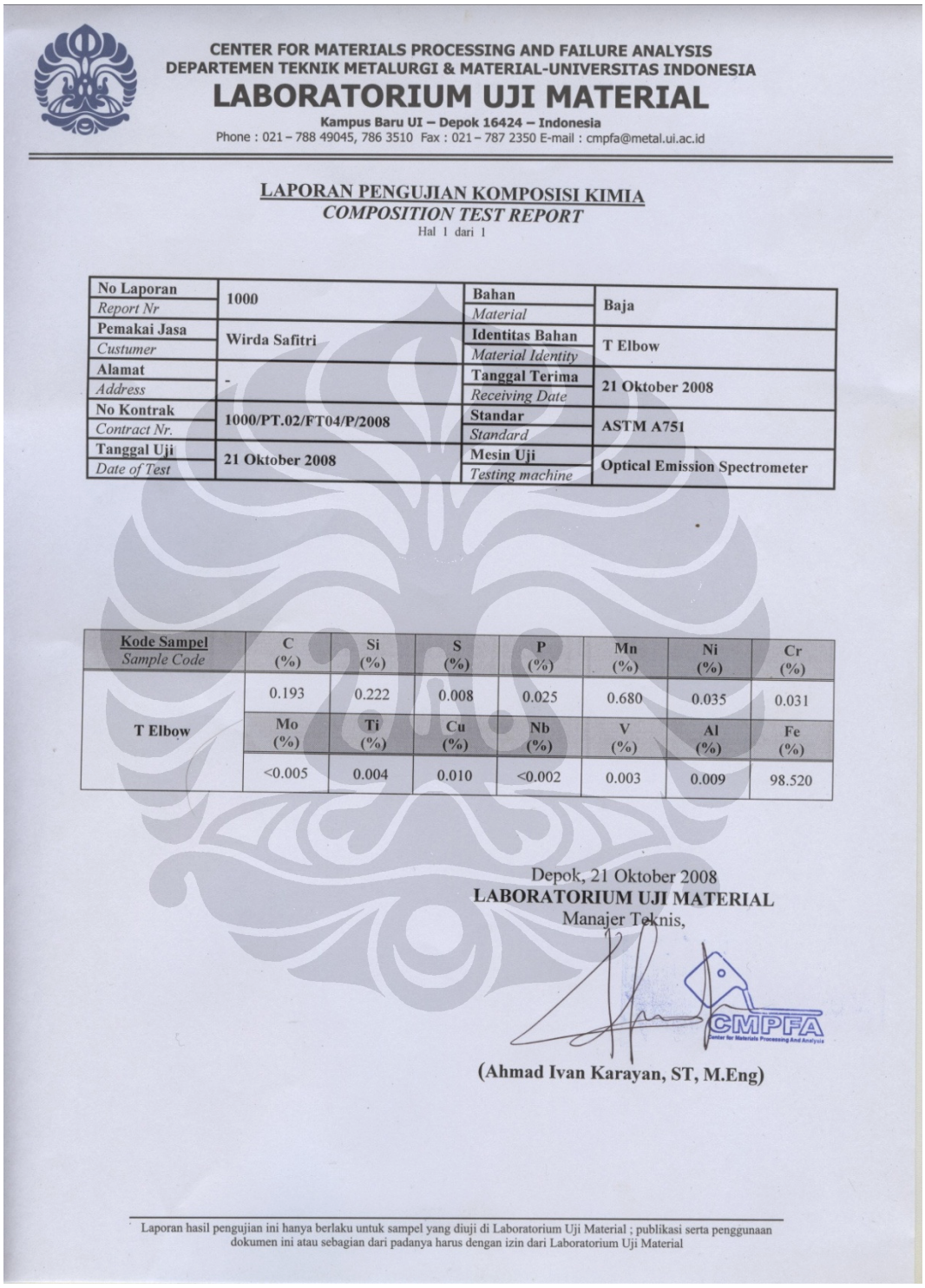
LAMPIRAN

Lampiran 1 Hasil spektro sampel pipa *elbow*



CENTER FOR MATERIALS PROCESSING AND FAILURE ANALYSIS
DEPARTEMEN TEKNIK METALURGI & MATERIAL-UNIVERSITAS INDONESIA
LABORATORIUM UJI MATERIAL
Kampus Baru UI – Depok 16424 – Indonesia
Phone : 021 – 788 49045, 786 3510 Fax : 021 – 787 2350 E-mail : cmpfa@metal.ui.ac.id

LAPORAN PENGUJIAN KOMPOSISI KIMIA
COMPOSITION TEST REPORT
Hal 1 dari 1

No Laporan *Report Nr*	**1000**	**Bahan** *Material*	**Baja**
Pemakai Jasa *Custumer*	**Wirda Safitri**	**Identitas Bahan** *Material Identity*	**T Elbow**
Alamat *Address*	-	**Tanggal Terima** *Receiving Date*	**21 Oktober 2008**
No Kontrak *Contract Nr.*	**1000/PT.02/FT04/P/2008**	**Standar** *Standard*	**ASTM A751**
Tanggal Uji *Date of Test*	**21 Oktober 2008**	**Mesin Uji** *Testing machine*	**Optical Emission Spectrometer**

Kode Sampel *Sample Code*	C (%)	Si (%)	S (%)	P (%)	Mn (%)	Ni (%)	Cr (%)
T Elbow	0.193	0.222	0.008	0.025	0.680	0.035	0.031
	Mo (%)	**Ti (%)**	**Cu (%)**	**Nb (%)**	**V (%)**	**Al (%)**	**Fe (%)**
	<0.005	0.004	0.010	<0.002	0.003	0.009	98.520

Depok, 21 Oktober 2008
LABORATORIUM UJI MATERIAL
Manajer Teknis,

(Ahmad Ivan Karayan, ST, M.Eng)

Laporan hasil pengujian ini hanya berlaku untuk sampel yang diuji di Laboratorium Uji Material ; publikasi serta penggunaan dokumen ini atau sebagian dari padanya harus dengan izin dari Laboratorium Uji Material

