# MERCURY EMISSION SOURCES IN RUSSIA

**The situation survey in six cities of the country**

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**For additional information please contact:**

**Olga Speranskaya, Head of Eco-Accord Pogram on Chemical Safety, speransk2004@mail.ru**

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**Introduction**

The problem of ensuring environmentally sound management of mercury and its compounds, including mercury-containing waste, belongs to the most important environmental problems.

In 2006, the Security Council of the Russian Federation discussed "problems of mercury pollution of the environment and measures to address these problems" at the session of the Inter-agency Commission on Environmental Security. On 07.12.2006, S.B. Ivanov - the Secretary of RF Security Council - approved the Protocol of the session and forwarded the document to Regional Plenipotentiaries of the President of the Russian Federation in federal districts. In addition, the Protocol and background documents were submitted to the Government of the Russian Federation.

The documents under review of the RF Security Council suggested that only purposeful application of mercury in industry, agriculture, health care and gold mining results in tens thousands of tons of mercury releases to the environment at the territory of Russia. Amounts of mercury releases to the environment due to fossil fuel burning, processing of metal ores and other mineral resources are fairly substantial but they cannot be measured precisely. So far, no large-scale federal projects were implemented to identify sources of mercury releases and assess mercury contamination of the national territory.

The Security Council recommended to address the problem more actively, with public involvement. Several constituents of the Russian Federation approved regional programs of urgent actions to tighten control over mercury waste management, NGOs and education facilities were involved into awareness raising activities.

Throughout the World, the mercury pollution problem is recognised as one of the most pressing problems. In the framework of international cooperation, on October 19 - 23, 2009, at the session of the Ad Hoc Open-ended WG (the WG is authorised to prepare activities of the Intergovernmental Negotiating Committee for development of the global legally binding instrument on mercury) approved the Plan of Study of Different Types of Mercury Emission Sources. The Plan was developed on request of the UNEP Governing Council (the UN Environmental Program).

Russia was selected as one of the countries for identification of sources of mercury emissions. As a pilot project, Eco-Accord initiated assessments of mercury emission sources in six Russian cities, namely in Moscow, Volgograd, Krasnodar, Chelyabinsk, Irkutsk and Magadan at the base of published data and other information sources.

In this Survey we consider the following key sources of mercury emissions:

- Coal-fired power plants;
- Chlorine-alkali production;
- Cement production;
- Production of copper and zinc;
- Incineration of solid household waste;
- Gold refining.

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**Chapter 1**

# MERCURY POLLUTION CONTROL AT THE TERRITORY OF THE RUSSIAN FEDERATION

Overall, there are about 5000 mercury deposits of different scale in the World that got individual names; from the above number of deposits, about 500 were exploited in different periods of time. For the whole history of mercury mining, the overwhelming share of mercury (more than 80%) was extracted from 8 deposits: Almaden (Spain), Idria (Slovenia), Monte-Amiata (Italy), Uankavalika (Peru), New Almaden and New Idria (US), Nikitovka (Ukraine), Khaidarkan (Kyrgyz Rep.). Two latter deposits produced the mercury pool of the former USSR.

Specialists estimate the overall mercury production as about 700,000 tons of marketable mercury - a substantial share of the amount is distributed at the Earth surface. Substantial amounts of mercury were also generated by other human activities, including mining, metal smelting, cement production, combustion of fossil fuel, etc. In addition to mercury minerals, ores and embedding rock, mercury also concentrates in other ores (copper and iron ores, complex ores, etc). Mercury was found to concentrate in bauxites, some clay minerals, oil-shale, limestone, dolomite, coal, natural gas and oil.[1]

According to the Russian State of the Environment Report - 2008[2], mercury pollution in Russia was monitored only selectively - in locations of background monitoring facilities of the Federal Service for Hydrometeorology and Environmental Monitoring of the Russian Federation. See the tables below for mercury levels in soils in background areas of the country, mercury levels in surface water bodies and dynamics of mercury soil contamination in individual cities and their periphery areas.

**Table 1.1**

Mercury levels in soil (background areas of the Russian Federation) mg/kg

| | |
|---|---|
| Irkutskaya oblast | 0.018 |
| Sverdlovskaya oblast | 0.04 |
| Mariinsk township | 0.028 |

According to the Survey, background level of mercury, lead and cadmium in surface water bodies of the majority of background areas of Russia, corresponded to observed ranges of recent years (0.1 - 2 µg/l for mercury).

**Table 1.2.** Background mercury levels in surface water bodies (µg/l) [1]

| | **Ranges** | **2008** |
|---|---|---|
| Kavkazskiy Biosphere Reserve, (1982 - 2008). | 0.006 - 0.2 | 0.1 |
| Prioksko-Terrasniy BR, (1987 - 2008) | 0.03 - 8.7 | 2.1 |
| Barguzinskiy BR, (1982 - 2008). | 0.01 - 9.7 | 1.03 |
| Astrakhanskiy BR, (1988 - 2008). | 0.03 - 74 | 0.7 |
| Voronezhskiy BR, (1990 - 2008). | 0.003 - 1.0 | 0.04 |
| Yailyu, (2002 - 2008). | 0.01 - 0.08 | 0.06* |
| Tsentralno-Lesnoi BR, (1988 - | 0.03 - 0.5 | 0.2* |

[1] http://www.ecotrom.ru/p12.html
[2] State of the Environment Report of the Russian Federation (2008) http://www.igce.ru/page/review2008, The RF Hydrometeorological Service, 2009 (Rus.).

| | | |
|---|---|---|
| 2008) | | |
| | | * - *the most recent measurements* |

In 2008, soluble mercury compounds were monitored in a few water samples from Buguldeika and Sarma rivers. The water sample from Sarma river, taken on September 13, 2008 revealed no measurable mercury. In the water sample taken from Buguldeika on September 14, 2008, mercury level was found to reach 0.010 µg/l (MAC)[3].

In the framework of federal statistical reporting with use of Form No. 2-TP (air) - "Information on Ambient Air Protection" - on operations of legal entities with fixed emission sources, the Federal State Statistics Service collects information on elementary mercury releases only (substance code 0183)[4]. See the below table for air releases of elementary mercury from fixed sources in six cities surveyed in the report (Moscow, Volgograd, Krasnodar, Chelyabinsk, Irkutsk and Magadan).

Air emissions of elementary mercury from fixed sources in selected cities of the Russian Federation (tons)

| | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|
| Moscow | - | - | - | 0.077 | - |
| Krasnodar | - | - | - | - | - |
| Volgograd | 0.209 | 0.14 | 0.129 | 0.124 | 0.158 |
| Chelyabinsk | 1.628 | 1.205 | 1.149 | 1.485 | 2.263 |
| Irkutsk | - | - | - | - | - |
| Magadan | - | - | - | - | - |

Such reporting data provide only a fairly basic information on levels of mercury pollution at the national territory. The reporting does not stipulate identification of specific pollution sources and resulting levels of environmental contamination. The below chapters of the survey are dedicated to review of specific facilities that - according to published information - are sources of mercury emissions in six Russian cities.

According to "Atmosfera" R&D Institute, there are no approved methodologies for estimates of mercury emissions of fixed and mobile pollution sources in the Russian Federation. According to the List of Methods for Determination of Pollutants in Emissions of Industrial Facilities, Approved for Application in 2009, there are five methodological manuals for analytical determination of mercury:

- Methodology for Determination of Mass Concentration of Metals in Workplace Air and Air Emissions of Industrial Facilities by Atomic Absorption Spectrometry with Electothermal Atomisation;
- Methodology for Determination of Mass Concentration of **Mercury** Vapour in Industrial Emissions by Atomic Absorption Spectrometry;
- Methodology for Determination of Metals in Industrial Emissions and Workplace Air of Metallurgy, Radio, and Metal Processing Facilities (atomic absorption spectrometry, determination of aerosols);
- Methodology for Photometric Determination of Mass Concentration of **Mercury** Vapour and Volatile Compounds at Emissions Sources;
- Methodology for Determination of Mass Concentration of **Mercury** in Industrial Emissions by Flameless Atomic Absorption Spectrometry.

So far, we have not identified available domestic instruments in the Russian Federation for determination of mercury in flue gases.

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[3] State of the Environment Report of the Russian Federation (2008) http://www.igce.ru/page/review2008, The RF Hydrometeorological Service, 2009 (Rus.)..
[4] Reference manual of "Atmosfera" R&D Institute - the List and Codes of Air Pollutants (Rus.).

## Chapter 2

## COAL-FIRED POWER PLANTS

Russia holds the world's largest natural gas reserves, the second largest coal reserves, and the eighth largest oil reserves. Russia is also the world's largest exporter of natural gas, the second largest oil exporter and the third largest energy consumer. Internally, Russia gets over half of its domestic energy needs from natural gas, up from around 49 percent in 1992. Since then, the share of energy use from coal and nuclear has stayed constant, while energy use from oil has decreased from 27 percent to around 19 percent[5].

Russia holds the second largest global coal reserves (with estimated extractable coal reserves of 173 billion short tons) - falling behind the United States only with its reserves of about 274 billion short tons). In 2006, Russia produced 321 million short tons of coal (or about a quarter of US coal production), in term of coal production, Russia is the fifth largest global producer. Domestic coal consumption reaches around 260 million short tons, the rest - 61 million short tons - is exported. More recent statistical data are available in EIA Country Energy Profiles[6].

According to the Energy Strategy of Russia up to 2030, approved by Decree No. 1715-r of the Government of the Russian Federation of November 13, 2009[7], by 2020, Russia is expected to produce from 441 to 496 million short tons annually. After restructuring in the coal sector in a few recent years, independent producers produce now about 80 percent of national coal supply. Growth in the Russian coal sector started in 1999 and continued for three years. After a minor decline in early years of the current decade, in recent years coal production substantially increased. The Governmental Strategy promotes coal production and commissioning of new coal-fired power plants - as a result, it might reduce domestic demand for natural gas and provide opportunities for expansion of gas exports.

Now, a proposal is under review on 50 percent reduction of excise duties on coal production. These measures might be accompanied by application of variable tax rates, promoting replacement of gas by coal in power generation and reduction of natural gas consumption.

### Coal use in the power sector

Supply of heat energy in Russia is provided by[8]:

- 485 thermal electric plants (TEPs);
- about 6.5 thousand boilers with capacity over 20 Gcal/hour (mainly municipal ones);
- more than 180 thousand small boilers (mainly municipal ones);
- about 600 thousand stand-alone heaters.

According to statistical data of the International Energy Agency[9], in Russia, 127 million tons of coal were used by TEPs and 34 million tons of coal were used by boilers, however, coal was not used by power plants that did not generate heat energy.

Now, natural gas is the main type of fuel for thermal power plants. Coal is the second most important fuel for the Russian power sector - its share in the fuel mix of power plants reaches 28% and it is expected to increase in the future.

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[5] http://www.eia.doe.gov/cabs/Russia/Background.html
[6] http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=1&aid=2
[7] http://www.energystrategy.ru/
[8] *Reutov B.F., Imenov V.G., Naumov A.V. et al.* Heat Supply in the Country on the Edge. // Energy: Economy, Technics, Ecology, 2002, # 1, p. 3 - 8. (Rus.)
[9] IEA. 2003. Energy Statistics of non-OECD countries. International Energy Agency, Paris

The most productive coal deposits (Kuznetsk and Kansko-Achinsk) are located in the southern part of Central Siberia. Coal there has low sulphur content and mining costs are low. However, use of coal from these deposits is limited due to high railway transportation costs. Notwithstanding low quality of the coal and variable characteristics of different batches, soon after the launch of mining operations at these deposits, Russian coal-fired power plants managed to reach a high economic/operational performance. Their environmental performance is much worse[10].

So far, Russian coal-fired power plants mainly use so called "design coal grades" - i.e. specific TEPs use particular grades of coal preselected at the design stage - they can hardly use other types of coal or enriched fuel without major additional investments.[11]

Russian coal power sector badly needs modernisation with application of modern technologies and environmental control equipment. Now, the following key options are under consideration to improve efficiency of coal-fired TEPs:

- use of higher capacity steam (comparatively to contemporary 24 MPa at 545/540°C) with parallel improvement of equipment and system of steam plants;
- development and modernisation of promising designs of coal-fired steam turbine generating units;
- improvement of already available emission control systems and development of new ones.

According to the earlier developed coal and gas strategy, development of heat and electric power sector of Russia was expected to result in 2010 (the end year of the long-term forecast) in the following fuel mix of TEPs: 67% of gas and 26% of coal, while the share of fuel oil was expected to decrease to 7%. However, in recent years, the gas sector encountered some negative trends due to a variety of causes. In this connection, Gazprom Corp. put forward some proposals to reduce gas supply to TEPs of national power generators[12].

Available forecasts suggest active growth of electric and heat energy consumption, in line with economic growth of Russia. The share of gas is expected to remain at the level of 60%, while the share of coal is expected to increase from 29% in 1998, to 35% in 2015. In 2001, in Russia, the share of coal in the overall fuel mix of electric/heat energy generators reached 34.1% for TEPs and 45% for municipal hearting utilities.[13]

In order to make coal competitive vis a vis natural gas, a range of major problems should be resolved in the sphere of clean coal technologies. Potential options to address these problems are provided in a Federal R&D Program for Environmentally Clean Energy. The Program particularly focuses on burning different types of coal in boilers with fluidised circulating bed, gas generation and burning solid fuel in liquid media (slug melt), electric technologies for coal burning (particularly in the case of coal with high contents of volatile substances).

Key problems in the sphere of application of coal in the power sector of Russia are associated with the need of accelerated development and introduction of domestic technologies and adoption of already tested foreign clean coal technologies for generation of electric and thermal energy.

**Air emissions of thermal power plants**

In 2003, for the first time in recent history, air emissions were found to increase. Gross emissions of fixed pollution sources in the sector increased by 2.8 percent comparatively to 2002, and reached 3446.6

[10] http://www.rao-ees.ru/ru/news/news/magazin/show.cgi?07_04.htm
[11] http://www.epr-magazine.ru/business/innovations/v_topku/
[12] http://www.rao-ees.ru/ru/news/news/magazin/show.cgi?5_01.htm
[13] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005

thousand tons. In comparison to 2002, some growth was observed for almost all air pollutants except hydrocarbons - in the latter case emissions decreased by almost 9% (hydrocarbons emissions include 53% of methane. The emission growth was attributed to changes in the fuel mix and to higher amounts of fuel consumed. In particular, coal consumption increased by 2.54 million tons FE (fuel equivalent), and gas consumption - by 3.5 million tons FE (figures of 2003 vs. 2002).[14]

See key indicators of the energy sector impact on the environment and natural resources in Table 2.1.[15]

**Table** 2.1.

The energy sector impacts on the environment and natural resources - key indicators

| **Indicators** | **Units** | **2000** | **2001** | **2002** | **2003** |
|---|---|---|---|---|---|
| Overall emissions of pollutants | th. tons | 3857.3 | 3655.8 | 3352.7 | 3446.6 |
| inc.: solid matter | th. tons | 1144.2 | 1092.6 | 965.1 | 994.1 |
| liquid and gaseous, | th. tons | 2713.1 | 2563.2 | 2387.6 | 2452.5 |
| inc: sulphur dioxide | th. tons | | 1403.9 | 1273.1 | 1310.4 |
| carbon monoxide | th. tons | 221.1 | 219.4 | 215.6 | 216.8 |
| nitrogen oxides | th. tons | 926.6 | 886.8 | 845.2 | 866.9 |
| hydrocarbons (excl. VOC) | th. tons | 3.3 | 4.2 | 3.5 | 3.2 |
| VOC (volatile organic compounds) | th. tons | 1.9 | 1.4 | 2.4 | 3.2 |
| Extracted/neutralised pollutants | % | 87.4 | 87.4 | 87.2 | 87.3 |

According to the RF Ministry of Environment and Natural Resources, SDPPs (state district power plants) are largest air emissions sources in the energy sector - four SDPPs occupy leading positions in the range of largest emitters in the sector (see Table 2.2):

**Table 2.2**

| **Largest sources of air emissions in the energy sector** | **Contribution to the sectoral emissions (%)** | | | |
|---|---|---|---|---|
| | **2000** | **2001** | **2002** | **2003** |
| Reftinskaya SDPP, Asbest, Sverdlovskaya oblast | 9.3 | 9.4 | 7.6 | 9.1 |
| Troitskaya SDPP, Troitsk-5, Chelyabinskaya oblast | 2.7 | 3.3 | 3.5 | 4.1 |
| LuTEK (Primorskaya SDPP), Luchegorsk, Primorskiy krai | 2.0 | 2.1 | 2.7 | 2.5 |
| Novocherkasskaya SDPP, Novocherkassk, Rostovskaya oblast | 3.2 | 3.0 | 2.6 | 2.0 |
| TEP-4, Omsk, Omskaya oblast | 1.5 | 1.6 | 1.7 | 1.8 |
| TEP-5, Omsk, Omskaya oblast | 1.4 | 1.4 | 1.7 | 1.5 |
| Tom-Usinskaya SDPP, Kemerovskaya oblast | 1.6 | 1.6 | 1.6 | 1.5 |
| Verkhnetagilskaya SDPP, Sverdlovskaya oblast | 1.9 | 2.0 | 1.2 | 1.4 |
| Nazarovskaya SDPP, Krasnoyarskiy krai | 1.4 | 1.1 | 1.3 | 1.3 |
| Argayashskaya TEP, Novogorniy township, Chelyabinskaya oblast | 1.6 | 1.2 | 1.3 | 1.3 |
| Yuzhnouralskaya SDPP, Chelyabinskaya oblast | 1.7 | 1.3 | 1.2 | 1.3 |
| TEP-10, Angarsk, Irkutskaya oblast | 0.6 | 0.5 | 0.7 | 1.3 |
| TEP-2, Vladivostok, Primorskiy krai | 1.1 | 1.2 | 1.3 | 1.2 |
| Cherepetskaya SDPP, Suvorov, Tulskaya oblast | 1.8 | 1.9 | 1.1 | 1.2 |
| TEP-2, Barnaul, Altaiskiy krai | 1.1 | 1.1 | 1.0 | 1.2 |
| TEP-2, Vorkuta, the Komi Republic | 1.3 | 1.3 | 1.2 | 1.1 |
| Serovskaya SDPP, Sverdlovskaya oblast | 1.3 | 1.2 | 1.1 | 1.1 |

[14] http://www.mnr.gov.ru/files/part/6031_otrasli.doc
[15] http://www.mnr.gov.ru/files/part/6031_otrasli.doc

| | | | | |
|---|---|---|---|---|
| TEP-9, Angarsk, Irkutskaya oblast | 0.9 | 1.0 | 1.1 | 1.1 |
| Ryazanskaya SDPP, Ryazanskaya oblast | 1.2 | 1.1 | 1.1 | 1.0 |
| TEP-1, Severodvinsk, Arkhangelskaya oblast | 1.1 | 1.2 | 1.1 | 1.0 |
| Kashirskaya SDPP-4, Moskovskaya oblast | 1.1 | 1.0 | 1.1 | 1.0 |
| **Total** | 39.8 | 39.5 | 37.2 | 39.0 |

## Coal burning and mercury emissions

At high temperatures of burning, almost all mercury compounds in coal evaporate and eventually mercury either comes to ambient air with flue gases or condensates on particles that might be separated by pollution control equipment[16]. As a result, in majority of cases emission control equipment does not allow to ensure efficient separation of mercury from flue gases. We could not find published data on efficiency of mercury separation by emission control equipment of Russian TEPs.

## Mercury behaviour in the course of coal burning[17]

Mercury has some unique properties: a low melting point (- 38.9°C) and a high vapour pressure (mercury boils at t = 356.66°C) - 0.25 Pa (= 0.25 $10^{-5}$ bar). Such properties mean that at temperatures of coal burning mercury may exist only as vapour of elementary mercury $Hg^0$; it starts to condensate at temperatures under ~357 °C, while such mercury as $Hg_2Cl_2$ (calomel) and $HgCl_2$ (corrosive sublimate) start to condensate at 384 and 302°C, respectively.

Due to such properties, volatility of mercury is surely its most important technological parameter. According to experimental data for coal-dust combustion furnaces with dry ash removal, up to 98 - 99% of Hg come to gaseous/aerosol phase from the high temperature zone of a combustion chamber. There are no available data for other types of furnaces, however, we may assume that regardless a specific furnace design and combustion conditions, mercury will almost completely transform into volatile products.

Further fate of mercury in TEPs furnaces depends on composition of coal and combustion conditions. These issues are intensively studied, including theoretical (thermodynamic modelling), laboratory and pilot-scale research, analytical studies (e.g. monitoring of mercury levels in waste ash and flue gases, including gaseous releases to ambient air).

1. Modern TEPs predominantly burn pulverised coal - coal dust (with particle size of about 0.05 mm) is injected by heated air to a combustion chamber and burns out almost immediately.
2. In such a case, solid waste is mainly represented by fly ash in flue gases (ash carry-over), the fly ash contains about 75 - 80% of the initial mineral content in coal; while the slag fraction (a mixture of ash and slag) remains in a furnace (20 - 25% of the mineral waste).
3. Ash separation equipment allows to separate 97 - 99 % of fly ash from flue gases (cyclone separators, bag filters and electrostatic separators - the most common ones). Later on, all ash waste is transported to ash collectors (sedimentation ponds). In such a way, the problem of mercury air pollution transforms into the problems of soil/water pollution, as mercury in ash waste may poison soils, water and vegetation nearby TEPs. We will not consider the latter problem in detail and focus on mercury emissions only.
4. In addition, modern TEPs are equipped by emission control systems, allowing to reduce emissions of nitrogen oxides ($NO_x$) and sulphur compounds - so called scrubbers filled with $CaO$, $CaCO_3$, or (sometimes) with $CaMg(CO_3)_2$. In scrubbers $SO_2$ from flue gases eventually transforms into calcium sulphate. Scrubbers were found to adsorb mercury vapour from flue gases in gypsum waste efficiently.

[16] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[17] http://masters.donntu.edu.ua/2006/ggeo/eretina/library/art3.htm (Communications of the Institute of Geology of Komi Scientific Centre, Urals Branch of the Russian Acad. Sci. - # 10 - 2004. - p. 6-12.) (Rus.)

5. Elementary Hg in flue gases of TEPs is easily released to ambient air. The only way to reduce mercury emissions is associated with its oxidation Hg => $Hg^{2+}$ as only $Hg^{2+}$ compounds may be adsorbed on surface of fly ash (carbon, silicate and sulphates) and gypsum in scrubbers.

Combustion furnaces may be subdivided into spreader and chamber ones[18]. In the case of spreader furnaces, solid fuel burns in a layer, while in the case of chamber ones fuel particles are suspended. In their turn, chamber furnaces include torch furnaces and cyclone furnaces. Torch furnaces for combustion of solid fuel - depending on design of ash and slag removal equipment - may apply dry (solid) and wet slag removal. In Russia, dry slag removal furnaces are predominantly used - in such furnaces a some part of coal ash (up to 10 - 15%) sediments in slag hoppers, while the rest comes to gas ducts of a boiler with flue gases.

In the case of furnaces with wet removal of coal ash (single and double chamber ones) shares of fly ash are lower comparatively to furnaces with wet slag removal, but anyway it is rather high (30 - 40% in single chamber furnaces and 50 - 60% in double chamber ones).

High capacity power plants (over 300 MW) usually use chamber furnaces with dry slag removal, while open/semi-open furnaces with wet slag removal are user more rarely. Medium capacity TEPs (50 - 300 MW), in addition to the above designs, may operate cyclone furnaces. In the case of low capacity power plants and boilers (under 50 MW) cyclone furnaces are applied more often than other types.

Russian energy facilities use the following types of ash removal equipment: dry cyclone ash collectors, wet ash collectors, electrostatic filters, or combined designs. Stand-alone and battery cyclone collectors are used for treatment of flue gases of low capacity steam generators; cyclone batteries ensure better removal of fly ash and higher efficiency (82 - 90%). Cyclone batteries are installed in the case of boilers with steam generation capacity of 25 to 320 tons/hour. Wet ash collectors sediment ash particles at the surface of a thin water layer inside a collector. In the case of steam generators of low to medium steam generation capacity (90 - 100 tons/hour), cyclone scrubbers are applied - vertical concurrent flow cyclones with permanent water flow. Steam generators with steam generation capacity of 120 - 150 tons/hour are usually equipped by wet ash collectors with internal turbulence coagulators. In addition, sometimes (usually in the case of medium capacity boilers) vertical/horizontal electrostatic filters are also applied. In mid-1990s, average ash removal factor in the Russian energy sector was estimated as 0.91[19].

In the case of Moscow TEPs, the above factor reached 0.89; while in industry, housing and utilities sectors it reaches only 0.70[20]. In addition, some generating installations are equipped by systems for $SO_2$ removal, including wet and dry scrubbers of different designs. In order to control $NO_x$ selective catalytic/non-catalytic reduction methods may be applied.

According to available estimates[21], the initial pollutants removal factor (or emission control efficiency) of major Russian power plants reaches 21%.

Accounting for the above considerations and specific technologies of Russian energy facilities, it seems that relative mercury emissions (i.e. mercury emissions vs. initial mercury contents in coal) may be assessed as follows:

[18] Valuable and Toxic Elements in Marketable Russian Coal: A Reference Book. M.: Nedra, 1996. 238 p. (Rosugol Russian State Company; The Russian Committee on Geology and Use of Mineral Resources). (Rus.)

[19] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

[20] Air Emissions of Heavy Metal: Experience of Assessment of Specific Parameters. Minsk: Nat. Resources Use R&D Institute of the National Acad. Sci. of Belarus, 1998. 156 p. (Rus.)

[21] Emissions of mercury from coal fired power plants in Russia - preliminary estimated for ACAP. Munthe J.; Wängberg I.; Chugaeva A.N.; Kiseleva N.V.; Smigol I.N.; Bragina O.N., Anichkov S.N.; Tumanovsky A.G. .IVL Swedish Environmental Research Institute, Sweden and VTI All Russia Thermal Engineering Institute, 2003.

- coal use in electricity generation - 80%;
- coal use in the housing and utilities sector - 95%;
- household and agricultural use of coal - 99%.
- coal use by other consumers - 90%.

The rest of mercury is bonded to ash and slug, including fly ash removed by emission control equipment[22].

Coal-fired energy facilities generate the most serious adverse environmental impacts, including toxic gaseous emissions, corrosive wastewater discharges, sludge ponds, fly ash and heat releases[23].

In the framework of assessment of mercury emissions of 129 largest Russian power plants, a survey of mercury contents in domestic coal was also conducted[24]. Accounting for coal consumption (74,420,000 tons), types of coal and mercury contents, the overall amount of mercury in coal fuel of 129 Russian power plants in 2002, was estimated. Assuming average mercury contents, the overall amount was assessed as 6.3 tons, while assuming maximal mercury contents, the assessment suggested about 8.8 tons. The average amount of mercury in coal fuel corresponds to its average level (0.08 mg/kg), that, in its turn, corresponds to average mercury contents[25]. The preliminary assessment was based on the assumption that the mercury distribution factor for air emissions reaches 81%. At such an assumption, mercury emissions of 129 largest Russian power plants that consumed 74.4 million tons of coal in 2002, were estimated to reach 5 tons (at average mercury contents) or 7 tons (at maximal mercury contents), while the amount of residual mercury in other types of combustion waste was estimated as 1.3 ton (average) or 2.2 tons (maximal).

For purposes of this survey we will review coal-fired TEPs of Moscow, Krasnodar, Chelyabinsk, Irkutsk and Magadan.

**<u>Moscow TEPs</u>**

**Address:**
119034, Moscow
Prechistenskaya Emb., 15/1
phone: 8 (495) 637-50-50

V.G. Yakovlev - the Director General of "Mosenergo" Co. Ltd.

"Mosenergo" Co. Ltd. is the largest regional generating companies of the Russian Federation and an integral technological element of the United Energy System of Russia. The company belongs also to largest heat energy suppliers in the World. The company operates 15 power plants with installed electric generation capacity of 11.9 thousand MW and heat generation capacity of 40.2 thousand MW (34.6 thousand Gcal/hour). Power plants of the company meet about 70% of electric power demand in Moscow region and 66% of heat energy demand of Moscow.

