; Cr <

Shelding gases, backing gases

Influence of the Shielding Gas on: G.T.A.W., P.A.W., G.M.A.W., F.C.A.W. and L.B.W.

Gas Tungsten Arc Welding (G.T.A.W.) or 141 - TIG Welding: Inert-gas arc welding process using a non-consumable tungsten electrode.
Plasma Arc Welding (P.A.W.): Inert-gas arc welding using a non-consumable tungsten electrode.
Gas Metal Arc Welding (G.M.A.W.): Metal-arc welding in which a continuous filler metal electrode is used. Shielding of the arc and weld pool is ensured entirely by an externally supplied gas.
Laser Beam Welding (L.B.W.): A welding process in which the heat for welding is obtained from the application of a concentrated coherent light beam focused on the joint.

The choice of shielding gas has a significant influence on the following factors:
• Shielding Efficiency (Controlled shielding gas atmosphere)
• Metallurgy, Mechanical Properties (Loss of alloying elements, pickup of atmospheric gases)
• Corrosion Resistance (Loss of alloying elements, pickup of atmospheric gases, surface oxidation)
• Weld Geometry (Bead and penetration profiles)
• Surface Appearance (Oxidation, spatters)
• Arc Stability and Ignition
• Metal Transfer
• Environment (Emission of fumes and gases)

Selection of Welding Gas

Welding Process	Shielding Gas Plasma Gas	Backing Gas
G.T.A.W.	Ar Ar + H_2 (up to 20%) – (1) Ar + He (up to 70%) Ar + He + H_2 (1) Ar + N_2 (2)	Ar N_2 (3) N_2 + 10% H_2 (1)
P.A.W.	Idem G.T.A.W.	Idem G.T.A.W.
G.M.A.W.	98% Ar + 2% O_2 97% Ar + 3% CO_2 95% Ar + 3% CO2 + 2% H_2 (1) 83% Ar + 15% He + 2% CO_2 69% Ar + 30% He + 1% O_2 90% He + 7.5% Ar + 2.5% CO_2	Idem G.T.A.W.
F.C.A.W.	No 97% Ar + 3% CO_2 80% Ar + 20% CO_2	No Idem G.T.A.W.
L.B.W.	He Ar	Idem G.T.A.W.
Ar: argon; H_2: hydrogen; He: helium; N_2: nitrogen; CO_2: carbon dioxide		

(1) Hydrogen–containing mixtures must not be used for welding ferritic, martensitic or duplex stainless steels

(2) For welding nitrogen–containing austenitic and duplex stainless steels, nitrogen can be added to the shielding gas

Classifications of welding consumables (A5)

Covered electrode: A filler rod having a covering flux (for S.M.A.W.) used in arc welding, consisting of a metal core with a relatively thick covering which provides protection for the molten metal and stabilises the arc.

Filler metal: Metal added during welding (brazing or surfacing).

Filler rod: Filler metal in the form of a rod (e.g. for G.T.A.W.).

Filler wire: Filler metal in the form of a coil of wire (e.g. for G.M.A.W. and S.A.W.)

Flux: A fusible material used to protect the weld from atmospheric contamination, to stabilise the arc and to perform a metallurgical function (to prevent, dissolve, or facilitate removal of oxides and other undesirable substances).

Flux cored electrode: Filler metal in the form of a small tube with flux in the core.

The core provides deoxidisers and slagforming materials and may also provide shielding gases (some flux cored electrodes are self-shielding).

Suggested welding consumables for welding stainless steels are:

Base Material			Welding Consumables		
EN 10088		AISI [1]	EN 1600	EN 12072	EN 12073
Name	Number		Covered Electrodes [2]	Wires and Rods [3]	Flux Cored Electrodes [4]
X5CrNi18-10	1.4301	304	E 19 9	G 19 9 L	T 19 9 L
X2CrNi18-9	1.4307	304 L	E 19 9 L	G 19 9 L	T 19 9 L
X2CrNi19-11	1.4306				
X5CrNiTi18-10	1.4541	321	E 19 9 Nb	G 19 9 Nb	T 19 9 Nb
X5CrNiMo17-12-2	1.4401	316	E 19 12 2	G 19 12 3 L	T 19 12 3 L
X2CrNiMo17-12-2	1.4404	316 L	E 19 12 3 L	G 19 12 3 L	T 19 12 3 L
X6CrNiMoTi17-12-2	1.4571	316 Ti	E 19 12 3 Nb	G 19 12 3 Nb	T 19 12 3 Nb
X2CrNiMo18-15-4	1.4438	317 L	E 19 13 4 N L	G 19 13 4 L	T 13 13 4 N L
X10CrNi18-8	1.4310	301	E 19 9	G 19 9 L	T 19 9 L
X2CrNiN18-7	1.4318	301 L	E 19 9 L	G 19 9 L	T 19 9 L
X12CrNi23-13	1.4833	309 S	E 22 12	G 22 12 H	T 22 12 H
X8CrNi25-21	1.4845	310 S	E 25 20	G 25 20	T 25 20
X25CrNiMo18-15-4	1.4438	317 L	E 19 13 4 N L	G 19 13 4 L	T 13 13 4 N L
X2CrTi12	1.4512	409	E 19 9 L	G 19 9 L	T 13 Ti
X6Cr17	1.4016	430	E 17 or 19 9 L	G 17 or 19 9 L	T 17 or 19 9 L
X3CrTi17	1.4510	430 Ti / 439	E 23 12 L	G 23 12 L	T 23 12 L
X2CrMoTi18-2	1.4521	444	E 19 12 3 L	G 19 12 3 L	T 19 12 3 L
X2CrTiNb18	1.4509	441	E 23 12 L	G 23 12 L	T 23 12 L
X6CrMo17-1	1.4113	434	E 19 12 3 L	G 19 12 3 L	T 19 12 3 Nb
X2CrNiN23-4	1.4362	–	E 25 7 2 N L	G 25 7 2 L	T 22 9 3 N L
X2CrNiMoN22-5-3	1.4462	–	E 25 7 2 N L	G 25 7 2 L	T 22 9 3 N L
X12Cr13	1.4006	410	E 13 or 19 9 L	G 13 or 19 9 L	T 13 or 19 9 L
X20Cr13	1.4021	–	E 13 or 19 9 L	G 13 or 19 9 L	T 13 or 19 9 L
X30Cr13	1.4028	420	E 13 or 19 9 L	G 13 or 19 9 L	T 13 or 19 9 L

