OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

ECV-Ges.m.b.H.,A-8704 Leoben/Austria

19909

56 p
tables
figures

TEST REPORT

Subject: **Laboratory Test** (10 coal samples test)
Execution of Services related to
bankable feasibility study of a
second generation integrated steel mill
in West or East Java

Commission: U N I D O
Project No.: US/INS/91/193
Purchase Order No: 15-2-2101H
Contract-Nr.: 92/101

Executed by: ECV
Energie und chem. Verfahrenstechnik Ges.m.b.H.

Autor: Mayer Franz-Wolfgang MSc

Date: 1992 09 21

ECV–Ges.m.b.H.,A–8704 Leoben/Austria

Executed according to UNIDO-Contract-Nr.: 92/101

by ECV-Laboratory

Laboratory-Tests: Pölzl Gerhard

Analysis: Pracher Friedrich

Coordinator: Mayer Franz-Wolfgang MSc

ECV Energie u. chem. Verfahren
Forschungs- u. Beratungs-Ges.m.b.H.
8700 Leoben, Johann-Sacklg. 65-67

1992 -06- 2 2
1992 -10- 1 4

Table of contents

1. INTRODUCTION

The UNIDO elaborates in co-operation with the government of Indonesia a feasibility study for future steel-making processes, especially the COREX process. For evaluation of the suitability of indigenous raw material, laboratory tests as reported below have been executed.

1.1. Scope of services

From ten Indonesian coal samples the suitability for application in the COREX process has been evaluated by laboratory test including:

- determination of the proximate analysis, comprising the determination of moisture, ash, fixed carbon and volatiles content in accordance with the DIN standards No. 51718, 51719 and 51720

- determination of the ultimate analysis, comprising the determination of the content on hydrogen, carbon, nitrogen, oxygen and sulphur on dry and ash free basis

- evaluation of the caking behaviour on the basis of determination of the caking index (Free Swelling Index) according to DIN standard No 51741

- determination of the ash composition in accordance with DIN standard No 51729, including the ratio of basic and acidic ash components

- determination of the tar content on the basis of the Fischer Assay according to ISO standard No R-647-1968(E).

- determination of the thermal stability (decrepitation behaviour) using an internal standard of VOEST-ALPINE Industrieanlagenbau, which basically measures the degradation behaviour of the samples during thermal treatment.

2. SUMMARY

All investigated coal samples show a high content of volatile matters and are characterized as subbituminous to lignite A. Ombilin coal and both Lumut coal are suitable for COREX-process, Prima coal limited and/or mixed with richer coal.

2.1. Suitability for application of Indonesian Coal in the COREX-Process

Referring to the quality figures of the Indonesion coal the following results can be concluded:

* The Indonesian coal, due to their carbonization, (volatile matter percentage) are situated in the range of subbituminous to lignite A. They are characterized (exceptted samples 4, 5 and 7) by a very low ash content and an average low sulphur content. The low swelling index of most investigated coals are related to the low carbonization, only Lumut coal shows swelling index 6.

  According to the publication of R. Hauk the most important properties of coal for usage in COREX-process are
  - the content of volatile matters
  - the atomic rations H/C and O/C

  which both determines the gasifications temperature (gasification to CO and H_2). The higher the gasification temperature, the more suitable the coal is to the COREX process and the lower the coal consumption.

The classification of coal according to its atomic ratios is more accurate than that according to volatile matters because gasification temperatures of coals with equal volatile matters can differ markedly.

Other properties such as swelling index and ash content and composition are of litte concern.

* Even the ratio fixed carbon/ash is high (especially for samples 1, 6 and 8) for the usage of this coal in the Corex-process due to the high content of volatile matters a blending part of hard coal will be necessary.

* The blending ratio for this coal depends on the quality of the basic coal which is to be used.

* The moisture content of samples 1, 2, 3 and 5 shall be reduced by pre-drying of this coal (eleminating approx 5 mass% water).

* Concerning the particle stability index the results of the tests are in normal range. The agglomeration of the coal particles can be an advantage and will be responsible for the desired transport of fixed carbon in the lower part of the COREX-reactor. For sample 6 the figure of particle stability (which is the percentage of - 2 mm after the test) is high but the resulting portion of particles - 2 mm are in average.

* The ash of all samples are reacting acetous.

* Conclusion

The investigated coals can be classified for suitability in COREX process according to Fig. 1 and 2 as follows

a) Lumut-A2, Lumut-B can be used unreservedly
b) Ombililin and possibly Primar coal are theoretically usable, but suitability in practice needs to be confirmed by testing
c) PINANG, Satui and Senakin coal have to be mixed with coals of higher quality

3. LABORATORY TEST

3.1. Description of coal samples as received

Table of samples

SAMPLE NO 1	PINANG - COAL	39,7 kg
SAMPLE NO 2	PRIMA - COAL	39,9 kg
SAMPLE NO 3	OMBILIN - COAL	41,9 kg
SAMPLE NO 4	SATUI ARUTMIN - COAL	40,2 kg
SAMPLE NO 5	SENAKIN ARUTMIN - COAL	41,2 kg
SAMPLE NO 6	ADARO - COAL	37,5 kg
SAMPLE NO 7	ANTRASIT	34 kg
SAMPLE NO 8	STEAM A2 COAL	33 kg
SAMPLE NO 9	LUMUT A2 COAL	36 kg
SAMPLE NO 10	LUMUT B COAL	23 kg

3.2. Table of coal analysis summarized

Sample No Name	proximate analysis						elementary analysis				low temp. destillation				Swelling index
	moisture	ash	fix. carb.	volat.	sulfur	chlorine	carbon	hydrogen	nitrogen	oxygen	water	tar	coke resid.	gas	
	as received (%)	dry (%)													
1/PINAG	11,60	4,32	52,18	43,50	0,479	0,020	73,47	5,24	1,90	14,57	4,30	17,13	69,48	9,19	0
2/PRIMA	7,15	2,71	53,65	43,64	0,634	0	76,69	5,41	1,95	12,61	5,22	17,47	68,50	8,81	0
3/OMBILIN	7,09	3,12	55,04	41,84	0,487	0,012	78,50	5,64	1,64	10,60	6,36	15,71	69,62	8,32	2
4/SATUI	7,74	9,29	45,87	44,84	0,786	0	71,43	5,63	1,28	11,58	7,87	17,36	65,79	8,97	1/2
5/SENAKIN	6,87	16,62	41,46	41,92	0,716	0	65,25	5,31	1,12	10,98	5,52	18,77	72,31	6,85	1/2
6/ADARO	11,87	1,73	50,30	47,97	0,138	0	72,60	5,12	1,11	19,30	10,27	11,54	66,09	12,10	1/2
7/ANTRASIT	3,18	13,78	78,17	8,06	1,501	0,048	70,51	3,50	1,49	9,17	-	-	-	-	-
8/STEAM-A 2	22,76	0,66	49,91	49,43	0,385	0,078	75,90	7,26	1,11	14,61	-	-	-	-	-
9/LUMUT-A 2	3,05	2,38	60,79	36,82	0,191	0,030	82,52	5,56	1,30	8,02	2,42	15,06	75,15	7,36	6
10/LUMUT-B	2,99	6,55	57,29	36,16	0,305	0,055	77,85	5,35	1,21	8,68	6,20	11,42	75,15	7,24	6

3.3. Tables for raw coal as received

3.3.1 sample No. 1 PINANG - COAL

3.3.1.1.

Proximate analysis Sample No. 1			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	11,60		
Ash	%	DIN 51719	3,82	4,32	
Fixed carbon	%	DIN 51720	46,13	52,18	54,54
Volatile	%	DIN 51720	38,45	43,50	45,46
Sulfur	%	DIN 51724/1	0,423	0,479	
Chlorine	%	DIN 51727	0,018	0,020	

3.3.1.2.

Swelling index	DIN 51741	0

3.3.1.3.

Low temperature distallation ISO 647 Sample No. 1		as-received	dry	dry-ash-free
Moisture	%	11,60		
Ash	%	3,82	4,32	
Water (decomposition)	%	3,80	4,30	
Tar	%	15,41	17,13	17,90
Coke residue	%	61,42	69,48	
Gas (plus errors)	%	8,04	9,10	

3.3.1.4.

Ultimate analysis Sample No. 1			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	4,63	5,24	5,48
Carbon	%		65,19	73,74	77,07
Nitrogen	%		1,68	1,90	1,99
Oxygen	%		12,88	14,57	15,23
H : C ratio				0,71	
O : C ratio				1,98	

3.3.2. sample No. 2 PRIMA - COAL

3.3.2.1.

Proximate analysis Sample No. 2			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	7,15		
Ash	%	DIN 51719	2,52	2,71	
Fixed carbon	%	DIN 51720	49,81	53,65	55,14
Volatile	%	DIN 51720	40,52	43,64	44,86
Sulfur	%	DIN 51724/1	0,589	0,634	
Chlorine	%	DIN 51727	0	0	

3.3.2.2.

Swelling index	DIN 51741	0

3.3.2.3.

Low temperature distallation ISO 647 Sample No. 2		as-received	dry	dry-ash-free
Moisture	%	7,15		
Ash	%	2,52	2,71	
Water (decomposition)	%	4,85	5,22	
Tar	%	16,22	17,47	17,96
Coke residue	%	63,60	68,50	
Gas (plus errors)	%	8,18	8,81	

3.3.2.4.

