LAMPIRAN A

PERHITUNGAN

Lampiran A. Contoh Perhitungan

1. *Burn Off Length (*ΔL*)*

$$L_0\text{-}L_1=\Delta L$$

Ket :
L_0 : Panjang Awal
L_1 : Panjang Akhir
ΔL: *Burn Off Length*

Contoh Perhitungan:

Sample pada Tabel 4.1 no 1 : 140 mm – 125,4 mm : 14,6 mm

2. *Flash (*V*)*

$$V=\pi r^2 \times \Delta L$$

Ket:

V : Volume tabung
π : nilai 3,14
r : jari jari lingkaran
ΔL :*burn off length*

Contoh perhitungan:

$$V=3{,}14 \times 6^2 \times 14{,}6$$
$$V = 1650{,}38\ mm^3$$

3. Kekuatan Tarik (MPa)

a. $$\sigma = \frac{F}{A}$$

b. $$A= \pi \times (D_0 \div 2)^2$$

Ket:

F = Gaya yang diterima (dapat dilihat pada lampiran B.6)
A = Alas pada sampel (dapat dilihat pada lampiran B.5)
π = nilai 3,14
D_0 = Diameter awal sampel

Contoh perhitungan:

$$A= 3{,}14 \times (11{,}91 \div 2)^2$$

$$A=111{,}351\ mm^2$$

$$MPa=\frac{8{,}8 \times 1000}{111{,}351}$$

$$MPa=79{,}0$$

4. Kalibrasi bar ke *newton*
   a. Interpolasi

$$y(n_x)=n_1+\frac{(n_x-n_1)}{(n_2-n_1)} \times (n_2-n_1)$$

ket :
n_1 dan n_2 : titik data yang diketahui
n_x : nilai yang ingin diinterpolasi
y : hasil interpolasi

Contoh perhitungan

$$y(80)=435{,}5+\frac{(80-15)}{(30-15)} \times (2116{,}7-435{,}5)$$

80 bar = 7730 N

$$y(100)=435{,}5+\frac{(100-15)}{(30-15)} \times (2116{,}7-435{,}5)$$

100 bar = 9710 N

5. Kalibrasi *newton* ke Mpa ≈ (P)

$$P=\frac{F}{A}$$

Ket
P = Tekanan yang dihasilkan
F = Gaya hasil ekstrapolasi
A = Diameter batang hidrolik (113,0972 mm^2)

Contoh perhitungan

$$P=\frac{2116{,}7500}{113{,}0972}$$

$$P=18{,}7161\ (19\ MPa)$$

6. Rumus presentase efesiensi kekuatan tarik

$$e\ (\%): \left(\frac{\sigma_1}{\sigma_0} \right) \times 100\%$$

Ket
σ_1 = Data hasil uji tarik
σ_0 = Data base metal uji tarik
Contoh perhitungan :

a. Efisiensi nilai tertinggi dari pengujian tarik

$$e\ \% = \frac{123{,}7\ \text{MPa}}{227\ \text{MPa}} \times 100\%$$

$$= 54{,}47\ \%$$

7. Rumus presentase efesiensi kekuatan tarik

$$e\ (\%): \left(\frac{HVN_1}{HVN_0} \right) \times 100\%$$

Ket
HVN_1 = Data hasil uji kekerasan
HVN_0 = Data base metal uji kekerasan
Contoh perhitungan :