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[22] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[23] http://www.sbras.ru/HBC/hbc.phtml?9+395+1 of January 28, 2010.
[24] Emissions of mercury from coal fired power plants in Russia - preliminary estimated for ACAP. Munthe J.; Wängberg I.; Chugaeva A.N.; Kiseleva N.V.; Smigol I.N.; Bragina O.N., Anichkov S.N.; Tumanovsky A.G. .IVL Swedish Environmental Research Institute, Sweden and VTI All Russia Thermal Engineering Institute, 2003.
[25] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

In 2008, the company generated 64,273.8 million kWh of electric power and 62.44 million Gcal of heat energy.

The majority of company's power plants are gas-fired. Only two TEPs use coal (In Dzerzhinskiy and Stupino).

**Fuel mix**

Natural gas dominates in the fuel mix of "Mosenergo" Co., while fuel oil and coal are used as reserve fuel. In 2008, the overall fuel consumption of "Mosenergo" decreased by 1.4% comparatively to 2007. In 2008, "Mosregiongaz" Co. was the sole supplier of natural gas for "Mosenergo" power plants according to long-term gas supply contracts. The share of gas in "Mosenergo" fuel mix increased by 0.2 percentage points comparatively to 2007 due to some supply arrangements - the generating company was allowed to consume up to 10% extra gas in workdays over the daily limit if relevant amounts were not consumed earlier.

According to Vitaliy Yakovlev, the Director General of "Mosenergo", only two power plants of the company use coal as an additional fuel - namely TEP-22 in Dzerzhinskiy and TEP-17 in Stupino. Referring to prospects of coal use by power plants, he admitted that "Mosenergo" does not plan to use coal in Moscow. The company considered an investment idea to construct pulverised coal power plant in Moskovskaya oblast, but the idea has not transformed into a design yet. The idea might be transformed into a design not earlier than by 2015 - 2016, but anyway its future fate will depend on relevant demand. The idea of switching to coal for power generation emerged on last summer in connection with shortages of gas supply for new generation units. In 3 - 5 nearest years, the problem might emerge again - in such a case, the coal option might be considered again.

**Table 2.3**

Fuel consumption by "Mosenergo" power plants (by types of fuel), thousand t.s.c.

| Fuel | 2006 | 2007 | 2008 |
|---|---|---|---|
| Gas | 25,504.0 | 25,443.0 | 25,126.8 |
| Fuel oil, diesel oil | 474.2 | 91.7 | 74.7 |
| **Coal** | **676.4** | **363.2** | **323.9** |
| Total | 26,654.6 | 25,897.9 | 25,525.4 |

**Analysis of air emissions vs. the previous year**

In 2009, the overall fuel consumption of "Mosenergo" power generation system decreased by 747.01 thousand t.s.c. comparatively to 2008 (or by 2.9%). Gas consumption decreased by 851.1 thousand t.s.c. (or by 3.4 %). Liquid fuel consumption increased by 92.88 thousand tons s.c. or in 2.2 times. Solid fuel (coal) consumption increased by 12.14 thousand tons s.c. or by 3.75%. The share of solid fuel in the overall fuel mix reached 1.4%, while the share of liquid fuel reached 0.7%.

As for Moscow TEPs, the overall fuel consumption in 2009 decreased in 2009 by 5.1% comparatively to 2008 or by 1029.4 thousand t.s.c. Gas consumption decreased by 1122.1 thousand t.s.c. (5.5%), and consumption of fuel oil decreased by 93.63 thousand t.s.c. (in 2.2 times).

Overall emissions of pollutants by power plants of "Mosenergo" Co. increased in 2009 comparatively to 2008 from 53.5 thousand tons to 54.8 thousand tons (by 2.4 %), including:

- emissions of solids decreased from 2.6 thousand tons to 2.1 thousand tons, or by 0.5 thousand tons (19.3 %);
- sulphur dioxide emissions increased from 6.7 thousand tons to 9.6 thousand tons, or by 2.9 thousand tons (44.1%);
- emissions of nitrogen oxides decreased from 43.8 thousand tons to 42.5 thousand tons, or by 1.3 thousand tons (2.8%).

In the case of Moscow TEPs, emissions increased from 28.1 thousand tons to 30.1 thousand tons, or by 2.0 thousand tons (7.3%), including:

- emissions of nitrogen oxides decreased from 25.2 thousand tons to 24.4 thousand tons or by 0.8 thousand ton (3.2%);
- emissions of solids (fuel oil ash in terms of vanadium content) increased from 0.0065 thousand ton to 0.0150 thousand ton, or by 0.0085 thousand ton (in 2.3 times);
- sulphur dioxide emissions increased from 2.4 thousand tons to 5.2 thousand tons, or by 2.8 thousand tons (in 2.2 times).
- carbon dioxide emissions increased from 0.487 to 0.530 thousand tons, or by 0.043 thousand tons (8.8%).

Higher releases of air pollutants are associated with higher consumption of fuel oil and solid fuel (coal).

## Waste

Operations of "Mosenergo" facilities result in generation of production and consumption waste. The company operates under a license for collection, neutralisation, transportation and disposal of hazardous waste of 1st to 5th environmental hazard classes - license # OT-00-010158(00), issued on 22.05.2009, effective up to 22.05.2014.

The bulk of the company's waste belong to waste of 5th hazard class - namely coal slug and ash (the company disposes such waste to its own ash dumps, that are operated under separate permits). Only burnt fluorescent bulbs are classified as 1st hazard class waste.

## Coal-fired TEPs of "Mosenergo" Co.

**TEP-22**
140091, Moskovskaya oblast, Dzerzhinskiy, 5 Energetikov St.
phone/fax: (+7 495) 551 56 72,
e-mail: rabota22@mosenergo.ru

**Table 2.4**[26]

Key performance indicators of TEP-22 as at 01.01.2009

| | |
|---|---|
| Installed power generation capacity, MW | 1310 |
| Electric energy generation, million kWh (data of 2008) | 8726.7 |
| Installed heat energy generation capacity, Gcal/hour | 3606 |
| Heat energy production Gcal (data of 2008) | 8818.1 |

TEP-22 of "Mosenergo" Co. belongs to the largest thermoelectric plants in the World. It operates in Dzerzhinskiy (Moskovskaya oblast) at the distance of 200 km from the Moscow ringway. The TEP uses

[26] http://www.mosenergo.ru/docs/info/521.aspx

gas and coal fuel and supplies electric power and heat energy to south-east districts of Moscow, Dzerzhinskiy town itself and a major part of Luberertskiy district of Moskovskaya oblast. The TEP supplies steam to Moscow oil refinery, greenhouses and other facilities of Luberetskiy district.

Construction of TEP-22 was launched in 1956 and conducted in three stages. The first turbine of the TEP was commissioned in December 1960. At the first stage, six PT-60 and PT-65 turbines were installed with the overall generating capacity of 380 MW, and six steam generation boilers. At the second stage, in 1967, two T-100-130 generating units were commissioned with the overall capacity of 100 MW each, as well as two boilers and two peak load boilers. At the third stage, three supercritical generating units with uniflow boilers were installed with the overall capacity of 750 MW, as well as six peak load boilers.

In late 1980s, reconstruction and modernisation works were launched at the power plant to improve economic performance and reliability of generating equipment and to reduce adverse environmental impacts.

From 1984 to 1990, in connection with expiration of service life of six PT-60-130 generating units, they were replaced by new PT-65/75 generators - as a result, installed capacity of the power plant was increased. In 2000, modernised # 7 turbine was commissioned - these measures allowed to increase installed electric power and heat energy generating capacity by 10 MW and 10 Gcal, respectively. In December 2003, in the course of reconstruction works, outdated turbine and generator of # 8 unit were replaced by modern hi-tech equipment. In particular, an induction generator was installed to regulate reactive capacity. Consumption of fuel per unit of power output was reduced by 5%. In 2006, the first stage of reconstruction of the coal storage unit was completed. In 2008, generating unit # 1 was reconstructed with replacement of the main generator, the main transformer, facility load transformer and high-voltage switches - as a result, installed generation capacity of the TEP was increased by 10 MW.

In the framework of "Mosenergo" environmental program, from 1995 to 1997, the company replaced outdated electrostatic filters by modern ABB equipment. Installation of new electrostatic filters allowed to reduce ash releases in 20 times. In the period from 1992 to 1998, boilers of TEP-22 were equipped by systems for recirculation of flue gases to the combustion chamber. These improvements allowed to reduce emissions of nitrogen oxides from 400 - 500 mg/m$^3$ to 140 - 180 mg/m$^3$ (in the case of gas fuel).

**Table 2.5**
TEP-22: Emissions of specific air pollutants in 2009 (tons/year)

| **Pollutants** | **Untreated** | | **Channelled to pollution control equipment (total)** | **Extracted and neutralised by emission control equipment** | | **Overall pollutant releases to the atmosphere** | | **Standard emission ceilings for the reporting year (tons/year)** |
|---|---|---|---|---|---|---|---|---|
| | **Total** | **Inc. from technological emission sources** | | **Total** | **inc. utilised pollutants** | **In the reporting year** | **in the previous year** | |
| **Overall** | 17 805.84 | 17 738.44 | 78 693.73 | 77 817.25 | | 18 682.31 | 18 890.02 | 42 638.38 |
| **$NO_2$** | 15 130.06 | 15 126.48 | | | | 15 130.06 | 15 130.06 | 15 130,06 |
| **$SO_2$** | 2 611.96 | 2 611.96 | | | | 2 611.96 | 2 312.44 | 8 622.71 |
| **Fuel oil ash** | | | | | | 0.053 | 0.012 | 1.194 |
| **CO** | 6.225 | 0.000 | | | | 6.225 | 3.382 | 6.225 |
| **Solids** | 55.19 | - | 78 693.73 | 77 817.25 | - | 931.66 | 901.15 | |
| | | | | | | | | |

**TEP-17**

142800, Moskovskaya oblast, Stupino, 19 Frunze St.  phone: 8 (49664) 207-02
phone/fax: (+7 495) 957 23 40, e-mail: rabota17@mosenergo.ru

**Table 2.6**[27]
Key performance indicators of TEP-17 as at 01.01.2009.

| | |
|---|---|
| Installed power generation capacity, MW | 192 |
| Electric energy generation, million kWh (annual) | 654.575 |
| Installed heat energy generation capacity, Gcal/hour | 712 |
| Heat energy production Gcal (annual) | 528.426 |

TEP-17 is located in Stupino town of Moskovskaya oblast, at the distance of 100 km to the South from Moscow.

Main types of fuel used: lignite from mines of Moscow region, natural gas.

The thermoelectric plant supplies electric power and heat energy to industrial facilities and municipal utilities of Stupino town with population of more than 75 thousand residents. The power plant uses an open heat supply system and a spray cooling pond for circulating water.

The first stage of TEP-17 was commissioned on May 9, 1950. By the end of 1953, all facilities of the power plant were ready for commissioning. Since 1985, in addition to local lignite, the power plant started to use natural gas as a mainstream fuel (for gas supply purposes, a gas distribution network was constructed).

TEP-17 maintains permanent works for modernisation and technological improvement of the power plant. In 1999, a facility for chemical water treatment of the municipal heating system of the town was commissioned with capacity up to 1200 tons/hour of water and a demineralisation installation with capacity of 420 tons/hour. In 2000, new TZFP-50-2 generator was installed in generating unit # 2. In 2002, PT-30-8.8 turbine was installed in generating unit # 3. In 2008, the electric equipment of TEP-17 underwent a partial reconstruction. In 2009, new TZFP-110-2 MUZ was installed in generating unit # 4. New TRDTsN-125000/110-U1 was installed. In the second quarter of 2009, completion of reconstruction of a pumping station was expected.

In 2008, in the framework of "Mosenergo" environmental policy, pollutants' emissions were reduced comparatively to 2007.

**Table 2.7**
TEP-17: Emissions of specific air pollutants in 2009 (tons/year).

| **Pollutants** | **Untreated** | **Channelled to pollution control equipment (total)** | **Extracted and neutralised by emission control equipment** | **Overall pollutant releases to the atmosphere** | **Standard emission ceilings for the reporting year (tons/year)** |
|---|---|---|---|---|---|

[27] http://www.mosenergo.ru/docs/info/518.aspx

| | Total | Inc. technological emission sources from | | Total | inc. pollutants utilised | In the reporting year | in the previous year | |
|---|---|---|---|---|---|---|---|---|
| **Overall** | 2534.21 | 2 524.06 | 12 876.18 | 11748.20 | | 3662.20 | 4 409.66 | 9 394.06 |
| **$NO_2$** | 747.3 | 746.96 | | | | 747.30 | 832.03 | 1 283.49 |
| **$SO_2$** | 1776.33 | 1 776.31 | | | | 1 776.33 | 1 902.52 | 5 078.98 |
| **Fuel oil ash** | | | | | | 0.15 | 0.183 | 0.610 |
| **CO** | 0.684 | 0.360 | | | | 0.684 | 0.684 | 0.684 |
| **Solids** | 8.72 | **0. 34** | 12 876.18 | 11 748.20 | | 1 136.70 | 1 673.23 | |
| | | | | | | | | |

**Estimates of mercury emissions**

Average mercury contents in coal from Moscow region coal deposits reaches 0.2 mg/kg.

In mid-1990s, the average ash removal factor in the Russian energy sector as assessed at the level of 0.91. In the case of Moscow TEPs, it reached 0.89; while in industry and in the housing and utilities sector it reached only 0.70[28].

In addition, some generating facilities are also equipped by pollution control installations for $SO_2$ removal, including different wet/dry scrubbers; selective catalytic/non-catalytic reduction may be used to control $NO_x$ releases[29].

## Chelyabinsk TEPs

### "Fortum" Co. Ltd.

454077, the Russian Federation, Chelyabinsk, 6 Brodokalmakskiy Trakt.
phone: +7 351 259-64-91/259-64-79
fax: + 7 351 259-64-09
e-mail: fortum@fortum.ru
Director General - O.V.Zharkov.

**"Fortum" Co. Ltd.** is the Russian subsidiary of Finnish Fortum Energy Concern - former TGK-10 Co. Ltd. was officially renamed into "Fortum" Co. Ltd. in April 2009.

The company belongs to leading suppliers of electric power and heat energy in Urals region and Western Siberia. Overall installed generation capacity of the company reaches about 2,800 MW of electric power and 13 600 Gcal/hour of heat energy. The company generates annually 16 billion kWh of electric power and 22 million Gcal of heat energy. Implementation of a major investment program is expected to increase the electric power generating capacity up to 2,300 MW.

Power plants of "Fortum" Co. operate in the Urals region and in Western Siberia, including 8 thermoelectric plants (five in Chelyabinskaya oblast and three in Tumenskaya oblast). The company sells

[28] Air Emissions of Heavy Metal: Experience of Assessment of Specific Parameters. Minsk: Nat. Resources Use R&D Institute of the National Acad. Sci. of Belarus, 1998. 156 p. (Rus.).
[29] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

electric power to the wholesale energy market and heat energy at local markets in cities where company's power plants operate. In addition to the company itself, in the sphere of heat energy supply its daughter company also provides heating services to different consumers ("Urals Heating Networks" Company).

The company operates Argayashskaya TEP (installed capacity of 250 MW), Chelyabinskaya TEP-1 (165 TEP), Chelyabinskaya TEP-2 (320 MW), Chelyabinskaya TEP-3 (180 MW), Chelyabisnkaya SDPP (82 MW). The overall generating capacity of "Chelyabenergo" reaches 1,629 MW, while "Yuzhnouralskaya GRES" Co. operates installed electric power generating capacity of 882 MW; and heat energy generation capacity of 395 Gcal/hour).

**Three TEPs use coal as a fuel. Coal from Chelyabinsk coalfields is supplied to** Argayashskaya TEP, TEP-1 and TEP-2 in Chelyabinsk, and Yuzhnouralskaya SDPP. Chelyabinsk Coal Co. supplies annually about 3 million tons of coal to the above power plants[30].

Chelyabinsk lignite coalfields are located at Eastern slopes of the Southern Ural Mountains at the territory of Chelyabinskaya oblast - the deposit is a narrow strip with maximal width of 15 km and length of about 170 km, almost parallel to the Urals Gorge (from the Techa river in the North to the Ui river in the South). Local lignite, in terms of its caloric value is close to hard coal[31]. Overall mercury contents in Chelyabinsk lignite is shown in the Table below (data for 2001)[32].

**Table 2.8**
*Overall annual mercury extraction with coal in Chelyabinskaya oblast*[33]

| Region, oblast | Coal extraction, million tons | Average mercury contents in coal, mg/kg | Mercury extraction with coal, tons |
|---|---|---|---|
| Chelyabinskaya oblast | 3.3 | 0.05 | 0.17 |

**Argayashskaya TEP**

Address: 456796, Chelyabinskaya oblast, Ozersk, Novogorniy township. 1 Lenina St.
phone: + 7 351 267 81 30
Director: Mescheryakov Ivan Vladimirovich

The power plant was commissioned on July 7, 1954. The TEP is the key source of electric power and heat energy for Novogorniy township, nearby districts, Ozersk town and "Mayak" Chemical Plant. The power plant is equipped for use of gas and coal fuel.

The share of coal in the TEP fuel mix reaches 37%. The TEP is equipped by 6 turbines, 9 power-generating boilers, 3 steam boilers and 3 water heating boilers.

Installed capacity: 195 MW electric power, 576 Gcal/hour heat energy.

Argayashskaya TEP in one of heaviest emitters of pollutants in the sector. First of all, such a situation is attributed to outdated equipment and extended periods between scheduled mandatory maintenance works

[30] http://www.businesspress.ru/newspaper/article_mId_43_aId_296867.html
[31] http://www.vipstd.ru/journal/content/view/44/39/
[32] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[33] Valuable and Toxic Elements in Marketable Russian Coal: A Reference Book. M.: Nedra, 1996. 238 p. (Rosugol Russian State Company; The Russian Committee on Geology and Use of Mineral Resources). (Rus.).

(as ordered by the United Energy System of Russia)[34]. In 2006, the TEP had to switch off its boilers due to equipment failures.

Argayashskaya TEP had failed to meet prescribed emission standards by January 1, 2007. According to a TEP representative, a delay in implementation of environmental actions was caused by transfer to new owners. Besides that, higher emissions are attributed to low grade coal.

**Chelyabinskaya TEP-1**

Address: 454119, Chelyabinsk, 40 Kopeiskoye Highway
phone: + 7 351 255 23 59
Director: Kolesnikov Anatoliy Leonidovich.

The first stage of the TEP was commissioned on January 18, 1942. The power plant is located in the south-east part of Chelyabinsk. The TEP uses gas and coal (less than 10%).

Chelyabinskaya TEP-2 is equipped by technologically cross-linked installations, including 6 back-pressure turbines, 8 generating boilers and 6 peak load water heater boilers.

Installed capacity: 149 MW (electric), 1341 Gcal/hour. Design documentation for modernisation of TEP-1 is under development now.

**Chelyabinskaya TEP-2**

Address: 454079, Chelyabinsk, 69 Lineinaya St.
phone: + 7 351 239 33 59; fax: + 7 351 775 15 70
Director: Suvorov Sergey Pavlovich.

The first generating unit of Chelyabinskaya TEP-2 (60 MW) was commissioned on December 1, 1962. The power plant is located in the eastern part of the city and uses gas as the mainstream fuel and coal as auxiliary fuel (10% of the TEP fuel mix).

Equipment: 4 turbines, 9 generating boilers and 2 peak load water heating boilers. 8 of 9 boilers may be switched to coal.

Installed capacity: 320 MW (electric), 956 Gcal/hour. Design documentation for modernisation of TEP-2 is under development now.

## Volgograd TEPs

The following thermoelectric plants operate now in Volgogradskaya oblast:

- Volgogradskaya SDPP;
- Volgogradskaya TEP-2;
- Volgogradskaya TEP-3;
- Volzhskaya TEP-1;
- Volzhskaya TEP-2.

None of the above power plants uses coal as a fuel, they use gas or fuel oil as a reserve fuel. In 1980s, mercury-containing instruments were used at Volgogradskaya SDPP, but now they are not used any more.

## Krasnodar TEPs

[34] 28.12.2006: Chelyabinskaya oblast Directorate of the RF Technical Supervision Service, www.gosnadzor.ru

**Krasnodarskaya TEP**

Address: 350021, Krasnodar, 13 Tramvainaya St.
phone: (8612) 37-13-14 fax: (8612) 37-16-47
Director: Proskurchenko Vladimir Nikovaevich

Krasnodarskaya TEP operates in Krasnodar (the Southern Federal District) as a power plant of "Lukoil-Kubanenergo" Co. (fully owned by "Lukoil" Co.). "Lukoil-Kubanenergo" Co. was established in 2009, in the course of reorganisation of "TGK-8". The company maintains electric and heat generating capacity in Krasnodarskiy Krai and the Republic of Adygeya[35].

Generating capacity of Krasnodarskaya TEP: 1 million kW.

At the initial stage of operation of the TEP, coal was used as the main type of fuel. To dispose off coal slag and ash, the ash dump was constructed at the distance of 2 km from the TEP site. The dump was operational up to 1961, later on the TEP switched to use of gas fuel.

Fuel types: gas, fuel oil, coal (only as a reserve fuel)[36].

Coal is supplied from Donetskiy coalfields[37]. Average mercury contents in the coal reaches 0.094 mg/kg[38].

L.A.Medvedev, the Director General of "Lukoil-Kubanenergo" Co. informed us that "mercury-containing raw materials are not used for generation of electric and heat energy, there are no sources of generation of mercury-containing waste". Burnt fluorescent bulbs represent the main mercury-containing waste materials of "Lukoil-Kubanenergo" Co. facilities. Such waste materials are stored in pressurised containers. After accumulation of a substantial batch, the company transfers the waste to a waste-processing company with a license to utilise mercury-containing waste.

Now, "Lukoil" Co. implements the largest investment project in the Southern Federal District at the site of Krasnodarskaya TEP - construction of a new exhaust-fired generator unit with electric power capacity of 410 MW and heat energy capacity of 220 Gcal/hour. Now, the company has completed construction of foundations for main installations, enclosing metal constructions and the framework of the heat recovery boiler are being assembled. As scheduled, construction works and commissioning of the new unit in Krasnodar will be completed in 2011[39].

**Irkutsk TEPs**

"Irkutskenergo" Co. Ltd.

Address: 664025, Irkutsk, 3 Sukhe-Batora St.
phone: (395-2) 790-300
fax: (395-2) 790-899
http://www.irkutskenergo.ru/

Executive director: E.A. Novikov

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35 www.ebrd.com/projects/eias/38714infor.pdf
36 http://www.e-m.ru/app/2008-03/23524/
37 http://geo.1september.ru/articlef.php?ID=200500109
38 Emissions of mercury from coal fired power plants in Russia - preliminary estimated for ACAP. Munthe J.; Wängberg I.; Chugaeva A.N.; Kiseleva N.V.; Smigol I.N.; Bragina O.N., Anichkov S.N.; Tumanovsky A.G. .IVL Swedish Environmental Research Institute, Sweden and VTI All Russia Thermal Engineering Institute, 2003.
39 http://www.yuga.ru/news/184435/

"Irkutskenergo" Co. incorporates major generating and coal mining facilities and operates in Irkutskaya oblast and Krasnoyarskiy Krai. The company operates a cascade of three hydroelectric plants at the Angara river, **9** thermoelectric clusters in major cities of Irkutskaya oblast, 6 coal mines under control of "Vostsibugol" Co. that produces coal and lignite, 2 cargo handling facilities and 1 coal clarification plant.

The overall installed generation capacity of the company reaches 12.9 GW of electric power (including over 9 GW of hydroelectric generation capacity) and 13.0 Gcal/hour of heat energy. In terms of capacity and production, the company's generating facilities are able to generate more than 70 billion kWh of electric power and up to 46 million Gcal of heat energy.

In 2005, "Irkutskenergo" Co. completed the project of integration of Novo-Irkutskaya TEP, TEP-5 in Shelekhov and Irkutsk Heating Networks. The project implementation resulted in expansion of Novo-Irkutskaya TEP, that incorporated newly established Shelekhovskiy cluster and heating networks. Now, Novo-Irkutskaya TEP is a major power supply cluster, operating 11 district heating facilities (in Irkutsk and Shelekhov), as well as 413.398 km of Irkutsk heating networks with associated pumping stations and boilers.

**Novo-Irkutskaya TEP**

Address: 664043, Irkutslkaya oblast, Irkutsk, 67 Ryabikova Blv.
phone: (3952) 795-309, 305-125. fax: (3952) 79-53-88, 30-51-33
E-mail: post@nitec.irkutskenergo.ru
Director: Nikolaev Viktor Vladimirovich

Novo-Irkutskaya TEP is the main source of heat energy for the centralised heating system of Irkutsk and supplies electric power to the Siberian power supply system.

In the course of construction works and expansion of the TEP, several modern generation units were installed:

- Boiler BKZ-500-140-1 at generator unit # 5 - the first industrial boiler of a new series of drum boilers (it was used for testing of technical solutions to design high-capacity lignite-fired boilers for Siberian power plants), the boiler was commissioned in 1985;
- Boiler BKZ-820-140-1 at generator unit # 8 - the largest (and the only) drum boiler in Russia equipped by annular furnace for lignite burning, commissioned in 2003;
- Steam turbine T-175/210-130 at generation unit # 3 - the first in a series of high-load turbines of domestic design, commissioned in 1979.

Now, the power plant operates 8 generating boilers with overall steam production of 4000 tons/hour and 5 extraction turbines.

- Installed electric power generating capacity: 655 MW.
- Installed heat energy generating capacity: 1850.4 Gcal/hour.

The power plant has some reserves for further expansion and capacity growth.

**Table 2.9**

The TEP was designed to use lignite of Eastern Siberia coalfield. According to available data, average mercury contents in lignite of Irkutsk coalfields reach:[40]

| **Average mercury contents in marketable coal of coal producers in the Republic of Buriatia** |
|---|

[40] Valuable and Toxic Elements in Marketable Russian Coal: A Reference Book. M.: Nedra, 1996. 238 p. (Rosugol Russian State Company; The Russian Committee on Geology and Use of Mineral Resources). (Rus.)

| Coalfields, deposits, mining facilities | Coal grades | Ash content Ad, % | Moisture content Wr t, % | Hg in coal, g/t |
|---|---|---|---|---|
| Gusinoozerskaoye, Gusinoozerskaya mine | 3B R | 26.9* | 20.0** | 0.005 |
| Kholbodzinskiy open cast mine | 3B R | 24.8* | 25** | 0.006 |
| Sanginskoye deposit. Sanginskiy open cast mine | 3B R | 23.0* | 23.0?? | 0.015 |

**Table 2.10**

Average mercury contents in marketable coal of coal producers in Chitinskaya oblast

| Coalfields, deposits, mining facilities | Coal grades | Ash content Ad, % | Moisture content Wr t, % | Hg in coal, g/t |
|---|---|---|---|---|
| Tarbagaiskoye deposit, Tigninskiy open cast mine | B R | 17.8* | 30-31** | 0.012 |
| Bukachachinskoye deposit, Bukachacha mine | G R | 18.4* | | 0.007 |
| Kharanoiskoye deposit, Kharanoiskiy open cast mine | 2B R | 17.3* | 40** | 0.02 |
| Tataurovskoye deposit, Vostochnoy open cast mine | 2B R | 14.5* | 32-34** | 0.006 |

**Magadanskaya TEP**

Address: 685021, Magadan, 25 Rechnaya St.
phone: +7(4132)620781
Director: Zausaiev Sergey Aleksandrovich

Magadanskaya TEP of "Magadanevnergo" Co. Ltd. still is the only source of heat energy supply in Magadan. Installed generating capacity: 96 MW (electric power), 210 Gcal/hour (heat energy).

Magadan belongs to cities with extremely high air pollution levels[41] . Magadanskaya TEP is one of the heaviest air polluters in the city, its pollution emissions contribute 63% to overall emissions of the city industrial facilities and 14% of overall emissions of industrial facilities of Magadanskaya oblast[42].

The key problem of Magadanskaya TEP is associated with its deterioration of its heating pipelines - as a result, the TEP cannot utilise its full capacity. In 2008, funds of the Program for Development of the Russian Far East and the Trans-Baikal region allowed to repair 1 km of heating pipelines from their overall length of 11 km.

