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HIGH-LEVEL ADVISORY SERVICES FOR THE BAIKALSK PULP AND PAPER MILL

SI/RUS/94/801/11-57

RUSSIA

Technical report: Air emission control and abatement in kraft pulping*

Prepared for the Government of the Russian Federation
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Engineer Jouni Eerikaeinen

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* This document has not been edited.

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I. EXPLANATORY NOTES

Adt/a	air dry metric tons pulp per annum
Adt/d	air dry metric tons pulp per day
BPPM	Baikalsk Pulp and Paper Mill
CHEM	The Centre for Hydrometeorology and Environmental Monitoring
Cl	chlorine
ClO2	Chlorine dioxide
CO	carbon monoxide
CS2	carbon disulphide
DMDS	dimethyl disulphide
DMS	dimethyl sulphide
H2S	Hydrogen disulphide
IET	Institute for Ecological Toxicology
kg/Adt	kilograms per air dry tons pulp
kgS/Adt	kilograms sulphur per air dry tons pulp calculated as total sulphur
MM	methyl mercaptane
MPC	maximum permissible concentration in milligrams per cubic meter
MPD	maximum permissible discharge in tons per annum
NOx	nitrous oxides
SCR	selective catalytic reduction
SNCR	selective non-catalytic reduction
SO2	sulphur dioxide
RCEP	Regional Committee for Environmental Protection
TCEP	Territorial Committee for Environmental Protection
TPD	temporary permitted discharges in grams per second or tons per annum
TRS	total reduced sulphur

II. ABSTRACT

The objective of the mission was to collect all relevant information concerning government limitations for air pollutants discharged in the Baikal Lake Ecosystem, access air pollution treatment facilities, evaluate their efficiency and propose measures to minimise air emissions. The process modifications proposed by Mr. Olli Jalkanen as a result of his mission in February-March 1995 were used as the starting point of this evaluation.

The Mill is constantly out of regulatory compliance mainly because of very large air emissions (dust, SO2, CO, NOx) related to energy production. The specific heat consumption 43 GJ/Adt is twice as much as in Kraft pulping in 70's. Thus the air emissions of five auxiliary coal boilers are very high. The specific sulphur emission from energy production for the pulp mill is ca. 13 kgS/Adt, which is more than six times the recommended level in Nordic countries.

The odour emissions of the Mill are on an acceptable level, ca. 2,6 kgTRS/Adt and the smell of the Mill is lower than in most of the Kraft mills the author has visited. However, the emissions of TRS compounds (H2S, MM, DMS, DMDS) are many times over the

regulatory limits, which are very strict. The measured concentrations of MM and H2S in the sanitary zone of the Mill have exceeded the MPC values in some cases.

The information presented to the author show, that the airborne emissions of the Mill to the Baikal Lake and its catchment area present less than 3 % of the total emissions from the industry which is mainly located on the valley of Angara river. Despite of the high specific emissions from the energy production of the Mill, its role in airborne pollution of Baikal Lake is insignificant.

The 33 emission treatment facilities of the Mill are in general at good or satisfactory level with scrubbers, electrostatic precipitators, desulphurization unit, bag filters etc. The efficiency of the lime kiln flue gas scrubber should be improved and dissolver tanks should be equipped with scrubbers.

The air emissions from the proposed future cooking plant will decrease because of the cold blow system. The strong odour gases from cooking are proposed to be burned in the Bark boiler NR. 5. The weak odour gases from cooking and black/white liquor tanks are proposed to be cooled and combusted in the Power boiler NR. 8. Both boilers are equipped with desulphurizing equipment (Lifac in boiler 8 and scrubber in bark boiler 5).

The emissions related to energy production should be decreased with the proposed process changes and implementing of an energy efficiency program. The estimated target heat consumption with 200 000 Adt/a production in future is 50-55 % and power consumption 60-65 % of the present consumption figures. The specific sulphur emissions will decrease with ca. 50-55 % to ca. 5,5-6,0 kg S/Adt. The TRS emissions will decrease ca. 70-75 %.

The investment costs for odour abatement, lime kiln scrubbers and recovery boiler dissolvers is ca. 4,3 MUSD.

The regulatory limits for dust and NOx at the present production level will not be met with the proposed changes. Low NOx burners or SNCR technology and improving of the efficiency of the electrostatic precipitator is recommended for the power boiler NR. 8. Complying with the methyl mercaptane MPD limit is probably not possible with present available odour abatement technologies.

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INTRODUCTION

PI-Consulting Ltd was commissioned on 16.06.1995 by UNIDO to provide independent expert advice on modifications to the processes employed at the Baikalsk Pulp and Paper Mill to minimise/eliminate impacts of potential emergency and continuous air pollutant releases on the Baikal ecosystem. This work is based on the pulping process modifications recommended by Mr. Olli Jalkanen, who visited the Mill earlier in 1995.

The mission was conducted by Senior Consultant Mr. Jouni Eerikäinen. The work started on 31st July 1995 and this report was delivered to UNIDO on 22nd August 1995. The mission at the Baikalsk Pulp and Paper mill was carried out between 1-.12.08.1995.

IV. GOVERNMENT LIMITATIONS FOR AIR POLLUTANT DISCHARGES IN THE BAIKAL LAKE ECOSYSTEM

A. Regulatory authorities

The regulatory agency for air emissions of the facility is the "Regional Committee for Environmental Protection & Natural Resources Conservation" (RCEP), located in Irkutsk. The "Territorial Committee for Environmental Protection & Natural Resources Conservation" (TCEP) in Baikalsk reports to RCEP and carries out air, water and soil sampling- and measuring in Sludjansk district including more than hundred plants and enterprises. Baikalsk City is a part of Sludjansk district. RCEP regulates and gives the limit values for air pollutants. TCEP has 3 specialists for water quality control and 3 specialists for air quality control.

"The Centre for Hydrometeorology and Environmental Monitoring" (CHEM) in Baikalsk is responsible of the regular control of air quality in the Baikalsk City area. It reports to TCEP on non compliance of the measured data with the regulatory limits.

"Institute for Ecological Toxicology" (IET) of Ministry of Environmental Protection of Russia is a research institute dedicated to study the ecosystem of Lake Baikal and its environmental impacts of anthropogenic origin. It is located in Baikalsk and started the research and education already in sixties when the BPPM was built. IET has no regulatory authority role, but delivers scientific data for public and environmental authorities.

TCEP and CHEM work in close co-operation with the analytical laboratory of BPPM which analyses the air quality in the sanitary area twice a month.

The following persons were met during the visit:

TCEP:	Ms. Ludmila Innokentevna Kalashnikovna,	Deputy Chief
CHEM:	Mr. Anatolyi Polovinskyi,	Chief of the Centre
	Ms. Ludmila Panchenko,	Chief of the Laboratory
IET	Dr. Albert M. Beim,	Director

B. Air emission regulations

The State law on environmental protection from 1987 and the State law for atmospheric protection regulate the air emissions. RCEP has issued permission on air emissions to BPPM, valid until 01.01.1996, see Annex 4. Maximum Permitted Discharges in grams per second and in tons per year, (MPD) and Temporary Permitted Discharges (TPD) are given to 18 components. The calculation of MPD values is based on recommendations issued by "Hydrometeolzdat" 1987. The calculation considers, that the emissions from the Mill will not raise the ground level concentration of the compound above MPC.

Maximum Permitted Concentrations mg/m3 (MPC) and Temporary Permitted Concentrations (TPC) in the sanitary area ca. 1 km around the Mill are stated by RCEP.

C. Sampling, measuring and reporting procedures

CHEM controls the air quality with two stationary stations (NR. 47 and 48) located in Baikalsk City. Also monitoring laboratory in a car is used for sampling and analysing of Cl2, CS2 and H2S. In 1994 10 723 analysis were done for 9 pollutants which are hazardous for human health and the results are analysed statistically. The samples are taken with absorption test tubes three times per day at 08.00, 14.00 and 20.00 hrs. The compounds analysed are dust, SO2, CO, NOx, H2S, CS2, Cl2, MM and bentsopyrene. Also snow samples are analysed. The analyses are made according to GOST standards RRD 5204 186-89 mainly with photometric methods using characteristic filters for each compound.

IET takes samples from ground level air and precipitation samples from snow in Baikal lake and its catchment area. Ca. 100 km protection zone is surrounding the Baikal Lake. Helicopter is used for air sampling from mountains. IET also studies the impact of air emissions to humans, insects, mammals, lichens and to the morphology of needles of coniferous trees. IET has published several articles and research literature of the Baikal lake ecosystem and of the environmental impacts of the industry.

TCEP uses absorption tubes and bags for sampling in the sanitary area of BPPM and in surrounding. The analyses are made with GOST standards based on classical analytical chemistry, TCEP has a gas chromatography and a liquid chromatography in its laboratory. The instruments are calibrated once a year according to standards and law. Ms Kalashnnikova would like to use portable quick gas analysers, but they are expensive and not certified by the authorities. The samples are normally taken ca. once per month for toxic substances and ca 2-6 times per year for less harmful substances. The compounds mostly measured are H2S, MM, DMS, DMDS, SO2, NOx, CO and dust.

The Sanitary Laboratory of the BPPM analyses the air quality in the sanitary area of the Mill and reports to TCEP.

D. Summary on air quality measurements

The main results are listed below:

Table 1. Baikalsk City air quality control data from 1994 prepared by CHEM

Compound	NR. of samples	Average concentration	Max. concentration	Month of max. conc.	Exceeding of max.perm. concentration
	pcs.	mg/m3	mg/m3		%
dust	1 611	0,1070	0,5999	3	0,3
SO2	1 613	0,0003	0,0039	1	0,0
CO	1 619	0,9573	5,0000	2	0,0
NO2	1 613	0,0353	0,4799	4	6,8
H2S	1 619	0,0007	0,0089	3	0,1
CS2	505	0,0054	0,0679	1	2,0
Cl	1 613	0,0008	0,0799	3	0,0

The highest concentrations have occurred in cold season between January and April. NO2 concentration have exceeded the max. permissible concentrations in 6,8 % of the samples. The high CS2 concentrations were explained as a reaction product from hydrogen sulphide and carbon monoxide.

The air quality measurements carried out by the Sanitary Laboratory of BPPM and reported to TCEP are shown below:

Table 2. Air quality measurement data from BPPM sanitary area, January-March 1995

Comp. measured	MPC mg/m3	Nr.of samples	NR. of detected comp.	NR. of exceedings of MPC	Min. mg/m3	Average mg/m3	Max. mg/m3
Turpentine	2,0	26	26	-	0,1234	0,3579	0,6572
ClO2	0,1	26		-			
H2S	0,008	26	26	4	0,00037	0,0035	0,0142
SO2	0,5	26	20	-	0,0019	0,0197	0,0958
Phenols	0,01	26	20	1	0,0003	0,0017	0,0076
MM	0,0001	13	12	12	0,0005	0,0039	0,0091
CS2							

Methyl Mercaptane (MM) and Hydrogen Sulphide (H2S) concentrations are the most problematic compounds. In order to reduce their concentrations below MPC, the emissions should be reduced to 18,3 t/a for H2S and to 0,3 t/a for MM. In the present permission of BPPM the MPD for H2S is 9,15 t/a and for MM 0,15 t/a. The actual emissions in 1994 were 110,2 t/a for H2S and 66,9 t/a for MM.

E. Review of past air emissions

The emissions statistics from 1990..1994 are shown in Annex 5.

F. Environmental impacts of air emissions

According to the research work by IET no signs of pollution has been observed in humans, mammals, insects and in needles of coniferous trees in the area of Baikal lake. In an area of ca. 360 km2 around BPPM a very sensitive Usnaja lichen is disappeared. The emissions from industry, cities and traffic affecting to the Baikal lake are presented in detail in Annex 6. It is clearly shown, that the impact of BPPM on the emissions and fall out of dust, sulphur, carbon monoxide and nitrogen on the aquatory and water catchment area is negligible and below 3 % from the total emissions of the area. The prevailing winds from north west carry atmospheric emissions from Angara river and Irkutsk industrialised area to the Baikal lake. The most polluting industry in Irkutsk consists of coal mining, oil refining and coal power stations. The impact of BPPM on the SO2 concentration and fall out in the southern part of Baikal lake is very local and represents only a minor part of the emissions in comparison with the emissions coming from the Angara river area.

The smell of TRS compounds in the vicinity of BPPM is rather low compared with Kraft mills with higher sulphidity. The smell can be detected at day time in adjacent hills, when the prevailing winds from Northwest blow the exhausts gases to the hills. During the night the direction of the wind turns back to the lake. Based on the study of Pavlov /1/, the at the distance of 6 km from the Mill SO2 concentration is below 0,05 mg/m2 and the impact of air emissions from BPPM covers an area within ca. 3-5 km radius from the Mill.

Pleshanov /2/ has observed, that if the level of BPPM emissions will remain at the present level, the trees in South East coast and valleys will be exposed to unfavourable conditions with micro diseases.

G. Regulatory compliance

According to the discussion with Ms Kalashnikova TCEP, the Mill is continuously out of regulatory compliance. The electrostatic precipitators are causing dust emission problems, when they are not working well. The coal power boilers fall out regularly because of reparations due to cracks in tubes etc. When the boiler is started again with heavy fuel oil, the electrostatic precipitator is out of use for a while before the flue gas temperature has raised sufficiently. This causes peak dust and smoke emissions lasting 2-3 hours. Other problematic compounds are especially MM and also DMDS.

TCEP would like to tighten the MPC levels. Written violation notices are given almost weekly to BPPM e.g. from dust emissions and TCEP receives complaints from the neighbouring inhabited area. However BPPM is not the only mill, which is exceeding the MPC values and giving reasons for violation notices in Sludjansk territory.

The Mill can not meet the MPD requirements for air emissions and is obligated to pay fines according to the exceeding of MPD and TPD values. The fines in 1994 were 116 million Rubles (ca. 29 Thousand USD)

Table 3. Emissions and MPD values in 1994

Compound	Emission in 1994 (t/a)	MPD (t/a)
Dust	3660,8	370,41
Sulphur dioxide SO2	2960,3	1750,00
Carbon oxide CO	811,5	468,50
Nitrous oxides NOx	2551,0	595,52
Hydrogen sulphide H2S	110,2	9,15
Methyl mercaptane MM	66,9	0,15
Dimethyl sulphide DMS	160,7	5,38
Dimethyl disulphide DMDS	128,2	7,68
Chlorine Cl2	3,1	1,54
Chlorine dioxide ClO2	4,2	2,85
Turpentine	46,4	18,25
Alkaline aerosols	14,0	7,02
Total	105217,3	3236,45

V. AIR EMISSION TREATMENT FACILITIES AT THE MILL AND MEASURES TO MINIMISE AIR EMISSIONS

The Mill has identified 126 air emission sources, 105 of them are operating constantly. 93 % of emissions are treated in 33 treatment equipment. The emissions are measured in 1989-90 by a research institute. The process description and emission sources are described in detail in Annex 7. All emission sources are numbered and the stacks and vents are shown in lay-out Annex 8.

In general the treatment facilities represent a good technology from sixties and seventies. Some innovative catalytic treatment facilities are installed for treatment of foul condensates and hot well relief gases. A catalytic "Emulgator" is installed after one of the two lime kiln scrubbers.

The main sources of emissions are related to energy production. Four recovery boilers and five coal power boilers are equipped with electrostatic precipitators. The power boiler NR. 8 is connected to "Lifac" desulphurizing equipment based on semidry lime method. Two bark boilers and the sludge furnaces are equipped with scrubbers.

In recent years the emission abatement in Kraft pulping is concentrated to decrease sulphur emissions. NOx emissions are normally quite low from recovery boilers and dust emissions can be easily reduced with conventional scrubbers, electrostatic precipitators (E.P.) and bag filters. Chlorine and chlorine dioxide emissions are also relatively small and decreasing due to shift to ECF or TCF bleaching.

Sulphur emissions in Nordic countries e.g. in Finland are at present on a level of ca. 2,5 kg S/Adt including both TRS (Total Reduced Sulphur including H2S, MM, DMS and DMDS) and SO2 (sulphur dioxide). The sulphur content in each emission component is calculated using molecular weights and the sum of sulphur is expressed as kilograms sulphur per produced air dry pulp ton, kg S/Adt. Sulphur emissions are divided to strong and weak odour gases from the process and to SO2 emissions from recovery boilers, bark boilers, auxiliary boilers and lime kiln.

Odour gases in a Kraft pulp mill has always been a nuisance and technologies have been developed recently in order to reduce the bad smell of Kraft pulp mills. Strong odour gases originate from blow heat recovery vent, turpentine recovery vent, evaporator hot well vent, foul condensate stripping, foul condensate storage tanks and continuous digester relief. Strong odour gas flows are small, ca 200..1500 Nm3/h and TRS concentrations are high. Weak odour gases are collected from the washing plant and from various black liquor tanks. The volumes of weak odour gases vary very much, 15 000...80 000 Nm3/h depending on the type of process, sulphidity level and from how many sources the odour is to be reduced.

The sulphur emissions in 1994 from the measured sources are presented in Annex 9. The dominant source of TRS gases is the relief gas from the accumulator tanks, ca. 54 % of the total TRS emissions. The relief gases from the hot wells of the evaporation plant are treated together with foul condensates in four catalytic scrubbers. The scrubber capacity is 100 m3/h. It is ca 16 m high, 3 m in diameter consisting of Antimony/PE pellet catalyst beds. Foul condensate and hot well gases are fed to the bottom of the scrubber through bubble nozzles. Air is mixed in 1:5...1:10 proportion and TRS compounds are oxidised to sodium thiosulphate ad sodium sulphate. The cleaned condensate is used in the washing plant.

The weak odour gases consist of vent gases from the white liquor dosing tank and vent gases from black liquor and white liquor tanks. The significance of weak odour gases from washer hoods from washing plant, chip bins, various chests and towers from washing, screening and bleaching plant is small. Thus the odour abatement is concentrated only to sources presented in Annex 10.

The emissions kgS/Adt are compared to the emissions in the Finnish Kraft pulp mills in seventies in Annex 9. Following conclusions can be made from the comparison and from the discussions with regulatory authorities:

- The specific SO2 emissions are more than six time higher compared with Finnish mills
- Main part of the fines are caused by the emissions related to the energy production: SO2, NOx and dust
- Total TRS emissions are in acceptable level compared to Finnish mills, but the local MPC levels of MM and H2S are often exceeded
- Emissions from the recovery boiler dissolving tanks are high
- Emissions from lime kiln flue gas scrubbers are twice higher than the acceptable level
- The malfunctioning of power boilers and E.P:s causes very often short time smoke and dust emissions

RECOMMENDATIONS

1. Proposed process changes and their influence on air emission abatement

Mr. Olli Jalkanen, whose target was to identify new cleaner technologies has recommended the following process changes:
- New cooking with cold blow
- Improved washing
- Closed new screening
- Oxygen delignification

An investment to a new batch cooking is recommended and it has a great influence in TRS gas releases and overall energy efficiency. Other recommendations would improve mainly energy efficiency and consequently reduce the air emissions from the energy production.