Ultimate analysis Sample No. 2			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	5,02	5,41	5,56
Carbon	%		71,21	76,69	78,83
Nitrogen	%		1,81	1,95	2,00
Oxygen	%		11,71	12,61	12,96
H : C ratio				0,71	
O : C ratio				1,64	

3.3.3. sample No. 3 OMBILIN - COAL

3.3.3.1.

Proximate analysis Sample No. 3			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	7,09		
Ash	%	DIN 51719	2,90	3,12	
Fixed carbon	%	DIN 51720	51,14	55,04	56,82
Volatile	%	DIN 51720	38,87	41,84	43,18
Sulfur	%	DIN 51724/1	0,452	0,487	
Chlorine	%	DIN 51727	0,011	0,012	

3.3.3.2.

Swelling index	DIN 51741	2

3.3.3.3.

Low temperature distallation ISO 647 Sample No. 3		as-received	dry	dry-ash-free
Moisture	%	7,09		
Ash	%	2,90	3,12	
Water (decomposition)	%	5,91	6,36	
Tar	%	14,60	15,71	16,22
Coke residue	%	64,68	69,62	
Gas (plus errors)	%	7,72	8,31	

3.3.3.4.

Ultimate analysis Sample No. 3			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	5,24	5,64	5,82
Carbon	%		72,93	78,50	81,03
Nitrogen	%		1,52	1,64	1,69
Oxygen	%		9,85	10,60	10,94
H : C ratio				0,72	
O : C ratio				1,35	

3.3.4. sample No. 4 SATUI ARUTMIN - COAL

3.3.4.1.

Proximate analysis Sample No. 4			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	7,74		
Ash	%	DIN 51719	8,57	9,29	
Fixed carbon	%	DIN 51720	42,32	45,87	50,57
Volatile	%	DIN 51720	41,37	44,84	49,43
Sulfur	%	DIN 51724/1	0,725	0,786	
Chlorine	%	DIN 51727	0	0	

3.3.4.2.

Swelling index	DIN 51741	1/2

3.3.4.3.

Low temperature distallation ISO 647 Sample No. 4		as-received	dry	dry-ash-free
Moisture	%	7,74		
Ash	%	8,57	9,29	
Water (decomposition)	%	7,26	7,87	
Tar	%	16,02	17,36	19,14
Coke residue	%	60,70	65,79	
Gas (plus errors)	%	8,28	8,97	

3.3.4.4.

Ultimate analysis Sample No. 4			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	5,19	5,63	6,21
Carbon	%		65,90	71,43	78,75
Nitrogen	%		1,18	1,28	1,41
Oxygen	%		10,68	11,58	12,77
H : C ratio				0,79	
O : C ratio				1,62	

3.3.5. sample No. 5 SENAKIN ARUTMIN - COAL

3.3.5.1.

Proximate analysis Sample No. 5			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	6,87		
Ash	%	DIN 51719	15,48	16,62	
Fixed carbon	%	DIN 51720	38,61	41,46	49,72
Volatile	%	DIN 51720	39,04	41,92	50,28
Sulfur	%	DIN 51724/1	0,667	0,716	
Chlorine	%	DIN 51727	0	0	

3.3.5.2.

Swelling index	DIN 51741	1/2

3.3.5.3.

Low temperature distallation ISO 647 Sample No. 5		as-received	dry	dry-ash-free
Moisture	%	3,66		
Ash	%	15,48	16,62	
Water (decomposition)	%	5,14	5,52	
Tar	%	17,48	18,77	22,71
Coke residue	%	67,34	72,31	
Gas (plus errors)	%	6,38	6,85	

3.3.5.4.

Ultimate analysis Sample No. 5			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	4,95	5,31	6,37
Carbon	%		60,77	65,25	78,26
Nitrogen	%		1,04	1,12	1,34
Oxygen	%		10,26	10,98	13,17
H : C ratio				0,80	
O : C ratio				1,68	

3.3.6. sample No. 6 ADARO - COAL

3.3.6.1.

Proximate analysis Sample No. 6			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	18,87		
Ash	%	DIN 51719	1,40	1,73	
Fixed carbon	%	DIN 51720	40,81	50,30	51,19
Volatile	%	DIN 51720	38,92	47,97	48,81
Sulfur	%	DIN 51724/1	0,112	0,138	
Chlorine	%	DIN 51727	0	0	

3.3.6.2.

Swelling index	DIN 51741	1/2

3.3.6.3.

Low temperature distallation ISO 647 Sample No. 6		as-received	dry	dry-ash-free
Moisture	%	18,87		
Ash	%	1,40	1,73	
Water (decomposition)	%	8,33	10,27	
Tar	%	9,36	11,54	11,74
Coke residue	%	53,62	66,09	
Gas (plus errors)	%	9,82	12,10	

3.3.6.4.

Ultimate analysis Sample No. 6			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	4,15	5,12	5,21
Carbon	%		58,90	72,60	73,88
Nitrogen	%		0,90	1,11	1,13
Oxygen	%		15,66	19,30	19,64
H : C ratio				0,70	
O : C ratio				2,65	

3.3.7. sample No. 7 ANTRASIT/B1

3.3.7.1.

Proximate analysis Sample No. 7			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	3,18		
Ash	%	DIN 51719	13,34	13,78	
Fixed carbon	%	DIN 51720	75,68	78,17	90,66
Volatile	%	DIN 51720	7,80	8,06	9,34
Sulfur	%	DIN 51724/1	1,453	1,501	
Chlorine	%	DIN 51727	0,047	0,048	

3.3.7.4.

Ultimate analysis Sample No. 7			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	3,39	3,50	4,06
Carbon	%		68,27	70,51	81,78
Nitrogen	%		1,44	1,49	1,73
Oxygen	%		8.88	9,17	10,64
H : C ratio				0,50	
O : C ratio				1,30	

3.3.8. sample No. 8 STEAM - COAL A2

3.3.8.1.

Proximate analysis Sample No. 8			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	22,76		
Ash	%	DIN 51719	0,51	0,66	
Fixed carbon	%	DIN 51720	38,55	49,91	50,24
Volatile	%	DIN 51720	38,18	49,43	49,76
Sulfur	%	DIN 51724/1	0,298	0,385	
Chlorine	%	DIN 51727	0,06	0,078	

3.3.8.4.

Ultimate analysis Sample No. 8			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	5,61	7,26	7,31
Carbon	%		58,63	75,90	76,40
Nitrogen	%		0,86	1,11	1,12
Oxygen	%		11,28	14,61	14,71
H : C ratio				0,96	
O : C ratio				1,92	

3.3.9. sample No. 9 LUMUT A2 COAL

3.3.9.1.

Proximate analysis Sample No. 9			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	3,05		
Ash	%	DIN 51719	2,31	2,38	
Fixed carbon	%	DIN 51720	58,94	60,79	62,28
Volatile	%	DIN 51720	35,70	36,82	37,72
Sulfur	%	DIN 51724/1	0,185	0,191	
Chlorine	%	DIN 51727	0,029	0,003	

3.3.9.2.

Swelling index	DIN 51741	6

3.3.9.3.

Low temperature distallation ISO 647 Sample No. 9		as-received	dry	dry-ash-free
Moisture	%	3,05		
Ash	%	2,31	2,38	
Water (decomposition)	%	2,35	2,42	
Tar	%	14,60	15,06	15,43
Coke residue	%	72,86	75,15	
Gas (plus errors)	%	47,14	7,36	

3.3.9.4.

Ultimate analysis Sample No. 9			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	5,39	5,56	5,69
Carbon	%		80,00	82,52	84,53
Nitrogen	%		1,26	1,3	1,33
Oxygen	%		7,78	8,02	8,22
H : C ratio				0,67	
O : C ratio				0,97	

3.3.10. sample No. 10 ARUTMIN - COAL

3.3.10.1.

Proximate analysis Sample No. 10			as-received	dry	dry-ash-free
Moisture	%	DIN 51718	2,99		
Ash	%	DIN 51719	6,35	6,55	
Fixed carbon	%	DIN 51720	55,58	57,29	61,31
Volatile	%	DIN 51720	35,08	36,16	38,69
Sulfur	%	DIN 51724/1	0,296	0,305	
Chlorine	%	DIN 51727	0,053	0,055	

3.3.10.2.

Swelling index	DIN 51741	6

3.3.10.3.

Low temperature distallation ISO 647 Sample No. 10		as-received	dry	dry-ash-free
Moisture	%	2,99		
Ash	%	6,35	6,55	
Water (decomposition)	%	6,01	6,20	
Tar	%	11,08	11,42	12,22
Coke residue	%	72,90	75,15	
Gas (plus errors)	%	7,02	7,24	

3.3.10.4.

