

APPENDIX A

(Particle size distribution curves)



MASTERSIZER X

Version 1.2a

Tue, Nov 14, 2000 11:49AM

Sulphide powder :Run Number 1

Mengtyd: 0 minute

Sample File Name: UFM_FEED, Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:35PM Last saved on: Fri, Jan 04, 1980 8:35PM

Presentation: 2OHD

Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.593 %

Concentration = 0.009 %

Obscuration = 19.69 %

d (0.5) = 27.79 μm d (0.1) = 8.63 μm d (0.9) = 79.38 μm D [4, 3] = 36.08 μm

Span = 2.62

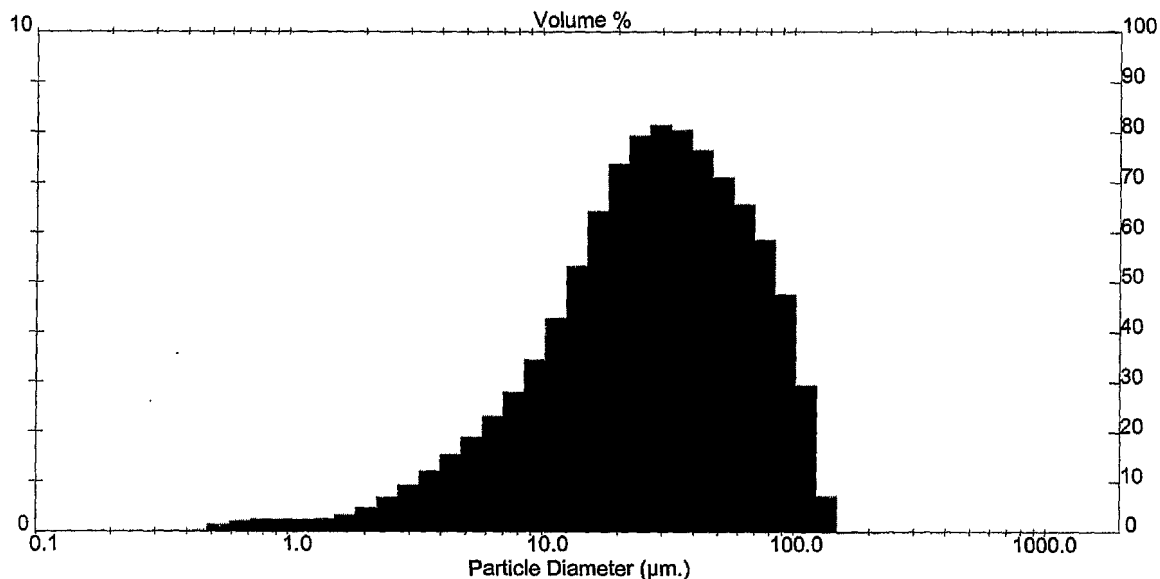
Mode = 30.53 μm Sauter Mean (D[3,2]) = 12.92 μm

Density = 1.00 gm. / c.c.

Specific Surface Area = 0.4645 sq. m. / gm

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
0.20	0.03	0.48	0.03
0.48	0.14	0.59	0.17
0.59	0.21	0.71	0.38
0.71	0.24	0.86	0.62
0.86	0.24	1.04	0.87
1.04	0.24	1.26	1.10
1.26	0.25	1.52	1.35
1.52	0.33	1.84	1.68
1.84	0.48	2.23	2.16
2.23	0.69	2.70	2.85
2.70	0.93	3.27	3.78
3.27	1.21	3.95	4.99
3.95	1.54	4.79	6.52
4.79	1.89	5.79	8.41
5.79	2.31	7.01	10.72
7.01	2.80	8.48	13.52

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
8.48	3.44	10.27	16.96
10.27	4.28	12.43	21.24
12.43	5.31	15.05	26.55
15.05	6.42	18.21	32.98
18.21	7.36	22.04	40.34
22.04	7.93	26.68	48.27
26.68	8.13	32.29	56.40
32.29	8.04	39.08	64.44
39.08	7.64	47.30	72.08
47.30	7.10	57.25	79.18
57.25	6.56	69.30	85.75
69.30	5.85	83.87	91.60
83.87	4.75	101.52	96.35
101.52	2.94	122.87	99.29
122.87	0.71	148.72	100.00
148.72	0.00	180.00	100.00

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Figure A1 Graph indicating the particle size distribution of the feed sample



MASTERSIZER X

Version 1.2a

Mon, Nov 20, 2000 11:31AM

Sulphide powder :Run Number 1

Mengtyd: 5 minute

Sample File Name: UFM_C5 , Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:26PM Last saved on: Fri, Jan 04, 1980 8:26PM

Presentation: 2OHD

Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.265 %

d (0.5) = 11.07 μm D [4, 3] = 14.47 μm Sauter Mean (D[3,2]) = 7.14 μm

Specific Surface Area = 0.8408 sq. m. / gm

Concentration = 0.005 %

d (0.1) = 3.87 μm

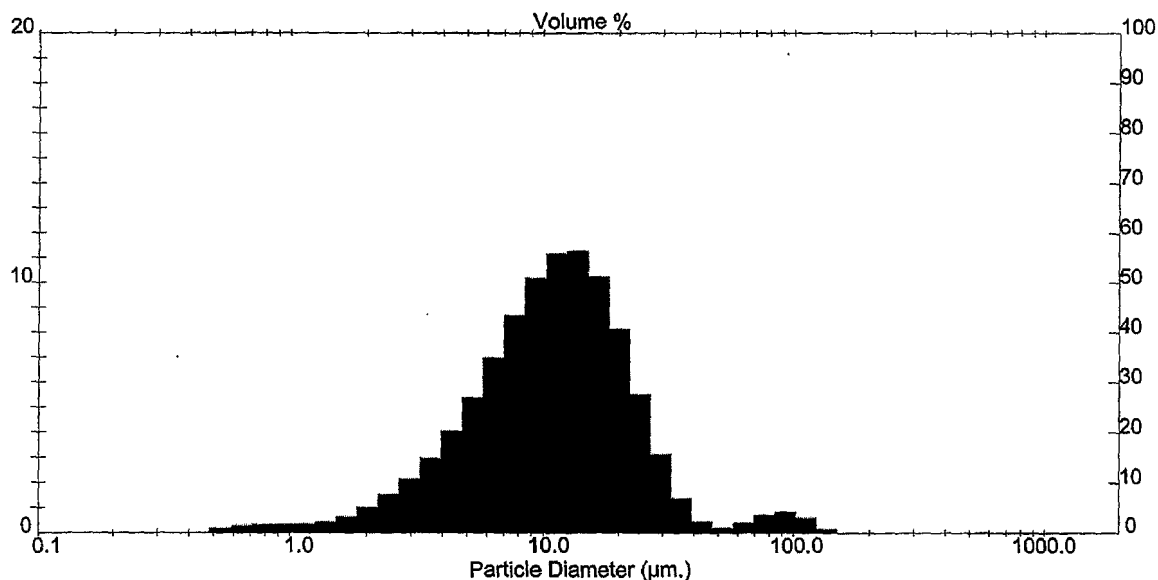
Span = 1.87

Obscuration = 19.98 %

d (0.9) = 24.58 μm Mode = 12.61 μm

Density = 1.00 gm. / c.c.

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %	Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
0.20	0.05	0.48	0.05	8.48	10.18	10.27	45.68
0.48	0.19	0.59	0.24	10.27	11.17	12.43	56.86
0.59	0.29	0.71	0.53	12.43	11.28	15.05	68.14
0.71	0.34	0.86	0.87	15.05	10.24	18.21	78.38
0.86	0.35	1.04	1.21	18.21	8.14	22.04	86.52
1.04	0.36	1.26	1.58	22.04	5.54	26.68	92.06
1.26	0.45	1.52	2.03	26.68	3.13	32.29	95.18
1.52	0.66	1.84	2.69	32.29	1.40	39.08	96.58
1.84	1.03	2.23	3.71	39.08	0.45	47.30	97.03
2.23	1.54	2.70	5.25	47.30	0.21	57.25	97.24
2.70	2.15	3.27	7.40	57.25	0.42	69.30	97.66
3.27	2.97	3.95	10.38	69.30	0.72	83.87	98.39
3.95	4.05	4.79	14.43	83.87	0.84	101.52	99.22
4.79	5.40	5.79	19.83	101.52	0.62	122.87	99.84
5.79	7.00	7.01	26.83	122.87	0.16	148.72	100.00
7.01	8.67	8.48	35.50	148.72	0.00	180.00	100.00

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Figure A2 Graph indicating the particle size distribution of a milled sample for time = 5 minutes



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Version 1.2a

Mon, Nov 20, 2000 11:31AM

Sulphide powder :Run Number 1

Mengtyd: 10 minute

Sample File Name: UFM_C10 , Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:31PM Last saved on: Fri, Jan 04, 1980 8:31PM

Presentation: 2OHD

Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.247 %

Concentration = 0.004 %

Obscuration = 18.17 %

d (0.5) = 8.16 μm d (0.1) = 3.18 μm d (0.9) = 17.58 μm D [4,3] = 10.60 μm

Span = 1.77

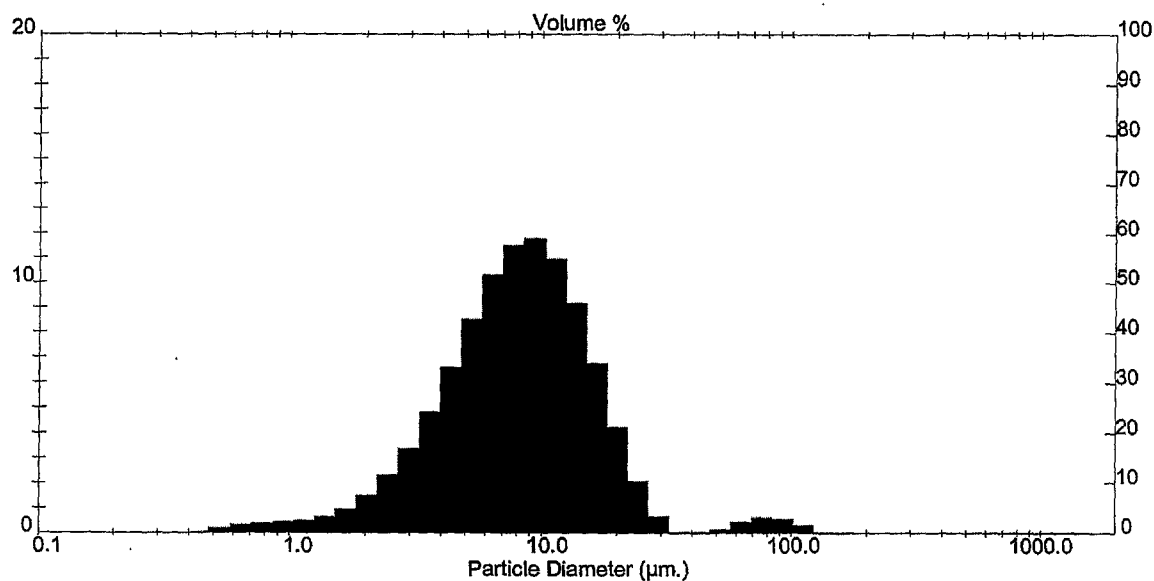
Sauter Mean (D[3,2]) = 5.73 μm Mode = 8.73 μm

Specific Surface Area = 1.0475 sq. m. / gm

Density = 1.00 gm. / c.c.

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
0.20	0.05	0.48	0.05
0.48	0.20	0.59	0.25
0.59	0.32	0.71	0.57
0.71	0.39	0.86	0.96
0.86	0.43	1.04	1.39
1.04	0.49	1.26	1.87
1.26	0.63	1.52	2.50
1.52	0.94	1.84	3.44
1.84	1.48	2.23	4.92
2.23	2.30	2.70	7.23
2.70	3.37	3.27	10.60
3.27	4.81	3.95	15.41
3.95	6.60	4.79	22.00
4.79	8.52	5.79	30.52
5.79	10.33	7.01	40.85
7.01	11.52	8.48	52.37

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
8.48	11.79	10.27	64.16
10.27	10.95	12.43	75.11
12.43	9.18	15.05	84.29
15.05	6.75	18.21	91.05
18.21	4.21	22.04	95.26
22.04	2.05	26.68	97.30
26.68	0.62	32.29	97.93
32.29	0.01	39.08	97.94
39.08	0.00	47.30	97.94
47.30	0.14	57.25	98.08
57.25	0.44	69.30	98.52
69.30	0.61	83.87	99.13
83.87	0.57	101.52	99.70
101.52	0.30	122.87	100.00
122.87	0.00	148.72	100.00
148.72	0.00	180.00	100.00



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Figure A3 Graph indicating the particle size distribution of a milled sample for time = 10 minutes



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Version 1.2a

Mon, Nov 20, 2000 11:32AM

Sulphide powder :Run Number 1

Menglyd: 20 minute

Sample File Name: UFM_C20 , Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:36PM Last saved on: Fri, Jan 04, 1980 8:36PM

Presentation: 2OHD
Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.208 %

Concentration = 0.005 %

Obscuration = 26.60 %

d (0.5) = 6.41 μm d (0.1) = 2.63 μm d (0.9) = 13.76 μm D [4, 3] = 8.27 μm

Span = 1.74

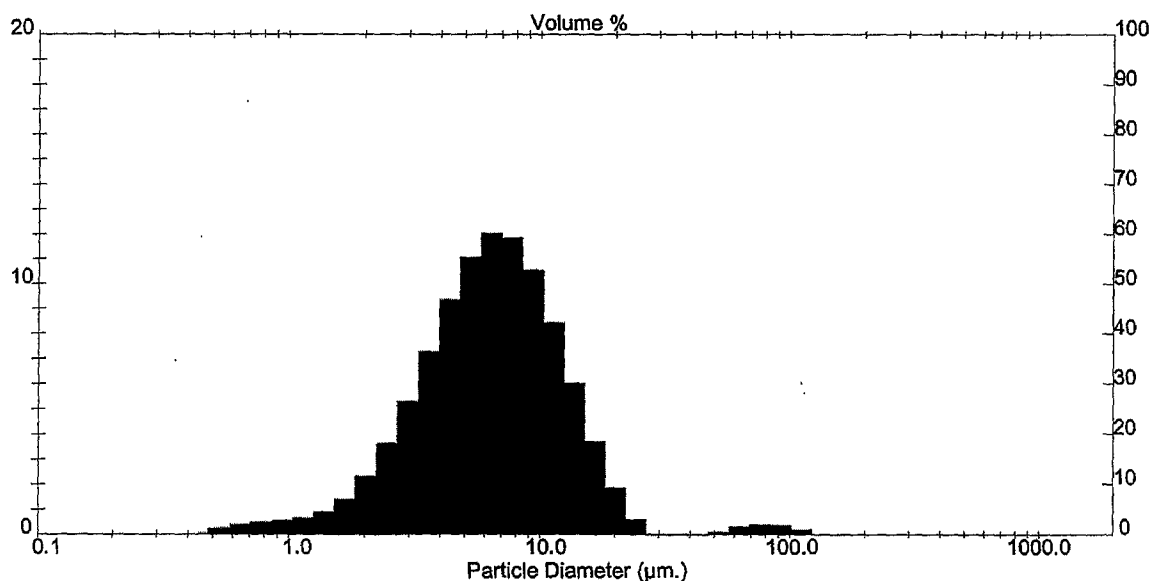
Mode = 6.97 μm Sauter Mean (D[3,2]) = 4.70 μm

Density = 1.00 gm. / c.c.

Specific Surface Area = 1.2775 sq. m. / gm

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
0.20	0.06	0.48	0.06
0.48	0.25	0.59	0.31
0.59	0.40	0.71	0.72
0.71	0.49	0.86	1.21
0.86	0.54	1.04	1.75
1.04	0.63	1.26	2.38
1.26	0.87	1.52	3.25
1.52	1.39	1.84	4.65
1.84	2.30	2.23	6.95
2.23	3.64	2.70	10.59
2.70	5.30	3.27	15.89
3.27	7.29	3.95	23.17
3.95	9.36	4.79	32.54
4.79	11.07	5.79	43.61
5.79	12.04	7.01	55.64
7.01	11.85	8.48	67.49

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
8.48	10.56	10.27	78.05
10.27	8.44	12.43	86.49
12.43	6.03	15.05	92.52
15.05	3.70	18.21	96.22
18.21	1.84	22.04	98.06
22.04	0.59	26.68	98.65
26.68	0.00	32.29	98.65
32.29	0.00	39.08	98.65
39.08	0.00	47.30	98.65
47.30	0.09	57.25	98.74
57.25	0.29	69.30	99.04
69.30	0.40	83.87	99.44
83.87	0.37	101.52	99.81
101.52	0.19	122.87	100.00
122.87	0.00	148.72	100.00
148.72	0.00	180.00	100.00

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Figure A4 Graph indicating the particle size distribution of a milled sample for time = 20 minutes



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Version 1.2a

Mon, Nov 20, 2000 11:32AM

Sulphide powder :Run Number 1

Mengtyd: 30 minute

Sample File Name: UFM_C30 , Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:40PM Last saved on: Fri, Jan 04, 1980 8:40PM

Presentation: 2OHD
Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.198 %

Concentration = 0.004 %

Obscuration = 26.55 %

d (0.5) = 5.87 μ md (0.1) = 2.46 μ md (0.9) = 12.38 μ mD [4, 3] = 7.49 μ m

Span = 1.69

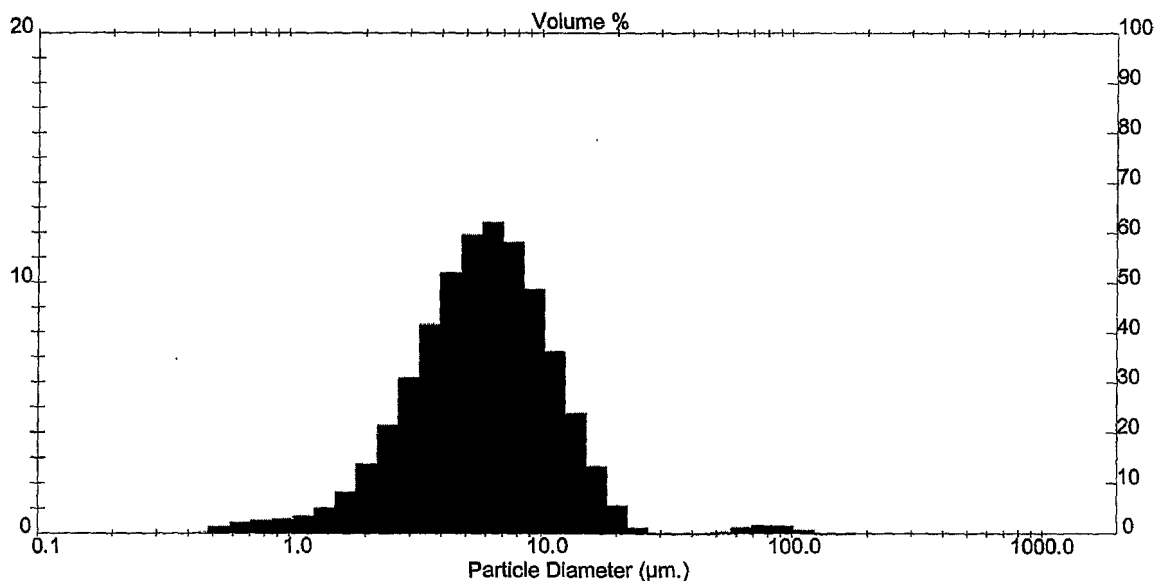
Mode = 6.11 μ mSauter Mean (D[3,2]) = 4.37 μ m

Specific Surface Area = 1.3736 sq. m. / gm

Density = 1.00 gm. / c.c.