a. Efisiensi nilai tertinggi dari pengujian kekerasan

$$e\ \% = \frac{88{,}2\ \text{HVN}}{83\ \text{HVN}} \times 100\%$$

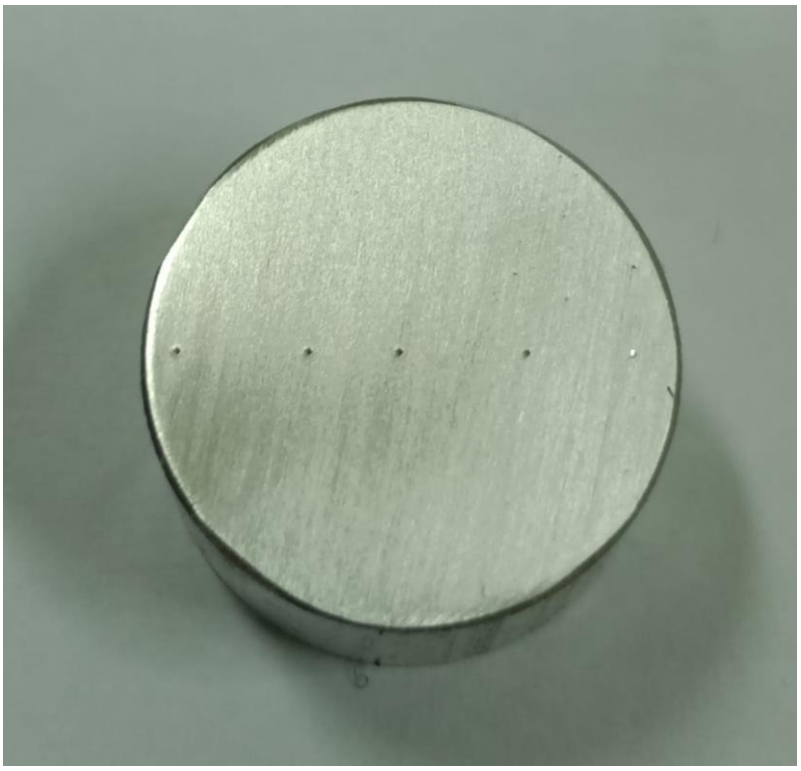
$$= 106{,}27\ \%$$

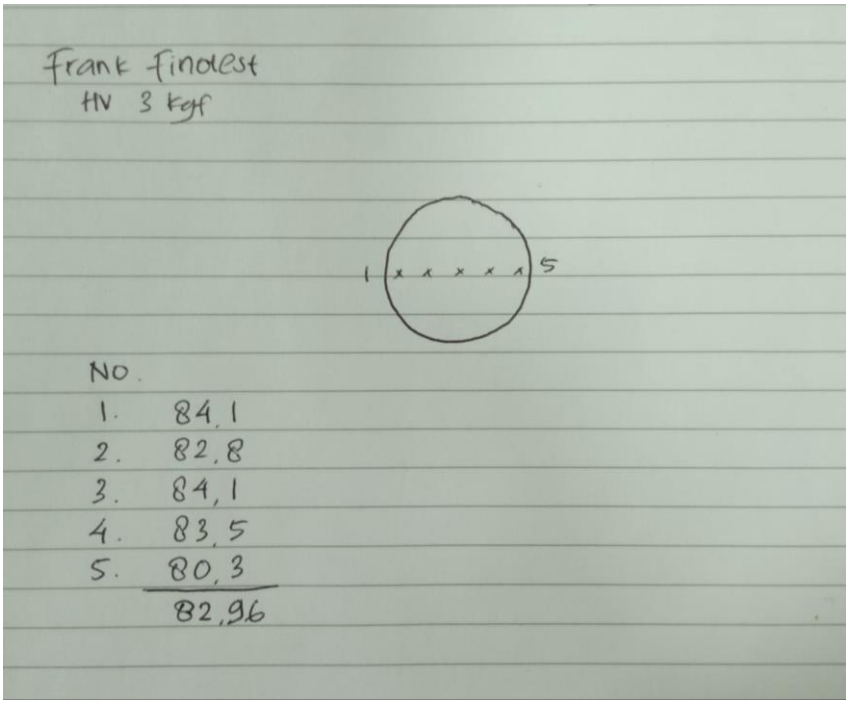
LAMPIRAN B

DATA PENELITIAN

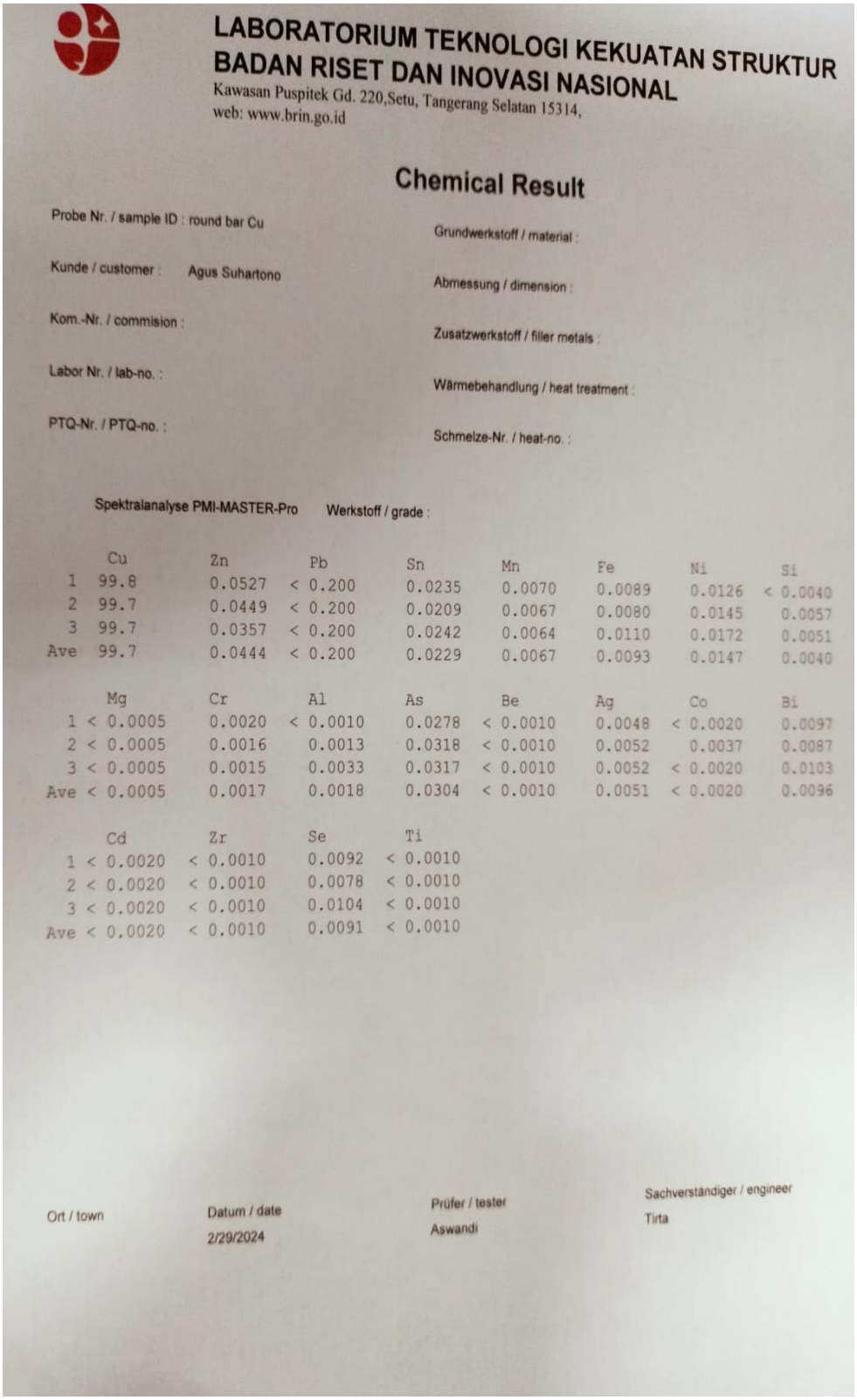
Lampiran B. Data Penelitian

B.1 Kekerasan *Base Material* Aluminium 6063





B.2 Komposisi Material Tembaga



LABORATORIUM TEKNOLOGI KEKUATAN STRUKTUR
BADAN RISET DAN INOVASI NASIONAL
Kawasan Puspitek Gd. 220,Setu, Tangerang Selatan 15314,
web: www.brin.go.id

