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1. Calculation procedure of annual quantity handled, releases and transfers

1.1. Calculation procedure of annual quantity handled of Class I Designated Chemical Substances (hereinafter described as Class I Substances)

(1) Class I Designated Chemical Substances required to report

Calculate annual quantities handled of Class I Designated Chemical Substances required to report, on work sheet 1 and 2.

Ⅰ. Prepare table of annual quantities handled or used of raw materials, or materials (work sheet-1)

(Main Class I Designated Chemical Substances related to iron casting industry are listed in Reference-1.)

a. Write down names of (raw) materials containing 1mass % or more of Class I Designated Chemical Substances used in the facility, and, name and content (%) of the Substance.

Note: Name and content (%) of the Substances are given in MSDS of materials.

If not, consult the supplier of materials.

Note: (Raw) materials containing less than 1mass % of Class I Designated Chemical Substances, need not be listed.

b. Write down annual quantity of materials handled, and then calculate annual quantity of Class I Designated Chemical Substances contained in them handled.

Example (work sheet-1)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Quantity</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance A</td>
<td>1000 kg</td>
<td>2.5 %</td>
</tr>
<tr>
<td>Substance B</td>
<td>1500 kg</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

Ⅱ. Class I Designated Chemical Substances used in a facility and their requiring notification

a. For each Class I Designated Chemical Substance in work sheet 1, annual quantity handled at all processes should be listed up on work sheet 2, and then total them.

b. If annual quantity of Class I Designated Chemical Substance handled is 1 ton or more, reporting is required. (In case of Specific Class I Designated Chemical Substance, 0.5 ton or more) Requiring notification for each chemical substance should be confirmed on the sheet.
1.2. Estimation procedure of releases and transfers

Releases to air, water bodies and soil from each release source in the process, and transfer in waste are calculated basically by the following 4 methods.

Ⅰ. Material balance
Ⅱ. Emission factor
Ⅲ. Physical properties
Ⅳ. Actual measurement

To calculate releases and transfers in iron casting industry, our recommendation is to choose Ⅱ, emission factor method. Emission factors are shown in calculation examples, but in case a facility has its own data, better results might be obtained using those data.

Using emission factors shown in calculation examples, (releases and transfers)

\[(\text{releases and transfers}) = (\text{annual quantity of substance handled}) \times (\text{emission factor})\]

 Releases and transfers calculated by this equation should be reported.
2. Outline of Manufacturing Processes

2.1. General Manufacturing Diagram

The following is the production processes of iron casting.
2.2. Melting Process

Materials are mixed according to the ingredients and nature of the desired molten metal, are placed in the melting furnace and heated. After the metal is melted, the ingredients are adjusted, the refining such as removal of oxides and desulfurization is conducted, and the heating necessary to allow the mix to be poured is applied. There are two types of methods: a method in which one furnace carries out the entire process, and the other in which two furnaces, cupola and low-frequency induction melting furnace, are responsible for each process of the melting and adjusting ingredients, and the heating (double melting method).

The pollutant release to the environment includes the release of corresponding chemical substances contained in raw materials and conditioning materials to the air, and the transfer of wastes collected by dust collectors (collected dust) and wastes (slag) generated through the refinery process.

Figure 1 shows the melting process.

Cleaning device: collection of dusts released to air by dust collectors
2.3. Casting Processes

(1) Casting design and production of a model for a mold

The important thing in iron casting is to examine and design how to make products safely and economically from the viewpoint of the mold model, molding method (lengthwise or sidewise), pouring method, the order of cooling procedures, pouring temperature, pouring speed, and pouring time, etc.

Iron casting requires a mold, and a model is first created to make the mold. The model can be made of wood, metal, resin, etc. and it must faithfully follow the drawing of the target product, taking into consideration not only the shape of the product but the path through which high-temperature molten metal is poured into the product part, the shrinkage of molten metal to be supplemented when it is cooled, and the finishing allowance. There are roughly two kinds of model for a mold; a main mold for the outside of casting and a core mold for the inner hollow part.

