INDUSTRIAL POLLUTION AND CONTROL MEASURES FOR FOUNDRIES IN CYPRUS

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Abstract

Over the last decades improvements have been achieved in industry regarding several major polluting substances, and that gradually the environmental impact has shifted towards so-called diffuse sources of pollution. Nevertheless, industrial production processes still account for a considerable share of the overall pollution in Europe and it is very important to further reduce their contribution to 'unsustainability'. The EU has a set of common rules on permitting for industrial installations. These rules are set out in the so-called IPPC Directive of 1996. Cyprus is one of the candidate countries to become a full member of the European Union. In order to access formally to the E.U., Cyprus has to follow an implementation process and take into account all the obligations that the 15 Member States have to respect. A large number of obligations derive from IPPC Directive, which intends to result in the protection of the environment as a whole and the public health as well. In this framework, the National Technical University of Athens, after thorough examination of a large number of documents relevant to the Best Available Techniques, developed guidelines for the

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application of BATs for 14 categories of the industry of Cyprus. This paper concerns the developed guidelines for foundries.

Keywords: best available techniques, foundries, pollution control, IPPC Directive

1. The IPPC Directive – The BAT Information Exchange

Pollution prevention is preferable to reliance on end-of-pipe pollution control. Cleaner production encompasses production processes and management procedures that entail less use of resources than conventional technologies and also generate less waste and smaller amounts of toxic or other harmful substances. It emphasizes the human and organizational dimensions of environmental management, including good plant operation to avoid deliberate or accidental discharges. Today, cleaner production aims to include everything from the drawing board to final disposal or reuse of the product. Cleaner production and pollution prevention can reduce the quantities of waste and eliminate some pollutants, but treatment and disposal of remaining wastes are required.

Prior to the adoption in September 1996 of Council Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC), air and water pollution and waste disposal in some MS were regulated separately, while others operated some form of integrated pollution control. However, emphasis on control of pollution in a single medium, focusing particularly on air and water quality, has resulted in some cases in a poor balance of priorities for processes emitting to different environmental media, and inconsistency in the environmental standards achieved. This is set to change with the future implementation of the IPPC Directive, which aims to introduce a Europe-wide system of integrated pollution control to achieve a high level of protection for the environment as a whole, and to establish a general framework of integrated pollution control. This means that no medium will be compromised in an attempt to protect another. Instead of independently concentrating on air, water and land, it concentrates on a source control of pollution where emissions from a facility will be preferentially eliminated, reduced, recovered or recycled. In the event where pollutant emissions cannot be prevented they will be treated using the best available 'end-of-pipe' treatment technologies (O’ Malley, 1999).

The directive applies to six industrial categories: energy, production and processing of metals, minerals, chemicals, waste management, and ‘others’, including pulp and paper production, textile treatment, tanning, food processing, etc. IPPC will set the standard for all activities for which environmental permits are required. Permits will be far broader than they were previously. Rather than an industry needing several permits, one for each environmental medium (air, water or soil), IPPC permits will be integrated. They will cover both direct and indirect discharges to any medium, as well as issues of waste minimisation, energy efficiency, resource utilisation, prevention of accidents, and the restoration of sites after the industrial activity has ceased. Permits are to be reconsidered and updated at periodic intervals, especially when excessive pollution occurs, or when technical or other developments allow a significant reduction in emissions at reasonable cost (Phare Project, 1999).

Best available techniques (BATs) are the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing, in principle, the basis for Emission Limit Values (ELVs) designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole.

Techniques include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned. This is a broad term to include all factors relevant to the environmental performance of an installation.

Available techniques are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages. As long as the techniques are reasonably accessible to the operator, whether or not the techniques are used or produced inside the MS in question, is of no importance. This definition is designed to avoid the two extremes of totally ignoring the cost or practical feasibility of applying a technique or leaving competent authorities the possibility to consider techniques used or developed only locally.

Best available techniques are the most effective in achieving a high general level of protection to the environment as a whole. This means that all the different types of environmental impacts an installation could have, must be considered when determining which techniques are 'best' (Council Directive 96/61/EC, 1996).