The basis for the recommendations below is that the modifications proposed by Mr. Jalkanen will be implemented.

The Mill personnel has identified process modifications, which will improve the air emission abatement. The most important modifications are:
- Polysulphide cooking with low TRS emissions
- Modernisation of boilers 7, 9, 10 and 11 including Low NOx burners or SNCR or SCR technology and reconstruction of E.P.
- Replacement of the E.P. for recovery boiler 4

The process modifications and recommended technology for air emission abatement is discussed below.

1.1. Emissions related to energy production

A modern Kraft pulp mill is self sufficient in electrical power and heat energy without external fuels and excess power is sold out. BPPM sells ca. 14 % of the produced heat to the Baikalsk City. 78 % of electrical power and 74 % of the heat for the Mill is produced in five coal power boilers using quite low calorific value coal, see Power and Heat production in Annex 11.

The specific energy consumption figures GJ/Adt and GWh/Adt are shown in Heat and Power Balance, Annex 11. Compared with the normal technology in Kraft pulping in 70's the specific heat consumption of process is ca. 175 % higher and power consumption ca. 24 % higher. Thus energy saving is an important issue both for the economy and environmental impacts of the mill. The water consumption 331 m3/Adt reflects the situation. In conventional and modern Kraft mills the water consumption is ca. 20..40 m3/Adt. Huge amounts of water is used in BPPM especially in screening and bleaching but also in other departments. Condensate return percentage is quite low. The effluent treatment plant uses large amount of energy for aerating of large waste water volumes including cooling waters.

Obviously the energy related air emissions SO2, NOx, CO and dust should be reduced by using energy more efficiently. Heat and energy production is responsible from 82% of sulphur emissions and of main part of dust, NOx and CO emissions of the Mill. Thus an professional energy audit and energy saving program is recommended to the Mill. The modernisation program recommended for the mill will decrease the energy consumption significantly, but still a great deal of energy should be saved after reconstruction with a special energy efficiency program.

The NOx abatement with low NOx, SNCR or SCR technology should be considered after implementation of the energy efficiency program and taking care of the real problem, which is high energy consumption.

The time reserved for the air emission abatement study does not allow to go very deep in energy saving issues. However, a rough estimate has been prepared for a target heat and power consumption based on future production 200 000 Adt/a, see Annex 11. Because the Mill has several external heat and power consumers like the paper machine, effluent treatment plant and Baikalsk City, the Mill can not be self sufficient in energy. The estimated specific target heat consumption in future is 52 % and power consumption 63 % of the present consumption figures including external consumers.

The heat and power production is evaluated for 200 000 Adt/a production with the target figures. The following conclusion can be made from the figures in Annex 12:

- One recovery boiler and two power boilers will be idle after improvements.
- Lifac should be operating all the time in order to reduce SO2 emissions.
- Specific sulphur emissions related to energy production for the Mill will decrease with 54 %

1.2. Odour abatement

The planned odour abatement system is shown in Annex 13. The principle is to combust the odour gases in boilers, which are equipped with sulphur removal equipment in order to avoid SO2 emissions.

The strong odour gases are treated as follows:
The blow and digester relief gases 300 Nm3/h are collected with AISI 316 DN 100 pipeline to the Bark boiler 5. The system consists of a steam ejector, condensate drums and water seal with pumps, droplet separator, flame arresters, rupture disks placed in 30 m distances, emergency shutdown, fan and a specially designed heavy fuel oil combustor fitted in the boiler secondary air zone. The present burner may also be reconstructed to odour gas combustion. A closed flare is used as a reserve burner. It is connected to the pipeline and separated with flame arrester from the system. The combustion efficiency and SO2 removal efficiency of the flare is quite low, ca. 70%, but it is much cheaper than a dedicated auxiliary burner or auxiliary boiler.

The weak odour gases are treated as follows:
The weak odour gases 9 000 Nm3/h from black liquor and white liquor tanks in the evaporation plant are collected via pipeline to a cooling scrubber. The weak odour gases from the blow and filtrate tanks and brown stock filters in the cooking plant are also collected to the cooling scrubber. After the cooling scrubber the odour gas flow 18 000 Nm3/h is conducted with a fan to a heat exchanger preheater and heated with medium pressure steam in order to remove humidity from the flow. The preheated flow is then conducted via AISI 316 DN 800 pipeline to the coal power boiler 8 tertiary air feed level. The boiler is equipped with Lifac desulphurization equipment. In case coal power boiler 8 cannot be used for odour treatment, alkali (white liquor or NaOH) is fed to the cooling scrubber instead of water in order to remove H_2S and MM from the weak odour gas. In this case the washed odour gas is conducted to the atmosphere via a separate stack.

The characteristic properties of the boilers are given in Annex 11. The air feeds are shown in the table below:

Table 4. Boilers for odour gas combustion

		Coal power boiler 8	Bark boiler 5
Odour gas flow	Nm3/h	18 000	300
Primary air flow	Nm3/h	61 000	22 000
Secondary air flow	Nm3/h	40 000	14 000
Tertiary air flow	Nm3/h	40 000	

1.3. Recovery boiler dissolvers

The recovery boiler dissolver tanks should be equipped with scrubbers in order to avoid alkaline dust and TRS emissions. Weak white liquor is pumped to the scrubbers and a part of the circulation is conducted to the dissolver tank for green liquor preparation.

1.4. Lime kiln flue gases

The emissions from the lime kiln flue gas scrubbers are unexpectedly high. Normally similar scrubbers are used for lime kiln flue gas treatment and the TRS emissions are only ca 20..60 % of the present emissions. The alkali content of the lime mud was measured during the visit and it was 0,57% which is a bit high but within the reasonable limits (0,4..0,6 %). The recommendations proposed in the report of Mr. Olli Jalkanen would probably help the situation: By improving the separation, washing and drying of lime mud the alkali and sodium sulphide content of the lime mud can be reduced and the dry solid content increased. However, it is recommended to study the present operation parameters like burning temperatures in lime kiln zones, lime mud properties and the mechanical condition of the inside parts of the scrubber. It is important to reduce Na_2S content of lime mud as much as possible e.g., with increased vacuum air flow in lime mud filtration or with small hydrogen peroxide addition. Na_2S will thus be oxidised to sodium thiosulphate and sodium sulphate.

2. Summary of air emission abatement with proposed changes

The summary on the present emissions and emissions after modifications described above with present production capacity 120 253 Adt/a and future capacity 200 000 Adt/a/a is given below:

Table 5. Summary on air emission abatement with proposed changes

	Emissions in 1994		Limit values	Future emissions with proposed changes			Reduction
Production	120 253 t/a				120 253 t/a	200 000 t/a	
Component	kg/Adt	t/a	MPD t/a	kg/Adt	t/a	t/a	% kg/Adt
Dust	30,44	3 660,8	370,41	12,71	1 528,42	2 541,0	- 58
SO2	24,62	2 960,3	1759,00	11,04	1 327,59	2 208,0	- 55
CO	6,75	811,5	468,50	3,61	434,11	721,0	- 47
NOx	21,21	2 551,0	595,52	11,34	1 363,67	2 267,0	-47
TRS	2,62	315,5		0,71	85,38	141,4	- 73
TOTAL	85,64	10 299,1		39,41	4 739,17	7 878,4	
MM	0,56	66,90	0,15	0,15	18,13	30,15	-73

Even with the proposed improvements in process and cleaning technology the regulatory compliance with MPD values can not be met for dust, NOx and TRS emissions. The NOx emissions may be further decreased ca. 50-70 % with better combustion control, Low NOx burners or SNCR technology. Dust can be reduced by improving the efficiency of the electrostatic precipitator of coal Power boiler 8. The most difficult item will be complying with methyl mercaptane MPD levels, which is probably impossible with the odour abatement technologies available at present.

3. Preliminary investment cost estimate

The preliminary investment cost estimate is given below:

Treatment of strong odour gases in Bark boiler 5:
Equipment:

- Odour gas burner with heavy fuel oil as support fuel
- Flare as a reserve combustor
- Steam ejector
- Fan
- Droplet separators
- Water seal with pumps
- Rupture disks and flame arresters
- Pressure relief and vacuum relief valves
- Emergency shutdown valve and bypass to the flare
- Automation & instrumentation, interlocking
- Electrical works
- Piping and ductwork

Erection and civil works	
Design and project management	
Total:	MUSD 1,4
Treatment of weak odour gases in the coal Power boiler:	
Cooling scrubber	
Preheater heat exchanger	
Fan	
New odour gas feed nozzles to the boiler, 2-3 pcs	
Droplet separators	
Emergency shut off valve and bypass to the stack	
Alkali feed system to the cooling scrubber	
Pressure and vacuum relief valves	
Automation & instrumentation, interlocking	
Electrical works	
Piping and ductwork	
Erection and civil works	
Design and project management	
Total:	MUSD 2,0
4 scrubbers to the recovery boiler dissolvers	MUSD 0,6
Lime kiln operation control	MUSD 0,3
TOTAL INVESTMENT COSTS TO AIR EMISSION ABATEMENT	MUSD 4,3

VI. LITTERATURE CITED

1. - Pavlov, B. K., The content intensitivity and distribution of air pollutants of BPPM, Monitoring of anthropogenic changes of mountain-taiga ecosystemsm, Moscow, Ecology, 1995, 208 p.

2. Pleshanov, A.S., Information about the present state of the forest of Baikal region, Institute of plant physiology and biochemistry, Siberian section of RAS, 1995

VII. ANNEXES

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ANNEX 1.

Job description

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

SI/RUS/94/801 - 11-57

Post Title: Consultant in Air emission control and abatement in kraft pulping

Duration: 0.7 m/m (2 weeks in the field, 1 week homebased)

Date required: ASAP

Duty station: Baikalsk, Russia
homebased

Purpose of the project:

To provide independent expert advice on modifications to the processes employed at the Baikalsk Pulp and Paper Mill designed to minimize/eliminate impacts of potential emergency and continuous pollutant releases on the Baikal Ecosystem.

Duties:

The consultant, in close co-operation with the mill management, other national and international consultants, government agencies and institutions is expected to:

1rst mission: (2 weeks in the field)

a. *collect all relevant information concerning government limitations for air pollutants discharges in the Baikal Lake Ecosystem;*

b. Access the actual air pollution treatment facilities available in the mill, evaluate its effectiveness and propose measures to minimize/eliminate air emission;

c. to prepare a report setting out the findings of the mission and with recommendations of measures to minimize/eliminate air emission in the mill;

2nd mission: (homebased, 1 week)

a. evaluate the impact that the proposal(s) for modifying/reprofiling the mill to be prepared by other international experts will have in the elimination/minimization of air emissions;

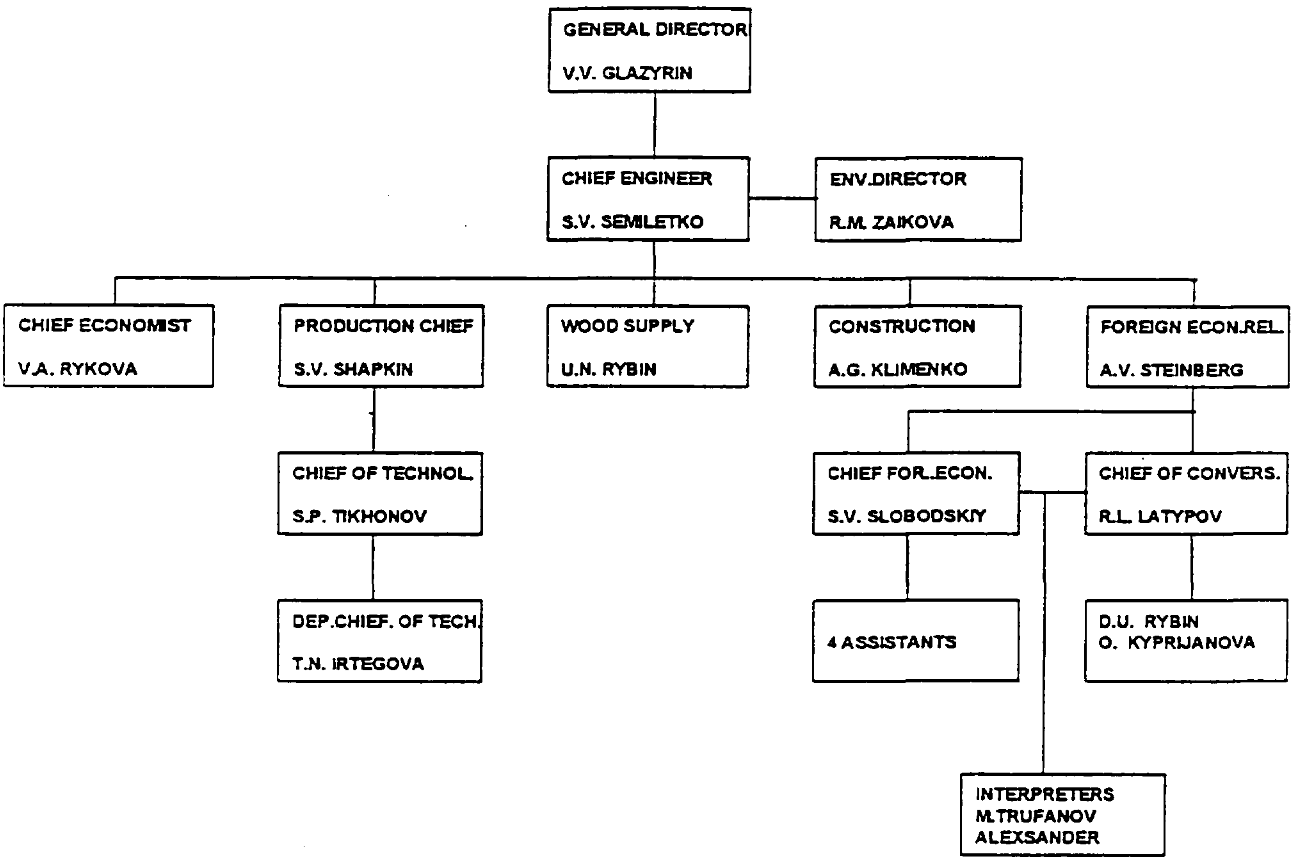
b. to prepare a report setting out the findings and with comments on the proposal (s) for modifying/reprofiling the mill and their impacts on air emissions;

ANNEX 2.

Senior counterpart staff

Glazyrin, Valeri Vasiljevich, general director
Semiletko, Sergei Vasiljevich, chief engineer
Rybin, Juri Nikolajevich, deputy manager for timber supply
Shapkin, Sergei Vladimirovich, production chief
Steinberg, Anatoli Vladimirovich, vice president, foreign economical relations
Klimenko, Anatoli Grigorjevich, deputy of director, construction

BAIKALSK PULP AND PAPER MILL
ORGANISATION



ANNEX 3.

List of people met

List of people met

Baikalsk Pulp and Paper Mill:

Baikalsk, Irkutsk Region, 665 914 Russia
Tel:+395 42 6 3 46

Glazyrin, Valeri Vasiljevich,	General Manager
Shapkin, Sergei Vladimirovich,	Production Manager
Zaikova, Raisa Matvejenna,	Deputy Chief Engineer in Environmental protection
Latipov, Rem Lufturahmanovitch	Chief of conversion division

The Centre for Hydrometeorology and Environmental Monitoring

Baikalsk, Irkutsk Region, 665914 Russia
Prombaza, BCGMS
Tel: +395 42 49 66

Mr. Anatolyi Polovinskyi,	Chief of the Centre
Ms. Ludmila Panchenko,	Chief of the Laboratory

Institute for Ecological Toxicology

Baikalsk, P.O.B. 48, Irkutsk Region, 665 914 Russia
Tel:+395 42 29 38

Dr. Albert M. Beim,	Director
Mr. Andrei Beim	Research Scientist

Territorial Committee for Environmental Protection

Baikalsk, P.O.B. 33, Irkutsk Region, 665 914 Russia
Tel:+395 42 20 39

Ms. Ludmila Innokentevna Kalashnikovna,	Deputy Chief

ANNEX 4.

Air emission permission

27.07.95.
1-6-1383

МИНПРИРОДЫ РОССИЙСКОЙ ФЕДЕРАЦИИ

Иркутский областной комитет по охране окружающей среды и природных ресурсов

664047, г. Иркутск, ул. Парковая, 16, тел. 27-49-69

Permission

РАЗРЕШЕНИЕ

for the discharge of pollutants to atmosp.

на выброс загрязняющих веществ в атмосферу

by stationary pollution sources

стационарными источниками загрязнения

BPPM

Given to

Выдано Байкальскому ЦБК

наименование предприятия, организации, ведомственная принадлежность, реквизиты

Reg. Com. for Environ. protection

Given by

Орган, выдавший разрешение Областной комитет по охране окружающей среды и природных ресурсов

его реквизиты

Valid for from to

Срок действия с 01.07.95 до 01.01.96

Регистрационный номер ОК-172/СРК Дата выдачи 19.07.95

Registr. No.

И.о.председателя комитета А.Л.Малевский

Иркутский областной комитет по охране окружающей среды и природных ресурсов

БАЙКАЛЬСКИЙ ... 5198 31 07 95

The list & number of pollutants permitted

Перечень и количество загрязняющих веществ, разрешённых к выбросу в атмосферу

for air emission

Загрязняющее вещество	TAD Лимит ВСВ Суммарный выброс Total emission т/год t/year	г/с	Норматив ПДВ MPD Суммарный выброс т/год t/year
inorganic dust ~~Пыль неорганическая~~	~~720,000~~		~~370,406~~
Пыль древесная wooden dust	0,5585		0,5585
Зола каменноугольная coal ash	I602,500		I223,725
Сернистый ангидрид SO_2	1750,000		1750.000
Сероводород H_2S	94,500		9,I50
Метилмеркаптан MM	35,026		0,I50
Диметилсульфид DMS	I9,I08		5,3765
Диметилдисульфид DMDS	7,68I5		7,68I5
~~Скипидар~~ Turpentine	23,I9I		I8,24575
Окислы азота NOx	I763,2325		585,5175
Окислы углерода COx	468,500		468,500
Аэрозоль щелочи Alk. aerosole	7,0I7		7,0I7
Двуокись хлора ClO_2	2,850		2,850
Хлор Cl	I,5425		I,5425
Фенолы Phenols	0,I885		0,I885
Метанол Methanol	0,00045		0,00045
Пятиокись ванадия V_2O_5	0,256I5		0,256I5
Бенз(а)пирен benz(a)pyrene	0,00II68		0,00II68

По каждому источнику в отдельности величины выбросов загрязняющих веществ в атмосферу зафиксированы в книге в приложении, которая составляет неотъемлемую часть настоящего разрешения.