Lampiran 2 Hasil spektro sampel bagian sambungan

Department of Metallurgy and Materials Engineering
UNIVERSITY OF INDONESIA

CHEMICAL COMPOSITION TEST REPORT

Contract No. / No. Kontrak Weld

Standards / Standar : ASTM A751

Customer / Pemberi Kerja :

Materials / Material : BAJA

	Fe	C	Si	Mn	P	S	Cr	Mo
1	98.218	0.141	0.353	0.863	0.0361	0.0169	0.0424	< 0.0050
2	98.249	0.126	0.373	0.841	0.0314	0.0150	0.0428	< 0.0050
Ave	98.233	0.134	0.363	0.852	0.0337	0.0160	0.0426	< 0.0050

	Ni	Al	Co	Cu	Nb	Ti	V	W
1	0.0261	< 0.0010	0.0037	0.0030	< 0.0020	0.0076	0.0097	< 0.0150
2	0.0219	< 0.0010	0.0042	0.0025	< 0.0020	0.0086	0.0092	< 0.0150
Ave	0.0240	< 0.0010	0.0040	0.0028	< 0.0020	0.0081	0.0095	< 0.0150

	Pb	Sn	B	Ca	Zr	As	Bi
1	< 0.0250	0.0601	0.0056	0.0005	< 0.0020	< 0.0050	> 0.210
2	< 0.0250	0.0564	0.0060	0.0004	< 0.0020	< 0.0050	> 0.210
Ave	< 0.0250	0.0583	0.0058	0.0005	< 0.0020	< 0.0050	> 0.210

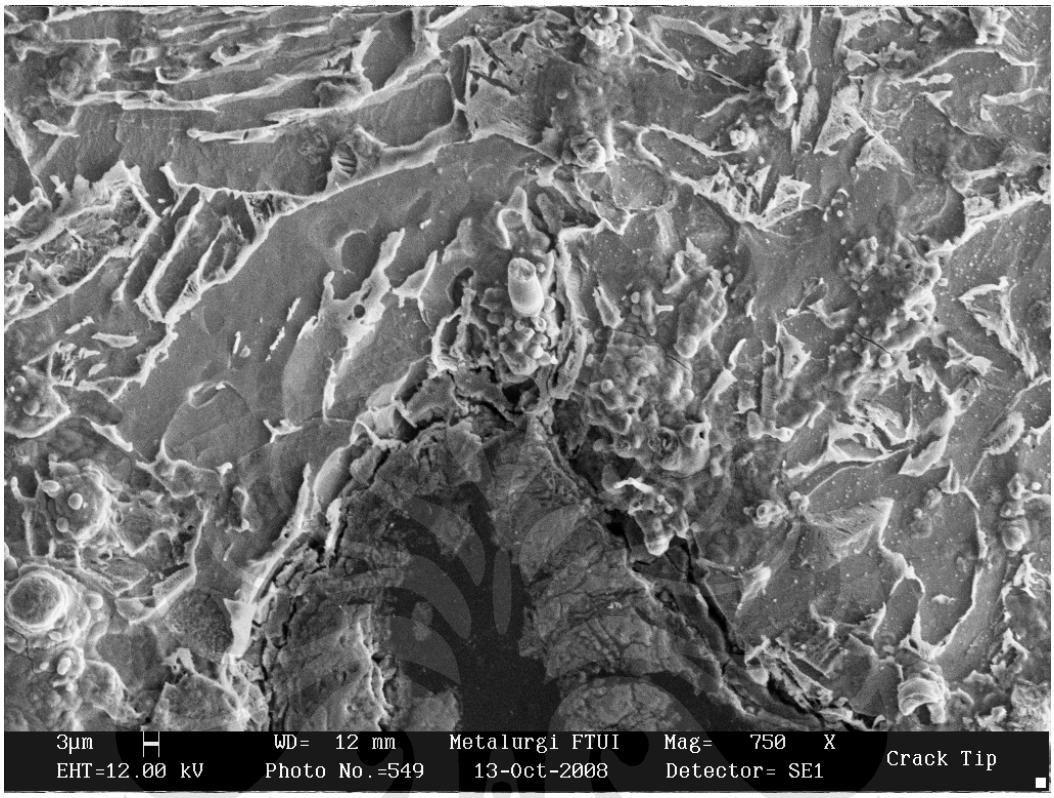
Datum / date
12/31/2008

Tested by / Diuji oleh :
Deni

Approved by / Disetujui oleh :
Pak Jaya

Center of Materials Processing and Failure Analysis
Dept. of Metallurgy and Material Engineering
Gedung Metalurgi dan Material FTUI
Kampus Baru Universitas Indonesia
Depok - West Java INDONESIA 16424
Tel. : +62 21 7863510 Fax: +62 21 7872350
Web: www.metal.ui.ac.id
e-mail: cmpfa@metal.ui.ac.id

Lampiran 3 Hasil SEM bagian *leak* perbesaran 750x.



Lampiran 4 Hasil XRD produk korosi pipa *elbow* untuk lapisan terluar

: PANJI01.DI 3-Nov-2008 18:14

Philips Analytical X-Ray B.V. Department of Metallurgy UI

Sample identification: panji01
Data measured at: 3-Nov-2008 17:04:00

Diffractometer type: PW1710 BASED
Tube anode: Cu
Generator tension [kV]: 40
Generator current [mA]: 30
Wavelength Alpha1 [Å]: 1.54056
Wavelength Alpha2 [Å]: 1.54439
Intensity ratio (alpha2/alpha1): 0.500
Divergence slit: AUTOMATIC
Irradiated length [mm]: 12
Receiving slit: 0.2
Monochromator used: YES

Start angle [°2θ]: 5.000
End angle [°2θ]: 89.000
Step size [°2θ]: 0.020
Maximum intensity: 100.0000
Time per step [s]: 1.000
Type of scan: CONTINUOUS
Intensities converted to: FIXED

Minimum peak tip width: 0.00
Maximum peak tip width: 1.00
Peak base width: 2.00
Minimum significance: 0.75
Number of peaks: 28

