PRTR Estimation Manual

09. Iron Casting Industry

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Japan Cast Iron Foundry Association
Japan Malleable Iron Society
Japan High Grade Cast Iron Association

Contents

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.

①. 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 Referrence-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)

No	Raw / Industrial materials							
	Name of raw / industrial materials	Calculation of annual quantity handled				Class I Designated Chemical substance		
		Annual quantity purchased (kg/year)	Quantity stored, at the end (kg)	Quantity stored, beginning (kg/year)	Annual quantity handled (kg/year)	Name of Substance	Content (%)	Annual quantity handled (kg/year)
1	Paint 1	1,000	500	200	700	Lead chromate	10	70
2	Thinner A	50	2	1	49	Toluene	70	34

②. 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.

Example (worksheet 2)

No.	CAS No.	Name of Substance	Annual quantity handled (kg/year)	Total (kg/year)	Requiring notification
1	108-88-3	Toluene	34 650	684	Not required
2	1330-20-7	Xylene	5,200	5,200	Required

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.

①. Material balance
②. Emission factor
③. Physical properties
④. Actual measurement

To calculate releases and transfers in iron casting industry, our recommendation is to choose ②, 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)

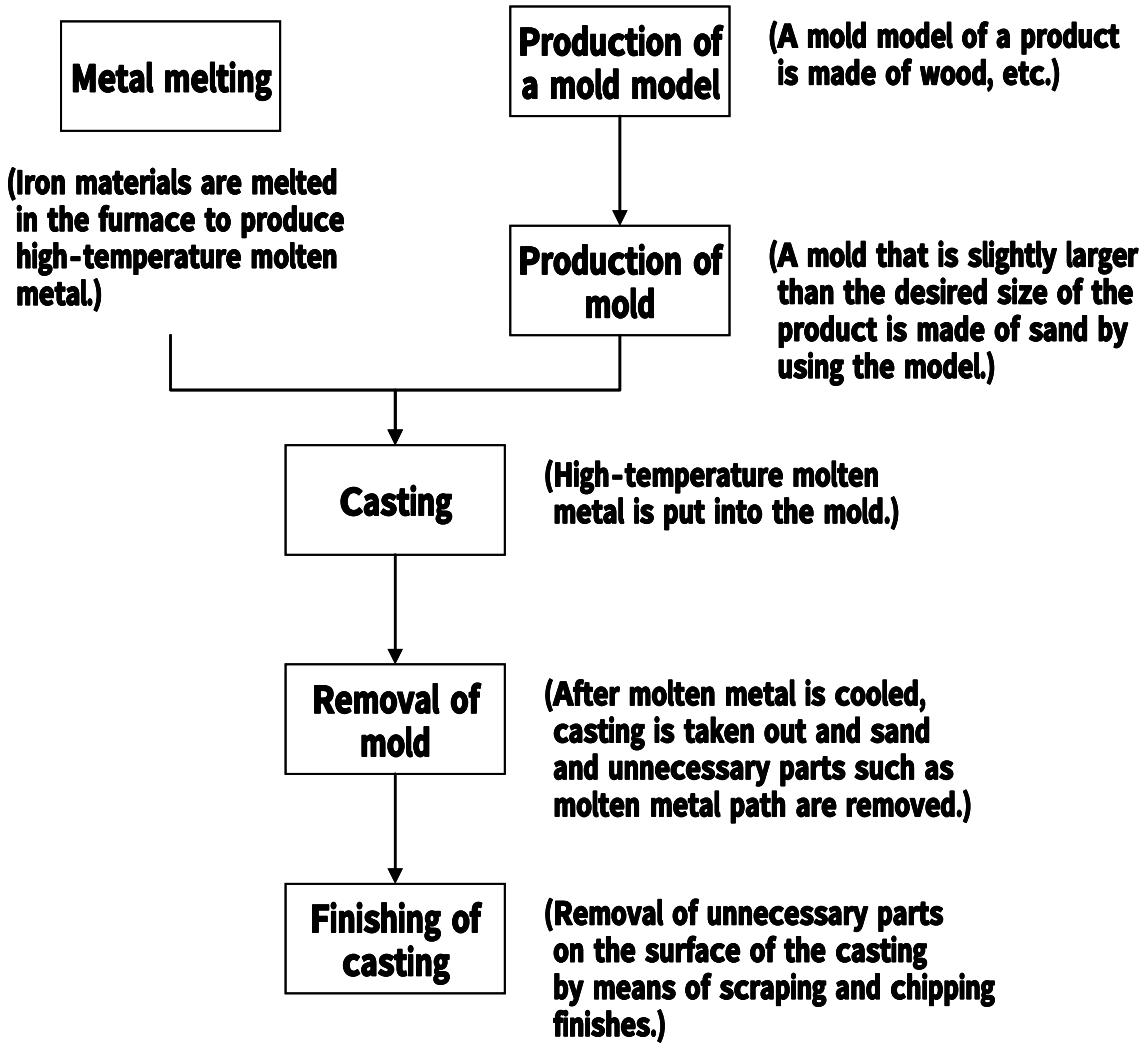
= (annual quantity of substance handled)×(emission factor)

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.

