Guidelines for utilization and disposal of solid wastes from integrated steel plants
TECHNICAL COMMITTEE REPRESENTATION

The following organizations were represented on the Technical Committee:

Government Chemist
Kenya Industrial Research and Development Institute (KIRDI)
National Environmental and Management Authority (NEMA)
Radiation Protection Board
Occupational Health and Safety Services
Pest Control and Products Board
Consumer Information Network
Kenya Plant Health Inspectorate (KEPHIS)
Agrochemical Association of Kenya
Nairobi Hospital
Radiation protection Board
University of Nairobi — Chemistry Department
Kenya Bureau of Standards — Secretariat

REVISION OF KENYA STANDARDS

In order to keep abreast of progress in industry, Kenya Standards shall be regularly reviewed. Suggestions for improvements to published standards, addressed to the Managing Director, Kenya Bureau of Standards, are welcome.
Guidelines for utilization and disposal of solid wastes from integrated steel plants
Foreword

This Kenya Standard has been prepared by the Technical Committee on Waste under the guidance of the Standards Projects Committee, and it is in accordance with the procedures of the Kenya Bureau of Standards. The Iron and Steel industry in Kenya forms about 13 percent of the manufacturing sector, which in turn contributes significantly to the GDP.

In any industry when basic raw materials are processed, along with the main products some other materials are also produced. Depending on the characteristics of these materials some of them, called by-products, may be economically used either in the same industry or in another industry, whereas the rest, called wastes, are totally discarded.

Dumping sites of the solid wastes preferred for recycle should be located adjacent to the recycle process units.

For example, solid wastes which are to be recycled to sintering plant should be dumped in close proximity to the sintering plant for effective recycling.

In the preparation of this standard, reference was made to the following documents:

IS 10447 Guidelines for utilization and disposal of solid wastes from integrated steel plants.

Acknowledgement is hereby made for the assistance received from these sources.
Guidelines for utilization and disposal of solid wastes from integrated steel plants

1 Scope

1.1 This standard prescribes guidelines for the present and possible future uses of the solid wastes generated in an integrated steel plant. Amount of generation and characteristics of these wastes have also been given.
1.2 This standard does not cover wastes generated at mines and collieries. It also does not include spillage at various stages of processing which is recycled into the system, for example, dust at coke ovens, sinter plant, etc., and also wastes generated in small quantities like dust from open hearth furnaces and sludge from water softening plants.

2. Terminology and sources of wastes

2.1 Blast Furnace Gas Cleaning Plant Sludge - These are finer particles of dust finally removed from the blast furnace gas in the gas cleaning plant.
2.2 Blast Furnace Slag - This is the waste material, consisting mainly of CaO, SiO₂, Al₂O₃, and MgO, coming out of the iron making blast furnaces. It is originally in liquid form but is finally disposed off as a solid after cooling.
2.3 Bottom Ash - The coal used in the grate type boilers, after combustion, turns into clinker form which is known as bottom ash.
2.4 Coal Tar Sludge - This material collects below the tar in the coke ovens by-product plant. It is a soft solid mass which turns into fluid at a temperature around 75430°C.
2.5 Fines and Dust from Caking Plant - These fines are generated during the processing of dolomite for the supply of sized material to steel melting shops. Lime and dolo dust are also generated during calcination of lime stone and dolomite in the kilns.
2.6 Flue Dust - The gas emitted by a blast furnace is laden with dust as it comes out of the furnace. During the gas cleaning process, the coarser particles, collected in the dust catcher, are called flue dust.
2.7 Fly Ash - Fly ash is a finely divided residue resulting from the combustion of ground or powdered coal and carried along with the flue gases of boilers fired by pulverized coal.
2.8 Foundry Wastes
   a) Foundry Sand - Large amount of used silica sand, a part of which is burnt, generated as a waste in the foundry.
   b) Cupola and Electric Furnace Slag - A slag generated during cupola or electrical furnace melting.
2.9 Mill & ale - While steel ingots or other sections are heated in soaking pits or reheating furnaces before rolling, the outer skin of the material is oxidised. The oxidised layer, called mill scale, drops down in the furnaces or under the rolling table.
2.10 Slimes - During crushing and washing of iron ore within the steel plant for improving its quality and size, finer fraction (less than 200 μm) is carried away by water in the form of slurry into a pond. These fine particles of iron ore are called slimes.
2.11 LD Converter/Open Hearth Slag - This material is generated during conversion of iron into steel in a steel making furnace.
2.12 Wastes from Refractories - Used broken bricks are generated during breaking of the refractory lining for rebuilding various furnaces. Dusts of various refractory materials are produced during the manufacture of refractory mortars or bricks in integrated steel plants.