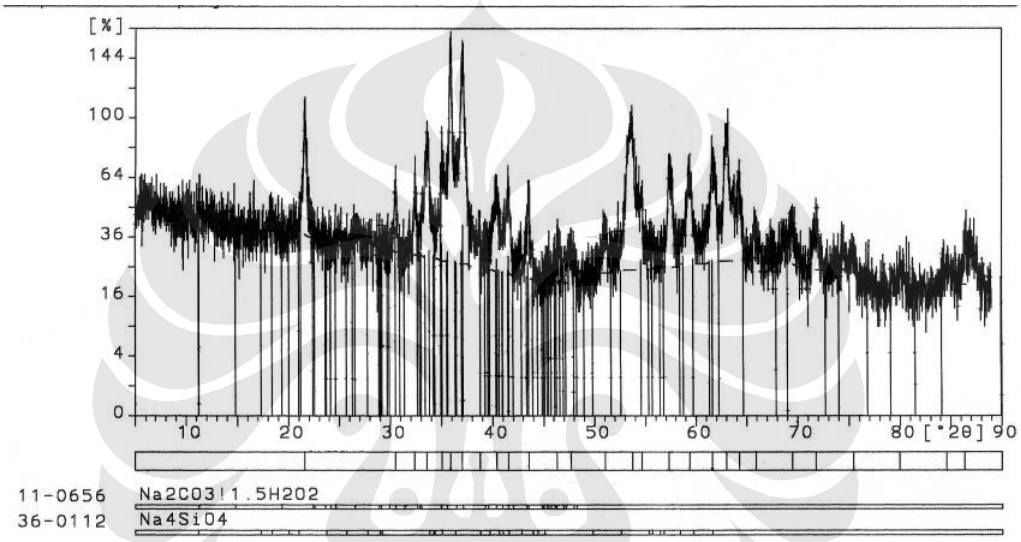
Angle [°2θ]	d-value α1 [Å]	d-value α2 [Å]	Peak width [°2θ]	Peak int [counts]	Back. int [counts]	Rel. int [%]	Signif.
21.560	4.1183	4.1285	0.120	90	50	90.2	1.68
30.485	2.9299	2.9372	0.160	27	29	27.0	0.83
32.365	2.7639	2.7707	0.240	28	26	28.1	1.66
33.570	2.6674	2.6740	0.320	50	24	50.4	2.10
35.045	2.5584	2.5647	0.240	40	23	39.7	2.55
35.900	2.4994	2.5056	0.100	100	22	100.0	0.83
37.000	2.4276	2.4336	0.280	90	20	90.2	3.45
38.775	2.3204	2.3262	0.160	12	19	11.6	0.92
40.420	2.2297	2.2353	0.480	23	18	23.0	2.41
41.525	2.1729	2.1783	0.320	23	16	23.0	1.21
43.540	2.0769	2.0821	0.120	25	14	25.0	1.21
46.320	1.9585	1.9634	0.480	6	13	5.8	0.85
47.660	1.9065	1.9113	0.800	7	12	7.3	1.44
51.020	1.7886	1.7930	0.480	10	14	9.6	2.12
53.700	1.7055	1.7097	0.320	36	14	36.0	1.04
54.645	1.6782	1.6823	0.160	17	13	16.8	0.75
57.290	1.6068	1.6108	0.160	24	13	24.0	0.98
59.385	1.5550	1.5589	0.480	20	13	20.3	2.85
61.630	1.5037	1.5074	0.400	24	13	24.0	1.97
62.985	1.4745	1.4782	0.400	30	13	30.3	3.24
64.275	1.4480	1.4516	0.320	16	13	16.0	0.97
65.915	1.4159	1.4194	0.480	5	13	4.8	1.77

Lampiran 4 Hasil XRD produk korosi pipa *elbow* untuk lapisan terluar (lanjutan)

File: PANJI01.DI 3-Nov-2008 18:14

Philips Analytical X-Ray B.V. Department of Metallurgy UI

Angle [°2θ]	d-value α1 [Å]	d-value α2 [Å]	Peak width [°2θ]	Peak int [counts]	Back. int [counts]	Rel. int [%]	Signif.
69.475	1.3518	1.3552	0.640	6	12	6.2	1.20
71.745	1.3145	1.3178	0.800	7	10	6.8	2.83
75.410	1.2595	1.2626	0.320	4	9	3.6	1.30
79.960	1.1988	1.2018	0.960	2	7	1.7	1.59
84.575	1.1448	1.1476	0.960	2	7	2.0	1.02



Lampiran 5 Hasil XRD produk korosi pipa *elbow*

File: CRCKSCLE.DI 13-Oct-2008 17:26

Philips Analytical X-Ray B.V. Department of Metallurgy UI

Sample identification: Crack Scale
Data measured at: 13-Oct-2008 16:01:00

Diffractometer type: PW1710 BASED
Tube anode: Cu
Generator tension [kV]: 40
Generator current [mA]: 30
Wavelength Alpha1 [Å]: 1.54056
Wavelength Alpha2 [Å]: 1.54439
Intensity ratio (alpha2/alpha1): 0.500
Divergence slit: AUTOMATIC
Irradiated length [mm]: 12
Receiving slit: 0.2
Monochromator used: YES

Start angle [°2θ]: 5.000
End angle [°2θ]: 89.000
Step size [°2θ]: 0.020
Maximum intensity: 225.0000
Time per step [s]: 1.000
Type of scan: CONTINUOUS
Intensities converted to: FIXED

Minimum peak tip width: 0.00
Maximum peak tip width: 1.00
Peak base width: 2.00
Minimum significance: 0.75
Number of peaks: 30