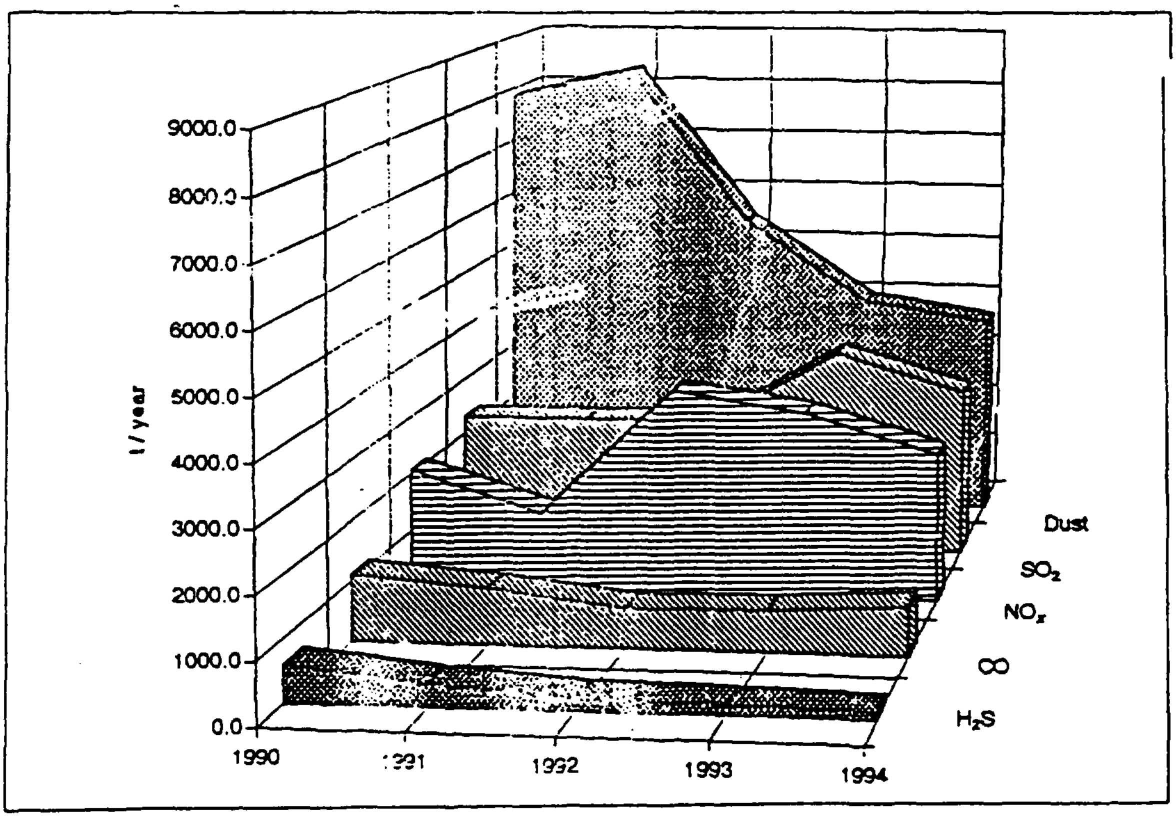
Начальник отдела нормирования   *[signature: Гальцева]*   И.Н.Гальцева

ANNEX 5.

Air emission statistics 1990-1994

Harmful substances discharges into atmosphere from stationary sources of the BPPM

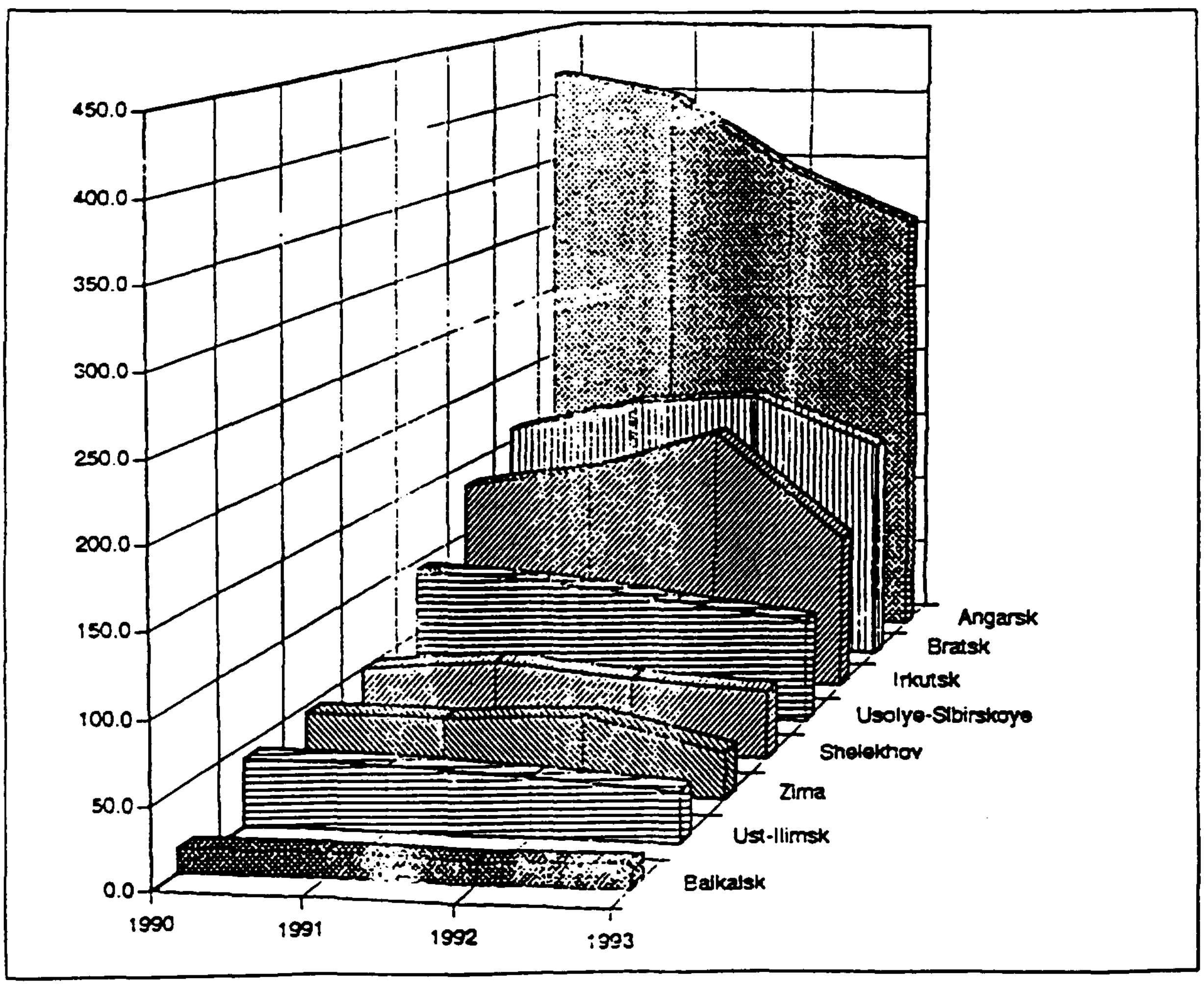
INGREDIENTS	FACTUAL DISCHARGES *(t./year)*				
	1990	1991	1992	1993	1994
H_2S	592.2	359.6	199.8	157.5	110.2
CO	1109.0	937.1	664.7	694.7	811.5
NO_x	2061.6	1355.9	3556.4	3220.0	2551.0
SO_2	2300.7	2305.6	2304.7	3623.0	2960.3
Dust	7857.0	8360.5	5497.0	4005.0	3660.8



The dynamics of the summary harmful substances discharges into atmosphere from stationary sources situated around Lake Baikal

(thousand t. / year)

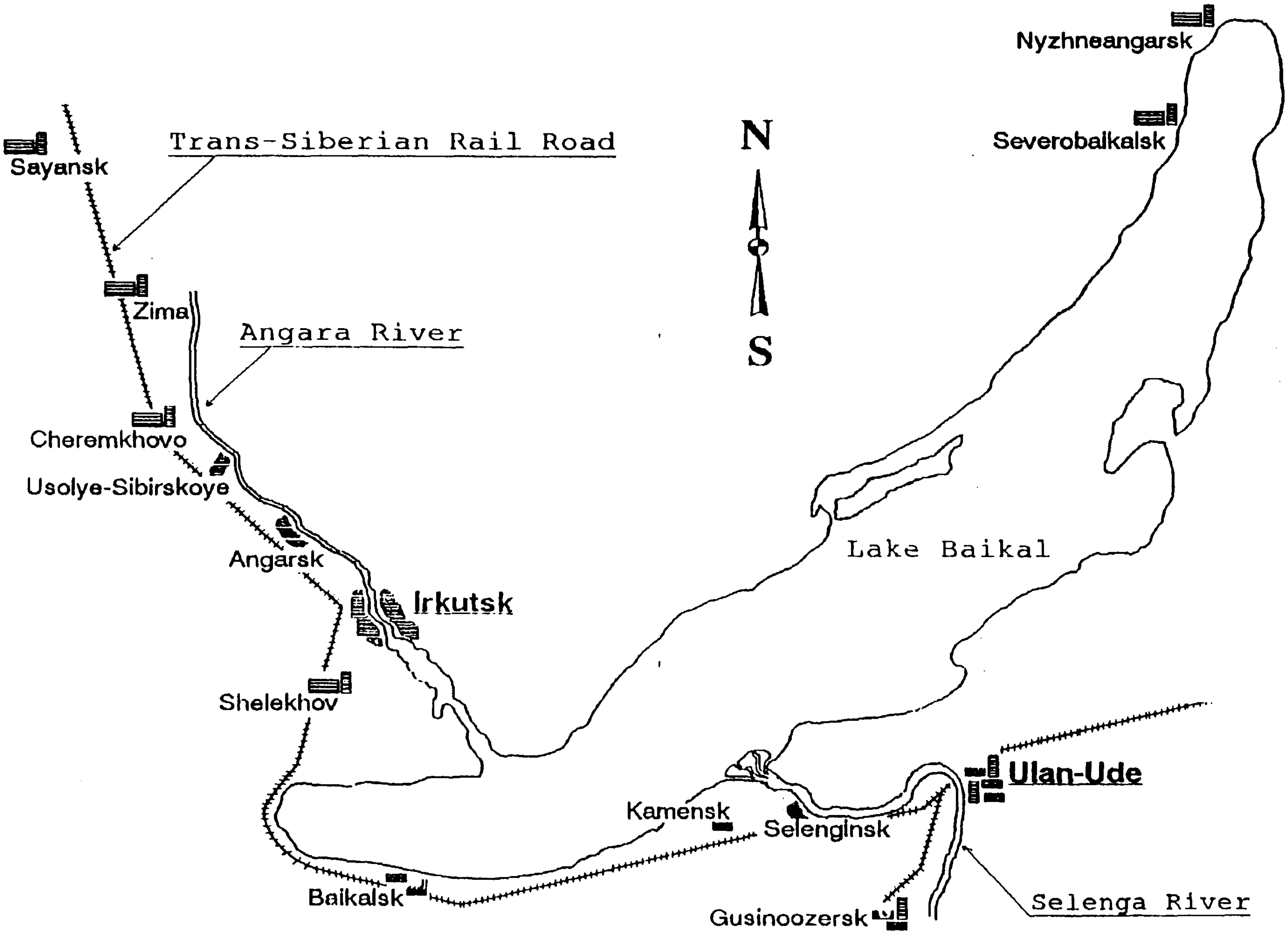
CITY	SUMMARY DISCHARGES *(th. t/year)*			
	1990	1991	1992	1993
Baikalsk	14.9	15.2	13.5	15.3
Ust-Ilimsk	42.1	40.5	36.6	30.9
Zima	45.4	44.5	49.7	29.4
Shelekhov	49.3	57.4	49.0	43.8
Usolye-Sibirskoye	93.9	88.8	77.9	67.5
Irkutsk	134.3	148.9	177.6	104.3
Bratsk	157.9	180.0	187.5	153.8
Angarsk	414.9	399.2	345.3	306.9

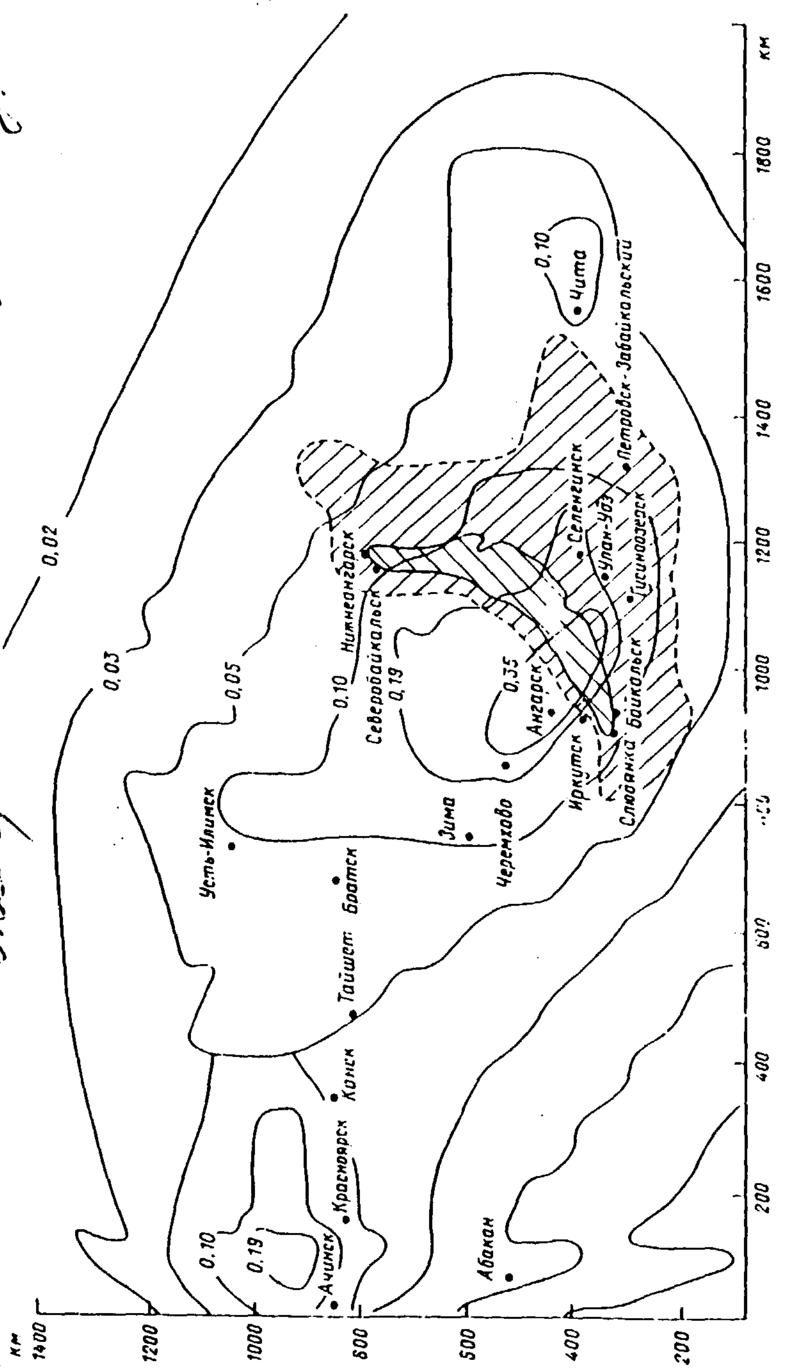


ANNEX 6.

Air emissions on Baikal Lake area

... stationary sources of air emissions
situated around Lake Baikal





Выпадение серы от выбросов промышленных предприятий 24 городов, г/(м²·год).
Заштрихована водосборная площадь оз. Байкал.

Суммарные выпадения серы и азота на акваторию оз. Байкал и на водосборную площадь и вклад от различных городов

Источник выбросов	Сера		Азот	
	на акваторию Байкала	на водосборную площадь	на акваторию Байкала	на водосборную площадь
Суммарный выброс 21 городов, тыс. т/год	4,3	23,3	0,42	2,3
В том числе, %				
Ангарск, Черемхово, Шелехово, Усолье-Сибирское	63	56	57	54
Иркутск	10	11	11	12
Байкальск	2	1,5	3	2
Слюдянка, Северобайкальск, Нижнеангарск	1	1	1	1
Селенгинск	2	1,5	2	1
Улан-Удэ, Петровск-Забайкальский	6	11	4	9
Гусиноозерск	4	10	7	13
Красноярск, Назарово	2	3	2	3
Ачинск, Канск, Братск, Свирск, Чита, Тайшет, Кяхта, Зима	10	5	13	5
КАТЭК (проект), тыс. т/год	1,1	9,7	0,39	2,8

ний дает Ангарско-Черемховский бассейн (63 % по сере и 57 % по азоту). За ним следуют Иркутск и Улан-Удэ, причем Улан-Удэ, Петровск-Забайкальский и Гусиноозерск в силу преобладания западных ветров вносят больший вклад загрязнения в поверхность водосбора, а не на озеро.

Соотношения по азоту примерно аналогичные.

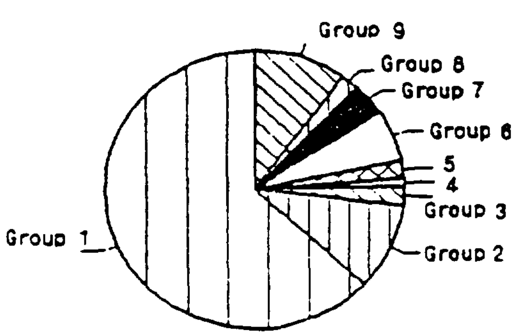
Выпадения от г. Назарово совместно с г. Красноярском составляют 2 % на Байкал и 2,8 % на водосбор. Введение в строй Березовской ГРЭС-1 увеличит выпадения серы и азота в 2,7 раза. Осуществление полной программы КАТЭКа, планируемой ранее (8 Березовских ГРЭС) привело бы к выпадениям азота на оз. Байкал, сравнимым с выпадениями от всех ближних городов, и выпадением серы, составляющим 30 % от них.

