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# **RECYCLING OF COPPER, LEAD AND ZINC BEARING WASTES**

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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# FOREWORD

Systems of control over the transfrontier movement of hazardous wastes have been developed by OECD Member Countries since the early 1980's and have resulted in several Council Acts having been adopted between 1984 and 1992. These Council Acts have contributed significantly in the creation of related European Community Directives and in the preparation of the Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal adopted in Basel in 1989 under the auspices of the United Nations Environment Programme.

The OECD systems of control require that all activities concerned with wastes are carried out in an environmentally sound manner. This Monograph has been prepared to provide guidance on what are regarded at the present time to constitute environmentally sound processes for the recovery of copper, lead and zinc from wastes.

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#### **INTRODUCTION**

The OECD Council, Decision-Recommendation of the Council on the Reduction of Transfrontier Movements of Wastes [C(90)178/FINAL], instructed the Environment Committee in co-operation with other relevant OECD bodies to develop and implement a programme of activities concerning wastes destined for recovery operations. Included in the Environment Committee programme, is a requirement to "Identify and assess environmentally sound and economically efficient practices for recovery operations".

This Guidance Document is concerned with the principal recovery operations applicable to copper, lead and zinc wastes. It includes those wastes given in OECD Decision C(92)39/FINAL Appendix 4 - Amber list of Wastes. It has been prepared primarily as guidance to assist those who may be concerned with the granting of authorisations for the transfrontier movements of wastes for recovery under the OECD Decisions. While it portrays and reflects good practice as undertaken within the industry, it is not intended to represent stated policy or provisions required by OECD Decisions. As such, any recommendations contained herein can be effected only by national legislation promulgated in Member countries.

Whether or not a recycling process proposed for a shipment of waste destined for recovery can satisfy the criteria of being environmentally sound and economically efficient needs to be evaluated by competent authorities in concerned countries before an authorisation can be granted. Such an evaluation usually needs to rely on a knowledge of the processes involved, whether the processes are capable of treating the waste in question in an environmentally sound manner and if the requirements of national environmental legislation can be satisfied. Environmentally sound and economically efficient are regarded as being interdependent. This Document therefore, outlines the processes which usually are used and are capable of being operated in an environmentally sound manner, it being assumed that they would not be undertaken if they were not economically efficient.

# THE ROLE OF OECD

Many recoverable materials contained in wastes continue to be discarded and not recycled. Principally this is due to the existence of less expensive means of disposal, the lack of incentives and investment in appropriate technology and other market factors. Consequently, organised segregation of waste at source and the provision of facilities in which the wastes can be processed to recover recyclable constituents present in them are not commonplace. Fears that wastes may be contaminated with other materials which could lead to widespread pollution if they were recycled have been stated, particularly in respect of liability. However, it can be shown that provided materials are handled and recycled in an environmentally sound manner to give a product which meets a specification such fears should not exist.

Initiatives which provide a more positive image of wastes recycling in an environmentally sound manner and the role that organised and properly controlled recycling of wastes can safely play need to be promoted and encouraged. The role of OECD in this area can be to act as a source of advice, such as that contained in the Risk Reduction Monograph No. 1 on Lead [OECD/GD(93)67]. By so doing governments can be assisted in promoting recycling and making decisions on environmentally sound practices and processes such that positive environmental benefits can be gained both nationally and internationally.

#### TRADE IN WASTE FOR RECYCLING

Statistics collected by OECD on trade in wastes destined to be recycled indicate that some 40 million tonnes per year of a variety of wastes for recovery of constituents contained in them are either exported or imported by Member countries, Of this total some 20% are concerned with the recycling of metals and metal compounds [Recovery Operation R4 in OECD Council Decision C(88)90 (Final)].

Various OECD Decisions seek to minimise the possibility of pollution resulting from such trade where two or more countries are involved. The Decisions require Member countries to promulgate national legislation which will stipulate controls to be exercised over transfrontier shipments of wastes for recycling both between Member countries and with other countries outside the membership, and hence jurisdiction, of OECD Decisions.

# **GENERAL CONSIDERATIONS**

For the purposes of this paper, recycling refers to the recovery of a basic product from materials, articles or products which no longer serve the purpose for which they were produced and non-product materials resulting from manufacturing operations. Both are regarded as wastes for recovery since when they are subjected to a process or series of processes they can provide a material which can be used subsequently for another purpose. With regard to metals recycling, recovery does not include operations such as refining or beneficiation of ores or production intermediates from mining/metallurgical operations.

Although practised by industry to a greater or lesser extent for many years, the recycling of waste materials is being expanded increasingly. Wastes have become recognised as a resource which has the potential to be exploited more extensively. While in recent years there has been a decrease in the total production of copper, lead and zinc, the proportion of these metals derived from secondary sources is significant. At the present time it is estimated that of the total world production some 38% Copper, 50% Lead and 23% Zinc production is derived from secondary sources. It is suggested that, apart from financial considerations, the principal ecological benefits to be derived include:

- 1) the conservation of raw materials, thus decreasing the need to further exploit and deplete reserves of natural resources;
- 2) the avoidance of wastes for ultimate disposal, thus decreasing the potential environmental pollution load; and
- 3) conservation of energy, in many instances variously estimated to be a saving between 40% and 85% in energy usage and reduced carbon dioxide emissions to the environment.

Also, at the same time it is possible to produce metals which meet specifications and are indistinguishable from the same metals produced by their extraction from ores.

Consequently, for a variety of reasons there are strong supportable arguments in favour of recycling. Whenever possible potentially valuable constituents in wastes should be segregated and processed to enable the extraction of those recoverable and subsequently marketable materials they contain. The benefits which can be derived from such practice have been recognised within the primary smelting industries. They have promoted and practised recycling to a greater or lesser extent for many years. Also, as processes and technologies have improved more efficient and less polluting production methods have become the norm. This, coupled with an increasing concern for the environment, has brought about significant changes within the industry in recent years, resulting in a further increase in the quantity of recycled metals derived from secondary sources. Also, as a direct consequence of research and development, residues accumulated from less efficient processes operated in earlier years are now able to be reworked

to extract the residual metals they contain. Some facilities now operate exclusively on materials derived from secondary sources.

In parallel an expanding secondary metals scrap processing industry has been built-up in which the financial incentives presented by recycling are able to be exploited. Wastes derived from manufacturing processes, discarded manufactured goods and other by-products are collected, brought together, sorted, processed and supplied to smelters in bulk. Such materials are discarded or rejected by their owners as being no longer wanted or usable by them since they are obsolete, broken, worn out, contaminated, surplus to requirements or otherwise spoiled, or suitable recovery processes are not readily available to them.