Chemical Result

Probe Nr. / sample ID : round bar Cu
Grundwerkstoff / material :

Kunde / customer : Agus Suhartono
Abmessung / dimension :

Kom.-Nr. / commision :
Zusatzwerkstoff / filler metals :

Labor Nr. / lab-no. :
Wärmebehandlung / heat treatment :

PTQ-Nr. / PTQ-no. :
Schmelze-Nr. / heat-no. :

Spektralanalyse PMI-MASTER-Pro Werkstoff / grade :

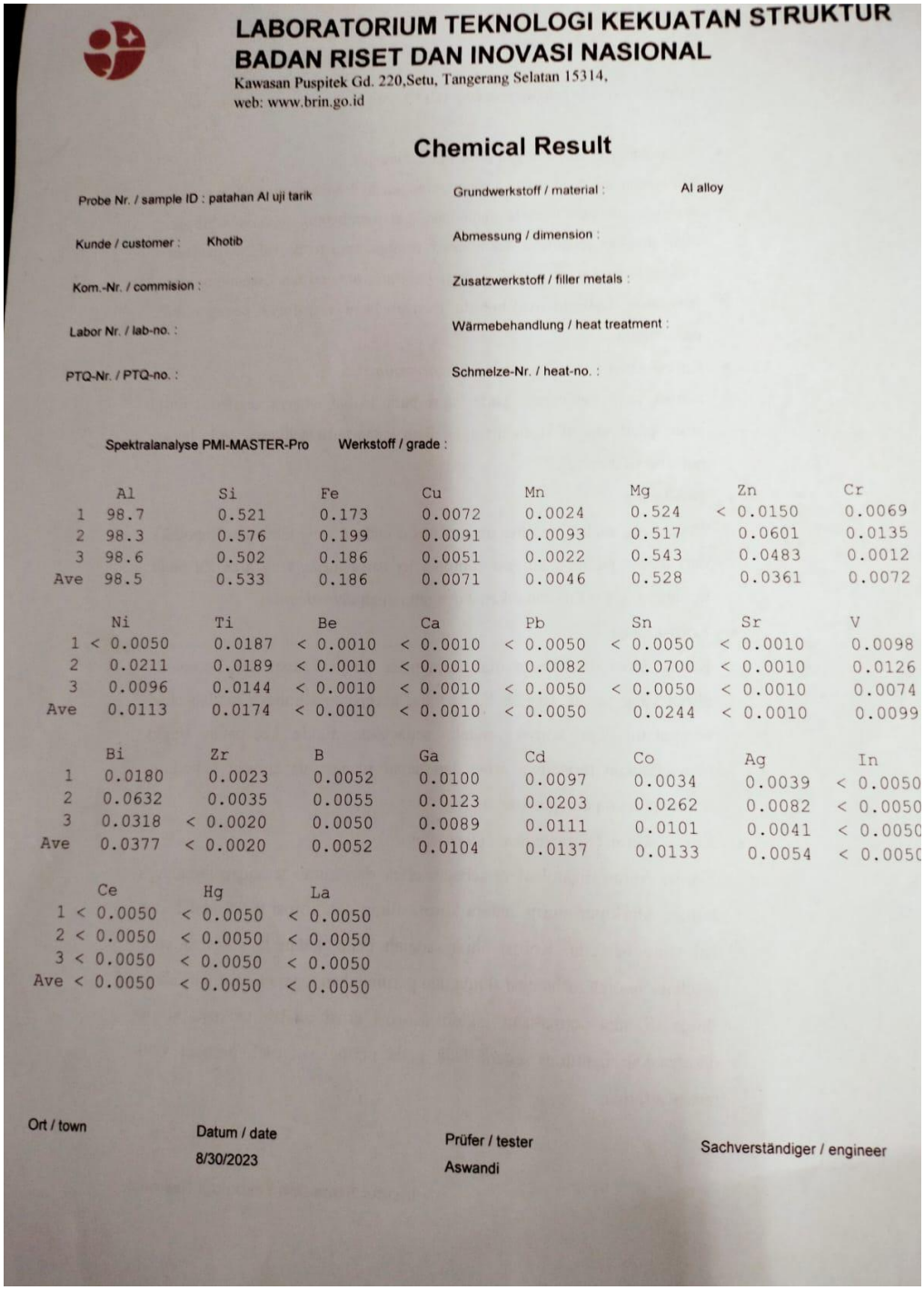
	Cu	Zn	Pb	Sn	Mn	Fe	Ni	Si
1	99.8	0.0527	< 0.200	0.0235	0.0070	0.0089	0.0126	< 0.0040
2	99.7	0.0449	< 0.200	0.0209	0.0067	0.0080	0.0145	0.0057
3	99.7	0.0357	< 0.200	0.0242	0.0064	0.0110	0.0172	0.0051
Ave	99.7	0.0444	< 0.200	0.0229	0.0067	0.0093	0.0147	0.0040