В заключение надо отметить, что полученные результаты носят оценочный характер. Подлежат уточнению расчеты выпадений от источников, находящихся в непосредственной близости от оз. Байкал, поскольку применение моделей дальнего переноса для них вносит большие погрешности в ближней зоне. Необходимо также оценить влияние рельефа на перенос и выпадения примеси в районе Байкала.

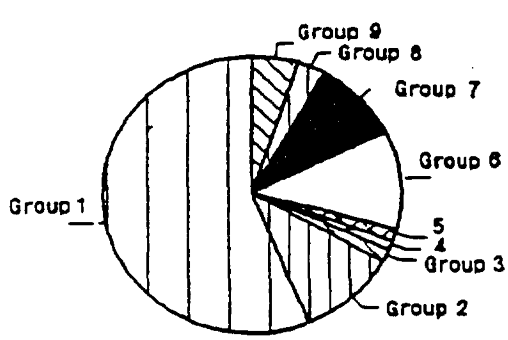
Summary fall of sulfur and nitrogen on the aquatory of Lake Baikal and its water catchment area and contribution of various cities

Group	EMISSION SOURCE	SULPHUR Fall on Lake Baikal aquatory	SULPHUR Fall on water catchment area	NITROGEN Fall on Lake Baikal aquatory	NITROGEN Fall on water catchment area
	Total emission of 24 cities (thous. t. / year)	4.3	23.3	0.42	2.3
Group	Including, %				
1	Angarsk, Cheremkhovo	63.0	56.0	57.0	54.0
2	Shelekhov, Usolye - Sibirskoye, Irkutsk	10.0	11.0	11.0	12.0
3	Baikalsk	2.0	1.5	3.0	2.0
4	Sludyanka, Severobaikalsk, Nyzhneangarsk	1.0	1.0	1.0	1.0
5	Selenginsk	2.0	1.5	2.0	1.0
6	Ulan-Ude, Petrovsk - Zabaikalsky	6.0	11.0	4.0	9.0
7	Gusinoozersk	4.0	10.0	7.0	13.0
8	Krasnoyarsk, Nazarovo	2.0	3.0	2.0	3.0
9	Achinsk, Kansk, Chita Bratsk, Svirsk, Zima, Kyakhta, Taishet	10.0	5.0	13.0	5.0
	KAHEC (project) (thous. t. / year)	1.4	9.7	0.39	2.8

SULFUR fall
on Lake Baikal aquatory



SULFUR fall
on water catchment area



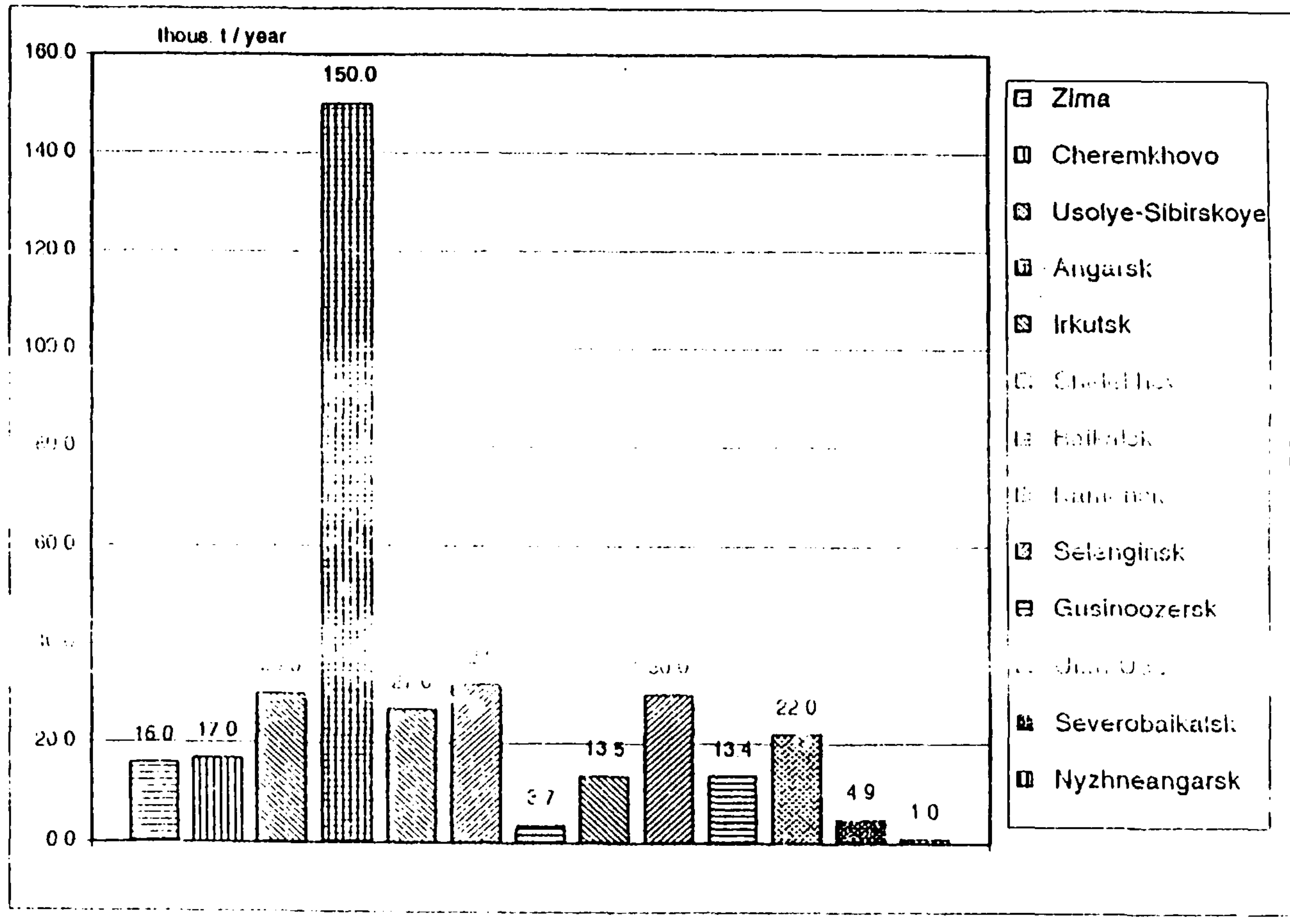
Prepared by Institute of Ecological Toxicology
RUSSIA

08-08-1995

stationary sources situated around Lake Baikal

DUST (thousand t./year)

City	Dust *(thous.t/year)*
Zima	16.0
Cheremkhovo	17.0
Usolye-Sibirskoye	30.0
Angarsk	150.0
Irkutsk	27.0
Shelekhov	32.0
Baikalsk	3.7
Kamensk	13.5
Selenginsk	30.0
Gusinoozersk	13.4
Ulan-Ude	22.0
Severobaikalsk	4.9
Nyzhneangarsk	1.0



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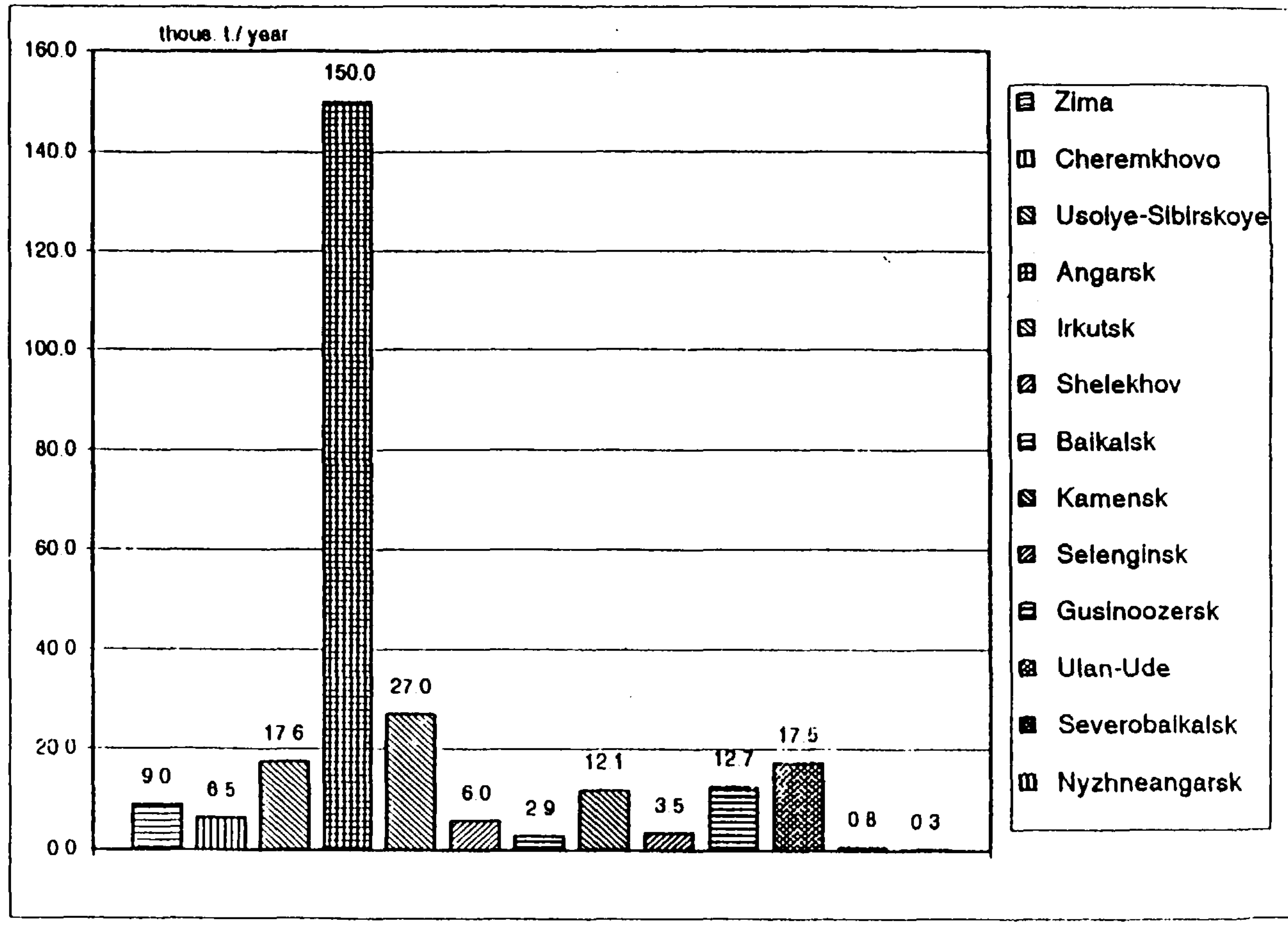
Harmful substances discharges into atmosphere from automobile transport and stationary sources situated around Lake Baikal

SO_2 (thousand t./year)

City	SO_2 *(thous.t/year)*
Zima	9.0
Cheremkhovo	6.5
Usolye-Sibirskoye	17.6
Angarsk	150.0
Irkutsk	27.0
Shelekhov	6.0
Baikalsk	2.9
Kamensk	12.1
Selenginsk	3.5
Gusinoozersk	12.7
Ulan-Ude	17.5
Severobaikalsk	0.8
Nyzhneangarsk	0.3



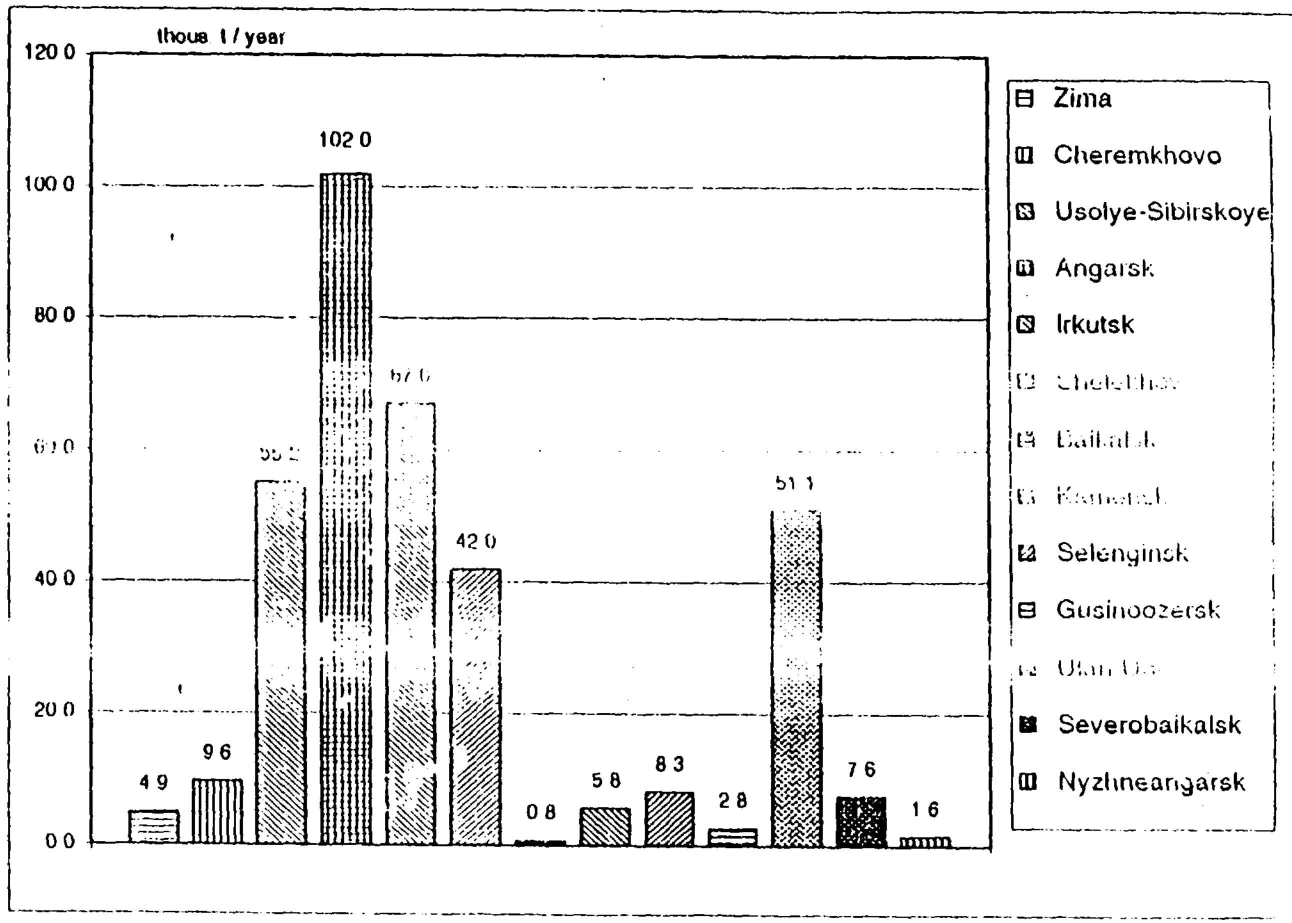
Prepared by Institute of Ecological Toxicology
RUSSIA

07-08-1995

... atmosphere from automobile transport and stationary sources situated around Lake Baikal

CO (thousand t. /year)

City	CO (thous.t /year)
Zima	4.9
Cheremkhovo	9.6
Usolye-Sibirskoye	55.2
Angarsk	102.0
Irkutsk	67.0
Shelekhov	42.0
Baikalsk	0.8
Kamensk	5.8
Selenginsk	8.3
Gusinoozersk	2.8
Ulan-Ude	51.1
Severobaikalsk	7.6
Nyzhneangarsk	1.6



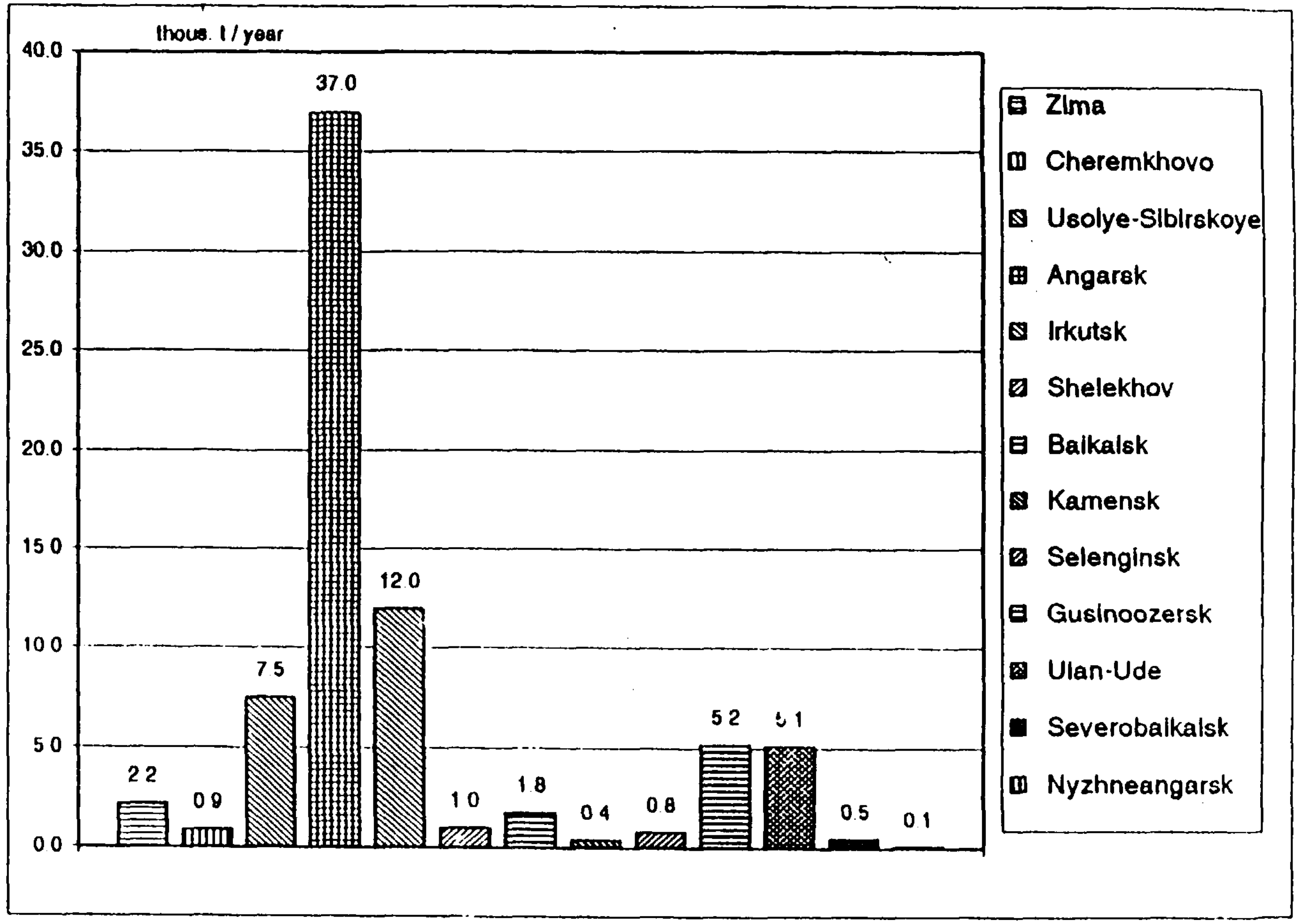
Prepared by the Institute of Ecological Toxicology
RUSSIA