Ultimate analysis Sample No. 10			as-received	dry	dry-ash-free
Hydrogen	%	DIN 51721	5,19	5,35	5,72
Carbon	%		75,52	77,85	83,31
Nitrogen	%		1,17	1,21	1,29
Oxygen	%		8,42	8,68	9,29
H : C ratio				0,69	
O : C ratio				1,11	

3.4. Ash composition

Chemical composition of ash DIN 517 29								
	Sample No							
	1	2	3	4	5	6	9	10
SiO_2	54,65	43,68	50,18	45,94	50,20	29,20	43,63	50,03
CaO	1,67	0,63	1,41	0,34	0,20	25,25	0,18	0,03
MgO	2,62	2,81	1,17	0,29	0,24	8,02	0,38	0,13
Al_2O_3	21,98	17,41	28,99	41,64	39,39	16,69	41,57	40,61
Fe_2O_3	12,75	28,60	11,69	5,21	3,77	7,42	6,73	1,68
K_2O	1,95	1,70	1,77	0,45	0,41	0,921	0,12	0,19
Na_2O	0,61	1,37	0,44	0,28	0,49	2,26	0,51	0,26
TiO_2	0,88	0,76	0,85	2,71	3,29	0,71	1,19	2,94
SO_3	0,71	0,88	1,90	0,31	1,23	6,84	1,34	1,34
P_2O_5	0,19	0,46	0,18	0,25	0,44	0,04	0,40	0,47

3.5. Thermal stability test (internal VOEST-ALPINE standard)

3.5.1. sample No. 1 PINANG - COAL

3.5.1.1. Proximate analysis in different stages of treatment

Proximate analysis Sample No. 1 feed material		16 - 20 mm	as received	dry	dry-ash-free
Moisture	%	DIN 51718	12,36		
Ash	%	DIN 51719	3,35	3,82	
Fixed carbon	%	DIN 51720	45,72	52,17	54,24
Volatile	%	DIN 51720	38,57	44,01	45,76

Proximate analysis Sample No. 1 Treatment: 1000 °C,		16 - 20 mm 2 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,68		
Ash	%	DIN 51719	2,52	2,54	
Fixed carbon	%	DIN 51720	74,62	75,13	77,09
Volatile	%	DIN 51720	22,18	22,33	22,91

Proximate analysis Sample No. 1 Treatment: 1000 °C,		16 - 20 mm 60 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,51		
Ash	%	DIN 51719	1,97	1,98	
Fixed carbon	%	DIN 51720	96,63	97,13	99,09
Volatile	%	DIN 51720	0,89	0,89	0,91

3.5.1.2. Particle size distribution and agglomeration behaviour thermal treated coal

Particle Thermal stability index
Sieve analysis of treated coal
Sample No 1

Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20		
16		
12,5		
10		
8		
5,6		
4	not scree	nable
2,8		
2		
1,4		
1		
0,5		
0,25		
0,125		
0		

agglomeration behaviour	moderate strong	strong
recovery mass%	61,40	45,82

3.5.2. sample No. 2 PRIMA - COAL

3.5.2.1.

Proximate analysis Sample No. 2 16 - 20 mm feed material			as received	dry	dry-ash-free
Moisture	%	DIN 51718	5,78		
Ash	%	DIN 51719	1,60	1,79	
Fixed carbon	%	DIN 51720	50,84	53,93	54,86
Volatile	%	DIN 51720	41,83	44,37	45,14

Proximate analysis Sample No. 2 16 - 20 mm Treatment: 1000 °C, 2 min.			as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,32		
Ash	%	DIN 51719	2,55	2,56	
Fixed carbon	%	DIN 51720	73,08	73,24	75,16
Volatile	%	DIN 51720	24,15	24,20	24,84

Proximate analysis Sample No. 2 16 - 20 mm Treatment: 1000 °C, 60 min.			as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,32		
Ash	%	DIN 51719	4,11	4,12	
Fixed carbon	%	DIN 51720	95,24	95,55	99,65
Volatile	%	DIN 51720	0,33	0,33	0,35

3.5.2.2.

Particle Thermal stability index Sieve analysis of treated coal Sample No 2		
Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20		
16		
12,5		
10		
8		
5,6		
4	not screenable	not screenable
2,8		
2		
1,4		
1		
0,5		
0,25		
0,125		
0		

agglomeration behaviour	strong	strong
mass recovery %	65,53	51,07

3.5.3. sample No. 3 OMBILIN - COAL

3.5.3.1.

Proximate analysis Sample No. 3 16 - 20 mm feed material			as received	dry	dry-ash-free
Moisture	%	DIN 51718	6,63		
Ash	%	DIN 51719	1,08	1,16	
Fixed carbon	%	DIN 51720	51,51	55,17	55,81
Volatile	%	DIN 51720	40,78	43,68	44,19

Proximate analysis Sample No. 3 16 - 20 mm Treatment: 1000 °C, 2 min.			as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,34		
Ash	%	DIN 51719	2,09	2,10	
Fixed carbon	%	DIN 51720	76,79	77,05	78,79
Volatile	%	DIN 51720	20,78	20,85	21,30

Proximate analysis Sample No. 3 16 - 20 mm Treatment: 1000 °C, 60 min.			as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,28		
Ash	%	DIN 51719	3,73	3,74	
Fixed carbon	%	DIN 51720	95,43	95,70	99,42
Volatile	%	DIN 51720	0,56	0,56	0,58

3.5.3.3.

Particle Thermal stability index
Sieve analysis of treated coal
Sample No 3

Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20		
16		
12,5		
10		
8		
5,6		
4	not screenable	
2,8		
2		
1,4		
1		
0,5		
0,25		
0,125		
0		

agglomeration behavior	very strong	very strong
mass recovery %	65,49	52,15

3.5.4. sample No. 4 SATUI ARUTMIN - COAL

3.5.4.1.

Proximate analysis Sample No. 4 feed material		16 - 20 mm	as received	dry	dry-ash-free
Moisture	%	DIN 51718	6,59		
Ash	%	DIN 51719	8,35	8,94	
Fixed carbon	%	DIN 51720	41,18	44,09	48,41
Volatile	%	DIN 51720	43,88	46,98	51,59

Proximate analysis Sample No. 4 Treatment: 1000 °C,		16 - 20 mm 2 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,27		
Ash	%	DIN 51719	15,01	15,05	
Fixed carbon	%	DIN 51720	59,07	59,23	69,72
Volatile	%	DIN 51720	25,65	25,72	30,28

Proximate analysis Sample No. 4 Treatment: 1000 °C,		16 - 20 mm 60 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,22		
Ash	%	DIN 51719	21,08	21,13	
Fixed carbon	%	DIN 51720	78,06	78,23	99,19
Volatile	%	DIN 51720	0,64	0,64	0,81

3.5.4.2.

Particle Thermal stability index
Sieve analysis of treated coal
Sample No 4

Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20		
16		
12,5		
10		
8		
5,6		
4	n o t s c r e e	n a b l e
2,8		
2		
1,4		
1		
0,5		
0,25		
0,125		
0		

agglomeration behavior	moderate strong	strong
mass recovery %	66,03	47,92

3.5.5. sample No. 5 SENAKIN ARUTMIN - COAL

3.5.5.1.

Proximate analysis Sample No. 5 feed material		16 - 20 mm	as received	dry	dry-ash-free
Moisture	%	DIN 51718	4,28		
Ash	%	DIN 51719	15,47	16,16	
Fixed carbon	%	DIN 51720	38,77	40,50	48,31
Volatile	%	DIN 51720	41,48	43,33	51,69

Proximate analysis Sample No. 5 Treatment: 1000 °C,		16 - 20 mm 2 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,51		
Ash	%	DIN 51719	22,89	23,01	
Fixed carbon	%	DIN 51720	58,51	58,81	76,38
Volatile	%	DIN 51720	18,09	18,18	23,62

Proximate analysis Sample No. 5 Treatment: 1000 °C,		16 - 20 mm 60 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,19		
Ash	%	DIN 51719	31,43	31,49	
Fixed carbon	%	DIN 51720	67,97	68,10	99,40
Volatile	%	DIN 51720	0,41	0,41	0,60

3.5.5.2.

Particle Thermal stability index
Sieve analysis of treated coal
Sample No 5

Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20		
16		
12,5		
10		
8		
5,6		
4	not	screenable
2,8		
2		
1,4		
1		
0,5		
0,25		
0,125		
0		

agglomeration behavior	strong	very strong
mass recovery %	67,83	54,07

3.5.6. sample No. 6 ADARO - COAL

3.5.6.1.

Proximate analysis Sample No. 6 feed material		16 - 20 mm	as received	dry	dry-ash-free
Moisture	%	DIN 51718	19,25		
Ash	%	DIN 51719	1,06	1,31	
Fixed carbon	%	DIN 51720	40,11	49,67	50,33
Volatile	%	DIN 51720	39,58	49,02	49,67

Proximate analysis Sample No. 6 Treatment: 1000 °C,		16 - 20 mm 2 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,39		
Ash	%	DIN 51719	2,65	2,66	
Fixed carbon	%	DIN 51720	71,98	72,26	74,24
Volatile	%	DIN 51720	24,98	25,08	25,76

Proximate analysis Sample No. 6 Treatment: 1000 °C,		16 - 20 mm 60 min.	as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,39		
Ash	%	DIN 51719	2,30	2,31	
Fixed carbon	%	DIN 51720	95,69	96,06	98,34
Volatile	%	DIN 51720	1,62	1,63	1,66

3.5.6.2.

