16th INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE SGEM2016

ECOLOGY, ECONOMICS, EDUCATION AND LEGISLATION
CONFERENCE PROCEEDINGS
VOLUME I

ECOLOGY AND ENVIRONMENTAL PROTECTION

ENVIRONMENTAL LEGISLATION, MULTILATERAL RELATIONS AND FUNDING OPPORTUNITIES

30 June – 6 July, 2016
Albena, Bulgaria

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Published by STEF92 Technology Ltd., 51 "Alexander Malinov" Blvd., 1712 Sofia, Bulgaria
Total print: 5000

ISBN 978-619-7105-65-0

ISSN 1314-2704

DOI: 10.5593/sgem2016B51

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IDENTIFYING BEST AVAILABLE TECHNIQUES FOR CERAMIC AND GLASS INDUSTRIES IN RUSSIA

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ABSTRACT

In 2015, Russia made first practical steps towards transition to Integrated Environmental Permitting (IEP) based on Best Available Techniques (BAT). The Government issued the list of industrial sectors and the minimum production capacity of installations to be regulated under the IEP regime. Glass and ceramic industries have been included in the national IEP list for which BATs have been identified and national Information and Technical Reference Books (ITRBs) developed. These sectors are not priority environmental polluters but they fall into the category of energy-intensive industries consuming from 2 to 50 GJ per tonne of product.

Selecting glass and ceramic industries for the primary development of ITRBs, Russian authorities considered results of pilot projects implemented in these sectors in 2003-2013. Industries participated in these projects compared their energy efficiency and environmental performance to BAT parameters set in Europe. Since ITRBs had to be completed for just six months, data obtained earlier were rather helpful.

Major difficulties faced by TWGs dealt with the reluctance of many operators (for brick production – over 80 %) to participate in the national benchmarking. Fortunately, leading industrial associations contributed a lot towards solving this problem: they provided the necessary data (collecting them from operators) and offered using industrial sites of several companies for practical studies and training exercises.

Resulting ITRB “Glass Manufacturing Industry” is a concise document, covering production of flat, container, domestic glass as well as glass fibre and sodium silicate. “Ceramic Manufacturing Industry” ITRB is more detailed and covers practically all sub-sectors characteristic of Russia. Identified BATs and resource efficiency parameters are quite similar to those listed in the EU Reference Books. Environmental performance data are scarce; in each book CO, NOx, SO_2 and particulate matter emission factors are presented only for 2-3 key sub-sectors.

It is suggested that preparing recommendations on IEP procedure in Russia, industrial associations should run additional case studies and provide more reliable data on environmental performance. Current legislation allows reviewing and improving ITRBs as soon as new information on BATs becomes available to practitioners.

Keywords: Integrated Pollution Prevention and Control, Best Available Techniques, Integrated Environmental Permits, glass and ceramic industries.

INTRODUCTION

Integrated Pollution Prevention and Control Law passed in Russian back in 2014 has been turning into a major environmental legislation, which aims to regulate around 40,000 installations in the country dealing with a wide range of industrial and agricultural activities [1, 2].

Russian Best Available Techniques Bureau was set up to catalyse an exchange of information between industrial associations, enterprises, consulting companies, researchers and educators and to develop national Information and Technical Reference Books.

Ceramic and glass industries belong to the first ten sectors for which such reference books were prepared and officially issued in 2015. This opened an opportunity to begin preparing larger installations to transferring to the new regulation regime and to share lessons learnt with other sectors falling under the Integrated Pollution Prevention and Control legislation [3].

WORKING PROCEDURES OF RUSSIAN BEST AVAILABLE TECHNIQUES BUREAU

In 2015, Russian Best Available Techniques Bureau (BAT Bureau, www.burondt.ru) was established as an analogue to the European IPPC Bureau functioning in Seville since the 90s. For each Information and Technical Reference Book (ITRB), Russian BAT Bureau sets up a Technical Working Group (TWG) to carry out the exchange of information on BAT. A TWG usually consists of between 40 to 200 specialists, while the core of TWG can be as small as 5-10 experts [3].

