"Year of the Fight Against Impunity and Corruption"

NATIONAL UNIVERSITY OF ENGINEERING

COLLEGE OF MECHANICAL ENGINEERING

WELDING TECHNOLOGY I

FINAL MONOGRAPH

"Welding Design and Analysis of a Bike Parking lot for the Mechanical Engineering College"

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To everybody that helped us in the realization of this project, specially to our professor, the engineer Enrique Sarmiento Sarmiento, for his patience and dedication in our formation as professionals.

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1. OBJECTIVES

1.1. Objectives Definition

The desired objectives to be reached in the project are those ones which allow us to acquire knowledge about the whole process of welding qualification, in this particular case, applied to steel materials.

1.1.1. General Objective

Develop the respective procedures of qualified welding to be able to correctly make an installation without risks, made of squared steel beams of 1.5 inch and tube of 0.5 inch chosen to elaborate a bike parking lot for the College of Mechanical Engineering.

1.1.2. Specific Objectives

- Stablish a long-term tasks schedule.
- Stablish the adequate procedure to weld.
- Identify and design the essential variables of this process.
- Qualify the welding process.

1.2. Scope

In this work, we'll develop the welding procedures for the construction of a bike parking lot for the College of Mechanical Engineering. It'll incorporate the elaboration of an adequate planification to develop the required activities, the implementation of metal testing tubes for its respective tests, subsequently, the preparation and welding of the steel testing tubes to make the required tests.

Meaning, this work allows the welding of a material which will be used to build a quality parking lot for its safe use in the College of Mechanical Engineering, testing this study effectiveness with the mechanical and chemical tests that support it.

The design and analysis of the bike welding arises from the lack of a good parking lot for our bikes, currently in our college building there is only one bikes parking lot, that's why we plan to build a parking lot for up to 30 bikes in an adequate space of free use for our students, covering the current and future demand.

As we have the adequate furniture and space to safely leave the bikes parked, increasing the use and increase of this transportation method.

1.3. Applied Standard and Codes

For our work, which consists in design a model structure for the bike parking lot using squared and round steel beams.

We chose the most common steel, ASTM A36, since according to the AWS D1.1 Standard, when smaller efforts than 400 MPa are required it's the indicated material.

- Chemical analysis of the sample: ASTM E415
- Fillet minimum sizes. Preheating temperature: AWS D1.1 / D1.1M.
- Micro attack test: AWS D1.1/D1.1M and AWS B2.1.

2. THEORETICAL FRAME

2.1. Steel

Steel is an iron alloy with an amount of carbon which can vary between 0.03 and 1.075% in weight of its composition, depending of the degree. Steel is not the same as iron. Both materials must not be confused. Iron is a relatively hard and tough metal, with an atomic diameter (dA) of 2.48 A, with a fusion temperature of 1535°C and boiling point of 2740°C.

The main difference between iron and steel is the carbon percentage: Steel is iron with a carbon percentage between 0.03 and 1.075%.

There are many steel types according to the present alloying elements. Each type of steel will allow different applications and uses, which makes it a versatile and very diffused material in the modern life, where we can find it everywhere.

The two main components are found abundantly in nature. Steel can be recycled indefinitely without losing its attributes, this favors its production at large scale. This variety and availability make it apt for numerous uses such as machinery, tools and buildings construction, aeronautics, car industry, medical tools, etc. Contributing to the technological development of the industrialized societies, since no other material can equal it when we evaluate impact and fatigue resistance.

2.2. Physical and Mechanical Characteristics

Among the steel physical characteristics, outstands the following.

- Medium Density: 7850 Kg/m3
- It can contract, dilatate or melt, depending its temperature.
- Its fusion point depends of the alloy and the alloying elements percentage. Commonly around 3’000°C.
- It’s a tough material, especially in alloys used to make tools.
- It’s relatively ductile; useful to make wires.
- It’s malleable; can be transformed in sheets as this as 0.5 and 0.12mm thick.
- Allows a good mechanization in machine tools before going through a thermic treatment.
- Some compositions keep a better memory and deform when surpass its elastic limit.
- The steel hardness varies between the iron toughness and the one it can reach through alloys or other thermic or chemical procedures, the most known being the steel quenching, applied to steels with a high carbon content, which allows, when superficial, to keep the tough core in the piece to avoid fragile fractures.
- Easy to weld.
- High electric conductivity. In the high-tension air lines aluminum conductors with steel core are frequently used.
- It’s used for the fabrication of artificial magnets, since a magnetized iron piece doesn’t loose its magnetism if it isn’t heated up to certain temperature.
- Steel can be recycled.

2.3. WELDING

It is the union of 2 materials or elements which require heat at a high temperature and the elements fusion to weld. There are different welding processes, however, mentioning all of them is not necessary, what peaks our interest us the most in this case, to perform a good welding work and prevent future risks, are the following points:

a) Type of material to weld: This is a very important point, since here the material properties are considered, which are important to secure a proper joint functioning.
b) Usually tests are performed to obtain more data of the material.
c) The origin of the material: Usually we must know where it came from an where it is going, to ensure the joint life and avoid accidents in the present and in the future.
d) Work place: This must be known to choose the welding process more fit to our work.
e) Radiation level: This will be useful to choose the necessary protection type.

