# BAB VI

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# DAFTAR LAMPIRAN

## Lampiran I Surat Permohonan Ijin Penelitian

KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN
UNIVERSITAS HASANUDDIN
**FAKULTAS TEKNIK**
**PROGRAM MAGISTER TEKNIK MESIN**
Jalan Poros Malino Km. 6 Bontomarannu Gowa, 90245, Sulawesi Selatan
☎ (0411) 586015, 586262 Fax (0411) 586015.
http://eng.unhas.ac.id. E-mail:teknik@unhas.ac.id

| | | |
|---|---|---|
| Nomor | : 9195/UN4.7.8/PT.01.04/2020 | 16 Juli 2020 |
| Lamp. | : -- | |
| Hal | : **Permohonan Izin Penelitian/ Pengambilan Data** | |

Kepada Yth.
Project Manager PT. WASA MITRA
ENGINEERING
Proyek SULSEL BARRU-2
COAL FIRED STEAM POWER PLANT
(1x100MW)
Barru

Dengan hormat, dengan ini kami sampaikan bahwa mahasiswa yang namanya tercantum dibawah ini :

| | |
|---|---|
| Nama | : Amal Ali Gazali |
| Stambuk | : D022181002 |
| Program Pendidikan | : S2 (Magister) |
| Program Studi | : Teknik Mesin |
| Konsentrasi | : Konstruksi Mesin |

Bermaksud melakukan penelitian/ pengambilan data dalam rangka penulisan tesis dengan judul : **"Analisa Pengaruh Post Weld Heat Treatment (PWHT) Terhadap Kombinasi Pengelasan Smaw-Gtaw Pada Pipa Baja Karbon SA-106B".**

Pembimbing : - Prof. Dr. Ir. Onny Sutresman, MT
- Dr. Muhammad Syahid, ST. MT

Atas Perhatian dan kerjasama yang baik, kami ucapkan terima kasih.

Ketua Program Studi Magister Teknik Mesin,

Dr. Hairul Arsyad, S.T., M.T
NIP. 197503222002121001

**Lampiran II WPS & PQR (Welding Procedure Specifikation and Procedure Qualifikation Record)**

# P.T. WASA MITRA ENGINEERING

Jl. Raya Cakung Cilincing Km. I No. 11, Jakarta Timur 13910 Phone : (62) 021-4404958 (hunting) Fax : (62) 021-4400040

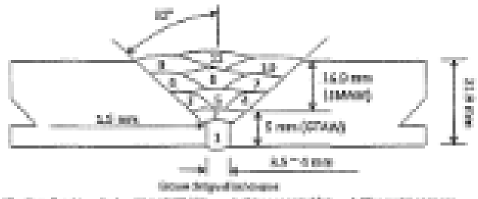
Certificate No. ID07 / 0831

According to ASME Section IX : 2011a

PROCEDURE QUALIFICATION RECORDS ( PQR )
( See QW-200.2, Section IX, ASME Boiler and Pressure Vessel Code )
Record Actual Conditions Used to Weld Test Coupon

Company Name : PT. WASA MITRA ENGINEERING
Procedure Qualification Record No. : 120 / CST / PQR / WME / ASME / 14 Date : 17 July 2014
WPS No. : 120 / CST / WPS / WME / ASME / 14
Welding Process (es) : GTAW + SMAW
TYPE (Manual, Automatic, Semi-Automatic) : MANUAL

**JOINT (QW - 402 )**




(For combination qualification, the deposited weld metal thickness shall be recorded for each filler metal or process used)

**BASE METALS ( QW - 403 )**

Material Spec. : SA-106 Gr. B
To Material Spec. : SA-106 Gr. B
P. No. : 1 Group 1 to P. No. 1 Group 1
Thickness of test coupon : 21.3 mm
Diameter of test coupon : 8"
Maximum Pass Thickness : 5 mm
Other : N/A

**POST WELD HEAT TREATMENT ( QW - 407 )**

Temperature : 630 °C
Time : 1.1 hour
Other : N/A

**GAS ( QW - 408 )**

| | Percent Composition | | |
|---|---|---|---|
| | Gas (es) | (Mixture) | Flow Rate |
| Shielding | Argon | 99.99% | 8 ~ 10 l/min |
| Trailing | N/A | N/A | N/A |
| Backing | N/A | N/A | N/A |