Particle Thermal stability index Sieve analysis of treated coal Sample No 6		
Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20	-	-
16	9,90	6,33
12,5	15,58	26,17
10	15,93	16,50
8	15,58	16,76
5,6	20,03	17,00
4	11,75	9,00
2,8	5,21	4,25
2	1,97	1,58
1,4	1,22	0,83
1	0,87	0,50
0,5	1,27	0,58
0,25	0,46	0,25
0,125	0,17	0,17
0	0,06	0,08

agglomeration behavior	non agglomeration	non agglomeration
mass recovery %	57,38	40,05

3.5.9. sample No. 9 LUMUT A2 - COAL

3.5.9.1.

Proximate analysis Sample No. 9 16 - 20 mm feed material		as received	dry	dry-ash-free
Moisture %	DIN 51718	3,02		
Ash %	DIN 51719	1,42	1,46	
Fixed carbon %	DIN 51720	59,05	60,89	61,79
Volatile %	DIN 51720	36,51	37,65	38,21

Proximate analysis Sample No. 9 16 - 20 mm Treatment: 1000 °C, 2 min.		as received	dry	dry-ash-free
Moisture %	DIN 51718	0,46		
Ash %	DIN 51719	4,21	4,23	
Fixed carbon %	DIN 51720	73,75	74,09	77,36
Volatile %	DIN 51720	21,58	21,68	22,64

Proximate analysis Sample No. 9 16 - 20 mm Treatment: 1000 °C, 60 min.		as received	dry	dry-ash-free
Moisture %	DIN 51718	0,32		
Ash %	DIN 51719	3,99	4,00	
Fixed carbon %	DIN 51720	94,82	95,12	99,09
Volatile %	DIN 51720	0,87	0,87	0,91

3.5.9.2. Particle size distribution and agglomeration behaviour thermal treated coal

Particle Thermal stability index Sieve analysis of treated coal Sample No 9		
Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20		
16		
12,5		
10		
8		
5,6		
4	not screenable	not screenable
2,8		
2		
1,4		
1		
0,5		
0,25		
0,125		
0		

agglomeration behaviour	very strong	very strong
recovery mass%	75,95	59,99

3.5.10. sample No. 10 LUMUT/B COAL

3.5.10.1.

Proximate analysis Sample No. 10 16 - 20 mm feed material			as received	dry	dry-ash-free
Moisture	%	DIN 51718	3,21		
Ash	%	DIN 51719	3,99	4,12	
Fixed carbon	%	DIN 51720	57,74	59,65	62,22
Volatile	%	DIN 51720	35,06	36,22	37,78

Proximate analysis Sample No. 10 16 - 20 mm Treatment: 1000 °C, 2 min.			as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,30		
Ash	%	DIN 51719	9,45	9,48	
Fixed carbon	%	DIN 51720	69,10	69,31	76,57
Volatile	%	DIN 51720	21,15	21,21	23,43

Proximate analysis Sample No. 10 16 - 20 mm Treatment: 1000 °C, 60 min.			as received	dry	dry-ash-free
Moisture	%	DIN 51718	0,23		
Ash	%	DIN 51719	6,63	6,65	
Fixed carbon	%	DIN 51720	92,82	93,03	99,66
Volatile	%	DIN 51720	0,32	0,32	0,34

3.5.10.2. Particle size distribution and agglomeration behaviour thermal treated coal

Particle Thermal stability index Sieve analysis of treated coal Sample No 10		
Fraction [mm]	1000 °C, 2 min. [m%]	1000 °C, 60 min. [m%]
> 20		
16		
12,5		
10		
8		
5,6		
4	not screenable	not screenable
2,8		
2		
1,4		
1		
0,5		
0,25		
0,125		
0		

agglomeration behaviour	very strong	very strong
recovery mass%	75,24	60,21

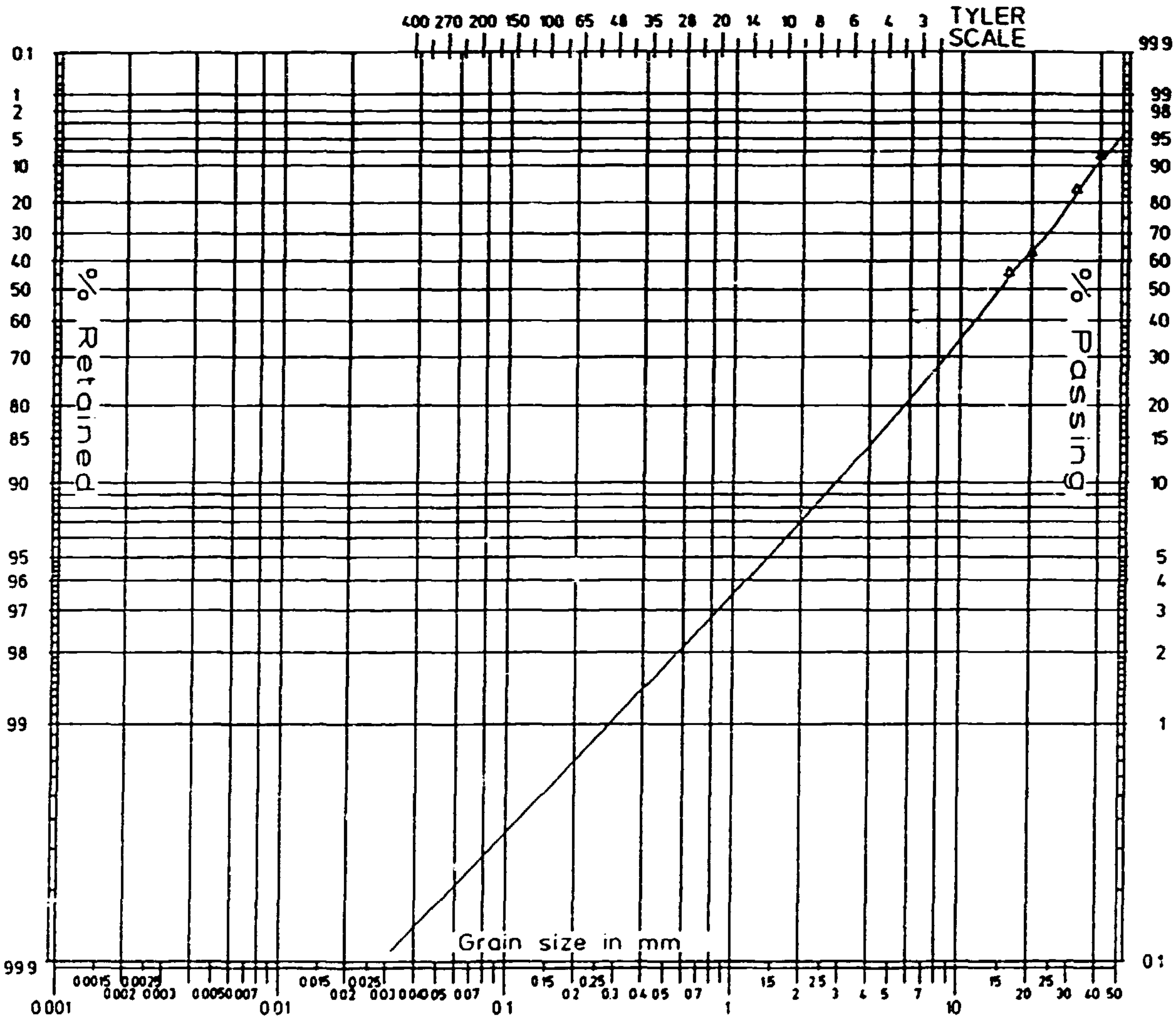
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No	815
		Rev. by KK	14-Jul-1992
	Project: US/INS/91/183		

Material: Sample No 1, PINANG-COAL

Bulk weight: kg/m³ Humidity: 11,60 %

Type of maschine: HAND Specific gravity: kg/m³



Series 1

Coefficient of constancy: 1.55

Size range index: 19.84

Grain size mm		0- 16	16- 20	20- 31.5	31.5- 40	40- 63					
Fraction (%)/mm	Series 1	56.18	7.20	20.96	8.21	7.45					
Grain size mm											
Fraction (%)/mm	Series 1										

