PRTR Estimation Manual

22. Painting / Coating Processes

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1. Outline of Painting/ Coating Processes

1.1 Outline

The objective of painting is to form a coating film on the surface of an object in order to protect the object and give a fine appearance. Painting may also have other special functions. There are various types of painting methods, and spray painting is currently used in many types of industrial painting. A flow diagram of the spray painting process is shown as an example in Fig. 1.

"Spray painting" consists of the painting operation itself followed by coated film drying. The paint used in the painting process is diluted with thinner, and solid portions in the paint form the coating film after the spraying operation. Annual amount of handled Class I Chemical Substances in paints and thinners is calculated based on the content of each chemical in paints and thinners, which should be obtained by MSDS and etc .

In the painting operation, various types of painting methods are used according to the shape, size, quality, and quantity of the object(s) to be painted. The "transfer efficiency" differs, in other words, the ratio of the quantity of the coated film formed on the object to the quantity of the paint sludge generated from overspray differs according to the differences in these operational conditions..

In "spray painting" inside a coating booth, most of the auxiliary solvent portions in the paints vaporizes to air. The solid portions over-sprayed are collected in the coating booth circulating solution (water or oil), and separated as paint sludge. So, vaporization of solvents in spraying operation and coated film drying process makes air emissions from total painting processes. In some cases, a vent gas from coated film drying process is treated by deodorizing device.

Paint sludge caused by overspray is either off-site transferred in waste, or incinerated. Releases to water bodies, or off-site transfers of waste oil occur at the time of renewal of circulating solution.

Residual paints and cleaning thinners are on-site or off-site recycled in some cases. Sometimes the (same) solvent is used to dilute paint and also to wash painting lines, so in this manual, the former is designated as thinner and the latter as cleaning thinner.

Many different types of painting processes are used in different industries, and so different figures are selected as transfer efficiency. For PRTR reporting, estimate the reasonable value referring to the calculation examples in this manual.

1.2 Class I Designated Chemical Substances (Class I Substances) related to the Painting Processes

Various kinds of chemical substances are used in painting processes, and typical Class I Designated Chemical Substances are shown in Table-1. On the occasion of actual reporting, it is necessary to confirm with MSDS etc.

Table-1 List of Class I Designated Chemical Substances used in the painting processes

Cabinet Order No.		CAS No.	Name of Substance
Solvent/ thinner	227	108-88-3	Toluene
	63	1330-20-7	Xylene
	177	100-42-5	Styrene
	40	100-41-4	Ethyl benzene
	43	107-21-1	Ethylene glycol
	44	110-80-5	Ethyl cellosolve (ethylene glycol mono ethyl ether)
	45	109-86-4	Methyl cellosolve (ethylene glycol mono methyl ether)
	101	111-15-9	2-etoxyethyl acetate (ethylene glycol mono ethyl ether acetate)
	103	110-49-6	2-metoxyethyl acetate (ethylene glycol mono methyl ether acetate)
	22	107-18-6	Allyl alcohol
	16	141-43-5	Ethanolamine (2-aminoethanol)
	58	111-87-5	1-octanol
	109	100-37-8	2-(diethylamino) ethanol
Pigment	1		Zinc compounds(water soluble)
	60		Cadmium and its compounds
	68		Chromium and chromium(I)compounds
	69		Chromium(VI)compounds
	346		Molybdenum and its compounds
	232		Nickel compounds
	230		Lead and its compounds
	304		Boron and its compounds
	311		Manganese and its compounds
	25		Antimony and its compounds
	100		Cobalt and its compounds
Others	272	117-81-7	Bis(2-ethyl hexyl) phthalate
	269	117-84-0	di-n-octyl phthalate
	270	84-74-2	di-n-butyl phthalate
	271	3648-21-3	di-n-heptyl phthalate
	273	85-68-7	n-butyl = benzyl phthalate
	29	1980/5/7	Bis phenol A
	30	25068-38-	Bis phenol A type epoxy resin (liquid)
	55	556-52-5	2, 3-epoxy-1-propanol
	57	122-60-1	2, 3-epoxypropyl = phenyl ether
	46	107-15-3	Ethylenediamine
	114	108-91-8	Cyclohexylamine
	310	50-00-0	Formaldehyde
	9	103-23-1	Bis(2-ethyl hexyl) adipate
	354	126-73-8	Tri-n-butyl phosphate

1.3 Release source/Transfer source

The release source and transfer source in the painting process (wet booth) are shown in Fig. 1.

1.3.1 Release source

(1) Release to air:

Since organic solvents are used for the painting operation, the operation is generally performed in an enclosure (booth) provided with a local exhauster for reasons of fire prevention and health, and much of the solvent is released to air from this painting booth. Part of the solvent accompanying the coated film is released to air from the drying furnace in the coated film drying process. In some cases, it is removed with a deodorizing device.

(2) Release to water bodies:

Wastewater generated at the time of renewal of the circulating water in the coating booth is released to water.

1.3.2 Transfer source

(1) Paint sludge:

Over-sprayed solid portions in paint are collected in the circulating solution and separated as paint sludge. The paint sludge is off-site transferred in waste.

(2) Waste paint:

Residual paint in a container, etc. is off-site transferred as waste .

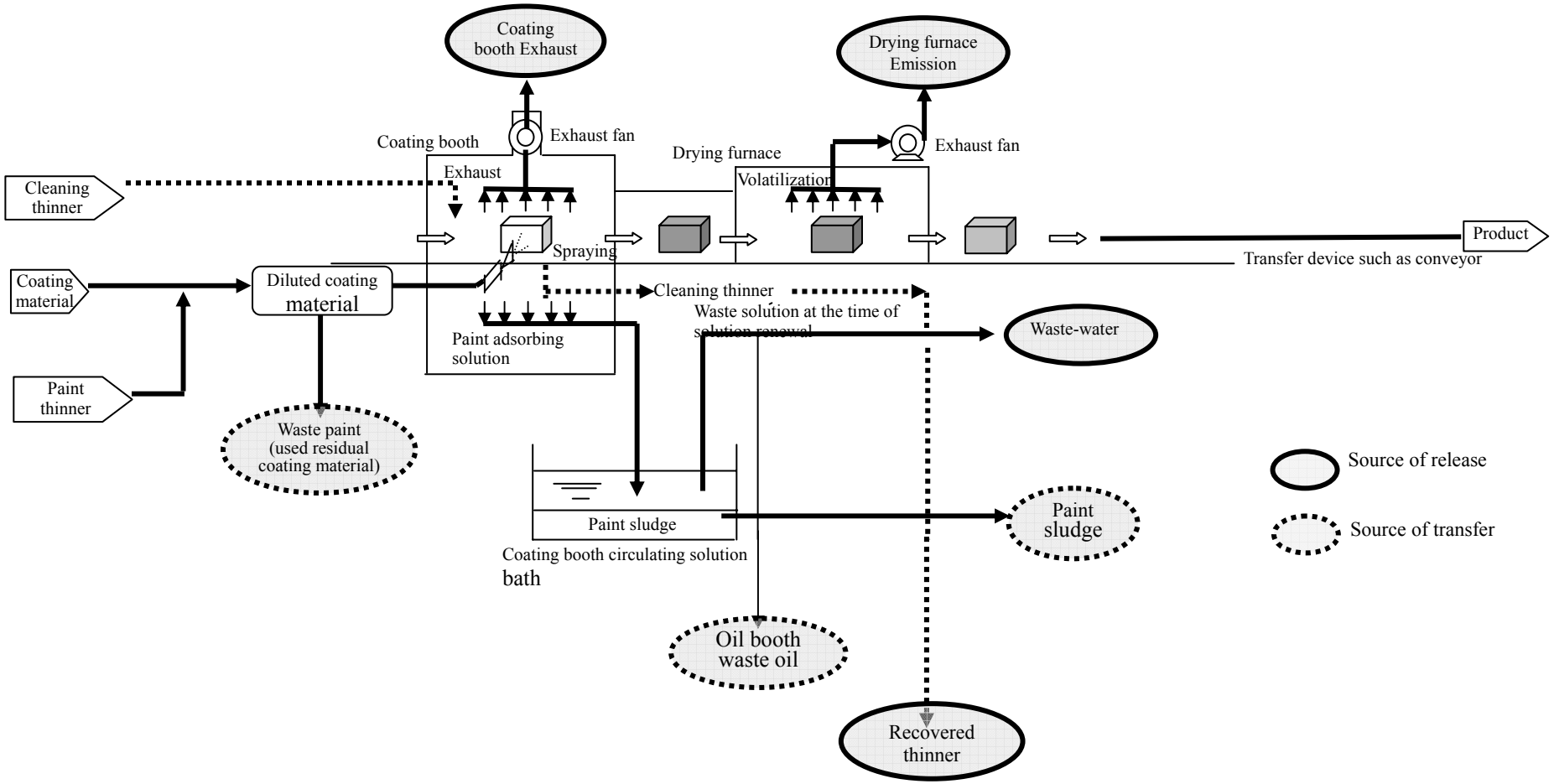
(3) Oil booth waste oil:

Oil booth waste oil is generated at the time of renewal of circulating oil in the painting booth and transferred for recycling or off-site transferred in waste.

(4) Recovered thinner:

Thinner used for cleaning at the time of color change, etc. is recovered and transferred for recycling or off-site transferred in waste.

Fig.-1 Flow Diagram for Painting Processes (wet type booths)



2 Method for Calculating Releases in the Painting Processes

2.1 Concept Used for Calculating Releases and Transfers

2.1.1 Solvent ingredient

(1) Since quantity of the solvent ingredient i shipped in products cannot be considered, it is regarded as zero.

(2) The releases (transfers) by renewal of the painting booth circulating solution is calculated by [waste solution amount] × [solvent ingredient i concentration]. When the actual analyzed data of the solvent ingredient i concentration in the paint sludge is not available, water washing booth is deemed to have a concentration of 0.01 mass % (wi = 0.0001) and oil booth has 0.1 mass % (doi = 0.001) (refer to Reference-1)

(3) The transfers contained in the paint sludge is estimated by [the amount of the paint sludge generated] × [solvent ingredient i concentration]. When the actual analyzed data of the solvent ingredient i concentration in the paint sludge is not available, both water washing booth and oil booth are deemed to have a concentration of 0.2 mass % (dsi = 0.002) (refer to Reference-2)

Notes:

1) When the amount of the paint sludge generated Ds (kg/year) is unknown, estimation is made based on the following formula using solid portion ratio in the paint (mass % ÷ 100) and transfer efficiency η (mass % ÷ 100).
   Amount of the paint sludge generated = (annual amount of paint used - amount of waste paint generated) × (solid content rate) × (1 - transfer efficiency).
2) The transfer efficiency η is calculated with reference to Table-6 and the estimation example (refer to note in (5)).

(4) When a deodorizing device is used, the releases before deodorizing treatment A2i (kg/year) from a drying furnace is estimated using the transfer efficiency η and drying furnace transfer rate α based on the concept shown in Fig.-2 according to the working sheet (1) [19] (when the actual measurement for α is not available, the estimation is made with α = 0.1)

2.1.2 Pigment Component

(5) Solid portions in the paint equivalent to the transfer efficiency η are painted on the product and all the residual over-sprayed amount is transferred as the paint sludge. (refer to Fig.-2)

Notes:

1) The transfer efficiency η is calculated with reference to Table-6 and the calculation examples.
2) When multiple types of painting machines are used in the same booth, the average transfer efficiency ηav defined in the following equation is used.
   The average transfer efficiency ηav
   = ∑ (painting machine transfer efficiency × load rate)
   Load rate = time of the painting machine used (minutes)
   /cycle time of the booth (minutes)
   or
   = amount of paint used in the painting machine (kg/cycle)
   /the total amount of paint used in the booth (kg/cycle)
   Provided that : ∑ (load rate) = 1.0

(6) The amount of the pigment component j shipped in the products is calculated by [the annual amount of the pigment component j sprayed] × [transfer efficiency η]. The transferred amount of the pigment component j contained in the paint sludge is calculated by subtracting the amount of the pigment component j shipped in the products from the sprayed amount per year.

Note:

1) The pigment is not generally dissolved into water and oil used as a circulating solution. In this test analysis, it is not detected

2.2 Procedure for Calculating Releases and Transfers

(1) The Class I Designated Chemical Substances contained in paints and thinner should be identified by MSDS, etc.

Notes:

1) For a determination as to whether or not it should be reported, refer to "Manual for Estimating Releases and Transfers for PRTR Chemicals" (hereinafter called "Basic Manual") prepared by the government.
2) Concerning the details of the Class I Designated Chemical Substances, refer to the reference in the basic manual, "List of Class I Designated Chemical Substances".

(2) On "Fig.-3 Flow sheet for estimating the releases and transfers in the painting process (p9)", line Nos. ([1] ~) corresponding to the target chemicals to be calculated is identified.

Note:

1) All the Nos. ([1] ~) in the working sheet (1), working sheet (2),calculation example, and working sheet entry example hereinafter correspond to the line Nos. ([1] ~) in the above-described Fig.-3.

(3) Amount (kg/year) of each calculation item (numeral value converted into metal as for pigment component) is estimated according to the calculation formulas shown in "Table-2 working sheet (1)" for each corresponding line No. identified in the above (2) with reference to the calculation example and the entry example of the working sheet (1).

Notes:

1) In calculation example 1-7, the one closest to the actual case should be selected.
2) "Calculation conditions" of the calculation target should be identified with reference to the calculation example.
   a. The transfer efficiency should be estimated with reference to the calculation example and "Table-6 transfer efficiency table". (When estimation of the transfer efficiency is difficult, ask the Society of Chemical Engineers or painting machine manufacturer for their cooperation.)
   b. The amount of the paint sludge generated should be identified (or calculated).
   c. Other than the above, the necessary conditions for calculation should be identified.
3) Each calculation item amount (kg/year) for each corresponding line No. should be calculated with reference to the calculation example and entry example. (In the entry example, oblique lines are entered in the blank of a line No. that does not correspond.)
4) Concerning the metal conversion factor of the pigment component, refer to the reference material "Example of chemical substances composing a substance group" in the basic manual.
5) Concerning any unknown symbols, etc. in the working sheet (1), refer to "Table-4 Calculation Procedure in Detail" and "Table-5 Listings of the symbols"

(4) The above-described results (entry blank with *) is transferred and organized in "Table-3 Working sheet (2)", and the entered numeral values should be checked

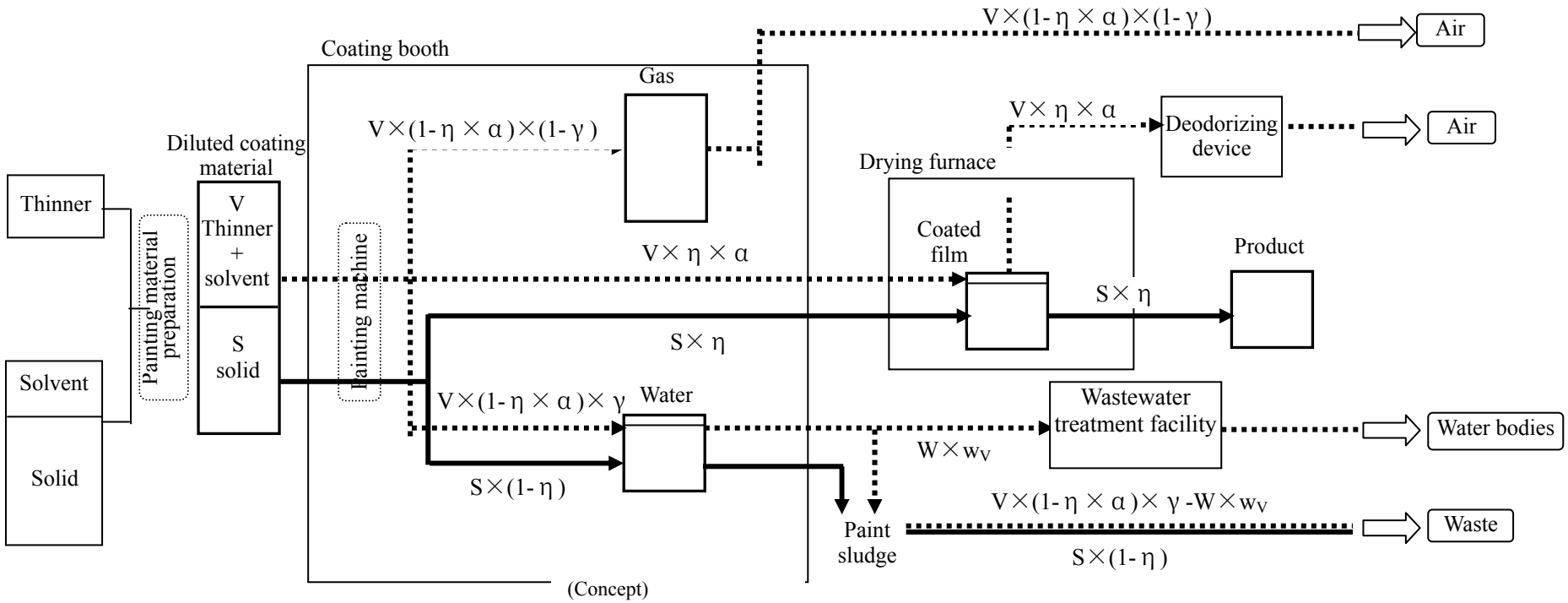
according to the procedure shown in remarks 3).

