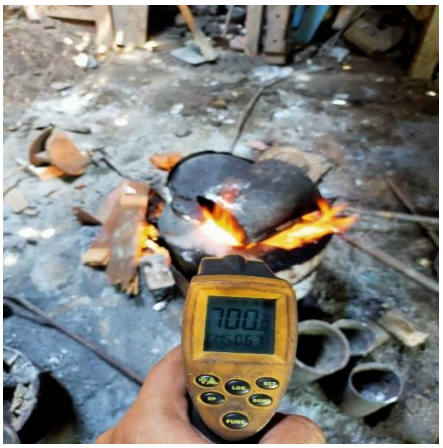
## LAMPIRAN

### 1. Persiapan Bahan


## 2. Elektroles Plating

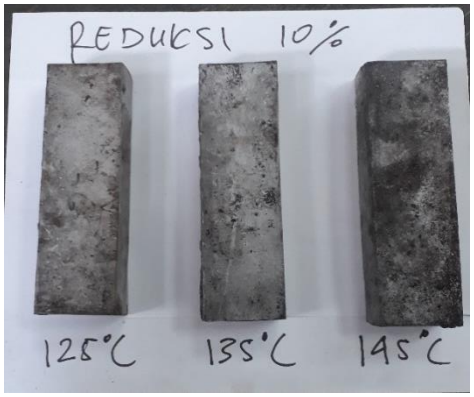

### 3. Proses Pengecoran



**4. Hasil Coran**

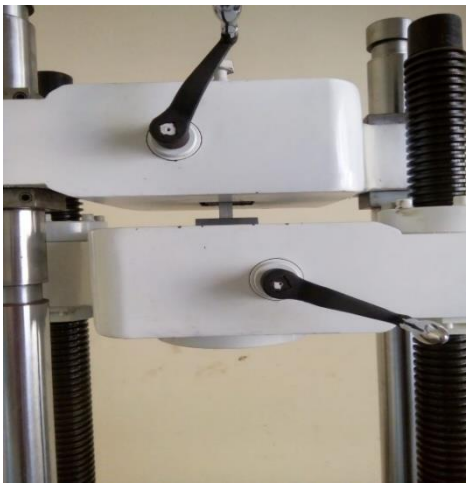
## 5. Homogenezing


## 6. Proses Penempaan


## 7. Pembuatan Spesimen

## 8. Pengujian Tarik




KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN
UNIVERSITAS NEGERI MALANG (UM)
**FAKULTAS TEKNIK**
Jl Semarang 5 Malang 65145
Telepon: 0341-565307
Laman: www.um.ac.id

# SURAT KETERANGAN

Yang bertanda tangan di bawah ini :

| | |
|---|---|
| Nama | : Drs. Imam Sudjono, MT |
| NIP | : 196003271986011002 |
| Jabatan | : Kepala Laboratorium Teknik Mesin FT UM |

Menerangkan bahwa :

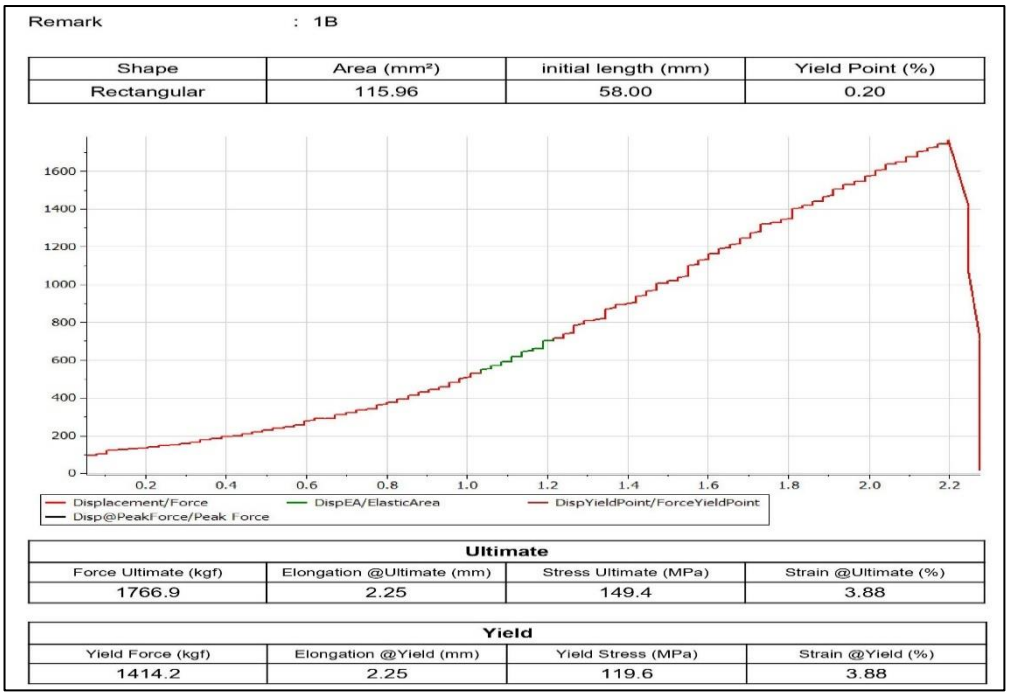
| | |
|---|---|
| Nama | : Rifki Santoso (NIM 1421600117) |
| Asal | : Mahasiswa Prodi Teknik Mesin |
| | Universitas Tujuh Belas Agustus 1945 Surabaya |

Telah melaksanakan penelitian di Laboratorium Teknik Mesin Fakultas Teknik Universitas Negeri Malang untuk keperluan penyusunan skripsi.
Demikian Surat Keterangan ini dibuat dengan sebenarnya.

Malang, 22 April 2021
Kepala Lab. Teknik Mesin

Drs. IMAM SUDJONO, MT
NIP 196003271986011002

## 9. Perhitungan Spesimen 1B sampai dengan 10B




Gambar grafik Pertambahan Panjang dan Pertambahan Beban 1B

Tabel data Hasil Uji Tarik Spesimen 1B

| No | Spesimen 1B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,3 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,3 |
| 4 | Luas penampang mula-mula (Ao), mm² | 152,3 |
| 5 | Beban yield (Py), N | 13869,05 |
| 6 | Beban Ultimate (Pu), N | 17327,98 |
| 7 | Beban putus (Ppts), N | 17184,8 |
| 8 | ΔL(yield), mm | 1,86 |
| 9 | ΔL(max/ultimate), mm | 2,25 |
| 10 | ΔL(putus), mm | 2,3 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,86 = 101,86 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,25 = 152,25 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,3 = 152,3 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{13869,05}{115,96}$ = 119,602 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{17327,98}{115,96}$ = 149,43 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{17184,804}{115,96}$ = 148,19 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,86-150}{150}$ x 100% = 1,24%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,25-150}{150}$ x 100% = 1,5%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,3-150}{150}$ x 100% = 1,533%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{17327,98}{115,96}$ = 149,43 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{13869,05}{115,96}$ = 119,6 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,3-150}{150}$ $x$ 100% = 1,53%

- **Kelentingan *(Resilience)***

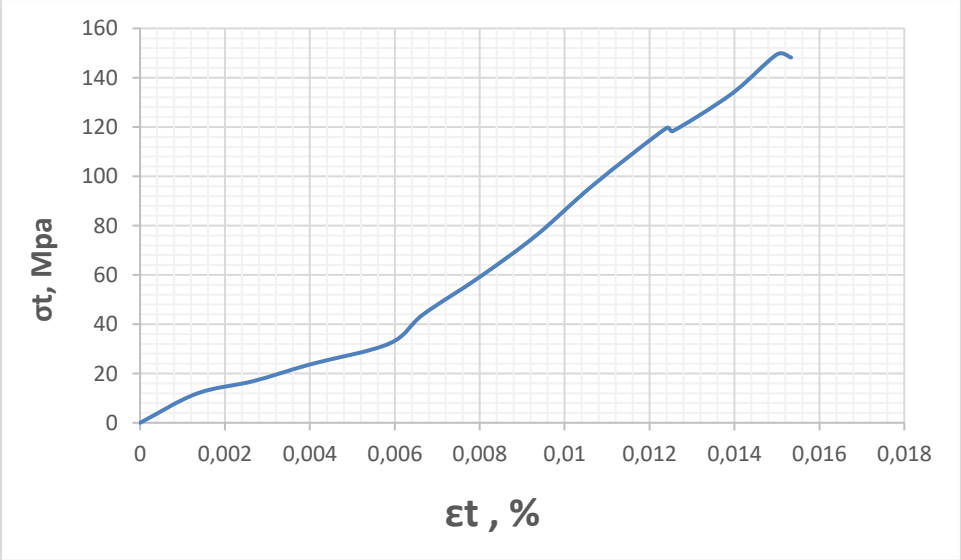
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y = \frac{1}{2}$ x 119,6 x 1,24 = 74,153 joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{119,6 + 149,43}{2}$ $x$ 1,53 = 206,258 joule/m³

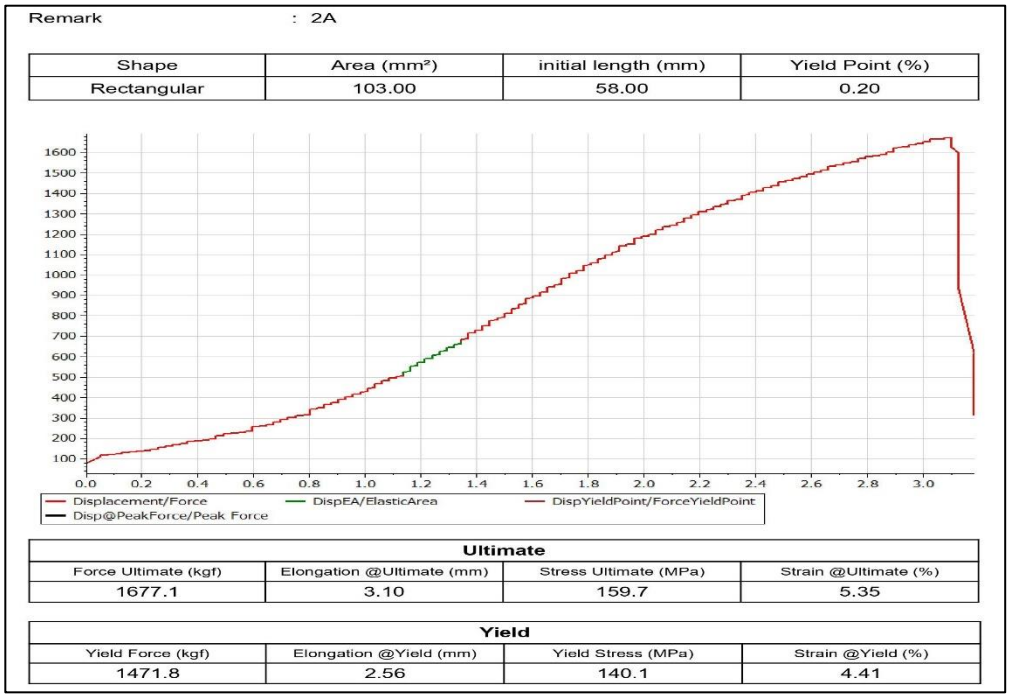
Tabel Tegangan Regangan Spesimen 1B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,2 | 1372 | 0,001333 | 11,83167 |
| 0,4 | 1960 | 0,002667 | 16,90238 |
| 0,6 | 2744 | 0,004 | 23,66333 |
| 0,88 | 3724 | 0,005867 | 32,11452 |
| 1 | 5096 | 0,006667 | 43,94619 |
| 1,2 | 6860 | 0,008 | 59,15833 |
| 1,4 | 8820 | 0,009333 | 76,06071 |
| 1,6 | 11172 | 0,010667 | 96,34357 |
| 1,86 | 13869,05 | 0,0124 | 119,602 |
| 1,881818 | 13720 | 0,012545 | 118,3167 |
| 2,090909 | 15484 | 0,013939 | 133,5288 |
| 2,25 | 17327,98 | 0,015 | 149,4307 |
| 2,3 | 17184,8 | 0,015333 | 148,1959 |




Gambar  Grafik Tegangan Regangan Spesimen 1B

### 4.1.2. Perhitungan Uji Tarik Temperatur benda kerja 145°C dan Reduksi ketabalan benda kerja 5%




Gambar grafik Pertambahan Panjang dan Pertambahan Beban 2A

Tabel data Hasil Uji Tarik Spesimen 2A

| No | Spesimen 2A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 153,2 |
| 3 | Pertambahan panjang (ΔLmax), mm | 3,2 |
| 4 | Luas penampang mula-mula (Ao), mm² | 103 |
| 5 | Beban yield (Py), N | 14532,01 |
| 6 | Beban Ultimate (Pu), N | 16447,31 |
| 7 | Beban putus (Ppts), N | 15930,49 |
| 8 | ΔL(yield), mm | 2,54 |
| 9 | ΔL(max/ultimate), mm | 3,1 |
| 10 | ΔL(putus), mm | 3,2 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 2,54 = 152,54 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 3,1 = 153,1 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 3,2 = 153,2 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{14532,01}{103}$ = 141,08 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{16447,31}{103}$ = 159,68 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{15930,49}{103}$ = 154,66 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{152,54-150}{150}$ x 100% = 1,69%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{153,1-150}{150}$ x 100% = 2,06%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{153,2-150}{150}$ x 100% = 2,13%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{16447,31}{103}$ = 159,68 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{14532,01}{103}$ = 141,08 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{153,2-150}{150}$ $x$ 100% = 2,13%

- **Kelentingan *(Resilience)***

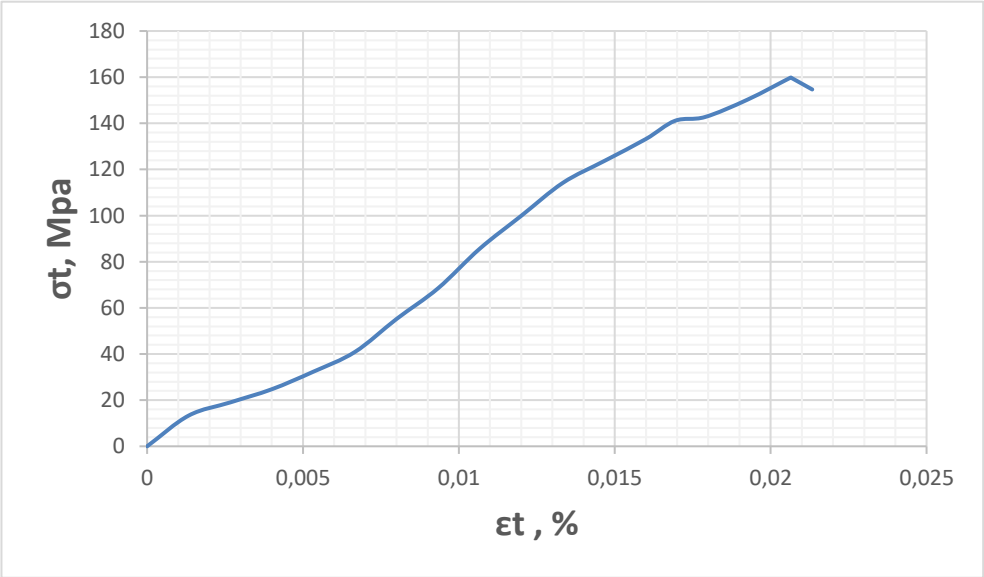
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 141,08 x 1,69 = 119,45 Joule/m³

- **Ketangguhan *(Toughness)***

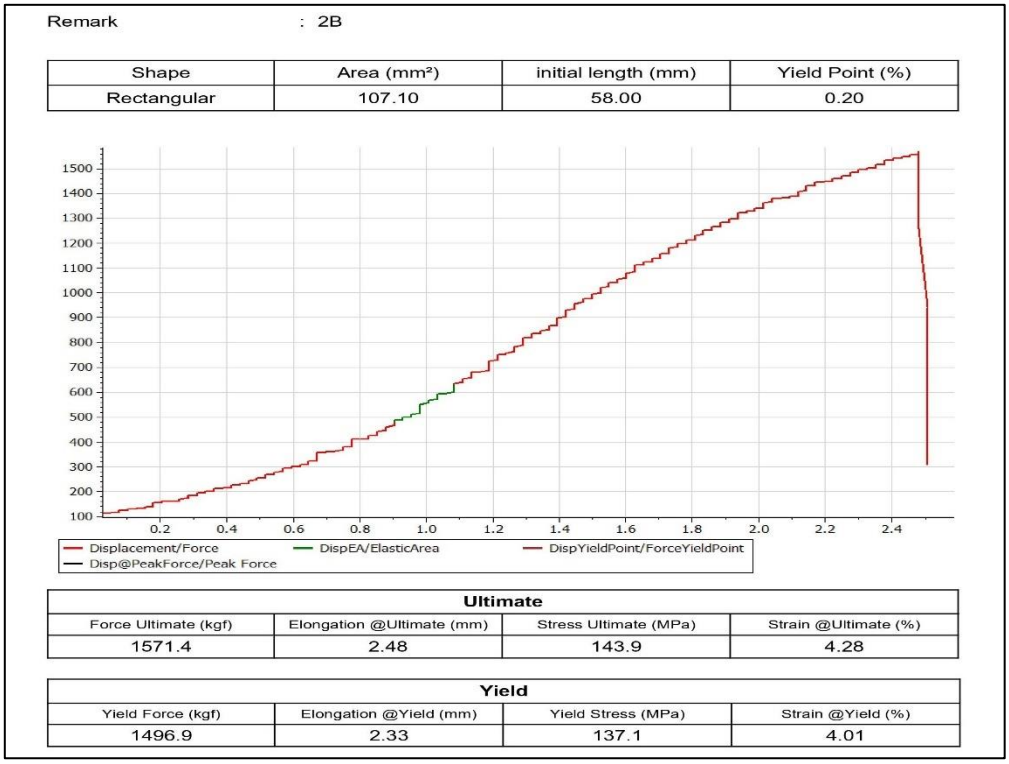
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{141,08 + 159,68}{2}$ $x$ 2,13 = 320,82 Joule/m³

Tabel Tegangan Regangan Teknik 2A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,2 | 1372 | 0,001333 | 13,32039 |
| 0,4 | 1960 | 0,002667 | 19,02913 |
| 0,6 | 2548 | 0,004 | 24,73786 |
| 0,8 | 3332 | 0,005333 | 32,34951 |
| 1 | 4214 | 0,006667 | 40,91262 |
| 1,2 | 5684 | 0,008 | 55,18447 |
| 1,4 | 7056 | 0,009333 | 68,50485 |
| 1,6 | 8820 | 0,010667 | 85,63107 |
| 1,8 | 10290 | 0,012 | 99,90291 |
| 2 | 11760 | 0,013333 | 114,1748 |
| 2,2 | 12740 | 0,014667 | 123,6893 |
| 2,4 | 13720 | 0,016 | 133,2039 |
| 2,54 | 14532 | 0,016933 | 141,0874 |
| 2,683871 | 14700 | 0,017892 | 142,7184 |
| 2,890323 | 15484 | 0,019269 | 150,3301 |
| 3,096774 | 16464 | 0,020645 | 159,8447 |
| 3,1 | 16447,31 | 0,020667 | 159,6826 |
| 3,2 | 15930,49 | 0,021333 | 154,665 |




Gambar grafik Tegangan Regangan Spesimen 2A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 2B

**Tabel** Data hasil uji tarik spesimen 2B

| No | Spesimen 2B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,5 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,5 |
| 4 | Luas penampang mula-mula (Ao), mm² | 107,1 |
| 5 | Beban yield (Py), N | 14680,09 |
| 6 | Beban Ultimate (Pu), N | 15410,71 |
| 7 | Beban putus (Ppts), N | 14829,16 |
| 8 | ΔL(yield), mm | 2,29 |
| 9 | ΔL(max/ultimate), mm | 2,48 |
| 10 | ΔL(putus), mm | 2,5 |

- **Tegangan Teknik dan Regangan Teknik**

  $Lyield$ = $L$e + $\Delta Ly$ = 150 + 2,29 = 152,29 mm

  $Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,48 = 152,48 mm

  $Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,5 = 152,5 mm

  - Tegangan Teknik

    $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{14680,09}{107,1}$ = 137,06 Mpa

    $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{15410,71}{107,1}$ = 143,89 Mpa

    $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{14829,16}{107,1}$ = 138,46 Mpa
  - Regangan Teknik

    $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{152,29-150}{150}$ x 100% = 1,52%

    $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,48-150}{150}$ x 100% = 1,65%

    $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,5-150}{150}$ x 100% = 1,67%
  - Kekuatan tarik maksimum (UTS)

    $Su = \frac{Pmax}{Ao} = \frac{15410,71}{107,1}$ = 143,89 Mpa
  - Batas luluh (Yielding)

    So = $\frac{Py}{Ao} = \frac{14680,09}{107,1}$ = 141,08 Mpa
  - Keliatan (keuletan)

    Presentase perpanjangan

    $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,5-150}{150}$ $x$ 100% = 1,66%

