NON-FERROUS METALS INDUSTRY

1. Metals we referred to in the following guidelines are aluminum, ferrous alloys, copper, plumb, zinc and nickel. There are also a lot of non-ferrous metals, but insofar as they are produced in small quantities by means of manufacturing highly specialized or are derived from other processes, the West African Development Bank is rarely involved in such projects.

Aluminum

2. Aluminum is produced from bauxite ore, a hydrated aluminum oxide. The ore must first be purified by getting rid of the other elements it contains and where the alumina is dissolved in a very concentrated solution of caustic soda. The residue is filtered (red mud) and reintroduced into the fabrication process. The residue obtained is finally scrapped. We obtain the separation of the alumina after crystallization, thickening, filtering and calcination. The alumina is then reduced by electrolysis, alloying and casting into ingots.

3. The secondary aluminum production uses aluminum residues and metal combustion recovered as raw materials. Residues and recycled aluminum are liquefied in a furnace added with fluxes and then to be allied, removal of magnesium, degassed with chlorine and skimmed before being cast into ingots.

Ferrous alloy

4. Ferrous alloy Producing consists essentially in reducing and melting a mixture of oxides in an electric furnace. Carbon, in the form of coke which is generally added to fuel, removes oxygen as carbon monoxide. Non reducible oxides are added to the slag and the reducible metal is alloying. Regularly the bottom of the furnace is emptying from liquid slag and formed alloy. The type of alloy - ferrochrome, ferromanganese, ferronickel, ferrovanadium, ferroniobium etc. - depends on the ore that feeds the

furnace. The slags and alloys are cooled and separated. The alloys are broken, crushed and sized to be marketed.

5. The emissions of carbon monoxide and the formation of large amounts of very fine particles of dust generated by electric arc furnaces are the main problems posed to the environment by ferrous alloy production. Rather than open-hearth furnaces (open fire) which was used before, modern facilities employ more efficient closed furnaces and which allow to better control the gas and smoke generated by the combustion at high temperature. The gases are scrubbed with cyclones, bag filters and scrubbers. The fine dust particles are agglomerate and are returned to the furnace. Carbon monoxide is used to preheat the fuel load or turn on the boiler.

6. Sometimes the molten slag and more rarely as alloys are reduced to granules in a water jet. This produces a liquid effluent and gives rise to fine solid slag, potentially harmful elements for the environment and must, therefore, be contained. The cooling of the furnaces with water produces another effluent stream.

Smelting of copper and nickel sulfide

7. Sulfide smelting Pyrometallurgical process produces the whole entire world production of copper and nickel. Most of these transactions is to melt and separate by gravity oxide molten slag with low density of the matte (sulfide mixture of metals) in heavier fusion.

8. We proceed to roasting the matte in manner to adjust the sulfur and iron compounds it contains and which are usually obtained after the melting phase. The toasting operation consists to heat the load which is then reacted with air. Superfluous sulfur evaporates as sulfur oxide while iron (which occurs mainly as sulfide) and molten iron oxide will be deposited in the slag. Due to impurities in many minerals such as arsenic, antimony,

cadmium, roasting is a problem for the environment. The oxides that are present tend to evaporate and then condense into particles in the flue gas.

9. Converting the matte follows the melting operation where the air, in which the oxygen content is sometimes higher, is injected into the molten matte in order to get rid of sulfur and iron. We obtain then an impure copper metal or the sulfides without iron and both require other treatments. The conversion process is a process that takes place at high temperature and uses large volumes of gas to remove impurities in the matte (eg. Plumb Oxides, arsenic and cadmium).

10. The equipment used in each of the steps described above has recently undergone major changes explained by economic or environmental protection reasons. These improvements have resulted in a reduction in fuel consumption and a reduction of gas with higher content in sulfur dioxide. They also helped to get rid of dust and recover sulfur, sulfuric acid or liquid sulfur dioxide, in more satisfactory manner.

Plumb

11. The melting process of plumb ores and concentrates ores is generally required to conduct sintering operations to separate the sulfur, oxidized the plumb and agglomerate fine particles followed by the reduction of ores in a furnace. The Popular Republic of China and Canada have adopted in recent years, a direct melting process in which the plumb sulfide concentrates fed at one end a melt and injected oxygen separates sulfur while is introduced at the other end the coal or reducing gas to remove the slag of plumb oxide which have formed. The slag at one end and the raw metal to the other side is removed. The plumb in the rough can then be electro- refined.