3. SOLID WASTES
The characteristics, quantity, and possible uses of the various solid wastes generated in an integrated steel plant are given in Table 1.
<table>
<thead>
<tr>
<th>SL No.</th>
<th>Type of Waste</th>
<th>Typical Generation for Integrated Steel Plant of 2 Million Tonne Ingot Steel</th>
<th>Percent of Total Quantity</th>
<th>Typical Chemical Analysis Percent (and Size)</th>
<th>Mode of Utilization/Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Iron ore slimes from ore-crushing plant inside works*</td>
<td>2,500 - 3,500 (4-6 percent of ore processed) tonne/month</td>
<td>1.7</td>
<td>Fe = 55-60, SiO₂ = 3-6, Al₂O₃ = 4-7 (60 percent smaller than 75 μm)</td>
<td>As a feed to pelletizing mix (20 percent Max for improving Al₂O₃/SiO₂ ratio of burden and improved strength of pellets during reduction.</td>
</tr>
<tr>
<td>ii)</td>
<td>Blast furnace flue-dust*</td>
<td>5,000 - 6,000 (35-45 kg/t hot metal)</td>
<td>3.2</td>
<td>Fe = 32-35, SiO₂ = 7-9, Al₂O₃ = 6-7, CaO = 6.5-7.5, MgO = 3-4, C = 21-24 (80-90 percent between 50 and 75 μm)</td>
<td>As a feed to the sinter plant. Ratio to be decided on the basis of operating condition of plant and size of flue dust. Generally disposed off on land in the form of cakes.</td>
</tr>
<tr>
<td>iii)</td>
<td>Sludge from gas cleaning plant</td>
<td>3,500 - 4,500 (25-30 kg/t hot metal)</td>
<td>2.3</td>
<td>Fe = 33-35, SiO₂ = 6-8, CaO = 7-5-8-5, FeO = 9-10, C = 22-25 (more than 80 percent smaller than 45 μm)</td>
<td>a) Granulated to make slag cement, b) To make light weight slag for use as insulating material, and c) Air cooled slag boulders for building roads.</td>
</tr>
<tr>
<td>iv)</td>
<td>Blast furnace slag†</td>
<td>85,000 - 95,000 (600 kg/t hot metal)</td>
<td>52.2</td>
<td>CaO = 31-33, SiO₂ = 30-33, Al₂O₃ = 22-24, MgO = 9-12</td>
<td></td>
</tr>
</tbody>
</table>
v) Steel making slag†
   a) Open hearth slag 27,000 - 30,000
      (30/40 scrap, 60/70 hot metal)
   b) LD converter slag‡ 120 - 220 kg/ton steel

vi) Mill scale (Both primary and finishing mills)*
    6,000 - 7,000 (2.5 - 3.5)
    9.5 percent of input material rolled

vii) Fines and dust at calcining plant
    a) Dolo fines (-5 mm)* 1,300 - 1,400
    b) Dolo dust* 100 - 150
    c) Lime dust† 400 - 450