2.4. SHIELDED METAL ARC WELDING (SMAW)

Consists in the use of an electrode with a determined coating, according to the specified characteristics. Through the same, a determined electrical current type circulates, be it alternating or direct. A short circuit is stablished between the electrode and the base material, at the same time through the coating combustion an atmosphere is created to protect the process, this protection includes avoiding humidity penetration and possible pollutant elements. Also, slag is produced which covers the generated wielding chord. The electrode consists of a core o metallic rod, covered by a coating layer, where the core is transferred to the base metal through an electric zone generated by the welding current.

2.5. JOINT TYPE

There 5 basic joints used in metal welding: butt, L, T, lap and edge. But we'll only mention the type of joints we'll use in our project.

2.5.1. Corner Joint or L

L joint is used to unite 2 objects in a 90° degree. The objects are collocated in such a way they only touch in one border.

This leaves an "L" shaped groove, that must be filled with welding material. Using this "L" joint welding allows is a much stronger joint, and also allows the welder to unite the objects in one step. If the objects where arranged in a different way, the union may require two separate welds (in the top and bottom) and may result not so strong.

2.5.2. Lap Joint

Lap joints are used to overlap two objects that don't lay directly one above the other. As a small portion of one of them is overlapped, a border joint isn't enough. Instead, the joints are weld where the border of one of them touches the other. For instance, imagine a stair with the steps representing a series of metallic objects. A lap joint would be located in the intersection of each vertical plane with the horizontal step.

2.5.3. T Joint

The T joint is used to unite two objects in an adequate angle to form a T shape. A simple example would be a metal beam suspended in the ceiling. The welding can be done in one of the two sides of the beam, where this meets the ceiling cover. If the metallic object were located above the ceiling in a cross shape, the welding result would be what is known as cross shaped joint.

2.6. FILLER MATERIAL

In some welding operations the union is produced with the fusion of the base metal in a pond without filler material addition, but in others it is required any other type of additional metal to generate the required coalescence. This additional metal is denominated filler material. For example, in the SMAW process there are the coated rods, which are also the energy conductive medium (electrodes).

Since the electrode is an important characteristic of the welding process by coated electrode arc, is necessary to understand how the different types are classified and identified. The American Welding Society has developed a system to identify the welding electrodes by coated electrode arc. The specifications of the American Welding Society A5.1 and A5.5 describe the requirements for the carbon steel electrodes and low alloy respectively. Describe the different classifications and characteristics of the electrodes.

2.7. WELDING POSITIONS

Generally, there are different welding positions, in an angle or in a corner designated with the letter F and the butt welding designated with the letter G according the American standards (AWS) according to the European standards (UNE) are always denominated with the letter P.

2.7.1. Welding Joint Position in Corner Angle

1 F Position (UNE – PA) Flat welding and one inclined coupon at 45° more or less.

2 F Position (UNE – PB) Horizontal welding and one coupon vertical.

3 F Position (UNE – PF) Vertical welding with both coupon s in vertical; in the American standard both the ascending and descending welding keep being 3 F, but in the European standard the ascending vertical welding is denominated PF and descending vertical is denominated PG.

2.7.2. Welding Joint Position Butt Set

1 G Position (UNE – PA) Horizontal coupons, flat welding.

2 G Position (UNE – PF) Vertical coupons with horizontal welding axis, or also denominated cornice.

3 G Position (UNE – PF) Ascending vertical welding, descending vertical welding (PG).

4 G Position (UNE – PF) Under roof welding.

3. WELDING DESIGN

3.1. Methodology

3.1.1. Base metal Qualification (Essential Variable)

WPS requires a qualification that uses the base metals numerated in the table 1.

Tabla 3.1
Metales base aprobados para WPS precalificadas (véase 3.3)

Grupo	Especificación del acero		Requisitos de la especificación del acero: Punto/límite elástico mínimo ksi	Punto/límite elástico mínimo MPa	Rango de tracción ksi	Rango de tracción MPa
	ASTM A36	(≤3/4 pulgadas [20 mm])	36	250	58–80	400–550

Table 1. Base Metal to Qualify according AWS D1.1

According AWS D1.1 standard, in the section 4 indicates the use of the section 3 to qualify the base material. ASTM A36 steel of the group 1 is verified for the performed tests.

Sample results of the steel sheet (Traction Test)

Thickness (mm)	Wide (mm)	Initial length (mm)	Yield Force (Kgf)	Yield Strength Kgf/mm2 (MPa)	Ultimate Tensile Strength Kg/mm2 (MPa)	Elongation (%)
7.76	12.2	50.8	2978	31.5 (308)	42.97 (421)	27.4

3.1.2. Preheating Temperatures (Essential Variable)

According the table shown below of the chemical results.