(5) The results completed in the above-described Table-3 should be written on the reporting form established by competent ministerial ordinance.

Note:

1) The details are established by competent ministerial ordinance hereafter, but attention must be paid especially to the handling of the amounts transferred, amount recycled off-site, significant figures, etc.

Fig.-2 Conceptual Diagram for Estimating Releases and Transfers (water washing booth)



V: Solvent ingredient (VOC) kg/year in diluted painting material

S: Solid portions in diluted painting material (solid portions: resin + pigment) kg/year

W: Wastewater amount at the solution renewal kg/year

Wv: Contents of solvent ingredient in wastewater (mass% ÷ 100)

η: Transfer efficiency (mass% ÷ 100) → if it is unknown, it is calculated from Table –4 and calculation example.

α: Drying furnace transfer ratio (mass% ÷ 100)

γ: Transfer ratio to water out of the portions subtracted the solvent carried into drying furnace, $V\times(1-\eta\times\alpha)$

Solid portions S

(1) The content equivalent to the transfer efficiency η of the solid portions S in the diluted paint, $S\times\eta$, is painted on an object and forms a coated film.

(2) The over-sprayed portions that are not painted on the object, $S\times(1-\eta)$ is transferred into a circulating solution, and the entire amount is transferred to the paint sludge as waste.

Solvent ingredient V

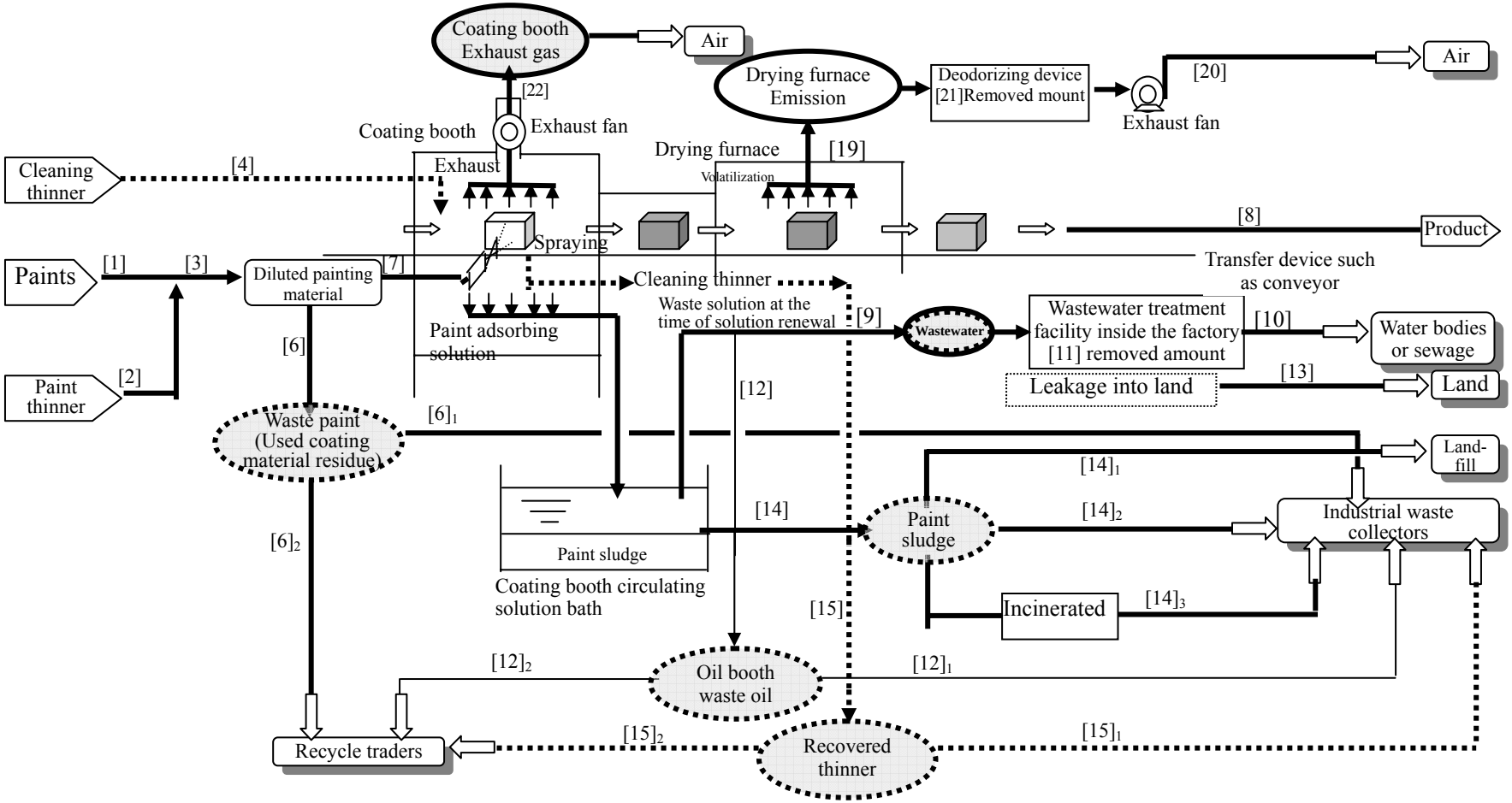
(1) $\eta\times\alpha$ of the solvent ingredient in the diluted paint V accompanies a coated film and is carried into a drying furnace. Here, α refers to a drying furnace transfer rate. Since the actual measurement of $\eta\times\alpha$ is 0.1 ~ 0.3, if the actual measurement of α is not available, $\alpha = 0.1$ is used, taking safety into consideration.

(2) Total Volume of the solvent ingredient of $V\times\eta\times\alpha$ accompanying the coated film carried into the drying furnace is Vaporized in the drying furnace and is guided to a deodorizing device.

(3) The solvent ingredient subtracted by the solvent ingredient carried into the drying furnace, $V\times(1-\eta\times\alpha)$, is distributed into the gaseous phase in the painting booth by $V\times(1-\eta\times\alpha)\times(1-\gamma)$ and into the circulating water phase by $V\times(1-\eta\times\alpha)\times\gamma$ at the rate of $(1-\gamma):\gamma$.

(4) Solvent in the diluted paint transferred to water, $V\times(1-\eta)\times\gamma$, is distributed to the solvent ingredient in the wastewater at the solution renewal, $W\times Wv$, and the solvent ingredient in the paint sludge, $V\times(1-\eta\times\alpha)\times\gamma-W\times Wv$.

Fig.-3 Flow Sheet for Estimating the Releases and Transfers in the Painting Processes



3 Calculation Method for Releases and Transfers in Painting Process

Table-2 Work Sheet (1) --- Calculating Releases and Transfers ---

Line No ※1	Calculation item	Solvent ingredient i =		Pigment component j =	
		Calculation formula ※2	kg/Y	Calculation formula ※2 ※3	kg/Y
[1]	Annual amount of Class I Substances in paint handled	F1i= F1×f1i ※4		F1j= F1×f1j ※4	
[2]	Annual amount of handled Class I Substances in thinner	F2i= F2×f2i			
[3]	Annual amount of Class I Substances in diluted paint handled	[1] + [2]		The same as [1]	
[4]	Annual amount of Class I Substances in cleaning thinner handled	F3i= F3×f3i			
[5]	Annual amount of Class I Substances handled	[3] + [4]	*	The same as [1]	*
[6]	Amount of Class I Substances in waste paint	Dpi= Dp×dpi ※5		Dpj= Dp×dpj ※5	
$[6]_1$	In case of handing over waste paint to industrial waste collector	D1i= D1×d1i	*	D1j= D1×d1j	*
$[6]_2$	In case of sending waste paint off site for recycling	R1i= R1×r1i	*	R1j= R1×r1j	*
[7]	Annual amount of Class I Substance in diluted paint sprayed	[3] - [6]		[3] - [6]	
[8]	Amount of Class I Substances shipped as product			Pj= [7]×transfer efficiency η ※6	*
[9]	Releases before wastewater treatment ※7	Wi= W×wi ※8	*		
[10]	Releases after wastewater treatment ※7	$Wi^{treated}$ = Wi×(1-removal efficiency)	*		
[11]	Amount removed by wastewater treatment facility ※9	[9] - [10]			
[12]	Amount of Class I Substances in oil booth waste oil	Doi= Do×doi ※8			
$[12]_1$	In case of handing over oil booth waste oil to industrial waste collector	D2i= D2×d2i	*		
$[12]_2$	In case of recycling oil booth waste oil off site	R2i= R2×r2i	*		

[13]	Amount leaked to land ※10	L1i= L1×l1i	*	L1j= L1×l1j	*
[14]	Amount of Class I Substances in paint sludge generated	Dsi= Ds×dsi ※11 ※12		[7] - [8]	
$[14]_1$	In case of disposing of paint sludge as landfills	L2i= L2×l2i ※12	*	L2j= L2×l2j	*
$[14]_2$	In case of handing over paint sludge to industrial waste collector	D3i= D3×d3i ※12	*	D3j= D3×d3j	*
$[14]_3$	In case of thermal disposal of paint sludge ※13			D4j= D4×d4j	*
[15]	Amount of Class I Substances in recovered thinner	Dri= Dr×dri			
$[15]_1$	In case of handing over recovered thinner to industrial waste collector	D5i= D5×d5i	*		
$[15]_2$	In case of sending recovered thinner off-site for recycling	R3i= R3×r3i	*		
[16]	Total transfers as waste	D1i+D2i+D3i+D5i	*	D1j+D3j+D4j	*
[17]	Total transfers for recycling	R1i+R2i+R3i	*	The same as $[6]_2$	*
[18]	Potential releases to air	[5] - ([9] or [10]) - [13] - $[14]_1$ - [16] - [17]			
[19]	Releases from dry furnace before deodorizing treatment	A2i= [7]×η×α ※6			
[20]	Releases after deodorizing treatment ※14	$A2i^{treated}$ = A2i×(1-removal efficiency)			
[21]	Removed amount by the deodorizing device	[19] - [20]	*		
[22]	Releases from coating booth	[18] - [19]			
[23]	Releases to air (without deodorizing device)	[18]	*		
[24]	Releases to air (with deodorizing device)	[22] +[20]	*		

Notes: (Entry blank marked with * should be transferred to working sheet (2))

※1 Concerning line No., refer to "Fig.-3 Flow sheet for calculating the releases in the painting process"

※2 1) Concerning details of the symbols, refer to "Table-5 Listings of the symbols".
2) Alphabetic capital letters represent variable quantity (kg/year).
F = paint, thinner; P = product; W = wastewater; D = waste; L = land; R = recycle; A = air
3) The lower-case alphabetic characters refer to the content of the Class I Designated Chemical Substances (mass% ÷ 100). f = Class I Designated Chemical Substance content in paint and thinner; d = Class I Designated Chemical Substance content in waste; w = Class I Designated Chemical Substance content in wastewater; …etc.
4) The final lower-case alphabetic characters suffixes i and j show whether the Class I Designated Chemical Substance content i, in solvent, or content j in pigment, respectively.

※3 When the Class I Designated Chemical Substance is used in pigment(content j), calculation should be made with metal converted value. As for metal conversion factor, refer to the reference material in the basic manual "Example of chemical substances composing a substance group".

※4 When there are several different paint sludges including component i (or j), the value of the above-described formula is obtained for each type of paint sludge, and is totaled.

※5 When the content dpi (or dpj) of the component i (or j) in the waste paint is unknown, the composition at the time of purchase is used.

※6 1) Transfer efficiency η is calculated with reference to "Table-6 transfer efficiency table" and the calculation example. Multiple different type of coating machines are used in the same booth, the average transfer efficiency η_{av} is used (refer to (Note) of Ⅱ—1-2(5)).
2) The idea is shown in Fig.-2.(concept), α is the drying furnace transfer rate, and η × α of the Solvent ingredient V in the diluted paint is considered to be carried into the drying furnace in the coated film. When the value of α is unknown, use α = 0.1.
3) The entire amount of the Solvent ingredient V × η × α accompanying the coating film carried into the drying furnace is vaporized in the drying furnace and guided to the deodorizing device.

※7 When transferred to POTWs, it is reported as "the transferred amount of wastewater to sewage" not as the released amount to water bodies. In the case without a waste water treatment equipment, the value [9] and in the case with a wastewater treatment equipment, the value [10] are entered in either blank of C or D of the working sheet (2). When the removal efficiency of the wastewater treatment equipment is unknown, the value in the reference material in the basic manual "Removal efficiency … of the typical wastewater treatment device" is used.

※8 When measurement data of the content i is not available, wi = 0.0001 in the case of water washing booth, and doi = 0.001 in the case of oil booth are used (refer to Table-5).

※9 In this case, since it is not decomposed by activated sludge etc., but is released to air by aeration. It should be added to the amount released to air, for reporting.

※10 The release to land is obtained by estimating the leakage factors from accident records, repair records, daily reports, and sampling times.

※11 When the amount of the paint sludge Ds (kg/year) is unknown, estimation is made based on Ds = (amount of paints used per year-amount of waste paint generated) × solid portions ratio × (1-η).

※12 When analyzed data of the content is not available, dsi = 12i = d3i = 0.002 is used for both water washing booth and oil booth (refer to Table-6),

※13 As for a furnace with the total grate area of 0.5m^2 or more or the total burning capacity of 50kg/hour or more, the reporting of dioxins is also necessary.

※14 When the removal efficiency of the deodorizing device is unknown, the value in the reference material in the basic manual "Removal efficiency Reference-3 of the typical exhaust gas device" is used.

Table-3 Work Sheet (2) - Summary -

		(i)	(ii)	(iii) Releases and transfers of wastewater		(iv)	(v)	(iv) Transfers contained in waste						(vii) Transfers for recycling				(viii) Releases to air		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	S	
		Annual amount of Class I Substances handled	Amount Shipped in product	Releases to water bodies	Transfers to POTWs	Releases to land	On-site landfills	Waste paint	Oil booth waste oil	Paint sludge (indusrial waste)	Paint sludge burnt ash	Recovered thinner	Total	Waste paint	Oil booth waste oil	Recovered thinner	Total	Without deodorizing treatment	With deodorizing treatment	
																			R Removed amount	
		[5]	[8]	[9] or [10] is entered into C or D		[13]	$[14]_1$	$[6]_1$	$[12]_1$	$[14]_2$	$[14]_3$	$[15]_1$	[16]	$[6]_2$	$[12]_2$	$[15]_2$	[17]	[23]	[21]	[24]
Solvent/thinner	Toluene																			
	Xylene																			
	Stylene																			
	Ethylbenzene																			
	Ethylene glycol																			
	Ethanol amine																			
	Ethyl cellosolve																			
	Methyl cellosolve																			
	Ethyl cellosolve acetate																			
	Methyl cellosolve acetate																			
Pigment	Cadmium																			
	Chromium and chromium (III)compounds																			
	Chromium (VI) compounds																			
	Molybdenum																			
	Nickel																			
	Lead																			
	Boron																			
	Manganese																			
	Antimony																			
	Cobalt																			
Others	di-n-octyl phthalate																			
	Bis (2-ethyl hexyl) phthalate																			
	di-n-butyl phthalate																			
	di-n-heptyl phthalate																			
	n-butyl = benzyl phthalate																			
	Formaldehyde																			
	Adipic acid bis(2-ethylhexyl)																			
	Tri-n-butyl phosphate																			

(Remarks)

1) The entry blank with * of the releases and transfers calculated in the work sheet (1) is transferred in the above table.
2) Concerning wastewater, in the case where there is no wastewater treatment equipment, the value of line No[9] of the work sheet (1), and in the case with the wastewater treatment equipment, the value of [10] are transferred in C or D in the above table according to their destinations.
3) After all the entries are completed, G +H +I +J + K = L; M+N +O = P; A-{(C or D) + E+ F +L +P + (Q or S) 0 is confirmed for each Class I Designated Chemical Substance.
4) The above results should be reported based on the form established by the competent ministerial ordinance.

