EVALUATION AND STANDARDIZATION OF ESTONIAN OIL SHALE QUALITY CHARACTERISTICS

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GENERAL

The most important mineral wealth of Estonia is oil shale, which is used as fuel for generating electricity, thermal energy, for producing the shale oil, impregnation oil, cement, concrete and other products.

Estonian oil shale (Kukersite) deposit occupies an extensive territory (about of 1830 square km). Proved reserves in this deposit were estimated about 4 billions tons of oil shale. (Fig. 1). The industrial oil shale seam (thickness 2,5 - 3,2 m) contains 6 oil shale layers (A - F2) which are separated from one other by limestone intercalation poor in kerogene. The calorific value of oil shale layers ranges between 7 - 15 MJ/kg. The bedding depth of oil shale deposit is from a few meters up to 150 m, now maximum depth in mines are about 70 m. At present oil shale mining is carried out in 6 mines and 3 opencast, oil shale output was 14,6 million tons in 1996.

The most important quality characteristics of oil shale are: calorific value Q, moisture W, ash content A, carbonic acid content CO_2, which have influence on efficiency of using oil shale in power and thermal processing plants and construction materials production. Therefore it is important to elaborate standards of oil shale quality, characteristics and investigate how to guarantine the required for consumers stable quality of oil shale. Checking necessary number of samples from mines, opencasts, power plants and other consumers, evaluating precision of sampling and determination of quality characteristics is also important.

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STANDARDS

Standards for moisture and ash content have been worked out by Estonian Oil Shale Corporation management (K.Koitmets) and verified as Estonian republican standards in 1995. Investigating methods for determination averages and primary increment variance of testing gross samples the coefficients of variance for moisture content W did not exceed 1,5% and results determining ash content A were:

for shortened method 52,38 ± 0,03%;

for key method 50,40 ± 0,04%.

The shortened method had bias (systematic deviation) and therefore was not included in verified standard.

Standard of oil shale sampling and calorific value is now in work. All these standards are necessary and corresponding to ISO standards, creating systems of quality for satisfying consumers needs and security, increasing efficience of quality politics.

EVALUATION OF OIL SHALE QUALITY

Research work staff members of Mining Institute Tallinn Technical University investigating these problems with experiments of sampling in mines, opencasts and power plants, statistical analyses of the samples and data from mining and power enterprises, the degree of variability oil shale quality characteristics in space and time had following key results:

1. Comparing coefficients of variance V and correlation matrix the Estonian oil shale quality characteristics may be ordered in following row by significance: low and high calorific value Q_S^d and Q_i^r, V<16%; moisture content W_t^r, V<12%; carbonic acid content $(CO_2)_M^d$ V<10%; ash content A^d V<8% (1).

2. Standard deviation of oil shale quality characteristics depends from size of delivered oil shale quantity, number of primary increments and time between taking it. Therefore it is necessary besides evaluating the common statistics of oil shale quality: average, variance, standard deviation, skewness and kurtosis to have information about conditions of sampling: time, place, apparatures and preparation.

3. Experiments of sampling in mining enterprises and power plants indicated that coefficient of variance calorific value in small portions of oil shale (100 - 200t) was 7,5 - 16%, what means that the precision of