Mixed metallic wastes for recycling containing residues which are not easily separated by mechanical means need not always be sent to large scale smelters for processing. The scrap processing industry itself has developed melting processes, to separate metals, which can be operated on a smaller scale. In many instances separation may be achieved by passing the waste in sequence through a series of ovens each operated at a temperature at which a particular metal will melt. The molten metal is collected at the bottom of the oven from which it can be tapped off. The separated impure metal is cast into ingots and sold either as an impure product or sent elsewhere for refining. Thus, it is *sometimes* possible to avoid the need to use more costly large scale smelting processes.

Residues can contain metals at concentrations worth recovering. These may arise from the extraction of metals from their ores, treatment sludges from the use of metals by industry and from secondary metals processing. However, the processes used by one facility may not be suitable to allow extraction of these metals. Such residues therefore, depending on the metals they still contain and their concentration, either can be traded both nationally and internationally for recovery of financially viable constituents by others using different processes or sent for final disposal as wastes. When there is an economic incentive to do so residues can be expected to be traded and transferred to facilities which operate suitable recovery processes.

However, such process residues sent for recycling do not always necessarily contain metals at concentrations having an intrinsic positive monetary value. Nevertheless, sometimes they are recycled because the cost of treatment and final disposal for certain metal bearing residues can be greater than the alternative of transporting them to a secondary metals processor. In such instances a financial contribution towards the cost of recovery of the metals is made by the supplier of the residues. This financial contribution, when coupled with the value of the metals recovered by the second processor makes the whole operation financially viable. It also results in metals being recycled which otherwise would have been disposed of as waste.

# **TECHNICAL CONSIDERATIONS**

Environmentally sound processes can be described as those processes which are consistent at all times with the principles of both sustainable development and avoidance of unacceptable harm to human health and the environment. To be accepted as being environmentally sound, a process must be able to be operated in a manner which protects human health and the environment.

Individual countries each set their own national environmental standards and these are not always consistent between countries. It is not the intention that this document should attempt either to harmonise national standards or to prescribe the policy choices available to national competent authorities in judging whether or not a transfer of hazardous waste for recovery to a particular facility should be allowed. Rather, it sets out some of the general principles against which environmental standards should be assessed and provides a considerable amount of technical information to assist competent authorities in understanding the industrial processes being evaluated.

To demonstrate that a recycling/recovery facility operates in an environmentally sound manner it must always satisfy environmental standards promulgated by national legislation in its country of operation. Normally, it will be supervised by the authorities responsible for exercising control over the facility, to ensure compliance with national environmental standards. However, the environmental standards applicable may not be sufficiently stringent to satisfy the authorities in the country of export. In such cases it is possible for the authorities in the country of export to apply a condition on the export of wastes requiring evidence to show that the facility in the country of import is operated to standards that are at least as strict as those applied in the country of export. Further, they could require independent evidence to show that the facility is operated to standards which, in the light of current knowledge, protect human health and the environment. The competent authorities in the country of export also may need other requirements to be demonstrated.

Thus, it is possible that the operator of a recovery/recycling facility may need to provide evidence which demonstrates that it conducts the operation of its plant in an environmentally sound manner to standards which exceed those required by its own national legislation. In some situations this could be satisfied by the operator having installed plant which is recognised as being "state of the art" and employing "best available technology". Otherwise, it may require that the facility utilises technical and operating practices that already have been shown fully to protect human health and the environment.

The considerations made on operating practices will be based on the latest available information regarding the potential risks presented by the waste, the processes used and there being a satisfactory means available for the disposal of process residues. Facilities which are unable or unwilling to meet such requirements may find themselves deprived of imports from countries making judgements pursuant to the Basel Convention on the export of wastes for recycling/recovery.

Industrial processes for the extraction of metals from their ores have been developed and improved progressively with time to satisfy both an increasing demand for higher quality products and the imposition by countries of legislative requirements which impose ever more stringent environmental standards. It can be stated that most if not all established modern primary processes for winning copper, lead and zinc from their ores have been designed and developed to an extent such that they can be operated in an environmentally sound manner. Principally, it is the way in which processes are controlled, operated, monitored and supervised which determines their efficacy with respect to being considered to be environmentally sound. In general terms, today's designs for processing plants, their ancillary equipment and on-line monitoring controls exercised over their operation have been developed to the extent of being capable of meeting the highest standards commensurate with satisfying health and safety and environmental requirements. For operators to be able to demonstrate that standards set by authorising authorities are being complied with, sampling, monitoring and analytical facilities are required. These may be set up either by the operator or under contract with consulting analysts. In either case they need to be approved by the authorising authorities.

Many risk reduction initiatives have been introduced by the secondary metals industry. For example, those undertaken by the lead industry are described in Risk Reduction Monograph No. 1. - LEAD - [OECD/GD(93)67]. Likewise, similar risk reduction initiatives also have taken place in the copper and zinc industries. It is generally recognised within the secondary metals industry that :

- a) co-production of metals is the norm in the non-ferrous metals industry and that lead is often a significant "by-product" from the production of other metals.
- b) technological advances have resulted in a reduction of all emission from facilities that coproduce significant quantities of lead (for example, zinc or copper production facilities).
- c) improved process efficiency permits the diversion into smelting processes of significant volumes of waste which were formerly discarded.

The form and composition of some wastes available for recycling at any particular time can be extremely variable. Essential steps in the recycling process mean that wastes have to be accumulated, segregated into waste types, where necessary or desirable subjected to preliminary processing, stored in bulk, packaged, transported to major processors, accommodated there and subsequently processed. To be regarded as environmentally sound, national or regional control must be exercised over such activities in each country. The industry must adopt environmental control measures which satisfy the authorising authorities under the standards set by its national environmental legislation or in its absence established international guidelines.

For wastes which are to be processed in another country it is the legislation in the country of production which controls accumulation of the wastes, their segregation, storage and packaging and their transport within the producing country. Legislation in the country of transit will apply to the waste as far as packaging and the means of transport to be used for its transit are concerned. In the country of import it is the national legislation principally concerned with transport, storage, processing operations and waste disposal which will apply. It is seen as being essential therefore, that the physical form and variability of waste and its constituents are known as a prerequisite to it being considered for recycling. Only those wastes which are within specified limits and can satisfy environmental criteria throughout the overall stages of recycling should be accepted for direct recycling.

