

DAFTAR PUSTAKA

- [1] Dhua, S. K. (2010). Metallurgical Investigation of Failed Boiler Water-Wall tubes Received from a Thermal Power Station. *Engineering Failure Analysis*, 17(7–8), 1572–1579. <https://doi.org/10.1016/j.engfailanal.2010.06.004>.
- [2] Liu, W. (2013). Failure analysis on the economisers of a biomass fuel boiler. *Engineering Failure Analysis*, 31, 101–117. <https://doi.org/10.1016/j.engfailanal.2013.01.024>.
- [3] Hong, M., Chae, H., Kim, W. C., Kim, J. G., Kim, H., & Lee, S. Y. (2019). Failure Analysis of a Water Wall Boiler Tube for Power Generation in a District Heating System. *Metals and Materials International*, 25(5), 1191–1201. <https://doi.org/10.1007/s12540-019-00267-6>.
- [4] Othman, H., Purbolaksono, J., & Ahmad, B. (2009). Failure investigation on deformed superheater tubes. *Engineering Failure Analysis*, 16(1), 329–339. <https://doi.org/10.1016/j.engfailanal.2008.05.023>.
- [5] Munda, P., Husain, M. M., Rajinikanth, V., & Metya, A. K. (2018). Evolution of Microstructure During Short-term Overheating Failure of a Boiler Water Wall Tube Made of Carbon Steel. *Journal of Failure Analysis and Prevention*, 18(1), 199–211. <https://doi.org/10.1007/s11668-018-0394-8>.
- [6] Gupta, J., Kujur, A., Talukdar, M. K., Velusshami, S. K., Prasad, S. R., Bhatia, B., Sharma, A., & Bhardwaj, A. (2019). Root cause analysis of evaporator tubes failure of a HRSG unit. *Engineering Failure Analysis*, 97(April 2018), 322–330. <https://doi.org/10.1016/j.engfailanal.2019.01.040>.
- [7] Rahman, M. M., Purbolaksono, J., & Ahmad, J. (2010). Root cause failure analysis of a division wall superheater tube of a coal-fired power station. *Engineering Failure Analysis*, 17(6), 1490–1494. <https://doi.org/10.1016/j.engfailanal.2010.05.005>.

- [8] Ahmad, J., & Purbolaksono, J. (2010). Hydrogen damage in a rear riser water wall tube of a power plant. *Engineering Failure Analysis*, 17(5), 1239–1245. <https://doi.org/10.1016/j.engfailanal.2010.01.005>
- [9] Noguchi, Y., Okada, H., Hirata, H., & Minami, F. (2018). Effect of aging on high temperature fatigue properties of Ni-23Cr-7W alloy for boiler pipes and tubes. *International Journal of Pressure Vessels and Piping*, 165(April), 81–89. <https://doi.org/10.1016/j.ijpvp.2018.06.007>.
- [10] Cardoso, B. R., Comeli, F. W., De Santana, R. M., Furtado, H. C., Lisboa, M. B., & De Almeida, L. H. (2012). Microstructural degradation of boiler tubes due to the presence of internal oxide layer. *Journal of Materials Research and Technology*, 1(2), 109–116. [https://doi.org/10.1016/S2238-7854\(12\)70020-0](https://doi.org/10.1016/S2238-7854(12)70020-0).
- [11] Saha, A., & Roy, H. (2017). Failure Investigation of a Secondary Superheater Tube in a 140 MW Thermal Power Plant. *Case Studies in Engineering Failure Analysis*, 8(May), 57–60. <https://doi.org/10.1016/j.csefa.2017.05.001>.
- [12] A. Snow, D. (2002). *Plant Engineer's Reference Book* (D. A. Snow (ed.); 2nd Editio). Butterworth-Heinemann.
- [13] Vakkilainen, E. K. (2017). *Steam Generation From Biomass: Construction And Design Of Large Boilers*. Butterworth-Heinemann, an imprint of Elsevier.
- [14] Tinga, T. (2013). *Principles of Loads and Failure Mechanisms, Applications in Maintenance, Reliability and Design* (H. Pham (ed.)). Springer.
- [15] Moakhar, R. S., Mehdipour, M., Ghorbani, M., Mohebbali, M., & Koohbor, B. (2013). Investigations of the failure in boilers economizer tubes used in power plants. *Journal of Materials Engineering and Performance*, 22(9), 2691–2697. <https://doi.org/10.1007/s11665-013-0567-2>.
- [16] Mobin, M., Malik, A. U., & Al-Hajri, M. (2008). Investigations on the failure of economizer tubes in a high-pressure boiler. *Journal of Failure Analysis and*

Prevention, 8(1), 69–74. <https://doi.org/10.1007/s11668-007-9094-5>.

- [17] Ahmad, J., Purbolaksono, J., Beng, L. C., Rashid, A. Z., Khinani, A., & Ali, A. A. (2009). Failure investigation on rear water wall tube of boiler. *Engineering Failure Analysis*, 16(7), 2325–2332. <https://doi.org/10.1016/j.engfailanal.2009.03.012>.
- [18] BPPT-PTKKE. (2013). *Daya Dukung Pembangkit Listrik Berbahan Bakar Batu Bara*. BPPT.
- [19] Rayaprolu, K. (2009). *Boilers for Power and Process*. CRC Press Taylor & Francis Group.
- [20] Viswanathan, R. (1989). *Damage Mechanisms And Life Assessment Of High-Temperature Components*. ASM INTERNATIONAL.
- [21] ASME BPVC Committee. (2015b). *ASME Boiler & Pressure Vessel Code, Section II Materials, Part D Properties (Metric): Vol. Part D* (2015th ed.). ASME Committee.
- [22] ASME BPVC Committee. (2015a). *ASME Boiler & Pressure Vessel Code, Section II Materials, Part A Ferrous Material Specifications (Beginning to SA-450): Vol. Part A* (2015th ed.). ASME Committee.
- [23] JR, William D. Callister, D. G. R. (2015). *Fundamentals of Materials Science and Engineering: An Integrated Approach* (W. Anderson (ed.); 5th ed., Vol. 5th). John Wiley & Sons, Inc.
- [24] Fujita, M., & Kuki, K. (2016). An evaluation of mechanical properties with the hardness of building steel structural members for reuse by NDT. *Metals*, 6(10). <https://doi.org/10.3390/met6100247>.
- [25] Geels, K., Kopp, W., & Rückert, M. (2007). Metallographic and Materialographic Specimen Preparation, Light Microscopy, Image Analysis

and Hardness Testing. In *Metallographic and Materialographic Specimen Preparation, Light Microscopy, Image Analysis and Hardness Testing*. ASTM International. <https://doi.org/10.1520/mnl46-eb>.

- [26] Campbell, F. C. (2012). *Fatigue And Fracture: Understanding The Basics* (F. C. Campbell (ed.)). ASM International.
- [27] Dowling, N. E. (2012). *Mechanical Behavior Of Materials: Engineering Methods For Deformation, Fracture, And Fatigue* (M. J. Horton & H. Stark (eds.); 4th ed., Vol. 4th). Pearson.
- [28] Dieter, G. E. (1988). *Mechanical Metallurgy: SI Metric Edition* (D. Bacon (ed.)). McGraw-Hill Book Company.
- [29] ASTM International Committee. (2013). *Standard Test Method for Shear Modulus at Room Temperature, E143 – 13*. ASTM International. <https://doi.org/10.1520/E0143-13.2>.
- [30] Budynas, R. G., & Nisbett, J. K. (2011). *Shigley's Mechanical Engineering Design, 9th Edition* (L. Neyens (ed.); 9th ed., Vol. 9th). McGraw-Hill.
- [31] Moss, R. D., & Basic, M. (2013). *Pressure Vessel Design Manual*. Butterworth-Heinemann - Elsevier.
- [32] McEvily, A. . J. (2013). *Metal Failures : Mechanisms, Analysis, Prevention* (2nd ed.). John Wiley & Sons, Inc.
- [33] ASM International Committee. (2000). *ASM Handbook Volume 8: Mechanical Testing and Evaluation* (Vol. 8). ASM INTERNATIONAL.
- [34] Kitto, J.B., & Stultz, S. C. (2005). *Steam: Its Generation and Use 41st Edition*. In John B. Kitto & S. C. Stultz (Eds.), *Babcock & Wilcox Company*. The Babcock & Wilcox Company.
- [35] Moran, M. J., Shapiro, H. N., Munson, B. R., & DeWitt, D. P. (2003).

Introduction To Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, And Heat Transfer. In J. Hayton (Ed.), *John Wiley And Sons*. John Wiley & Sons, Inc. All.

- [36] Seshadri, R. (1988). *Design and Life Prediction of Fired Heater Tubes in the Creep Range*. 110 (June 1987). <https://doi.org/doi.org/10.1115/1.3265606>.
- [37] Timoshenko, S., & Goodier, J. N. (1951). *Theory of Elasticity by Timoshenko* (2nd ed.).
- [38] ASM International Committee. (2006). *ASM handbook Volume 13C Corrosion: Environments and Industries* (S. D. Cramer & J. Bernard S. Covino (eds.); Vol. 13C). ASM INTERNATIONAL.
- [39] Frayne, C. (2002). *Boiler Water Treatment: Principles And Practice: Vol. I* (C. Frayne (ed.)). Chemical Publishing Co. Inc.
- [40] Meyers, M. A., & Chawla, K. K. (2009). *Mechanical Behavior of Materials, 2nd Edition*. Cambridge University Press.
- [41] Port, R. D., & Herro, H. M. (1991). *The Nalco Guide To Boiler Failure Analysis*. McGraw-Hill Inc.,.
- [42] ASM International Committee. (1997). *ASM Handbook Volume 17: Nondestructive Evaluation and Quality Control* (Vol. 17). ASM INTERNATIONAL.
- [43] ASME BPVC Committee. (2015c). Section I - Rules for Construction of Power Boilers. In *ASME Boiler and Pressure Vessel Code* (2015th ed.). ASME Committee.
- [44] Prager, M., Osage, D. A., Panzarella, C. H., & Brown, R. G. (2014). *Development of a Material Databook for API Std 530*. 1–10. <https://doi.org/10.1115/pvp2014-28538>.

- [45] Pavlina, E. J., & Van Tyne, C. J. (2018). *Correlation of Yield Strength and Tensile Strength with Hardness for Steels*. December 2008. <https://doi.org/doi.org/10.1007/s11665-008-9225-5>.
- [46] Jones, D. R. H. (2004). *Creep failures of overheated boiler , superheater and reformer tubes*. *11*, 873–893. <https://doi.org/10.1016/j.engfailanal.2004.03.001>.
- [47] Pal, U., Kishore, K., Mukhopadhyay, S., Mukhopadhyay, G., & Bhattacharya, S. (2019). Failure analysis of boiler economizer tubes at power house. *Engineering Failure Analysis*, *104*(January 2017), 1203–1210. <https://doi.org/10.1016/j.engfailanal.2019.06.085>.
- [48] Sanjay, P. S., & Mandloi, R. K. (2016). A Failure Analysis and Remaining Life assessment of Boiler Water Wall tube. *International Journal of Advanced Engineering Research and Science (IJAERS)*, *3*(7), 2456–1908. www.ijaers.com.
- [49] Sankhala, K., Gauri, Z., Sharma, P., & Kumar Jain, D. (2014). Study of Microstructure Degradation of Boiler Tubes Due To Creep for Remaining Life Analysis. *International Journal of Engineering Research and Applications*, *4*(7), 93–99.
- [50] Nečas, D., & Klapetek, P. (2012). Gwyddion: An open-source software for SPM data analysis. *Central European Journal of Physics*, *10*(1), 181–188. <https://doi.org/10.2478/s11534-011-0096-2>.
- [51] Bakre, C., & Lissenden, C. J. (2021). *Surface Roughness Effects on Self-Interacting and Mutually Interacting Rayleigh Waves*. <https://doi.org/doi.org/10.3390/s21165495>.
- [52] Haghghat-Shishavan, B., Firouzi-Nerbin, H., Nazarian-Samani, M., Ashtari, P., & Nasirpouri, F. (2019). Failure analysis of a superheater tube ruptured in a power plant boiler: Main causes and preventive strategies. *Engineering*

Failure Analysis, 98 (December 2018), 131–140.
<https://doi.org/10.1016/j.engfailanal.2019.01.016>.

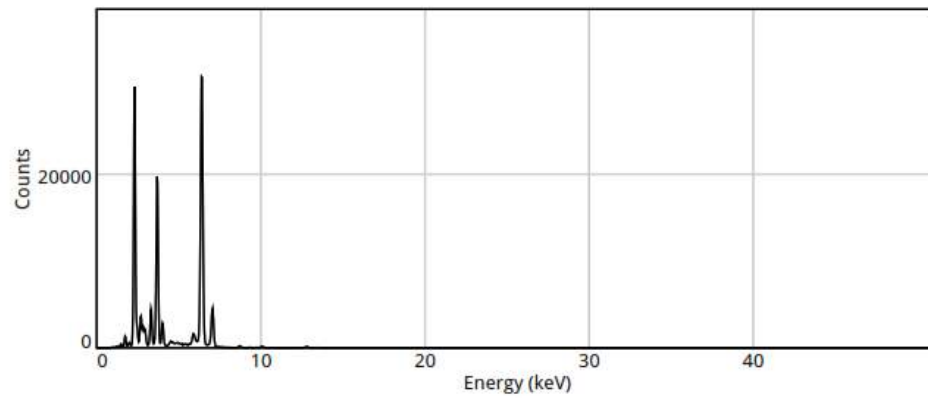
- [53] Vakhguelt, A., Kapayeva, S. D., & Bergander, M. J. (2017). Combination Non-Destructive Test (NDT) Method for Early Damage Detection and Condition Assessment of Boiler Tubes. *Procedia Engineering*, 188, 125–132.
<https://doi.org/10.1016/j.proeng.2017.04.465>.
- [54] ASTM International Committee. (2017b). *Standard Test Method for Leeb Hardness Testing of Steel Products, A956/A956M – 17a*. ASTM International.
<https://doi.org/10.1520/A0956>.
- [55] ASTM International Committee. (2012b). *Standard Test Method for Analysis of Low-Alloy Steels and Cast Irons by Wavelength, E322 – 12*. ASTM International. <https://doi.org/10.1520/E0322-12>.
- [56] Klapetek, P., Nečas, D., & Anderson, C. (2021). *Gwyddion User Guide* (gwyddion.net/documentation/user-guide-en). GNU General Public License. gwyddion.net/documentation/user-guide-en
- [57] ASTM International Committee. (2015). *Standard Practice for Microetching Metals and Alloys, E407 – 07 (Reapproved 2015)*. ASTM International.
<https://doi.org/10.1520/E0407-07R15>.
- [58] ASTM International Committee. (2012a). *Standard Practice for Production and Evaluation of Field Metallographic Replicas, E1351 – 01 (Reapproved 2012)*. ASTM International. <https://doi.org/10.1520/E1351-01R12>.
- [59] ASTM International Committee. (2020). *Standard Test Methods for Rockwell Hardness of Metallic Materials, E18-20*. ASTM International.
<https://doi.org/10.1520/E0018-20>
- [60] ASTM International Committee. (2021). *Standard Test Methods for Tension Testing of Metallic Materials, E8/E8M–21*. ASTM International.

https://doi.org/10.1520/E0008_E0008M-16AE01.

- [61] ASTM International Committee. (2017c). *Standard Test Methods for Analysis of Carbon and Low-Alloy Steel by Spark Atomic Emission Spectrometry, E415–17*. ASTM International. <https://doi.org/10.1520/E0415-15>
- [62] ASTM International Committee. (2017a). *Standard Guide for Preparation of Metallographic Specimens, E3–11 (Reapproved 2017)*. ASTM International. <https://doi.org/10.1520/E0003-11R17>.
- [63] ASTM International Committee. (2018a). *Standard Practice for Assessing the Degree of Banding or Orientation of Microstructures, E1268–18*. ASTM International. <https://doi.org/10.1520/E1268-18>.
- [64] ASTM International Committee. (2018b). *Standard Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials, E139–11 (Reapproved 2018)*. ASTM International. <https://doi.org/10.1520/E0139-11R18>.
- [65] API-ASME Committee. (2016). *Fitness-For-Service, API 579-1/ASME FFS-1, June, 2016* (3rd ed.). API Publishing Services.
- [66] Prager, Martin, & Osage, D. A. (2011). *WRC Bulletin 541, Evaluation Of Material Strength Data For Use In API Std 530*. Welding Research Council, Inc.
- [67] Jawad, M. H., Washington, C., & Jetter, R. I. (2009). Design and analysis of Asme Boiler & Pressure Vessel components in the creep range. In *Mechanical Engineering* (Vol. 131, Issue 10). ASME PRESS. <https://doi.org/10.1115/1.802847>.
- [68] Bramfitt, B. L., & Benscoter, A. O. (2002). Metallographer's guide practices and procedures for irons and steels. In *Metallurgia Italiana*. ASM INTERNATIONAL.

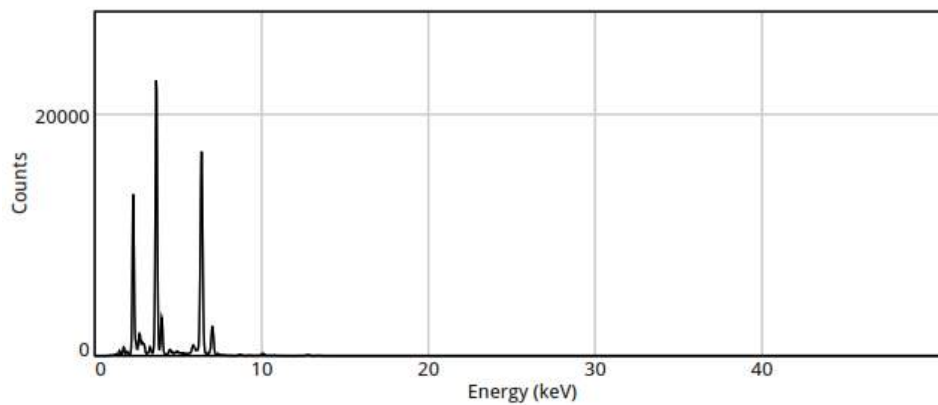
LAMPIRAN

Lampiran A Data Gambar Investigasi di Lokasi



Name	economizer2		Class	Alloy_LE_FP		Date	26/11/2018		Time	10:36:38		Duration	15.5 s	
Element	Fe %	S %	Mg %	Al %	Si %	Mn %	Ti %	Co %	Ni %	Zn %				
	57.23	22.01	9.07	6.30	4.40	0.51	0.27	0.11	0.07	0.03				

(A)



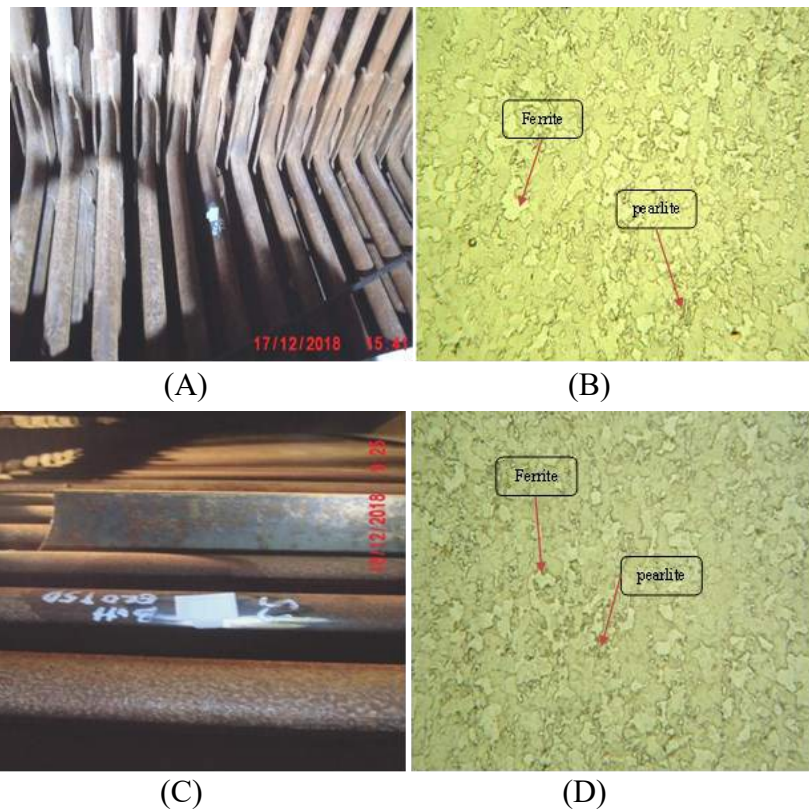
Name	economizer 7		Class	Alloy_LE_FP		Date	26/11/2018		Time	11:26:45		Duration	10.5 s	
Element	Fe %	S %	Mg %	Al %	Si %	Mn %	Ti %	Ni %						
	65.94	12.55	10.12	7.43	3.22	0.48	0.21	0.04						

(B)

A.1 Gambar Hasil pengujian *X-Ray Fluorescence (XRF) Spectrometric*, (A) *economizer tubes* baris ke 2 dan (B) *economizer tubes* baris ke 7.



A.2 Gambar pengukuran dimensi *economizer tube*, (A) *economizer tubes* baris ke 7 dan (B) *economizer tubes* baris ke 10.



A.3 Gambar hasil pengujian struktur mikro *in-situ metallography/replica* dengan *Equivalent Operating Hours* (EOH) ± 24.500 hours, (A) Gambar aktual *economizer tubes*-row 17, (B) *In-situ metallography economizer tubes*-row 17 dengan pembesaran 200x, (C) Gambar aktual *economizer tubes*-row 50, (D) *In-situ metallography economizer tubes*-row 50 dengan pembesaran 200x.



(A)

(B)

- A.4** Gambar Hasil pengujian struktur mikro *in-situ metallography/replica* dengan *Equivalent Operating Hours* (EOH) \pm 49.000 hours, (A) Gambar aktual *economizer header*, (B) *In-situ metallography economizer header* dengan pembesaran 200x.

Lampiran B Tabel Data Investigasi di Lokasi

B.1 Tabel *mechanical properties economizer tubes* berdasarkan *Manufacturing Data Report (MDR)*.

Outside Diameter (mm)	Nominal Thickness (mm)	Tensile Strength (MPa)		Yield Strength (MPa)		Hardness (HRB)		Elongation (%)	
		Min.	Maks.	Min.	Maks.	Min.	Maks.	Min.	Maks.
31,8	4,0	420	465	290	354	73	76,5	60	51

B.2 Tabel komposisi kimia (*weight, %*) *economizer tubes* berdasarkan *Manufacturing Data Report (MDR)*.

C	Si	Mn	P	S	Mo	Cr
0,13	0,22	0,77	0,14	0,09	-	-

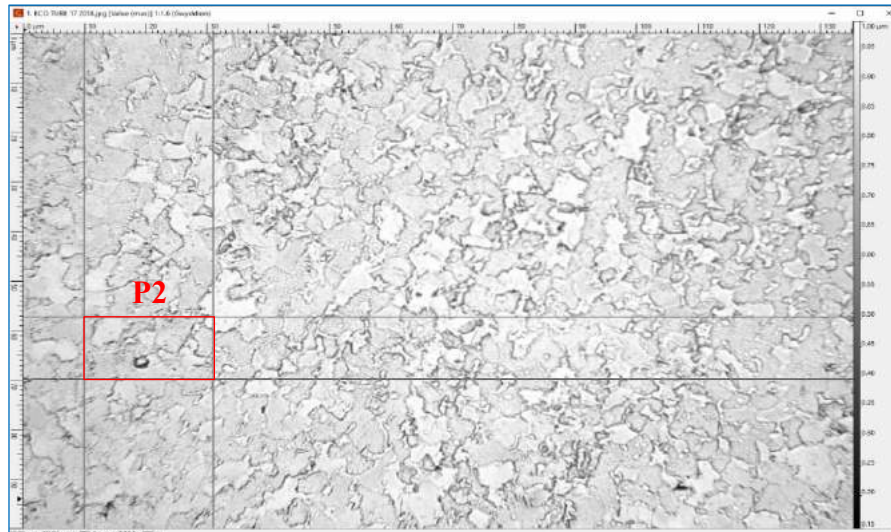
B.3 Tabel data dimensi aktual *economizer tubes* di lokasi, nilai minimum dan rata-rata.

No.	Deskripsi	Ketebalan aktual /t_{act} (mm)				Outside Diameter/O_D (mm)	Kriteria
		0°	90°	270°	Selected		
1.	<i>Row 1</i>	4,30	4,31	4,31	4,30	31,90	<i>Minimum</i>
		4,36	4,38	4,39	4,38	31,93	<i>Average</i>
2.	<i>Row 4</i>	4,25	4,19	4,13	4,13	31,90	<i>Minimum</i>
		4,34	4,25	4,28	4,29	31,93	<i>Average</i>
3.	<i>Row 7</i>	4,31	4,38	4,36	4,31	31,90	<i>Minimum</i>
		4,40	4,41	4,46	4,42	32,0	<i>Average</i>
4.	<i>Row 10</i>	4,23	4,19	4,3	4,19	31,80	<i>Minimum</i>
		4,28	4,27	4,36	4,30	31,93	<i>Average</i>
5.	<i>Row 15</i>	4,27	4,31	4,29	4,27	31,90	<i>Minimum</i>
		4,30	4,33	4,38	4,34	31,97	<i>Average</i>

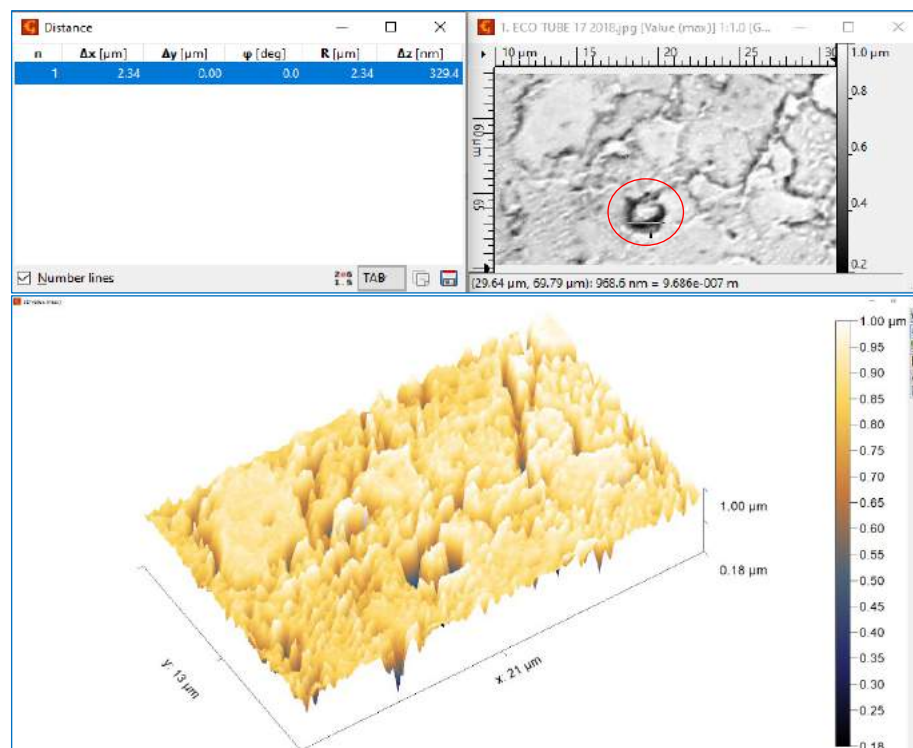
B.4 Tabel data pengujian nilai kekerasan (*hardness test*) dengan skala *Hardness Brinell* pada *economizer tubes*, nilai minimum dan rata-rata.

No.	Deskripsi	Nilai Kekerasan (HBN)			<i>Selected</i>	Kriteria
		<i>0 - 590</i> mm	<i>590-1200</i> mm	<i>1200-1900</i> mm		
1.	<i>Row 1</i>	123	119	122	119	<i>Minimum</i>
		134	131	132	132	<i>Average</i>
2.	<i>Row 4</i>	113	83	113	83	<i>Minimum</i>
		139	113	123	125	<i>Average</i>
3.	<i>Row 7</i>	126	97	127	97	<i>Minimum</i>
		132	116	133	127	<i>Average</i>
4.	<i>Row 10</i>	111	96	104	96	<i>Minimum</i>
		126	111	127	121	<i>Average</i>
5.	<i>Row 15</i>	126	128	92	92	<i>Minimum</i>
		133	133	125	131	<i>Average</i>

Lampiran C Hasil Analisa Data Gambar Investigasi di Lokasi



C.1 Visualisasi *In-situ metallography* pada *economizer tubes-row 17* dari Gambar (4.4 (B)) di titik 2 (P2)



C.2 Gambar rongga (*microvoid*) pada batas butir *ferrite* dengan dimensi arah memanjang sebesar 2,34 μm hasil visualisasi ditampilkan dalam Gambar Lampiran D.1.

Lampiran D Hasil Analisa Data Perhitungan Investigasi di Lokasi

D.1 Tabel hasil analisa data nilai skala kekerasan *Vickers*, kekuatan tarik (T_s), kekuatan luluh (Y_s) dan nilai tegangan maksimum yang diizinkan (S) pada fungsi temperatur pada *economizer tubes*.

Deskripsi	Kekerasan (HVN)		T_s (MPa)		Y_s (MPa)		S (MPa)	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
Row 1	125	139	413	448	272	310	110,23	119,34
Row 4	87	131	318	429	169	289	85,11	114,39
Row 7	102	134	355	434	209	295	94,78	115,64
Row 10	101	128	353	419	206	279	94,18	111,88
Row 15	97	137	342	444	194	306	91,31	118,31
	Ave.	133,85	Ave.	435	Ave.	296	Ave.	115,91
	Dev.	4,56	Dev.	11,41	Dev.	12,49	Dev.	3,01

D.2 Tabel hasil analisa data nilai ketebalan minimum yang diizinkan (t_{min}), tekanan kerja maksimum yang diizinkan (MAWP) pada *economizer tubes*.

Deskripsi	t_{act} (mm)		O_D (mm)		t_{min} (mm)		MAWP (MPa)	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
Row 1	4,30	4,38	31,90	31,93	2,03	1,89	32,88	36,32
Row 4	4,13	4,29	31,90	31,93	2,54	1,96	24,20	33,99
Row 7	4,31	4,42	31,90	32,00	2,31	1,95	28,35	35,55
Row 10	4,19	4,30	31,80	31,93	2,32	2,00	27,34	33,37
Row 15	4,27	4,34	31,90	31,97	2,39	1,91	27,01	35,56
	Ave.	4,35	Ave.	31,95	Ave.	1,94	Ave.	34,96
	Dev.	0,05	Dev.	0,03	Dev.	0,04	Dev.	1,23

D.3 Tabel data perhitungan radius luar (r_o), radius dalam (r_i), radius pada lokasi tertentu (r) serta kriteria silinder berdinding tebal atau tipis pada *economizer tubes*.

Des-kripsi	r_o (mm)		r_i (mm)		r (mm)		rasio (r/r_o)		Kriteria	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
Row 1	15,95	15,965	11,65	11,585	13,800	13,775	0,730	0,726	$r/t < 10$	$r/t < 10$
Row 4	15,95	15,965	11,82	11,675	13,885	13,820	0,741	0,731	$r/t < 10$	$r/t < 10$
Row 7	15,95	16,000	11,64	11,580	13,795	13,790	0,730	0,724	$r/t < 10$	$r/t < 10$
Row 10	15,90	15,965	11,71	11,665	13,805	13,815	0,736	0,731	$r/t < 10$	$r/t < 10$
Row 15	15,95	15,985	11,68	11,645	13,815	13,815	0,732	0,728	$r/t < 10$	$r/t < 10$
	Ave.	15,976	Ave.	11,630	Ave.	13,803	Ave.	0,728		
	Dev.	0,02	Dev.	0,04	Dev.	0,02	Dev.	0,003		

D.4 Tabel hasil analisa data perhitungan tegangan elastis tangensial/*circumferential/hoop stress* (σ_{He}), tegangan elastis aksial/longitudinal (σ_{Ze}), tegangan elastis radial (σ_{Re}) dan tegangan equivalen elastis (σ_{Eqe}) pada *economizer tubes*.

Des- kripsi	σ_{He} (N/mm ²)		σ_{Ze} (N/mm ²)		σ_{Re} (N/mm ²)		σ_{Eqe} (N/mm ²)	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
Row 1	36,597	35,705	15,667	15,238	-5,262	-5,230	36,251	35,451
Row 4	38,711	36,765	16,689	15,748	-5,333	-5,268	38,143	36,402
Row 7	36,478	35,358	15,610	15,070	-5,258	-5,217	36,144	35,139
Row 10	37,780	36,645	16,239	15,691	-5,303	-5,264	37,311	36,294
Row 15	36,958	36,235	15,842	15,493	-5,275	-5,249	36,574	35,926
	Ave.	36,142	Ave.	15,448	Ave.	-5,246	Ave.	35,843
	Dev.	0,60	Dev.	0,29	Dev.	0,02	Dev.	0,54

D.5 Tabel hasil analisa data perhitungan regangan elastis tangensial (ϵ_{He}), regangan elastis aksial/longitudinal (ϵ_{Ze}), regangan elastis radial (ϵ_{Re}) dan regangan equivalen (ϵ_{Eqe}) elastis pada *economizer tubes*.

	ϵ_{He}		ϵ_{Ze}		ϵ_{Re}		ϵ_{Eqe}	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
	1,89E-04	1,85E-04	3,54E-05	3,44E-05	-1,18E-04	-1,16E-04	1,77E-04	1,74E-04
	1,99E-04	1,90E-04	3,77E-05	3,56E-05	-1,24E-04	-1,19E-04	1,87E-04	1,78E-04
	1,89E-04	1,83E-04	3,53E-05	3,41E-05	-1,18E-04	-1,15E-04	1,77E-04	1,72E-04
	1,95E-04	1,89E-04	3,67E-05	3,55E-05	-1,22E-04	-1,18E-04	1,83E-04	1,78E-04
	1,91E-04	1,87E-04	3,58E-05	3,50E-05	-1,19E-04	-1,17E-04	1,79E-04	1,76E-04
	Ave.	1,87E-04	Ave.	3,49E-05	Ave.	-1,17E-04	Ave.	1,76E-04
	Dev.	2,95E-06	Dev.	6,57E-07	Dev.	1,64E-06	Dev.	2,65E-06

D.6 Tabel Hasil analisa data perhitungan tegangan plastis tangensial/*circumferential/hoop stress* (σ_{Hp}), tegangan plastis aksial/longitudinal (σ_{Zp}), tegangan plastis radial (σ_{Rp}) dan tegangan equivalen plastis (σ_{Eqp}) pada *economizer tubes*.

Des-kripsi	σ_{Hp} (N/mm ²)		σ_{Zp} (N/mm ²)		σ_{Rp} (N/mm ²)		σ_{Eqp} (N/mm ²)	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
Row 1	37,295	36,418	15,490	15,057	-6,314	-5,230	37,767	36,072
Row 4	39,379	37,461	16,520	15,572	-5,333	-5,268	38,725	37,008
Row 7	37,178	36,076	15,432	14,888	-5,258	-5,217	36,754	35,765
Row 10	38,461	37,343	16,066	15,514	-5,303	-5,264	37,904	36,902
Row 15	37,651	36,939	15,666	15,314	-5,275	-5,249	37,178	36,540
	<i>Ave.</i>	36,847	<i>Ave.</i>	15,269	<i>Ave.</i>	-5,246	<i>Ave.</i>	36,457
	<i>Dev.</i>	0,594	<i>Dev.</i>	0,293	<i>Dev.</i>	0,022	<i>Dev.</i>	0,533

D.7 Tabel hasil analisa data perhitungan regangan plastis tangensial (ϵ_{Hp}), regangan plastis aksial/longitudinal (ϵ_{Zp}), regangan plastis radial (ϵ_{Rp}) dan regangan equivalen (ϵ_{Eqp}) plastis pada *economizer tubes*.

	ϵ_{Hp}		ϵ_{Zp}		ϵ_{Rp}		ϵ_{Eqp}	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
	1,95E-04	1,89E-04	3,50E-05	3,22E-05	-1,25E-04	-1,17E-04	1,85E-04	1,77E-04
	2,04E-04	1,94E-04	3,56E-05	3,34E-05	-1,25E-04	-1,20E-04	1,90E-04	1,81E-04
	1,93E-04	1,87E-04	3,31E-05	3,18E-05	-1,19E-04	-1,16E-04	1,80E-04	1,75E-04
	1,99E-04	1,94E-04	3,46E-05	3,33E-05	-1,22E-04	-1,19E-04	1,86E-04	1,81E-04
	1,95E-04	1,92E-04	3,36E-05	3,28E-05	-1,20E-04	-1,18E-04	1,82E-04	1,79E-04
	<i>Ave.</i>	1,91E-04	<i>Ave.</i>	3,27E-05	<i>Ave.</i>	-1,18E-04	<i>Ave.</i>	1,79E-04
	<i>Dev.</i>	2,89E-06	<i>Dev.</i>	6,87E-07	<i>Dev.</i>	1,63E-06	<i>Dev.</i>	2,61E-06

D.8 Tabel hasil analisa data perhitungan tegangan termal tangensial/*circumferential/hoop stress* (σ_{Ht}), tegangan termal aksial/longitudinal (σ_{Zt}), tegangan termal radial (σ_{Rt}) dan tegangan equivalen termal (σ_{Eqt}) pada *economizer tubes*.

Des-kripsi	σ_{Ht} (N/mm ²)		σ_{Zt} (N/mm ²)		σ_{Rt} (N/mm ²)		σ_{Eqt} (N/mm ²)	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
Row 1	32,057	32,704	-16,236	-16,573	-48,293	-49,277	70,057	71,480
Row 4	30,617	31,938	-15,489	-16,174	-46,106	-48,112	66,894	69,795
Row 7	32,142	32,964	-16,280	-16,708	-48,423	-49,671	70,245	72,050
Row 10	31,235	32,023	-15,809	-16,218	-47,045	-48,241	68,252	69,982
Row 15	31,802	32,317	-16,103	-16,371	-47,906	-48,688	69,497	70,628
	<i>Ave.</i>	32,389	<i>Ave.</i>	-16,409	<i>Ave.</i>	-48,798	<i>Ave.</i>	70,787
	<i>Dev.</i>	0,439	<i>Dev.</i>	0,229	<i>Dev.</i>	0,668	<i>Dev.</i>	0,966

D.9 Tabel hasil analisa data perhitungan regangan termal tangensial (ϵ_{Ht}), regangan termal aksial/longitudinal (ϵ_{Zt}), regangan termal radial (ϵ_{Rt}) dan regangan equivalen (ϵ_{Eqt}) termal pada *economizer tubes*.