	Mg	Cr	Al	As	Be	Ag	Co	Bi
1	< 0.0005	0.0020	< 0.0010	0.0278	< 0.0010	0.0048	< 0.0020	0.0097
2	< 0.0005	0.0016	0.0013	0.0318	< 0.0010	0.0052	0.0037	0.0087
3	< 0.0005	0.0015	0.0033	0.0317	< 0.0010	0.0052	< 0.0020	0.0103
Ave	< 0.0005	0.0017	0.0018	0.0304	< 0.0010	0.0051	< 0.0020	0.0096

	Cd	Zr	Se	Ti
1	< 0.0020	< 0.0010	0.0092	< 0.0010
2	< 0.0020	< 0.0010	0.0078	< 0.0010
3	< 0.0020	< 0.0010	0.0104	< 0.0010
Ave	< 0.0020	< 0.0010	0.0091	< 0.0010

Ort / town
Datum / date
2/29/2024
Prüfer / tester
Aswandi
Sachverständiger / engineer
Tirta

B.3 Komposisi Material Aluminium 6063



LABORATORIUM TEKNOLOGI KEKUATAN STRUKTUR
BADAN RISET DAN INOVASI NASIONAL
Kawasan Puspitek Gd. 220,Setu, Tangerang Selatan 15314,
web: www.brin.go.id

Chemical Result

Probe Nr. / sample ID : patahan Al uji tarik
Grundwerkstoff / material : Al alloy
Kunde / customer : Khotib
Abmessung / dimension :
Kom.-Nr. / commision :
Zusatzwerkstoff / filler metals :
Labor Nr. / lab-no. :
Wärmebehandlung / heat treatment :
PTQ-Nr. / PTQ-no. :
Schmelze-Nr. / heat-no. :

Spektralanalyse PMI-MASTER-Pro Werkstoff / grade :

	Al	Si	Fe	Cu	Mn	Mg	Zn	Cr
1	98.7	0.521	0.173	0.0072	0.0024	0.524	< 0.0150	0.0069
2	98.3	0.576	0.199	0.0091	0.0093	0.517	0.0601	0.0135
3	98.6	0.502	0.186	0.0051	0.0022	0.543	0.0483	0.0012
Ave	98.5	0.533	0.186	0.0071	0.0046	0.528	0.0361	0.0072

	Ni	Ti	Be	Ca	Pb	Sn	Sr	V
1	< 0.0050	0.0187	< 0.0010	< 0.0010	< 0.0050	< 0.0050	< 0.0010	0.0098
2	0.0211	0.0189	< 0.0010	< 0.0010	0.0082	0.0700	< 0.0010	0.0126
3	0.0096	0.0144	< 0.0010	< 0.0010	< 0.0050	< 0.0050	< 0.0010	0.0074
Ave	0.0113	0.0174	< 0.0010	< 0.0010	< 0.0050	0.0244	< 0.0010	0.0099

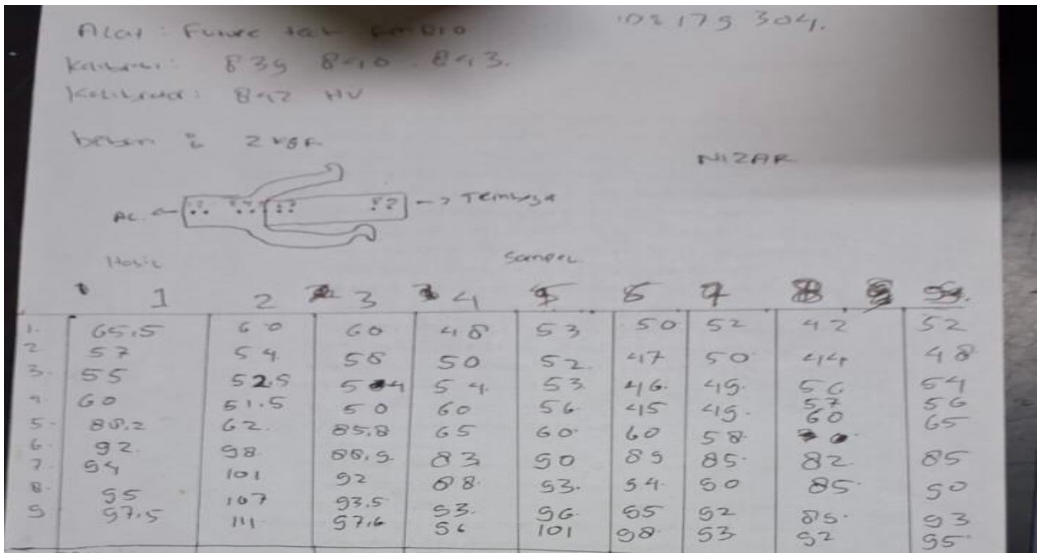
	Bi	Zr	B	Ga	Cd	Co	Ag	In
1	0.0180	0.0023	0.0052	0.0100	0.0097	0.0034	0.0039	< 0.0050
2	0.0632	0.0035	0.0055	0.0123	0.0203	0.0262	0.0082	< 0.0050
3	0.0318	< 0.0020	0.0050	0.0089	0.0111	0.0101	0.0041	< 0.0050
Ave	0.0377	< 0.0020	0.0052	0.0104	0.0137	0.0133	0.0054	< 0.0050

	Ce	Hg	La
1	< 0.0050	< 0.0050	< 0.0050
2	< 0.0050	< 0.0050	< 0.0050
3	< 0.0050	< 0.0050	< 0.0050
Ave	< 0.0050	< 0.0050	< 0.0050