Magadanskaya TEP uses coal fuel - the coal is supplied from Kuzbass coalfields (Kemerovskaya oblast)[43].

[41] http://www.mnr.gov.ru/part/?act=more&id=6454&pid=11
[42] http://www.vnagaevo.ru/node/1242
[43] http://severdv.ru/news/show/?id=30764&rubrics[19]=1&rubrics[20]=1&r=19&sec=20&order=d&p=5

Weighted average mercury contents in Russian coal are estimated at the level of 0.08 mg/kg - the latter figure substantially depends on mercury contents in coal from Kuzbass coalfields in Kemerovskaya oblast (the key source of marketable coal), as Kuzbass coal contributes about a half of all mercury contents into the overall amount of mercury extraction with coal in Russia.[44]

Average mercury contents in Kuzbass coal are shown in the Table below.[45]

**Table 2.11**

| Coalfields, deposits, mining facilities | Coal grades | Ash content Ad, % | Moisture content Wr t, % | Hg in coal, g/t |
|---|---|---|---|---|
| Kuznetskaya mine | G coke | 18.2 | 8.2 | 0.01 |
| Novosergeevskiy open cast mine | SS | 8.2 | 5.2 | 0.01 |
| Cherkassovskaya mine | K | 17.4 | 6.2 | 0.01 |
| Shushtalepskaya mine | T | 23.5 | 8.2 | 0.01 |
| Tom-Usinskiy, Krasnogorskiy open cast mine | T | 18.9 | 5.9 | 0.01 |
| Kalinina mine | K, KO, KS, SS | 22.1 | 5.3 | 0.02 |
| Ziminka mine | K, KO, KS | 15.1 | 6.7 | 0.02 |
| Biryulinskaya mine | K, KO | 32.2 | 7.4 | 0.03 |
| Yuzhnaya mine | SS | 14.5 | 7.2 | 0.03 |
| Tyrganskaya mine | SS | 10.4 | 6.5 | 0.03 |
| Baidayevskiy, Bolshevik mine | G coke | 13.1 | 7.1 | 0.03 |
| Novokuznetskaya mine | G coke, GJ | 14.9 | 7.1 | 0.03 |
| Kolmogorovskiy open cast mine, section Kolmogorovskiy 1 | D, G en. | 13 | 16.8 | 0.03 |
| Zarechnaya mine | G en. | 13.1 | 11 | 0.03 |
| Prokipievsko-Kiselevskiy, Krasnobrodskiy open cast mine | T | 10.5 | 4.7 | 0.03 |
| Kolmogorovskiy-2 open cast mine | D | 15.5 | 17.1 | 0.03 |
| Aralichevskiy, Ordzhonikidze mine | T | 27 | 6.5 | 0.03 |
| Kondomskiy, Severniy Kandysh mine | T | 24.2 | 5.9 | 0.04 |
| Vysokaya mine | J | 32.5 | 5.9 | 0.04 |
| Prokipievsko-Kiselevskiy, Prokopievskoye, Tsentralnaya mine | T | 16.6 | 5.5 | 0.05 |
| Prokopievskiy open cast mine | SS | 8.3 | 8.7 | 0.05 |
| Zyryanovskaya mine | G coke, GJ | 23.5 | 7.6 | 0.05 |
| Leninskiy, Signal mine | G en. | 13.9 | 1.4 | 0.05 |
| Alarda mine | K, KO, KS | 19.1 | 7 | 0.05 |
| Tersinskiy, Baidaevskiy open cast mine | DG, G en. | 16.2 | 9.6 | 0.05 |
| Belovskiy, Kolmogorskaya mine | DG, G en. | 13.1 | 8.7 | 0.05 |
| Berezonskaya mine | K | 26.1 | 5.4 | 0.06 |
| Dimitrova mine | T | 21.2 | 6.7 | 0.06 |
| Kemerovskiy, Volkova mine | GJ | 26.5 | 7.5 | 0.08 |
| Kedrovskiy open cast mine | SS | 13.1 | 8.7 | 0.08 |
| Anzherskiy, Sudzhenskaya mine | TS | 18.1 | 2.3 | 0.08 |
| Kolchuginskoye mine cluster | D | 17.8 | 8.6 | 0.08 |
| Osinovskiy, Kapitalnaya mine | J | 27.9 | 5.9 | 0.08 |
| 7 Noyabrya mine | G coke | 14.5 | 8.4 | 0.1 |
| Shevyakova mine | K, KO, KS, OS | 29.5 | 8.1 | 0.1 |

[44] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[45] Valuable and Toxic Elements in Marketable Russian Coal: A Reference Book. M.: Nedra, 1996. 238 p. (Rosugol Russian State Company; The Russian Committee on Geology and Use of Mineral Resources). (Rus.).

| | | | | |
|---|---|---|---|---|
| Raspadskaya mine | GJ | 19.4 | 5.6 | 0.2 |
| Olzherasskiy open cast mine | SS | 22.5 | 6.4 | 0.3 |
| Mrasskiy, Mezhduirechenskiy open cast mine | K, KO, T | 18.4 | 4.2 | 0.5 |
| Kaltanskiy open cast mine | T | 19.8 | 7.6 | 0.6 |
| Tomusinskiy open cast mine | OS | 17.8 | 5.1 | 0.6 |

*Note*. Kuzbass coalfields are the largest source of coal for production of coke and by-products, as well as for power industry; in terms of coal reserves the coalfields are the largest in the country, coke-grade coal is particularly important (about a half of the overall coal production).

## Chapter 3

### Chlorine-alkali production in Russia

In response to request of the Mercury Ad Hoc Open-ended WG, UNEP produced a report with assessment of prospects of meeting foreseen mercury demand in the case of phase-out of primary mercury mining[46]. The Table below shows mercury consumption in chlorine-alkali production in 2005, and forecasts of future mercury consumption up to 2015. The report describes two scenarios. The first scenario stipulates maximal future consumption and reflects contemporary trends, legislation and limited initiatives. The second scenario stipulates lower mercury consumption for production of mercury-containing products. To a some extent, the actual situation will depend on introduction of more progressive measures, such as new political initiatives, dedicated financing and other incentives that have not been confirmed yet.

**Table 3.1**

Mercury consumption in chlorine-alkali production

| Sphere of application | Consumption range in 2005 (tons) | Conservative "status quo" scenario up to 2015 |
|---|---|---|
| **Chlorine-alkali production** | 450 - 550 | reduction by 30% |

According to the report, in addition to primary mercury extraction, there are some other mercury sources, that are usually utilised to meet mercury demand. The most substantial source is associated with mercury recovery from chlorine electrolysers. These electrolysers contain substantial amounts of mercury, necessary for their operation. Mercury is recovered from the electrolysers in the course of decommissioning works or after switch to mercury-free technologies.

According to data of the report, main sources of mercury include primary extraction and mercury recovery from chlorine-alkali electrolysers. In 2005, from 700 to 900 metric tons of mercury were recovered, while primary mercury extraction reached from 1150 to 1500 metric tons.

Chlorine-alkali production still remains the key sphere of mercury application in Russia (mercury is uses as liquid electrode material in the production process). In 2002, mercury consumption for these purposes reached about 103 tons, however, its consumption in the sector varies in different years, and in some years it may increase. In addition, about 7.5 tons of mercury (as mercury chloride) were used as a

[46] Report on Current Mercury Supply and Demand, Including Forecasts of Phase-out of Primary Mercury Extraction. Meeting Future Mercury Demand without Primary Mercury Extraction - the report produced in response to request of Mercury Open-ended WG, 14.07.2008, http://www.chem.unep.ch/mercury/OEWG2/documents/f6)/Russian/OEWG_2_%206_r.doc

catalyser for production of vinyl chloride monomer (for PVC production). In the both cases, mercury is used as a process chemical and only a minor part of mercury comes to final products[47].

Mercury emissions from chlorine-alkali production in Russia are assessed as follows:

**Table 3.2**

Mercury emissions from chlorine-alkali production in Russia

| Activity categories | Mercury emissions | | |
|---|---|---|---|
| | The optimal estimate, tons/year | % of the total amount | Uncertainty categories**** |
| Purposeful use of mercury | | | |
| Chlorine-alkaline production | 1.2*** | 3.0 | 3.0 |

*** Direct emissions in the course of technological processes. Certain amounts of mercury may be released to air as so called unaccounted losses (in 2002, these losses were estimated as 50 tons).
**** Uncertainty categories: A: according to actual facilities' data - uncertainly is associated with unaccounted losses; B: expert assessments - the actual value will most likely belong to the range of ± 50% around the most accurate assessment; C: expert estimates - the actual value may substantially exceed the range of ± 50% around the most accurate estimate.

Mercury emissions from production of chlorine and caustic soda in 2002 were estimated at the level of 1.2 ton (direct pollutant emissions with ventilation exhaust and flue gases).

Authors of the assessment[48], from the outset assumed that unaccounted losses of mercury in chlorine-alkali production of Russia exceed 50 tons, and that mercury predominantly concentrates in constructions, soils on facilities' sites and within nearby territories. Assessments of mercury emissions of chlorine-alkaline facilities meet data of environmental reporting of these facilities and data of the official mercury inventories. Precise amounts of mercury emissions due to unaccounted losses are unknown.

About a half of chlorine in the Russian Federation was produced with application of mercury electrodes, while the rest was produced with application of diaphragm electrolysers[49]. Now, there are four operational chlorine-alkaline production facilities in Russia:

- "Kaustik" Co., Sterlitamak, the Republic of Bashkortostan (since 1977);
- "Kaustik" Co., Volgograd, Volgogradskaya oblast (since 1968);
- "Kirovo-Chepetskiy Chemical Plant" Co. , Kirovo-Chepetsk, Kirovskaya oblast (since 1955),
- "Sayanskhimplast" Co., Sayansk, Irkutskaya oblast (since 1979).

In this survey, data are provided for "Kaustik" Co. (Volgograd, Volgogradskaya oblast) and "Sayanskhimplast" Co. (Sayansk, Irkutskaya oblast).

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[47] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation, http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/Udgiv/publications/2005/87-7614-541-7/html/kap06_rus.htm
[48] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation, http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/Udgiv/publications/2005/87-7614-541-7/html/kap06_rus.htm
[49] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

**"Kaustik" Co.**

Russia, 400097, Volgograd, 57 "40 Let VLKSM" St.
The Director General of the Superior Company: Azizov Eldor Englenovich
phone: 40-69-90
The Chief Engineer of "Kaustik" Co.: Sergeev Sergei Aleksandrovich
phone: 40-69-80.

Mainstream production activities: production of chlorine, caustic soda, hydrochloric acid and diverse chemical products.

At Volgograd facility of "Kaustik" Co. mercury-based production of chlorine was launched in 1968, while in 1984 diaphragm electrolysers were put into operation. Now, the both production lines are operational.

**Products of chlorine-alkali production facilities**
Liquid chlorine in tanks
Liquid chlorine in cylinders
Liquid chlorine in containers
Sodium hydroxide technical grade RD
Sodium hydroxide purified grade RR
Granulated sodium hydroxide technical grade 99%
Reagents: sodium hydroxide
Hydrochloric acid synthetic
Hydrochloric acid (recovered)
Hydrochloric acid (inhibited)
Hydrochloric acid reagent grade (Ch)
Sodium hypochlorite A grade

**Table 3.3**
Production of "Kaustik" Co. in 2005 - 2006.

| Products | 2005 (thousand tons) | 2006 (thousand tons) | shares in 2005 (%) | shares in 2006 (%) |
|---|---|---|---|---|
| sodium hydroxide (solution) | 210 | 216 | 18 | 18 |
| sodium hydroxide solid | 67504 | 63510 | 62 | 60 |

**Technology of electrolysis with liquid mercury cathode**

Main technological process: electrolysis in an electrolytic cell with liquid mercury cathode, connected to a decomposition tank. Mercury circulates in the cell and the decomposition tank (forced circulation by a mercury pump). Graphite or low-wear anodes are used in the process. Anolite (sodium chloride solution) also circulates in the unit. Anode process: electrochemical oxidation of $Cl^-$ ions with release of gaseous chlorine:

$$\mathbf{2\,Cl^- - 2\mathit{e} = Cl_2^0\uparrow,}$$

Chlorine is removed from the unit.

Cathode process: electrochemical reduction of sodium ions to metal sodium, that dissolves in liquid mercury, forming a weak sodium amalgam:

$$Na^{+} + e + Hg = Na^{0}(Hg)$$

Sodium amalgam flows to the decomposition tank with purified water. In the decomposition tank dissolved sodium spontaneously reacts with water with formation of sodium hydroxide and hydrogen:

$$Na(Hg) + H_2O = NaOH + ½H_2\uparrow + Hg$$

The caustic soda solution obtained in the process is a marketable product - it does not contain sodium chloride (presence of the latter compound adversely affects viscose production processes). After almost complete removal of dissolved sodium, mercury is again returned to the electrolyser. Hydrogen is removed and purified. Anolite solution from the electrolyser is enriched by sodium chloride, purified from impurities (the impurities from raw sodium chloride and products of decomposition of anodes and other materials) and returned to the electrolytic cell. Prior to adding new sodium chloride to the anolite, it undergoes two-stage or three-stage removal of dissolved chlorine.

**Mercury-containing inputs**

Metal mercury is supplied in cylinders (4.1 tons/year).

**Mercury releases**

According to the material balance scheme, mercury is released with:

- with caustic soda;
- with hydrogen;
- with sulphuric acid;
- with wastewater, including wastewater flows from washing and steaming of production equipment in the course of preparatory, inspection and repair works;
- with anolite sludge;
- with gaseous emissions;
- with mechanical losses in the technological cycle.

**Unaccounted (or, more likely, unorganised) sources of mercury releases to the environment**

The chlorine-alkali shop (mercury-based process): production of caustic soda, liquid chlorine and synthetic hydrochloric acid:

a) the facility for incineration of mercury-containing waste and lamps in induction furnaces

- the unit for filling of mercury cylinders;
- the unit for uploading of ash from induction furnaces;
- induction furnaces: in 2009, one absorber was excluded from the two-tier emission control system - absorber + absorber + two SKD TsN cyclone filters - without any substantiation (the absorber is installed but switched off)/ As a result, the system is overloaded and operates with lower efficiency.
- the unit for discharge of mercury-containing wastewater from the collector tank to trucks;
- emissions in the course of all-seasons storage of mercury-containing sludges in containers at an uncovered storage place.

b) the building of caustic soda production shop:

- unorganised emissions from the electrolyser unit through windows and doors in the course of normal technological operations of the unit, in the course of steaming and inspection of electrolysers prior to scheduled maintenance/repair works;
- unorganised emissions from open chutes for discharge of mercury-containing wastewater;

- in the absorber unit - in the course of replacement of KhPR-3 activated charcoal sorbent - these operations are conducted every 18 months instead of 6 months as required.

c) the building of electrolyser repair unit

d) the unit for collection of mercury-containing wastewater:
- unorganised releases in the course of discharge of mercury-containing wastewater from trucks to the collector;
- permanent unorganised releases from the collector of mercury-containing wastewater through its unpressurised cover;
- unorganised releases in the course of periodical works in the collector (cleaning and inspection).

According to the inventory results, overall, the facility releases **0.689 ton of mercury**. The figure includes **0.616 ton of untreated mercury emissions in the course of launching electrolyses in shop # 6**.

"Kaustik" Co. developed the Draft Waste Generation and Disposal Limits document, that was approved (20.02.2007) by the Russian Technical Supervision Agency.

According to the draft, the overall annual waste generation by the facility is estimated to reach 117,730. 622 thousand $m^3$, including:
1st hazard class - 341.978
2nd hazard class - 23,148.522

**Table 3.4**

Mercury-containing waste:

| | |
|---|---|
| Mercury-containing waste (***used activated charcoal***) | 3531070002011 |
| Mercury-containing waste (***mercury-containing sludge***) | 3531070002011 |

In 2009, in the course of inspection works, at the distance of 25 to the East from facility building 3-16, barrels and drums (0.7 $m^3$) with mercury-containing waste and sludge of the wastewater treatment unit were found on the bare ground - these barrels and drums cover area of about 200 $m^2$.

These barrels and drums are completely filled by mercury-containing waste and sludge and are stored on the bare ground without any protective covers or soil lining (107 barrels contain about 70.0 tons of waste - 650 kg in a barrel).

As a result, in warm seasons, mercury vapour releases from the dump cause over-standard mercury pollution of the ambient air.

## Mercury emissions control

Facility's practice of sampling air pollutants at emission sources does not comply to the Manual for Sampling of Pollutants in Emissions of Industrial Facilities of 1987 (lack of equipped control sampling points for air emissions).

The facility only controls emissions of gas/particulates control units, emissions of other fixed sources are not controlled and relevant sampling points are not equipped. (Reliability of results of the emissions inventory at fixed sources, that were obtained by direct measurements, seems questionable ( *the inventory suggests that emissions of some pollution sources were measured directly*), as there were no sampling points equipped, e.g. in shop # 6 (mercury-based production of caustic soda, liquid chlorine and synthetic hydrochloric acid):

- building # 14-16 - adsorber exhaust (removal of mercury vapour) - samples were taken through a blowing airhose instead of direct sampling from the source;
- building # 14-16 - emission source V - 1 - a sampling hole does not exist (the inventory suggests that the source emissions are measured directly).

The facility does not measure input/output gas flows of gas/particulates control units - as a result, it is impossible to estimate actual emissions at the emission sources quantitatively.

According to results of quantitative analysis of ambient air samples, collected on 11. 09.2009 on section #2 (so called "dirty section at the distance of 10 km SW from "Kaustik" Co. collector pond, mercury levels were found to exceed the relevant MAC of 1.2 folds (Hg level of 0.00032 mg/m$^3$ was registered at MAC of 0.0003 mg/m$^3$). The analysis results confirm that mercury in wastewater flows channelled to section # 2 (analysis suggests Hg levels in water of 0.14 mg/m$^3$) causes mercury emissions from the latter fixed source.

Mercury emissions were calculated according to the Methodology for Estimation of Air Concentrations of Hazardous Substances from Industrial Emission Sources (OND-86, the All-Union Standard, approved by the State Committee for Hydrometeorology in 1986 and agreed by the Public Health Ministry), the Manual on Setting Discharge (Emission) Limits (approved in 1989), Recommendations on Compiling and Maintenance of Emission Limits for Industrial Facilities (issued in 1989), and the Methodology for Estimation of Discharge Limits for Substances with Wastewater Flows (recommended in 1991).

The facility uses the following instruments for quantitative analysis of emissions:
- RA-915 atomic adsorption spectrometer;
- Yulia-5 atomic adsorption spectrometer.

**"Plascard" Co. Ltd.**

Russia, 400097, Volgograd, 57a "40 Let VLKSM" St.
Director General: Kleibanov Mikhail Semenovich
The Chief Engineer: Kravtsov Sergey Mikhailovich, phone 40-67-79

Mainstream production: industrial-scale production of vinyl chloride (VCM) and suspension polyvinylchloride (PVC-S) - PVC-S-7059M, PVC-S-7058M, PVC-S-7058MTS, PVC-S-6768M, PVC-S-6358M, PVC-S-5868PJ, PVC-S-6149U, PVC-S-6669JS and other chemical products.

**Production capacity**

Annual rated production of the facility: 90,000 tons of PVC-S. In 2008, the facility reached record production output levels - 93,793 tons of PVC-SD and 96,279 tons of VCM.

**Production technology**

**Catalytic hydrochlorination of acetylene** (acetylene is produced from calcium carbide).

Chemistry of the production process:
- Acetylene production:

$$\mathbf{CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2}$$

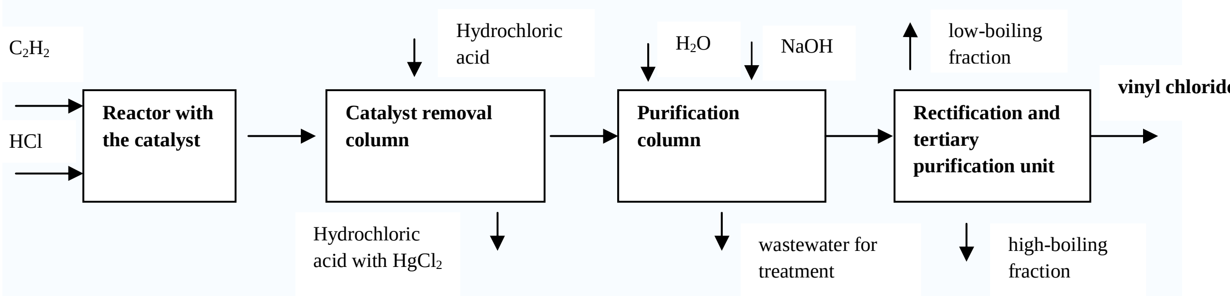
- Hydrochlorination of acetylene:

$$\mathbf{C_2H_2 + HCl \xrightarrow{HgCl_2} CH_2{=}CHCl}$$

**Brief outline of the technology:**

Cleaned and dried acetylene (with max. moisture content of 1.5 g/m³) is mixed with dry cleaned hydrogen chloride in ratio of about 1.0:1.1. The gaseous mixture is supplied to the upper part of a tubular reactor, filled with the catalyst (activated charcoal, impregnated by mercury dichloride $HgCl_2$ (10-15 %). The reactor is made of carbon steel (tube length: 3 - 6 metres, diameter: 50 - 80 m). Temperature in the reaction zone is maintained at the level of 150 - 180°C. Gases from the reactor come to a special spray column with hydrochloric acid for removal of mercury dichloride. From the first spray column reaction gases come to the second splay column for treatment by water and alkaline solution for removal of hydrogen chloride, acetaldehyde and carbon dioxide. Then the reaction gases are cooled in the condenser for removal of water and come to the rectification stage for removal of high-boiling impurities. At the final stage, vinyl chloride goes through a column with solid sodium hydroxide for final drying and neutralisation of acidic compounds.

See the production chart below:




In addition to its economic shortcomings, the method of catalytic hydrochlorination of acetylene is environmentally hazardous, as notwithstanding mercury recirculation in the process, it inevitably releases to the environment with production emissions and discharges. In 2002, such releases in Russia reached about 31 kg.

In the period from 2003 to 2008, the above technology attracted new interest due to substantial growth of global oil and gas prices, however, the economic crisis of 2008 made direct oxychlorination of ethylene the most economically attractive option again.

**Mercury-containing production inputs**

Mercury is used in the production process as a catalyser - activated charcoal, impregnated by mercury dichloride $HgCl_2$ (10-15 %)

**Mercury emissions and discharges**

Mercury in the facility may escape with:

- hydrochloric acid after the column for removal of the catalyst.
- with wastewater after washing and steaming of production equipment in the course of - preparatory, inspection and repair works.

According to the draft waste generation and disposal limits (WGL) "Plaskard" Co. was issued waste disposal permit (reg. # RRS 39 02695-ot of 26.09.2007). The WGL was later extended up to 26.09.2009.

According to the draft WGL, the overall annual generation of waste at the facility reaches 19185.56 tons, including:

- 1st hazard class - 0.982 tons;
- 2nd hazard class - 524.63 tons;
- 3rd hazard class - 13902.196 tons;
- 4th hazard class - 4322.566 tons;
- 5th hazard class - 435.186 tons.

**Table 3.5**

| **Waste types** | **Estimated waste generation rates according to technical regulations (per 1 tons of VC), tons** | | **Estimated waste generation rates according to WGL (per 1 ton of VC), tons** |
|---|---|---|---|
| | ***Design*** | ***Actual*** | |
| VC rectification residues | 0.025344 | 0.00836 | 0.010 |
| DCE rectification residues | 0.01452 | 0.03757 | 0.043 |
| Tar and soot (coke powder in WGL) | | 0.018 | 0.043 |

According to **hazardous waste form 314 801 00 09 01 3 used granulated catalyst** is classified as 3rd hazard class waste.

There are no hazard class assessments and results of components' analysis for the above type of waste - in such a case its hazard class should be assessed by bio-tests. For the time of compiling the hazardous waste form, no protocols of bio-testing for the waste were available.

According to available analytical data, mercury dichloride contents in the used catalyst are over 10%. Therefore, for purposes of hazard class assessment, the maximal possible concentration for the given type of waste should be used.

In 2009, representatives of the Centre of Laboratory Analysis and Technical Measurements (CLA) and the facility collected the following samples:

- # 1 (SB1) - used activated charcoal, contaminated by hazardous substances (granulated used catalyst); sampling point: building 12, the used catalyst storage facility;
- - # 5 (PP-3) - used activated charcoal, contaminated by hazardous substances (granulated used catalyst); sampling point: building 12, the used catalyst storage facility.

Quantitative analysis of sample PP-3 revealed 2.8150% of mercury and 0.4352% of iron. As quantitative analysis of the sample did not allow to identify all components of the sample, and the waste contains mercury in different forms (metal mercury , monovalent and bivalent mercury compounds) CLA specialists estimated hazard class of the waste by bio-testing and issued their decision on classification of the waste as ***1 (first)*** hazard class waste.

***At the same time, estimates with application of INTEGRAL 2001-2003 software suggest 2 (second) hazard class of the waste at $HgCl_2$ level of 10%.***

***Besides that, the name of the waste does not reveal that it contains mercury - i.e. a substance of 1st hazard class (extremely hazardous substance according to standard GOST 12.1.007-76 - "Hazardous substances").***

As the hazard class was determined by two methods (calculations and experiments), according to clause 1.5.2 of the Methodological Manual on Application of the Criteria of Categorisation of Hazardous Waste by Environmental Hazard Classes the most high hazard class should be selected. In other words, "used activated charcoal, contaminated by hazardous substances (used granulated catalyst)" should be categorised as waste of 1st environmental hazard class.

**Table 3.6**

Used granulated catalyst

| Waste composition according to approved technical regulations (according to a material balance) | | Waste composition according to draft WGL (table "Physical, chemical properties and composition of the waste") | | Waste composition according to the hazardous waste form | |
|---|---|---|---|---|---|
| Name | Mass concentration of the component (%) | Name | Mass concentration of the component (%) | Name | Mass concentration of the component (%) |
| Mass concentration of mercury and mercury salts | 3-5 % | Granulated catalyst | variable | Activated charcoal ($K_2CO_3$) | 89,3 |
| | | | | Water | 3 |
| | | | | Mercury dichloride | 7 |
| | | | | TOTAL | 99.3 |

**"Khimprom" Co.**

Russia, 400057, Volgograd, 23 Promyslovaya St.
Deputy Director General - Radkovskiy Grigoriy Yakovlevich, phone: 45-88-05

Mainstream production - technical chemical products (inorganic and organochlorine compounds, plastics, plasticisers, solvents, halocarbons, flame retardants), consumer goods, including surfactants, insecticides, disinfectants, car cosmetics, etc.