The concept of BAT plays a central role in the Directive because its objective is made clear in Article 2, which ‘‘is to provide a basis for ELVs’’. These are primarily the ELVs set by the competent authorities as permit conditions. In addition to forming the basis for ELVs, the BAT concept more generally provides the principal benchmark for determining the obligations of industrial operators in respect of pollution prevention and control. Although ELVs will be based on BATs, there is a provision in Article 9, which should also take account of the geographical location of the activity and local environmental conditions. Therefore, BATs can vary from place to place so that sensitive environmental problems can be addressed locally (O’ Malley, 1999).

In determining the best available techniques, special consideration should be given to the following items (Council Directive 96/61/EC, 1996):

- The use of low-waste technology.
- The use of less hazardous substances.
- The furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate.
- Comparable processes, facilities or methods of operation, which have been tried with success on an industrial scale.
- Technological advances and changes in scientific knowledge and understanding.
- The nature, effects and emissions concerned.
- The commissioning dates for new or existing installations.
- The length of time needed to introduce the best available technique.
- The consumption and nature of raw materials (including water) used in the process and their energy efficiency.
- The need to prevent or reduce to a minimum the overall impact on the environment and the risks to it.
- The need to prevent accidents and to minimise the consequences for the environment.
- The information published by the Commission or by international organisations.

The fifteen EU MS were expected to adjust their national legislation in line with the Directive before the end of October 1999. As from October 1999 the Directive applies to all new installations, as well as existing installations that intend to carry out changes that may have significant negative effects on human beings or the environment. The Directive does not immediately apply to existing installations. These have been granted an additional eight years of grace.

The European Commission organises an exchange of information between experts from the EU MS, industry and environmental organisations. This work is coordinated by the European IPPC Bureau (EIPPCB) and it has been divided into some 30 sectors along the lines of Annex I of the Directive. Each sector is examined by a technical working group (TWG) and it takes around two years to complete the work and to produce a so-called BREF (BAT reference document). The draft BREFs are then examined and discussed in the Information Exchange Forum (IEF), which draws up to the final BREFs. The IEF consists of representatives from all MS, as well as from industry, the EIPPCB, the commission, and the European Environmental Bureau (the federation of all European Environmental Agencies). While the BREFs are intended to assist the licensing authorities, the final decision still lies with these authorities, because Article 9 of the Directive establishes that they must take into account, (a) the technical characteristics of the installation, (b) its geographical location and (c) the local environmental conditions.

The Technical Working Group (TWG) for the Smitheries and Foundries industry sector is organised for the purposes of information exchange under Article 16.2 of the Council Directive 96/61/EC. On 15th to 16th April 1999, the EIPPCB, part of the Joint Research Centre’s Institute for Prospective Technological Studies (IPTS) organised the first meeting in Seville. The TWG agreed that foundries can be characterised for the work on the basis of: - the metal, the technique for core making, the way the moulds are filled and the degree of automation and size. The sub-division of these stages was agreed. The metal groups would include their alloys. The reports available to EIPPC Bureau at the moment on information needed for developing a BREF do not cover all countries or all parts of the sector, (European Commission, TWG1, 1999)

EIPPCB identified key issues in all of the foundry stages. For convenience, these stages were defined as Raw Materials Handling and Storage; Melting Furnaces and Metal Treatment; Waste Gas Scrubbing and Foundry Processes (Moulding and Core Making, etc). The key issues included Emissions to all Environmental Media; Consumption of Energy and Raw Materials; Other Environmental Issues (such as noise, vibration, heat and odour); Other Factors (such as training, management, process control, decommissioning and emerging and transferable technology).

2. Foundries: Description and Practices

In foundries, molten metals are cast into objects of desired shapes. Castings of iron, steel, light metals (such as aluminum), and heavy metals (such as copper and zinc) are made in units that may be independent or part of a production line. Auto manufacturing facilities usually have foundries within their production facilities or as ancillaries. The main production steps include: i) preparation of raw materials, ii) metal melting, iii) preparation of molds, iv) casting and v) finishing (which includes fettling and tumbling), (World Bank Group, 1998).