Zinc

12. The sulfides are the main sources of zinc production. Two methods of metal extraction are used: one in which one carries out the combination of pyrometallurgical, hydrometallurgical and an electrometallurgy and the other a single pyrometallurgical method is employed. Both methods begin by converting the sulfur oxide. In the pyrometallurgical method, the zinc oxide sinter feed the furnace. The metal vaporizes and condenses into molten zinc from the waste gases. In the hydrometallurgical stage, zinc oxide is dissolved in sulfuric acid, the solution is purified and the recovered zinc by electrolysis (electroplating). Jarosite, an iron sulfate is a solid waste produced by the purification step, the recovery by electrolysis tends to produce fine acidic vapors. 161

Potential impacts on the environment

13. The evacuation of red mud (a mixture of clay and highly corrosive caustic soda), emissions given off by burning fuel and aluminum smelting and the flow of liquid waste and sludge are part of main dangers that represent for the environment the production of aluminum. The red mud can degrade the receiving waters and the subsoil.

14. The emissions from the electrolysis unit are comprised of hydrofluoric acid, a very corrosive and dangerous gas. The magnesium and the gases emitted by the processes of getting rid of magnesium and degassing containing chlorine that needs to be purified. The cleaning solution must, for all, be neutralized.

15. The production of ferrous alloy generates important quantities of fine dust particles and coke (coke crackled). The electric furnaces produce large quantities of toxic gases containing carbon monoxide and Arsenic compounds. If the slag cannot be used for other purposes, it is important to eliminate them. It is possible, because of cyclones and bag filters, to clean

waste gas or purify them further by separators. A pellets reduction unit can recycle the recovered dust. Purification activities give rise to waste that cannot be discharged without treatment.

16. The environmental impacts from the production of nickel depend on the adopted processes. The ferronickel electrometallurgical production will generate significant amounts of particles and carbon oxide as well as trace emissions of sulfur containing gases. The pyrometallurgical process emits gases rich in particles; roasters, smelting and conversion furnace as well as energy generation units, which are often an integral part of production facilities, emit toxic gases.

17. The gas may contain sulfur dioxide, nitrogen oxides, carbon monoxide and hydrogen sulfide. The effluents are generated by gas cleaning operations, the cooling of matte and slag converter, matte and reduction furnace, etc. The solid waste is comprised of slag, solid deposits from the cooling tanks and sludge produced by waste treatment. If we proceed to the formation of carbonyl, we obtained as an intermediate substance a nickel carbonyl, an extremely toxic gas.

18. The molten copper and the gas that is purified contain sulfur dioxide and particulate. There is a need to recover sulfur dioxide and turn it into sulfuric acid. The liquid effluents are issued by blow down acid production units, the cooling devices and the methods by pelletizing slag. Effluent produced by the refining units contains electrolytic waste, cathode washing water, slag fines and anodic sludge.

19. Second time copper production gives birth to effluents emitted by operations such as slag milling, pollution control equipment equipped by melting furnaces, the cooling systems by contact, by electrolytes and a pelletizing of slag. Solid waste comes mainly from air scrubbers, cyclones,

precipitators and slag furnaces; second time copper production generates scrap copper or pretreated waste.

20. The air pollutants which generate by plumb treatment undertaken in sinter plants include particles, sulfur dioxide, arsenic, antimony and cadmium. The sulfuric acid unit should recover the stream of sulfur dioxide highly concentrated which gives rise to blast furnaces. It would require that equipment made by bag house and scrubbers remove particles whose plumb content is high.

21. Filters of sintering units, acids drainage facilities and other purification system used in the factory generate aqueous effluents that may contain toxic metals. Slag pelletizing is another source of effluent containing plumb, zinc, copper and cadmium. Solid waste generated by bag houses, cyclones, etc. can, for the most part, be recycled in the factory.

22. The secondary plumb factory produce effluents containing acid emitted by washers cracked batteries and from purification equipment which is destine to fight against air pollution. It would be good to keep them separate from other waste and not dump the accumulator acid polluted by metals such as plumb, antimony, cadmium, arsenic and zinc.

23. Emissions from zinc pyrometallurgical contain sulfur dioxide, arsenic, plumb and cadmium. Sulfur dioxide is recovered for the production of sulfuric acid. Carbon monoxide is an important compound formed by the reduction of gaseous effluents. The zinc vapor not condensed is purified before being reintroduced into the refining units. The zinc electrometallurgical treatment creates the same air emissions, sometimes containing mercury (that a scrubber separates). The effluent from scrubbers, acid unit drainage system and leaching units are likely to contain the same elements found in air emissions.