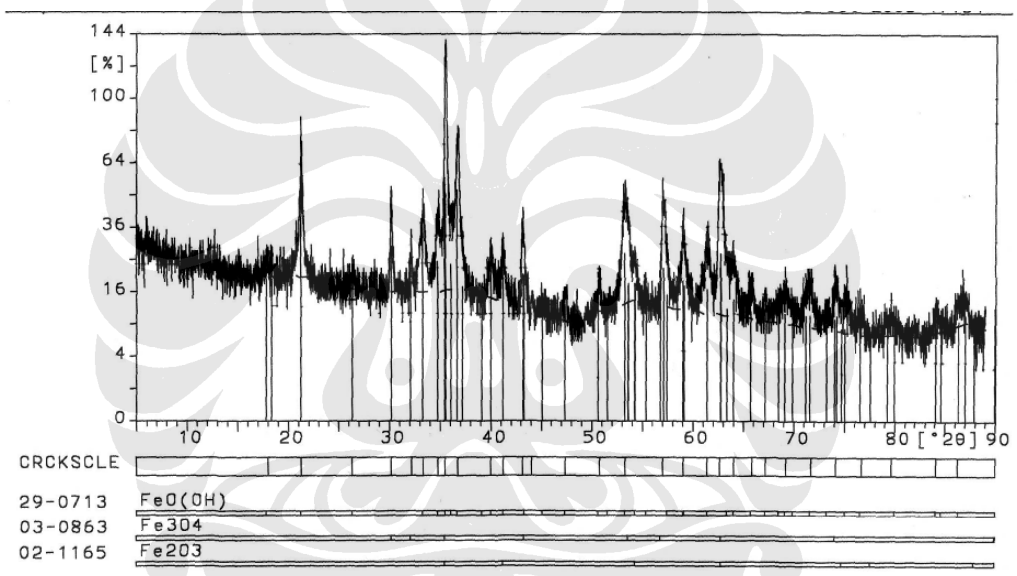
Angle [°2θ]	d-value α1 [Å]	d-value α2 [Å]	Peak width [°2θ]	Peak int [counts]	Back. int [counts]	Rel. int [%]	Signif.
18.020	4.9186	4.9308	0.960	14	72	6.1	1.46
21.255	4.1767	4.1871	0.280	125	61	55.8	3.53
26.300	3.3858	3.3942	0.480	8	42	3.7	0.75
30.170	2.9598	2.9671	0.120	79	35	35.2	2.03
32.165	2.7806	2.7875	0.160	24	32	10.7	1.13
33.320	2.6868	2.6935	0.200	52	31	23.0	1.08
34.755	2.5791	2.5855	0.320	45	30	20.0	1.82
35.475	2.5284	2.5346	0.100	225	30	100.0	1.43
36.735	2.4445	2.4506	0.280	110	30	49.0	4.78
39.965	2.2540	2.2596	0.200	27	24	12.0	0.87
41.215	2.1885	2.1940	0.240	23	22	10.2	0.76
43.145	2.0950	2.1002	0.200	32	19	14.4	1.48
44.025	2.0551	2.0602	0.200	5	18	2.2	0.85
47.355	1.9181	1.9229	0.240	8	14	3.7	0.92
50.775	1.7966	1.8011	0.200	10	15	4.3	0.99
53.280	1.7179	1.7222	0.560	44	17	19.4	5.42
57.010	1.6140	1.6181	0.060	53	14	23.7	0.77
59.050	1.5631	1.5669	0.240	24	14	10.7	1.83
61.360	1.5096	1.5134	0.400	21	12	9.4	1.91
62.610	1.4825	1.4862	0.240	58	12	25.7	2.42
64.020	1.4532	1.4568	0.480	15	12	6.8	2.07
65.845	1.4172	1.4208	0.560	7	10	3.2	2.52

Lampiran 5 Hasil XRD produk korosi pipa *elbow* (lanjutan)