**FILLER METALS ( QW - 404 )**

| | GTAW | SMAW |
|---|---|---|
| SFA Specification | 5.18 | 5.1 |
| AWS Classification | ER 70 SG | E 7016 |
| Filler Metal F No. | 6 | 4 |
| A - No. | 1 | 1 |
| Size of Filler Metal | 2.4 | 3.2 |
| Filler Metal Product Form | Solid | Solid |
| Weld Metal Thickness | 5 mm | 16.3 mm |
| Supplemental Filler Metal | N/A | N/A |
| Electrodes Flux (Class) | N/A | N/A |
| Flux Type | N/A | N/A |
| Flux Trade Name | N/A | N/A |
| Other | N/A | N/A |

**ELECTRICAL CHARACTERISTICS ( QW - 409 )**

Tungsten Electrode Size : 2W Th. ø 2.4 mm
Heat Input (max.) : N/A
Mode of Metal Transfer for GMAW (FCAW) : N/A
Other : N/A

**TECHNIQUE ( QW - 410 )**

String or Weave Bead : String & Weave
Oscillation : N/A
Multiple or Single pass (per side) : Multiple Pass
Single or Multiple Electrode : Single
Other : 2% Thoriated

**POSITION ( QW - 405 )**

Position of Groove : 6 G
Weld Progression (Uphill, Downhill) : UPHILL
Other : N/A

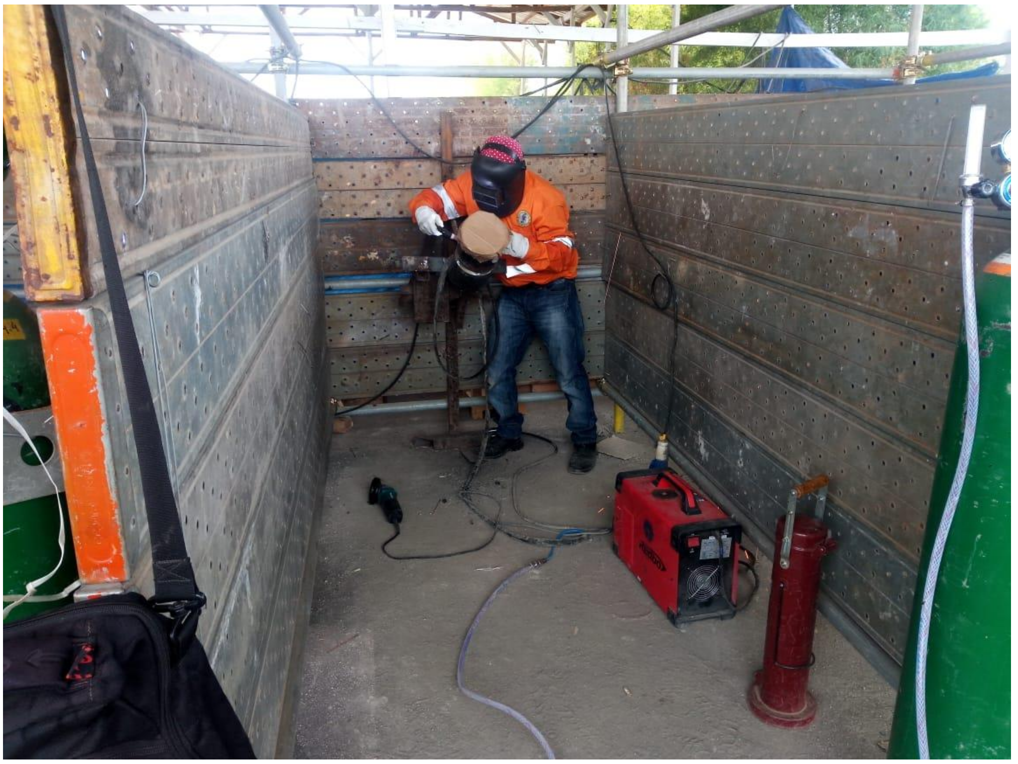
**PREHEAT ( QW - 406 )**

Preheat temperature : 30 °C (Ambient)
Interpass Temp. Max. : 300 °C
Other : N/A

| Weld Layers | Process | Filler metal | | Current type and Polarity | Amps. | Volts | Travel Speed (mm/min) | Interpass temp. ( °C ) | Weld Deposit Thickness (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | | Class | Dia. (mm) | | | | | | |
| Root pass | GTAW | ER70S-G | 2.4 | DC-SP | 85 | 10 | 50 ~ 80 | Max. 300 | 5 mm |
| Hot pass | GTAW | ER70S-G | 2.4 | DC-SP | 155 | 10 | 50 ~ 80 | | |
| Filler | SMAW | E7016 | 3.2 | DC-RP | 85 ~ 105 | 16 | 50 ~ 100 | | 16.3 mm |
| Cap | SMAW | E7016 | 3.2 | DC-RP | 85 ~ 95 | 16 | 50 ~ 100 | | |
| | | | | | | | | | |
| | | | | | | | | | |