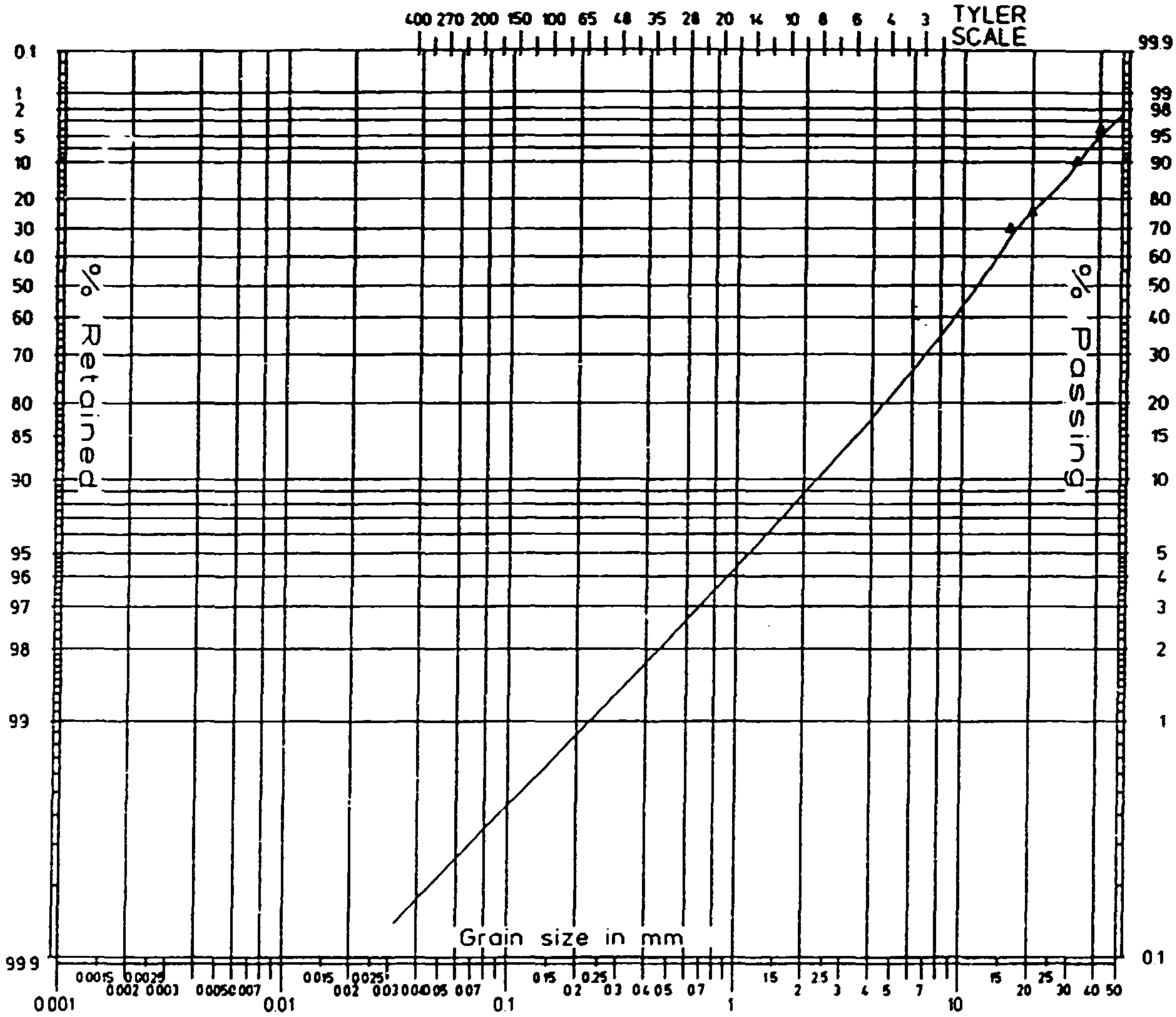
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No 816
		Rev. by: KK — 14-Jul-1992
	Project: US/INS/91/183	

Material: Sample No. 2, PRIMA-COAL

Bulk weight: kg/m³ — Humidity: 7,15 %

Type of maschine: HAND — Specific gravity: kg/m³



Series 1

Coefficient of constancy: 1.53

Size range index: 16.71

Grain size mm	0- 16	16- 20	20- 31.5	31.5- 40	40- 63				
Fraction (%)/mm — Series 1	70.27	5.77	14.55	5.52	3.89				
Grain size mm									
Fraction (%)/mm — Series 1									

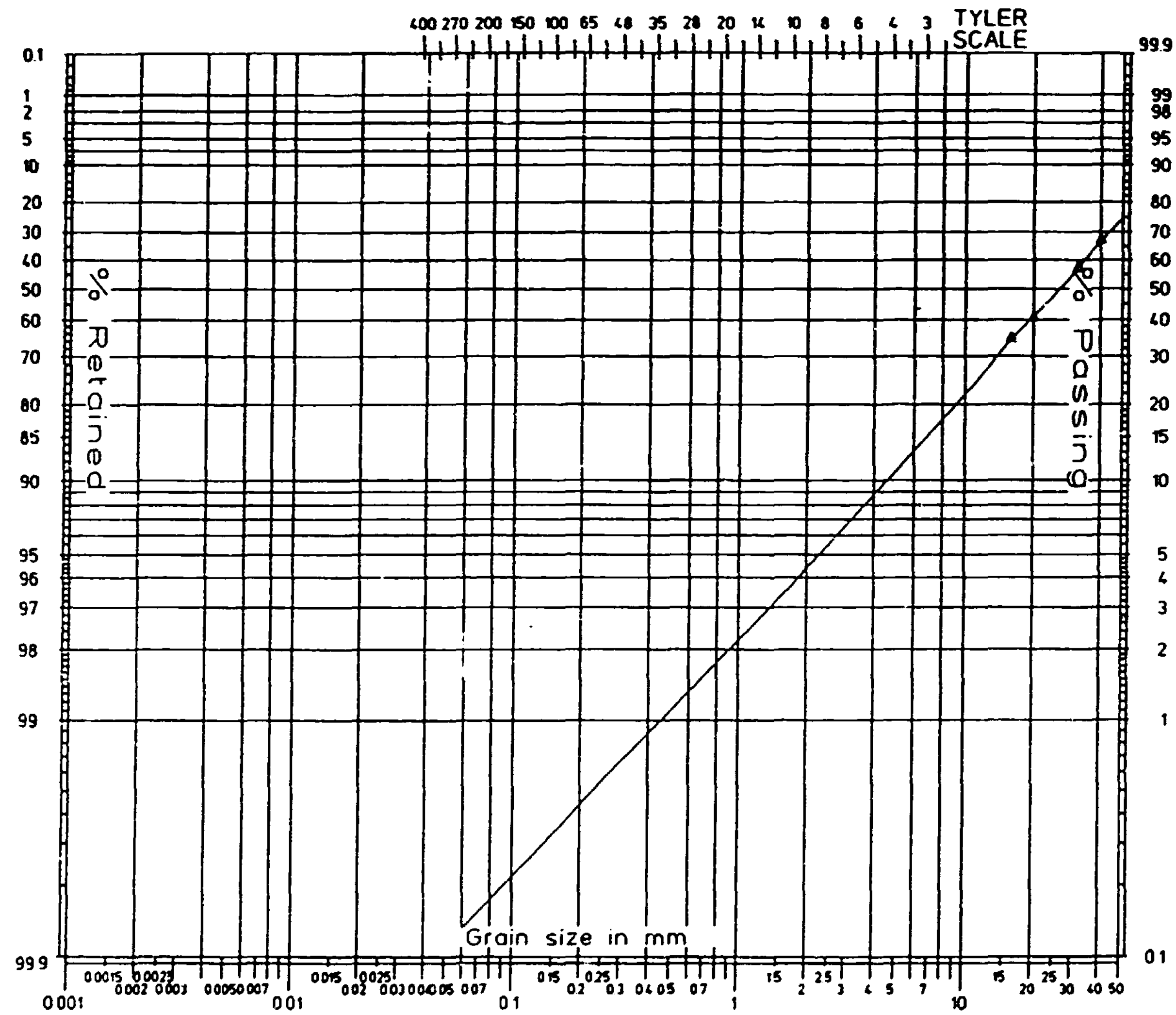
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No. 817
		Rev. by: KK — 14-Jul-1992
	Project: US/INS/91/183	

Material: Sample No. 3. OMBILIN-COAL

Bulk weight: kg/m³ — Humidity: 7,09 %

Type of maschine: HAND — Specific gravity: kg/m³



Series 1:

Coefficient of constancy: 1.37

Size range index: 34.08

Grain size mm	0-16	16-20	20-31.5	31.5-40	40-63	63-80	80-120		
Fraction (%)/mm Series 1	35.13	5.85	16.73	9.80	17.32	11.47	3.70		