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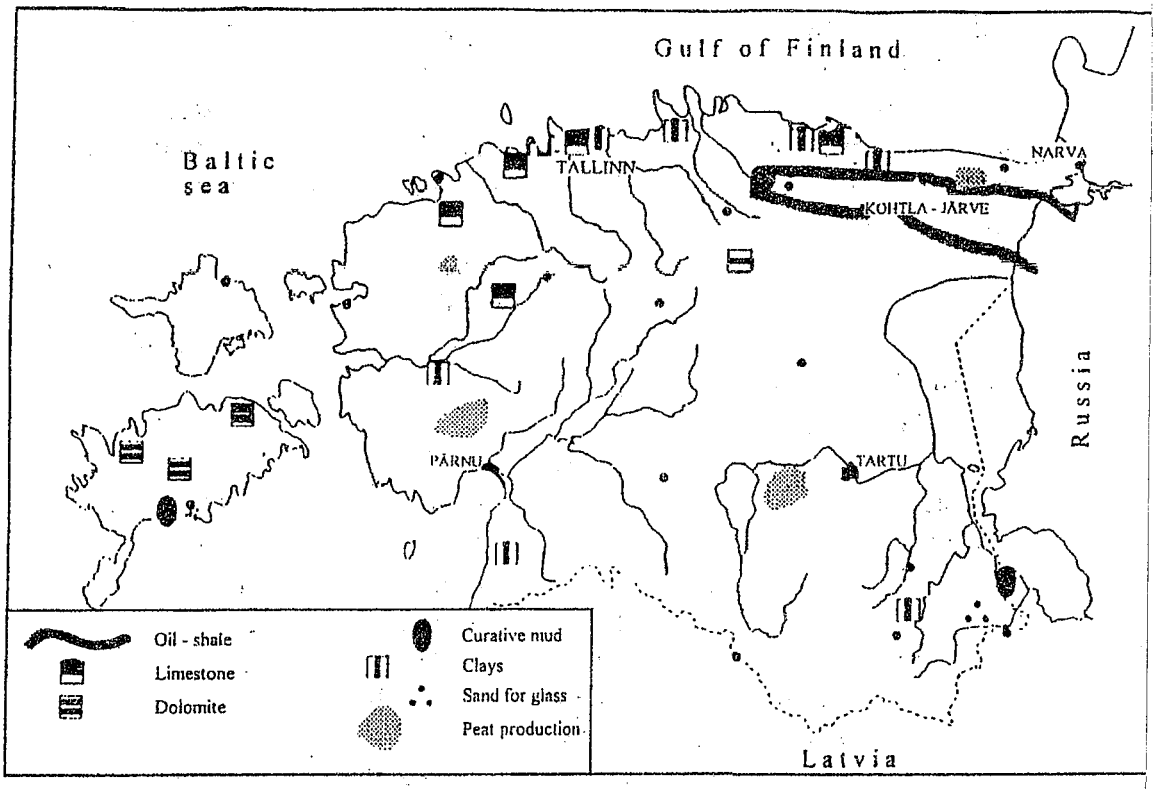

Deposits of mineral resources in Estonia

MINERAL RESOURCES Resource	Unit	Explored resorces 01.01.1997.	Mined in 1996
Oil - shale	million tons	3972	14,6
Limestone, dolomite	million m³	271	1,125
Sand, gravel	million m³	426	0,703
Peat	million tons	1547	1,124
Currative mund	million m³	3	0,001

Figure 1

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indicating data from samples in power plants is 180 - 300 KJ/kg. All quality characteristics of oil shale samples showed, that statistics had normal distribution and time series random variability.

4. Analysis distribution tables of sold oil shale quantities (lots) and qualities Q in 1994 - 1997 (Table1, Figures 2, 3) indicated, that statistics of lots were stable and coefficients of variance special low calorific value did not exceed 8 %.

Note: For all oil shale classes, excerpt class P2 (0 - 125 mm) coefficients of variance Q did not exceed 5%.

5. To guarantee that the uncertainity (precision) of sampling determining Q for lots do not exceed:

class K - 550 KJ/kg;

class P - 630 KJ/kg,

it is necessary to take no less as 25 and 20 increments for gross sample. In this case uncertainity of determining $CO2 < 1\%$ and $A < 2{,}3\%$.

6. Detailed checking the variances of sample preparation and testing (Fig.4) gave results that variances were (K. Koitmets):

at the first stage of sample division V1=1225 KJ/kg;

at the second stage of sample division V2=101 KJ/kg;

at the analysis V3=216 KJ/kg;

at whole sample preparation and testing V=1541 KJ/kg.

The uncertainity of sample preparation and testing was evaluated as 177 KJ/kg and did not exceed 20% of whole uncertainity by sampling, sample preparation and analyzing.

Therefore, it is more important do investigate carefully procedures of taking increments for gross sample to guarantee representative and reability sampling. It consists methods checking random and normal distribution of increments statistics, statistical hypothesis comparision of means and of variances.

7. Analyses indicated that the low calorific value Q as the main quality index possesses high and significant coefficient of correlation with all other quality indexes and therefore it is recommended to base this index for classification and determining price scale for selling oil shale to consumers (1).

8. Experiments showed that the stability of oil shale quality can be considerable increased by storing oil shale in depots of opencasts and power plants. Decreasing standard deviation of oil shale calorific value for power plant boilers, it decreased specific quantity of oil shale for production electricity.