1 / 2

**Lampiran III Proses pengelasan pipa baja karbon SA-106 B**



Proses pengelasan kombinasi SMAW-GTAW posisi 6G


Pipa SA-106 B pengelasan kombinasi SMAW-GTAW

**Lampiran IV Proses pemotongan pipa baja karbon SA-106 B**


Pemotongan pipa hasil pengelasan kombinasi SMAW-GTAW

**Lampiran V Spesimen struktur mikro**

# Lampiran VI Spesimen dan hasil pengujian komposisi kimia

FMX 52V0001    Optik 52V0041
Sample    :Specimen I
Alloy    : FE_150
Mode    : GS 19/12/2021 13:54:20

| | Fe | C | Si | Mn | P | S | Cr |
|---|---|---|---|---|---|---|---|
| 1 | 98.4 | 0.195 | 0.341 | 0.629 | 0.0217 | 0.0012 | L 0.170 |
| 2 | 87.8 | 0.101 | 0.298 | H 1.92 | 0.0103 | < 0.0010 | H 6.00 |
| 3 | 88.5 | L 0.0752 | 0.265 | H 1.54 | 0.0105 | < 0.0010 | H 6.00 |

| | Mo | Ni | Al | Co | Cu | Nb | Ti |
|---|---|---|---|---|---|---|---|
| 2 | L 0.0179 | 0.0520 | < 0.0010 | 0.0102 | 0.0925 | < 0.0005 | 0.0054 |
| 4 | H 0.934 | 0.831 | 0.0043 | 0.0051 | 0.0189 | 0.0169 | 0.0046 |
| 5 | H 0.883 | 0.768 | 0.0021 | 0.0050 | 0.0194 | 0.0186 | 0.0040 |

| | V | W | Pb | Sn | B | Zr | Zn |
|---|---|---|---|---|---|---|---|
| 2 | 0.0028 | 0.0455 | 0.0063 | 0.0050 | < 0.0004 | 0.0008 | 0.0007 |
| 4 | 0.205 | 0.0526 | 0.0218 | < 0.0010 | < 0.0004 | < 0.0005 | 0.0076 |
| 5 | 0.192 | 0.0413 | 0.0183 | < 0.0010 | < 0.0004 | < 0.0005 | 0.0081 |

FMX 52V0001 Optik 52V0041
Sample :Spesimen II
Alloy : FE_150
Mode : GS 19/12/2021 14:25:19

| | Fe | C | Si | Mn | P | S | Cr |
|---|---|---|---|---|---|---|---|
| 1 | 98.5 | 0.117 | 0.328 | 0.612 | 0.0202 | 0.0014 | L 0.168 |
| 2 | 98.6 | 0.0247 | 0.311 | 0.594 | 0.0207 | 0.0011 | L 0.179 |
| 3 | 88.5 | 0.0507 | 0.262 | 1.64 | 0.0101 | < 0.0010 | L 7.50 |

| | Mo | Ni | Al | Co | Cu | Nb | Ti |
|---|---|---|---|---|---|---|---|
| 1 | 0.0176 | L 0.0509 | 0.0011 | 0.0072 | 0.0942 | < 0.0005 | 0.0043 |
| 2 | 0.0187 | L 0.0534 | 0.0066 | 0.0083 | 0.0949 | < 0.0005 | 0.0046 |
| 3 | 0.905 | L 0.762 | 0.0054 | 0.0051 | 0.0200 | 0.0178 | 0.0035 |

| | V | W | Pb | Sn | B | Zr | Zn |
|---|---|---|---|---|---|---|---|
| 1 | 0.0027 | 0.0377 | 0.0046 | 0.0048 | < 0.0004 | < 0.0005 | < 0.0005 |
| 2 | 0.0033 | 0.0458 | 0.0053 | 0.0042 | < 0.0004 | < 0.0005 | < 0.0005 |
| 3 | 0.193 | 0.0505 | 0.0186 | < 0.0010 | < 0.0004 | < 0.0005 | 0.0065 |