Russian BAT Bureau organises the work of the TWG, fosters the exchange of information, makes a scientific and technical analysis of the vast amount of information exchanged, proposes compromise solutions on issues when views of TWG members differ, and writes the ITRB. Russian BAT Bureau acts as a neutral, technically competent and permanent body to all TWGs.

The procedure used to develop an ITRB includes a few plenary meetings of the TWG, sub-group meetings, visits to installations, and submission of a draft ITRB for comments. Comments arrive from TWG members as well as practitioners and scholars informed about environmental performance and resource efficiency of Russian industries. In general, practical arrangements for the exchange of information are laid down in the specific guidance national standards of the Russian Federation. These documents aim in particular at guiding Russian BAT Bureau and members of the TWGs in the drawing up and reviewing the whole series of ITRBs [3].

Once it has been finalised, each ITRB is presented by BAT Bureau to the Technical Committee 113 "Best Available Techniques" and to the Federal Agency for Technical Regulation and Metrology (Rosstandart). Adopted ITRBs are issued officially as the Russian Federation standardisation documents. Special documents containing the parts of particular ITRB displaying the conclusions on Best Available Techniques (similar to European BAT conclusions) shall be issued as Governmental Decrees to become the reference for setting the permit conditions to installations covered by the IPPC legislation in Russia. Each ITRB must be reviewed at least once in 10 years but can be reviewed as early as necessary.

DETERMINATION OF BEST AVAILABLE TECHNIQUES: GENERAL APPROACHES

In order to determine a BAT, there is a need to select the technology, technique or management instrument that is the most effective in achieving a high general level of protection of the environment taken as a whole. The overall process is based on the sector benchmarking, which the compilation and the comparative analysis of the consumption and emission levels characteristic for each of the alternative techniques (Fig 1). In some sectors, there is a range of emissions, discharges or resources used by the alternative techniques under consideration, and it is necessary to look at ways of expressing the environmental effects so that comparisons can be made between the alternatives. In ceramic and glass production, such effects as human toxicity, global warming, aquatic toxicity, acidification, and eutrophication differ rather numerically than qualitatively.

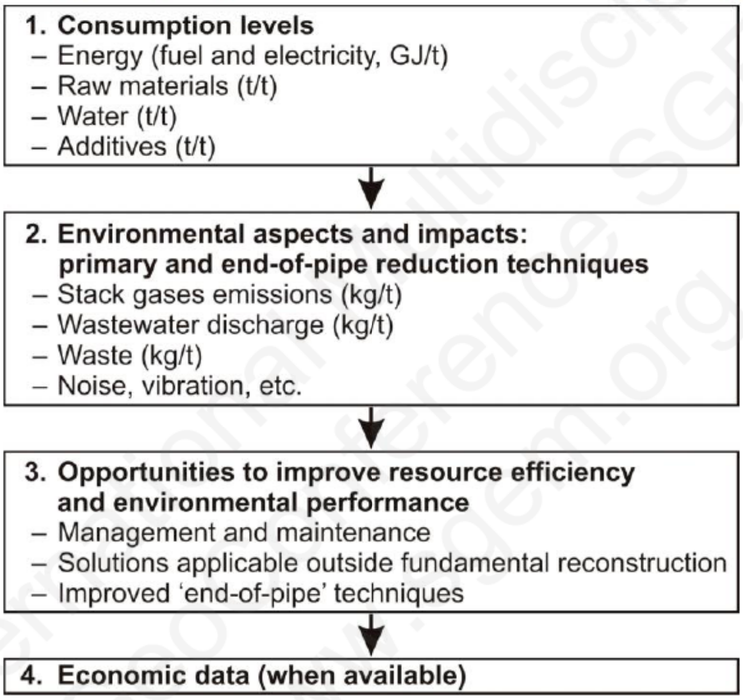

Fig. 1. Staged approach in the determination of best available techniques

In general, TWGs established to prepare ITRBs for ceramic and glass industries in Russia tried to apply international approaches used by the European IPPC Bureau since the 90s. Still, the methodology was simplified (Fig. 1), but even this streamlined version was difficult to follow due to scarce data submitted by the operators. While overall descriptions of techniques used were available, reliable consumption and emission data were rarely provided. In addition, industrial associations and individual operators were prepared to discuss economic aspects only in general, submitting figures reflecting costs of typical development projects implemented in 2005-2010.