ϵ_{Ht}		ϵ_{Zt}		ϵ_{Rt}		ϵ_{Eqt}	
Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
0,005265	0,005273	0,004910	0,004911	0,004674	0,004671	0,000343	0,000350
0,005246	0,005263	0,004907	0,004910	0,004682	0,004675	0,000328	0,000342
0,005266	0,005276	0,004910	0,004912	0,004674	0,004670	0,000344	0,000353
0,005254	0,005264	0,004908	0,004910	0,004679	0,004675	0,000334	0,000343
0,005261	0,005268	0,004909	0,004910	0,004676	0,004673	0,000340	0,000346
<i>Ave.</i>	0,005269	<i>Ave.</i>	0,004911	<i>Ave.</i>	0,004673	<i>Ave.</i>	0,000347
<i>Dev.</i>	5,74E-06	<i>Dev.</i>	8,37E-07	<i>Dev.</i>	2,39E-06	<i>Dev.</i>	4,73E-06

D.10 Tabel hasil analisa data perhitungan tegangan *steady-state* tangensial/*circumferential/hoop stress* (σ_{Hss}), tegangan *steady-state* aksial/longitudinal (σ_{Zss}), tegangan *steady-state* radial (σ_{Rss}) dan tegangan equivalen *steady-state* (σ_{Eqss}) pada *economizer tubes*.

Des-kripsi	σ_{Hss} (N/mm ²)		σ_{Zss} (N/mm ²)		σ_{Rss} (N/mm ²)		σ_{Eqss} (N/mm ²)	
	Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
Row 1	37,279	36,401	15,561	15,130	-6,157	-6,142	37,617	36,844
Row 4	39,364	37,445	16,588	15,643	-6,188	-6,159	39,449	37,762
Row 7	37,162	36,059	15,504	14,961	-6,155	-6,137	37,513	36,543
Row 10	38,446	37,327	16,136	15,585	-6,175	-6,157	38,642	37,659
Row 15	37,635	36,923	15,736	15,386	-6,162	-6,151	37,930	37,303
	Ave.	36,831	Ave.	15,341	Ave.	-6,149	Ave.	37,222
	Dev.	0,594	Dev.	0,292	Dev.	0,010	Dev.	0,523

D.11 Tabel hasil analisa data perhitungan regangan *steady-state* tangensial (ϵ_{Hss}), regangan *steady-state* aksial/longitudinal (ϵ_{Zss}), regangan *steady-state* radial (ϵ_{Rss}) dan regangan equivalen (ϵ_{Eqss}) *steady-state* pada *economizer tubes*.

ϵ_{Hss}		ϵ_{Zss}		ϵ_{Rss}		ϵ_{Eqss}	
Min.	Ave.	Min.	Ave.	Min.	Ave.	Min.	Ave.
0,000195	0,000190	0,0000352	0,0000342	-0,0001243	-0,0001220	0,000184	0,000180
0,000205	0,000195	0,0000375	0,0000354	-0,0001298	-0,0001248	0,000193	0,000185
0,000194	0,000189	0,0000350	0,0000338	-0,0001240	-0,0001211	0,000184	0,000179
0,000200	0,000195	0,0000365	0,0000352	-0,0001274	-0,0001245	0,000189	0,000184
0,000196	0,000193	0,0000356	0,0000348	-0,0001253	-0,0001234	0,000186	0,000183
Ave.	0,000193	Ave.	0,0000347	Ave.	-0,000123	Ave.	0,000182
Dev.	2,88E-06	Dev.	6,60E-07	Dev.	1,56E-06	Dev.	2,56E-06

D.12 Tabel hasil analisa data perhitungan regangan *steady-state Arrhenius* pada *economizer tubes*.

Deskripsi	<i>T</i> (K)	$\sigma_{E_{qe}}$ (N/mm ²)		$\epsilon_{ss,Arh}$	
		<i>Min.</i>	<i>Ave.</i>	<i>Min.</i>	<i>Ave.</i>
<i>Row 1</i>	636,1	36,251	35,451	3,133E-27	2,732E-27
Row 4	635,7	38,143	36,402	4,288E-27	3,214E-27
<i>Row 7</i>	636,1	36,144	35,139	3,077E-27	2,587E-27
<i>Row 10</i>	635,8	37,311	36,294	3,742E-27	3,156E-27
<i>Row 15</i>	636,0	36,574	35,926	3,309E-27	2,965E-27
		<i>Ave.</i>	35,843	<i>Ave.</i>	2,931E-27
		<i>Dev.</i>	0,541	<i>Dev.</i>	2,693E-28

D.13 Tabel Hasil analisa data perhitungan penilaian umur (*Life Assessment*) untuk nilai C minimum sebesar 15,6 pada *economizer tubes*.

Deskripsi	<i>Temp.</i> (°C)	$\sigma_{E_{qe}}$ (N/mm ²)	<i>PLM</i>	<i>Time to Rupture</i> (Hours)
<i>Row 1</i>	363,07	36,251	15941,7	2.901.962.563,7
<i>Row 4</i>	362,66	38,143	15865,7	2.288.227.032,8
<i>Row 7</i>	363,10	36,144	15946,1	2.941.693.270,4
<i>Row 10</i>	362,84	37,311	15898,8	2.538.508.850,4
<i>Row 15</i>	363,00	36,574	15928,5	2.785.275.301,5

D.14 Tabel hasil analisa data perhitungan penilaian umur (*Life Assessment*) untuk nilai C average sebesar 15,15 pada *economizer tubes*.

Deskripsi	<i>Temp.</i> (°C)	$\sigma_{E_{qe}}$ (N/mm ²)	<i>PLM</i>	<i>Time to Rupture</i> (Hours)
<i>Row 1</i>	363,07	36,251	15941,7	8.178.841.756,7
<i>Row 4</i>	362,66	38,143	15865,7	6.449.100.012,1
<i>Row 7</i>	363,10	36,144	15946,1	8.290.818.102,2
<i>Row 10</i>	362,84	37,311	15898,8	7.154.490.014,7
<i>Row 15</i>	363,00	36,574	15928,5	7.849.972.368,5

D.15 Tabel hasil analisa data perhitungan penilaian sisa umur (*Remaining-Life Assessment*) dengan *safety factor* untuk nilai C minimum sebesar 15,6 pada *economizer tubes*.

Deskripsi	Temp. (°C)	σ_{Eqs} (N/mm²)	PLM	Time to Rupture (Hours)
<i>Row 1</i>	363,07	36,251	15941,7	1.934.609.042,5
<i>Row 4</i>	362,66	38,143	15865,7	1.525.452.021,9
<i>Row 7</i>	363,10	36,144	15946,1	1.961.096.180,2
<i>Row 10</i>	362,84	37,311	15898,8	1.692.306.566,9
<i>Row 15</i>	363,00	36,574	15928,5	1.856.817.534,3

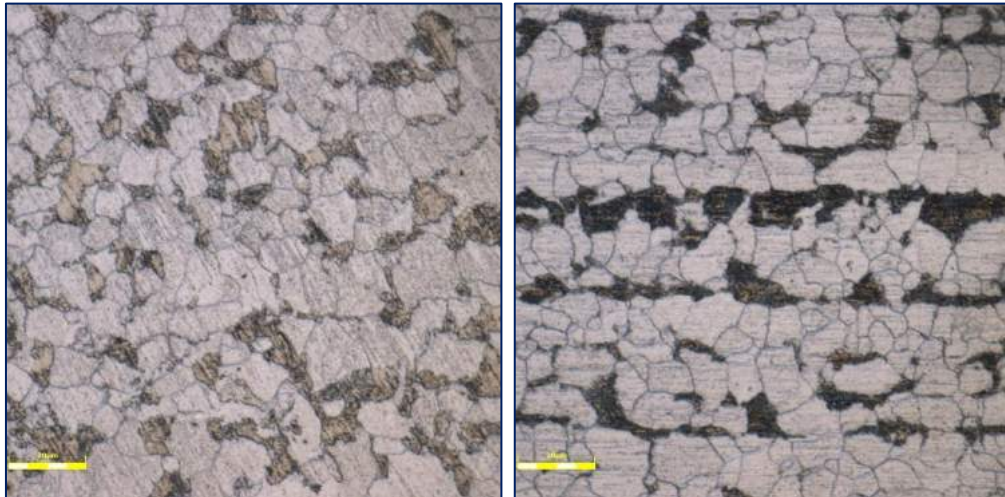
D.16 Tabel Hasil analisa data perhitungan penilaian sisa umur (*Remaining-Life Assessment*) dengan *safety factor* untuk nilai C average sebesar 15,15 pada *economizer tubes*.

Deskripsi	Temp. (°C)	σ_{Eqs} (N/mm²)	PLM	Time to Rupture (Hours)
<i>Row 1</i>	363,07	36,251	15941,7	5.452.528.504,46
<i>Row 4</i>	362,66	38,143	15865,7	4.299.367.341,40
<i>Row 7</i>	363,10	36,144	15946,1	5.527.179.401,48
<i>Row 10</i>	362,84	37,311	15898,8	4.769.627.343,14
<i>Row 15</i>	363,00	36,574	15928,5	5.233.282.245,69

D.17 Tabel dimensi ukuran butir arah memanjang (horizontal) pada *economizer tube-row 17*.

Deskripsi	Ukuran Butir (μm)
<i>Point 1</i>	9,74
<i>Point 2</i>	5,60
<i>Point 3</i>	6,27
<i>Point 4</i>	4,03
<i>Point 5</i>	5,60
<i>Point 6</i>	4,48
<i>Point 7</i>	4,59
<i>Minimum</i>	4,03
<i>Average</i>	5,759
<i>Deviate</i>	1,846

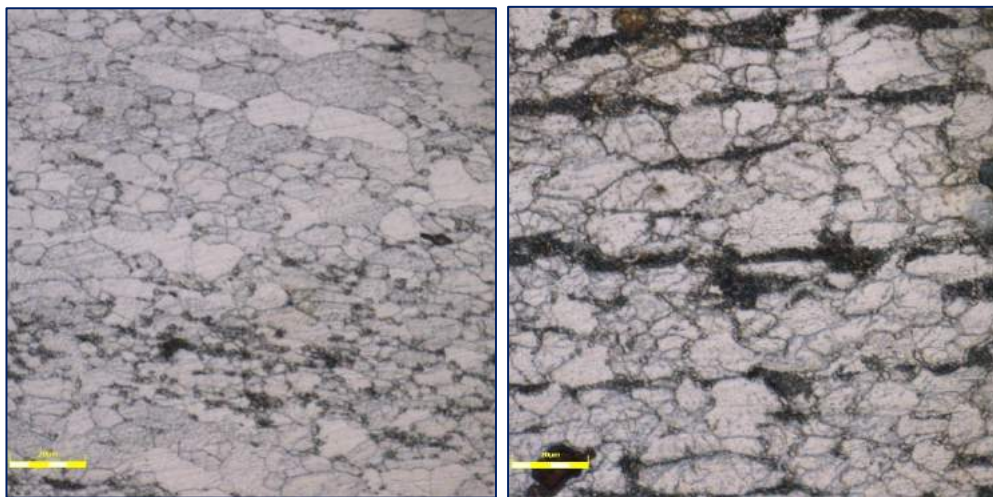
Lampiran E Data Gambar Penelitian di Laboratorium



(A)

(B)

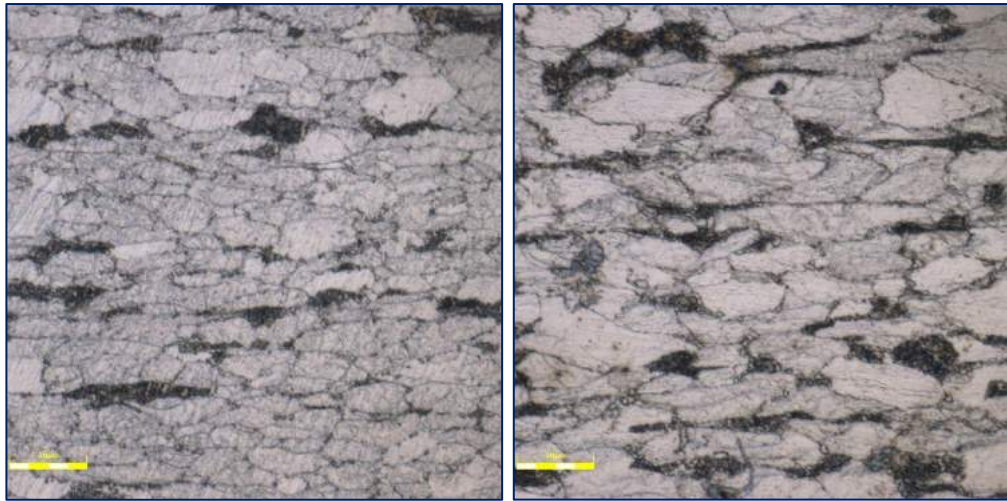
E.1. Gambar hasil mikrostruktur spesimen 4C *raw material* dengan pembesaran 500x, (A) Mikrostruktur spesimen 4C *width side*, (B) Mikrostruktur spesimen 4C *thick side*.



(A)

(B)

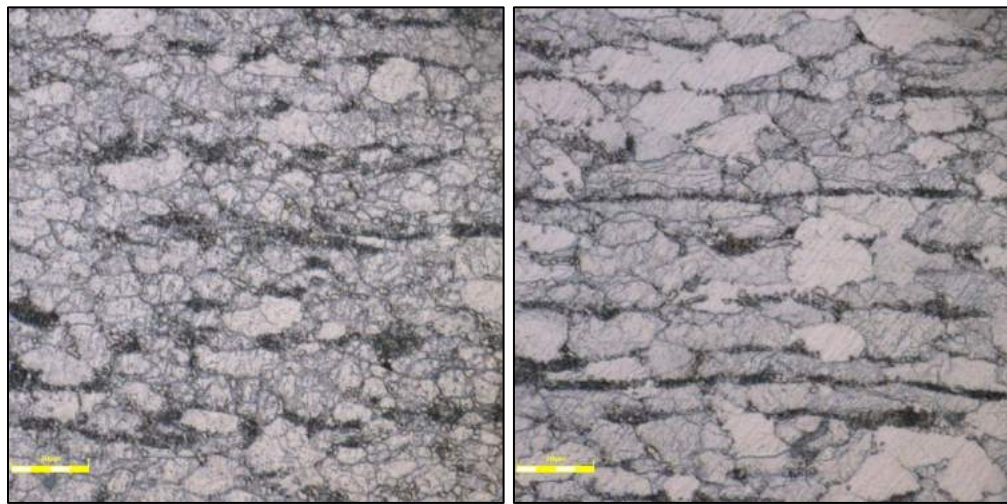
E.2 Gambar hasil mikrostruktur spesimen 2D, temperatur uji *creep* 538 °C, tegangan (σ), 154,29 MPa dengan pembesaran 500x, (A) Mikrostruktur spesimen 2D *width side*, (B) Mikrostruktur spesimen 2D *thick side*.



(A)

(B)

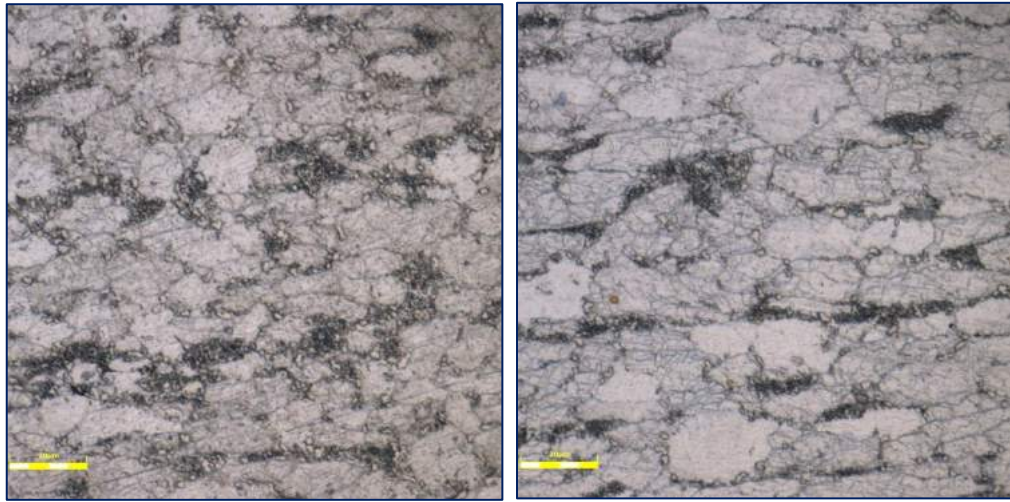
E.3 Gambar hasil mikrostruktur spesimen 2F, temperatur uji *creep* 538 °C, tegangan (σ), 155,70 MPa dengan pembesaran 500x, (A) Mikrostruktur spesimen 2F *width side*, (B) Mikrostruktur spesimen 2F *thick side*.



(A)

(B)

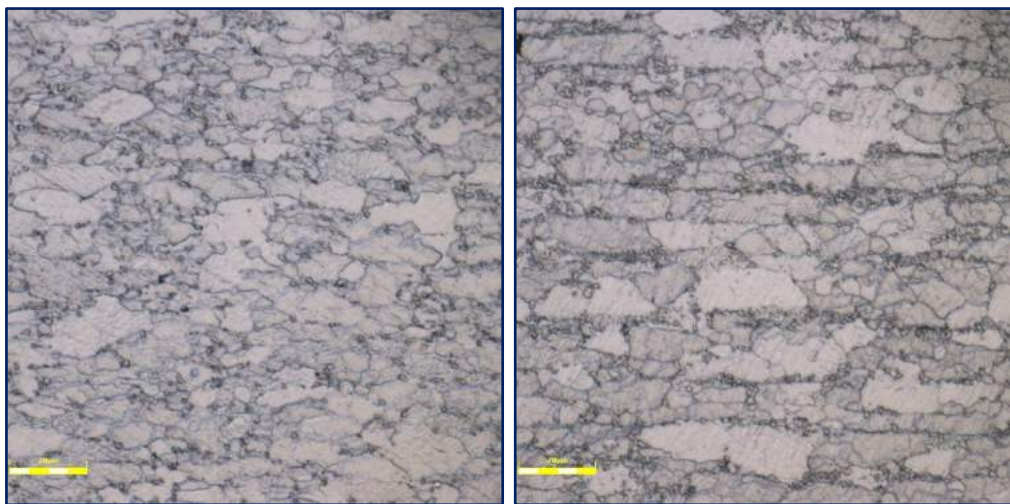
E.4 Gambar hasil mikrostruktur spesimen 3C, temperatur uji *creep* 538 °C, tegangan (σ), 110,14 MPa dengan pembesaran 500x, (A) Mikrostruktur spesimen 3C *width side*, (B) Mikrostruktur spesimen 3C *thick side*.



(A)

(B)

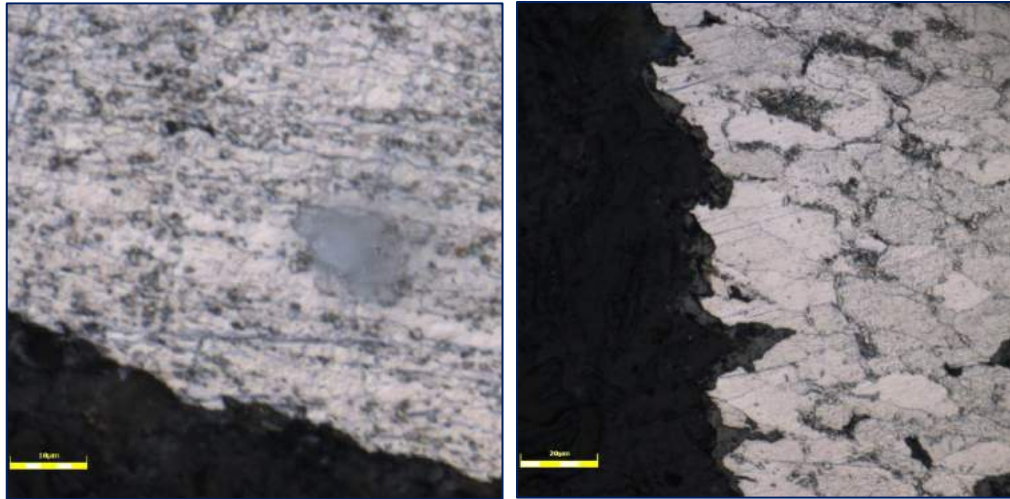
E.5 Gambar hasil mikrostruktur spesimen 3D, temperatur uji *creep* 538 °C, tegangan (σ), 97,59 MPa dengan pembesaran 500x, (A) Mikrostruktur spesimen 3D *width side*, (B) Mikrostruktur spesimen 3D *thick side*.



(A)

(B)

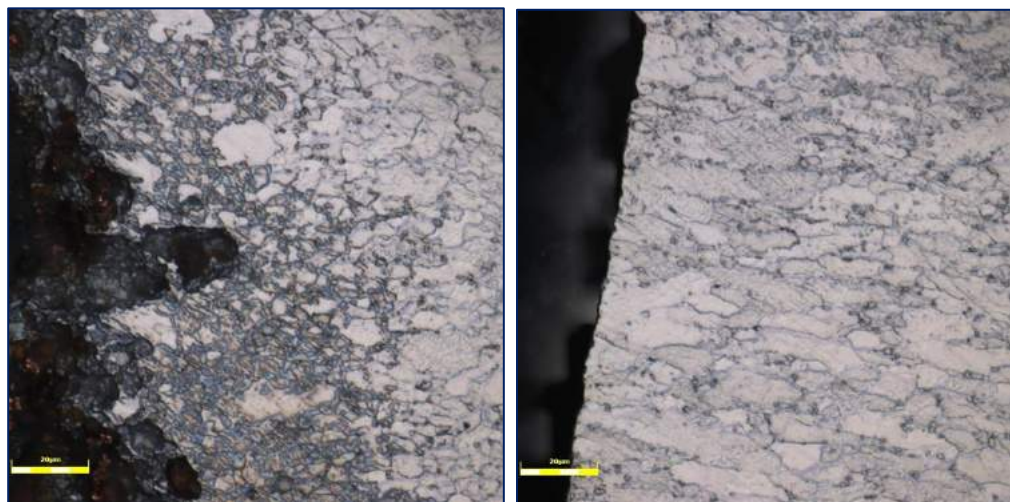
E.6 Gambar hasil mikrostruktur spesimen 4D, temperatur uji *creep* 627 °C, tegangan (σ), 79,22 MPa dengan pembesaran 500x, (A) Mikrostruktur spesimen 4D *width side*, (B) Mikrostruktur spesimen 4D *thick side*.



(A)

(B)

E.7 Gambar patahan pada spesimen uji, (A) *Transgranular*, spesimen 2D dengan pembesaran 1000x, (B) *Intergranular*, spesimen 3D dengan pembesaran 500x.



(A)

(B)

E.8 Gambar Patahan pada spesimen uji 4D dengan pembesaran 500x, (A) *Intergranular*, awal patahan (*initial crack*), (B) *Transgranular*.

Lampiran F Tabel Data Penelitian di Laboratorium

F.1 Tabel data hasil pengukuran dimensi spesimen uji tarik.

Deskripsi	<i>Outside Diameter, OD (mm)</i>	<i>Inside Diameter, D (mm)</i>	<i>Actual Thickness, t_{act} (mm)</i>	<i>Actual Width, W_{act} (mm)</i>	<i>Initial Area, A_0 (mm)</i>
<i>Tube t_{nom}, 2 mm</i>	60,30	55,80	2,25	12,45	28,0125
	60,30	55,80	2,25	12,45	28,0125
	60,30	55,82	2,24	12,45	27,888
	60,30	55,82	2,24	12,45	27,888
	60,30	55,80	2,25	12,3	27,675
<i>Minimum</i>	60,30	55,80	2,24	12,30	27,68
<i>Average</i>	60,30	55,81	2,25	12,42	27,90
<i>Deviante</i>	0,0	0,011	0,005	0,067	0,138
<i>Tube t_{nom}, 3 mm</i>	60,30	53,96	3,17	12,3	38,991
	60,30	54,12	3,09	12,35	38,1615
	60,30	54,18	3,06	12,45	38,097
	60,30	54,18	3,06	12,7	38,862
	60,30	54,16	3,07	12,75	39,1425
<i>Minimum</i>	60,30	53,96	3,06	12,30	38,10
<i>Average</i>	60,30	54,12	3,09	12,51	38,65
<i>Deviante</i>	0,0	0,093	0,046	0,204	0,487
<i>Tube t_{nom}, 4 mm</i>	60,30	52,00	4,15	12,5	51,875
	60,30	52,02	4,14	12,55	51,957
	60,30	52,04	4,13	12,6	52,038
	60,30	52,04	4,13	12,55	51,8315
	60,30	51,98	4,16	12,45	51,792
<i>Minimum</i>	60,30	51,98	4,13	12,45	51,79
<i>Average</i>	60,30	52,02	4,14	12,53	51,90
<i>Deviante</i>	0,0	0,026	0,013	0,057	0,099

F.2 Tabel data hasil pengujian tarik di laboratorium.

Deskripsi	Tensile Strength, T_s (MPa)	Yield Strength, Y_s (MPa)	Elongation, e_f (%)	Reduction Area, RA (%)
<i>Tube t_{nom}, 2 mm</i>	540	345	24,80	43,81
<i>Tube t_{nom}, 3 mm</i>	515	320	23,20	58,06
<i>Tube t_{nom}, 4 mm</i>	515	395	26,90	64,56
Minimum	515,0	320,0	23,2	43,8
Average	523,33	353,33	24,97	55,48
Deviate	14,434	38,188	1,856	10,615

F.3 Tabel data sertifikat material (*mill certificate*) dari pabrik pembuat.

Deskripsi	Tensile Strength, T_s (MPa)	Yield Strength, Y_s (MPa)	Elongation, e (%)	HRB
<i>Tube SA-210 A1</i>	475	365	34,5	76
<i>(60,3 x 4,0 mm);</i>	472	342	34,3	77
<i>Certificate No.</i>	472	351	33,0	77
<i>1601994010;</i>	472	341	35,0	77
<i>Date, 02/11/2016</i>	472	356	34,8	77
Minimum	472,0	341,0	33,0	76,0
Average	472,60	351,00	34,32	76,80
Deviate	1,342	10,025	0,785	0,447

F.4 Tabel data hasil pengujian di laboratorium, nilai kekerasan dengan menggunakan skala *Rockwell*.

Deskripsi	Hardness	
	HBW	HRB
<i>Tube t_{nom}, 2 mm</i>	140,00	76,50
	141,30	77,10
	139,80	76,40
Minimum	139,80	76,40
Average	140,37	76,67
Dev.	0,814	0,379
<i>Tube t_{nom}, 3 mm</i>	143,40	77,80
	149,10	79,70
	147,60	79,20
Minimum	143,40	77,80
Average	146,70	78,90
Dev.	2,955	0,985
<i>Tube t_{nom}, 4 mm</i>	141,00	77,00
	147,90	79,30
	142,20	77,40
Minimum	141,00	77,00
Average	143,70	77,90
Dev.	3,686	1,229

F.5 Tabel data hasil pengujian komposisi kimia (*chemical composition*) berdasarkan sertifikat material (*mill certificate*) SA-210 A1.

Deskripsi	Komposisi Kimia (<i>Chemical Composition</i>)								
	Fe	C	Si	Mn	P	S	Cr	Mo	Ni
<i>Tube SA-210 A1 (60,3 x 4,0 mm); Certificate No. 1601994010; Date, 02/11/2016</i>	Bal.	0,13	0,24	0,78	0,007	0,001	0,14	0,02	0,06
	Al	Co	Cu	Nb	Ti	V	W	Pb	Sn
	0,025	N/A	0,09	0,0001	0,001	0	N/A	N/A	0,005
	B	Ca	Zr	Zn	Bi	As	Se	Sb	
	0,0002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

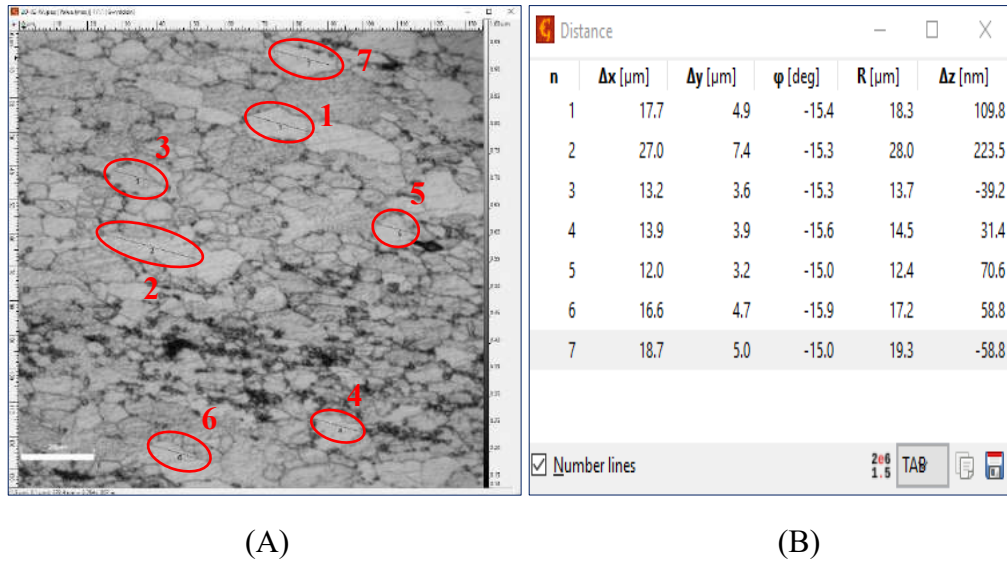
F.6 Tabel data hasil pengujian komposisi kimia (*chemical composition*) di laboratorium menggunakan *Optical Emission Spectroscopy*.

Deskripsi	Komposisi Kimia (<i>Chemical Composition</i>)								
	Fe	C	Si	Mn	P	S	Cr	Mo	Ni
<i>Tube t_{nom}: 4 mm; 4C; Temp. test, 27 °C (Raw Material)</i>	98,40	0,117	0,237	0,797	0,004	0,001	0,134	0,024	0,061
	Al	Co	Cu	Nb	Ti	V	W	Pb	Sn
	0,0219	0,0053	0,0664	0,0005	0,0015	0,0025	0,038	0,005	0,0024
	B	Ca	Zr	Zn	Bi	As	Se	Sb	
	0,0004	0,0066	0,0016	0,0139	0,0146	0,001	0,0129	0,036	
<i>Tube t_{nom}: 2 mm; 2D; Temp. Creep-Test, 538 °C</i>	98,40	0,114	0,246	0,803	0,0048	0,001	0,135	0,0248	0,0626
	Al	Co	Cu	Nb	Ti	V	W	Pb	Sn
	0,0234	0,0062	0,0696	0,0005	0,0025	0,0028	0,0378	0,0058	0,0025
	B	Ca	Zr	Zn	Bi	As	Se	Sb	
	0,0004	0,0065	0,0018	0,0135	0,0143	0,001	0,0131	0,004	
<i>Tube t_{nom}: 2 mm; 2F; Temp. Creep-Test, 538 °C</i>	98,40	0,113	0,248	0,788	0,0043	0,001	0,137	0,0237	0,0581
	Al	Co	Cu	Nb	Ti	V	W	Pb	Sn
	0,0234	0,0054	0,0634	0,0005	0,0012	0,0025	0,0318	0,0055	0,0024
	B	Ca	Zr	Zn	Bi	As	Se	Sb	
	0,0004	0,0051	0,0015	0,0135	0,0141	0,001	0,0118	0,003	
<i>Tube t_{nom}: 3 mm; 3C; Temp. Creep-Test, 538 °C</i>	98,40	0,115	0,246	0,806	0,0049	0,001	0,136	0,024	0,0601
	Al	Co	Cu	Nb	Ti	V	W	Pb	Sn
	0,0219	0,0079	0,068	0,0005	0,0012	0,0026	0,0454	0,0054	0,0029
	B	Ca	Zr	Zn	Bi	As	Se	Sb	
	0,0004	0,0034	0,0008	0,0148	0,0141	0,001	0,0116	0,003	
<i>Tube t_{nom}: 3 mm; 3D; Temp. Creep-Test, 538 °C</i>	98,40	0,12	0,259	0,78	0,0046	0,001	0,137	0,0264	0,0637
	Al	Co	Cu	Nb	Ti	V	W	Pb	Sn
	0,0238	0,0033	0,0716	0,0005	0,0019	0,0032	0,0509	0,007	0,0029
	B	Ca	Zr	Zn	Bi	As	Se	Sb	
	0,0004	0,008	0,0018	0,02	0,0139	0,001	0,0125	0,003	
<i>Tube t_{nom}: 4 mm; 4D; Temp. Creep-Test, 627 °C</i>	97,20	0,0759	0,307	0,875	0,0033	0,001	0,15	0,023	0,062
	Al	Co	Cu	Nb	Ti	V	W	Pb	Sn
	0,0283	0,0065	0,062	0,0005	0,0022	0,0032	0,0491	0,0072	0,0024
	B	Ca	Zr	Zn	Bi	As	Se	Sb	
	0,0004	0,008	0,0008	0,02	0,0119	0,001	0,0092	0,003	

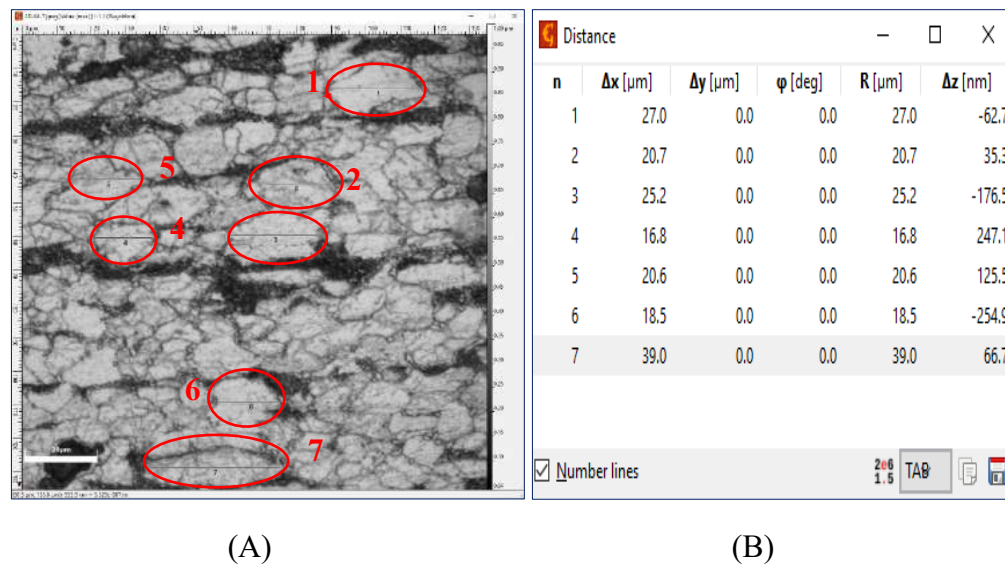
F.7 Tabel data pengukuran dimensi untuk spesimen uji *creep-rupture*

<i>Deskripsi/Kriteria</i>		<i>Outside Diameter, O_D (mm)</i>	<i>Initial Length, L_i (mm)</i>	<i>Width, W (mm)</i>	<i>Thickness, t_{act} (mm)</i>
<i>Tube t_{nom}, 2 mm</i>	<i>2D</i>	60,3	50	12,5	1,9
<i>Tube t_{nom}, 2 mm</i>	<i>2F</i>	60,3	50	12,35	2,18
<i>Tube t_{nom}, 3 mm</i>	<i>3C</i>	60,3	50	12,5	2,94
<i>Tube t_{nom}, 3 mm</i>	<i>3D</i>	60,3	50	12,55	3,25
<i>Tube t_{nom}, 4 mm</i>	<i>4D</i>	60,3	50	12,6	4,18

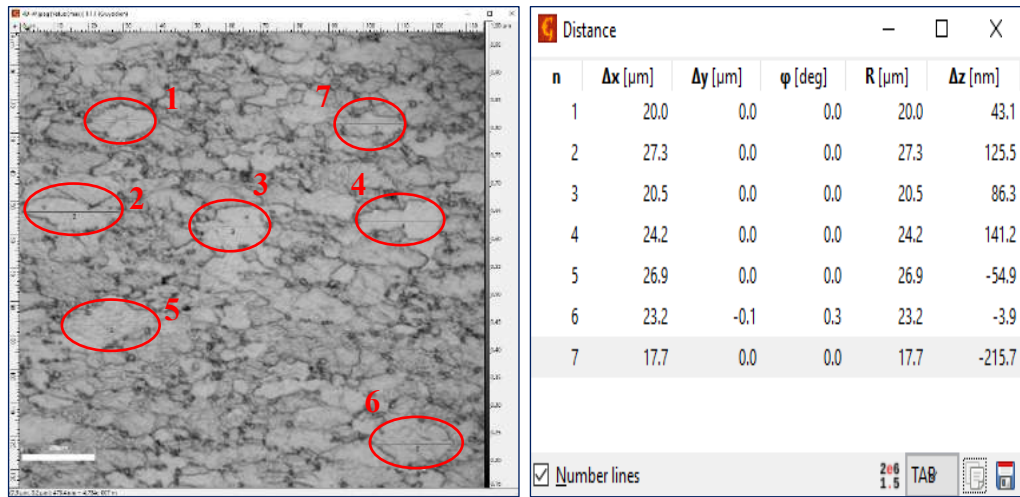
Lampiran G Hasil Analisa Data Gambar Penelitian di Laboratorium



G.1 Gambar mikrostruktur spesimen uji 2D, (A) Mikrostruktur sisi lebar/*width side*, (B) Hasil pengukuran arah memanjang butir *ferrite* (*width side*).