< Calculation Example 1> Water washing booth

(1) Calculation Conditions

1) Process

Booth	water washing booth, wastewater amount is 30,000kg/year
Painting machine	air spray
Object to be painted	flat metal plate
Wastewater treatment equipment	activated sludge treatment (removal efficiency: 60%), treated water is released to water bodies
Deodorizing device	combustion treatment (removal efficiency: 99.5%)

2) Paint used: melamine alkyd resin paint PRTR・SK-008 (finish coating)

Annual amount used	20,000kg/year (solid portions: 50 mass %)
Composition (pigment)	lead chromate ($PbCrO_4$): 18.7 mass % As chromium (VI) metal, 18.7 × 0.161 (hexavalent chromium conversion coefficient) = 3.0 mass%, As lead metal, 18.7 × 0.641 (lead conversion coefficient) = 12 mass% (For the conversion coefficient, refer to reference material in the basic manual)
(solvent)	xylene: 25 mass%
Annual amount of the waste paint generated	300kg/year, the entire amount is assumed to be handed over to industrial waste processor

3) Paint thinner

Annual amount used	10,000kg/year
Composition	xylene: 20 mass%, chemical substances not included in the Class I Designated Chemical Substances: 80 mass%

4) Cleaning thinner

Annual amount used	20,000kg/year
Composition	toluene: 60 mass%, chemical substances not included in the Class I Designated Chemical Substances: 40 mass%
Amount of thinner recovered	6,000kg/year, the entire amount is assumed to be handed over to recycling firms.

5) Estimation of transfer efficiency

The transfer efficiency is estimated to be 40% ($\eta = 0.4$) from Table-6 and process conditions.

6) Paint sludge

Annual amount generated: 5,910kg/year, the entire amount is assumed to be handed over to industrial waste processors.

Amount of paint sludge generated is calculated by the following formula when there is no data

Amount of point sludge ganerated
= (annual amount of paint used - amount of waste paint generated)
× solid portions ratio × (1 - transfer efficiency)
= (20,000 - 300) × 0.5 × (1 - 0.4)
= 5,910kg/year

7) Others

It is assumed that there is no release to land and no on-site landfills.

(2) Calculation of the Releases and Transfers of Solvent ingredient

[Xylene]

1) Calculation of the annual amount of xylene handled

[1] Xylene in paint

20,000kg/year × 0.25 = 5,000kg/year

[2] Xylene in paint thinner

10,000kg/year × 0.20 = 2,000kg/year

[3] Xylene in diluted paint

[1] + [2] = 5,000 + 2,000 = 7,000kg/year

[4] Xylene in cleaning thinner

20,000kg/year × 0 = 0kg/year

[5] Annual amount of xylene handled

[3] + [4] = 7,000 + 0 = 7,000kg/year

2) Waste paint (residual paint)

[6] Xylene in waste paint

300kg/year × 0.25 = 75kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processor,

$[6]_1$ = [6] = 75kg/year

3) Amount of diluted paint sprayed

[7] Amount of xylene sprayed

[3] - [6] = 7,000 - 75 = 6,925kg/year

4) Releases to water bodies

[9] Potential (before wastewater treatment) releases

30,000kg/year × 0.0001 = 3.0kg/year

(when xylene content rate in wastewater is unknown, :0.01 mass%)

[10] Releases after wastewater treatment

[9] × (1 - removal efficiency) = 3.0 × 0.4 = 1.2kg/year

[11] Removed amount by the wastewater treatment

[9] - [10] = 3.0 - 1.2 = 1.8kg/year

5) Paint sludge

[14] Xylene in paint sludge

5,910kg/year × 0.002 = 12kg/year

(when xylene content in paint sludge is unknown,: 0.2 mass%)

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 12kg/year

6) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[6]_1$ + $[14]_2$ = 75 + 12 = 87kg/year

7) Releases to air

[18] Potential releases to air

[5] - [10] - [16] = 7,000 - 1.2 - 87= 6,912kg/year

[19] Releases from drying furnace before deodorizing treatment

[7] × η × α = 6,925kg/year × 0.4 × 0.1 = 277kg/year

(when drying furnace transfer rate is unknown, 10% (α = 0.1))

[20] Releases after deodorizing treatment

[19] × (1 - removal efficiency) = 277 × 0.005 = 1.4kg/year

[21] Removed amount by the deodorizing device

[19] - [20] = 277 - 1.4 = 276kg/year

[22] Releases from painting booth

[18] - [19] = 6,912 - 277 = 6,635kg/year

[24] Releases to air

[22] + [20] = 6,635 + 1.4 = 6,636kg/year

[Toluene]

1) Calculation of the annual amount of toluene handled

[4] Toluene in cleaning thinner

20,000kg/year × 0.60 = 12,000kg/year

[5] Annual amount of toluene handled

[3] + [4] = 0 + 12,000 = 12,000kg/year

2) Releases to water bodies

[9] Potential (before wastewater treatment) releases

30,000kg/year × 0.0001 = 3.0kg/year

(when toluene content in wastewater is unknown, :0.01 mass%)

[10] Releases after wastewater treatment

[9] × (1 - removal efficiency) = 3.0 × 0.4 = 1.2kg/year

[11] Removed amount by the wastewater treatment facility

[9] - [10] = 3.0 - 1.2 = 1.8kg/year

3) Paint sludge

[14] Toluene in paint sludge

5,910kg/year × 0.002 = 12kg/year

(when toluene content in paint sludge is unknown, :0.2 mass%)

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 12kg/year

4) Recovered thinner

[15] Toluene in recovered thinner

6,000kg/year × 0.60 = 3,600kg/year

$[15]_2$ Since the entire amount of recovered thinner is handed over to recycling firms,

$[15]_2$ = [15] = 3,600kg/year

5) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[14]_2$ = 12kg/year

[17] Total amount for recycling

[17] = $[15]_2$ = 3,600kg/year

6) Releases to air

[18] Potential releases to air

[5] - [10] - [16] - [17] = 12,000 - 1.2 - 12 - 3,600 = 8,387kg/year

[22] Releases from painting booth

[18] - [19] = 8,387 - 0 = 8,387kg/year

[24] Releases to air

[22] + [20] = 8,387 + 0 = 8,387kg/year

(3) Calculation of the Releases and Transfers of Pigment Component

[Hexavalent chromium]

1) Calculation of the annual amount of hexavalent chromium handled

[1] Hexavalent chromium in paint

20,000kg/year × 0.030 = 600kg/year

[3] Hexavalent chromium in diluted paint

[3] = [1] = 600kg/year

[5] Annual amount of hexavalent chromium handled

[5] = [1] = 600kg/year

2) Waste paint(unused paint)

[6] Hexavalent chromium in waste paint

300kg/year × 0.030 = 9.0kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processors,

$[6]_1$ = [6] = 9.0kg/year

3) Amount of diluted paint sprayed

[7] Amount of hexavalent chromium sprayed

[3] - [6] = 600 - 9.0 = 591kg/year

4) Amount shipped in products

[8] Amount shipped in products

[7] x(transfer efficiency) = 591 × 0.4 = 236kg/year

5) Paint sludge

[14] Hexavalent chromium in paint sludge

[7] - [8] = 591 - 236 = 355kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 355kg/year

6) Total of waste/recycle amount

[16] Total transfers as waste

[16] $= [6]_1 + [14]_2$ = 9.0 + 355 = 364kg/year

[Lead]

1) Calculation of the annual amount of lead handled

[1] Lead in paint

20,000kg/year × 0.12 = 2,400kg/year

[3] Lead in diluted paint

[3] = [1] = 2,400kg/year

[5] Annual amount of lead handled

[5] = [1] = 2,400kg/year

2) Waste paint (residual paint)

[6] Lead in waste paint

300kg/year × 0.12 = 36kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processors,

$[6]_1$ = [6] = 36kg/year

3) Amount of diluted paint sprayed

[7] Amount of lead sprayed

[3] - [6] = 2400 - 36 = 2,364kg/year

4) Amount shipped in products

[8] Amount shipped in products

[7] × (transfer efficiency)= 2,364 × 0.4 = 946kg/year

5) Paint sludge

[14] Lead in paint sludge

[7] - [8] = 2,364 - 946 = 1,418kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 1,418kg/year

6) Total of waste/recycle amount

[16] Total transfers as waste

[16] $= [6]_1 + [14]_2$ = 36 + 1,418 = 1,454kg/year

Work Sheet (1) Entry Example

< Calculation Example 1> --- Water washing booth 1/2 ---

		Solvent ingredient i = xylene		**Pigment component j = hexavalent chromium compound**	
Line No ※1	Calculation item	Solvent ingredient i		Pigment component j	
		Calculation formula ※2	kg/Y	Calculation formula ※2 ※3	Metal kg/Y
[1]	Annual amount of Class I Substances in paint handled	F1i= F1×f1i ※4	5,000	F1j= F1×f1j ※4	600
[2]	Annual amount of handled Class I Substances in thinner	F2i= F2×f2i	2,000		
[3]	Annual amount of Class I Substances in diluted paint handled	[1] + [2]	7,000	The same as [1]	600
[4]	Annual amount of Class I Substances in cleaning thinner handled	F3i= F3×f3i	0		
[5]	Annual amount of Class I Substances handled	[3] + [4]	*7,000	The same as [1]	* 600
[6]	Amount of Class I Substances in waste paint	Dpi= Dp×dpi ※5	75	Dpj= Dp×dpj ※5	9
$[6]_1$	When handing over waste paint to industrial waste collector	D1i= D1×d1i	* 75	D1j= D1×d1j	* 9.0
$[6]_2$	When sending waste paint off site for recycling	R1i= R1×r1i	*	R1j= R1×r1j	*
[7]	Annual amount of Class I Substance in diluted paint sprayed	[3] - [6]	6,925	[3] - [6]	591
[8]	Amount of Class I Substances shipped as product			Pj= [7]×transfer efficiency η ※6	* 236
[9]	Releases before wastewater treatment ※7	Wi= W×wi ※8	* 3.0		
[10]	Releases after wastewater treatment ※7	$Wi^{treated}$ = Wi×(1-removal efficiency)	* 1.2		
[11]	Amount removed by wastewater treatment facility ※9	[9] - [10]	1.8		
[12]	Amount of Class I Substances in oil booth waste oil	Doi= Do×doi ※8			
$[12]_1$	When handing over oil booth waste oil to industrial waste collector	D2i= D2×d2i	*		
$[12]_2$	When recycling oil booth waste oil off site	R2i= R2×r2i	*		
[13]	Amount leaked to land ※10	L1i= L1×l1i	*	L1j= L1×l1j	*
[14]	Amount of Class I Substances in paint sludge generated	Dsi= Ds×dsi ※11 ※12	12	[7] - [8]	355
$[14]_1$	When disposing of paint sludge as landfills	L2i= L2×l2i ※12	*	L2j= L2×l2j	*
$[14]_2$	When handing over paint sludge to industrial waste collector	D3i= D3×d3i ※12	* 12	D3j= D3×d3j	* 355
$[14]_3$	When thermal disposal of paint sludge ※13			D4j= D4×d4j	*
[15]	Amount of Class I Substances in recovered thinner	Dri= Dr×dri			
$[15]_1$	When handing over recovered thinner to industrial waste collector	D5i= D5×d5i	*		
$[15]_2$	When sending recovered thinner off-site for recycling	R3i= R3×r3i	*		
[16]	Total transfers as waste	D1i+D2i+D3i+D5i	* 87	D1j+D3i+D4j	* 364
[17]	Total transfers for recycling	R1i+R2i+R3i	*	The same as $[6]_2$	*
[18]	Potential releases to air	[5] - ([9] or [10]) - [13] - $[14]_1$ - [16] - [17]	6,912		
[19]	Releases from dry furnace before deodorizing treatment	A2i= [7]× η × α ※6	277		
[20]	Releases after deodorizing treatment ※14	$A2i^{treated}$ = A2i×(1-removal efficiency)	1.4		
[21]	Removed amount by the deodorizing device	[19] - [20]	* 275.6		
[22]	Releases from coating booth	[18] - [19]	6,635		
[23]	Releases to air (without deodorizing device)	[18]	*		
[24]	Releases to air (with deodorizing device)	[22] + [20]	*6,636		

Work Sheet (1) Entry Example

< Calculation example 1> --- Water washing booth 2/2 ---

		Solvent ingredient i = toluene		Pigment component j = lead compound	
Line No ※1	Calculation item	Solvent ingredient i		Pigment component j	
		Calculation formula ※2	kg/Y	Calculation formula ※2 ※3	Metal kg/Y
[1]	Annual amount of Class I Substances in paint handled	F1i= F1×f1i ※4		F1j= F1×f1j ※4	2,400
[2]	Annual amount of handled Class I Substances in thinner	F2i= F2×f2i			
[3]	Annual amount of Class I Substances in diluted paint handled	[1] + [2]		The same as [1]	2,400
[4]	Annual amount of Class I Substances in cleaning thinner handled	F3i= F3×f3i	12,000		
[5]	Annual amount of Class I Substances handled	[3] + [4]	*12,000	The same as [1]	* 2,400
[6]	Amount of Class I Substances in waste paint	Dpi= Dp×dpi ※5		Dpj= Dp×dpj ※5	36
$[6]_1$	When handing over waste paint to industrial waste collector	D1i= D1×d1i	*	D1j= D1×d1j	* 36
$[6]_2$	When sending waste paint off site for recycling	R1i= R1×r1i	*	R1j= R1×r1j	*
[7]	Annual amount of Class I Substance in diluted paint sprayed	[3] - [6]		[3] - [6]	2,364
[8]	Amount of Class I Substances shipped as product			Pj= [7]×adhesion efficiency η ※6	* 946
[9]	Releases before wastewater treatment ※7	Wi= W×wi ※8	* 3.0		
[10]	Releases after wastewater treatment ※7	$Wi^{treated}$ = Wi(1-removal efficiency)	* 1.2		
[11]	Amount removed by wastewater treatment facility ※9	[9] - [10]	1.8		
[12]	Amount of Class I Substances in oil booth waste oil	Doi= Do×doi ※8			
$[12]_1$	When handing over oil booth waste oil to industrial waste collector	D2i= D2×d2i	*		
$[12]_2$	When recycling oil booth waste oil off site	R2i= R2×r2i	*		
[13]	Amount leaked to land ※10	L1i= L1×l1i	*	L1j= L1×l1j	*
[14]	Amount of Class I Substances in paint sludge generated	Dsi= Ds×dsi ※11 ※12	12	[7] - [8]	1,418
$[14]_1$	When disposing of paint sludge as landfills	L2i= L2×l2i ※12	*	L2j= L2×l2j	*
$[14]_2$	When handing over paint sludge to industrial waste collector	D3i= D3×d3i ※12	* 12	D3j= D3×d3j	* 1,418
$[14]_3$	When thermal disposal of paint sludge ※13			D4j= D4×d4j	*
[15]	Amount of Class I Substances in recovered thinner	Dri= Dr×dri	3,600		
$[15]_1$	When handing over recovered thinner to industrial waste collector	D5i= D5×d5i	*		
$[15]_2$	When sending recovered thinner off-site for recycling	R3i= R3×r3i	*3,600		
[16]	Total transfers as waste	D1i+D2i+D3i+D5i	* 12	D1j+D3i+D4j	* 1,454
[17]	Total transfers for recycling	R1i+R2i+R3i	*3,600	The same as $[6]_2$	*
[18]	Potential releases to air	[5]-([9]or[10])-[13] - $[14]_1$ - [16] - [17]	8,387		
[19]	Releases from dry furnace before deodorizing treatment	A2i= [7]× η × α ※6			
[20]	Releases after deodorizing treatment ※14	$A2i^{treated}$ = A2i(1-removal efficiency)			
[21]	Removed amount by the deodorizing device	[19] - [20]	*		
[22]	Releases from coating booth	[18] - [19]	8,387		
[23]	Releases to air (without deodorizing device)	[18]	*		
[24]	Releases to air (with deodorizing device)	[22] + [20]	8,387. 8,387		

Work Sheet (2) Entry Example

<Calculation Example 1> --- Water washing booth ---

		(i)	(ii)	(iii) Releases and transfers of wastewater		(iv)	(v)	(iv) Transfers contained in waste						(vii) Transfers for recycling				(viii) Releases to air		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	S	
		Annual amount of Class I Substances handled	Amount Shipped in product	Releases to water bodies	Transfers to POTWs	Releases to land	On-site landfills	Waste paint	Oil booth waste oil	Paint sludge (indusrial waste)	Paint sludge burnt ash	Re-covered thinner	Total	Waste paint	Oil booth waste oil	Recovered thinner	Total	Without deodorizing treatment	With deodorizing treatment R Removed amount	
		[5]	[8]	[9] or [10] is entered into C or D		[13]	$[14]_1$	$[6]_1$	$[12]_1$	$[14]_2$	$[14]_3$	$[15]_1$	[16]	$[6]_2$	$[12]_2$	$[15]_2$	[17]	[23]	[21]	[24]
Solvent/thinner	Xylene	7,000		1.2				75		12			87						276	6,636
	Toluene	12,000		1.2						12			12			3,600	3,600			8,387
Pigment	Hexavalent chromium	600	236					9		355			364							
	Lead	2,400	946					36		1,418			1,454							
Others																				

(Remarks)

1) The entry blank with * of the releases and transfers calculated in the work sheet (1) is transferred in the above table.