- **Kelentingan *(Resilience)***

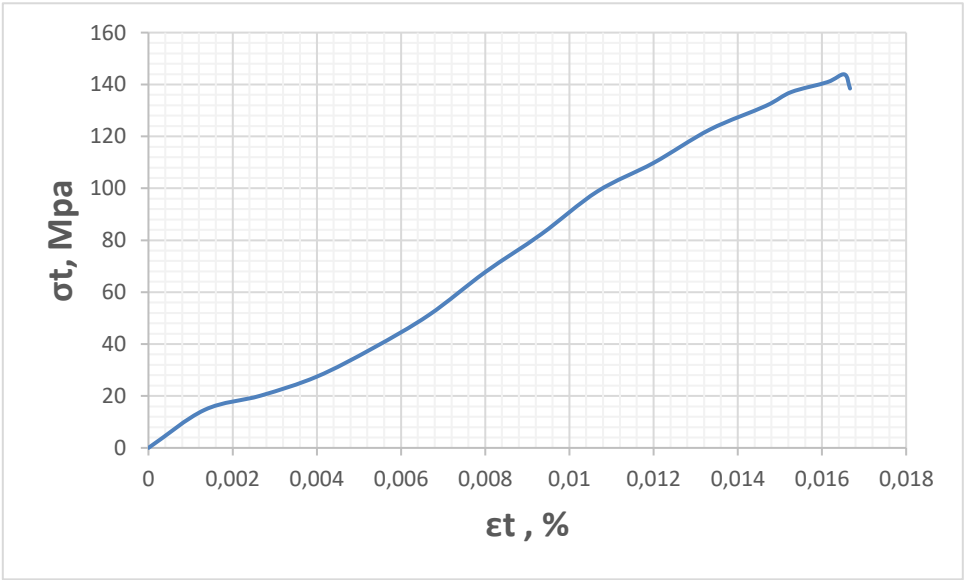
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 141,08 x 1,52 = 104,62 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{141,08+143,89}{2}$ $x$ 1,66 = 234,13 Joule/m³

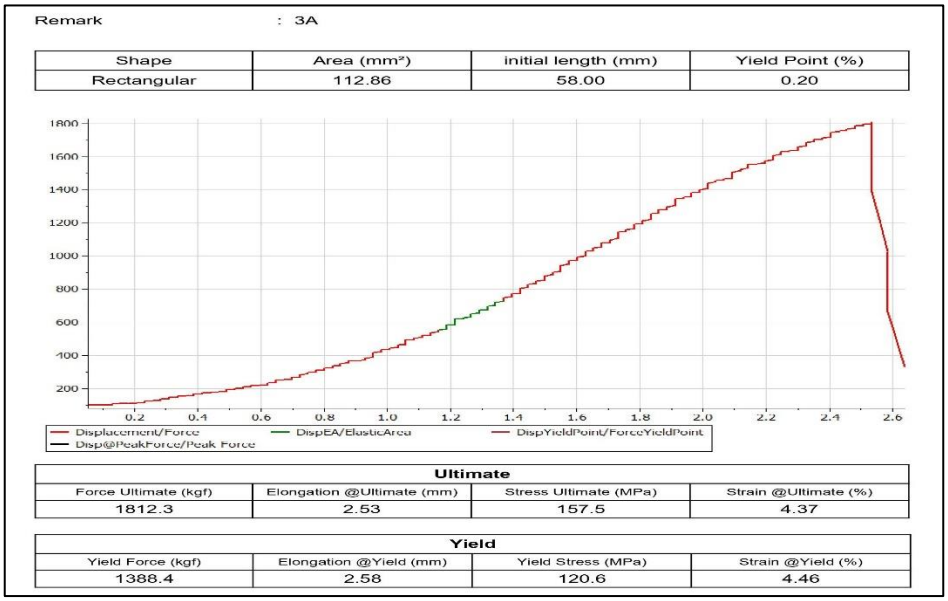
**Tabel** Tegangan Regangan Teknik Spesimen 2B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,2 | 1568 | 0,001333 | 14,64052 |
| 0,4 | 2156 | 0,002667 | 20,13072 |
| 0,6 | 2940 | 0,004 | 27,45098 |
| 0,8 | 4116 | 0,005333 | 38,43137 |
| 1 | 5488 | 0,006667 | 51,24183 |
| 1,2 | 7252 | 0,008 | 67,71242 |
| 1,4 | 8820 | 0,009333 | 82,35294 |
| 1,6 | 10584 | 0,010667 | 98,82353 |
| 1,8 | 11760 | 0,012 | 109,8039 |
| 2 | 13132 | 0,013333 | 122,6144 |
| 2,2 | 14112 | 0,014667 | 131,7647 |
| 2,29 | 14680,09 | 0,015267 | 137,069 |
| 2,419355 | 15092 | 0,016129 | 140,915 |
| 2,48 | 15410,71 | 0,016533 | 143,8908 |
| 2,5 | 14829,16 | 0,016667 | 138,4609 |




**Gambar** Grafik Tegangan Regangan spesimen 2B

### 4.1.3. Perhitungan Uji Tarik Temperatur benda kerja 145°C dan Reduksi ketabalan benda kerja 10%




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 3A

**Tabel** Data hasil uji tarik spesimen 3A

| No | Spesimen 3A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,68 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,68 |
| 4 | Luas penampang mula-mula (Ao), mm² | 112,86 |
| 5 | Beban yield (Py), N | 13616,03 |
| 6 | Beban Ultimate (Pu), N | 17773,22 |
| 7 | Beban putus (Ppts), N | 17498,63 |
| 8 | ΔL(yield), mm | 1,97 |
| 9 | ΔL(max/ultimate), mm | 2,53 |
| 10 | ΔL(putus), mm | 2,68 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,97 = 151,97 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,53 = 152,53 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,68 = 152,68 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{13616,03}{112,86}$ = 120,64 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{17773,22}{112,86}$ = 157,48 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{17498,63}{112,86}$ = 155,46 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,97-150}{150}$ x 100% = 1,31%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,53-150}{150}$ x 100% = 1,68%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,68-150}{150}$ x 100% = 1,78%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{17773,22}{112,86}$ = 157,48 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{13616}{112,86}$ = 120,64 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,68-150}{150}$ $x$ 100% = 1,78%

- **Kelentingan *(Resilience)***

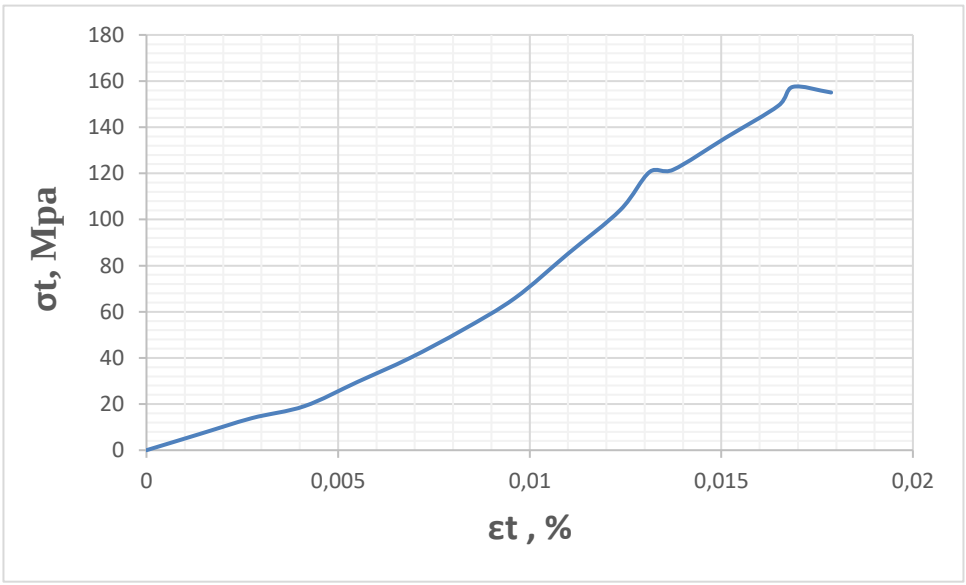
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 120,64 x 1,31 = 79,223 Joule/m³

- **Ketangguhan *(Toughness)***

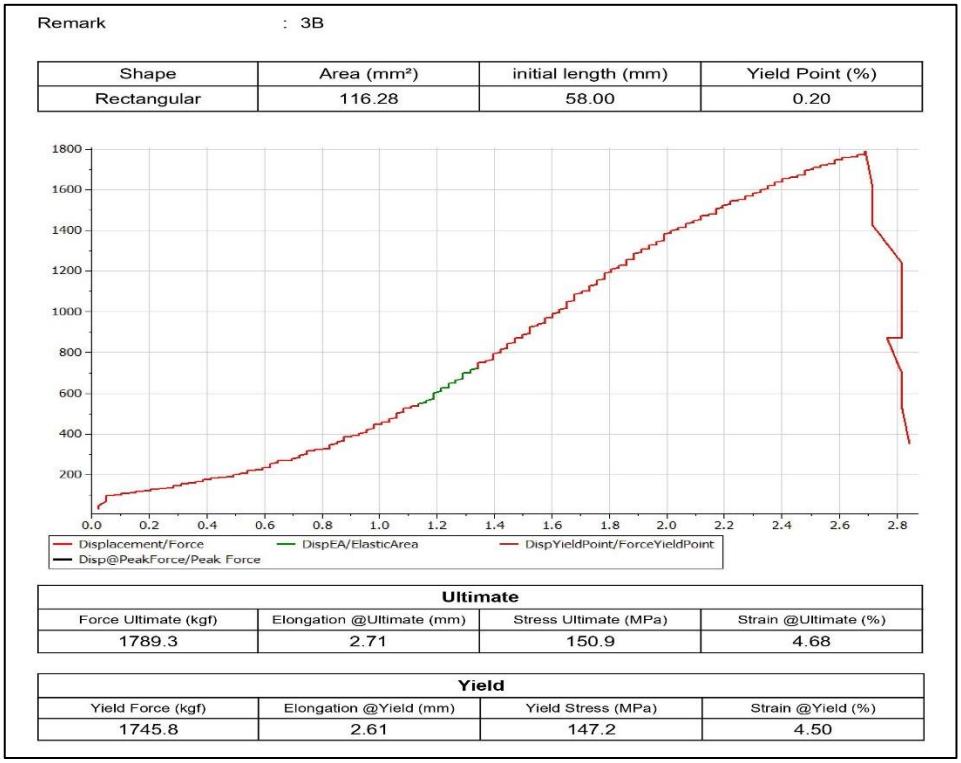
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{120,64 + 157,48}{2}$ $x$ 1,78 = 248,45 Joule/m³

**Tabel** Tegangan Regangan Teknik spesimen 3A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,206154 | 784 | 0,001374 | 6,94666 |
| 0,412308 | 1568 | 0,002749 | 13,89332 |
| 0,618462 | 2156 | 0,004123 | 19,10331 |
| 0,824615 | 3332 | 0,005497 | 29,5233 |
| 1,030769 | 4508 | 0,006872 | 39,94329 |
| 1,236923 | 5880 | 0,008246 | 52,09995 |
| 1,443077 | 7448 | 0,009621 | 65,99327 |
| 1,649231 | 9604 | 0,010995 | 85,09658 |
| 1,855385 | 11760 | 0,012369 | 104,1999 |
| 1,97 | 13616,03 | 0,013133 | 120,6453 |
| 2,061538 | 13720 | 0,013744 | 121,5665 |
| 2,267692 | 15288 | 0,015118 | 135,4599 |
| 2,473846 | 16856 | 0,016492 | 149,3532 |
| 2,53 | 17773,22 | 0,016867 | 157,4802 |
| 2,68 | 17498,63 | 0,017867 | 155,0472 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 3A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 3B

**Tabel** Data hasil uji tarik spesimen 3B

| No | Spesimen 3B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,81 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,81 |
| 4 | Luas penampang mula-mula (Ao), mm² | 116,28 |
| 5 | Beban yield (Py), N | 17121,06 |
| 6 | Beban Ultimate (Pu), N | 17547,66 |
| 7 | Beban putus (Ppts), N | 17179,9 |
| 8 | ΔL(yield), mm | 2,64 |
| 9 | ΔL(max/ultimate), mm | 2,71 |
| 10 | ΔL(putus), mm | 2,81 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 2,64 = 152,64 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,71 = 152,71 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,81 = 152,81 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{117121,06}{116,28}$ = 147,24 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{17547,66}{116,28}$ = 150,9 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{17179,9}{116,28}$ = 147,75 Mpa
- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{152,64-150}{150}$ x 100% = 1,76%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,71-150}{150}$ x 100% = 1,8%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,81-150}{150}$ x 100% = 1,87%
- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{17547,66}{116,28}$ = 150,9 Mpa
- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{17121,06}{116,28}$ = 147,23 Mpa
- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,81-150}{150}$ $x$ 100% = 1,87%

- **Kelentingan *(Resilience)***

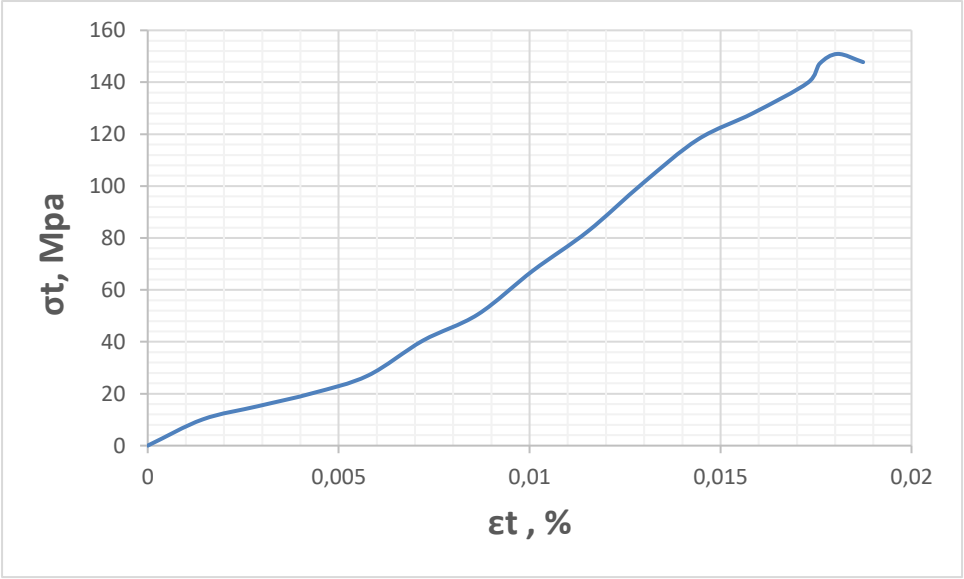
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 147,23 x 1,76 = 129,57 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{147,23 + 150,9}{2}$ $x$ 1,87 = 279,26 Joule/m³

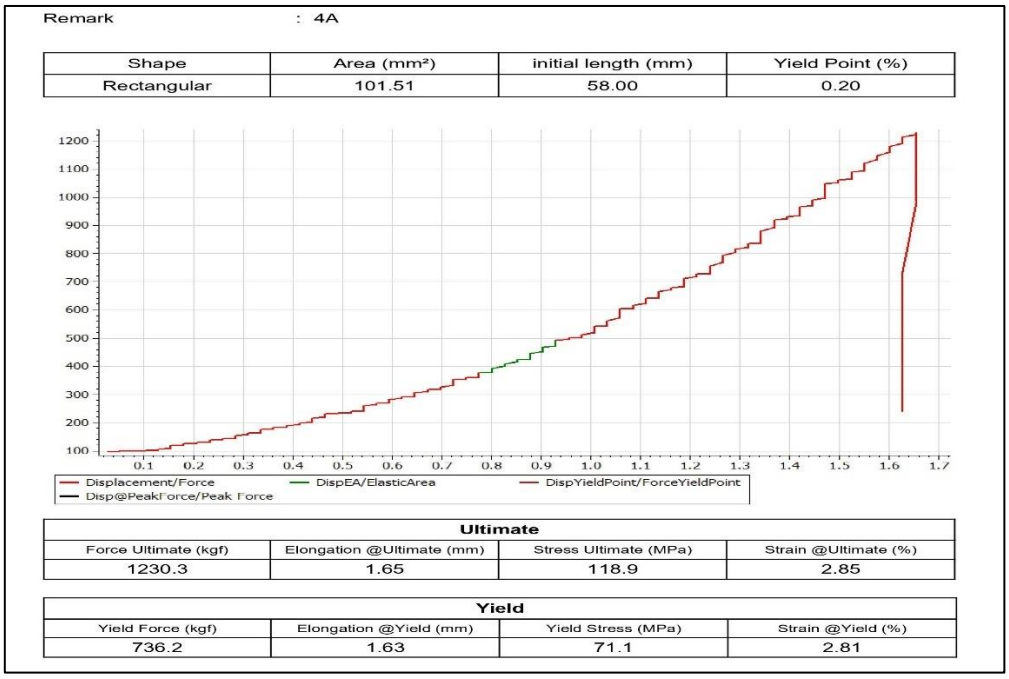
**Tabel** Tegangan Regangan Teknik Spesimen 3B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,216154 | 1176 | 0,001441 | 10,11352 |
| 0,432308 | 1764 | 0,002882 | 15,17028 |
| 0,648462 | 2352 | 0,004323 | 20,22704 |
| 0,864615 | 3136 | 0,005764 | 26,96938 |
| 1,080769 | 4704 | 0,007205 | 40,45408 |
| 1,296923 | 5880 | 0,008646 | 50,5676 |
| 1,513077 | 7840 | 0,010087 | 67,42346 |
| 1,729231 | 9604 | 0,011528 | 82,59374 |
| 1,945385 | 11760 | 0,012969 | 101,1352 |
| 2,161538 | 13720 | 0,01441 | 117,9911 |
| 2,377692 | 14896 | 0,015851 | 128,1046 |
| 2,593846 | 16268 | 0,017292 | 139,9037 |
| 2,64 | 17121,06 | 0,0176 | 147,2399 |
| 2,71 | 17547,66 | 0,018067 | 150,9087 |
| 2,81 | 17179,9 | 0,018733 | 147,746 |




**Gambar** Grafik Tegangan Regangan Spesimen 3B

### 4.1.4. Perhitungan Uji Tarik Temperatur benda kerja 145°C dan Reduksi ketabalan benda kerja 15%




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 4A

**Tabel** Data hasil uji tarik spesimen 4A

| No | Spesimen 4A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 151,66 |
| 3 | Pertambahan panjang (ΔLmax), mm | 1,66 |
| 4 | Luas penampang mula-mula (Ao), mm² | 101,51 |
| 5 | Beban yield (Py), N | 7219,91 |
| 6 | Beban Ultimate (Pu), N | 12065,55 |
| 7 | Beban putus (Ppts), N | 11803,7 |
| 8 | ΔL(yield), mm | 1,24 |
| 9 | ΔL(max/ultimate), mm | 1,65 |
| 10 | ΔL(putus), mm | 1,66 |

- **Tegangan Teknik dan Regangan Teknik**

  $Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,24 = 151,24 mm

  $Lmax$ = $L$e + $\Delta Lu$ = 150 + 1,65 = 151,65 mm

  $Lputus$ = $L$e + $\Delta Lpts$ = 150 + 1,66 = 151,66 mm

  - Tegangan Teknik

    $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{7219,91}{101,51}$ = 71,12 Mpa

    $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{12065,55}{101,51}$ = 118,86 Mpa

    $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{11803,7}{101,51}$ = 116,28 Mpa
  - Regangan Teknik

    $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,24-150}{150}$ x 100% = 0,82%

    $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{151,65-150}{150}$ x 100% = 1,1%

    $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{151,66-150}{150}$ x 100% = 1,106%
  - Kekuatan tarik maksimum (UTS)

    $Su = \frac{Pmax}{Ao} = \frac{12065,55}{101,51}$ = 118,86 Mpa
  - Batas luluh (Yielding)

    So = $\frac{Py}{Ao} = \frac{7219,91}{101,51}$ = 71,12 Mpa
  - Keliatan (keuletan)

    Presentase perpanjangan

    $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{151,66-150}{150}$ $x$ 100% = 1,106%

- **Kelentingan *(Resilience)***

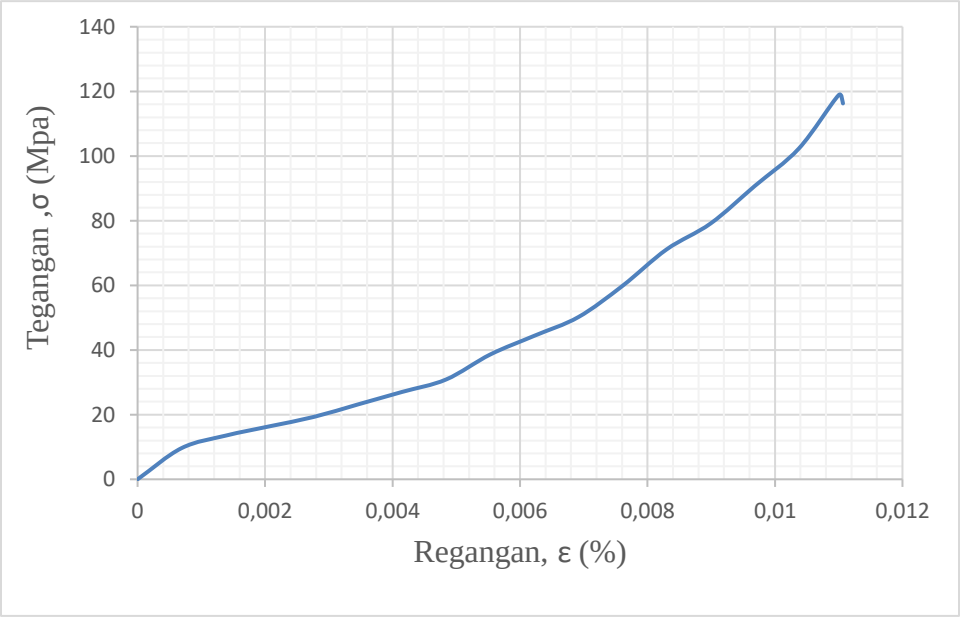
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 71,12 x 0,82 = 29,39 Joule/m³