**Products:**

benzoic acid anhydride, benzyl acetate, benzyl chloride, glycine, dimethylphosphite, diphenylcrezolephosphate, calcium carbide, hydroxyethylydenediphosponic acid, chloroacetic acid, phosphoric acid, HP-734 lacquer, HSP-L lacquer, metylenedichloride, methylchloride, sodium phosphate, sodium chlorate, flexible PVC, plasticisers, polyethylene, chlorosulphonated polyethylene, lesterol, caustic soda (diaphragm process), benzoic alcohol, thibutylphosphate, trichloroethylene, carbon tetrachloride, phosphorous oxychloride, phosphorous trichloride, chloroform, chlorinated paraffins, zinc chloride

**Table 3.7**

Production levels

| Products | 2005 (th. tons) | 2006 (th. tons) | 2008 (th. tons) | 2009 (th. tons) |
|---|---|---|---|---|
| caustic soda solution | 87 | 90 | no data available | no data available |
| caustic soda solid | 5768 | 7115 | no data available | no data available |
| VC | no data available | no data available | 21.7 | 22.7 |

**Outline scheme of VC production with a mercury catalyst:**

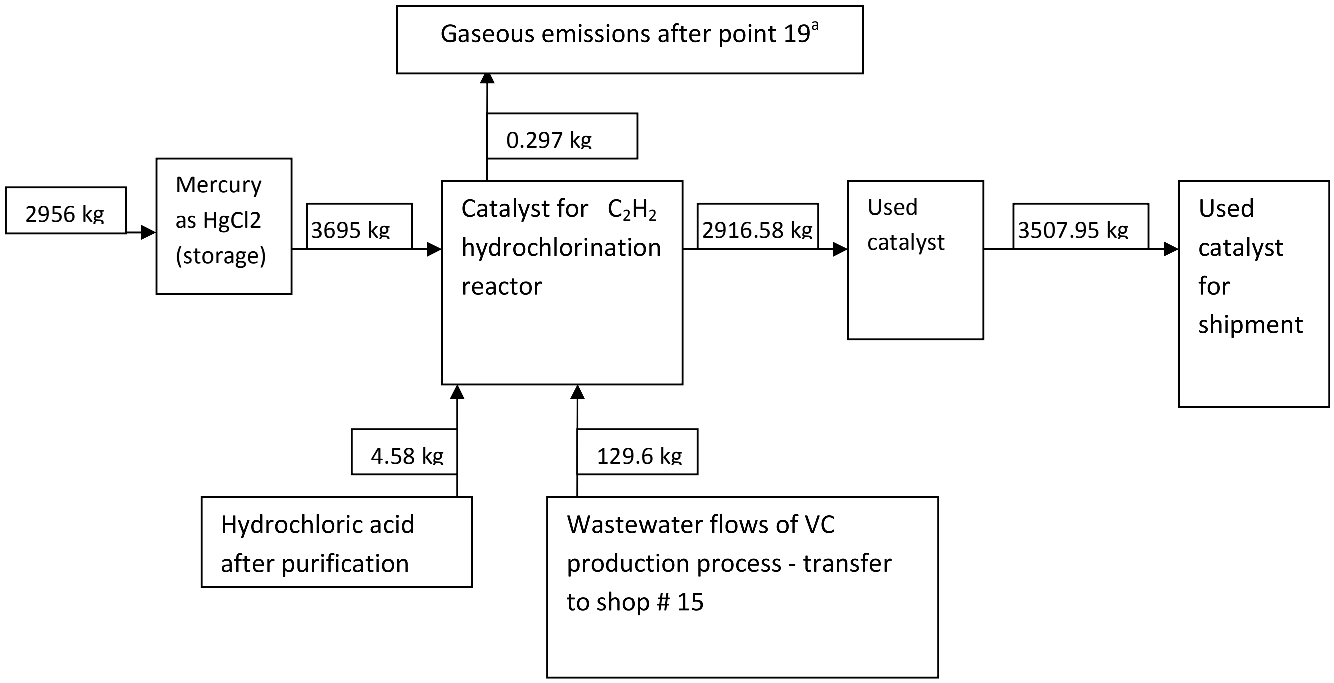



**Table 3.8**
Mercury-containing production inputs and outputs

| # | VC production process inputs | | # | VC production process outputs | |
|---|---|---|---|---|---|
| | **Mercury** | **Quantity (kg)** | | **Mercury** | **Quantity (kg)** |
| 1. | Residues on 01.01.2007 | 1182.4 | 1. | Used for production of the catalyst | 3695.00 |
| 2. | Supplied to shop # 43 in 2007. | 2956.0 | 2. | In gaseous emissions after point19a | 0.297 |
| 3. | Residues on 01.01.2008 | 443.4 | 3. | In hydrochloric acid after purification of the reaction gaseous mixture | 4.58 |
| 4. | Residues on 01.01.2007 in the catalyst for acetylene hydrochlorination reactor | 5413.17 | 4. | In wastewater channelled to shop # 15 | 129.6 |
| 5. | Residues on 01.01.2008 in the catalyst for acetylene hydrochlorination reactor | 6066.45 | 5. | Removed in 2007 from the VC production process in the used catalyst | 2916.58 |
| 6. | Residues on 01.01.2007 in the used catalyst | 1398.73 | 6. | Shipped for utilisation to "Kubantsvetmet" Co. facility | 3507.95 |
| 7. | Residues on 01.01.2008 in the used catalyst | 807.36 | | | |

**Table 3.9**

Potential sources of mercury emissions and discharges

| Source # | Emissions/discharges | Release sources |
|---|---|---|

| | | |
|---|---|---|
| | ($m^3$/hour) | |
| 1551/0688 | 14400 | Catalyst production section - bins, points 6a, 15a; sanitary column, point 36a (VU-21, 21a) |
| 1553/0690 | 3240 | Catalyst storage section (VU-24) |
| 1556/0653 | 1080 | Reactors, points.2a, 4a, 6a, 15a, 5a, 12a, 39a, 35a (sanitary column, point.36a) |
| 1560 | 1860 | Pumps, points.$19_{1,2}$ (VU-22, 22a) |
| 1561 | 20,52 | Circulation tank VVN $19_4$ (airflow) |

| Discharge sources | Discharges |
|---|---|
| Tank, point.37 | 5 $m^3$/day |

**Mercury emission control (methods, instruments):**

Photometry, the method for determination of mass concentrations of mercury dichloride in industrial emissions of "Khimprom" Co.

**"Sayanskhimplast" Co.**

**Address:** Irkutskaya oblast, Sayansk, the facility site
**phone:** 8(39553)455-40
**e-mail:** mail@sibvinyl.ru
**official web-site:** http://www.sibvinyl.ru
Director General: Melnik Nikolay Viktorovich

**Mainstream production activities:** production of chemical products, inc. PVC, caustic soda, flexible PVC, finished PVC products.

Main products:
- Suspension PVC (PVC-S) - S-7058 M, S-7059 M, SI 67, SSI 64.
- Flexible PVC for cable production - I 40-13 A (formulae 8/2), I 40-14 (formulae E-40-1), O-40, O-40 (formulae OM-40).
- Flexible PVC for footwear production - POSL-1, POSL-2, POSL-2P.
- Caustic soda (sodium hydroxide).
- "Belizna" bleacher.
- Wall panels with associated beams.
- Corrugated pipes.
- Cable chutes with accessories.
- Window frames fixtures.

The electrolysis section is equipped by SDM-200/7.5 electrolysers and vertical decomposition reactors. Overall, 96 electrolysers are installed with current load of 200 kA. In 1997, 34 electrolysers under current load of 140 kA were operational, while in 2002, 60 electrolysers were operational with current load of 160 kA[50].

Sodium chloride solution for the electrolysis is prepared by adding clean salt to the exhausted anolite solution with subsequent 2-stage filtering. Chlorine and caustic soda are produced from underground sodium chloride brine, after pre-purification and evaporation of water.

Some parts of equipment of the anolite cycle are made of carbon steel, with acid/alkali resistant coatings, while some pipelines are covered by rubber. Corrosion protection of the anolite cycle equipment is poor -

[50] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

as a result, it is impossible to ensure the necessary quality of the return anolite solution without complete removal of dissolved chlorine by sulphide treatment. The latter treatment causes mercury losses in brine sludge (as mercury sulphide) and adversely affects electrolysers, resulting in high mechanical losses of mercury vapour with ventilation exhaust.

Sludge from electrolysers and other mercury-containing sludge are used for thermal recovery of mercury.

In 1998 - 2002, some measures were implemented to reduce mercury losses, however, these measures were not of systemic nature and failed to improve the situation.

Estimates of mercury losses in 1997 and 2002 are shown below.

***Mercury losses in anolite filtration sludge***

Brine filtration sludge, containing mercury sulphide, is channelled to a specially equipped sludge collector pond, as well as other sulphide sludges from wastewater treatment installations. Volume of the collector: 223 thousand $m^3$ (area: 4.3 hectares, height: 9 m). Bottom of the pond in covered by PE lining, fixed by sand and gravel.

Mercury losses with anolite filtration sludge:
10,360 kg in 1997,
22,908 kg in 2002.

***Mercury losses with wastewater***

The overall amount of mercury-containing wastewater reached:
78,989 $m^3$ in 1997,
12,7690 $m^3$ in 2002.

Mercury levels in untreated wastewater varied from 15 to 20 $mg/dm^3$. The wastewater was treated by mercury sulphide sedimentation with further water evaporation. Treated wastewater with NaCl concentrations close to its levels in exhausted anolite, was returned to the anolite cycle, while the water condensate underwent adsorption (activated charcoal) treatment for removal of residual mercury.

Treated wastewater is returned to the production process (for washing of equipment and preparation of technological solutions). Excessive treated condensates are discharged to the storm sewer and - eventually - to Oka river.

Sulphide sludge from wastewater treatment operations is buried with sludges from brine treatment operations.

Mercury levels in treated wastewater that was discharged to surface water bodies reached 0.016 $mg/dm^3$ in 1997 and 0.0003 $mg/dm^3$ in 2002. Volumes of the condensate that was discharged to surface water bodies were not registered. Measured mercury level in the control cross-section of Oka river reached 0.00001 $mg/dm^3$.

Mercury losses with treated wastewater flows cannot be estimated, but accounting for the production technology applied and the treatment levels, such losses may be assumed to be minimal. There are no direct measurements of mercury losses at the stage of sulphide treatment, however the latter losses are likely accounted for as losses with sulphide sludge at the brine treatment stage.

***Mercury losses with ventilation exhaust***
The building where electrolysers are installed, is equipped by a plenum ventilation system with release of exhaust air through 22 m high aeration lanterns. Air intakes reached 2.48 million $m^3$/hour in 1997 and 0.68 million $m^3$/hour in 2002.

Average mercury levels in the indoor air varied in the following ranges:
from 0.027 to 0.033 $mg/m^3$ in 1997,
from 0.042 to 0.046 $mg/m^3$ in 2002.

Mercury losses with ventilation exhaust reached:
652 kg in 1997,
238 kg in 2002.

***Mercury losses with hydrogen***
The facility vents the bulk (~99%) of hydrogen it generates to the air (through 22 m high stack. The rest is used for production of hydrogen chloride. Hydrogen undergoes sorption treatment with application of HPR-3P activated charcoal.

Mercury levels in purified hydrogen reached 0.048 $mg/m^3$ in 1997 and 0.0024 $mg/m^3$ (at standard limit of 0.01 $mg/m^3$.

Overall mercury losses with hydrogen reached:
0.788 kg in 1997,
0.083 kg in 2002.

***Mercury losses with chlorine***
According to the facility, these losses are practically non-existent.

***Mercury losses with off-gases***
Off-gases undergo sorption treatment at HPR-3P activated charcoal to remove mercury and chlorine. After the sorption treatment, mercury levels in off-gases vary from 0.003 to 0.0049 $mg/m^3$ (at standard limit of 0.01 $mg/m^3$).

Mercury losses with off-gases reached:
0.181 kg in 1997,
0.032 kg in 2002.

***Mercury losses with caustic soda***
There are no available data on these losses. However, accounting for the fact that the system of filtration of caustic soda solutions at "Sayanskhimplast" Co. facility is similar to filtration systems of other facilities, the losses might be estimated at the base of annual production data.

Estimated mercury losses reached:
~ 0.08 kg in 1997,
~ 0.16 kg in 2002.

***Mechanical mercury losses***
Mercury purchased to fill electrolysers:
24,391 kg in 1997,
70,833.5 kg in 2002.

Mechanical losses of mercury, estimated as the difference between purchased amounts and registered losses, reached:
13,377 kg in 1997,
47,687 kg in 2002.

According to the facility data, after more than 20 years of its operations, about 800 - 1000 tons of mechanically lost mercury are accumulated in porous soils and constructions under the electrolysis shop.

***Mercury in production***

The facility's electrolysers contain 171 tons of mercury. There are not other mercury reserves at the facility's site. Mercury losses, including air emissions, mercury in sludge and mechanical mercury losses under the electrolysis shop, are shown in Table 3.10 [51].

**Table 3.10**

| Year | 1997 | | 2002 | |
|---|---|---|---|---|
| Caustic soda production (tons) | 51800 | | 121500 | |
| Mercury losses | absolute (t) | specific (kg/t NaOH) | absolute (t) | specific (kg/t NaOH) |
| - emissions with ventilation exhaust and off-gases | 0.653 | $1.26\ 10^{-2}$ | 0.238 | $1.96\ 10^{-3}$ |
| - waste burial (brine and wastewater treatment sludge) | 10.360 | 0.20 | 22.908 | 0.189 |
| - released in products | 0.031 | $5.98\ 10^{-4}$ | 0.080 | $6.6\ 10^{-4}$ |
| - mechanical losses in soils | 13.377 | 0.258 | 47.687 | 0.392 |
| - discharges to water bodies | no data available | | no data available | |
| TOTAL | 24.421 | 0.471 | 70.913 | 0.583 |

## Chapter 4

## Cement production

Extremely high depreciation of production equipment is a generally recognised "disease" of the Russian cement industry. As a result, at official production capacity of 50 operational Russian cement plants of 69.2 million tons, independent assessments suggest that now Russian plants can produce maximum 62.3 million tons of cement annually.

Another - equally serious - problem of the industry is associated with its high energy intensity. In recent years, growth rates in the cement sector were higher than in other basic industries. In 2002 - 2005, average growth rates in the cement industry reached 108.3%, comparatively to 105.2% in manufacturing and 104.7% in production of construction materials.

The cement industry grows more intensively than power industry, oil and gas, coal mining, chemical industry and metallurgy. These growth rates clearly demonstrate high economic capacity of the sector at the base of stable and growing demand[52].

Main environmental impacts of cement production are associated with the following factors[53]:

- Dust (stack emissions and volatile compounds);
- Gaseous emissions ($NO_x$, $SO_2$, $CO_2$, VOCs, etc.);
- Other releases (noise, vibrations, smell, technological water, production waste, etc.)
- Consumption of resources (energy, raw materials).

Gaseous emissions of cement kilns amount to the key environmental problem of cement production. Main gaseous pollutants include $NO_x$ and $SO_2$. In addition, cement kilns release VOCs (volatile organic compounds), CO, ammonia, HCl, and heavy metals, including mercury.

[51] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[52] http://www.beton.ru/library/2650/elem_225289/
[53] http://www.kcement.ru/ecology.html

**Cement production technologies in Russia**

Now, several different types of cement kilns are used: with preheating and preroasting (PHP), with preheating (PH), with long drying (LD), with application of dry, semi-wet and wet production technologies. In terms of environmental performance, PHP cement kilns are generally preferable[54].

In Russia, energy intensive wet production technology prevails (about 85% of the overall cement production). The share of fuel and energy costs in the overall production and sales costs reaches up to 41%. Wet process cement kilns represent the oldest technology of vertical cement kilns, they are characterised by highest heat demand and lowest production capacity[55].

Raw materials for cement production include carbonates and clay minerals. Mercury levels in these input minerals are stable[56]: - 0.031 mg/kg (131 samples) for Russian platform carbonates (age D2-K2), 0.035 mg/kg for clay minerals (58 samples), - 0.039 mg/kg (45 samples) for sand and siltstone. A specialised research study of limestone open cast mines within the Russian platform (age D3-K2) suggests that the average mercury level for 19 merged samples from 3117 individual samples reaches 0.037 mg/kg[57], i.e. under the Earth crust abundance of the element (0.05 mg/kg) [58].

In the course of cement and lime production, mercury escapes from heated carbonates and clay minerals. Mercury evaporates and escapes with flue gases. Experimental studies[59] suggest that in the course of steady heating of carbonates and clay minerals from room temperature to 800°C almost all mercury releases at temperatures of about 300°C. Cement production processes include heating of raw minerals to high temperatures in the roasting zone: 1450°C in the solid charge and 2000°C in gases.

As a result, we may assume that almost all mercury releases with flue gases.

It is necessary to note, that in the course of cement production, corrective additives are used to ensure required chemical composition of cement (usually under 0.09 ton per 1 ton of cement clinker). Such additives include gypsum, iron ore, bauxite, quartz sand, tuff, diatomite, nepheline with fairly low mercury contents[60], fuel ash and pyrite cinder. According to research results[61], mercury levels in pyrite cinder used for cement production in Byelorussian and Novosibirsk cement plants, are higher and reach 0.116 - 0.121 mg/kg and 0.19 - 4.0 mg/kg, respectively.

Such results allow us to assume that pyrite cinder additives might substantially increase mercury releases with particulate and gaseous emissions. Small amounts of mercury may come to the roasting zone with fuel and then escape with flue gases. Kilns are designed as an inclined cylinder, solid charge is loaded to

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[54] http://www.docstoc.com/docs/13830406/%D1%80%D1%83%D1%81%D1%81%D0%BA%D0%B8%D0%B9-(Russian)-Cement-and-Lime-Manufacturing

[55] http://www.docstoc.com/docs/13830406/%D1%80%D1%83%D1%81%D1%81%D0%BA%D0%B8%D0%B9-(Russian)-Cement-and-Lime-Manufacturing

[56] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

[57] *Kler V.R., Nenakhova V.F., Saprykin F.Ya. et al* Metalogenia and Geochemistry of Coal-bearing and Shale-bearing Rocks in the USSR. Elements' Concentration Patterns and Methods of their Study. - M.: Nauka, 1988. - 256 p. (Rus.)

[58]Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

[59] *Fursov V.Z.* Mercury as Indicator Element for Geochemical Exploration of Ore Deposits. - M.: Nedra, 1977 (Rus.).

[60] *Saukov A.A., Aidinyan N.H., Ozerova N.A.* Geochemistry of Mercury. - M., Nauka, 1972; *Ozerova N.A.* Mercury and Endogenic Ore Formation. - M.: Nauka, 1986. - 232 p. (Rus.)

[61] *Kakareka S.V.,Kukharchik T.I., Khomich V.S., Yanin E.P.* State and Problems of Inventorying Mercury Emissions // Environmental and Geochemical Problems of Mercury. - M.: IMGRE 2000, p. 12-37 (Rus.);

the upper end of the kiln - countercurrently to flow of hot gases, generated by burning fuel in the lower part of the kiln.

Wet and dry cement production processes differ by moisture content of the kiln charge (32 - 45% add 1 - 2%, respectively). As it was already noted, wet process requires a higher fuel input (gas or coal) for clinker production - as a result, a higher amount of mercury may enter a cement kiln with fuel, comparatively to dry process. Anyway, use of coal substantially increases mercury input (and subsequent mercury emissions), comparatively to gas (see Table 4.1)[62].

**Table 4.1**

| Indicators | Cement production | |
|---|---|---|
| | Wet process | Dry process |
| Fuel consumption per 1 ton of clinker: | | |
| - gas | 200 $m^3$ | 110 $m^3$ |
| - coal | 300 kg | 170 kg |
| Average mercury level in flue gases * | 2.4 $10^{-6}$ $g/m^3$ | |
| Average mercury content in coal (background) ** | 0.045 mg/g | |
| Mercury releases from fuel in the course of cement production in 2001 (35271 thousand tons): | | |
| - gas-fired | 16.9 kg | 9 kg |
| - coal-fired | 476 kg | 260 kg |

Table 4.2. shows relevant figures for cement plants and assessments of mercury releases. Mercury emissions were assessed at the base of its average levels in raw materials (0.035 mg/kg) and amounts of raw materials consumed (1.6 tons per 1 ton of cement). In 2001, 35 million tons of cement were produced in Russia.[63]

**Table 4.2**

Mercury releases in the course of cement production at the following Russian cement plants:

| Federal districts, constituents of the Russian Federation | Shares of cement production (%) | Mercury release estimates (tons/year) | Key cement producers |
|---|---|---|---|
| Moskovskaya oblast | 6.49 | 0.128 | "Voskresentstsement", Voskresenk; "Schurovskiy Tsement", Kolomna |
| Volgogradskaya oblast | 6.02 | 0.119 | "Sebryakovtsement", Mikhailovka |
| Chelyabinskaya oblast | 3.79 | 0.075 | "Uraltsement", Korkino |
| Irkutskaya oblast | 1.2 | 0.024 | Angarskiy Cement Plant |
| Magadanskaya oblast | 0.04 | 0.001 | "Kolymatsement" Co., Magadan |

In 2001, the overall mercury emissions with flue gases and particulate matter in cement production reached almost 2 tons (or 2.8 tons if volcanic minerals were added). Estimates suggest overall mercury

[62] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

[63] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

releases to the environment at the level of 2.0 - 2.8 tons (including 1.3 - 2.1 tons from inorganic production inputs)[64].

**Emission control systems of cement plants**

Main sources of dust releases in cement production include cement kilns and mills, cement kilns release up to 85% of all dust emissions of cement plants[65]. Particulate emissions of cement kilns are usually polydisperse with high shares of fine particulates (less than 10 μm) - as a result, these particulates efficiently adsorb many heavy metals, including mercury.

If emission control systems are installed, filters allow to intercept substantial amounts of mercury. Russian cement plants use cyclone filters, bag filters and electrostatic filters with dust removal efficiency of 80 - 99%; in the majority of cases, utilisation factors of electrostatic filters at cement kilns vary from 80 to 84%[66].

Electrostatic filters are most often used for dust removal from flue gases of rotating cement kilns (about 74% of all emission control installations), however, only a third of installed filters are highly efficient. Gaseous and particulate emissions of cement kilns contain up to 90 - 95% of mercury inputs to the production process.

Application of activated charcoal for removal of residual traces of mercury, VOCs (volatile organic compounds) and PCDD/PCDF in cement production is still limited to experimental research studies, mainly due to variable composition of flue gases[67].

There are no available data on actual efficiency of mercury capture by filters that are applied in Russia. In contrast to other heavy metals, mercury is only partially removed by filters. Generally, it is rather difficult to assess efficiency of different methods of control of particulate matter emissions applied by cement plants. Only some scattered data on mercury balance in cement kilns are available[68]. In addition to other factors, mercury capture efficiency of the filters depends on mercury forms and temperature. It seems appropriate to use information for coal-fired TEPs for preliminary assessments.

Efficiency of adsorption of mercury from flue gases depends on types of mercury compounds present (bivalent mercury compounds are adsorbed more easily than elementary mercury - $Hg^0$)[69]. Cement kilns, fired by bituminous coal or lignite, usually demonstrate relatively low $Hg^{2+}$ to $Hg^0$ ratios in exhaust gases of pollution control equipment, comparatively to coal-fired ones. As a result, average efficiency of mercury removal by electrostatic filters or bag filters in the former case would be lower. Average shares

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64 Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

65 *Varum Ya.I., Izyumskaya L.A.* Efficiency of Kiln Electrostatic Filters // Tsement, 1990, # 4, p. 5-6.; *Kolbasov V.M., Leonov I.I., Sultmenko L.M.* Technology of Binding Materials. M., Stroyizdat, 1987. (Rus.)

66 *Chelnokov A.A., Plyshevskiy S.V.* Concerting Possibility for Application of the Guideline Manual for Emissions Inventory for Assessment of Emissions of Construction Materials Industry // Problems of Inventorying Pollutants Emissions. Proceedings of the International Symposium on Inventories of Pollutants Emissions and Application of EMER/CORINAIR Guideline Manual. Minsk-Raubichi, Belarus, 1997. Minsk: The R&D Institute of Environment and Natural Resource Use of the National Acad. Sci. of Belarus, 1998, p. 91 - 102.; *Chelnokov A.A., Plyshevskiy S.V.* Concerning Emissions of Heavy Metals in Cement Production // Cement and Its Application, 2000, # 6, p. 41-45. (Rus.)

67 http://www.docstoc.com/docs/13830406/%D1%80%D1%83%D1%81%D1%81%D0%BA%D0%B8%D0%B9-(Russian)-Cement-and-Lime-Manufacturing

68 *Johansen, V.C., Hawkins, G.J.* Mercury speciation in cement Kilns: A literature review //R&D Serial, 2003, № 2567, Portland Cement Association, Skokie, USA.

69 US EPA. 2001. Kilgroe J.D., Sedman, C. B., Srivastava R.K., Ryan J.V., Lee C.W., Thorneloe, S.A. Control of mercury emissions from coal- fired electric utility boilers: Interim Report. U.S. Environmental Protection Agency Office of Research and Development.

of mercury capture at cold parts of electrostatic filters reach only 3%, while hot parts of electrostatic filters and bag filters capture 6% and 72% of mercury, respectively.

There are no available data on mercury contents in flue gases of cement kilns. Accounting for low efficiency of electrostatic filters (due to high shares of $Hg^0$ in gases and only a third of efficient equipment installed), we may assume that mercury capture efficiency cannot exceed 10 - 30%. If we assume that 80% of mercury inputs to the cement production escape to the atmosphere, the overall estimated mercury emissions of cement kilns reach 1.6 tons/year (or 0.045 g/ton of cement production).

According to research data[70], average mercury levels in marketable cement reach 0.043 mg/kg. To a some extent, mercury levels in cement depend on mercury contents in materials that are added to cement clinker after the thermal process.

Further improvement of environmental quality at the territory of Russia in locations of cement plants primarily depends on modernisation and upgrade of particulate emission control equipment to capture heavy metals, especially mercury. The International Association of Cement Producers, jointly with "Concern Cement" Co., developed a program for development of Russian cement industry for 2001 - 2005. The program particularly focused on reconstruction of electrostatic filters for reduction of emissions of particulate matter to the level of applicable MACs.

**Main cement producers in Russia:**

**It is necessary to note that none of the below facilities monitors mercury emissions.**

**Moskovskaya oblast:**

**"Voskresensktsement" - a subsidiary of Lafarge Cement Co.**

Address: 140200, Russia, Moskovskaya oblast, Voskresensk, 3 Giganta St.
phone: +7(49644)44-007
Director General: Lvov Yuriy Nikolayevich.

Production capacity: 1 million tons/year.

In 2001, the annual production reached 1.3 million tons of cement.
Production technology: wet process. Wet process entails the highest fuel consumption, as a result, higher amounts of mercury enter the production process with fuel (comparatively to dry process).

Fuel: gas.
Raw materials used: limestone and marl.

Corrective additives added: cinder, conversion slag, active mineral additives (slag, diatomite, coal ash). Use of pyrite cinder substantially increase mercury levels in gaseous and particulate emissions of the plant.

[70] Emissions of Heavy Metals: Assessments of Specific Indicators. Minsk: The R&D Institute of Environment and Natural Resource Use of the National Acad. Sci. of Belarus, 1998. 156 p.; *Plyshevskiy S.V., Chelnokov A.A.* Emissions of Heavy Metals in Cement Production // 2nd International Meeting on Cement Chemistry and Technology, Moscow, 2000: Poster Presentation. v. 3. M., RTHU, 2000, p. 262-265.; *Chelnokov A.A., Plyshevskiy S.V.* Concerting Possibility for Application of the Guideline Manual for Emissions Inventory for Assessment of Emissions of Construction Materials Industry // Problems of Inventorying Pollutants Emissions. Proceedings of the International Symposium on Inventories of Pollutants Emissions and Application of EMER/CORINAIR Guideline Manual. Minsk-Raubichi, Belarus, 1997. Minsk: The R&D Institute of Environment and Natural Resource Use of the National Acad. Sci. of Belarus, 1998, p. 91 - 102.

"Voskresensktsement" Co. supplies its products to customers of Moscow and Moskovskaya oblast, including Moscow construction contractors.

Products of "Voskresensktsement" Co.:
- Portland cement 400
- Portland cement 500
- High early strength portland cement M 400
- High early strength portland cement M 500
- Portland cement PTs 400-D0 (additives-free)
- Portland cement PTs 400-D5
- Portland cement  PTs 400-D20
- Slag portland cement ShPTs 400
- High early strength portland cement PTs 400-D20-B
- High early strength portland cement PTs 500-D20-B
- Portland cement for production of asbestos-concrete items PtsA

**Podolskiy cement plant**

Address: 142101, Moskovskaya oblast, Podolsk, 15 Plestcheevskaya St.
phone: (4967) 63-88-48
http://www.cement.podolsk.ru/
Director General: Burlov Yuriy Aleksandrovich

Production capacity: 0.33 million tons/year.

Production technology: wet process. Wet process entails the highest fuel consumption, as a result, higher amounts of mercury enter the production process with fuel (comparatively to dry process).

Fuel: gas.