In circumstances where wastes destined for recovery operations are not in a suitable form and composition for direct recovery of valuable constituents, they will need to be subjected to processes which convert them to a suitable form. Such conversion processes could be carried out in either the country of export or of import. In certain circumstances it is possible that conversion of the waste to a suitable form may take place in an intermediate country. In such a case the conditioned waste will then be re-exported to a third country for final recovery of constituents of value. In some instances conditioning of waste can convert it to a form which allows it to be exported as an OECD Green List waste. In such cases the conditioned waste no longer needs to be subject to controls under the OECD System, unless legislation in the country of import decrees otherwise.

However, if the conditioning of the waste is to be carried out in another OECD country the OECD System always will apply and the facility receiving the waste for conditioning can be regarded as the consignee for the waste. As such, it needs to have been established to the satisfaction of the competent authorities concerned that suitable operational facilities exist in the country of import which are capable of converting the waste to a form which will allow direct recycling subsequently to be carried out elsewhere. Also that the conditioning processes themselves can be shown to be capable of being operated in an environmentally sound manner and in accord with national environmental legislation, or in its absence, internationally accepted environmental guidelines.

#### **METAL BEARING WASTES**

Depending on their origin, metal bearing wastes can vary considerably in their physical and chemical form and hence properties. In most instances they arise in association with other materials from which they need to be separated and conditioned before they can be introduced into processes to produce the metal. It is exceptional to find a waste which contains one metal only or one metal in association with other materials only, from which it can be separated directly. While a waste may be described as being a particular metal waste, e.g. zinc dross, it is almost inevitable that other metals, metal compounds and materials will be present. Also, it is possible that the other materials present in a waste when concentrated by a process may possess properties more hazardous than the metal it is intended to recycle. This hazardous residue must then either be recycled or disposed of in an environmentally sound manner. The need to have detailed information on constituents present such that any potential hazards can be readily recognised and controls exercised to mitigate their effect is essential.

As has been stated already, metals bearing wastes for recycling can arise in a variety of physical and chemical forms which may be variously described. Possibilities include the descriptors given in OECD Decision C(92)39/FINAL (and subsequent modifications), the OECD International Waste Identification Code (IWIC), the EC European Waste Catalogue (EWC) code or, for certain materials, those commonly used by a particular sector of industry. Whenever possible they should accord also with the description and code number of the Harmonised Commodity Description and Coding System established by the Brussels Convention of 14 June 1983 under the auspices of the Customs Co-operation Council (Harmonised System Code).

For trade purposes, the scrap metal industry frequently uses either the European Classification for Non-ferrous Metal Scrap (EURO), the US National Association of Secondary Materials Industries Inc. Classification for Non-ferrous Scrap Metals (NASMI), or the US Institute of Scrap Recycling Industries Inc. Scrap Specifications (ISRI) to describe scrap metal they have processed and prepared for recycling. It can be expected that in most instances these classifications will be used for materials on the OECD Green List of Wastes.

On the other hand, because they arise in a variety of physical and chemical forms, many OECD Amber List wastes are usually given general descriptions by industry. Indeed, wastes arising within different sectors of industry having different constituents and properties may nevertheless have identical names. Descriptors such as "residues from secondary metal extraction" are commonplace and Harmonised System Codes used may not be consistent. For such materials it is essential that details of the physical form of the waste (e.g. slag, sludge, powder, etc.), the process or unit operation in which the waste was generated (e.g. wastewater treatment sludges, metal plating slimes, etc.), its chemical composition and concentration of hazardous constituents are always provided to qualify any generally accepted description which may be used.

In particular, the physical forms of metal bearing wastes for recycling can vary widely and be variously described as being massive metal, bars, wires and cables, slabs, plates, sheets, foil, off-cuts, borings, drillings, turnings, shredded clippings, granules, dusts, powders, drosses, skimmings, slags, sludges which may also include those from waste water treatment, residues, etc. Sometimes these descriptors can be made more precise by indicating the origin of the material, whether it arises in a wet or dry state, etc. For example, even to the initiated, the descriptor 'furnace dust' is assisted considerably by being preceded by 'steel electric arc' or 'blast furnace' to provide significant additional implied information on the type of material concerned, its likely constituents and physical form. However, such descriptors do not obviate the need to provide detailed information on the chemical constituents present and their concentrations actually present in a particular consignment of waste for recycling. It is always possible that at some stage in its life the waste could have become contaminated by contact or being mixed with other materials. Also important from an environmental viewpoint is the means of containment and its appropriateness for the particular material to be handled and transported. Wastes rarely possess properties identical to products.

#### **DIRECT RECOVERY**

When it is possible, the introduction of waste materials for recycling directly into primary processes used for the extraction of metals from their ores may nevertheless require some changes in the ways in which certain operations are performed. Many plants are able to be operated satisfactorily, and in accord with national legislation and/or guideline international environmental standards, when processing a combination of materials coming from both primary and secondary origins. Usually the versatility in operation of the plants is such that they could be operated satisfactorily on materials arising wholly from either origin. Therefore, provided the composition of the feed stock to the plant is known and appropriate handling and management controls exercised, the introduction of secondary raw materials into the primary process and vice-versa can be expected not to result in adverse environmental effects. The introduction of materials coming from secondary sources to the process assumes that the concentration of metals they contain are such that the products obtained are significant in quantity and value. Otherwise the operation may be regarded as being a means of disposal for hazardous waste rather than a recovery operation.

The operators record in management, operation and maintenance of a particular plant therefore, are the principal means by which it should be possible to judge whether or not a particular facility actually can be said to operate in an environmentally sound manner. Such information should be available from and be provided by the competent authorities in the country of the plant's location.

It can be seen therefore, that there are many combinations of possibilities for the recycling of waste materials. In respect of their suitability for direct recycling there exists the extremes of direct processing or the need to carry out pre-processing to convert the waste to a suitable form and composition for direct recycling subsequently. In between, there is the option of modifying an established process method used for ores to accommodate the waste and/or the need for a limited amount of pre-processing. Where any doubt exists that a particular process may not be suitable for a particular waste, the results obtained from small scale trials, when using the process proposed for use on the waste, should be made available to competent authorities in support of any proposed process to recycle wastes. Where in-house expertise is not available to evaluate a proposed process independent authoritative advice should be obtained.