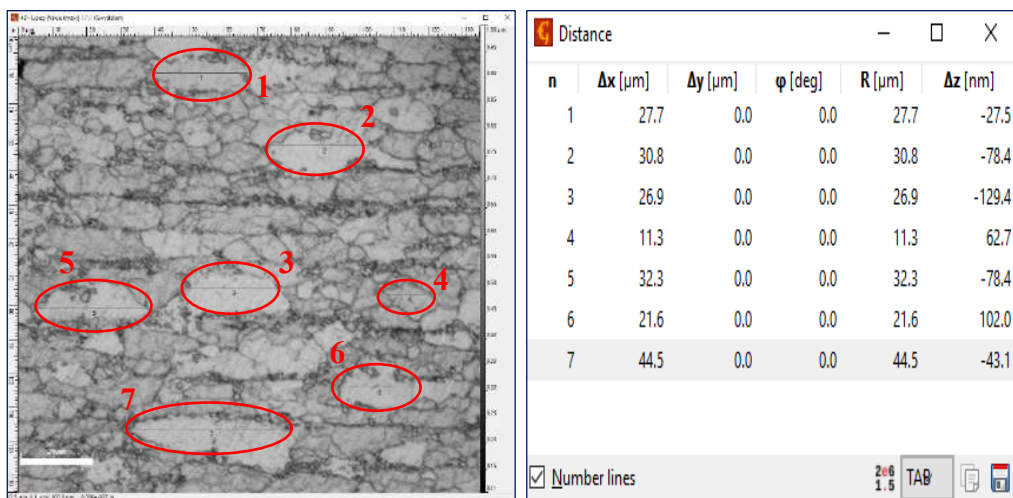
G.2 Gambar mikrostruktur spesimen uji 2D, (A) Mikrostruktur sisi ketebalan (*thick side*), (B) Hasil pengukuran arah memanjang butir *ferrite* *thick side*.



(A)

(B)

G.3 Gambar mikrostruktur spesimen uji 4D, (A) Mikrostruktur sisi lebar/*width side*, (B) Hasil pengukuran arah memanjang butir *ferrite* (*width side*).



(A)

(B)

G.4 Gambar mikrostruktur spesimen uji 4D, (A) Mikrostruktur sisi ketebalan (*thick side*), (B) Hasil pengukuran arah memanjang butir *ferrite* *thick side*.

Lampiran H Hasil Analisa Data Perhitungan Penelitian di Laboratorium

H.1 Tabel hasil analisa data perhitungan berdasarkan pengujian laboratorium (pengujian tarik), nilai tegangan maksimum yang diizinkan (S) pada fungsi temperatur spesimen uji.

Deskripsi		T_S (MPa)	Temp. (°C)	T_{ST} (MPa)	R_T	S (MPa)
Tube t_{nom} , 2 mm	2D	540,0	355,89	538,699	1,0323421000	148,56
Tube t_{nom} , 2 mm	2F	540,0	351,82	538,699	1,0499772555	151,10
Tube t_{nom} , 3 mm	3C	515,0	351,03	513,759	1,0534410578	144,58
Tube t_{nom} , 3 mm	3D	515,0	350,69	513,759	1,0548811057	144,78
Tube t_{nom}, 4 mm	4D	515,0	349,68	513,759	1,0592998423	145,39
	Min.	515,0	349,68	513,76	1,0323421000	144,58
	Ave.	525,0	351,82	523,735	1,0499882722	146,88
	Dev.	93,750	2,880	93,299	0,0000542443	4,0733

H.2 Tabel hasil analisa data perhitungan berdasarkan pengujian laboratorium (pengujian tarik), nilai ketebalan minimum yang diizinkan (t_{min}), tekanan kerja maksimum yang diizinkan (MAWP) pada spesimen uji.

Deskripsi		t_a (mm)	O_D (mm)	MAWP (MPa)	P (MPa)	t_{min} (mm)
Tube t_{nom} , 2 mm	2D	1,90	60,30	8,09	13,70	2,96
Tube t_{nom} , 2 mm	2F	2,18	60,30	9,72	13,70	2,92
Tube t_{nom} , 3 mm	3C	2,94	60,30	13,23	13,70	3,03
Tube t_{nom} , 3 mm	3D	3,25	60,30	14,89	13,70	3,03
Tube t_{nom}, 4 mm	4D	4,18	60,30	19,99	13,70	3,01

H.3 Tabel hasil analisa data perhitungan berdasarkan sertifikat material, nilai tegangan maksimum yang diizinkan (S) pada fungsi temperatur spesimen uji.

Deskripsi		T_S (MPa)	Temp. (°C)	T_{ST} (MPa)	R_T	S (MPa)
Tube t_{nom} , 2 mm	2D	472,60	355,89	471,46	1,0323421000	130,02
Tube t_{nom} , 2 mm	2F	472,60	351,82	471,46	1,0499772555	132,24
Tube t_{nom} , 3 mm	3C	472,60	351,03	471,46	1,0534410578	132,68
Tube t_{nom} , 3 mm	3D	472,60	350,69	471,46	1,0548811057	132,86
Tube t_{nom}, 4 mm	4D	472,60	349,68	471,46	1,0592998423	133,42
	Min.	472,60	349,68	471,46	1,0323421000	130,02
	Ave.	472,60	351,82	471,46	1,0499882722	132,24
	Dev.	0,0	2,8797	0,0	0,0000542443	0,8605

H.4 Tabel hasil analisa data perhitungan berdasarkan sertifikat material, nilai ketebalan minimum yang diizinkan (t_{min}), tekanan kerja maksimum yang diizinkan (MAWP) pada spesimen uji.

Deskripsi		t_a (mm)	O_D (mm)	MAWP (MPa)	P (MPa)	t_{min} (mm)
Tube t_{nom} , 2 mm	2D	1,90	60,30	7,08	13,70	3,32
Tube t_{nom} , 2 mm	2F	2,18	60,30	8,50	13,70	3,27
Tube t_{nom} , 3 mm	3C	2,94	60,30	12,14	13,70	3,26
Tube t_{nom} , 3 mm	3D	3,25	60,30	13,66	13,70	3,26
Tube t_{nom} , 4 mm	4D	4,18	60,30	18,34	13,70	3,25

H.5 Tabel hasil analisa data perhitungan nilai skala kekerasan *Vickers*, kekuatan tarik (T_s), kekuatan luluh (Y_s) dan nilai tegangan maksimum yang diizinkan (S) pada fungsi temperatur spesimen uji.

Desk.	Kekerasan		T_s (MPa)	Temp. (°C)	T_{ST} (MPa)	R_T	S (MPa)
	HBN	HVN					
2D	139,80	147,16	467,89	355,89	466,8	1,0323421000	128,73
2F	139,80	147,16	467,89	351,82	466,8	1,0499772555	130,93
3C	143,40	150,95	477,37	351,03	476,2	1,0534410578	134,02
3D	143,40	150,95	477,37	350,69	476,2	1,0548811057	134,20
4D	141,00	148,42	471,05	349,68	469,9	1,0592998423	132,98
Min.	139,80	147,16	467,89	349,68	466,77	1,0323421000	128,73
Ave.	141,48	148,93	472,32	351,82	471,178	1,0499882722	132,17
Dev.	1,656	1,835	11,468	2,880	11,413	0,0000542443	2,6994

H.6 Tabel hasil analisa data perhitungan berdasarkan nilai kekerasan, nilai ketebalan minimum yang diizinkan (t_{min}), tekanan kerja maksimum yang diizinkan (MAWP) pada spesimen uji.

Deskripsi		t_a (mm)	O_D (mm)	MAWP (MPa)	P (MPa)	t_{min} (mm)
Tube t_{nom} , 2 mm	2D	1,90	60,30	7,01	13,70	3,35
Tube t_{nom} , 2 mm	2F	2,18	60,30	8,42	13,70	3,30
Tube t_{nom} , 3 mm	3C	2,94	60,30	12,26	13,70	3,23
Tube t_{nom} , 3 mm	3D	3,25	60,30	13,80	13,70	3,23
Tube t_{nom} , 4 mm	4D	4,18	60,30	18,28	13,70	3,26

H.7 Tabel data perhitungan radius luar (r_o), radius dalam (r_i), radius pada lokasi tertentu (r) serta kriteria silinder ber dinding tebal atau tipis pada spesimen uji.

Deskripsi		r_o (mm)	r_i (mm)	r (mm)	rasio (r_i/r_o)	Kriteria
Tube t_{nom} , 2 mm	2D	30,15	28,25	29,20	0,937	$r/t \geq 10$
Tube t_{nom} , 2 mm	2F	30,15	27,97	29,06	0,928	$r/t \geq 10$
Tube t_{nom} , 3 mm	3C	30,15	27,21	28,68	0,902	$r/t < 10$
Tube t_{nom} , 3 mm	3D	30,15	26,90	28,53	0,892	$r/t < 10$
Tube t_{nom}, 4 mm	4D	30,15	25,97	28,06	0,861	$r/t < 10$

H.8 Tabel hasil analisa data perhitungan tegangan elastis tangensial/circumferential/hoop stress (σ_{He}), tegangan elastis aksial/longitudinal (σ_{Ze}), tegangan elastis radial (σ_{Re}) dan tegangan equivalen elastis (σ_{Eqe}) pada spesimen uji.

Deskripsi		σ_{He} (N/mm ²)	σ_{Ze} (N/mm ²)	σ_{Re} (N/mm ²)	σ_{Eqe} (N/mm ²)
Tube t_{nom} , 2 mm	2D	203,586	98,535	0,0	176,341
Tube t_{nom} , 2 mm	2F	175,646	84,591	0,0	152,149
Tube t_{nom} , 3 mm	3C	126,620	60,148	-6,324	115,133
Tube t_{nom} , 3 mm	3D	113,199	53,467	-6,265	103,459
Tube t_{nom}, 4 mm	4D	84,863	39,389	-6,086	78,764

H.9 Tabel hasil analisa data perhitungan regangan elastis tangensial (ϵ_{He}), regangan elastis aksial/longitudinal (ϵ_{Ze}), regangan elastis radial (ϵ_{Re}) dan regangan equivalen (ϵ_{Eqe}) elastis pada spesimen uji.

ϵ_{He}	ϵ_{Ze}	ϵ_{Re}	ϵ_{Eqe}
0,0009832	0,0002116	-0,0005121	0,0008634
0,0008490	0,0001802	-0,0004411	0,0007450
0,0006241	0,0001359	-0,0003523	0,0005637
0,0005595	0,0001208	-0,0003179	0,0005066
0,0004230	0,0000890	-0,0002450	0,0003857

H.10 Tabel Hasil analisa data perhitungan tegangan plastis tangensial/*circumferential/hoop stress* (σ_{Hp}), tegangan plastis aksial/longitudinal (σ_{Zp}), tegangan plastis radial (σ_{Rp}) dan tegangan equivalen plastis (σ_{Eqp}) pada spesimen uji.

Deskripsi		σ_{Hp} (N/mm^2)	σ_{Zp} (N/mm^2)	σ_{Rp} (N/mm^2)	σ_{Eqp} (N/mm^2)
<i>Tube t_{nom}, 2 mm</i>	<i>2D</i>	203,735	98,498	0,0	176,471
<i>Tube t_{nom}, 2 mm</i>	<i>2F</i>	175,818	84,548	0,0	152,300
<i>Tube t_{nom}, 3 mm</i>	<i>3C</i>	126,853	60,090	-6,324	115,335
<i>Tube t_{nom}, 3 mm</i>	<i>3D</i>	113,459	53,402	-6,265	103,684
<i>Tube t_{nom}, 4 mm</i>	<i>4D</i>	85,202	39,304	-6,086	79,058

H.11 Tabel hasil analisa data perhitungan regangan plastis tangensial (ϵ_{Hp}), regangan plastis aksial/longitudinal (ϵ_{Zp}), regangan plastis radial (ϵ_{Rp}) dan regangan equivalen (ϵ_{Eqp}) plastis pada spesimen uji.

ϵ_{Hp}	ϵ_{Zp}	ϵ_{Rp}	ϵ_{Eqp}
0,0009841	0,0002112	-0,0005123	0,0008641
0,0008500	0,0001797	-0,0004413	0,0007457
0,0006256	0,0001352	-0,0003526	0,0005647
0,0005611	0,0001200	-0,0003182	0,0005077
0,0004251	0,0000880	-0,0002454	0,0003871

H.12 Tabel hasil analisa data perhitungan tegangan termal tangensial/*circumferential/hoop stress* (σ_{Ht}), tegangan termal aksial/longitudinal (σ_{Zt}), tegangan termal radial (σ_{Rt}) dan tegangan equivalen termal (σ_{Eqt}) pada spesimen uji.

Deskripsi		σ_{Ht} (N/mm^2)	σ_{Zt} (N/mm^2)	σ_{Rt} (N/mm^2)	σ_{Eqt} (N/mm^2)
<i>Tube t_{nom}, 2 mm</i>	<i>2D</i>	6,680	-3,342	0,0	8,838
<i>Tube t_{nom}, 2 mm</i>	<i>2F</i>	7,611	-3,808	0,0	10,070
<i>Tube t_{nom}, 3 mm</i>	<i>3C</i>	10,367	-5,191	-15,558	22,601
<i>Tube t_{nom}, 3 mm</i>	<i>3D</i>	11,506	-5,763	-17,269	25,086
<i>Tube t_{nom}, 4 mm</i>	<i>4D</i>	14,974	-7,509	-22,483	32,655

H.13 Tabel hasil analisa data perhitungan regangan termal tangensial (ϵ_{Ht}), regangan termal aksial/longitudinal (ϵ_{Zt}), regangan termal radial (ϵ_{Rt}) dan regangan equivalen (ϵ_{Eq_t}) termal pada spesimen uji.

ϵ_{Ht}	ϵ_{Zt}	ϵ_{Rt}	ϵ_{Eq_t}
0,0049191	0,0048455	0,0048700	0,0000433
0,0048694	0,0047856	0,0048135	0,0000493
0,0049028	0,0047885	0,0047124	0,0001107
0,0049086	0,0047817	0,0046972	0,0001228
0,0049260	0,0047609	0,0046509	0,0001599

H.14 Tabel hasil analisa data perhitungan tegangan *steady-state* tangensial/*circumferential/hoop stress* (σ_{Hss}), tegangan *steady-state* aksial/longitudinal (σ_{Zss}), tegangan *steady-state* radial (σ_{Rss}) dan tegangan equivalen *steady-state* (σ_{Eqss}) pada spesimen uji.

Deskripsi	σ_{Hss} (N/mm^2)	σ_{Zss} (N/mm^2)	σ_{Rss} (N/mm^2)	σ_{Eqss} (N/mm^2)
<i>Tube t_{nom}, 2 mm 2D</i>	203,731	98,513	0,0	176,468
<i>Tube t_{nom}, 2 mm 2F</i>	175,814	84,565	0,0	152,296
<i>Tube t_{nom}, 3 mm 3C</i>	126,848	60,113	-6,623	115,589
<i>Tube t_{nom}, 3 mm 3D</i>	113,453	53,428	-6,597	103,967
<i>Tube t_{nom}, 4 mm 4D</i>	85,195	39,338	-6,519	79,427

H.15 Tabel hasil analisa data perhitungan regangan *steady-state* tangensial (ϵ_{Hss}), regangan *steady-state* aksial/longitudinal (ϵ_{Zss}), regangan *steady-state* radial (ϵ_{Rss}) dan regangan equivalen (ϵ_{Eqss}) *steady-state* pada spesimen uji.

ϵ_{Hss}	ϵ_{Zss}	ϵ_{Rss}	ϵ_{Eqss}
0,0009841	0,0002113	-0,0005123	0,0008641
0,0008500	0,0001798	-0,0004413	0,0007457
0,0006260	0,0001358	-0,0003543	0,0005660
0,0005616	0,0001207	-0,0003201	0,0005091
0,0004257	0,0000889	-0,0002479	0,0003889

H.16 Tabel hasil analisa data perhitungan tegangan equivalen elastis (σ_{Eqe}), tegangan equivalen plastis (σ_{Eqp}), tegangan equivalen termal (σ_{Eq_t}) dan tegangan equivalen *steady-state* ($\sigma_{Eq_{ss}}$) pada spesimen uji.

Deskripsi		σ_{Eqe} (N/mm^2)	σ_{Eqp} (N/mm^2)	σ_{Eq_t} (N/mm^2)	$\sigma_{Eq_{ss}}$ (N/mm^2)
<i>Tube</i> t_{nom} , 2 mm	2D	176,341	176,471	8,838	176,468
<i>Tube</i> t_{nom} , 2 mm	2F	152,149	152,300	10,070	152,296
<i>Tube</i> t_{nom} , 3 mm	3C	115,133	115,335	22,601	115,589
<i>Tube</i> t_{nom} , 3 mm	3D	103,459	103,684	25,086	103,967
<i>Tube</i> t_{nom}, 4 mm	4D	78,764	79,058	32,655	79,427

H.17 Tabel hasil analisa data perhitungan regangan equivalen elastis (ϵ_{Eqe}), regangan equivalen plastis (ϵ_{Eqp}), regangan equivalen termal (ϵ_{Eq_t}) dan regangan equivalen *steady-state* ($\epsilon_{Eq_{ss}}$) pada spesimen uji.

ϵ_{Eqe}	ϵ_{Eqp}	ϵ_{Eq_t}	$\epsilon_{Eq_{ss}}$
0,0008634	0,0008641	0,0000433	0,0008641
0,0007450	0,0007457	0,0000493	0,0007457
0,0005637	0,0005647	0,0001107	0,0005660
0,0005066	0,0005077	0,0001228	0,0005091
0,0003857	0,0003871	0,0001599	0,0003889

H.18 Tabel hasil analisa data perhitungan penilaian umur (*Life Assessment*), tegangan equivalen elastis (σ_{Eqe}), waktu prediksi putus/pecah dan waktu putus/pecah aktual pada spesimen uji.

<i>Deskripsi</i>	t_{act} (mm)	σ_{Eqe} (N/mm^2)	<i>Temp.</i> ($^{\circ}C$)	P_{LM}	<i>Time to Rupture (Hours)</i>		
					<i>Min.</i>	<i>Ave.</i>	<i>Actual</i>
2D	1,9	154,29	538	13261,6	5,65	15,93	8,002
2F	2,18	155,70	538	13241,2	5,33	15,03	14,368
3C	2,94	110,14	538	13986,5	44,26	124,73	119,78
3D	3,25	97,60	538	14230,7	88,54	249,55	246,45
4D	4,18	79,22	627	14633,4	4,56	12,86	4,76

H.19 Tabel parameter pendukung dan hasil pengujian *creep-rupture* pada spesimen uji.

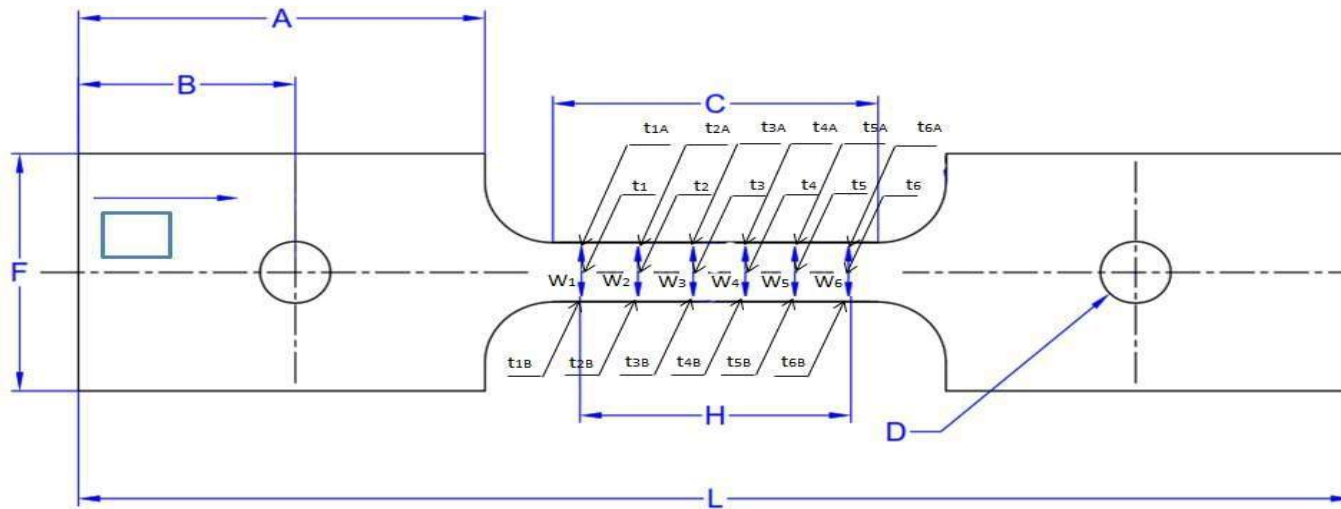
<i>RA</i> (%)	<i>l_f</i> (mm)	<i>C_{SR}</i> (h ⁻¹)	<i>E</i> (N/mm ²)	<i>G</i> (N/mm ²)	σ_{Eqs} / G	<i>Criteria</i>
39,39	60,5	0,0229	1,40E+05	5,40E+04	0,00286	$0,0001 \leq \sigma/G \leq 0,01$
64,8	67,2	0,0124	1,40E+05	5,40E+04	0,00288	$0,0001 \leq \sigma/G \leq 0,01$
58,47	71,3	0,0024	1,40E+05	5,40E+04	0,00204	$0,0001 \leq \sigma/G \leq 0,01$
49,25	72,85	0,0011	1,40E+05	5,40E+04	0,00181	$0,0001 \leq \sigma/G \leq 0,01$
66,27	93,4	0,0930	1,15E+05	4,44E+04	0,00178	$0,0001 \leq \sigma/G \leq 0,01$

H.20 Tabel data hasil pengukuran butir *ferrite* arah horizontal/memanjang untuk sisi lebar/*width side* dan sisi ketebalan/*thick side*.

Deskripsi	<i>Spesimen 4C</i>		<i>Spesimen 2D</i>		<i>Spesimen 3D</i>		<i>Spesimen 4D</i>	
	<i>grain size</i> (μm) <i>width side</i>	<i>grain size</i> (μm) <i>thick side</i>	<i>grain size</i> (μm) <i>width side</i>	<i>grain size</i> (μm) <i>thick side</i>	<i>grain size</i> (μm) <i>width side</i>	<i>grain size</i> (μm) <i>thick side</i>	<i>grain size</i> (μm) <i>width side</i>	<i>grain size</i> (μm) <i>thick side</i>
<i>Point 1</i>	16,70	14,20	18,30	27,00	20,30	29,80	20,00	27,70
<i>Point 2</i>	18,20	22,40	28,00	20,70	22,40	32,30	27,30	30,80
<i>Point 3</i>	15,00	18,40	13,70	25,20	16,10	48,00	20,50	26,90
<i>Point 4</i>	15,90	17,40	14,50	16,80	15,00	36,90	24,20	11,30
<i>Point 5</i>	18,40	11,40	12,40	20,60	22,30	28,70	26,90	32,30
<i>Point 6</i>	12,20	18,90	17,20	18,50	32,80	18,50	23,20	21,60
<i>Point 7</i>	9,50	20,30	19,30	39,00	23,80	27,60	17,70	44,50
<i>Minimum</i>	9,50	11,40	12,40	16,80	15,00	18,50	17,70	11,30
<i>Average</i>	15,139	17,571	17,629	23,971	21,814	31,686	22,829	27,871
<i>Deviate</i>	5,290	6,891	13,630	28,331	17,216	41,396	6,526	51,635

H.21 Tabel data hasil pengujian *creep-rupture* spesimen uji 2D.

<i>Material/Specimen</i>		SA-210 A1 -- 2D
<i>Machine</i>		GCTM (BM)
<i>Mass/test load</i>		130 kgs
<i>Temperature Set</i>		538 °C
<i>Start to Temperature</i>	<i>Time</i>	12.00 WITA
	<i>Date</i>	09/08/2021
<i>Finish at Temperature</i>	<i>Expansion</i>	1,956 mm
	<i>Time</i>	13.53 WITA
	<i>Date</i>	09/08/2021
	<i>Duration</i>	1 Hour 53 Min
<i>Duration (Heating Homogen)</i>		1 Hour 57 Min
<i>Start loading</i>	<i>Time</i>	15.56 WITA
	<i>Date</i>	09/08/2021
	<i>Expansion</i>	2,055 mm
<i>Instantaneous Deformation (ID)</i>		4,695 mm
<i>Break/Fracture</i>	<i>Time</i>	23.49 WITA
	<i>Date</i>	09/08/2021
	<i>Duration (Predict. Fracture)</i>	5,65 Hrs -- 15,93Hrs
	<i>Duration (actual Fracture)</i>	8 Hour 0,1 Min (8,002 Hours)
	<i>Length at Fracture (Dial)</i>	66,66 mm
	<i>Final Length (Ambient)</i>	60,50 mm
	<i>Area Fracture (W x t)</i>	9,25 x 1,55 mm
	<i>Reduction in Area (RA)</i>	39,39 %
	<i>Creep Strain Rate</i>	2,29E-02 h ⁻¹



MATERIAL :			SA-210 A1			SPECIMEN :		2D									
A (mm)	B (mm)	C (mm)	D (mm)	F (mm)	H (mm)	L (mm)	Width/W (mm)	Thickness/t (mm)						Hardness/H (BHN)		Applied For Test (mm ²)	
75	40	85	13	50	50	234,5	W1: 12,50	t1: 2,04	t1A: 2,10	t1B: 2,10	t1AVE: 2,08	H1: 123	25,5000				
							W2: 12,70	t2: 2,09	t2A: 2,15	t2B: 2,10	t2AVE: 2,11	H2: 137	26,5430				
							W3: 12,70	t3: 2,02	t3A: 2,05	t3B: 2,05	t3AVE: 2,04	H3: 104	25,6540				
							W4: 12,55	t4: 2,04	t4A: 2,10	t4B: 2,15	t4AVE: 2,10	H4: 105	25,6020				
							W5: 12,65	t5: 1,93	t5A: 2,05	t5B: 2,10	t5AVE: 2,03	H5: 98	24,4145				
							W6: 12,45	t6: 1,84	t6A: 1,94	t6B: 1,92	t6AVE: 1,90	H6: 114	22,9080				
							WAVE: 12,59	tMIN: 1,84	tMIN: 1,94	tMIN: 1,92	tAVEtot: 2,04	HAVE: 113,50	Amin.				
							WMIN: 12,45	Selected	N/A			tMIN: 1,90	HMIN: 98	22,9080			

CREEP-RUPTURE DATA													
MATERIAL		SA-210 A1			SPECIMEN		2D		THICKNESS			Minimum (mm)	1,90
TEMPERATURE		538 °C			LOAD/MASS		130 kgs					Average (mm)	2,04
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)
		Hour	Min.	Sec.					Hour	Min.	Sec.		
1	09/08/2021	12	00	00	0,0	0,0	58						
2	Start Temp.	12	15	00	0,25	0,010	59						
3	--	12	30	00	0,25	0,252	60						
4	--	12	45	00	0,25	0,845	61						
5	--	13	00	00	0,25	1,335	62						
6	--	13	15	00	0,25	1,538	63						
7	--	13	30	00	0,25	1,752	64						
8	--	13	45	00	0,25	1,900	65						
9	Finish Temp.	13	53	19	0,1386	1,956	66						
10	--	14	08	20	0,25	1,982	67						
11	--	14	23	20	0,25	1,999	68						
12	--	14	38	20	0,25	2,007	69						
13	--	14	53	20	0,25	2,008	70						
14	--	15	08	20	0,25	2,012	71						
15	--	15	23	20	0,25	2,015	72						
16	--	15	38	20	0,25	2,021	73						
17	Finish Heat.	15	50	50	0,2083	2,055	74						
18	Start Load	15	56	12	0,0015	4,695	75						
19	--	16	11	12	0,25	5,382	76						
20	--	16	26	12	0,25	5,742	77						
21	--	16	41	12	0,25	6,046	78						
22	--	16	56	12	0,25	6,338	79						
23	--	17	11	12	0,25	6,615	80						
24	--	17	26	12	0,25	6,884	81						
25	--	17	41	12	0,25	7,168	82						
26	--	17	56	12	0,25	7,430	83						
27	--	18	11	12	0,25	7,672	84						
28	--	18	26	12	0,25	7,915	85						
29	--	18	41	12	0,25	8,188	86						
30	--	18	56	12	0,25	8,460	87						
31	--	19	11	12	0,25	8,718	88						
32	--	19	26	12	0,25	8,978	89						
33	--	19	41	12	0,25	9,248	90						
34	--	19	56	12	0,25	9,534	91						
35	--	20	11	12	0,25	9,812	92						
36	--	20	26	12	0,25	10,112	93						
37	--	20	41	12	0,25	10,405	94						
38	--	20	56	12	0,25	10,781	95						
39	--	21	11	12	0,25	11,051	96						
40	--	21	26	12	0,25	11,385	97						
41	--	21	41	12	0,25	11,722	98						
42	--	21	56	12	0,25	12,072	99						
43	--	22	11	12	0,25	12,450	100						
44	--	22	26	12	0,25	12,825	101						
45	--	22	41	12	0,25	13,280	102						
46	--	22	56	12	0,25	13,721	103						
47	--	23	11	12	0,25	14,235	104						
48	--	23	26	12	0,25	14,838	105						
49	--	23	41	12	0,25	15,578	106						
50	Fracture	23	49	35	0,25	16,660	107						
51	--						108						
52	--						109						
53	--						110						
54	--						111						
55	--						112						
56	--						113						
57	--						114						
TOTAL DURATION CREEP & LENGTH					8,0015	16,660	TOTAL DURATION CREEP & LENGTH					--	--
TOTAL TIME CREEP-RUPTURE (HOURS)												11,8484	

DATA ACTUAL ANALYSIS TABLE

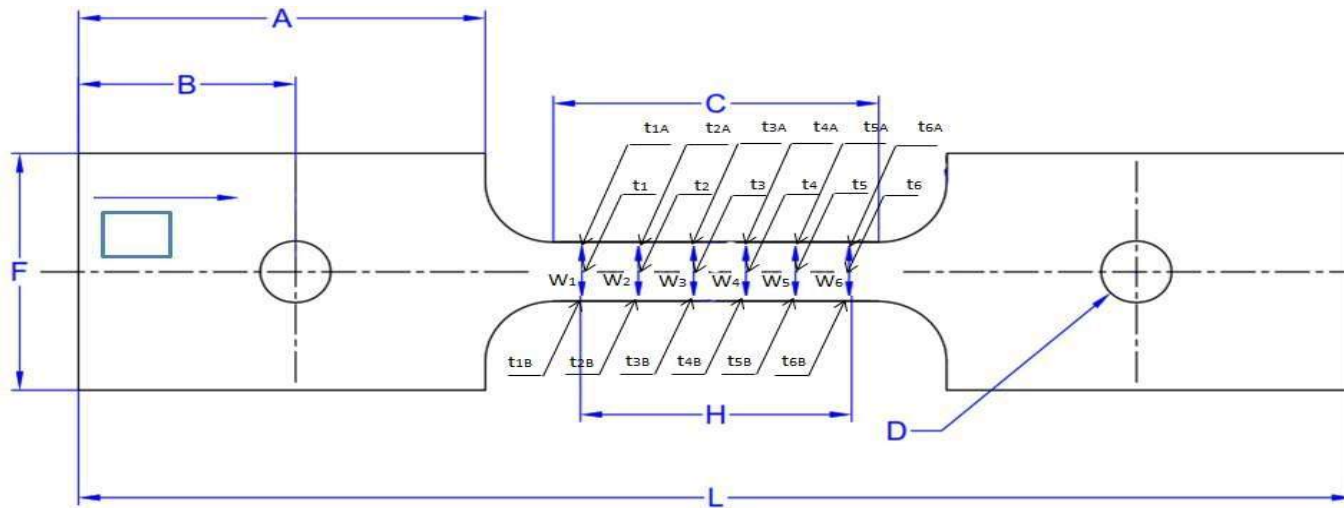
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58					
2	0,010	0,010	50,0	0,0002	0,020	59					
3	0,252	0,242	50,252	0,0050	0,504	60					
4	0,845	0,593	50,845	0,0169	1,690	61					
5	1,335	0,490	51,335	0,0267	2,670	62					
6	1,538	0,203	51,538	0,0308	3,076	63					
7	1,752	0,214	51,752	0,0350	3,504	64					
8	1,900	0,148	51,900	0,0380	3,800	65					
9	1,956	0,056	51,956	0,0391	3,912	66					
10	1,982	0,026	51,982	0,0396	3,964	67					
11	1,999	0,017	51,999	0,0400	3,998	68					
12	2,007	0,008	52,007	0,0401	4,014	69					
13	2,008	0,001	52,008	0,0402	4,016	70					
14	2,012	0,004	52,012	0,0402	4,024	71					
15	2,015	0,003	52,015	0,0403	4,030	72					
16	2,021	0,006	52,021	0,0404	4,042	73					
17	2,055	0,034	52,055	0,0411	4,110	74					
18	4,695	2,640	54,695	0,0939	9,390	75					
19	5,382	0,687	55,382	0,1076	10,764	76					
20	5,742	0,360	55,742	0,1148	11,484	77					
21	6,046	0,304	56,046	0,1209	12,092	78					
22	6,338	0,292	56,338	0,1268	12,676	79					
23	6,615	0,277	56,615	0,1323	13,230	80					
24	6,884	0,269	56,884	0,1377	13,768	81					
25	7,168	0,284	57,168	0,1434	14,336	82					
26	7,430	0,262	57,430	0,1486	14,860	83					
27	7,672	0,242	57,672	0,1534	15,344	84					
28	7,915	0,243	57,915	0,1583	15,830	85					
29	8,188	0,273	58,188	0,1638	16,376	86					
30	8,460	0,272	58,460	0,1692	16,920	87					
31	8,718	0,258	58,718	0,1744	17,436	88					
32	8,978	0,260	58,978	0,1796	17,956	89					
33	9,248	0,270	59,248	0,1850	18,496	90					
34	9,534	0,286	59,534	0,1907	19,068	91					
35	9,812	0,278	59,812	0,1962	19,624	92					
36	10,112	0,300	60,112	0,2022	20,224	93					
37	10,405	0,293	60,405	0,2081	20,810	94					
38	10,781	0,376	60,781	0,2156	21,562	95					
39	11,051	0,270	61,051	0,2210	22,102	96					
40	11,385	0,334	61,385	0,2277	22,770	97					
41	11,722	0,337	61,722	0,2344	23,444	98					
42	12,072	0,350	62,072	0,2414	24,144	99					
43	12,450	0,378	62,450	0,2490	24,900	100					
44	12,825	0,375	62,825	0,2565	25,650	101					
45	13,280	0,455	63,280	0,2656	26,560	102					
46	13,721	0,441	63,721	0,2744	27,442	103					
47	14,235	0,514	64,235	0,2847	28,470	104					
48	14,838	0,603	64,838	0,2968	29,676	105					
49	15,578	0,740	65,578	0,3116	31,156	106					
50	16,660	1,082	66,660	0,3332	33,320	107					
51						108					
52						109					
53						110					
54						111					
55						112					
56						113					
57						114					

DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58					
2	2,640	2,640	52,6	0,0528	5,280	59					
3	3,327	0,687	53,327	0,0665	6,654	60					
4	3,687	0,360	53,687	0,0737	7,374	61					
5	3,991	0,304	53,991	0,0798	7,982	62					
6	4,283	0,292	54,283	0,0857	8,566	63					
7	4,560	0,277	54,560	0,0912	9,120	64					
8	4,829	0,269	54,829	0,0966	9,658	65					
9	5,113	0,284	55,113	0,1023	10,226	66					
10	5,375	0,262	55,375	0,1075	10,750	67					
11	5,617	0,242	55,617	0,1123	11,234	68					
12	5,860	0,243	55,860	0,1172	11,720	69					
13	6,133	0,273	56,133	0,1227	12,266	70					
14	6,405	0,272	56,405	0,1281	12,810	71					
15	6,663	0,258	56,663	0,1333	13,326	72					
16	6,923	0,260	56,923	0,1385	13,846	73					
17	7,193	0,270	57,193	0,1439	14,386	74					
18	7,479	0,286	57,479	0,1496	14,958	75					
19	7,757	0,278	57,757	0,1551	15,514	76					
20	8,057	0,300	58,057	0,1611	16,114	77					
21	8,350	0,293	58,350	0,1670	16,700	78					
22	8,726	0,376	58,726	0,1745	17,452	79					
23	8,996	0,270	58,996	0,1799	17,992	80					
24	9,330	0,334	59,330	0,1866	18,660	81					
25	9,667	0,337	59,667	0,1933	19,334	82					
26	10,017	0,350	60,017	0,2003	20,034	83					
27	10,395	0,378	60,395	0,2079	20,790	84					
28	10,770	0,375	60,770	0,2154	21,540	85					
29	11,225	0,455	61,225	0,2245	22,450	86					
30	11,666	0,441	61,666	0,2333	23,332	87					
31	12,180	0,514	62,180	0,2436	24,360	88					
32	12,783	0,603	62,783	0,2557	25,566	89					
33	13,523	0,740	63,523	0,2705	27,046	90					
34	14,605	1,082	64,605	0,2921	29,210	91					
35						92					
36						93					
37						94					
38						95					
39						96					
40						97					
41						98					
42						99					
43						100					
44						101					
45						102					
46						103					
47						104					
48						105					
49						106					
50						107					
51						108					
52						109					
53						110					
54						111					
55						112					
56						113					
57						114					

CALCULATION DATA GRAPH								
$\sigma = 154,29 \text{ MPa}; 538 \text{ }^\circ\text{C}$								
No.	Time (Hours)	Strain	No.	Time (Hours)	Strain	No.	Time (Hours)	Strain
1	0,0	0,0	58			115		
2	0,0015	0,0528	59			116		
3	0,2515	0,0665	60			117		
4	0,5015	0,0737	61			118		
5	0,7515	0,0798	62			119		
6	1,0015	0,0857	63			120		
7	1,2515	0,0912	64			121		
8	1,5015	0,0966	65			122		
9	1,7515	0,1023	66			123		
10	2,0015	0,1075	67			124		
11	2,2515	0,1123	68			125		
12	2,5015	0,1172	69			126		
13	2,7515	0,1227	70			127		
14	3,0015	0,1281	71			128		
15	3,2515	0,1333	72			129		
16	3,5015	0,1385	73			130		
17	3,7515	0,1439	74			131		
18	4,0015	0,1496	75			132		
19	4,2515	0,1551	76			133		
20	4,5015	0,1611	77			134		
21	4,7515	0,1670	78			135		
22	5,0015	0,1745	79			136		
23	5,2515	0,1799	80			137		
24	5,5015	0,1866	81			138		
25	5,7515	0,1933	82			139		
26	6,0015	0,2003	83			140		
27	6,2515	0,2079	84			141		
28	6,5015	0,2154	85			142		
29	6,7515	0,2245	86			143		
30	7,0015	0,2333	87			144		
31	7,2515	0,2436	88			145		
32	7,5015	0,2557	89			146		
33	7,7515	0,2705	90			147		
34	8,0015	0,2921	91			148		
35			92			149		
36			93			150		
37			94			151		
38			95			152		
39			96			153		
40			97			154		
41			98			155		
42			99			156		
43			100			157		
44			101			158		
45			102			159		
46			103			160		
47			104			161		
48			105			162		
49			106			163		
50			107			164		
51			108			165		
52			109			166		
53			110			167		
54			111			168		
55			112			169		
56			113			170		
57			114			171		

H.22 Tabel data hasil pengujian *creep-rupture* spesimen uji 2F.