Products of "Podolskiy cement plant" Co.:
- Portland cement 400-D20
- Portland cement 500-D5
- Special purpose cement (sulphate-resistant)
- Special purpose cement (self-stressing)
- Special purpose cement (for oil wells)
- Alumina cement VGTs
- White and coloured cement
- Sand concrete M300
- Dry mix for self-levelling underlayment
- Cement, lime and sand dry mix
- Water-proof cement M600
- Heat-resistant mix
- Tiling mix
- Plastering mix M100
- Masonry mix M150
- Universal dry mix M150 and M200
- Polymer filler
- Cement filler for finishing works
- Cement filler for repair works
- Dry plastering mix for foam concrete, expanded concrete
- Adhesive cement for installation of foam/expanded concrete blocks

- Foam concrete blocks (Podolsk wall blocks)

**Schurovskiy cement plant**

Address: 140414, Moskovskaya oblast, Kolomna, 1 Tsementnikov St.

Production capacity: 2.1 million tons.

Production technology: wet process. Wet process entails the highest fuel consumption, as a result, higher amounts of mercury enter the production process with fuel (comparatively to dry process).

Fuel: gas.

Main production inputs: ash, kaolin (for white cement production), limestone, clay. Limestone is delivered from "Priokskiy" open cast mine. Corrective additives: sand for production of white cement and cinder. Necessary active mineral additives: slag.

Types of cement produced:

- White additives-free portland cement BPTs 400-D0;
- Additives-free portland cement PTs 400-D0;
- High early strength portland cement with mineral additives PTs 400-D20-B;
- Portland cement with mineral additives PTs 400-D20.

**"Sebryakovtsement" Co.**

Address: 403342, Volgogradskaya oblast, Mikhailovka, 2 Industrialnaya St.
phone: (84463) 2-94-93
fax: (84463) 2-98-60
Director General: Rogachev Sergey Petrovich

Production capacity: 2.4 million tons/year.

Production technology: wet process. Wet process entails the highest fuel consumption, as a result, higher amounts of mercury enter the production process with fuel (comparatively to dry process).

Fuel: gas.

Main production inputs: clay and limestone. Necessary corrective additives: cinder. Use of pyrite cinder substantially increase mercury levels in gaseous and particulate emissions of the plant. Slag is used as an active mineral additive.

The company produces about 5.6% of Russian cement. In 2004, due to transition to market-based management the annual production increased in 2.8 times and reached 2538 thousand tons, or by 11.8% (268 thousand tons) higher that in the previous year.

Sebryakovskiy cement plant operates 7 cement kilns that use wet cement production process. The decision to construct a new production line with application of semi-dry production process was rather appropriate as the plant was able to use the already operational production equipment for processing of raw materials. Design capacity of kiln # 8: 2300 tons of cement clinker/day at fuel consumption of 1000 kcal/kg of clinker (or 143 kg s.c./ton of cement clinker[71]).

[71] http://www.sebcement.ru/zav/zc/

Products of "Sebryakovskiy cement plant" Co.:

- Additives-free portland cement PTs 500-D0
- Additives-free portland cement PTs 600-D0
- Plasticised portland cement with mineral additives PTs 500-D20-PL
- Portland cement for production of asbestos-cement items PTsA
- Sulphate-resistant additives-free portland cement SSPTs 400-D0
- Sulphate-resistant portland cement SSPTs 500
- Slag portland cement ShPTs 300
- Portland cement clinker
- Dry mixes.

**"Uraltsement" subsidiary of "Lafarge" Co.**

Address: Chelyabinskaya oblast, Korkino, Pervomaiskiy township
phone: +7(35152)56-636
Director General: Gusev Vladislav Anatolievich

Production capacity: 2.3 million tons/year.

Production technology: wet process. Wet process entails the highest fuel consumption, as a result, higher amounts of mercury enter the production process with fuel (comparatively to dry process).

Fuel: gas;

Main production inputs: limestone ("Sheinskoye" mine), clay ("Sheinskoye" mine);

Corrective additives: cinder, bauxite; use of pyrite cinder substantially increases mercury levels in gaseous and particulate emissions of the plant.

Active mineral additives: slag.

Products: 3 types of cement for construction applications according to GOST 10178-85, oil well cement according to GOST 1581-96, cement for production of asbestos-cement items according to TU 21-26-18-91, sulphate resistant cement according to GOST 22266-94.

**Chelyabinskiy cement plant**

Address: 454047, Russia, Chelyabinsk, NE industrial zone of Metallurgicheskiy district.
**phone:** (351) 278-65-71, 278-82-23,
**fax:** (351) 725-41-39, 725-36-08

Production technology: wet process. Wet process entails the highest fuel consumption, as a result, higher amounts of mercury enter the production process with fuel (comparatively to dry process).

"Chelyabinskiy cement plant" Co. (also known as "Master Craft" Co. is the only Russian producer of famous Master Craft cement brand (high quality cement, dry mixes for construction applications etc.). The company uses a German technology.

Products of "Chelyabinskiy cement plant" Co.:

- Dry mixes for construction applications;
- Cement, lime and sand plastering mix M100;
- Cement, slag portland cement ShPTs-400;

- Cement clinker;
- Alumina cement VGTs-2;
- Priming mixtures.

**Magadanskiy cement plant of "Kolymatsement" Co.**

Address: 685000, Magadan,12-A Yuzhnaya St.
phone: +7(4132)606-157
Director General: Snyatkova Raisa Grigorievna

Production capacity: 0.15 million ton/year
Production technology: milling
Fuel: coal.
Use of coal fuel results in higher mercury input with fuel and in higher mercury emissions comparatively to gas fuel.

The plant produces portland cement from cement clinker (a semi-product) by grinding in a ball mill with production capacity of 20 tons/hour. Clinker is supplied by Spasskiy cement plant. Average annual production of the plant: 25,000 tons.

**Spasskiy cement plant - "Spassktsement" Co.**

Address: Russia, 692210, Primorskiy krai, Spassk-Dalniy, 2 Tsementnaya St.
phone: +7(42352)3-27-37
web: http://www.parkgroup.ru

Production capacity: 3.4 million tons
Production technology: dry process
Fuel: coal and fuel oil. Use of coal fuel results in higher mercury input with fuel and higher mercury emissions comparatively to gas fuel.

Limestone for the cement production is mined nearby the plant site.

Spasskiy cement plant belongs to key pollution sources of the city. The plant generates substantial emissions of particulate matter, clay, coal, cement, asbestos, sulphur dioxide, carbon oxides, nitrogen oxides and other pollutants.

Pollutants emissions and discharges of Spasskiy cement plant are shown in Table 4.3[72].

Table 4.3

Pollutants emissions and discharges of Spasskiy cement plant.

| Industrial facilities | Pollutants releases from all fixed sources (tons/year) | Pollutants emissions and discharges to surface water bodies (thousand tons/year) | | |
|---|---|---|---|---|
| Spasskiy cement plant | | Total | Solids | Gaseous and liquid |
| | 320.204 | 21.829 | 15.08 | 6.74 |

[72] www.ebiblioteka.lt/resursai/Uzsienio%20leidiniai/MFTI/2005/036.pdf

**Angarskiy cement plant**

**Address:** Irkutskaya oblast, Angarsk,
**e-mail: info@sibcem.ru** :
**web: www.sibcem.ru/**

Installed capacity: 2.1 million tons
Production technology: wet process

The plan uses dense limestone as a carbonate component and ash of the local thermoelectric plant as a clay component. The open cast mine is located at the distance of 7 km from the plant, raw materials are delivered by trucks.

Pyrite cinder is used as a corrective additive. Composition of the kiln charge:

- limestone: 81 - 82 %
- ash: 17 - 17.5 %
- cinder: 0.5 %

Products:

- PTs 400-D0
- PTs 500-D0
- PTs 400-D20
- PTs 400-D5
- PTs 500-D5

Filters installed at the plant have pollutants capture rate of 6 mg/sec and meet emission limits. However, the filters are 25 years old[73].

## Chapter 5

## Non-ferrous metallurgy

Naturally occurring mercury impurities in ores of non-ferrous metals may become environmentally mobile in the course of mineral extraction works and mercury may be also released in the course of ore-processing and other technological processes. In 2001, in Russia, in terms of potential mercury releases to the environment, the most substantial sources were associated with production of primary zinc, copper and nickel, production of other non-ferrous metal was 1 - 2 orders of magnitude lower (see Table 5.1)[74].

**Table 5.1**
Key Russian producers of non-ferrous metals

| Metal | thousand tons | Main producers (percentage shares) |
|---|---|---|
| Electrolytic copper | 840 | "GMK Norilskiy Nickel" Co. (> 54%) |
| High grade zinc | 250.6 | "Chelyabinskiy zinc plant" Co. (> 62%) |
| Primary nickel | 250 | "GMK Norilskiy Nickel" Co. (> 89%) |
| High grade lead | 34 | "Dalpolimetall Lead Plant" Co., "Elektrotsink" Co. |
| Cobalt | 6.5 | "GMK Norilskiy Nickel" Co. (70%), "Ufaleinikel" Co. |

[73] http://www.sibcem.ru/template.html?/moduls/fullpublic.php?id=293&tbl=sc_press
[74] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

| | | |
|---|---|---|
| High grade tin | 4.5 | "Novosibirskiy Tin Plant" Co. (100%) |
| Antimony | 1.5 | "Ryaztsvetmed" Co. (100%) |

* Production of bismuth, molybdenum and other rare metal reached a few tens (most often) or a few hundreds (less often) tons/year.

There are numerous ore deposits that contain mercury minerals (e.g. copper and silver ores), complex mercury minerals (platinum deposits) or contain traces of mercury (copper pyrite, copper and nickel ores, complex ores, etc.). Highest mercury contents are generally observed in copper and zinc ores, while lowest Hg levels are observed in iron pyrite ores (see Table 5.2)[75].

**Table 5.2**[76]

Mercury levels in ores and minerals of lead, zinc and copper ore deposits (g/t)

| Types of industrial deposits | Ores | Sphalerite | Galenite | Copper pyrite | Pyrite | Fahlore |
|---|---|---|---|---|---|---|
| Complex pyrite ores deposits (Altai) | 0.1 - 20 | 0.2 - 26.1 | 0.01 - 16 | 0.4 - 3.4 | 0.2 - 10 | traces - 300 |
| Stratiform lead and zinc ores deposits (Atasui) | 0.9 - 406 | 23 - 7600 | 0.6 - 530 | 1 - 240 | 2 - 50 | up to 12% |
| Lead and zinc ores vein deposits | ?* | 0.4 - 1000 | 0.075 - 25 | ?* | 0.1 - 100 | 80 - 800 |
| Copper pyrite deposits | 0.6 - 900 | 70 - 250 ( up to 0.5 - 1.5%) | ?* | ?* | ?* | up to 3% |

According to generalised assessments[77], overall potential mercury resources in main industrial concentrates of lead and zinc and copper ores are distributed as follows: zinc concentrates - 42%, pyrite concentrates - 26%, copper concentrate - 19% and lead concentrate - 13%. Zinc (lead and zinc) and copper plants of the country annually receive rather substantially amounts of mercury with concentrates of main ores (65% with zinc concentrates, 20% with copper concentrates and high grade ores, 15% with lead concentrates).

On-site dumps of ore-dressing facilities contain substantial amounts of production waste with varying mercury contents. In the course of destruction processes in tailings under external impacts, mercury may potentially migrate to the environment. In addition, mercury may escape to the environment directly in the course of mining works. In particular, mercury levels in mine water of Sibaiskiy and Oktyabrskiy deposits reached 20 and 13 µg/l, respectively[78], while mercury levels in mine water of Buribaiskiy open cast mine - that is used for closed circuit water supply of the mining facility and periodically discharged to Tanalyk river - were found to reach 28.3 µg/l[79] (many times over typical background Hg levels in natural water sources. Pollutants may also infiltrate to surface water courses through dams with washout

[75] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[76] *Bobrova L.V., Kondrashova O.V., Fedorchuk N.V.* Economy of Geological Survey for Mercury, Antimony and Bismuth. M.: Nedra, 1990. 156 p. (Rus.).
[77] *Bobrova L.V., Kondrashova O.V., Fedorchuk N.V.* Economy of Geological Survey for Mercury, Antimony and Bismuth. M.: Nedra, 1990. 156 p. (Rus.).
[78] *Mustafin S.K., Minigazimov N.S., Zainullin H.N. et al.* Mercury Security Problems of the Southern Urals // Environmental Problems of Urals Industrial Zones. v. 1. - Magnitogorsk: MGMA, 1998, p. 148-154. (Rus.)
[79] *Zainullin H.N., Galimova E.J.* Assessment of Impacts of Waste and Wastewater of Buribaevskiy Mining Directorate on Tanalyk River Pollution // Environmental Problems of Urals Industrial Zones. v. 1. - Magnitogorsk: MGMA, 1998, p. 137-142. (Rus.)

flows from tailing ponds. In warm seasons mercury may also evaporate from tailings of mining and ore-dressing facilities[80].

## Zinc production

### Chelyabinskiy zinc plant (ChTsZ)

Address: 454008, Chelyabinsk, 24 Sverdlovskiy trakt
phone**:** (351) 799-00-09
fax**:** (351) 799-00-65
Director General: Aleksandr Zatonskiy

The plant belongs to major mercury emission sources.

Chelyabinskiy zinc plant ("ChTsZ" Co.) is a vertically integrated company, managing the full cycle of zinc production: from extraction and clarification of zinc ores to production of high grade metal zinc and zinc alloys. The company controls more than 60% of Russian zinc production and about 2% of the global production.

Installed capacity of the plant allows to produce up to 200 thousand tons of zinc annually.

The company receives zinc ores from "Akzhal" lead and zinc ore deposit in Kazakhstan and Amurskiy zinc ore deposit in Dredinskiy district of Chelyabinskaya oblast.[81]

**Table 5.3**

Zinc production, *thousand tons*:

| Industrial facility | Location | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|
| **Chelyabinskiy zinc plant** | Chelyabinsk | 138.3 | 145.7 | 155.5 | 165.8 |

In 2008, the company processed 1,330.5 thousand tons of different ores.

In addition to metal zinc, the plant produces zinc and aluminium alloys, zinc alloys in ingots, cadmium, metal indium, zinc sulphate (technical grade), zinc oxide and sulphuric acid (technical grade). In 2008, the plant increased zinc production up to 166 thousand tons (by 0.6%) comparatively to 165 thousand tons in 2007. 51.5% of marketable zinc were sold on the Russian market.

In 2001, Chelyabinskiy zinc plant predominantly processed zinc ores from mineral deposits of the Urals region, that produce more than 75% of Russian zinc concentrates. Zinc concentrates from Uchalinskiy, Gaiskiy and Sibaiskiy ore-dressing plants and Bashkirskiy copper and sulphur plant cover about 95% of the plant's demand in raw materials. In 2001, Uchalinskiy ore-dressing plant supplied up to a half of all zinc ore concentrate to ChTsZ. In recent years Chelyabinskiy zinc plant also imported up to 20 thousand tons of zinc concentrate with zinc contents of 55 - 60%. In 2001, the plant processed about 330 thousand tons of zinc concentrates.

[80] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[81] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

In 2008, a daughter company of "ChTsZ" - "Nova-Zinc" (the company-operator of Akzhal lead and zinc deposit in Kazakhstan) processed 1330.5 thousand tons of ores or by 3.8% more that in the precious year (1281.8 thousand tons). Average zinc contents in the ore reached 2.67% (comparatively to 2.54% in 2007), while lead levels reached 0.54% (comparatively to 0.46% in 2007). In 2008, the latter company produced 32,348 tons of zinc in concentrates (growth by 7.8% comparatively to 30 thousand tons in 2007 and 5,747 tons of lead in concentrates (growth by 20% comparatively to 4,785 tons in 2007).

According to data of April 29, 2010[82], in 2009, Chelyabinskiy zinc plant produced 119.9 thousand tons of Special High Grade zinc and alloys or by 20% less comparatively to 2008 (150 thousand tons).

Zinc sales of "ChTsZ" Co. in 2009 reached 119.8 thousand tons (a decrease by 20% comparatively to 149.9 thousand tons in 2008). The company sold 64% of its zinc sales (76.4 thousand tons) at the Russian market and exported 43.4 thousand tons (or 36% of its total zinc sales in 2009). In 2008, the company exported 72.7 thousand tons and sold 77.2 thousand tons at the domestic markets.

In 2009, "Nova-Zinc" Co. (the company-operator of Akzhal lead and zinc ore deposit in Kazakhstan) produced 34.8 tons of zinc in zinc concentrates (comparatively to 32.3 thousand tons in 2008). The bulk of produced concentrate (84%) was supplied to Chelyabinskiy zinc plant. Lead production of the company in lead concentrates reached 4 thousand tons in 2009.

In 2009, Brock Metal Ltd. (a daughter company of "ChTsZ" Co. and the leading British producer of zinc alloys for die casting) sold 22.2 thousand tons or by 13% less than in 2008 (25.5 thousand tons).

Zinc concentrates, especially concentrates of ore-dressing facilities of the Urals region that process chalcopyrite ores, have rather high mercury contents (see Table 5.4). Published data [83] on mercury levels in zinc concentrates of Uchalinskiy ore-dressing plant suggest mercury contents from 76 to 123 g/t.

**Table 5.4**

Composition of zinc concentrates (according to the State R&D Institute of Non-ferrous Metallurgy)

| Ore-dressing facilities | Zinc (%) | Mercury (g/t) |
|---|---|---|
| Uchalinskiy | 45.5 | 20 |
| Gaiskiy | 49.9 | 100 |
| Bashkirskiy copper and sulphur plant | 44.1 | 30 |
| Novoshirokinskiy mine | 54.0 | 10 |
| Altaiskiy | 34.5 | < 3 |
| "Dalpolimetal" Co. | 49.1 | 3 |

**Table 5.5**

Mercury levels in ore concentrates from pyrite and complex pyrite deposits (g/t)[84]

| Regions | Ore deposits | Mercury contents in concentrates (g/t) | Averages (estimates) (g/t) |
|---|---|---|---|
| Middle Urals | III Internatsionala | 4.5 | 4.5 |
| | Lomovskoye, Levikhinskoye | 1 - 2 | 1.5 |
| Southern Urals | Gaiskoye | 10 - 25 | 17 |
| | Uchalinskoye | 10 - 75 | 42 |

[82] http://zinc.ru/_pressFiles/271.pdf
[83] *Kutliakhmetov A.N.* Mercury Landscape Pollution by Mining and Ore-dressing Facilities of Bashkir Trans-Urals Region: Synopsis of Cand. Sci. (Geography) Thesis. - Yekaterinburg, 2002. . 25 p. (Rus.)
[84] *Ozerova N.A.* Mercury and Endogenic Ore Formation. - M.: Nauka, 1986. - 232 p. (Rus.).

| | | | |
|---|---|---|---|
| | XIX Partcyezda<br>Sibaevskoye | 25 - 75<br>1.8 - 7.5 | 50<br>4.7 |

**Table 5.6**

Mercury levels in zinc concentrates of ore-dressing plants of the Urals region - key suppliers of Chelyabinskiy zinc plant

| Ore-dressing plant | Mercury levels (g/t) |
|---|---|
| Gaiskaya | 65 |
| Uchalinskaya | 53 |
| Sibaiskaya | 93 |
| Average | 70.3 |

The above data suggest that zinc concentrates supplied about 20 tons of mercury to the production process of Chelyabinskiy zinc plant in 2001.

**Zinc concentrate processing technology**

Zinc concentrates are processed with application of a hydrometallurgical process. Initially, zinc concentrates are roasted to transform sulphides into oxides. Zinc concentrates are roasted in fluidised bed furnaces (at fluidised bed zone temperatures of 900 - 950°C; and temperature of gases in the furnace arch zone of 800 - 850°C). Roasted cinder contains 55 - 65% of zinc, as well as compounds of copper, lead, iron, cadmium, arsenic, antimony, cobalt, precious and rare metals; sulphide sulphur levels are under 1%.

Fluidised bed furnaces are key sources of gaseous and particulate emissions of zinc plants. Exhaust gases of these furnaces are characterised by high temperatures (up to 950°C), high particulate loads (up to 300 g/m$^3$) with prevailing fine particles (2.5 - 4.5 µm). Yields of exhaust gases of the roasting process varies from 1.3 to 3.1 thousand m$^3$ per 1 ton of zinc concentrate. The scheme of treatment of the exhaust gases prior to their utilisation for production of sulphuric acid includes cyclone filters (rough purification) and dry electrostatic filters (fine purification). In addition, in the sulphur acid production shop roaster gases are treated in gas washing towers and wet electrostatic filters[85]. According to published data[86], in mid-1990s, particulate emissions rates of zinc production plants of CIS countries reached: 57.2 kg per 1 ton of crude zinc at exhaust treatment efficiency of 95%, 17.2 kg at 98.5% efficiency and 2.29 kg at 99.8% efficiency. Published data[87] suggest that efficiency of roaster gases treatment at plants of the former USSR varied from 81.6 to 99.6%. Estimates of the average efficiency of the gas purification equipment suggest the figure of 98.5% [88]. There are reasons to believe that the last figure corresponds to average gas treatment efficiency of 2001.

Behaviour of mercury in production of primary zinc is poorly studied. Published sources lack reliable data on distribution of mercury in key products and wastes, on its releases to the environment. Some research data below provide estimates of mercury releases in waste and products of primary zinc production processes.

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[85] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[86] Air Emissions of Heavy Metal: Experience of Assessment of Specific Parameters. Minsk: Nat. Resources Use R&D Institute of the National Acad. Sci. of Belarus, 1998. 156 p. (Rus.)
[87] *Denisov S.I.* Capture and Utilisation of Gases and Particulates. M.: Metallurgia, 1991. (Rus.)
[88] *Savrayev O.V.* Dust Capture from Flue Gases of Zinc and Lead Plants and Options for Improvement. M.: Metallurgia, 1990. (Rus.)

It is known that in 1988 - 1990, about 35 - 40 tons of mercury entered production processes of Chelyabinskiy zinc plant annually with zinc concentrates[89]. According to published data[90], mercury contents in zinc concentrates that were processed by Chelyabinskiy zinc plant in late 1070s - early 1980s, reached 200 g/t. Authors of these publications assumed that in the course of the roasting process, mercury evaporates and enters the sulphuric acid production line with roaster gases. As the gas treatment technology in the sulphuric acid production shop of the plant did not ensure complete mercury capture, substantial amounts of mercury were assumed to end in the sulphuric acid produced (a technical grade product). According to authors[91], about 10 - 12 tons of mercury/year precipitated as mercury and selenium silt in the gas washing section, while the rest (25 - 30 tons) ended in sulphuric acid. At that time, every year, 30 - 35 tons of mercury-containing silt formed.

Table 5.7 shows data of the State R&D Institute of Non-ferrous Metallurgy on generation of mercury-containing silt at Chelyabinskiy zinc plant in 1985 - 2000 (tons)

**Table 5.7**

| Industrial facility | 1985 - 1990 | | 1990 - 1995 | | 1995 - 2000 | |
|---|---|---|---|---|---|---|
| | Hg-Se silt | Hg | Silt | Hg | Silt | Hg |
| Chelyabinskiy zinc plant | 250 | 70 | 404 | 88 | 525 | 115 |

Research studies at the plant[92] demonstrated that mercury in roaster gases that enter the sulphuric acid production line distributed as follows (assuming that mercury levels in the gases = 100%): gas washing acid - 16.7%; silt - 43.3%; sulphuric acid (product) - 36.6%; exhaust gases - 0.4%. Therefore, 60% of mercury intake with roaster gases were captured in the gas washing section and removed with gas washing acid and silt. Remaining mercury entered drying and absorption section and contaminated the sulphuric acid produced. The authors also studied distribution of different mercury compounds in different products (see Table 5.8).

**Table 5.8**

Distribution of different mercury compounds in different products of the sulphuric acid production line of Chelyabinskiy zinc plant (%)

| **Products** | **$Hg^0$** | **$Hg_2Hal_2^*$** | **HgS** | **$Hg_2SO_4$** | **$Hg_mSe_n$** | **$HgSO_4$** |
|---|---|---|---|---|---|---|
| Roaster gas | 99.3 | 0.4 | 0.3 | - | - | - |
| Silt | 4 | 9.5 | 50.5 | - | 36 | - |
| Sulphuric acid | - | - | - | 3.2 | - | 96.8 |

* Hal = halogen

Available information suggests that Chelyabinsk zinc plant has managed to resolve the problem of mercury-selenium silt completely (the plant allegedly supplies the silt to Kyrgyzstan for processing) and recently the plant approached a solution of the problem of mercury removal from gases[93]. In particular, in

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[89] Analysis of Mercury Environmental Contamination in the Russian Federation. Research Report - Mytistchi: R&D Centre for Resource Conservation and Waste Management, 1999. - 47 p. (Rus.)

[90] *Kamenev V.F., Fadeeva L.V.* Mercury Distribution in Sulphuric Acid Production // Non-ferrous Metals, 1983, # 8, p. 35-36 (Rus.).

[91] Analysis of Mercury Environmental Contamination in the Russian Federation. Research Report - Mytistchi: R&D Centre for Resource Conservation and Waste Management, 1999. - 47 p. (Rus.).

[92] *Kamenev V.F., Fadeeva L.V.* Mercury Distribution in Sulphuric Acid Production // Non-ferrous Metals, 1983, # 8, p. 35-36 (Rus.).

[93] *Stepanov I.* Larox Environmental Effect. Chelyabinskiy Zinc Plant Eliminated Lead Emissions to the Environment ("Delovoi Ural", 2002, # 33) // http://www.infoural.ru/delur/2002/33-8.ht. (17.9.2002). (Rus.)

order to reduce mercury levels in sulphuric acid, the plant planned to purchase equipment of *Boliden Company* that would allow the plant to eliminate mercury emissions and reduce emissions of sulphur oxides substantially.

In 2002, the European Bank for Reconstruction and Development (EBRD) signed a loan agreement with Chelyabinskiy zinc plant on provision of $12 million loan for 6 years to finance implementation of the second phase of plant reconstruction works. The loan funds are allocated for construction of a plant for mercury processing and production of sulphuric acid - these measures would allow Chelyabinskiy zinc plant to eliminate mercury emissions and reduce $SO_2$ emissions substantially. The new production line would allow to reduce zinc losses and increase production of marketable zinc. EBRD provided its first $15 million loan to "ChTsZ" Co. in 2000. The loan funds were used for extension of the plant's production capacity and improvement of zinc processing. "ChTsZ" Co. produces 150 thousand ton of zinc annually[94].

**Mercury emissions of Chelyabinskiy zinc plant**

In 1996, mercury emissions of Chelyabinskiy zinc plant reached 2.51 tons[95]. At its annual zinc production of about 115,000 tons, mercury emissions per unit of output reached 21.8 g/t (the figure is close to the above estimates). These parameters seem to reflect actual situation in the zinc industry at that time rather adequately. In particular, it is known that in late 1980s quality of zinc concentrates decreased - as a result, zinc producers had to process higher amounts of zinc concentrates and operate fluidised bed roasters and associated emission control equipment at higher loads.

Efficiency of emission control equipment was low due to expired service life of the installations and frequent equipment failures; only 50% of installed capacity of electrostatic filters were utilised as the filters were often switched off for maintenance and capital repairs. In mid-1990s, in some districts of Chelyabinsk, mercury levels in outdoor air of 1.5 - 2 MACs were observed regularly. Within the site of Chelyabinskiy zinc plant mercury levels in ambient air exceeded MAC in 5 times, while mercury levels in soil nearby the plant exceeded background levels in 100 times. It is known also that mercury-selenium silt was stored at the territory of the plant's site.

According to official data[96], in 2001, mercury emissions of the zinc plant in Chelyabinsk reached 1229 kg. At annual zinc production of Chelyabinskiy zinc plant of 155,500 tons, mercury emissions per ton of zinc production reached 7.9 g Hg. A substantial reduction of mercury emissions per unit of output in 2001 comparatively to 1996, to a some extent may be attributed to technological improvements at the plant in 2000 - 2001, that were reported in published sources[97].

**Copper production**

In terms of mercury releases to the environment, production of crude copper from copper concentrate is of particular importance; its emissions in the course of waste/secondary copper processing and production of refined copper are substantially lower. Processing of copper ores and concentrates is usually accompanied by production of sulphur (sulphuric acid) from roaster gases. In the course of the latter process mercury intensively concentrates in sludges of sulphuric acid production lines[98].