C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	Al %	Cu %
0.198	0.033	0.43	0.005	0.036	0.014	0.0048	0.016	0.0013	0.008

Having these results, we procced to calculate the equivalent carbon percentage and to verify the preheating temperature it'll be done with the Seferian formula and with the hydrogen control method.

a) Equivalent Carbon Calculation

According the laboratory results we have the material chemical composition. Applying the following formula of the IIW to calculate the CE:

$$CE = C + \frac{Mn}{6} + \frac{c_r + M_o + v}{5} + \frac{Ni + C_u}{15}$$

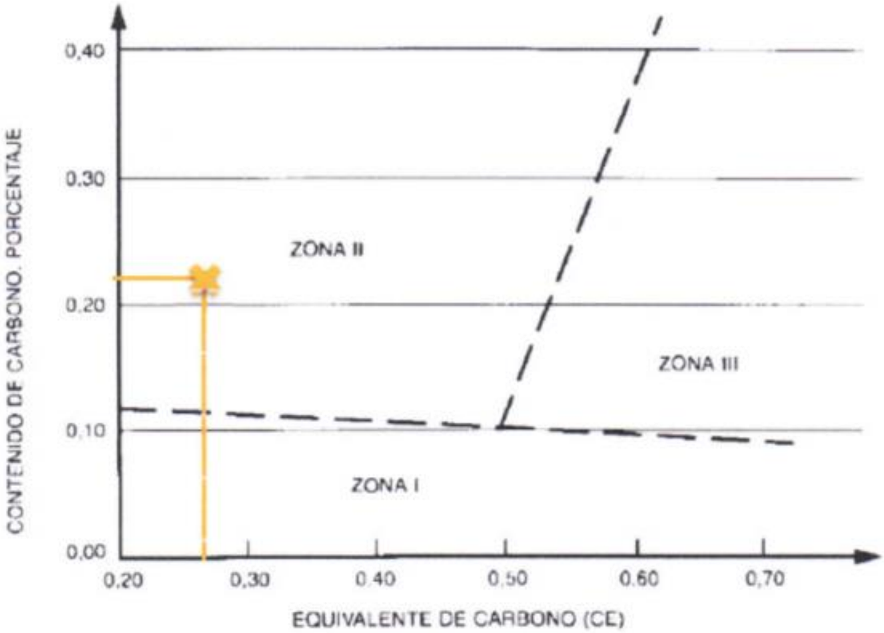
Replacing and operating:

$$CE = 0.198 + \frac{0.43}{6} + \frac{0.014 + 0.005}{5} + \frac{0.016 + 0.008}{15} = 0.275$$

Locating our steel in the Graville Diagram:

Carbon 0.267%

Equivalent carbon: 0.275%



We conclude that the material in the ZONE II (Careful Welding)

b) With the Seferian formula

Next, we procced to calculate the preheating temperature through the Seferian formula:

$$T_p = 350 \cdot \sqrt{c - 0.25}$$

Where:

$$C = CE * (1 + 0.005 * e)$$

e: thickness mm

Replacing:

$$C = 0.275 * (1 + 0.005 * 2.1)$$
$$C = 0.278$$

$$T_p = 350 * \sqrt{0.278 - 0.25} = 58.56°C$$

c) By the hydrogen control method

By the hydrogen control method to determine the preheating, according the H annex.

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

According the composition parameter formula:

$$Pcm = 0.198 + \frac{0.033}{30} + \frac{0.43}{20} + \frac{0.008}{20} + \frac{0.016}{60} + \frac{0.014}{20} + \frac{0.0048}{15}$$

$$P_{cm} = 0.222$$

Tabla H.1
Agrupamiento del índice de susceptibilidad como función del nivel de hidrógeno "H" y parámetro de composición P_{cm} (véase H6.2.3)

Nivel de hidrógeno, H	Agrupamiento [b] del índice de susceptibilidad [c]				
	Equivalente de carbono – P^a_{cm}				
	< 0,18	< 0,23	< 0,28	< 0,33	< 0,38
H1	A	B	C	D	E
H2	B	C	D	E	F
H3	C	D	E	F	G

Table 2. Susceptibility Grouping

And the restriction level is low. This level describes fillet joints and in common spline, in these exist a reasonable movement freedom of the members.

Tabla H.2 (continuación)
Temperaturas mínimas de precalentamiento y entre pasadas para tres niveles de restricción (véase H6.2.4)

Nivel de restricción	Espesor[a] mm	Temperatura mínima de precalentamiento y entre pasadas (°C)[f]						
		Agrupación del índice de susceptibilidad						
		A	B	C	D	E	F	G
Bajo	< 10	< 20	< 20	< 20	< 20	60	140	150
	10 - 20 incl.	< 20	< 20	20	60	100	140	150
	> 20 - 38 incl.	< 20	< 20	20	80	110	140	150
	> 38 - 75 incl.	20	20	40	95	120	140	150
	> 75	20	20	40	95	120	140	150

Table 3. Minimum Preheating Temperature according the Hydrogen Control

Hence, the minimum preheating temperature is of 20°C, which indicates us that the it'll be weld at room temperature.

3.1.3. Fillet Welding Position (Essential Variable)

Tabla 4.1
Calificación de la WPS—Posiciones de soldadura de producción calificadas por ensayos de placa, conducto y tubo rectangular (véase 4.4)

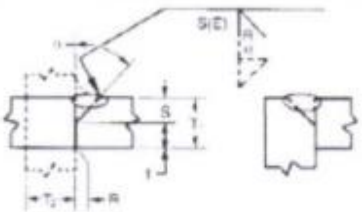
	Ensayo de calificación		Soldadura de placa de producción calificada			Soldadura de tubos de producción calificada					Soldadura de tubo rectangular de producción calificada				
						Junta a tope		Conexiones en T-, Y-, K-			Junta a tope		Conexiones en T-, Y-, K-		
	Tipo de soldadura	Posiciones del ensayo	Ranura con CJP	Ranura con PJP	Filete	CJP	PJP	CJP	PJP	Filete	CJP	PJP	CJP	PJP	Filete
PLACA	Ranura con CJP	1G 2G 3G 4G	F F, H V OH	F F, H V OH	F F, H V OH	F F, H V OH	F F, H V OH			F F, H V OH	F F, H V OH	F F, H V OH			F F, H V OH
	Filete	1F 2F 3F 4F			F F, H V OH					F F, H V OH					F F, H V OH
	Tapón/Ranura	Califica la soldadura en ranura de tapón solo para las posiciones probadas													

Table 4. Qualified Welding Positions

The tests to perform will be done in flat position (2F) fillet welding in squared beams.