<i>Material/Specimen</i>		SA-210 A1 -- 2F
<i>Machine</i>		BCTM
<i>Mass/test load</i>		115,93 kgs
<i>Temperature Set</i>		538 °C
<i>Start to Temperature</i>	<i>Time</i>	09.20 WITA
	<i>Date</i>	02/09/2021
<i>Finish at Temperature</i>	<i>Expansion</i>	1,898 mm
	<i>Time</i>	11.05 WITA
	<i>Date</i>	02/09/2021
	<i>Duration</i>	1 Hour 45 Min
<i>Duration (Heating Homogen)</i>		3 Hours
<i>Start loading</i>	<i>Time</i>	13.57 WITA
	<i>Date</i>	02/09/2021
	<i>Expansion</i>	2,141 mm
<i>Instantaneous Deformation (ID)</i>		4,720 mm
<i>Break/Fracture</i>	<i>Time</i>	04.12 WITA
	<i>Date</i>	03/09/2021
	<i>Duration (Predict. Fracture)</i>	5,33 Hrs -- 15,03 Hrs
	<i>Duration (actual Fracture)</i>	14 Hour 22 Min (14,37 Hours)
	<i>Length at Fracture (Dial)</i>	72,31 mm
	<i>Final Length (Ambient)</i>	67,2 mm
	<i>Area Fracture (W x t)</i>	7,6 x 1,25 mm
	<i>Reduction in Area (RA)</i>	64,77 %
	<i>Creep Strain Rate</i>	1,24E-02 h ⁻¹



MATERIAL :			SA-210 A1			SPECIMEN :		2F											
A (mm)	B (mm)	C (mm)	D (mm)	F (mm)	H (mm)	L (mm)	Width/W (mm)		Thickness/t (mm)						Hardness/H (BHN)		Applied For Test (mm ²)		
75	40	85	13	50	50	234,5	W1:	12,55	t1:	2,26	t1A:	2,25	t1B:	2,25	t1AVE:	2,25	H1:	123	28,3630
							W2:	12,35	t2:	2,22	t2A:	2,20	t2B:	2,15	t2AVE:	2,19	H2:	137	27,4170
							W3:	12,35	t3:	2,20	t3A:	2,15	t3B:	2,20	t3AVE:	2,18	H3:	104	27,1700
							W4:	12,35	t4:	2,21	t4A:	2,20	t4B:	2,30	t4AVE:	2,24	H4:	105	27,2935
							W5:	12,45	t5:	2,34	t5A:	2,45	t5B:	2,40	t5AVE:	2,40	H5:	98	29,1330
							W6:	12,70	t6:	2,41	t6A:	2,45	t6B:	2,45	t6AVE:	2,44	H6:	114	30,6070
							WAVE:	12,46	tMIN:	2,20	tMIN:	2,15	tMIN:	2,15	tAVEtot:	2,28	HAVE:	113,50	Amin.
							WMIN:	12,35	Selected		N/A			tMIN:	2,18	HMIN:	98	27,1700	

CREEP-RUPTURE DATA														
MATERIAL			SA-210 A1			SPECIMEN		2F		THICKNESS			Minimum (mm)	2,18
TEMPERATURE			538 °C			LOAD/MASS		115,93 kgs					Average (mm)	2,28
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)	
		Hour	Min.	Sec.					Hour	Min.	Sec.			
1	02/09/2021	09	19	36	0,0	0,0	58	--	23	57	24	0,25	10,612	
2	Start Temp.	09	44	36	0,25	0,560	59	03/09/2021	00	12	24	0,25	10,885	
3	--	10	09	36	0,25	1,258	60	--	00	27	24	0,25	11,172	
4	--	10	34	36	0,25	1,664	61	--	00	42	24	0,25	11,481	
5	--	10	59	36	0,25	1,862	62	--	00	57	24	0,25	11,801	
6	Finish Temp.	11	05	20	0,0955	1,898	63	--	01	12	24	0,25	12,128	
7	--	11	20	20	0,25	1,972	64	--	01	27	24	0,25	12,486	
8	--	11	35	20	0,25	2,008	65	--	01	42	24	0,25	12,855	
9	--	11	50	20	0,25	2,028	66	--	01	57	24	0,25	13,244	
10	--	12	05	20	0,25	2,045	67	--	02	12	24	0,25	13,651	
11	--	12	20	20	0,25	2,058	68	--	02	27	24	0,25	14,114	
12	--	12	35	20	0,25	2,068	69	--	02	42	24	0,25	14,595	
13	--	12	50	20	0,25	2,084	70	--	02	57	24	0,25	15,138	
14	--	13	05	20	0,25	2,099	71	--	03	12	24	0,25	15,746	
15	--	13	20	20	0,25	2,111	72	--	03	27	24	0,25	16,440	
16	--	13	35	20	0,25	2,126	73	--	03	42	24	0,25	17,305	
17	Finish Heat.	13	50	20	0,25	2,141	74	--	03	57	24	0,25	18,474	
18	Start Load	13	57	24	0,1177	4,720	75	Fracture	04	12	13	0,25	22,310	
19	--	14	12	24	0,25	4,935	76							
20	--	14	27	24	0,25	5,019	77							
21	--	14	42	24	0,25	5,072	78							
22	--	14	57	24	0,25	5,132	79							
23	--	15	12	24	0,25	5,192	80							
24	--	15	27	24	0,25	5,255	81							
25	--	15	42	24	0,25	5,317	82							
26	--	15	57	24	0,25	5,392	83							
27	--	16	12	24	0,25	5,464	84							
28	--	16	27	24	0,25	5,527	85							
29	--	16	42	24	0,25	5,605	86							
30	--	16	57	24	0,25	5,680	87							
31	--	17	12	24	0,25	5,767	88							
32	--	17	27	24	0,25	5,868	89							
33	--	17	42	24	0,25	5,968	90							
34	--	17	57	24	0,25	6,074	91							
35	--	18	12	24	0,25	6,185	92							
36	--	18	27	24	0,25	6,302	93							
37	--	18	42	24	0,25	6,425	94							
38	--	18	57	24	0,25	6,565	95							
39	--	19	12	24	0,25	6,698	96							
40	--	19	27	24	0,25	6,842	97							
41	--	19	42	24	0,25	6,998	98							
42	--	19	57	24	0,25	7,156	99							
43	--	20	12	24	0,25	7,325	100							
44	--	20	27	24	0,25	7,498	101							
45	--	20	42	24	0,25	7,674	102							
46	--	20	57	24	0,25	7,868	103							
47	--	21	12	24	0,25	8,051	104							
48	--	21	27	24	0,25	8,255	105							
49	--	21	42	24	0,25	8,458	106							
50	--	21	57	24	0,25	8,664	107							
51	--	22	12	24	0,25	8,888	108							
52	--	22	27	24	0,25	9,108	109							
53	--	22	42	24	0,25	9,345	110							
54	--	22	57	24	0,25	9,574	111							
55	--	23	12	24	0,25	9,820	112							
56	--	23	27	24	0,25	10,070	113							
57	--	23	42	24	0,25	10,329	114							
TOTAL DURATION CREEP & LENGTH					9,8677	10,329	TOTAL DURATION CREEP & LENGTH					14,3677	22,310	
TOTAL TIME CREEP-RUPTURE (HOURS)												18,2132		

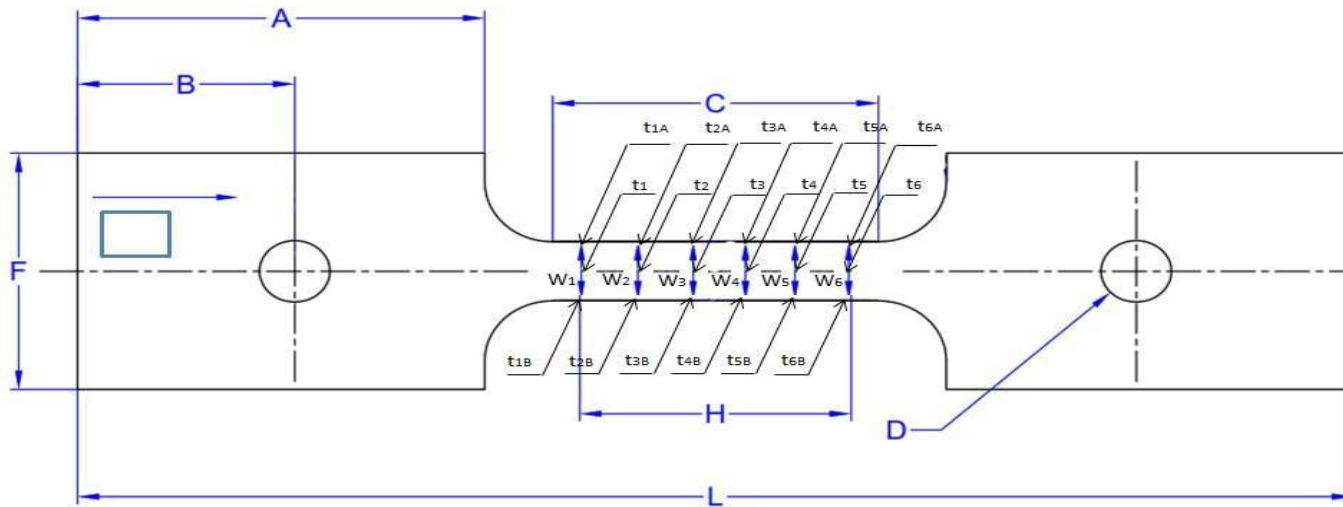
DATA ACTUAL ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58	10,612	0,283	60,612	0,2122	21,224
2	0,560	0,560	50,6	0,0112	1,120	59	10,885	0,273	60,885	0,2177	21,770
3	1,258	0,698	51,3	0,0252	2,516	60	11,172	0,287	61,172	0,2234	22,344
4	1,664	0,406	51,7	0,0333	3,328	61	11,481	0,309	61,481	0,2296	22,962
5	1,862	0,198	51,9	0,0372	3,724	62	11,801	0,320	61,801	0,2360	23,602
6	1,898	0,036	51,9	0,0380	3,796	63	12,128	0,327	62,128	0,2426	24,256
7	1,972	0,074	52,0	0,0394	3,944	64	12,486	0,358	62,486	0,2497	24,972
8	2,008	0,036	52,0	0,0402	4,016	65	12,855	0,369	62,855	0,2571	25,710
9	2,028	0,020	52,0	0,0406	4,056	66	13,244	0,389	63,244	0,2649	26,488
10	2,045	0,017	52,0	0,0409	4,090	67	13,651	0,407	63,651	0,2730	27,302
11	2,058	0,013	52,1	0,0412	4,116	68	14,114	0,463	64,114	0,2823	28,228
12	2,068	0,010	52,1	0,0414	4,136	69	14,595	0,481	64,595	0,2919	29,190
13	2,084	0,016	52,1	0,0417	4,168	70	15,138	0,543	65,138	0,3028	30,276
14	2,099	0,015	52,1	0,0420	4,198	71	15,746	0,608	65,746	0,3149	31,492
15	2,111	0,012	52,1	0,0422	4,222	72	16,440	0,694	66,440	0,3288	32,880
16	2,126	0,015	52,1	0,0425	4,252	73	17,305	0,865	67,305	0,3461	34,610
17	2,141	0,015	52,1	0,0428	4,282	74	18,474	1,169	68,474	0,3695	36,948
18	4,720	2,579	54,7	0,0944	9,440	75	22,310	3,836	72,310	0,4462	44,620
19	4,935	0,215	54,9	0,0987	9,870	76					
20	5,019	0,084	55,0	0,1004	10,038	77					
21	5,072	0,053	55,1	0,1014	10,144	78					
22	5,132	0,060	55,1	0,1026	10,264	79					
23	5,192	0,060	55,2	0,1038	10,384	80					
24	5,255	0,063	55,3	0,1051	10,510	81					
25	5,317	0,062	55,3	0,1063	10,634	82					
26	5,392	0,075	55,4	0,1078	10,784	83					
27	5,464	0,072	55,5	0,1093	10,928	84					
28	5,527	0,063	55,5	0,1105	11,054	85					
29	5,605	0,078	55,6	0,1121	11,210	86					
30	5,680	0,075	55,7	0,1136	11,360	87					
31	5,767	0,087	55,8	0,1153	11,534	88					
32	5,868	0,101	55,9	0,1174	11,736	89					
33	5,968	0,100	56,0	0,1194	11,936	90					
34	6,074	0,106	56,1	0,1215	12,148	91					
35	6,185	0,111	56,2	0,1237	12,370	92					
36	6,302	0,117	56,3	0,1260	12,604	93					
37	6,425	0,123	56,4	0,1285	12,850	94					
38	6,565	0,140	56,6	0,1313	13,130	95					
39	6,698	0,133	56,7	0,1340	13,396	96					
40	6,842	0,144	56,8	0,1368	13,684	97					
41	6,998	0,156	57,0	0,1400	13,996	98					
42	7,156	0,158	57,2	0,1431	14,312	99					
43	7,325	0,169	57,3	0,1465	14,650	100					
44	7,498	0,173	57,5	0,1500	14,996	101					
45	7,674	0,176	57,7	0,1535	15,348	102					
46	7,868	0,194	57,9	0,1574	15,736	103					
47	8,051	0,183	58,1	0,1610	16,102	104					
48	8,255	0,204	58,3	0,1651	16,510	105					
49	8,458	0,203	58,5	0,1692	16,916	106					
50	8,664	0,206	58,7	0,1733	17,328	107					
51	8,888	0,224	58,9	0,1778	17,776	108					
52	9,108	0,220	59,1	0,1822	18,216	109					
53	9,345	0,237	59,3	0,1869	18,690	110					
54	9,574	0,229	59,6	0,1915	19,148	111					
55	9,820	0,246	59,8	0,1964	19,640	112					
56	10,070	0,250	60,1	0,2014	20,140	113					
57	10,329	0,259	60,3	0,2066	20,658	114					

DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff Length (mm)	Length/l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58	16,333	1,169	66,333	0,3267	32,666
2	2,579	2,579	52,6	0,0516	5,158	59	20,169	3,836	70,169	0,4034	40,338
3	2,794	0,215	52,8	0,0559	5,588	60					
4	2,878	0,084	52,9	0,0576	5,756	61					
5	2,931	0,053	52,9	0,0586	5,862	62					
6	2,991	0,060	53,0	0,0598	5,982	63					
7	3,051	0,060	53,1	0,0610	6,102	64					
8	3,114	0,063	53,1	0,0623	6,228	65					
9	3,176	0,062	53,2	0,0635	6,352	66					
10	3,251	0,075	53,3	0,0650	6,502	67					
11	3,323	0,072	53,3	0,0665	6,646	68					
12	3,386	0,063	53,4	0,0677	6,772	69					
13	3,464	0,078	53,5	0,0693	6,928	70					
14	3,539	0,075	53,5	0,0708	7,078	71					
15	3,626	0,087	53,6	0,0725	7,252	72					
16	3,727	0,101	53,7	0,0745	7,454	73					
17	3,827	0,100	53,8	0,0765	7,654	74					
18	3,933	0,106	53,9	0,0787	7,866	75					
19	4,044	0,111	54,0	0,0809	8,088	76					
20	4,161	0,117	54,2	0,0832	8,322	77					
21	4,284	0,123	54,3	0,0857	8,568	78					
22	4,424	0,140	54,4	0,0885	8,848	79					
23	4,557	0,133	54,6	0,0911	9,114	80					
24	4,701	0,144	54,7	0,0940	9,402	81					
25	4,857	0,156	54,9	0,0971	9,714	82					
26	5,015	0,158	55,0	0,1003	10,030	83					
27	5,184	0,169	55,2	0,1037	10,368	84					
28	5,357	0,173	55,4	0,1071	10,714	85					
29	5,533	0,176	55,5	0,1107	11,066	86					
30	5,727	0,194	55,7	0,1145	11,454	87					
31	5,910	0,183	55,9	0,1182	11,820	88					
32	6,114	0,204	56,1	0,1223	12,228	89					
33	6,317	0,203	56,3	0,1263	12,634	90					
34	6,523	0,206	56,5	0,1305	13,046	91					
35	6,747	0,224	56,7	0,1349	13,494	92					
36	6,967	0,220	57,0	0,1393	13,934	93					
37	7,204	0,237	57,2	0,1441	14,408	94					
38	7,433	0,229	57,4	0,1487	14,866	95					
39	7,679	0,246	57,7	0,1536	15,358	96					
40	7,929	0,250	57,9	0,1586	15,858	97					
41	8,188	0,259	58,2	0,1638	16,376	98					
42	8,471	0,283	58,471	0,1694	16,942	99					
43	8,744	0,273	58,744	0,1749	17,488	100					
44	9,031	0,287	59,031	0,1806	18,062	101					
45	9,340	0,309	59,340	0,1868	18,680	102					
46	9,660	0,320	59,660	0,1932	19,320	103					
47	9,987	0,327	59,987	0,1997	19,974	104					
48	10,345	0,358	60,345	0,2069	20,690	105					
49	10,714	0,369	60,714	0,2143	21,428	106					
50	11,103	0,389	61,103	0,2221	22,206	107					
51	11,510	0,407	61,510	0,2302	23,020	108					
52	11,973	0,463	61,973	0,2395	23,946	109					
53	12,454	0,481	62,454	0,2491	24,908	110					
54	12,997	0,543	62,997	0,2599	25,994	111					
55	13,605	0,608	63,605	0,2721	27,210	112					
56	14,299	0,694	64,299	0,2860	28,598	113					
57	15,164	0,865	65,164	0,3033	30,328	114					

CALCULATION DATA GRAPH								
$\sigma = 155,70 \text{ MPa}; \text{Temp. } 538 \text{ } ^\circ \text{C}$								
No.	Time (Hours)	Strain	No.	Time (Hours)	Strain	No.	Time (Hours)	Strain
1	0,0	0,0	58	14,118	0,327	115		
2	0,118	0,052	59	14,368	0,403	116		
3	0,368	0,056	60			117		
4	0,618	0,058	61			118		
5	0,868	0,059	62			119		
6	1,118	0,060	63			120		
7	1,368	0,061	64			121		
8	1,618	0,062	65			122		
9	1,868	0,064	66			123		
10	2,118	0,065	67			124		
11	2,368	0,066	68			125		
12	2,618	0,068	69			126		
13	2,868	0,069	70			127		
14	3,118	0,071	71			128		
15	3,368	0,073	72			129		
16	3,618	0,075	73			130		
17	3,868	0,077	74			131		
18	4,118	0,079	75			132		
19	4,368	0,081	76			133		
20	4,618	0,083	77			134		
21	4,868	0,086	78			135		
22	5,118	0,088	79			136		
23	5,368	0,091	80			137		
24	5,618	0,094	81			138		
25	5,868	0,097	82			139		
26	6,118	0,100	83			140		
27	6,368	0,104	84			141		
28	6,618	0,107	85			142		
29	6,868	0,111	86			143		
30	7,118	0,115	87			144		
31	7,368	0,118	88			145		
32	7,618	0,122	89			146		
33	7,868	0,126	90			147		
34	8,118	0,130	91			148		
35	8,368	0,135	92			149		
36	8,618	0,139	93			150		
37	8,868	0,144	94			151		
38	9,118	0,149	95			152		
39	9,368	0,154	96			153		
40	9,618	0,159	97			154		
41	9,868	0,164	98			155		
42	10,118	0,169	99			156		
43	10,368	0,175	100			157		
44	10,618	0,181	101			158		
45	10,868	0,187	102			159		
46	11,118	0,193	103			160		
47	11,368	0,200	104			161		
48	11,618	0,207	105			162		
49	11,868	0,214	106			163		
50	12,118	0,222	107			164		
51	12,368	0,230	108			165		
52	12,618	0,239	109			166		
53	12,868	0,249	110			167		
54	13,118	0,260	111			168		
55	13,368	0,272	112			169		
56	13,618	0,286	113			170		
57	13,868	0,303	114			171		

H.23 Tabel data hasil pengujian *creep-rupture* spesimen uji 3C.

<i>Material/Specimen</i>		SA-210 A1 -- 3C
<i>Machine</i>		BCTM
<i>Mass/test load</i>		108,26 kgs
<i>Temperature Set</i>		538 °C
<i>Start to Temperature</i>	<i>Time</i>	18.35 WITA
	<i>Date</i>	06/09/2021
<i>Finish at Temperature</i>	<i>Expansion</i>	1,916 mm
	<i>Time</i>	20.15 WITA
	<i>Date</i>	06/09/2021
	<i>Duration</i>	1 Hour 40 Min
<i>Duration (Heating Homogen)</i>		3 Hours
<i>Start loading</i>	<i>Time</i>	23.19 WITA
	<i>Date</i>	06/09/2021
	<i>Expansion</i>	2,035 mm
<i>Instantaneous Deformation (ID)</i>		4,334 mm
<i>Break/Fracture</i>	<i>Time</i>	23.02 WITA
	<i>Date</i>	11/09/2021
	<i>Duration (Predict. Fracture)</i>	44,26 Hrs -- 124,73 Hrs
	<i>Duration (actual Fracture)</i>	119 Hour 47 Min (119,78 Hours)
	<i>Length at Fracture (Dial)</i>	78,06 mm
	<i>Final Length (Ambient)</i>	71,30 mm
	<i>Area Fracture (W x t)</i>	8,25 x 1,85 mm
	<i>Reduction in Area (RA)</i>	58,47 %
	<i>Creep Strain Rate</i>	2,45E-03 h ⁻¹



MATERIAL :			SA-210 A1			SPECIMEN :		3C								
A (mm)	B (mm)	C (mm)	D (mm)	F (mm)	H (mm)	L (mm)	Width/W (mm)	Thickness/t (mm)						Hardness/H (BHN)		Applied For Test (mm ²)
75	40	85	13	50	50	234,5	W1: 12,50	t1: 3,05	t1A: 3,05	t1B: 3,05	t1AVE: 3,05	H1: 116	38,1250			
							W2: 12,45	t2: 3,09	t2A: 3,10	t2B: 3,10	t2AVE: 3,10	H2: 128	38,4705			
							W3: 12,45	t3: 3,06	t3A: 3,10	t3B: 3,00	t3AVE: 3,05	H3: 131	38,0970			
							W4: 12,50	t4: 2,82	t4A: 3,05	t4B: 2,95	t4AVE: 2,94	H4: 98	35,2500			
							W5: 12,50	t5: 2,90	t5A: 3,10	t5B: 3,05	t5AVE: 3,02	H5: 102	36,2500			
							W6: 12,70	t6: 3,03	t6A: 3,05	t6B: 3,05	t6AVE: 3,04	H6: 138	38,4810			
							WAVE: 12,52	tMIN: 2,82	tMIN: 3,05	tMIN: 2,95	tAVEtot: 3,03	HAVE: 118,83	Amin.			
							WMIN: 12,45	Selected		N/A		tMIN: 2,94	HMIN: 98	35,2500		

CREEP-RUPTURE DATA														
MATERIAL		SA-210 A1			SPECIMEN		3C		THICKNESS			Minimum (mm)		2,94
TEMPERATURE		538 °C			LOAD/MASS		108,26 kgs					Average (mm)		3,03
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)	
		Hour	Min.	Sec.					Hour	Min.	Sec.			
1	06/09/2021	18	35	27	0	0,0	58	--	02	19	54	1	9,614	
2	Start Temp.	19	35	27	1	1,428	59	--	03	19	54	1	9,715	
3	Finish Temp.	20	15	10	0,662	1,916	60	--	04	19	54	1	9,842	
4	--	21	15	10	1	2,001	61	--	05	19	54	1	9,962	
5	--	22	15	10	1	2,019	62	--	06	19	54	1	10,072	
6	Finish Heat.	23	15	10	1	2,035	63	--	07	19	54	1	10,188	
7	Start Load	23	19	54	0,0791	4,334	64	--	08	19	54	1	10,339	
8	07/09/2021	00	19	54	1	4,559	65	--	09	19	54	1	10,478	
9	--	01	19	54	1	4,645	66	--	10	19	54	1	10,611	
10	--	02	19	54	1	4,727	67	--	11	19	54	1	10,712	
11	--	03	19	54	1	4,812	68	--	12	19	54	1	10,850	
12	--	04	19	54	1	4,874	69	--	13	19	54	1	10,960	
13	--	05	19	54	1	4,945	70	--	14	19	54	1	11,095	
14	--	06	19	54	1	5,012	71	--	15	19	54	1	11,228	
15	--	07	19	54	1	5,096	72	--	16	19	54	1	11,374	
16	--	08	19	54	1	5,189	73	--	17	19	54	1	11,494	
17	--	09	19	54	1	5,285	74	--	18	19	54	1	11,654	
18	--	10	19	54	1	5,374	75	--	19	19	54	1	11,810	
19	--	11	19	54	1	5,478	76	--	20	19	54	1	11,955	
20	--	12	19	54	1	5,564	77	--	21	19	54	1	12,095	
21	--	13	19	54	1	5,646	78	--	22	19	54	1	12,235	
22	--	14	19	54	1	5,752	79	--	23	19	54	1	12,415	
23	--	15	19	54	1	5,844	80	10/09/2021	00	19	54	1	12,547	
24	--	16	19	54	1	5,958	81	--	01	19	54	1	12,698	
25	--	17	19	54	1	6,070	82	--	02	19	54	1	12,861	
26	--	18	19	54	1	6,154	83	--	03	19	54	1	13,020	
27	--	19	19	54	1	6,255	84	--	04	19	54	1	13,165	
28	--	20	19	54	1	6,352	85	--	05	19	54	1	13,324	
29	--	21	19	54	1	6,450	86	--	06	19	54	1	13,481	
30	--	22	19	54	1	6,549	87	--	07	19	54	1	13,645	
31	--	23	19	54	1	6,650	88	--	08	19	54	1	13,814	
32	08/09/2021	00	19	54	1	6,755	89	--	09	19	54	1	13,988	
33	--	01	19	54	1	6,858	90	--	10	19	54	1	14,168	
34	--	02	19	54	1	6,958	91	--	11	19	54	1	14,338	
35	--	03	19	54	1	7,062	92	--	12	19	54	1	14,510	
36	--	04	19	54	1	7,172	93	--	13	19	54	1	14,699	
37	--	05	19	54	1	7,284	94	--	14	19	54	1	14,878	
38	--	06	19	54	1	7,389	95	--	15	19	54	1	15,058	
39	--	07	19	54	1	7,485	96	--	16	19	54	1	15,266	
40	--	08	19	54	1	7,600	97	--	17	19	54	1	15,460	
41	--	09	19	54	1	7,720	98	--	18	19	54	1	15,662	
42	--	10	19	54	1	7,814	99	--	19	19	54	1	15,878	
43	--	11	19	54	1	7,915	100	--	20	19	54	1	16,104	
44	--	12	19	54	1	8,029	101	--	21	19	54	1	16,328	
45	--	13	19	54	1	8,118	102	--	22	19	54	1	16,544	
46	--	14	19	54	1	8,242	103	--	23	19	54	1	16,778	
47	--	15	19	54	1	8,355	104	11/09/2021	00	19	54	1	17,014	
48	--	16	19	54	1	8,458	105	--	01	19	54	1	17,240	
49	--	17	19	54	1	8,562	106	--	02	19	54	1	17,481	
50	--	18	19	54	1	8,694	107	--	03	19	54	1	17,715	
51	--	19	19	54	1	8,802	108	--	04	19	54	1	17,962	
52	--	20	19	54	1	8,920	109	--	05	19	54	1	18,211	
53	--	21	19	54	1	9,025	110	--	06	19	54	1	18,472	
54	--	22	19	54	1	9,142	111	--	07	19	54	1	18,729	
55	--	23	19	54	1	9,254	112	--	08	19	54	1	19,001	
56	09/09/2021	00	19	54	1	9,367	113	--	09	19	54	1	19,315	
57	--	01	19	54	1	9,482	114	--	10	19	54	1	19,612	
TOTAL DURATION CREEP & LENGTH					50,0791	9,482	TOTAL DURATION CREEP & LENGTH					107,0791	19,612	

CREEP-RUPTURE DATA													
MATERIAL		SA-210 A1			SPECIMEN		3C		THICKNESS			Minimum (mm)	2,94
TEMPERATURE		538 °C			LOAD/MASS		108,26 kgs					Average (mm)	3,03
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)
		Hour	Min.	Sec.					Hour	Min.	Sec.		
115	11/09/2021	11	19	54	1	19,948	172						
116	--	12	19	54	1	20,278	173						
117	--	13	19	54	1	20,648	174						
118	--	14	19	54	1	21,032	175						
119	--	15	19	54	1	21,451	176						
120	--	16	19	54	1	21,881	177						
121	--	17	19	54	1	22,388	178						
122	--	18	19	54	1	22,908	179						
123	--	19	19	54	1	23,498	180						
124	--	20	19	54	1	24,145	181						
125	--	21	19	54	1	25,010	182						
126	--	22	19	54	1	26,111	183						
127	Fracture	23	01	58	0,701	28,060	184						
128							185						
129							186						
130							187						
131							188						
132							189						
133							190						
134							191						
135							192						
136							193						
137							194						
138							195						
139							196						
140							197						
141							198						
142							199						
143							200						
144							201						
145							202						
146							203						
147							204						
148							205						
149							206						
150							207						
151							208						
152							209						
153							210						
154							211						
155							212						
156							213						
157							214						
158							215						
159							216						
160							217						
161							218						
162							219						
163							220						
164							221						
165							222						
166							223						
167							224						
168							225						
169							226						
170							227						
171							228						
TOTAL DURATION CREEP & LENGTH					119,7801	28,060	TOTAL DURATION CREEP & LENGTH					--	--
TOTAL TIME CREEP-RUPTURE (HOURS)											124,4421		

DATA ACTUAL ANALYSIS TABLE											
No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58	9,614	0,132	59,614	0,1923	19,228
2	1,428	1,428	51,428	0,0286	2,856	59	9,715	0,101	59,715	0,1943	19,430
3	1,916	0,488	51,916	0,0383	3,832	60	9,842	0,127	59,842	0,1968	19,684
4	2,001	0,085	52,001	0,0400	4,002	61	9,962	0,120	59,962	0,1992	19,924
5	2,019	0,018	52,019	0,0404	4,038	62	10,072	0,110	60,072	0,2014	20,144
6	2,035	0,016	52,035	0,0407	4,070	63	10,188	0,116	60,188	0,2038	20,376
7	4,334	2,299	54,334	0,0867	8,668	64	10,339	0,151	60,339	0,2068	20,678
8	4,559	0,225	54,559	0,0912	9,118	65	10,478	0,139	60,478	0,2096	20,956
9	4,645	0,086	54,645	0,0929	9,290	66	10,611	0,133	60,611	0,2122	21,222
10	4,727	0,082	54,727	0,0945	9,454	67	10,712	0,101	60,712	0,2142	21,424
11	4,812	0,085	54,812	0,0962	9,624	68	10,850	0,138	60,850	0,2170	21,700
12	4,874	0,062	54,874	0,0975	9,748	69	10,960	0,110	60,960	0,2192	21,920
13	4,945	0,071	54,945	0,0989	9,890	70	11,095	0,135	61,095	0,2219	22,190
14	5,012	0,067	55,012	0,1002	10,024	71	11,228	0,133	61,228	0,2246	22,456
15	5,096	0,084	55,096	0,1019	10,192	72	11,374	0,146	61,374	0,2275	22,748
16	5,189	0,093	55,189	0,1038	10,378	73	11,494	0,120	61,494	0,2299	22,988
17	5,285	0,096	55,285	0,1057	10,570	74	11,654	0,160	61,654	0,2331	23,308
18	5,374	0,089	55,374	0,1075	10,748	75	11,810	0,156	61,810	0,2362	23,620
19	5,478	0,104	55,478	0,1096	10,956	76	11,955	0,145	61,955	0,2391	23,910
20	5,564	0,086	55,564	0,1113	11,128	77	12,095	0,140	62,095	0,2419	24,190
21	5,646	0,082	55,646	0,1129	11,292	78	12,235	0,140	62,235	0,2447	24,470
22	5,752	0,106	55,752	0,1150	11,504	79	12,415	0,180	62,415	0,2483	24,830
23	5,844	0,092	55,844	0,1169	11,688	80	12,547	0,132	62,547	0,2509	25,094
24	5,958	0,114	55,958	0,1192	11,916	81	12,698	0,151	62,698	0,2540	25,396
25	6,070	0,112	56,070	0,1214	12,140	82	12,861	0,163	62,861	0,2572	25,722
26	6,154	0,084	56,154	0,1231	12,308	83	13,020	0,159	63,020	0,2604	26,040
27	6,255	0,101	56,255	0,1251	12,510	84	13,165	0,145	63,165	0,2633	26,330
28	6,352	0,097	56,352	0,1270	12,704	85	13,324	0,159	63,324	0,2665	26,648
29	6,450	0,098	56,450	0,1290	12,900	86	13,481	0,157	63,481	0,2696	26,962
30	6,549	0,099	56,549	0,1310	13,098	87	13,645	0,164	63,645	0,2729	27,290
31	6,650	0,101	56,650	0,1330	13,300	88	13,814	0,169	63,814	0,2763	27,628
32	6,755	0,105	56,755	0,1351	13,510	89	13,988	0,174	63,988	0,2798	27,976
33	6,858	0,103	56,858	0,1372	13,716	90	14,168	0,180	64,168	0,2834	28,336
34	6,958	0,100	56,958	0,1392	13,916	91	14,338	0,170	64,338	0,2868	28,676
35	7,062	0,104	57,062	0,1412	14,124	92	14,510	0,172	64,510	0,2902	29,020
36	7,172	0,110	57,172	0,1434	14,344	93	14,699	0,189	64,699	0,2940	29,398
37	7,284	0,112	57,284	0,1457	14,568	94	14,878	0,179	64,878	0,2976	29,756
38	7,389	0,105	57,389	0,1478	14,778	95	15,058	0,180	65,058	0,3012	30,116
39	7,485	0,096	57,485	0,1497	14,970	96	15,266	0,208	65,266	0,3053	30,532
40	7,60	0,115	57,600	0,1520	15,200	97	15,460	0,194	65,460	0,3092	30,920
41	7,720	0,120	57,720	0,1544	15,440	98	15,662	0,202	65,662	0,3132	31,324
42	7,814	0,094	57,814	0,1563	15,628	99	15,878	0,216	65,878	0,3176	31,756
43	7,915	0,101	57,915	0,1583	15,830	100	16,104	0,226	66,104	0,3221	32,208
44	8,029	0,114	58,029	0,1606	16,058	101	16,328	0,224	66,328	0,3266	32,656
45	8,118	0,089	58,118	0,1624	16,236	102	16,544	0,216	66,544	0,3309	33,088
46	8,242	0,124	58,242	0,1648	16,484	103	16,778	0,234	66,778	0,3356	33,556
47	8,355	0,113	58,355	0,1671	16,710	104	17,014	0,236	67,014	0,3403	34,028
48	8,458	0,103	58,458	0,1692	16,916	105	17,240	0,226	67,240	0,3448	34,480
49	8,562	0,104	58,562	0,1712	17,124	106	17,481	0,241	67,481	0,3496	34,962
50	8,694	0,132	58,694	0,1739	17,388	107	17,715	0,234	67,715	0,3543	35,430
51	8,802	0,108	58,802	0,1760	17,604	108	17,962	0,247	67,962	0,3592	35,924
52	8,920	0,118	58,920	0,1784	17,840	109	18,211	0,249	68,211	0,3642	36,422
53	9,025	0,105	59,025	0,1805	18,050	110	18,472	0,261	68,472	0,3694	36,944
54	9,142	0,117	59,142	0,1828	18,284	111	18,729	0,257	68,729	0,3746	37,458
55	9,254	0,112	59,254	0,1851	18,508	112	19,001	0,272	69,001	0,3800	38,002
56	9,367	0,113	59,367	0,1873	18,734	113	19,315	0,314	69,315	0,3863	38,630
57	9,482	0,115	59,482	0,1896	18,964	114	19,612	0,297	69,612	0,3922	39,224