(2) Sand preparation

The mold of iron casting is made of sand and should hold high-temperature molten metal in it when the metal is poured. Certain suitable binding agents are added to sand in the optimal mixing proportion for casting, and they are kneaded in a kneading machine. Casting sand mainly uses green sand that consists of mineral clay called bentonite as a binding agent and organic self-hardening sand that takes advantage of chemical reaction of synthetic resin.

(3) Making of the mold and the core

The lower and upper parts of the model are mounted to different stools. The lower part, the upper part, and the core are made individually and combined to produce a mold that forms a desired shape.

The core is used to make a hollow part in casting. The core mold is made separately from the main mold and incorporated in the hollow part of the main mold. The most typical one is the shell-type core.

(4) Casting (pouring)

High-temperature molten metal is poured through the inlet of the mold with ladles, etc., using an appropriate method and at an appropriate speed, to fill up molten metal in the mold.

(5) Removal of frame

Removal of frame (shake-out) is a process subsequent to the casting process. When the molten metal in the mold is cooled down to an appropriate temperature, the mold frame is removed to take out the cast iron away from the casting sand and the core.
(6) Recycling of sand

This process is to collect the sand generated in the removal of the mold frame and to make it in an optimal state for kneading, by adjusting the surface and the size of the sand grains. For the organic self-hardening sand, most of the binding agent adhering to the surface is removed and collected as dust.

(7) Cast finishing and coating

Unnecessary parts (gates and burrs) on the surface of the cast iron are scraped and removed with tools. Rust-preventing coating is applied to the surface if necessary.

The following shows the casting, finishing and coating processes.

Cleaning device: Dust collectors are installed in sand recycling process. The organic binding agent are flaked off from the surface of sand and collected as dust before released to air.

Situation of waste treatment: Organic binding agent that flaked off from the surface of sand and collected as dust is landfilled or effectively used as raw materials for cement, together with the waste sand released from sand recycling.
3. Procedure and Examples of Calculating Releases and Transfers

3.1. Calculation Examples for Melting Process

Facilities that use raw materials or materials, of which components are unknown, need to obtain MSDS of the raw materials and materials from manufacturers, from which the factories purchase them, and check the presence and content of Class I Designated Chemical Substances in materials.

Table 3-1 shows typical raw materials and materials that contain 1 percent or more of Class I Substances (0.1 percent or more of Specific Designated Chemical Substances) and are used in the melting process of the iron casting industry.

Table 3-1: List of Class I Designated Chemical Substances related to melting process

<table>
<thead>
<tr>
<th>No</th>
<th>Substance Name</th>
<th>Quantity</th>
<th>Presence</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Substance A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Substance B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Substance C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Substance D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Substance E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Substance F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Substance G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Substance H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Substance I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Substance J</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculation using emission factors

(1) Quantity of Class I Substances handled

Annually used quantity of each Class I Substance listed in Table 3-1 should be calculated by following calculation procedure in chapter 1 on work sheet 1 and 2.

It is necessary to report the chemical substances of which annual quantities used are 1 ton or more (5 tons or more for the first 2 years), (For Specific Chemical Substances: 0.5 ton or more).

(2) Calculating releases and transfers

The emission factors of individual release routes shown in Table 3-2 are used for the calculation.

[1] Quantity shipped as products (reporting is not required)

Calculation of quantity of Class I Substances shipped as products:

\[ \text{Quantity shipped as products} = \text{quantity of Class I Substances handled} \times \text{emission factor} \]
[2] Estimating releases to air

Calculation of quantity released to air:

[Releases to air]

\[ \text{Releases to air} = \text{[quantity of Class I Substances handled]} \times \text{[emission factor to air]} \]


Calculation of the quantity transferred in waste:

[Transfers]

\[ \text{Transfers} = \text{[quantity of Class I Substances handled]} \times \text{[emission factor for transfer]} \]