- **Ketangguhan *(Toughness)***

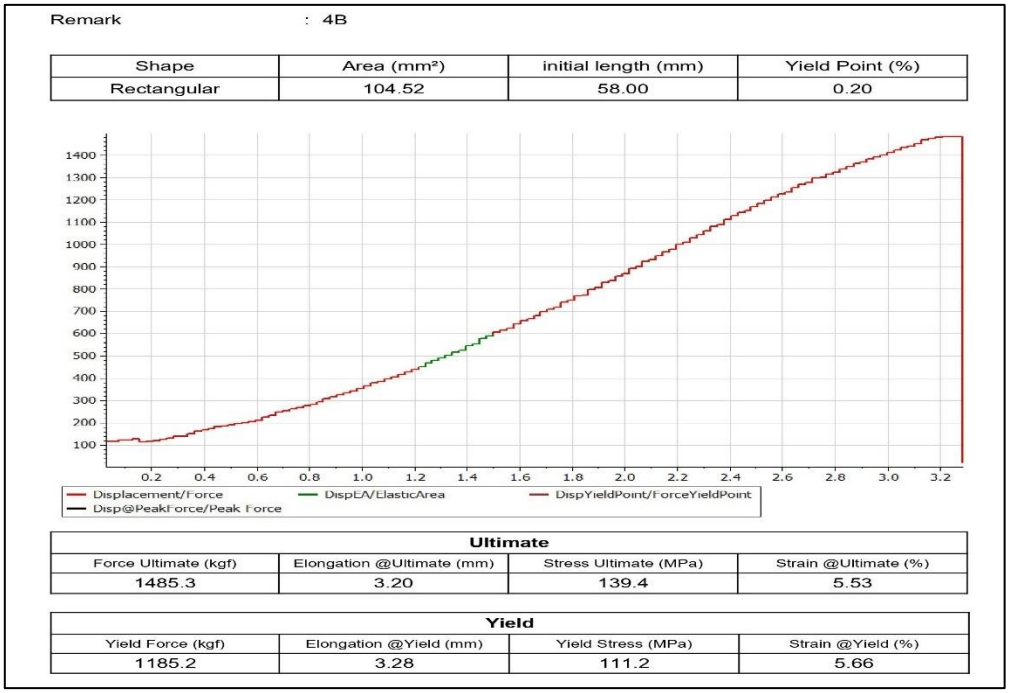
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{71,12+118,86}{2}$ $x$ 1,106 = 105,12 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 4A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,10375 | 980 | 0,000692 | 9,654221 |
| 0,2075 | 1372 | 0,001383 | 13,51591 |
| 0,31125 | 1666 | 0,002075 | 16,41218 |
| 0,415 | 1960 | 0,002767 | 19,30844 |
| 0,51875 | 2352 | 0,003458 | 23,17013 |
| 0,6225 | 2744 | 0,00415 | 27,03182 |
| 0,72625 | 3136 | 0,004842 | 30,89351 |
| 0,83 | 3920 | 0,005533 | 38,61689 |
| 0,93375 | 4508 | 0,006225 | 44,40942 |
| 1,0375 | 5096 | 0,006917 | 50,20195 |
| 1,14125 | 6076 | 0,007608 | 59,85617 |
| 1,245 | 7219,91 | 0,0083 | 71,12511 |
| 1,34875 | 8036 | 0,008992 | 79,16461 |
| 1,4525 | 9212 | 0,009683 | 90,74968 |
| 1,55625 | 10388 | 0,010375 | 102,3347 |
| 1,65 | 12065,55 | 0,011 | 118,8607 |
| 1,66 | 11803,7 | 0,011067 | 116,2812 |




**Gambar** Grafik Tegangan Regangan Spesimen 4A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 4B

**Tabel** Data hasil uji tarik spesimen 4B

| No | Spesimen 4B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 153,3 |
| 3 | Pertambahan panjang (ΔLmax), mm | 3,3 |
| 4 | Luas penampang mula-mula (Ao), mm² | 104,52 |
| 5 | Beban yield (Py), N | 11623,25 |
| 6 | Beban Ultimate (Pu), N | 14566,33 |
| 7 | Beban putus (Ppts), N | 14506,51 |
| 8 | ΔL(yield), mm | 2,51 |
| 9 | ΔL(max/ultimate), mm | 3,2 |
| 10 | ΔL(putus), mm | 3,3 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 2,51 = 152,51 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 3,2 = 153,2 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 3,3 = 153,3 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{11623,25}{104,52}$ = 111,206 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{14566,33}{104,52}$ = 139,36 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{14506,51}{104,52}$ = 138,79 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{152,51-150}{150}$ x 100% = 1,67%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{153,2-150}{150}$ x 100% = 2,13%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{153,3-150}{150}$ x 100% = 2,2%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{14566,33}{104,52}$ = 139,36 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{11623,25}{104,52}$ = 111,206 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{153,3-150}{150}$ $x$ 100% = 2,2%

- **Kelentingan *(Resilience)***

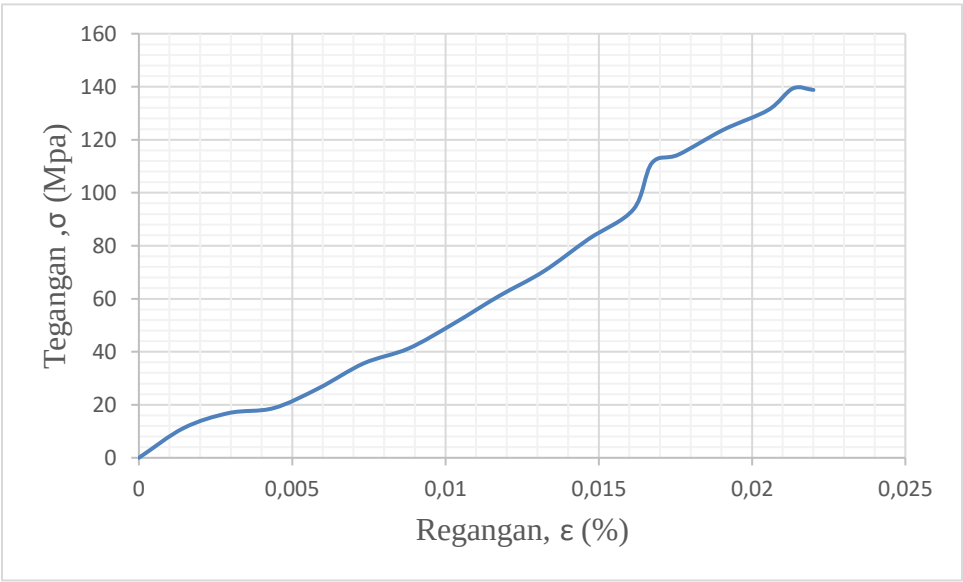
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 111,206 x 1,67 = 93,04 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{111,206+139,36}{2}$ $x$ 2,2 = 275,62 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 4B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,22 | 1176 | 0,001467 | 11,25144 |
| 0,44 | 1764 | 0,002933 | 16,87715 |
| 0,66 | 1960 | 0,0044 | 18,75239 |
| 0,88 | 2744 | 0,005867 | 26,25335 |
| 1,1 | 3724 | 0,007333 | 35,62954 |
| 1,32 | 4312 | 0,0088 | 41,25526 |
| 1,54 | 5292 | 0,010267 | 50,63146 |
| 1,76 | 6370 | 0,011733 | 60,94527 |
| 1,98 | 7350 | 0,0132 | 70,32147 |
| 2,2 | 8624 | 0,014667 | 82,51052 |
| 2,42 | 9800 | 0,016133 | 93,76196 |
| 2,51 | 11623,25 | 0,016733 | 111,206 |
| 2,64 | 11956 | 0,0176 | 114,3896 |
| 2,86 | 12936 | 0,019067 | 123,7658 |
| 3,08 | 13720 | 0,020533 | 131,2667 |
| 3,2 | 14566,33 | 0,021333 | 139,364 |
| 3,3 | 14506,51 | 0,022 | 138,7917 |

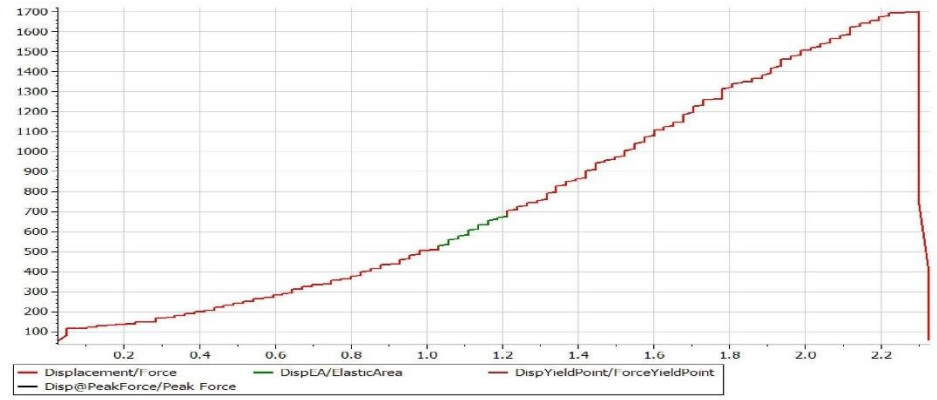



**Gambar** Grafik Tegangan Regangan Teknik Spesimen 4B

### 4.1.5. Perhitungan Uji Tarik Temperatur benda kerja 135°C dan Reduksi ketabalan benda kerja 5%

Remark : 5A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 112.35 | 58.00 | 0.20 |




| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1705.6 | 2.30 | 148.9 | 3.97 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1381.4 | 2.30 | 120.6 | 3.97 |

**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 5A

**Tabel** Data hasil uji tarik spesimen 5A

| No | Spesimen 5A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,35 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,35 |
| 4 | Luas penampang mula-mula (Ao), mm² | 112,35 |
| 5 | Beban yield (Py), N | 13547,38 |
| 6 | Beban Ultimate (Pu), N | 16726,81 |
| 7 | Beban putus (Ppts), N | 16584,61 |
| 8 | ΔL(yield), mm | 1,9 |
| 9 | ΔL(max/ultimate), mm | 2,3 |
| 10 | ΔL(putus), mm | 2,35 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,9 = 151,9 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,3 = 152,3 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,35 = 152,35 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{13547,38}{112,35}$ = 120,58 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{16726,81}{112,35}$ = 148,88 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{16584,61}{112,35}$ = 147,61 Mpa
- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,9-150}{150}$ x 100% = 1,26%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,3-150}{150}$ x 100% = 1,53%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,35-150}{150}$ x 100% = 1,7%
- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{16726,81}{112,35}$ = 148,88 Mpa
- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{13547,38}{112,35}$ = 120,58 Mpa
- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,35-150}{150}$ $x$ 100% = 1,7%

- **Kelentingan *(Resilience)***

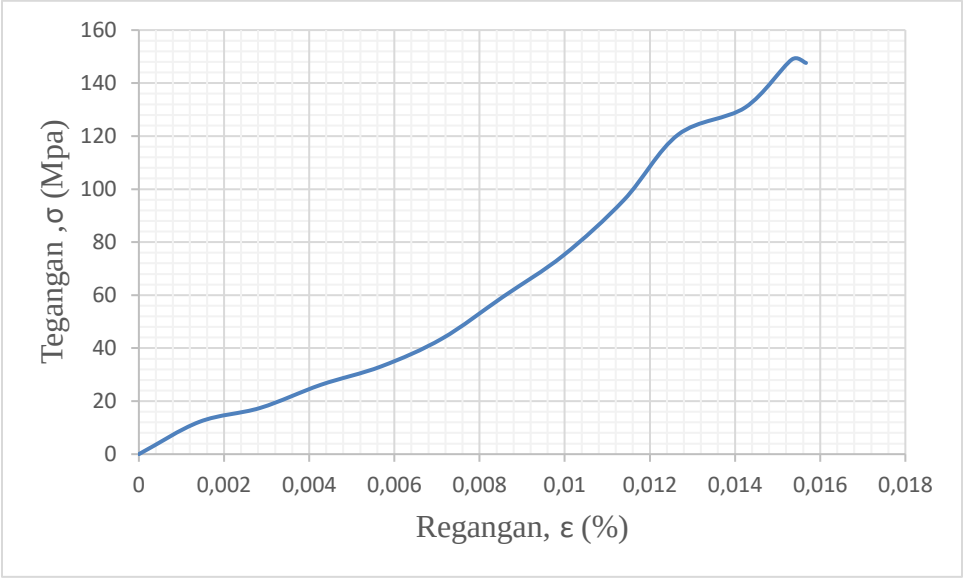
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 120,58 x 1,26 = 76,36 Joule/m³

- **Ketangguhan *(Toughness)***

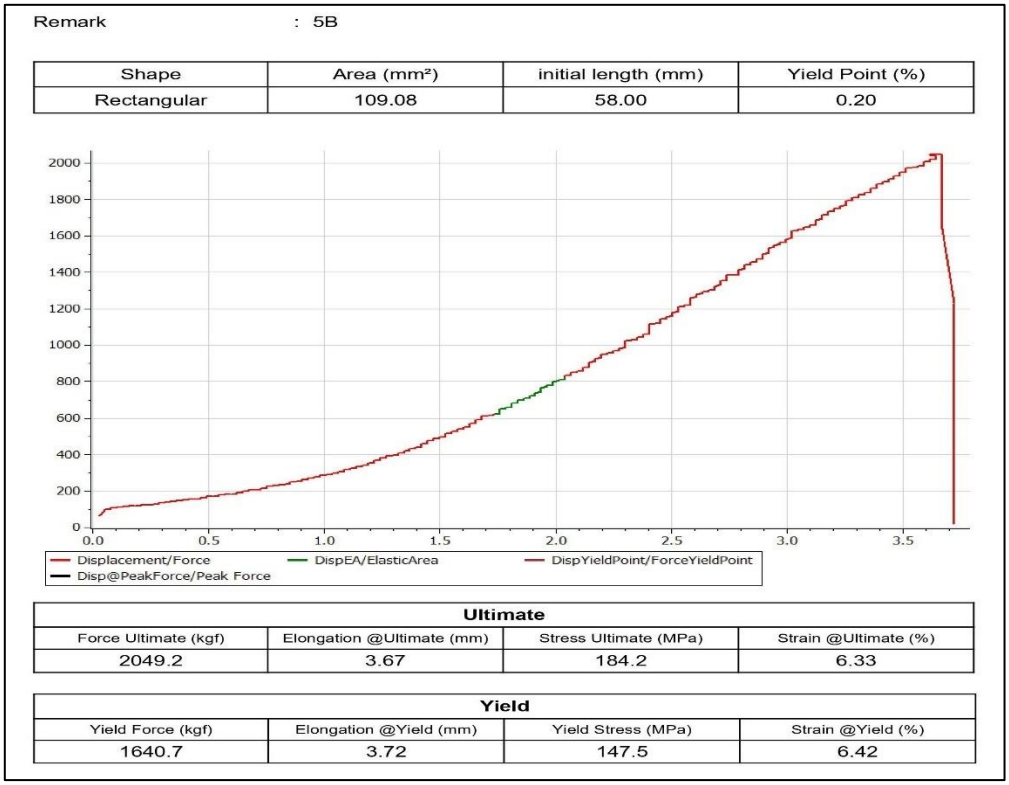
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{120,58 + 148,88}{2}$ $x$ 1,7 = 211,07 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 5A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,213636 | 1372 | 0,001424 | 12,21184 |
| 0,427273 | 1960 | 0,002848 | 17,44548 |
| 0,640909 | 2940 | 0,004273 | 26,16822 |
| 0,854545 | 3724 | 0,005697 | 33,14642 |
| 1,068182 | 4900 | 0,007121 | 43,61371 |
| 1,281818 | 6664 | 0,008545 | 59,31464 |
| 1,495455 | 8428 | 0,00997 | 75,01558 |
| 1,709091 | 10780 | 0,011394 | 95,95016 |
| 1,9 | 13547,35 | 0,012667 | 120,5817 |
| 2,136364 | 14700 | 0,014242 | 130,8411 |
| 2,3 | 16726,81 | 0,015333 | 148,8813 |
| 2,35 | 16584,61 | 0,015667 | 147,6156 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 5A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 5B

**Tabel** Data hasil uji tarik spesimen 5B

| No | Spesimen 5B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 153,71 |
| 3 | Pertambahan panjang (ΔLmax), mm | 3,71 |
| 4 | Luas penampang mula-mula (Ao), mm² | 109,08 |
| 5 | Beban yield (Py), N | 16090,34 |
| 6 | Beban Ultimate (Pu), N | 20096,5 |
| 7 | Beban putus (Ppts), N | 19709,12 |
| 8 | ΔL(yield), mm | 3,02 |
| 9 | ΔL(max/ultimate), mm | 3,67 |
| 10 | ΔL(putus), mm | 3,71 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 3,02 = 153,02 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 3,67 = 153,67 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 3,71 = 153.71 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{16090,34}{109,08}$ = 147,5 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{20096,5}{109,08}$ = 184,23 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{19709,12}{109,08}$ = 180,68 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{153,02-150}{150}$ x 100% = 2,01%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{153,67-150}{150}$ x 100% = 2,4%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{153,71-150}{150}$ x 100% = 2,5%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{20096,5}{109,08}$ = 184,23 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{16090,34}{109,08}$ = 147,5 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{le}$ x 100% = $\frac{153,71-150}{150}$ $x$ 100% = 2,47%

- **Kelentingan *(Resilience)***

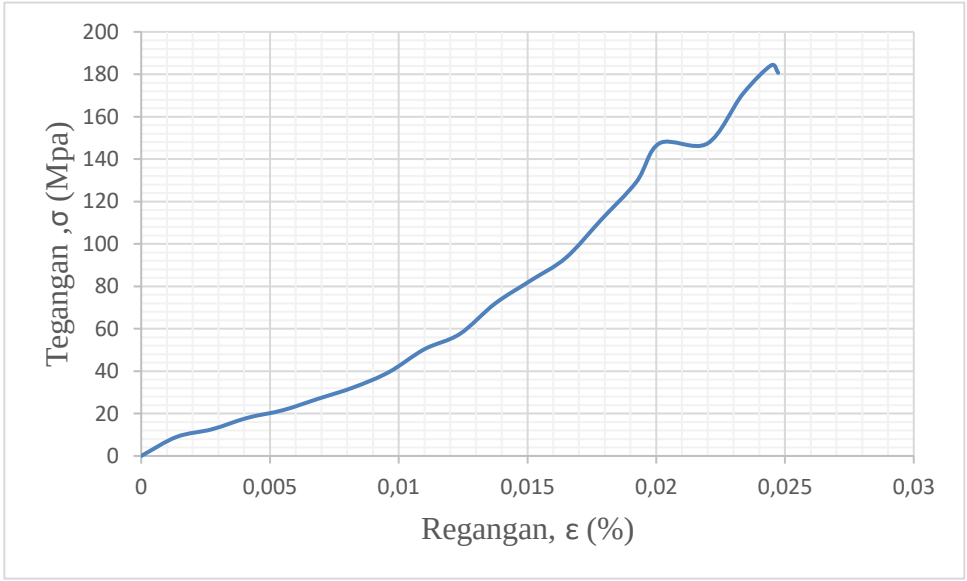
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 147,5 x 2,01 = 148,49 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{147,5+184,23}{2}$ $x$ 2,47 = 410,25 Joule/m³

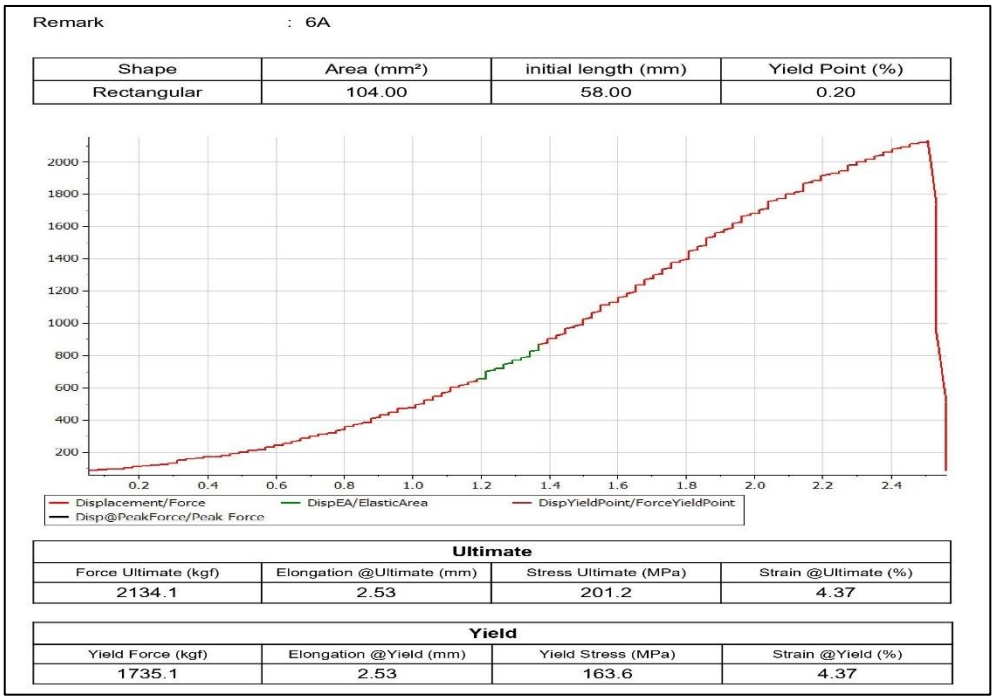
**Tabel** Tegangan Regangan Teknik Spesimen 5B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,206111 | 980 | 0,001374 | 8,984232 |
| 0,412222 | 1372 | 0,002748 | 12,57792 |
| 0,618333 | 1960 | 0,004122 | 17,96846 |
| 0,824444 | 2352 | 0,005496 | 21,56216 |
| 1,030556 | 2940 | 0,00687 | 26,9527 |
| 1,236667 | 3528 | 0,008244 | 32,34323 |
| 1,442778 | 4312 | 0,009619 | 39,53062 |
| 1,648889 | 5488 | 0,010993 | 50,3117 |
| 1,855 | 6272 | 0,012367 | 57,49908 |
| 2,061111 | 7840 | 0,013741 | 71,87385 |
| 2,267222 | 9016 | 0,015115 | 82,65493 |
| 2,473333 | 10192 | 0,016489 | 93,43601 |
| 2,679444 | 12152 | 0,017863 | 111,4045 |
| 2,885556 | 14112 | 0,019237 | 129,3729 |
| 3,02 | 16090,34 | 0,020133 | 147,5095 |
| 3,297778 | 16072 | 0,021985 | 147,3414 |
| 3,503889 | 18620 | 0,023359 | 170,7004 |
| 3,67 | 20096,5 | 0,024467 | 184,2363 |
| 3,71 | 19709,12 | 0,024733 | 180,685 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 5B