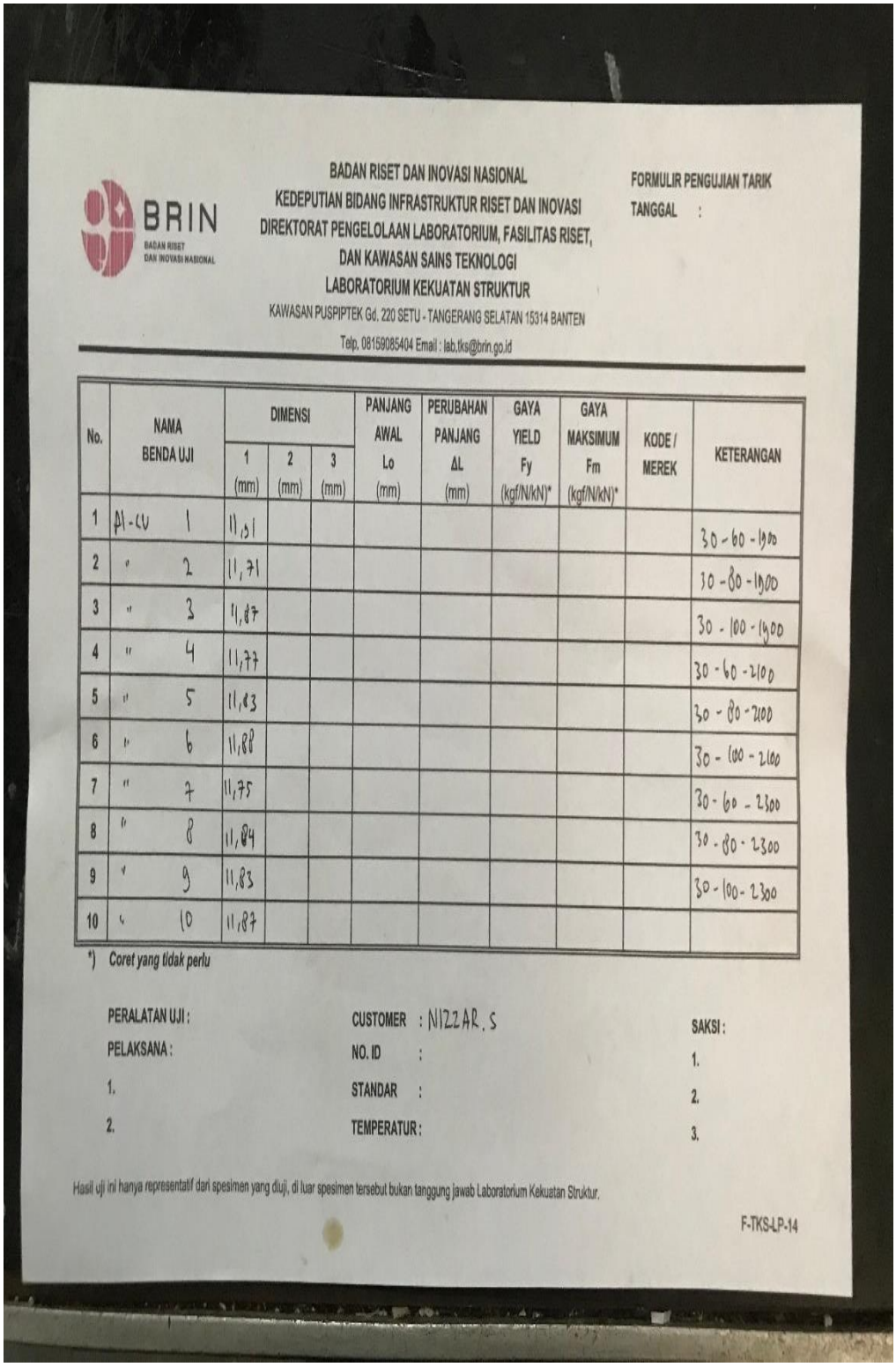
Ort / town
Datum / date 8/30/2023
Prüfer / tester Aswandi
Sachverständiger / engineer

B.4 Data Uji kekerasan

	1	2	3	4	5	6	7	8	9
1	65,5	60	60	48	53	50	52	42	52
2	57	54	58	50	52	47	50	44	48
3	55	52,5	54	54	53	46	49	56	54
4	60	51,5	50	60	56	45	49	57	56
5	88,2	62	85,8	65	60	60	58	60	65
6	92	98	88,9	83	90	89	85	82	85
7	94	101	92	88	93	94	90	85	90
8	95	107	93,5	93	96	95	92	89	93
9	97,5	111	97,6	96	101	98	93	92	95



B.5 Data Sebelum Uji Tarik



BRIN
BADAN RISET DAN INOVASI NASIONAL

BADAN RISET DAN INOVASI NASIONAL
KEDEPUTIAN BIDANG INFRASTRUKTUR RISET DAN INOVASI
DIREKTORAT PENGELOLAAN LABORATORIUM, FASILITAS RISET, DAN KAWASAN SAINS TEKNOLOGI
LABORATORIUM KEKUATAN STRUKTUR
KAWASAN PUSPIPTEK Gd. 220 SETU - TANGERANG SELATAN 15314 BANTEN
Telp. 08159085404 Email : lab.tks@brin.go.id

FORMULIR PENGUJIAN TARIK
TANGGAL :

No.	NAMA BENDA UJI	DIMENSI 1 (mm)	DIMENSI 2 (mm)	DIMENSI 3 (mm)	PANJANG AWAL Lo (mm)	PERUBAHAN PANJANG ΔL (mm)	GAYA YIELD Fy (kgf/N/kN)*	GAYA MAKSIMUM Fm (kgf/N/kN)*	KODE / MEREK	KETERANGAN
1	P1-CU 1	11,51								30-60-1900
2	" 2	11,71								30-80-1900
3	" 3	11,87								30-100-1900
4	" 4	11,77								30-60-2100
5	" 5	11,83								30-80-2100
6	" 6	11,88								30-100-2100
7	" 7	11,75								30-60-2300
8	" 8	11,84								30-80-2300
9	" 9	11,83								30-100-2300
10	" 10	11,87								

*) Coret yang tidak perlu

PERALATAN UJI :
PELAKSANA :
1.
2.