Table 3-2: Emission factors of Class I Substances (Reporting of the quantity shipped as products is not required.)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting in Cupola</th>
<th>Melting in Induction Furnace (with dust collector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: – A: melting in cupola, B: melting in induction furnace (with dust collector),
C: melting in induction furnace (without dust collector)
– Melting in cupola and melting in induction furnace have the same emission factor of Ba because Ba is used at molten metal pouring process.
– The emission factor of substances released to air is zero because they float as oxide, precipitate to become sedimentary dust, and are transferred as waste. (Emission factors in this table are surveyed by The Iron Casting Industry Association)

[Example] Calculation of quantity of manganese in the melting process

(1) Calculation of quantity of Class I Substances handled
   Following calculation procedure in chapter 1, calculate annual quantity handled on work sheet 1 and 2.
   In case of a facility that annually uses 8 tons of ferromanganese (content of manganese: 75 %), the annual quantity of manganese handled, a Class I Substance, is 6 tons (= 8 tons x 0.75) and exceeds annually used quantity of 1 ton (5 tons for the first 2 years). Therefore the release and transfer of manganese should be reported.

(2) Estimating releases and transfers
   Calculation is made by release route in accordance with Table 3-2 as follows:
   [1] Quantity shipped as products (Reporting is not required.)
      The quantity of Class I Substances shipped as products is (in case of induction furnace):
      \[
      \text{[Quantity shipped as products]} = \text{[quantity of Class I Substances handled]} \times \text{[emission factor]} \\
      \text{[Quantity shipped as products]} = 6 \text{ tons} \times 98 \% = 5.88 \text{ tons}
      \]
   [2] Releases to air
      Quantity released to air is:
      \[
      \text{[Releases to air]} = \text{[Quantity of Class I Substances handled]} \times \text{[emission factor to air]} \\
      \text{[Releases to air]} = 6 \text{ tons} \times 0 \% = 0 \text{ ton}
      \]
   [3] Quantity transferred in waste (Transfers)
      The quantity transferred is:
      \[
      \text{[Quantity transferred in waste]} = \text{[quantity of Class I Substances handled]} \times \text{[emission factor for transfer]} \\
      \text{[Quantity transferred in waste]} = 6 \text{ tons} \times 2 \% = 0.12 \text{ ton}
      \]
3.2. Calculation Example of Casting Process

Facilities that use raw materials or materials, of which components are unknown, need to obtain MSDS of the raw materials and materials from manufacturers from which the facilities purchase them and make an inquiry about the presence and content of Class I Substances in the materials.

Table 3-3 below shows typical materials that contain designated chemical substances of 1 percent or more (Specific Designated Chemical Substances of 0.1 percent or more).

Table 3-3: List of Class I Substances in the casting process

<table>
<thead>
<tr>
<th>No.</th>
<th>Class I Substances</th>
<th>Quantity Used</th>
<th>Emission Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Substance A</td>
<td>100</td>
<td>0.5</td>
<td>5~7</td>
</tr>
<tr>
<td>2</td>
<td>Substance B</td>
<td>50</td>
<td>0.2</td>
<td>5~9</td>
</tr>
<tr>
<td>3</td>
<td>Substance C</td>
<td>20</td>
<td>0.1</td>
<td>6~8</td>
</tr>
</tbody>
</table>

Calculation by using emission factors

(1) Annual quantity used of each Class I Substance listed in Table 3-3 should be calculated by following calculation procedure in chapter 1 on work sheet 1 and 2.

It is necessary to report the chemical substances of which annual quantities used are 1 ton or more (5 tons or more for the first 2 years), (For Specific Chemical Substances: 0.5 ton or more).

(2) Calculation of releases and transfers

The emission factors of individual release routes shown in Table 3-3 are used for the calculation.

[1] Quantity shipped as products (Reporting not required.)

Calculation of Class I Substances shipped as products:

[Quantity shipped in product] = [quantity of Class I Substances handled] x [emission factor]

[2] Estimation of releases to air

Calculation of quantity released to air:

[Releases to air] = [quantity of Class I Substances handled] x [emission factor to air]


Calculation of the quantity transferred in waste:

[Transfers] = [quantity of Class I Substances handled] x [emission factor for transfer]
Notes:  
– Most of phenol contained in phenol resin and cold box binding agent hardens and becomes urethane resin. So the emission factor of the substance transferred as waste is 0 % on the assumption that the remaining quantity after the hardening reaction is infinitesimal. 
– The emission factor of 1-3-5 trimethylbenzene released to air is 100 % because 1-3-5 trimethylbenzene contained in phenol resin curing agent and cold box curing agent is used as solvent. 