16.6 Flue slag: SiO₂ = 20.1, Fe₂O₃ = 36.4, FeO =
      30.4, Al₂O₃ = 5.9,
      CaO = 20.2, MgO =
      6.1, P₂O₅ = 4.6,
      MnO = 7.0

Tab slag: SiO₂ = 18.6,
      Fe₂O₃ = 40.0, FeO =
      13.1, Al₂O₃ = 4.8,
      CaO = 37.0, MgO =
      12.0, P₂O₅ = 3.3,
      MnO = 7.0

CaO = 43-50 SiO₂ =
      13-16, MgO = 5-8,
      MnO = 3-5, P₂O₅ =
      2-3, FeO = 16-20

Fe = 31.2, FeO = 63.3
SiO₂ = 1.4, Al₂O₃ =
      0.4, CaO = 0.2, MgO
      = 0.9

a) High CaO/SiO₂ ratio slag as a soil conditioner in agricultural fields having acidic soil.
b) Partly charging to the sinter mix, and
c) High P₂O₅ slag for manufacture of fertilisers.
a) Soil conditioner for acidic soil, and
b) Source of flux in the blast furnace either directly or through the sinter.
a) As a feed in the sinter plant (-10 mm),
b) Recycle through open hearth furnace (+6 mm),
c) Feed to hearth furnace mix (up to 5 percent) to increase compressive strength of pellets, and
d) As feed to blast furnace (+10 mm).

As a feed in sinter.
As a feed in sinter.
a) For spreading on the ground with tar
   sludge for preventing growth of vegetation, and
b) Adding to steel melting shops after briquetting.

(Continued)
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Waste</th>
<th>Typical Generation for Integrated Steel Plant of 2 Million Tonnes Ingot Steel</th>
<th>Percent of Total Quantity</th>
<th>Typical Chemical Analysis Percent (and Size)</th>
<th>Mode of Utilization/Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(3) tonne/month</td>
<td>(4)</td>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td>viii)</td>
<td>Refractories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Used broken bricks†</td>
<td>400 - 500</td>
<td>0.5</td>
<td></td>
<td>Crushed and used for making mortar.</td>
</tr>
<tr>
<td>b)</td>
<td>Dust (chrome, magnesite, kyanite, clay, etc.)†</td>
<td>200 - 250</td>
<td></td>
<td></td>
<td>Used for making mortar.</td>
</tr>
<tr>
<td>c)</td>
<td>Dust (magnesite)†</td>
<td>100 - 150</td>
<td></td>
<td></td>
<td>Feed to sinter mix.</td>
</tr>
<tr>
<td>ix)</td>
<td>Coal tar sludge†</td>
<td>200 - 300</td>
<td></td>
<td></td>
<td>Mixing with lime dust and hot pitching to prevent growth of vegetation.</td>
</tr>
<tr>
<td>x)</td>
<td>Bottom ash†</td>
<td>24 000</td>
<td>13.9</td>
<td>SiO₂ = 41.9, Al₂O₃ = 21.3, Fe₂O₃ = 5.7, CaO = 1.7, MgO = 0.94, (Na₂O + K₂O) = 0.32, TiO₂ = 2, P₂O₅ = 1 Total (SO₃ + SO₄) = 0.84, Loss on ignition = 27.6</td>
<td>Bricks for building purposes and construction of walls by casting along with fly ash.</td>
</tr>
<tr>
<td>xi)</td>
<td>Fly ash†</td>
<td>7500 (If only coal is used)</td>
<td>4.3</td>
<td>SiO₂ = 50.55, Al₂O₃ = 22.25, Fe₂O₃ = 2.4, CaO = &lt;2.5, MgO = 0.25, Total (SO₃ + SO₄) = 5 (Na₂O + K₂O = 1.0, Max, TiO₂ = 1.9, P₂O₅ = 0.9, Loss on ignition = 3 percent Size: more than 106 μm = 12-20 percent, 106 to 75 μm = 15-25 percent, less than 75 μm = 60-70 percent</td>
<td></td>
</tr>
</tbody>
</table>
xii) Foundry sand* 500 - 700 0.3  SiO₂ = 80 percent, balance Fe₂O₃, TiO₂ and Al₂O₃  
Half of the sand may be used for recycle after screening the fused material.