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Table 1

Average specific low calorific value MJ/kg for lots of oil - shale

Enterprise	Oil - shale class	1994	1995	1996	1997 *
Mines:					
Ahtme	K	11.27	11.25	11.16	11.08
	P	9.04	9.13	8.78	8.78
Viru	K	11.48	11.54	11.54	11.56
	P	8.99	8.71	8.66	8.47
Kohtla	K				
	P		8.84	8.68	8.68
Sompa	K				
	P		8.88	8.96	9.02
Tammiku	K	11.85	11.90	11.78	11.75
	P	9.51	9.59	9.26	8.94
Estonia	K	11.20	11.20	11.18	11.20
	P	8.67	8.45	8.34	8.26
Opencats:					
Sirgala	K				
	P	8.72	8.75	8.73	8.71
Narva	K				
	P	8.42	8.34	8.37	8.41
Viivikonna	K				
	P		8.69	8.71	8.70
Aidu	K	11.44	12.13	11.89	11.49
	P	8.29	8.26	8.41	8.61
Eesti Põlevkivi	K	11.48	11.51	11.46	11.34
	P	8.65	8.64	8.57	8.58

* only January and February;
K - concentrate oil - shale 25 - 125 mm;
P - oil - shale 0 - 300 mm

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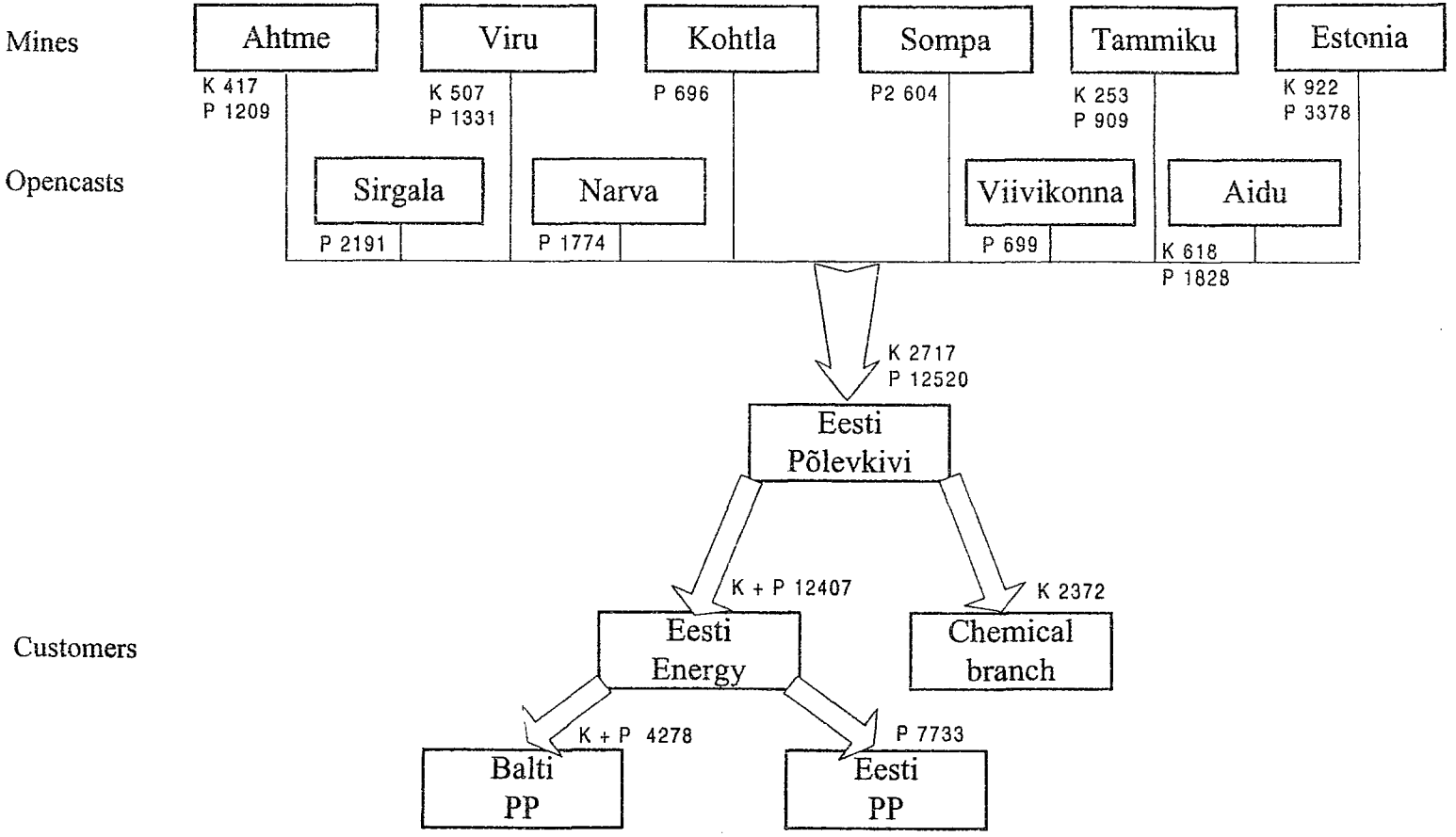