[Example] Calculation of phenol in the casting process 
(1) Calculation of quantity of phenol used, a Class I Substance 
   In case where 40 tons of phenol resin is used annually, the content of phenol in the phenol resin is 5 %. So the quantity of Class I Substances (phenol) handled is 2 tons (= 40 tons x 0.05) and exceeds annually used quantity of 1 ton (5 tons for the first 2 years). Therefore the figure should be reported. (Reporting is not needed for the first 2 years.) 
(2) Estimation of releases and transfers 
   Calculation is made for individual release routes in accordance with Table 3-4 as
follows:

[1] **Quantity shipped as products**
   
   The quantity of Class I Substances shipped as products is (in case of induction furnace):
   
   
   \[
   \text{[Quantity shipped as products]} = \text{[Quantity of Class I Substances handled]} \times \text{[emission factor]}
   \]
   
   \[
   \text{[Quantity shipped as products]} = 2 \text{ tons} \times 0 \% = 0 \text{ ton}
   \]

[2] **Releases to air**
   
   The quantity released to air is:
   
   \[
   \text{[Releases to air]} = \text{[quantity of Class I Substances handled]} \times \text{[emission factor to air]}
   \]
   
   \[
   \text{[Releases to air]} = 2 \text{ tons} \times 0 \% = 0 \text{ ton}
   \]

[3] **Quantity transferred in waste**
   
   The quantity transferred is:
   
   \[
   \text{[Quantity transferred in waste]} = \text{[quantity of Class I Substances handled]} \times \text{[emission factor for transfer]}
   \]
   
   \[
   \text{[Quantity transferred in waste]} = 2 \text{ tons} \times 0 \% = 0 \text{ ton}
   \]
3.3. Calculation Example of Painting /Coating Process

Facilities that use materials, of which components are unknown, need to make an inquiry to manufacturers about the presence and content of Class I Substances in materials.

Table 3-5 below shows typical materials used in painting /coating process that contain 1 percent or more of the Class I Substances.

Table 3-5: List of Class I Substances used in coating process

<table>
<thead>
<tr>
<th>No</th>
<th>Substance Name</th>
<th>Quantity</th>
<th>Emission Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Substance A</td>
<td>100 kg</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>Substance B</td>
<td>200 kg</td>
<td>0.6</td>
</tr>
<tr>
<td>3</td>
<td>Substance C</td>
<td>300 kg</td>
<td>0.7</td>
</tr>
<tr>
<td>4</td>
<td>Substance D</td>
<td>400 kg</td>
<td>0.8</td>
</tr>
<tr>
<td>5</td>
<td>Substance E</td>
<td>500 kg</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Estimations by using emission factors

(1) Quantity of Class I Substances handled

For each Class I Substance listed in Table 3-5, annual quantity used is calculated on work sheet 1 and 2.

(2) Estimation of releases and transfers

The emission factors of individual release routes in Table 3-6 are used for the calculation.

[1] Quantity shipped as products

Calculation of quantity of Class I Substances shipped as products:

[Quantity shipped as product] = [quantity of Class I Substances handled] x [emission factor]

[2] Estimation of releases to air

Calculation of quantity released to air:

[Releases to air] = [quantity of Class I Substances handled] x [emission factor to air]

[3] Estimation of transfer

Calculation of the quantity transferred in waste:

[Transfers] = [quantity of Class I Substances handled] x [emission factor for transfer]
Table 3-6: Emission factor of Class I Substances