Grain size mm									
Fraction (%)/mm Series 1									

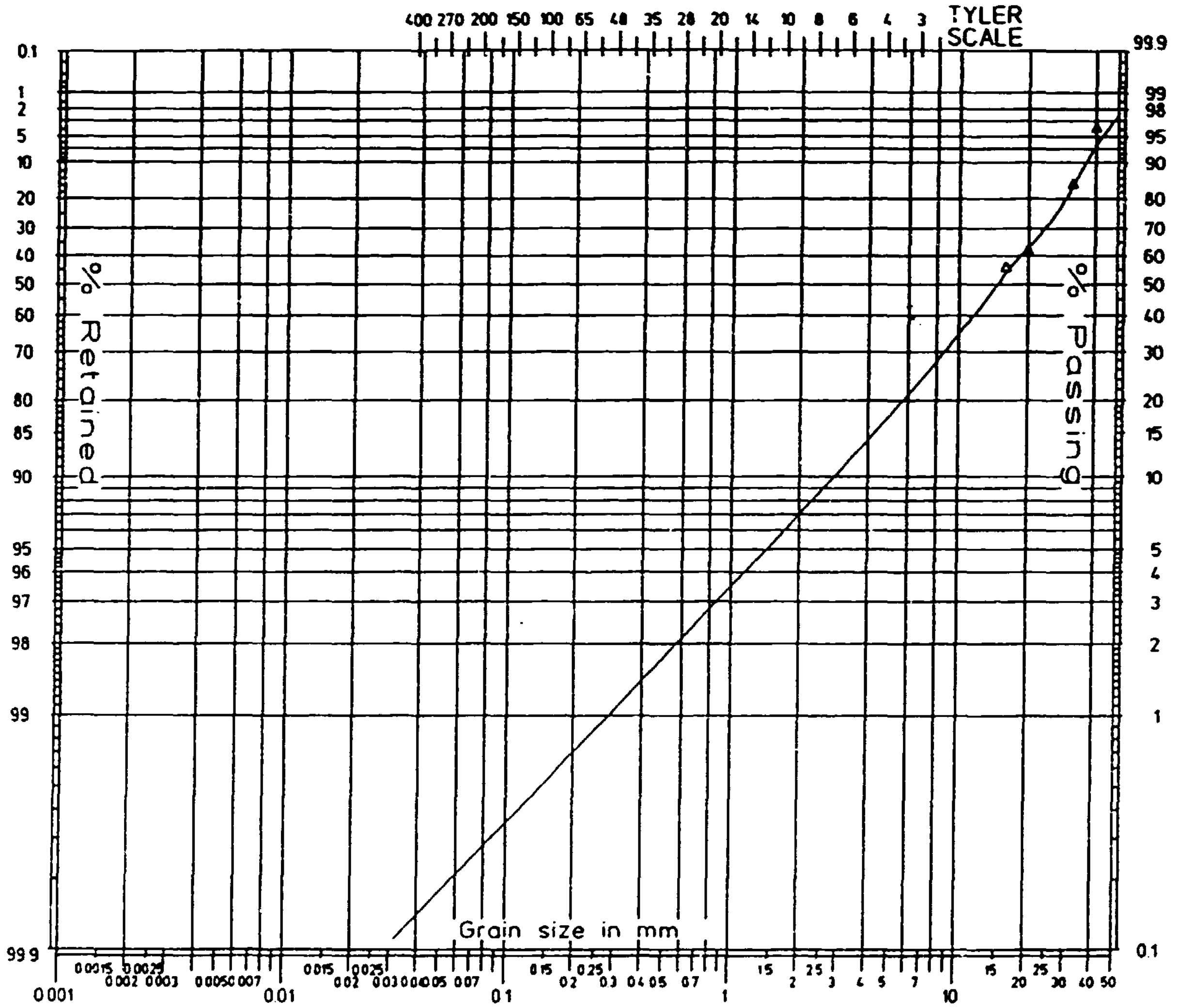
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No.	818
		Rev. by. KK	14-Jul-1992
	Project: US/INS/91/183		

Material: Sample No. 4. SATUI ARTUMIN-COAL

Bulk weight: kg/m³ Humidity: 7,74 %

Type of maschine: HAND Specific gravity: kg/m³



Series 1

Coefficient of constancy: 156

Size range index: 1922

Grain size mm	0-16	16-20	20-31.5	31.5-40	40-63				
Fraction (%)/mm Series 1	56.16	6.35	22.17	11.58	3.74				
Grain size mm									
Fraction (%)/mm Series 1									

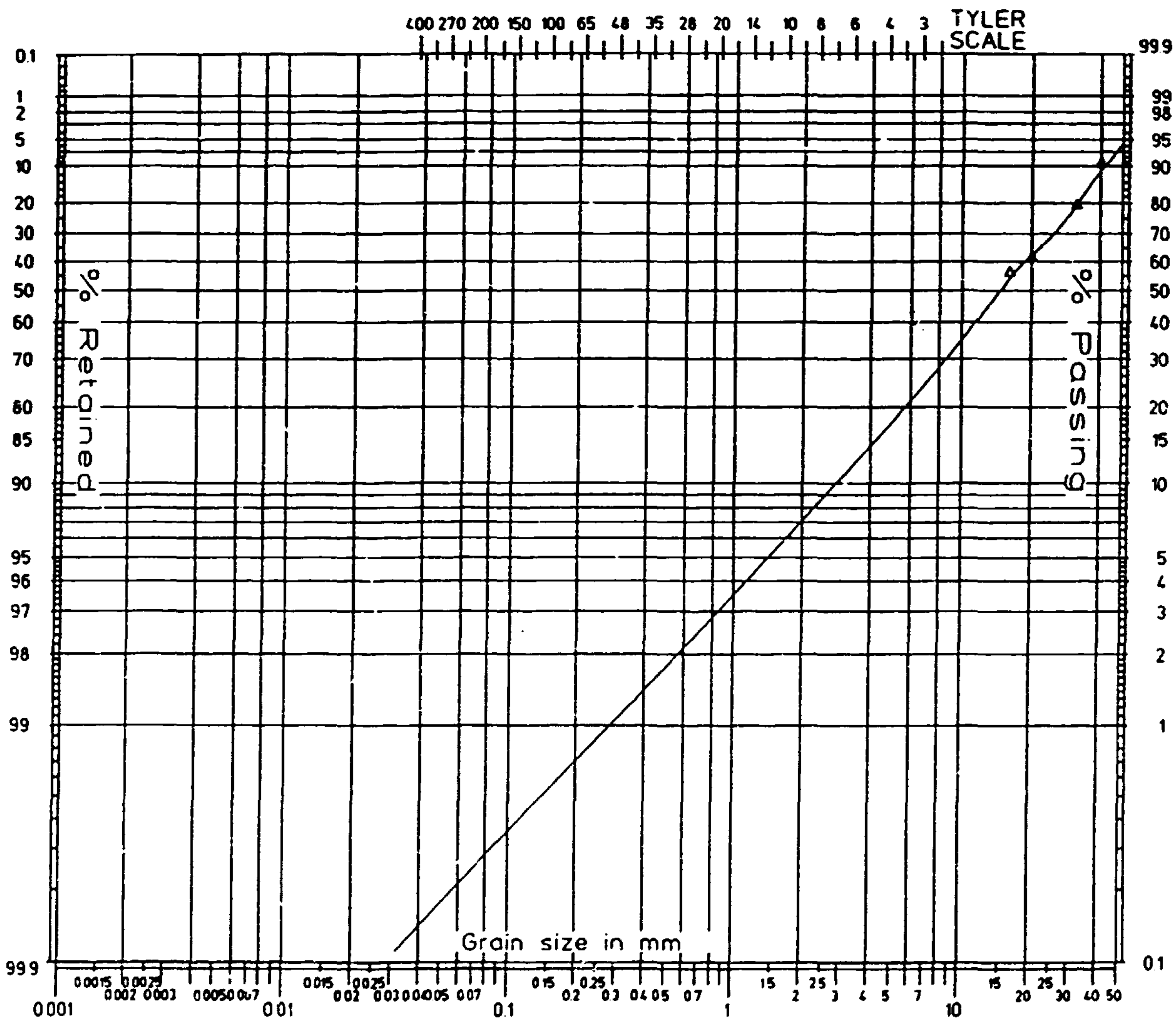
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No. 819
		Rev. by. KK — 14-Jul-1992
	Project: US/INS/91/183	

Material: Sample No. 5. SENAKIN ARUTMIN-COAL

Bulk weight: kg/m³ — Humidity: 6,87%

Type of maschine: HAND — Specific gravity: kg/m³



Series 1: △—△—△

Coefficient of constancy: 153

Size range index: 2003

Grain size mm		0- 16	16- 20	20- 315	315- 40	40- 63				
Fraction (%)/mm	Series 1	5661	5.49	17.74	11.05	9.11				
Grain size mm										
Fraction (%)/mm	Series 1									

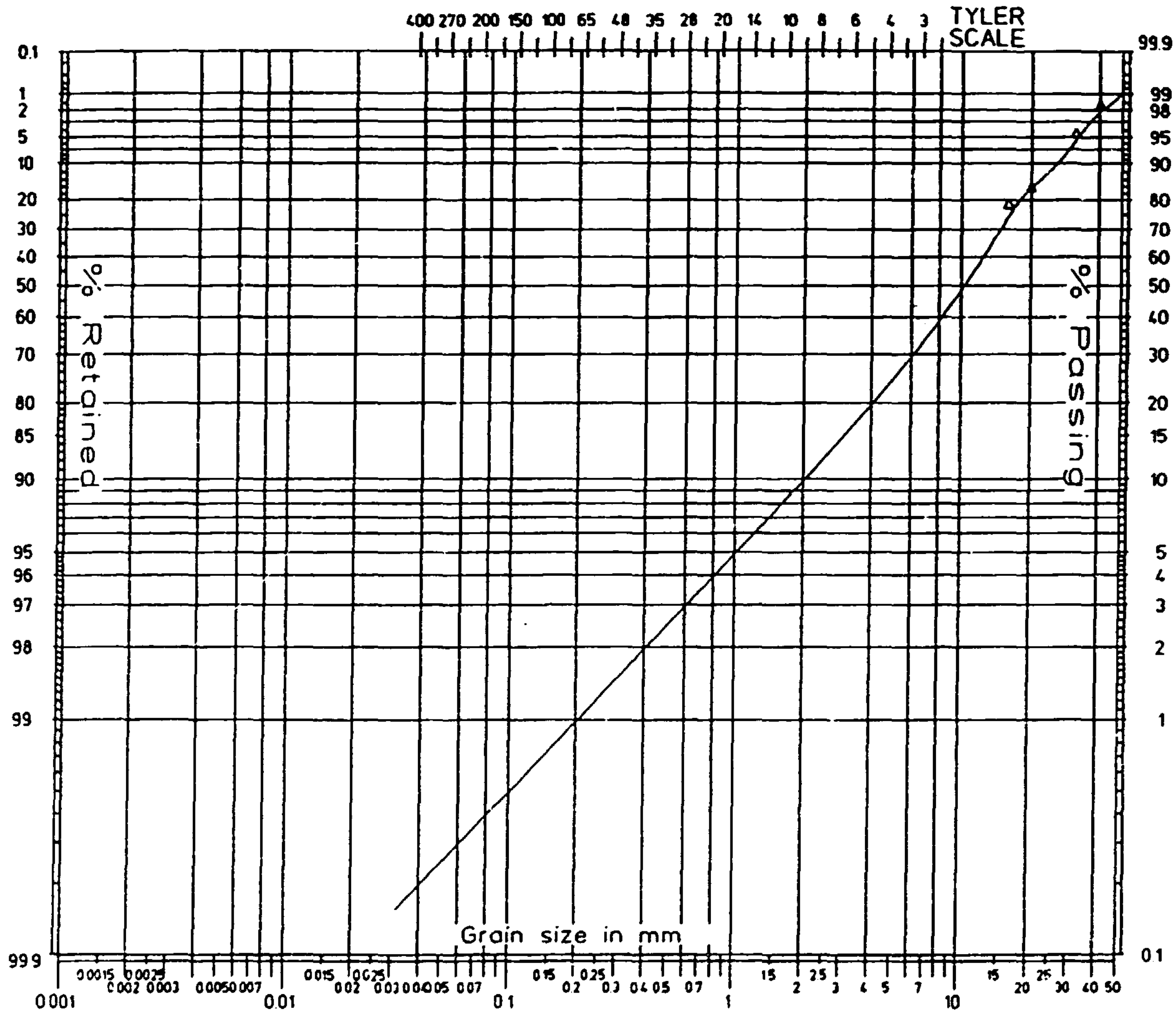
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No. 820
		Rev. by: KK 14-Jul-1992
	Project: US/INS/91/183	