In summary, a decision on whether or not to allow a particular transfrontier shipment of waste for recycling, principally relies on information provided in support of the application. It should include the results from determination of the physical and chemical composition of waste obtained from an accredited source. Where necessary, details of the pre-treatment and recovery processes to which the wastes are to be subjected, together with their environmental impact, should be included, (see Appendix 5). Other considerations required to be taken into account by the competent authorities in each country concerned with the shipment, include the provision of evidence that the means of packaging, handling and transportation to be used satisfy the requirements of international transport codes. Also, that the processes to be carried out on the waste in the receiving country are regarded as "environmentally sound" in accord with its national legislation.

# **RECYCLING PROCESSES**

The recycling of copper, lead and zinc secondary metals and metal compounds inevitably involves melting or smelting processes. For Amber List wastes in particular, refining processes also need to be used to remove unwanted constituents. These are necessarily used by the primary industry following extraction of metals from their ores. In some instances, depending on the form, quality and purity of the waste involved, secondary materials can be melted and cast into ingots or other physical forms either for direct reuse or subjected to refining processes. Any skimmings or residues can be incorporated directly at the appropriate point in the primary process. In other instances, specialised plants need to be used to condition the secondary materials to a form which makes them suitable for smelting, for example, by roasting, sintering and/or pelletising. Such conditioning transforms the waste into a suitable chemical and physical state such that the conditioned material can be introduced directly into the primary process. In general terms, the physical form and composition of the waste dictate whether remelting is sufficient or the point at which it can be introduced into the primary production process.

Smelting is always undertaken in furnaces at a high temperature under controlled conditions. By such means the metal is separated from other materials and can be directly subjected to refining processes to produce the pure metal. Refining processes usually involve several steps to remove particular impurities selectively and may be carried out in other furnaces or by electrolytic processes.

Other materials separated out during pre-treatment processes may be processed themselves to produce recycled products. Almost all solid materials can be either recycled after further treatment or, depending on their metals content, transferred or sold to others to process and extract other metals. Slags which contain only a low or not financially viable metal content and other by-products such as plastics fractions from lead-acid batteries, usually can be processed to give marketable products. Otherwise, their disposal should be undertaken in an environmentally sound manner.

# ENVIRONMENTALLY SOUND PROCESSES

#### Waste Production

For all wastes, consideration of recycling processes which are possible and which are regarded as being environmentally sound commences at the premises of the waste generator. As far as possible different waste types and forms should be kept segregated at source. Not to do so may prevent certain materials from being recycled. Storage requirements which are considered to be environmentally sound will vary, depending on the nature and physical state of the waste. To be considered as being environmentally sound, it is imperative that wastes should be stored under conditions which minimise their escape to the environment. Generally, for many wastes and particularly those on the Amber List of Wastes, unless they are insoluble in water and in massive form physically, this means that they should be stored in sealed drums or under cover in dry conditions, neither to be affected by wind such that resuspension of dusty material into the atmosphere can take place nor such that they can escape into the aquatic environment. Thus, all storage should be on impervious surfaces with drainage connected to an effluent treatment plant under the control of the site operator. Treated effluent discharged to the environment should satisfy quality standards set by the local controlling authorities. Liquid wastes always should be stored in bunded or bermed areas having a capacity sufficient that in excess of the volume stored can be contained at all times.

#### Waste Collection and Sorting

An important sector of the scrap recycling industry concerns itself with collecting wastes. The means of containment used should satisfy recognised transportation requirements. Such wastes are then subjected to various means of sorting, segregation and grading into physical forms which satisfy specifications for trading and are accumulated in quantities acceptable for recycling. For some forms of wastes, chemical (hydrometallurgical) processing may be required to remove contaminants or transform them into a suitable form and composition for subsequent processing. Another sector of the recycling industry is concerned specifically with the separation of metals contained in residues. The metals recovered from such residues are obtained by smelting, leaching and/or by electrolytic means.

# Wastes Segregation

Waste segregation is an important step in the recycling of materials. The means used can be extremely diverse ranging from simple hand sorting and mechanical baling to sophisticated segregation methods such as milling followed by air classification and/or linear induction separation, chemical

dissolution and precipitation, liquid/liquid phase separation, etc. In between, electrical cables, for example, need to have their casing (possibly fabrics, steel wire or lead) and insulation (usually rubber or plastics) removed and separated from the copper core. In many instances granulation of the cable followed by separation into its component parts by classifiers is preferable from an environmentally sound process viewpoint. Burning off the insulation, unless carried out under properly controlled conditions in designated plant, such that the off-gases from the process are filtered and scrubbed to produce an acceptable quality of gaseous discharge to atmosphere, is not acceptable. In many instances, unless it is destroyed in the process, the insulation can be segregated and recycled separately. Premises used for the storage and processing of wastes should possess similar storage facilities to those indicated above as being necessary for producer's premises. In addition, plant and monitoring and control facilities such that processes can be shown to be carried out in environmentally sound manner are essential.

# **Pre-Processing**

In many instances wastes for recycling will be residues which are heterogeneous in nature. It is important therefore, that information on the physical and chemical composition of the waste has been determined and possibly laboratory scale processing trials carried out to verify that the material is entirely suitable and amenable to the treatment envisaged. This implies that representative samples of the material will have been obtained to provide the information required to enable processing to be carried out in an environmentally sound manner.

Consistent with national legislation and guidelines, the storage of such materials awaiting processing should be under conditions such that their escape to the environment cannot occur. Also, since in many instances the materials will be moved around the site, care needs to be taken to avoid spillage during their handling and transportation. Any spillages which do occur should be dealt with and cleaned up as soon as practicable after they occur. In addition, preventive measures such as the sweeping of roadways and their damping down with water to prevent dust resuspension by vehicles, particularly by their wheels and engine exhaust, should be undertaken on a routine basis at regular intervals in relation to weather conditions.

Depending on the physical form and properties of materials being handled environmental monitoring may be necessary. Confirmation that air quality in the environs of the site is satisfactory at all times and meets national and local standards should be demonstrated by carrying out routine atmospheric air sampling and analysis. Likewise drainage systems should be connected to a collection facility, and where necessary conveyed to a treatment plant under the control of the site operator. In many instances drainage water can be treated and reused. Any effluent discharges should satisfy the standards set by the controlling regulatory authorities for quality and quantity such that the physical and chemical quality of the receiving waters can be maintained in a suitable state at all times.