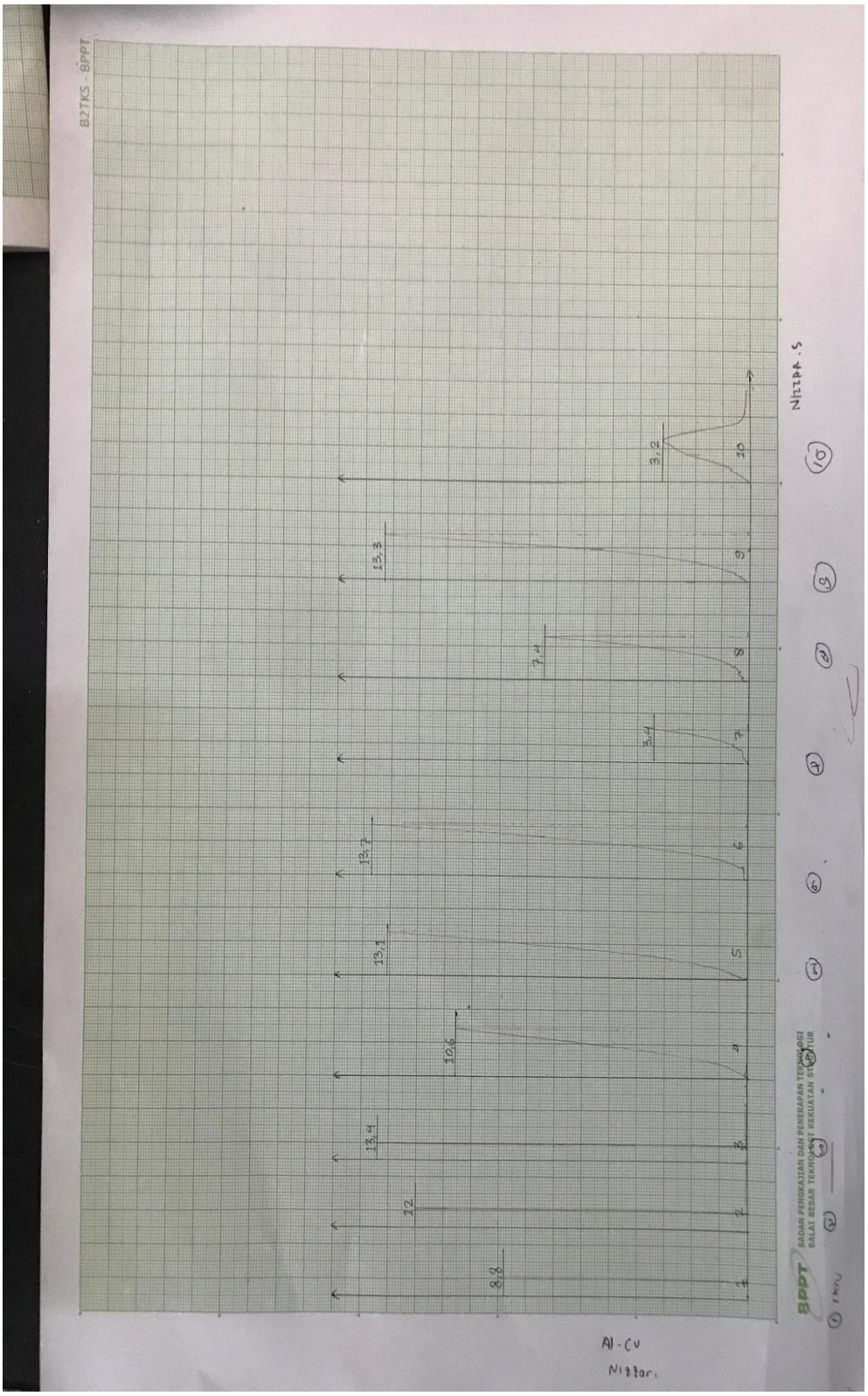
CUSTOMER : NIZZAR. S
NO. ID :
STANDAR :
TEMPERATUR :

SAKSI :
1.
2.
3.

Hasil uji ini hanya representatif dari spesimen yang diuji, di luar spesimen tersebut bukan tanggung jawab Laboratorium Kekuatan Struktur.

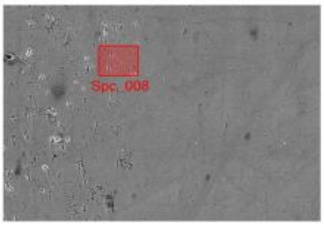
F-TKS-LP-14

B.6 Data Sesudah Uji Tarik

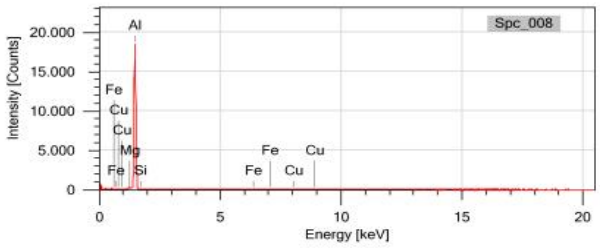


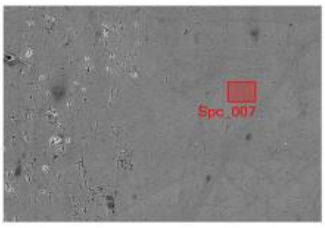
B.7 Data SEM (*scanning electron microscopy*)