IDENTIFYING BEST AVAILABLE TECHNIQUES: CERAMIC INDUSTRY

In Russia, ceramic manufacturing enterprises form a very diverse industry including production of bricks, wall and floor tiles, refractory products, technical ceramics, sanitaryware, household ceramics, etc. The manufacture of ceramic products takes place in different types of kilns, with a wide range of raw materials and in numerous shapes, sizes and colours. The general process of manufacturing ceramic products, however, is rather uniform, besides the fact that for production of wall and floor tiles, refractory products, technical ceramics, sanitaryware and household ceramics a multiple stage firing process is often used [4].

The Technical Working Group "Ceramic Manufacturing Industry" included representatives of Industrial Associations, enterprises, as well as Universities and consulting companies. Brick manufacturers dominated in TWG 4 as they dominate in the overall structure of the ceramic industry in Russia: nearly 300 plants of different capacities keep functioning in nearly each region of the country.

Identifying BATs for ceramic manufacturing sub-sectors, TWG 4 members considered results of the national and international projects implemented in Russia in 2005-2014. Leading industries became experimental sites of TWG 4 and provided both environmental performance and energy efficiency data and valuable comments on technological processes descriptions, BAT identification methodology and BAT parameters included in Ceramic ITRB [6].

Important issues for the implementation of IPPC in Russian ceramic industry were prioritised as follows: energy efficiency, reduction of emissions to air and water (in several sub-sectors), raw material and water usage, minimisation, recovery and recycling of process losses/waste and process waste water, as well as effective management systems. These issues can be addressed by a variety of process-integrated (primary) and 'end-of-pipe' (secondary) techniques, taking into account the applicability in individual ceramic sub-sectors. In this context, techniques for pollution prevention and control presented in the final ITRB, are divided in several categories.

Environmental Management Systems (EMS) are essential for minimising environmental impacts of industrial activities. EMS is a part of the management system used to control environmental aspects, fulfil compliance obligations, and address risks and opportunities [5]. In Russia, few ceramic industries (mostly refractory materials producers) implement and achieve registration of full-scale EMSs, which resulted in formulating this BAT as 'Environmental Management Systems and their instruments'.

Energy Efficiency (reduction of energy consumption). Since Russian ceramic manufacturers use the natural gas as the main energy source, the choices of firing technique and heat recovery method are central to the design of the kiln and are also some of the most important factors affecting the environmental performance and energy efficiency of the manufacturing process. With this regard, one of the key challenges of the ITRB development was the energy efficiency benchmarking process aimed at the identification of current energy consumption levels.

Questionnaires were sent to nearly 400 hundred operators manufacturing ceramic products in the Russian Federation; somewhat 10% of them responded in each sub-sector. Energy consumption benchmarking results are shown in Fig. 2 for Russian ceramic brick sub-sector [6].

The list of main BATs for reducing energy consumption, which can be applied individually or in combination, embrace improved design of kilns and dryers, recovery of excess heat from kilns, and modification of ceramic bodies [6].