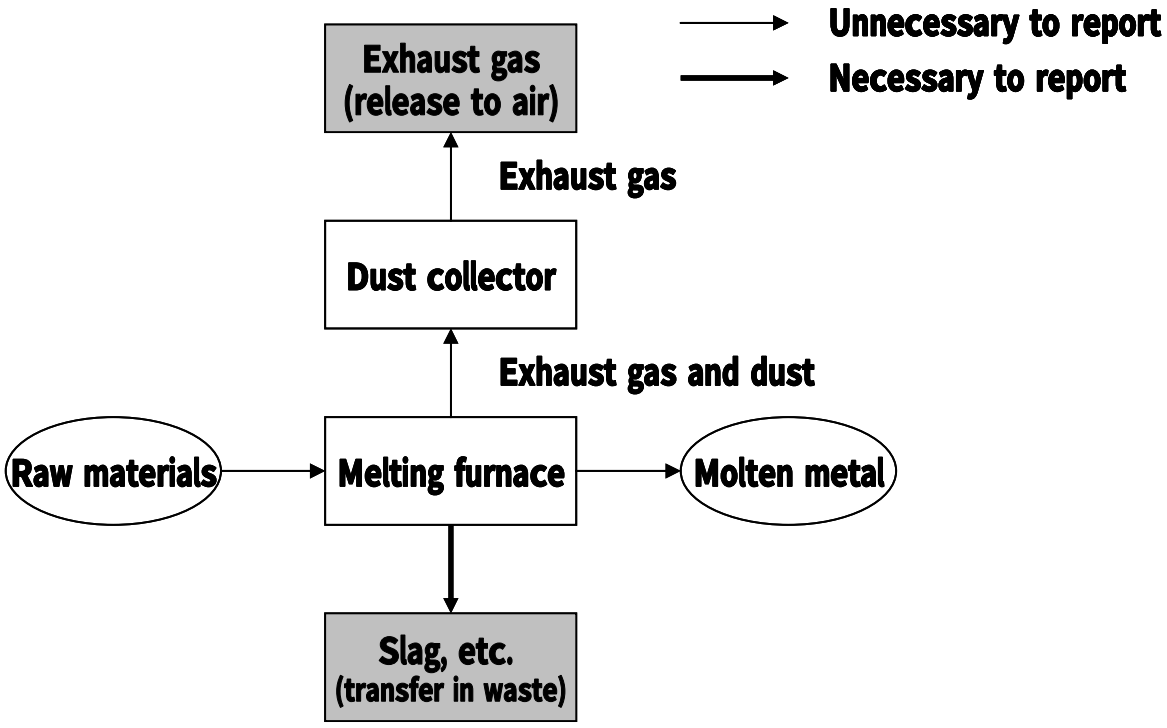


Figure 1: Melting process

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.