24. Solid waste containing substantial amounts of other metals are generally sold to other processing factory, with the exception of cadmium, which in most of the time, is recuperated by the zinc fabrication factory. (For more details concerning the effects of the non-ferrous metals industry on the environment, see Table 10.15 at the end of this section).

Specific issues

Air quality

25. The production of aluminum from the electrolysis of alumina is at the origin of fluorine gas emissions which contains gas which can be very dangerous to human health and to the environment. Careful monitoring of these emissions is needed. Generally the procedure is to purifying these gases through drying by using alumina powder which eliminates all fluorine. The rest must be removed by using a humid alkaline purification.

26. The ferrochrome and ferromanganese production can be the source of significant particle emissions. The choice of furnace (open, semi- open or closed) and the decision to include a pelletizing unit to recycle the particles during the design phase of the project can help to reduce these emissions.

27. Sulfur dioxide from the sintering of sulfide ores is, in most of factories, recovered, purified and used to supply sulfuric acid production units. The gas cleaning generates effluent containing arsenic, selenium and other metal salts that cannot be discharged into natural waters and that we must treat to remove these substances.

Effluents

28. In general, waste waters are not a problem if good management accompanied by an appropriate monitoring is adopted. All particles should, wherever possible, be settled and be removed in order to restore the waters circulation after treatment, if necessary. We should allow no

discharge of water from the treatment of copper, chromium, manganese, nickel, zinc and plumb and in which metal ions concentrations (metal salts) exceed the specified limits in the Guidelines related to the environment adopted by the West African Development Bank .

29. All spent acid which was used in the leaching process or another type of treatment cannot be discharged into natural waters but must be neutralized or recycled. If it has been neutralized, the discharge shall be made only to the extent that the level of concentration of metals and other dangerous compounds are below the official limits.

Solid waste

30. Aluminum production generates large amounts of red sludge that must be removed. You cannot dump these substances in natural river; its must instead be stored on the ground such that the discharge or leachate cannot contaminate surface water or underground one. The projects the Bank are supporting are projects that recommend and use a method of confinement by land with cup holder and for which eventually calls for stabilization and restoring of vegetation

31. The production of most of other non-ferrous metals generates solid wastes that contain substances that can be recycled. However, it should consider recycling during the measures elaboration for waste elimination. The sludge that are not sold to processing plants should be stored in controlled conditions so that the leachate does not seep into groundwater or do not flow in the surface waters. Moreover, the sludge produced by plumb treatment factories, which may contain high concentrations of toxic metals, gives a particular problem.

Waste Reduction

32. Projects financed by the Bank require that produced waters are recycled in the processing operations. It is often possible to sell the solid waste to other facilities that recover the matter that can be used or, if they are harmless and manipulated in meticulous control conditions, used for other purposes (such as , for example, the use of red mud for the reclamation of the shoreline). If you sell or transfer, solid waste to entrepreneurs to serve other types of processing or to be evacuated in a discharge, the project must prescribe strict control conditions.

Safe handling of heated metals

33. There are, in all operations where metal smelting occurs, explosions caused by contact with water. The reasons that cause this conflagration are not well understood. While the methods which consist to immerse the metal or reducing pellets matte do not present a danger, the pouring of small quantity of water on molten metal can be fatal. **Alternatives solutions to Project**

34. Even though there are various ways to design and implement a project, the technologies and available raw materials restrict the type of non-ferrous metals treatment facilities.

Selection of a location

35. General issues which should be considered when it comes to install an industry are discussed in the section entitled "Factory location and valorization of land for industrial purposes." The nature of a non-ferrous metals production factory, which proceeds to the evacuation of solid waste generated by production operations, is such that the effects on water and soil quality require a particular attention to the possible locations evaluation. Outfalls that water quality is unsatisfactory or whose flow does not receive well-treated effluents are not shown.

36. If the ore mining and production activities take place on the same site or in close proximity to one another, it is appropriate, then, to assess the overall impact of these two operations on the environment. Perhaps it will lead to a positive conclusion that the old mines could be used to deposit solid waste in strictly controlled conditions.

Methods of Treatment

37. The methods of non-ferrous metals fabrication vary according to produced metals and raw materials used. Even though the issue of recycling opportunities available in any country is not something on which we look when it comes to analyzing a particular project, yet it would be important to examine thoroughly before develop new facilities. This approach is not only beneficial for the environment but also for the national economy, in this way, could save its energy costs that represent the production as well as mining.