2) Concerning wastewater, in the case where there is no wastewater treatment facility, the value of line No[9] of the work sheet (1), and in the case with the wastewater treatment facility, the value of [10] are transferred in U or E in the above table according to their .destinations.

< Calculation Example 2> Water washing booth (use of multiple Painting machines)

(1) Calculation Conditions

1) Process

Booth: water washing booth, wastewater amount is 30,000kg/year (replacement solution amount 5,000kg/time × two times/year)

Painting machine: air → airless → electrostatic air

Object to be painted: aluminum building material → aluminum building material → aluminum building material

Load rate: 30% → 30% → 40%

Wastewater treatment equipment: None. All the amount is released to POTWs.

Deodorizing device: combustion treatment (removal efficiency: 99.5%)

2) Paint used: melamine alkyd resin paint PRTR SK-008 (finish coating)

Annual amount used: 20,000kg/year (solid portions: 50 mass %)

Composition (pigment): lead chromate ($PbCrO_4$): 18.7 mass%
As hexavalent chromium metal, 18.7 × 0.161 (hexavalent chromium conversion factor) = 3.0 mass%,
As lead metal, 18.7 × 0.641 (lead conversion factor) = 12 mass%
(concerning conversion factor, refer to reference material in the basic manual)

(solvent) xylene: 25 mass%

Annual amount of waste paint generated: 300kg/year, the entire amount is assumed to be handed over to industrial waste dealers

3) Paint thinner

Annual amount used: 10,000kg/year

Composition: xylene: 20 mass%, other chemical substances that do not include any Class I Substances: 80 mass%

4) Cleaning thinner

Annual amount used: 20,000kg/year

Composition: toluene: 60 mass%,: other chemical substances that do not include any Class I Substances: 40 mass%

Amount of thinner recovered: 6,000kg/year, the entire amount is assumed to be handed over to recycling firms.

5) Estimation of average transfer efficiency

The average transfer efficiency is calculated to be 42% from Table-4 and process conditions. η_{av} = 0.3 × 0.2 + 0.4 × 0.3 + 0.6 × 0.4 = 0.42

6) Paint sludge

Annual amount generated: 5,710kg/year, the entire amount is assumed to be handed over to industrial waste processors.

Amount of paint sludge generated
= (annual amount of paint used - amount of waste paint)
× (solid portions ratio) × (1 - transfer efficiency)
= (20,000 - 300) × 0.5 × (1 - 0.42)
= 5,710kg/year

7) Others

It is assumed that there is no release to land and no on-site landfills

(2) Calculation of Releases and Transfers of Solvent ingredient

[Xylene]

1) Calculation of the annual amount of xylene handled

[1]Xylene in paint

20,000kg/year × 0.25 = 5,000kg/year

[2] Xylene in paint thinner

10,000kg/year × 0.20 = 2,000kg/year

[3] Xylene in diluted paint

[1] + [2] = 5,000 + 2,000 = 7,000kg/year

[4] Xylene in cleaning thinner

20,000kg/year × 0 = 0kg/year

[5] Annual amount of xylene handled

[3] + [4] = 7,000 + 0 = 7,000kg/year

2) Waste paint (unused paint)

[6] Xylene in waste paint

300kg/year × 0.25 = 75kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processor,

$[6]_1$ = [6] = 75kg/year

3) Amount of diluted paint sprayed

[7] Amount of xylene sprayed

[3] - [6] = 7,000 - 75 = 6,925kg/year

4) Releases to water bodies

[9] Potential (before wastewater treatment) releases

30,000kg/year × 0.0001 = 3.0kg/year

(when xylene content in wastewater is unknown,: 0.01 mass%)

5) Paint sludge

[14] Xylene in paint sludge

5,710kg/year × 0.002 = 11kg/year

(when xylene content in paint sludge is unknown,: 0.2 mass%)

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 11kg/year

6) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[6]_1 + [14]_2$ = 75 + 11 = 86kg/year

7) Releases to air

[18] Potential releases to air

[5] - [9] - [16] - [17] = 7,000 - 3.0 - 86 - 0 = 6,911kg/year

[19] Releases from drying furnace before treatment

[7] × η × α = 6,925kg/year × 0.42 × 0.1 = 291kg/year

(when drying furnace transfer rate is unknown, 10% (α = 0.1))

[20] Releases after deodorizing treatment

[19] × (1 - removal efficiency) = 291 × 0.005 = 1.5kg/year

[21] Amount removed by deodorizing device

[19] - [20] = 291 - 1.5 = 290kg/year

[22] Releases from painting booth

[18] - [19] = 6,911 - 291 = 6,620kg/year

[24] Releases to air

[22] + [20] = 6,620 + 1.5 = 6,622kg/year

[Toluene]

1) Calculation of the annual amount of toluene handled

[4] Toluene in cleaning thinner

20,000kg/year × 0.60 = 12,000kg/year

[5] Annual amount of toluene handled

[3] + [4] = 0 + 12,000 = 12,000kg/year

2) Releases to water bodies

[9] Potential (before wastewater treatment) releases

30,000kg/year × 0.0001 = 3.0kg/year

(when toluene content in wastewater is unknown, :0.01 mass%)

3) Paint sludge

[14] Toluene in paint sludge

5,710kg/year × 0.002 = 11kg/year

(when toluene content in paint sludge is unknown, :0.2 mass%)

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 11kg/year

4) Recovered thinner

[15] Toluene in recovered thinner

6,000kg/year × 0.60 = 3,600kg/year

$[15]_2$ Since the entire amount of recovered thinner is handed over to recycling firms,

$[15]_2$ = [15] = 3,600kg/year

5) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[14]_2$ = 11kg/year

[17] Total amount for recycling

[17] = $[15]_2$ = 3,600kg/year

6) Releases to air

[18] Potential releases to air

[5] - [9] - [16] - [17] = 12,000 - 3.0 - 11 - 3,600 = 8,386kg/year

[22] Releases from painting booth

[18] - [19] = 8,386 - 0 = 8,386kg/year

[24] Releases to the air

[22] + [20] = 8,386 + 0 = 8,386kg/year

(3) Calculation of Releases and Transfers of Pigment Component

[Hexavalent chromium]

1) Calculation of annual amount of hexavalent chromium handled

[1] Hexavalent chromium in paint

20,000kg/year × 0.030 = 600kg/year

[3] Hexavalent chromium in diluted paint

[3] = [1] = 600kg/year

[5] Annual amount of hexavalent chromium handled

[5] = [1] = 600kg/year

2) Waste paint (residual paint)

[6] Hexavalent chromium in waste paint

300kg/year × 0.030 = 9.0kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processors,

$[6]_1$ = [6] = 9.0kg/year

3) Amount of diluted paint sprayed

[7] Amount of hexavalent chromium sprayed

[3] - [6] = 600 - 9.0 = 591kg/year

4) Amount shipped as products

[8] Amount shipped as products

[7] × transfer efficiency = 591 × 0.42 = 248kg/year

5) Paint sludge

[14] Hexavalent chromium in paint sludge

[7] - [8] = 591 - 248 = 343kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 343kg/year

6) Total of waste/recycle amount

[16] Total transfers in waste

[16] $= [6]_1 + [14]_2$ = 9.0 + 343 = 352kg/year

[Lead]

1) Calculation of the annual amount of lead handled

[1] Lead in paint

20,000kg/year × 0.12 = 2,400kg/year

[3] Lead in diluted paint

[3] = [1] = 2,400kg/year

[5] Annual amount of lead handled

[5] = [1] = 2,400kg/year

2) Waste paint (unused paint))

[6] Lead in waste paint

300kg/year × 0.12 = 36kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processors,

$[6]_1$ = [6] = 36kg/year

3) Amount of diluted paint sprayed

[7] Amount of lead sprayed

[3] - [6] = 2400 - 36 = 2,364kg/year

4) Amount shipped in products

[8] Amount shipped in products

[7] × transfer efficiency = 2,360 × 0.42 = 991kg/year

5) Paint sludge

[14] Lead in paint sludge

[7] - [8] = 2,364 - 991 = 1,373kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 1,373kg/year

6) Total of waste/recycle amount

[16] Total transfers in waste

[16] = $[6]_1 + [14]_2$ = 36 + 1,373 = 1,409kg/year

< Calculation Example 3> Oil booth

(1) Calculation Conditions

1) Process

Booth	oil booth, waste oil generation amount is 10,000kg/year (Replaced solution amount 5000kg/time × twice/year)
Painting machine	air spray
Object to be painted	small bore joint component
Deodorizing device	combustion treatment (rate of removal : 99.5%)

2) Paint used: melamine alkyd resin paint PRTR・SK-008 (under coating)

Annual amount used	20,000kg/year (solid portions: 50 mass%)
Composition (pigment)	zinc chromate ($ZnCrO_4$): 7.0 mass% As hexavalent chromium metal, 7.0 × 0.287 (hexavalent chromium conversion factor) = 2.0 mass% (For the conversion factor, refer to the reference material in the basic manual. Since zinc chromate has water solubility of less than 1 mass%, it is not included in "water soluble compound of zinc")
(solvent)	xylene: 25 mass%

Annual amount of waste paint generated: 300kg/year, the entire amount is assumed to be handed over to industrial waste dealers

3) Paint thinner

Annual amount used	10,000kg/year
Composition	toluene: 10 mass%, xylene: 30 mass%, other chemical substances that are not included in the Class I Substances: 60 mass%

4) Cleaning thinner

Annual amount used	20,000kg/year
Composition	toluene: 60 mass%, other chemical substances that are not included in the Class I Substances: 40 mass%

Amount of recovered thinner generated: 6,000kg/year, the entire amount is assumed to be handed over to recycling firms.

5) Estimation of transfer efficiency

The transfer efficiency is estimated as 30% ($\eta = 0.3$) by some actual measurements

6) Amount of paint sludge generated

Annual amount generated: 6,900kg/year, the entire amount is assumed to be handed over to industrial waste processors

If the amount of paint sludge generated is unknown, estimation should be made from the following formula:

Amount of paint sludge generated

= (annual amount of paint used-amount of waste paint) × (solid portions ratio) × (1 – transfer efficiency)

= (20,000 - 300) × 0.5 × (1 - 0.3)

= 6,900kg/year

7) Others

It is assumed that there is no release to land nor on-site landfills.

(2) Calculation of Releases and Transfers of Solvent ingredient

[Xylene]

1) Calculation of the annual amount of xylene handled

[1] Xylene in paint

20,000kg/year × 0.25 = 5,000kg/year

[2] Xylene in paint thinner

10,000kg/year × 0.30 = 3,000kg/year

[3] Xylene in diluted paint

[1] + [2] = 5,000 + 3,000 = 8,000kg/year

[4] Xylene in cleaning thinner

20,000kg/year × 0 = 0kg/year

[5] Annual amount of xylene handled

[3] + [4] = 8,000 + 0 = 8,000kg/year

2) Waste paint (residual paint)

[6] Xylene in waste paint

300kg/year × 0.25 = 75kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processor,

$[6]_1$ = [6] = 75kg/year

3) Amount of diluted paint sprayed

[7] Amount of xylene sprayed

[3] - [6] = 8,000 - 75 = 7,925kg/year

4) Oil booth waste oil

[12] Xylene in oil booth waste oil

10,000kg/year × 0.001 = 10kg/year

(when xylene content in waste oil is unknown,: 0.1 mass%)

$[12]_2$ Since the entire amount of oil booth waste oil is handed over to recycling firms,

$[12]_2$ = [12] = 10kg/year

5) Paint sludge

[14] Xylene in paint sludge

6,900kg/year × 0.002 = 14kg/year

(when xylene content in paint sludge is unknown,: 0.2 mass%)

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 14kg/year

6) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[6]_1 + [14]_2$ = 75 + 14 = 89kg/year

[17] Total transfers for recycling

[17] = $[12]_2$ = 10kg/year

7) Releases to air

[18] Potential releases to air

[5] - [16] - [17] = 8,000 - 89 - 10 = 7,901kg/year

[19] Releases from drying furnace before treatment

[7] × η × α = 7,925kg/year × 0.3 × 0.1 = 238kg/year

(when drying furnace transfer rate is unknown, 10% (α = 0.1))

[20] Releases after deodorizing treatment

[19] × (1 - removal efficiency) = 238 × 0.005 = 1.2kg/year

[21] Amount removed in deodorizing device

[19] - [20] = 238 - 1.2 = 237kg/year

[22] Releases from painting booth

[18] - [19] = 7,901 - 238 = 7,663kg/year

[24] Releases to air

[22] + [20] = 7,663 + 1.2 = 7,664kg/year

[Toluene]

1) Calculation of annual amount of toluene handled

[1] Toluene in paint

20,000kg /year × 0 = 0kg/year

[2] Toluene in paint thinner

10,000kg/year × 0.10 = 1,000kg/year

[3] Toluene in diluted paint

[1] + [2] = 0 + 1,000 = 1000kg/year

[4] Toluene in cleaning thinner

20,000kg/year × 0.60 = 12,000kg/year

[5] Annual amount of toluene handled

[3] + [4] = 1,000 + 12,000 = 13,000kg/year

2) Amount of diluted paint sprayed

[7] Amount of toluene sprayed

[7] = [3] = 1,000kg/year

3) Oil booth waste oil

[12] Toluene in oil booth waste oil

10,000kg/year × 0.001 = 10kg/year

(When toluene content in waste oil is unknown,: 0.1 mass%)

$[12]_2$ Since the entire amount of oil booth waste oil is handed over to recycling firms

$[12]_2$ = [12] = 10kg/year

4) Paint sludge

[14] Toluene in paint sludge

6,900kg/year × 0.002 = 14kg/year

(when toluene content in paint sludge is unknown, :0.2 mass%)

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 14kg/year

5) Recovered thinner

[15] Toluene in recovered thinner

6,000kg/year × 0.60 = 3,600kg/year

$[15]_2$ Since the entire amount of recovered thinner is handed over to recycling firms,

$[15]_2$ = [15] = 3,600kg/year

6) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[14]_2$ = 14kg/year

[17] Total transfers for recycling

[17] = $[12]_2 + [15]_2$ = 10 + 3600 = 3,610kg/year

7) Releases to air

[18] Potential releases to air

[5] - [16] - [17] = 13,000 - 14 - 3,610= 9,376kg/year

[19] Releases from drying furnace before treatment

[7] × η × α = 1,000kg/year × 0.3 × 0.1 = 30kg/year
(When drying furnace transfer rate is unknown, :10% (α = 0.1))
[20] Releases after deodorizing treatment
[19] × (1 - removal efficiency) = 30 × 0.005 = 0.2kg/year
[21] Amount removed by deodorizing device
[19] - [20] = 30 - 0.2 = 30kg/year
[22] Releases from painting booth
[18] - [19] = 9,376 - 30 = 9,346kg/year
[24] Releases to air
[22] + [20] = 9,346 + 0.2 = 9,346kg/year

(3) Calculation of the Releases and Transfers of Pigment Component

[Hexavalent chromium]

1) Calculation of the annual amount of hexavalent chromium handled

[1] Hexavalent chromium in paint

20,000kg/year × 0.020 = 400kg/year

[3] Hexavalent chromium in diluted paint

[3] = [1] = 400kg/year

[5] Annual amount of hexavalent chromium handled

[5] = [1] = 400kg/year

2) Waste paint (unused paint)

[6] Hexavalent chromium in waste paint

300kg/year × 0.020 = 6.0kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processors,

$[6]_1$ = [6] = 6.0kg/year

3) Amount of diluted paint sprayed

[7] Amount of hexavalent chromium sprayed

[3] - [6] = 400 - 6.0 = 394kg/year

4) Amount shipped in products

[8] Amount shipped in products

[7] × transfer efficiency = 394 × 0.3 = 118kg/year

5) Paint sludge

[14] Hexavalent chromium in paint sludge

[7] - [8] = 394 - 118 = 276kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 276kg/year

6) Total of waste/recycle amount

[16] Total transfers in waste

[16] = $[6]_1$ + $[14]_2$ = 6.0 + 276 = 282kg/year

< Calculation Example 4> Dry booth

(1) Calculation Conditions

1) Process

Booth	dry booth, over-sprayed paint sludge mist is collected with filter
Painting machine	electric static, air
Object to be painted	flat metal plate
Deodorizing device	None.