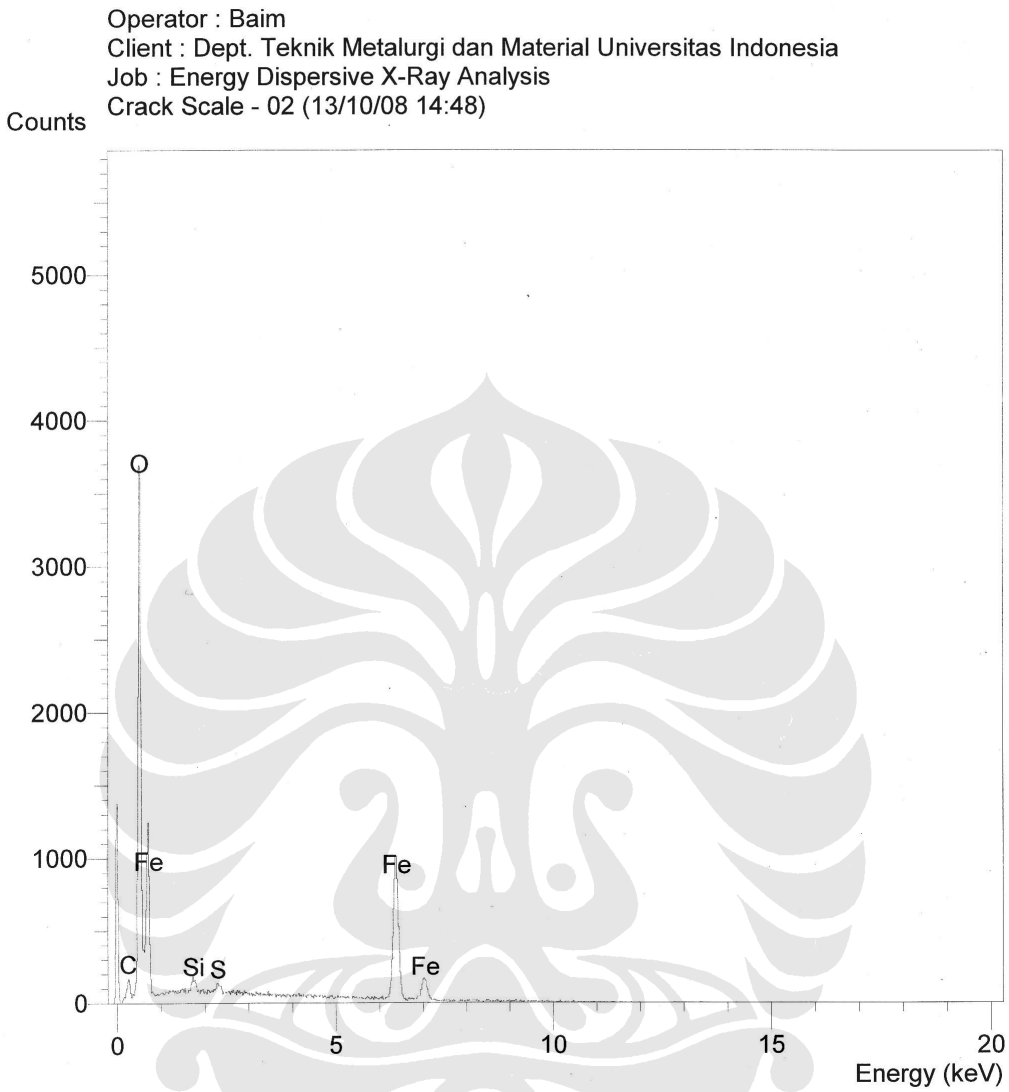
File: CRCKSCLE.DI 13-Oct-2008 17:26

Philips Analytical X-Ray B.V. Department of Metallurgy UI

Angle [°2θ]	d-value α1 [Å]	d-value α2 [Å]	Peak width [°2θ]	Peak int [counts]	Back. int [counts]	Rel. int [%]	Signif.
67.130	1.3932	1.3967	0.320	6	10	2.6	0.80
69.195	1.3566	1.3600	0.640	7	9	3.2	0.85
71.700	1.3152	1.3185	0.720	9	8	4.0	3.39
74.135	1.2779	1.2811	0.400	10	7	4.3	2.02
76.665	1.2419	1.2450	0.640	3	6	1.3	0.99
79.640	1.2029	1.2058	0.960	3	6	1.4	1.22
84.080	1.1503	1.1531	0.480	3	6	1.4	1.45
86.230	1.1270	1.1298	0.480	4	7	1.8	0.84



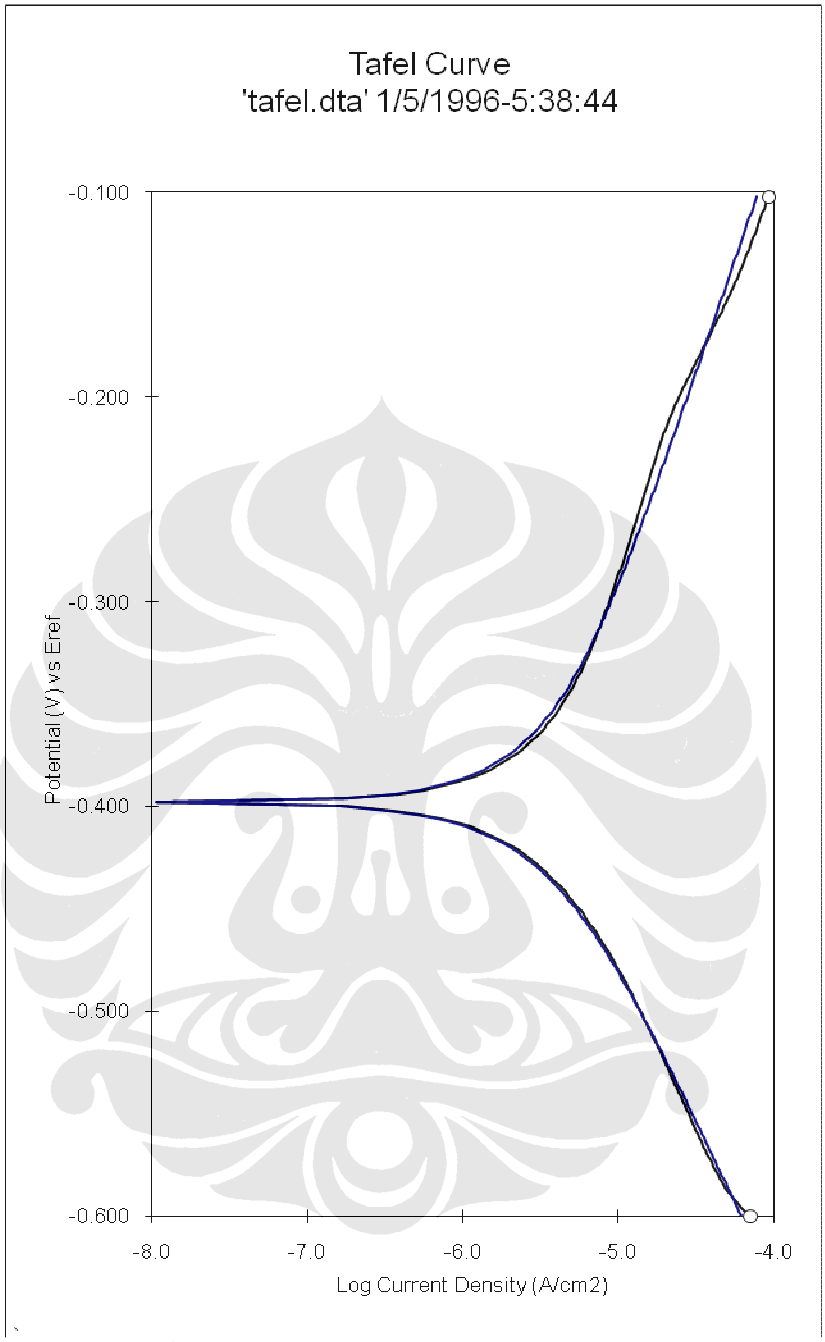
Lampiran 6 Hasil EDX produk korosi pipa *elbow*



Lampiran 6 Hasil EDX produk korosi pipa *elbow* (lanjutan)