Electric induction furnaces are used to melt iron and other metals. However, large car component foundries and some small foundries melt iron in gas or coke-fired cupola furnaces and use induction furnaces for aluminum components of engine blocks. Melting capacities of cupola furnaces generally range from 3 to 25 metric tons per hour (t/hr). Induction furnaces are also used in zinc, copper, and brass foundries. Electric arc furnaces are usually used in stainless steel and sometimes in copper foundries. Flame ovens, which burn fossil fuels, are often used for melting nonferrous metals. The casting process usually employs nonreusable molds of green sand, which consists of sand, soot, and clay (or water glass). The sand in each half of the mold is packed around a model, which is then removed. The two halves of the mold are joined, and the complete mold is filled with molten metal, using ladles or other pouring devices. Large foundries often have pouring furnaces with automatically controlled pouring. The mold contains channels for introducing and distributing the metal. For hollow casting, the mold is fitted with a core. Cores must be extremely durable, and so strong bonding agents are used for the core, as well as for the molds themselves. These bonding agents are usually organic resins, but inorganic ones are also used. Plastic binders are being used for the manufacture of high-quality products. Sand cores and chemically bonded sand molds are often treated with water-based or spirit-based blacking to improve surface characteristics. Aluminum and magnesium, as well as copper and zinc alloys, are frequently die-cast or gravity-cast in reusable steel molds. Die casting involves the injection of metal under high pressure by a plunger into a steel die. Centrifugal casting methods are used for pipes. Finishing processes such as fettling involves the removal from the casting of the gating system, fins (burrs), and sometimes feeders. This is accomplished by cutting, blasting, grinding, and chiseling. Small items are usually ground by tum-bling, carried out in a rotating or vibrating drum, usually with the addition of water, which may have surfactants added to it.

Emissions of particulate matter (PM) from the melting and treatment of molten metal, as well as from mold manufacture, shakeout, cleaning and after-treatment, is generally of greatest concern. PM may contain metals that may be toxic. Oil mists are released from the lubrication of metals. Odor and alcohol vapor (from surface treatment of alcohol-based blacking) and emissions of other volatile organic compounds (VOCs) are also of concern. Oil and suspended solids are released into process effluents, and treatment is warranted before their discharge. Wet scrubbers release wastewaters that may contain metals. Wastewater from tumbling may contain metals and surfactants. Cooling waters, used in amounts of up to 20 m^3/t, may contain oil and some chemicals for the control of algae and corrosion. Sand molding creates large quantities of waste sand. Other wastes include slag (300–500 kg/t of metal), collected particulate matter, sludges from separators used in wastewater treatment, and spent oils and chemicals. Discarded refractory lining is another waste produced. The primary hazardous components of collected dust are zinc, lead, and cadmium, but its composition can vary greatly depending on scrap composition and furnace additives. (Nickel and chromium are present when stainless steel scrap is used.) Generally, foundries produce 10 kg of dust per ton of molten metal, with a range of 5–30 kg/t, depending on factors such as scrap quality. However, induction furnaces (with emissions of 3 kg/t of molten metal) and flame ovens tend to have lower air emissions than cupolas and electric arc furnaces (EAF). Major pollutants present in the air emissions include particulates of the order of 1,000 mg/Nm^3. Foundries can generate up to 20 m^3 of wastewater per metric ton of molten metal when cooling water, scrubber water, and process water are not regulated. Untreated wastewaters may contain high levels of total suspended solids, copper (0.9 mg/l), lead (2.5 mg/l), total chromium (2.5 mg/l), hexavalent chromium, nickel (0.25 mg/l), and oil and grease. The characteristics of the wastewater will depend on the type of metal and the quality of scrap used as feed to the process. Solid wastes (excluding dust) are generated at a rate of 300–500 kg/t of molten metal. Sludges and scale may contain heavy metals such as chromium, lead, and nickel, (Swedish EPA, 1991).