38. It is important in the aluminum production, to ensure that the technologies have been integrated into the project and may have a beneficial effect on the management of waste, such as fluidized bed processes for the recovery of waste heat emitted from melting furnaces for aluminum.

39. Regarding the fabrication of nickel, copper and zinc produced from sulfur ore, there are often two treatments lanes available: pyro-metallurgical or hydrometallurgical. The choice is based on many different factors ranging from inherent properties of minerals criteria relating to geographic location, availability of water and energy and market conditions. The advantage of the hydrometallurgical process is that it is well suited to lower quality ores and more complex. This is the more important aspect as global mineral resources of high quality exhaust. This process is also suitable for small deposits using relatively modest facilities.

Nevertheless, the assertion that the hydrometallurgical process is preferable to the pyro-metallurgical method is not necessarily defensible in terms of the environment; the question is not so clear and should be estimated for each project.

Fight against air pollution means

40. Projects financed by the Bank require measures against air pollution. Possible solutions that should be considered include: 165

• Process design and equipment selection, electrostatic precipitators, flue gas cleaning (by dry way or wet way);

• Electrostatic precipitators;

• Flue gas scrubbers (by dry way or wet way)

• Intensive cyclones;

• Bag house;

• Separation of sulfur dioxide and use for the production of sulfuric acid;

• Separation of carbon monoxide and use as fuel.

Water quality controlling means

41. Fight against water pollution solutions is including:

• Waste water recycling;

• Solar evaporation;

• Precipitation;

• Flocculation, sedimentation, clarification and filtration;

• Ion exchange, membrane filtration and reverse osmosis;

• Neutralization (active pH control);

• Biological treatment, if necessary.

Management and Training

42. Effective management that enables to fight against pollution and reduce waste requires institutional support in order to mitigate the potentially negative effects that ferrous metals treatment factories have on air quality and water. A trained engineer expert in fighting against pollution of water and air and knowing control technologies in use should be part of the factory team personnel. Manufacturers are usually willing, upon request, to provide training sessions explaining how to operate and maintain the equipment.

43. The standard operating and planned maintenance procedures should be established and implemented by the factory management. They should also include pollution control equipment, procedures for monitoring air and water as well as instructions for notice and closure of the facility or other precautions to cope with equipment defective clearance.

44. Regulations on health and safety should be developed and implemented in the factory. These regulations should include:

• Provisions to stop and deal with accidental releases of dangerous gases and acid spills.

• Procedures to keep exposure to toxic gases and particles transported by air within national boundaries or regulations established by the World Bank.

• A program of routine medical visits.

• A continuous training program on issues of health and safety aspects and on the maintenance of environmental practices.

• An action plan including emergency procedures through regular training exercises to respond to a spill, leak, explosion or fire.

(See "Managing Industrial Risk" and guidelines for health and safety at work of the West African Development Bank).

45. Standards for emissions and effluents are applied to the factory should be based on national regulations where they exist or be established from the standards recommended by the Bank. Government agencies in charge of monitoring of pollution control equipment, the quality of air and water, enforce standards and to supervise the activities of waste evacuation should have the necessary equipment and be vested with power. Specialized training may be required. The environmental assessment should take into account an estimate of local capacity in relation to these issues and recommend ways to contribute to the project.

Monitoring

46. The implementation of specific plans for factory monitoring and the location is required and, as a general rule, the following elements:

• smoke opacity;
• particles emissions, sulfur dioxide, hydrogen fluoride, hydrogen sulfide , chlorine , ammonia , nitrogen oxides, as appropriate;
• process parameters related to the functioning equipment of pollution reduction as the temperature of the flue gas;
• air quality around factory by monitoring critical pollutants;
• quality of the outlet downstream by controlling dissolved oxygen , pH, suspended solids , cyanide , free chlorine and relevant toxic metals ;
• flow of liquid waste produced by the factory by monitoring pH levels (continuously), the suspended solids, total dissolved solids, and depending on the case, cyanide, hydrogen sulfide, sulfuric acid, caustic, toxic metal ions, radioactivity, pH, BOD_5, oil and grease;

• quantities of rainwater from facilities and storage areas may be released containing the pollutants mentioned above;

• noise levels at workplaces of all facilities;

• monitoring of stored materials, sludge retention basins protected by dikes;

• monitoring of security measures respect and procedures for pollution control , their updating and upgrading of security plans and emergency services.