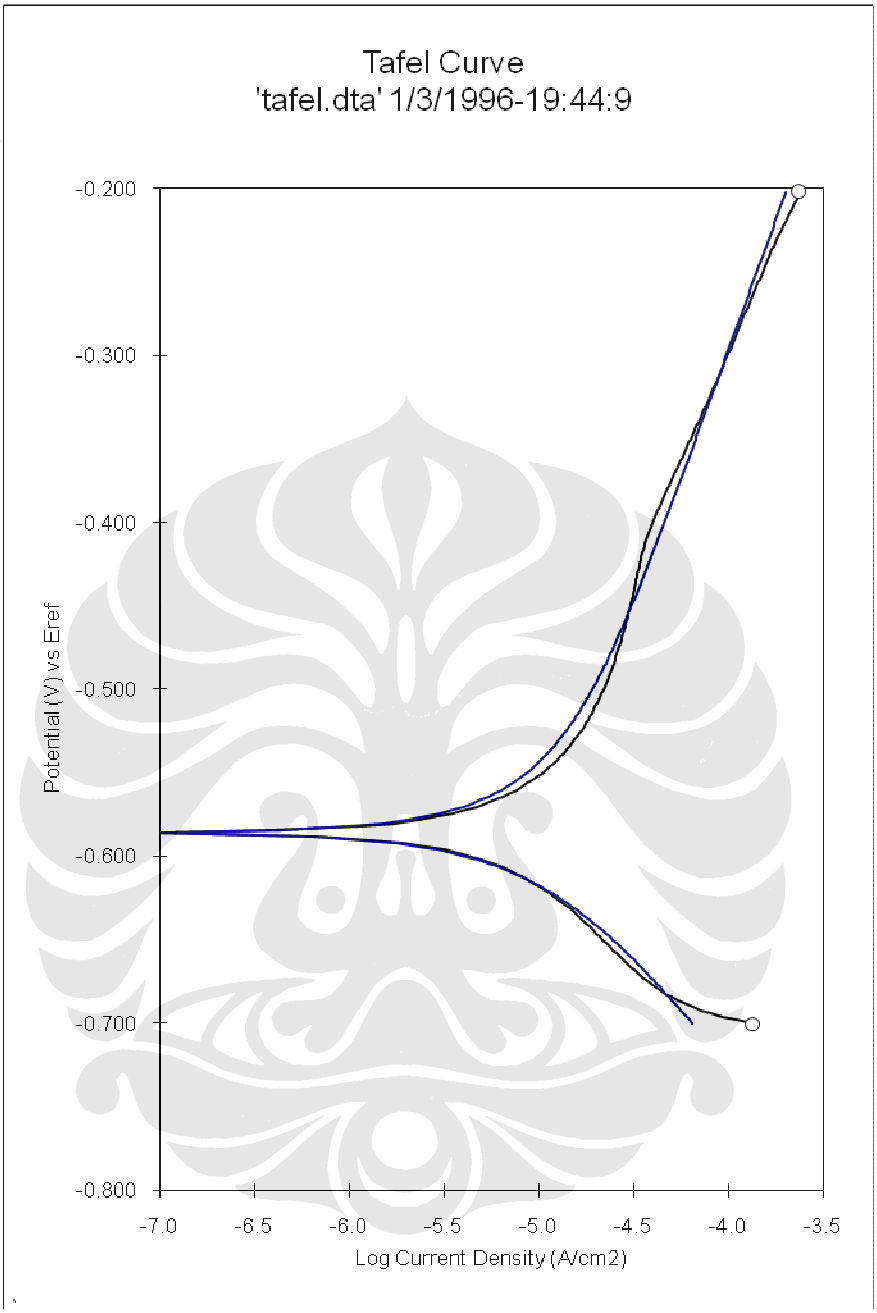
```
SEMQuant results. Listed at 14:49:17 on 13/10/08
Operator: Baim
Client: Dept. Teknik Metalurgi dan Material Universitas Indonesia
Job: Energy Dispersive X-Ray Analysis
Spectrum label: Crack Scale - 02

System resolution =  61 eV

Quantitative method: ZAF ( 3 iterations).
 Analysed all elements and normalised results.

Standards :
 C  K      Carbon Low 13/09/06
 O  K      AL2O3 22/03/06
 Si K      Low Carbon Steel 13/09/06
 S  K      FeS2 22/03/06
 Fe K      FeS2 22/03/06


Elmt   Spect.  Element  Atomic
       Type      %        %
C  K     ED      0.34     1.01
O  K     ED     21.66    48.47
Si K     ED      0.45     0.57
S  K     ED      0.50     0.56
Fe K     ED     77.05    49.39
Total          100.00   100.00

* = <2 Sigma
```

Lampiran 7 Hasil polarisasi air untuk daerah logam induk (*base*)



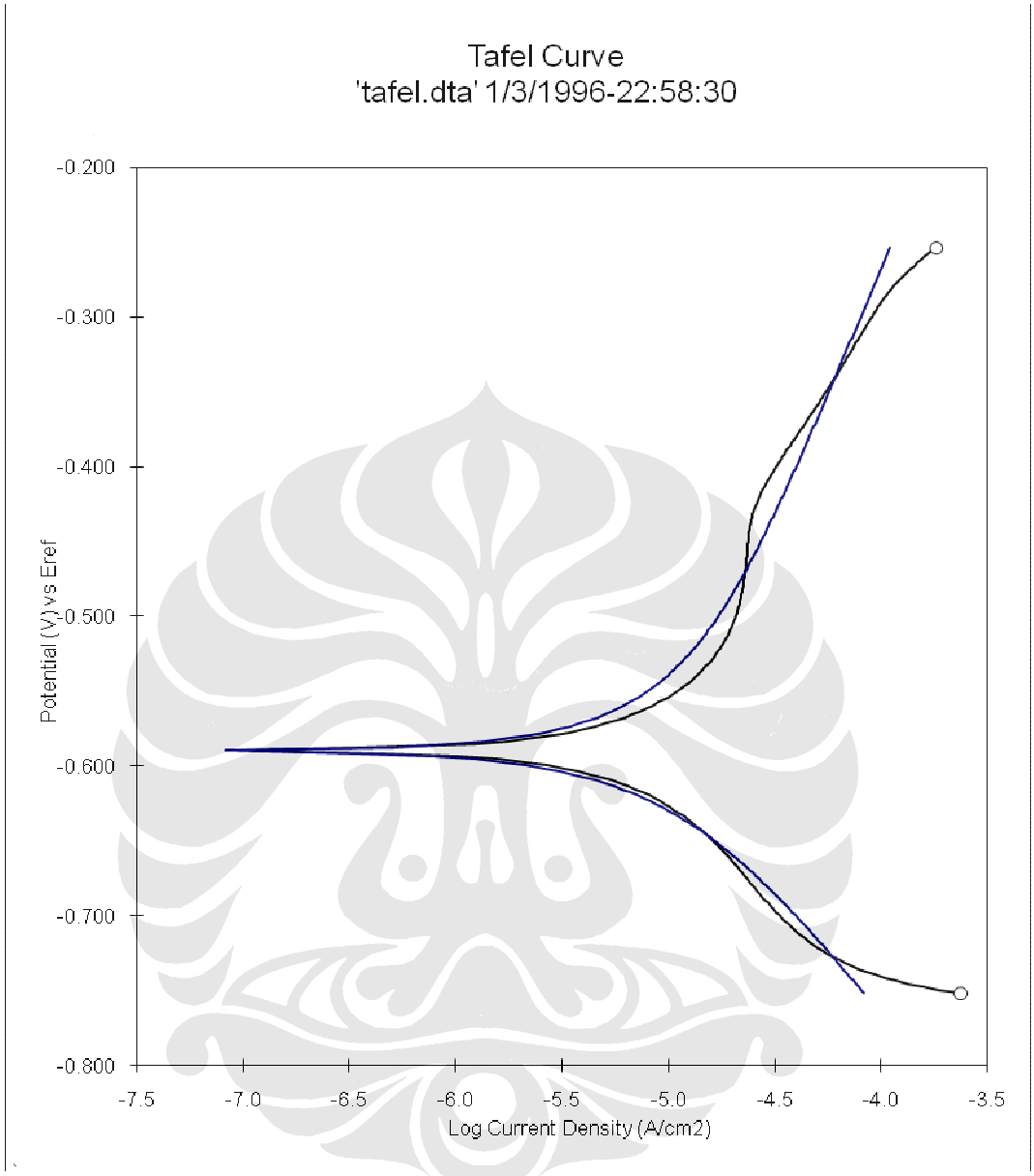
TAFEL RESULTS
Region = -600.0 mV to -102.0 mV
Ecorr = -398.1 mV
Icorr = 3.505E-06 A/cm2
BetaC = 162.7 mV/Decade
BetaA = 221.1 mV/Decade
Rp = 1.161E+04 Ohm cm2
CorrRate = 1.602 mpy