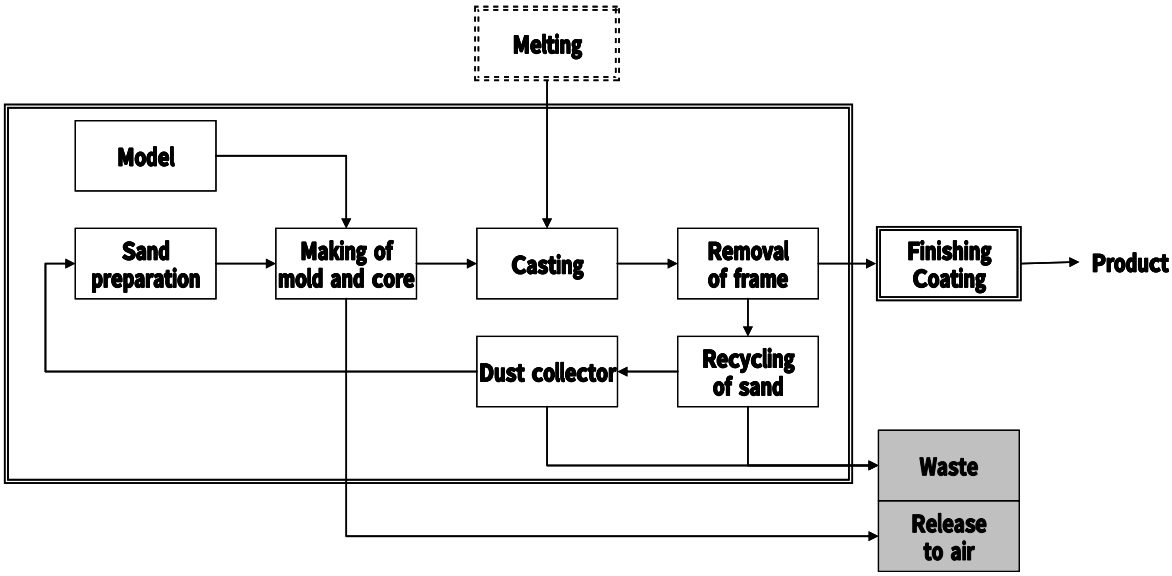
(6) Recycling of sand

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.



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.

Table3 -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

No.	Name of product	Cabinet Order No.	Class I Designated Chemical Substance	Content (%)
1	Pig iron	311	Manganese (Mn)	0.3～1.3
2	Ferromanganese	311	Manganese (Mn)	73～78
3	Silicon manganese	311	Manganese (Mn)	60～70
4	Ferrochromium	68	Chromium (Cr)	55～70
5	Ferromolybdenum	346	Molybdenum (Mo)	55～70
6	Seeding agent	243	Barium (Ba)	0.28～18
7	Graphite spheroidizing agent	231	Nickel (Ni)	80～85

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:

[Quantity shipped as products]

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

[2] Estimating releases to air

Calculation of quantity released to air:

[Releases to air]

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

[3] Estimating transfers

Calculation of the quantity transferred in waste:

[Transfers]

= [quantity of Class I Substances handled] x [emission factor for transfer]

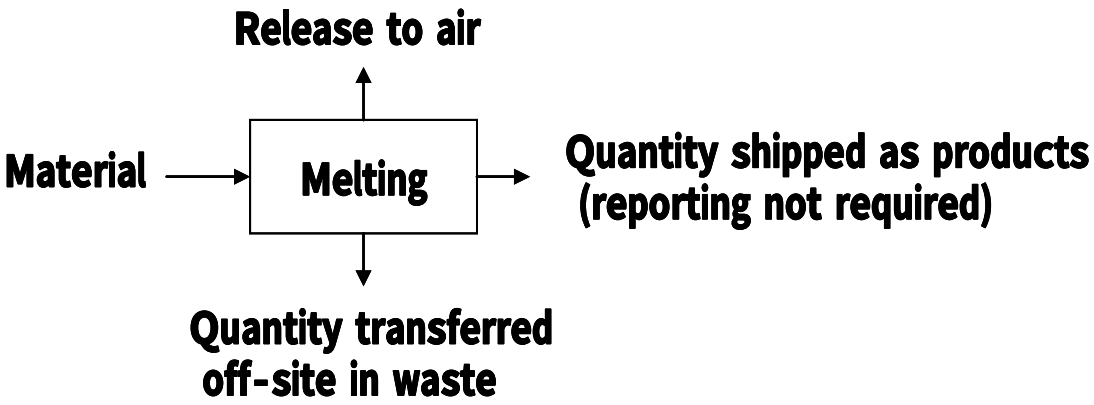


Table 3-2: Emission factors of Class I Substances (Reporting of the quantity shipped as products is not required.)

Cabnet Order No.	Class I Substances		Emission factor for Class I Substance (%)		
			Product	Air	Waste
311	Manganese (Mn)	A	80	0	20
		B	98	0	2
		C	98	0	2
68	Chromium (Cr)	A	85	0	15
		B	98	0	2
		C	98	0	2
346	Molybdenum (Mo)	A	95	0	5
		B	100	0	0
		C	100	0	0
231	Nickel (Ni)	A	100	0	0
		B	100	0	0
		C	100	0	0
243	Barium (Ba)		0	0	100

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):

[Quantity shipped as products]

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

[Quantity shipped as products] = 6 tons x 98 % = 5.88 tons

[2] Releases to air

Quantity released to air is:

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

[Releases to air] = 6 tons x 0 % = 0 ton

[3] Quantity transferred in waste (Transfers)

The quantity transferred is:[Quantity transferred in waste]

= [quantity of Class I Substances handled] x [emission factor for transfer]

[Quantity transferred in waste] = 6 tons x 2 % = 0.12 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