Material: Sample No. 6, ADARO-COAL

Bulk weight: kg/m³ Humidity: 18,87 %

Type of maschine: HAND Specific gravity: kg/m³



Series 1:
Coefficient of constancy: 1.55
Size range index: 14.87

Grain size mm	0-16	16-20	20-31.5	31.5-40	40-63				
Fraction (%)/mm Series 1	78.64	5.47	11.48	2.80	1.60				
Grain size mm									
Fraction (%)/mm Series 1									

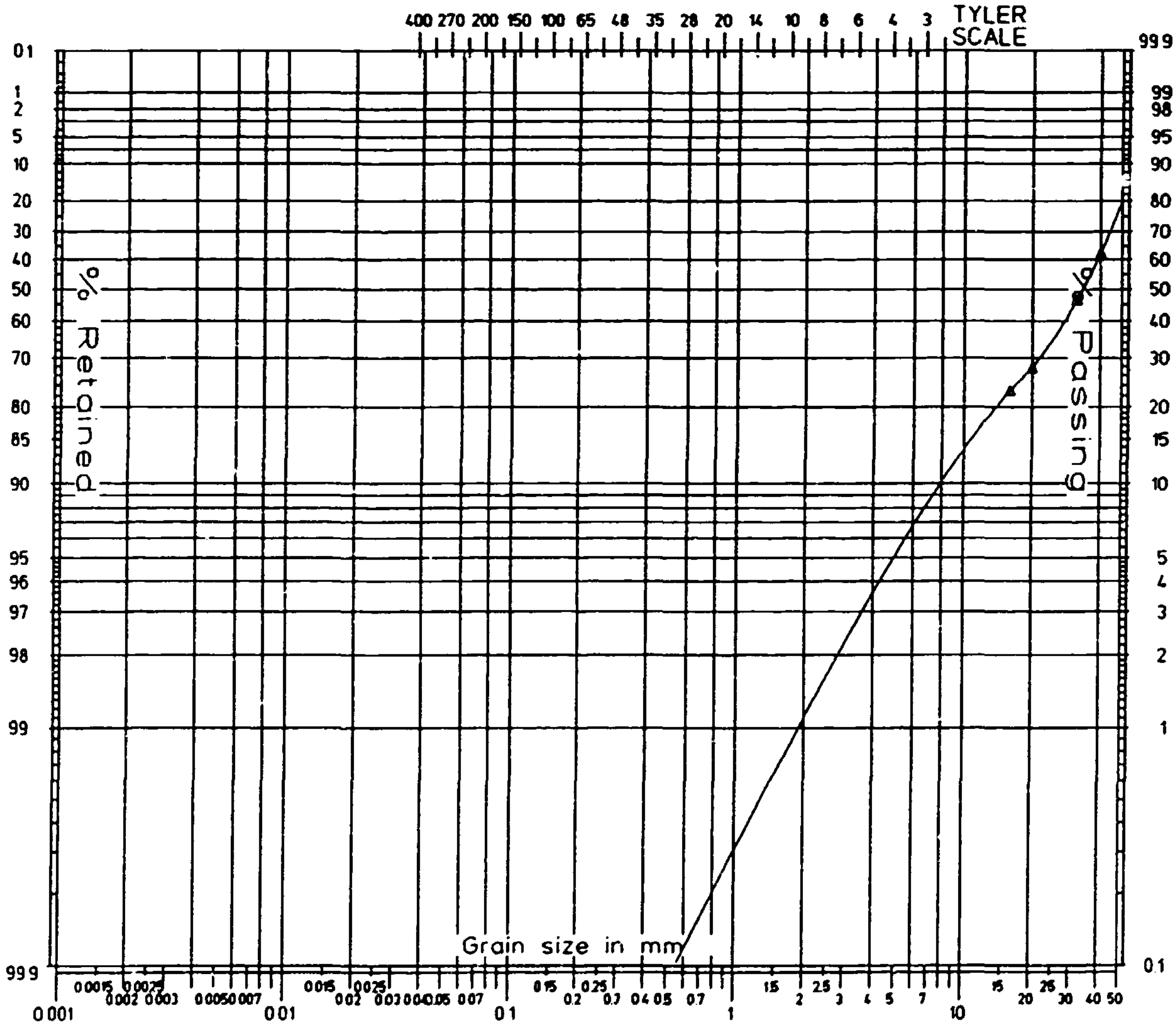
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No.	903
		Rev. by: BS	14-Oct-1992
	Project: US/INS/91/183		

Material: SAMPLE NO.9 - LUMUT A2 -COAL

Bulk weight: kg/m³ Humidity: 3,1 %

Type of maschine: BY HAND Specific gravity: kg/m³



Series 1: △—△—△

Coefficient of constancy: 1.61

Size range index: 33.87

Grain size mm	0-16	16-20	20-31.5	31.5-40	40-63	63-80			
Fraction (%)/mm Series 1	22.96	4.84	18.68	15.92	33.29	4.31			
Grain size mm									
Fraction (%)/mm Series 1									