Lampiran 8 Hasil polarisasi air untuk daerah HAZ (*heat affected zone*)



TAFEL RESULTS
Region = -700.3 mV to -202.3 mV
Ecorr = -585.9 mV
Icorr = 1.189E-05 A/cm2
BetaC = 148.5 mV/Decade
BetaA = 311.6 mV/Decade
Rp = 3.674E+03 Ohm cm2
CorrRate = 5.431 mpy

Lampiran 9 Hasil polarisasi air untuk daerah lasan (*weld*)



TAFEL RESULTS
Region = -751.5 mV to -253.5 mV
Ecorr = -589.9 mV
Icorr = 1.135E-05 A/cm2
BetaC = 183.3 mV/Decade
BetaA = 340.5 mV/Decade
Rp = 4.559E+03 Ohm cm2
CorrRate = 5.187 mpy

Lampiran 10 Hasil pengujian komposisi air

WATER ANALYSIS REPORT

To :

Date : October 07, 2008

Ref. No : W-002/LAB/10/08

	Kind of sample	D5	CT. 01	CT. 02	CT. 03
	Sampling point				
	Sampling date	September 26, 2008			
	Sampling time				
1	Color (Pt-Co-degree)	n.a.	n.a.	n.a.	n.a.
2	Turbidity	< 1	< 1	< 1	< 1
3	pH (at 25°C)	6.3	6.5	6.2	6.3
4	Electrical conductivity (µS/cm)	262	241	252	297
5	P-Alkalinity (as $CaCO_3$)	n.a.	n.a.	n.a.	n.a.
6	M-Alkalinity (as $CaCO_3$)	23	24	18	21
7	Total Hardness (as $CaCO_3$)	< 1	8	4	< 1
8	Calcium Hardness (as $CaCO_3$)	< 1	5	3	< 1
9	Chloride ion (as Cl^-)	< 2	< 2	< 2	< 2
10	Sulfate ion (as SO_4^{2-})	n.a.	n.a.	n.a.	n.a.
11	Soluble Silica (as SiO_2)	1.65	1.50	0.67	0.15
12	Phosphate ion (as PO_4^{3-})	n.a.	n.a.	n.a.	n.a.
13	Total Phosphate (as PO_4^{3-})	n.a.	< 0.1	< 0.1	< 0.1
14	Total iron (as Fe)	0.14	0.06	0.07	0.13
15	Hydrazine (as N_2H_4)	n.a.	n.a.	n.a.	n.a.
16	Nitrite ion (as NO_2^-)	n.a.	n.a.	n.a.	n.a.

Lampiran 11 Database untuk menghitung indeks korosifitas

Table 1: Input table

pH	*	
Conductivity in TDS	*	mg/L
$[Ca^{2+}]$	*	mg/L
$[HCO3^-]$	*	mg/L
Water temperature	*	degree C

Calculate the Langlier Saturation Index

Erase input values

Table 2 : Additional data

pH =	7.7	8	8.6	
TDS =	20	34483	273	mg/l
$[Ca^{2+}]$ =	5	400	49	mg/l
$[HCO_3^-]$ =	10	140	121	mg/l
T =	20	20	20	degree C
	Example	Seawater	Tap water	

Table 3: Results Langelier Saturation Index

pH_s	
LSI	
Indication based on Langelier (1936)	
Indication based on improved Langelier by Carrier (1965)	

The Langelier Saturation Index formula is

$$LSI = pH - pH_s$$

For an explanation of the formula click **here**.

Give the values of your water analysis. You have to fill all the boxes with *.