Size (Lo) μ m	Result In %	Size (Hi) μ m	Result Below %
0.20	0.07	0.48	0.07
0.48	0.27	0.59	0.34
0.59	0.43	0.71	0.77
0.71	0.52	0.86	1.30
0.86	0.58	1.04	1.88
1.04	0.70	1.26	2.58
1.26	1.01	1.52	3.59
1.52	1.65	1.84	5.24
1.84	2.74	2.23	7.98
2.23	4.30	2.70	12.28
2.70	6.18	3.27	18.46
3.27	8.33	3.95	26.78
3.95	10.41	4.79	37.19
4.79	11.91	5.79	49.10
5.79	12.41	7.01	61.51
7.01	11.62	8.48	73.12

Size (Lo) μ m	Result In %	Size (Hi) μ m	Result Below %
8.48	9.74	10.27	82.87
10.27	7.25	12.43	90.12
12.43	4.77	15.05	94.89
15.05	2.64	18.21	97.53
18.21	1.12	22.04	98.65
22.04	0.22	26.68	98.87
26.68	0.00	32.29	98.87
32.29	0.00	39.08	98.87
39.08	0.00	47.30	98.87
47.30	0.08	57.25	98.95
57.25	0.24	69.30	99.19
69.30	0.33	83.87	99.52
83.87	0.31	101.52	99.83
101.52	0.16	122.87	100.00
122.87	0.00	148.72	100.00
148.72	0.00	180.00	100.00

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Figure A5 Graph indicating the particle size distribution of a milled sample for time = 30 minutes



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Version 1.2a

Mon, Nov 20, 2000 11:32AM

Sulphide powder :Run Number 1

Mengtyd: 40 minute

Sample File Name: UFM_C40 , Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:44PM Last saved on: Fri, Jan 04, 1980 8:45PM

Presentation: 2OHD
Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.205 %

Concentration = 0.005 %

Obscuration = 30.28 %

d (0.5) = 5.91 μ md (0.1) = 2.52 μ md (0.9) = 12.16 μ mD [4,3] = 7.32 μ m

Span = 1.63

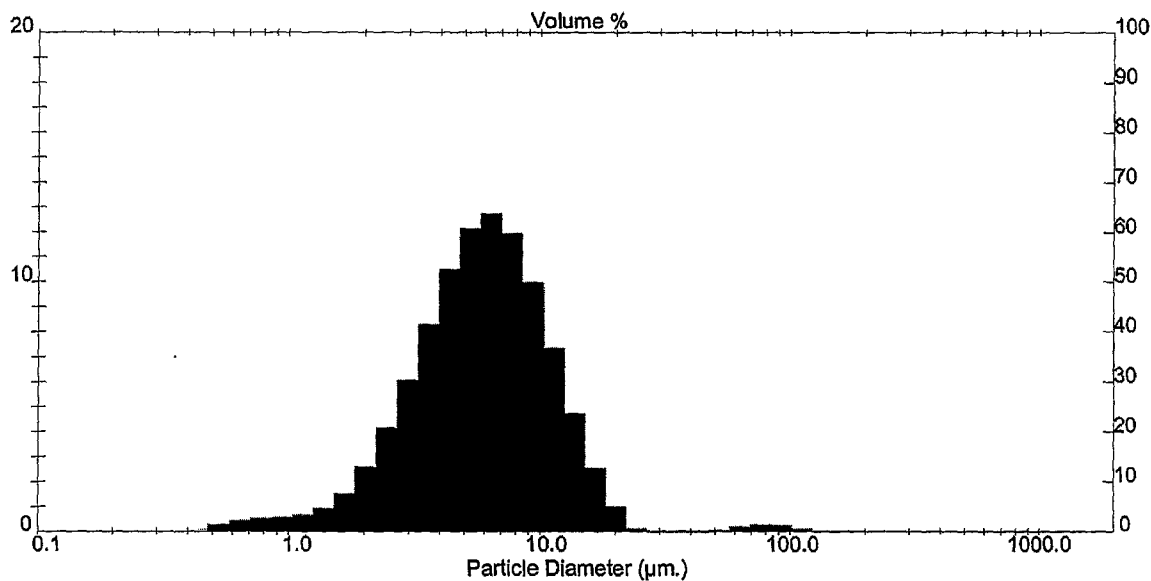
Mode = 6.20 μ mSauter Mean (D[3,2]) = 4.41 μ m

Density = 1.00 gm. / c.c.

Specific Surface Area = 1.3608 sq. m. / gm

Size (Lo) μ m	Result in %	Size (Hi) μ m	Result Below %
0.20	0.07	0.48	0.07
0.48	0.28	0.59	0.35
0.59	0.43	0.71	0.78
0.71	0.52	0.86	1.30
0.86	0.56	1.04	1.86
1.04	0.65	1.26	2.51
1.26	0.92	1.52	3.43
1.52	1.52	1.84	4.96
1.84	2.59	2.23	7.55
2.23	4.15	2.70	11.70
2.70	6.05	3.27	17.75
3.27	8.28	3.95	26.03
3.95	10.50	4.79	36.53
4.79	12.14	5.79	48.66
5.79	12.74	7.01	61.41
7.01	11.95	8.48	73.36

Size (Lo) μ m	Result in %	Size (Hi) μ m	Result Below %
8.48	9.98	10.27	83.34
10.27	7.35	12.43	90.69
12.43	4.74	15.05	95.43
15.05	2.54	18.21	97.97
18.21	1.00	22.04	98.97
22.04	0.13	26.68	99.10
26.68	0.00	32.29	99.10
32.29	0.00	39.08	99.10
39.08	0.00	47.30	99.10
47.30	0.05	57.25	99.15
57.25	0.20	69.30	99.35
69.30	0.28	83.87	99.63
83.87	0.25	101.52	99.88
101.52	0.12	122.87	100.00
122.87	0.00	148.72	100.00
148.72	0.00	180.00	100.00

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Figure A6 Graph indicating the particle size distribution of a milled sample for time = 40 minutes



MASTERSIZER X

Version 1.2a

Mon, Nov 20, 2000 11:32AM

Sulphide powder :Run Number 1

Mengtyd: 50 minute

Sample File Name: UFM_C50 , Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:49PM Last saved on: Fri, Jan 04, 1980 8:49PM

Presentation: 2OHD
Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.318 %

Concentration = 0.004 %

Obscuration = 24.46 %

d (0.5) = 5.31 μ md (0.1) = 2.28 μ md (0.9) = 10.65 μ mD [4, 3] = 5.99 μ m

Span = 1.58

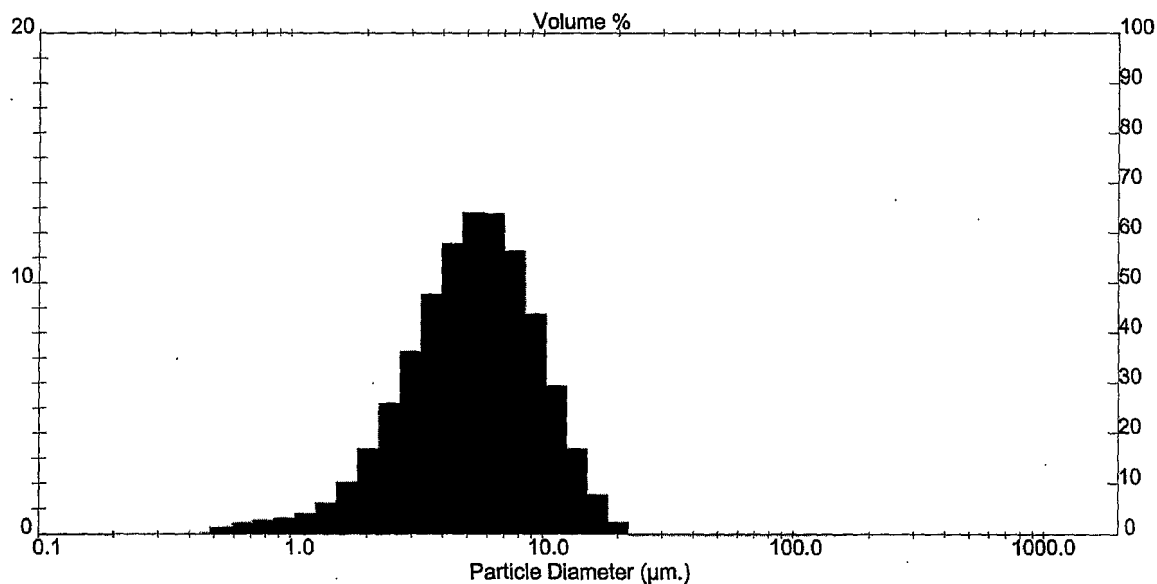
Mode = 5.63 μ mSauter Mean (D[3,2]) = 4.01 μ m

Density = 1.00 gm. / c.c.

Specific Surface Area = 1.4966 sq. m. / gm

Size (Lo) μ m	Result In %	Size (Hi) μ m	Result Below %
0.20	0.07	0.48	0.07
0.48	0.29	0.59	0.36
0.59	0.45	0.71	0.81
0.71	0.55	0.86	1.36
0.86	0.64	1.04	2.00
1.04	0.82	1.26	2.81
1.26	1.24	1.52	4.05
1.52	2.05	1.84	6.10
1.84	3.38	2.23	9.48
2.23	5.20	2.70	14.68
2.70	7.27	3.27	21.96
3.27	9.54	3.95	31.50
3.95	11.58	4.79	43.07
4.79	12.80	5.79	55.87
5.79	12.76	7.01	68.63
7.01	11.27	8.48	79.90

Size (Lo) μ m	Result In %	Size (Hi) μ m	Result Below %
8.48	8.75	10.27	88.66
10.27	5.89	12.43	94.55
12.43	3.39	15.05	97.94
15.05	1.57	18.21	99.51
18.21	0.49	22.04	100.00
22.04	0.00	26.68	100.00
26.68	0.00	32.29	100.00
32.29	0.00	39.08	100.00
39.08	0.00	47.30	100.00
47.30	0.00	57.25	100.00
57.25	0.00	69.30	100.00
69.30	0.00	83.87	100.00
83.87	0.00	101.52	100.00
101.52	0.00	122.87	100.00
122.87	0.00	148.72	100.00
148.72	0.00	180.00	100.00

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Figure A7 Graph indicating the particle size distribution of a milled sample for time = 50 minutes



MASTERSIZER X

Version 1.2a

Mon, Nov 20, 2000 11:33AM

Sulphide powder :Run Number 1

Mengtyd: 60 minute

Sample File Name: UFM_C60 , Record: 1

Source: Analysed

Measured on: Fri, Jan 04, 1980 8:54PM Last saved on: Fri, Jan 04, 1980 8:54PM

Presentation: 2OHD
Polydisperse model

Volume Result

Focus = 100 mm.

Residual = 0.199 %

Concentration = 0.003 %

Obscuration = 24.32 %

d (0.5) = 5.23 μm d (0.1) = 2.27 μm d (0.9) = 10.72 μm D [4, 3] = 6.49 μm

Span = 1.62

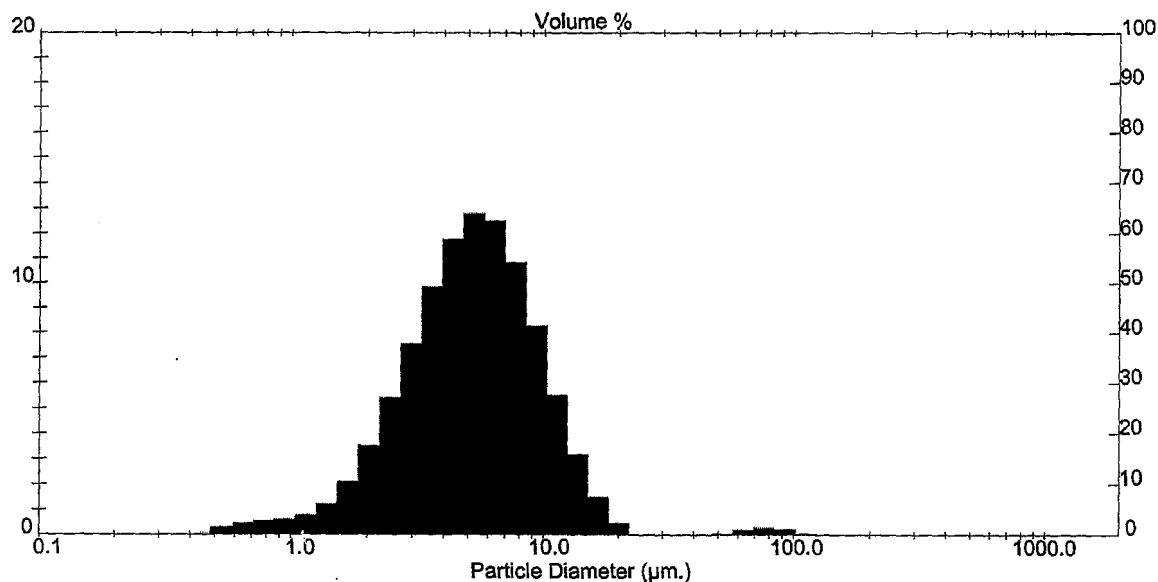
Mode = 5.50 μm Sauter Mean (D[3,2]) = 3.98 μm

Density = 1.00 gm. / c.c.

Specific Surface Area = 1.5081 sq. m. / gm

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
0.20	0.08	0.48	0.08
0.48	0.30	0.59	0.38
0.59	0.46	0.71	0.84
0.71	0.55	0.86	1.38
0.86	0.62	1.04	2.00
1.04	0.79	1.26	2.79
1.26	1.22	1.52	4.01
1.52	2.09	1.84	6.09
1.84	3.50	2.23	9.60
2.23	5.42	2.70	15.02
2.70	7.55	3.27	22.57
3.27	9.83	3.95	32.40
3.95	11.78	4.79	44.18
4.79	12.78	5.79	56.96
5.79	12.49	7.01	69.45
7.01	10.82	8.48	80.27

Size (Lo) μm	Result In %	Size (Hi) μm	Result Below %
8.48	8.27	10.27	88.55
10.27	5.51	12.43	94.06
12.43	3.18	15.05	97.23
15.05	1.48	18.21	98.71
18.21	0.46	22.04	99.17
22.04	0.01	26.68	99.18
26.68	0.00	32.29	99.18
32.29	0.00	39.08	99.18
39.08	0.00	47.30	99.18
47.30	0.05	57.25	99.23
57.25	0.20	69.30	99.42
69.30	0.28	83.87	99.71
83.87	0.24	101.52	99.94
101.52	0.06	122.87	100.00
122.87	0.00	148.72	100.00
148.72	0.00	180.00	100.00

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Figure A8 Graph indicating the particle size distribution of a milled sample for time = 60 minutes

APPENDIX B

(Detailed data sheets of Activox[®] tests)

Table B1 Detailed data sheet of Activox® tests for various agitation rates (400 r/min)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	400	r/min
Aeration	60	L/h
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	1880	3102	16.5	30	49.5	6.4	844	1393	10.6	2902	4788	7.2	2.49	251	1.37
Soln.	30	1650	2660	4389	23.3	45	74.3	9.6	1078	1779	13.5	3442	5679	8.5	2.28	263	1.86
Soln.	50	1650	3910	6452	34.3	63	104.0	13.5	1337	2206	16.7	4157	6859	10.3	2.01	279	2.94
Soln.	90	1650	6690	11039	58.7	132	217.8	28.3	2544	4198	31.8	5210	8597	12.9	1.70	298	5.00
Soln.	150	1650	10300	16995	90.4	385	635.3	82.4	6890	11369	86.3	4373	7215	10.8	1.35	318	10.09
Residue	150	141	12905	1814		962	135.3		12888	1812		421943	59325				
Calc head			94047	18809		3853	771		65903	13181		332703	66541				

Other assays

	Head %	Residue %
S(total)	31.8	23.7
S ²⁻	27.5	3.9
S ⁰	3.5	19.2
SO ₄	0.8	0.6

Sulph. Oxdtn. % = 90.0

Table B2 Detailed data sheet of Activox® tests for various agitation rates (600 r/min)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	600	r/min
Aeration	60	L/h
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3070	5066	26.6	74	122.1	15.9	1109	1830	13.3	4775	7879	12.2	2.54	248	0.98
Soln.	30	1650	7170	11831	62.2	216	356.4	46.3	2322	3831	27.9	5244	8653	13.4	1.92	285	2.16
Soln.	50	1650	10270	16946	89.0	370	610.5	79.3	4892	8072	58.7	3528	5821	9.0	1.56	306	7.06
Soln.	90	1650	11150	18398	96.7	412	679.8	88.3	7103	11720	85.2	2328	3841	6.0	1.42	315	9.51
Soln.	150	1650	11270	18596	97.7	443	731.0	94.9	7578	12504	90.9	2270	3746	5.8	1.24	326	11.66
Residue	150	140	3138	439		279	39.1		8912	1248		434308	60803				
Calc head			95174	19035		3850	770		68757	13751		322743	64549				

Other assays

	Head %	Residue %
S(total)	31.8	20.5
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdm. % = *

* No results due to financial constraints

Table B3 Detailed data sheet of Activox® tests for various agitation rates (800 r/min)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3930	6485	32.8	104	171.6	21.2	1412	2330	16.8	4746	7831	11.9	2.53	249	2.25
Soln.	30	1650	8890	14669	74.3	310	511.5	63.1	2967	4896	35.4	5122	8451	12.9	1.90	286	3.23
Soln.	50	1650	10810	17837	90.3	405	668.3	82.5	5152	8501	61.5	3392	5597	8.5	1.59	304	6.76
Soln.	90	1650	11180	18447	93.4	438	722.7	89.2	7178	11844	85.6	2184	3604	5.5	1.42	314	9.11
Soln.	150	1650	11690	19289	97.7	466	768.9	94.9	7567	12486	90.3	2201	3632	5.5	1.29	322	11.56
Residue	150	146	3126	455		285	41.5		9255	1348		426251	62062				
Calc head			98718	19744		4052	810		69165	13833		328469	65694				