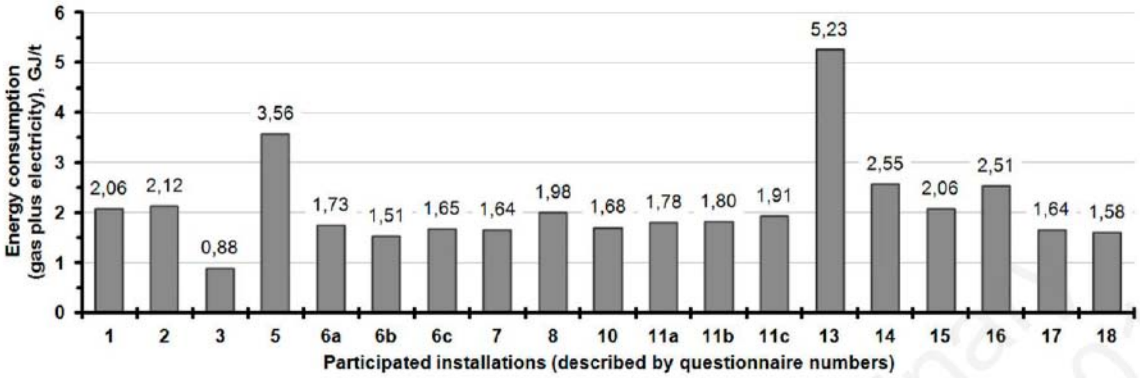

Fig. 2. Energy consumption benchmarking of Russian ceramic brick industries

BATs for the **reduction of diffuse dust emissions** include application of good reliable maintenance protocols for dusty operations and bulk storage area measures. Channelled dust emissions from dusty operations other than from drying or firing can be reduced by applying bag filters; the suggested dust removal efficiency varies from 97 to 99.5%. The range may be higher depending on specific operating conditions.

Channelled dust emissions from drying processes can be minimised by cleaning the dryer, by avoiding the accumulation of dust residues in the dryer and by adopting adequate maintenance protocols. BATs for the reduction of dust emissions from kiln firing processes include minimisation of dust formation caused by the charging of the ware to be fired in the kiln. By applying dry Flue-gas cleaning is not applied by Russian industries and thus cannot be listed among BAT solutions.

In Russian ceramic industry, emissions of gaseous compounds (CO, NOx, SO_2) are reduced exclusively by primary measures/techniques, namely by reducing the input of pollutant precursors (sulphur compounds) and optimising firing conditions. In the national benchmarking process, brick and tile producers provided rather contradictory figures, and BAT levels included in in Ceramic ITRB [6] are limited to the parameters specified in Table 1.

Table 1. Identification of Best Available Techniques: emission levels in ceramic brick and tile production

Contaminants	BAT emissions levels, kg/t of product	
	Manufacture of bricks	Manufacture of tiles
NOx (expressed as NO_2)	≤ 0.5	≤ 0.8
CO	≤ 0.8	≤ 1.5
SO_2	≤ 0.2	≤ 0.2

Re-use of process wastewater was identified as BAT for the production of wall and floor tiles, household ceramics, and sanitaryware. Process wastewater recycling ratios vary from 50 to 99 % and can be achieved by applying a combination of process optimisation measures and process wastewater treatment systems. It is also recommended to re-use the sludge arising from process wastewater treatment in the ceramic body preparation process in a ratio of 0.5-1.5 % per weight of added dry sludge to the ceramic body, by applying a sludge recycling system, when applicable.

Reduction of the amount of **solid process losses/solid waste** can be achieved by introducing a robust waste management system requiring waste separation in workshops and in some cases by replacing plaster moulds by polymer or metal moulds.

IDENTIFYING BEST AVAILABLE TECHNIQUES: GLASS INDUSTRY

The glass industry in Russia is rather diverse, both in the products made and the manufacturing techniques applied. Products range from traditional handmade lead crystal to the huge volumes of float glass produced for the construction and automotive industries. Manufacturing techniques vary from the small electrically-heated furnaces (less that 10 tonnes of melted glass per day) to the huge cross-fired regenerative furnaces in the flat glass sector, producing up to 8-10 hundred tonnes of melted glass daily. Today Russian glass industry embraces enterprises producing container glass (6.7 mln t/year), flat glass (3.2 mln t/year), domestic glass (0.5 mln t/year), continuous filament glass fibre (0.3 mln t/year), special glass (0.4 mln t/year), as well as glass wool and stone wool. According to the current classification of economic sectors in Russia, continuous filament glass fibre production falls under the category of chemical industry, while stone wool production is often discussed as a part of construction materials industry. Considering time scale and preparedness of operators to share consumption and emission data, members of TWG 5 "Glass Manufacturing Industry" members decided to focus their attention on the production of flat, container and, to a certain extent, domestic glass; continuous filament glass fibre was described based on practices of one national installation. In addition, liquid sodium silicate production is analysed due to the interest of larger industries.

Identifying BATs for glass manufacturing sub-sectors, TWG 5 members considered results of the national and international projects implemented in Russia in 2000-2005. It appeared rather difficult to reach a compromise upon the structure and contents of the final Glass ITRB [10], and at the final stage it was the Association of Glass Producers who carried on the drawing process rather that experts who started collecting data and drafting ITRB in spring 2015. The resulting ITRB includes both general and sub-sector related BATs, in some cases associated consumption and emission levels are specified.