<table>
<thead>
<tr>
<th>Source</th>
<th>A</th>
<th>B1</th>
<th>B2</th>
<th>C1</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Notes:  | - A: dip coating  
|      | - B1: spray painting (air gun)  
|      | - B2: spray painting (airless gun)  
|      | - C1: air electrostatic coating  
|      | - C2: airless electrostatic coating  
Examples of large casting: worktable of machine tool, framework of printing machine, and engine parts for vessel  
Examples of medium casting: engine parts of automobile, transmission case, and hydraulic valve  
Examples of small casting: casting products for electric goods, coupler parts, etc.  
(Emission factors in this table are surveyed by The Iron Casting Industry Association)
[Example] Calculation of xylene in the solvent of the coating process

(1) Calculation of quantity of Class I Substances handled
In case where 30 tons of coating solvent is used annually, the content of xylene in the coating solvent is 20%. So the annual quantity of Class I Substances used is 6 tons (= 30 tons x 20 %) and exceeds annually used quantity of 1 ton (5 tons for the first 2 years). Therefore releases and transfers of xylene should be reported.

(2) Estimation of releases and transfers
Calculation is made for individual release routes in accordance with Table 3-6 as follows:

[1] Quantity shipped as products
The quantity of Class I Substances shipped as products is:

\[
\text{Quantity shipped as products} = \text{quantity of Class I Substances handled} \times \text{emission factor}
\]

[Quantity shipped as products] = 6 tons x 0 % = 0 ton

[2] Releases to air
The quantity released to air is:

\[
\text{Releases to air} = \text{quantity of Class I Substances handled} \times \text{emission factor to air}
\]

[Releases to air] = 6 tons x 100 % = 6 tons

[3] Quantity transferred in waste
The quantity transferred is:

\[
\text{Quantity transferred in waste} = \text{quantity of Class I Substances handled} \times \text{emission factor}
\]

[Quantity transferred in waste] = 6 tons x 0 % = 0 ton
Reference – 1  Typical Class I Designated Chemical Substances (Class I Substances) related to the Industry

Table II-1 shows typical raw materials that are used in the iron casting industry and contain Class I Substances.

Table II-1: Typical raw materials that are used in the iron casting industry and contain Class I Substances

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Use in Industry</th>
<th>Class I Substance</th>
<th>Class I Substance Use</th>
</tr>
</thead>
</table>

1. Typical raw materials that are used in the iron casting industry and contain Class I Substances.
### Reference – 2 Emission factor

(1) Emission factors of Class I Substances (Reporting of the quantity shipped as products is not required.)

<table>
<thead>
<tr>
<th></th>
<th>Emission factor of Class I Substances</th>
<th>Emission factor of Class I Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:  – A: melting in cupola, B: melting in induction furnace (with dust collector), C: melting in induction furnace (without dust collector)

(2) Emission factors of Class I Substances

<table>
<thead>
<tr>
<th></th>
<th>Emission factor of Class I Substances</th>
<th>Emission factor of Class I Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(3) Emission factors in painting process

<table>
<thead>
<tr>
<th>Method</th>
<th>A</th>
<th>B1</th>
<th>B2</th>
<th>C1</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dip coating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray painting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air gun</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airless gun</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air electrostatic coating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airless electrostatic coating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examples of large casting: worktable of machine tool, framework of printing machine, and engine parts for vessel.

Examples of medium casting: engine parts of automobile, transmission case, and hydraulic valve.

Examples of small casting: casting products for electric goods, coupler parts, etc.

Notes:
- A: dip coating
- B1: spray painting (air gun)
- B2: spray painting (airless gun)
- C1: air electrostatic coating
- C2: airless electrostatic coating
Reference – 3  (Work sheet 1)

Table of annual quantity of (raw ) materials handled.

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>1234</td>
<td>Raw Material A</td>
<td>Batch 1</td>
</tr>
<tr>
<td>2021</td>
<td>4321</td>
<td>Raw Material B</td>
<td>Batch 2</td>
</tr>
</tbody>
</table>

Reference – 4  (Work sheet 2 )

Table of annual quantity of Class 1 designated Chemical substances handled.

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity</th>
<th>Designation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>9876</td>
<td>Class 1 Chemical</td>
<td>Batch 1</td>
</tr>
<tr>
<td>2021</td>
<td>6789</td>
<td>Class 1 Chemical</td>
<td>Batch 2</td>
</tr>
</tbody>
</table>