Other assays

	Head %	Residue %
S(total)	31.8	17.3
S ²⁻	27.5	1.3
S ⁰	3.5	15.6
SO ₄	0.8	0.4

Sulph. Oxdtn. % = 96.5

Table B4 Detailed data sheet of Activox® tests for various agitation rates (1000 r/min)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	1000	r/min
Aeration	60	L/h
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	4210	6947	36.2	97	160.1	20.1	1322	2181	16.2	5580	9207	13.4	2.42	255	1.47
Soln.	30	1650	9800	16170	84.2	344	567.6	71.3	3249	5361	39.9	4482	7395	10.8	1.77	293	3.82
Soln.	50	1650	10730	17705	92.1	396	653.4	82.0	5286	8722	64.9	2957	4879	7.1	1.60	304	6.08
Soln.	90	1650	11050	18233	94.9	432	712.8	89.5	7059	11647	86.7	2028	3346	4.9	1.44	313	8.23
Soln.	150	1650	11420	18843	98.1	459	757.4	95.1	7393	12198	90.8	2136	3524	5.1	1.28	322	11.17
Residue	150	145	2566	371		271	39.2		8539	1235		450942	65206				
Calc head			96070	19214		3983	797		67166	13433		343653	68731				

Other assays

	Head %	Residue %
S(total)	31.8	12.82
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B5 Detailed data sheet of Activox® tests for various pulp densities (5% solids)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	5	weight %
Solids	88	g
Pulp	1765	g

Agitation	800	r/min
Aeration	60	L/h
H ₂ SO ₄	2.88	ml
H ₂ SO ₄	5.3	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh	Free acid
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %		mV	g/l
Head	0	88	101100	8896.8		3930	345.84		70500	6204		388500	34188				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			3.10
Soln.	15	1650	1900	3135	34.7	54	89.1	23.1	626.5	1034	17.6	1815	2995	9.4	2.26	266	2.45
Soln.	30	1650	4010	6617	73.2	141	232.7	60.3	1210	1997	34.0	2141.5	3533	11.1	1.91	286	2.84
Soln.	50	1650	5155	8506	94.1	200.5	330.8	85.8	1967.5	3246	55.3	1521	2510	7.9	1.61	304	4.61
Soln.	90	1650	5210	8597	95.1	209.5	345.7	89.6	2699	4453	75.9	947.5	1563	4.9	1.52	309	6.57
Soln.	150	1650	5320	8778	97.1	218.5	360.5	93.5	3027	4995	85.1	644.5	1063	3.3	1.43	314	7.15
Residue	150	71	3742	266		355	25.2		12288	872		434198	30828				
Calc head			102769	9044		4383	386		66670	5867		362403	31891				

Other assays

	Head %	Residue %
S(total)	31.8	17.5
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B6 Detailed data sheet of Activox® tests for various pulp densities (11% solids)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3930	6485	32.8	104	171.6	21.2	1412	2330	16.8	4746	7831	11.9	2.53	249	2.25
Soln.	30	1650	8890	14669	74.3	310	511.5	63.1	2967	4896	35.4	5122	8451	12.9	1.90	286	3.23
Soln.	50	1650	10810	17837	90.3	405	668.3	82.5	5152	8501	61.5	3392	5597	8.5	1.59	304	6.76
Soln.	90	1650	11180	18447	93.4	438	722.7	89.2	7178	11844	85.6	2184	3604	5.5	1.42	314	9.11
Soln.	150	1650	11690	19289	97.7	466	768.9	94.9	7567	12486	90.3	2201	3632	5.5	1.29	322	11.56
Residue	150	146	3126	455		285	41.5		9255	1348		426251	62062				
Calc head			98718	19744		4052	810		69165	13833		328469	65694				

Other assays

	Head %	Residue %
S(total)	31.8	17.3
S ²⁻	27.5	1.3
S ⁰	3.5	15.6
SO ₄	0.8	0.4

Sulph. Oxdtn. % = 96.5

Table B7 Detailed data sheet of Activox® tests for various pulp densities (15% solids)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	15	weight %
Solids	287	g
Pulp	1911	g

Agitation	800	r/min
Aeration	60	L/h
H ₂ SO ₄	9.4	ml
H ₂ SO ₄	17.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	287	101100	29015.7		3930	1127.91		70500	20233.5		388500	111499.5				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			10.10
Soln.	15	1650	5120	8448	31.3	114	188.1	17.4	1731	2856	14.5	7563	12479	13.0	2.28	264	2.65
Soln.	30	1650	11520	19008	70.5	396	653.4	60.5	3864	6376	32.4	8491	14010	14.7	1.83	291	4.90
Soln.	50	1650	14460	23859	88.5	546	900.9	83.5	8156	13457	68.5	5482	9045	9.5	1.55	307	7.25
Soln.	90	1650	15380	25377	94.1	588	970.2	89.9	10704	17662	89.8	2902	4788	5.0	1.38	317	11.37
Soln.	150	1650	16060	26499	98.2	620	1023.0	94.8	10930	18035	91.7	2318	3825	4.0	1.23	327	12.74
Residue	150	210	2246	472		269	56.5		7719	1623		436753	91805				
Calc head			93976	26971		3761	1080		68491	19657		333206	95630				

Other assays

	Head %	Residue %
S(total)	31.8	18.1
S ²⁻	27.5	1.8
S ⁰	3.5	15.9
SO ₄	0.8	0.4

Sulph. Oxidn. % = 95.2

Table B8 Detailed data sheet of Activox® tests for various pulp densities (20% solids)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	20	weight %
Solids	400	g
Pulp	1994	g

Agitation	800	r/min
Aeration	60	L/h
H ₂ SO ₄	13	ml
H ₂ SO ₄	23.9	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	400	101100	40440		3930	1572		70500	28200		388500	155400				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			14.10
Soln.	15	1650	6280	10362	26.8	120	198.0	12.0	1740	2871	9.3	10484	17299	12.8	2.16	271	2.35
Soln.	30	1650	13280	21912	56.6	332	547.8	33.1	4224	6970	22.6	13514	22298	16.4	1.90	286	3.04
Soln.	50	1650	19960	32934	85.1	762	1257.3	76.0	10502	17328	56.3	8894	14675	10.8	1.63	302	7.25
Soln.	90	1650	21700	35805	92.6	866	1428.9	86.4	16108	26578	86.3	4708	7768	5.7	1.41	315	10.00
Soln.	150	1650	22880	37752	97.6	950	1567.5	94.8	17244	28453	92.4	4082	6735	5.0	1.19	329	11.56
Residue	150	311	2991	930		279	86.7		7499	2331		414449	128852				
Calc head			96705	38682		4136	1654		76960	30784		338969	135587				

Other assays

	Head %	Residue %
S(total)	31.8	21.4
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B9 Detailed data sheet of Activox® tests for various pressures (4 bar)**TEST PARAMETERS**

Temperature	110	°C
Pressure	400	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	2140	3531	18.8	32	52.8	6.9	864	1426	10.7	3496	5768	8.2	2.32	261	1.47
Soln.	30	1650	3520	5808	30.9	64	105.6	13.9	1197	1975	14.8	4491	7410	10.6	2.10	274	2.35
Soln.	50	1650	6220	10263	54.7	134	221.1	29.0	2080	3432	25.7	5191	8565	12.2	1.75	295	3.82
Soln.	90	1650	10110	16682	88.9	374	617.1	80.9	5918	9765	73.1	4338	7158	10.2	1.41	315	7.74
Soln.	150	1650	10950	18068	96.2	420	693.0	90.9	7353	12132	90.8	3322	5481	7.8	1.24	325	10.49
Residue	150	149	4759	707		467	69.3		8273	1229		435523	64675				
Calc head			93871	18774		3812	762		66805	13361		350782	70156				

Other assays

	Head %	Residue %
S(total)	31.8	19.5
S ²⁻	27.5	2.2
S ⁰	3.5	17.1
SO ₄	0.8	0.2

Sulph. Oxdtn. % = 94.0

Table B10 Detailed data sheet of Activox® tests for various pressures (7 bar)**TEST PARAMETERS**

Temperature	110	°C
Pressure	700	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh	Free acid
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %		mV	g/l
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	2900	4785	25.1	62	102.3	12.9	1074	1772	13.1	4580	7557	11.3	2.43	255	1.96
Soln.	30	1650	5940	9801	51.4	151	249.2	31.4	1984	3274	24.2	5404	8917	13.4	2.00	280	3.23
Soln.	50	1650	9850	16253	85.3	365	602.3	75.8	4350	7178	53.1	4120	6798	10.2	1.62	303	6.08
Soln.	90	1650	10920	18018	94.5	418	689.7	86.8	6809	11235	83.2	2531	4176	6.3	1.40	316	9.11
Soln.	150	1650	11210	18497	97.0	447	737.6	92.8	7335	12103	89.6	2414	3983	6.0	1.29	322	11.47
Residue	150	147	3827	563		389	57.2		9552	1404		425935	62612				
Calc head			95295	19059		3974	795		67534	13507		332978	66596				

Other assays

	Head %	Residue %
S(total)	31.8	18.3
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B11 Detailed data sheet of Activox® tests for various pressures (10 bar)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3930	6485	32.8	104	171.6	21.2	1412	2330	16.8	4746	7831	11.9	2.53	249	2.25
Soln.	30	1650	8890	14669	74.3	310	511.5	63.1	2967	4896	35.4	5122	8451	12.9	1.90	286	3.23
Soln.	50	1650	10810	17837	90.3	405	668.3	82.5	5152	8501	61.5	3392	5597	8.5	1.59	304	6.76
Soln.	90	1650	11180	18447	93.4	438	722.7	89.2	7178	11844	85.6	2184	3604	5.5	1.42	314	9.11
Soln.	150	1650	11690	19289	97.7	466	768.9	94.9	7567	12486	90.3	2201	3632	5.5	1.29	322	11.56
Residue	150	146	3126	455		285	41.5		9255	1348		426251	62062				
Calc head			98718	19744		4052	810		69165	13833		328469	65694				

Other assays

	Head %	Residue %
S(total)	31.8	17.3
S ²⁻	27.5	1.3
S ⁰	3.5	15.6
SO ₄	0.8	0.4

Sulph. Oxdtn. % = 96.5

Table B12 Detailed data sheet of Activox® tests for various pressures (13 bar)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1300	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	4600	7590	39.3	111	183.2	22.4	1355	2236	16.2	5396	8903	13.2	2.17	270	2.06
Soln.	30	1650	9980	16467	85.3	372	613.8	75.1	2928	4831	34.9	4271	7047	10.5	1.76	295	3.33
Soln.	50	1650	10530	17375	90.0	402	663.3	81.1	4735	7813	56.5	2526	4168	6.2	1.61	304	5.39
Soln.	90	1650	10830	17870	92.6	428	706.2	86.4	6953	11472	82.9	1663	2744	4.1	1.46	313	8.53
Soln.	150	1650	11420	18843	97.6	468	772.2	94.5	7537	12436	89.9	1717	2833	4.2	1.32	321	10.88
Residue	150	159	2909	462		285	45.3		8805	1399		405608	64451				
Calc head			96526	19305		4087	817		69176	13835		336421	67284				

Other assays

	Head %	Residue %
S(total)	31.8	20.5
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxidn. % = *

* No results due to financial constraints

Table B13 Detailed data sheet of Activox® tests for various temperatures (90°C)**TEST PARAMETERS**

Temperature	90	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3160	5214	26.7	97	160.1	20.4	1458	2406	19.0	2192	3617	5.8	2.74	236	1.18
Soln.	30	1650	6150	10148	51.9	214	353.1	45.0	2045	3374	26.7	2321	3830	6.1	2.75	236	1.27
Soln.	50	1650	8530	14075	72.0	307	506.6	64.5	2909	4800	37.9	2641	4358	7.0	2.64	242	1.86
Soln.	90	1650	10470	17276	88.4	394	650.1	82.8	4098	6762	53.5	2515	4150	6.6	2.27	264	2.84
Soln.	150	1650	11170	18431	94.3	427	704.6	89.7	5235	8638	68.3	1908	3148	5.0	2.02	279	3.82
Residue	150	143	7851	1123		563	80.5		28052	4011		415385	59400				
Calc head			97766	19553		3925	785		63246	12649		312741	62548				

Other assays

	Head %	Residue %
S(total)	31.8	20.1
S ²⁻	27.5	3.9
S ⁰	3.5	15.7
SO ₄	0.8	0.5

Sulph. Oxdtn. % = 89.8

Table B14 Detailed data sheet of Activox® tests for various temperatures (100°C)**TEST PARAMETERS**

Temperature	100	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3620	5973	31.6	110	181.5	23.1	1564	2581	19.4	3403	5615	8.6	2.63	242	1.57
Soln.	30	1650	7390	12194	64.5	250	412.5	52.5	2512	4145	31.1	4331	7146	11.0	2.34	260	2.74
Soln.	50	1650	9860	16269	86.1	371	612.2	78.0	4001	6602	49.5	3138	5178	8.0	1.85	289	5.19
Soln.	90	1650	10580	17457	92.4	418	689.7	87.8	5760	9504	71.3	2090	3449	5.3	1.65	300	5.68
Soln.	150	1650	11120	18348	97.1	441	727.7	92.7	6915	11410	85.6	1437	2371	3.6	1.49	310	8.82
Residue	150	157	3492	548		366	57.5		12250	1923		399619	62740				
Calc head			94481	18896		3926	785		66665	13333		325556	65111				

Other assays

	Head %	Residue %
S(total)	31.8	20.13
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B15 Detailed data sheet of Activox® tests for various temperatures (110°C)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3930	6485	32.8	104	171.6	21.2	1412	2330	16.8	4746	7831	11.9	2.53	249	2.25
Soln.	30	1650	8890	14669	74.3	310	511.5	63.1	2967	4896	35.4	5122	8451	12.9	1.90	286	3.23
Soln.	50	1650	10810	17837	90.3	405	668.3	82.5	5152	8501	61.5	3392	5597	8.5	1.59	304	6.76
Soln.	90	1650	11180	18447	93.4	438	722.7	89.2	7178	11844	85.6	2184	3604	5.5	1.42	314	9.11
Soln.	150	1650	11690	19289	97.7	466	768.9	94.9	7567	12486	90.3	2201	3632	5.5	1.29	322	11.56
Residue	150	146	3126	455		285	41.5		9255	1348		426251	62062				
Calc head			98718	19744		4052	810		69165	13833		328469	65694				

Other assays

	Head %	Residue %
S(total)	31.8	17.3
S ²⁻	27.5	1.3
S ⁰	3.5	15.6
SO ₄	0.8	0.4

Sulph. Oxidn. % = **96.5**

Table B16 Detailed data sheet of Activox® tests for various temperatures (120°C)**TEST PARAMETERS**

Temperature	120	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3860	6369	31.1	101	166.7	19.7	1152	1901	13.3	5313	8766	10.6	2.15	271	1.96
Soln.	30	1650	10180	16797	81.9	355	585.8	69.1	3532	5828	40.9	5115	8440	10.2	1.50	309	7.06
Soln.	50	1650	11280	18612	90.8	421	694.7	82.0	6506	10735	75.3	3398	5607	6.8	1.37	317	10.29
Soln.	90	1650	11580	19107	93.2	462	762.3	89.9	7659	12637	88.6	3337	5506	6.6	1.24	325	12.74
Soln.	150	1650	12230	20180	98.4	497	820.1	96.7	7967	13146	92.2	2842	4689	5.7	1.13	331	15.88
Residue	150	152	2161	327		182	27.6		7386	1119		516494	78249				
Calc head			102534	20507		4238	848		71323	14265		414691	82938				

Other assays

	Head %	Residue %
S(total)	31.8	29.0
S ²⁻	27.5	1.0
S ⁰	3.5	26.6
SO ₄	0.8	1.4

Sulph. Oxdtn. % = 97.2

Table B17 Detailed data sheet of Activox[®] tests for various sulphuric acid concentrations (H₂SO₄ = 0 kg/ton)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	0	ml
H ₂ SO ₄	0	g
H ₂ SO ₄	0	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			0.00
Soln.	15	1650	2840	4686	23.5	64	105.6	13.3	573	945	6.8	3002	4953	7.3	2.33	259	1.57
Soln.	30	1650	8670	14306	71.7	293	483.5	60.7	2726	4498	32.2	3981	6569	9.7	1.80	291	3.43
Soln.	50	1650	10540	17391	87.1	381	628.7	78.9	5136	8474	60.7	2666	4399	6.5	1.57	305	5.98
Soln.	90	1650	10980	18117	90.8	404	666.6	83.7	6934	11441	81.9	1700	2805	4.2	1.43	313	8.82
Soln.	150	1650	11550	19058	95.5	449	740.9	93.0	7664	12646	90.6	1572	2594	3.8	1.36	318	9.31
Residue	150	148	6069	898		375	55.5		8889	1316		438889	64956				
Calc head			99779	19956		3982	796		69806	13961		337747	67549				

Other assays

	Head %	Residue %
S(total)	31.8	18.1
S ²⁻	27.5	1.8
S ⁰	3.5	15.8
SO ₄	0.8	0.5

Sulph. Oxdtn. % = 95.2

Table B18 Detailed data sheet of Activox® tests for various sulphuric acid concentrations (H₂SO₄ = 30 kg/ton)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	3.33	ml
H ₂ SO ₄	6.06	g
H ₂ SO ₄	30	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			3.60
Soln.	15	1650	3050	5033	25.6	73	120.5	15.2	861	1421	10.5	3907	6447	9.6	2.36	259	1.47
Soln.	30	1650	7900	13035	66.4	265	437.3	55.0	2532	4178	30.9	4900	8085	12.0	1.97	282	3.82
Soln.	50	1650	10710	17672	90.0	385	635.3	79.9	5005	8258	61.0	2924	4825	7.2	1.62	303	5.49
Soln.	90	1650	11130	18365	93.6	418	689.7	86.8	6847	11298	83.5	1863	3074	4.6	1.44	313	8.43
Soln.	150	1650	11590	19124	97.4	454	749.1	94.3	7313	12066	89.2	1853	3057	4.5	1.34	319	10.68
Residue	150	144	3478	502		316	45.6		10163	1468		444896	64243				
Calc head			98129	19626		3974	795		67670	13534		336502	67300				