If you do not have a water analysis you can use the values in table 2. Click on a button at the bottom of table 2

Table 1: Input table

pH	*	
Conductivity in TDS	*	mg/l
$[Ca^{2+}]$	*	mg/L
$[HCO_3^-]$	*	mg/l
Water temperature	*	degree C

Calculate the Ryznar Stability Index

Erase input values

Table 2: Additional data

pH =	7.7	8	8.6	
TDS =	20	34483	273	mg/l
$[Ca^{2+}]$ =	5	400	49	mg/l
$[HCO_3^-]$ =	10	140	121	mg/l
T =	20	20	20	degree C
	Example	Seawater	Tap water	

Table 3: Results Ryznar Stability Index

pH_s	
RI	
Indication base on Ryznar (1942)	
Indication based on improved Ryznar index by Carrier 1965	

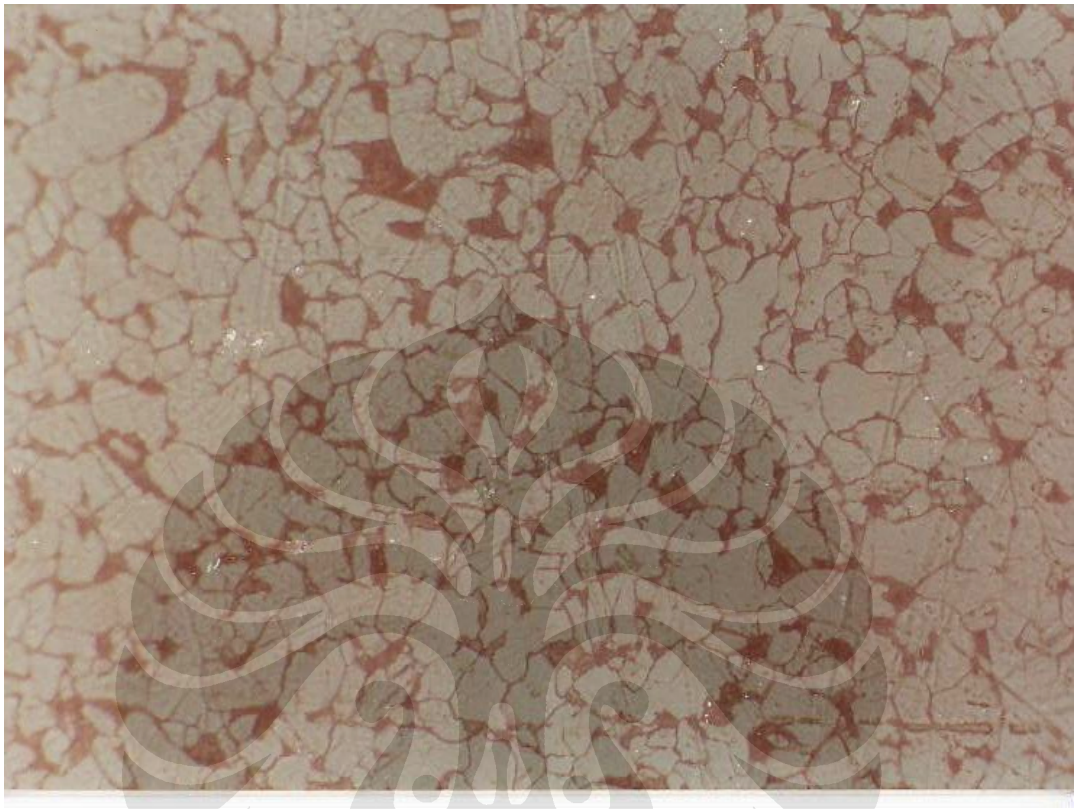
The Ryznar Stability Index formula is:

$$RI = 2 \cdot pH_s - pH$$

For an explanation of the formula click **here**.

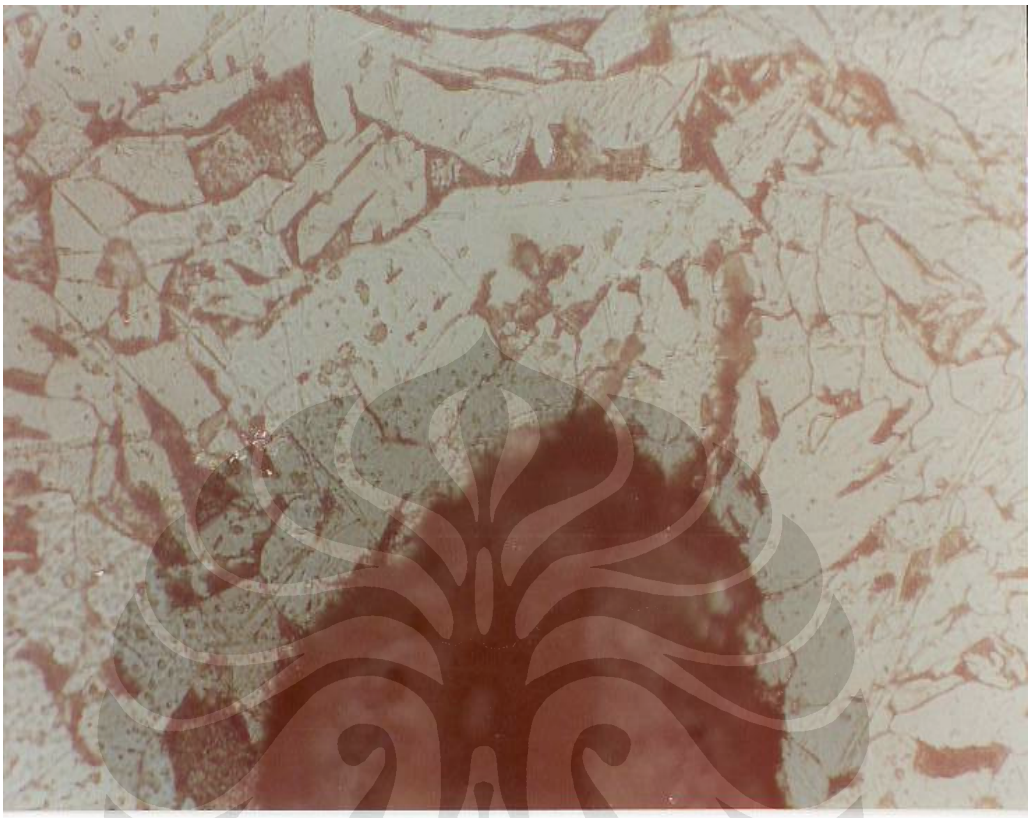
Lampiran 12 Foto penampang melintang sampel perbesaran 8x

Lampiran 13 Foto mikrostruktur bagian logam induk etsa 2% natal dan perbesaran 100x.



Lampiran 14 Foto mikrostruktur bagian HAZ etsa 2% natal dan perbesaran 100x.

Lampiran 15 Foto mikrostruktur bagian *leak* etsa 2% natal dan perbesaran 100x.



Lampiran 16 Foto mikrostruktur bagian logam lasan etsa 2% natal dan perbesaran 100x.