Even though in Russia flat glass manufacturers mostly possess full scale **Environmental Management Systems**, the first general BAT identified by TWG 5 was described as the implementation of an EMS or at least of its key instruments such as efficient process control, maintenance programmes, and safeguarding compliance with environmental legislation.

Since all glass industries are energy intensive, the second BAT was determined as the **reduction of the specific energy consumption** by using one or a combination of the following techniques: (1) process optimisation, through the control of the operating parameters, (2) regular maintenance of the melting furnace, (3) increasing levels of cullet, and (4) using waste heat boiler for energy recovery (where available and economically and technically viable).

Glass industries are commonly addressed as 'dusty ones' though it is not true for newer installations. Nevertheless, **materials storage and handling** need special attention. BAT is to prevent, or where necessary, to reduce dust emissions from the storage and handling of solid materials by (1) stoking bulk powder materials in enclosed silos equipped with a dust abatement system (such as fabric filter with filtering efficiency up to 99.9%), (2) storing fine materials in enclosed containers or sealed bags (3) storing under cover stockpiles of coarse dusty materials, and (4) applying road cleaning vehicles and water damping techniques.

In Russia, 'end-of-pipe' techniques are rarely used to combat emissions originated from glass melting; some data are reported only by lead crystal manufacturers. Still, primary measures allow reducing emissions of CO, NOx and dust (see Table 2).

Table 2. Identification of Best Available Techniques: emission levels in flat and container glass production (glass melting process)

Contaminants	BAT emissions levels, kg/t of product	
	Manufacture of flat glass	Manufacture of container glass
NOx (expressed as NO_2)	≤ 12	≤ 10
CO	≤ 1.0	≤ 1.0
Dust	≤ 1.5	≤ 1.5

Emission levels specified in Table 2 are rather high, but industry operators suggested setting them this way due to the very wide variety of data obtained in benchmarking.

Water use and wastewater reduction wise, BATs identified include (1) minimisation of spillages and leaks: (2) re-use of cooling and cleaning waters after purging; (3) operating quasi-closed loop water system as far as technically and economically feasible. Both industry wastewater treatment systems and collaboration with wastewater utilities are used by Russian glass manufacturers, and practical recommendations depend on regional and local circumstances.

As far as **solid waste** is concerned, glass enterprises are often called 'no waste industries' due to good opportunities for recycling cullet in the manufacturing process. BATs here include (1) recycling of waste batch materials, where quality requirements allow for it; (2) minimising material losses during the storage and handling of raw materials (not applicable to the continuous filament glass fibre and high temperature insulation wool); (3) recycling of dust in the batch preparation (again, formulation where quality requirements allow for it).

Numerical data are not many in "Glass Manufacturing Industry" ITRB, and Russian practitioners hope to fill this gap participating in sector pilot projects and obtaining Integrated Environmental Permits on the voluntary basis (before they become obligatory for glass producers in 2021-2022).

CONCLUSION

Since 2014, Russian environmental regulation system has been fundamentally reformed in accordance with IPPC principles. To form the necessary basis for Integrated Environmental Permits, BATs are being identifying for key economic sectors, including those manufacturing ceramic and glass products.

Not being major polluters, ceramic and glass industries were included in the list of first ten sectors, for which Best Available Techniques were determined and Information and Technical Reference Books on BATs drawn. No surprise that Technical Working Groups working on these ITRBs identified many similar approaches applicable to optimise energy consumption and to minimise pollution in these high temperature industries.

Energy efficiency became not only the key the major resource oriented solution but also the key to pollution prevention supported by most practitioners participated in the development of ceramic and glass ITRBs.

While consumption levels associated with BATs are determined rather well, emission factors remain quite uncertain, which is caused both by the reluctance of operators to share reliable data and by poor environmental self-monitoring practices characteristic of many sub-sectors. In general, BATs are very similar to those identified for the EU industries, though available emission factors are set higher than those in EU BREFs.

BAT is a dynamic concept and so the development and review of ITRB of Best Available Techniques is a continuing process. This is why pilot projects and voluntary implementation of Integrated Environmental Permits are seen as promising instruments to better evaluate BAT characteristics and disseminate BAT related experience in Russian ceramic and glass manufacturing sectors.

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