In deciding whether or not a recovery process can be regarded as environmentally sound, the means by which wastes are pre-processed and the ability of plant and equipment to be used to transform wastes into a suitable state for recycling are essential considerations. All plant and equipment used in the preparation of materials for processing should be provided with adequate safeguards to avoid it being a source of environmental pollution. Operatives, whether or not required under legislation, should always be afforded protection against any hazardous properties of the materials being handled, including for example air extraction in the work area. Extracted air always should be required to pass through filtration plant before its discharge to atmosphere. Emissions to the environment should always satisfy the requirements of national legislation. Waste water should be collected and be connected to a controlled drainage system. Its treatment and release to the environment should always be undertaken under controlled conditions. During handling, blending, storage and transfer of materials, some releases to the environment can be

expected. Except for short periods of time and in emergency situations plant designs should be such that it should not be necessary for operative to have need to use respiratory protection. Rather, conditions should be maintained routinely such that only normal industrial protective clothing should be required. Environmental monitoring equipment should be installed in all work areas and regular readings taken and recorded.

#### Processing

As outlined above, a variety of types of furnaces are required to be used, *usually* in sequential stages, to allow the extraction of copper, lead and zinc from prepared residues. In the case of copper usually these are a blast furnace followed by either a converter and/or reverberatory furnace and an anode furnace. In most instances for processing lead a rotary kiln followed by or in parallel with a short rotary furnace and refining furnaces are used. For zinc a rotary kiln followed by a shaft furnace and distillation furnace are necessary.

In all instances the furnaces need to be provided with and connected to filtration equipment to collect and remove smoke, fume and dust from any part of the plant and prevent its escape into the atmosphere in an uncontrolled manner. Usually, high chimneys are necessary to provide adequate dispersion of gases and particulate matter into the atmosphere such that ground level concentrations satisfy atmospheric environmental criteria. In some instances the filtered air can be recycled and used subsequently as an air feed to a furnace or heat exchanger, otherwise it is discharged to atmosphere. The quality of air discharged should be such as to satisfy national and local air quality standards with a built in safety margin to allow for abnormal events. In order that it can be demonstrated that air quality standards are satisfied, continuous monitoring of all of discharges to atmosphere should be carried out on a routine basis. At the same time air quality and particulate deposition in the vicinity of the plant should be monitored routinely.

Processes for the recovery of metals consume large quantities of water. For economic reasons effluent and surface drainage water often is collected, treated and reused. Effluent treatment sludges can usually be conditioned and introduced at an appropriate point in the metals recovery process. Any cooling water used in indirect systems can be reused after passing through heat exchangers or cooling towers. The temperature and quantity of any water discharged to the natural environment should be such that thermal pollution does not occur.

As indicated earlier many of the process slags and by-products are recycled within the plant or passed on to other processors to enable the maximum economical amount of metal to be extracted. Many slags exhausted of their recoverable metal content may be able to be processed to give a marketable product, e.g. abrasives, foundation materials, etc. However, before any slag is used for purposes which are environmentally sensitive its properties and suitability for a particular use must be determined and be shown to be acceptable. When used in such applications as road making foundations and similar uses the chemical and leaching effects of local groundwater on the slag need to be determined and considered as part of its acceptability criteria.

In summary, before consideration can be given to whether or not a recycling process proposed for a particular waste is regarded as environmentally sound, it is necessary to have knowledge of the materials and their constituents, the ways in which materials are to be handled and stored and the operations and operational standards to which the facilities of concern are required to operate. To be considered environmentally sound, processes performed on the wastes and disposal of any by-products derived therefrom, should satisfy the requirements of national legislation. The aim should be to achieve, to the maximum extent which is technically and economically feasible, the minimum environmental impact caused by any processes carried out on the waste and by the final disposal of any by-products to air, water and land. Internal recycling of process by-products should be practised whenever possible.

#### CHECK LIST FOR ENVIRONMENTALLY SOUND PROCESSES

It is possible to construct a list of criteria which can be used to support and supplement the information required on the Waste Notification and Tracking Form.

Achieving environmentally sound and economically efficient recycling of wastes to a significant extent is concerned with activities carried out in conditioning wastes to allow their direct recovery, principally in major facilities. If necessary other or additional criteria may be more appropriate. These can be considered in the light of the individual circumstances which may be encountered in particular situations. It is not the intention that the following list is exhaustive. Rather, it provides an indication of the information which could be expected to be made available to competent authorities for their consideration in assessing a proposed transfrontier movement of waste for recovery:-

Production process and/or unit operations from which the waste is derived Materials to be recovered Physical form of waste Chemical composition of waste Hazard characteristics of waste How material is stored at site of production Proposed packaging arrangements for transportation Proposed means of transport for movement to recovery site Proposed means of storage at recovery site Processes means of storage at recovery site Processes to be carried out on the material By-products and wastes from the processes Fate of by-products and wastes Environmental monitoring - air, water, atmospheric deposition

In support of an application for a transfrontier movement of waste destined for recovery operations it could be expected that much of the information required in undertaking an assessment would be available already. The appropriate competent authority normally would have been provided with plans of plant and buildings and details of operations to be performed there at the time of making an application seeking authorisation to operate a facility. The principal considerations needed, in relation to a proposed transfrontier movement of waste for recovery therefore, are related to the ability of the facility chosen by the notifier to process in an environmentally sound manner the particular consignment of waste for recovery detailed in the notification form. This requires :-

- a) A detailed description of the physical state of the waste, the process from which it originates, its constituents and their properties.
- b) How the waste is being kept at the generator's premises and how it will be stored at the processors premises. E.g. Under normal conditions does the waste exhibit hazardous characteristics what are these. How is the waste normally stored is it kept in a loose state in the open, is it dusty, is it within a bunded or burned area of hard standing, does the waste material need to be kept damp at all times to prevent its dispersion, are roadways being swept on a routine basis, is the drainage serving the storage area and roadways contained and connected to a treatment plant under the control of the site operator.
- c) The packaging and means of transport proposed to be used should be described and confirmation given that it accords in all respects with national and international transport codes for the materials concerned. The nature of the waste will determine the appropriate

means of packaging and transport to be used, such that the material cannot escape under normal transport conditions.

- d) Details on any pre-processing required and the processes to which the waste will be subjected to in achieving recovery of recycled materials and where these will be carried out.
- e) The fate of by-products arising from processes to be performed on the waste, i.e.

Gaseous - the means of filtration used and the fate of dusts collected.

Liquids - effluents disposal/recycle; treated on site before discharge? sludges recycled?