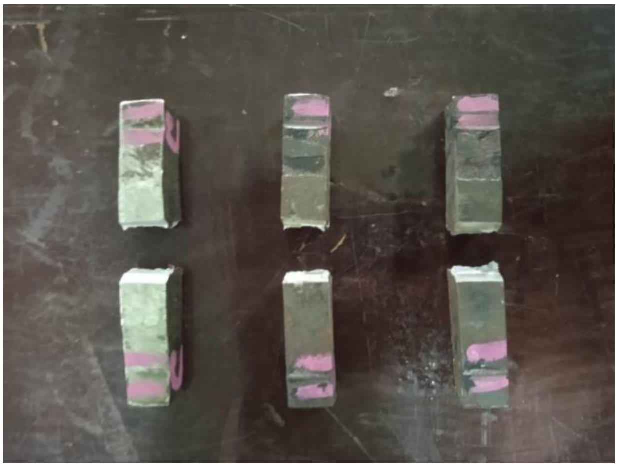
FMX 52V0001 Optik 52V0041
Sample :Spesimen III
Alloy : FE_150
Mode : GS 19/12/2021 13:03:58

| | Fe | C | Si | Mn | P | S | Cr |
|---|---|---|---|---|---|---|---|
| 1 | 98.1 | 0.297 | 0.450 | 0.642 | 0.0181 | 0.0042 | L 0.203 |
| 2 | 88.4 | L 0.0815 | 0.266 | H 1.63 | 0.0106 | < 0.0010 | H 6.00 |
| 3 | 88.6 | L 0.0738 | 0.233 | H 1.61 | 0.0105 | < 0.0010 | H 6.00 |

| | Mo | Ni | Al | Co | Cu | Nb | Ti |
|---|---|---|---|---|---|---|---|
| 1 | L 0.0179 | 0.0445 | 0.0228 | 0.0060 | 0.0748 | < 0.0005 | 0.0064 |
| 2 | H 0.889 | 0.704 | 0.0084 | 0.0018 | 0.0185 | 0.0129 | 0.0038 |
| 3 | H 0.857 | 0.699 | 0.0064 | 0.0056 | 0.0182 | 0.0149 | 0.0039 |

| | V | W | Pb | Sn | B | Zr | Zn |
|---|---|---|---|---|---|---|---|
| 1 | 0.0037 | 0.0615 | 0.0062 | 0.0047 | < 0.0004 | < 0.0005 | < 0.0005 |
| 2 | 0.182 | 0.0266 | 0.0157 | < 0.0010 | < 0.0004 | < 0.0005 | 0.0077 |
| 3 | 0.180 | 0.0551 | 0.0160 | < 0.0010 | < 0.0004 | < 0.0005 | 0.0071 |

**Lampiran VII Hasil pengujian impak**



# LABORATORIUM METALURGI FISIK

KEMENTRIAN RISET,DAN TEKNOLOGI

FAKULTAS TEKNIK UNIVERSITAS HASANUDDIN

Jalan Poros Malino KM, 6 Bontomarannu Gowa, 92171, Sulawesi Selatan

Gowa, 20 Desember 2021

**Nama :** Amal Ali Gazali

**PENGUJIAN IMPACT**

Massa Bandul (300 J)
Panjang Pandul (850 mm)
Sudut Angkat α (150°)

| Perlakuan | Spec | L | T | IG (Joule) | Taugness( J/cm2) |
|---|---|---|---|---|---|
| 650° C | 1a | 9.45 | 8.58 | 37.62 | 46.40 |
| | 1b | 9.85 | 7.81 | 22.80 | 29.64 |
| | 1c | 11.21 | 9.24 | 61.78 | 59.64 |
| 850° C | 2a | 9.51 | 9.20 | 70.77 | 80.89 |
| | 2b | 9.60 | 9.48 | 97.08 | 106.67 |
| | 2c | 10.70 | 8.40 | 79.00 | 87.89 |
| Non PWHT | 3a | 10.70 | 9.34 | 58.84 | 58.88 |
| | 3b | 10.37 | 6.80 | 35.03 | 49.68 |
| | 3c | 10.90 | 7.81 | 47.47 | 55.76 |