3. Implementation of the IPPC Directive in Cyprus

Cyprus applied for membership of the European Union on 4th July, 1990. Accession negotiations between the EU and Cyprus were launched on 31st March, 1998. The first stage, known as 'acquis screening', involves the analytical examination of the acquis communautaire, during which the European Commission presents and explains the acquis in a certain area, the applicant country presents its own policy in the area, and the two are compared, so that the necessary legislative or other changes needed to achieve harmonisation are identified. Compliance with the EU environmental *acquis* will inevitably improve the quality of the natural environment in Cyprus and will mainly benefit Cyprus through:

- Reduced levels of air pollution,
- Reduced levels of water and ground contamination,
- The provision of suitable sanitation capacity to support tourist growth.

All of these will result in the protection of the natural environment and improve the welfare of Cypriots and tourists alike. Compliance will also require a coordinated approach to all the aspects listed above in contrast to the present piecemeal legislation and control. This overall view will have benefits in terms of increased efficiency, as well as with respect to the integration of environmental protection (Boyd and Markandya, 1999).

In the framework of the Life Project, the National Technical University of Athens has developed guidelines for the implementation of the BATs for 14 categories of industry in Cyprus that fall into the IPPC directive. Moreover, a comparison has been made between the present situation for five industrial categories and the intended

BATs and finally recommendations have been forwarded to the relevant Cypriot Ministries.

The guidelines are constituted in three parts:

- Control techniques: for load minimisation, for prevention of pollution, for recovery and recycling, for treating emissions.
- Emission limit values (ELVs).
- Compliance monitoring.

4. Guidelines for Foundries

1. Pollution Prevention and Control Measures

The following pollution prevention measures should be considered, (World Bank Group, 1998):

- Prefer induction furnaces to cupola furnaces.
- Replace the cold-box method for core manufacture, where feasible.
- Improve feed quality: use selected and clean scrap to reduce the release of pollutants to the environment. Preheat scrap, with afterburning of exhaust gases.
- Store scrap under cover to avoid contamination of stormwater.
- Provide hoods for cupolas or doghouse enclosures for EAFs and induction furnaces.
- Use dry dust collection methods such as fabric filters instead of scrubbers.
- Use continuous casting for semifinished and finished products wherever feasible.
- Store chemicals and other materials in such a way that spills, if any, can be collected.
- Control water consumption by recirculating cooling water after treatment.

- Use closed-loop systems in scrubbers where the latter are necessary.
- Reduce nitrogen oxide (NOx) emissions by use of natural gas as fuel, use low-NOx burners.
- Reclaim sand after removing binders.

2. Pollution Reduction Targets

The recommended pollution prevention measures can achieve the target levels given below.

Air Emissions

Recover metals from collected dust. The target value for PM from furnaces and die casting machinery is not to exceed 0.5 kg/t of molten metal (after controls). The oil aerosol should not exceed 5 mg/Nm^3.

Wastewaters

Recycle wastewaters, if any. Avoid allowing contamination of stormwater with oil; oil in stormwater is not to exceed 5 mg/l.

Solid Wastes

Reclaim sand used in molding.

3. Treatment Technologies

Air Emissions

Dust emission control technologies include cyclones, scrubbers (with recirculating water), baghouses, and electrostatic precipitators (ESPs).

Scrubbers are also used to control mists, acidic gases, and amines. Gas flame is used for incineration of gas from core manufacture. Target values for emissions passing through a fabric filter are normally around 10 mg/Nm^3 (dry). Emissions of PM from furnaces (including casting machines used for die casting) should not exceed 0.1–0.3 kg/t of molten metal, depending on the nature of the PM and the melting capacity of the plant. At small iron foundries, a somewhat higher emission factor may be acceptable, while in large heavy-metal foundries, efforts should be made to achieve a target value lower than 0.1 kg PM per metric ton. Odors may be eliminated by using bioscrubbers.

Wastewater Treatment

Recirculate tumbling water by sedimentation or centrifuging followed by filtering (using sand filters or ultrafilters); separate oil from surface water. In the very rare cases in which scrubbers are used, recirculate water and adjust its pH to pre-cipitate metals. Precipitate metals in wastewater by using lime or sodium hydroxide. Cooling waters should be recirculated, and polluted stormwater should be treated before discharge.

4. Emissions Guidelines

The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems. The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is un-acceptable. All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours, (World Bank Group, 1998).

Air Emissions

Air emissions of PM should be below 20 mg/Nm^3 where toxic metals are present and 50 mg/Nm^3 in other cases. This would correspond to total dust emissions of less than 0.5 kg/t of molten metal.