Other assays

	Head %	Residue %
S(total)	31.8	16.6
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B19 Detailed data sheet of Activox[®] tests for various sulphuric acid concentrations (H₂SO₄ = 60 kg/ton)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3930	6485	32.8	104	171.6	21.2	1412	2330	16.8	4746	7831	11.9	2.53	249	2.25
Soln.	30	1650	8890	14669	74.3	310	511.5	63.1	2967	4896	35.4	5122	8451	12.9	1.90	286	3.23
Soln.	50	1650	10810	17837	90.3	405	668.3	82.5	5152	8501	61.5	3392	5597	8.5	1.59	304	6.76
Soln.	90	1650	11180	18447	93.4	438	722.7	89.2	7178	11844	85.6	2184	3604	5.5	1.42	314	9.11
Soln.	150	1650	11690	19289	97.7	466	768.9	94.9	7567	12486	90.3	2201	3632	5.5	1.29	322	11.56
Residue	150	146	3126	455		285	41.5		9255	1348		426251	62062				
Calc head			98718	19744		4052	810		69165	13833		328469	65694				

Other assays

	Head %	Residue %
S(total)	31.8	17.3
S ²⁻	27.5	1.3
S ⁰	3.5	15.6
SO ₄	0.8	0.4

Sulph. Oxidn. % = 96.5

Table B20 Detailed data sheet of Activox® tests for various sulphuric acid concentrations (H₂SO₄ = 90 kg/ton)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	10	ml
H ₂ SO ₄	18.36	g
H ₂ SO ₄	90	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			10.80
Soln.	15	1650	3790	6254	32.2	92	151.8	19.1	1447	2388	17.8	6830	11270	16.9	2.27	264	2.84
Soln.	30	1650	9360	15444	79.6	338	557.7	70.3	3097	5110	38.1	4899	8083	12.1	1.63	302	4.80
Soln.	50	1650	11000	18150	93.5	419	691.4	87.2	5436	8969	66.9	3917	6463	9.7	1.53	308	6.86
Soln.	90	1650	11420	18843	97.1	436	719.4	90.7	7229	11928	88.9	2536	4184	6.3	1.38	317	9.51
Soln.	150	1650	11510	18992	97.8	456	752.4	94.9	7428	12256	91.4	2500	4125	6.2	1.27	323	12.15
Residue	150	150	2787	418		271	40.7		7689	1154		417391	62650				
Calc head			97049	19410		3965	793		67052	13410		333877	66775				

Other assays

	Head %	Residue %
S(total)	31.8	21.1
S ²⁻	27.5	1.7
S ⁰	3.5	18.8
SO ₄	0.8	0.6

Sulph. Oxidn. % = **95.4**

Table B21 Detailed data sheet of Activox® tests for various oxygen flow rates (O₂ = 15 l/h)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	15	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3540	5841	30.3	77	127.1	16.1	1051	1734	13.1	5239	8644	12.8	2.48	253	1.18
Soln.	30	1650	7120	11748	61.0	204	336.6	42.7	2217	3658	27.7	5304	8752	13.0	1.95	283	2.94
Soln.	50	1650	9510	15692	81.4	333	549.5	69.6	3897	6430	48.6	4523	7463	11.1	1.63	302	5.10
Soln.	90	1650	10790	17804	92.4	406	669.9	84.9	6574	10847	82.0	2983	4922	7.3	1.42	315	8.53
Soln.	150	1650	11430	18860	97.9	453	747.5	94.7	7284	12019	90.9	2923	4823	7.2	1.23	326	11.76
Residue	150	143	2862	410		291	41.7		8441	1210		436216	62553				
Calc head			96350	19270		3946	789		66145	13229		336882	67376				

Other assays

	Head %	Residue %
S(total)	31.8	17.17
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxidn. % = *

* No results due to financial constraints

Table B22 Detailed data sheet of Activox® tests for various oxygen flow rates (O₂ = 40 l/h)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	40	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3350	5528	29.2	73	120.5	15.0	1084	1789	13.8	5156	8507	12.1	2.45	254	2.16
Soln.	30	1650	6940	11451	60.4	192	316.8	39.4	2196	3623	27.9	5677	9367	13.3	1.94	284	2.74
Soln.	50	1650	10410	17177	90.7	374	617.1	76.8	4370	7211	55.6	4364	7201	10.3	1.57	306	6.08
Soln.	90	1650	11070	18266	96.4	434	716.1	89.1	6702	11058	85.2	2628	4336	6.2	1.39	317	9.51
Soln.	150	1650	11300	18645	98.4	465	767.3	95.4	7157	11809	91.0	2583	4262	6.1	1.25	325	11.66
Residue	150	145	2072	301		252	36.6		8006	1164		453722	65971				
Calc head			94731	18946		4019	804		64866	12973		351166	70233				

Other assays

	Head %	Residue %
S(total)	31.8	17.11
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B23 Detailed data sheet of Activox® tests for various oxygen flow rates (O₂ = 60 l/h)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3930	6485	32.8	104	171.6	21.2	1412	2330	16.8	4746	7831	11.9	2.53	249	2.25
Soln.	30	1650	8890	14669	74.3	310	511.5	63.1	2967	4896	35.4	5122	8451	12.9	1.90	286	3.23
Soln.	50	1650	10810	17837	90.3	405	668.3	82.5	5152	8501	61.5	3392	5597	8.5	1.59	304	6.76
Soln.	90	1650	11180	18447	93.4	438	722.7	89.2	7178	11844	85.6	2184	3604	5.5	1.42	314	9.11
Soln.	150	1650	11690	19289	97.7	466	768.9	94.9	7567	12486	90.3	2201	3632	5.5	1.29	322	11.56
Residue	150	146	3126	455		285	41.5		9255	1348		426251	62062				
Calc head			98718	19744		4052	810		69165	13833		328469	65694				

Other assays

	Head %	Residue %
S(total)	31.8	17.3
S ²⁻	27.5	1.3
S ⁰	3.5	15.6
SO ₄	0.8	0.4

Sulph. Oxidn. % = 96.5

Table B24 Detailed data sheet of Activox® tests for various oxygen flow rates (O₂ = 90 l/h)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	90	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	4210	6947	34.9	86	141.9	18.1	1309	2160	15.3	5634	9296	13.4	2.38	258	1.76
Soln.	30	1650	9750	16088	80.9	344	567.6	72.2	3154	5204	36.9	4484	7399	10.7	1.68	299	4.31
Soln.	50	1650	10800	17820	89.6	392	646.8	82.3	5175	8539	60.6	3240	5346	7.7	1.55	307	5.29
Soln.	90	1650	11220	18513	93.1	421	694.7	88.4	7269	11994	85.1	2216	3656	5.3	1.39	316	8.72
Soln.	150	1650	11780	19437	97.8	450	742.5	94.4	7750	12788	90.8	2262	3732	5.4	1.30	322	11.86
Residue	150	148	3020	447		295	43.6		8793	1300		442401	65431				
Calc head			99418	19884		3931	786		70440	14088		345817	69163				

Other assays

	Head %	Residue %
S(total)	31.8	17.95
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxidn. % = *

* No results due to financial constraints

Table B25 Detailed data sheet of Activox[®] test done on as received concentrate (80% - 62µm)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	1100	1815	9.3	35	57.8	7.4	361	596	4.7	4062	6702	10.0	2.09	278	2.84
Soln.	30	1650	1850	3053	15.7	59	97.4	12.5	447	738	5.8	4025	6641	9.9	1.87	291	3.82
Soln.	50	1650	3210	5297	27.2	110	181.5	23.3	770	1271	9.9	3425	5651	8.5	1.65	305	5.68
Soln.	90	1650	5640	9306	47.7	203	335.0	43.0	1755	2896	22.6	2696	4448	6.7	1.55	311	7.15
Soln.	150	1650	7710	12722	65.2	282	465.3	59.8	2925	4826	37.7	1809	2985	4.5	1.47	315	8.53
Residue	150	158	42783	6777		1978	313.3		50337	7973		403218	63870				
Calc head			97492	19498		3893	779		63998	12800		334273	66855				

Other assays

	Head %	Residue %
S(total)	31.8	21.5
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxidn. % = *

* No results due to financial constraints

Table B26 Detailed data sheet of Activox® test done with the addition of nitrogen species (HNO₃ = 3 g/l)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	15	weight %
Solids	287	g
Pulp	1911	g

Agitation	800	r/min
Aeration	60	L/h O ₂
HNO ₃	3	g/l
H ₂ SO ₄	9.4	ml
H ₂ SO ₄	17.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			11.30
Soln.	15	1650	4500	7425	41.6	105	173.3	25.8	1899	3133	22.2	5692	9392	14.1	2.3	266	1.47
Soln.	30	1650	8480	13992	78.4	259	427.4	63.5	3608	5953	42.1	4921	8120	12.2	1.76	298	4.31
Soln.	50	1650	8680	14322	80.2	302	498.3	74.1	5631	9291	65.7	3163	5219	7.8	1.57	309	7.06
Soln.	90	1650	9320	15378	86.1	332	547.8	81.4	7236	11939	84.4	2085	3440	5.2	1.41	319	8.72
Soln.	150	1650	10480	17292	96.9	382	630.3	93.7	7724	12745	90.1	1916	3161	4.7	1.31	325	10.68
Residue	150	153	3661	558		278	42.4		9149	1395		416999	63592				
Calc head			89252	17850		3363	673		70699	14140		333769	66754				

Other assays

	Head %	Residue %
S(total)	31.8	20.4
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxidn. % = *

* No results due to financial constraints

Table B27 Detailed data sheet of Activox[®] test done with the addition silver catalyst (AgNO₃ = 0.32 g/l)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
AgNO ₃	0.32	g/l
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	1790	2954	15.8	19	31.4	4.6	2012	3320	26.0	3129	5163	7.9	2.22	271	1.67
Soln.	30	1650	4890	8069	43.1	27	44.6	6.5	2811	4638	36.3	3344	5518	8.5	1.98	285	2.84
Soln.	50	1650	6190	10214	54.6	76	125.4	18.4	4519	7456	58.3	3146	5191	8.0	1.74	299	4.70
Soln.	90	1650	8690	14339	76.6	258	425.7	62.4	6827	11265	88.1	1964	3241	5.0	1.46	315	8.33
Soln.	150	1650	10630	17540	93.7	364	600.6	88.1	6997	11545	90.3	1436	2369	3.6	1.3	325	11.37
Residue	150	144	8107	1171		562	81.2		8612	1244		435635	62906				
Calc head			93551	18710		3409	682		63943	12789		326375	65275				

Other assays

	Head %	Residue %
S(total)	31.8	21.3
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B28 Detailed data sheet of Activox® test done with the addition of goethite (FeOOH = 30 g)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
FeOOH	30	g
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3480	5742	31.1	73	120.5	17.7	1424	2350	18.4	6060	9999	14.5	2.55	251	2.45
Soln.	30	1650	8750	14438	78.1	249	410.9	60.3	3701	6107	47.9	5456	9002	13.1	1.85	292	4.70
Soln.	50	1650	9620	15873	85.9	309	509.9	74.8	6363	10499	82.4	3720	6138	8.9	1.64	304	7.25
Soln.	90	1650	10220	16863	91.2	346	570.9	83.7	6781	11189	87.8	2746	4531	6.6	1.45	316	9.21
Soln.	150	1650	10890	17969	97.2	392	646.8	94.9	7019	11581	90.9	2600	4290	6.2	1.32	324	11.96
Residue	150	145	3551	515		241	34.9		7978	1157		445843	64647				
Calc head			92417	18483		3409	682		63691	12738		344686	68937				

Other assays

	Head %	Residue %
S(total)	31.8	20.5
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B29 Detailed data sheet of baseline Activox[®] test (1)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	3930	6485	32.8	104	171.6	21.2	1412	2330	16.8	4746	7831	11.9	2.53	249	2.25
Soln.	30	1650	8890	14669	74.3	310	511.5	63.1	2967	4896	35.4	5122	8451	12.9	1.90	286	3.23
Soln.	50	1650	10810	17837	90.3	405	668.3	82.5	5152	8501	61.5	3392	5597	8.5	1.59	304	6.76
Soln.	90	1650	11180	18447	93.4	438	722.7	89.2	7178	11844	85.6	2184	3604	5.5	1.42	314	9.11
Soln.	150	1650	11690	19289	97.7	466	768.9	94.9	7567	12486	90.3	2201	3632	5.5	1.29	322	11.56
Residue	150	146	3126	455		285	41.5		9255	1348		426251	62062				
Calc head			98718	19744		4052	810		69165	13833		328469	65694				

Other assays

	Head %	Residue %
S(total)	31.8	17.3
S ²⁻	27.5	1.3
S ⁰	3.5	15.6
SO ₄	0.8	0.4

Sulph. Oxidn. % = 96.5

Table B30 Detailed data sheet of baseline Activox[®] test (2)

TEST PARAMETERS

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	4110	6782	34.7	114	188.1	23.3	1443	2381	18.0	4130	6815	10.5	2.55	248	2.64
Soln.	30	1650	8980	14817	75.7	316	521.4	64.6	2626	4333	32.7	5449	8991	13.9	2.07	276	3.52
Soln.	50	1650	10800	17820	91.1	417	688.1	85.3	4676	7715	58.2	3636	5999	9.3	1.75	295	6.68
Soln.	90	1650	11340	18711	95.6	437	721.1	89.4	6750	11138	84.0	2105	3473	5.4	1.50	310	9.26
Soln.	150	1650	11610	19157	97.9	463	764.0	94.7	7181	11849	89.4	1703	2810	4.3	1.34	319	11.74
Residue	150	145	2853	413		297	43.0		9730	1410		427495	61944				
Calc head			97849	19570		4035	807		66293	13259		323770	64754				

Other assays

	Head %	Residue %
S(total)	31.8	18.8
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxdtn. % = *

* No results due to financial constraints

Table B31 Detailed data sheet of baseline Activox[®] test (3)**TEST PARAMETERS**

Temperature	110	°C
Pressure	1000	kPa
Time	150	min
% Solids	11	weight %
Solids	200	g
Pulp	1850	g

Agitation	800	r/min
Aeration	60	L/h O ₂
H ₂ SO ₄	6.7	ml
H ₂ SO ₄	12.2	g
H ₂ SO ₄	60	kg/ton

Product			Nickel			Cobalt			Copper			Iron			pH	Eh mV	Free acid g/l
	Time min	Mass g	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %	Assay mg/kg	Mass mg	Dist %			
Head	0	200	101100	20220		3930	786		70500	14100		388500	77700				
Soln.	0	1650	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0			7.20
Soln.	15	1650	4897	8080	35.5	138	227.7	23.5	1483	2447	16.7	5550	9158	12.1	2.42	254	2.19
Soln.	30	1650	10245	16904	74.3	385	635.3	65.7	3175	5239	35.8	5970	9851	13.0	1.85	289	3.28
Soln.	50	1650	12355	20386	89.6	479	790.4	81.7	5550	9158	62.6	4050	6683	8.8	1.52	308	6.82
Soln.	90	1650	12900	21285	93.6	532	877.8	90.7	7713	12726	87.0	3025	4991	6.6	1.37	316	9.27
Soln.	150	1650	13475	22234	97.7	556	917.4	94.8	8063	13304	90.9	3088	5095	6.7	1.25	324	11.65
Residue	150	156	3317	517		322	50.2		8516	1327		451777	70423				
Calc head			113754	22751		4838	968		73157	14631		377591	75518				

Other assays

	Head %	Residue %
S(total)	31.8	18.2
S ²⁻	27.5	*
S ⁰	3.5	*
SO ₄	0.8	*

Sulph. Oxidn. % = *

* No results due to financial constraints

APPENDIX C

(EDAX quantification spectra of SEM micrographs)

- * Please note that the aluminium (Al) peaks shown on the following spectrums is not brought into account for the quantitative analysis. This Al present is a result of the grinding media used.

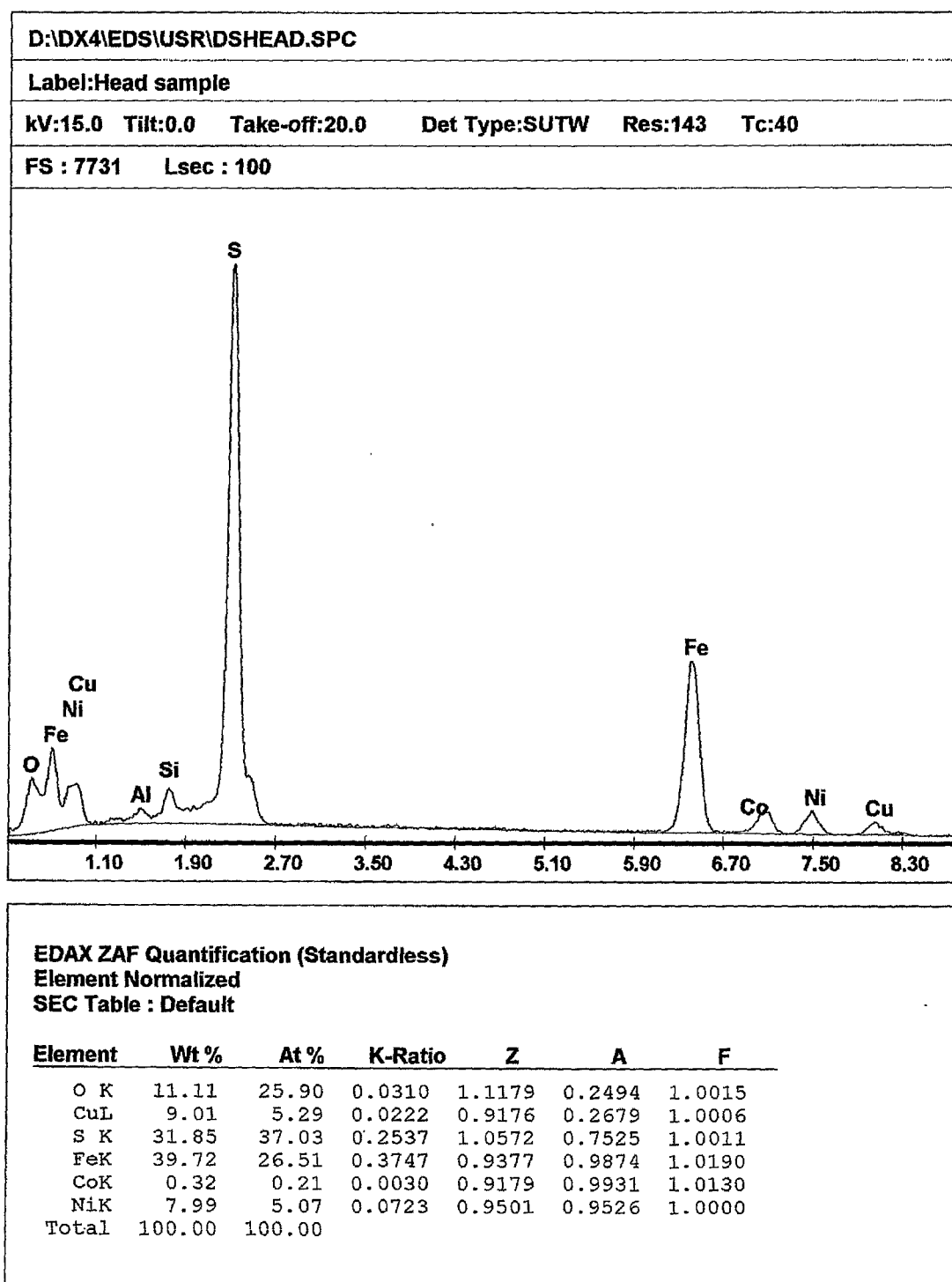


Figure C1 EDAX quantification spectrum of SEM micrograph represented in figure 4.22