Ver Notas en la página 68

Soldadura en ranura con bisel simple (4)
Junta a tope (B)
Junta en T (T)
Junta en esquina (C)



Proceso de soldadura	Designación de junta	Espesor del metal base (U = ilimitado) T1	T2	Preparación de la ranura: Abertura de la raíz / Cara de la raíz / Ángulo de la ranura	Tolerancias: Según detalle (véase 3.12.3)	Tolerancias: Según acoplamiento (véase 3.12.3)	Posiciones de soldadura permitidas	Tamaño de la soldadura (E)	Notas
SMAW	BTC-P4	U	U	R = 0 f = 1/8 min α = 45°	+1/16, −0 +U, −0 +10°, −0°	+1/8, −1/16 ±1/16 +10°, −5°	Todas	S−1/8	b, e, f, g, j, k
GMAW FCAW	BTC-P4-GF	1/4 min	U	R = 0 f = 1/8 min α = 45°	+1/16, −0 +U, −0 +10°, −0°	+1/8, −1/16 ±1/16 +10°, −5°	F, H V, OH	S S−1/8	a, b, f, g, j, k
SAW	TC-P4-S	7/16 min	U	R = 0 f = 1/4 min α = 60°	±0 +U, −0 +10°, −0°	+1/16, −0 ±1/16 +10°, −5°	F	S	b, f, g, j, k

Table 5. Fillet Welding

3.1.4. Filler Material (Essential Variable)

TABLE 6-16. Recommended Electrodes for Carbon and Low Alloy ASTM Steels (See Note 10)
(Plate, Shapes, Forgings and Castings)

ASTM Specifications	Description	Grades	Recommended Electrodes
STEEL PLATES, SHEETS, FORGINGS, SHAPES AND CASTINGS			
A36-91	Structural 36,000 psi Min. YS		Note 1
A113-70B	Railway rolling stock (Discontinued)		Note 1
A131-91	Structural for ships	A, B, CS, D, DS & E	Note 1

Note 1. Unless restricted by specifications; use any E60XX or E70XX electrode for steel grades with 60,000 psi or less tensile strength, for steel grades with 60,000 to 70,000 psi tensile strength use E70XX electrodes.
Note 2. Use E7010-G, specially designed for field-welding pipe.
Note 3. Use E8018-C1 or E8010-B2 for best color match on unpainted steels with enhanced atmospheric corrosion resistance.Consult the steel supplier.

Table 6. Recommended Electrodes according its Material

The electrode to be used is E6011 for the root and E7018 for the filler of a diameter of 1/8 inch, according the 1 note for steel ASTM A36.

Tabla 3.2
Metales de aporte para las resistencias coincidentes en Tabla 3.1,
Metales de Grupos I, II, III y IV —SMAW y SAW (véase 3.3)

		SMAW		SAW	
Grupo de metal base	Especificación de AWS del electrodo	A5.1, Acero al carbono	A5.5ᵃ, Acero de baja aleación	A5.17, Acero al carbono	A5.23ᵃ, Acero de baja aleación
I	Clasificación del electrodo de AWS	E60XX E70XX	E70XX-X	F6XX-EXXX F6XX-ECXXX F7XX-EXXX F7XX-ECXXX	F7XX-EXXX-XX F7XX-ECXXX-XX
II	Clasificación del electrodo de AWS	E7015 E7016 E7018 E7028	E7015-X E7016-X E7018-X	F7XX-EXXX F7XX-ECXXX	F7XX-EXXX-XX F7XX-ECXXX-XX
III	Clasificación del electrodo de AWS	N/A	E8015-X E8016-X E8018-X	N/A	F8XX-EXXX-XX F8XX-ECXXX-XX
IV	Clasificación del electrodo de AWS	N/A	E9015-X E9016-X E9018-X E9018M	N/A	F9XX-EXXX-XX F9XX-ECXXX-XX

Table 7. Filler Materials to Coincident Resistances

3.1.5. Current for the chosen electrode (Essential Variable)

TABLE 6-15. Typical Current Ranges for Electrodes

Electrode Diameter (in.)	Current Range (amp)											
	Electrode Type											
	E6010, E6011 DC –	E6012	E6013	E6019	E6020	E6022	E6027 E7027	E7014	E7015, E7016	E7018M E7018	E7024, E7028	E7048
1/16	—	20-40	20-40	—	—	—	—	—	—	—	—	—
5/64	—	25-60	25-60	35-55	—	—	—	—	—	—	—	—
3/32	40-80	35-85	45-90	50-90	—	—	—	80-125	65-110	70-100	100-145*	—
1/8	75-125	80-140	80-130	80-140	100-150	110-160	125-185	110-160	100-150	115-165	140-19[illegible]	80-140
5/32	110-170	110-190	105-180	130-190	130-190	140-190	160-240	150-210	140-200	150-220	180-250	150-220
3/16	140-215	140-240	150-230	190-260	175-250	170-400	210-300	200-275	180-255	200-275	230-305	210-270
7/32	170-250	200-320	210-300	240-310	225-310	370-520	250-350	260-340	240-320	260-340	275-365	—
1/4	210-320	250-400	250-350	310-360	275-375	—	300-420	330-415	300-390	315-400	335-430	—
5/16	275-425	300-500	320-430	360-410	340-450	—	375-475	390-500	375-475	375-470	400-525*	—

* The E7028 classification is not manufactured in this diameter.