2) Paint used — melamine alkyd resin paint PRTR・SK-008 (priming)

Annual amount used	20,000kg/year (solid portions: 50 mass%)
Composition (pigment)	zinc chromate ($ZnCrO_4$): 7.0 mass% As hexavalent chromium metal, 7.0 × 0.287 (hexavalent chromium conversion factor) = 2.0 mass% (For the conversion factors, refer to reference material in the basic manual. Since zinc chromate has water solubility of less than 1 mass%, it is not a water soluble compound of zinc.)
(solvent)	xylene: 25 mass%
Waste paint amount per year	300kg/year, the entire amount is assumed to be handed over to industrial waste dealers

3) Paint thinner

Annual amount used	10,000kg/year
Composition	toluene: 10 mass%, xylene: 30 mass%, other chemical substances that are not included in the Class I chemical substances: 60 mass%

4) Cleaning thinner

Annual amount used	20,000kg/year
Composition	toluene: 60 mass%, chemical substances not included in the Class I chemical substances: 40 mass%
Amount of recovered thinner generated	6,000kg/year, the entire amount is assumed to be handed over to recycling firms.

5) Estimation of transfer efficiency

The transfer efficiency is calculated to be 60% (η = 0.6) from Table-4 and process conditions.

6) Paint sludge

Amount of paint sludge generated 3,940kg/year, the entire amount is assumed to be handed over to industrial waste processors.
The solvent ingredient content in paint sludge is assumed to be 1 mass%.

When the paint sludge amount is unknown, estimation is made from the following formula:

Amount of paint sludge generated
= (annual amount of paint sludge used-amount of waste paint) × (solid portions ratio) × (1 - transfer efficiency)
= (20,000 - 300) × 0.5 × (1 - 0.6)
= 3,940kg/year

7) Others

It is assumed that there is no release to land nor on-site landfills.

(2) Calculation of Releases and Transfers of Solvent ingredient

[Xylene]

1) Calculation of the annual amount of xylene handled

[1] Xylene in paint

20,000kg/year × 0.25 = 5,000kg/year

[2] Xylene in paint thinner

10,000kg/year × 0.30 = 3,000kg/year

[3] Xylene in diluted paint

[1] + [2] = 5,000 + 3,000 = 8,000kg/year

[4] Xylene in cleaning thinner

20,000kg/year × 0 = 0kg/year

[5] Annual amount of xylene handled

[3] + [4] = 8,000 + 0 = 8,000kg/year

2) Waste paint (unused paint)

[6] Xylene in waste paint

300kg/year × 0.25 = 75kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processor,

$[6]_1$ = [6] = 75kg/year

3) Amount of diluted paint sprayed

[7] Amount of xylene sprayed

[3] - [6] = 8,000 - 75 = 7,925kg/year

4) Paint sludge

[14] Xylene in paint sludge

3,940kg/year × 0.01 = 39kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 39kg/year

5) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[6]_1 + [14]_2$ = 75 + 39 = 114kg/year

6) Releases to air

[18] Potential releases to air

[5] - [16] = 8,000 - 114 = 7,886kg/year

[23] Releases to air

[23] = [18] = 7,886kg

[Toluene]

1) Calculation of the annual amount of toluene handled

[1] Toluene in paint

20,000kg/year × 0 = 0kg/year

[2] Toluene in paint thinner

10,000kg/year × 0.10 = 1,000kg/year

[3] Toluene in diluted paint

[1] + [2] = 0 + 1,000 = 1,000kg/year

[4] Toluene in cleaning thinner

20,000kg/year × 0.60 = 12,000kg/year

[5] Annual amount of toluene handled

[3] + [4] = 1,000 + 12,000 = 13,000kg/year

2) Amount of diluted paint sprayed

[7] Sprayed amount of toluene

[7] = [3] = 1,000kg/year

3) Paint sludge

[14] Toluene in paint sludge

3,940kg/year × 0.01 = 39kg/year

(when toluene content in paint sludge is unknown, :0.2 mass%)

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 39kg/year

4) Recovered thinner

[15] Toluene in recovered thinner

6,000kg/year × 0.60 = 3,600kg/year

$[15]_2$ Since recovered thinner entire amount is handed over to recycling firms,

$[15]_2$ = [15] = 3,600kg/year

5) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[14]_2$ = 39kg/year

[17] Total amount for recycling

[17] = $[15]_2$ = 3,600kg/year

6) Releases to air

[18] Potential releases to air

[5] - [16] - [17] = 13,000 - 39 - 3,600= 9,361kg/year

[23] Releases to air

[23] = [18] = 9,361kg/year

(3) Calculation of Releases and Transfers of Pigment Component

[Hexavalent chromium]

1) Calculation of the annual amount of hexavalent chromium handled

[1] Hexavalent chromium in paint

20,000kg/year × 0.020 = 400kg/year

[3] Hexavalent chromium in diluted paint

[3] = [1] = 400kg/year

[5] Annual amount of hexavalent chromium handled

[5] = [1] = 400kg/year

2) Waste paint (unused paint)

[6] Hexavalent chromium in waste paint

300kg/year × 0.020 = 6.0kg/year

$[6]_1$ Since the entire amount of waste paint is handed over to industrial waste processors,

$[6]_1$ = [6] = 6.0kg/year

3) Amount of diluted paint sprayed

[7] Amount of hexavalent chromium sprayed

[3] - [6] = 400 - 6.0 = 394kg/year

4) Amount shipped in products

[8] Amount shipped in products

[7] × transfer efficiency = 394 × 0.6 = 236kg/year

5) Paint sludge

[14] Hexavalent chromium in paint sludge

[7] - [8] = 394 - 236 = 158kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 158kg/year

6) Total of waste/recycle amount

[16] Total transfers as waste

[16] $= [6]_1 + [14]_2$ = 6.0 + 158 = 164kg/year

Work Sheet (2) Entry Example <Calculation Example 2> --- Water washing booth (using multiple coating machines) ---
< Calculation Example 3> --- Oil booth --- < Calculation Example 4> --- Dry booth ---

		(i)	(ii)	(iii) Releases and transfers of wastewater		(iv)	(v)	(iv) Transfers contained in waste						(vii) Transfers for recycling				(viii) Releases to air		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	S	
		Annual amount of Class I Substances handled	Amount Shipped in product	Releases to water bodies	Transfers to POTWs	Releases to land	On-site landfills	Waste paint	Oil booth waste oil	Paint sludge (indusrial waste)	Paint sludge burnt ash	Re-covered thinner	Total	Waste paint	Oil booth waste oil	Recovered thinner	Total	Without deodorizing treatment	With deodorizing treatment	
																			R Removed amount	
		[5]	[8]	[9] or [10] is entered into C or D		[13]	$[14]_1$	$[6]_1$	$[12]_1$	$[14]_2$	$[14]_3$	$[15]_1$	[16]	$[6]_2$	$[12]_2$	$[15]_2$	[17]	[23]	[21]	[24]
Solvent/thinner	<example 2>																			
	Xylene	7000			3.0			75		11			86						290	6622
	Toluene	12000			3.0					11			11			3600	3600			8386
	<example 3>																			
	Xylene	8000						75		14			89		10		10		237	7664
	Toluene	13000								14			14		10	3600	3610		30	9346
	<example 4>																			
	Xylene	8000						75		39			114					7886		
	Toluene	13000								39			39			3600	3600	9361		
Pigment	<example 2>																			
	Chromium(VI)	600	248					9.0		343			352							
	Lead	2400	991					36		1373			1409							
	<example 3>																			
	Chromium(VI)	400	118					6.0		276			282							
	<example 4>																			
	Chromium(VI)	400	236					6.0		158			164							
Others																				

(Remarks)
1) The blank entry with * for the releases and transfers calculated in the work sheet (1) is transferred in the above table.
2) Concerning wastewater, in the case without a wastewater treatment facility, the value of line No[9] of the work sheet (1), and in the case with the wastewater treatment facility, the value of [10] are transferred in U or E in the above table, according to their destinations.

< Calculation Example 5> Painting of Automobile Parts

(1) Calculation Conditions

1) Process

Booth	water washing booth,
Painting machine	air spray
Object to be painted	automobile part (medium size flat plate)
Waste water treatment	treated by the plant facility
Deodorizing device	none.

2) Paint used

Annual amount used	40,000kg/year
Composition	xylene: 25 mass%, toluene: 20mass%,2-ethoxyethyl acetate:5.0 mass%

pigment (copper salts: less than 1%):
none

3) Paint thinner

Annual amount used	20,000kg/year
Composition	toluene: 40mass%, xylene: 40 mass%

4) Cleaning thinner

Annual amount used	50,000kg/year
Composition	toluene: 40 mass%, xylene: 40 mass%

5) Estimation of transfer efficiency
The transfer efficiency is estimated to be 40% ($\eta = 0.4$) from Table-4 and process conditions.

6) Transfers in waste
Estimated for each solvent as xylene 0.2 mass% of the annual amount used : toluene 0.015 mass% of the annual amount used: 2-ethoxyethyl acetate:1 mass% of the annual amount used: (by actual measurement)

7) Amount for off-site recycling
Estimated for each solvent as xylene 31 mass% of the annual amount used : toluene 29.5 mass% of the annual amount used: 2-ethoxyethyl acetate:4 mass% of the annual amount used (by actual measurement)

8) Others
It is assumed that there is no release to land nor on-site landfills.

(2) Calculation of Releases and Transfers of Solvent ingredient

[Xylene]

1) Calculation of the annual amount of xylene handled

[1] Xylene in paint

40,000kg/year × 0.25 = 10,000kg/year

[2] Xylene in paint thinner

20,000kg/year × 0.40 = 8,000kg/year

[3] Xylene in diluted paint

[1] + [2] = 10,000 + 8,000 = 18,000kg/year

[4] Xylene in cleaning thinner

50,000kg/year × 0.40 = 20,000kg/year

[5] Annual amount of xylene handled

[3] + [4] = 18,000 + 20,000 = 38,000kg/year

2) Paint sludge

[14] Xylene in paint sludge

[5] × 0.002 = 38,000kg/year × 0.002 = 76kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 76kg/year

3) Recovered thinner

[15] Xylene in recovered thinner

[5] × 0.31 = 38,000kg/year × 0.31 = 11,800kg/year

$[15]_2$ Since recovered thinner entire amount is handed over to recycling firms,

$[15]_2$ = [15] = 11,800kg/year

4) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[14]_2$ = 76kg/year

[17] Total amount for recycling

[17] = $[15]_2$ = 11,800kg/year

5) Releases to air

[18] Potential releases to air

[5] - [16] - [17] = 38,000 - 76 - 11,800 = 26,120kg/year

[23] Releases to air

[23] = [18] = 26,120kg/year

[Toluene]

1) Calculation of the annual amount of toluene handled

[1] Toluene in paint

40,000kg/year × 0.20 = 8,000kg/year

[2] Toluene in paint thinner

20,000kg/year × 0.40 = 8,000kg/year

[3] Toluene in diluted paint

[1] + [2] = 8,000 + 8,000 = 16,000kg/year

[4] Toluene in cleaning thinner

50,000kg/year × 0.40 = 20,000kg/year

[5] Annual amount of toluene handled

[3] + [4] = 16,000 + 20,000 = 36,000kg/year

2) Paint sludge

[14] Toluene in paint sludge

[5] × 0.00015 = 36,000kg/year × 0.00015 = 5.4kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 5.4kg/year

3) Recovered thinner

[15] Toluene in recovered thinner

[5] × 0.295 = 36,000kg/year × 0.295 = 10,600kg/year

$[15]_2$ Since entire amount of recovered thinner is handed over to recycling firms,

$[15]_2$ = [15] = 10,620kg/year

4) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[14]_2$ = 5.4kg/year

[17] Total amount for recycling

[17] = $[15]_2$ = 10,620kg/year

5) Releases to air

[18] Potential releases to air

[5] - [16] - [17] = 36,000 - 5.4 - 10,620 = 25,375kg/year

[23] Releases to air

[23] = [18] = 25,375kg/year

[2-ethoxyethyl acetate]

1) Calculation of the annual amount of 2-ethoxyethyl acetate handled

[1] 2-Ethoxyethyl acetate in paint

40,000kg/year × 0.050 = 2,000kg/year

[2] 2-Ethoxyethyl acetate in paint thinner

20,000kg/year × 0 = 0kg/year

[3] 2-Ethoxyethyl acetate in diluted paint

[1] + [2] = 2,000 + 0 = 2,000kg/year

[4] 2-Ethoxyethyl acetate in cleaning thinner

50,000kg/year × 0 = 0kg/year

[5] Annual amount of 2-ethoxyethyl acetate handled

[3] + [4] = 20,000 + 0= 2,000kg/year

2) Paint sludge

[14] 2-ethoxyethyl acetate in paint sludge

[5] × 0.01 = 2,000kg/year × 0.01 = 20kg/year

$[14]_2$ Since the entire amount of paint sludge is handed over to industrial waste processors,

$[14]_2$ = [14] = 20kg/year

3) Recovered thinner

[15] 2-Ethoxyethylacetate in recovered thinner

[5] × 0.04 = 2,000kg/year × 0.04 = 80kg/year

$[15]_2$ Since entire amount of recovered thinner is handed over to recycling firms,

$[15]_2$ = [15] = 80kg/year

4) Total of waste/recycle amount

[16] Total transfers as waste

[16] = $[14]_2$ = 20kg/year

[17] Total amount for recycling

[17] = $[15]_2$ = 80kg/year

5) Releases to air

[18] Potential releases to air

[5] - [16] - [17] = 2,000 - 20 - 80 = 1,900kg/year

[23] Releases to air

[23] = [18] = 1,900kg/year

Work Sheet (2) Entry Example <Calculation Example 5> ---Painting of Automobile Parts---

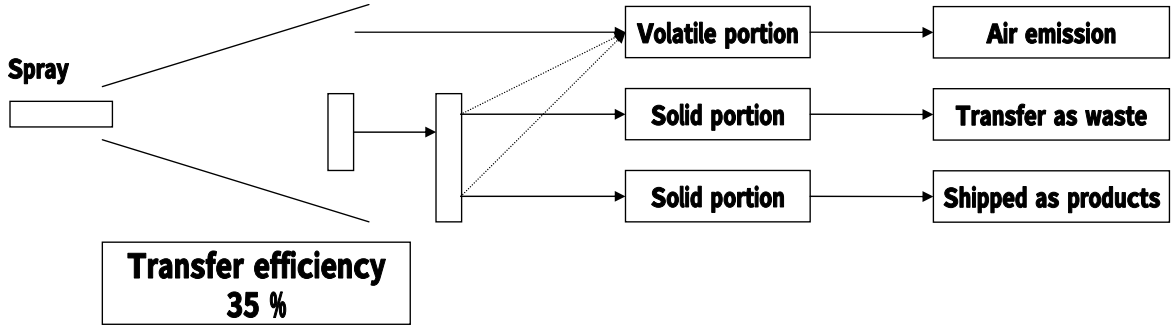
		(i)	(ii)	(iii) Releases and transfers of wastewater		(iv)	(v)	(iv) Transfers contained in waste						(vii) Transfers for recycling				(viii) Releases to air		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	S	
		Annual amount of Class I Substances handled	Amount Shipped in product	Releases to water bodies	Transfers to POTWs	Releases to land	On-site landfills	Waste paint	Oil booth waste oil	Paint sludge (indusrial waste)	Paint sludge burnt ash	Re-covered thinner	Total	Waste paint	Oil booth waste oil	Recovered thinner	Total	Without deodorizing treatment	With deodorizing treatment	
																			R Removed amount	
		[5]	[8]	[9] or [10] is entered into C or D		[13]	$[14]_1$	$[6]_1$	$[12]_1$	$[14]_2$	$[14]_3$	$[15]_1$	[16]	$[6]_2$	$[12]_2$	$[15]_2$	[17]	[23]	[21]	[24]
Solvent/thinner	Xylene	38,000								80			80			11,800	11,800	26,120		
	Toluene	36,000								5.4			5.4			10,600	10,600	25,395		
	2-ethoxyethyl acetate	2,000								20			20			80	80	1,900		
Pigment																				
Others																				