Fig. 2. Oil - shale consumption and production 1996 10^3 tonns

K - class concentrate 25 - 125 mm sized from preparation plants;
P - class 0 - 300 mm from opencasts and mines.

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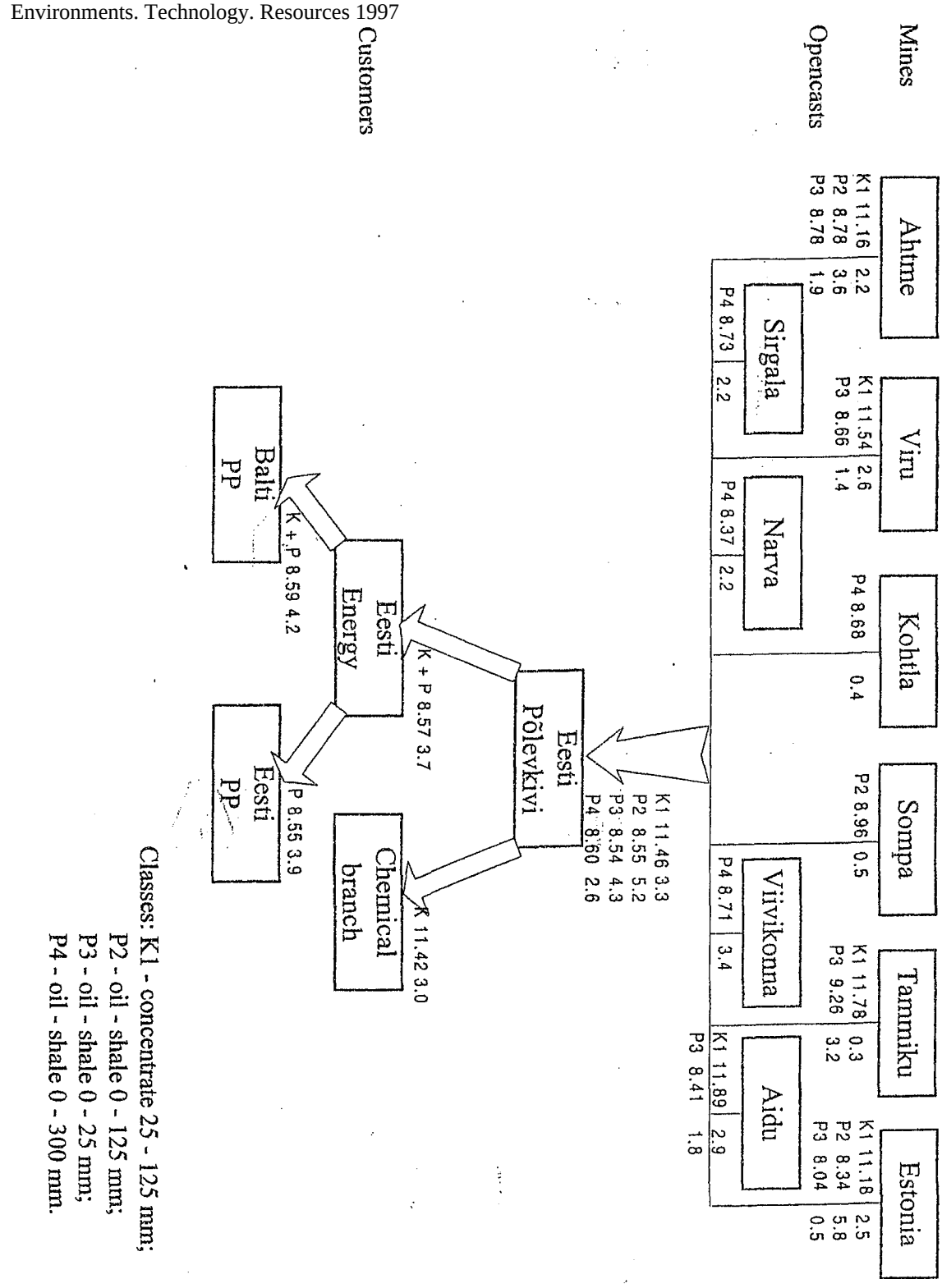