Table 8. Recommended Currents for Electrodes

The current for its application in the E6011 electrode is 80 A and the electrode E7018 works with 98 A.

3.1.6. Essay for Tubular Testing in Fillet

Tabla 4.4
Cantidad y tipo de probetas de ensayo y rango de espesor calificado— Calificación de la WPS; soldaduras en filete (véase 4.12)

			Probetas de ensayo requeridas[a]			Tamaños calificados	
Probetas de ensayo	Tamaño del filete	Cantidad de soldaduras por WPS	Macroataque 4.12.1 4.9.4	Tracción del metal de soldadura (véase Fig. 4.14)	Doblado lateral (véase Figura 4.9)	Espesor de la placa/conducto	Tamaño del filete
Ensayo de placa en T (Figura 4.15)	Pasada única, tamaño máximo a usar en construcción	1 pulgada en cada posición a ser usada	3 caras	—	—	Sin límite	Pasada única de ensayo, máx. y más pequeña
	Pasadas múltiples, tamaño mínimo a usar en construcción	1 pulgada en cada posición a ser usada	3 caras	—	—	Sin límite	Pasadas múltiples de ensayo, mín. y más grande

Table 9. Fillet Tests

Table 3.6
Limitations for Performance Qualification on Groove Welds in Pipe and Tube

Test Weldment, in.		Qualifies for Pipe and Plate: Minimum Outside Diameter		Qualifies for Pipe and Plate: Maximum Deposit Thickness	
Outside Diameter	Deposit Thickness (t)	Grooves	Fillets	Grooves	Fillets
Less than 1		Size welded	All		
1 through 2-7/8		1	All		
Over 2-7/8		2-7/8	All		
	Less than 3/4			2t	All
	3/4 and over			Unlimited	All

t = thickness of the deposited weld metal

General Note: For GMAW-S, the maximum weld metal thickness deposited shall not exceed 1.1 times the thickness of weld metal deposited by the GMAW-S process in the qualification test. For base metals 3/8 in. thick and greater, side bends are required for GMAW-S

Table 10. Minimum Dimensions for Coupon

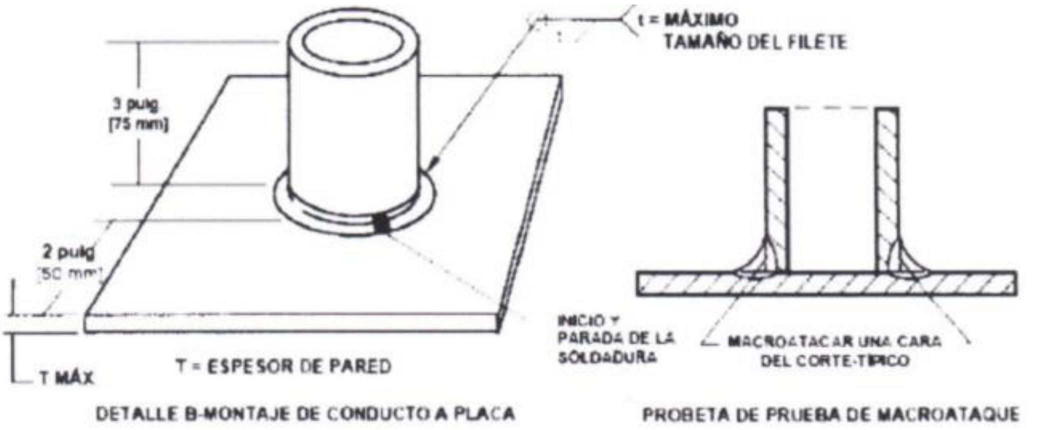


Figure 2. Macro attack test tube

Three macro attack tests will be performed for the squared tubular coupon weld to a metallic sheet.