< Calculation Example 6> Painting Process in Casting Industry

Calculation procedure of releases and transfers in painting process of casting products

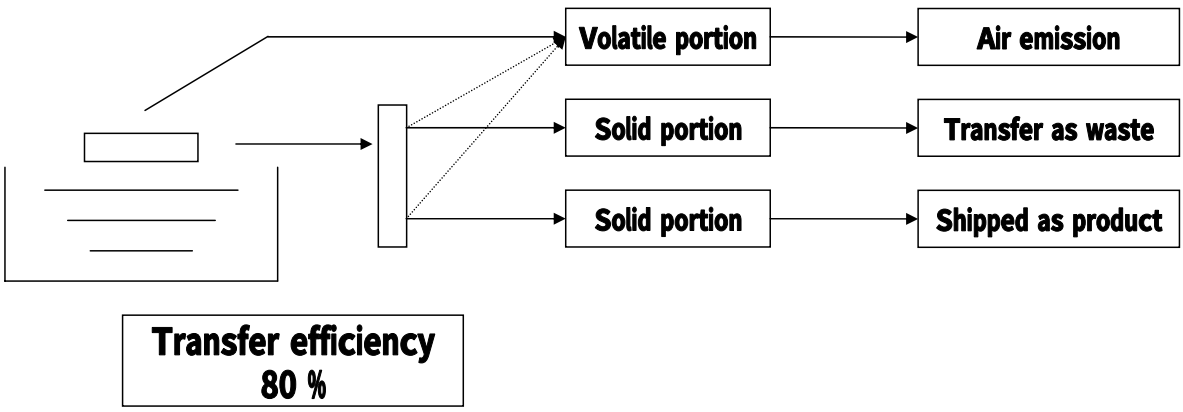
- In fig.4, painting process in the general manufacturing diagram of casting products, and in fig.5 an example of painting process diagram are shown.
- In the actual paint for air spray(A) and for dipping(C) in Table-9, no Class Ⅰ Designated Chemical Substance was contained, and so, for calculation example, imaginary paints B and D were chosen.
- Suppose a casting product to be painted is medium-sized, choose 35% for air spray line and 80% for dipping line as transfer efficiencies
- Annual amount of paint handled Q is supposed to be 10 tons.

Air spray painting of a casting product



			Q= 10 tons
Pigments	Chromium(III) 1% content	Q × 0.01 × 0.65= 0.0065Q = 65kg	transferred as waste
		Q × 0.01 × 0.35= 0.0035Q = 35kg	shipped as product
	Lead and its 2% conten	Q × 0.02 × 0.65= 0.013Q = 130kg	transferred as waste
		Q × 0.02 × 0.35= 0.0070Q = 70kg	shipped as product
Solvents	Xyrene 5% content	Q × 0.05 × 1= 0.05Q= 500kg	release to air
	Toluene 2% content	Q × 0.02 × 1= 0.02Q = 200kg	release to air

Dipping Process of a casting product



Pigments	Chromium(III) 2% content	Q × 0.02 × 0.2= 0.004Q = 400kg	transferred as waste
		Q × 0.02 × 0.8= 0.016Q = 160kg	shipped as product
	Lead and its 3% content	Q × 0.03 × 0.2= 0.006Q = 60kg	transferred as waste
		Q × 0.03 × 0.8 = 0.024Q = 240kg	shipped as product
Solvent	Xyrene 45% content	Q × 0.45 × 1= 0.45Q= 4,500kg	release to air

Fig.4 Releases from Painting Process in the General Manufacturing Diagram of Casting Products

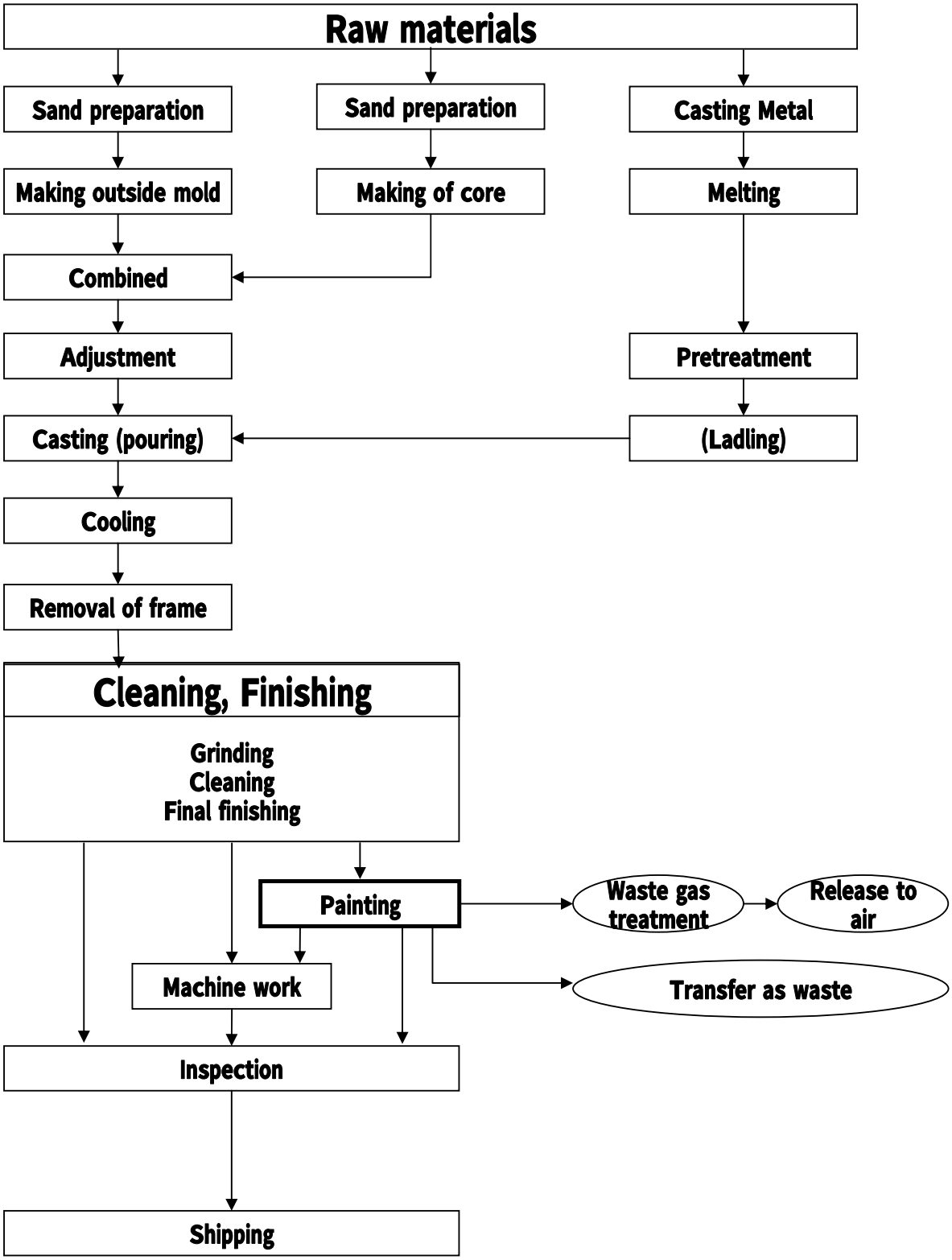


Fig.5 Example of Painting Process of Casting Products

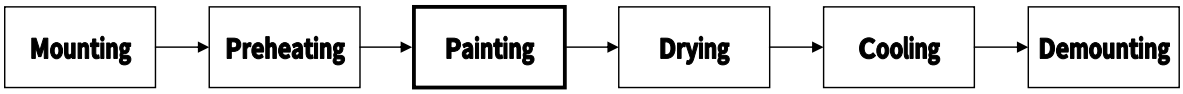


Table-9 Standard Composition of Paints for PRTR Calculation

Class I Designated Chemical Substances		Air spray		Dipping	
		A	B	C	D
Pigments	Chromium compound	0%	1%	0%	2%
	Lead compound	0%	2%	0%	3%
	Zinc compound	0%	0%	0%	0%
Solvent	Xylene	0%	5%	0%	45%
	Toluene	0%	2%	0%	0%
Other Chemicals		100%	90%	100%	50%

Table 10 Estimation of transfer efficiency in painting process of casting products

Painting process	Casting Product			General products
	Large size	Medium size	Small size	
Air spray	40%	35%	30%	30-40%
Airless spray	60%	55%	50%	50-60%
Electrostatic air	--	60%	50%	50-60%
Electrostatic airless	--	70%	65%	65-75%
Dipping	--	80%	80%	80-90%

Example of large size Casting Products

Worktable of machine tool、framework of printing machine, engine parts of ship

Example of medium size Casting Products

Engine parts of automobile, housing of transmission, oil pressure valve

Example of small size Casting Products

Casting products for electric goods, joint parts, etc.

< Calculation Example 7> Painting Process in Shipbuilding

1. Painting process in general

(Steel Plate to be coated):

Hot Rolled Steel Plate with mill scale is supplied.

↓

Shop primer coating

To keep from rusting and corrosion in fabrication and construction process, and to make painting process afterwards easier, the surface of steel plates is undercoated. As shop primer coating process is usually exclusive and automated within doors, paint dust is not scattered outdoors. Some shipyards purchase primer coated steel plates from mill makers, to omit shop primer coating within shipyard.

↓

(Welding, Cutting, Bending):

Undercoated steel plates are processed to fabricate each block of the hull.

↓

Painting/coating of blocks:

Before construct the hull by assembling blocks, each block above mentioned is painted either in the exclusive process indoors, or in general multi-purpose process outdoors. In the latter case, while over sprayed paint dust is scattered in shipyard mostly, a small part of paint dust is scattered to outside of shipyard.

↓

Construction of hull by assembling blocks:

Painted/coated blocks are transferred to building berth or building dock, and hull is constructed by jointing all the blocks.

↓

(Launching):

The ship is launched after constructed.

↓

Painting of subdivision:

Painting after the hull is constructed is usually processed outdoors, and so over sprayed paint dust is scattered outdoors, like painting process outdoors in block fabricating stage. But, at some areas like inside of tanks, paint dust is not scattered outside of the area.

2. Painting process and releases to environment

To calculate releases to environment from painting processes in shipbuilding industry, the fundamental items are as follows.

① Airless spray painting is the most popular painting process and the amount of paint used for brush coating and roller coating is negligibly small.

② In painting processes, yield rate of paint used in painting process is not 100% of the total amount of paint used. Usually waste paint which is residual paint in containers is generated and mostly off-site transferred in waste.

③ Transfer efficiency for airless spray painting differs in painting conditions, namely, about 80% for painting process indoors, and approximately 60% for outdoors, estimated by empirical knowledge in the past.

④ From spray painting process indoors and that of enclosed subdivision, no paint mist is released to outside of shipyard, and all the paint mist is recovered, and then off-site transferred in waste.

⑤ From spray painting process outdoors and that of open subdivision, paint mist is released to outside of workshop, and a part of paint mist is scattered even to the outside of shipyard.

In this case, on average, about 80% of paint mist is released to inside of shipyard, and about 20% is scattered outside of shipyard.

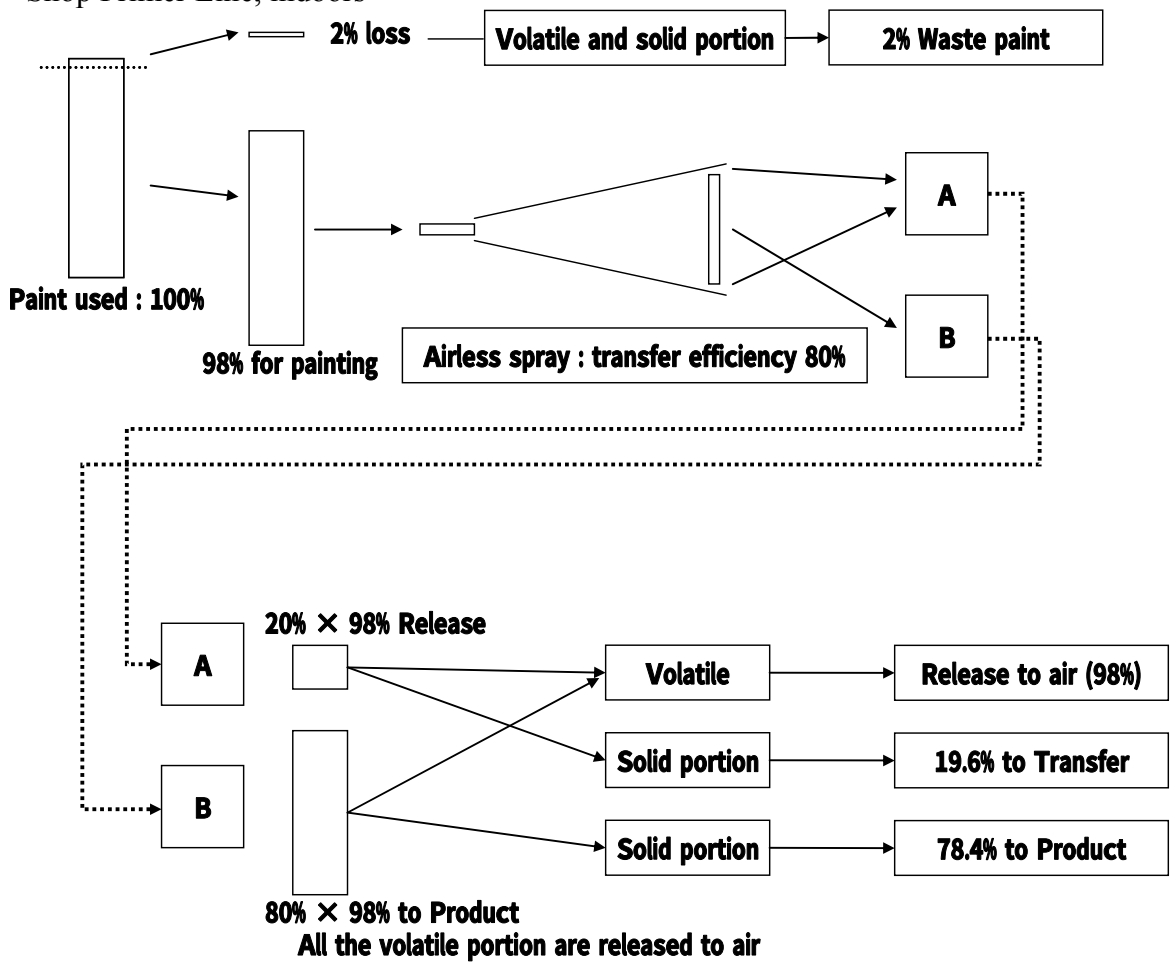
Painting process	Painting conditions	Paint loss	Transfer efficiency	Releases	
				Volatile	Solid
Shop primer coating	Automated, indoors airless spray	2%	80%	Releases to air	Transferred in waste
Block fabricating stage painting	Indoors, airless spray	5%	80%		Transferred in waste
	Outdoors, airless spray	5%	60%		80% waste 20% releases
Painting of subdivision	Closed, airless spray	5%	80%		Transferred in waste
	Open, airless spray	5%	60%		80% waste 20% releases

3.Calculation Example

3-1. Shop Primer Coating

(Coating conditions):

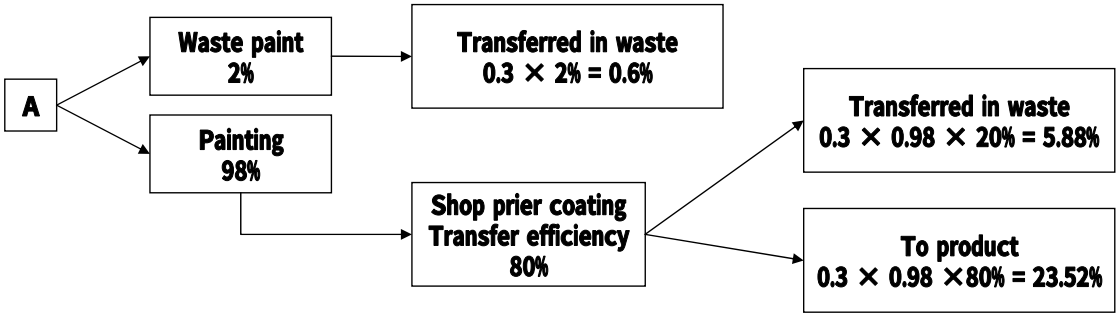
Shop Primer Line, indoors



(Calculation Example):