### 4.1.6. Perhitungan Uji Tarik Temperatur benda kerja 135°C dan Reduksi ketabalan benda kerja 10%




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 6A

**Tabel** Data hasil uji tarik spesimen 6A

| N | Spesimen 6A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,56 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,56 |
| 4 | Luas penampang mula-mula (Ao), mm² | 104 |
| 5 | Beban yield (Py), N | 17016,12 |
| 6 | Beban Ultimate (Pu), N | 20929,11 |
| 7 | Beban putus (Ppts), N | 17560,41 |
| 8 | ΔL(yield), mm | 2,04 |
| 9 | ΔL(max/ultimate), mm | 2,53 |
| 10 | ΔL(putus), mm | 2,56 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 2,04 = 152,04 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,53 = 152,53 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,56 = 152,56 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{17016,12}{104}$ = 163,61 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{20929,11}{104}$ = 201,24 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{17560,11}{104}$ = 168,85 Mpa
- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{152,04-150}{150}$ x 100% = 1,36%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,53-150}{150}$ x 100% = 1,68%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,56-150}{150}$ x 100% = 1,71%
- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{20929,11}{104}$ = 201,24 Mpa
- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{17016,12}{104}$ = 163,61 Mpa
- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,56-150}{150}$ $x$ 100% = 1,71%

- **Kelentingan *(Resilience)***

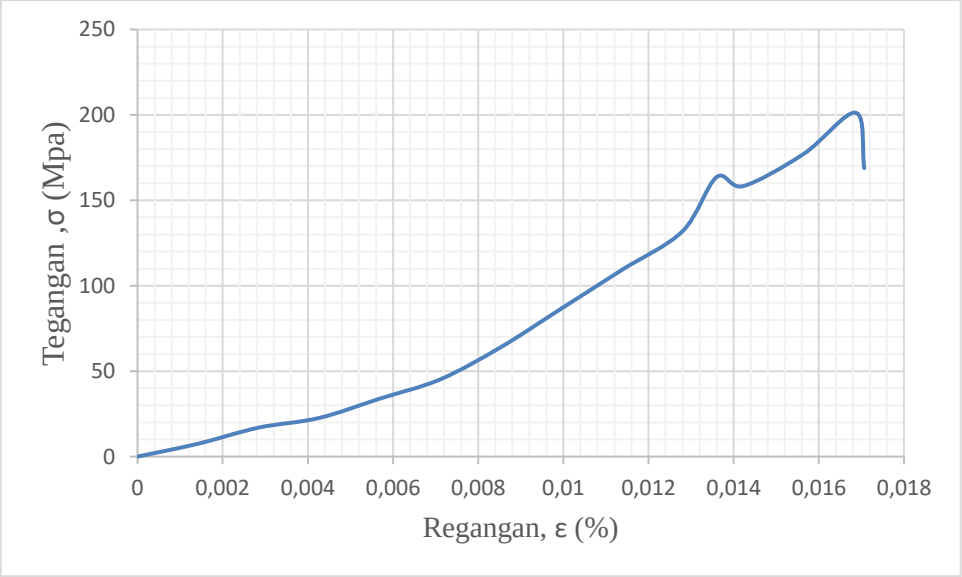
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 163,61 x 1,36 = 111,25 Joule/m³

- **Ketangguhan *(Toughness)***

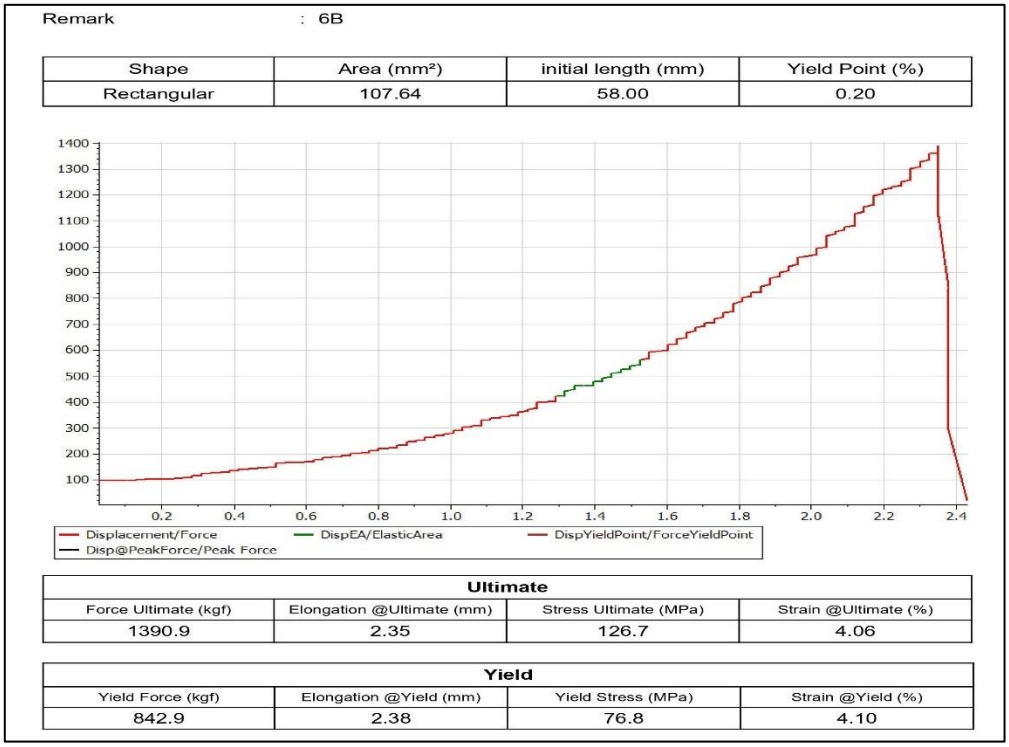
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{163,61+201,24}{2}$ $x$ 1,71 = 311,34 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 6A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,213333 | 784 | 0,001422 | 7,538462 |
| 0,426667 | 1764 | 0,002844 | 16,96154 |
| 0,64 | 2352 | 0,004267 | 22,61538 |
| 0,853333 | 3528 | 0,005689 | 33,92308 |
| 1,066667 | 4704 | 0,007111 | 45,23077 |
| 1,28 | 6664 | 0,008533 | 64,07692 |
| 1,493333 | 9016 | 0,009956 | 86,69231 |
| 1,706667 | 11368 | 0,011378 | 109,3077 |
| 1,92 | 13720 | 0,0128 | 131,9231 |
| 2,04 | 17016,12 | 0,0136 | 163,6165 |
| 2,133333 | 16464 | 0,014222 | 158,3077 |
| 2,346667 | 18424 | 0,015644 | 177,1538 |
| 2,53 | 20929,11 | 0,016867 | 201,2414 |
| 2,56 | 17560,41 | 0,017067 | 168,8501 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 6A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 6B

**Tabel** Data hasil uji tarik spesimen 6B

| No | Spesimen 6B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,42 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,42 |
| 4 | Luas penampang mula-mula (Ao), mm² | 107,64 |
| 5 | Beban yield (Py), N | 8266,32 |
| 6 | Beban Ultimate (Pu), N | 13640,55 |
| 7 | Beban putus (Ppts), N | 13305,15 |
| 8 | ΔL(yield), mm | 1,86 |
| 9 | ΔL(max/ultimate), mm | 2,35 |
| 10 | ΔL(putus), mm | 2,42 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,86 = 151,86 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,35 = 152,35 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,42 = 152,42 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{8266,32}{107,64}$ = 76,79 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{13640,55}{107,64}$ = 126,72 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{13305,15}{107,64}$ = 123,6 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,86-150}{150}$ x 100% = 1,24%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,35-150}{150}$ x 100% = 1,56%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,42-150}{150}$ x 100% = 1,61%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{13640,55}{107,64}$ = 126,72 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{8266,32}{107,64}$ = 76,79 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{le}$ x 100% = $\frac{152,42-150}{150}$ $x$ 100% = 1,61%

- **Kelentingan *(Resilience)***

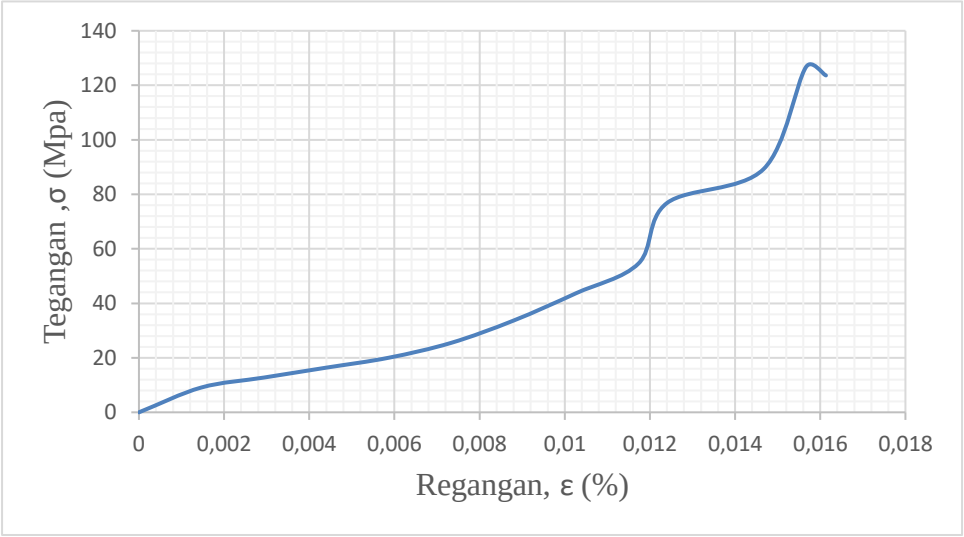
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 76,79 x 1,24 = 47,613 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{76,79+126,72}{2}$ $x$ 1,61 = 164,17 Joule/m³

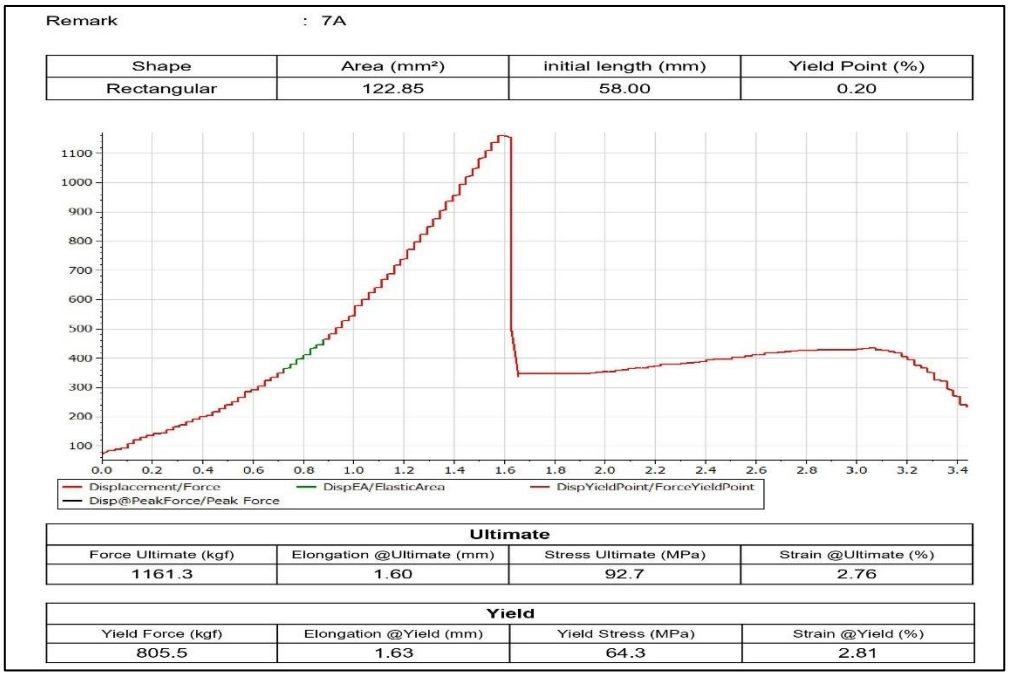
**Tabel** Tegangan Regangan Teknik 6B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,22 | 980 | 0,001467 | 9,104422 |
| 0,44 | 1372 | 0,002933 | 12,74619 |
| 0,66 | 1764 | 0,0044 | 16,38796 |
| 0,88 | 2156 | 0,005867 | 20,02973 |
| 1,1 | 2744 | 0,007333 | 25,49238 |
| 1,32 | 3626 | 0,0088 | 33,68636 |
| 1,54 | 4704 | 0,010267 | 43,70123 |
| 1,76 | 5880 | 0,011733 | 54,62653 |
| 1,86 | 8266,32 | 0,0124 | 76,79599 |
| 2,2 | 9604 | 0,014667 | 89,22334 |
| 2,35 | 13640,55 | 0,015667 | 126,7238 |
| 2,42 | 13305,15 | 0,016133 | 123,6079 |




**Gambar** Grafik Tegangan Regangan Teknik 6B

### 4.1.7. Perhitungan Uji Tarik Temperatur benda kerja 135°C dan Reduksi ketabalan benda kerja 15%




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 7A

**Tabel** Data hasil uji tarik spesimen 7A

| No | Spesimen 7A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 151,64 |
| 3 | Pertambahan panjang (ΔLmax), mm | 1,64 |
| 4 | Luas penampang mula-mula (Ao), mm² | 122,85 |
| 5 | Beban yield (Py), N | 7899,53 |
| 6 | Beban Ultimate (Pu), N | 11388,86 |
| 7 | Beban putus (Ppts), N | 11190,76 |
| 8 | ΔL(yield), mm | 1,28 |
| 9 | ΔL(max/ultimate), mm | 1,6 |
| 10 | ΔL(putus), mm | 1,64 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,28 = 151,28 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 1.6 = 151,6 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 1,64 = 151,64 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{7899,53}{122,85}$ = 64,3 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{11388,86}{122,85}$ = 92,7 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{11190,76}{122,85}$ = 92,1 Mpa
- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,28-150}{150}$ x 100% = 0,85%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{151,6-150}{150}$ x 100% = 1,06%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{151,64-150}{150}$ x 100% = 1,09%
- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{11388,86}{122,85}$ = 92,7 Mpa
- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{7899,53}{122,85}$ = 64,3 Mpa
- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{151,64-150}{150}$ $x$ 100% = 1,09%

- **Kelentingan *(Resilience)***

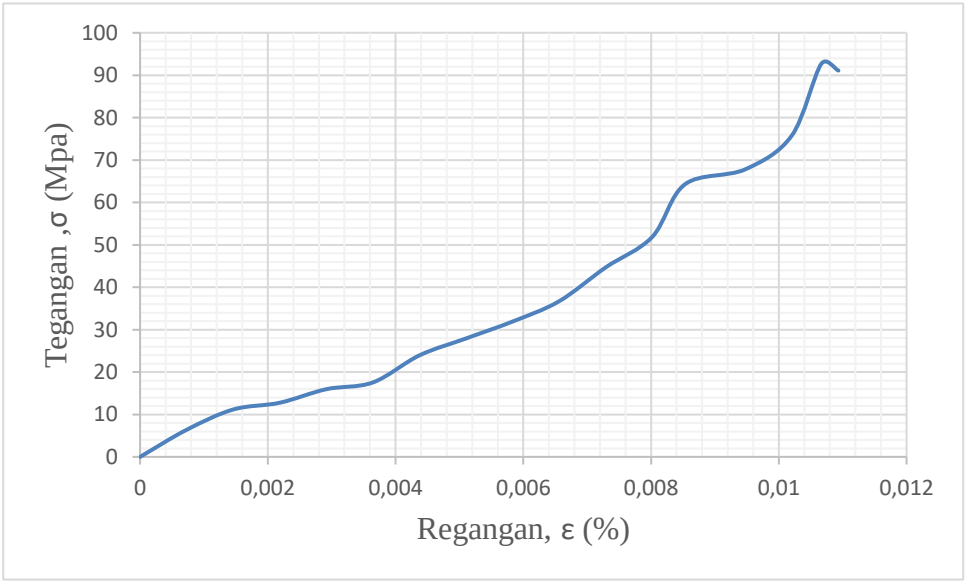
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 64,3 x 0,85 = 27,44 Joule/m³

- **Ketangguhan *(Toughness)***

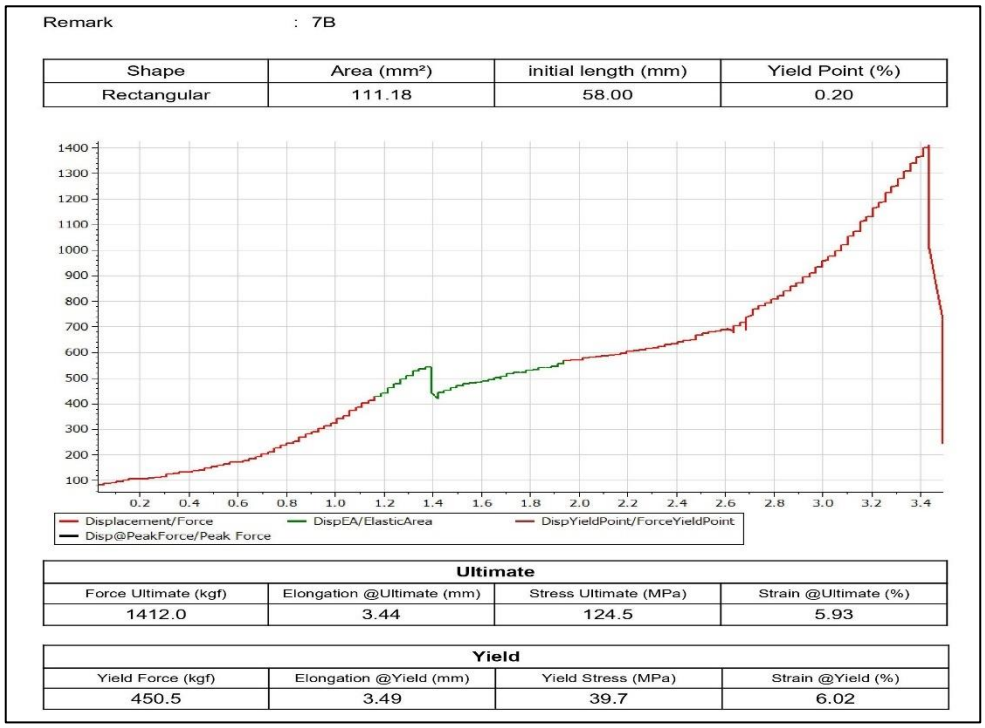
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{64,3 + 92,7}{2}$ $x$ 1,09 = 85,83 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 7A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,109333 | 784 | 0,000729 | 6,381766 |
| 0,218667 | 1372 | 0,001458 | 11,16809 |
| 0,328 | 1568 | 0,002187 | 12,76353 |
| 0,437333 | 1960 | 0,002916 | 15,95442 |
| 0,546667 | 2156 | 0,003644 | 17,54986 |
| 0,656 | 2940 | 0,004373 | 23,93162 |
| 0,765333 | 3430 | 0,005102 | 27,92023 |
| 0,874667 | 3920 | 0,005831 | 31,90883 |
| 0,984 | 4508 | 0,00656 | 36,69516 |
| 1,093333 | 5488 | 0,007289 | 44,67236 |
| 1,202667 | 6370 | 0,008018 | 51,85185 |
| 1,28 | 7899,53 | 0,008533 | 64,30224 |
| 1,421333 | 8330 | 0,009476 | 67,80627 |
| 1,530667 | 9310 | 0,010204 | 75,78348 |
| 1,6 | 11388,86 | 0,010667 | 92,70541 |
| 1,64 | 11190,76 | 0,010933 | 91,09288 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 7A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 7B