No.	Product name	Cabinet Order No.	Name of PRTR substance	Content (%)
1	Phenol resin	266	Phenol	1～5
2	Phenol resin	224	1, 3, 5- trimethylbenzene	2～3
3	Cold box	266	Phenol	1～5
4	Cold box	224	1, 3, 5- trimethylbenzene	2～3

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]

[3] Estimation of transfers

Calculation of the quantity transferred in waste:

[Transfers] = [quantity of Class I Substances handled] x [emission factor for transfer]

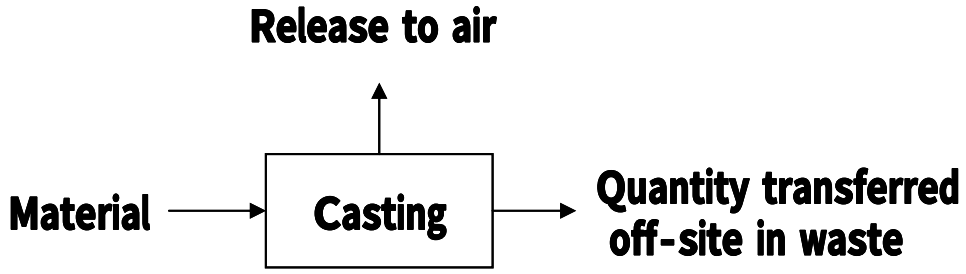


Table 3-4: Emission factors of Class I Substances

No.	Name of Class I Substance	Emission factors of Class I Substance (%)		
		Product	Air	Waste
266	Phenol (phenol resin binding agent)	0	0	0
224	1-3-5 trimethylbenzene (phenol resin curing agent)	0	100	0
266	Phenol (cold box binding agent)	0	0	0
224	1-3-5 trimethylbenzene (cold box curing agent)	0	100	0

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):

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

[Quantity shipped as products]
= 2 tons x 0 % = 0 ton

[2] Releases to air

The quantity released to air is:

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

[Releases to air]
= 2 tons x 0 % = 0 ton

[3] Quantity transferred in waste

The quantity transferred is:

[Quantity transferred in waste]
= [quantity of Class I Substances handled] x [emission factor for transfer]

[Quantity transferred in waste] = 2 tons x 0 % = 0 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.

Table3-5 below shows typical materials used in painting /coating process that contain 1 percent or more of the Class I Substances.

Table3 -5: List of Class I Substances used in coating process

No.	Product name	Cabinet Order No.	Name of Class I Substance	Content (%)
1	Solvent	63	Xylene	10～45
2	Solvent	227	Toluene	20～70
3	Paint	101	Ethylene glycol monoethyl ether acetate	5～10
4	Paint	68	Chromium sulfate	1～10
5	Paint	69, 230	Lead chromate	5～15
6	Paint	230	Basic lead silicate	～10
7	Paint	69	Zinc chromate	1～10

Estimations by using emission factors

(1) Quantity of Class I Substances handled

For each Class I Substance listed in Table3 -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]

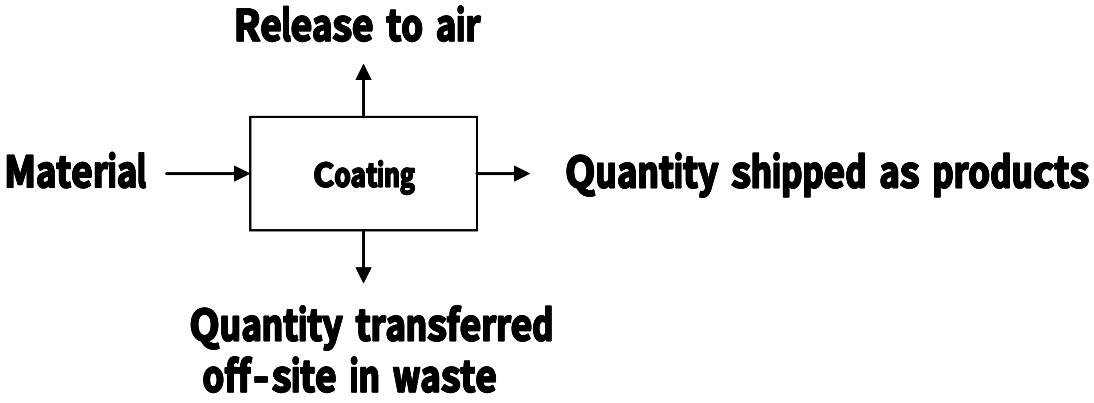


Table 3-6: Emission factor of Class I Substances

Name of Class I Substance (name of product)		Emission factor for Class I Substance (%)						
		Product			Air	Waste		
		Large casting	Medium casting	Small casting		Large casting	Medium casting	Small casting
Solvent		0	0	0	100	0	0	0
Paint	A	-	80	80	0	-	20	20
	B1	40	35	30	0	60	65	70
	B2	60	55	50	0	40	45	50
	C1	-	60	50	0	-	40	50
	C2	-	70	65	0	-	30	35