Shop Primer Line(Inorganic)

Class I Chemicals			Content		
	Pigments	Zinc compounds(w-s)	30%	Solid	→ A
	Solvents		---	Volatile	
Other Chemicals			70%	Solid / Volatile	



So, in the case, the amount of paint used is A Kg:

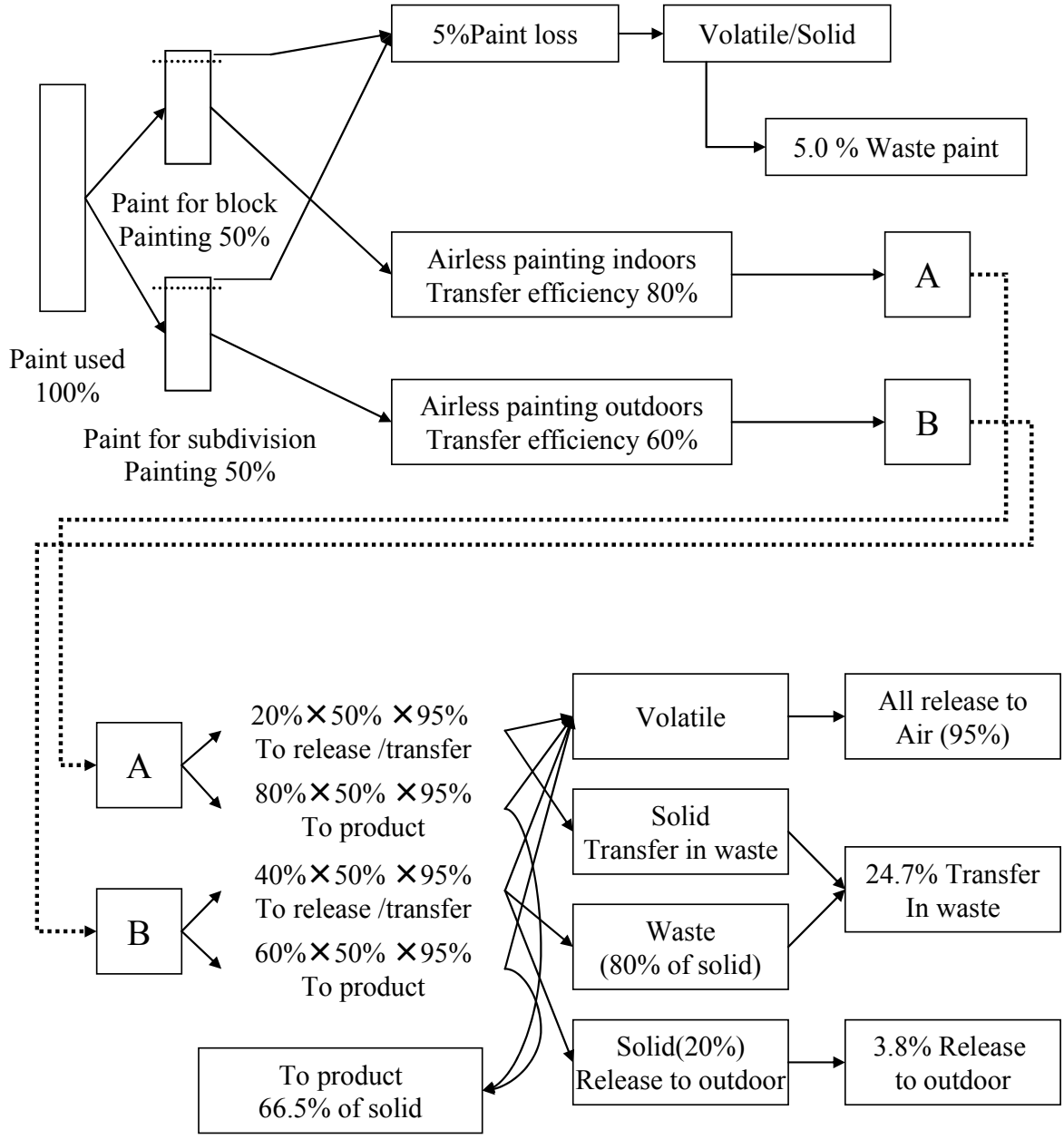
Class I Chemicals	Release / Transfer	Amount(Release / Transfer) (Kg)
Zinc componds (water-soluble)	Waste paint (transfer)	A × 0.006
	Transfer	A × 0.0588
	To product	A × 0.2352

(Notes) Zinc compound contained in this shop primer paint is powder of zinc metal, and so, not zinc compound (water-soluble). As powder of zinc metal is not designated in Class I Chemicals of the PRTR Law, reporting is not required.

3-2. Continuous painting process from block fabricating stage painting (indoors) to subdivision painting. (outdoors)

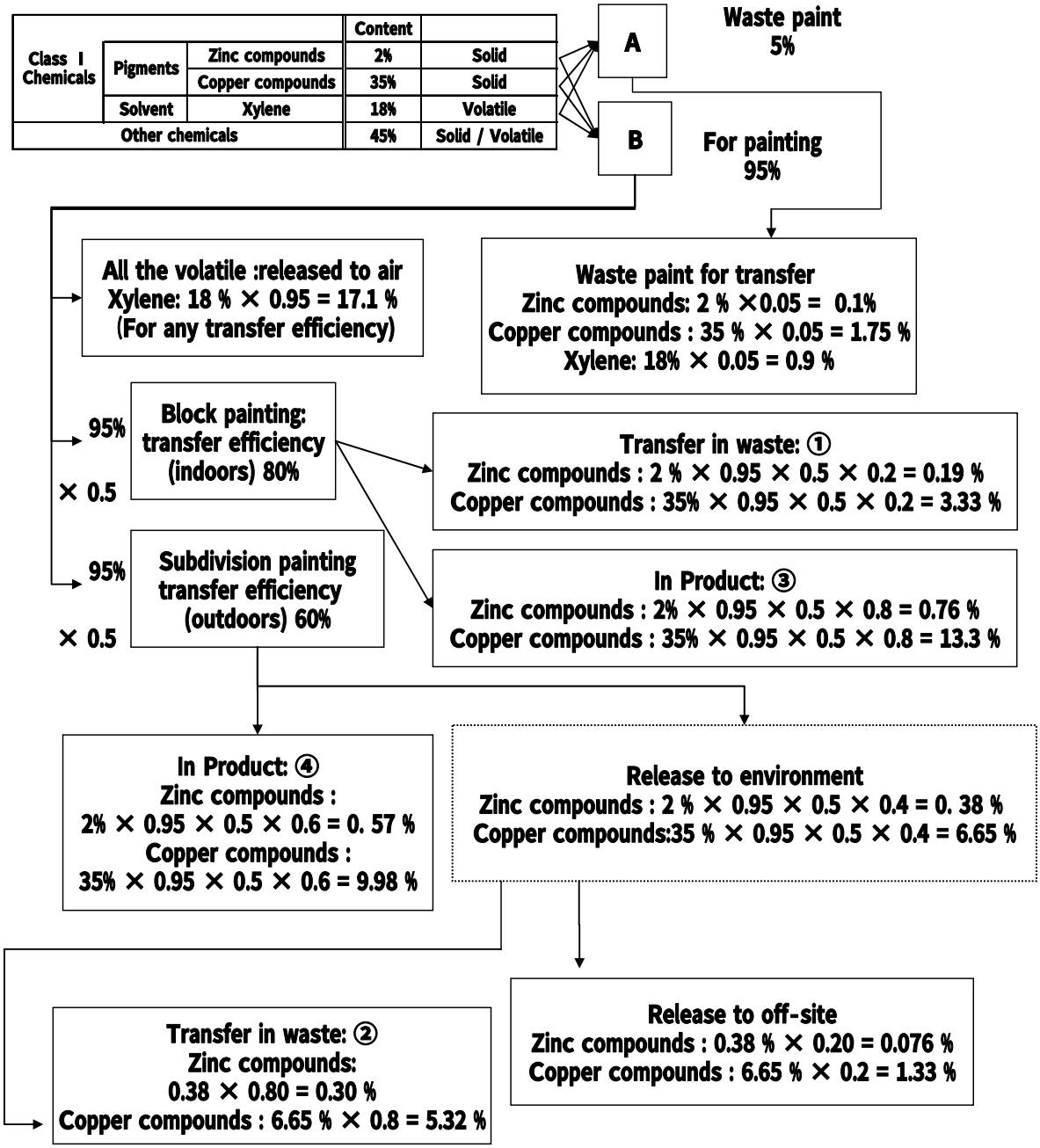
(Painting condition)

Combination of block fabricating stage painting and subdivision painting process.



(Calculation Example)

Ships bottom Antifouling Paint (Self-polishing paint)



In case the annual amount of paint used is A kg, calculation result is as follows.

Class I chemicals	Release/Transfer (media)	Amount (kg)	Notes
Zinc compound	Waste paint (transfer)	A × 0.001	
	Transfer (in waste)	A × 0.00494	① + ②
	Release to off-site	A × 0.00076	
	In product	A × 0.0133	③ + ④
Copper compound	Waste paint (transfer)	A × 0.0175	
	Transfer (in waste)	A × 0.0865	① + ②
	Release to on-site	A × 0.0133	
	In product	A × 0.233	③ + ④
Xylene	Waste paint (transfer)	A × 0.009	
	Release to air	A × 0.0171	

Table - 4.Calculation Procedure in Detail

LineNo.	Calculation item	Class I Chemicals (solvent ingredient i)	Class I Chemicals (Pigment j) (as metallic element)
①	Annual amount of Class I Chemicals handled in paint	Annual amount of solvent ingredient i handled F1i (kg/Y) =Annual amount of paint used F1(kg/Y) × concentration of solvent ingredient i(f1i) ・notes 1)concentration=mass%÷100 2)when solvent ingredient i is contained in many types of paints ,calculate for each paint and sum up them.	Annual amount of pigment j handled F1j (kg/Y) =Annual amount of paint used F1(kg/Y) × concentration of pigment j (f1j) ・notes 1) if pigment is a metallic compound, calculate as the metallic element,using metal conversion factors 2) concentration=mass%÷100 3)when pigment j is contained in many types of paints ,calculate for each paint and sum up them.
②	Annual amount handled in thinner	Annual amount of solvent ingredient i handled in thinner F2i (kg/Y) =Annual amount of thinner used F2(kg/Y) × concentration of solvent ingredient i(f2i)	
③	Annual amount handled in diluted paint	Annual amount of solvent ingredient i handled in diluted paint F12i (kg/Y) = F1i＋F2i = ① ＋ ②	Annual amount of pigment j handled in diluted paint F12j (kg/Y) = F1j ＋F2j = F1j = ①
④	Annual amount handled in cleaning thinner	Annual amount of solvent ingredient i handled in cleaning thinner F3i (kg/Y) = annual amount of cleaning thinner used × concentration of solvent ingredient i(f3i)	
⑤	Annual amount handled	Total annual amount of solvent ingredient i handled Fi (kg/Y) = F1i ＋F2i ＋F3i = ③ ＋ ④	Total annual amount of pigment j handled Fj (kg/Y) = F1j = ①
⑥	Class I Chemicals in waste paint	Annual amount of solvent ingredient i in waste paint generated (unused paint) Dpi (kg/Y) = Annual amount of waste paint Dp (kg/Y) × concentration of solvent ingredient i(dpi) ・note 1)if (dpi) is unknown, use (f1i)	Annual amount of pigment j in wastepaint generated (unused paint) Dpj (kg/Y) = Annual amount of waste paint Dp (kg/Y) × concentration of pigment j (dpj) ・note 1)if (dpj) is unknown, use (f1j)
⑥$_1$	In case waste paint is transferred as waste	Annual amount of solvent ingredient i in unused paint , transferred as waste D1i (kg/Y) = Annual amount of transfer as waste paint D1 (kg/Y) × concentration of solvent ingredient i (d1i) ・note 1)if (d1i) is unknown, use (dpi)	Annual amount of pigment j in unused paint, transferred as waste D1j (kg/Y) = Annual amount of transfer as waste paint D1 (kg/Y) × concentration of pigment j (d1j) ・note 1)if (d1j) is unknown, use (dpj)

LineNo.	Calculation item	Class I Chemicals (solvent ingredient i)	Class I Chemicals (Pigment j) (as metallic element)
⑥$_2$	In case waste paint is off-site recycled	Annual amount of solvent ingredient i in unused paint , off-site recycled R1i (kg/Y) = Annual amount of unused paint , off-site recycled R1 (kg/Y) × concentration of solvent ingredient i (r1i) ・note 1)if (r1i) is unknown, use (dpi)	Annual amount of pigment j in unused paint , off-site recycled R1j (kg/Y) = Annual amount of unused paint , off-site recycled R1 (kg/Y) × concentration of pigment j (r1j) ・note 1)if (r1j) is unknown, use (dpj)
⑦	Annual amount handled in diluted paint used	Annual amount of solvent ingredient i in diluted paint sprayed (kg/Y) = ③ - ⑥	Annual amount of pigment j in diluted paint sprayed (kg/Y) = ③ - ⑥
⑧	Annual amount shipped in product		Annual amount of pigment j shipped in product Pj (kg/Y) = ⑦ × transfer efficiency η (%÷100) ・note 1) While in the amount of diluted paint sprayed, proportional part to transfer efficiency η is shipped as product, another part(over sprayed part) is transferred as waste. 2) Transfer efficiency η is shown in [Table-6], or should be estimated by [calculation examples] 3)When multiple types of painting machines are used in the same booth, the average transfer efficiency η av should be used. (II -1-2)
⑨	Potential amount of releases to water bodies before waste water treatment	Annual amount of potential release to water bodies (before waste water treatment) of solvent ingredient i , Wi (kg/Y) = Annual amount of waste water before treatment W(kg/Y) × concentration of solvent ingredient i in waste water wi ・notes 1) In case no data is available, use wi=0.0001for water washing booth 2) In case waste water is released to POTWs, Wi (kg/Y) should be reported as off-site transfer. 3) In case waste water is released to another waste water treatment, proportionally devided amount of final release to water bodies, among the facilities concerned, should be reported as release to water bodie. 4) In case plant have not waste water treatment facility, the value ⑨, and in case have not, the value ⑩ are filled on the C and D of wark sheet (2)	

LineNo.	Calculation item	Class I Chemicals (solvent ingredient i)	Class I Chemicals (Pigment j) (as metallic element)
⑩	Release to water bodies (after wastewater treatment)	Annual amount of release to water bodies (after waste water treatment) of solvent ingredient i , $Wi^{treated}$(kg/Y) = Annual amount of waste water after treatment $W^{treated}$ (kg/Y) × concentration of solvent ingredient i in waste water after treatment $wi^{treated}$ = Annual amount of potential release to water bodies (before waste water treatment) of solvent ingredient i , Wi (kg/Y) × (1-removal efficiency) ・notes 1)In case removal efficiency is unknown, refer to Table-10.	
⑪	Annual amount of class I chemicals re-moved by wastewater treatment	Annual amount removed by waste water treatment $Wi^{removed}$ (kg/Y) = Wi (kg/Y) × removal efficiency = Wi -$Wi^{treated}$ = ⑨ - ⑩ ・notes 1) In this case, class I chemicals are just released to air by aeration ,different from treatment by the activated sludge method.	
⑫	Annual amount of solvent ingredient i in waste oil (oil booth)	Annual amount of solvent ingredient i in waste oil from oil booth, Doi (kg/Y) = Annual amount of waste oil Do (kg/Y) × concentration of solvent ingredient i (doi) ・notes 1) In case no data is available, use doi = 0.001for oil booth (Reference-1)	
$⑫_1$	In case waste oil is off-site transferred as waste	Annual amount of solvent ingredient i in waste oil off-site transferred D2i (kg/Y) = Annual amount of waste oil transferred D2 (kg/Y) × concentration of solvent ingredient i (d2i) ・notes 1) In case no data is available, use d2i=doi	

LineNo.	Calculation item	Class I Chemicals (solvent ingredient i)	Class I Chemicals (Pigment j) (as metallic element)
⑬	Releases to land	Annual amount of solvent ingredient i released to land L1i (kg/Y) = Annual amount released to land L1 (kg/Y) × concentration of solvent ingredient i (l1i) ・notes 1)Lli should be estimated by records of accident, repair,daily reports, sampling , etc.	Annual amount of pigment j released to landL1j (kg/Y) = Annual amount released to land L1 (kg/Y) × concentration of pigment j (l1j) ・notes 1)Lli should be estimated by records of accident, repair,daily reports, sampling , etc.
⑭	Annual amount of solvent ingredient in paint sludge	Annual amount of solvent ingredient i in paint sludge Dsi (kg/Y) = Annual amount of paint sludge Ds (kg/Y) × concentration of solvent ingredient i (dsi) ・notes 1) In case no data is available for (dsi), use (dsi) = 0.002 (Reference-2)	Annual amount of pigment j in paint sludge Dsj (kg/Y) = Annual amount of paint sludge Ds (kg/Y) × concentration of pigment j in paint sludge (dsj) Or, = ⑦-⑧
⑭$_1$	In case paint sludge is on-site landfilled	Annual amount of solvent ingredient i in paint sludge landfilled L2i (kg/Y) = Annual amount of paint sludge landfilled L2 (kg/Y) × concentration of solvent ingredient i (l2i) ・notes 1) In case no data is available for (l2i) , assume (l2i) =dsi	Annual amount of pigment j in paint sludge landfilled L2j (kg/Y) = Annual amount of paint sludge landfilled L2 (kg/Y) × concentration of pigment j (l2j) ・notes 1) In case no data is available for (l2j) , assume (l2j) =dsj
⑭$_2$	In case paint sludge is off-site transferred as waste	Annual amount of solvent ingredient i in paint sludge off-site transferred D3i (kg/Y) = Annual amount of paint sludge transferred D3 (kg/Y) × concentration of solvent ingredient i (d3i) ・notes 1) In case no data is available for (d3i) , assume (d3i) =dsi	Annual amount of pigment j in paint sludge off-site transferred D3j (kg/Y) = Annual amount of paint sludge transferred D3 (kg/Y) × concentration of pigment j (d3j) ・notes 1) In case no data is available for (d3j) , assume (d3j) =dsj
⑭$_3$	In case paint sludge is on-site incinerated		Annual amount of pigment j in ash generated by incineration off-site transferred D4j = Annual amount of ash generated by incineration off-site transferred D 4 (kg/Y) × concentration of pigment j (d4j) in ash ・notes 1) In case incinerator furnace with the total grate area of 0.5m2 or more or the total burning capacity of 50kg/hour or more, the reporting of dioxins is also necessary.