**Tabel** Data hasil uji tarik spesimen 7B

| No | Spesimen 7B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 153,5 |
| 3 | Pertambahan panjang (ΔLmax), mm | 3,5 |
| 4 | Luas penampang mula-mula (Ao), mm² | 111,18 |
| 5 | Beban yield (Py), N | 4418,05 |
| 6 | Beban Ultimate (Pu), N | 13847,48 |
| 7 | Beban putus (Ppts), N | 13622,9 |
| 8 | ΔL(yield), mm | 1,4 |
| 9 | ΔL(max/ultimate), mm | 3,44 |
| 10 | ΔL(putus), mm | 3,5 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,4 = 151,4 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 3,44 = 153,44 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 3,5 = 153,5 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{4418,05}{111,18}$ = 39,73 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{13847,48}{111,18}$ = 124,55 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{13622,9}{111,18}$ = 122,53 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,4-150}{150}$ x 100% = 0,93%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{153,44-150}{150}$ x 100% = 2,29%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{153,5-150}{150}$ x 100% = 2,33%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{13847,48}{111,18}$ = 124,55 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{4418,05}{111,18}$ = 39,73 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{le}$ x 100% = $\frac{153,5-150}{150}$ $x$ 100% = 2,33%

- **Kelentingan *(Resilience)***

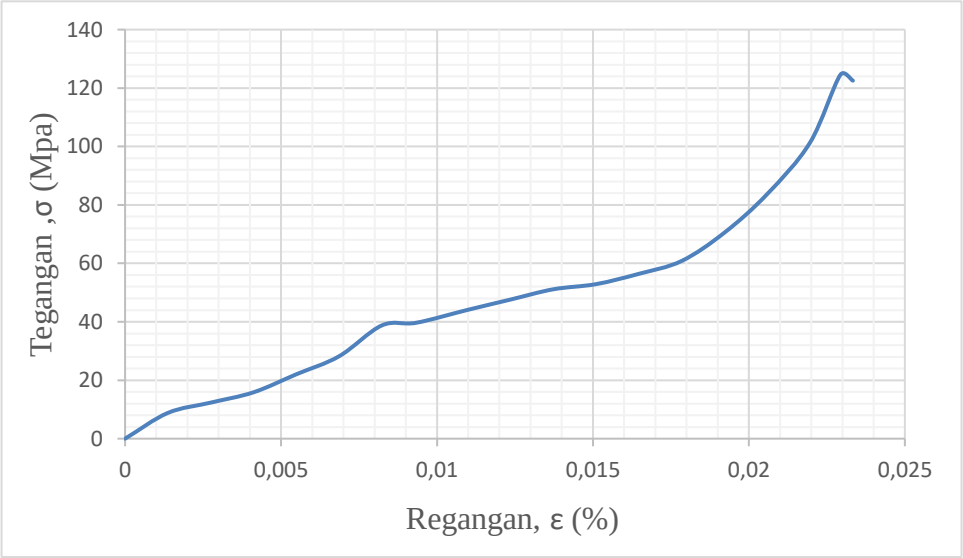
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 39,73 x 0,93 = 18,54 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{39,73+124,55}{2}$ $x$ 2,33 = 191,67 Joule/m³

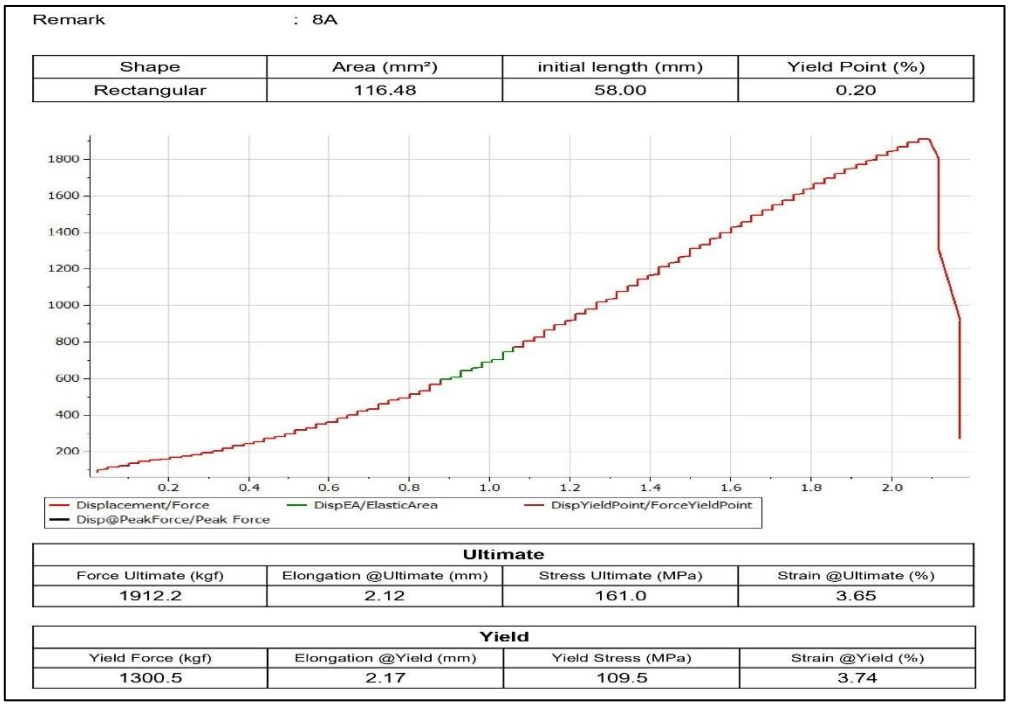
**Tabel** Tegangan Regangan Teknik 7B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,205882 | 980 | 0,001373 | 8,814535 |
| 0,411765 | 1372 | 0,002745 | 12,34035 |
| 0,617647 | 1764 | 0,004118 | 15,86616 |
| 0,823529 | 2450 | 0,00549 | 22,03634 |
| 1,029412 | 3136 | 0,006863 | 28,20651 |
| 1,235294 | 4312 | 0,008235 | 38,78395 |
| 1,4 | 4410 | 0,009333 | 39,66541 |
| 1,647059 | 4900 | 0,01098 | 44,07267 |
| 1,852941 | 5292 | 0,012353 | 47,59849 |
| 2,058824 | 5684 | 0,013725 | 51,1243 |
| 2,264706 | 5880 | 0,015098 | 52,88721 |
| 2,470588 | 6272 | 0,016471 | 56,41302 |
| 2,676471 | 6762 | 0,017843 | 60,82029 |
| 2,882353 | 7840 | 0,019216 | 70,51628 |
| 3,088235 | 9310 | 0,020588 | 83,73808 |
| 3,294118 | 11270 | 0,021961 | 101,3672 |
| 3,44 | 13847,28 | 0,022933 | 124,5483 |
| 3,5 | 13622,9 | 0,023333 | 122,5301 |




**Gambar** Grafik Tegangan Regangan Teknik 7B

### 4.1.8. Perhitungan Uji Tarik Temperatur benda kerja 125°C dan Reduksi ketabalan benda kerja 5%




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 8A

**Tabel** Data hasil uji tarik spesimen 8A

| No | Spesimen 8A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,18 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,18 |
| 4 | Luas penampang mula-mula (Ao), mm² | 116,48 |
| 5 | Beban yield (Py), N | 12754 |
| 6 | Beban Ultimate (Pu), N | 18752,94 |
| 7 | Beban putus (Ppts), N | 17712,42 |
| 8 | ΔL(yield), mm | 1,52 |
| 9 | ΔL(max/ultimate), mm | 2,12 |
| 10 | ΔL(putus), mm | 2,18 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,52 = 151,52 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,12 = 152,12 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,18 = 152,18 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{12754}{116,48}$ = 109,49 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{17752,94}{116,48}$ = 160,99 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{17712,42}{116,48}$ = 152,06 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,52-150}{150}$ x 100% = 1,01%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,12-150}{150}$ x 100% = 1,41%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,18-150}{150}$ x 100% = 1,45%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{17752,94}{116,48}$ = 160,99 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{12754}{116,48}$ = 109,49 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,18-150}{150}$ $x$ 100% = 1,45%

- **Kelentingan *(Resilience)***

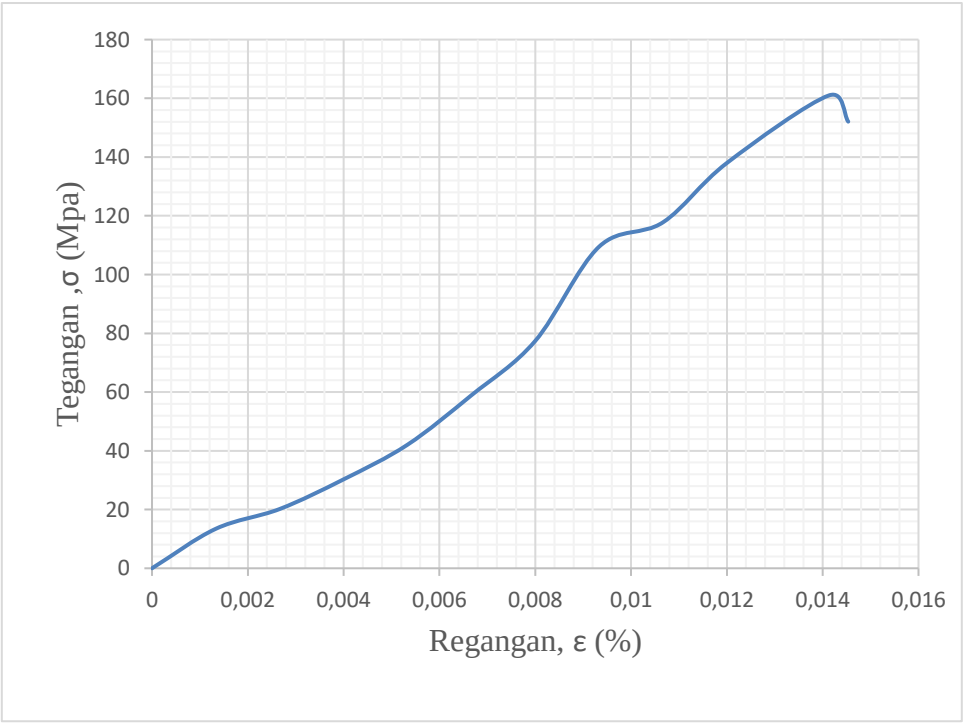
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 109,49 x 1,01 = 55,47 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{109,49+160,99}{2}$ $x$ 1,45 = 196,55 Joule/m³

**Tabel** Tegangan Regangan Teknik 8A

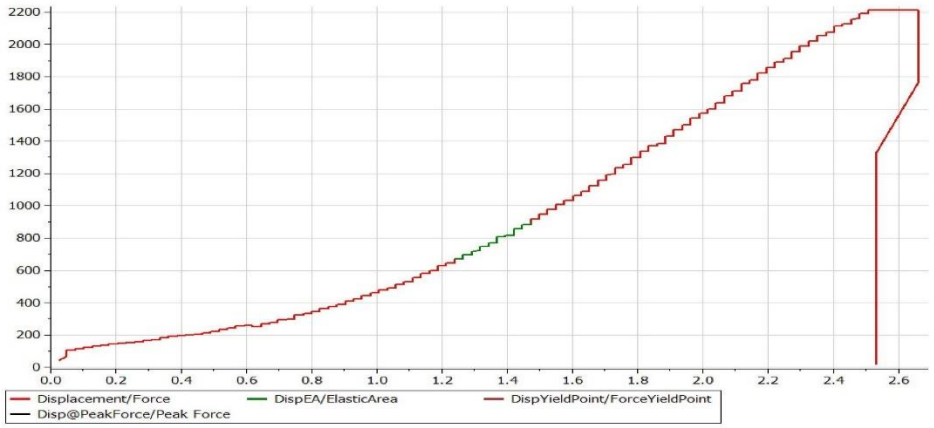
| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,218 | 1568 | 0,001453 | 13,46154 |
| 0,436 | 2352 | 0,002907 | 20,19231 |
| 0,654 | 3528 | 0,00436 | 30,28846 |
| 0,872 | 4900 | 0,005813 | 42,06731 |
| 1,09 | 6860 | 0,007267 | 58,89423 |
| 1,308 | 9016 | 0,00872 | 77,40385 |
| 1,526 | 12754 | 0,010173 | 109,4952 |
| 1,744 | 13720 | 0,011627 | 117,7885 |
| 1,962 | 16072 | 0,01308 | 137,9808 |
| 2,12 | 18752,94 | 0,014133 | 160,9971 |
| 2,18 | 17712,42 | 0,014533 | 152,064 |




**Gambar** Grafik Tegangan Regangan Teknik 8A

Remark : 8B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 123.83 | 58.00 | 0.20 |




| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 2213.5 | 2.66 | 175.3 | 4.59 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1771.8 | 2.53 | 140.3 | 4.37 |

**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 8B

**Tabel** Data hasil uji tarik spesimen 8B

| No | Spesimen 8B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,69 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,69 |
| 4 | Luas penampang mula-mula (Ao), mm² | 123,48 |
| 5 | Beban yield (Py), N | 17376,04 |
| 6 | Beban Ultimate (Pu), N | 21707,79 |
| 7 | Beban putus (Ppts), N | 21578,34 |
| 8 | ΔL(yield), mm | 2,11 |
| 9 | ΔL(max/ultimate), mm | 2,66 |
| 10 | ΔL(putus), mm | 2,69 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 2,11 = 152,11 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,66 = 152,66 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,69 = 152,69 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{17376,04}{123,48}$ = 140,32 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{21707,79}{123,48}$ = 175,3 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{21578,34}{123,48}$ = 174,25 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{152,11-150}{150}$ x 100% = 1,4%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,66-150}{150}$ x 100% = 1,77%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,69-150}{150}$ x 100% = 1,79%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{21707,79}{123,48}$ = 175,3 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{17376,04}{123,48}$ = 140,32 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{le}$ x 100% = $\frac{152,69-150}{150}$ $x$ 100% = 1,79%

- **Kelentingan *(Resilience)***

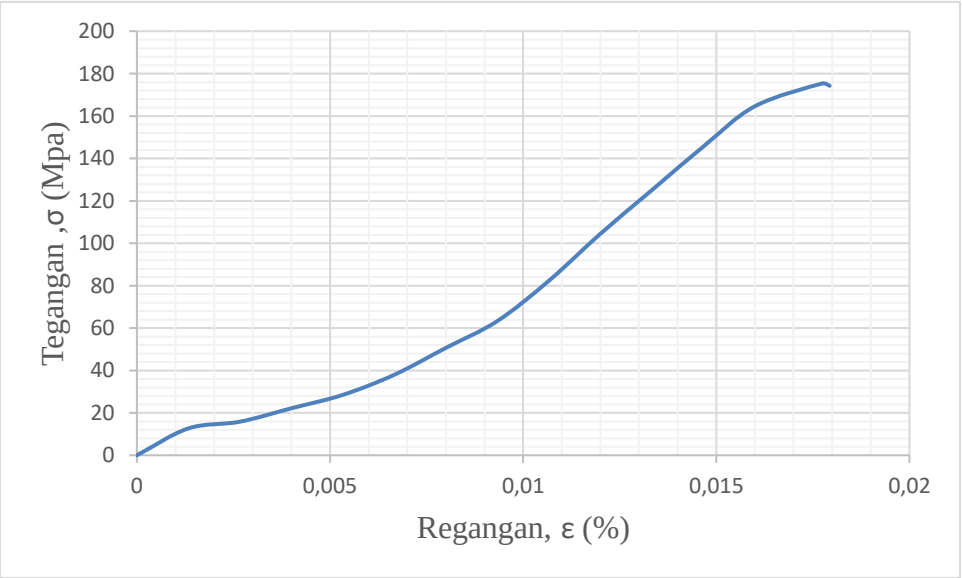
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 140,32 x 1,4 = 98,69 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{140,32+175,3}{2}$ $x$ 1,79 = 283,01 Joule/m³

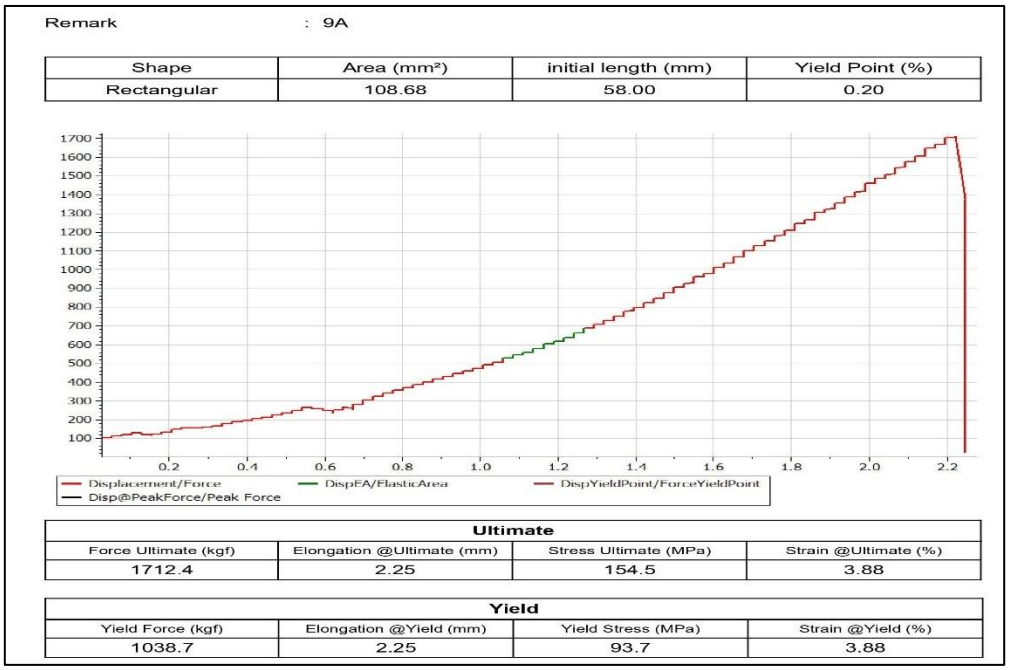
**Tabel** Tegangan Regangan Teknik Spesimen 8B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,224167 | 1568 | 0,001494 | 12,66252 |
| 0,448333 | 1960 | 0,002989 | 15,82815 |
| 0,6725 | 2744 | 0,004483 | 22,15941 |
| 0,896667 | 3528 | 0,005978 | 28,49067 |
| 1,120833 | 4704 | 0,007472 | 37,98756 |
| 1,345 | 6272 | 0,008967 | 50,65008 |
| 1,569167 | 7840 | 0,010461 | 63,31261 |
| 1,793333 | 10192 | 0,011956 | 82,30639 |
| 2,0175 | 12936 | 0,01345 | 104,4658 |
| 2,11 | 17376 | 0,014067 | 140,3214 |
| 2,241667 | 15484 | 0,014944 | 125,0424 |
| 2,465833 | 18032 | 0,016439 | 145,619 |
| 2,66 | 21707,8 | 0,017733 | 175,3032 |
| 2,69 | 21578,3 | 0,017933 | 174,2574 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 8B

### 4.1.9. Perhitungan Uji Tarik Temperatur benda kerja 125°C dan Reduksi ketabalan benda kerja 10%




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 9A

**Tabel** Data hasil uji tarik spesimen 9A

| No | Spesimen 9A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,29 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,29 |
| 4 | Luas penampang mula-mula (Ao), mm² | 108,68 |
| 5 | Beban yield (Py), N | 10186,53 |
| 6 | Beban Ultimate (Pu), N | 16793,5 |
| 7 | Beban putus (Ppts), N | 16623,84 |
| 8 | ΔL(yield), mm | 1,63 |
| 9 | ΔL(max/ultimate), mm | 2,25 |
| 10 | ΔL(putus), mm | 2,29 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,63 = 151,63 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,25 = 152,25 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,29 = 152,29 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{10186,53}{108,68}$ = 93,72 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{16793,5}{108,68}$ = 154,52 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{16623,84}{108,68}$ = 152,96 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,63-150}{150}$ x 100% = 1.08%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,25-150}{150}$ x 100% = 1,5%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,29-150}{150}$ x 100% = 1,53%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{16793,84}{108,68}$ = 154,52 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{10186,53}{108,68}$ = 93,72 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,29-150}{150}$ $x$ 100% = 1,53%

- **Kelentingan *(Resilience)***

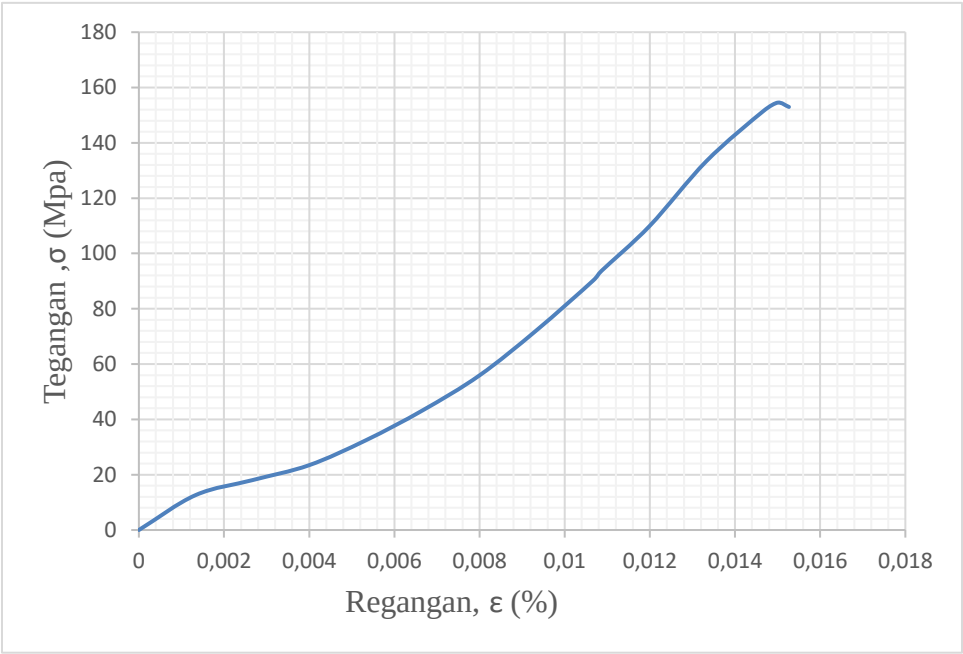
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 93,72 x 1,08 = 50,92 Joule/m³