JSM IT – 200 LA JEOL

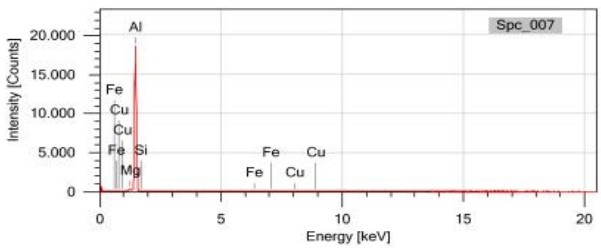


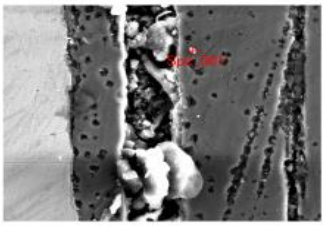
Element	Line	Mass%	Atom%
Mg	K	0,55±0,03	0,61±0,04
Al	K	98,52±0,36	98,66±0,36
Si	K	0,60±0,06	0,57±0,06
Fe	K	0,26±0,04	0,12±0,02
Cu	K	0,08±0,05	0,03±0,02
Total		100,00	100,00
Spc_008			Fitting ratio 0,0621



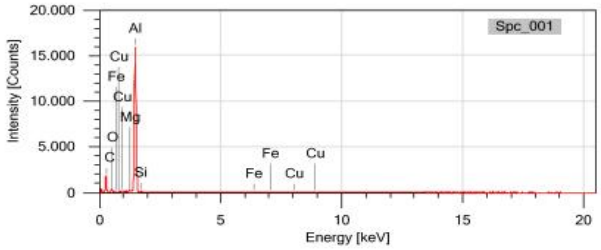


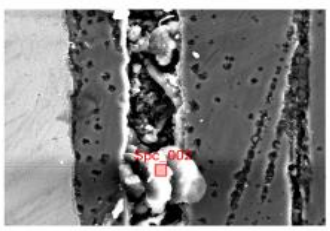
Element	Line	Mass%	Atom%
Mg	K	0,55±0,03	0,61±0,04
Al	K	98,97±0,36	99,01±0,36
Si	K	0,33±0,05	0,31±0,05
Fe	K	0,12±0,04	0,06±0,02
Cu	K	0,03±0,05	0,01±0,02
Total		100,00	100,00
Spc_007			Fitting ratio 0,0567



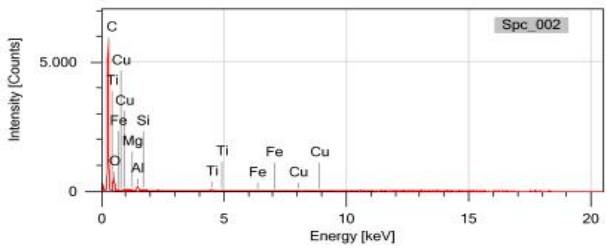


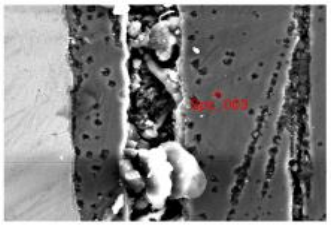
Element	Line	Mass%	Atom%
C	K	55,74±0,30	72,92±0,39
O	K	3,84±0,11	3,77±0,10
Mg	K	0,21±0,02	0,13±0,01
Al	K	39,04±0,15	22,74±0,09
Si	K	0,46±0,02	0,25±0,01
Fe	K	0,29±0,02	0,08±0,01
Cu	K	0,44±0,04	0,11±0,01
Total		100,00	100,00
Spc_001			Fitting ratio 0,0399



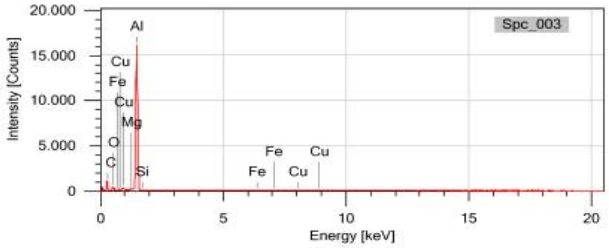


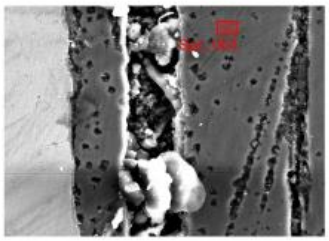
Element	Line	Mass%	Atom%
C	K	79,55±0,24	84,68±0,26
O	K	18,17±0,37	14,52±0,30
Mg	K	0,06±0,02	0,03±0,01
Al	K	0,94±0,04	0,45±0,02
Si	K	0,04±0,02	0,02±0,01
Ti	K	0,65±0,04	0,17±0,01
Fe	K	0,30±0,04	0,07±0,01
Cu	K	0,29±0,05	0,06±0,01
Total		100,00	100,00
Spc_002			Fitting ratio 0,0456