09-08-1995

ıarmful substances discharges into atmosphere from automobile transport and stationary sources situated around Lake Baikal

NO_x (thousand t./year)

City	NO_x (thous.t/year)
Zima	2.2
Cheremkhovo	0.9
Usolye-Sibirskoye	7.5
Angarsk	37.0
Irkutsk	12.0
Shelekhov	1.0
Baikalsk	1.8
Kamensk	0.4
Selenginsk	0.8
Gusinoozersk	5.2
Ulan-Ude	5.1
Severobaikalsk	0.5
Nyzhneangarsk	0.1



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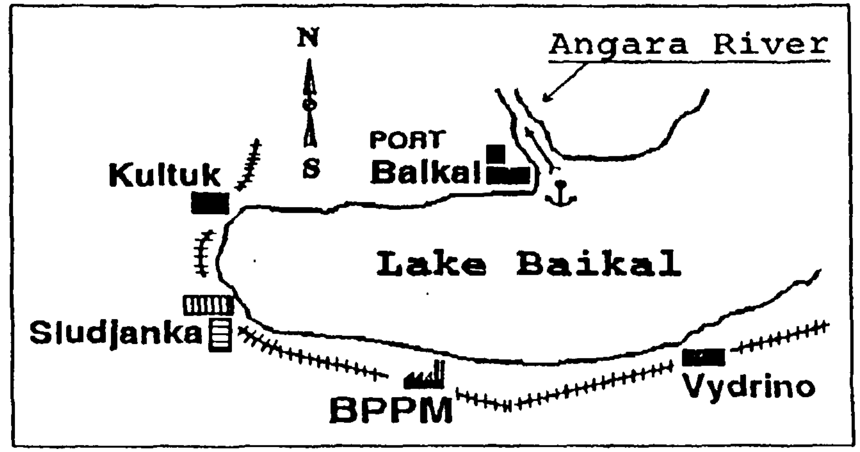
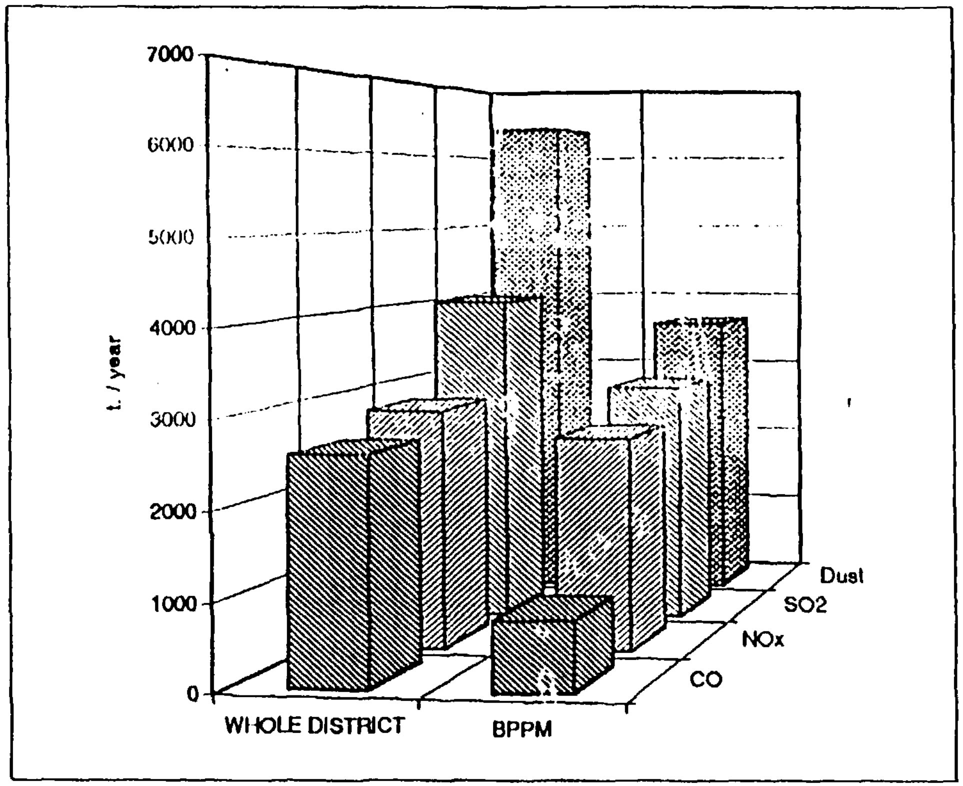
Prepared by Institute of Ecological Toxicology
RUSSIA

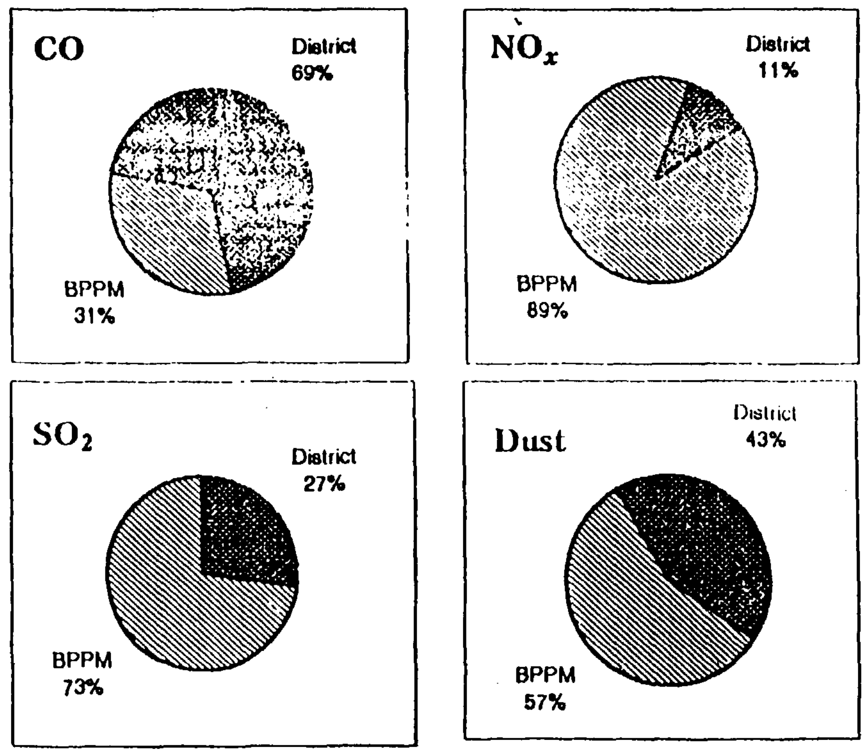
07-08-1995

... in 1994 A.D. (t./year)

INGREDIENTS	FACT. DISCHARGES *(t./year)*	
	WHOLE DISTRICT	BPPM
CO	2598.334	811.501
NO_x	2863.58	2551.417
SO_2	4066.196	2960.236
Dust	6392.795	3660.779
SOURCES NUMBER	*391*	*104*







Prepared by the Institute of Ecological Toxicology
RUSSIA

10-08-1995

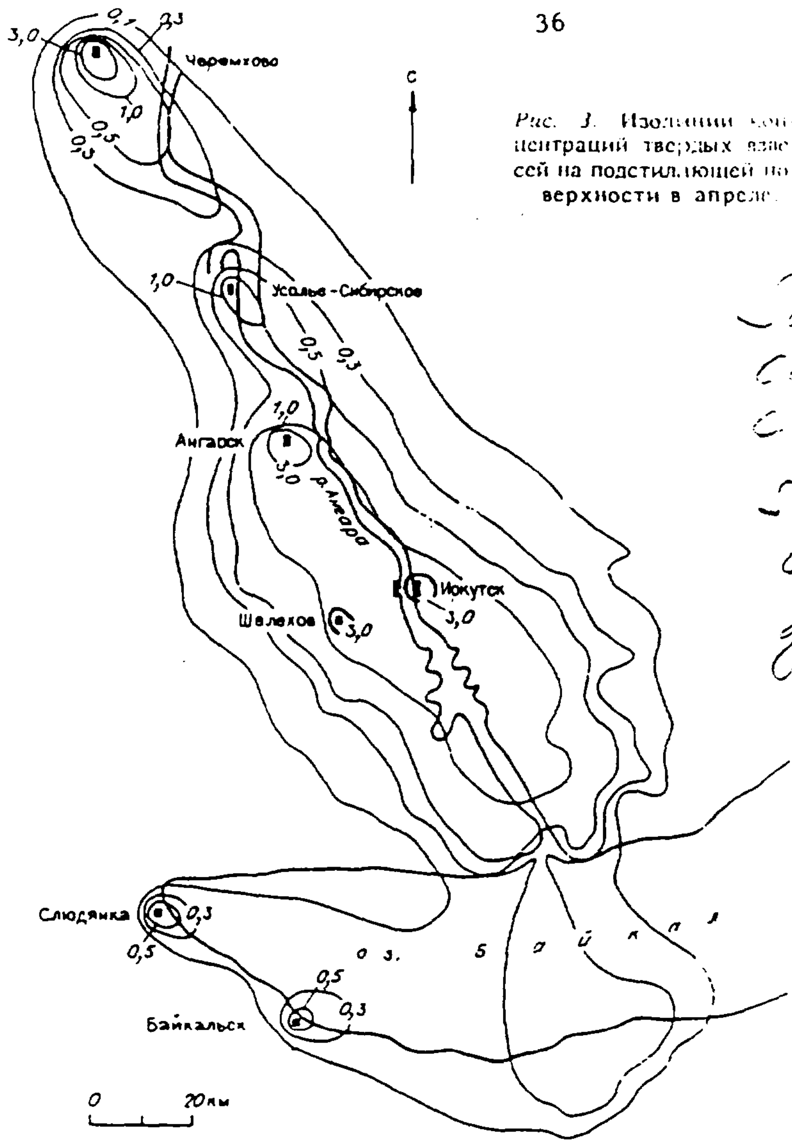


Рис. 3. Изолинии концентраций твердых взвесей на подстилающей поверхности в апреле.

Sulfur dioxide concentration = curve, mg/m³
Southern part of Baical Lake
ground level

ве, Усолье-Сибирском и Черемхове 25 км². Открытая поверхность Байкала загрязняется в основном предприятиями Слюдянки и Байкальска.

Следует отметить, что в качестве входной информации в расчетах использованы только данные о выбросах промышленных приподнятых источников. Пыление отвалов ТЭЦ и горно-рудных предприятий, выбросы жилищно-бытовых объектов и транспорта в данных расчетах не учтены.

Эксперимент 2. Задается характерное для северо-западного типа на Байкале ветровое поле по классификации [3], причем для лучшей аппроксимации ветра рассматриваются дополнительные пункты наблюдений (см. таблицу).

Поток твердых взвешенных частиц, подхваченный направленным северо-западным переносом, по долине Ангары устремляется в сторону Байкала (рис. 3, 4). Вблизи промышленных центров запыленность уменьшается по сравнению с результатами расчетов эксперимента 1. Площади превышения значений максимальных разовых ПДК в Ангарске и Черемхове 25 км².

ANNEX 7.

Process descriptions and emission sources

TECHNICAL REPORT # 1070

Identification of dust and gas emissions into the air from technological units at Baikalsk P.P.M.

1. Introduction.

Works on indentification of dust-gas emissions into the air from technological equipment of Baikalsk P.P.M. were made on the basis of Agreement # 26-50 dd on Nov.10.1889 since Jan. up to Dec. 1990.

The inspection of emissions was made from the equipment of cooking-washing plant, vaporation plant, bleaching plant, drying plant, lime caustisation & recovery plant, by-products plant, bleaching chemicals plant, sediment treatment plant, mechanical-repairing plant, sewage water treatment plant, Heat & Power plant.

Pulp cooking is realised by two stages. At the first stage (redhydraulisys) acute steam (t = 200 Celcium degrees) is loaded into the digester (#4) charged by chips (Fig.1). During the process of hydraulisys in the digester are formed fumes of: turpentne, methyl alcohol, volatile organic substances, and also steam and air, resting after the digester loading. The presence of gasforming products creates surplus pressure in the digester, so reaching 100 Celcium degrees a turpentine blowing is made. The blowing is made continiously up to the end of hydraulisys. Blowing gases are moved to alkali separator (5), the gass coming through filters are moved for cooling into heat exchangers (6).

Water-turpentine emulsion (gases condensated in heat exchangers) are moved to turpentine section, non-condensated gases are emmitted ino the air. At the end of cooking (3 - 3,5 hours later) pulp mass is blowed out from the digester. For heat saving, emitted as blowing steam is used a Rosenblad system unit.
Blowing steams coming throug "Gethner" trap unit are moved into jet condensator (9), where cooled water is fed, which forms condensate while mixing with blowing steam. Non-condensated steams and air are removed from tank-accumulator into the air. There is a steam removing line moving gases to gas-washing tower.

2.2 Technological emission sources of bleaching plant. (Fig.3;4)

Main technological process of pulp bleaching is taking place in tower of continious action of "Kamur" system. Pulp washing after each bleaching stage is made in "Rauma-Repola" vacuum-filters. Screened, washed and diluted in vacuum-filter "A" pulp is moved into fiber storage tower Б-1, where fresh water is added. From the tower pulp comes inyo mixer IB, where it is mixed with chlorine, and then it is moved to chlorination tower, after which pulp is washed in vacuum-filter I and moved to the second bleaching stage. Caustic is moved into vacuum-filter screw. After that pulp is moved into tank 1Б through the mixer 2B, washed in vacuum-filter 2 and moved to the third (sodium hypochlorite) bleaching stage. The fourth (hot alkalinity) bleaching is started at vacuum-filter 4a screw. Pulp washed in mixer 4B comes to vacuum-filter 5, where starts the fifth (chlorine dioxide treatment) beaching stage.Sodium hypochlotite is added to the pulp washed in vaccum filter (6). To nuetralize the balance chlorine, extract mineral dashes and stabilize brightness is made the final bleaching stage in vacuum-filter 7 (oxidizing by sulphur dioxide). Vacuum-filters are covered by caps. Steam-gas mixture from the caps is pumped out by fans and discharged into the air.

The works goals: numerical identification of harmful substances, emmitted into the air fromm technological equipment and ventilation systems of the mill.

The staff of inspection team:
N. Antooshev - I category engineer;
A. Shmelev - II category engineer;
I. Radaeva - II category engineer;
N. Korikova - engineer;
M. Gryaznova - lab. assistant;
A. Antoosheva - technician.

The given report gives data for 1990.

2. Brief technical characteristics of production line.

The main product manufactured by Baikalsk P.P.M. is cord sulphate pulp, meeting TY-81-04-468-76, on the first technological line, and sulphate viscose pulp, meeting TY 81-04-346-75, on the second technological line. Production capacity of Baikalsk P.P.M. are designed to produce 280 000 tons of pulp annually.
Besides the main product - pulp, the mill fabricates tall oil, raw turpentine, wrapping paper.

2.1. Technological emission sources of cooking-washing plant.(Fig.1;2)

Pulp cooking is made with the help of sulphate method from soft & hard wood species in 24 stationary digesters of periodic action with volume of 140 c.m. each.
The process of sulphate pulp cookingis followed by forming of considerable amounts of sulphur composotions, such as sulphur hydrogen, methylmercaptane, dymethylsulphyde, dymethyldisulphide and also methanol, turpentine and other compositions.
The presence of bad-ordour compositions in steam-gas emissions of cooking plant is determined by the presence of sodium sulphyde in cooking liquor and methoxyl groups in wood.The formation of sulphur content compositions is influenced by the followingtechnological paprameters of the cooking procerss: sulphidity of the cooking liquor, concentration of active alkali, temperature and time of cooking, wood specie.

2.1.1.Cooking plant.

2.3. Technological emission sources of bleching chemicals plant.

2.3.1. Chlorine dioxide preparation (Fig.5;6).

The plant is fabricating liquid chlorine dioxide. with the help of Matisson method. Plant capacity - 1600 t/y.
The main reaction of chlorine dioxide obtaining is taking place in reactor #2, where sulphiric acid and 50% solution of sodium chlorate is fed continiously. To the lower part of reactor 2 is fed sulphur dioxide diluted by air, which coming up is reacting with sodium chlorate forming chlorine dioxide. $2NaClO_3 + SO_3 - 2ClO_3 + Na_2SO_4$.
The mixture of chlorine and chlorine dioxide coming out from the upper part of the reactor is moved into absorbation tower 3, filled by Rushig coils. In absorbation towers chlorine dioxide is diluted in the water and moved into storage tanks. Gases not absorbed in the towers are discharged by fans into the air.

2.4. Technological emission sources of lime caustisation and recovery plant. (Fig. 7;8)

At lime caustisation and recovery plant white liquor preparation and sludge recovery is taking place. White liquor preparation is made by continiouse method. Plant capacity - 340 c.m./day of white liquor with concentration 110 g/l of active Na_2O. As a result of sodium carbonate caustisation reaction 80-90% of green liquor transits into calcium hydro oxigen and turns into calcium carbonate (lime sludge). This process is taking place in slake-classificators 2, where white liquor and lime is moved. The obtained suspension is decolored in devices of sedimentation type 4. Decolored liquid (white liquor) is moved into storage tanks 12, and sediment (lime sludge), passing through additional caustisators 5, it is washed in washer 6, condensed in vacuum-filters up to 60 % and moved into rotating lime regeneration kilns. To resore losses of lime crashed lime stone is added into kiln. As a result of lime sludge and stone burning at temperature 1100 - 1200 Celcium degrees lime is formed, which is moved for green liquor caustisation.

2.5. Tall oil production. (Fig. 9;10)

Sulphate soap, coming from tank facilities of vaporation plant, after precipitation in tanks 1;2, is pumped into reactor 4, where sulphuric acid at concentration 30 - 40% and water is added. After heating precipitation

part of liquid is pumped out,saulphate soap is added and starts the main cooking, steam feeding is increased.
Formed tall oil is moved into dryers 5, where drying is taking place with the help of steam, and reactionary bad-odour gases, containing sulphur hydrate and methylmercaptain, coming through rotorclone,sprinkled by weak white liquor, are discharged by fan into the air. Harmful gases annual emmision into the air is calculatedfor equipment operation during 345 days. Ventilation from pos. 1;2;3;5 - natural type.