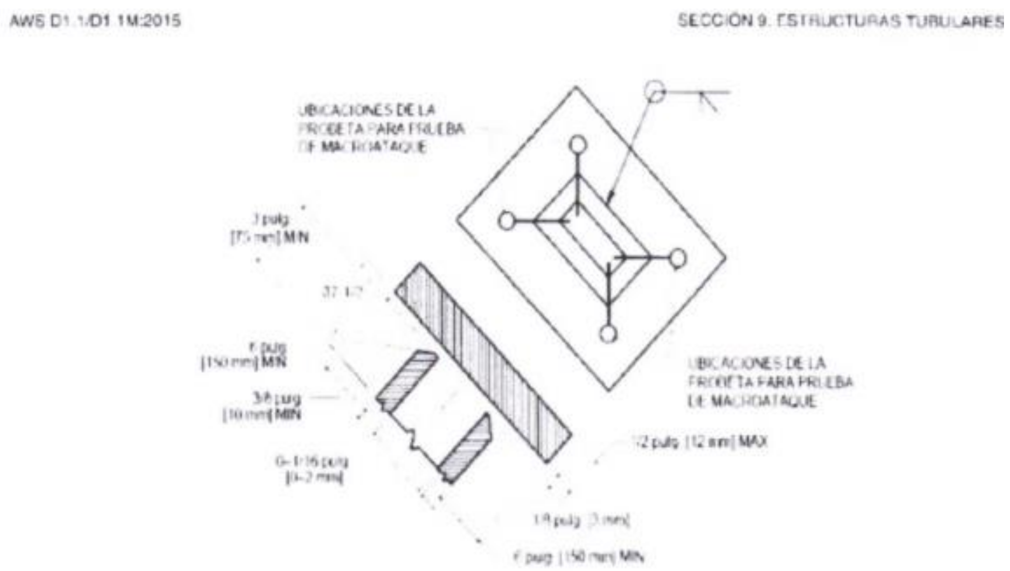


Fig. 3. Macro attack test in the corner joints

4. CALCULATION

4.1. Welding Chord Calculation

Since our model won't be used for works that demand permanent shear and axial forces because it is design to support its own weight and work as safety pole for bikes, considering that the effort of a person pulling a bike compared to the material and chord resistance is negligible.

According to the standard the minimum size of the welding fillet is the thickness of the thickest part, with a single pass.

e: 1/8'' = 3.175 mm = min. size of the fillet welding

Tabla 5.7
Tamaños mínimos de la soldadura en filete
(véase 5.13)

Espesor del metal base (T) [a]		Tamaño mínimo de la soldadura en filete [b]	
pulgadas	mm	pulgadas	mm
$T \leq 1/4$	$T \leq 6$	1/8 [c]	3 [c]
$1/4 < T \leq 1/2$	$6 < T \leq 12$	3/16	5
$1/2 < T \leq 3/4$	$12 < T \leq 20$	1/4	6
$3/4 < T$	$20 < T$	5/16	8

[a] En el caso de los procesos que no son de bajo hidrógeno y no tienen precalentamiento calculado de conformidad con 4.8.4, T es igual al espesor de la parte más gruesa unida, se deben utilizar soldaduras de pasada única.
Tanto en los procesos de bajo hidrógeno como en los que no lo son y están establecidos para evitar el agrietamiento de conformidad con 4.8.4, T es igual al espesor de la parte unida más delgada; no se aplica el requisito de pasada única.

[b] Excepto que no es necesario que el tamaño de la soldadura supere el espesor de la parte más delgada unida.

[c] El tamaño mínimo para las estructuras cargadas cíclicamente debe ser de 3/16 pulg. [5 mm]

5. PROCEDURE QUALIFICATION

5.1. WPS

WPS — ESPECIFICACION DEL PROCEDIMIENTO DE SOLDADURA

Nombre de la Empresa:	ISFIM	Identificación No.:	1
Proceso(s) de soldadura:	SMAW	Basado en el WPS No.:	1
TIPO:	Manual [x] Semiautomático [ ] Automático [ ]	Revisión: ____ Fecha: ____ Por: ____	
Soldador:		Tipo:	

DISEÑO DE LA UNION

Tipo de la unión: Junta en T
Tipo de soldadura: Sin Filete SIMPLE [x] DOBLE [ ]
Abertura de Raíz: Sin abertura
Longitud de cara de Raíz:
Angulo de ranura: Radio (J/U): ----------
Soporte: SI [ ] NO [x]
Material de soporte: ----------------------
Limpieza de raíz: SI [x] NO [ ] Método: Amoladora

POSICION

Ranura: ------ Filete: 2F
Plancha [x] Tubería [x]

CARACTERISTICAS ELECTRICAS

MODO DE TRANSFERENCIA (GMAW):
Corto Circuito [ ] Globular [ ] Spray [ ]
CORRIENTE: AC [ ] DCEP [ ]
PULSO [ ] DCEN [ ]
ELECTRODO DE TUNGSTENO:
Tipo:
Tamaño:

METALES BASE

	MB 1	MB 2
Grupo:	I	I
Especificaciones del Acero:	ASTM A36	ASTM A36
Grado:	1	1
Espesor de la plancha:		1/8 pulg.
Diámetro (tubería):	1 ½ pulg.	----------

TECNICA

Aportación: Recta [ ] Oscilante [ ]
Pase: Simple [ ] Múltiple [x]
Limpieza entre pases: Si [x] No [ ] Método: Amoladora

METAL DE APORTE

Especificación AWS: D1.1
Clasificación AWS: E6011 - E7018
Marca: INDURA
Tamaño del electrodo: 1/8 pulg.