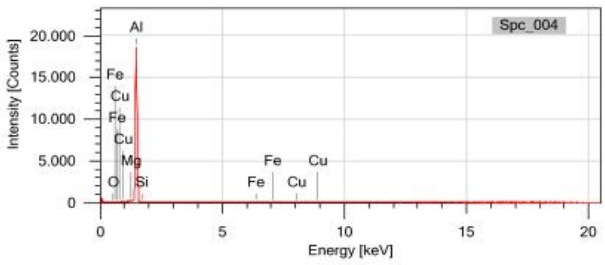


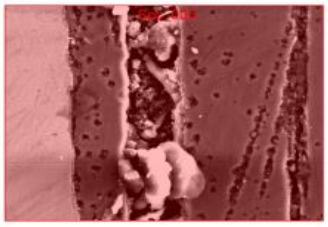
Element	Line	Mass%	Atom%
C	K	45,94±0,32	64,52±0,45
O	K	5,09±0,12	5,37±0,13
Mg	K	0,25±0,02	0,17±0,01
Al	K	47,09±0,18	29,44±0,11
Si	K	0,20±0,02	0,12±0,01
Fe	K	0,09±0,02	0,03±0,01
Cu	K	1,34±0,07	0,36±0,02
Total		100,00	100,00
Spc_003			Fitting ratio 0,0411



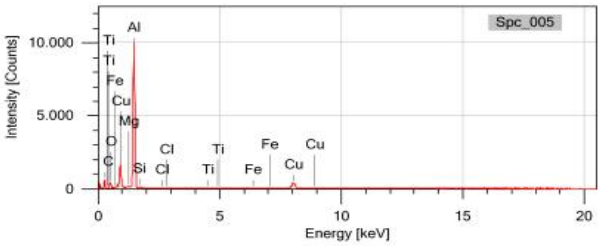


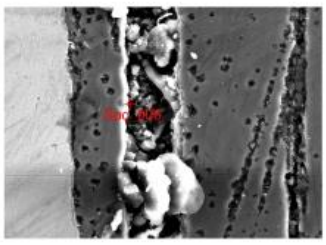
Element	Line	Mass%	Atom%
O	K	1,26±0,07	2,12±0,11
Mg	K	0,45±0,03	0,50±0,04
Al	K	96,40±0,35	96,27±0,35
Si	K	0,54±0,06	0,52±0,05
Fe	K	0,20±0,04	0,10±0,02
Cu	K	1,14±0,10	0,48±0,04
Total		100,00	100,00
Spc_004			Fitting ratio 0,0518



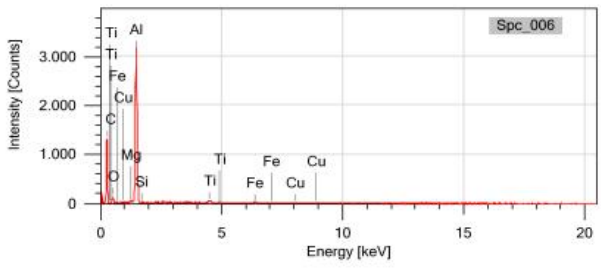


Element	Line	Mass%	Atom%
C	K	33,41±0,32	54,81±0,53
O	K	5,28±0,13	6,50±0,16
Mg	K	0,28±0,03	0,23±0,02
Al	K	45,70±0,23	33,38±0,17
Si	K	0,60±0,04	0,42±0,03
Cl	K	0,22±0,02	0,12±0,01
Ti	K	0,22±0,02	0,09±0,01
Fe	K	0,37±0,04	0,13±0,01
Cu	K	13,93±0,25	4,32±0,08
Total		100,00	100,00
Spc_005			Fitting ratio 0,0446





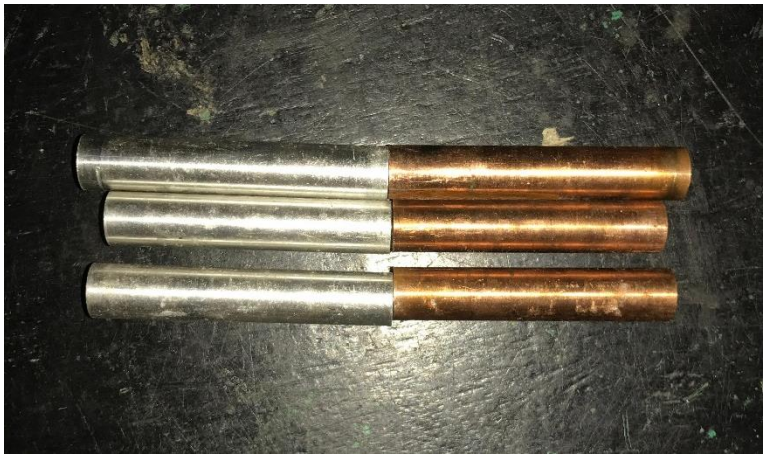
Element	Line	Mass%	Atom%
C	K	70,12±0,43	82,96±0,51
O	K	5,01±0,22	4,45±0,19
Mg	K	0,10±0,02	0,06±0,01
Al	K	22,66±0,20	11,94±0,10
Si	K	0,14±0,03	0,07±0,01
Ti	K	0,77±0,05	0,23±0,02
Fe	K	0,79±0,07	0,20±0,02
Cu	K	0,40±0,07	0,09±0,02
Total		100,00	100,00
Spc_006			Fitting ratio 0,0721



LAMPIRAN C

GAMBAR ALAT DAN BAHAN

LAMPIRAN C. Gambar Alat dan Bahan



Gambar C.1 Bahan Aluminium dan Tembaga

Gambar C.2 Ampelas

Gambar C.3 Aquades

Gambar C.4 Etanol

Gambar C.5 gelas beker

Gambar C.6 Gelas ukur

Gambar C.7 Gerinda

Gambar C.8 Kain *Polish*

Gambar C.9 Mesin *Grinding*

Gambar C.10 mesin bubut

Gambar C.11 Mesin Ui Kekerasan

Gambar C.12 Mikroskop Optik

Gambar C.13 Pasta *Polish*

Gambar C.14 Pipet

Gambar C.15 Tisu

Gambar C.16 Alat *friction welding*

Gambar C.17 Alat uji tarik