(1) AISI: American Iron and Steel Institute

(2) Covered electrodes for manual metal arc welding of stainless and heat resisting steels. There are two basic flux coverings: basic (B) or lime (direct current) and rutile (R) or titania (direct or alternating current)

(3) Wire electrodes, wires and rods for arc welding of stainless and heat-resisting steels: G for G.M.A.W., W for G.T.A.W., P for P.A.W. or S for S.A.W.

(4) Tubular cored electrodes for metal arc welding with or without a gas shield of stainless and heat resisting steels

Storage drying and handling (A5)

Welding consumables should be designed in accordance with the relevant standard. Consumables shall be with regard to the particular application, e.g. joint design, welding position and properties required to meet the service conditions. Any special recommendations given by the manufacturer/supplier shall be observed.

All consumables shall be stored and handled with care and in accordance with the relevant standards and\or the manufacturer/supplier recommendations.

Covered electrodes, wire electrodes, rods and fluxes as well as their packaging, which show signs of damage or deterioration shall not be used.

Examples of damage or deterioration are cracked or flaked coatings on covered electrodes, rusty or dirty wire electrodes and wire with flaked or damage protection coatings.

Consumables returned to the stores shall be treated in accordance with the manufacturer/supplier's recommendation before re-issue.

Types of welds and joints, characteristics, size, surface finish (A6)

Angle of bevel: The angle at which the edge of a component is prepared for making a weld.

Bevel: An angular edge preparation.

Backing strip: A piece of material placed at a root and used to control the penetration of a weld.

Butt joint: a joint between the ends or edges of two abutting members aligned approximately in the same plane (i.e. making an angle to one another close to 180°).

Butt weld: A weld in which the weld metal is deposited within the edge of a butt joint.

Chamfer: Another term for bevel.

Closed joint: A joint in which the surfaces to be joined (edges of two parts) are in contact while being welded.

Concave fillet weld: A fillet weld in which the weld face is concave.

Corner joint: A joint between the ends or edges of two parts making an angle of more than 30° but less than 135°.

Cruciform joint: A joint in which two flat plates are welded to another flat plate at right angles and in the same axis.

141 - TIG and 15 - PAW

The **square-edge butt joint** is the easiest to prepare and can be welded with or without filler metal depending on the thickness of the two pieces being welded. Part positioning for a square-edge butt joint should always be true enough to assure 100% penetration. When welding light gauge material without adding filler metal, extreme care should be taken to avoid lack of penetration or burn through.

The **flange type butt joint** should be used in place of the square edge butt joint where some reinforcement is desired. This joint is practical only on relatively thin material (1,5 to 2,0 mm).

The **lap joint** has the advantage of entirely eliminating the need for edge preparation.

The only requirement for making a good lap weld is that the sheets be in close contact along the entire length of the joint to be welded.
Corner joints are frequently used in the fabrication of pans, boxes and all types of containers. According to the thickness of the base metal, filler metal may or may not be required to provide adequate reinforcement on all corner joints. Make sure that the parts are in good contact along the entire length of the seam.
All **T joints** require the addition of filler metal to provide the necessary build up.
When 100 per cent penetration is required, be sure that the intensity of the welding current is adequate for the thickness of the base material.
Edge joints are used solely on light gauge material and require no filler metal addition.
The preparation is simple but this configuration should not be used where direct tensile loads are to be applied to the finished joint, since this type of joint may fail at the root under relatively low stresses.

131/135 MIG/MAG

For 131/135 MIG/MAG welds, the root opening as well as the V angles can frequently be reduced from those normally employed in 111 - SMAW.
The amount of weld metal per unit length can thus be reduced up to 30% by providing designs which require less filler metal.
When designing 131/135 MIG/MAG welds for narrow grooves, it is often necessary to employ a high current density (spray transfer).

136 - FCAW

In butt weld joints, the root openings and V angles can be reduced, often enabling a saving of the order of 40% in the amount of filler metal used in the joint.
The optimum joint design will often be determined by the ease with which slag can be removed in multi-pass welds.
In fillet welding, smaller sizes can be employed for the same strength. The deep penetration capacity of flux cored wire gives the same strength as the larger fillet from a 111 - SMAW electrode, which has low penetrating power.
By comparison with 111 - SMAW electrodes, 136 - FCAW wires offer significant cost savings in a variety of ways, such as higher deposition rates, narrower grooves and sometimes two passes before stopping for slag removal.

121 SAW

The groove openings are reduced compared to those required by other arc processes. The weld passes are heavier than for 111 - SMAW electrodes. For open root configurations, it is often desirable to provide a flux backing held in place by a copper chill bar or by a ceramic bar.
For all processes, beveling is not required for thicknesses of 3,0 mm and less, but thicker base material should be beveled to form a “V”, “U” or “J” groove.

The choice of joint details (angle, gap, thickness of root face) depends on the joint thickness, the position and the welding process.