- **Ketangguhan *(Toughness)***

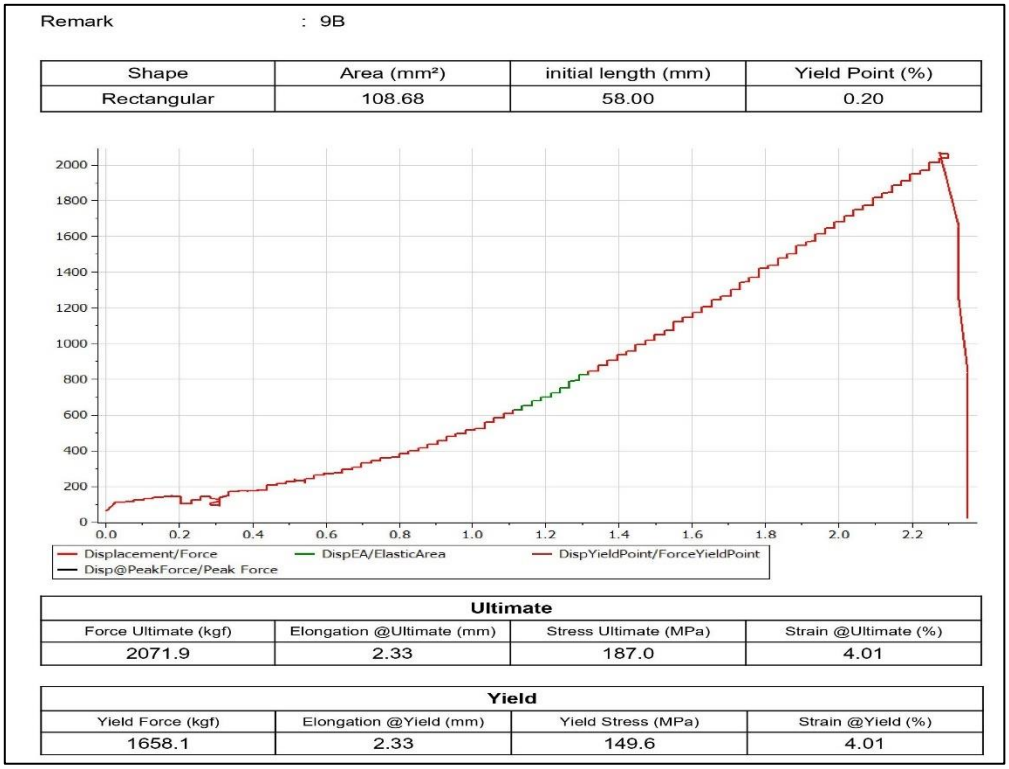
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{93,72+154,52}{2}$ $x$ 1,53 = 189,49 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 9A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,2 | 1372 | 0,001333 | 12,62422 |
| 0,4 | 1960 | 0,002667 | 18,0346 |
| 0,6 | 2548 | 0,004 | 23,44498 |
| 0,8 | 3528 | 0,005333 | 32,46227 |
| 1 | 4704 | 0,006667 | 43,28303 |
| 1,2 | 6076 | 0,008 | 55,90725 |
| 1,4 | 7840 | 0,009333 | 72,13839 |
| 1,6 | 9800 | 0,010667 | 90,17298 |
| 1,63 | 10186,5 | 0,010867 | 93,7293 |
| 1,8 | 11956 | 0,012 | 110,011 |
| 2 | 14504 | 0,013333 | 133,456 |
| 2,2 | 16464 | 0,014667 | 151,4906 |
| 2,25 | 16793,5 | 0,015 | 154,5225 |
| 2,29 | 16623,8 | 0,015267 | 152,961 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 9A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 9B

**Tabel 4**Data hasil uji tarik spesimen 9B

| No | Spesimen 9B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,38 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,38 |
| 4 | Luas penampang mula-mula (Ao), mm² | 108,68 |
| 5 | Beban yield (Py), N | 16260,98 |
| 6 | Beban Ultimate (Pu), N | 20319,12 |
| 7 | Beban putus (Ppts), N | 20085,71 |
| 8 | ΔL(yield), mm | 1,98 |
| 9 | ΔL(max/ultimate), mm | 2,33 |
| 10 | ΔL(putus), mm | 2,38 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,98 = 151,98 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,33 = 152,33 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,38 = 152,38 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{16260,98}{108,68}$ = 149,62 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{20319,12}{108,68}$ = 186,96 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{20085,71}{108,68}$ = 184,81 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,98-150}{150}$ x 100% = 1,32%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,33-150}{150}$ x 100% = 1,55%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,38-150}{150}$ x 100% = 1,59%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{20319,12}{108,68}$ = 186,96 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{16260,98}{108,68}$ = 149,62 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{le}$ x 100% = $\frac{152,38-150}{150}$ $x$ 100% = 1,59%

- **Kelentingan *(Resilience)***

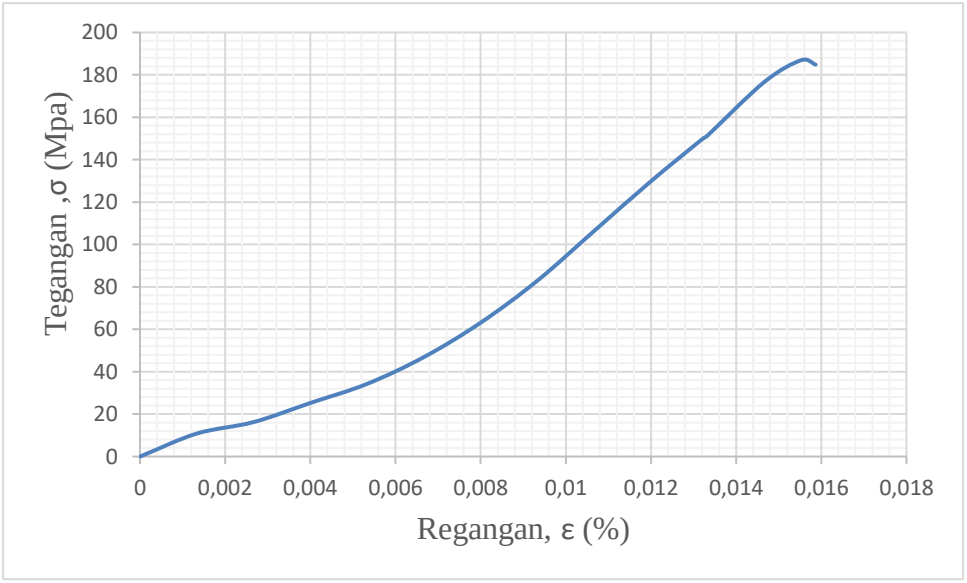
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y = \frac{1}{2}$ x 149,62 x 1,32 = 98,75 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{149,62+186,96}{2}$ $x$ 1,59 = 267,02 Joule/m³

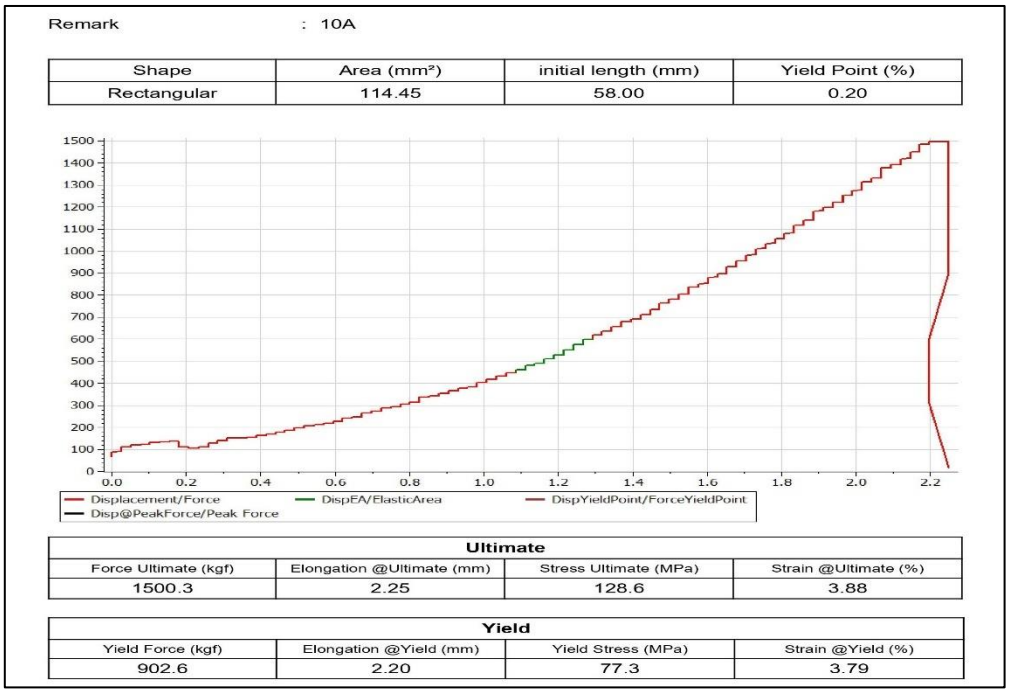
**Tabel** Tegangan Regangan Teknik Spesimen 9B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,2 | 1176 | 0,001333 | 10,82076 |
| 0,4 | 1764 | 0,002667 | 16,23114 |
| 0,6 | 2744 | 0,004 | 25,24844 |
| 0,8 | 3724 | 0,005333 | 34,26573 |
| 1 | 5096 | 0,006667 | 46,88995 |
| 1,2 | 6860 | 0,008 | 63,12109 |
| 1,4 | 9016 | 0,009333 | 82,95915 |
| 1,6 | 11564 | 0,010667 | 106,4041 |
| 1,8 | 14112 | 0,012 | 129,8491 |
| 1,98 | 16260,9 | 0,0132 | 149,6218 |
| 2 | 16464 | 0,013333 | 151,4906 |
| 2,2 | 19208 | 0,014667 | 176,7391 |
| 2,33 | 20319,1 | 0,015533 | 186,9626 |
| 2,38 | 20085,7 | 0,015867 | 184,8151 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 9B

### 4.1.10. Perhitungan Uji Tarik Temperatur benda kerja 125°C dan Reduksi ketebalan benda kerja 15%




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 10A

**Tabel** Data hasil uji tarik spesimen 10A

| No | Spesimen 10A | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,3 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,3 |
| 4 | Luas penampang mula-mula (Ao), mm² | 114,45 |
| 5 | Beban yield (Py), N | 8851,79 |
| 6 | Beban Ultimate (Pu), N | 14713,44 |
| 7 | Beban putus (Ppts), N | 14654,6 |
| 8 | ΔL(yield), mm | 1,65 |
| 9 | ΔL(max/ultimate), mm | 2,25 |
| 10 | ΔL(putus), mm | 2,3 |

- **Tegangan Teknik dan Regangan Teknik**

  $Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,65 = 151,65 mm

  $Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,25 = 152,25 mm

  $Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,3 = 152,3 mm

  - Tegangan Teknik

    $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{8851,79}{114,45}$ = 77,34 Mpa

    $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{14713,44}{114,45}$ = 128,55 Mpa

    $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{14654,6}{114,45}$ = 128,04 Mpa
  - Regangan Teknik

    $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,65-150}{150}$ x 100% = 1,1%

    $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,25-150}{150}$ x 100% = 1,5%

    $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,3-150}{150}$ x 100% = 1,53%
  - Kekuatan tarik maksimum (UTS)

    $Su = \frac{Pmax}{Ao} = \frac{14713,44}{114,45}$ = 128,55 Mpa
  - Batas luluh (Yielding)

    So = $\frac{Py}{Ao} = \frac{8851,79}{114,45}$ = 77,34 Mpa
  - Keliatan (keuletan)

    Presentase perpanjangan

    $e_f = \frac{lf-le}{lo}$ x 100% = $\frac{152,3-150}{150}$ $x$ 100% = 1,53%

- **Kelentingan *(Resilience)***

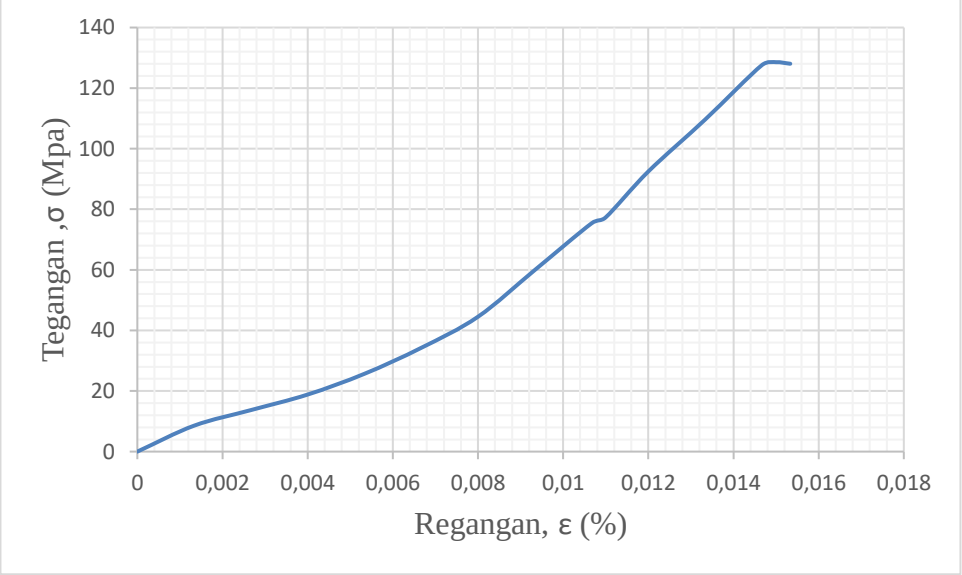
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y$ = $\frac{1}{2}$ x 77,34 x 1,1 = 42,53 Joule/m³

- **Ketangguhan *(Toughness)***

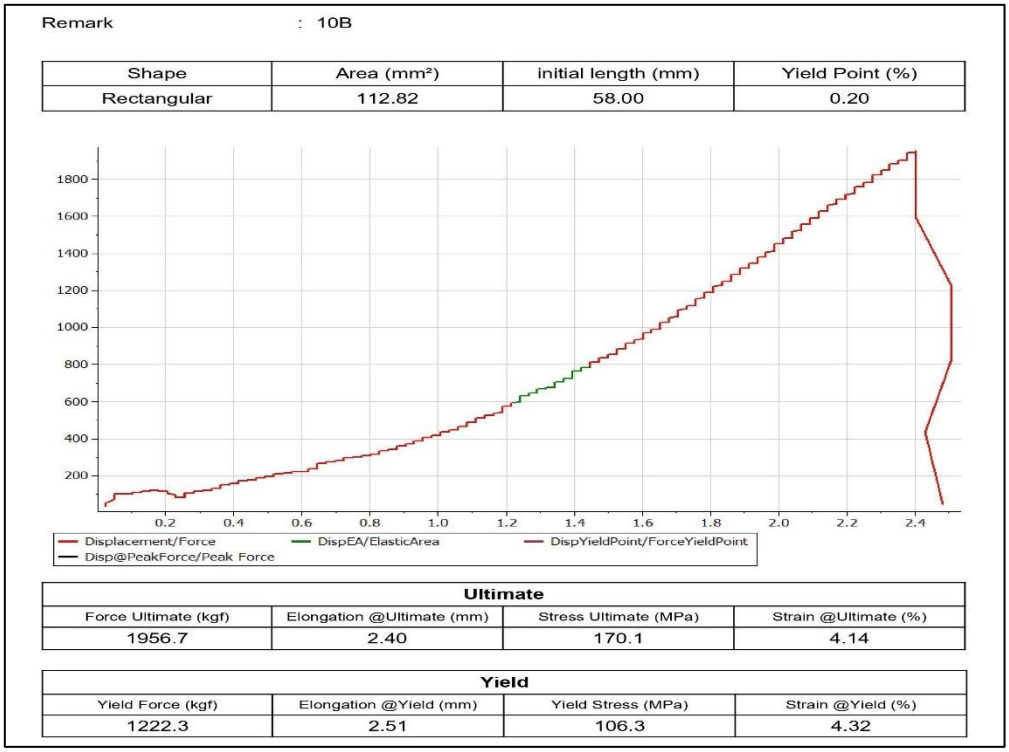
  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{77,34+128,55}{2}$ $x$ 1,53 = 157,85 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 10A

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,2 | 980 | 0,001333 | 8,562691 |
| 0,4 | 1568 | 0,002667 | 13,70031 |
| 0,6 | 2156 | 0,004 | 18,83792 |
| 0,8 | 2940 | 0,005333 | 25,68807 |
| 1 | 3920 | 0,006667 | 34,25076 |
| 1,2 | 5096 | 0,008 | 44,52599 |
| 1,4 | 6860 | 0,009333 | 59,93884 |
| 1,6 | 8624 | 0,010667 | 75,35168 |
| 1,65 | 8851,79 | 0,011 | 77,34198 |
| 1,8 | 10584 | 0,012 | 92,47706 |
| 2 | 12544 | 0,013333 | 109,6024 |
| 2,2 | 14602 | 0,014667 | 127,5841 |
| 2,25 | 14713,44 | 0,015 | 128,5578 |
| 2,3 | 14654,6 | 0,015333 | 128,0437 |




**Gambar** Grafik Tegangan Regangan Teknik Spesimen 10A




**Gambar** Grafik Pertambahan Panjang dan Pertambahan Beban 10B

**Tabel** Data hasil uji tarik spesimen 10B

| No | Spesimen 10B | Keterangan |
|---|---|---|
| 1 | Panjang awal (Le), mm | 150 |
| 2 | Panjang akhir (Lf), mm | 152,51 |
| 3 | Pertambahan panjang (ΔLmax), mm | 2,51 |
| 4 | Luas penampang mula-mula (Ao), mm² | 112,82 |
| 5 | Beban yield (Py), N | 11987,09 |
| 6 | Beban Ultimate (Pu), N | 19189,35 |
| 7 | Beban putus (Ppts), N | 18675,47 |
| 8 | ΔL(yield), mm | 1,83 |
| 9 | ΔL(max/ultimate), mm | 2,4 |
| 10 | ΔL(putus), mm | 2,51 |

- **Tegangan Teknik dan Regangan Teknik**

$Lyield$ = $L$e + $\Delta Ly$ = 150 + 1,83 = 151,83 mm

$Lmax$ = $L$e + $\Delta Lu$ = 150 + 2,4 = 152,4 mm

$Lputus$ = $L$e + $\Delta Lpts$ = 150 + 2,51 = 152,51 mm

- Tegangan Teknik

  $\sigma_{t(y)} = \frac{Py}{Ao} = \frac{11987,09}{112,82}$ = 106,24 Mpa

  $\sigma_{t(max)} = \frac{Pmax}{Ao} = \frac{19189,35}{112,82}$ = 170,08 Mpa

  $\sigma_{t(putus)} = \frac{Pputus}{Ao} = \frac{18675,47}{112,82}$ = 165,53 Mpa

- Regangan Teknik

  $\varepsilon_y = \frac{Ly-Le}{Le}$ x 100% = $\frac{151,83-150}{150}$ x 100% = 1,22%

  $\varepsilon_{max} = \frac{Lu-Le}{Le}$ x 100% = $\frac{152,4-150}{150}$ x 100% = 1,6%

  $\varepsilon_{putus} = \frac{Lputus-Le}{Le}$ x 100% = $\frac{152,51-150}{150}$ x 100% = 1,67%

- Kekuatan tarik maksimum (UTS)

  $Su = \frac{Pmax}{Ao} = \frac{19189,35}{112,82}$ = 170,08 Mpa

- Batas luluh (Yielding)

  So = $\frac{Py}{Ao} = \frac{11987,09}{112,82}$ = 106,24 Mpa

- Keliatan (keuletan)

  Presentase perpanjangan

  $e_f = \frac{lf-le}{le}$ x 100% = $\frac{152,51-150}{150}$ $x$ 100% = 1,67%

- **Kelentingan *(Resilience)***

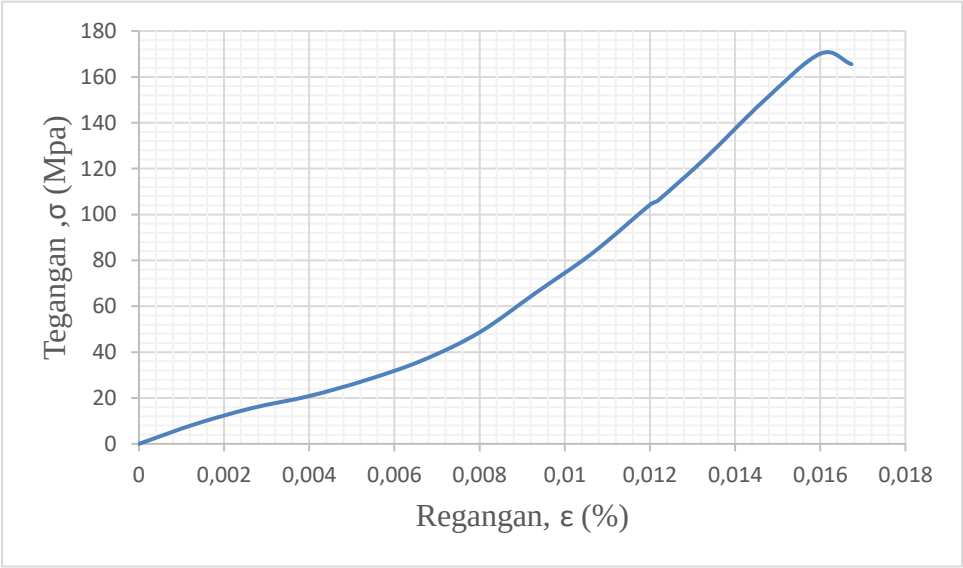
  $U_R = \frac{1}{2}$ x So x $\varepsilon_y = \frac{1}{2}$ x 106,24 x 1,22 = 64,81 Joule/m³