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[94] http://www.metal-trade.ru/news/2002/10/10/news_48691.html

[95] Ambient Air, Waste, Radiation . Chelyabinskaya oblast. //www.grenpeace.ru/default/8300 (10.1.2003). (Rus.)

[96] The Summary Report on Ambient Air Protection in 2001. - M.: The State Committee for Statistics of Russia, 2002. (Rus.)

[97] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

[98] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

Russian copper plants are located at Taymyr Peninsula (Krasnoyarskiy krai), in Murmanskaya oblast ("GMK Norilskiy Nikel"), and in the Urals region. In the latter case, the majority of copper producers belong to "Urals Mining and Metallurgy Company" holding, except "Kyshtymskiy Copper Electrolysis Plant" Co. and "Karabashmed" Co., that form the third group of Russian copper producers.

In this Survey we consider only "Karabashmed" Co. operating in Karabash (Chelyabinskaya oblast) and "Kyshtymskiy Copper Electrolysis Plant" Co." in Kystym (Chelyabinskaya oblast).

Now, the bulk of Russian copper is produced from nickel-copper ores (with copper contents of 0.2 - 3.5%), copper pyrite ores (0.5 - 3%) and copper and zinc pyrite ores (1 - 6%)[99].

**Copper smelting and refining[100]**

Copper is mined in open cast/underground mines, depending on types of copper ores and specifics of a deposit. Copper ores usually contain less than 1% of copper in sulphide minerals. After extraction, the ore is ground into a fine powder and concentrated for further processing. In the process of ore clarification copper ore is slurred with water and chemical reagents. Air is blown through the mixture - copper-containing minerals float to the top of flotation chambers and are then removed with a skimmer. Copper concentrates contain 20 - 30 percent of copper. Other minerals sink to the bottom - these tailings are removed, dewatered and disposed of in tailing ponds. All water used in these operations - from dewatering to delivery of tailings to the tailing pond - is recovered and returned to the technological process.

Depending on quality of copper ores, copper may be recovered by pyrometallurgy or hydrometallurgy. Pyrometallurgy is used for ore concentrates with copper sulphide and iron sulphide minerals for production of pure copper. Oxidised copper ores (containing copper oxide minerals) are processed hydrometalurgically with other types of oxidised copper waste.

Smelting is used to produce metal copper from a copper ore concentrate. The concentrate is dried and fed into a furnace. The minerals are partially oxidised and melted, resulting in segregated layers. The matte layer (iron-copper sulphide mixture) sinks to the bottom under the slag.

The resulting matte undergoes further processing in converters, while the slag is discarded on site or sold in minor quantities as railroad ballast and sand blasting grit. Exhaust gases of the process - sulphur dioxide - are collected, cleaned and transformed into sulphuric acid for use in hydrometallurgical leaching.

After the initial smelting, the matte is recovered and moved to the converter, a cylindrical vessel (app. 10 x 4 m) equipped by air blowing pipes. Lime and silica are added to react with iron oxides and formation of slag. Scrap copper may also be added to the converter. The converter is rotated to immerse air blowing pipes into the reaction mass. Air is blown through the melted matte, oxidising residual iron sulphide with formation of iron oxide and sulphur dioxide. Then, the converter is rotated again to pour the iron-silicate slag out.

After complete removal of iron, the converter is rotated to its previous position and air is blown thought the melt again for oxidation of residual sulphur. Then, the converter is rotated to pour produced blister copper out (the term refers to uneven surface of the metal if allowed to solidify at that stage due to releases of oxygen and sulphur). Sulphur dioxide from the converter is channelled to the gas purification

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[99] *Krivtsov A.I., Klimenko N.G.* Mineral Resources. Copper. A Reference Book. M.: Geoinformmark, 1997. 51 p. (Rus.)

[100] http://base.safework.ru/iloenc?print&nd=857200675&nh=0

system with gases from the smelting stage for production of sulphuric acid. The slag of the convertor contains copper and it is returned to the smelter.

Blister copper contains at least 98.5 percent of copper and undergoes two-stage refining. At the first stage melted blister copper is placed into a converter-like cylindrical furnace and blown by air and then by natural gas or propane for removal of residual sulphur and oxygen. Then the metal is poured into a casting machine for production of copper anodes that are sufficiently clean for electrolysis-based refining.

In the course of copper electrochemical refining process, copper anodes are placed into electrolytic cells with copper sulphate electrolyte. Between copper anodes, pure copper plates (cathodes) are placed. When direct current is applied, copper from anodes dissolves and deposits on cathodes. After accumulation of a sufficiently large amount of purified copper, cathodes are removed and replaced by new ones. Solid impurities sink to the bottom of the electrolytic cell as anode silt - the material is collected and processed for recovery of gold and silver.

Cathode copper after the electrolysis contains 99.99+ percent of copper. Copper cathodes may be sold for wire production or cast as rods. For production of copper rods, cathode copper is melted in a shaft furnace and poured into a casting machine to cast copper ingots. Then, these ingots are rolled into 3/8 inch rods. These rods are used for production of copper wire.

In hydrometallurgical process, oxidised ores and waste are leached by sulphuric acid. The leaching may be conducted *in situ* or in heaps on acid-resistant lining to prevent groundwater pollution. Copper from the copper-containing leachate may be recovered by cementation on iron or by electrolysis. In cementation process (rarely used) metal copper ions are reduced to metal copper by scrap iron from the acidic leachate solution. After recovery of a substantial amount of copper, solid residues (copper and residual scrap iron) are smelted with primary copper concentrates.

In the course of copper extraction from leachates, copper concentrates in an organic solvent, while other metals (such as iron) remain in the aqueous phase. Copper-containing organic solution is separated by decantation. Then, enriched organic solution is treated by sulphuric acid to extract copper to the aqueous electrolytic solution. The residual leachate with iron and other impurities is returned to the leaching process, while the copper-containing solution undergoes electrochemical treatment. In contrast to the copper refining electrolysis, permanent inert anodes are installed in electrolytic cells for copper recovery from solutions. Similarly to the copper electrolytic refining process, metal copper deposits on cathode plates. Exhausted electrolyte is returned to the stage of copper extraction from the organic solvent. Cathode copper of the recovery process is processed similarly to copper cathodes of the electrolytic refinery process.

### Adverse environmental factors of ore processing and smelting[101]

Main adverse environmental factors include: dust releases in the course of ore processing and smelting, exhaust gases (containing copper, leas and arsenic), sulphur dioxide, carbon monoxide, noise of grinding equipment, high temperatures, sulphuric acid and electric factors of the electrolysis process.

Main pollutants at different stages of copper smelting and refining are shown in Table 5.9.

**Table 5.9**

Technological inputs and pollutants; releases of copper smelting and refining operations

[101] http://base.safework.ru/iloenc?print&nd=857200675&nh=0

| Production processes | Inputs | Emissions | Waste | Other waste |
|---|---|---|---|---|
| Copper ore clarification | Copper ore, water, reagents, thickening agents | | Flotation wastewater | Tailings with limestone and quartz |
| Copper leaching | Copper concentrates, sulphuric acid | | Uncontrolled releases of leaching products | Waste of leaching in heaps |
| Copper smelting | Copper concentrates, silica flux | Sulphur dioxide, particulates containing arsenic, antimony, cadmium, lead, mercury and zinc | | Disposal of acidic waste materials/ sediments, slag with iron sulphide and silica |
| Copper conversion | Matte, scrap copper, silica flux | Sulphur dioxide, particulates containing arsenic, antimony, cadmium, lead, mercury and zinc | | Disposal of acidic waste materials/ sediments, slag with iron sulphide and silica |
| Electrolytic copper refining | Blister copper, sulphuric acid | | | Silt containing gold, silver, arsenic, bismuth, iron, lead, nickel, selenium, sulphur and zinc |

**"Uchalinskiy Mining and Ore-dressing Plant" Co.**

Address: 453700, Russia, Bashkortostan, Uchaly, 2 Gornozavodskaya St.
phone: +7-34791 - 6-20-03
fax: +7-34791- 6-05-36
e-mail: ugok@ugok.ru, jashma@bashnet.ru
web: www.ugok.ru
Director General: I.A. Abdrakhmanov

www.ugok.ru

"Uchalinskiy Mining and Ore-dressing Plant" Co. extracts and clarifies copper pyrite ores of deposits at the territory of the Republic of Bashkortostan (Uchalinskoye and Zapadno-Ozerskoye) and in Chelyabinskaya oblast (Uzelginskoye, Molodezhnoye and Talganskoye).

The range of main components of the ores includes copper, zinc and sulphur. The ores also contain such associated components as gold, silver, selenium, tellurium, cadmium and indium. The associated components are recovered from copper and zinc concentrates in the course of metallurgical processing at plants of "UGMK-Holding". In addition, the range of extracted minerals of Molodezhnoye and Talganskoye deposits includes barite, while in the case of Talganskoye deposit the range includes also lead and mercury. Mercury levels in ores at the launch of industrial exploitation of these deposits reached 0.0060% in S1 grade ore and 0.0075% in S2 grade ore (mercury contents are rather low and only slightly exceed average Hg levels in the Earth crust.

Mercury minerals predominantly concentrate in tetrahedrite, blende, galenite and (to a lesser extent) in copper and iron pyrite (in the latter case mercury is present as an impurity). Mercury occurs in these ores as coloradoite (HgTe), tetrahedrite $(Hg,Cu)_{12}Sb_4S_{13}$ and (rarely) cinnabar (HgS). Metal mercury does not occur in natural ores.

Ore extraction and processing figures for 2009 are shown in Table 5.10.

Table 5.10

| | | | Yield | |
|---|---|---|---|---|
| Deposits | Ore extraction (thousand tons) | Ore processing (thousand tons) | Copper concentrates (thousand tons) | Zinc concentrates (thousand tons) |
| Uchalinskoye | 1986.0 | 2013.4 | 82.36 | 132.26 |
| Zapadno-Ozerskoye* | 22.6 | 10.0 | 0.57 | - |
| Uzelginskoye | 2453.6 | 2473.8 | 132.20 | 59.27 |
| Molodezhnoye | 629.4 | 629.4 | 56.78 | 27.76 |
| Talganskoye | 311.0 | 302.0 | 44.30 | 13.73 |
| Safianovskaya | - | 21.7 | 0.28 | 0.53 |
| Maiskaya | - | 10.9 | 0.53 | 0.49 |
| Yubileinaya | - | 8.8 | 0.82 | 0.05 |
| Total | 5402.6 | 5470.0 | 317.84 | 234.09 |

*Note. Off-balance lose gold and pyrite ore was extracted at the deposit.

All ores, extracted at deposits of "Uchalinskiy Mining and Ore-dressing Plant" Co. were clarified at Uhalinskiy ore-dressing plant by collective selective flotation without application of cyanides. The plant produces copper and zinc concentrates. The plant applies the following reagents for its ore-clarification operations: depressors, collectors, activators, frothers, pH-correctors and flocculants. The process does not result in destruction of crystalline lattice of minerals (including mercury minerals) and is not associated with direct chemical impacts on materials processed.

According to information provided by: I.A. Abdrakhmanov, Director General "Uchalinskiy Mining and Ore-dressing Plant" Co. and M.P. Orlov, the Chief Geologist of the plant, "the above mercury concentrations in pyrite ores are close to average Hg levels in alkaline basalt rock. Accounting for these considerations, technical regulations do not stipulate mercury monitoring at different stages of copper pyrite ores processing in Uchalinskiy Mining and Ore-dressing Plant" Co."

Ore clarification operations are usually conducted at low temperatures (under 100°C), as a result, mercury releases to air are practically negligible - the assumption is confirmed by mercury measurements at the site of Uchalinskiy Mining and Ore-dressing Plant[102]. Almost all mercury in pyrite ores comes to concentrates that are delivered to processing plants and only a tiny fraction of mercury (up to 2 - 7% of the overall mercury content) remains in tailings of the ore-dressing plant. Mercury contents are particularly high in pyrite concentrates and zinc concentrates (the highest levels observed). Mercury levels in tailings may be also fairly high (up to 1 - 9 g/t). In the area of Uchalinskiy Mining and Ore-dressing Plant the overall amount of tailings of the plant reaches 28 million tons.

[102] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

**"Karabashmed" Co.**

Address: 456140, Chelyabinskaya oblast, Karabash, 27-a Osbobozhdenie Urala St.
phone (35153) 2-36-10, fax (35153) 2-36-45

**Table 5.11**

Copper production in 2000 - 2001 (thousand tons) [103]

| Industrial facility | Copper | 2000 | 2001 | 2002 |
|---|---|---|---|---|
| "Karabashmed" Co. | Blister copper | 36.4 | 41.7 | 42.4 |

In 2001, "Karabashmed" Co. produced more than 134 thousand tons of copper concentrate.

Table 5.12 shows characteristics of copper-containing raw materials processed by Karabashmed" Co. in 2001.

**Table 5.12**

| Industrial facility | Main products and sources of raw materials |
|---|---|
| "Karabashmed" Co. | Blister copper: processing of copper concentrates of its own from Urals deposits (134.4 thousand tons) and briquetted copper concentrates from Urals deposits from "Kyshtymskiy Copper Electrolysis Plant" Co. (125.1 thousand tons). |

Table 5.13 provides information on average mercury levels in ores of Urals copper deposits (at confidence level of 0.95)[104]

**Table 5.13**

| Deposits, regions | Ores | Number of samples | Hg, averages and ranges (g/t) |
|---|---|---|---|
| | Copper pyrite | | |
| Uchaly, Southern Urals | Massive | 7 | 9.8 (3.2 - 19.75) |
| XIX Partsiezda, Southern Urals | Massive | 9 | 12 (4 - 27) |
| Cibai, Southern Urals | Massive | 8 | 11.2 (3.7 - 23.10) |
| Gaiskoye, Southern Urals | Massive | 14 | 13 (5 - 27) |

**Ore processing**

The plant processes raw copper ore by smelting (three shaft furnaces are installed) with further conversion of matte produced (three converters). In May 2001, the first phase installations for utilisation of roaster gases were commissioned - the oxygen unit allowed to improve environmental performance of smelting operations.

[103] Metal Supply and Sales, 2001, # 12.; Mineral Resources of the World at 1.1 2001 (a statistical reference book, official publication). - M.: FGUNPP .Aerogeologia, 2002. - 475 p. ; Non-ferrous Metallurgy, 2002, # 6; (Rus.)
[104] *Fursov V.Z.* Mercury Atmosphere of Natural and Anthropogenic Zones // Geochemistry, 1997, # 6, p. 644-652. (Rus.)

In 2002, "Karabashmed" Co. emitted 79 tons of lead (at its overall pollutants emission > 97 thousand tons)[105]. In 2002, pollutants emissions of the company reached more than 2 tons per 1 ton of blister copper.

Table 5.14 provides estimates of mercury emission and its distribution in products of "Karabashmed" Co. at the stage of blister copper production in 2001. In addition, about 10% (2.3 tons) of mercury migrate to sulphuric acid.

**Table 5.14**[106]

| Industrial facility | Blister copper (thousand tons) | Hg input with raw materials (tons) | Hg emissions (tons) | Hg in silt (tons) | Hg in slag (tons) | Hg discharge to the sewer (tons) |
|---|---|---|---|---|---|---|
| "Karabashmed" Co. | 41.7 | 4.12 | 0.0350 | 1.11 | 0.083 | 0.062 |

**Modernisation of the copper smelting operations to reduce environmental impacts and to approach a zero-waste production**

So far, about $120 million have been invested into modernisation of "Karabashmed" Co, production facilities. At the first stage, in May 2001, the oxygen unit of Linde AG (Germany) was commissioned. Application of pure oxygen in furnaces and converters allowed to reduce amounts of technological gases and air pollution. In parallel, the new water intake and associated networks were constructed on Bogorodskiy pond and a closed circuit water supply was commissioned.

Modern gas and water treatment installations of Swedish Boliden Contech AB were also commissioned. New installations for removal of particulate matter (dust) from roaster gases allowed to eliminate emissions of particulates that contained hazardous heavy metals and other elements.

WSA installation (Danish Haldor Topsoe A.S) was assembled for adsorption of sulphur dioxide for production of sulphuric acid. The installation was commissioned in May 2005. For the first time in Russian metallurgy, a so called "wet catalysis" technology was applied. After the launch of the WSA installation, sulphur dioxide emissions decreased radically and MAC for $SO_2$ in ambient air was met. Other pollution control equipment was also installed, such as "Frik 5200" bag filter, etc.

The new, fully automatic unit in the gas utilisation shop allowed to produce high grade sulphuric acid from dust-free exhaust gases of copper smelting operations. Investments into installation of the unit reached 646 million roubles. The gas utilisation shop produces over 200 tons of sulphuric acid annually.

Installation of Australian (Ausmelt Ltd) copper smelting furnace with immersion tuyere was completed (the first such furnace in Russia). The furnace allows to produce blister copper from copper concentrates and enriched copper slag.[107] Reconstruction works of "Karabashmed" Co. would allow the company to increase its annual output from 40 thousand tons of blister copper to 90 thousand tons, in addition the company would produce a new product - high grade sulphuric acid. Planned further modernisation works are expected to increase production of blister copper up to 190 thousand tons/year.

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[105] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[106] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[107] http://www.rmk-group.ru/proizvodstvo/predpriyatia/pg1/26/

Specialists of "Karabashmed" Co. and "Mechanobr-engineering" Co. from St. Petersburg designed and constructed the new plant for processing of metallurgical slag. The plant was commissioned in 2007. The new plant allows "Karabashmed" Co. to ensure a high degree of copper recovery from raw materials and to address both production and environmental problems. New technologies allow to produce three marketable products from metallurgical slag: copper concentrate, iron concentrate and sand for construction applications. The facility sells all these products to external customers and uses them in its own production processes**.**

**But...**

"Karabashmed" Co. is the key copper producer of the Urals region, it is categorised as 1st hazard class facility and continuously releases many tons of hazardous pollutants from its blister copper production line. The facility's site is located at the distance of merely 100 m from nearest residential districts at the mountainous slope. A sanitary protection zone seems to be non-existent and all industrial emissions of the plant predominantly precipitate on residential areas of the city lower. UN officially recognised Karabash as an environmental disaster and environmental emergency zone[108].

In NE part of Karabash, the slag disposal area covers 27.2 hectares of land and contains more than 10 million $m^3$ of hazardous waste. Another artificial waste deposit is located nearby the facility's site - the latter one contains more than 5 million $m^3$ of waste. A pyrite tailing pond is located in Sak-Elga river valley and covers about 90 hectares. Environmental assessments of soil nearby the plant site suggest extraordinary high levels of contamination by heavy metals from waste of ore mining and clarification operations. In some districts of the city (the area nearby the city hospital, Gagarina St., Lenina St,, Severniy township) record chemical pollution levels were registered - 483.5 points (for comparison - specialists assess pollution levels in excess of 128 points as an environmental disaster). The city residents are advised to avoid drinking water from city wells and Serebryanskiy waterline. Heavily contaminated lands in Karabash were not recultivated for many years.

According to official statistical reporting, "Karabashmed" Co. annually releases tens thousand tons of toxic gases and particulates, even higher amounts of toxic waste with carcinogenic and embryotoxic substances are disposed of within the city area. For example, in 2000, air emissions reached 113.356 thousand tons. In 2001, additional 591,055.874 tons of toxic waste were disposed of onto the slag disposal area of "Karabashmed". Such a situation is observed every consecutive year. Today, in connection with arrival of the new finance and industrial group of Igor Altushkin in Chelyabinskaya oblast, that extended production capacity of the plant, emissions of highly toxic sulphur dioxide further increased, in parallel with increased blister copper production. Correspondingly, in 2003 alone, 1,004,391.843 tons of waste were disposed of onto slag disposal sites within the city area. Surprisingly enough, "businessmen" of "Karabashmed" Co. seem to agree provisional $SO_2$ emission limits with Chelyabinsk oblast authorities - these provisional limits authorise substantially higher emissions of sulphur dioxide comparatively to relevant MACs, set by experts.

Investigators of Chelyabinskaya oblast Prosecutor Office have found that top managers of "Karabashmed" Co. were issued an individual package of emission limits - a tailored permit to release substantial quantities of hazardous pollutants. According to Order on Setting Pollutants Emission Limits for "Karabashmed" Co. of 19.02.2003, signed by Petr Sumin, the Governor of Chelyabinskaya oblast, Mr. Dzurko, the acting Chief of Chelyabinskaya oblast Environmental Authority issues a permit to the company, authorising it to emit even higher amounts of pollutants to the city air. In addition, chief officials of oblast-level control and supervisory agencies prefer to avoid upsetting the holding, as law enforcement bodies suspect that in addition to support of the State Administration of Chelyabinskaya oblast, the holding belongs to the sphere of interest of the largest organised criminal organisation of the country.

[108] http://www.rg.ru/2005/10/01/ural.html

On June 26, 2004, due to poor meteorological conditions, a major pollution release occurred at the plant - as a result, pollutants caused chemical burn of local vegetation. The release almost completely destroyed 102 hectares of forest and vegetation in 400 gardens of Karabash residents. The city residents were also affected: the number of Karabash residents who applied for medical assistance with respiratory problems sharply increased. Urals Federal District Directorate of the RF General Prosecutor Office initiated a criminal case on the fact of hazardous pollution releases of "Karabashmed" Co. The investigation of the criminal case revealed that Viktor Ermilov, the Technical Director of the Company had authorised launch of a new shaft furnace without the necessary documentation and conduction of state environmental expert assessment. Moreover, technological conditions of operation of the furnace were altered, a non-certified fuel was used and the gas converted was depressurised.

Due to all these factors, emissions of sulphur dioxide substantially increased. On June 26, 2004, a dense chemical smog covered residential areas of Karabash and a forest nearby. As $SO_2$ levels in the air were many times higher than usually, the oxygen unit of the metallurgical plant switched off automatically[109].

The Sanitary and Epidemiological Supervision Centre of Chelyabinskaya oblast, without any publicity, conducts research studies to "estimate levels of metals in blood and hair of Karabash children". The research results suggest substantial metabolic deviations, caused by toxic body burdens of lead, cadmium and arsenic. In 5 recent years, cancer morbidity indicators alone increased in Chelyabinskaya oblast from 335 to 364 cases per 100 thousand residents (compare to the Russian average of 300). But even the severe degradation of environmental quality in the Southern Urals region, that leaves no opportunities for choice to local residents, was not convincing enough to persuade MPs from Chelyabinskaya oblast in the need to introduce stricter pollution standards and to institutionalise responsibility of unscrupulous industrialists and officials who lobby their interests for radiation and toxic damages of their operations.

In the last year, the Hydrometeorological Service 251 times warned Karabash residents on high levels of pollutants in outdoor air of the city. 96 percent of these warnings were for real. Relatively recently, officers of the Environmental Prosecutor Office found that the plant releases pollutants almost without any treatment. Multi-element analysis research at the whole territory of Karabash clearly shows that there is one common source of air pollution in the region. In addition, experts found that toxic components of air pollutants in the region fully correspond to composition of particulate emissions of shaft furnaces and converters of "Karabashmed" Co. - the company that enjoys a particular support of the oblast authorities.

Groundwater resources in Chelyabinsk, Magnitogorsk, Karabash, Kyshtym and many other settlements of the oblast are under heavy industrial loads. Mine water releases from underground mining facilities severely contaminate all watercourses of Karabash area. In connection with decommissioning of Karabash ore-dressing facility, all water treatment facilities of the area were destroyed fully or partly - these facilities prevented infiltration of wastewater from Karabash collector ponds (mine water in the area is contaminated by ions of highly toxic heavy metals). Wastewater from Soimonovskaya and Sak-Elginskaya valleys, contaminated by sludge of the former ore-dressing facility and the chemical plant, metallurgical slag and technological water of "Karabashmed" Co. from Bogorodskiy pond, as well as Sak-Elga, Atkus and Olkhovka rivers that collect wastewater flows of the city - all these contaminated waters reach the Argazinskiy water reservoir basin - the key source of drinking water supply for Chelyabinskiy industrial cluster.

Analysis of bottom sediments reveals industrial mining grade contents of heavy metals (including mercury, copper, zinc, arsenic and lead) that are thousands times higher than applicable MACs. Predatory overexploitation of "Karabashmed" Co. production capacity with for higher production of blister copper and processing of imported copper ores with higher contents of rare metals and mercury facilitated additional mercury releases to the regional environment[110].

109 http://www.ombudsman.gov.ru/dad05/dad_52/r01.doc
110 http://www.ombudsman.gov.ru/dad05/dad_52/r01.doc

On 19.04.2010[111], "Karabashmed' Co. was found to be in non-compliance with environmental standards. In particular, the company exceeded emission limits for several hazardous pollutants, including silica, carbon monoxide and lead compounds. In addition, the company failed to meet the prescribed schedule of inspecting emission control equipment of the copper smelter. The Environmental Prosecutor Office of Chelyabinskaya oblast initiated an administrative offence case under articles 8.1 and 8.2 of the Administrative Offences Code of the Russian Federation. "Karabashmed" Co. had to pay administrative fines of RR 100 thousand and RR 30 thousand. The Director General of the company was issued an administrative order on elimination of the violations identified.

**"Kyshtymskiy Copper Electrolysis Plant"**

Kyshtym, 2 Parizhskoy Kommuny St.

**phone: +7(35151)4-74-81**

fax: +7 (35151) 4-74-63

Director General: N.A. Azarov

Volkhin Aleksandr Ivanovich

*Copper production in 2000 - 2001, thousand tons* [112]

Table 5.15

| Industrial facility | Copper grade | 2000 | 2001 | 2002 |
|---|---|---|---|---|
| "Kyshtymskiy Copper Electrolysis Plant" Co. | Refined copper | 77.7 | 82.1 | 76.3 |

In 2001, "Kyshtymskiy Copper Electrolysis Plant" Co. produced more than 124 thousand tons of copper concentrate.

The table below shows key characteristics of raw copper processed by "Kyshtymskiy Copper Electrolysis Plant" Co. in 2001.

For many years, Kyshtymskiy Copper Electrolysis Plant specialised in electrolytic refining of blister copper of Urals producers. Silt of the electrolysis process contains substantial quantities of precious metals such as gold, silver and platinoids, and copper refining operations allow to recover these metals (see Table 5.16) [113].

**Table 5.16**

| Industrial facility | Mainstream products and raw materials used |
|---|---|
| "Kyshtymskiy Copper Electrolysis Plant" Co. | Products: refined copper, production of precious metal, nickel sulphate of reagent grade (for electroplating operations), copper cathodes. The plant is the only Russian producer of electroplated copper foil for production of copper-clad dielectrics. The unique technology allows to produce copper foil tapes (for radiators/shields) 0.018+ mm. |

111 http://mediazavod.ru/shorties/86433

112 The Metallurgist, 2001, # 1.; Mineral Resources of the World at 1.1 2001 (a statistical reference book, official publication). - M.: FGUNPP .Aerogeologia, 2002. - 475 p. ; Non-ferrous Metallurgy, 2002, # 6; (Rus.)

113 The Metallurgist, 2001, # 1.; Mineral Resources of the World at 1.1 2001 (a statistical reference book, official publication). - M.: FGUNPP .Aerogeologia, 2002. - 475 p. ; Non-ferrous Metallurgy, 2002, # 6; (Rus.)

| | |
|---|---|
| | Raw materials: processing of blister copper from "Karabashmed Co.", scrap copper and waste materials with precious metals. |

Overall, in 2004 - 2007, production capacity of the plant increased almost in three times - by 140 thousand tons of copper cathodes/year - and reached 220 thousand tons/year. In 2005, the company reconstructed its second anode furnace and constructed a new electrolysis unit - as a result, production capacity of the plant was increased from 75,000 to 120,000 tons of copper cathodes/year. The production capacity increased up to 160,000 tons by June 01, 2008 and up to 220,000 tons in 2009.

Since 1996, the plant operates ISO 9001 quality ensurance system for production of its mainstream products - the system was certified by TÜV NORD CERT GmbH, Germany. In 2003 and 2006, the plant was successfully re-certified under ISO 9001-2000. In 2001, ISO 14001 environmental management system was introduced.