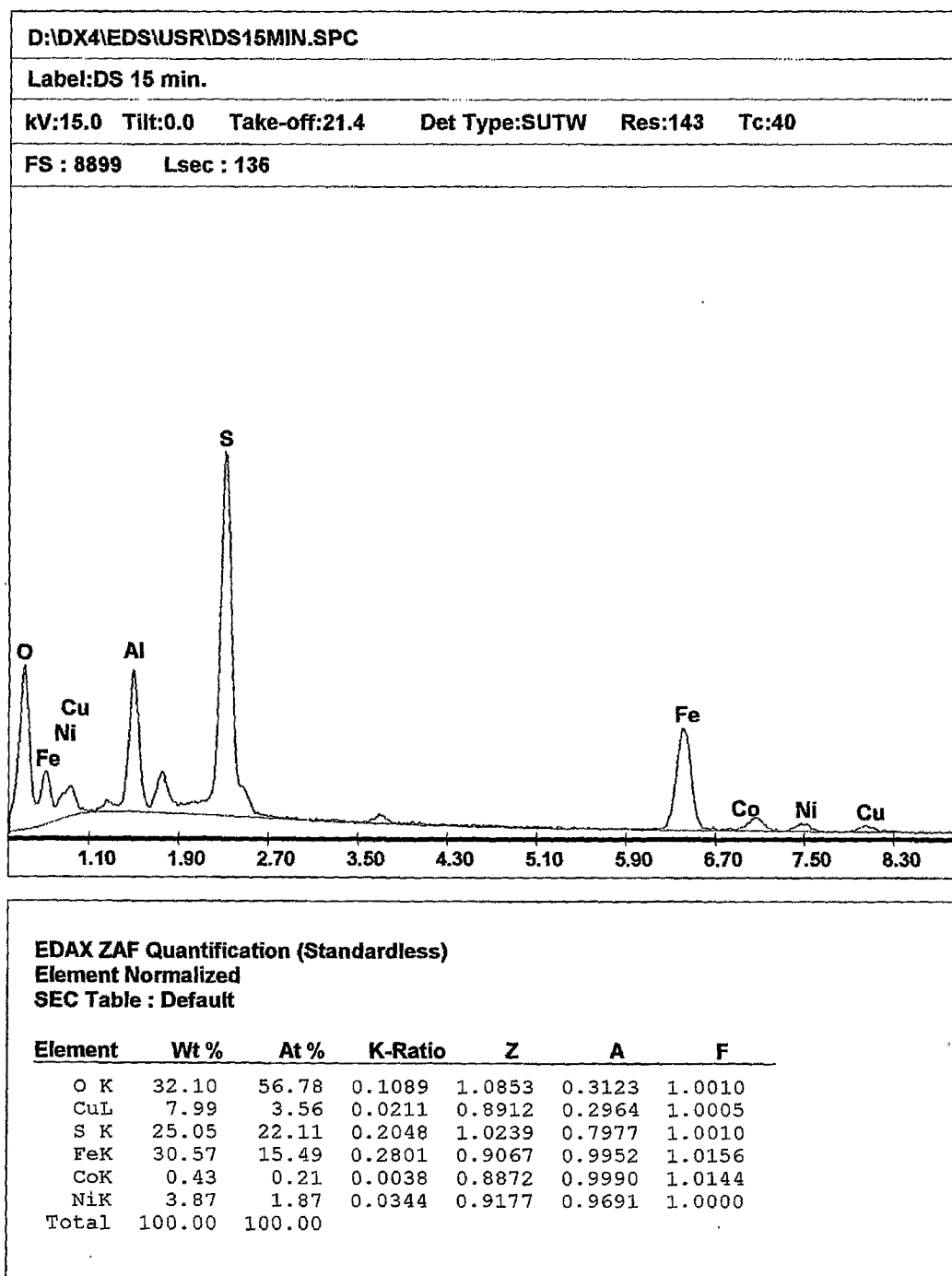


Figure C2 EDAX quantification spectrum of SEM micrograph represented in figure 4.23

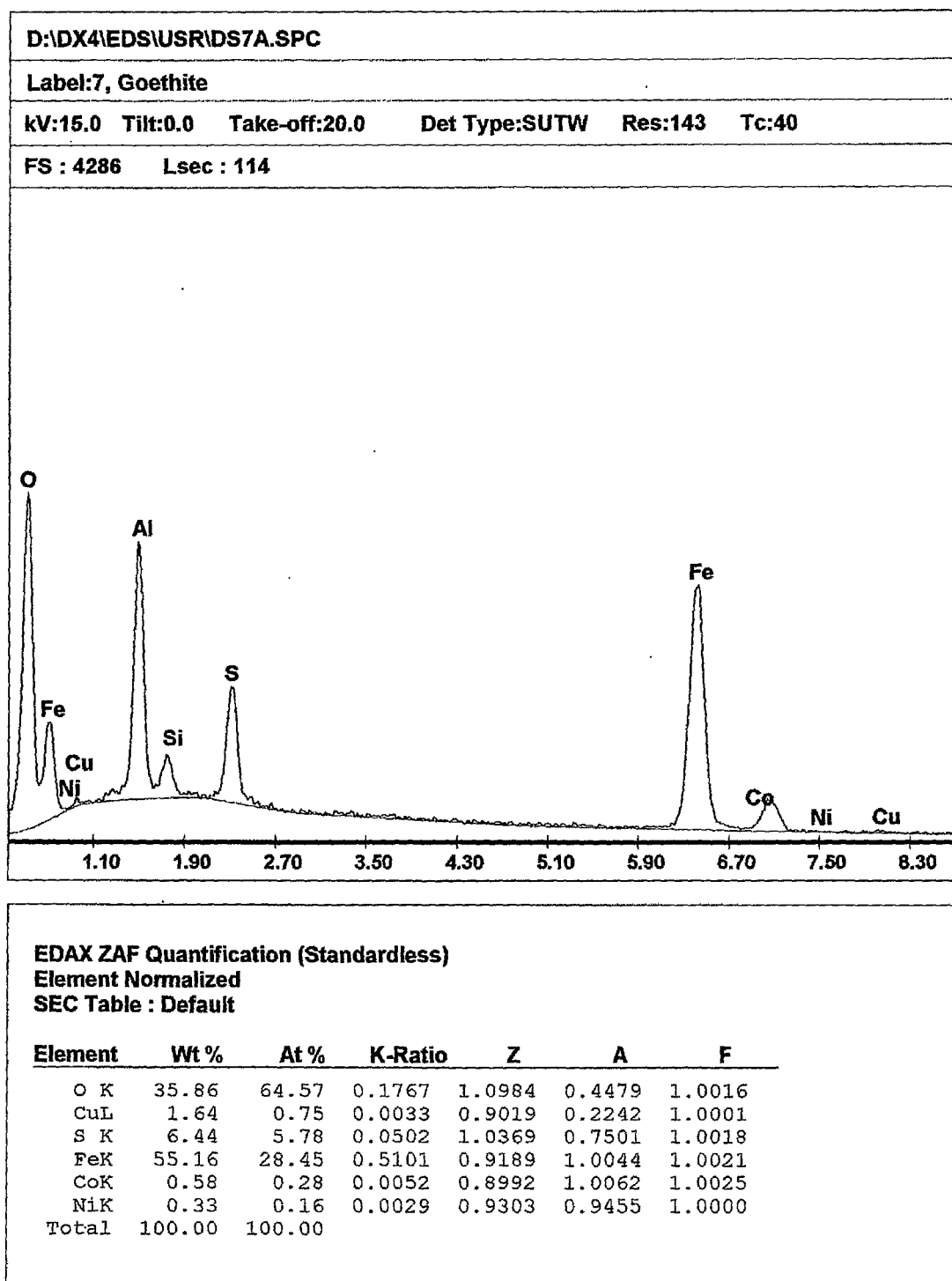


Figure C3 EDAX quantification spectrum of SEM micrograph represented in figure 4.24

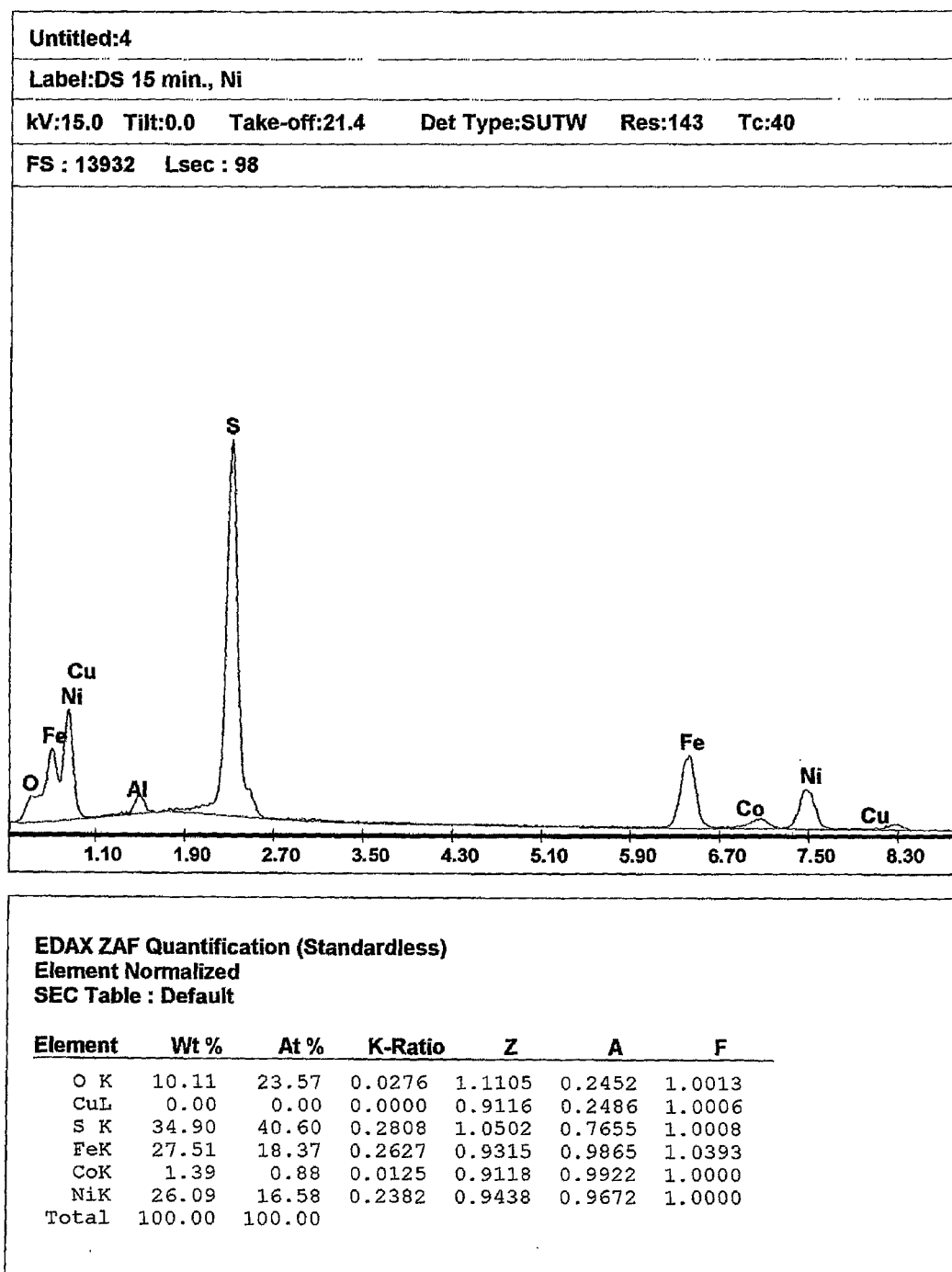


Figure C4 EDAX quantification spectrum of SEM micrograph represented in figure 4.25

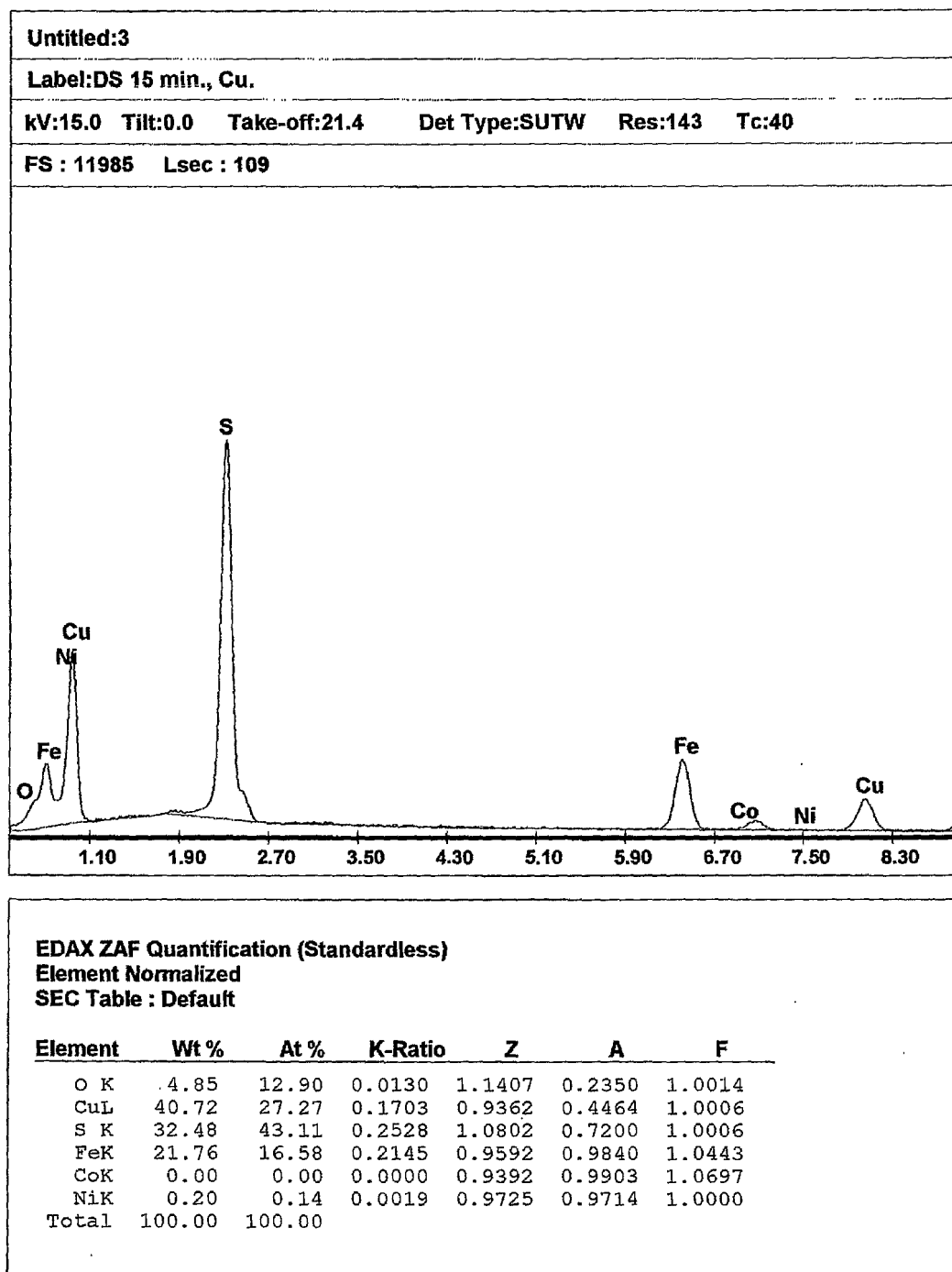


Figure C5 EDAX quantification spectrum of SEM micrograph represented in figure 4.26

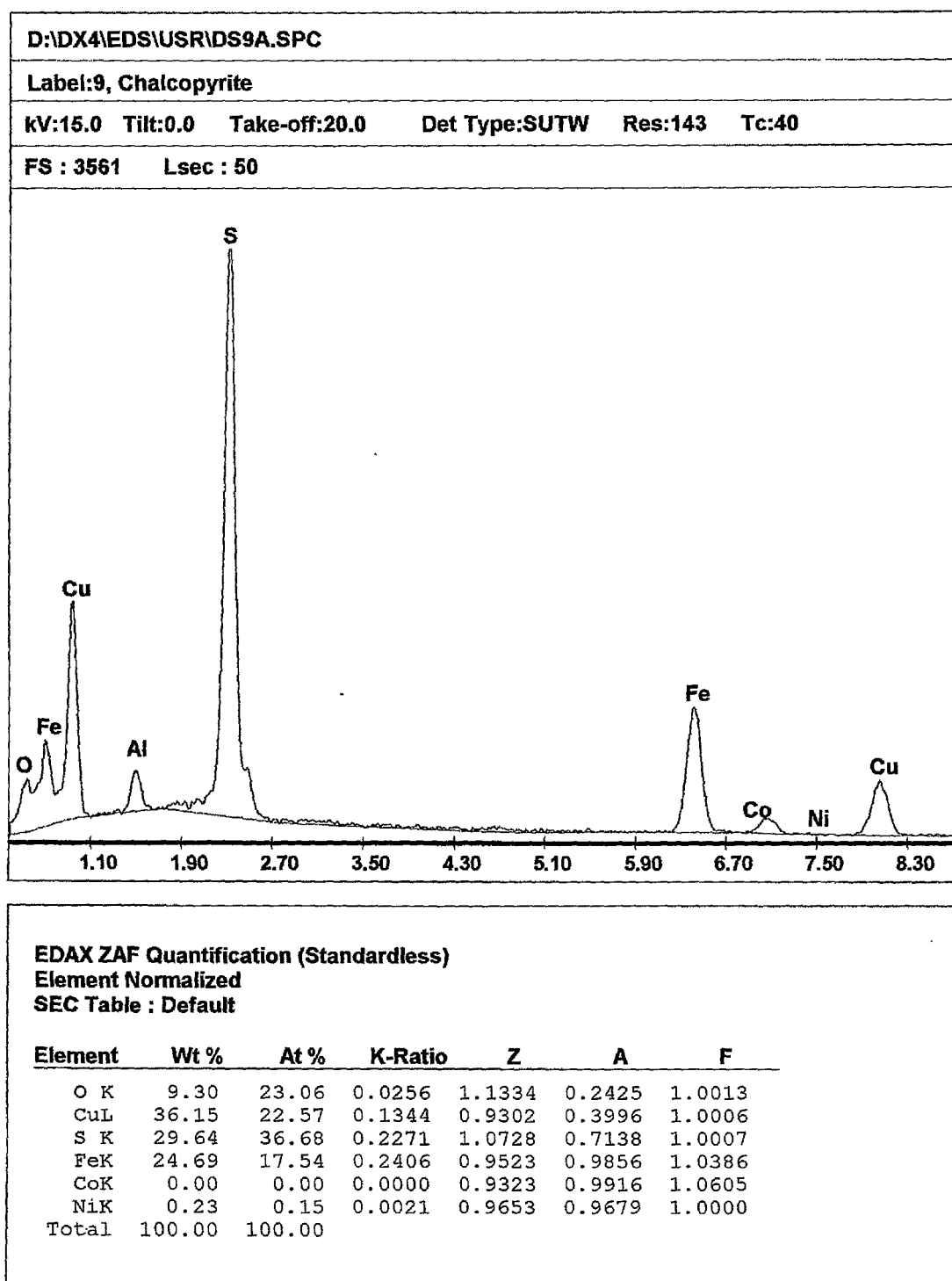


Figure C6 EDAX quantification spectrum of partially leached metal from SEM micrograph represented in figure 4.27