2.6. Technological emission sources of mechanical-repairing plant. (Fig.11;12)

Air polluting sources at mechanical-repairing plant are electric arc hating furnaces, press for plastic masses, lumber and grinding devices.Metal melting is taking place in electric arc furnace, in heating furnace metal articles are heated up to necessary temperature for further hardening or tempering. The furnaces are covered by caps. Dust-gas mixture is emmitted into the air by fans. For welding works a special, site is made, gas pumping out is made by fans.
Wooden and metal dust removing from lumber and grinding devices is made by fan. For air treatment are installed cyclones 5;6.

2.7. Technological emission sources of drying plant. (F. 13;14).

Bleached and washed stock is moved onto mesh part of paper machine, where pulp linen is formed, which after pressing comes for drying. During the drying process great amount of water is vaporated, which is necessary to be removed from caps of drying cylinders. Air exchange is made with the help of air-intake fan unit with utilization of heat of the outgoing air. Moisture saturated air is emmitted into the air.

2.8. Technological emission sources of vaporation plant.(Fig.15;16)

At vaporation plant black liquor is vaporated at for six-body vacuum-vaporation station I -VI. Capacity of each station at vaporated water is 100 t/h. To the body I heating steam is moved. Vaporation in the following bodies is made on account of recycling steam heat. At body VI vacuum is kept 530 mm mercury post on account of clean steam condensation in barometric condensator 15 and sucking out non-condenced gases by vacuum pump. Condensate from body V and VI is purified from sulphur content compositions at dezodoration unit 11, to the lower part of which condensate (up to 400 c.m./h) and air (up to 2000 c.m./h) is moved . Gas-steam mixture, formed in the unit is emitted into the air. Gas-steam mixture from the pit of bad odour gases is discharged into the air. Gas-steam mixture from tank facilities also is discharged into the air.

2.9. Heat & Power Plant technological emissions (Fig. 17; 18).

The main emission sources of HPP are soda recovery boilers; bark boilers, power boilers, melted soda tank collectors. At soda recovery section takes place burning of condenced black liquor, coming from vaporation plant.

Mineral part in the form of melted soda comes from the melted soda tank collector 2, where weak white liquor is added for melted sode dilution.

After boilers smoke gases are treated in electric filters 4 (dust (sulphate) removing), and then by smoke sucker 13 they are moved to the second treatment stage - deezodoration-smoke unit 5, at which additional teatment of smoked gase from dust, sulphur conent compositions - sulphur hydrate, sulphureous gas, methylmercaptane takes place.

Traetment in DDU is made with the help of caustic solution, coming from bleaching chemicals plant.

Steam-gas emissions from melted soda tank-collectors passing through heat exchangers are discharged into the air.

In heavy fuel - bark boilers 7 bark is burnt. Smoke gases are treated in scrubber MC-BTU 8.Water is used as sprinkling liquid. After scrubber treated gases are discharged by smoke sicker 13 to the pipe 9 . Power boilers are designed for coal burning for steam obtaining, used for technological needs and elctric power production. Smoke gases after the boilers are treated in electric filters 11(dust removing), and discharged by smoke sucker 13 into smoke pipe 12.

2.10. Technological emission sources of sewage water treatment plant. (Fig.19)

Sewage water treatment plant was deisigned for treating industrial waste waters and sewage waters. After biological and chemical treatment in sedimentation ponds waste waters are discharged into lake Baikal. Design capacity of the plant is 269000 c.m.

Biological and chemical treatment.

Waste waters are moved to the mixer-nuetralizer 1, in case of necessaty - to alarm discharge pond, where waste water neutralizationis made with the help of sulphuric acid up to pH 6,5 - 7,5; after this it comes to average- preaerator, where waste water averaging and gas blowing (

sulphur hydrate methylmercaptane dymethylsulphide) takes place. From the averager through the distribution channel waste waters are duistributed in four channel aerotanks 5, where air is added. Coming through all channels, water comes to the channel of silt mixture, and then to sedimentation pools 8. After sedimentation silt is moved to the reservour of active silt.
Biologically treated waste water after sedimentation ponds 8 is moved into mixer 9, where aluminium sulphide and polyakriamide is added and through distribution chamber 10 is distributed among sedimetation ponds. Formed sediment from sedimentation chamber is moved into sediment treatment plant.

2.11.Technological emission sources of sediment treatment plant. (Fig.20;21)

At sediment treatment plantis made sediment extraction and dewatering with further partial transporting out or burning. The plant consists of head flotation section, dewatering section, drying and burning section.
The initial raw for flotation is sludge lignin coming from chemical treatment sedimentation ponds.The dewatering process by the method of head flotation is concluded in extra pressure air charging of sludge lignin.The air balls flotate the particles of sludge lignin to the water surface, at which a foam layer is formed. To increase dewatering efficiency flocullants-polyacriamide is used with the help of which small particles of sediment are enlarged. The final product of head flotation is flotosludge, which is moved into section of mechanical dewatering on centrifuges. The final product of this section is dewatered flotosludge coming for drying and burning to fluidised bed furnaces and filter.
The main emission source is fluidised bed furnaces for sediment burning.]

3. Preparation works.

During preparation works technological process and documentation was studied, determined the points of samples taking, connecting pipes for sample taking and gas streams measuring were joined.
Dust content in gas was determined according to isokinthic method of inner filtration with allonges using 2.
Flow speed measuring was made on methodics, based on taling spped areas by pneumatic pipe type НИИОГАЗ (NIIOGAS), measured dynamic gas pressure, propotional to to square of thie speed. The amount of dynamic pressure was measured by micri manometer type MMH-240/1/.
Sulphur ahnydride content was determined by photocoloric method with phucsin phormaldehyde reactive agent /3/.

Sulphur hydrate was determined by the method of potenciometric titration /3/.
Methylmercaptane, dymethilsulphide, dymethildisulphide, was measured by the method of chromotography analysis /7/.
Turpentine was determined by the method of gas chromotography /1/.
Chlorine dioxide was determined by titrometric method, based on interaction of chlorine with potassium iodide.
Chlorine was determined by photocolometric method by iodine-starch reaction /1/.
Nitrogen oxides were determined by the method, based on interaction of nitrit-ione and p-aminobensosulphuric acid /1/.
Corbon oxide concentration was determined with the help of device ГХ-4.
Alkaline aerozoles were determined by the method based on acid-alkaline indicators capability to change color depending on pH medium /5/.
Phenol was determined by photometric method with 4-aminoantipirin /6/.
During the works were used the following devices and instruments:
- pnuemometric & dust-intake pipes
- micromanometer, type MMH-240
- U-shape druaght-pressure meters
- manual anemometers, wing type & cup type
- fir aspirator AM-3 &electric aspirator
- timer
- portable universal gas analyser, type УГ-2
- photoelectrocolormeter ФЭК-M
- pH-meter, millivoltmeter
- laboratoriy balance
- sample taking of gas-dust emissions was made with the help of electric aspirator, water aspirator, air ejectors
- ГХ-4.

4. Production line inspection

The results of determination of harmful substances emission into the air from technological units of Biakalsk P.P.M. are given in Table 1 - 3. Foe each emission source were made from five up to ten measurings with two-three parallel samples at each mesuring. From obtained results were chosen the minimum an maximum values, and then the average value was calculated.
The amount of emissions per year was calculated taking into consideration actual operational time of equipment.

The working time fund for heating and electric arc furnaces, plastic casting presses, welding sites, cyclones and grinding devices in Mechanical - Repairing Plant is 4 hoyrs/day (345 day a yaer). for reactors of sulphste soap destructuring plant - 3 - 6 hours a day (345 days a year), for soda recovery, power, bark boilers od Heat & Power Plant - 24 hours a day (300 days a year). The rest inspected effluent sources are calculatedcoming from the length of equipment operation as 3435 days ayear, 24 hours a day.
Newly formed emission sources are numbered from No. 400.
Lime recovery kiln: annual emission calculated from actual operation time - 7504 h/y.
Emission determination from technological units of sewage water tyreatmenmt plant was made by methodics, designed by УФНИИ-hygene /15/. The wind speed was determined by slow moving of wing anemometer on the whole square of the conventional cross-cut (at the outflow from the pond).
Air consumtion, coming under the pond is determined by formula
alpha = 3600 x V_I x S_I ,
where V_I - wind speed, m/sec,
S_I - conventional cross cut, sq.m.

For the heigth of conventional cross cut was teken the level, at which harmful substances concentration is equial the concentration of background pollution.
While determining the conventional cross cut for mixer-neutralizer, distribution channels and sedimentation ponds, coming out from wind rose, was taking their length, and for other water ponds - their width.

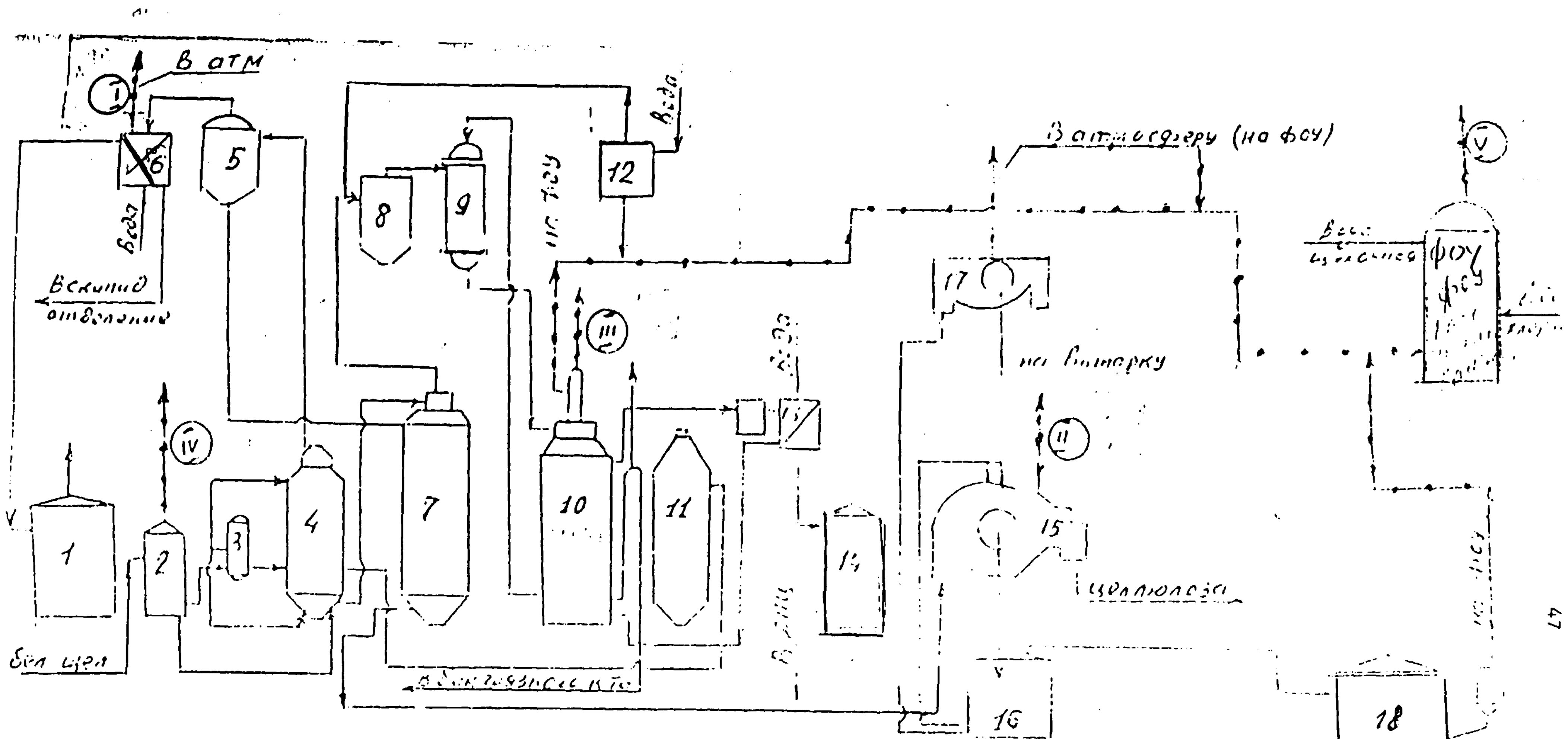


Fig.1. Cooking - Was .ing Plant

1 - Warm water tank 2 - White liquor measuring unit 3 - Calorisator 4 - Digester 5 - Liquor separator 6 - Blowing gases heat exchanger
7 - Blowing reservour 8 - Getner trap 9 - Jet condeser 10 - Accumulation tank 11 - Hydraulisate tank 12 - Mixing deck condenser
13 - Heat exchanger 14. Hot water tank 15 - Black liquor filter 16 - Weak black liquor tank 17 - Weak black liquor filter 18 - Foam collecting tank
ФОУ - gas washing tower I - Emission sources No.90; II - No.122, 134; III - # 153, 157; IV -# 401 V - # 135, 136;

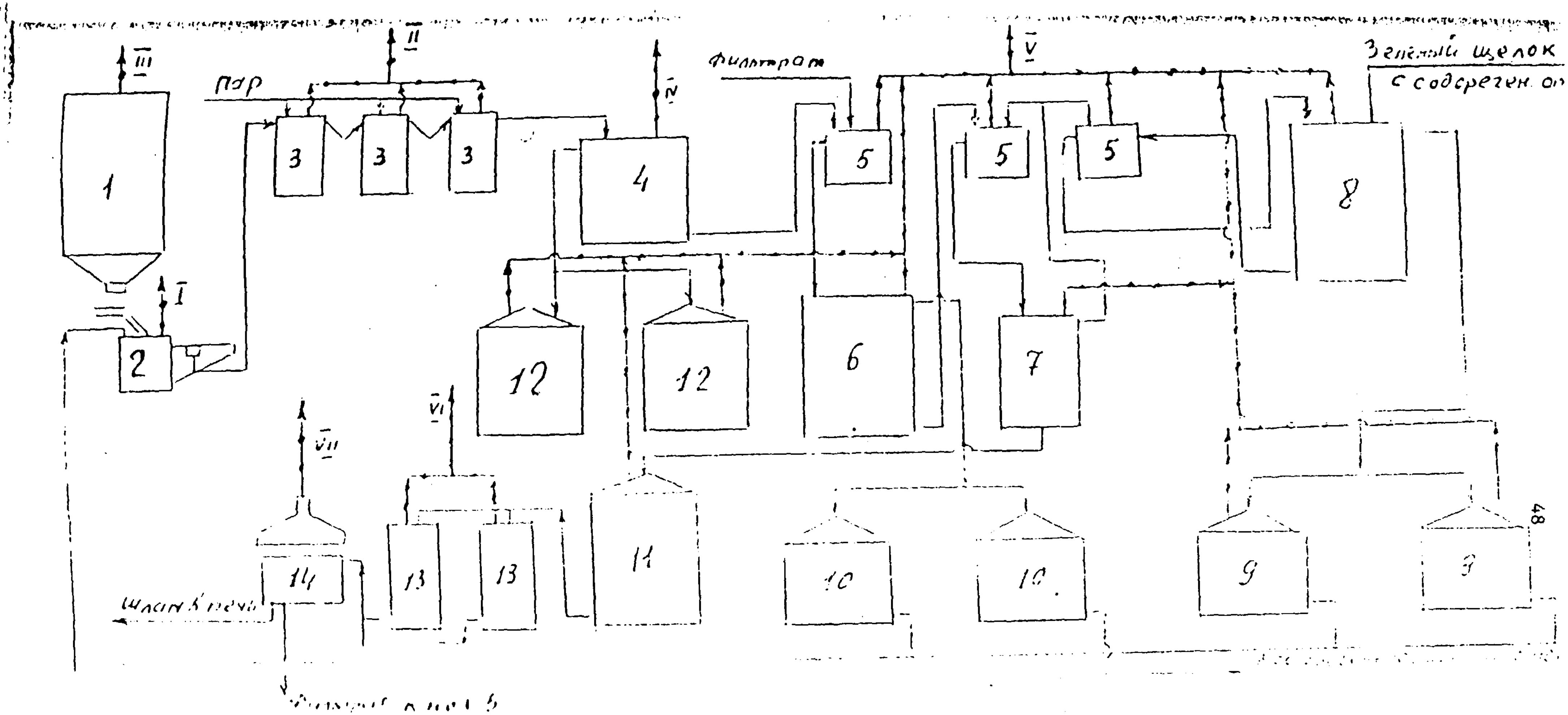


Fig.7. Lime caustisation & recovery scheme .

1 - Lime bunker 2- Classificator - slaker 3 - caustisators 4 - four chamber white liquor decolorizator 5 - additional caustisators
6 - White liquor sludge washer (1st stage) 7 - Washer-condenser (2nd stage) 8 - green liquor decolorizator 9 - green liquor storage tanks
10 - white weak liquor tanks 11- intermidiate tank 12- white strong liquor storage tanks 13 - Sludge storage tanks 14 - vacuum filter
I - Emission source into the air #.80, 83, 85, 86.12, 313, II - #322 III - #103, IV - #70, 4 V - #67 VI - #65 VII - # 53, 409

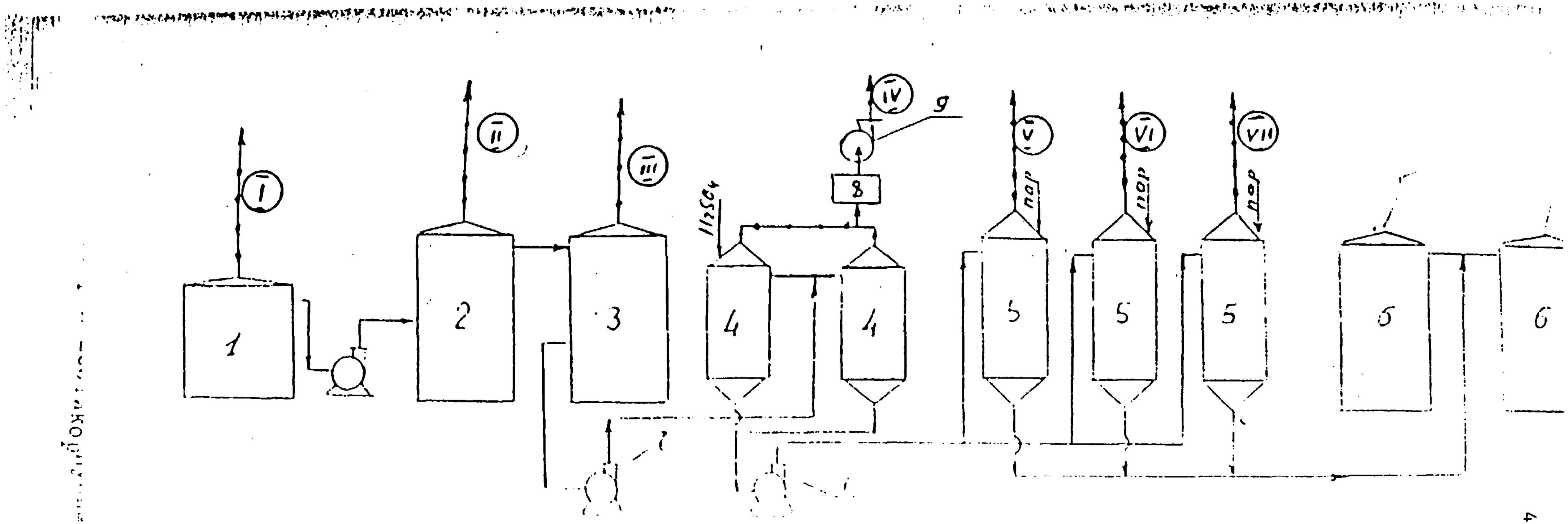


Fig.9. Tall oil production principle technologica, scheme.