Table 10.15. Non- ferrous metals industry

Potential negative impacts	Mitigation measures
Direct impacts: **Selection of location:** 1. Establishment of a factory on or near by sensitive habitats, such as mangroves, estuaries, wetlands and coral reefs.	1. • Install, if possible, the factory in an industrial area so as to reduce and concentrate the pressure on environmental services in the region and to facilitate the monitoring of discharges. • Involve agencies managing natural resources in the choice of location to conduct the review of alternatives.
2. A factory locating along a watercourse that causing it degradation.	2. • The choice of location should consider solutions that have on the environment as little impact as possible and do not compromise the benefits that represent the use of

	water plans. • Factories that emit liquid discharges should only be located near a river which the assimilative capacity of the treated effluent is sufficient.
3. Situation that could cause serious air pollution problems in the locality.	3. Install the factory at a high level that is greater than the topography of the region, in an area that does not undergo atmospheric inversions and where prevailing winds to relatively sparsely populated areas.
4. Location which may intensify solid waste problems that the community is facing.	4. It would be important to assess the location using the following guidelines : • closeness to a suitable discharge • size of the field allowing to provide a discharge or on-site elimination system • accessibility for public or private

	collection services to transport solid waste to its final destination • Reuse or recycling of materials to reduce waste volumes.
Direct impacts: Factory exploitation 5. Water pollution caused by discharges of liquid effluent, cooling water or runoff from piled up waste. • Factory : metals, oil and grease, ammonia nitrogen • Flowing of stored materials : MES, pH , metal	5. It should be good to analyze in the laboratory liquid waste including: metals, MES, oil and grease, ammonia nitrogen, pH, and to ensure the monitoring of the local temperature. **<u>All types of factories</u>** • No discharge of cooling water. If their recycling is not possible, they will be discharged in the condition that the rise of the temperature does not exceed 3 ° C. • Maintaining of pH level from effluent discharge between 6.0 and 9.0.

	• Effluent Control according to the restrictions set by the Bank or by other standards (such as the EPA 40 CFR 421) for specific processes. **<u>Material storage areas and evacuation areas of solid waste</u>** • Avoid rainwater and runoff, in excessive manner, to seep through the material. • Proceed to the coating of soil and open storage area.
6. Air emissions of particles from factory activities in general.	6. Control particles by installing filter, cloth collectors or electrostatic dust collectors.
7. Gas emission releases by the metal processing and oil combustion.	

	7. • Purify the gas by using alkaline solutions. • An analysis of raw materials during the feasibility phase of the project, may determine the levels of sulfur in order to design control emissions equipment.
8. Accidentally spills of potentially dangerous solvents, acids and alkalis substance.	8. • Maintain areas used for the storage and elimination of substances to stop accidental releases. • Install spill control equipment, double-walled tanks or digging ditches around storage tanks.
9.	9. • It is possible to control the

Surface runoff of raw materials, coal, coke sizzle and other substances usually stacked in the factory may be factors of pollution.	infiltration of rainwater and runoff from solids, oil and stacked waste by covering substances with a tarp or by confining them to prevent the pollution of surface and subsurface. • The diked areas should be of sufficient size to contain an average rainfall of 24 hours.

Indirect impacts

10. • Risks for workers health caused by the manipulation of materials or manufacturing processes and exposed to fugitive dust and noise. • Accidents occurring more frequently than average due to a lack of staff or skills.	10. The factory should establish a health and safety program by proposing to: • identify, assess , exercise monitoring and risks control for workers health and safety • provide training in safety

11. Regional problem of solid waste intensified by an intermediate storage system inadequate or lack of final discharge.	11. Provide on-site elimination areas on the assumption that the characteristics of dangerous leachates are known.
12. Disruption of transit circuits, the appearance of noise created by traffic and increase of accidents risk that the walkers are exposed to which entails the comings and goings of heavy trucks that carrying raw materials and fuels.	12. • The choice of location can alleviate a number of these problems. • It should be nice to conduct, during the feasibility study of the project, studies on transport to determine the safest routes. • Provide transport regulations and an action plan in order to reduce the risk of accidents
13. Local exploitation of minerals and coal for the manufacture of metal may come into conflict with other industries (using of coal in public services) and aggravate erosion or sedimentation of rivers due to excessive or improper extraction methods.	13. • Make sure that the uses of coal correspond to the available quantities and impose restrictions on mining methods. • Coordinate with the agency in charge to discuss possible solutions to restore the site after installation

	dismantled.
14. Metal treatment is likely to require significant energy into electricity that can be confrontational with other industrial uses.	14. • Perform metal treatment at times when other industries operating from electricity are not active. • Increase the capacity of power generation