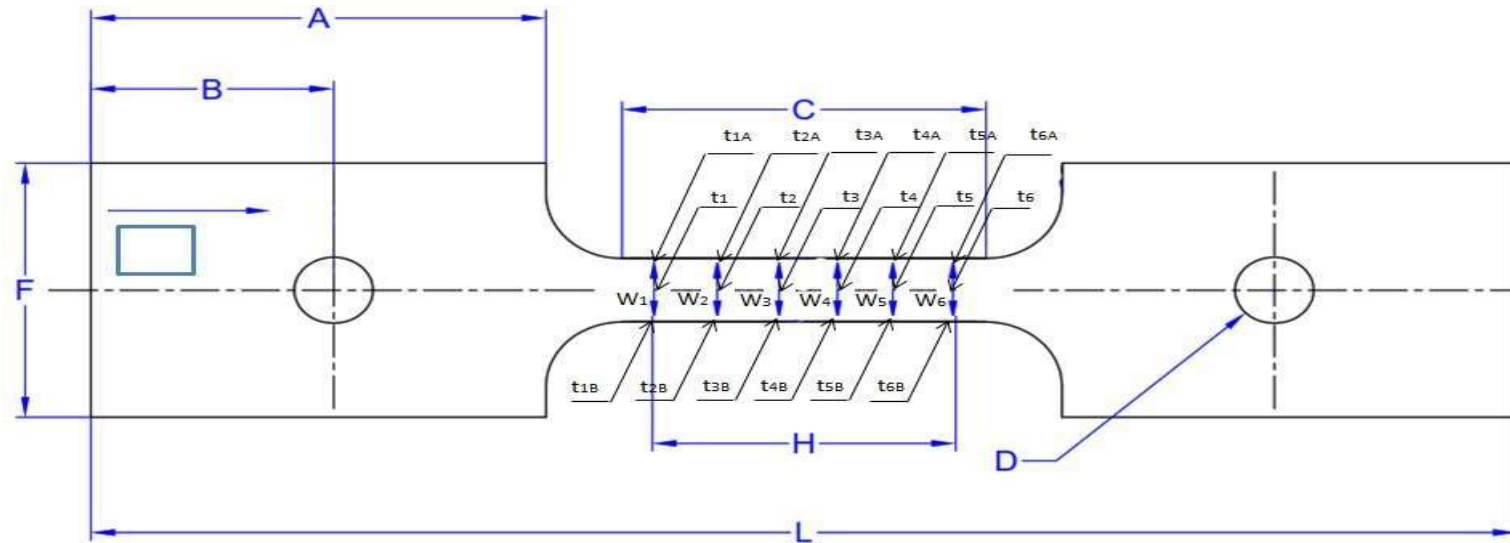
DATA ACTUAL ANALYSIS TABLE											
No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
115	19,948	0,336	69,948	0,3990	39,896	172					
116	20,278	0,330	70,278	0,4056	40,556	173					
117	20,648	0,370	70,648	0,4130	41,296	174					
118	21,032	0,384	71,032	0,4206	42,064	175					
119	21,451	0,419	71,451	0,4290	42,902	176					
120	21,881	0,430	71,881	0,4376	43,762	177					
121	22,388	0,507	72,388	0,4478	44,776	178					
122	22,908	0,520	72,908	0,4582	45,816	179					
123	23,498	0,590	73,498	0,4700	46,996	180					
124	24,145	0,647	74,145	0,4829	48,290	181					
125	25,010	0,865	75,010	0,5002	50,020	182					
126	26,111	1,101	76,111	0,5222	52,222	183					
127	28,060	1,949	78,060	0,5612	56,120	184					
128						185					
129						186					
130						187					
131						188					
132						189					
133						190					
134						191					
135						192					
136						193					
137						194					
138						195					
139						196					
140						197					
141						198					
142						199					
143						200					
144						201					
145						202					
146						203					
147						204					
148						205					
149						206					
150						207					
151						208					
152						209					
153						210					
154						211					
155						212					
156						213					
157						214					
158						215					
159						216					
160						217					
161						218					
162						219					
163						220					
164						221					
165						222					
166						223					
167						224					
168						225					
169						226					
170						227					
171						228					

DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58	8,153	0,116	58,153	0,1631	16,306
2	2,299	2,299	52,299	0,0460	4,598	59	8,304	0,151	58,304	0,1661	16,608
3	2,524	0,225	52,524	0,0505	5,048	60	8,443	0,139	58,443	0,1689	16,886
4	2,610	0,086	52,610	0,0522	5,220	61	8,576	0,133	58,576	0,1715	17,152
5	2,692	0,082	52,692	0,0538	5,384	62	8,677	0,101	58,677	0,1735	17,354
6	2,777	0,085	52,777	0,0555	5,554	63	8,815	0,138	58,815	0,1763	17,630
7	2,839	0,062	52,839	0,0568	5,678	64	8,925	0,110	58,925	0,1785	17,850
8	2,910	0,071	52,910	0,0582	5,820	65	9,060	0,135	59,060	0,1812	18,120
9	2,977	0,067	52,977	0,0595	5,954	66	9,193	0,133	59,193	0,1839	18,386
10	3,061	0,084	53,061	0,0612	6,122	67	9,339	0,146	59,339	0,1868	18,678
11	3,154	0,093	53,154	0,0631	6,308	68	9,459	0,120	59,459	0,1892	18,918
12	3,250	0,096	53,250	0,0650	6,500	69	9,619	0,160	59,619	0,1924	19,238
13	3,339	0,089	53,339	0,0668	6,678	70	9,775	0,156	59,775	0,1955	19,550
14	3,443	0,104	53,443	0,0689	6,886	71	9,920	0,145	59,920	0,1984	19,840
15	3,529	0,086	53,529	0,0706	7,058	72	10,060	0,140	60,060	0,2012	20,120
16	3,611	0,082	53,611	0,0722	7,222	73	10,200	0,140	60,200	0,2040	20,400
17	3,717	0,106	53,717	0,0743	7,434	74	10,380	0,180	60,380	0,2076	20,760
18	3,809	0,092	53,809	0,0762	7,618	75	10,512	0,132	60,512	0,2102	21,024
19	3,923	0,114	53,923	0,0785	7,846	76	10,663	0,151	60,663	0,2133	21,326
20	4,035	0,112	54,035	0,0807	8,070	77	10,826	0,163	60,826	0,2165	21,652
21	4,119	0,084	54,119	0,0824	8,238	78	10,985	0,159	60,985	0,2197	21,970
22	4,220	0,101	54,220	0,0844	8,440	79	11,130	0,145	61,130	0,2226	22,260
23	4,317	0,097	54,317	0,0863	8,634	80	11,289	0,159	61,289	0,2258	22,578
24	4,415	0,098	54,415	0,0883	8,830	81	11,446	0,157	61,446	0,2289	22,892
25	4,514	0,099	54,514	0,0903	9,028	82	11,610	0,164	61,610	0,2322	23,220
26	4,615	0,101	54,615	0,0923	9,230	83	11,779	0,169	61,779	0,2356	23,558
27	4,720	0,105	54,720	0,0944	9,440	84	11,953	0,174	61,953	0,2391	23,906
28	4,823	0,103	54,823	0,0965	9,646	85	12,133	0,180	62,133	0,2427	24,266
29	4,923	0,100	54,923	0,0985	9,846	86	12,303	0,170	62,303	0,2461	24,606
30	5,027	0,104	55,027	0,1005	10,054	87	12,475	0,172	62,475	0,2495	24,950
31	5,137	0,110	55,137	0,1027	10,274	88	12,664	0,189	62,664	0,2533	25,328
32	5,249	0,112	55,249	0,1050	10,498	89	12,843	0,179	62,843	0,2569	25,686
33	5,354	0,105	55,354	0,1071	10,708	90	13,023	0,180	63,023	0,2605	26,046
34	5,450	0,096	55,450	0,1090	10,900	91	13,231	0,208	63,231	0,2646	26,462
35	5,565	0,115	55,565	0,1113	11,130	92	13,425	0,194	63,425	0,2685	26,850
36	5,685	0,120	55,685	0,1137	11,370	93	13,627	0,202	63,627	0,2725	27,254
37	5,779	0,094	55,779	0,1156	11,558	94	13,843	0,216	63,843	0,2769	27,686
38	5,880	0,101	55,880	0,1176	11,760	95	14,069	0,226	64,069	0,2814	28,138
39	5,994	0,114	55,994	0,1199	11,988	96	14,293	0,224	64,293	0,2859	28,586
40	6,083	0,089	56,083	0,1217	12,166	97	14,509	0,216	64,509	0,2902	29,018
41	6,207	0,124	56,207	0,1241	12,414	98	14,743	0,234	64,743	0,2949	29,486
42	6,320	0,113	56,320	0,1264	12,640	99	14,979	0,236	64,979	0,2996	29,958
43	6,423	0,103	56,423	0,1285	12,846	100	15,205	0,226	65,205	0,3041	30,410
44	6,527	0,104	56,527	0,1305	13,054	101	15,446	0,241	65,446	0,3089	30,892
45	6,659	0,132	56,659	0,1332	13,318	102	15,680	0,234	65,680	0,3136	31,360
46	6,767	0,108	56,767	0,1353	13,534	103	15,927	0,247	65,927	0,3185	31,854
47	6,885	0,118	56,885	0,1377	13,770	104	16,176	0,249	66,176	0,3235	32,352
48	6,990	0,105	56,990	0,1398	13,980	105	16,437	0,261	66,437	0,3287	32,874
49	7,107	0,117	57,107	0,1421	14,214	106	16,694	0,257	66,694	0,3339	33,388
50	7,219	0,112	57,219	0,1444	14,438	107	16,966	0,272	66,966	0,3393	33,932
51	7,332	0,113	57,332	0,1466	14,664	108	17,280	0,314	67,280	0,3456	34,560
52	7,447	0,115	57,447	0,1489	14,894	109	17,577	0,297	67,577	0,3515	35,154
53	7,579	0,132	57,579	0,1516	15,158	110	17,913	0,336	67,913	0,3583	35,826
54	7,680	0,101	57,680	0,1536	15,360	111	18,243	0,330	68,243	0,3649	36,486
55	7,807	0,127	57,807	0,1561	15,614	112	18,613	0,370	68,613	0,3723	37,226
56	7,927	0,120	57,927	0,1585	15,854	113	18,997	0,384	68,997	0,3799	37,994
57	8,037	0,110	58,037	0,1607	16,074	114	19,416	0,419	69,416	0,3883	38,832

DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
115	19,846	0,430	69,846	0,3969	39,692	172					
116	20,353	0,507	70,353	0,4071	40,706	173					
117	20,873	0,520	70,873	0,4175	41,746	174					
118	21,463	0,590	71,463	0,4293	42,926	175					
119	22,110	0,647	72,110	0,4422	44,220	176					
120	22,975	0,865	72,975	0,4595	45,950	177					
121	24,076	1,101	74,076	0,4815	48,152	178					
122	26,025	1,949	76,025	0,5205	52,050	179					
123						180					
124						181					
125						182					
126						183					
127						184					
128						185					
129						186					
130						187					
131						188					
132						189					
133						190					
134						191					
135						192					
136						193					
137						194					
138						195					
139						196					
140						197					
141						198					
142						199					
143						200					
144						201					
145						202					
146						203					
147						204					
148						205					
149						206					
150						207					
151						208					
152						209					
153						210					
154						211					
155						212					
156						213					
157						214					
158						215					
159						216					
160						217					
161						218					
162						219					
163						220					
164						221					
165						222					
166						223					
167						224					
168						225					
169						226					
170						227					
171						228					

H.24 Tabel data hasil pengujian *creep-rupture* spesimen uji 3D.

<i>Material/Specimen</i>		SA-210 A1 -- 3D
<i>Machine</i>		BCTM
<i>Mass/test load</i>		106,6 kgs
<i>Temperature Set</i>		538 °C
<i>Start to Temperature</i>	<i>Time</i>	16.40 WITA
	<i>Date</i>	19/08/2021
<i>Finish at Temperature</i>	<i>Expansion</i>	2,478 mm
	<i>Time</i>	18.35 WITA
	<i>Date</i>	19/08/2021
	<i>Duration</i>	1 Hour 40 Min
<i>Duration (Heating Homogen)</i>		3 Hours
<i>Start loading</i>	<i>Time</i>	22.09 WITA
	<i>Date</i>	19/08/2021
	<i>Expansion</i>	2,666 mm
<i>Instantaneous Deformation (ID)</i>		4,585 mm
<i>Break/Fracture</i>	<i>Time</i>	11.31 WITA
	<i>Date</i>	30/08/2021
	<i>Duration (Predict. Fracture)</i>	88,54 Hrs -- 249,55 Hrs
	<i>Duration (actual Fracture)</i>	246 Hour 27 Min (246,45 Hours)
	<i>Length at Fracture (Dial)</i>	78,85 mm
	<i>Final Length (Ambient)</i>	72,85 mm
	<i>Area Fracture (W x t)</i>	9,2 x 2,25 mm
	<i>Reduction in Area (RA)</i>	49,25 %
	<i>Creep Strain Rate</i>	1,08E-03 h ⁻¹



MATERIAL :			SA-210 A1			SPECIMEN :		3D											
A (mm)	B (mm)	C (mm)	D (mm)	F (mm)	H (mm)	L (mm)	Width/W (mm)		Thickness/t (mm)						Hardness/H (BHN)		Applied For Test (mm ²)		
75	40	85	13	50	50	234,5	W1:	12,55	t1:	3,25	t1A:	3,25	t1B:	3,30	t1AVE:	3,27	H1:	152	40,7875
							W2:	12,55	t2:	3,25	t2A:	3,25	t2B:	3,25	t2AVE:	3,25	H2:	119	40,7875
							W3:	12,55	t3:	3,25	t3A:	3,20	t3B:	3,30	t3AVE:	3,25	H3:	113	40,7875
							W4:	12,55	t4:	3,25	t4A:	3,25	t4B:	3,35	t4AVE:	3,28	H4:	113	40,7875
							W5:	12,60	t5:	3,30	t5A:	3,25	t5B:	3,30	t5AVE:	3,28	H5:	114	41,5800
							W6:	12,70	t6:	3,25	t6A:	3,30	t6B:	3,25	t6AVE:	3,27	H6:	130	41,2750
							WAVE:	12,58	tMIN:	3,25	tMIN:	3,20	tMIN:	3,25	tAVEtot:	3,27	HAVE:	123,50	Amin
							WMIN:	12,55	Selected		N/A			tMIN:	3,25	HMIN:	tMIN:	40,7875	

CREEP-RUPTURE DATA														
MATERIAL			SA-210 A1		SPECIMEN		3D		THICKNESS			Minimum (mm)		3,25
TEMPERATURE			538 °C		LOAD/MASS		106,6 kgs					Average (mm)		3,27
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)	
		Hour	Min.	Sec.					Hour	Min.	Sec.			
1	19/08/2021	16	40	00	0	0,0	54	22/08/2021	04	38	01	1	6,282	
2	Start Temp.	17	40	00	1	1,686	55	--	05	38	01	1	6,320	
3	Finish Temp.	18	35	33	0,9283	2,478	56	--	06	38	01	1	6,372	
4	--	19	35	33	1	2,636	57	--	07	38	01	1	6,424	
5	--	20	35	33	1	2,655	58	--	08	38	01	1	6,456	
6	Fnish Heat.	21	35	33	1	2,666	59	--	09	38	01	1	6,488	
7	Start Load	22	09	08	0,5597	4,585	60	--	10	38	01	1	6,532	
8	--	23	09	08	1	4,764	61	--	11	38	01	1	6,572	
9	20/09/2021	00	09	08	1	4,806	62	--	12	38	01	1	6,615	
10	--	01	09	08	1	4,831	63	--	13	38	01	1	6,662	
11	--	02	09	08	1	4,852	64	--	14	38	01	1	6,715	
12	--	03	09	08	1	4,874	65	--	15	38	01	1	6,755	
13	--	04	09	08	1	4,898	66	--	16	38	01	1	6,800	
14	--	05	09	08	1	4,918	67	--	17	38	01	1	6,850	
15	--	06	09	08	1	4,938	68	--	18	38	01	1	6,888	
16	--	07	09	08	1	4,958	69	--	19	38	01	1	6,941	
17	--	08	09	08	1	4,985	70	--	20	38	01	1	6,988	
18	--	09	09	08	1	5,022	71	--	21	38	01	1	7,035	
19	--	10	09	08	1	5,044	72	--	22	38	01	1	7,072	
20	--	11	09	08	1	5,077	73	--	23	38	01	1	7,124	
21	--	12	09	08	1	5,082	74	23/08/2021	00	38	01	1	7,170	
22	--	13	09	08	1	5,101	75	--	01	38	01	1	7,220	
23	--	14	09	08	1	5,131	76	--	02	38	01	1	7,270	
24	--	15	09	08	1	5,149	77	--	03	38	01	1	7,315	
25	--	16	09	08	1	5,179	78	--	04	38	01	1	7,355	
26	--	17	09	08	1	5,210	79	--	05	38	01	1	7,405	
27	--	18	09	08	1	5,225	80	--	06	38	01	1	7,445	
28	--	19	09	08	1	5,250	81	--	07	38	01	1	7,485	
29	--	20	09	08	1	5,280	82	--	08	38	01	1	7,535	
30	Interrupted	21	09	08	1	5,320	83	--	09	38	01	1	7,584	
	Power Outage	21	22	08			84	--	10	38	01	1	7,624	
	Continue	22	49	28			85	--	11	38	01	1	7,668	
31	--	23	49	28	1	5,372	86	--	12	38	01	1	7,715	
32	21/08/2021	00	49	28	1	5,399	87	--	13	38	01	1	7,760	
33	--	01	49	28	1	5,430	88	--	14	38	01	1	7,815	
34	--	02	49	28	1	5,460	89	--	15	38	01	1	7,869	
35	--	03	49	28	1	5,490	90	--	16	38	01	1	7,919	
36	--	04	49	28	1	5,525	91	--	17	38	01	1	7,970	
37	--	05	49	28	1	5,558	92	--	18	38	01	1	8,004	
38	Interrupted	06	49	28	1	5,594	93	--	19	38	01	1	8,072	
	Power Outage	06	53	07			94	--	20	38	01	1	8,120	
	Continue	12	38	01			95	--	21	38	01	1	8,170	
39	--	13	38	01	1	5,654	96	--	22	38	01	1	8,224	
40	--	14	38	01	1	5,716	97	--	23	38	01	1	8,268	
41	--	15	38	01	1	5,750	98	24/08/2021	00	38	01	1	8,312	
42	--	16	38	01	1	5,800	99	--	01	38	01	1	8,360	
43	--	17	38	01	1	5,825	100	--	02	38	01	1	8,419	
44	--	18	38	01	1	5,862	101	--	03	38	01	1	8,469	
45	--	19	38	01	1	5,899	102	--	04	38	01	1	8,520	
46	--	20	38	01	1	5,949	103	--	05	38	01	1	8,566	
47	--	21	38	01	1	6,028	104	--	06	38	01	1	8,652	
48	--	22	38	01	1	6,055	105	--	07	38	01	1	8,702	
49	--	23	38	01	1	6,085	106	--	08	38	01	1	8,754	
50	22/08/2021	00	38	01	1	6,125	107	--	09	38	01	1	8,810	
51	--	01	38	01	1	6,150	108	--	10	38	01	1	8,859	
52	--	02	38	01	1	6,205	109	--	11	38	01	1	8,909	
53	--	03	38	01	1	6,241	110	--	12	38	01	1	8,945	
TOTAL DURATION CREEP & STRAIN					46,5597	6,241	TOTAL DURATION CREEP & STRAIN					103,5597	8,945	

CREEP-RUPTURE DATA														
MATERIAL		SA-210 A1			SPECIMEN		3D		THICKNESS			Minimum (mm)		3,25
TEMPERATURE		538 °C			LOAD/MASS		106,6 kgs					Average (mm)		3,27
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)	
		Hour	Min.	Sec.					Hour	Min.	Sec.			
111	24/08/2021	13	38	01	1	9,000	168	--	22	38	01	1	12,548	
112	--	14	38	01	1	9,052	169	--	23	38	01	1	12,626	
113	--	15	38	01	1	9,115	170	27/08/2021	00	38	01	1	12,702	
114	--	16	38	01	1	9,170	171	--	01	38	01	1	12,778	
115	--	17	38	01	1	9,225	172	--	02	38	01	1	12,855	
116	--	18	38	01	1	9,269	173	--	03	38	01	1	12,940	
117	--	19	38	01	1	9,315	174	--	04	38	01	1	13,021	
118	--	20	38	01	1	9,380	175	--	05	38	01	1	13,106	
119	--	21	38	01	1	9,430	176	--	06	38	01	1	13,176	
120	--	22	38	01	1	9,484	177	--	07	38	01	1	13,258	
121	--	23	38	01	1	9,538	178	--	08	38	01	1	13,349	
122	25/08/2021	00	38	01	1	9,584	179	--	09	38	01	1	13,458	
123	--	01	38	01	1	9,648	180	--	10	38	01	1	13,540	
124	--	02	38	01	1	9,702	181	--	11	38	01	1	13,622	
125	--	03	38	01	1	9,760	182	--	12	38	01	1	13,709	
126	--	04	38	01	1	9,814	183	--	13	38	01	1	13,790	
127	--	05	38	01	1	9,870	184	--	14	38	01	1	13,892	
128	--	06	38	01	1	9,919	185	--	15	38	01	1	13,969	
129	--	07	38	01	1	9,985	186	--	16	38	01	1	14,069	
130	--	08	38	01	1	10,050	187	--	17	38	01	1	14,161	
131	--	09	38	01	1	10,105	188	--	18	38	01	1	14,259	
132	--	10	38	01	1	10,158	189	--	19	38	01	1	14,356	
133	--	11	38	01	1	10,218	190	--	20	38	01	1	14,448	
134	--	12	38	01	1	10,274	191	--	21	38	01	1	14,542	
135	--	13	38	01	1	10,340	192	--	22	38	01	1	14,640	
136	--	14	38	01	1	10,415	193	--	23	38	01	1	14,739	
137	--	15	38	01	1	10,482	194	28/08/2021	00	38	01	1	14,840	
138	--	16	38	01	1	10,542	195	--	01	38	01	1	14,940	
139	--	17	38	01	1	10,598	196	--	02	38	01	1	15,040	
140	--	18	38	01	1	10,652	197	--	03	38	01	1	15,141	
141	--	19	38	01	1	10,718	198	--	04	38	01	1	15,240	
142	--	20	38	01	1	10,772	199	--	05	38	01	1	15,350	
143	--	21	38	01	1	10,839	200	--	06	38	01	1	15,469	
144	--	22	38	01	1	10,899	201	--	07	38	01	1	15,569	
145	--	23	38	01	1	10,961	202	--	08	38	01	1	15,681	
146	26/08/2021	00	38	01	1	11,025	203	--	09	38	01	1	15,785	
147	--	01	38	01	1	11,090	204	--	10	38	01	1	15,910	
148	--	02	38	01	1	11,151	205	--	11	38	01	1	16,025	
149	--	03	38	01	1	11,218	206	--	12	38	01	1	16,138	
150	--	04	38	01	1	11,278	207	--	13	38	01	1	16,270	
151	--	05	38	01	1	11,340	208	--	14	38	01	1	16,384	
152	--	06	38	01	1	11,414	209	--	15	38	01	1	16,488	
153	--	07	38	01	1	11,470	210	--	16	38	01	1	16,590	
154	--	08	38	01	1	11,549	211	--	17	38	01	1	16,745	
155	--	09	38	01	1	11,618	212	--	18	38	01	1	16,888	
156	--	10	38	01	1	11,690	213	--	19	38	01	1	16,955	
157	--	11	38	01	1	11,760	214	--	20	38	01	1	17,138	
158	--	12	38	01	1	11,816	215	--	21	38	01	1	17,280	
159	--	13	38	01	1	11,881	216	--	22	38	01	1	17,424	
160	--	14	38	01	1	11,958	217	--	23	38	01	1	17,560	
161	--	15	38	01	1	12,035	218	28/08/2021	00	38	01	1	17,720	
162	--	16	38	01	1	12,106	219	--	01	38	01	1	17,861	
163	--	17	38	01	1	12,180	220	--	02	38	01	1	18,010	
164	--	18	38	01	1	12,250	221	--	03	38	01	1	18,160	
165	--	19	38	01	1	12,322	222	--	04	38	01	1	18,300	
166	--	20	38	01	1	12,400	223	--	05	38	01	1	18,470	
167	--	21	38	01	1	12,481	224	--	06	38	01	1	18,635	
TOTAL DURATION CREEP & STRAIN					160,5597	12,481	TOTAL DURATION CREEP & STRAIN					217,5597	18,635	

CREEP-RUPTURE DATA													
MATERIAL		SA-210 A1			SPECIMEN		3D		THICKNESS			Minimum (mm)	3,25
TEMPERATURE		538 °C			LOAD/MASS		106,6 kgs		Average (mm)			3,27	
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)
		Hour	Min.	Sec.					Hour	Min.	Sec.		
225	29/08/2021	07	38	01	1	18,799	282						
226	--	08	38	01	1	18,979	283						
227	--	09	38	01	1	19,150	284						
228	--	10	38	01	1	19,339	285						
229	--	11	38	01	1	19,516	286						
230	--	12	38	01	1	19,714	287						
231	--	13	38	01	1	19,919	288						
232	--	14	38	01	1	20,079	289						
233	--	15	38	01	1	20,315	290						
234	--	16	38	01	1	20,552	291						
235	--	17	38	01	1	20,779	292						
236	--	18	38	01	1	21,016	293						
237	--	19	38	01	1	21,279	294						
238	--	20	38	01	1	21,525	295						
239	--	21	38	01	1	21,795	296						
240	--	22	38	01	1	22,059	297						
241	--	23	38	01	1	22,351	298						
242	30/08/2021	00	38	01	1	22,649	299						
243	--	01	38	01	1	22,960	300						
244	--	02	38	01	1	23,285	301						
245	--	03	38	01	1	23,645	302						
246	--	04	38	01	1	24,020	303						
247	--	05	38	01	1	24,434	304						
248	--	06	38	01	1	24,880	305						
249	--	07	38	01	1	25,389	306						
250	--	08	38	01	1	25,938	307						
251	--	09	38	01	1	26,628	308						
252	--	10	38	01	1	27,494	309						
253	Fracture	11	31	41	0,8944	28,850	310						
254							311						
255							312						
256							313						
257							314						
258							315						
259							316						
260							317						
261							318						
262							319						
263							320						
264							321						
265							322						
266							323						
267							324						
268							325						
269							326						
270							327						
271							328						
272							329						
273							330						
274							331						
275							332						
276							333						
277							334						
278							335						
279							336						
280							337						
281							338						
TOTAL DURATION CREEP & LENGTH					246,4541	28,850	TOTAL DURATION CREEP & LENGTH					--	--
TOTAL TIME CREEP-RUPTURE (HOURS)												251,3824	

DATA ACTUAL ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	54	6,282	0,041	56,282	0,1256	12,564
2	1,686	1,686	51,686	0,0337	3,372	55	6,320	0,038	56,320	0,1264	12,640
3	2,478	0,792	52,478	0,0496	4,956	56	6,372	0,052	56,372	0,1274	12,744
4	2,636	0,158	52,636	0,0527	5,272	57	6,424	0,052	56,424	0,1285	12,848
5	2,655	0,019	52,655	0,0531	5,310	58	6,456	0,032	56,456	0,1291	12,912
6	2,666	0,011	52,666	0,0533	5,332	59	6,488	0,032	56,488	0,1298	12,976
7	4,585	1,919	54,585	0,0917	9,170	60	6,532	0,044	56,532	0,1306	13,064
8	4,764	0,179	54,764	0,0953	9,528	61	6,572	0,040	56,572	0,1314	13,144
9	4,806	0,042	54,806	0,0961	9,612	62	6,615	0,043	56,615	0,1323	13,230
10	4,831	0,025	54,831	0,0966	9,662	63	6,662	0,047	56,662	0,1332	13,324
11	4,852	0,021	54,852	0,0970	9,704	64	6,715	0,053	56,715	0,1343	13,430
12	4,874	0,022	54,874	0,0975	9,748	65	6,755	0,040	56,755	0,1351	13,510
13	4,898	0,024	54,898	0,0980	9,796	66	6,800	0,045	56,800	0,1360	13,600
14	4,918	0,020	54,918	0,0984	9,836	67	6,850	0,050	56,850	0,1370	13,700
15	4,938	0,020	54,938	0,0988	9,876	68	6,888	0,038	56,888	0,1378	13,776
16	4,958	0,020	54,958	0,0992	9,916	69	6,941	0,053	56,941	0,1388	13,882
17	4,985	0,027	54,985	0,0997	9,970	70	6,988	0,047	56,988	0,1398	13,976
18	5,022	0,037	55,022	0,1004	10,044	71	7,035	0,047	57,035	0,1407	14,070
19	5,044	0,022	55,044	0,1009	10,088	72	7,072	0,037	57,072	0,1414	14,144
20	5,077	0,033	55,077	0,1015	10,154	73	7,124	0,052	57,124	0,1425	14,248
21	5,082	0,005	55,082	0,1016	10,164	74	7,170	0,046	57,170	0,1434	14,340
22	5,101	0,019	55,101	0,1020	10,202	75	7,220	0,050	57,220	0,1444	14,440
23	5,131	0,030	55,131	0,1026	10,262	76	7,270	0,050	57,270	0,1454	14,540
24	5,149	0,018	55,149	0,1030	10,298	77	7,315	0,045	57,315	0,1463	14,630
25	5,179	0,030	55,179	0,1036	10,358	78	7,355	0,040	57,355	0,1471	14,710
26	5,210	0,031	55,210	0,1042	10,420	79	7,405	0,050	57,405	0,1481	14,810
27	5,225	0,015	55,225	0,1045	10,450	80	7,445	0,040	57,445	0,1489	14,890
28	5,250	0,025	55,250	0,1050	10,500	81	7,485	0,040	57,485	0,1497	14,970
29	5,280	0,030	55,280	0,1056	10,560	82	7,535	0,050	57,535	0,1507	15,070
30	5,320	0,040	55,320	0,1064	10,640	83	7,584	0,049	57,584	0,1517	15,168
						84	7,624	0,040	57,624	0,1525	15,248
						85	7,668	0,044	57,668	0,1534	15,336
31	5,372	0,052	55,372	0,1074	10,744	86	7,715	0,047	57,715	0,1543	15,430
32	5,399	0,027	55,399	0,1080	10,798	87	7,760	0,045	57,760	0,1552	15,520
33	5,430	0,031	55,430	0,1086	10,860	88	7,815	0,055	57,815	0,1563	15,630
34	5,460	0,030	55,460	0,1092	10,920	89	7,869	0,054	57,869	0,1574	15,738
35	5,490	0,030	55,490	0,1098	10,980	90	7,919	0,050	57,919	0,1584	15,838
36	5,525	0,035	55,525	0,1105	11,050	91	7,970	0,051	57,970	0,1594	15,940
37	5,558	0,033	55,558	0,1112	11,116	92	8,004	0,034	58,004	0,1601	16,008
38	5,594	0,036	55,594	0,1119	11,188	93	8,072	0,068	58,072	0,1614	16,144
						94	8,120	0,048	58,120	0,1624	16,240
						95	8,170	0,050	58,170	0,1634	16,340
39	5,654	0,060	55,654	0,1131	11,308	96	8,224	0,054	58,224	0,1645	16,448
40	5,716	0,062	55,716	0,1143	11,432	97	8,268	0,044	58,268	0,1654	16,536
41	5,750	0,034	55,750	0,1150	11,500	98	8,312	0,044	58,312	0,1662	16,624
42	5,800	0,050	55,800	0,1160	11,600	99	8,360	0,048	58,360	0,1672	16,720
43	5,825	0,025	55,825	0,1165	11,650	100	8,419	0,059	58,419	0,1684	16,838
44	5,862	0,037	55,862	0,1172	11,724	101	8,469	0,050	58,469	0,1694	16,938
45	5,899	0,037	55,899	0,1180	11,798	102	8,520	0,051	58,520	0,1704	17,040
46	5,949	0,050	55,949	0,1190	11,898	103	8,566	0,046	58,566	0,1713	17,132
47	6,028	0,079	56,028	0,1206	12,056	104	8,652	0,086	58,652	0,1730	17,304
48	6,055	0,027	56,055	0,1211	12,110	105	8,702	0,050	58,702	0,1740	17,404
49	6,085	0,030	56,085	0,1217	12,170	106	8,754	0,052	58,754	0,1751	17,508
50	6,125	0,040	56,125	0,1225	12,250	107	8,810	0,056	58,810	0,1762	17,620
51	6,150	0,025	56,150	0,1230	12,300	108	8,859	0,049	58,859	0,1772	17,718
52	6,205	0,055	56,205	0,1241	12,410	109	8,909	0,050	58,909	0,1782	17,818
53	6,241	0,036	56,241	0,1248	12,482	110	8,945	0,036	58,945	0,1789	17,890

DATA ACTUAL ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)
111	9,000	0,055	59,000	0,1800	18,000	168	12,548	0,067	62,548	0,2510	25,096
112	9,052	0,052	59,052	0,1810	18,104	169	12,626	0,078	62,626	0,2525	25,252
113	9,115	0,063	59,115	0,1823	18,230	170	12,702	0,076	62,702	0,2540	25,404
114	9,170	0,055	59,170	0,1834	18,340	171	12,778	0,076	62,778	0,2556	25,556
115	9,225	0,055	59,225	0,1845	18,450	172	12,855	0,077	62,855	0,2571	25,710
116	9,269	0,044	59,269	0,1854	18,538	173	12,940	0,085	62,940	0,2588	25,880
117	9,315	0,046	59,315	0,1863	18,630	174	13,021	0,081	63,021	0,2604	26,042
118	9,380	0,065	59,380	0,1876	18,760	175	13,106	0,085	63,106	0,2621	26,212
119	9,430	0,050	59,430	0,1886	18,860	176	13,176	0,070	63,176	0,2635	26,352
120	9,484	0,054	59,484	0,1897	18,968	177	13,258	0,082	63,258	0,2652	26,516
121	9,538	0,054	59,538	0,1908	19,076	178	13,349	0,091	63,349	0,2670	26,698
122	9,584	0,046	59,584	0,1917	19,168	179	13,458	0,109	63,458	0,2692	26,916
123	9,648	0,064	59,648	0,1930	19,296	180	13,540	0,082	63,540	0,2708	27,080
124	9,702	0,054	59,702	0,1940	19,404	181	13,622	0,082	63,622	0,2724	27,244
125	9,760	0,058	59,760	0,1952	19,520	182	13,709	0,087	63,709	0,2742	27,418
126	9,814	0,054	59,814	0,1963	19,628	183	13,790	0,081	63,790	0,2758	27,580
127	9,870	0,056	59,870	0,1974	19,740	184	13,892	0,102	63,892	0,2778	27,784
128	9,919	0,049	59,919	0,1984	19,838	185	13,969	0,077	63,969	0,2794	27,938
129	9,985	0,066	59,985	0,1997	19,970	186	14,069	0,100	64,069	0,2814	28,138
130	10,050	0,065	60,050	0,2010	20,100	187	14,161	0,092	64,161	0,2832	28,322
131	10,105	0,055	60,105	0,2021	20,210	188	14,259	0,098	64,259	0,2852	28,518
132	10,158	0,053	60,158	0,2032	20,316	189	14,356	0,097	64,356	0,2871	28,712
133	10,218	0,060	60,218	0,2044	20,436	190	14,448	0,092	64,448	0,2890	28,896
134	10,274	0,056	60,274	0,2055	20,548	191	14,542	0,094	64,542	0,2908	29,084
135	10,340	0,066	60,340	0,2068	20,680	192	14,640	0,098	64,640	0,2928	29,280
136	10,415	0,075	60,415	0,2083	20,830	193	14,739	0,099	64,739	0,2948	29,478
137	10,482	0,067	60,482	0,2096	20,964	194	14,840	0,101	64,840	0,2968	29,680
138	10,542	0,060	60,542	0,2108	21,084	195	14,940	0,100	64,940	0,2988	29,880
139	10,598	0,056	60,598	0,2120	21,196	196	15,040	0,100	65,040	0,3008	30,080
140	10,652	0,054	60,652	0,2130	21,304	197	15,141	0,101	65,141	0,3028	30,282
141	10,718	0,066	60,718	0,2144	21,436	198	15,240	0,099	65,240	0,3048	30,480
142	10,772	0,054	60,772	0,2154	21,544	199	15,350	0,110	65,350	0,3070	30,700
143	10,839	0,067	60,839	0,2168	21,678	200	15,469	0,119	65,469	0,3094	30,938
144	10,899	0,060	60,899	0,2180	21,798	201	15,569	0,100	65,569	0,3114	31,138
145	10,961	0,062	60,961	0,2192	21,922	202	15,681	0,112	65,681	0,3136	31,362
146	11,025	0,064	61,025	0,2205	22,050	203	15,785	0,104	65,785	0,3157	31,570
147	11,090	0,065	61,090	0,2218	22,180	204	15,910	0,125	65,910	0,3182	31,820
148	11,151	0,061	61,151	0,2230	22,302	205	16,025	0,115	66,025	0,3205	32,050
149	11,218	0,067	61,218	0,2244	22,436	206	16,138	0,113	66,138	0,3228	32,276
150	11,278	0,060	61,278	0,2256	22,556	207	16,270	0,132	66,270	0,3254	32,540
151	11,340	0,062	61,340	0,2268	22,680	208	16,384	0,114	66,384	0,3277	32,768
152	11,414	0,074	61,414	0,2283	22,828	209	16,488	0,104	66,488	0,3298	32,976
153	11,470	0,056	61,470	0,2294	22,940	210	16,590	0,102	66,590	0,3318	33,180
154	11,549	0,079	61,549	0,2310	23,098	211	16,745	0,155	66,745	0,3349	33,490
155	11,618	0,069	61,618	0,2324	23,236	212	16,888	0,143	66,888	0,3378	33,776
156	11,690	0,072	61,690	0,2338	23,380	213	16,955	0,067	66,955	0,3391	33,910
157	11,760	0,070	61,760	0,2352	23,520	214	17,138	0,183	67,138	0,3428	34,276
158	11,816	0,056	61,816	0,2363	23,632	215	17,280	0,142	67,280	0,3456	34,560
159	11,881	0,065	61,881	0,2376	23,762	216	17,424	0,144	67,424	0,3485	34,848
160	11,958	0,077	61,958	0,2392	23,916	217	17,560	0,136	67,560	0,3512	35,120
161	12,035	0,077	62,035	0,2407	24,070	218	17,720	0,160	67,720	0,3544	35,440
162	12,106	0,071	62,106	0,2421	24,212	219	17,861	0,141	67,861	0,3572	35,722
163	12,180	0,074	62,180	0,2436	24,360	220	18,010	0,149	68,010	0,3602	36,020
164	12,250	0,070	62,250	0,2450	24,500	221	18,160	0,150	68,160	0,3632	36,320
165	12,322	0,072	62,322	0,2464	24,644	222	18,300	0,140	68,300	0,3660	36,600
166	12,400	0,078	62,400	0,2480	24,800	223	18,470	0,170	68,470	0,3694	36,940
167	12,481	0,081	62,481	0,2496	24,962	224	18,635	0,165	68,635	0,3727	37,270