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:

[Quantity shipped as products]
= [quantity of Class I Substances handled] x [emission factor]
[Quantity shipped as products] = 6 tons x 0 % = 0 ton

[2] Releases to air

The quantity released to air is:

[Releases to air]
= [quantity of Class I Substances handled] x [emission factor to air]
[Releases to air] = 6 tons x 100 % = 6 tons

[3] Quantity transferred in waste

The quantity transferred is:

[Quantity transferred in waste]
= [quantity of Class I Substances handled] x [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

No.	Application	Material	Cabinet Order No.	Name of Class I Substances	Content (%)
1	Raw materials	Pig iron	311	Manganese (Mn)	0.3～1.3
2	Conditioning materials	Ferromanganese	311	Manganese (Mn)	73～78
3	Conditioning materials	Silicon manganese	311	Manganese (Mn)	60～70
4	Conditioning materials	Ferrochromium	68	Chromium (Cr)	55～70
5	Conditioning materials	Ferromolybdenum	346	Molybdenum (Mo)	55～70
6	Seeding agent	Seed	243	Barium (Ba)	0.28～18
7	Spheroidizing agent	Graphite spheroidizing agent	231	Nickel (Ni)	80～85
8	Binding agent	Phenol resin	266	Phenol	1～5
9	Curing agent	Phenol resin	224	1,3,5- trimethylbenzene	2～3
10	Binding agent	Cold box	266	Phenol	1～5
11	Curing agent	Cold box	224	1,3,5- trimethylbenzene	2～3
12	Lubricant	Lubricant	227	Toluene	20～70
13	Solvent	Solvent	63	Xylene	10～45
14	Solvent	Solvent	227	Toluene	20～70
15	Coating	Coating material	101	Ethylene glycol monomethyl ether acetate	5～10
16	Coating	Coating material	68	Chromium sulfate	1～10
17	Coating	Coating material	69	Lead chromate	5～15
18	Coating	Coating material	230	Basic silicic acid lead	～10
19	Coating	Coating material	69	Zinc chromate	1～10

Reference – 2 Emission factor

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

Cabnet Order No.	Class I Substances		Emission factor for Class I Substance (%)		
			Product	Air	Waste
311	Manganese(Mn) (modifier)	A	80	0	20
		B	98	0	2
		C	98	0	2
68	Chromium(Cr) (modifier)	A	85	0	15
		B	98	0	2
		C	98	0	2
346	Molybdenum(Mo) (modifier)	A	95	0	5
		B	100	0	0
		C	100	0	0
231	Nickel (Ni) (spheroidizer)	A	100	0	0
		B	100	0	0
		C	100	0	0
243	Barium(Ba) (seed)		0	0	100

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

No.	Name of Class I Substance	Emission factors of Class I Substance (%)		
		Product	Air	Waste
266	Phenol (phenol resin binding agent)	0	0	0
224	1-3-5 trimethylbenzene (phenol resin curing agent)	0	100	0
266	Phenol (cold box binding agent)	0	0	0
224	1-3-5 trimethylbenzene (cold box curing agent)	0	100	0

(3) Emission factors in painting process

Name of Class I Substance (name of product)		Emission factor for Class I Substance (%)						
		Product			Air	Waste		
		Large casting	Medium casting	Small casting		Large casting	Medium casting	Small casting
Solvent		0	0	0	100	0	0	0
Paint	A	-	80	80	0	-	20	20
	B1	40	35	30	0	60	65	70
	B2	60	55	50	0	40	45	50
	C1	-	60	50	0	-	40	50
	C2	-	70	65	0	-	30	35

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.

Reference – 3 (Work sheet 1)

Table of annual quantity of (raw) materials handled.

No	Raw / Industrial materials							
	Name of raw / industrial materials	Calculation of annual quantity handled				Class I Designated Chemical substance		
		Annual quantity purchased (kg/year)	Quantity stored, at the end (kg)	Quantity stored, beginning (kg/year)	Annual quantity handled (kg/year)	Name of Substance	Content (%)	Annual quantity handled (kg/year)
1								
2								
3								
4								

Reference – 4 (Work sheet 2)

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

No.	CAS No.	Name of Substance	Annual quantity handled (kg/year)	Total (kg/year)	Requiring notification
1					
2					
3					
4					