Solids - means used for disposal of solid waste not recycled.

f) Environmental monitoring results for air and water discharges arising from the processes, in comparison with the standards set by the relevant authorising authorities, or in their absence applicable international standards e.g. WHO recommendations. Also, for those wastes which are to be landfilled as being not technically and economically processable, description of and confirmation that the means to be used ensures that environmentally sound final disposal can be achieved.

The submission of such information (see example at APPENDIX 5) should provide evidence sufficient to enable a competent authority to decide whether or not a process is likely to be carried out in an environmentally sound manner at all times. In accordance with national laws and regulations, competent authorities may require verification that the material of concern was actually processed and recycled in an environmentally sound manner. Such verification may require, for example, the submission of records of monitoring undertaken during the time period in which the waste was actually processed and confirmation that by-products from the process were disposed of properly.

# **GENERAL RESPONSIBILITIES**

The generator of waste has a responsibility to classify and describe factually the materials which are to be passed on to a pre-processor. At the same time the pre-processor should not accept materials unless they satisfy the generators description and adequate facilities are available at the pre-processors premises to store and condition the waste to a form suitable for recovery. Similar responsibilities exist between the pre-processor and the recoverer. None of the parties in the chain should contract to process materials for which facilities within their control, adequate to ensure environmentally sound processing of particular wastes, do not exist.

In relation to copper, zinc and lead, general information is provided in APPENDICES 1, 2 and 3 as an aide memoire.

# **GLOSSARY OF TERMS USED:**

In addition to the Definitions of Terms given in OECD Decisions the following terms and their intended meaning are used in this document:

"Broker": an agent operating on behalf of a waste producer who arranges for wastes to be transported to and processed by a waste recovery facility.

"Pre-Process": physical or chemical processes undertaken as a step in the overall recycling operation to transform wastes to a form which make them suitable for direct entry into a primary production process.

"Primary Production Process": processes used to produce metals from their ores.

"Process": operations carried out on materials to allow the separation of a constituent.

"Processor": an organisation which operates plant to process materials.

#### **APPENDIX 1**

# COPPER

#### Occurrence

In nature copper occurs mainly as sulphide ores which must be processed initially to provide the impure metal and then refined to give a grade of metal appropriate to its intended use. After suitable pre-treatment copper bearing wastes can be fed into the processes used normally for the production of primary copper.

# **Properties**

Because of its inherent properties and ready availability, copper finds use in a wide variety of applications. The metal is malleable, ductile and a good conductor of heat and electricity. It can be alloyed easily with other metals the most widely used of these being brass (copper/zinc), bronze (copper/tin), beryllium-copper, monel (copper/nickel) and gun-metal (copper/tin). Copper can provide a decorative and/or protective finish to many products by electroplating and finds use as an undercoating for other metal finishes such as nickel, chromium and zinc plated products. The primary metal is marketed to accord with specifications and is readily available in the form of billets, cathodes, sheets, rods, wire bars, tubing, shot and powder. These basic forms are further processed by industry to produce a wide variety of manufactured products.

#### Uses

The principal uses made of the metal include a wide range of applications such as: electrical and electronic circuit wiring, electric motors field coils armatures and commutators, electrical switches, plumbing, heating, building construction e.g.. roofing, chemical and pharmaceutical processing plant and as a catalyst, heat exchangers used both industrially and in automobiles, household products including kitchenware.

# **Copper Wastes**

Because of its widespread use it follows that the quantity of copper for recovery and recycling can be significant and can arise from a multiplicity of diverse sources. As a relatively valuable material there is normally a financial incentive not to dispose of copper bearing material but to send it for reprocessing and thereby, provide the raw materials for the creation of other products. However, in some instances the complex nature of discarded products containing a variety of materials in addition to copper makes it very difficult if not impossible to recycle for its copper content.

Much of the metallic copper containing waste for recycling is obtained by scrap metal merchants who sort and accumulate it until a sufficient quantity has been assembled to provide quantities large enough to send to a smelter or refinery. They accept or buy-in the metal from a variety of sources such as materials derived from manufacturing processes using copper, e.g.. stampings, off-cuts and the like, copper stripped from a factory or property redevelopment involving pipework, rewiring, printed circuit boards from the electronics industry, discarded electric motors, etc. or it may have been segregated at source from, for example, household waste. In many instances the metal as received by the scrap metal merchant will not be in a form directly suitable for selling on to a smelter for recycling. It is necessary therefore, for the merchant initially to sort the scrap and in some instances to process it into a form which will be acceptable to a smelter, e.g. shearing or cutting to acceptable dimensions, by separating metal from insulation in electric cable, granulating, etc. Value is added to the scrap if it meets quality and physical state specifications for recycling, e.g. bales of a size which can be fed directly into a furnace or crucible at a smelter. The baled scrap is usually transported internationally in standardised containers.

The scrap metal industry world-wide has produced grading systems and specifications for scrap metal destined for recycling such that a consistent quality can be expected for a particular grade of scrap metal on an international basis. Three specifications which are used widely are the US Institute of Scrap Recycling Industries Inc. Scrap Specifications Circular, the European Classification for Non-Ferrous Metal Scrap prepared in collaboration with the consumers of non-ferrous scrap metal in Europe and various National and International Associations and the Standard Classification for Non-Ferrous Scrap Metals published by the US National Association of Secondary Materials Industries Inc. Each grade specification sets minimum limits on the copper content and maximum percentage of particular impurities which may be present such that the material meets the specification and is acceptable for recycling. For example, most grades must be free of coating material and other foreign substances, must be neither excessively leaded, tinned or soldered, nor have an excessive oil, iron or non-metallic content. Also, elements or compounds of antimony, arsenic, beryllium, cadmium, chlorine, mercury, selenium, sulphur or tellurium, or cyanides, or organic compounds, or explosives, pyrophoric or noxious materials at a concentration which could constitute a hazard or be injurious to health must not be present. Details on acceptable physical requirements and impurity concentration limits are given in the specifications. It could be expected that in most instances such wastes would be on the OECD Green List. However, while scrap metal for recycling may satisfy the specifications, nevertheless contaminants other than those listed could be present and may cause problems to the recycling process unless properly identified.

Other copper bearing wastes which can be processed to enable their copper content to be recovered include: certain ashes, drosses, dusts and slags; brass refining residues, copper refining residues, zinc refining residues, electrolytic copper wastes, electronic scrap, gun metal scrap, separated fragmentizer materials, etc. For these materials there can be no particular specification. Reliance has to be placed therefore, on a detailed chemical analysis of the constituents present in the waste. The copper content and physical state of the waste usually controls at which stage of the primary production process such materials are added and whether or not pre-processing is required to make the waste suitable for entry into the primary production process. It could be expected that most these waste would be on the OECD Amber List of Wastes.