DATA ACTUAL ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)
225	18,799	0,164	68,799	0,3760	37,598	282					
226	18,979	0,180	68,979	0,3796	37,958	283					
227	19,150	0,171	69,150	0,3830	38,300	284					
228	19,339	0,189	69,339	0,3868	38,678	285					
229	19,516	0,177	69,516	0,3903	39,032	286					
230	19,714	0,198	69,714	0,3943	39,428	287					
231	19,919	0,205	69,919	0,3984	39,838	288					
232	20,079	0,160	70,079	0,4016	40,158	289					
233	20,315	0,236	70,315	0,4063	40,630	290					
234	20,552	0,237	70,552	0,4110	41,104	291					
235	20,779	0,227	70,779	0,4156	41,558	292					
236	21,016	0,237	71,016	0,4203	42,032	293					
237	21,279	0,263	71,279	0,4256	42,558	294					
238	21,525	0,246	71,525	0,4305	43,050	295					
239	21,795	0,270	71,795	0,4359	43,590	296					
240	22,059	0,264	72,059	0,4412	44,118	297					
241	22,351	0,292	72,351	0,4470	44,702	298					
242	22,649	0,298	72,649	0,4530	45,298	299					
243	22,960	0,311	72,960	0,4592	45,920	300					
244	23,285	0,325	73,285	0,4657	46,570	301					
245	23,645	0,360	73,645	0,4729	47,290	302					
246	24,020	0,375	74,020	0,4804	48,040	303					
247	24,434	0,414	74,434	0,4887	48,868	304					
248	24,880	0,446	74,880	0,4976	49,760	305					
249	25,389	0,509	75,389	0,5078	50,778	306					
250	25,938	0,549	75,938	0,5188	51,876	307					
251	26,628	0,690	76,628	0,5326	53,256	308					
252	27,494	0,866	77,494	0,5499	54,988	309					
253	28,850	1,356	78,850	0,5770	57,700	310					
254						311					
255						312					
256						313					
257						314					
258						315					
259						316					
260						317					
261						318					
262						319					
263						320					
264						321					
265						322					
266						323					
267						324					
268						325					
269						326					
270						327					
271						328					
272						329					
273						330					
274						331					
275						332					
276						333					
277						334					
278						335					
279						336					
280						337					
281						338					

DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	54	3,822	0,032	53,822	0,0764	7,644
2	1,919	1,919	51,919	0,0384	3,838	55	3,866	0,044	53,866	0,0773	7,732
3	2,098	0,179	52,098	0,0420	4,196	56	3,906	0,040	53,906	0,0781	7,812
4	2,140	0,042	52,140	0,0428	4,280	57	3,949	0,043	53,949	0,0790	7,898
5	2,165	0,025	52,165	0,0433	4,330	58	3,996	0,047	53,996	0,0799	7,992
6	2,186	0,021	52,186	0,0437	4,372	59	4,049	0,053	54,049	0,0810	8,098
7	2,208	0,022	52,208	0,0442	4,416	60	4,089	0,040	54,089	0,0818	8,178
8	2,232	0,024	52,232	0,0446	4,464	61	4,134	0,045	54,134	0,0827	8,268
9	2,252	0,02	52,252	0,0450	4,504	62	4,184	0,050	54,184	0,0837	8,368
10	2,272	0,02	52,272	0,0454	4,544	63	4,222	0,038	54,222	0,0844	8,444
11	2,292	0,02	52,292	0,0458	4,584	64	4,275	0,053	54,275	0,0855	8,550
12	2,319	0,027	52,319	0,0464	4,638	65	4,322	0,047	54,322	0,0864	8,644
13	2,356	0,037	52,356	0,0471	4,712	66	4,369	0,047	54,369	0,0874	8,738
14	2,378	0,022	52,378	0,0476	4,756	67	4,406	0,037	54,406	0,0881	8,812
15	2,411	0,033	52,411	0,0482	4,822	68	4,458	0,052	54,458	0,0892	8,916
16	2,416	0,005	52,416	0,0483	4,832	69	4,504	0,046	54,504	0,0901	9,008
17	2,435	0,019	52,435	0,0487	4,870	70	4,554	0,050	54,554	0,0911	9,108
18	2,465	0,030	52,465	0,0493	4,930	71	4,604	0,050	54,604	0,0921	9,208
19	2,483	0,018	52,483	0,0497	4,966	72	4,649	0,045	54,649	0,0930	9,298
20	2,513	0,030	52,513	0,0503	5,026	73	4,689	0,040	54,689	0,0938	9,378
21	2,544	0,031	52,544	0,0509	5,088	74	4,739	0,050	54,739	0,0948	9,478
22	2,559	0,015	52,559	0,0512	5,118	75	4,779	0,040	54,779	0,0956	9,558
23	2,584	0,025	52,584	0,0517	5,168	76	4,819	0,040	54,819	0,0964	9,638
24	2,614	0,030	52,614	0,0523	5,228	77	4,869	0,050	54,869	0,0974	9,738
25	2,654	0,040	52,654	0,0531	5,308	78	4,918	0,049	54,918	0,0984	9,836
						79	4,958	0,040	54,958	0,0992	9,916
						80	5,002	0,044	55,002	0,1000	10,004
26	2,706	0,052	52,706	0,0541	5,412	81	5,049	0,047	55,049	0,1010	10,098
27	2,733	0,027	52,733	0,0547	5,466	82	5,094	0,045	55,094	0,1019	10,188
28	2,764	0,031	52,764	0,0553	5,528	83	5,149	0,055	55,149	0,1030	10,298
29	2,794	0,030	52,794	0,0559	5,588	84	5,203	0,054	55,203	0,1041	10,406
30	2,824	0,030	52,824	0,0565	5,648	85	5,253	0,050	55,253	0,1051	10,506
31	2,859	0,035	52,859	0,0572	5,718	86	5,304	0,051	55,304	0,1061	10,608
32	2,892	0,033	52,892	0,0578	5,784	87	5,338	0,034	55,338	0,1068	10,676
33	2,928	0,036	52,928	0,0586	5,856	88	5,406	0,068	55,406	0,1081	10,812
						89	5,454	0,048	55,454	0,1091	10,908
						90	5,504	0,050	55,504	0,1101	11,008
34	2,988	0,060	52,988	0,0598	5,976	91	5,558	0,054	55,558	0,1112	11,116
35	3,050	0,062	53,050	0,0610	6,100	92	5,602	0,044	55,602	0,1120	11,204
36	3,084	0,034	53,084	0,0617	6,168	93	5,646	0,044	55,646	0,1129	11,292
37	3,134	0,050	53,134	0,0627	6,268	94	5,694	0,048	55,694	0,1139	11,388
38	3,159	0,025	53,159	0,0632	6,318	95	5,753	0,059	55,753	0,1151	11,506
39	3,196	0,037	53,196	0,0639	6,392	96	5,803	0,050	55,803	0,1161	11,606
40	3,233	0,037	53,233	0,0647	6,466	97	5,854	0,051	55,854	0,1171	11,708
41	3,283	0,050	53,283	0,0657	6,566	98	5,900	0,046	55,900	0,1180	11,800
42	3,362	0,079	53,362	0,0672	6,724	99	5,986	0,086	55,986	0,1197	11,972
43	3,389	0,027	53,389	0,0678	6,778	100	6,036	0,050	56,036	0,1207	12,072
44	3,419	0,030	53,419	0,0684	6,838	101	6,088	0,052	56,088	0,1218	12,176
45	3,459	0,040	53,459	0,0692	6,918	102	6,144	0,056	56,144	0,1229	12,288
46	3,484	0,025	53,484	0,0697	6,968	103	6,193	0,049	56,193	0,1239	12,386
47	3,539	0,055	53,539	0,0708	7,078	104	6,243	0,050	56,243	0,1249	12,486
48	3,575	0,036	53,575	0,0715	7,150	105	6,279	0,036	56,279	0,1256	12,558
49	3,616	0,041	53,616	0,0723	7,232	106	6,334	0,055	56,334	0,1267	12,668
50	3,654	0,038	53,654	0,0731	7,308	107	6,386	0,052	56,386	0,1277	12,772
51	3,706	0,052	53,706	0,0741	7,412	108	6,449	0,063	56,449	0,1290	12,898
52	3,758	0,052	53,758	0,0752	7,516	109	6,504	0,055	56,504	0,1301	13,008
53	3,790	0,032	53,790	0,0758	7,580	110	6,559	0,055	56,559	0,1312	13,118

DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
111	6,603	0,044	56,603	0,1321	13,206	168	10,274	0,085	60,274	0,2055	20,548
112	6,649	0,046	56,649	0,1330	13,298	169	10,355	0,081	60,355	0,2071	20,710
113	6,714	0,065	56,714	0,1343	13,428	170	10,440	0,085	60,440	0,2088	20,880
114	6,764	0,050	56,764	0,1353	13,528	171	10,510	0,070	60,510	0,2102	21,020
115	6,818	0,054	56,818	0,1364	13,636	172	10,592	0,082	60,592	0,2118	21,184
116	6,872	0,054	56,872	0,1374	13,744	173	10,683	0,091	60,683	0,2137	21,366
117	6,918	0,046	56,918	0,1384	13,836	174	10,792	0,109	60,792	0,2158	21,584
118	6,982	0,064	56,982	0,1396	13,964	175	10,874	0,082	60,874	0,2175	21,748
119	7,036	0,054	57,036	0,1407	14,072	176	10,956	0,082	60,956	0,2191	21,912
120	7,094	0,058	57,094	0,1419	14,188	177	11,043	0,087	61,043	0,2209	22,086
121	7,148	0,054	57,148	0,1430	14,296	178	11,124	0,081	61,124	0,2225	22,248
122	7,204	0,056	57,204	0,1441	14,408	179	11,226	0,102	61,226	0,2245	22,452
123	7,253	0,049	57,253	0,1451	14,506	180	11,303	0,077	61,303	0,2261	22,606
124	7,319	0,066	57,319	0,1464	14,638	181	11,403	0,100	61,403	0,2281	22,806
125	7,384	0,065	57,384	0,1477	14,768	182	11,495	0,092	61,495	0,2299	22,990
126	7,439	0,055	57,439	0,1488	14,878	183	11,593	0,098	61,593	0,2319	23,186
127	7,492	0,053	57,492	0,1498	14,984	184	11,690	0,097	61,690	0,2338	23,380
128	7,552	0,060	57,552	0,1510	15,104	185	11,782	0,092	61,782	0,2356	23,564
129	7,608	0,056	57,608	0,1522	15,216	186	11,876	0,094	61,876	0,2375	23,752
130	7,674	0,066	57,674	0,1535	15,348	187	11,974	0,098	61,974	0,2395	23,948
131	7,749	0,075	57,749	0,1550	15,498	188	12,073	0,099	62,073	0,2415	24,146
132	7,816	0,067	57,816	0,1563	15,632	189	12,174	0,101	62,174	0,2435	24,348
133	7,876	0,060	57,876	0,1575	15,752	190	12,274	0,100	62,274	0,2455	24,548
134	7,932	0,056	57,932	0,1586	15,864	191	12,374	0,100	62,374	0,2475	24,748
135	7,986	0,054	57,986	0,1597	15,972	192	12,475	0,101	62,475	0,2495	24,950
136	8,052	0,066	58,052	0,1610	16,104	193	12,574	0,099	62,574	0,2515	25,148
137	8,106	0,054	58,106	0,1621	16,212	194	12,684	0,110	62,684	0,2537	25,368
138	8,173	0,067	58,173	0,1635	16,346	195	12,803	0,119	62,803	0,2561	25,606
139	8,233	0,060	58,233	0,1647	16,466	196	12,903	0,100	62,903	0,2581	25,806
140	8,295	0,062	58,295	0,1659	16,590	197	13,015	0,112	63,015	0,2603	26,030
141	8,359	0,064	58,359	0,1672	16,718	198	13,119	0,104	63,119	0,2624	26,238
142	8,424	0,065	58,424	0,1685	16,848	199	13,244	0,125	63,244	0,2649	26,488
143	8,485	0,061	58,485	0,1697	16,970	200	13,359	0,115	63,359	0,2672	26,718
144	8,552	0,067	58,552	0,1710	17,104	201	13,472	0,113	63,472	0,2694	26,944
145	8,612	0,060	58,612	0,1722	17,224	202	13,604	0,132	63,604	0,2721	27,208
146	8,674	0,062	58,674	0,1735	17,348	203	13,718	0,114	63,718	0,2744	27,436
147	8,748	0,074	58,748	0,1750	17,496	204	13,822	0,104	63,822	0,2764	27,644
148	8,804	0,056	58,804	0,1761	17,608	205	13,924	0,102	63,924	0,2785	27,848
149	8,883	0,079	58,883	0,1777	17,766	206	14,079	0,155	64,079	0,2816	28,158
150	8,952	0,069	58,952	0,1790	17,904	207	14,222	0,143	64,222	0,2844	28,444
151	9,024	0,072	59,024	0,1805	18,048	208	14,289	0,067	64,289	0,2858	28,578
152	9,094	0,070	59,094	0,1819	18,188	209	14,472	0,183	64,472	0,2894	28,944
153	9,150	0,056	59,150	0,1830	18,300	210	14,614	0,142	64,614	0,2923	29,228
154	9,215	0,065	59,215	0,1843	18,430	211	14,758	0,144	64,758	0,2952	29,516
155	9,292	0,077	59,292	0,1858	18,584	212	14,894	0,136	64,894	0,2979	29,788
156	9,369	0,077	59,369	0,1874	18,738	213	15,054	0,160	65,054	0,3011	30,108
157	9,440	0,071	59,440	0,1888	18,880	214	15,195	0,141	65,195	0,3039	30,390
158	9,514	0,074	59,514	0,1903	19,028	215	15,344	0,149	65,344	0,3069	30,688
159	9,584	0,070	59,584	0,1917	19,168	216	15,494	0,150	65,494	0,3099	30,988
160	9,656	0,072	59,656	0,1931	19,312	217	15,634	0,140	65,634	0,3127	31,268
161	9,734	0,078	59,734	0,1947	19,468	218	15,804	0,170	65,804	0,3161	31,608
162	9,815	0,081	59,815	0,1963	19,630	219	15,969	0,165	65,969	0,3194	31,938
163	9,882	0,067	59,882	0,1976	19,764	220	16,133	0,164	66,133	0,3227	32,266
164	9,960	0,078	59,960	0,1992	19,920	221	16,313	0,180	66,313	0,3263	32,626
165	10,036	0,076	60,036	0,2007	20,072	222	16,484	0,171	66,484	0,3297	32,968
166	10,112	0,076	60,112	0,2022	20,224	223	16,673	0,189	66,673	0,3335	33,346
167	10,189	0,077	60,189	0,2038	20,378	224	16,850	0,177	66,850	0,3370	33,700

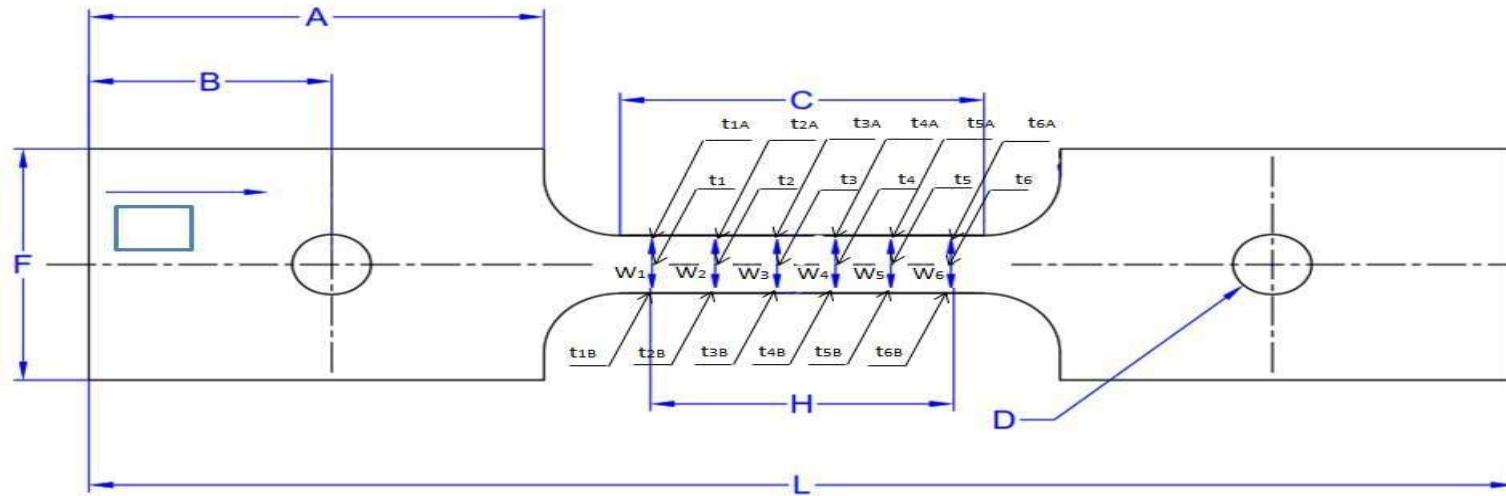
DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
225	17,048	0,198	67,048	0,3410	34,096	282					
226	17,253	0,205	67,253	0,3451	34,506	283					
227	17,413	0,160	67,413	0,3483	34,826	284					
228	17,649	0,236	67,649	0,3530	35,298	285					
229	17,886	0,237	67,886	0,3577	35,772	286					
230	18,113	0,227	68,113	0,3623	36,226	287					
231	18,350	0,237	68,350	0,3670	36,700	288					
232	18,613	0,263	68,613	0,3723	37,226	289					
233	18,859	0,246	68,859	0,3772	37,718	290					
234	19,129	0,270	69,129	0,3826	38,258	291					
235	19,393	0,264	69,393	0,3879	38,786	292					
236	19,685	0,292	69,685	0,3937	39,370	293					
237	19,983	0,298	69,983	0,3997	39,966	294					
238	20,294	0,311	70,294	0,4059	40,588	295					
239	20,619	0,325	70,619	0,4124	41,238	296					
240	20,979	0,360	70,979	0,4196	41,958	297					
241	21,354	0,375	71,354	0,4271	42,708	298					
242	21,768	0,414	71,768	0,4354	43,536	299					
243	22,214	0,446	72,214	0,4443	44,428	300					
244	22,723	0,509	72,723	0,4545	45,446	301					
245	23,272	0,549	73,272	0,4654	46,544	302					
246	23,962	0,690	73,962	0,4792	47,924	303					
247	24,828	0,866	74,828	0,4966	49,656	304					
248	26,184	1,356	76,184	0,5237	52,368	305					
249						306					
250						307					
251						308					
252						309					
253						310					
254						311					
255						312					
256						313					
257						314					
258						315					
259						316					
260						317					
261						318					
262						319					
263						320					
264						321					
265						322					
266						323					
267						324					
268						325					
269						326					
270						327					
271						328					
272						329					
273						330					
274						331					
275						332					
276						333					
277						334					
278						335					
279						336					
280						337					
281						338					

CALCULATION DATA GRAPH								
$\sigma = 97,59 \text{ MPa}; 538 \text{ }^\circ\text{C}$								
No.	Time (Hours)	Strain	No.	Time (Hours)	Strain	No.	Time (Hours)	Strain
1	0,0	0,0	58	56,560	0,080	115	113,560	0,136
2	0,560	0,038	59	57,560	0,081	116	114,560	0,137
3	1,560	0,042	60	58,560	0,082	117	115,560	0,138
4	2,560	0,043	61	59,560	0,083	118	116,560	0,140
5	3,560	0,043	62	60,560	0,084	119	117,560	0,141
6	4,560	0,044	63	61,560	0,084	120	118,560	0,142
7	5,560	0,044	64	62,560	0,086	121	119,560	0,143
8	6,560	0,045	65	63,560	0,086	122	120,560	0,144
9	7,560	0,045	66	64,560	0,087	123	121,560	0,145
10	8,560	0,045	67	65,560	0,088	124	122,560	0,146
11	9,560	0,046	68	66,560	0,089	125	123,560	0,148
12	10,560	0,046	69	67,560	0,090	126	124,560	0,149
13	11,560	0,047	70	68,560	0,091	127	125,560	0,150
14	12,560	0,048	71	69,560	0,092	128	126,560	0,151
15	13,560	0,048	72	70,560	0,093	129	127,560	0,152
16	14,560	0,048	73	71,560	0,094	130	128,560	0,153
17	15,560	0,049	74	72,560	0,095	131	129,560	0,155
18	16,560	0,049	75	73,560	0,096	132	130,560	0,156
19	17,560	0,050	76	74,560	0,096	133	131,560	0,158
20	18,560	0,050	77	75,560	0,097	134	132,560	0,159
21	19,560	0,051	78	76,560	0,098	135	133,560	0,160
22	20,560	0,051	79	77,560	0,099	136	134,560	0,161
23	21,560	0,052	80	78,560	0,100	137	135,560	0,162
24	22,560	0,052	81	79,560	0,101	138	136,560	0,163
25	23,560	0,053	82	80,560	0,102	139	137,560	0,165
26	24,560	0,054	83	81,560	0,103	140	138,560	0,166
27	25,560	0,055	84	82,560	0,104	141	139,560	0,167
28	26,560	0,055	85	83,560	0,105	142	140,560	0,168
29	27,560	0,056	86	84,560	0,106	143	141,560	0,170
30	28,560	0,056	87	85,560	0,107	144	142,560	0,171
31	29,560	0,057	88	86,560	0,108	145	143,560	0,172
32	30,560	0,058	89	87,560	0,109	146	144,560	0,173
33	31,560	0,059	90	88,560	0,110	147	145,560	0,175
34	32,560	0,060	91	89,560	0,111	148	146,560	0,176
35	33,560	0,061	92	90,560	0,112	149	147,560	0,178
36	34,560	0,062	93	91,560	0,113	150	148,560	0,179
37	35,560	0,063	94	92,560	0,114	151	149,560	0,180
38	36,560	0,063	95	93,560	0,115	152	150,560	0,182
39	37,560	0,064	96	94,560	0,116	153	151,560	0,183
40	38,560	0,065	97	95,560	0,117	154	152,560	0,184
41	39,560	0,066	98	96,560	0,118	155	153,560	0,186
42	40,560	0,067	99	97,560	0,120	156	154,560	0,187
43	41,560	0,068	100	98,560	0,121	157	155,560	0,189
44	42,560	0,068	101	99,560	0,122	158	156,560	0,190
45	43,560	0,069	102	100,560	0,123	159	157,560	0,192
46	44,560	0,070	103	101,560	0,124	160	158,560	0,193
47	45,560	0,071	104	102,560	0,125	161	159,560	0,195
48	46,560	0,072	105	103,560	0,126	162	160,560	0,196
49	47,560	0,072	106	104,560	0,127	163	161,560	0,198
50	48,560	0,073	107	105,560	0,128	164	162,560	0,199
51	49,560	0,074	108	106,560	0,129	165	163,560	0,201
52	50,560	0,075	109	107,560	0,130	166	164,560	0,202
53	51,560	0,076	110	108,560	0,131	167	165,560	0,204
54	52,560	0,076	111	109,560	0,132	168	166,560	0,205
55	53,560	0,077	112	110,560	0,133	169	167,560	0,207
56	54,560	0,078	113	111,560	0,134	170	168,560	0,209
57	55,560	0,079	114	112,560	0,135	171	169,560	0,210

CALCULATION DATA GRAPH								
$\sigma = 97,59 \text{ MPa}; 538 \text{ }^\circ\text{C}$								
No.	Time (Hours)	Strain	No.	Time (Hours)	Strain	No.	Time (Hours)	Strain
172	170,560	0,212	229	227,560	0,358	286		
173	171,560	0,214	230	228,560	0,362	287		
174	172,560	0,216	231	229,560	0,367	288		
175	173,560	0,217	232	230,560	0,372	289		
176	174,560	0,219	233	231,560	0,377	290		
177	175,560	0,221	234	232,560	0,383	291		
178	176,560	0,222	235	233,560	0,388	292		
179	177,560	0,225	236	234,560	0,394	293		
180	178,560	0,226	237	235,560	0,400	294		
181	179,560	0,228	238	236,560	0,406	295		
182	180,560	0,230	239	237,560	0,412	296		
183	181,560	0,232	240	238,560	0,420	297		
184	182,560	0,234	241	239,560	0,427	298		
185	183,560	0,236	242	240,560	0,435	299		
186	184,560	0,238	243	241,560	0,444	300		
187	185,560	0,239	244	242,560	0,454	301		
188	186,560	0,241	245	243,560	0,465	302		
189	187,560	0,243	246	244,560	0,479	303		
190	188,560	0,245	247	245,560	0,497	304		
191	189,560	0,247	248	246,454	0,524	305		
192	190,560	0,250	249			306		
193	191,560	0,251	250			307		
194	192,560	0,254	251			308		
195	193,560	0,256	252			309		
196	194,560	0,258	253			310		
197	195,560	0,260	254			311		
198	196,560	0,262	255			312		
199	197,560	0,265	256			313		
200	198,560	0,267	257			314		
201	199,560	0,269	258			315		
202	200,560	0,272	259			316		
203	201,560	0,274	260			317		
204	202,560	0,276	261			318		
205	203,560	0,278	262			319		
206	204,560	0,282	263			320		
207	205,560	0,284	264			321		
208	206,560	0,286	265			322		
209	207,560	0,289	266			323		
210	208,560	0,292	267			324		
211	209,560	0,295	268			325		
212	210,560	0,298	269			326		
213	211,560	0,301	270			327		
214	212,560	0,304	271			328		
215	213,560	0,307	272			329		
216	214,560	0,310	273			330		
217	215,560	0,313	274			331		
218	216,560	0,316	275			332		
219	217,560	0,319	276			333		
220	218,560	0,323	277			334		
221	219,560	0,326	278			335		
222	220,560	0,330	279			336		
223	221,560	0,333	280			337		
224	222,560	0,337	281			338		
225	223,560	0,341	282			339		
226	224,560	0,345	283			340		
227	225,560	0,348	284			341		
228	226,560	0,353	285			342		

H.25 Tabel data hasil pengujian *creep-rupture* spesimen uji 4D.

<i>Material/Specimen</i>		SA-210 A1 -- 4D
<i>Machine</i>		GCTM
<i>Mass/test load</i>		113,806 kgs
<i>Temperature Set</i>		627 °C
<i>Start to Temperature</i>	<i>Time</i>	18.35 WITA
	<i>Date</i>	06/09/2021
<i>Finish at Temperature</i>	<i>Expansion</i>	2,719 mm
	<i>Time</i>	21.15 WITA
	<i>Date</i>	06/09/2021
	<i>Duration</i>	2 Hour 40 Min
<i>Duration (Heating Homogen)</i>		3 Hour
<i>Start loading</i>	<i>Time</i>	00.15 WITA
	<i>Date</i>	07/09/2021
	<i>Expansion</i>	2,802 mm
<i>Instantaneous Deformation (ID)</i>		5,414 mm
<i>Break/Fracture</i>	<i>Time</i>	23.49 WITA
	<i>Date</i>	07/09/2021
	<i>Duration (Predict. Fracture)</i>	4,69 Hrs -- 13,22 Hrs
	<i>Duration (actual Fracture)</i>	4 Hour 45 Min (4,76 Hours)
	<i>Length at Fracture (Dial)</i>	101,91 mm
	<i>Final Length (Ambient)</i>	93,40 mm
	<i>Area Fracture (W x t)</i>	7,1 x 2,5 mm
	<i>Reduction in Area (RA)</i>	66,27 %
	<i>Creep Strain Rate</i>	9,30E-02 h ⁻¹



MATERIAL :			SA-210 A1			SPECIMEN :		4D											
A (mm)	B (mm)	C (mm)	D (mm)	F (mm)	H (mm)	L (mm)	Width/W (mm)		Thickness/t (mm)						Hardness/H (BHN)		Applied For Test (mm ²)		
62,6	27	83,9	13	50	50	210,8	W ₁ :	12,60	t ₁ :	4,32	t _{1A} :	4,15	t _{1B} :	4,20	t _{1AVE} :	4,22	H ₁ :	117	54,4320
							W ₂ :	12,55	t ₂ :	4,33	t _{2A} :	4,20	t _{2B} :	4,25	t _{2AVE} :	4,26	H ₂ :	102	54,3415
							W ₃ :	12,60	t ₃ :	4,28	t _{3A} :	4,15	t _{3B} :	4,10	t _{3AVE} :	4,18	H ₃ :	130	53,9280
							W ₄ :	12,60	t ₄ :	4,29	t _{4A} :	4,15	t _{4B} :	4,15	t _{4AVE} :	4,20	H ₄ :	107	54,0540
							W ₅ :	12,65	t ₅ :	4,32	t _{5A} :	4,25	t _{5B} :	4,30	t _{5AVE} :	4,29	H ₅ :	104	54,6480
							W ₆ :	12,65	t ₆ :	4,36	t _{6A} :	4,25	t _{6B} :	4,30	t _{6AVE} :	4,30	H ₆ :	89	55,1540
							W _{AVE} :	12,61	t _{MIN} :	4,28	t _{MIN} :	4,15	t _{MIN} :	4,10	t _{AVEtot} :	4,24	H _{AVE}	108,17	A _{min}
							W _{MIN} :	12,55	Selected		N/A			t _{MIN} :	4,18	H _{MIN}	89	53,9280	

CREEP-RUPTURE DATA														
MATERIAL		SA-210 A1			SPECIMEN		4D		THICKNESS			Minimum (mm)		4,18
TEMPERATURE		627 °C			LOAD/MASS		113,806 kgs					Average (mm)		4,24
No.	Date	Time			Duration (hour)	Length / l (mm)	No.	Date	Time			Duration (hour)	Length / l (mm)	
		Hour	Min.	Sec.					Hour	Min.	Sec.			
1	06/09/2021	18	35	38	0,0	0,0	58							
2	Start Temp.	18	50	38	0,25	0,0	59							
3	--	19	05	38	0,25	0,650	60							
4	--	19	20	38	0,25	1,190	61							
5	--	19	35	38	0,25	1,562	62							
6	--	19	50	38	0,25	1,831	63							
7	--	20	05	38	0,25	2,061	64							
8	--	20	20	38	0,25	2,266	65							
9	--	20	35	38	0,25	2,430	66							
10	--	20	50	38	0,25	2,576	67							
11	--	21	05	38	0,25	2,668	68							
12	Finish Temp.	21	15	36	0,1661	2,719	69							
13	--	21	30	36	0,25	2,761	70							
14	--	21	45	36	0,25	2,775	71							
15	--	22	00	36	0,25	2,781	72							
16	--	22	15	36	0,25	2,785	73							
17	--	22	30	36	0,25	2,789	74							
18	--	22	45	36	0,25	2,794	75							
19	--	23	00	36	0,25	2,795	76							
20	--	23	15	36	0,25	2,795	77							
21	--	23	30	36	0,25	2,796	78							
22	--	23	45	36	0,25	2,798	79							
23	07/09/2021	00	00	36	0,25	2,799	80							
24	Finish Heat.	00	13	27	0,2142	2,802	81							
25	Start Load	00	14	48	0,25	5,414	82							
26	--	00	29	48	0,25	6,608	83							
27	--	00	44	48	0,25	7,285	84							
28	--	00	59	48	0,25	7,936	85							
29	--	01	14	48	0,25	8,630	86							
30	--	01	29	48	0,25	9,398	87							
31	--	01	44	48	0,25	10,188	88							
32	--	01	59	48	0,25	11,050	89							
33	--	02	14	48	0,25	11,984	90							
34	--	02	29	48	0,25	13,020	91							
35	--	02	44	48	0,25	14,180	92							
36	--	02	59	48	0,25	15,438	93							
37	--	03	14	48	0,25	16,864	94							
38	--	03	29	48	0,25	18,474	95							
39	--	03	44	48	0,25	20,351	96							
40	--	03	59	48	0,25	22,571	97							
41	--	04	14	48	0,25	25,361	98							
42	--	04	29	48	0,25	29,010	99							
43	--	04	44	48	0,25	34,510	100							
44	Aground	04	58	34	0,0038	46,800	101							
45	Split	12	01	30	0,0	47,590	102							
46	Fracture	12	01	58	0,0078	51,910	103							
47							104							
48							105							
49							106							
50							107							
51							108							
52							109							
53							110							
54							111							
55							112							
56							113							
57							114							
TOTAL DURATION CREEP & LENGTH					4,7616	51,910	TOTAL DURATION CREEP & LENGTH							
TOTAL TIME CREEP-RUPTURE (HOURS)												10,392		

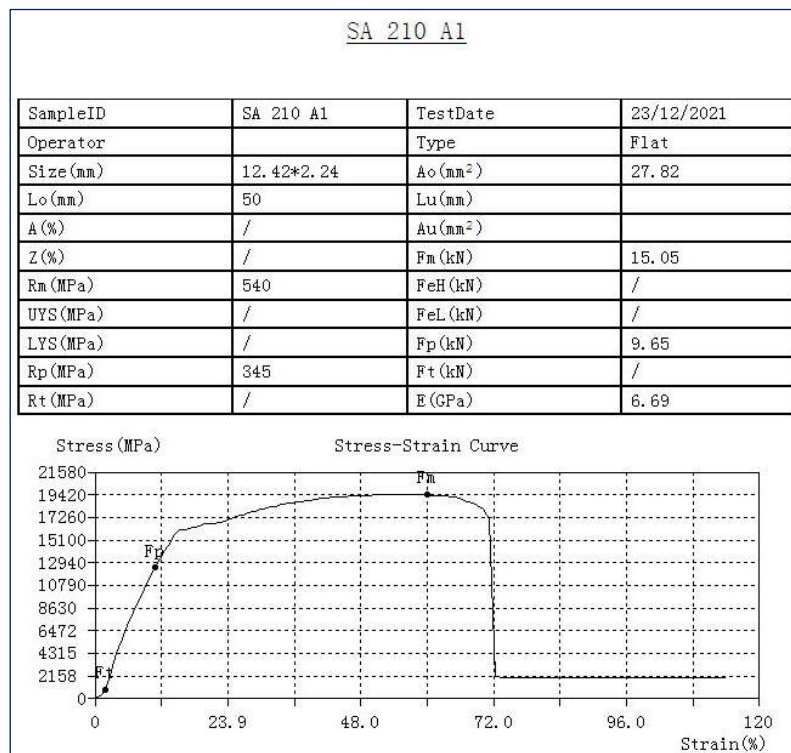
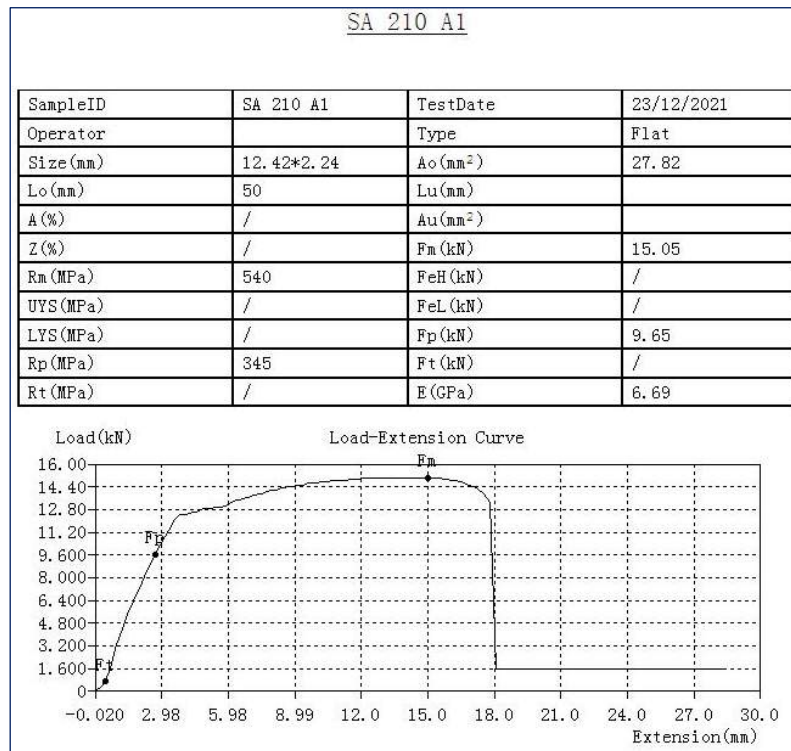
DATA ACTUAL ANALYSIS TABLE

No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58					
2	0,650	0,650	50,650	0,0130	1,300	59					
3	1,190	0,540	51,190	0,0238	2,380	60					
4	1,562	0,372	51,562	0,0312	3,124	61					
5	1,831	0,269	51,831	0,0366	3,662	62					
6	2,061	0,230	52,061	0,0412	4,122	63					
7	2,266	0,205	52,266	0,0453	4,532	64					
8	2,430	0,164	52,430	0,0486	4,860	65					
9	2,576	0,146	52,576	0,0515	5,152	66					
10	2,668	0,092	52,668	0,0534	5,336	67					
11	2,719	0,051	52,719	0,0544	5,438	68					
12	2,761	0,042	52,761	0,0552	5,522	69					
13	2,775	0,014	52,775	0,0555	5,550	70					
14	2,781	0,006	52,781	0,0556	5,562	71					
15	2,785	0,004	52,785	0,0557	5,570	72					
16	2,789	0,004	52,789	0,0558	5,578	73					
17	2,794	0,005	52,794	0,0559	5,588	74					
18	2,795	0,001	52,795	0,0559	5,590	75					
19	2,795	0,000	52,795	0,0559	5,590	76					
20	2,796	0,001	52,796	0,0559	5,592	77					
21	2,798	0,002	52,798	0,0560	5,596	78					
22	2,799	0,001	52,799	0,0560	5,598	79					
23	2,802	0,003	52,802	0,0560	5,604	80					
24	5,414	2,612	55,414	0,1083	10,828	81					
25	6,608	1,194	56,608	0,1322	13,216	82					
26	7,285	0,677	57,285	0,1457	14,570	83					
27	7,936	0,651	57,936	0,1587	15,872	84					
28	8,630	0,694	58,630	0,1726	17,260	85					
29	9,398	0,768	59,398	0,1880	18,796	86					
30	10,188	0,790	60,188	0,2038	20,376	87					
31	11,050	0,862	61,050	0,2210	22,100	88					
32	11,984	0,934	61,984	0,2397	23,968	89					
33	13,020	1,036	63,020	0,2604	26,040	90					
34	14,180	1,160	64,180	0,2836	28,360	91					
35	15,438	1,258	65,438	0,3088	30,876	92					
36	16,864	1,426	66,864	0,3373	33,728	93					
37	18,474	1,610	68,474	0,3695	36,948	94					
38	20,351	1,877	70,351	0,4070	40,702	95					
39	22,571	2,220	72,571	0,4514	45,142	96					
40	25,361	2,790	75,361	0,5072	50,722	97					
41	29,010	3,649	79,010	0,5802	58,020	98					
42	34,510	5,500	84,510	0,6902	69,020	99					
43	46,800	12,290	96,800	0,9360	93,600	100					
44	47,590	0,790	97,590	0,9518	95,180	101					
45	51,910	4,320	101,910	1,0382	103,820	102					
46						103					
47						104					
48						105					
49						106					
50						107					
51						108					
52						109					
53						110					
54						111					
55						112					
56						113					
57						114					