**But...**

**In June 2009**[114], Kyshtym City Prosecutor Office of Chelyabinskaya oblast, jointly with the territorial office of the Federal Service for Consumers Protection and Human Welfare inspected environmental compliance of "Kyshtymskiy Copper Electrolysis Plant" Co. The inspection revealed non-compliance. Inspectors collected air samples in the plant impact zone (Vtoraya Irtyashskaya St. in Kyshtym). Laboratory analysis of these samples revealed levels of hazardous substances in the air in excess of applicable MACs in violation of Law on Sanitary and Epidemiological Wellbeing of the Population.

The city prosecutor initiated an administrative offence case against "Kyshtymskiy Copper Electrolysis Plant" Co. under Article 6.3 of Administrative Offences Code of the Russian Federation (non-compliance with the due legislation on sanitary and epidemiological wellbeing). The company had to pay fine of RR **10 thousand**.

## Chapter 6

## Waste incineration plants

Main sources of mercury input into solid municipal waste (SMW) include mercury-containing lamps, thermometers, other mercury-containing household appliances and batteries/cells. Depending on a particular technology, every fluorescent lamp contains from 20 to 500 mg of mercury. Overall, fluorescent lamps in use in Russia (app. 400 - 500 million) contain about 50 tons of mercury. About 100 million fluorescent lamps become unusable every year. As a result, eventually, about 10 tons of mercury were released to the environment. Mercury-containing lamps are particularly hazardous in term of local toxic contamination, as mercury from a broken lamp evaporates rather quickly. Substantial amounts of mercury enter SMW with broken medical thermometers. A similar amount of mercury is released to the environment with obsolete cells[115]. Estimates suggest, that overall mercury input to waste flows due to used mercury-containing items may reach 16 - 23 tons. In addition, fluorescent lamps add about 1.6 tons of mercury (plus 1.6 tons in obsolete cells and 0.4 ton in electric switches).

Mercury inputs to SMW associated with mercury contents in different waste materials potentially may be rather high, but one can hardly estimate these inputs, mainly due to lack of information on initial mercury levels in such materials.

Average mercury levels in SMW, including used mercury-containing instruments and materials were estimated at the base of source assessments (see Table 6.1) and the overall SMW generation in the Russian Federation. Estimates suggest that mercury levels in SMW (except cases of mercury

[114] http://www.regnum.ru/look/cafbf8f2fbecf1eae8e920ece5e4e5fdebe5eaf2f0eeebe8f2edfbe920e7e0e2eee4/
[115] http://www.komtek-eco.ru/othodi.html

contamination of different materials) may reach 0.7 - 0.9 mg/kg (these figures lower that MAC for mercury in soils - 2.1 mg/kg).[116]

**Table 6.1**
Sources of mercury releases to SMW

| Sources of mercury releases to SMW | app. amounts of Hg (t/year) | notes |
|---|---|---|
| Mercury-containing instruments (mainly thermometers) | 16 - 23 | section 3.5 |
| Cells | 1.6* | section 3.6 |
| Lamps | 2 | section 3.8 |
| Dental amalgam | 6* | section 3.4 |
| Switches | 0.4 | section 3.9 |
| trace micro-element in all types of waste materials | 26 - 33 | |

*Precise amounts of mercury releases to SMW are not known

In the Russian Federation, almost all solid municipal waste is disposed of to landfills/dumps. Waste incinerators operate in Moscow, Pyatigorsk, Sochi, Vladivostok and Murmansk. The share of incinerated SMW may be assessed at the level of 2 - 3% of the overall waste generation. Accounting for the above estimates, we may assess the amount of mercury in incinerated waste as about 0.5 ton.

In this Survey only waste incinerators of Moscow are considered.

Now, there are three operational waste incineration plants in Moscow - in Eastern, Southern and North-eastern districts. The city daily generates up to 5.5 million tons of waste, including 3.8 million tons of household waste, about 250 thousand tons of hospital waste and 1.4 million tons of bulky demolition waste. Operational WIPs incinerate 27% of waste. In addition, five Moscow waste processing facilities maintain waste separation, while all other waste is disposed of to landfills. The city authorities estimate that capacity of these landfills as sufficient to maintain them in operation for three to five years[117].

It is worth to note[118] that none of the operational WIPs monitors composition of waste incineration products or the material balance of the incineration process. At the same time, the material balance is necessary for getting complete and reliable information on qualitative and quantitative composition of hazardous products generated. As a result, claims that pollution control equipment can ensure capturing 95% or 99% of hazardous emissions are merely empty words. In the best case, these figures are just an illusion. Actually, the number of reports on environmental releases of hazardous substances in zones of impacts of waste incinerators is growing, in parallel with reports on growing morbidity indicators there. Unfortunately, nobody can provide evidence to the contrary.

None of actual WIP designs[119] accounts for real-life operational conditions of a plant - designers use theoretical models of waste composition, incineration and waster treatment technologies. In reality, actual situations are much worse - waste separation is inefficient, incineration regimes are far from optimal conditions and pollution control systems fail to meet their declared performances indicators.

**Moscow WIP # 3**

Address: Moscow, Southern Administrative District, 22a Podolskih Kursantov St., build. 1
Company-operator: "EFN - Ekotekhprom WIP 3"

[116] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[117] http://infox.ru/science/tech/2010/03/17/Osobo_opasnyyye_otho.phtml
[118] http://www.ecounion.ru/ru/site.php?content=detailcontent.php&blockID=894
[119] http://www.ecounion.ru/ru/site.php?content=detailcontent.php&blockID=894

phone: + 7 (495) 510-3338
The deputy Director on Sanitary and Environmental Matters - Sinkova N.V.

Mainstream operations of the plant: thermal processing of solid household waste with utilisation of heat energy and generation of electric energy. Incineration capacity: 360,000 tons SMW/year (45 tons/hour).

Waste incineration plant # 3 applies a continuous waste processing technology in 2 SMW incineration lines with waste incineration on grates in spreader stockers of boilers. Excess heat of the incineration process is utilised for energy generation.

In 2008, the plant implemented inventory works to identify emission sources and their qualitative and quantitative parameters. The inventory works were conducted by Moscow city authorities (the Centre for Environmental Works and Services). According to the due legislation (inc. OND-86) estimates of pollutants dispersion in air were incorporated into provisional emission limits, agreed with the RF Env. Supervision Service. The plant was issued emission permit # 60136 of 13.04.2009 by Moscow city Technical Supervision Service Directorate - the permit specifies mercury emissions up to **0.11 ton/year**.

Stacks of every technological line are equipped by "automatic emission monitoring systems" - similar systems are installed at waste incinerating plants in Europe. The system continuously monitors levels of pollutants in flue gases (the list of such pollutants is prescribed by the city authorities). Measurement data are registered and transmitted to "Moscow Eco-monitoring" in on-lone mode.

The plant is claimed to be the most modern WIP in Russia. Every second, it emits 14 grams of pollutants. Every year, residents of Birulevo and Chertanovo are exposed to 70 kg of mercury, cadmium and 12 other toxic heavy metals, 15 mg of dioxins (dioxins are hazardous even in nanograms), particulates and many other hazardous pollutants[120].

**Moscow WIP # 2**

Address: Moscow, 33a Altufievskoye Highway
phone: +7(499)201-19-44
**Company-operator:** State-run facility "Specialised Plant # 2 of Ekotekhprom" for thermal processing of solid municipal waste.

SMW processing capacity: 160 thousand tons/year
Manufactures of the main equipment: "KNIP" (France).
Waste is incinerated on a sloping grate stocker.
Metal recovery: 4.810 thousand tons/year.
Electric power generation to the city grid: ~ 4MW.
SMW inputs undergo entry radiation control.

Due to relatively low incineration temperatures, the plans releases more dioxins, arsenic and other "healthy: compounds than similar European plants.

Natural gas is used to initiate the incineration process and to maintain its necessary temperature.

The plant:

- Incinerates SMW;
- Generates electric power and heat energy;
- Transmits electric and heat energy;
- Supplies electric power to Mosenergo grid.

[120] www.greanpeace.ru

The plant generates waste incineration slag (19.6 thousand tons/year). After fractioning and secondary metal recovery the slag is utilised as a filler for construction and heat-resistant materials, while separated fly ash (8.7 thousand tons/year) is utilised as an artificial construction material.

**Results of the extraordinary inspection[121]**

In June 2009, Moscow WIP # 2 was inspected by the RF Environmental Supervision Service (the inspection was launched in April 2009). Inspectors of the Service visited the plant in connection with complains of a local resident who claimed that she "cannot breath" there. The inspection was completed on June 23, 2009. Findings of the inspection are described in Protocol # 09-00-07/3A[122], that revealed the following facts:

Since 2004, the plant incinerated 65 thousand tons/year of waste illegally. In December 2004. Moscow WIP # 2 launched the third waste incineration line with capacity of 65 thousand tons/year. However, the official commissioning of the reconstruction works happened only in May 2006, while the relevant Moscow city department completed its official environmental expert assessment only in December 2006. Inspectors of the RF Environmental Supervision Service found that the line was not approved by the state expert environmental assessment. In other words, the plant operated one waste incineration line illegally for five years.

In May 2006, the first deputy Mayor of Moscow commissioned Waste Incineration Plant # 2 with installed capacity of 160 thousand tons/year. However, three operational technological lines of the plant process 65 thousand tons of waste each - therefore, the overall capacity should reach 195 thousand tons/year. What happens with these extra 35 thousand tons? One more question: how the Moscow government is expected to extend capacity of the plant in April 2008 from 130 thousand tons to 180 thousand tons, it was commissioned in 2006 with capacity of 160 thousand tons?

In additional to the above strange mismatches, inspectors of the Service revealed a lot of other violations as well. In 2008, the plant emitted 4 kg of manganese oxide over the emission limits (in Moscow, the compound is categorised as a 3rd hazard class substance). In addition, mercury was found in ash and slag of the plant, making claims of adherents of waste incinerators that ash and slag are safe rather questionable.

The company doest not maintain technical inspections of its emission control installations. In addition, "actual efficiency of emission control equipment in terms of capture of dioxins and furans is lower than their certified design efficiency". At declared efficiency of 99.99%, the manufacturer's certificate specifies 98%, while actual efficiency reached only 95.89%. If someone considers 4% as a tiny fraction, we should note that reduction of emission control efficiency by 1% increases dioxins emissions practically two-fold[123].

**SMW processing plant of "Ecotekhprom"**

Address: Moscow, Pekhorskaya St., estate 1A.
phone: +7(495)465-8965

Manufacturer of the main technological equipment: "Helter" (Germany).

Annual waste processing capacity: 250 thousand tons of unsegregated SMW, after separation of some types of waste (scrap metal, glass, PETP bottles) residual SMW (up to 95%) are incinerated in fluidised bed furnaces (275 thousand tons).

[121] http://www.greenpeace.org/russia/ru/news/3752110
[122] http://www.greenpeace.org/russia/ru/press/reports/3752099
[123] http://www.greenpeace.org/russia/ru/news/3752110

Utilised waste flows: paper, cardboard - 10.00 thousand tons; plastic - 4.00 thousand tons; glass - 3.00 thousand tons; scrap iron - 7.0 thousand tons; scrap non-ferrous metals 1.0 thousand tons.

According to Aleksey Kiselev (Greenpeace Russia), the waste incineration plant in "Rudnevo" industrial zone, is equipped by a fluidised bed furnace that is not tailored for incineration of SMW. Such a furnace may be used only for incineration of a highly uniform waste. In other words, application of such a furnace substantially complicates maintenance of the necessary technological regime and emissions control operations or even make them practically impossible.

According to A.N. Tsokur, the Director General of WIP # 2 and WIP # 4, technological lines of these facilities are equipped by multistage emission control installations for treatment of flue gases of the SMW incineration process. The equipment allows to comply with requirements of environmental authorities to emissions of hazardous substances.

The above waste incineration plants are not specially certified for management of mercury-containing materials. However, actually, their technological inputs (usegregated SMW) do include mercury-containing materials, as potentially hazardous items (batteries/cells, etc.) are not separated.

The waste incineration plants periodically control mercury levels in flue gases and fly ash in bag filters. These measurements are conducted by a specialized certified organisation. According to these measurements, mercury emissions with flue gases reach 0.2179 kg/year at WIP # 2 and 0.004 kg/year at WIP # 4, while mercury levels in fly ash do not exceed 0.1 µg/g. Mercury levels in the ambient air were estimated with application of OND-86 methodology.

## Chapter 7

### Hospital waste management

On March 22, 1999, Sanitary Rules and Standards (SanPiN) 2.1.7.728-99 were enacted in the Russian Federation - "Rules of Collection, Storage and Disposal of Health Care Facilities". These rules are applicable to all medical facilities and organisations dealing with collection, storage, transportation and processing of hospital waste. The regulation categorises all hospital waste into 5 classes depending on associated epidemiological, toxicological and radiation hazards. Mercury-containing waste belongs to **Class D. Industrial-like waste** (pharmaceutical preparations and disinfectants with expired shelf-life, waste medical/diagnostic preparations, mercury-containing items, instruments, equipment, etc.)[124].

Pursuant to Federal Law on Sanitary and Epidemiological Wellbeing of the Population (Law # 52 FZ of March 30, 1999, Compendium of Legislative Acts of the Russian Federation, 1999, # 14, p.1650) and Regulations on State Sanitary and Epidemiological Standardisation, approved by Decree # 554 of the Government of the Russian Federation of June 24, 2000 (Compendium of Legislative Acts of the Russian Federation, 2000, # 31, p. 3295), since June 15, 2003, new Sanitary and Epidemiological Rules and Standards were enacted (SanPiN 2.1.7.1322-03) - Hygiene Requirements to Disposal and Neutralisation of Production and Consumption Waste. The new Rules were approved by the Chief State Sanitarian of the Russian Federation on April 30, 2003[125]. The due Sanitary and Epidemiological Rules set hygiene requirements to disposal, management, technologies, operation regimes and recultivation of centralised facilities for use, neutralisation and disposal of production and consumption waste (items).

In recent years, environmental authorities tightened their waste management requirements to medical facilities. In this connection, medical facilities started to conduct inventories of hospital waste generated in their operations. Medical facilities generally maintain reporting on mercury-containing instruments and

[124] http://www.waste.ru/modules/section/item.php?itemid=20
[125] http://www.tehbez.ru/Docum/DocumShow_DocumID_500.html

preparations, radioactive components, disposable syringes and systems. Such types of hospital waste are transferred to specialised facilities for eventual utilisation[126].

According to SanPiN requirements, hospital waste of A class (**non-hazardous waste)** may be disposed of to SMW landfills without limitations, while hospital waste of B class (**hazardous waste)** or C class (**extremely hazardous waste)** should be neutralised by specialised thermal treatment methods (incineration, pyrolisis, plasma technologies)[127].

**Incineration of hospital waste**

Practices of incineration or hazardous and hospital waste are not broadly applied in the Russian Federation. In the majority of constituents of the Russian Federation, health care facilities are not equipped by installations for thermal destruction of hospital waste (incinerators). In 2007, only 263 (0.3%) of hospital waste incinerators were operational, while in 2006, 239 such incinerators (0.3%) operated[128].

An approximate composition of hospital waste for incineration looks as follows[129]: 74.5% of bandages, 9.3% of plastics, 7.9% of food waste, rubber and metals (3.1% of each type), 1.09% of biological waste. Probability of presence of mercury in such types of waste is rather low - the waste is usually buried or incinerated in boilers or crematoria[130].

**Small incinerators**

Installation of small incinerators in health care facilities (with associated emission control systems) is economically inappropriate. Moreover, application of small incinerators entails risks of environmental contamination by dioxins and heavy metals. Studies of waste incinerators revealed that dioxins are generated in combustion and gas cooling zones. Toxic emissions of different incinerators do not change in the range of temperatures from 700 to 1500°C, in the range of gas retention times from 2 to 6 seconds and in the range of oxygen concentrations from 2 to 15%. Dioxins are predominantly adsorbed by fly ash particles[131].

In 2000, the European Community introduced strict requirements to waste incinerators. New European standards prohibit application of small local installations for waste incineration. Waste must be incinerated within 24 hours from their delivery to the incinerator. Incinerators must be equipped by control instruments to monitor temperature, carbon and oxygen levels. Operational temperatures must reach 850°C in the combustion chamber and 1200°C in the after-burner. Flue gases must be treated to ensure the following levels of pollutants: dioxins $<0.1$ ng/m$^3$; carbon monoxide $<50$ mg/m$^3$; cadmium $<0.05$ mg/m$^3$; mercury $<0.05$ mg/m$^3$; other heavy metals (lead, arsenic) $<0.5$ mg/m$^3$ .

Nevertheless, the Russian market is filled by different installations for incineration of hospital and biological waste[132]. Many facilities that provide services of hospital waste incineration, do not have necessary emission permits and their pollution emissions substantially exceed relevant MACs[133].

The most high shares of health care facilities with medical waste incinerators in the Russian Federation are observed among hospitals ( 2.7% in 2007, 2.6% in 2006), TB dispensaries (1.7% in 2007, 1.3% in

126 http://ecomanager.ru/medical_waste.phtml
127 http://www.proza.ru/2010/03/01/606
128 http://www.fumc.ru/rules/24190.html
129 State of the Environment Report of the Russian Federation in 2001. M. 2002 (Rus.)
130 Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
131 http://www.proza.ru/2010/03/01/606
132 http://www.1stanok.ru/pages/kremator.html
133 http://www.new-garbage.com/?id=11819&page=3&part=12

2006), and surgeries ( 1.4% in 2007, 1.4% in 2006). Waste incinerators are not used by children's infarction hospital, children's TB dispensaries, maternity clinics.

In Kotlas (Arkhangelskaya oblast), a hospital waste incinerator with processing capacity of 20 kg/hour was commissioned in 2006 - from November 2006, 5.6 tons of hospital waste were incinerated. Two other incinerator units were purchased for planned installation in Arkhangelsk and Severodvinsk in 2008.

In Belgorodskaya oblast, two incinerator units are being installed in Belgorodskaya oblast TB clinic and at the landfill of Belgorod - these units would allow to collect and neutralise B and C class waste of health care facilities of the city and nearby districts. Now, potential construction of incinerators at landfills is being considered - these units are expected to serve several districts and utilise waste of B and C hazard classes.

In St. Petersburg, only 5 clinics operate decentralised systems for hospital waste processing. Five hospitals are equipped by installations for utilisation of medical waste.

In Kaliningradskaya oblast, hazardous hospital waste of B and C hazard classes is processed in a multi-disciplinary hospital - since 2006, the central facility operates a waste incinerator unit with capacity of 150 kg/hour.

In 2007, in Kemerovskaya oblast, 3 health care facilities were equipped by waste processing units with automatic packagers (Kemerovskaya oblast hospital, the oblast-level TB dispensary and Novokuznetskiy TB hospital). There were plans to equip 6 other major public health facilities by waste utilisation units in 2008.

In Krasnoyarsk (Krasnoyarskiy krai), two units for neutralisation of "hazardous" and "extremely hazardous" (B and C classes) are operated now. Since 2005, a unit for thermal waste destruction is used - the unit incorporates an incinerator for high-temperature destruction of solid and biological waste, including infected hospital waste. In 2006, an Italian waste utilisation unit with an automatic packager was commissioned for disinfection of hospital waste of B and C classes - the unit uses treatment by disinfection agents at temperatures of 150 - 155°C.

In Samarskaya oblast, according to WHO recommendations on switch from chemical disinfection of hospital waste to thermal destruction, in 2006 - 2007, 25 specialised Italian units for thermal destruction and grinding of hospital waste of B and C hazard classes were purchased for major health care facilities (one of such units is installed in Tolyatti TB dispensary). In addition, 29 smaller units of Czech and Chinese producers were purchased for district-level hospitals and clinics (the latter units use high pressure steam disinfection).

In Saratovskaya oblast, in the framework of Federal Program for Prevention and Treatment of Socially-conditioned Diseases, a unit for disinfection of hospital waste of B and C hazard classes was supplied to the oblast.

In Omskaya oblast, the problem of thermal destruction of hospital waste has not been resolved yet. In health care facilities of rural areas (district-level hospitals, village primary health care facilities, etc.), boilers or ovens are used from waste utilisation (including utilisation of organic waste). Only two local incinerators are used in the oblast - in the oblast-level hospital and in Omsk Ambulance Hospital # 2. Other Omsk clinics (including TB and dermatovernerologic facilities) dispose of their waste of B and C hazard classes to municipal landfills. The option of centralised thermal destruction of hospital waste has not been addressed yet.

In Kurskaya oblast, 40% of health care facilities incinerate their class B wastes in boilers after disinfection. Kursk oblast Centre for AIDS Prevention and Treatment is equipped by a muffle furnace.

Oblast level Children's Infection Hospital considers installation of muffle furnaces for destruction of medical and biological waste[134].

At the territory of the Republic of Adygeya, 2 muffle furnaces are used in Giaginskaya Central District Hospital and Maikop City Hospital for destruction of surgical organic waste (organs, tissues, etc.). Other clinics bury such waste in special burial sites.

Some municipalities of Sverdlovskaya oblast utilise hospital waste by incineration in boilers and crematoria and by disposal of to municipal landfills.

In Stavropolskiy krai, incinerators for destruction of hospital waste are used in 5 districts (central district-level hospitals of Kochubeevskiy and Neftekumskiy districts, Nevinnomyssk Central City Hospital, Yessentuky Maternity Hospital and Stavropol TB Dispensary). Twelve health care facilities use adjusted ovens for waste incineration purposes.

In Noviy Urengoi (Yamalo-Nenetshiy Autonomous District), hospital waste of all health care facilities is destroyed in a muffle furnace. Incineration capacity of the furnace is not sufficiently high now, but so far no decisions were made to purchase a new high-load incinerator.

**Pyrolisis**

Pyrolisis is an alternative to traditional methods of solid waste incineration - pyrolisis-based technologies use preliminary thermal decomposition of organic components in oxygen-depleted media with further after-burning of concentrated gas mixtures generated - controlled after-burning allows to transform toxic substances to less hazardous ones.

At the Russian market of medical equipment, two pyrolisis units are offered: Russian "ECHUTO" and French "Muller"[135].

**Plasma treatment technologies**

In plasma treatment technologies, an inert gas (e.g. argon) is ionised by electric arch at temperatures of about 6000°C. Hospital waste in plasma treatment units is heated up to 1300 - 1700°C. The thermal impact destroys microorganisms and transforms the waste into melted slag, compact metals and safe gases.

**Low temperature thermal processing**

Physical disinfection technologies include thermal treatment at 97 - 177°C or combined thermal treatment with steam/vacuum. Waste may be heated by hot steam, heaters, microwave or IR radiation, or by mechanical impact.

**Moscow**

Moscow city authorities abandoned their plant to construct new waste incineration plants, but they decided to construct a facility for incineration of extremely hazardous hospital waste. Moscow generates annually from 100 to 250 thousand tons of hospital waste. According to Stanislav Khramenkov, the director of the city water utility, every health care facility of the city generates about 300 - 400 kg of different waste daily. He told, that "so far, such a facility does not exist in Moscow, but relevant tender documentation is being developed now"[136].

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134

135 http://www.rumex.ru/products/index.php?cat=c717_------------------------------.html

136 http://infox.ru/science/tech/2010/03/17/Osobo_opasnyyye_otho.phtml

Official data suggest that hospital waste is disposed of to Moscow landfills with food and industrial waste[137]. Some part of the hospital waste comes to waste incineration plants. Organic surgery waste (organs, tissues, etc.) are usually treated by 10% solution of formaldehyde and incinerated in crematoria.[138]

### Chelyabinsk

According to official sources, hospital waste of Chelyabinsk and Chelyabinskaya oblast is disposed of to municipal landfills. Every year, up to 50 thousand tons of hospital waste are generated in the Southern Urals region. Chelyabinsk alone generates up to 300 tons of hospital waste annually[139]. Hundreds of thousands of surgeries - each one is accompanied by generation of up to 3.5 kg of blood-stained materials - are conducted in the city and such waste is disinfected by chlorination and disposed of to the municipal landfill. Environmental Prosecutor Office of Chelyabinskaya oblast many times warned Chelyabinsk oblast Hospital on severe violations of the due legislation on management of hazardous hospital waste. The most recent such warning was registered on 28.12.2009[140].

Another problem is associated with disposable syringes. According to the Russian Consumer Protection Supervision Service, the oblast generates 7 thousand tons of such waste every month, and only 2 facilities process it. However, these waste processing facilities do not accept self-locking syringes (in such syringes needles retract after injection, preventing reuse), as their technologies allow to recycle only plastic.

So far, the oblast authorities managed to purchase only microwave units for RR 10 million, however, a half of clinics that got these units lack even equipped premises for their installation - as a result, the equipment stays idle. There were plans to buy a waste treatment installation for the morbid anatomy dept. but no funds were available for the purpose (RR 5 million). So far, only one unit for disinfection and grinding of hospital waste was purchased in Chelyabinskaya oblast - it will be installed in Chelyabinskaya oblast Children's Hospital[141].

### Magadan

The problem of utilisation of medical waste in Magadan became more pressing recently in connection with growing numbers of diverse health care facilities of different ownership forms, resulting in higher generation of hospital waste and associated waste management costs[142].

Since 01.07.08, a municipal utility of Magadan deals with hospital waste management. In 2007, the city authorities installed 2 incinerators for hospital waste with treatment capacity of 20 kg/hour.

Now, at the first stage, hospital waste is collected in places of generation, according to relevant sanitary rules, after disinfection and packaging into standard plastic bags. However, some violations of the rules at the stage of waste collection, storage and utilisation are observed due to lack of necessary rooms and equipment (containers, sealed cans, etc.). At the stage of incineration all types of hospital waste are often mixed with solid household waste.

Inspections revealed some violations in the course of collection and utilisation of SMW and hospital waste. Hospital waste is offer stored in open containers for household waste at the territory of health care facilities.

[137] http://www.narcom.ru/ideas/common/72.html
[138] http://www.fumc.ru/rules/24190.html
[139] http://health.russiaregionpress.ru/archives/date/2009/09/15/page/2
[140] http://chelyabinsk.ru/newsline/254870.html
[141] http://www.nr2.ru/chel/179254.html
[142] http://www.49.rospotrebnadzor.ru/old/news_021208.htm

There were some cases of untimely utilisation of unusable medical thermometers and UV lamps and their storage in workplace areas of health care facilities.

Sometimes hospital waste and solid household waste are burned at territories of medical facilities.

## Chapter 8

### Gold refining from concentrates with high mercury contents

Now, five key sources of mercury emissions in the course of gold mining operations may be identified. Associated quantitative indicators depend on types of deposits, available gold reserves, intensity of mining operations and application of mercury in technological processes[143]:

1. Mercury emissions from used rock, tailings, contaminated soils, infiltration of mercury from these materials due to surface washout and pollution of watercourses, soils, aqueous and terrestrial ecosystems.
2. Commonly used practices of secondary exploitation of artificial alluvial deposits and processing of tailings of vein/alluvial gold mining.
3. Illegal application of mercury for enrichment of gold-containing concentrates and raw materials.
4. Gold recovery from deposits with naturally elevated mercury contents.
5. Processing of gold concentrates with elevated mercury levels due to natural/industrial causes at gold refining plants.

**In this Survey we consider only operations of some gold-refining plants, namely:** Schelkovskiy Secondary Precious Metals Plant (Schelkovo, Moskovskaya oblast) and Kolymskiy Refining Plant (Khasyn township, Magadanskaya oblast). Overall, there are 10 operational plants in the country that are authorised to refine precious metals.[144]

According to official information, mercury contents in gold concentrates of refining plants (up to 1988), reached 0.2 - 4.0 g/t[145]. Novosibirskiy Refining Plant (the oldest gold refining plant in the country, that processed up to 60% of all primary gold production before early 1990s) seems to be the source of heaviest mercury releases. Due to processing of gold concentrates and placer gold with elevated mercury contents, soils around the plant site contain 0.03 - 18.9 mg/kg of mercury. Concentrations of elementary mercury in soil air exceeded local background levels in 100 times[146].

Today, elevated mercury levels in gold concentrates may be attributed to natural factors, such as higher mercury contents in cyanine process silt, and to consequences of mercury application earlier (in the case of processing secondary artificial alluvial deposits and tailings), as well as to contemporary illegal application of mercury. It is impossible to assess overall mercury emissions associated with refining of gold concentrates as quantities of different concentrates (placer gold, ingots, cyanide process silt, etc.) and associated mercury levels are not known.