### **Copper Recycling Processes**

The reclamation of copper from residues and wastes relies on two principal stages of processing. These are Smelting including roasting and sintering, to produce metal of a suitable quality for subsequent Refining.

#### Smelting

Smelting usually is carried out in three stages of processing in sequence to produce metallic copper in a form which is suitable for electrolytic refining to further improve its purity and provide a marketable product. These are: using a blast furnace to improve the copper content of the waste from about 30% to 80%, a converter (both conventional and top-blown rotary) and/or reverberatory furnace to improve the copper concentration from 80% to about 95% followed by an anode furnace to give a product for electrolytic refining containing ~99% copper. The fume and dust produced in the furnaces is collected on filters and usually is either returned to the blast furnace or provides a feed stock for the recycling of other metals such as zinc and tin.

The quality and physical state of the waste materials with respect to their copper content determines at which stage of the smelting processes they can be introduced. Materials such as fine residues, ashes and dusts which usually contain approximately 30% metal content, normally require to be formed into briquettes to make them suitable for feeding to the first stage of the smelting processes - the blast furnace. More coarse materials such as drosses, shredded material and certain refining wastes also containing about 30% copper can usually be fed directly into the blast furnace. Metal containing about 80% copper is tapped from the base of the blast furnace and transferred to converters. Other wastes such as copper alloy scrap and similar materials with a copper content of about 80% copper can be added to the converters. The copper concentration of metal in the converter is increased to about 95%. The copper is then transferred to an anode casting furnace where the addition of good quality copper scrap, blister copper and anode scrap from the refining process is recycled. The concentration of copper in the furnace is increased to about 99% at which stage the metal is cast into anodes for refining.

Each furnace in the smelting process is provided with filtration equipment to collect the fume produced by the process. Filtered air is discharged to atmosphere via a chimney. The fume collected contains high concentrations of other metals such as lead, tin and zinc, usually as the oxide and sulphate. These materials can be processed to produce the respective metals and their oxides and tin/lead alloy. Usually, slags from the processes can be recycled internally or converted to marketable products for use elsewhere, e.g. as abrasive grit, otherwise they can be disposed of in an environmentally sound manner.

# Refining

Usually, refining is carried out using an electrolytic process in which the cast anodes from the smelting process are placed in an electrolytic cell with a cathode and sulphuric acid as the electrolyte. The copper is transferred and deposited on the cathode in the process thus producing high purity copper. Cathodes are either sold as such for others to process or melted in a furnace and cast into physical forms such as billets, slabs, rod, etc. for sale. Impurities collect in the bottom of the electrolytic cell as a slime. This is removed from the cell from time to time and processed, or sold on to others to process and extract other metals.

#### **APPENDIX 2**

# ZINC

#### Occurrence

Zinc occurs in nature principally as sulphide, carbonate or silicate ores. Usually the ores are roasted to yield the oxide which is either reduced with carbon to yield the metal or leached with sulphuric acid and the solution obtained electrolysed to produce the metal. The metal can be further purified by distillation.

# **Properties and Uses**

Because of its properties zinc finds use in a wide variety of applications. It can be alloyed easily with other metals the most widely used of these being brass, bronze and zinc die-cast alloys. It can provide a protective finish to many steel products by galvanising, electroplating and metal spraying processes. It also finds use as an electrode in cathodic protection systems and in storage and dry cell batteries. The primary metal is marketed in the form of ingots, slabs,sheets, shot, powder and wires. These basic forms are further processed to produce a wide variety of products. For example, in the building industry sheet zinc is sometimes used as a substitute for lead. Zinc oxide is used also in a wide variety of applications, including: rubber, plastics, glass, ceramics, catalysts, pharmaceuticals, etc. Some of these latter uses are regarded as dispersive and direct recovery of zinc from such sources is considered to be impractical.

# **Zinc Wastes**

As indicated above, except in certain specialised applications, zinc is not itself used widely as the metal in products and therefore, except for the residues arising from the steel galvanising industry and other much less significant applications zinc does not usually occur as a separate waste in isolation. A significant source of zinc for recycling is old and new brass scrap. The motor industry where a number of automobile parts are made from die-cast zinc alloys which contain a high percentage of zinc, is a significant source also. Automobile breakers are able to separate out such zinc containing parts either manually or as one of the products separated in fragmentizer processes.

Old and new brass scrap together with foundry dusts collected in filtration plants, skimmings and drosses from galvanising processes and die cast zinc alloys separated in fragmentizer plants, all of which contain more than ~50% zinc, are the main sources of zinc for recycling. Many other uses for zinc are dispersive therefore making it unavailable for direct recycling. However, zinc contained in metal bearing wastes processed for the recovery of other metals increasingly provide additional sources of zinc for recovery. Dusts, such as those arising from the recycling of steels using electric arc furnaces and to a lesser extent blast furnaces, separated streams from fragmentizers and slag from primary zinc processing are all significant sources of zinc for recycling. To a much lesser extent zinc containing residues from the chemical industry and those from chemical leaching processes for stripping zinc from coated steel also are possible sources of zinc for recovery but are not widely used.

# **Zinc Recycling Processes**

When the concentration of zinc in materials for recycling is comparatively low (less than  $\sim$ 35%) it may not be economically viable, in the absence of a financial contribution from the waste generator, to recycle materials directly in competition with the comparatively high concentration zinc sources quoted in the paragraph above, or ore concentrates. Therefore, a pre-process must be carried out on the waste to

increase its zinc content to at least 55-60% at which concentration zinc recovery becomes *economically* viable. For many zinc bearing secondary materials, such as emission control dusts from electric arc furnaces for steel recycling, a financial contribution towards the cost of such pre-processing is usually made by the waste producer. This cost can be offset by the waste producer in savings made by not having to dispose of the waste.

The principal means of concentrating zinc bearing ashes and residues, particularly non-ferrous metal foundry and steel electric arc furnace dust which usually contain between 10% and 35% zinc, is the Waelz Process. The dust residues are pelletised and fed, together with the correct proportions of coke breeze and silica sand to act as a flux, into a rotary kiln operating at ~1200°C in the presence of excess air. Zinc, together with any lead contained in the residues, is volatilised and reacts with oxygen in the excess air present to form zinc and lead oxides. The oxides which become entrained in the off-gases leaving the kiln, are cooled and collected, usually in an electrostatic precipitator from where they can be removed for further processing. The filtered gases are discharged to atmosphere through a chimney stack. The slag produced in the kiln is discharged continuously and quenched in a water bath. The slag, after processing, finds use as a material for road construction or other similar applications.