PRECALENTAMIENTO

Temperatura de precalentamiento: 20 °C
Temperatura de interface: ---------

PROTECCION

Fundente: ------ Gas: ----
Composición: ----------
Velocidad de Flujo: ----------
Tamaño de la boquilla: -----------

POSTCALENTAMIENTO

Temperatura: -------------
Tiempo: ------------

PROCEDIMIENTO DE SOLDADURA

Pase	Proceso	Progresión	Metal de aporte		Corriente			Velocidad de alimentación del alambre (mm/min)	Velocidad de avance (cm/min)	Detalles de la unión Y Secuencia de soldadura
			Clase	Diam.	Tipo y Polaridad	Amperaje (Amp)	Voltaje (Volt)			
1	SMAW		E6011	3/32"	DECP	60	-		50	
2	SMAW		E7018	1/8"	DECP	90	-		40	

ELABORADO POR	Equipo N°1	FECHA	06/12/12
APROBADO POR		COMPAÑÍA	FIM-UNI

5.2. PQR

PQR	RESULTADO DE ENSAYOS

PRUEBAS DE TENSION

Probeta No.	Ancho (mm)	Espesor (mm)	Área Sección (mm2)	Carga de Fluencia (Kg)	Esfuerzo de Fluencia Espécimen (MPa)	Esfuerzo de Fluencia del metal base (MPa)	Localización de la rotura
--------	---------	--------	--------	--------	--------	--------	--------

ENSAYOS DE DOBLEZ GUIADO

TIPO	RESULTADO	TIPO	RESULTADO
DOBLEZ FILETE	Aprobado		
	Sin Grietas		

ENSAYO DE TENACIDAD (IMPACTO)

Probeta No.	Ubicación Entalla	Tamaño de Entalla	Temperatura de ensayo	Valores de impacto	Expansión Lateral % Corte/Mils	Ensayo de Caída de Peso	
						Rota	No Rota
--------	--------	--------	--------	--------	--------	--------	--------

INSPECCION VISUAL		ENSAYOS NO DESTRUCTIVOS	
APARIENCIA:	Falta de Penetración	ENSAYO DE RADIOGRAFIA	
SOCAVAMIENTO:	Exceso de Mordedura (1 mm)	RESULTADO ------	FECHA DE ENSAYO ----
POROSIDAD GRANDE:	Sin Porosidad	INSPECCIONADO POR:	-------
CONVEXIDAD	Aceptable	ENSAYO DE ULTRASONIDO	
FECHA DE ENSAYO:	27/06/2019	RESULTADO -----	FECHA DE ENSAYO -----
INSPECCIONADO POR:	-------	INSPECCIONADO POR:	------

Nombre soldador ----------- Identidad No. ------

Ensayos conducidos por: Ensayo de laboratorio No.

Certificamos que el contenido de este informe es correcto y que las pruebas de soldadura han sido preparadas, soldadas y ensayadas de acuerdo con los requerimientos del Código AWS B2.1

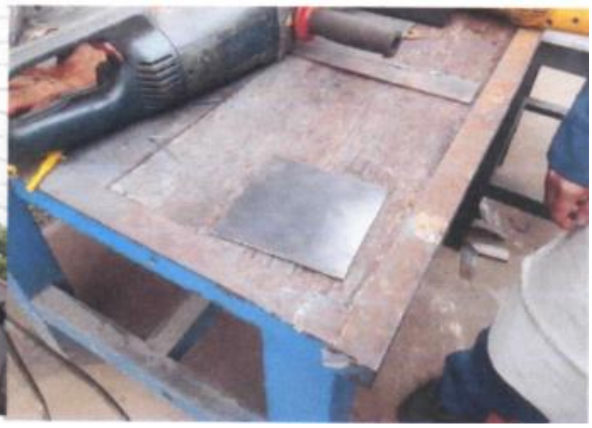
ELABORADO POR: -------- APROBADO POR: ------ FECHA: 27/06/19

5.3. Applying the qualified procedure

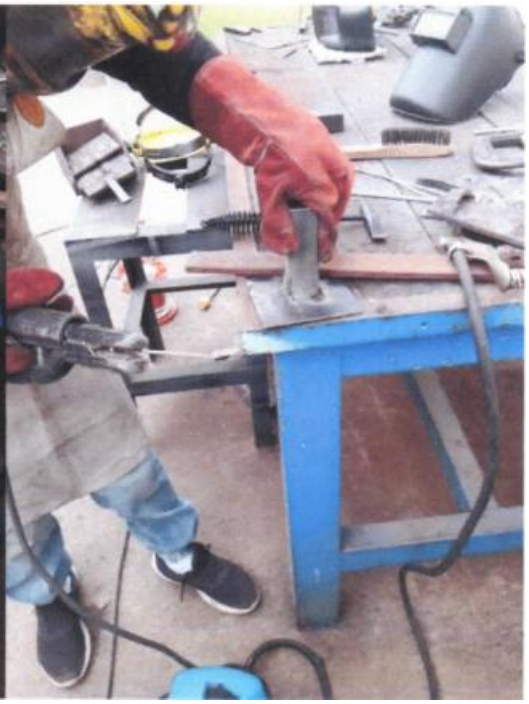
To perform the qualification of the qualified procedure, we followed the standards and procced to:

i. Prepare the steel tube A36.