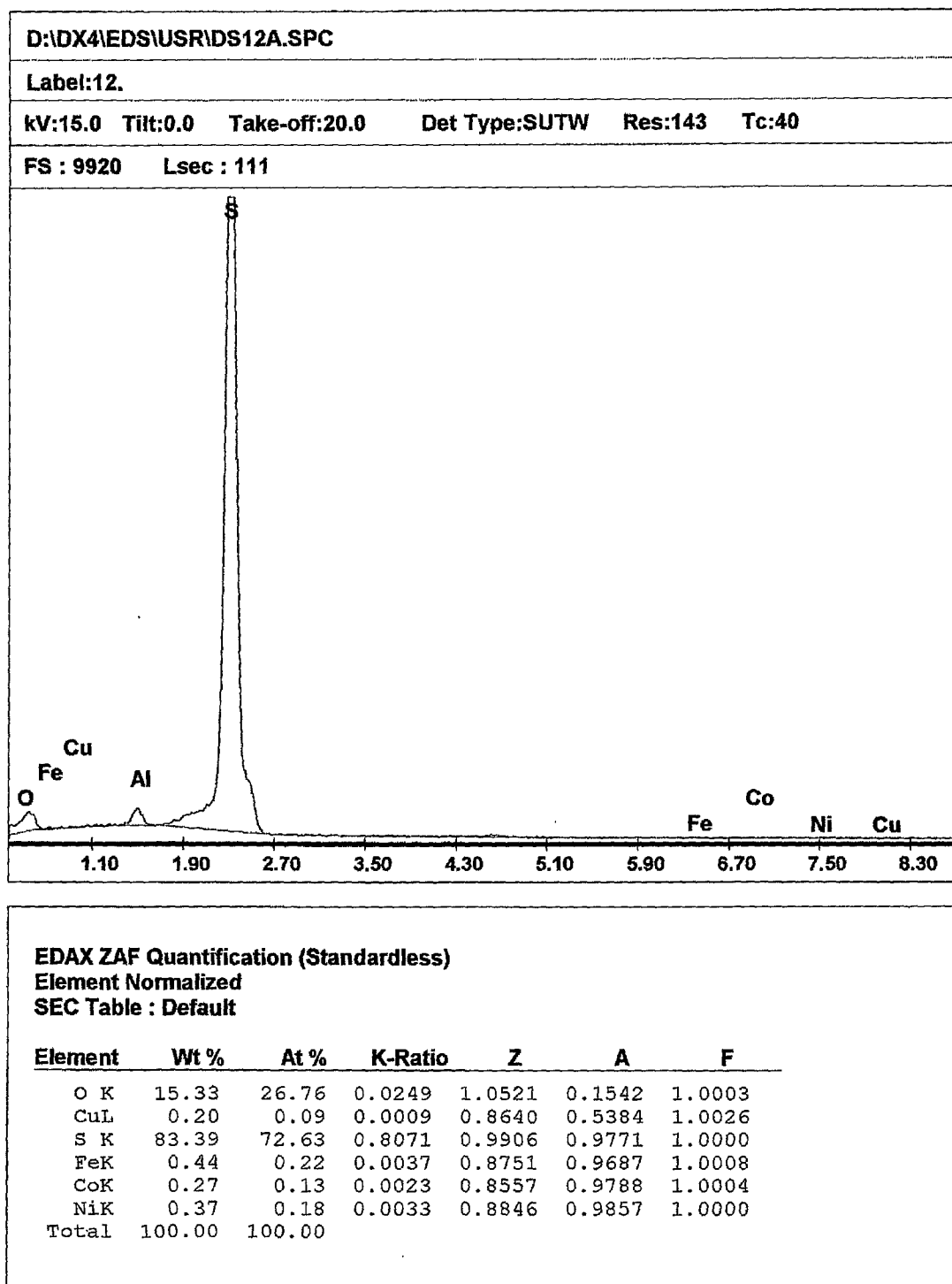


Figure C7 EDAX quantification spectrum of sulphur drops from SEM micrograph represented in figure 4.28

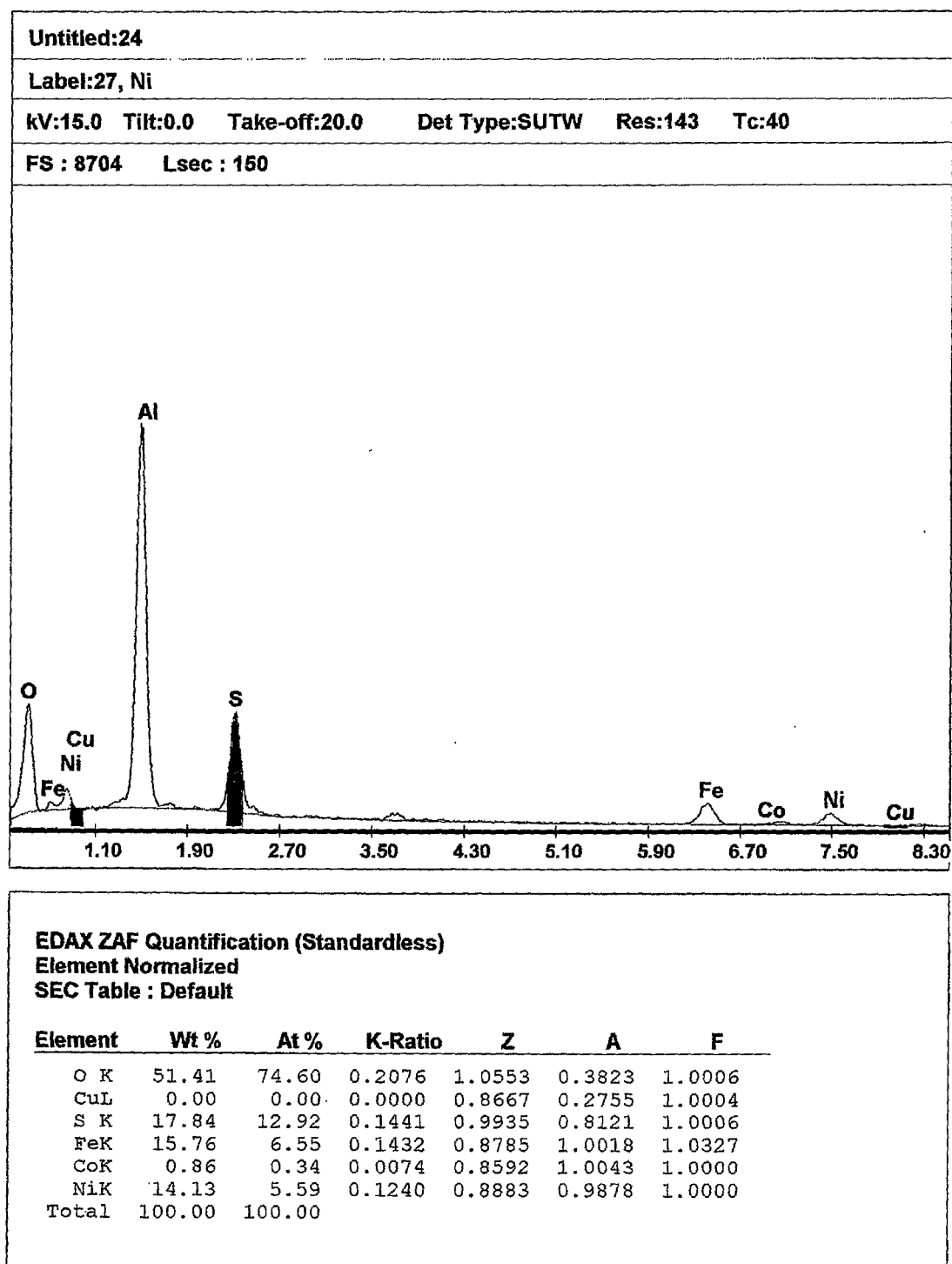


Figure C8 EDAX quantification spectrum of SEM micrograph represented in figure 4.29

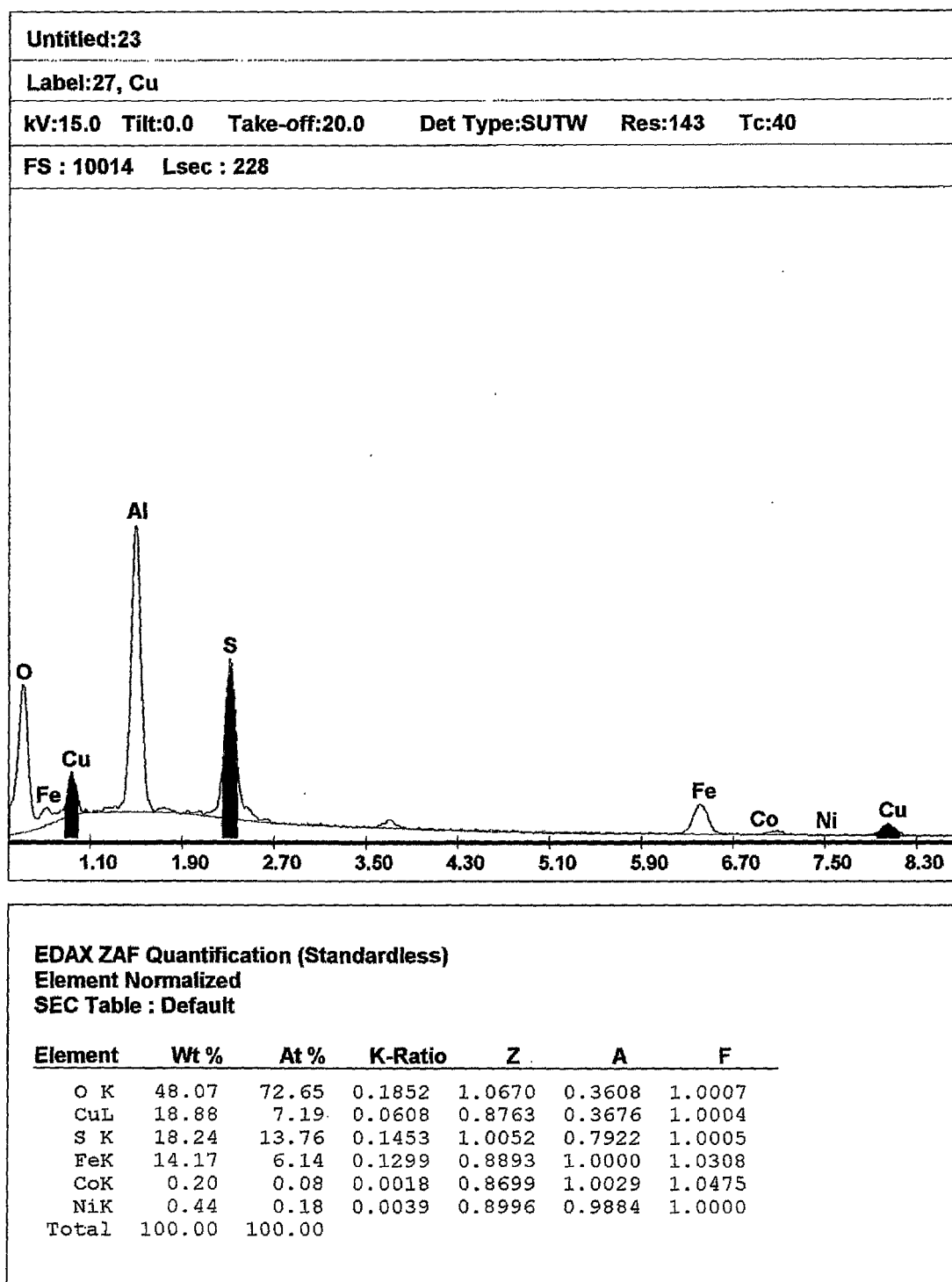


Figure C9 EDAX quantification spectrum of SEM micrograph represented in figure 4.30

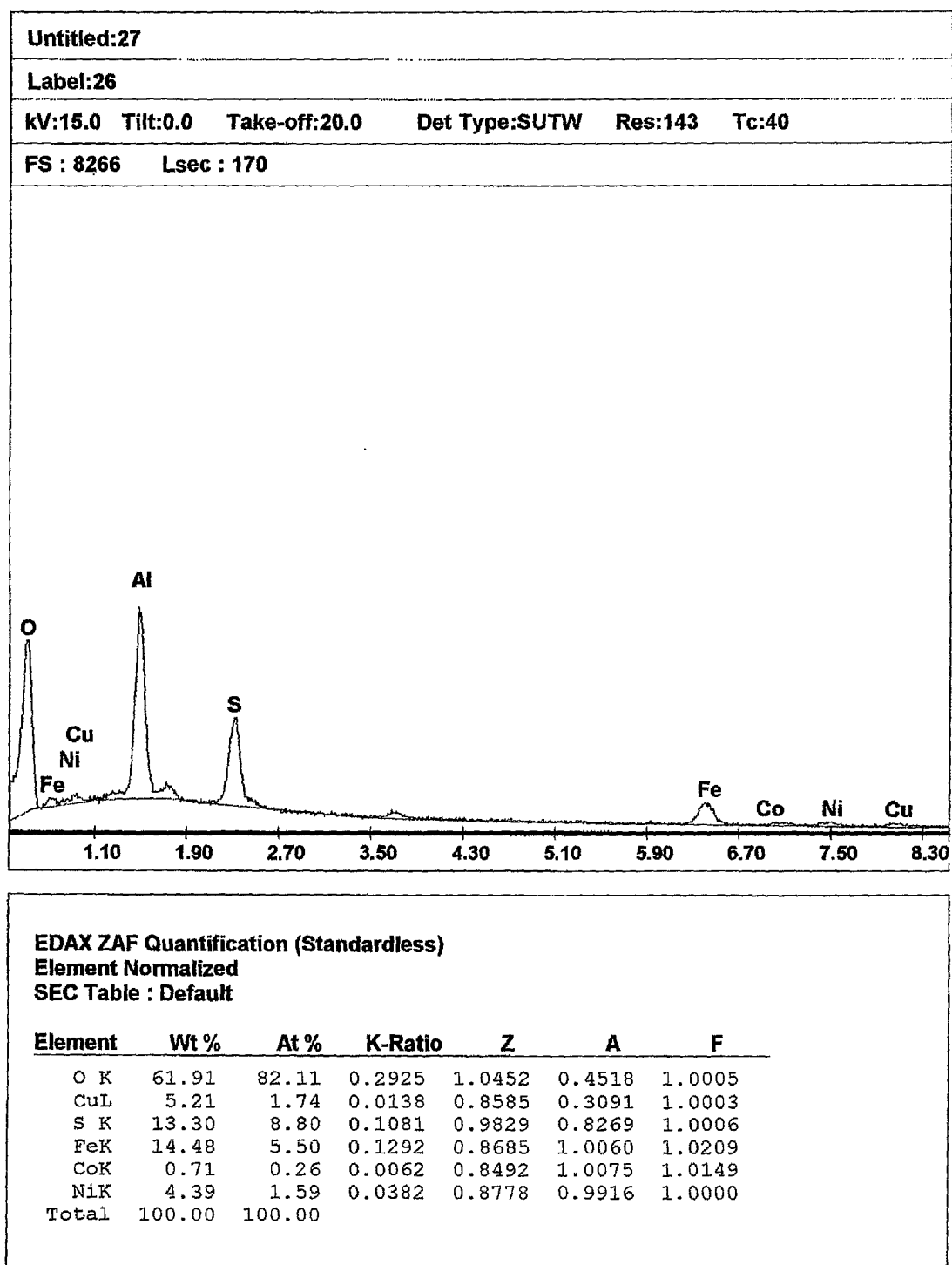


Figure C10 EDAX quantification spectrum of SEM micrograph represented in figure 4.31

APPENDIX D

(Calculation of reaction rate constants)

The reaction rate constants for the relevant leach data obtained from the present investigation were calculated using the following model:

$$x = 1 - e^{-kt} \quad \text{.....(21)}$$

where, k = reaction rate constant (1/min), x = leached fraction and t = time (min)

The calculation and values of the reaction rate constant, k , are shown in Tables D1 to D6. Please note the following description and formula for Table captions used in Tables D1 to D6:

t (min)	= time in minutes
x (%)	= percentage metal leached
x (frac)	= fraction of metal leached ($x/100$)
x_2 (frac)	= fraction of metal leached predicted by model
Error	= error margin between actual leached fraction and predicted leached fraction
	$(x-x_2)^2$

The reaction rate constant, k , is calculated by iterating k to a value that produced the lowest total error.