- **Ketangguhan *(Toughness)***

  $U_T = \frac{So+Su}{2}$ $x$ $ef$ = $\frac{106,24+170,08}{2}$ $x$ 1,67 = 231,2 Joule/m³

**Tabel** Tegangan Regangan Teknik Spesimen 10B

| ΔL, mm | F, (N) | εt , % | σt, Mpa |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0,2 | 980 | 0,001333 | 8,686403 |
| 0,4 | 1764 | 0,002667 | 15,63553 |
| 0,6 | 2352 | 0,004 | 20,84737 |
| 0,8 | 3136 | 0,005333 | 27,79649 |
| 1 | 4116 | 0,006667 | 36,48289 |
| 1,2 | 5488 | 0,008 | 48,64386 |
| 1,4 | 7448 | 0,009333 | 66,01666 |
| 1,6 | 9408 | 0,010667 | 83,38947 |
| 1,8 | 11760 | 0,012 | 104,2368 |
| 1,83 | 11987,09 | 0,0122 | 106,2497 |
| 2 | 14112 | 0,013333 | 125,0842 |
| 2,2 | 16856 | 0,014667 | 149,4061 |
| 2,4 | 19189,35 | 0,016 | 170,0882 |
| 2,51 | 18675,47 | 0,016733 | 165,5333 |

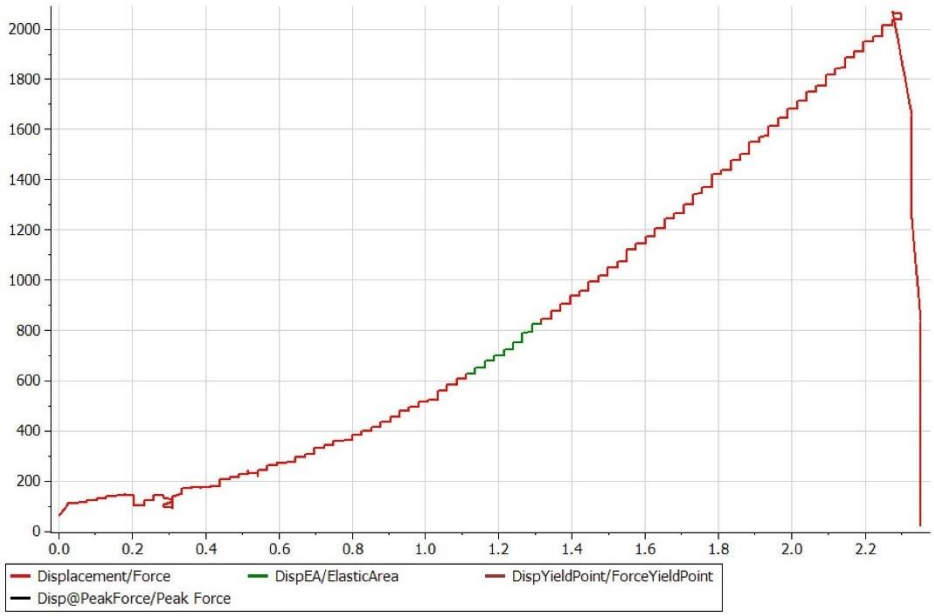



**Gambar** Grafik Tegangan Regangan Teknik Spesimen 10B

## 10. Pertambahan Panjang dan Pertambahan Beban

Remark : 9B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 108.68 | 58.00 | 0.20 |

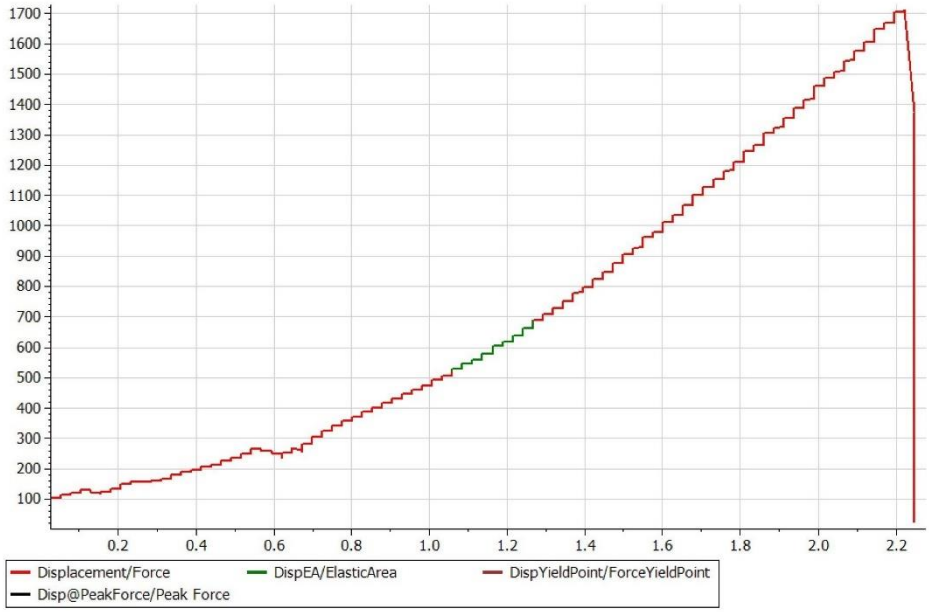



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 2071.9 | 2.33 | 187.0 | 4.01 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1658.1 | 2.33 | 149.6 | 4.01 |

Remark : 9A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 108.68 | 58.00 | 0.20 |

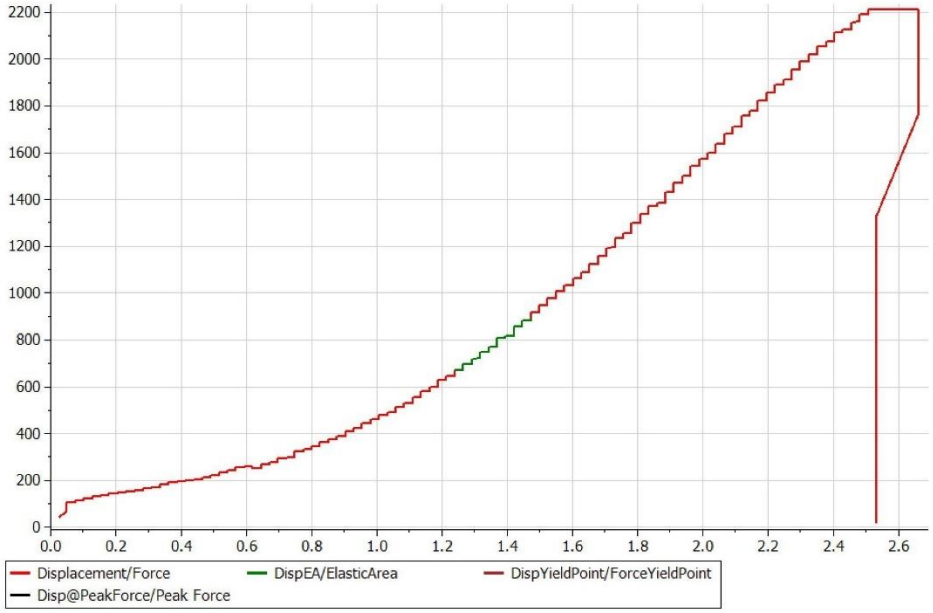



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1712.4 | 2.25 | 154.5 | 3.88 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1038.7 | 2.25 | 93.7 | 3.88 |

Remark : 8B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 123.83 | 58.00 | 0.20 |

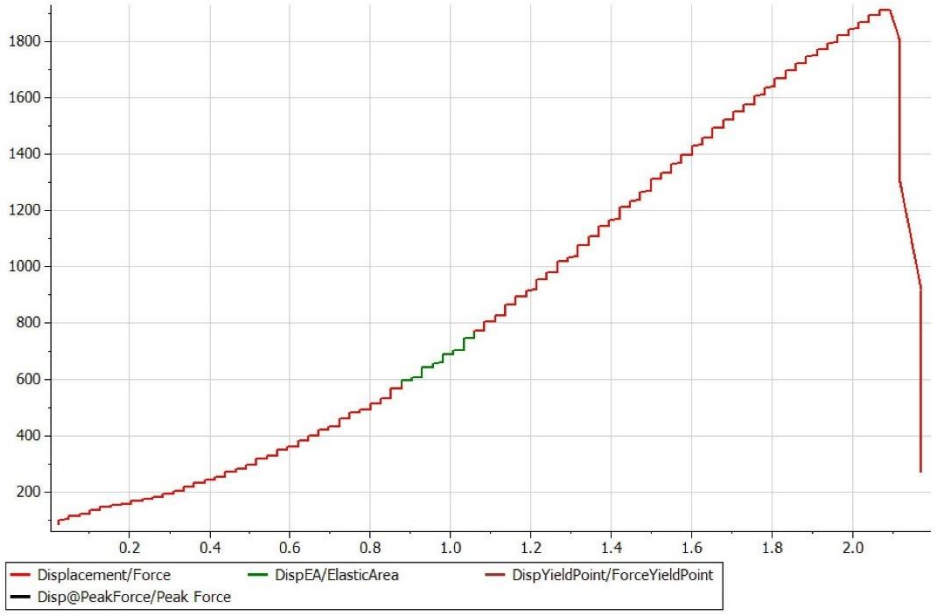



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 2213.5 | 2.66 | 175.3 | 4.59 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1771.8 | 2.53 | 140.3 | 4.37 |

Remark : 8A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 116.48 | 58.00 | 0.20 |

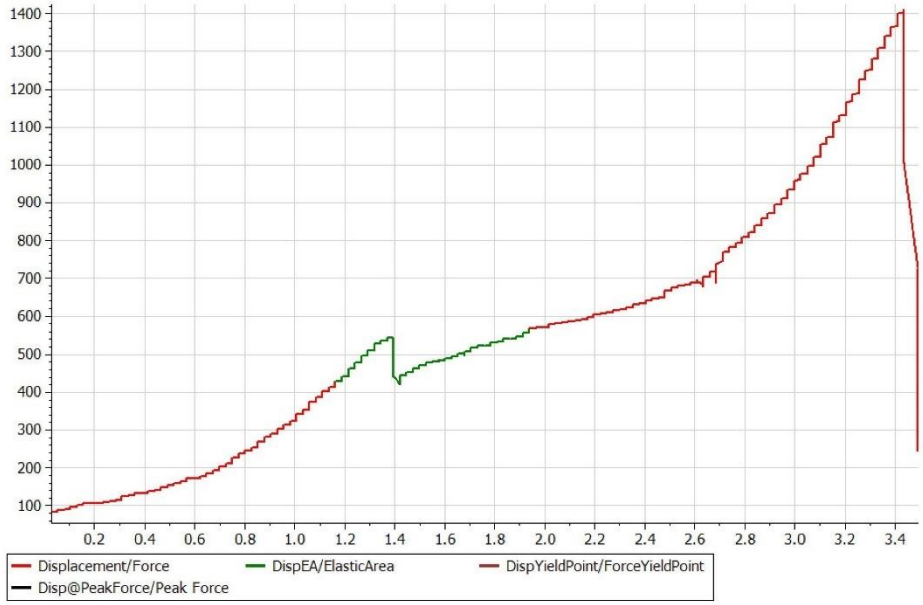



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1912.2 | 2.12 | 161.0 | 3.65 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1300.5 | 2.17 | 109.5 | 3.74 |

Remark : 7B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 111.18 | 58.00 | 0.20 |

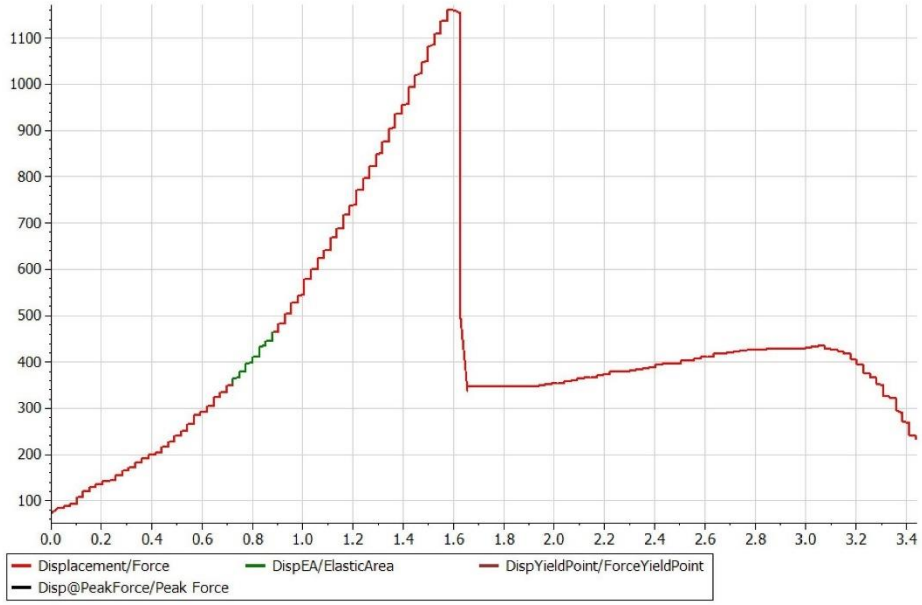



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1412.0 | 3.44 | 124.5 | 5.93 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 450.5 | 3.49 | 39.7 | 6.02 |

Remark : 7A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 122.85 | 58.00 | 0.20 |

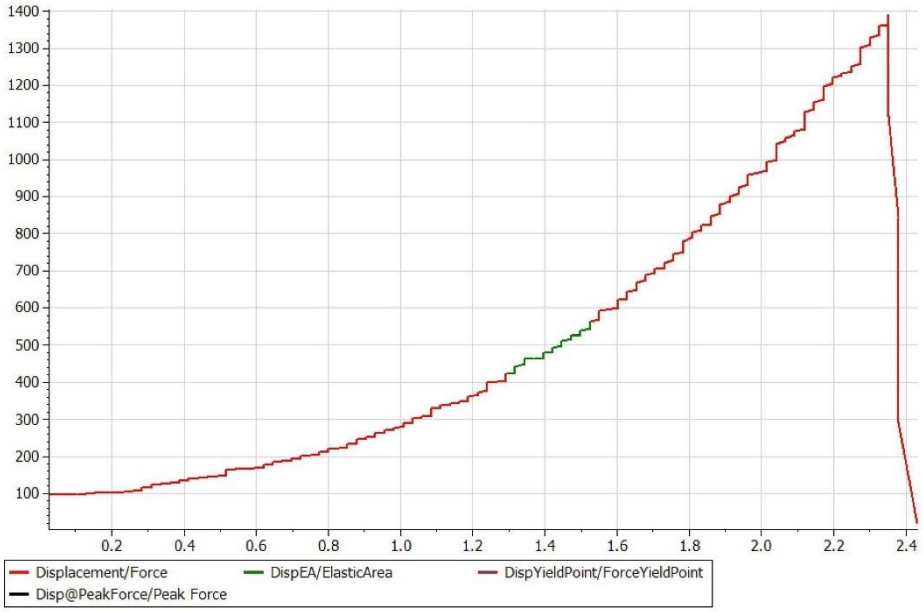



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1161.3 | 1.60 | 92.7 | 2.76 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 805.5 | 1.63 | 64.3 | 2.81 |

Remark : 6B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 107.64 | 58.00 | 0.20 |

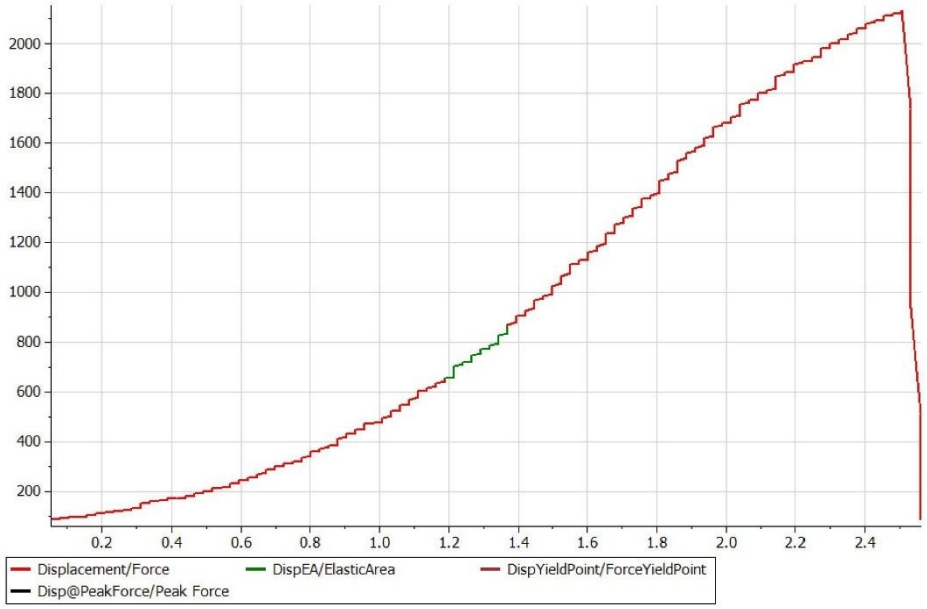



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1390.9 | 2.35 | 126.7 | 4.06 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 842.9 | 2.38 | 76.8 | 4.10 |

Remark : 6A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 104.00 | 58.00 | 0.20 |

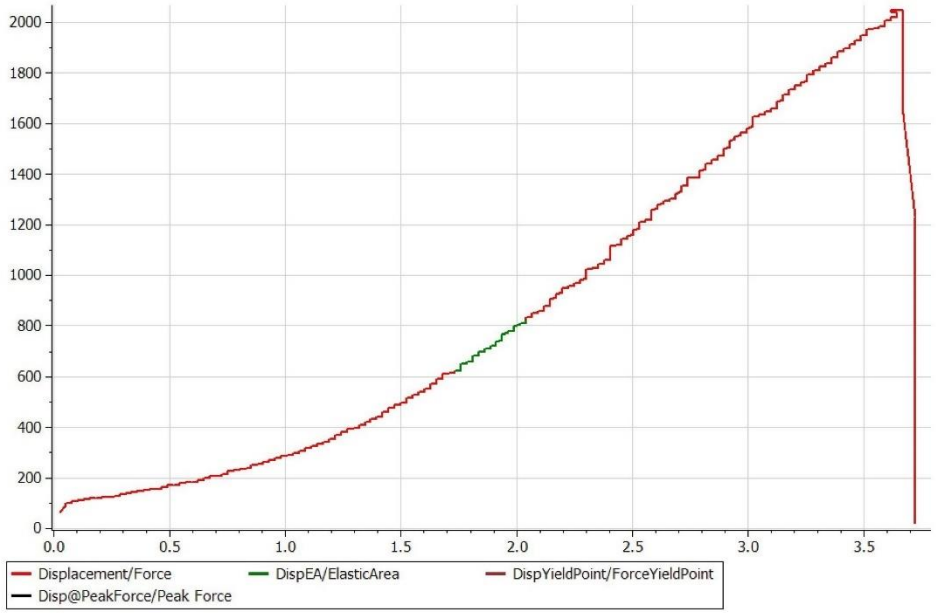



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 2134.1 | 2.53 | 201.2 | 4.37 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1735.1 | 2.53 | 163.6 | 4.37 |

Remark : 5B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 109.08 | 58.00 | 0.20 |

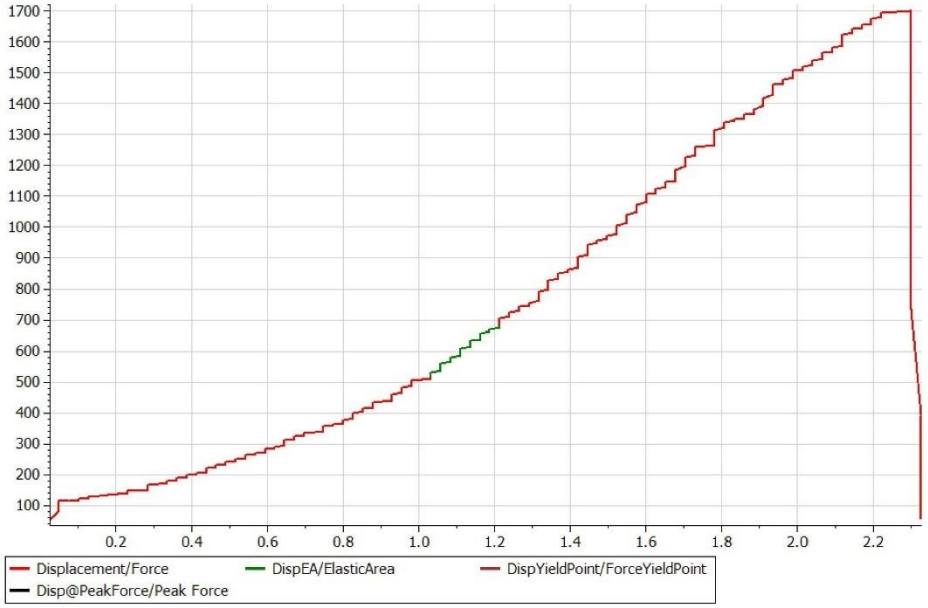



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 2049.2 | 3.67 | 184.2 | 6.33 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1640.7 | 3.72 | 147.5 | 6.42 |