ii. Acquire and prepare the sheet of the same material

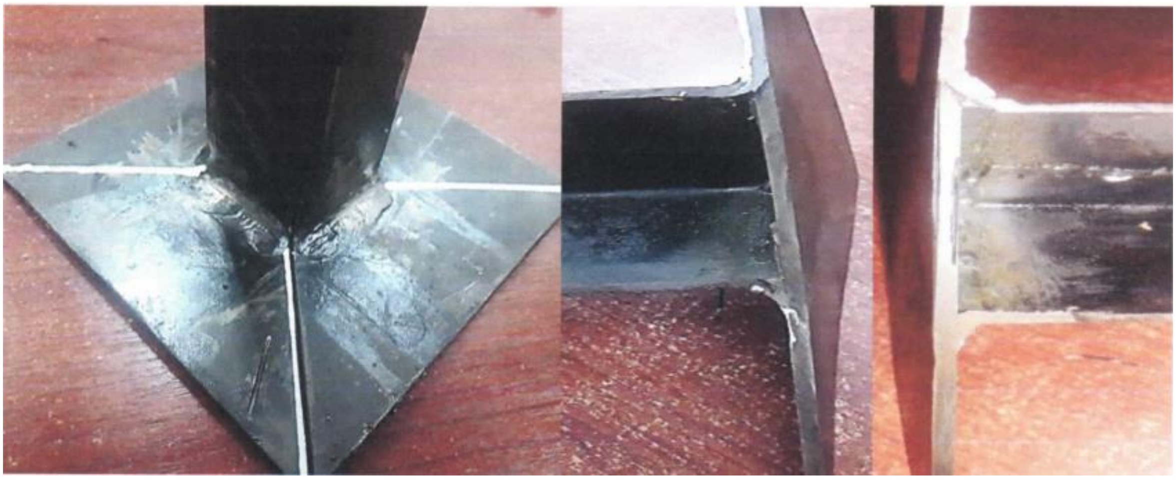



iii. Unite the tube and the sheet in 4 points.

iv. Unite the tube and the sheet, at the root and filling.

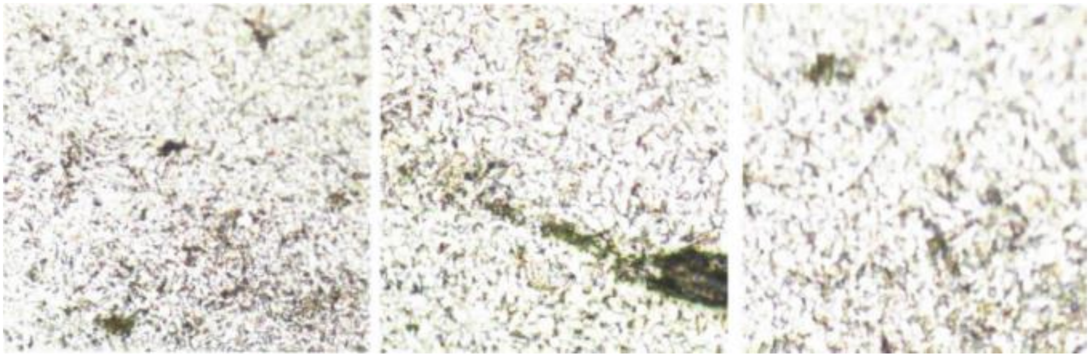
v. Prepare the test tubes.



MACRO ATTACK TEST

Chemical attach with Nital

Micrography



6. COSTS

Filler material cost: s/. 13.00 Electrodes cost.

E6011: s/. 11.4 per Kg.

It was used 24 E6011 electrodes and 20 E7018 electrodes, besides, the number of electrodes per kilogram is:

E6011: 74 electrodes/Kg, for a length of 300mm and 2.4mm of diameter.

E7018: 28 electrodes/Kg, for a length of 300mm and 3.2mm of diameter.

Then, the cost in *soles* of the used electrodes would be:

Total cost for electrodes would be: s/. 3.31

Cost of the welding personnel:

Welding payment per inch: s/. 5 per inch.

Length to weld: 110 inches.

Then the total cost for personnel: s/. 550

Materials Cost

The squared and circular beams of 5m and 10m respectively are observed, which equal to 15m.

We'd use 1 squared beam of 6m, its cost would be: 120*1 = s/. 120.00

We'd use 2 circular beam of 6m, its cost would be: 60*2 = s/. 120.00

TOTAL COST OF THE PROJECT

240 + 550 + 13*44 = s/. 1'362.00

7. CONCLUSIONS AND RECOMMENDATIONS

- The standards used to perform the procedures and qualifications of the WPS and PQR for fillet welding with structural beams, are: AWS D1.1 and AWS B2.1.
- The tests were done to qualify the WPS (macro attack), with results with excess in bite, greater than 1/32'' according to the standard, but we had a correct lateral and root fusion.
- The welded fillet size in the coupon is of 3.2mm which is greater that the minimum indicated by the standard 3mm.
- The preheating temperature was just at room temperature (20°C), which was verified by the hydrogen control method.
- It was decided to weld in two passes, uno for the root (E6011) and the other for the filler (E7018) with a diameter of 1/8''.
- The cleaning in the first and last passes were done with a grinder with a brush equipped and to perform the cleaning between each pass it was used a roughing disc to eliminate any type of slag and dirt which would be shown in the macro attack test.

- It is recommended to ease the preparation of the test tube for the macro attack, that the face to prepare to have a certain small concavity, which outstands the union for an easy sanding and polishing in the rotatory machine with alumina and procced with the chemical attack with Nital.
- It is verified that there is no Widmanstatten structure and that the structures are similar, the welding and the base material.
- The macho attack test shows an imperfection for the lack of penetration in the root, which would be fixed with a slower speed.