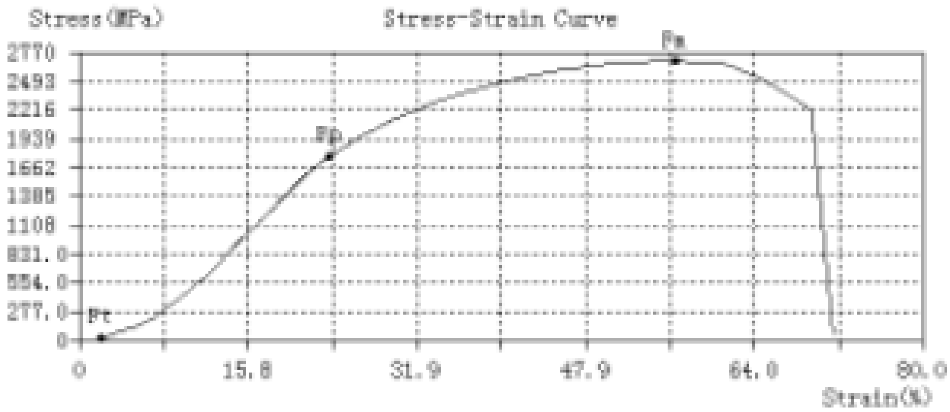
Kepala Laboratorium
Metalurgi Fisisk

Dr. Lukmanul Hakim, ST., MT
Nip.197404151999031001

## Lampiran VIII Spesimen hasil pengujian tarik

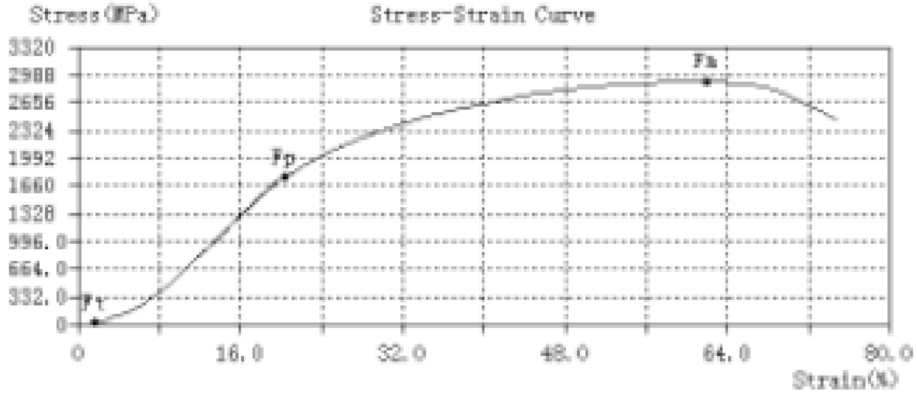
SA 106 GR B Non PWHT 2

| SampleID | SA 106 GR B Non P | TestDate | 2/12/2020 |
|---|---|---|---|
| Operator | WHT 2 | Type | Flat |
| Size(mm) | 14.5*12.5 | Ao(mm²) | 181.25 |
| Lo(mm) | 50 | Lu(mm) | |
| A(%) | / | Au(mm²) | |
| Z(%) | / | Fm(kN) | 88.25 |
| Rm(MPa) | 485 | FeH(kN) | / |
| UYS(MPa) | / | FeL(kN) | / |
| LYS(MPa) | / | Fp(kN) | 58.25 |
| Rp(MPa) | 320 | Ft(kN) | / |
| Rt(MPa) | / | E(GPa) | 3.68 |



## SA 106 GR B 650 PWHT 2

| | | | |
|---|---|---|---|
| SampleID | SA 106 GR B 650 | TestDate | 2/12/2020 |
| Operator | PWHT 2 | Type | Flat |
| Size(mm) | 14.5*12.5 | Ao(mm²) | 181.25 |
| Lo(mm) | 50 | Lu(mm) | |
| A(%) | / | Au(mm²) | |
| Z(%) | / | Fm(kN) | 95.35 |
| Rm(MPa) | 525 | FeH(kN) | / |
| UYS(MPa) | / | FeL(kN) | / |
| LYS(MPa) | / | Fp(kN) | 57.75 |
| Rp(MPa) | 320 | Ft(kN) | / |
| Rt(MPa) | / | E(GPa) | 4.20 |




## SA 106 GR B 850 PWHT 2

| | | | |
|---|---|---|---|
| SampleID | SA 106 GR B 850 | TestDate | 2/12/2020 |
| Operator | PWHT 2 | Type | Flat |
| Size(mm) | 14.5*12.5 | Ao(mm²) | 181.25 |
| Lo(mm) | 50 | Lu(mm) | |
| A(%) | / | Au(mm²) | |
| Z(%) | / | Fm(kN) | 88.40 |
| Rm(MPa) | 490 | FeH(kN) | 56.25 |
| UYS(MPa) | 310 | FeL(kN) | 54.80 |
| LYS(MPa) | 300 | Fp(kN) | 51.65 |
| Rp(MPa) | 285 | Ft(kN) | / |
| Rt(MPa) | / | E(GPa) | 4.25 |