Some processes used for the recovery of zinc also can recover lead at the same time. The most widely used process is the Imperial Smelting ISF Process, originally used to process zinc/lead ores, in which zinc and lead containing sinter and/or preformed briquettes together with coke is fed into a shaft furnace counter current to an hot air blast. Under the operating conditions in the furnace zinc contained in the feed becomes vaporised and leaves the top of the furnace where it is condensed in a lead splash condenser. The zinc which is less dense than lead can be removed from the surface of the molten lead bath contained in the condenser and cast into ingots. The lead contained in the feed stock to the ISF furnace is reduced to a lead bullion falls and is removed with the slag from which it is separated, cast into ingots and taken away for refining elsewhere. The separated zinc is refined and sold for conversion to various products including zinc oxide for which there is a ready market.

## **APPENDIX 3**

# LEAD

# Occurrence

In nature, lead occurs principally as the sulphide, sulphate or carbonate ores from which it can be extracted by sintering, reduction to the metal and refining.

#### **Properties and Uses**

Lead is a ductile, heavy, grey metal. Its exploitation by man for thousands of years means that there are now considered to be no parts of the world in which lead and its compounds cannot be found. Its usefulness relies significantly on its property of long term resistance to corrosion, so much so that it has been discovered, for example, as lead pipes used by the Romans. Today it finds application in industrial areas such as building construction, communications, energy production and distribution and transport. It is a poor conductor of electricity although finding use as a component in the lead acid battery which today is one of its principal uses. It alloys easily with other metals as a component in fusible alloys, solders, type metal and various anti-friction bearing. Although slowly soluble in acidic conditions it is used to provide a corrosion resistant cover for electrical cables and is used extensively in chemicals production plants. It has been much used in the past for plumbing. It is used in ammunition and in the manufacture of lead tetramethyl and tetraethyl, an anti-knock agent in petrol (gasoline). Lead salts including the carbonate, chromate, oxide and sulphate are used extensively in industrial paint formulations and other chemical applications.

## Lead Wastes

Its widespread use for a diversity of applications means that lead is present to a greater or lesser extent in many wastes. The feasibility of recycling lead containing materials therefore, depends on the lead content of the material. Only certain drosses and residues from other processes and containing a high percentage of lead are considered viable for direct recycling. In some instances it is a recoverable component in other wastes that are recycled, e.g.. steel mill dusts processed principally for zinc recovery and in many solder containing wastes recycled for their copper content. The main source of lead for recycling is discarded lead acid batteries from automobiles, traction vehicles and stand-by power supplies.

# Lead Recycling Processes

Although, many lead producers are able to process a proportion of secondary material, most recycled lead is produced by secondary processors. Their principal source of supply is from discarded lead-acid batteries. Any process used can also accommodate at the same time metallic lead or other lead containing materials coming from other sources such as dusts, sludges, drosses, ashes, turnings, cuttings, stampings, etc. .

The battery processors prefer to receive their supply of discarded batteries whole and undrained of their acid. Usually, they are stored under cover in an acid proof contained area from which they are taken and fed by conveyor into a roll crusher to open up the cases, release the acid and expose the lead plates. After passing under an electro-magnet, to remove any ferrous metal, the roll crushed material is then fed to a wet crushing hammer mill. The resulting material is then fed to a vibrating screen through which the fine material passes and which is subsequently dewatered. The unscreened material is fed to a classifier which separates the lead from less dense materials originally in the make-up of the battery. The separated lead containing materials are fed continuously to a smelting furnace where they are reduced to the metal. Off-gases from the smelting furnace are filtered and the dust collected returned to the furnace. The metal tapped from the kiln is transferred to refining kettles and processed to produce commercial quality lead.

# **APPENDIX 4**

# WASTE STATISTICS

# **Statistics on Wastes Quantities**

Statistics collected by OECD show that metallic and metal bearing wastes for recovery are traded on an international basis to a significant extent such that worldwide some 40 million tonnes of these materials are either exported or imported annually.

# Statistics on Wastes Recovered\*

#### Copper

For 1992 the world production of refined copper was estimated to be about 11.1 million tonnes of which some 4.25 million tonnes was derived from waste materials.

#### Lead

The world production of refined lead in 1992 was estimated to be about 5.6 million tonnes of which some 2.2 million tonnes was derived from scrap materials.

# Zinc

Some 7.2 million tonnes of refined zinc was estimated to have been produced in 1992. Of this quantity some 1.4 million tonnes was obtained from the processing of waste materials.

## **Facilities for Processing Wastes**

Information collated from the Membership Directory of the Bureau International de la Recuperation (BIR) indicates that within OECD Member countries there are at least 143 traders/processors with scrap yards specifically indicating the handling of copper and/or zinc and/or lead wastes. Also, there are 42 consumers of one or more of these metals operating as founders, refiners or producers of recycled metals.

\* Source - World Metal Statistics

# **APPENDIX 5**

# **RECOVERY PROCESSES DESCRIPTION**

Example of general description of processes involved and environmental considerations for the recovery of particular materials.

Electric Arc Furnace Dust from secondary steel production for Zinc and Lead Recovery

Waste arises as a fine powder collected in bag filters from air filtration of gases from furnace. Powder is pelletised and kept damped down to make it less dispersible and thereby reduce its release to the environment. Principal hazard is as a nuisance dust.

Material is stored in open in bays having concrete walls on hard standing drained to site water treatment facility.

Material is loaded into watertight trailers by front-end loaders and sheeted down. Vehicles pass through wheel-wash and are hosed-down before leaving site of production. Wash water drained to site water treatment facility.

Material off-loaded at processor facility by tipping into underground hoppers. Empty lorries washed down before leaving site. Washings collected and transferred to site water treatment facility.

Material processed using the Waelz process by being fed by conveyor, together with coke and silica into rotary kiln. The zinc and lead content of waste removed as fume and dust which is collected by electrostatic precipitators and bag filters in series. Filtered material is now in suitable form to be conveyed to the Imperial Smelting ISF primary production process situated nearby.

By-product from Waelz process is slag which is discharged from the rotary kiln and quenched in water. Slag is in suitable form and non-leachable composition for use as road making or similar material.

Environmental monitoring undertaken, results well within limiting criteria set by permitting authorities.