1 - receiving tank 2 - Sedimentation tank 3 - Raw soap dosator 4 - reactor 5 - Tall oil washing & drying unit 6 - Tall oil storge tank 7 - Pump
8 - Rotoclone 9 -Fan I - Emission source into the air #.413, II - #414 III - # 415 IV - # 213 V - # 410 VI - # 411 VII - #412

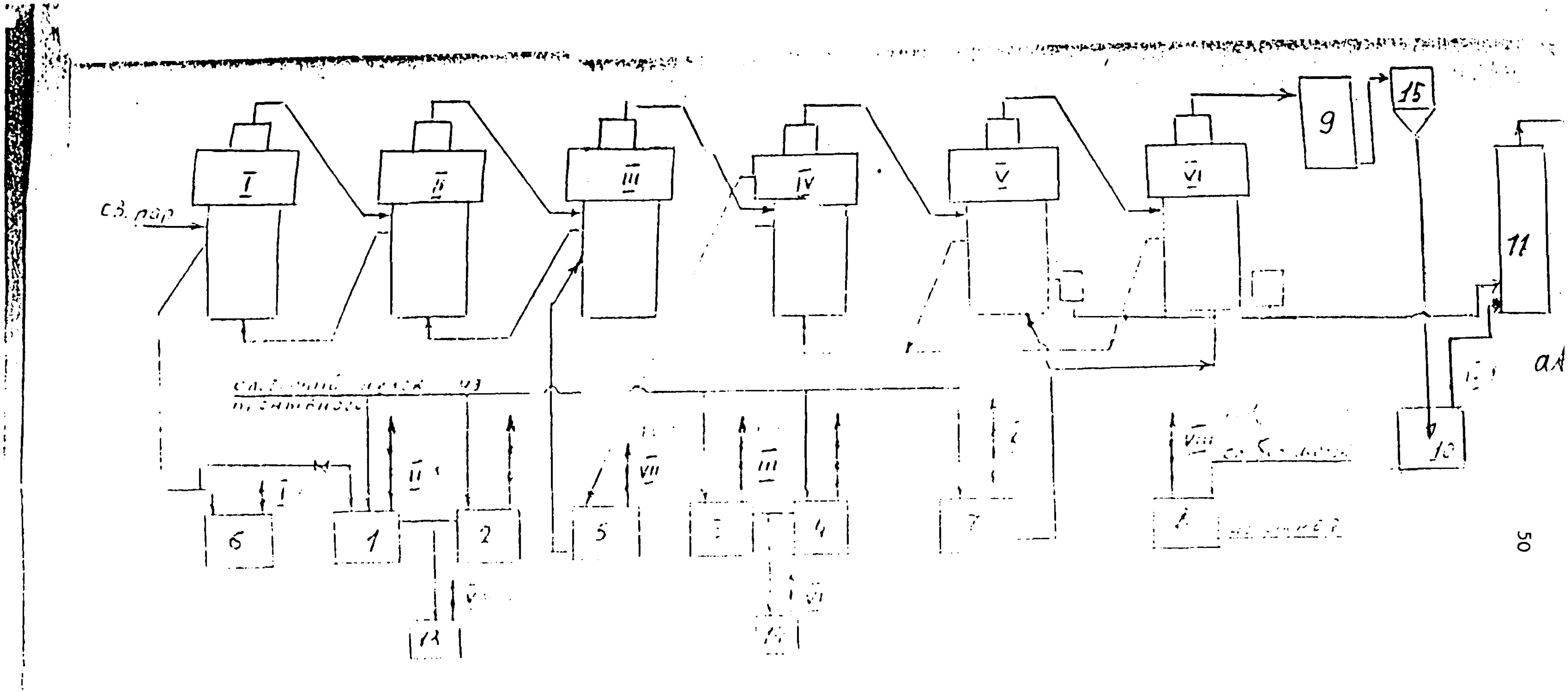


Fig.15. Vaporation Plant principle scheme.

I, II, II, IV, V, VI -vaporation stations bodies 1, 2, 3, 4 - weak liquor tanks 5 - semi-va:orated liquor tank
[illegible] tank 7 - feeding tank 8 - weak white liquor tank 9 - surface condensator
11; 12 - Condensate dezodoration unit 13, 14 - Soap tanks #1; #2. 15 - jet condensator 10 - Ordour gases pit
I; II - Emission source into the air # 215,216 III - # 217 IV - # 230 V; VI - # 105; 106 VII - # 104 VIII - # 214 IX - # 231 X - # 220

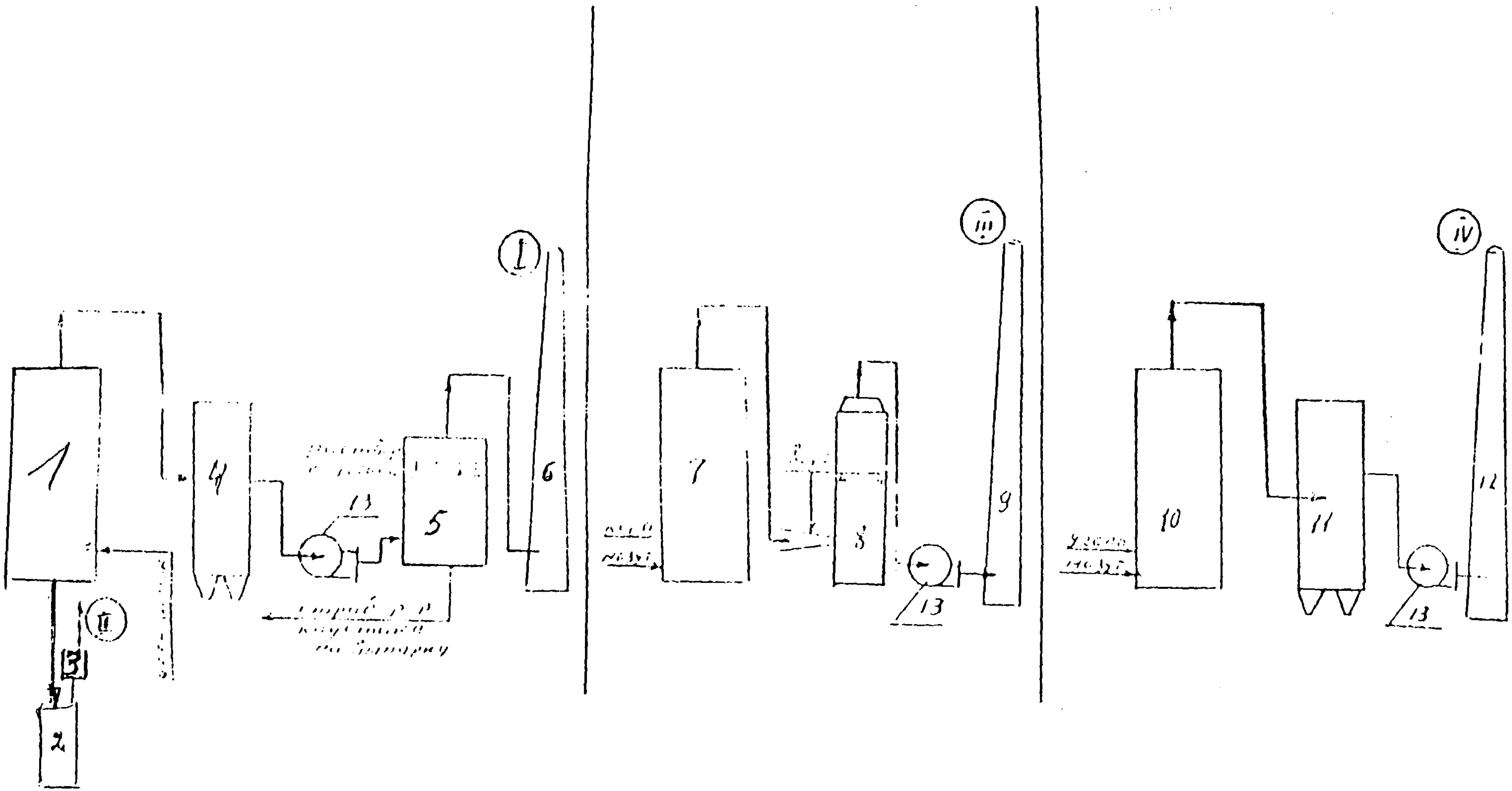


Fig.17. Principle scheme of emission into the air from the technological equipment of Heat & Power Plant .

1 - Soda recovery boiler unit
2 - Melted soda tank
3 - heat exchanger
4 - electric filter
5 - Dezodoration smoke unit
6 - chimney of SRB
7 - Heavy fuel bark boiler
8 - Scrubber МС-ВТИ;
9 - Chimney of bark boiler
10 - Power boiler
11 - el. filter
12 - Power boiler chimney
13 - Smoke sucke,
I - Emission source into the air # 240
II - # 92 - 95; 229
III - # 221
IV - # 222

III. Gas treating and dust removing units operational indicies.

Emission source name & its number	Gas treating and dust removing units			Treated harmful substances	Providing co-efficient		Harmful substances concentration	
	Total	Defective	Non-effective		normative.%	actual, %	before treatment, g/c.m.	after treatment, g/c.m.
1	2	3	4	5	6	7	8	9
Electrofilters plus dezo-	8 + 4	1		dust	100	100	8,32	0,764
doration of soda reco-				SO2			0,05	
very boilers, 1-5(240)				MM			0,0004	0,0003
				H2S			0,1081	0,0744
Power boilers	5			dust	100	100	11,6001	0,336
electrofilters (222)								
Ventury scrubbers	2			dust	100	100	0,4229	0,089
of bark boilers (221)				SO2			0,12	0,0007
Melted soda tank-collec-	1			dust	100	100	3,7133	0,557
tor dezodoration CPK-1 (92)				H2S			0,425	0,085
				MM			0,0064	0,0032
Melted soda tank-collec-	1	+		H2S	100	100	0,1188	0,1188
tor dezodoration CPK-2 (93)				dust			0,629	0,629
Melted soda tank-collec-	1			H2S	100	100	0,31	0,087
tor dezodoration CPK-3 (94)				dust			0,91	0,546
				MM			0,0136	0,0068
Melted soda tank-collec-	1			H2S	100	100	0,132	0,0665
tor dezodoration CPK-5 (229)				dust			0,6988	0,571
				MM			0,00341	0,00341
Lumber units cyclone (223)	1			dust	100	100	2,6425	0,061
Grinding units cyclone (224)	2			dust	100	100	0,89	0,089
Rotoclone (213)	1			H2S	100	100	3,1711	0,469
				MM			0,0953	0,0073

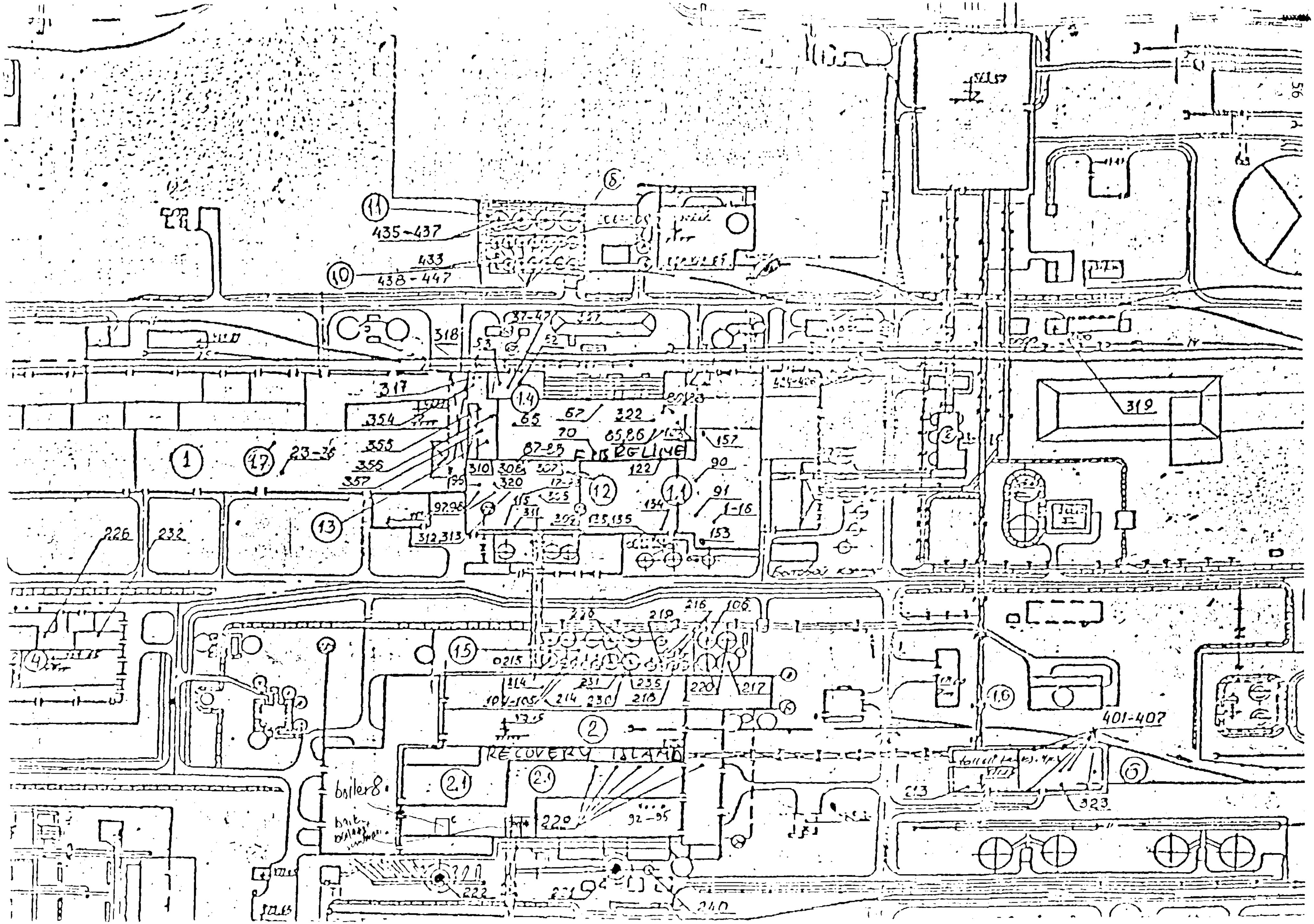
1	2	3	4	5	6	7	8	9
				DMDS			0,0159	0,0013
				DMS			0,0027	0,0078
Scrubber at chlorine dioxide tower (87)	2			ClO_2	100	100	1,1058	0,3292
Scrubber at chlorine dioxide tower (88)	2			ClO_2	100	100	1,3678	0,0324
Scrubber at lime kilns (62)	2			dust	100	100	18,2015	0,9206
				H_2S			0,288	0,2147
				SO_2			0,111	0,0788
Hose filter at sulphate storage (323)	3			dust	100	100	5,42	0,271
Gas-washing tower (135)	1			H_2S	100	100	0,4349	0,08
				MM			0,0732	0,064
				DMS			0,6739	0,017
				DMDS			none	none
				turpentine			2,1317	0,55
				phenol			0,0067	0,0045
Gas-washing tower (136)	1			phenol	100	100	0,0189	0,0063
				H_2S			1,665	0,0332
				MM			0,1592	0,0425
				DMS			0,0226	0,0104
				DMDS			none	none
				turpentine			0,522	0,323
Scrubber at fluidized bed furnaces (300)	2			SO_2	100	100	3,58	0,1795
				dust			18,5	0,367
Cyclone at lime conveyor(407)	1			dust	100	100	5,252	1,4945
Cyclone at lime conveyor(103)	1			dust	100	100	3,905	2,488

IV. Total emission amount of effluent substances into the air, its treatment and utilization, t/y

Effluent name	Amount of effluents, coming from all pollution sources	including: emitted without treatment	From those moved for treament					Totally emmited into the air	Caught & deharmed in % ratio to total amount	
			Moved to treatment system	Emmited into the air	Caught & deharmed					
					Plan	Actual	Utilized		Plan	Actual
A	1	2	3	4	5	6	7	B	C	D
TOTAL	151550,163 (cln.2 + cln.3)	5660,147	145890,011 (cln4 + cln6)	8126,607		137763,404	11396,1117	13786,754 (cln.2 + cln.4)		(cln.6 x 100 / cln.1) 90,9
including:										
solids (non-ordanic dust)	142555,409	112,352	142443,057	7322,598		135120,459	11127,471	7434,95		94,8
gaseous & liquid	8994,754	5547,705	3446,954	804,009		2642,945	268,6407	6351,804		29,4
from them:										
SO_2	4657,279	2161,871	2495,408	258,934		2236,474	0,687	2420,805		48
H_2S	908,154	82,202	825,952	518,379		307,573	249,24	600,581		33,9
Methylmercaptane	138,454	131,003	7,451	4,314		3,137	0,898	135,317		2,3
Dimethylsulphide	60,501	37,039	23,462	0,598		22,864	0,0447	37,637		37,8
Dimethyldisulphide	39,726	39,404	0,316	0,005		0,311	0,311	39,409		0,8
Turpentine	101,232	26,956	74,276	19,231		55,045		46,187		54,4
Nitrogen oxides	1974,02	1974,02						1974,02		
Carbon oxide	1076,165	1076,165						1076,165		
Alkaline aerozoles	14,034	14,034						14,034		
ClO_2	21,341	1,491	19,85	2,39		17,46	17,46	3,881		81,8
Clorine	3,085	3,085						3,085		
Phenol	0,763	0,524	0,239	0,158		0,081		0,682		10,6

ANNEX 8.