Table D1 Calculation sheet of reaction rate constants for various agitation rates

Ni					Co					Cu				
400 rpm					400 rpm					400 rpm				
k = 0.010523					k = 0.00604					k = 0.006784				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	16.5	0.165	0.146	0.00036	15	6.4	0.064	0.087	0.000512	15	10.6	0.106	0.097	8.54E-05
30	23.3	0.233	0.271	0.001423	30	9.6	0.096	0.166	0.004864	30	13.5	0.135	0.184	0.002416
50	34.3	0.343	0.409	0.004373	50	13.5	0.135	0.261	0.015795	50	16.7	0.167	0.288	0.014563
90	58.7	0.587	0.612	0.000631	90	28.3	0.283	0.419	0.018596	90	31.8	0.318	0.457	0.019314
150	90.4	0.904	0.794	0.012164	150	82.4	0.824	0.596	0.052035	150	86.3	0.863	0.639	0.050372
				0.018951					0.091802					0.086751

600 rpm					600 rpm					600 rpm				
k = 0.032034					k = 0.022756					k = 0.015923				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	26.6	0.266	0.382	0.013348	15	15.9	0.159	0.289	0.016948	15	13.3	0.133	0.212	0.006314
30	62.2	0.622	0.617	2.03E-05	30	46.3	0.463	0.495	0.001007	30	27.9	0.279	0.380	0.010158
50	89	0.89	0.798	0.008382	50	79.3	0.793	0.679	0.012887	50	58.7	0.587	0.549	0.001449
90	96.7	0.967	0.944	0.000527	90	88.3	0.883	0.871	0.000144	90	85.2	0.852	0.761	0.008204
150	97.7	0.977	0.992	0.000219	150	94.9	0.949	0.967	0.000327	150	90.9	0.909	0.908	5.97E-07
				0.022497					0.031313					0.026125

800 rpm					800 rpm					800 rpm				
k = 0.037937					k = 0.028255					k = 0.017415				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	32.8	0.328	0.434	0.011224	15	21.2	0.212	0.345	0.017812	15	16.8	0.168	0.230	0.003831
30	74.3	0.743	0.680	0.004022	30	63.1	0.631	0.572	0.003531	30	35.4	0.354	0.407	0.002802
50	90.3	0.903	0.850	0.002813	50	82.5	0.825	0.757	0.004689	50	61.5	0.615	0.581	0.001131
90	93.4	0.934	0.967	0.001096	90	89.2	0.892	0.921	0.000862	90	85.6	0.856	0.791	0.004173
150	97.7	0.977	0.997	0.000385	150	94.9	0.949	0.986	0.001337	150	90.3	0.903	0.927	0.000558
				0.01954					0.028231					0.012495

1000 rpm					1000 rpm					1000 rpm				
k = 0.04431					k = 0.030253					k = 0.018666				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	36.2	0.362	0.486	0.015265	15	20.1	0.201	0.365	0.026826	15	16.2	0.162	0.244	0.006758
30	84.2	0.842	0.735	0.011376	30	71.3	0.713	0.597	0.013572	30	39.9	0.399	0.429	0.000886
50	92.1	0.921	0.891	0.000906	50	82	0.82	0.780	0.001626	50	64.9	0.649	0.607	0.001786
90	94.9	0.949	0.981	0.001054	90	89.5	0.895	0.934	0.001545	90	86.7	0.867	0.814	0.002851
150	98.1	0.981	0.999	0.000313	150	95.1	0.951	0.989	0.001467	150	90.8	0.908	0.939	0.000972
				0.028914					0.045036					0.013253

Table D2 Calculation sheet of reaction rate constants for various pulp densities

Ni					Co					Cu				
5%					5%					5%				
k = 0.039529					k = 0.028731					k = 0.014785				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	34.7	0.347	0.447	0.01006	15	23.1	0.231	0.350	0.014188	15	17.6	0.176	0.199	0.000525
30	73.2	0.732	0.695	0.001405	30	60.3	0.603	0.578	0.000643	30	34	0.34	0.358	0.000333
50	94.1	0.941	0.861	0.006329	50	85.8	0.858	0.762	0.009168	50	55.3	0.553	0.523	0.000929
90	95.1	0.951	0.971	0.00042	90	89.6	0.896	0.925	0.000821	90	75.9	0.759	0.736	0.000543
150	97.1	0.971	0.997	0.000894	150	93.5	0.935	0.987	0.002659	150	85.1	0.851	0.891	0.001612
				0.018908					0.027479					0.003941

11%					11%					11%				
k = 0.037937					k = 0.028255					k = 0.017415				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	32.8	0.328	0.434	0.011224	15	21.2	0.212	0.345	0.017812	15	16.8	0.168	0.230	0.003831
30	74.3	0.743	0.680	0.004022	30	63.1	0.631	0.572	0.003531	30	35.4	0.354	0.407	0.002802
50	90.3	0.903	0.850	0.002813	50	82.5	0.825	0.757	0.004689	50	61.5	0.615	0.581	0.001131
90	93.4	0.934	0.967	0.001096	90	89.2	0.892	0.921	0.000862	90	85.6	0.856	0.791	0.004173
150	97.7	0.977	0.997	0.000385	150	94.9	0.949	0.986	0.001337	150	90.3	0.903	0.927	0.000558
				0.01954					0.028231					0.012495

15%					15%					15%				
k = 0.035571					k = 0.027189					k = 0.018535				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	31.3	0.313	0.413	0.010098	15	17.4	0.174	0.335	0.025893	15	14.5	0.145	0.243	0.009551
30	70.5	0.705	0.656	0.0024	30	60.5	0.605	0.558	0.002241	30	32.4	0.324	0.427	0.010514
50	88.5	0.885	0.831	0.002903	50	83.5	0.835	0.743	0.008427	50	68.5	0.685	0.604	0.006533
90	94.1	0.941	0.959	0.000335	90	89.9	0.899	0.913	0.000209	90	89.8	0.898	0.811	0.007497
150	98.2	0.982	0.995	0.000174	150	94.8	0.948	0.983	0.00123	150	91.7	0.917	0.938	0.00044
				0.01591					0.03800					0.034536

20%					20%					20%				
k = 0.02893					k = 0.019339					k = 0.015116				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	26.8	0.268	0.352	0.007065	15	12	0.12	0.252	0.017372	15	9.3	0.093	0.203	0.012071
30	56.6	0.566	0.580	0.000201	30	33.1	0.331	0.440	0.011925	30	22.6	0.226	0.365	0.019205
50	85.1	0.851	0.765	0.007464	50	76	0.76	0.620	0.019666	50	56.3	0.563	0.530	0.001065
90	92.6	0.926	0.926	1.83E-13	90	86.4	0.864	0.825	0.001554	90	86.3	0.863	0.743	0.014293
150	97.6	0.976	0.987	0.00012	150	94.8	0.948	0.945	8.85E-06	150	92.4	0.924	0.896	0.000761
				0.01485					0.050526					0.047396

Table D3 Calculation sheet of reaction rate constants for various pressures

Ni					Co					Cu				
4 bar					k = 0.016949					4 bar				
										k = 0.010525				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	18.8	0.188	0.224	0.001332	15	6.9	0.069	0.155	0.007443	15	10.7	0.107	0.146	0.001524
30	30.9	0.309	0.399	0.008026	30	13.9	0.139	0.286	0.021737	30	14.8	0.148	0.271	0.015068
50	54.7	0.547	0.571	0.0006	50	29	0.29	0.430	0.019656	50	25.7	0.257	0.409	0.023158
90	88.9	0.889	0.782	0.011349	90	80.9	0.809	0.637	0.029698	90	73.1	0.731	0.612	0.014117
150	96.2	0.962	0.921	0.001655	150	90.9	0.909	0.815	0.008836	150	90.8	0.908	0.794	0.013051
				0.022961					0.087369					0.066918

7 bar					k = 0.027562					7 bar				
										k = 0.019069				
										k = 0.014557				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	25.1	0.251	0.339	0.007677	15	12.9	0.129	0.249	0.014344	15	13.1	0.131	0.196	0.004246
30	51.4	0.514	0.563	0.002359	30	31.4	0.314	0.436	0.014798	30	24.2	0.242	0.354	0.012509
50	85.3	0.853	0.748	0.011038	50	75.8	0.758	0.615	0.020565	50	53.1	0.531	0.517	0.000194
90	94.5	0.945	0.916	0.000824	90	86.8	0.868	0.820	0.002279	90	83.2	0.832	0.730	0.010359
150	97	0.97	0.984	0.000196	150	92.8	0.928	0.943	0.000218	150	89.6	0.896	0.887	7.46E-05
				0.022094					0.052204					0.027384

10 bar					k = 0.037937					10 bar				
										k = 0.028255				
										k = 0.017415				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	32.8	0.328	0.434	0.011224	15	21.2	0.212	0.345	0.017812	15	16.8	0.168	0.230	0.003831
30	74.3	0.743	0.680	0.004022	30	63.1	0.631	0.572	0.003531	30	35.4	0.354	0.407	0.002802
50	90.3	0.903	0.850	0.002813	50	82.5	0.825	0.757	0.004689	50	61.5	0.615	0.581	0.001131
90	93.4	0.934	0.967	0.001096	90	89.2	0.892	0.921	0.000862	90	85.6	0.856	0.791	0.004173
150	97.7	0.977	0.997	0.000385	150	94.9	0.949	0.986	0.001337	150	90.3	0.903	0.927	0.000558
				0.01954					0.02823					0.012495

13 bar					k = 0.045398					13 bar				
										k = 0.031271				
										k = 0.016227				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	39.3	0.393	0.494	0.010175	15	22.4	0.224	0.374	0.022624	15	16.2	0.162	0.216	0.002922
30	85.3	0.853	0.744	0.011917	30	75.1	0.751	0.609	0.020266	30	34.9	0.349	0.385	0.001327
50	90	0.9	0.897	1.11E-05	50	81.1	0.811	0.791	0.000416	50	56.5	0.565	0.556	8.55E-05
90	92.6	0.926	0.983	0.003271	90	86.4	0.864	0.940	0.005785	90	82.9	0.829	0.768	0.003736
150	97.6	0.976	0.999	0.000524	150	94.5	0.945	0.991	0.002099	150	89.9	0.899	0.912	0.000178
				0.025898					0.05119					0.008248

Table D4 Calculation sheet of reaction rate constants for various temperatures

Ni					Co					Cu				
90°C					90°C					90°C				
k = 0.023859					k = 0.019129					k = 0.008789				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	26.7	0.267	0.301	0.001146	15	20.4	0.204	0.249	0.002065	15	19.03	0.190	0.124	0.004456
30	51.9	0.519	0.511	6.11E-05	30	45	0.45	0.437	0.000178	30	26.69	0.267	0.232	0.001232
50	72	0.72	0.697	0.000544	50	64.5	0.645	0.616	0.000856	50	37.96	0.380	0.356	0.000576
90	88.4	0.884	0.883	6.36E-07	90	82.8	0.828	0.821	4.6E-05	90	53.48	0.535	0.547	0.00014
150	94.3	0.943	0.972	0.000846	150	89.8	0.898	0.943	0.002049	150	68.32	0.683	0.732	0.002427
				0.002598					0.005193					0.008831

100°C					100°C					100°C				
k = 0.032632					k = 0.024586					k = 0.013421				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	31.6	0.316	0.387	0.005049	15	23.1	0.231	0.308	0.005995	15	19.4	0.194	0.182	0.000136
30	64.5	0.645	0.624	0.000429	30	52.5	0.525	0.522	1.07E-05	30	31.1	0.311	0.331	0.000418
50	86.1	0.861	0.804	0.003205	50	78	0.78	0.707	0.005256	50	49.5	0.495	0.489	3.81E-05
90	92.4	0.924	0.947	0.000528	90	87.8	0.878	0.891	0.000159	90	71.3	0.713	0.701	0.00014
150	97.1	0.971	0.993	0.000463	150	92.7	0.927	0.975	0.002302	150	85.6	0.856	0.866	0.000109
				0.009673					0.013722					0.00084

110°C					110°C					110°C				
k = 0.037937					k = 0.028255					k = 0.017415				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	32.8	0.328	0.434	0.011224	15	21.2	0.212	0.345	0.017812	15	16.8	0.168	0.230	0.003831
30	74.3	0.743	0.680	0.004022	30	63.1	0.631	0.572	0.003531	30	35.4	0.354	0.407	0.002802
50	90.3	0.903	0.850	0.002813	50	82.5	0.825	0.757	0.004689	50	61.5	0.615	0.581	0.001131
90	93.4	0.934	0.967	0.001096	90	89.2	0.892	0.921	0.000862	90	85.6	0.856	0.791	0.004173
150	97.7	0.977	0.997	0.000385	150	94.9	0.949	0.986	0.001337	150	90.3	0.903	0.927	0.000558
				0.01954					0.02823					0.012495

120°C					120°C					120°C				
k = 0.040363					k = 0.029644					k = 0.020639				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	30.6	0.306	0.454	0.021955	15	19.7	0.197	0.359	0.026229	15	13.3	0.133	0.266	0.017754
30	81.9	0.819	0.702	0.013672	30	69.1	0.691	0.589	0.010392	30	40.9	0.409	0.462	0.002767
50	90.8	0.908	0.867	0.001673	50	82	0.82	0.773	0.002222	50	75.3	0.753	0.644	0.011951
90	93.2	0.932	0.974	0.001727	90	89.9	0.899	0.931	0.000999	90	88.6	0.886	0.844	0.00177
150	98.4	0.984	0.998	0.000186	150	96.7	0.967	0.988	0.000453	150	92.2	0.922	0.955	0.001073
				0.039213					0.040295					0.035314

Table D5 Calculation sheet of reaction rate constants for various sulphuric acid concentrations

Ni					Co					Cu				
0 kg/ton					0 kg/ton					0 kg/ton				
k = 0.032834					k = 0.024428					k = 0.015774				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	23.5	0.235	0.389	0.023689	15	13.3	0.133	0.307	0.030204	15	6.8	0.068	0.211	0.020362
30	71.7	0.717	0.627	0.008177	30	60.7	0.607	0.519	0.007663	30	32.2	0.322	0.377	0.003025
50	87.1	0.871	0.806	0.004179	50	78.9	0.789	0.705	0.007024	50	60.7	0.607	0.546	0.003776
90	90.8	0.908	0.948	0.001594	90	83.7	0.837	0.889	0.002708	90	81.9	0.819	0.758	0.003697
150	95.5	0.955	0.993	0.001424	150	93	0.93	0.974	0.001969	150	90.6	0.906	0.906	2.18E-08
				0.039064					0.049568					0.03086

30 kg/ton					30 kg/ton					30 kg/ton				
k = 0.032922					k = 0.024255					k = 0.016007				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	25.6	0.256	0.390	0.017881	15	15.2	0.152	0.305	0.023406	15	10.5	0.105	0.213	0.011762
30	66.4	0.664	0.628	0.001328	30	55	0.55	0.517	0.001092	30	30.9	0.309	0.381	0.005234
50	90	0.9	0.807	0.008611	50	79.9	0.799	0.703	0.009288	50	61	0.61	0.551	0.003501
90	93.6	0.936	0.948	0.000152	90	86.8	0.868	0.887	0.000372	90	83.5	0.835	0.763	0.005152
150	97.4	0.974	0.993	0.000355	150	94.3	0.943	0.974	0.000943	150	89.2	0.892	0.909	0.000302
				0.028327					0.0351					0.025952

60 kg/ton					60 kg/ton					60 kg/ton				
k = 0.037937					k = 0.028255					k = 0.017415				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	32.8	0.328	0.434	0.011224	15	21.2	0.212	0.345	0.017812	15	16.8	0.168	0.230	0.003831
30	74.3	0.743	0.680	0.004022	30	63.1	0.631	0.572	0.003531	30	35.4	0.354	0.407	0.002802
50	90.3	0.903	0.850	0.002813	50	82.5	0.825	0.757	0.004689	50	61.5	0.615	0.581	0.001131
90	93.4	0.934	0.967	0.001096	90	89.2	0.892	0.921	0.000862	90	85.6	0.856	0.791	0.004173
150	97.7	0.977	0.997	0.000385	150	94.9	0.949	0.986	0.001337	150	90.3	0.903	0.927	0.000558
				0.01954					0.02823					0.012495

90 kg/ton					90 kg/ton					90 kg/ton				
k = 0.04126					k = 0.031278					k = 0.019231				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	32.2	0.322	0.461	0.01945	15	19.1	0.191	0.374	0.033666	15	17.8	0.178	0.251	0.005269
30	79.6	0.796	0.710	0.0074	30	70.3	0.703	0.609	0.008887	30	38.1	0.381	0.438	0.003292
50	93.5	0.935	0.873	0.003853	50	87.2	0.872	0.791	0.006612	50	66.9	0.669	0.618	0.002632
90	97.1	0.971	0.976	2.12E-05	90	90.7	0.907	0.940	0.001096	90	88.9	0.889	0.823	0.004375
150	97.8	0.978	0.998	0.000398	150	94.9	0.949	0.991	0.00175	150	91.4	0.914	0.944	0.000908
				0.031122					0.05201					0.016476

Table D6 Calculation sheet of reaction rate constants for various oxygen flow rates

Ni					Co					Cu				
15 l/h					15 l/h					15 l/h				
k = 0.029949					k = 0.019882					k = 0.014338				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	30.3	0.303	0.362	0.003467	15	16.1	0.161	0.258	0.009384	15	13.1	0.131	0.194	0.003908
30	61	0.61	0.593	0.000296	30	42.7	0.427	0.449	0.000495	30	27.7	0.277	0.350	0.005267
50	81.4	0.814	0.776	0.001421	50	69.6	0.696	0.630	0.004363	50	48.6	0.486	0.512	0.000662
90	92.4	0.924	0.932	7.2E-05	90	84.9	0.849	0.833	0.000258	90	82	0.82	0.725	0.009056
150	97.9	0.979	0.989	9.62E-05	150	94.7	0.947	0.949	5.41E-06	150	90.9	0.909	0.884	0.000646
				0.005352					0.014505					0.019538

40 l/h					40 l/h					40 l/h				
k = 0.032558					k = 0.021127					k = 0.015579				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	29.2	0.292	0.386	0.008906	15	15	0.15	0.272	0.014787	15	13.8	0.138	0.208	0.004955
30	60.4	0.604	0.623	0.000379	30	39.4	0.394	0.469	0.005691	30	27.9	0.279	0.373	0.008903
50	90.7	0.907	0.804	0.01068	50	76.8	0.768	0.652	0.013391	50	55.6	0.556	0.541	0.000222
90	96.4	0.964	0.947	0.000302	90	89.1	0.891	0.851	0.001628	90	85.2	0.852	0.754	0.009619
150	98.4	0.984	0.992	7.11E-05	150	95.4	0.954	0.958	1.57E-05	150	91	0.91	0.903	4.4E-05
				0.020338					0.035513					0.023742

65 l/h					65 l/h					65 l/h				
k = 0.037937					k = 0.028255					k = 0.017415				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	32.8	0.328	0.434	0.011224	15	21.2	0.212	0.345	0.017812	15	16.8	0.168	0.230	0.003831
30	74.3	0.743	0.680	0.004022	30	63.1	0.631	0.572	0.003531	30	35.4	0.354	0.407	0.002802
50	90.3	0.903	0.850	0.002813	50	82.5	0.825	0.757	0.004689	50	61.5	0.615	0.581	0.001131
90	93.4	0.934	0.967	0.001096	90	89.2	0.892	0.921	0.000862	90	85.6	0.856	0.791	0.004173
150	97.7	0.977	0.997	0.000385	150	94.9	0.949	0.986	0.001337	150	90.3	0.903	0.927	0.000558
				0.01954					0.028231					0.012495