Fig. 3. Average low specific calorific value Q_M^i MJ/kg and coefficient of variance V% lots of oil - shale from mines and opencasts, for consumers in 1996

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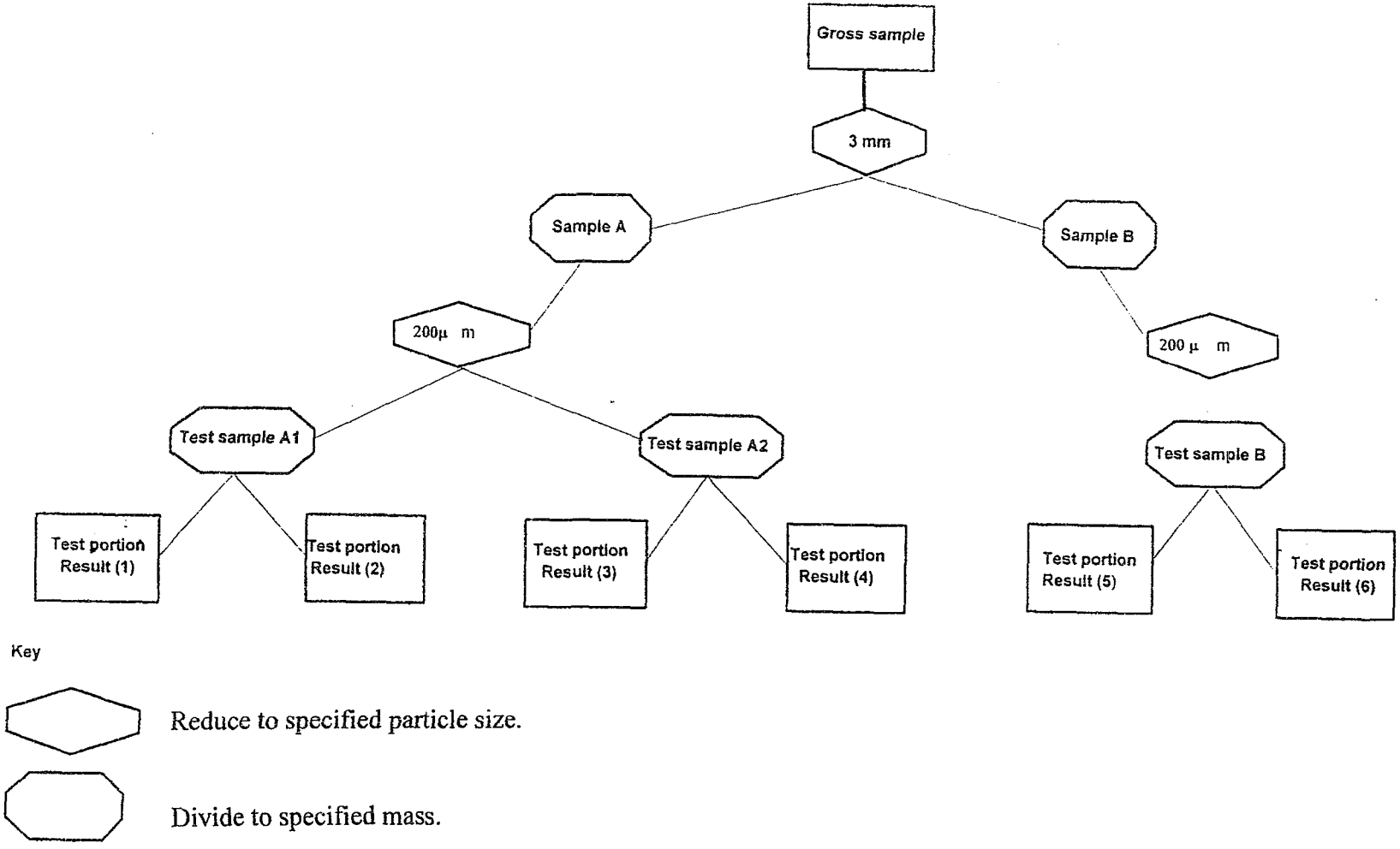

Fig. 4. Detailed check of sample preparation.

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9. Predicting relationship between boiler performance and oil shale quality needed to be developed to predict the costs and price of producing electricity.

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