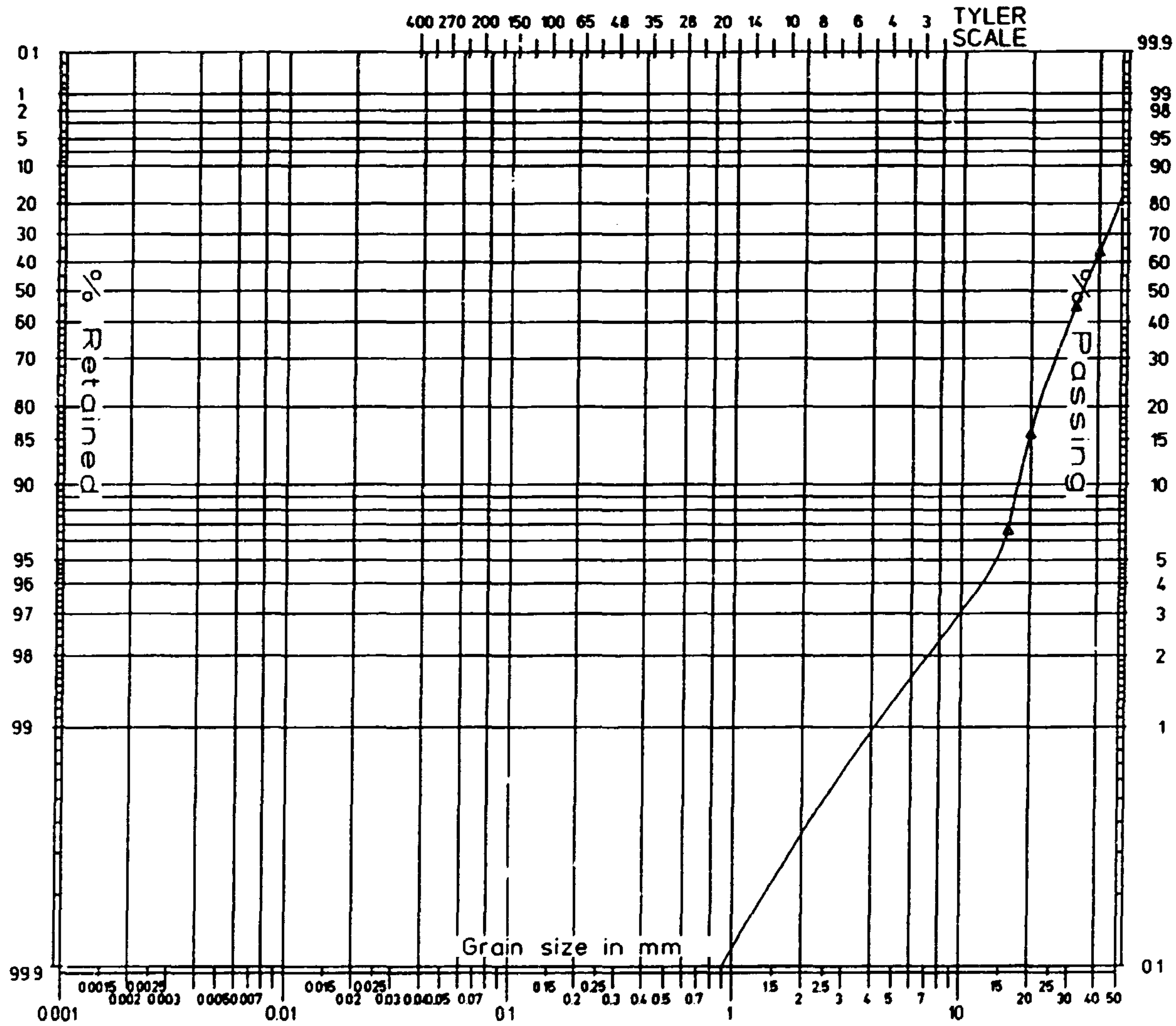
Annex

ARP - Ges.m.b.H. 8700 LEOBEN	Grain size distribution	Test No. 904	
		Rev. by: BS	14-Oct-1992
	Project: US/INS/91/183		

Material: SAMPLE NO. 10 - LUMUT B COAL

Bulk weight: kg/m³ Humidity: 30 %

Type of maschine: BY HAND Specific gravity: kg/m³



Series 1: ▵—▵—▵

Coefficient of constancy: 1.91

Size range index: 39.99

Grain size mm	0-16	16-20	20-31.5	31.5-40	40-63	63-80			
Fraction (%)/mm Series 1	6.65	9.20	28.98	19.06	32.90	3.21			
Grain size mm									
Fraction (%)/mm Series 1									

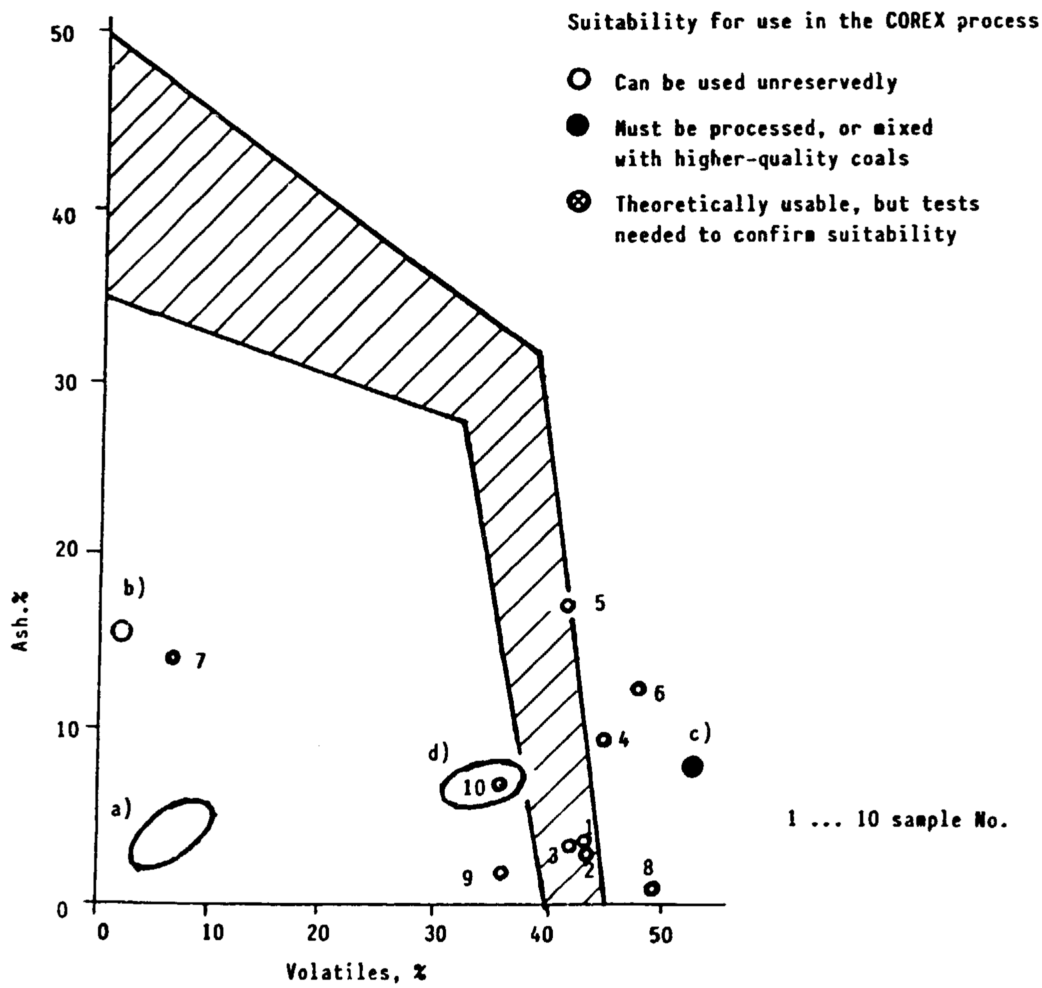


Fig. 1 - Classification of coals in accordance with their contents of ash (dry basis) and volatiles (dry, ash-free basis)

a) Antracitc
b) Lignite charcoal
c) High-volatile bituminous coal
d) Lignite

Annex

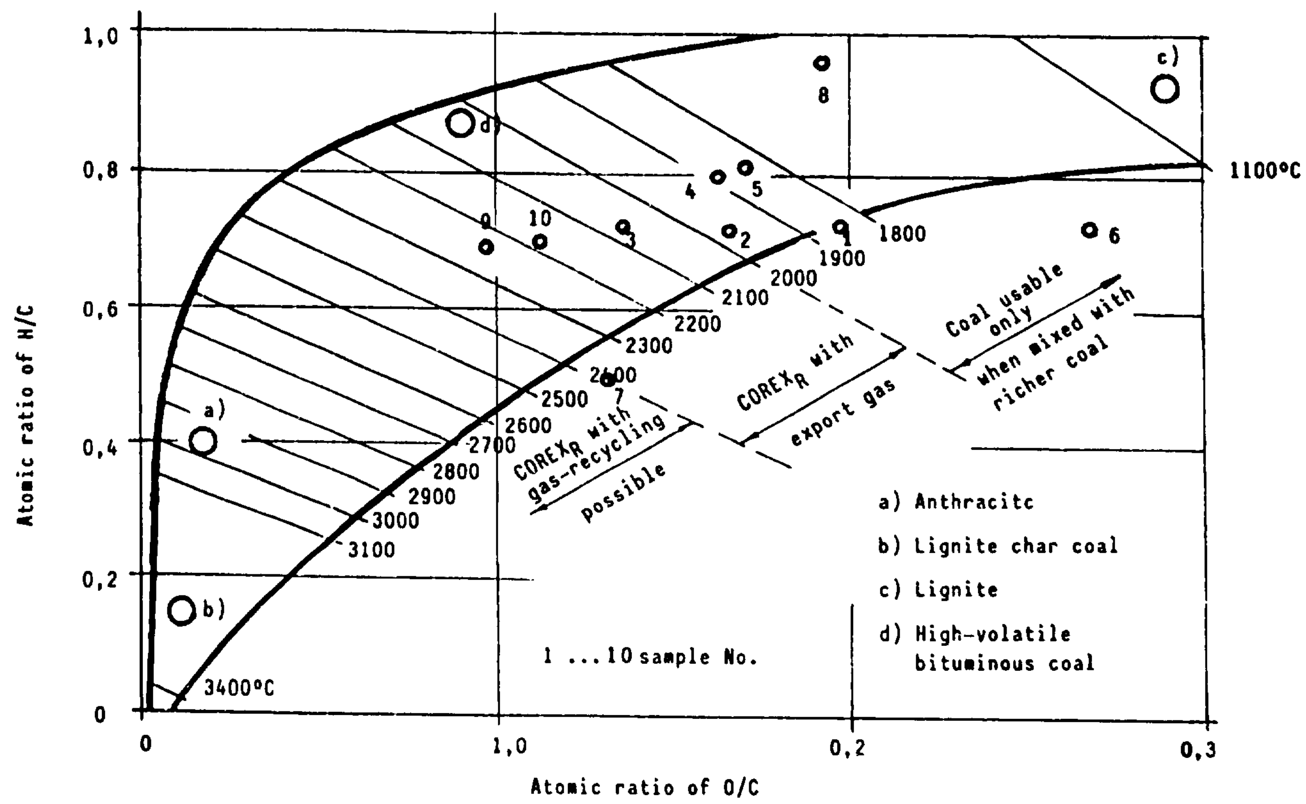


Fig. 2 - Classification of coal by its adiabatic gasification temperature (H_2 + CO_2) independent of its atomic ratios