Liquid Effluents

For foundries, the effluent levels presented in Table 1 should be achieved. In Table 2 the emission limits applied in some EU member states are shown, (Haskoning, 1997).

Solid Waste

Sludges from wastewater treatment operations should be disposed of in a secure landfill after stabilization.

Ambient Noise

Noise abatement measures should achieve either the levels given below in Table 3, or a maximum increase in background levels of 3 dB (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

5. Monitoring and Reporting

Air emissions should be monitored continuously for PM using an opacity meter (for an opacity level of less than 10%). Wastewater discharges should be monitored daily except for metals, which may be monitored monthly or when there are process hanges. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

5. Foundries in Cyprus

The Foundries in Cyprus can be classified as being small or medium sized enterprises. These enterprises have a predominantly local impact on the environment. As in other countries, they make a substantial contribution to the total environmental burden because of their location and the way the majority of these businesses are run. A sizable part of this environmental burden is not yet covered by restrictive legislation. Furthermore there is little financial incentive to prevent pollution or waste generation for the companies. In most Western European countries, levy systems and waste disposal charges provide government with income and act as an encouragement to industry to minimize their environmental impact.

The foundry in Cyprus that has been examined is located in a densely urbanized area. The foundry melts, cast and pig iron to make various products. The installation consists of two cupola ovens and an automated casting line where the moulds automatically are prepared and the products are cast, finished and released. Furthermore there is an area where special moulds (cores) are made, (Haskoning, 1997).

The emissions from the cupola ovens are treated in a wet-scrubber and emitted through a stack at a height of 17 m. The water make-up is approximately 3-4 m^3/hr and the water circulation is approximately 25-30 m^3/hr. The emissions from the cupola oven flue gas concerning dust concentrations fluctuate around 350 mg/Nm^3.

The production of casts is 80% binder free. So, no specific odor emission can be detected from the production line. Specific VOC-emission could only be detected in the area where special moulds are made.

The industry produces on yearly base turbine pumps (5000 pieces), centrifugal pumps (1000 pieces), electro pumps (2000 pieces), concrete mixes and hoists (1000 pieces) and cast iron products (2500 pieces). The foundry produces continuously during 12 hours a day. The capacity of the installed cupola furnaces is approximately 3 tn/hr.

The materials used in the foundries are ferrous materials, cokes (fuel in the cupola oven), binders and sand. Mostly scarp metal is used whereas in some cases cleaned or virgin metal is used. The binder material consists of furan based alcohol. The binder-free moulds were constructed with bentonite and coal.

Besides the use of scrap material the foundry uses cleaned iron acquired outside Cyprus. 70% of the raw material consists of scrap material/engine. The raw materials used are: pig iron ingots, scrap metal, bronze ingots, brass ingots, iron ware, steel pipes, stainless steel shafts, bearings, blocks and bolts, electro motors and engines, foundry coke, silica sand, bentonite, binder, rubber bushings paints and thinners, other helping aids, grease, oil, petrol and alcohol.

6. Emission reduction – Suggested measures for the Cypriot foundry

In the Table 4, a comparison is made between the techniques generally applied and the techniques already applied at the Cypriot foundry.

Special attention has to be paid to the selection and the quality of the raw materials (cast iron) to prevent unnecessary emissions to the air during the melting process. At the foundry, a cupola oven is used for melting the iron and a venturi scrubber is used to clean the air. Considering the results of the dust measurements, which are not in line with the emission limits used in the EU the performance of this installation is not applying BAT. The reason for this lack of performance is malfunction of the scrubber, bad design or bad maintenance of this equipment. Furthermore it was observed that the contaminated water is released to the surrounding area which is considered as a shift of the environmental problem from air to the soil.

The emission during casting is not collected or treated. There is no need to treat the air from the casting process because the composition of the mould depends upon bentonite.