DATA CALCULATION ANALYSIS TABLE											
No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)	No.	Length (Dial)/ l (mm)	Diff. Length (mm)	Length/ l _f (mm)	Strain	Elongation (%)
1	0,0	0,0	50,0	0,0	0,0	58					
2	3,806	3,806	53,806	0,0761	7,612	59					
3	4,483	0,677	54,483	0,0897	8,966	60					
4	5,134	0,651	55,134	0,1027	10,268	61					
5	5,828	0,694	55,828	0,1166	11,656	62					
6	6,596	0,768	56,596	0,1319	13,192	63					
7	7,386	0,790	57,386	0,1477	14,772	64					
8	8,248	0,862	58,248	0,1650	16,496	65					
9	9,182	0,934	59,182	0,1836	18,364	66					
10	10,218	1,036	60,218	0,2044	20,436	67					
11	11,378	1,160	61,378	0,2276	22,756	68					
12	12,636	1,258	62,636	0,2527	25,272	69					
13	14,062	1,426	64,062	0,2812	28,124	70					
14	15,672	1,610	65,672	0,3134	31,344	71					
15	17,549	1,877	67,549	0,3510	35,098	72					
16	19,769	2,220	69,769	0,3954	39,538	73					
17	22,559	2,790	72,559	0,4512	45,118	74					
18	26,208	3,649	76,208	0,5242	52,416	75					
19	31,708	5,500	81,708	0,6342	63,416	76					
20	43,998	12,290	93,998	0,8800	87,996	77					
21	44,788	0,790	94,788	0,8958	89,576	78					
22	49,108	4,320	99,108	0,9822	98,216	79					
23						80					
24						81					
25						82					
26						83					
27						84					
28						85					
29						86					
30						87					
31						88					
32						89					
33						90					
34						91					
35						92					
36						93					
37						94					
38						95					
39						96					
40						97					
41						98					
42						99					
43						100					
44						101					
45						102					
46						103					
47						104					
48						105					
49						106					
50						107					
51						108					
52						109					
53						110					
54						111					
55						112					
56						113					
57						114					

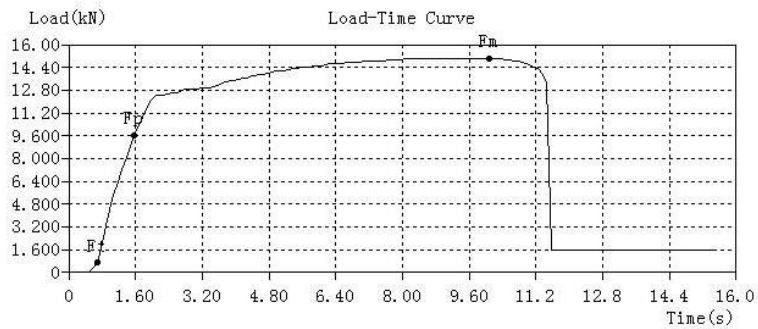
CALCULATION DATA GRAPH								
$\sigma = 79,22 \text{ MPa}; 627 \text{ }^\circ\text{C}$								
No.	Time (Hours)	Strain	No.	Time (Hours)	Strain	No.	Time (Hours)	Strain
1	0,0	0,0	58			115		
2	0,25	0,0761	59			116		
3	0,50	0,0897	60			117		
4	0,75	0,1027	61			118		
5	1,00	0,1166	62			119		
6	1,25	0,1319	63			120		
7	1,50	0,1477	64			121		
8	1,75	0,1650	65			122		
9	2,00	0,1836	66			123		
10	2,25	0,2044	67			124		
11	2,50	0,2276	68			125		
12	2,75	0,2527	69			126		
13	3,00	0,2812	70			127		
14	3,25	0,3134	71			128		
15	3,50	0,3510	72			129		
16	3,75	0,3954	73			130		
17	4,00	0,4512	74			131		
18	4,25	0,5242	75			132		
19	4,50	0,6342	76			133		
20	4,75	0,8800	77			134		
21	4,75	0,8958	78			135		
22	4,76	0,9822	79			136		
23			80			137		
24			81			138		
25			82			139		
26			83			140		
27			84			141		
28			85			142		
29			86			143		
30			87			144		
31			88			145		
32			89			146		
33			90			147		
34			91			148		
35			92			149		
36			93			150		
37			94			151		
38			95			152		
39			96			153		
40			97			154		
41			98			155		
42			99			156		
43			100			157		
44			101			158		
45			102			159		
46			103			160		
47			104			161		
48			105			162		
49			106			163		
50			107			164		
51			108			165		
52			109			166		
53			110			167		
54			111			168		
55			112			169		
56			113			170		
57			114			171		

H.26 Hasil pengujian kekuatan tarik spesimen uji ketebalan nominal 2 mm.



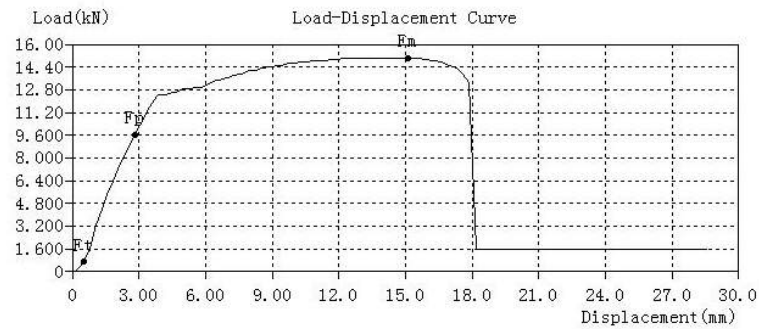
SA 210 A1

SampleID	SA 210 A1	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.42*2.24	Ao(mm ²)	27.82
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	15.05
Rm(MPa)	540	FeH(kN)	/
UYS(MPa)	/	FeL(kN)	/
LYS(MPa)	/	Fp(kN)	9.65
Rp(MPa)	345	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.69



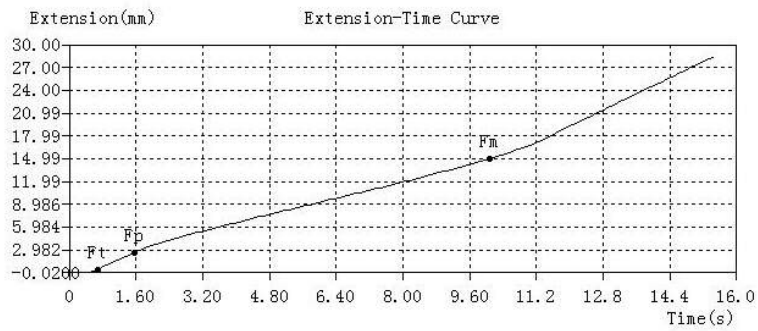
SA 210 A1

SampleID	SA 210 A1	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.42*2.24	Ao(mm ²)	27.82
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	15.05
Rm(MPa)	540	FeH(kN)	/
UYS(MPa)	/	FeL(kN)	/
LYS(MPa)	/	Fp(kN)	9.65
Rp(MPa)	345	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.69



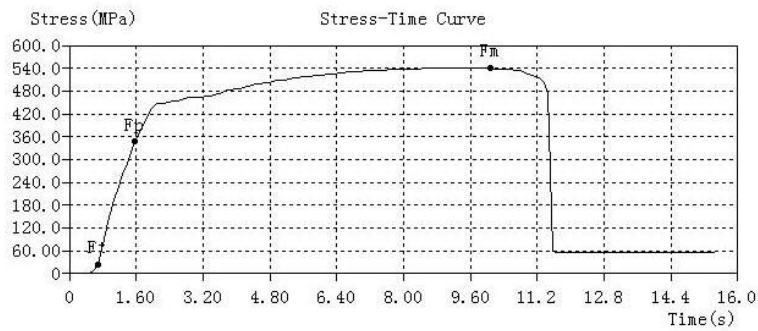
SA 210 A1

SampleID	SA 210 A1	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.42*2.24	Ao(mm ²)	27.82
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	15.05
Rm(MPa)	540	FeH(kN)	/
UYS(MPa)	/	FeL(kN)	/
LYS(MPa)	/	Fp(kN)	9.65
Rp(MPa)	345	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.69

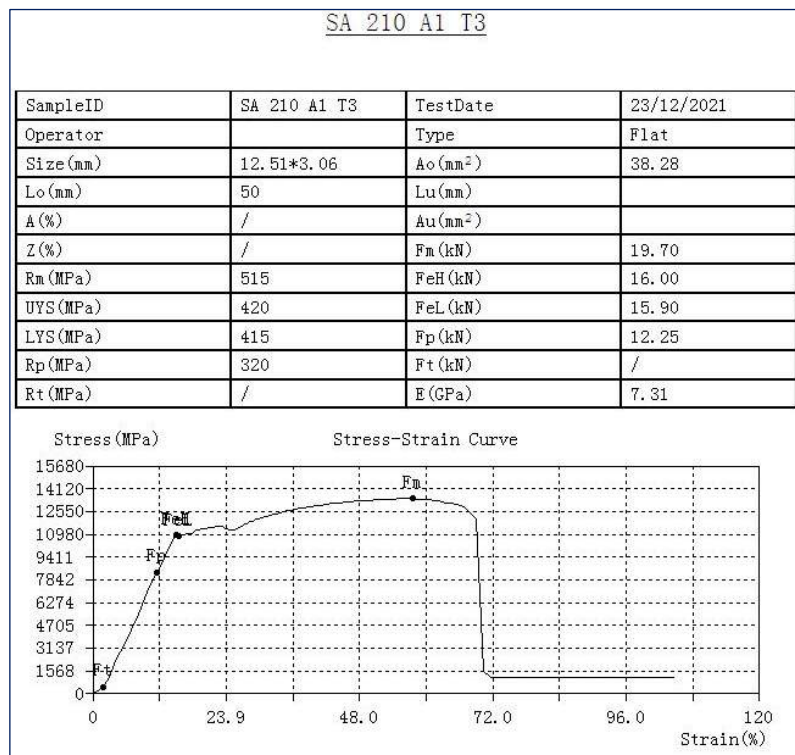
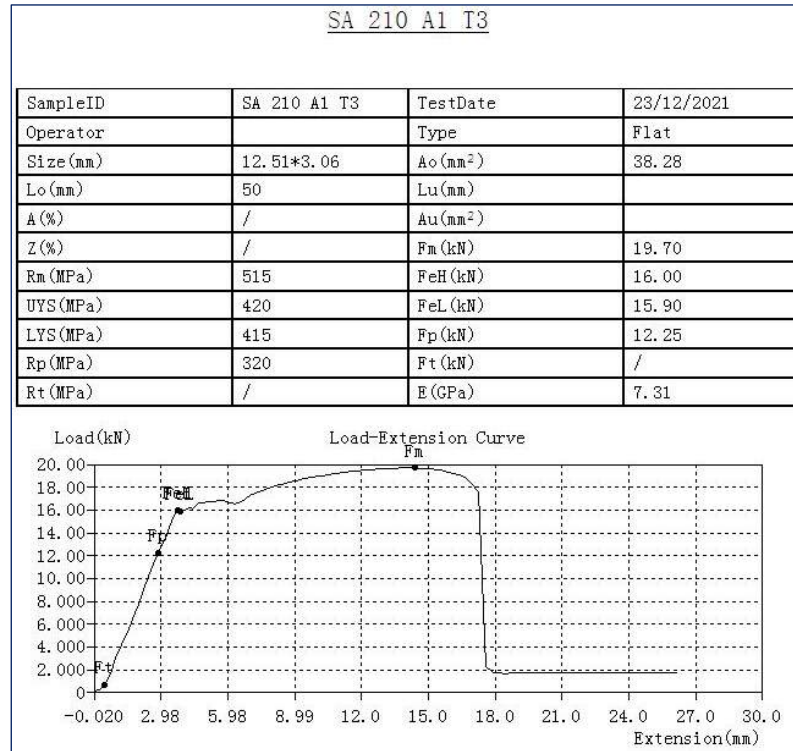


SA 210 A1

SampleID	SA 210 A1	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.42*2.24	Ao(mm ²)	27.82
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	15.05
Rm(MPa)	540	FeH(kN)	/
UYS(MPa)	/	FeL(kN)	/
LYS(MPa)	/	Fp(kN)	9.65
Rp(MPa)	345	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.69

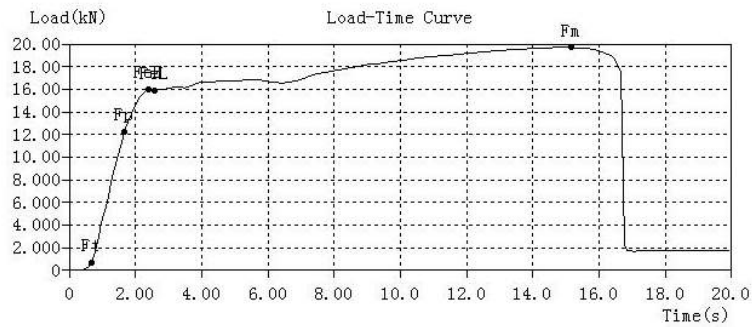


H.27 Hasil pengujian kekuatan tarik spesimen uji ketebalan nominal 3 mm.



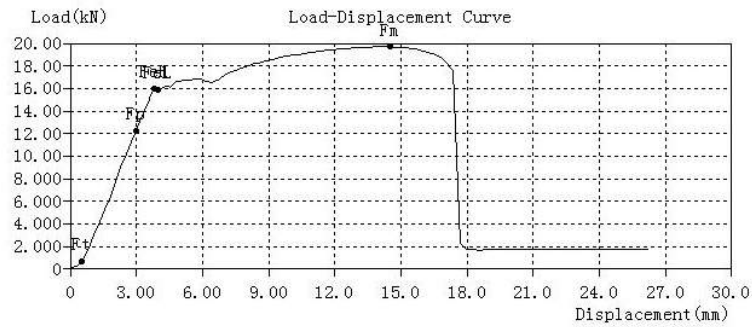
SA 210 A1 T3

SampleID	SA 210 A1 T3	TestDate	23/12/2021
Operator		Type	Flat
Size (mm)	12.51*3.06	Ao (mm ²)	38.28
Lo (mm)	50	Lu (mm)	
A (%)	/	Au (mm ²)	
Z (%)	/	Fm (kN)	19.70
Rm (MPa)	515	FeH (kN)	16.00
UYS (MPa)	420	FeL (kN)	15.90
LYS (MPa)	415	Fp (kN)	12.25
Rp (MPa)	320	Ft (kN)	/
Rt (MPa)	/	E (GPa)	7.31



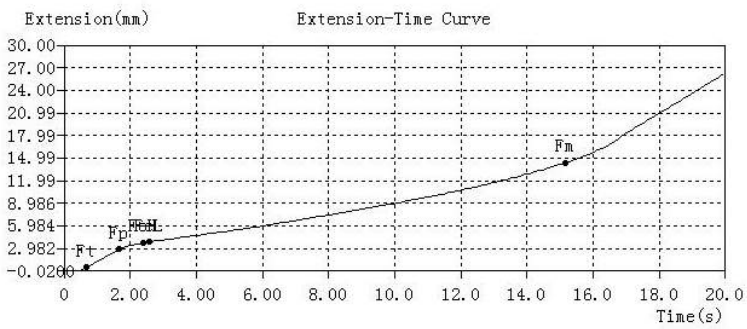
SA 210 A1 T3

SampleID	SA 210 A1 T3	TestDate	23/12/2021
Operator		Type	Flat
Size (mm)	12.51*3.06	Ao (mm ²)	38.28
Lo (mm)	50	Lu (mm)	
A (%)	/	Au (mm ²)	
Z (%)	/	Fm (kN)	19.70
Rm (MPa)	515	FeH (kN)	16.00
UYS (MPa)	420	FeL (kN)	15.90
LYS (MPa)	415	Fp (kN)	12.25
Rp (MPa)	320	Ft (kN)	/
Rt (MPa)	/	E (GPa)	7.31



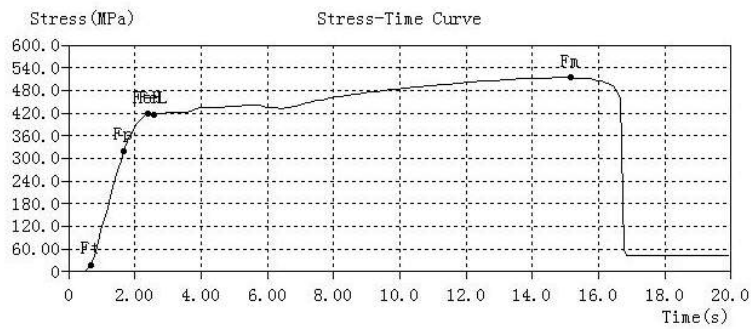
SA 210 A1 T3

SampleID	SA 210 A1 T3	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.51*3.06	Ao(mm ²)	38.28
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	19.70
Rm(MPa)	515	FeH(kN)	16.00
UYS(MPa)	420	FeL(kN)	15.90
LYS(MPa)	415	Fp(kN)	12.25
Rp(MPa)	320	Ft(kN)	/
Rt(MPa)	/	E(GPa)	7.31

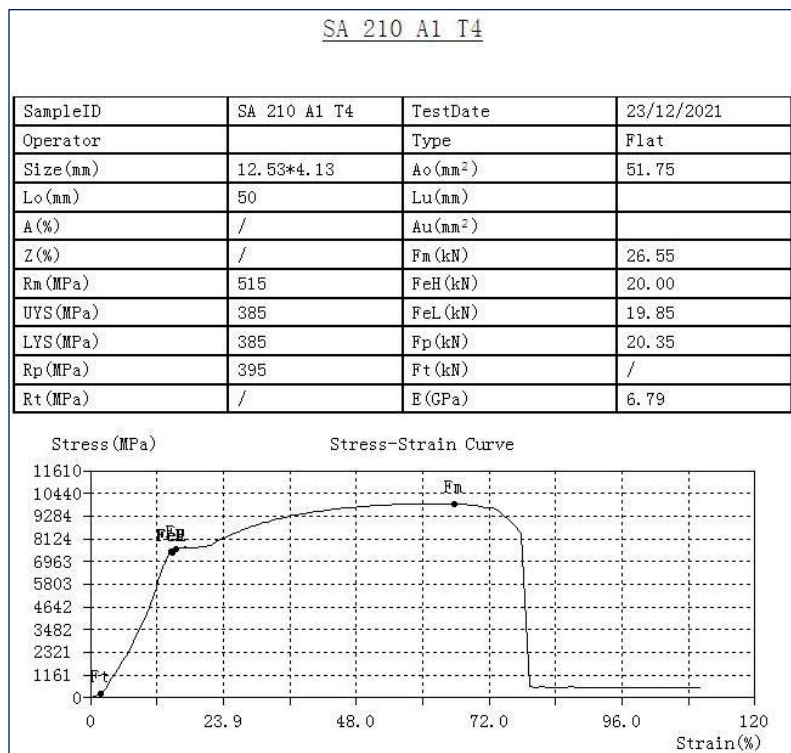
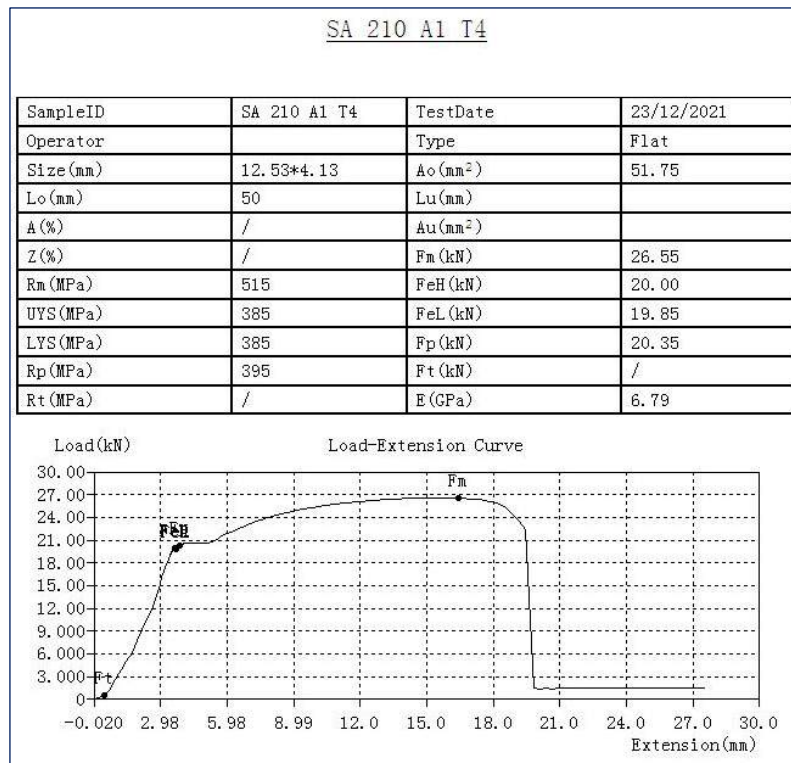


SA 210 A1 T3

SampleID	SA 210 A1 T3	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.51*3.06	Ao(mm ²)	38.28
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	19.70
Rm(MPa)	515	FeH(kN)	16.00
UYS(MPa)	420	FeL(kN)	15.90
LYS(MPa)	415	Fp(kN)	12.25
Rp(MPa)	320	Ft(kN)	/
Rt(MPa)	/	E(GPa)	7.31

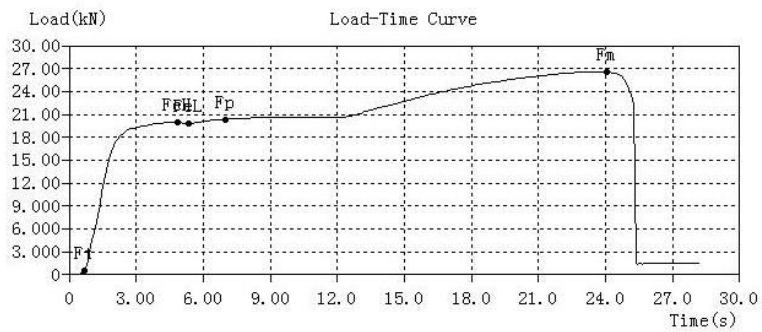


H.28 Hasil pengujian kekuatan tarik spesimen uji ketebalan nominal 4 mm.



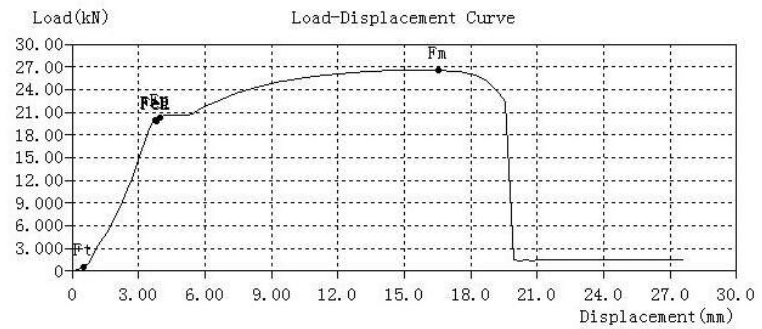
SA 210 A1 T4

SampleID	SA 210 A1 T4	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.53*4.13	Ao(mm ²)	51.75
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	26.55
Rm(MPa)	515	FeH(kN)	20.00
UYS(MPa)	385	FeL(kN)	19.85
LYS(MPa)	385	Fp(kN)	20.35
Rp(MPa)	395	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.79



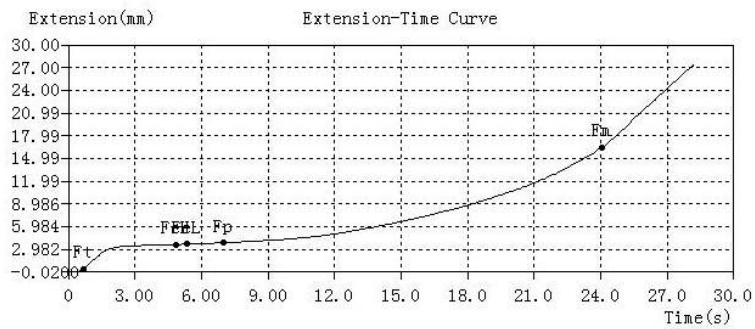
SA 210 A1 T4

SampleID	SA 210 A1 T4	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.53*4.13	Ao(mm ²)	51.75
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	26.55
Rm(MPa)	515	FeH(kN)	20.00
UYS(MPa)	385	FeL(kN)	19.85
LYS(MPa)	385	Fp(kN)	20.35
Rp(MPa)	395	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.79



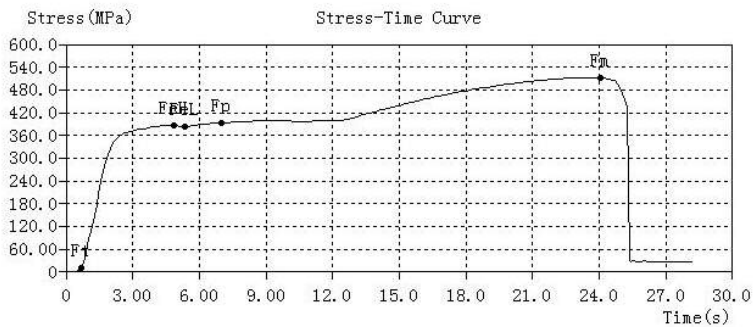
SA 210 A1 T4

SampleID	SA 210 A1 T4	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.53*4.13	Ao(mm ²)	51.75
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	26.55
Rm(MPa)	515	FeH(kN)	20.00
UYS(MPa)	385	FeL(kN)	19.85
LYS(MPa)	385	Fp(kN)	20.35
Rp(MPa)	395	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.79



SA 210 A1 T4

SampleID	SA 210 A1 T4	TestDate	23/12/2021
Operator		Type	Flat
Size(mm)	12.53*4.13	Ao(mm ²)	51.75
Lo(mm)	50	Lu(mm)	
A(%)	/	Au(mm ²)	
Z(%)	/	Fm(kN)	26.55
Rm(MPa)	515	FeH(kN)	20.00
UYS(MPa)	385	FeL(kN)	19.85
LYS(MPa)	385	Fp(kN)	20.35
Rp(MPa)	395	Ft(kN)	/
Rt(MPa)	/	E(GPa)	6.79






H.29 Hasil pengujian kekerasan spesimen uji skala Rockwell.

Perlakuan	Spec	Pengukuran Rookwell	Konversi
Pipa 2 mm	1	76.50 HRB	140.00 HBW
	2	77.10 HRB	141.30 HBW
	3	76.40 HRB	139.80 HBW
Pipa 3 mm	1	77.80 HRB	143.40 HBW
	2	79.70 HRB	149.10 HBW
	3	79.20 HRB	147.60 HBW
Pipa 4 mm	1	77.00 HRB	141.00 HBW
	2	79.30 HRB	147.90 HBW
	3	77.40 HRB	142.20 HBW




Kepala Laboratorium
Metalurgi Fisisk
[Signature]
Dr. Lukmanul Hakim, ST., MT
Nip.197404151999031001

H.30 Sertifikat material (*mill certificate*) spesimen uji ketebalan nominal 4 mm.

Rohrwerk Maxhütte GmbH 92237 Sulzbach-Rosenberg				Abnahmeprüfzeugnis / Inspection certificate / Certificat de réception DIN EN 10204 :08.1995 - 3.1C / :01.2005 - 3.2				 Post: 92237 Sulzbach-Rosenberg, Franz-Kunze-Straße 1 Telefon 09661 814 161																									
Konformität zur Druckgeräterichtlinie 2014/68/EU Anhang I Abs. 4.3 u. 7.5 ist sichergestellt / Conformity to the Pressure Equipment Directive 2014/68/EU appendix I exp. 4,3 and 7,5 is guaranteed				Erzeugnisform/Product/Produit: nahtlose Stahlrohre/ seamless steel tubes Tubes en acier sans soudure				Lieferbedingungen und/oder amtliche Vorschriften / Terms of delivery and/or official regulations / Conditions de livraison et/ou prescriptions officielles: ASTM A210/A210M : 2012 ASTM A450/A450M : 2015 ASME SA-210/SA-210M ASME SA-450/SA-450M ASME Sect. II Part A 2015																									
PT. Indoboller Jl. Puri Dagiin Raya Blok I-3 No. 5 Kel. Jatimelati, Kec. Pondok Melati 17113 Kota Bekasi / Jawa Barat Indonesia				Werkstoff/Lieferzustand / Quality/Condition of delivery Qualität/Etat de livraison ASTM A 210 GR A-1				Dede Rukanda IB-214-2016																									
Lieferanzettel/delivery note:/concernement l' avis d'expédition Nr./No.: GWA007				Bestell-Nr./Order No./No. de commande:				Chemische Zusammensetzung (Schmelzenanalyse) / of cast/composition chimique																									
Auftrags-Nr./Order-No./ No. de l'usine		Pos.		Abmessungen/Dimensions/Dimensions mm		Zeichen/ Bundel bundles		Stück/ pieces		Gewicht/ weight kg		Meter		Schmelzen-Nr./ Heat No./ Cauté No.		% C		% Si		% Mn		% P		% S		% Nb		% V		% Ti		% Cr	
VK 1601994 RW 801263		010 1		2,374 x 0,157 in. x 393,700 in. [60,3 x 4,0 mm] x 10000 mm Mindestwand / Minimum wall		14		310		19.258		3.100,00		287008		0,13		0,24		0,78		0,007		0,001		0,001		0,000		0,001		0,14	
The manufacturer states that the material has been manufactured by an approved process and tested in accordance with the Rules of LR.																% Ni		% Mo		% Cu		% N		% Al		% Sn		% B		CEV		J-Faktor	
0,06																0,02		0,09		0,0070		0,025		0,005		0,0002		0,30		122			
Erschmelzungsart/melting process/mode d'elaboration:				frei von Radioaktivität				E-Stahl				full killed				Schmelzen-Nr. = Ident-Nr.																	
Ergebnis der Prüfungen/Test results/resultats des essais																Zerstörungsfreie Prüfung / non destructive test / Essai non destructif Ultraschallprüfung / ultrasonic testing method / ultra-sons test Prüfanforderung/testing requirement/Exigences d'essai																	
Pos./ Item		Probe Nr./ Test No Epreuve		Yield strength (MPa / N/mm ²)		Tensile Strength (MPa / N/mm ²)		Elongation in 2in (%)		X Besichtigung und Ausmessung/ Inspection and measurement/ Inspection et mesure X Zugversuch (s. Tafel)/tensile test (cf. table)/essai de traction (voir tableau) ASTM A 370 : 2016 X Ringaufdiversuch/ ring expanding test/essai d'évasement de diamètre ASTM A 370 : 2016 X Ringfaltversuch/ flatterring test/essai d'aplatissement ASTM A 370 : 2016 X Aufwölbversuch/expanding test/essai d'évasement ASTM A 370 : 2016 X Biegeversuch / bending test / essai d'pliage ASTM A 370 : 2016 X Härteprüfung / hardness test / essai de dureté ASTM A 370 : 2016 76 / 77 / 77 Ø 77 HRB Kerbschlag-Biegeversuch/ notched bar impact bend test/essai de résilience : ISO-V longitudinal ASTM A 370 : 2016 ASTM E 23 : 2016 ASTM E 23 DIN EN ISO 148-1:2011-01 Solwert: ≥ 27 J																							
010		1		365		475		34,5		Verwechslungsprüfung / test for mixing up steel grade / essai au confusion de qualités d'acier (PMI) US-Prüfung am Vormaterial / ultrasonic testing on blooms / essai d'ultra-son sur blooms X Auf Dichtheit geprüft/ inspected for tightness/Essays sur étanchéité ungeprüfte Rohrenden wurden abgezeichnet X Mit Wirbelstrom/with eddy current test/avec courant de Foucault (NDE) ASTM E 309 : 2016 X Mit Wasserinnendruck/ with hydr. test/hydrauiquement ASTM A 450 à MPa X Die Röhre haben freien Durchgang/ The tubes have free passages/propres pas d'objections X Walzandtemperatur/ final temperature of rolling/température finale de laminage ca. 900°C X Glühzustand/ annealing condition/ état recuit einwandfrei/unobjectionable/ irrécusable X normalisiert/ normalized/ normalisé; normalisierend gewalzt / normalized rolled / normalisée laminés NT (normalized and tempered) X Die mit "X" bezeichneten Prüfungen wurden durchgeführt und nicht beanstandet / The tests marked with "X" were performed and did not lead to objection / Les essais marqués d'un "X" étaient accomplis et n'entraînent pas d'objections.																							
2		342		472		34,3		Zeichen des Herstellers: RMH Mark of the manufacturer: / Signe du manufacture: Stamp of the inspection representative:  Timbre du contrôleur:  Qualitätsstelle / Abnahmebeauftragter quality control point Inspection representative poste de contrôle de qualité / contrôleur																									
3		351		472		33,0		Es wird bestätigt, dass die Lieferung den Vereinbarungen bei der Bestellung entspricht. We hereby certify, that the material described above has been tested and complies with the terms of the order. Il est confirmé que le matériel est essayé et conforme aux conditions de la commande.																									
4		341		472		35,0		Certificate-No. 1601994010 Datum/Date: 02.11.2016 Blatt 1 von 1 / Page 1 of 1																									
5		356		472		34,8		92237 Sulzbach-Rosenberg Plewsh																									

Lampiran I Data Pendukung Penelitian

I.1 Berita Acara pengambilan data.

	<p>KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN UNIVERSITAS HASANUDDIN DEPARTEMEN MESIN FAKULTAS TEKNIK Jalan Poros Malino Km. 6 Bontomarannu Gowa, 90245, Sulawesi Selatan ☎ (0411) 586015, 586262 Fax (0411) 586015 http://eng.unhas.ac.id E-mail: teknik@unhas.ac.id</p>
<u>BERITA ACARA PENGAMBILAN DATA</u>	
<p>Pada hari ini selasa, tanggal dua puluh tujuh bulan oktober tahun dua ribu dua puluh (27-10-2020), yang bertanda tangan dibawah ini :</p>	
1. Nama	: WAHYU HARI PURNOMO, S.T., M.M.
NPP	: 1016788426
Jabatan	: CFPP Manager PT. ANTAM, Tbk UBPN Sulawesi Tenggara.
2. Nama	: MISWAR.
NIM	: D022181004
Jabatan	: Mahasiswa Program Pendidikan S2 (Magister) Teknik Mesin Universitas Hasanuddin
<p>Bahwa Mahasiswa tersebut di atas telah selesai melakukan pengambilan data penelitian dalam rangka penulisan jurnal dan/atau tesis pada objek penelitian <i>economizer tube</i> dengan spesifikasi boiler,</p>	
Tipe	: <i>Circulating Fluidized Bed (CFB)</i> ,
No. Seri/No. Unit	: VVDC0100-U2 / Unit 2,
Tahun Pembuatan	: 2014,
Tekanan Kerja Maks.	: 13,7 MPa (MAWP),
Pemilik/Pemakai	: PT. ANTAM, Tbk UBPN Sulawesi Tenggara.
<p>Adapun data terlampir.</p>	
<p>Demikian berita acara ini dibuat dan untuk dipergunakan sebagaimana mestinya.</p>	
Mengetahui, PT. ANTAM, Tbk UBPN Sulawesi Tenggara	Yang mengambil data, Mahasiswa
	
<u>WAHYU HARI PURNOMO, S.T., M.M.</u> CFPP Manager	<u>MISWAR</u>

I.2 Hasil pengukuran dimensi ketebalan aktual dan diameter luar *economizer tubes* di lokasi PLTU.

Page : 1


INSPECTION RECORD
(Wall Thickness Check)

1. Nama Perusahaan : PT. ANTAM , Tbk UBPN Sulawesi Tenggara
2. Objek/peralatan : Economizer Tubes Boiler; Type CFB, S/N : *VVDC0100-U2 (Unit 2)*
3. Material/bahan : SA-210 Gr. A1; Temperatur operasi (Inlet); 214 °C
4. Lokasi : Area PLTU, PT. ANTAM, Tbk UBPN Sulawesi Tenggara
5. Tanggal Pemeriksaan : 26 November 2018

No.	Nama/Posisi	0° (mm)	90° (mm)	180° (mm)	270° (mm)	Diameter OD (mm)	Keterangan
1.	Economizer Tube, Row : 1	4.30	4.32	N/A	4.39	31.9	0 - 590 mm
	Economizer Tube, Row : 1	4.42	4.52	N/A	4.46	31.9	590-1200 mm
	Economizer Tube, Row : 1	4.35	4.31	N/A	4.31	32.0	1200-1900 mm
2.	Economizer Tube, Row : 4	4.25	4.19	N/A	4.13	31.9	0 - 590 mm
	Economizer Tube, Row : 4	4.29	4.34	N/A	4.33	32.0	590-1200 mm
	Economizer Tube, Row : 4	4.47	4.23	N/A	4.37	31.9	1200-1900 mm
3.	Economizer Tube, Row : 7	4.46	4.44	N/A	4.59	32.0	0 - 590 mm
	Economizer Tube, Row : 7	4.31	4.40	N/A	4.36	32.1	590-1200 mm
	Economizer Tube, Row : 7	4.42	4.38	N/A	4.42	31.9	1200-1900 mm
4.	Economizer Tube, Row : 10	4.32	4.25	N/A	4.30	32.0	0 - 590 mm
	Economizer Tube, Row : 10	4.23	4.38	N/A	4.35	31.8	590-1200 mm
	Economizer Tube, Row : 10	4.29	4.19	N/A	4.44	32.0	1200-1900 mm
5.	Economizer Tube, Row : 15	4.34	4.32	N/A	4.29	31.9	0 - 590 mm
	Economizer Tube, Row : 15	4.27	4.37	N/A	4.38	32.0	590-1200 mm
	Economizer Tube, Row : 15	4.28	4.31	N/A	4.48	32.0	1200-1900 mm


Catatan : Pengambilan sampel dari arah kiri boiler (left boiler), bagian atas (baris pertama) .