Remark : 5A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 112.35 | 58.00 | 0.20 |

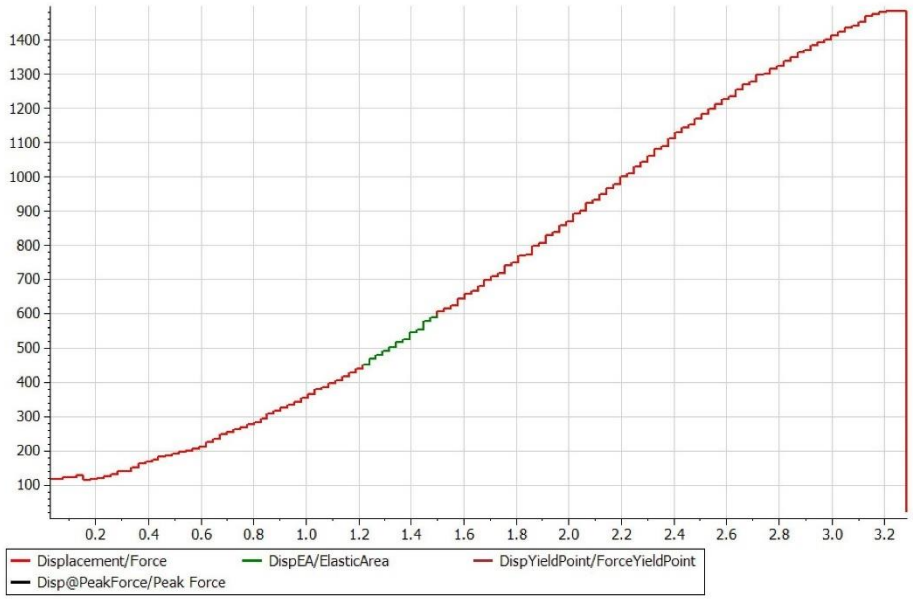



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1705.6 | 2.30 | 148.9 | 3.97 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1381.4 | 2.30 | 120.6 | 3.97 |

Remark : 4B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 104.52 | 58.00 | 0.20 |

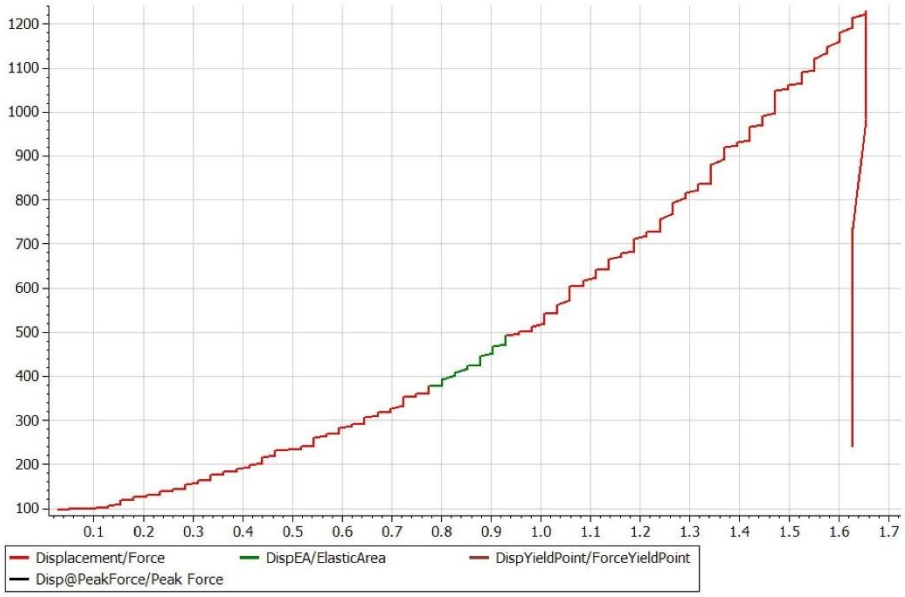



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1485.3 | 3.20 | 139.4 | 5.53 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1185.2 | 3.28 | 111.2 | 5.66 |

Remark : 4A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 101.51 | 58.00 | 0.20 |

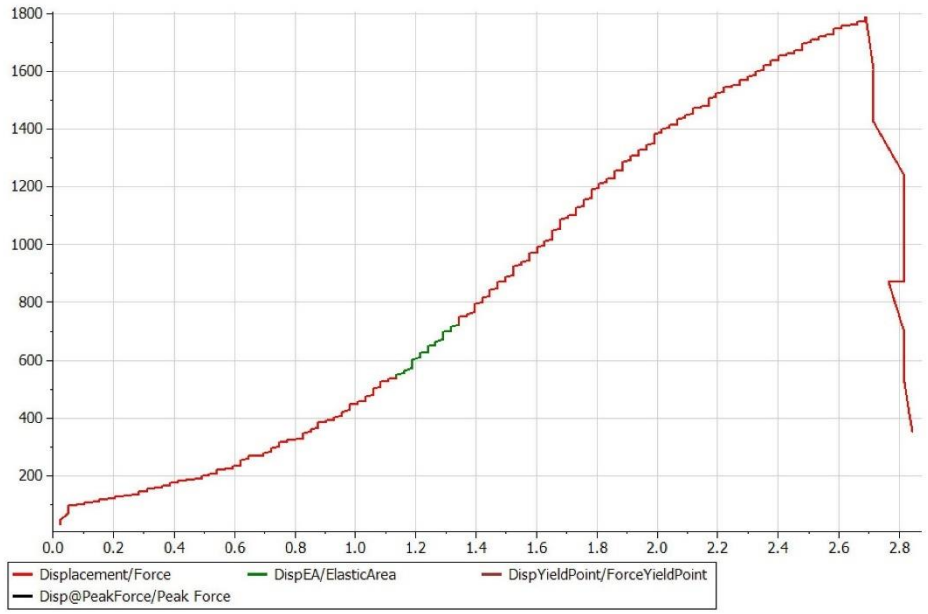



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1230.3 | 1.65 | 118.9 | 2.85 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 736.2 | 1.63 | 71.1 | 2.81 |

Remark : 3B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 116.28 | 58.00 | 0.20 |

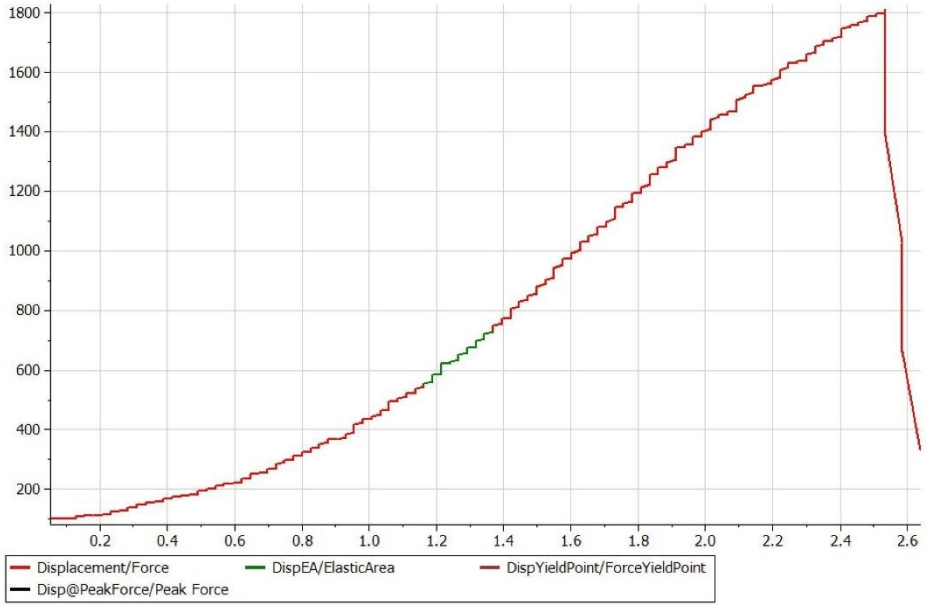



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1789.3 | 2.71 | 150.9 | 4.68 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1745.8 | 2.61 | 147.2 | 4.50 |

Remark : 3A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 112.86 | 58.00 | 0.20 |

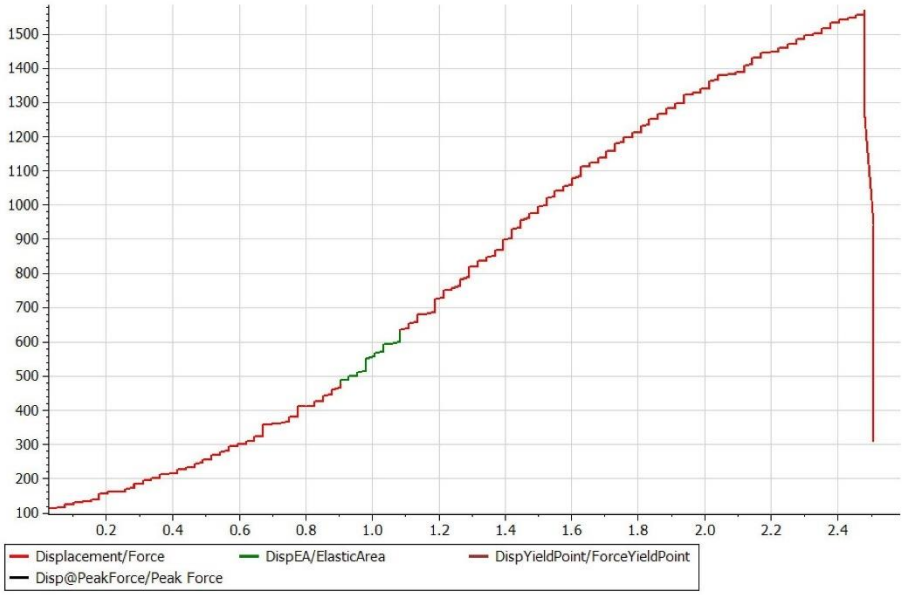



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1812.3 | 2.53 | 157.5 | 4.37 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1388.4 | 2.58 | 120.6 | 4.46 |

Remark : 2B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 107.10 | 58.00 | 0.20 |

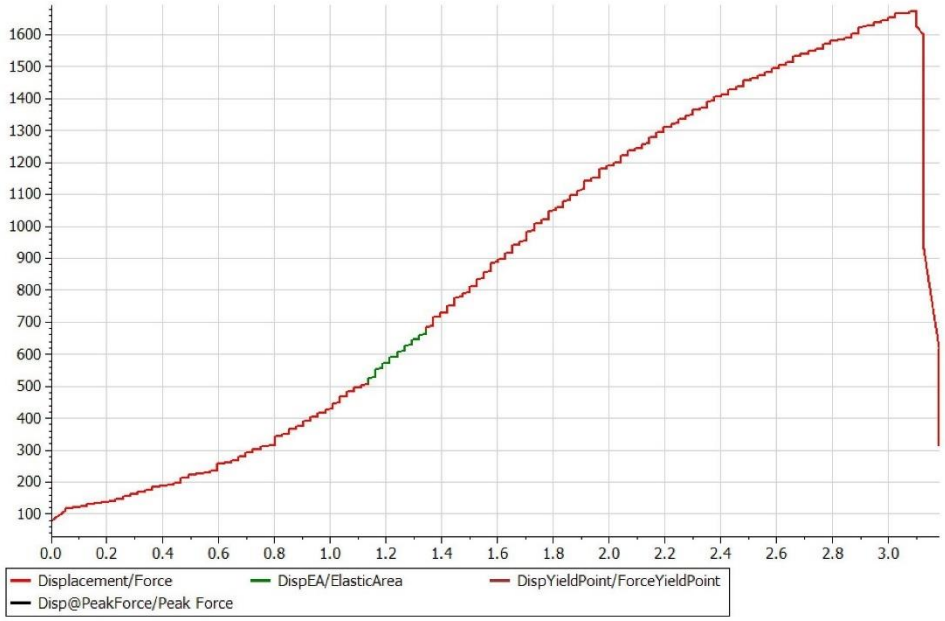



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1571.4 | 2.48 | 143.9 | 4.28 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1496.9 | 2.33 | 137.1 | 4.01 |

Remark : 2A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 103.00 | 58.00 | 0.20 |

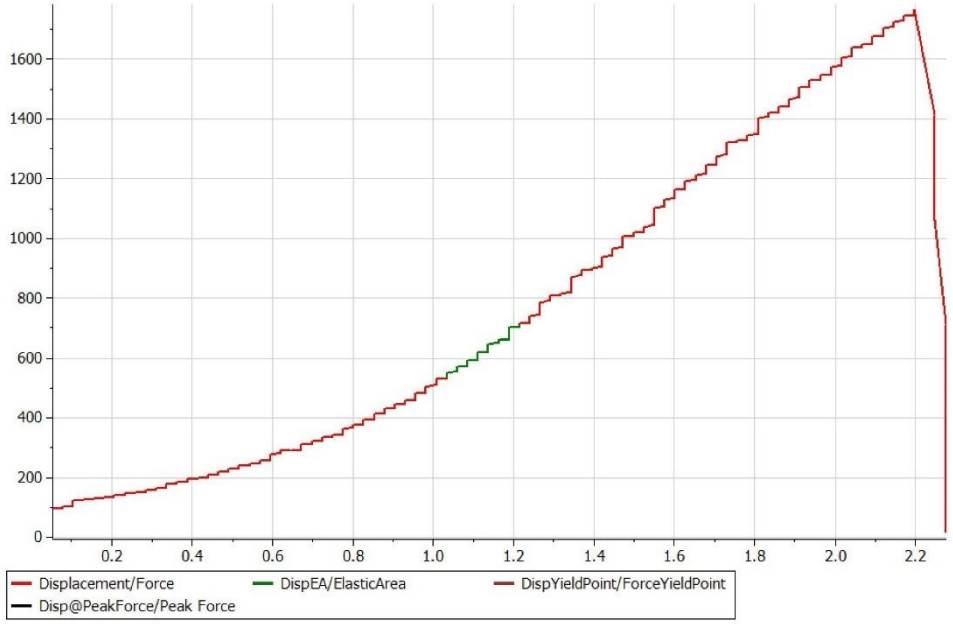



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1677.1 | 3.10 | 159.7 | 5.35 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1471.8 | 2.56 | 140.1 | 4.41 |

Remark : 1B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 115.96 | 58.00 | 0.20 |

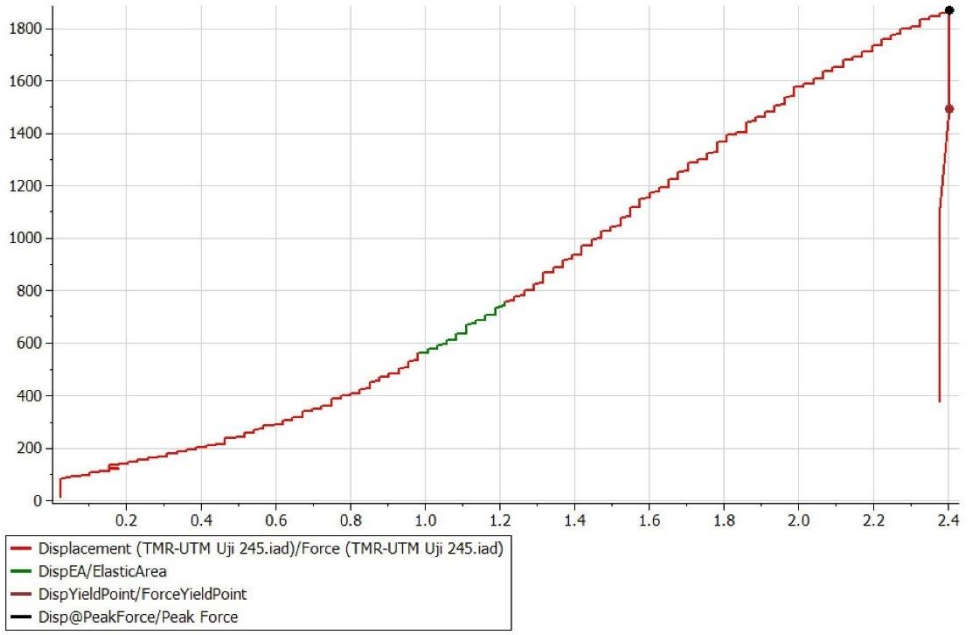



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1766.9 | 2.25 | 149.4 | 3.88 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1414.2 | 2.25 | 119.6 | 3.88 |

Remark : 1A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 113.91 | 58.00 | 0.20 |

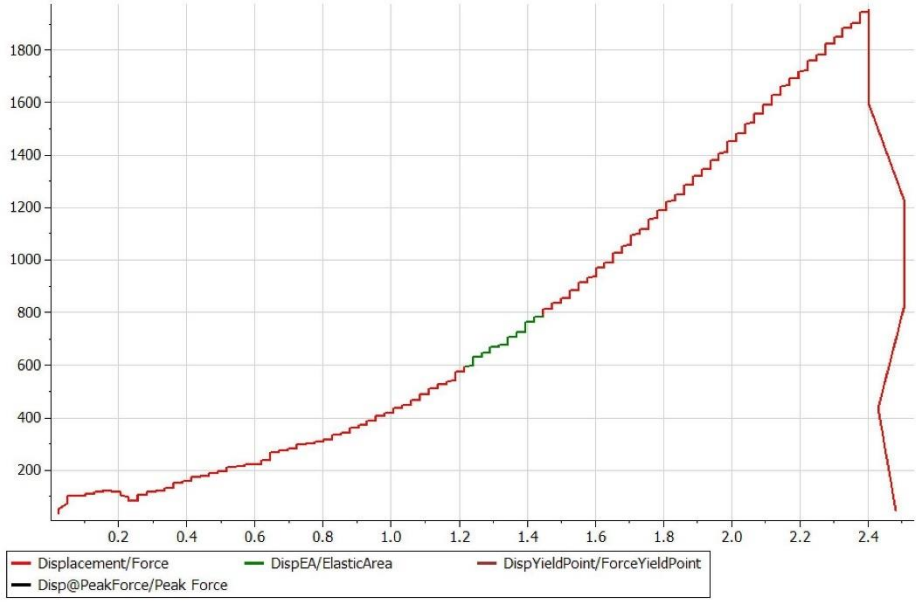



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1869.3 | 2.40 | 160.9 | 4.14 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1492.9 | 2.40 | 128.5 | 4.14 |

Remark : 10B

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 112.82 | 58.00 | 0.20 |

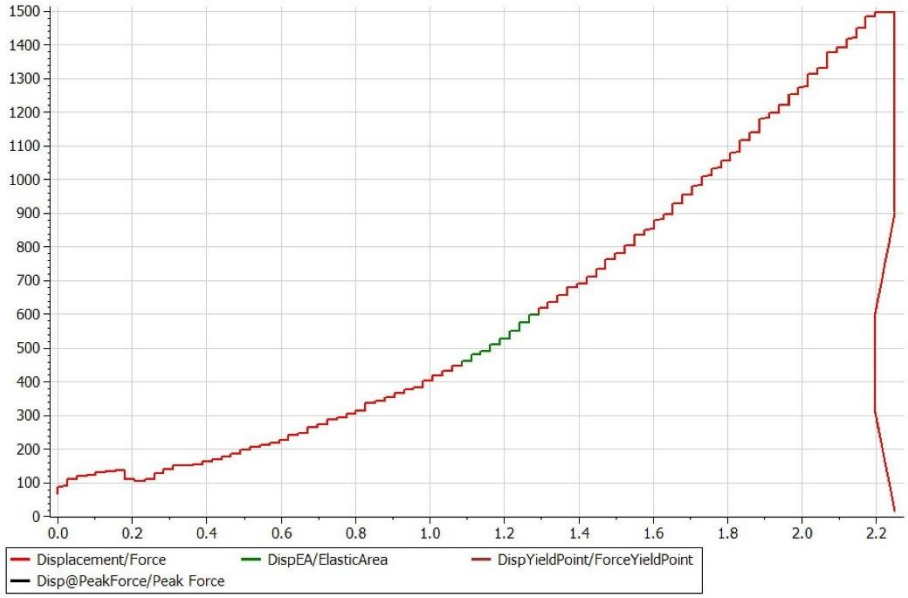



| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1956.7 | 2.40 | 170.1 | 4.14 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 1222.3 | 2.51 | 106.3 | 4.32 |

Remark : 10A

| Shape | Area (mm²) | initial length (mm) | Yield Point (%) |
|---|---|---|---|
| Rectangular | 114.45 | 58.00 | 0.20 |




| Ultimate | | | |
|---|---|---|---|
| Force Ultimate (kgf) | Elongation @Ultimate (mm) | Stress Ultimate (MPa) | Strain @Ultimate (%) |
| 1500.3 | 2.25 | 128.6 | 3.88 |

| Yield | | | |
|---|---|---|---|
| Yield Force (kgf) | Elongation @Yield (mm) | Yield Stress (MPa) | Strain @Yield (%) |
| 902.6 | 2.20 | 77.3 | 3.79 |