90 l/h					90 l/h					90 l/h				
k = 0.041238					k = 0.030253					k = 0.017322				
t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error	t (min)	x (%)	x (frac)	x2 (frac)	error
15	34.9	0.349	0.461	0.012607	15	18.1	0.181	0.365	0.033777	15	15.3	0.153	0.229	0.005748
30	80.9	0.809	0.710	0.009844	30	72.2	0.722	0.597	0.015749	30	36.9	0.369	0.405	0.001316
50	89.6	0.896	0.873	0.000539	50	82.3	0.823	0.780	0.001877	50	60.6	0.606	0.579	0.000707
90	93.1	0.931	0.976	0.001985	90	88.4	0.884	0.934	0.002531	90	85.1	0.851	0.790	0.003764
150	97.8	0.978	0.998	0.000398	150	94.4	0.944	0.989	0.002052	150	90.8	0.908	0.926	0.00031
				0.025373					0.055987					0.011845

APPENDIX E

(Autoclave design features)

*** Please note that the following drawings are not machine drawings and only schematic representations of the autoclave design**

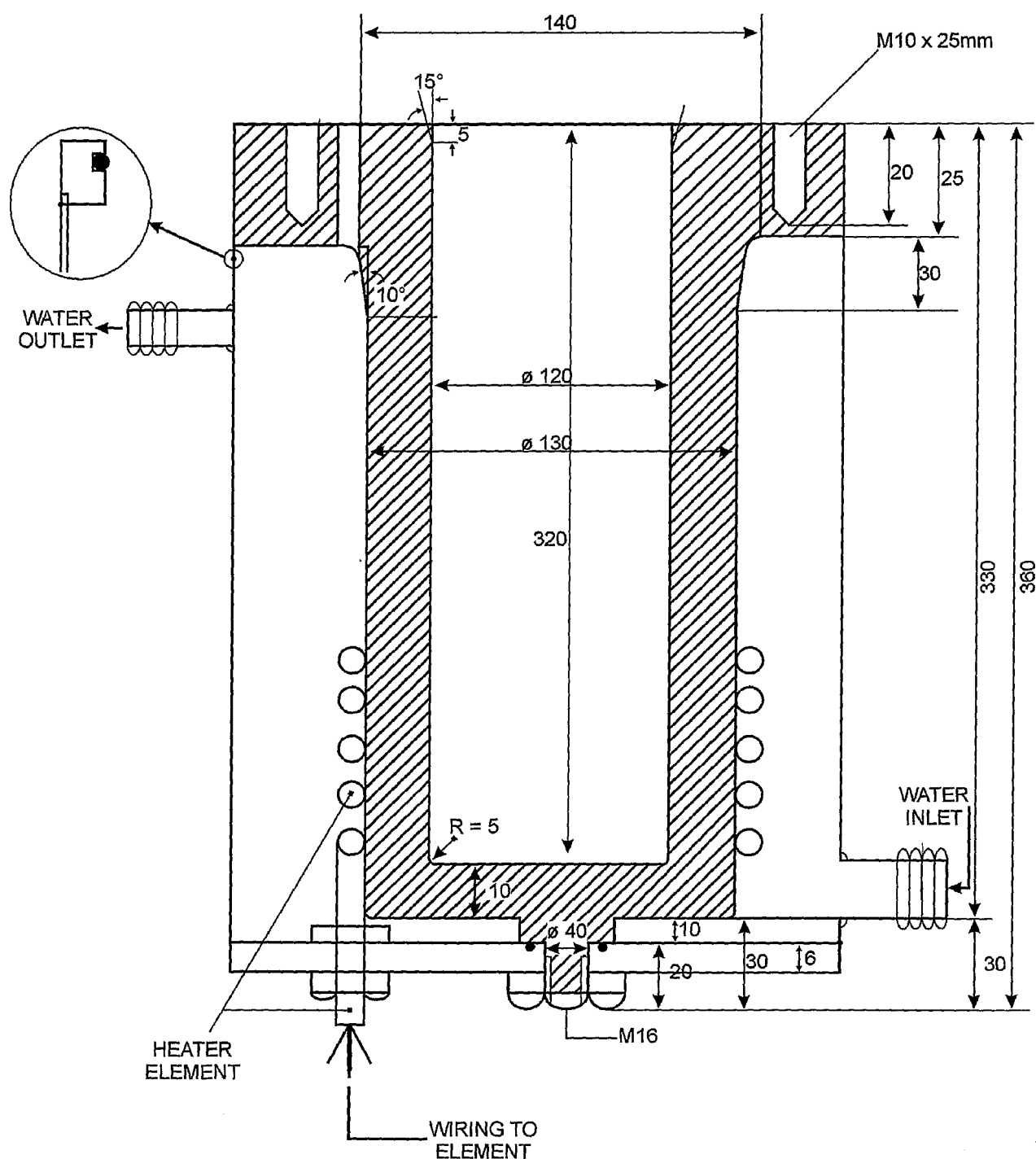


Figure E1 *Cross-section drawing of the autoclave*

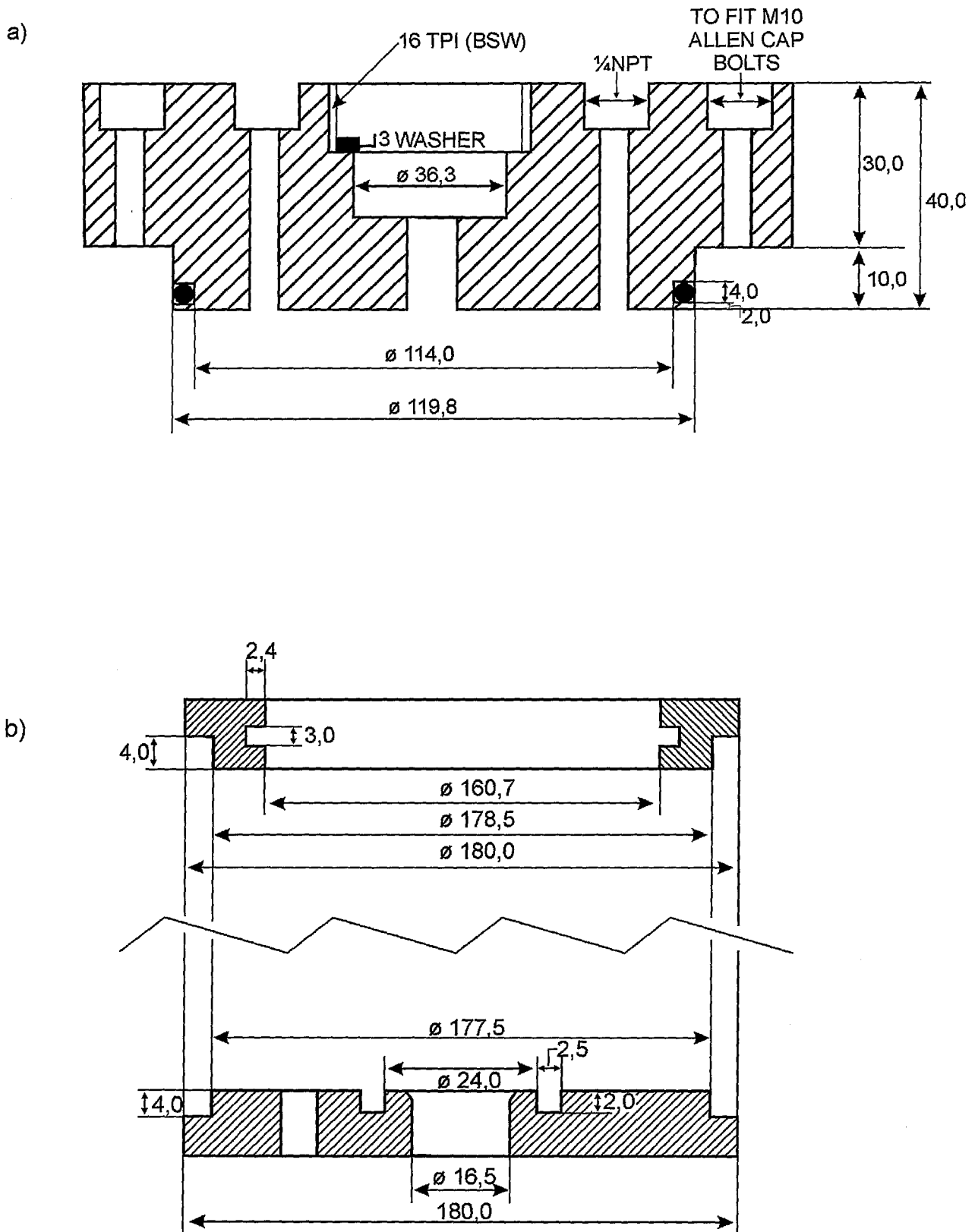


Figure E2 Cross-section view of autoclave top (a) and cooling mantle (b)

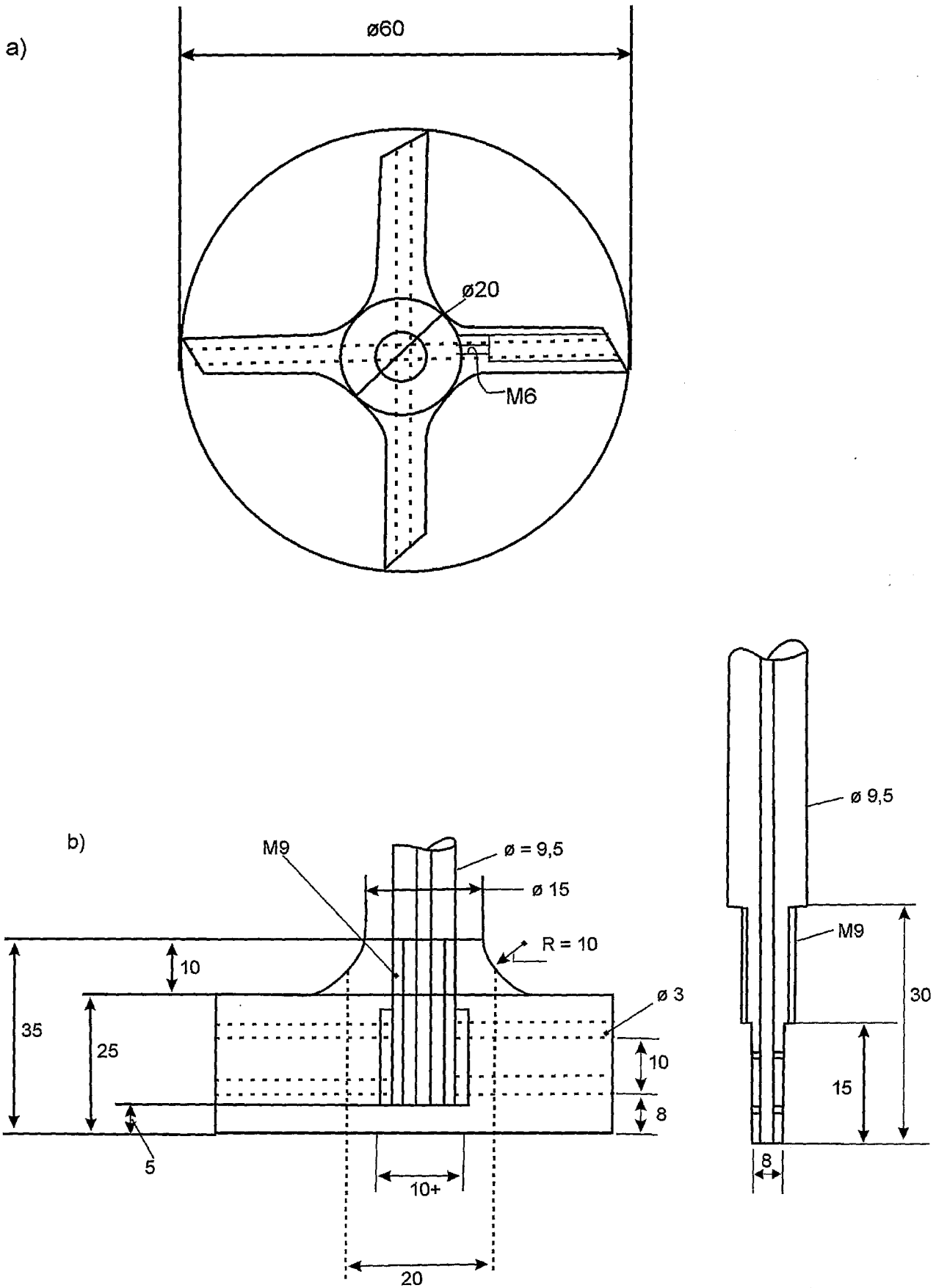


Figure E3 Top view (a) and cross-section view (b) of the agitator impeller

Maximum working pressure	= 15 bar (217.8 psi)
Material	= 904 L Stainless Steel
Tensile strength (s_t)	= 565 MPa (81 981 psi)
Diameter (inside)	= 115 mm (4.53 inch)
Safety factor (η)	= 0.9
Safety factor (N)	= 4

$$\text{Safety factor due to fluctuating pressure } \left(\frac{s_y}{s_n} \right) = 0.92$$

Tensile strength

$$\begin{aligned} s_t &= 81\,981 \times 0.92 \\ &= 75423 \text{ psi} \end{aligned}$$

$$\begin{aligned} \text{safe tensile strength } (s_{ts}) &= \frac{s_t}{N} \\ &= \frac{75423}{4} \\ &= 18\,855 \text{ psi} \end{aligned}$$

Wall thickness

$$\begin{aligned} \text{wall thickness } (t) &= \frac{P \cdot D_i}{2 \cdot s_{ts} \cdot \eta} \\ &= \frac{217.8 \cdot 4.53}{2 \cdot 18855 \cdot 0.9} \\ &= 0.029 \text{ inch} \\ &= 0.74 \text{ mm} \end{aligned}$$

*** For practical purposes a wall thickness of 5 mm was used.**

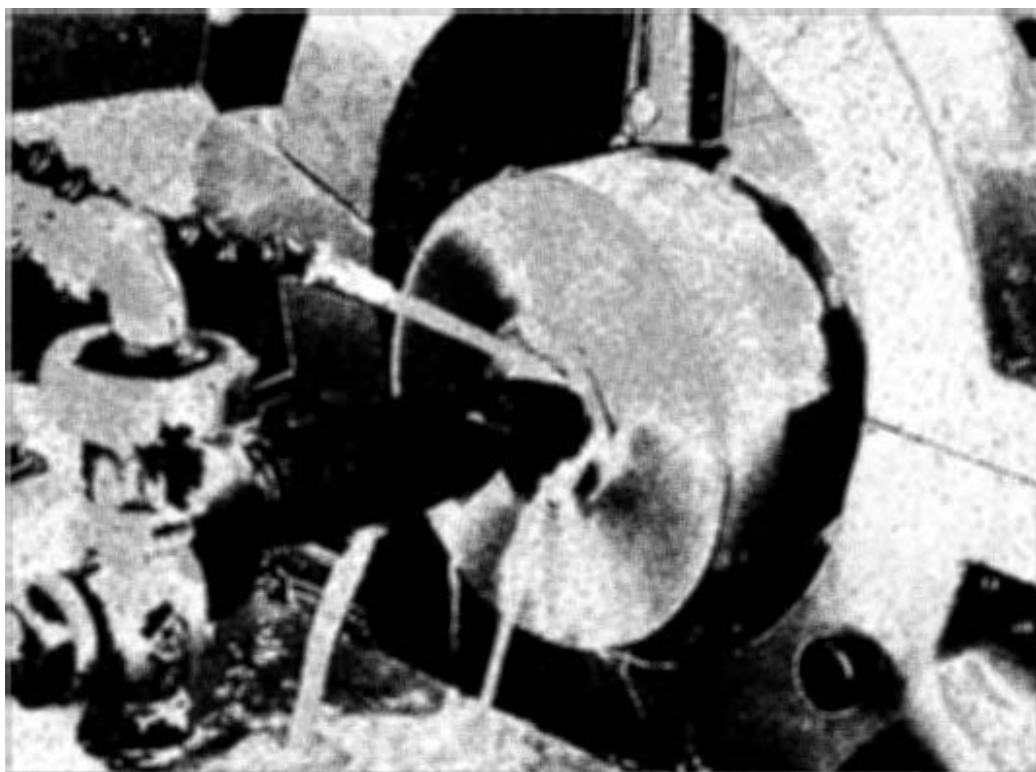


Figure E4 Photograph representing the beginning of a successful laboratory autoclave

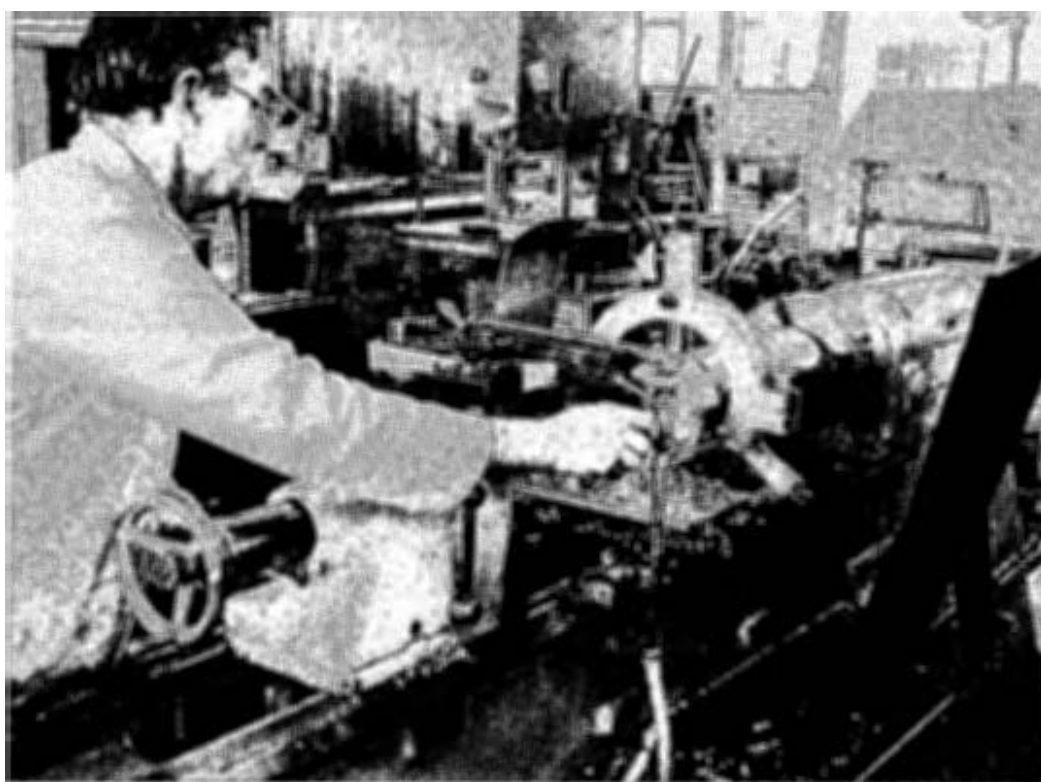


Figure E5 Photograph indicating the expertise of Mr. H. van Zyl

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