Mengetahui,
PT. ANTAM, Tbk
UBPN Sulawesi Tenggara



WAHYU HARI PURNOMO, ST, MM
CFPP Manager

Pemeriksa/ Inspector



MISWAR

I.3 Hasil pengukuran nilai kekerasan *economizer tubes* di lokasi PLTU.

Page : 2

INSPECTION RECORD
(Hardness Test)

1. Nama Perusahaan : PT. ANTAM, Tbk UBPN Sulawesi Tenggara
 2. Objek/peralatan : Economizer Tubes Boiler ; Type CFB, S/N : *VVDC0100-U2 (Unit 2)*
 3. Material/Bahan : SA-210 Gr. A1; Temperatur operasi (Inlet); 214 ° C.
 4. Lokasi : Area PLTU, PT. ANTAM, Tbk UBPN Sulawesi Tenggara
 4. Tanggal Pemeriksaan : 26 November 2018

No.	Nama/Posisi	HARDNESS (I)			HARDNESS (II)			HARDNESS (III)			HARDNESS (AV.)			Ket.
		HB	HV	HRB	HB	HV	HRB	HB	HV	HRB	HB	HV	HRB	
1.	Economizer Tube, Row : 1	148	150	80.6	123	124	70.2	130	131	73.4	133.7	135.0	74.7	0 - 590 mm
	Economizer Tube, Row : 1	135	136	75.6	138	139	76.7	119	120	68.7	130.7	131.7	73.7	590-1200 mm
	Economizer Tube, Row : 1	122	123	69.9	127	128	72.3	147	145	79.4	132.0	132.0	73.9	1200-1900 mm
2.	Economizer Tube, Row : 4	146	148	79.7	157	159	83.1	113	114	65.1	138.7	140.3	76.0	0 - 590 mm
	Economizer Tube, Row : 4	138	139	76.7	119	120	68.4	83	83	41.1	113.3	114.0	62.1	590-1200 mm
	Economizer Tube, Row : 4	113	114	65.1	142	143	78.2	113	114	65.1	122.7	123.7	69.5	1200-1900 mm
3.	Economizer Tube, Row : 7	135	137	75.9	135	136	75.6	126	127	72	132.0	133.3	74.5	0 - 590 mm
	Economizer Tube, Row : 7	141	143	77.9	97	97	54.7	109	108	62.4	115.7	116.0	65.0	590-1200 mm
	Economizer Tube, Row : 7	127	128	72.3	139	140	77.2	133	134	74.8	133.0	134.0	74.8	1200-1900 mm
4.	Economizer Tube, Row : 10	132	133	74.2	135	137	75.9	111	111	63.8	126.0	127.0	71.3	0 - 590 mm
	Economizer Tube, Row : 10	147	148	79.9	96	96	53.9	91	91	49.4	111.3	111.7	61.1	590-1200 mm
	Economizer Tube, Row : 10	135	137	75.9	104	104	59.6	141	143	77.9	126.7	128.0	71.1	1200-1900 mm

No.	Nama/Posisi	HARDNESS (I)			HARDNESS (II)			HARDNESS (III)			HARDNESS (AV.)			Ket.
		HB	HV	HRB	HB	HV	HRB	HB	HV	HRB	HB	HV	HRB	
5.	Economizer Tube, Row : 15	135	136	75.6	126	127	72.0	139	140	77.2	133.3	134.3	74.9	0 - 590 mm
	Economizer Tube, Row : 15	128	129	72.8	136	138	76.1	136	138	76.1	133.3	135.0	75.0	590-1200 mm
	Economizer Tube, Row : 15	148	150	80.4	92	93	50.7	135	137	75.9	125.0	126.7	69.0	1200-1900 mm

Mengetahui,
PT. ANTAM, Tbk
UBPN Sulawesi Tenggara



WAHYU HARI PURNOMO, ST, MM
CFPP Manager



Pemeriksa/Inspector



MISWAR

DATE : 27/08/2018



**UNIT 2 BOILER
DAILY LOGGING SHEET 1**

CHECKED BY 	APPROVED BY 
---	--

TIME	20HFB12	20HFB22	20B0F01 FK1	20HAC10 CT021KQ S4	20HAC10	20HAC10	20HAC10	20HAC10	20LAB60	20LAB50	20HAD11	20HAD11 CP131KQ S2	20LSA25	20LSA25	20LSA25	20LAB70	20HAH10	20HAH20	20HAH20	20HAH30	20HAH30	20HAH40	20HAH40			
	AF001KQ S8	AF001KQ S8			CF031KQ S4	CF032KQ S4	CF032KQ S4	CF111KQ S1	CF111KQ S1	CF111KQ S1	CF111KQ S1		CF151KQ S0	CF021KQ S0	CF111KQ S1	CF121KQ S0	CF101KQ S2	CF031KQ S4	CF021KQ S4	CF081KQ S4	CF021KQ S4	CF031KQ S4	CF031KQ S4	CF021KQ S4	CF021KQ S4	CF031KQ S4
	CFW A WEIGHT SCALE	CFW B WEIGHT SCALE			FUEL OIL FD LOW INPUT	ECO I/L TEMP	ECO O/L TEMP (FRONT)	ECO O/L TEMP (REAR)	ECO INLET PRESS	BFW FLOW	BFP DISCHAR GE PRESS		STEAM DRUM PRESS	CONF BL DWIN FLOW	MAIN STEAM TEMP	MAIN STEAM FLOW	MAIN STM PRESS	DESH SPRAY WATER FLOW	15H O/L TEMP	25H I/L TEMP	25H O/L TEMP	35H I/L TEMP	35H O/L TEMP	45H I/L TEMP	45H O/L TEMP	
t/h	t/h	kl/h	degC	degC	degC	MPaG	t/h	MPa	MPa	t/h	degC	t/h	MPa	t/h	degC	degC	degC	degC	degC	degC	degC	degC				
00:00	8,54	8,55	0,00	214,36	278,74	275,63	10,92	100,06	16,26	10,75	2,38	525,19	108,26	10,07	12,01	433,8	389,8	445,0	401,1	469,0	468,1	528,2				
01:00	8,33	8,33	0,00	213,68	278,55	275,44	10,88	98,52	16,32	10,71	2,35	524,48	106,23	10,05	11,65	432,3	390,3	445,0	400,1	467,4	466,5	527,1				
02:00	8,23	8,23	0,00	212,63	278,36	275,25	10,83	96,38	16,40	10,67	2,36	522,34	103,97	10,03	11,45	431,9	390,5	445,0	398,6	468,0	467,2	525,0				
03:00	7,87	7,87	0,00	210,73	276,72	273,67	10,80	93,14	16,52	10,63	2,35	518,17	99,81	10,04	10,82	429,2	391,2	445,0	396,2	466,7	466,0	520,6				
04:00	8,17	8,17	0,00	212,07	278,35	275,27	10,84	96,11	16,43	10,68	2,35	520,57	103,32	10,05	11,07	430,5	391,4	445,0	398,2	470,0	469,3	523,6				
05:00	8,21	8,21	0,00	212,55	278,96	275,87	10,85	96,83	16,40	10,68	2,35	522,12	103,97	10,04	11,02	429,6	391,6	445,0	398,6	469,8	469,2	524,8				
06:00	8,16	8,17	0,00	212,07	278,81	275,73	10,83	96,07	16,44	10,66	2,36	521,37	102,78	10,04	10,75	428,4	392,0	445,0	397,9	468,3	467,5	524,1				
07:00	8,12	8,12	0,00	211,79	278,35	275,27	10,84	95,89	16,45	10,67	2,35	520,70	102,41	10,05	10,49	426,9	392,5	445,0	397,7	467,6	466,9	523,5				
08:00	8,17	8,17	0,00	212,24	278,77	275,70	10,85	96,90	16,42	10,68	2,36	521,62	103,34	10,05	10,42	428,1	393,0	445,0	398,2	467,5	466,6	524,4				
09:00	8,16	8,16	0,00	212,68	279,42	276,31	10,87	97,85	16,40	10,70	2,36	522,72	104,21	10,07	10,36	425,6	393,3	445,0	398,8	466,7	465,9	525,7				
10:00	8,25	8,26	0,00	213,14	279,91	276,78	10,86	98,79	16,36	10,69	2,34	523,36	105,30	10,04	10,38	425,4	393,6	445,0	399,4	468,3	467,3	526,3				
11:00	8,54	8,54	0,00	213,76	280,08	276,83	10,87	101,61	16,24	10,70	2,32	523,94	107,66	10,02	11,75	424,6	384,3	441,1	397,3	469,8	468,8	526,7				
12:00	8,49	8,49	0,00	214,15	276,73	273,68	10,98	99,64	16,23	10,81	1,99	522,30	108,78	10,13	13,17	435,9	383,1	441,1	398,2	470,4	469,5	525,4				
13:00	8,28	8,27	0,00	214,23	277,12	274,04	10,90	98,92	16,29	10,73	2,00	521,85	107,81	10,05	12,40	435,4	387,6	445,0	400,7	472,5	471,7	526,6				
14:00	8,41	8,40	0,00	214,76	278,67	275,72	10,90	99,56	16,26	10,73	2,00	524,83	108,90	10,04	12,70	437,0	387,7	445,0	401,4	472,3	471,8	527,6				
15:00	8,29	8,29	0,00	213,96	279,07	275,89	10,88	98,07	16,32	10,71	1,98	523,23	107,05	10,04	12,35	436,3	388,3	444,9	400,3	470,9	470,5	526,0				
16:00	8,37	8,36	0,00	214,33	279,28	276,14	10,91	99,38	16,29	10,74	2,00	524,06	108,09	10,05	12,13	435,1	389,1	445,0	400,9	470,0	469,4	526,9				
17:00	8,30	8,30	0,00	214,08	279,02	275,91	10,89	99,04	16,30	10,72	2,00	523,49	107,57	10,04	11,84	433,2	389,9	445,0	400,5	467,8	467,2	526,3				
18:00	8,34	8,35	0,00	217,23	282,35	279,18	10,98	105,60	16,06	10,81	2,01	528,57	114,86	10,04	12,61	435,9	390,0	445,0	404,3	472,4	471,3	531,5				
19:00	9,28	9,29	0,00	218,61	284,49	281,33	11,03	108,50	15,93	10,86	2,00	530,52	117,71	10,06	12,80	437,2	390,4	444,9	406,1	476,2	474,9	533,4				
20:00	9,29	9,31	0,00	218,99	284,77	281,64	11,06	109,50	15,89	10,89	2,00	531,37	118,40	10,07	12,75	436,6	390,7	445,0	406,8	478,6	477,4	534,2				
21:00	8,98	8,98	0,00	217,58	283,71	280,58	10,99	106,55	16,02	10,82	2,00	529,41	114,72	10,04	12,26	434,0	391,1	445,0	404,8	476,4	475,4	532,1				
22:00	8,76	8,77	0,00	216,33	282,87	279,73	10,95	103,77	16,14	10,78	1,99	527,51	113,84	10,04	11,80	432,9	391,1	445,0	403,0	474,0	473,0	530,3				
23:00	8,46	8,46	0,00	214,62	281,06	277,96	10,91	100,81	16,27	10,74	1,99	524,99	108,25	10,06	11,12	429,8	391,6	445,0	401,0	470,7	469,8	527,7				
Minimum	7,87	7,87	0,00	210,73	276,72	273,67	10,80	93,14	16,52	10,63	1,98	518,17	99,81	10,02	10,36	424,6	383,1	441,1	396,2	466,7	465,9	520,6				
Maximum	9,29	9,31	0,00	218,99	284,77	281,64	11,06	109,50	16,52	10,89	2,38	531,37	118,40	10,13	13,17	437,2	393,6	445,0	406,8	478,6	477,4	534,2				
Average	8,44	8,44	0,00	214,19	279,77	276,65	10,90	99,90	16,28	10,75	2,18	524,20	107,72	10,05	11,67	431,8	390,2	444,7	400,4	470,5	469,6	527,0				

DATE : 27/08/2018



**UNIT 2 BOILER
DAILY LOGGING SHEET 3**

CHECKED BY	APPROVED BY
	

TIME	20HL010	20HL020	20HL010	20HL020	20HLA14	20HLA15	20HLA16	20HLA17	20HLA25	20HLA26	20TAF01	20HLA14	20HLA30		20HBK12	20HBK11	20HBK11	20HBK11	20HBK11	20HBK11	20HBK11	20HBK11	20HBK11	20HBK12	20HBK12	20HBK12	20HBK12	20HBK13	20HBK13
	CT041XQ	CT041XQ	CP131XQ	CP131XQ	CF131ZQ	CF131TPC	CF131TPC	CF131PTC	CF131TPC	CF131TPC	PV15	CP144XQ	CP132XQ		CPPV11	CTPV11	CT002XQ	CT003XQ	CT004XQ	CT032XQ	CT033XQ	CT034XQ	CT092XQ	CT092XQ	CT093XQ	CT094XQ	CT094XQ	CF141XQ	CF151XQ
	PA (1GAH O/L) TEMP	SA (2GAH O/L) TEMP	PA (1GAH O/L) PRESS	SA (2GAH O/L) PRESS	WIND BOX AIRFLOW	0.5M AIR FLOW/CORRECTION	COAL FEEDING SYS AIR FLOW	ST-UP BRN AIR FLOW/COR	ZM AIR FLOW CORRECTION	4M AIR FLOW CORRECTION	TOTAL AIR FLOW	WIND BOX PRESS	HP BLOWER OUTLET PRESS		FURNACE LOWPRESS	FRNC BOTTOM TEMP	FRNC BOTTOM TEMP (PT A)	FRNC BOTTOM TEMP (PT B)	FRNC BOTTOM TEMP (PT C)	FRNC BOTTOM TEMP (RR A)	FRNC BOTTOM TEMP (RR B)	FRNC BOTTOM TEMP (RR C)	FURNACE LOW TEMP (R)	FURNACE LOW TEMP (R)	FURNACE LOW TEMP (L)	FURNACE LOW TEMP (RR)	FURNACE MID. PRESS (R)	FURNACE MID. PRESS (L)	
degC	degC	kPa	kPa	kNm3/h	kNm3/h	kNm3/h	kNm3/h	kNm3/h	kNm3/h	kNm3/h	kPa	kPa		kPa	degC	degC	degC	degC	degC	degC	degC	degC	degC	degC	degC	degC	kPa	kPa	
00:00	207.4	215.3	15.31	6.77	56.40	5.13	7.31	4.50	12.18	10.11	101.8	10.79	55.0		6.76	839	848	818	844	853	837	835	818	818	805	815	-0.03	-0.04	
01:00	208.2	216.5	15.00	6.62	54.92	4.99	7.27	4.49	12.11	9.88	99.9	10.26	55.0		6.48	842	851	824	844	853	837	835	821	821	808	822	-0.05	-0.05	
02:00	207.3	215.9	14.84	6.31	54.31	4.94	7.25	4.50	11.80	9.42	98.5	10.16	55.1		6.50	843	845	825	851	846	839	843	815	815	814	820	-0.05	-0.06	
03:00	205.8	214.8	14.32	5.52	51.83	4.71	7.12	4.49	10.95	8.47	94.0	10.04	54.9		6.73	847	846	827	864	847	841	859	816	816	826	822	-0.05	-0.06	
04:00	205.9	215.0	14.82	6.11	54.19	4.93	7.23	4.50	11.55	9.21	97.8	10.31	54.9		6.67	843	838	826	866	839	818	857	808	808	827	819	-0.04	-0.04	
05:00	207.1	216.4	14.80	6.09	54.48	4.96	7.25	4.50	11.51	9.17	98.1	10.41	55.0		6.69	842	839	824	860	840	816	851	810	820	818	818	-0.04	-0.05	
06:00	207.5	217.2	14.81	5.82	54.11	4.92	7.22	4.50	11.19	8.85	97.0	10.44	55.2		6.78	842	843	822	856	843	824	847	813	813	816	816	-0.06	-0.06	
07:00	207.5	217.1	14.73	5.78	53.74	4.89	7.24	4.51	11.13	8.79	96.5	10.47	54.9		6.85	844	846	822	857	846	834	848	816	816	817	817	-0.04	-0.05	
08:00	208.7	218.2	14.81	5.95	54.16	4.93	7.54	4.51	11.32	9.04	97.4	10.52	54.9		6.83	844	847	822	855	848	834	846	817	817	815	818	-0.04	-0.05	
09:00	210.0	218.7	14.84	6.37	54.29	4.95	7.50	4.50	11.81	9.53	98.6	10.55	55.0		6.83	845	852	824	851	853	836	842	822	822	812	820	-0.04	-0.04	
10:00	211.3	219.4	15.01	6.62	55.01	4.99	7.50	4.51	12.08	9.89	99.9	10.66	55.2		6.82	844	849	824	851	851	836	843	819	819	813	818	-0.04	-0.04	
11:00	213.4	222.0	15.41	6.96	56.94	5.17	7.50	4.50	12.36	10.37	102.8	10.93	55.0		6.73	841	838	824	856	841	835	848	809	809	818	816	-0.03	-0.03	
12:00	210.9	220.2	15.33	7.04	56.43	5.12	7.50	4.50	12.47	10.41	102.4	10.87	55.0		6.76	839	834	823	860	836	835	835	805	805	822	816	-0.03	-0.03	
13:00	206.7	215.7	15.02	7.01	55.09	5.01	7.50	4.49	12.48	10.43	101.0	10.79	55.0		6.96	842	837	825	865	839	836	856	808	808	824	816	-0.02	-0.03	
14:00	207.3	214.9	15.20	7.53	55.92	5.08	7.50	4.51	13.18	11.09	103.2	10.82	54.9		6.39	843	840	826	859	841	840	850	811	811	817	821	-0.03	-0.05	
15:00	207.0	214.0	15.06	7.49	55.31	5.03	7.50	4.49	13.21	10.98	102.5	10.29	54.9		6.46	841	838	826	856	839	838	847	809	809	814	819	-0.04	-0.06	
16:00	207.5	214.2	15.19	7.68	55.83	5.08	7.50	4.50	13.37	11.30	103.6	10.36	54.9		6.48	841	843	825	851	843	839	842	813	813	810	819	-0.03	-0.05	
17:00	208.0	214.6	15.07	7.38	55.35	5.04	7.50	4.50	13.26	11.22	102.8	10.37	55.0		6.53	843	849	825	848	849	838	838	819	819	808	820	-0.03	-0.04	
18:00	210.7	216.5	16.01	8.11	59.63	5.42	7.50	4.50	14.58	13.24	110.8	10.77	55.0		6.23	836	841	825	837	845	837	828	811	811	796	818	-0.02	-0.03	
19:00	213.1	219.2	16.50	9.45	61.89	5.62	7.50	4.49	14.81	13.72	114.0	11.06	55.1		6.04	830	828	822	835	831	836	829	799	799	794	814	-0.02	-0.03	
20:00	213.6	220.1	16.56	9.39	62.11	5.64	7.50	4.49	14.71	13.61	114.1	11.12	54.9		6.01	830	822	822	842	824	836	837	795	795	801	815	-0.01	-0.02	
21:00	212.9	219.2	16.06	8.75	59.86	5.44	7.50	4.50	14.19	12.67	110.1	10.91	55.2		6.24	832	827	823	846	827	836	840	800	800	805	815	-0.03	-0.03	
22:00	212.0	218.7	15.79	8.13	58.59	5.31	7.49	4.49	13.65	11.85	107.4	10.84	55.0		6.41	834	832	822	846	833	834	839	804	804	805	813	-0.03	-0.04	
23:00	210.7	218.0	15.30	7.37	56.39	5.12	7.50	4.50	12.99	10.85	103.3	10.69	54.8		6.63	840	841	822	849	847	836	841	812	812	809	817	-0.04	-0.04	
Minimum	205.8	214.0	14.32	5.52	51.83	4.71	7.12	4.49	10.95	8.47	94.0	10.04	54.8		6.01	830	822	818	835	824	831	828	795	795	794	813	-0.06	-0.06	
Maximum	213.6	222.0	16.56	9.45	62.11	5.64	7.54	4.51	14.81	13.72	114.1	11.12	55.2		6.96	847	852	827	866	853	841	857	822	822	827	822	-0.01	-0.02	
Average	209.2	217.2	15.24	7.14	56.11	5.10	7.41	4.50	12.62	10.59	102.4	10.58	55.0		6.57	840	841	824	852	842	836	844	811	811	812	818	-0.03	-0.04	

DATE : 27/08/2018

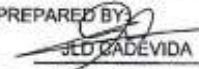
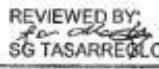
**UNIT 2 BOILER
DAILY LOGGING SHEET 4**

CHECKED BY	APPROVED BY
	

TIME	20HBK15 CT042KQ 54	20HBK15 CT043KQ 54	20HBK15 CT052KQ 54	20HBK15 CT053KQ 54	20HBK15 CP131KQ 90	20HBK21 CP131KQ 51	20HBK32 CP131KQ 51	20HBK23 CT030KQ 54	20HBK33 CT030KQ 54	20HBK22 CT030KQ 54	20HBK32 CT030KQ 54	20HBK25 CTPVI1	20HBK35 CTPVI1		20HBK33 EJ240	20HBK24 EJ230	20HBK33 EJ240	20HBK34 EJ230	20HBK22 EJ240	20HBK32 EJ240	20HBK42 CT032KQ 54	20HBK42 CT033KQ 54	20HBK43 CT033KQ 54	20HBK44 CT033KQ 54	20HBK45 CT033KQ 54	20HBK46 CT033KQ 54	20HNA10 CT041KQ 90	20HNA20 CT041KQ 54
	FURNACE UPPR TEMP (R- A)	FURNACE UPPR TEMP (R- B)	FURNACE UPPR TEMP (L- A)	FURNACE UPPR TEMP (L- B)	FURN DRAFT PRESS	COMPAC T SEP PRESS (L)	COMPAC T SEP PRESS (R)	35H WS LIFT LEG TEMP	45H WS LIFT LEG TEMP	35H WS DOWN LEG TEMP	45H WS DOWN LEG TEMP	35H DL BOTM TEMP	45H DL BOTM TEMP		35H DOWN LEG MID- UPP DP	35H DOWN LEG BT- MID DP	45H DOWN LEG MID- UPP DP	45H DOWN LEG BT- MID DP	SEPARAT OR LEFT DP	SEPARAT OR RIGHT DP	H/G DUCT GAS TEMP (R)	H/G DUCT GAS TEMP (L)	25H I/L FLUE GAS TEMP	15H I/L FLUE GAS TEMP	ECCO I/L FLUE GAS TEMP	GAH I/L FLUE GAS TEMP	BGF I/L FLUE GAS TEMP	BGF O/L FLUE GAS TEMP
	degC	degC	degC	degC	kPa	kPa	kPa	degC	degC	degC	degC	degC	degC		kPa	kPa	kPa	kPa	kPa	kPa	degC	degC	degC	degC	degC	degC	degC	degC
00:00	816	829	812	808	-0.102	-0.63	-0.66	788	805	772	787	715	745		-0.03	-16.04	-0.16	-16.41	-3.35	-3.40	791	794	689	530	410.9	315.3	158.5	154.9
01:00	825	829	808	804	-0.098	-0.60	-0.62	784	805	769	787	709	743		-0.01	-16.63	-0.08	-16.35	-3.23	-3.26	791	790	685	530	410.3	314.7	158.3	155.5
02:00	810	814	815	812	-0.105	-0.60	-0.61	790	793	776	774	712	728		-0.01	-16.60	-0.08	-16.31	-3.17	-3.21	781	795	688	533	411.4	314.3	157.6	154.9
03:00	796	800	821	818	-0.095	-0.52	-0.55	794	774	779	759	768	709		0.00	-16.49	-0.05	-16.25	-2.97	-3.07	767	797	689	533	410.0	311.7	156.1	153.4
04:00	796	800	830	826	-0.099	-0.57	-0.58	803	777	788	760	721	714		-0.01	-16.63	-0.08	-16.26	-3.07	-3.23	768	807	698	542	415.5	315.7	157.3	153.8
05:00	803	806	826	823	-0.100	-0.58	-0.59	800	783	785	766	720	723		-0.01	-16.65	-0.08	-16.29	-3.11	-3.22	772	805	697	543	416.4	316.8	158.2	155.2
06:00	805	809	821	818	-0.107	-0.58	-0.59	795	784	780	767	713	721		-0.01	-16.61	-0.08	-16.29	-3.13	-3.19	773	800	693	542	415.3	316.3	158.5	155.6
07:00	807	811	819	816	-0.095	-0.55	-0.58	792	785	777	768	711	721		-0.01	-16.65	-0.07	-16.30	-3.15	-3.16	773	797	690	542	414.7	315.5	158.7	155.7
08:00	813	817	816	812	-0.102	-0.57	-0.60	788	791	773	773	710	727		-0.01	-16.68	-0.09	-16.33	-3.25	-3.21	777	793	687	543	415.2	316.4	160.3	156.7
09:00	823	826	808	805	-0.100	-0.58	-0.61	783	799	769	782	707	736		-0.02	-16.73	-0.10	-16.35	-3.31	-3.24	786	789	685	544	415.9	317.5	161.7	157.9
10:00	819	822	815	811	-0.096	-0.60	-0.63	788	797	773	780	713	736		-0.02	-16.73	-0.12	-16.40	-3.32	-3.38	784	793	688	547	417.5	318.8	163.5	159.1
11:00	811	813	812	828	-0.094	-0.64	-0.67	805	793	790	775	731	735		-0.03	-16.89	-0.16	-16.42	-3.37	-3.46	782	808	699	536	419.2	322.5	166.9	162.0
12:00	804	807	826	832	-0.103	-0.64	-0.65	810	788	795	770	736	731		-0.03	-16.88	-0.17	-16.42	-3.38	-3.46	778	814	703	518	406.8	318.5	165.3	163.6
13:00	804	807	835	831	-0.094	-0.61	-0.62	806	785	793	769	734	728		-0.05	-16.54	-0.17	-16.16	-3.32	-3.43	775	813	701	525	408.5	317.3	159.3	157.6
14:00	812	815	835	831	-0.100	-0.62	-0.61	810	792	796	775	734	734		-0.03	-16.66	-0.08	-16.28	-3.13	-3.25	782	816	706	531	411.5	317.7	159.0	156.1
15:00	808	811	811	827	-0.102	-0.62	-0.61	806	787	793	770	738	729		-0.02	-16.61	-0.07	-16.25	-3.10	-3.21	779	813	703	533	411.7	316.9	158.2	155.1
16:00	819	821	823	819	-0.096	0.61	-0.62	799	796	784	779	723	717		-0.02	-16.68	-0.09	-16.28	-3.24	-3.24	786	806	698	535	412.4	317.6	158.4	155.0
17:00	827	830	814	811	-0.097	-0.60	-0.61	789	803	774	785	714	742		-0.02	-16.63	-0.10	-16.28	-3.24	-3.26	791	797	691	534	411.3	316.8	158.5	154.8
18:00	834	836	820	816	-0.105	-0.73	-0.75	798	814	784	797	733	763		-0.07	-16.90	-0.27	-16.40	-3.56	-3.58	803	806	701	545	419.1	323.7	161.6	156.9
19:00	824	826	831	827	-0.103	-0.80	-0.81	810	810	798	792	749	762		-0.11	-17.02	-0.40	-16.40	-3.74	-3.73	800	817	712	553	424.5	328.4	163.7	160.1
20:00	816	818	840	836	-0.104	-0.79	-0.82	819	804	809	787	759	758		-0.11	-17.01	-0.40	-16.41	-3.79	-3.78	796	828	721	559	427.5	330.2	163.5	161.3
21:00	815	817	837	833	-0.100	-0.73	-0.75	815	800	804	782	749	750		-0.06	-16.92	-0.29	-16.36	-3.57	-3.60	791	824	716	557	425.0	327.7	162.4	160.7
22:00	818	820	832	828	-0.101	-0.68	-0.70	808	799	794	781	739	745		-0.04	-16.85	-0.20	-16.38	-3.47	-3.47	790	816	709	554	422.2	325.1	162.0	160.0
23:00	818	821	825	821	-0.097	-0.62	-0.64	799	797	785	779	725	739		-0.02	-16.76	-0.13	-16.33	-3.33	-3.35	787	807	699	549	418.4	321.5	160.7	158.8
Minimum	796	800	808	804	-0.107	-0.80	-0.82	783	774	769	756	707	709		-0.11	-17.02	-0.40	-16.42	-3.79	-3.78	767	789	685	518	406.8	311.7	156.1	153.4
Maximum	834	836	840	836	-0.094	-0.52	-0.55	829	814	809	797	759	763		0.00	-16.49	-0.05	-16.16	-2.97	-3.07	803	828	721	559	427.5	330.2	166.9	163.6
Average	814	817	824	821	-0.100	-0.63	-0.64	799	794	785	777	725	736		-0.03	-16.73	-0.15	-16.33	-3.31	-3.35	783	805	698	540	415.5	319.0	160.3	157.3

I.5 Sertifikat Bahan (*mill certificate*) Economizer Tubes.

BHPi		RECORD OF MATERIAL TRACEABILITY/MARKING			QCF - 017 _b	
PROJECT : SHI-API BOILER 2		WORK No. : 9124162610			Record No.: SHI-API(BOILER 2)-MTR-C-001	
TITLE : ECONOMIZER COIL						
DRAWING No.	Part No.	Q'TY	PLATE/HEAT/CHARGE No.	CODED MARKING	ORIGINAL IDENTIFICATION MARKING	PAGE
PH2-003-062	1	92	013040316T	-	SA210 Gr.A1, Ø31.8x4t	1-6
	2	184	013040316T	-	SA210 Gr.A1, Ø31.8x4t	1-6
	3	184	013040316T	-	SA210 Gr.A1, Ø31.8x4t	1-6
	4	184	013040316T / 013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	5	184	013040316T / 013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	6	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	7	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	8	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	9	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	10	92	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	11	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	12	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	13	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	14	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	15	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	16	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	17	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	18	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	19	184	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	20	1	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	21	91	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
	22	91	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
(PH2-003-062)	23	1	013040317	-	SA210 Gr.A1, Ø31.8x4t	1-6
API-12101C	19	736	304100	A1	SA36 6bx6	7
API-12101C	20	276	S09646	N1	SA276 TP304, Ø12x10	8

PREPARED BY:  JED RADEVIDA 7/26/13 QC ENGINEER	REVIEWED BY:  SG TASARRUOLO 07/26/13 QC SV / QC MANAGER	APPROVED BY:  GC DUCUSIN QA MGR/ QC MGR REPRESENTATIVE
--	---	---

ASME CODE "S"

FORM REV. 8 DATED JUL. 16 2012

PROJECT NAME: SHI-API BOILER 2
 ITEM NAME: ECONOMIZER COIL
 DRAWING NO.: API-T2101C(PH2-003-062)
 PART NO.: 1-23
 CHANGZHOU CHANGHAI PRECISION & SPECIAL STEEL TUBE CO., LTD

产品质量证明书 INSPECTION CERTIFICATE

RECORD NO.: SHI-API(BOILER 2)-MTR-C-0

江苏省常州市武进区558号 邮编:213018
 558 YANLINGDONG ROAD CHANGZHOU
 JIANGSU CHINA 213018
 TEL:0519 88906438 FAX:0519 88899638

产品名称 PRODUCT	SEAMLESS MEDIUM-CARBON STEEL BOILER AND SUPERHEATER TUBES 无缝中碳锅炉管和过热蒸汽管	管坯状态 CONDITION OF BILLETS	HOT ROLLED 热轧	证书号 CERTIFICATION NUMBER	SD2019030051-9820130508
订/收货单位 CUSTOMER	SUMITOMO HEAVY INDUSTRIES, LTD. ASME CODE "S"	管坯供方 SUPPLIER OF BILLETS	ZHONGTIAN IRON & STEEL GROUP CO., LTD. 中天钢铁集团有限公司	买卖合同 CONTRACT NUMBER	S02013030051-28
标准 STANDARD	ASME SA-210M-2010ED+2011AB	客户定单编号 PURCHASE ORDER NUMBER	YB30746-2007-FDM-02(20)	发货日期 DATE OF ISSUE	2015-6-3
规格 SPECIFICATION		工厂检验印章 STAMP OF MILL INSPECTION		许可证号 LICENSE NO.	TEST10E24-2018

制造方法 MAKING METHOD		COLD DRAWN SEAMLESS 冷拔无缝			钢级 STEEL GRADE		SA210 Gr. A1		交货状态 DELIVERY CONDITION		N 正火		规格(mm) SPECIFICATION(mm)		φ		3L B		×		E		MVT		长度(O) LENGTH(O)		ID																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
序号 NO.	炉号 HEAT NO.	试验批号 TEST LOT NO.	机械性能 MECHANICAL PROPERTY					化学成分(%) CHEMICAL COMPOSITION (%)																			晶粒度 (GB) GRAIN SIZE	组织 MICRO STRUCTURE	脱碳层 DECARBONIZED LAYER			探伤 SUB- FILES	硬度 PIE- CES	重量 WEIGHT (T)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
			室温拉伸试验 ROOM TEMPERATURE TENSILE TEST (L)			硬度 (球化后) HARDNESS (CORUS SECTION)	冲击试验 IMPACT TEST			C	Si	Mn	P	S	Nb	Cu	Cr	Ni	Al	Ti	Zr	As	Sb	Bi	N	O			H	Fe	Cu				Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	Ti	Zr	As	Sb	Bi	N	O	H	Fe	Cu	Ni	Mo	V	B	Mn	Al	

I.6 Surat Permintaan Izin Penelitian.

	<p style="text-align: center;">KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN UNIVERSITAS HASANUDDIN FAKULTAS TEKNIK PROGRAM MAGISTER TEKNIK MESIN Jalan Poros Malino Km. 6 Bontomarannu Gowa, 90245, Sulawesi Selatan ☎ (0411) 586015, 586262 Fax (0411) 586015. http://eng.unhas.ac.id E-mail: teknik@unhas.ac.id</p>	
Nomor	: 4486/UN4.7.8/PT.01.04/2020	08 April 2020
Lamp.	: --	
Hal	: Permohonan Izin Penelitian/ Pengambilan Data	
Kepada Yth General Manager PT. ANTAM, Tbk UPBN Sulawesi Tenggara		
Dengan hormat, dengan ini kami sampaikan bahwa mahasiswa yang namanya tercantum dibawah ini :		
Nama	: Miswar	
Stambuk	: D022181004	
Program Pendidikan	: S2 (Magister)	
Program Studi	: Teknik Mesin	
Konsentrasi	: Konstruksi Mesin	
Bermaksud melakukan penelitian/ pengambilan data dalam rangka penulisan tesis dengan judul : "Kajian Degradasi Material Komponen <i>Economizer Tube SA-210 Gr. A1</i> Pada <i>Circulating Fluidized Bed Boiler</i>" .		
Pembimbing	: - Dr. Hairul Arsyad, ST., MT - Dr. Eng. Lukmanul Hakim Arma, ST., MT	
Atas Perhatian dan kerjasama yang baik, kami ucapkan terima kasih.		
 Ketua Program Studi Magister Teknik Mesin,  Dr. Hairul Arsyad, S.T., M.T NIP. 197501222002121001		
Tembusan:		
1. Gubernur Sulawesi Tenggara di Kendari;		
2. Ka. Dinas Transnaker Prov. Sulawesi Tenggara di Kendari;		
3. Arsip;		

I.7 Surat Balasan Izin Penelitian.

Nomor : 419/603/PUN/2020
Lampiran :-
Perihal : Penelitian / Pengambilan Data

Pomalaa, 28 Agustus 2020

**Yang Terhormat,
Ketua Program Studi Magister Teknik Mesin
Fakultas Teknik, Universitas Hasanuddin
Di
Tempat**

Menindaklanjuti Surat Ketua Program Studi Magister Teknik Mesin, Fakultas Teknik Universitas Hasanuddin, No. 4486/UN.7.8/PT.01.04/2020 Perihal Permohonan Izin Penelitian / Pengambilan Data, maka dengan ini kami sampaikan bahwa pada dasarnya PT. ANTAM UBPN Sulawesi Tenggara bersedia untuk memfasilitasi mahasiswa yang bersangkutan sesuai dengan bidang atau tempat untuk melakukan penelitian dengan tetap memperhatikan protokol kesehatan yang berlaku. Selanjutnya untuk waktu pelaksanaan penelitian tersebut akan disampaikan kepada Mahasiswa yang bersangkutan.

Demikian kami sampaikan, atas perhatian dan kerjasamanya diucapkan terimakasih.

General Manager (SVP),
Southeast Sulawesi Nickel Mining Business Unit



Khaidir Said, ST
NPP. 1004796773

PT. ANTAM, Tbk.
Nickel Mining Business Unit
Southeast Sulawesi
Jln. Jend. Ahmad Yani No. 5
Pomalaa, Kolaka 93562
Southeast Sulawesi, Indonesia

T 62-405 2310 171
F 62-405 2310 833
E mis_nikel@antam.com

www.antam.com



I.8 Foto dokumentasi pengambilan data penelitian di lokasi PLTU PT. ANTAM, Tbk UBPN Sulawesi Tenggara.





I.9 Foto dokumentasi pengambilan data penelitian di laboratorium.