xiii) Sintering plant slime (recovered from battery cyclones of exhausters and other de-dusting units)*  
Total Fe = 33-40, FeO = 24-5, SiO₂ = 6.9, Al₂O₃ = 4.5-5, CaO = 11-14, MgO = 2.4, Loss on ignition = 7-10 percent
Size > 0.0 percent larger than 5 mm, 0.3 percent larger than 3 mm, 50-60 percent larger than 150 μm, and 40-50 percent smaller than 150 μm.  
60 to 70 percent of the total slime may be used along with the sinter mix. All of it may be used in the sintering mix if the moisture is brought down to 10-15 percent.

xiv) LD converter dust 10 - 15 kg/t steel  
Fe total = 65.0 (Fe metal = 24.6, FeO = 49.4 and Fe₂O₃ = 1)  
CaO = 5.7, SiO₂ = 3.5, Al₂O₃ = 0.5, MgO = 0.9, MnO = 2.0, S = 0.14, P₂O₅ = 0.5  
May be used as a source of iron in blast furnace either through sinter after air classification to use + 0.125 mm (which is about 50 percent) or by briquetting with suitable binders.

Note—The figures given are likely to vary from plant to plant depending on the raw materials used and operating conditions. Since the possible uses of wastes are dependent on their chemical and physical properties, corresponding variations are likely in this respect also.

*Suitable for re-cycling.
†Suitable for by-product recovery.
‡Guidelines for utilization and disposal of fly ash.
# INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

## Base Units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>metre</td>
<td>m</td>
</tr>
<tr>
<td>Mass</td>
<td>kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>Time</td>
<td>second</td>
<td>s</td>
</tr>
<tr>
<td>Electric current</td>
<td>ampere</td>
<td>A</td>
</tr>
<tr>
<td>Thermodynamic temperature</td>
<td>kelvin</td>
<td>K</td>
</tr>
<tr>
<td>Luminous intensity</td>
<td>candela</td>
<td>cd</td>
</tr>
<tr>
<td>Amount of substance</td>
<td>mole</td>
<td>mol</td>
</tr>
</tbody>
</table>

## Supplementary Units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane angle</td>
<td>radian</td>
<td>rad</td>
</tr>
<tr>
<td>Solid angle</td>
<td>steradian</td>
<td>sr</td>
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</table>

## Derived Units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>newton</td>
<td>N</td>
<td>1 N = 1 kg.m/s²</td>
</tr>
<tr>
<td>Energy</td>
<td>joule</td>
<td>J</td>
<td>1 J = 1 N.m</td>
</tr>
<tr>
<td>Power</td>
<td>watt</td>
<td>W</td>
<td>1 W = 1 J/s</td>
</tr>
<tr>
<td>Flux</td>
<td>weber</td>
<td>Wb</td>
<td>1 Wb = 1 V.s</td>
</tr>
<tr>
<td>Flux density</td>
<td>tesla</td>
<td>T</td>
<td>1 T = 1 Wb/m²</td>
</tr>
<tr>
<td>Frequency</td>
<td>hertz</td>
<td>Hz</td>
<td>1 Hz = 1 c/s (s⁻¹)</td>
</tr>
<tr>
<td>Electric conductance</td>
<td>siemens</td>
<td>S</td>
<td>1 S = 1 A/V</td>
</tr>
<tr>
<td>Electromotive force</td>
<td>volt</td>
<td>V</td>
<td>1 V = 1 W/A</td>
</tr>
<tr>
<td>Pressure, stress</td>
<td>pascal</td>
<td>Pa</td>
<td>1 Pa = 1 N/m²</td>
</tr>
</tbody>
</table>