The following measures are suggested:

Process integrated measures

- Investigation of the possibilities to use alternative binder materials
- Use quality criteria to select scrap metal that will be molten in the oven
- Set up a maintenance program where the equipment is maintained on a regular basis
- Keep a log-file where the results of the inspections and measurements of every installation is described.
- Give training to people on the working floor and teach the basics of ‘good housekeeping’

Technical measures

- Upgrade and optimize existing scrubbers or install new techniques by
  - Repairing and cleaning the scrubber, spraying nozzles and droplet collector
  - Increasing the amount of washing water
  - Introducing chemicals in the washing water to remove specific (organic) compounds
- Suction of released fumes during casting and emission through a stack if resins are used as a binder material
- Find solution for disposal of contaminated washing water and waste from cupola oven.

Regulations

- Regulate emission limits for dust, SO_2, NO_x and CO and eventually VOC
- Prescribe an investigation of the possibility to collect the diffusive emissions during casting and allow their release at a height if the investigation of the possibilities of the use of alternatives proves to be negative
- Provide regulation to be sure that the contained water and melting waste (slag) from the oven is disposed properly.

7. Concluding Remarks

Nowadays, the need for integrated prevention and control of pollution is unquestionable, and so all MS of the European Union should step towards the direction of implementing the IPPC Directive. Although specific techniques are not obligatory and their application lays on self-imposed grounds, the concept of BATs is underlined as it provides a basis for setting ELVs. Furthermore, it establishes the principal benchmark for determining the obligations of industrial operators in respect of pollution prevention and control. In addition, Article 9 of the Directive recommends that competent authorities in each MS must take into account the technical characteristics of the installation, its geographical location and the local environmental conditions.

Therefore, coordinated efforts are needed on behalf of industry, the Ministry of Environment and the local competent authorities in each MS for the elaboration of studies in order to determine BATs, to trace and address adequately the sensitive environmental issues. The next step should be the implementation of a pilot IPPC application on behalf of selected plants and a relevant licensing from the competent authorities. Finally, the planning-out and the implementation of an action plan is essential for every MS in order to adopt the IPPC Directive sufficiently within the scheduled time (year 2007).

In general, it can be stated that the Cypriot foundry apply generally accepted techniques according to European Standards. Therefore it is remarkable that these techniques do not meet the emission standards as used by the member states of the European Community. The reason for this rather high dust emission might be the malfunctioning of the installed scrubbers due to engineering (not engineered to meet the rather low emission limits used in the EU) or bad maintenance of the equipment. It can be assumed that the dust emission will meet the standards by upgrading or changing the existing equipment and improving maintenance. It is also suggested to measure Co, VOC and SO_2 on a regular basis.

To reduce the emissions and to keep the emissions as low as necessary it is not sufficient to implement technical measures only. It is also important to consider the 'human factor' in the environmental regulations. Therefore it is suggested to ask for a log file of the maintenance actions in the future regulations.

Acknowledgements

The authors wish to thank Mr Alexandros Karavanas, Department of Industry, Ministry for the Environment, Planning and Public Works of Greece, for his collaboration during the development of the project and the valuable information and experience provided.

References

Boyd R. and Markandya A., 1999. Approximation of environmental legislation- the role of compliance costing for approximation of EU environmental legislation in Cyprus. In de Courcy, A. (Ed.), Final report, DGXI.

Council Directive 96/61/EC, 1996. Integrated Pollution Prevention and Control. Official Journal L 257, pp. 26 – 40.

European Commission, 1999. Smitheries and Foundries. Note of meeting, DG JRC, EIPPCB, TWG1 Seville, 15-16/4/99.

Haskoning Ltd, 1997. Control of Industrial Pollution. Technical Report for Foundries in Cyprus, Technical Assistance to the Government of Cyprus.

O' Malley V., 1999. The Integrated Pollution Prevention and Control (IPPC) Directive and its implications for the environment and industrial activities in Europe. Sensors and Actuators B (59), 78-82.

Phare Project, 1999. Implementation of the IPPC Directive and its legal enforcement in Hungary, (HU 9513-03-01-L002) Seminar: Talk on EU Implementation.

World Bank Group, 1998. Pollution Prevention and Abatement Handbook, Foundries.

Swedish Environmental Protection Agency, 1991. Informs on Foundries – Industry Fact Sheet. SNV 91-620-9377 0/91-03/500ex. Solna.