The lay-out of the Mill and air emission sources


RECOVERY ISLAND
FIBERLINE
boiler 8
435-437
438-447
433
401-407
319
323
317
318
354
355
356
357
226
232
222
220
240
92-95
23-36

ANNEX 9.

Sulphur emissions in 1994

J.Eerikäinen 1995-08-17

SULFUR EMISSIONS IN 1994, PRODUCTION 120 253 ADt

SOURCE		TREATMENT	VENT	FLOW nr	SO2 kgS/ADt	TRS kgS/ADt
STRONG ODOR GASES						
Cooking plant:			Stack 30m	153,157		1,432
*Accumulator tanks	Relief gas	Alkaline Scrubber	Pipe	135,136		0,103
*Foam collect. tank	Vent gas					
*Brown stock filters	Vent gas					
			Pipe	122,134		0,001
*Turpentine recov.	Relief gas		Pipe	90		0,018
*Prehydrolysate tank	Vent gas		Pipe			0,004
Evaporation plant	Relief gases,hot well Foul condensate	4 catalytic scubbers, air:condensate 10:1	Pipe	231		0,000
WEAK ODOR GASES						
Cooking plant	Vent gas from white liquor dosing tank		Pipe	401		0,000
Tall oil preparation	Reactor gases	Rotoclone scrubber	Pipe	213		0,011
Evaporation plant:						
*Weak B.L tanks	Vent lines connected from 6 tanks		Pipe	217		0,024
*Strong B.L. tanks	Vent lines connected from 4 tanks		2 pipes	215,216		
*Med. B.L.tanks	Vent lines connected from 5 tanks		Pipe	104		
*Weak W.L. tanks	Vent lines connected from 2 tanks		2 pipes	424,409		
*Strong W.L. tanks	Vent lines connected from 2 tanks		Pipe	214		
OTHER SULFUR CONTAINING PROCESS WASTE GASES						
Recovery boiler dissovers	Vent gases	4 Heat exchangers	4 Stacks	92...95		0,088
2 Lime kilns	Flue gases	2 Alkali scrubbers 1 Emulgator reactor	Stack 60m	62	0,06	0,352
Bleaching plant	Vent gases from tower		Pipe		0,02	
Other miscellanious sources: *Cooking plant *Sludge processing *W.water tr. plant *Storages					0,06	0,363

SULFUR EMISSIONS IN 1994, PRODUCTION 120 253 ADt

SOURCE		TREATMENT		VENT	FLOW nr	SO2 kgS/ADt	TRS kgS/ADt
FLUE GASES FROM BOILERS							
Recovery boiler 1	Flue gas		Electr. precipitator	Stack 120m	240	0,16	0,117
Recovery boiler 2	Flue gas		Electr. precipitator				
Recovery boiler 3	Flue gas		Electr. precipitator	Stack 120m	221	0,55	0,110
Recovery boiler 4	Flue gas		Electr. precipitator				
Bark boiler 5	Flue gas		Cyclones+scrubber			0,00	
Bark boiler 6	Flue gas		Cyclones+scrubber				
Coal power boiler 7	Flue gas		El.precip.				
Coal power boiler 8	Flue gas	Desulfurization Lifac	El.precip.				
Coal power boiler 9	Flue gas		El.precip.	Stack 120 m	222	11,44	
Coal power boiler 10	Flue gas		El.precip.				
Coal power boiler 11	Flue gas		El.precip.				
Effluent sludge boiler	Flue gas	Cyclones and scrubber		Stack 120m	300	0,03	
Effluent sludge boiler	Flue gas	Cyclones and scrubber					

	SO2+TRS kgS/ADt	SO2 kgS/ADt	TRS kgS/ADt
TOTAL SULFUR EMISSIONS:	14,93	12,31	2,624
SULFUR EMISSIONS FROM HEAT GENERATION TO BAIKALSK CITY:		-1,60	
TOTAL SULFUR EMISIONS OF MILL OPERATIONS:	13,33	10,71	2,624
Recommended level in Finland:	2,00		
New permits in Finland:	1,5..2,0		

	Finland TRS kgS/ADt	BPPM TRS kgS/ADt
TRS emissions from strong odor gases	1,4..2,8	1,559
TRS emissions from weak odor gases	0,4..1,1	0,035
TRS emissions from recovery boiler dissolver tanks	0..0,05	0,088
TRS emissions from the lime kiln	0,08..0,2	0,352
TRS emissions from miscellanious sources		0,363
TRSemissions from recovery boilers	0,05..0,1	0,227
Total TRS emissions	1,9..4,2	2,624

ANNEX 10.

Sulphur emissions after modifications

J.Eerikäinen 1995-08-17

SULFUR EMISSIONS AFTER MODIFICATIONS, PRODUCTION 200 000 ADt

Situation in 1994 | **Modifications**

SOURCE	TREATMENT	FLOW nr	SO2 kgS/ADt	TRS kgS/ADt
STRONG ODOR GASES				
Super Batch cooking *Blow gases *Digester relief	Relief gases 300 m3/h → To Bark Boiler 5			0,050
Evaporation plant	Relief gases,hot well → / Foul condensate → 4 catalytic scubbers, air:condensate 10:1 → Pipe	231		0,000
WEAK ODOR GASES				
Cooking plant *Blow tanks *Filtrate tanks *Brown stock filters	Vent gases 9000m3/h → Cooling scrubber+ preheater → Dry gases 18 000 m3/h → To Power boiler 8 or flare as reserve			0,030
Evaporation plant: *Weak B.L tanks *Strong B.L tanks *Med. B.L.tanks *Weak W.L. tanks *Strong W.L. tanks	Vent gases 9 000 m3/h → (Cooling scrubber+ preheater)			0,024
Tall oil preparation	Reactor gases → Rotoclone scrubber → Pipe	213		0,011
OTHER SULFUR CONTAINING PROCESS WASTE GASES				
Recovery boiler dissovers	Vent gases → 4 Heat exchangers and 4 scrubbers → 4 Stacks	92...95		0,040
2 Lime kilns with operation control	Flue gases → 2 Alkali scrubbers 2 Emulgator reactors → Stack 60m	62		0,150
Bleaching plant	Vent gases from tower → Pipe		0,02	
Other miscellanious sources: *Cooking plant *Sludge processing *W.water tr. plant *Storages	→		0,06	0,360

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J.Eerikäinen 1995-08-17

SULFUR EMISSIONS AFTER MODIFICATIONS, PRODUCTION 200 000 ADt

SOURCE		TREATMENT	VENT	FLOW nr	SO2 kgS/ADt	TRS kgS/ADt
FLUE GASES FROM BOILERS						
Recovery boiler 1	Flue gas	Electr. precipitator	Stack 120m	240	0,17325	0,125
Recovery boiler 2	Flue gas	Electr. precipitator				
Recovery boiler 3	Flue gas	Electr. precipitator	Stack 120m	221	0,105	0,021
Recovery boiler 4	Flue gas	Electr. precipitator				
Bark boiler 5	Flue gas	Cyclones+scrubber			0,01	
Bark boiler 6	Flue gas	Cyclones+scrubber				
Coal power boiler 7	Flue gas	El.precip.				
Coal power boiler 8	Flue gas	Desulfurization Lifac / El.precip.				
Coal power boiler 9	Flue gas	El.precip.	Stack 120 m	222	5,21	
Coal power boiler 10	Flue gas	El.precip.				
Coal power boiler 11	Flue gas	El.precip.				
Effluent sludge boiler	Flue gas	Cyclones and scrubber	Stack 120m	300	0,03	
Effluent sludge boiler	Flue gas	Cyclones and scrubber				

	SO2+TRS kgS/ADt	SO2 kgS/ADt	TRS kgS/ADt
TOTAL SULFUR EMISSIONS:	6,31	5,606	0,707
SULFUR EMISSIONS FROM HEAT GENERATION TO BAIKALSK CITY:		-0,73	
TOTAL SULFUR EMISSIONS OF MILL OPERATIONS:	5,58	4,88	0,707
Recommended level in Finland:	2,00		
New permits in Finland:	1,5..2,0		

	Finland TRS kgS/ADt	BPPM TRS kgS/ADt
TRS emissions from strong odor gases	1,4..2,8	0,000
TRS emissions from weak odor gases	0,4..1,1	0,011
TRS emissions from recovery boiler dissolver tanks	0..0,05	0,040
TRS emissions from the lime kiln	0,08..0,2	0,150
TRS emissions from miscellanious sources		0,360
TRSemissions from recovery boilers	0,05..0,1	0,146
Total TRS emissions	1,9..4,2	0,707

ANNEX 11.

Power and heat production in 1994

FUTURE PULP PROD.	120 253	ADt/a													
	Units	TOTAL	Rec boil.1	Rec boil.2	Rec.boil.3	Rec.boil.4	Bark boil.5	Bark boil.6	Power boil.7	Power boil.8	Power boil.9	Power boil.10	Power boil.11	Sludge furnace
Boiler type			Tampella	Tampella	Tampella	Tampella	KM/Tamp.	KM75-40	BKS-160/100	BKS-160/100	BKS-160/100	BKS-160/100	BKS-160/100	KC/Marubeni
Operating hours	h/a	51 179	3 494	4 962	7 010	2 696	5 421	179	6 397	1 554	3 615	4 768	3 915	7 168
Capacity														
Rated power	MWth													
Steam pressure	bar		39	39	39	39	40	40	100	100	100	100	100	
Steam temperature	C		440	440	440	440	440	440	520	520	520	520	520	
Rated steam production	t/h		63	63	63	63	50	75	160	160	160	160	160	
Rec.boiler capacity	tDS/d	1 520	380,0	380,0	380,0	380,0								
Fuel consumption														
Bl. liquor dry solids cons.	t/a													
Coal consumption	t/a	464 504							139 775,0	39 593,0	78 185,0	111 790,0	95 161,0	
Heavy fuel oil consumption	t/a	15 593					25,0		11 884,0	1 105,0	368,0	737,0	1 179,0	295,0
Bark consumption	m3/a						164 062,0							
Flue gas treatment			E.P	E.P	E.P	E.P	Scrubber	Scrubber	E.P.	E.P.+Lifac	E.P.	E.P.	E.P.	Cyclone+Scrub
Efficiency	% SO2						90,0	90,0		60,0				80,0
	%Dust		98,5	97,5	99,6	75,5	93,8	91,0	87,8	90,0	97,9	85,0	95,2	96,0
Fuel properties														
Heavy fuel oil	%S						0,9	0,9						
Lower Heat Value	MJ/kg						40,2	40,2						
Specific SO2 emission	mg/MJ	448												
Coal	%S								0,5	0,5	0,5	0,5	0,5	
	%ash								16,0	16,0	16,0	16,0	16,0	
	%DS								77,0	77,0	77,0	77,0	77,0	
Lower Heat Value	MJ/kg								15,6	15,6	15,6	15,6	15,6	
Specific SO2 emission	mg/MJ	639												
Black liquor	%DS		67	67	67	67								
Emissions														
SO2	t/a	2 931,2	16,2	22,8	93,1	39,9		0,5	902,0	283,0	541,0	627,0	399,0	6,7
	mg/Nm3		38,8	38,2	110,7	123,5	55,0	93,0	653,0	843,0	693,0	609,0	472,0	
	mg/MJ								350	450	369	325	252	
NOx	t/a	2 261,0					89,4	3,0	715,0	252,0	361,0	497,0	337,0	6,6
	mg/Nm3						110,0	112,0	517,0	750,0	462,0	482,0	398,0	
	mg/MJ								276,0	400,0	246,0	257,0	212,0	
Dust	t/a	3 149,3	19,3	45,7	10,4	357,8	44,5	2,5	1 065,0	267,0	121,0	919,0	272,0	25,1
	mg/Nm3		46,0	77,0	12,0	1 107,0			771,0	795,0	155,0	892,0	322,0	
	mg/MJ								414,0	424,0	83,0	479,0		
Heat and power production														
Electrical power production	GWh/a	337,2	12,9	18,4	26,0	10,0	8,3		82,6	20,1	46,7	61,6	50,6	
	TJ	1 213,9	46,6	66,2	93,5	36,0	29,9		297,5	72,3	168,1	221,8	182,1	
	kWh/ADt	2 804,1												
Total heat production	TJ	10 336,6	618,3	863,9	1 252,3	448,4	391,7		2 064,3	563,8	1 187,3	1 591,7	1 355,0	
Heat to city	TJ	1 206,5							1 206,5					
Heat to mill after turbines	TJ	7 612,4												

ANNEX 12

Power and heat balance

1994 PRODUCTION ADt/a	120 400					
FUTURE PRODUCTION ADt/a	200 000					
HEAT BALANCE		**BPPM**	**Cond.**	**Finland 70's**	**Target BPPM**	
	GJ	GJ/ADt	ret.%	GJ/ADt	GJ/ADt	GJ
Woodhandling	45 960	0,38		0,35	0,35	70 000
Cooking+washing+screen	1 079 930	8,97		4,60	5,00	1 000 000
Bleaching+bleach chemicals	456 626	3,79		1,50	1,50	300 000
Drying	772 011	6,41	80,00	3,80	3,80	760 000
Evaporation	2 320 196	19,27	80,00	4,00	8,00	1 600 000
Recovery+power boilers	481 706	4,00		1,25	2,00	400 000
Causticisation+lime kilns	20 057	0,17		0,15	0,15	30 000
Total, process	5 176 486	42,99		15,65	20,80	4 160 000
Effluent treatment+sludge	105 249	0,87			0,35	70 000
Paper machine 2 t/t paper	41 141	0,34			0,32	64 000
Town	1 267 202	10,52			6,34	1 267 202
Heating +ventilation+hot water	891 904	7,41			4,46	891 904
Other departments	42 156	0,35			0,34	68 000
Losses	88 262	0,73			0,70	140 000
TOTAL	7 612 400	63,23			33,31	6 661 106
POWER BALANCE		**BPPM**		**Finland 70's**	**Target BPPM**	
		kWh/ADt	GWh/a	kWh/ADt	kWh/ADt	GWh/a
Woodhandling		84	10,11	50,00	50,00	10,00
Cooking		98	11,80	40,00	50,00	10,00
Washing+screening		100	12,04	150,00	100,00	20,00
Bleaching+bleach chem.prep.		123	14,81	200,00	120,00	24,00
Drying		237	28,53	150,00	170,00	34,00
Evaporation		71	8,55	20,00	50,00	10,00
Causticisation+lime kilns		70	8,43	20,00	60,00	12,00
Total pulp process		783	94,27	630,00	600,00	120,00
Water supply		102	12,28		60,00	12,00
Effluent treatment+sludge		490	59,00		220,00	44,00
Compressed air station		164	19,75		90,00	18,00
Paper machine 630 kWh/t paper		46	5,54		44,00	8,80
Lighting+ventilation+maintenance		172	20,71		100,00	20,00
Other departments		64	7,71		40,00	8,00
Losses		18	2,17		12,00	2,40
TOTAL		1 839	221,42		1 166,00	233,20

ANNEX 13

Target power and heat production

FUTURE PULP PROD.	200 000	ADt/a												
	Units	TOTAL	Rec.boil.1	Rec.boil.2	Rec.boil.3	Rec.boil.4	Bark boil.5	Bark boil.6	Power boil.7	Power boil.8	Power boil.9	Power boil.10	Power boil.11	Sludge furnace
Boiler type			Tampella	Tampella	Tampella	Tampella	KM/Tamp.	KM75-40	BKS-160/100	BKS-160/100	BKS-160/100	BKS-160/100	BKS-160/100	KC/Marubeni
Operating hours	h/a	50 958	7 500	7 500	3 160		7 300	2 000	3 330	7 000	6 000			7 168
Capacity			18 160											
Rated power	MWth													
Steam pressure	bar		39	39	39	39	40	40	100	100	100	100	100	
Steam temperature	C		440	440	440	440	440	440	520	520	520	520	520	
Rated steam production	t/h		63	63	63	63	50	75	160	160	160	160	160	
Rec.boiler capacity	tDS/d	1 520	380,0	380,0	380,0	380,0								
Fuel consumption														
Bl. liquor dry solids cons.	t/a													
Coal consumption	t/a	380 875							72 760,8	178 346,8	129 767,6			
Heavy fuel oil consumption	t/a	12 103					33,7		6 186,3	4 977,5	610,8			295,0
Bark consumption	m3/a						220 928,4							
Flue gas treatment			E.P	E.P	E.P	E.P	Scrubber	Scrubber	E.P.	E.P.+Lifac	E.P.	E.P.	E.P.	Cyclone+Scrub
Efficiency	% SO2						90,0	90,0		60,0				80,0
	%Dust		98,5	97,5	99,6	75,5	93,8	91,0	87,8	90,0	97,9	85,0	95,2	96,0
Fuel properties														
Heavy fuel oil	%S						0,9	0,9						
Lower Heat Value	MJ/kg						40,2	40,2						
Specific SO2 emission	mg/MJ	448												
Coal	%S								0,5	0,5	0,5	0,5	0,5	
	%ash								16,0	16,0	16,0	16,0	16,0	
	%DS								77,0	77,0	77,0	77,0	77,0	
Lower Heat Value	MJ/kg								15,6	15,6	15,6	15,6	15,6	
Specific SO2 emission	mg/MJ	639												
Black liquor	%DS		67	67	67	67								
Emissions														
SO2	t/a	2 204,3	34,8	34,5	42,0			5,6	469,5	713,4	897,9			6,7
	mg/Nm3		38,8	38,2	110,7	123,5	55,0	93,0	653,0	843,0	693,0	609,0	472,0	
	mg/MJ								350	450	369	325	252	
NOx	t/a	2 267,0					120,4	33,5	372,2	1 135,1	599,2			6,6
	mg/Nm3						110,0	112,0	517,0	750,0	462,0	482,0	398,0	
	mg/MJ								276,0	400,0	246,0	257,0	212,0	
Dust	t/a	2 186,1	41,4	69,1	4,7		59,9	27,9	554,4	1 202,7	200,8			25,1
	mg/Nm3		46,0	77,0	12,0	1 107,0			771,0	795,0	155,0	892,0	322,0	
	mg/MJ								414,0	424,0	83,0	479,0		
Heat and power production														
Electrical power production	GWh/a	286,4	67,3				8,3		43,0	87,1	80,6			
	TJ	1 031,1	242,4				30,0		154,9	313,6	290,3			
	kWh/ADt	1 432,1												
Total heat production	TJ	9 159,2	618,3	863,9	1 252,3	448,4	391,7		1 074,6	2 539,4	1 970,7			
Heat to city	TJ	1 206,5							1 206,5					
Heat to mill after turbines	TJ	6 663,7												