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[143] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

[144] *Tereshina T.O.* Geography of Russian Gold Industry // Communications of the Moscow University. Series 5. Geography, 2000, # 4, p. 27-33. (Rus.)

[145] Order of the Precious Metals Dept. under the USSR Council of Ministers # 124 of 29.2.88. On Terminating Use of Mercury (Amalgamation) in Technological Processes of Enrichment of Gold-containing Ores and Alluvial Deposits. (Rus.)

[146] *Roslyakov N.A., Kirillova O.V.* Mercury Pollution of the Environment in the Course of Gold Mining in Russia // Chemistry for Sustainable Development, 1995, # 3, p. 43-55. (Rus.)

In recent years, some attempts were made to assess mercury releases associated with gold mining and processing operations[147]. However, these estimates were rather rough, moreover they relied on past gold mining structure and technologies applied (with domination of alluvial gold deposits).

**Kolymskiy Refining Plant**

Address: Khasyn township, Magadanskaya oblast, Russia.
phone: (41322) 2-7440.
fax: (41322) 2-7440.

"Kolymskiy Refining Plant" Co. operates in the sphere of precious metals refining since 1998. The company is included into the List of Organisations Authorised to Refine Precious Metals. The analytical laboratory of the plant is accredited in the system of similar laboratories of Russia. The plant produces refined precious metal in ingots (under GOST 28058-89, 28595-90) and in pellets (under TU 1753-33954329-001-2000, 1752-33954329-002-2000). The plant ensures minimal unrecoverable losses of precious metals in production processes.

From 1998 to 2000, the plant exported 25 tons of high grade refined gold in ingots (under GOST 28058-89). The technological equipment of the plant allows to produce 35 tons of pure gold from both high grade and low grade raw products. In 2000 - 2001, the plant commissioned a technological line for processing of silver from intermediate silver products supplied from new silver and gold deposits being put into exploitation in Magadanskaya oblast.

In 2007, the plant accepted for processing 153.8 tons of precious metal, including 23.6 tons of gold (1.6 times higher than in the previous year - 14.5 tons), and 130.2 tons of silver (5.8 times higher that in the previous year - 22.4 tons).

Raw products to the plant are predominantly supplied by mining companies: "Magadan Silver" Co., "Omsukchanskaya GGK" Co., "Nelkobazoloto" Co., "Karalveem Mine" Co., "Susumanzoloto" Co. "Chukotskaya GGK" Co. is the key supplier of the plant - from May to September 2008, the company supplied 8.5 tons of gold and 89.8 tons of silver to the refining plant.

In 2002, Magadanskaya oblast Prosecutor Office had found[148] that "Kolymskiy Refining Plant" Co. operated its melting shop since November 2002 without official commissioning of a hazardous industrial facility and without a license. The prosecutor issued notifications to the company managers and the territorial office of the RF Technical Supervision Service, accusing the latter body in lack of a systemic control over facilities under its supervision.

"Kolymskiy Refining Plant" Co. and the Khasynskiy district Administration had signed an agreement stipulating that the plant disposes of its waste (inc. Mn; Cu; Hg and Zn) and maintains its tailing pond in due conditions while the district administration maintains control of its operations[149].

**Schelkovskiy Secondary Precious Metal Plant**

Address: 141100, Moskovskaya oblast, Schelkovo, 103 A Zarechnaya St.
phone: 495-526-4904

[147] *Roslyakov N.A., Kirillova O.V.* Mercury Pollution of the Environment in the Course of Gold Mining in Russia // Chemistry for Sustainable Development, 1995, # 3, p. 43-55.; *Yagolnitser M.A., Sokolov V.M., Ryabtsev A.D. et al.* Assessments of Industrial Mercury Emissions in Siberia // Chemistry for Sustainable Development, 1995, 3. # 1-2. p. 23-35. (Rus.)
[148] http://genproc.gov.ru/documents/orders/document-13/
[149] http://www.ecoindustry.ru/news/view/3894.html

**Production activities:**

- processing of primary and secondary products containing precious metal, including waste electronic equipment and photographic waste;
- production of refined gold and silver in ingots and granules;
- production of diverse unique silver salts and powders[150].

The plant monitors emissions of NO-$NO_2$-NOx , $SO_2$, CO, HCl.

In 1992 - 2006, the plant mainly processed scrap electronic components of military hardware, circuit boards, mixed electronic waste, obsolete computer equipment, switches, transistors and glass insulators. Main valuable elements of electronic waste included: Au, Ag, Cu, Al, Fe, Ni, Pb, Sb, platinoids and other metals.

Detailed studies of composition of different types of electronic waste and analysis of the statistical data obtained allowed to subdivide these types of waste into 6 groups depending on their origin (see Table 7.1)[151].

**Table 7.1**

Categories of electronic waste depending on origin

| Metals, % (mass). | Group | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| | Scrap electronic components of military hardware | Circuit boards | Mixed electronic waste | Computer components | Switches | Transistors and glass insulators |
| Gold | 0.08 | 0.27 | 0.02 | 0.31 | 0.01 | 1.00 |
| Silver | 0.43 | 2.50 | 0.18 | 2.89 | 0.20 | 0.20 |
| Copper | 21.11 | 23.04 | 18.60 | 12.00 | 33.00 | 1.31 |
| Aluminium | 15.20 | 15.40 | 14.60 | 17.61 | 13.70 | 32.78 |
| Iron | 7.15 | 12.30 | 10.20 | 7.45 | 35.26 | 22.50 |
| Nickel | 2.14 | 3.25 | 2.85 | 2.20 | 1.05 | 1.25 |
| Lead | 3.15 | 2.80 | 2.25 | 0.85 | 3.97 | 0.96 |
| Tin | 12.41 | 1.40 | 4.70 | 1.23 | 4.00 | 1.25 |
| Platinoids | 0.70 | 0.90 | 0.02 | 0.15 | 0.00 | 0.11 |
| Other | 37.63 | 38.14 | 46.58 | 55.31 | 8.81 | 38.64 |

The plant specialists had developed and introduced a technology for hydrometallurgical processing of electronic waste with selective recovery of precious (gold, silver) and non-ferrous metals (copper, tin, zinc). The new technology allowed to reduce environmental pressures. A similar technology was also introduced in "V.N. Gulidov Krasnoyarskiy Non-ferrous Metal Plant" Co.

In addition, specialists of Schelkovskiy plant had developed technological specifications for design of an electric cylindrical rotary furnace for incineration of scrap electronic waste. The furnace with processing capacity of 75 - 80 kg of electronic waste per hour was designed, manufactured and commissioned.

The plant also developed technological specifications for design of an arc smelting furnace with air blowing for production of copper from electronic waste (copper concentrates precious metals). EPZ-1.5 (1.5 MW) continuous action furnace was designed, manufactured and commissioned

150 http://www.chem.msu.su/rus/books/analitika/1.html
151 http://vak.ed.gov.ru/common/img/uploaded/files/vak/announcements/techn/2009/30-11/LoleytSI.doc

The plant introduced a pyrometallurgical technology for comprehensive processing of electronic waste - the technology allowed to improve recovery of gold, silver, platinoids, copper and other non-ferrous metals, and to enhance production capacity of the technological equipment.[152]

### JSC "Prioksky Приокский non-ferrous metal enterprise"391303, Kasimov, Riazan region

Director General: Alexandr Boguslavsky
*Tel: +7(49131)32000*
pzcm@zvetmet.ru
http://zvetmet.ru/index.php?option=com_content&task=view&id=13&Itemid=28

Maximum allowable estimated capacity on refining:
Gold - 260 t/year
Silver – 2500 t/year
Platinum– 15 t/year
Palladium – 15 t/year

Information on leading of estimated capacity in 2008, %:
Gold – 12,2
Silver – 3,5
Platinum– 2,0
Palladium – 2,5

List of main activities:
- refining;
- production and realization of standard and small bars;
- production and realization of powders and chemical compounds of precious metals in the form of solutions;
- pry waste of precious and ferrous metals reprocessing a.

## CONCLUSIONS

In the course of collection and analysis of information on mercury emission sources in Russia, we analysed data on the following industrial facilities:

**Coal-fired thermoelectric plants (TEPs)**

**Coal-fired TEPs of "Mosenergo" Co.:**

TEP-22 (Dzerzhinskiy)

| | |
|---|---|
| Installed power generation capacity, MW | 1310 |
| Electric energy generation, million kWh (data of 2008) | 8726.7 |
| Installed heat energy generation capacity, Gcal/hour | 3606 |
| Heat energy production Gcal (data of 2008) | 8818.1 |

TEP-17 (Stupino)

| | |
|---|---|
| Installed power generation capacity, MW | 192 |
| Electric energy generation, million kWh (annual) | 654.575 |
| Installed heat energy generation capacity, Gcal/hour | 712 |
| Heat energy production Gcal (annual) | 528.426 |

[152] http://vak.ed.gov.ru/common/img/uploaded/files/vak/announcements/techn/2009/30-11/LoleytSI.doc

**Coal-fired TEPs of "Fortum" Co.:**

Argayashskaya TEP (Ozersk)
Installed capacity: 195 MW electric power, 576 Gcal/hour heat energy.

Chelyabinskaya TEP-1 (Chelyabinsk)
Installed capacity: 149 MW (electric), 1341 Gcal/hour heat energy.

Chelyabinskaya TEP-2 (Chelyabinsk).
Installed capacity: 320 MW (electric), 956 Gcal/hour.

**Krasnodarskaya TEP** (Krasnodar)
Generating capacity of Krasnodarskaya TEP: 1 million kW

**Coal-fired TEPs of "Irkutskenergo" Co.**: Novoirkutskaya TEP (Irkutsk),
The overall installed generation capacity of the company reaches 12.9 GW of electric power (including over 9 GW of hydroelectric generation capacity) and 13.0 Gcal/hour of heat energy. In terms of capacity and production, the company's generating facilities are able to generate more than 70 billion kWh of electric power and up to 46 million Gcal of heat energy.

**Magadanskaya TEP** (Magadan)
Installed generating capacity: 96 MW (electric power), 210 Gcal/hour (heat energy).

**<u>Chlorine-alkali production facilities</u>**

**"Kaustik" Co.** (Volgograd)

| Products | 2005 (thousand tons) | 2006 (thousand tons) | shares in 2005 (%) | shares in 2006 (%) |
|---|---|---|---|---|
| sodium hydroxide (solution) | 210 | 216 | 18 | 18 |
| sodium hydroxide solid | 67504 | 63510 | 62 | 60 |

Mercury emissions were calculated according to the Methodology for Estimation of Air Concentrations of Hazardous Substances from Industrial Emission Sources (OND-86, the All-Union Standard, approved by the State Committee for Hydrometeorology in 1986 and agreed by the Public Health Ministry), the Manual on Setting Discharge (Emission) Limits (approved in 1989), Recommendations on Compiling and Maintenance of Emission Limits for Industrial Facilities (issued in 1989), and the Methodology for Estimation of Discharge Limits for Substances with Wastewater Flows (recommended in 1991).

The facility uses the following instruments for quantitative analysis of emissions:
- RA-915 atomic adsorption spectrometer;
- Yulia-5 atomic adsorption spectrometer.

**"Plascard" Co. Ltd. (Volgograd)**
Annual rated production of the facility: 90,000 tons of PVC-S. In 2008, the facility reached record production output levels - 93,793 tons of PVC-SD and 96,279 tons of VCM.

**"Khimprom" Co. (Volgograd)**

| Products | 2005 (th. tons) | 2006 (th. tons) | 2008 (th. tons) | 2009 (th. tons) |
|---|---|---|---|---|
| caustic soda solution | 87 | 90 | no data available | no data available |
| caustic soda solid | 5768 | 7115 | no data available | no data available |
| VC | no data available | no data available | 21.7 | 22.7 |

**Mercury emission control (methods, instruments):** Photometry, the method for determination of mass concentrations of mercury dichloride in industrial emissions of "Khimprom" Co.

**"Sayankhimplast" Co.** (Sayansk, Irkutskaya oblast)

| Year | 1997 | | 2002 | |
|---|---|---|---|---|
| Caustic soda production (tons) | 51800 | | 121500 | |
| Mercury losses | absolute (t) | specific (kg/t NaOH) | absolute (t) | specific (kg/t NaOH) |
| - emissions with ventilation exhaust and off-gases | 0.653 | $1.26\ 10^{-2}$ | 0.238 | $1.96\ 10^{-3}$ |
| - waste burial (brine and wastewater treatment sludge) | 10.360 | 0.20 | 22.908 | 0.189 |
| - released in products | 0.031 | $5.98\ 10^{-4}$ | 0.080 | $6.6\ 10^{-4}$ |
| - mechanical losses in soils | 13.377 | 0.258 | 47.687 | 0.392 |
| - discharges to water bodies | no data available | | no data available | |
| TOTAL | 24.421 | 0.471 | 70.913 | 0.583 |

## Cement plants

**Voskresenskiy cement plant** (Voskresensk, Moskovskaya oblast)
Production capacity: 1 million tons/year.
In 2001, the annual production reached 1.3 million tons of cement.

**Schurovskiy cement plant** (Kolomna, Moskovskaya oblast)
Production capacity: 0.33 million tons/year.

**Sebryakovskiy cement plant** (Mikhailovka, Volgogradskaya oblast)
Production capacity: 2.4 million tons/year.

**"Uraltsement" Co.** (Korkino, Chelyabinskaya oblast)
Production capacity: 2.3 million tons/year.

**Magadanskiy cement plant** (Magadan)
Production capacity: 0.15 million ton/year

**Angarskiy cement plant** (Angarsk, Irkutskaya oblast)
Installed capacity: 2.1 million tons

**Spasskiy cement plant** (Spassk-Dalniy, Primorskiy Krai)
Production capacity: 3.4 million tons

## Non-ferrous metallurgy facilities

**Chelyabinskiy zinc plant** (Chelyabinsk)

According to data of April 29, 2010, in 2009, Chelyabinskiy zinc plant produced 119.9 thousand tons of Special High Grade zinc and alloys or by 20% less comparatively to 2008 (150 thousand tons).

**"Karabashmed" Co.** (Karabash, Chelyabinskaya oblast)
Copper production in 2000 - 2001 (thousand tons)

| **Industrial facility** | **Copper** | **2000** | **2001** | **2002** |
|---|---|---|---|---|
| "Karabashmed" Co. | Blister copper | 36.4 | 41.7 | 42.4 |

In 2001, "Karabashmed" Co. produced more than 134 thousand tons of copper concentrate.

**Kyshtymskiy copper electrolysis plant** (Kyshtym, Chelyabinskaya oblast)
*Copper production in 2000 - 2001, thousand tons*

| **Industrial facility** | **Copper grade** | **2000** | **2001** | **2002** |
|---|---|---|---|---|
| "Kyshtymskiy Copper Electrolysis Plant" Co. | Refined copper | 77.7 | 82.1 | 76.3 |

In 2001, "Kyshtymskiy Copper Electrolysis Plant" Co. produced more than 124 thousand tons of copper concentrate.

## Waste incineration plants

**Moskovskiy WIP # 3** (Moscow)
Incineration capacity: 360,000 tons SMW/year (45 tons/hour)

**Moskovskiy WIP # 2** (Moscow)
Incineration capacity: 160 thousand tons/year

**Solid municipal waste neutralisation plant # 4 in "Rudnevo" industrial zone** (Moscow)
Annual waste processing capacity: 250 thousand tons of unsegregated SMW

**Incineration of hospital waste -** analysis of situation in different regions of Russia.

## Metal refining plants

**Kolymskiy metal refining plant (**Khasyn township, Magadanskaya oblast)
The technological equipment of the plant allows to produce 35 tons of pure gold from both high grade and low grade raw products. In 2007, the plant accepted for processing 153.8 tons of precious metal, including 23.6 tons of gold (1.6 times higher than in the previous year - 14.5 tons), and 130.2 tons of silver (5.8 times higher that in the previous year - 22.4 tons).

**Schelkovskiy Secondary Precious Metal Plant**
In 1992 - 2006, the plant mainly processed scrap electronic components of military hardware, circuit boards, mixed electronic waste, obsolete computer equipment, switches, transistors and glass insulators. Main valuable elements of electronic waste included: Au, Ag, Cu, Al, Fe, Ni, Pb, Sb, platinoids and other metals.

**JSC "Prioksky Приокский non-ferrous metal enterprise"**Maximum allowable estimated capacity on refining:
Gold - 260 t/year
Silver – 2500 t/year
Platinum– 15 t/year
Palladium – 15 t/year

In the course of analysis of available published data we submitted information requests to the Federal Environmental, Technology and Nuclear Supervision Service of the Russian Federation, the Federal Service for Consumers Protection and Human Welfare, and to chief managers of the facilities surveyed.

The analysis of available information suggests that the selected facilities are or may be sources of mercury emissions.

However, information supplied by these facilities (according to the due environmental legislation, they are obliged to maintain technological/laboratory environmental control) does not confirm the above assumption.

**A few examples:**

**Subsidiaries of "Fortum" Co. in Chelyabinskaya oblast**

In response to our request on use of mercury-containing raw materials and control of mercury emissions by "Fortum" Co. subsidiaries (Coal-fired TEPs of "Fortum" **Co.:** Argayashskaya TEP (Ozersk), Chelyabinskaya TEP-1 (Chelyabinsk), Chelyabinskaya TEP-2 (Chelyabinsk)), the deputy Chief Engineer of the company, V.N. Kargapolov answered: "The company does not maintain any production processes, that stipulate application of mercury or mercury-containing raw materials. There are no sources of mercury emissions". In addition, V.N. Kargapolov specified: "Raw materials of the company include solid and gaseous fuel. Adverse impacts of operations of "Fortum" Co. subsidiaries on the ambient air are associated with emissions of coal and gas combustion products".

According to our data, three surveyed TEPs of "Fortum" Co. (Argayashskaya TEP, TEP-1 and TEP-2) use coal as a fuel. Coal is supplied from mines of Chelyabinskiy lignite coalfields**. The above TEPs consume annually about 3.3 million tons of coal with average mercury content of 0.05 mg/kg**. The mercury extraction with the coal reaches about 0.17 ton.

According to V.N. Kargapolov, "all our subsidiaries maintain individual certified laboratories, that control emissions on sources according to control schedules, stipulated by draft emission limits". However, our data suggest that draft ELs of "Fortum" Co. subsidiaries do not stipulate limits for emissions of mercury vapour. Laboratories of "Fortum" Co. subsidiaries have not been certified in the oblast for determination of mercury emissions. As a result, it is hardly appropriate to claim lack of mercury emissions by facilities that do not maintain relevant monitoring.

A similar response was provided by chief managers of **Novoirkutskaya TEP -** they argued that the power plant "does not use mercury-containing materials and does not have any mercury emissions". However, published sources, referred to in this Survey, suggest that the TEP was designed to use lignite from Eastern Siberia coalfields (with average mercury contents from 0.005 to 0.02 g/ton of lignite).

None of the surveyed cement plants does not monitor mercury emissions in the course of their technological (laboratory) environmental control operations. For example, according to R.G.Snyatkov, the Director General of **"Kolymatsement" Co.**, mercury is not listed among hazardous substances emitted from production operations of the plant. As already noted in this Survey, in cement and lime production processes, mercury releases in the course of thermal treatment of carbonates and clay materials. At high temperatures mercury evaporates and escapes with flue gases. Nevertheless, Russian cement plants do not measure/estimate mercury emissions. We failed to find any data on actual efficiency of mercury capture by filters installed at Russian cement plants.

None of the surveyed non-ferrous metallurgy facilities monitors mercury levels. We received response letters from "Karabashmed" Co., "Kyshtymskiy copper electrolysis plant" Co., "Mednogorskiy copper and sulphur plant" Co. and "Uralelektromed" Co. These facilities produce blister and electrolytic copper.

All of these facilities, according to published sources, including the report of the Federal Environmental, Technology and Nuclear Supervision Service and the Danish EPA[153], are sources of mercury emissions.

However, data submitted by production facilities themselves, suggest the opposite situation. For example, according to A.P. Rybnikov, the Director General of Mednogorskiy copper and sulphur plant, "the plant does not use mercury-containing raw materials". It sounds strange as the plant processes copper concentrates, copper ores and slag, producing blister copper and sulphuric acid. The plant processes copper concentrate from Mongolian "Erdenet" Concern (about 40 thousand tons), and copper concentrates of Gaiskiy Ore Clarifying Plant). In copper pyrite ores of Gaiskiy deposit mercury contents reach 1 - 90 g/t[154]. In copper concentrates from Erdenetiyn-Obo deposit (Mongolia) mercury contents reach about 1.2 g/t[155].

Mednogorskiy copper and sulphur plant processes copper ores by smelting in shaft furnaces with further converting of copper matte. The production technology stipulated production of elementary sulphur from exhaust gases of shaft furnaces. Electrostatic filters are used for treatment of exhaust gases of smelters and convertors. In the course of roasting of copper concentrates, 80 - 90% of mercury evaporate[156]. In the course of treatment of exhaust sulphur-containing gases, mercury is partially captured with particulates (mercury levels in dust reach 15 - 560 g/t), and partially comes with gases to the sulphur acid production shop. Table A shows estimates of mercury emissions and mercury distribution within Mednogorskiy copper and sulphur plant. Besides that, about 10% of mercury come to sulphur acid.

**Table A**

Production of blister copper at Mednogorskiy copper and sulphur plant.

| Producer | Blister copper (thousand tons) | Hg input with raw materials (tons) | Hg emissions (tons) | Hg in sludge (tons) | Hg in slag (tons) | Hg discharges to the sewer (tons) |
|---|---|---|---|---|---|---|
| Mednogorskiy copper and sulphur plant | 23.9 | 1.43 | 0.124 | 0.394 | 0.029 | 0.022 |

We received a similar response from "Uralelektromed" Co. According to the Chief Engineer of the Company V.V. Ashikhin: "production processes of "Uralelektromed" Co. include application of blister copper and scrap copper, that do not contain mercury. We do not monitor mercury emissions".

[153] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[154] *Ozerova N.A.* Mercury and Endogenic Ore Formation. - M.: Nauka, 1986. - 232 p. (Rus.).
[155] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.
[156] *Bobrova L.V., Kondrashova O.V., Fedorchuk N.V.* Economy of Geological Survey for Mercury, Antimony and Bismuth. M.: Nedra, 1990. 156 p. (Rus.)

It is worth to note that "Uralelektromed" Co. produces electrolytic copper[157]. The facility processes blister copper from smelters of the Urals region (a substantial part of the blister copper is produced from copper concentrates of Krasnouralskiy and Sredneuralskiy ore clarifying plants, that process primary ores of Safianovskiy copper deposit) and its own secondary copper (anode sludge and external scrap copper and copper alloys). High levels of mercury in copper ores of Safianovskiy deposit are confirmed by the State Balance of Mineral Resources of the Russian Federation[158].

Differences in reported data of mercury-emitting facilities themselves and information of published sources suggest that the majority of Russian production facilities do not control their mercury emissions. They lack certified laboratories for mercury emission control. Mercury is not included into plans of measures to control compliance with emission limits (ELs).

Lack of references to mercury sources and mercury as a pollutant in draft Emission Limits (ELs), draft Discharge Limits (DLs) and Waste Disposal Limits (WDLs) suggests that mercury escapes from the system of pollution control and monitoring at the stage of issuance of pollutant emission/discharge permits by the Federal Environmental, Technology and Nuclear Supervision Service. Every particular industrial facility maintains technical regulations for particular technologies applied - these regulations list all existing emission/discharge sources of the facility and pollutants that are released to the environment due to its production operations.

Unfortunately enough, at the stage of development of draft ELs, DLs and WDLs, some pollution sources and some pollutants are not accounted for. A facility has incentives to avoid including mercury (an extremely hazardous substance) into draft ELs, DLs and WDLs, as its environmental charges and fines depend on amounts of pollutants released and their environmental hazard classes.

At the base of draft ELs, DLs and WDLs, the Federal Environmental, Technology and Nuclear Supervision Service issues permits, that specify maximal permitted pollutants emissions, discharges and waste disposal limits for every particular pollutant and for every particular facility. Naturally, a facility is obliged to provide reliable information on pollution sources and individual pollutants to the Federal Supervision Service. However, in the course of issuance of pollution permits, the Federal Supervision Service is obliged to check accuracy of the facility's data (e.g. to cross-check them against technical regulations, material balances and raw materials lists).

By the end of the reporting year, the facility reports its actual annual emissions, discharges and waste disposal in Form 2 TP. Should reported data in Form 2 TP exceed planned ones in draft ELs, DLs and WDLs, the facility must pay environmental fees for excessive pollution or a fine.

In Russia, the State Committee for Hydrometeorology is responsible for state monitoring of air quality, water quality in natural water bodies, etc. (laboratory control), including control of mercury. However, the control is selective.

In the course of state environmental supervision (according to the Regulations of the Federal Service for Supervision of Natural Resources Use, approved by Decree # 400 of the Government of the Russian Federation of July 30, 2004), the Service supervises and controls compliance with the due environmental legislation of the Russian Federation, including legislative acts on air quality protection and waste management. In the course of its inspections, the Service may use additional analytical data of certified laboratories that were issued certificates for relevant measurements by the State Committee for Technical Regulation (the State Committee for Standardisation). However, such studies are conducted rarely, in exceptional cases only.

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[157] Assessment of Mercury Releases to the Environment from the Territory of the Russian Federation. Produced for the Arctic Council. The Federal Environmental, Technology and Nuclear Supervision Service, the Danish EPA, 2005.

[158] Mineral Resources of the World in early 1999 (official publication). - M.: FGUNPP .Aerogeologia, 2000. - 911 p. (Rus.)

Once in two years, the Federal Service for Supervision of Natural Resources Use is obliged to conduct a scheduled inspection of an industrial facility to check its compliance with pollution permits issued - i.e. to check actual emissions and discharges against ELs/DLs, to check compliance with scheduled environmental control measures, especially in the case of facilities that handle substances of 1st and 2nd hazard classes. However, provided substantiated complains of residents or legal entities (e.g. schools or other facilities nearby), accidents or other emergencies, a relevant Prosecutor Office may order an emergency inspection.

Facilities themselves report their emissions if they cannot hide them, such as emission of chlorine-alkali plants. However, according to our information, in such cases they do not comply with the Manual for Sampling of Pollutants in Emissions of Industrial Facilities (lack of equipped sampling points for emission control purposes). These facilities only measure emissions in exhaust gases of emission control installations, other fixed emission sources are not monitored and are not equipped by sampling points. Chlorine-alkali facilities do not register input and output gas flows of emission control installations - as a result, it is impossible to estimate actual emissions of pollutants quantitatively. In particular, "Kaustik" Co. does not monitor mercury pollution levels in its sanitary protection zone; the company categorised mercury-containing sludge after wastewater treatment operations as 4th hazard class waste and disposed off it with industrial and municipal waste.

As one expert of the Russian Technical Supervision Service said: "All these facts are fairly natural, as the state policy in the sphere did not require mandatory data reporting. In any case, even if a facility is found to exceed its emission limits, its managers prefer to pay a minor fine instead of investing real money into modernisation of production equipment and pollution control installations".

In the course of development of the Survey, we came to the conclusion, that Russian facilities report only emissions of substances that are listed in their ELs documents. If mercury is not listed in ELs, its emissions are not measured and controlled. Generally, information on mercury emissions is reported only by facilities that use mercury in their technological processes, such as chlorine-alkali plants. Facilities that process burnt fluorescent lamps are obliged to classify them as 1st hazard class materials according to specialised legislative acts on waste processing. Other facilities, that use or process raw materials with mercury impurities, are obliged to report mercury emissions and include mercury into their environmental reporting according to requirements to industrial environmental control (Article 67 of Law of Environmental Protection). The Russian Technical Supervision Service is obliged to control compliance with the above requirements, namely - by requesting a facility to submit its material balance (the base of its technical regulations). However, actually facilities do not submit reporting on mercury arguing that they do not deal with mercury-containing raw materials. The Russian Technical Supervision Service doest not require industrial facilities to provide additional evidence of accuracy of their reporting data, the Service relies on submitted draft ELs only in the course of issuance of relevant permits.