LineNo.	Calculation item	Class I Chemicals (solvent ingredient i)	Class I Chemicals (Pigment j) (as metallic element)
⑮	Annual amount of solvent ingredient in recovered thinner	Annual amount of solvent ingredient i in recovered thinner Dri (kg/Y) = Annual amount of recovered thinner Dr (kg/Y) × concentration of solvent ingredient i (dri) in recovered thinner	
⑮$_1$	In case recovered thinner is off-site transferred as waste	Annual amount of solvent ingredient i in recovered thinner D5i (kg/Y) = Annual amount of recovered thinner off-site transferred D5 (kg/Y) × concentration of solvent ingredient i (d5i) in recovered thinner	
⑮$_2$	In case recovered thinner is off-site recycled	Annual amount of solvent ingredient i in recovered thinner off-site recycled R3i (kg/Y) = Annual amount of recovered thinner off-site recycled R3 (kg/Y) × concentration of solvent ingredient i (r3i) in recovered thinner	
⑯	Total annual amount of off-site transfers as waste	Total annual amount of solvent ingredient i off-site transferred as waste Di (kg/Y) = D1i ＋D2i ＋D3i ＋D5i = ⑥$_1$＋⑫$_1$＋⑭$_2$＋⑮$_1$	Total annual amount of pigment j off-site transferred Dj (kg/Y) = D1j ＋D3j ＋D4j = ⑥$_1$＋⑭$_2$＋⑭$_3$
⑰	Total annual amount of off-site recycled	Total annual amount of solvent ingredient i off-site recycled Ri (kg/Y) = R1i ＋R2i ＋R3i = ⑥$_2$＋⑫$_2$＋⑮$_2$	Total annual amount of pigment j off-site recycled Rj (kg/Y) = R1j = ⑥$_2$
⑱	Potential amount of releases to air	Potential annual amount of releases to air Ai (kg/Y) = ⑤- {⑨ or ⑩} -⑬ -⑭$_1$ -⑯-⑰	
⑲	Releases from drying furnace before treatment	Annual amount of releases from drying furnace before treatment A2i (kg/Y) = ⑦ × transfer efficiency η (%÷100) × drying furnace transfer rate α ・notes 1)Transfer efficiency η is shown in [Table-5], or should be estimated by [calculation examples] 2))When multiple types of painting machines are used in the same booth, the average transfer efficiency ηav should be used. (II -1-2) 3) η (%÷100) × α of volatile components V in diluted paint is supposed to be introduced to drying furnace,and then to deodorizing device (Fig. 2) 4) In case α is unknown, α=0.1, because experimentally α=0.1～0.3	

LineNo.	Calculation item	Class I Chemicals (solvent ingredient i)	Class I Chemicals (Pigment j) (as metallic element)
⑳	Releases from deodorizing device	Annual amount of releases from deodorizing device $A2i^{treated}$ (kg/Y) = Releases from drying furnace A2i (kg/Y) × (1-removal efficiency) ・notes 1)In case removal efficiency is unknown, see (Reference-3)	
㉑	Annual amount re-moved by deodorizing device	Annual amount removed by deodorizing device $A2i^{removed}$(kg/Y) = Annual amount of releases from drying furnace A2i (kg/Y) × (removal efficiency) = A2i - A2itreated = ⑲ - ⑳ = $A2it^{removed}$	
㉒	Releases from painting booth	Releases from painting booth to air A1i (kg/Y) = ⑱ - ⑲	
㉓	Releases to air (no deodorizing device)	⑱	
㉔	Total releases to air (with deodorizing device)	⑳+㉒	

Table-5 List of Symbols

Symbol	Name	Unit
A1i	Releases of solvent ingredient i from coating booth	kg/year
A2i	Releases of solvent ingredient i from dry furnace	kg/year
$A2i^{treated}$	Releases of solvent ingredient i from dry furnace after deodorizing treatment	kg/year
$A2i^{removed}$	Removed amount by deodorizing device	kg/year
Ai	Potential (before treatment) releases of solvent ingredient i to air (= A1i + A2i)	kg/year
Do	Oil booth waste oil generation amount	kg/year
doi	Content of solvent ingredient i in oil booth waste oil	Mass% ÷ 100
Doi	Amount of solvent ingredient i in oil booth waste oil	kg/year
Dp	Amount of waste paint (unused paint) generated	kg/year
dpi	Content of solvent ingredient i in waste paint	Mass% ÷ 100
dpj	Content of pigment component j in waste paint	Mass% ÷ 100
Dpi	Amount of solvent ingredient i in waste paint	kg/year
Dpj	Amount of pigment component j in waste paint	kg/year
Dr	Amount of recovered thinner generated	kg/year
dri	Content of solvent ingredient i in recovered thinner	Mass% ÷ 100
Dri	Amount of solvent ingredient i in recovered thinner	kg/year
Ds	Amount of paint sludge generated	kg/year
dsi	Content of solvent ingredient i in paint sludge	Mass% ÷ 100
dsj	Content of pigment component j in paint sludge	Mass% ÷ 100
Dsi	Amount of solvent ingredient i in paint sludge	kg/year
Dsj	Amount of pigment component j in paint sludge	kg/year
D1	Transfers of waste paint as waste	kg/year
d1i	Content of solvent ingredient i in waste paint as waste	Mass% ÷ 100
d1j	Content of pigment component j in waste paint as waste	Mass% ÷ 100
D1i	Transfers of solvent ingredient i in waste paint as waste	kg/year
D1j	Transfers of pigment component j in waste paint as waste	kg/year
D2	Transfers of oil booth waste oil as waste	kg/year
d2i	Content of solvent ingredient i in oil booth waste oil as waste	Mass% ÷ 100
D2i	Transfers of solvent ingredient i in oil booth waste oil as waste	kg/year
D3	Transfers of paint sludge as waste	kg/year
d3i	Content of solvent ingredient i in paint sludge residual as waste	Mass% ÷ 100
d3j	Content of pigment component j in paint sludge residual as waste	Mass% ÷ 100
D3i	Transfers of solvent ingredient i in paint sludge as waste	kg/year
D3j	Transfers of pigment component j in paint sludge as waste	kg/year
D4	Transfers of burnt ash as waste	kg/year
d4j	Content of pigment component j in burnt ash as waste	Mass% ÷ 100
D4j	Transfers of pigment component j in burnt ash as waste	kg/year
D5	Transfers of recovered thinner as waste	kg/year
d5i	Content of solvent ingredient i in recovered thinner as waste	Mass% ÷ 100
D5i	Transfers of solvent ingredient i in recovered thinner as waste	kg/year
Di	Total transfers of solvent ingredient i as waste (= D1i + D2i + D3i + D5i)	kg/year
F1	Annual amount of paint handled	kg/year
f1i	Content of solvent ingredient in paint	Mass% ÷ 100
f1j	Content of pigment component j in paint	Mass% ÷ 100
F1i	Annual amount of solvent ingredient i in paint handled	kg/year
F1j	Annual amount of pigment component j in paint handled	kg/year
F2	Annual amount of paint thinner handled	kg/year
f2i	Content of solvent ingredient i in paint thinner	Mass% ÷ 100
F2i	Annual amount of solvent ingredient i in thinner handled	kg/year
F12	Annual amount of diluted paint handled (= F1 + F2)	kg/year
f12i	Content of solvent ingredient i in diluted paint	Mass% ÷ 100
F12i	Annual amount of solvent ingredient i in diluted paint handled (= F1i + F2i)	kg/year
f12j	Content of pigment component j in diluted paint	Mass% ÷ 100
F12j	Annual amount of pigment component j in diluted paint handled (= F1j)	kg/year

Symbol	Name	Unit
F3	Annual amount of cleaning thinner handled	kg/year
f3i	Content of solvent ingredient i in cleaning thinner	Mass% ÷ 100
F3i	Annual amount of solvent ingredient i in cleaning thinner handled	kg/year
Fi	Annual amount of solvent ingredient i handled (= F1i + F2i + F3i)	kg/year
Fj	Annual amount of pigment component j handled (= F1j)	kg/year
i	Representing solvent ingredient i	
j	Representing pigment component j	
L1	Annual amount of leakage to land etc.	kg/year
l1i	Content of solvent ingredient i in leaked solution etc. to land	Mass% ÷ 100
l1j	Content of pigment component j in leaked solution etc. to land	Mass% ÷ 100
L1i	Releases of solvent ingredient i to land	kg/year
L1j	Releases of pigment component j to land	kg/year
L2	Onsite landfills	kg/year
l2i	Content of solvent ingredient i in the onsite landfills	Mass% ÷ 100
l2j	Content of pigment component j in the onsite landfills	Mass% ÷ 100
L2i	Onsite landfills of solvent ingredient i	kg/year
L2j	Onsite landfills of pigment component j	kg/year
P	Production amount of product	kg/year
pj	Content of pigment component j in product	Mass% ÷ 100
Pj	Amount of pigment component j shipped as product	kg/year
R1	Amount of waste paint (unused paint)sent offsite for recycling	kg/year
r1i	Content of solvent ingredient i in waste paint sent offsite for recycling	Mass% ÷ 100
r1j	Content of pigment component j in waste paint sent offsite for recycling	Mass% ÷ 100
R1i	Amount of solvent ingredient i included in waste paint sent offsite for recycling	kg/year
R1j	Amount of pigment component j included in waste paint sent offsite for recycling	kg/year
R2	Amount of oil booth waste oil sent offsite for recycling	kg/year
r2i	Content of solvent ingredient i in oil booth waste oil	Mass% ÷ 100
R2i	Amount of solvent ingredient i included in oil booth waste oil sent offsite for recycling	kg/year
R3	Amount of recovered thinner sent offsite for recycling	kg/year
r3i	Content of solvent ingredient i in recovered thinner sent offsite for recycling	Mass% ÷ 100
R3i	Recycled amount of solvent ingredient i included in recovered thinner	kg/year
Ri	Total transfers of solvent ingredient i sent offsite for recycling (= R1I + R2I + R3I)	kg/year
S	Solid content in diluted paint (solids: resin + pigment)	kg/year
V	Solvent ingredient in diluted paint (VOC)	kg/year
W	Annual amount of wastewater before wastewater treatment	kg/year
wi	Content of solvent ingredient i in wastewater before treatment	Mass% ÷ 100
Wi	Potential releases of solvent ingredient i to wastewater (before treatment)	kg/year
$Wt^{treated}$	Annual amount of wastewater discharged after wastewater treatment	kg/year
$Wi^{treated}$	Content of solvent ingredient i in wastewater after treatment	Mass% ÷ 100
$Wi^{treated}$	Releases of solvent ingredient i after wastewater treatment	Kg/year
wV	Content of solvent (VOC) in wastewater before treatment	Mass% ÷ 100
$Wi^{re-moved}$	Removed amount by wastewater treatment facility	kg/year
α	Dry furnace transfer rate	Mass% ÷ 100
Y	Rate of Solvent ingredient transferred to water excepting Solvent ingredient take into dry furnace	Mass% ÷ 100
η	Transfer efficiency	Mass% ÷ 100
η av	Average transfer efficiency η av = Σ (coating machine transfer efficiency × load rate) Load rate = using time period for coating machine (minute/cycle)/cycle time period of the booth (minute) Or Load rate = amount of paint used for coating machine (kg/cycle) amount of paint used of the booth (kg/cycle) where Σ (load rate) = 1.0	Mass% ÷ 100

Table-6 Transfer Efficiency Table

		Flat plate	Beverage can		Large diameter pipe	Aluminum building material	Automobile		Electric appliance	Wood building material	Construction equipment railway vehicle
			Inner surface	Outer surface			Face coating	Inside			
Air atomized spray		40～50%	50～60%	20～30%	-	20～30%	20～30%	40～50%	30～40%	40～50%	50～60%
Low pressure air		50～60%	60～70%	30～40%	-	30～40%	-	50～60%	40～50%	50～60%	50～60%
Airless		60～70%	80～90%	60～70%	70～80%	40～50%	-	-	-	60～70%	60～70%
Air airless		65～75%	80～90%	60～70%	75～85%	40～50%	-	-	-	65～75%	65～75%
Electrostatic	Air	60～70%	-	60～70%	-	60～70%	40～50%	70～80%	60～70%	60～70%	65～75%
	Air airless	70～80%	-	80～90%	-	65～75%	-	-	-	70～80%	70～80%
	Bell	80～90%	-	-	-	75～85%	60～70%	-	70～80%	80～85%	80～90%
	Disk	-	-	-	-	-	-	-	-	-	-

Based on values from coating machine makers.

Reference-1(Table-7)　　Analysis Results of Solvent ingredients in Waste Solution

	Water washing booth	Oil booth
Toluene ppm (average)	～10	120～1300 (550)
Xylene ppm (average)	～70 (30)	170～720 (360)

(Based on analysis results of 5 water washing booths and 2 oil booths.)

Reference-2(Table-8)　　Analysis Results of Solvent ingredients in Paint Sludge

	Water washing booth	Oil booth	Total average
Water content %	54.5	-	54.5
Toluene ppm (average)	70～7800 (950)	110～990 (490)	820
Xylene ppm (average)	50～6700 (1200)	130～720 (450)	980

(Based on analysis results of 5 water washing booths and 2 oil booths.)

Reference-3(Table-9) Removal efficiency and decomposition rate (%) of exhaust gas treatment devices

Name of treatment device	Substance to be treated					
	Dust particles		Gaseous organic compound		Gaseous inorganic compound	
Cyclon	60	(0)	0	(0)	0	(0)
Bug filter	90	(0)	0	(0)	0	(0)
Electric dust collector	90	(0)	0	(0)	0	(0)
Combustion equipment	0	(0)	99.5	(99.5)	0	(0)
Absorber (scrubber)	80	(0)	0	(0)	80	(80)
Activated carbon adsorber	10	(0)	80	(0)	50	(0)

Reference-4(Table-10) Removal efficiency and decomposition rate (%) of effluent treatment devices

Type of treatment device	Substance to be treated							
	Suspended inorganic compound		Suspended organic compound		Soluble inorganic compound		Soluble organic compound	
General precipitation device	40	(0)	20	(0)	0	(0)	0	(0)
Coagulating sedimentation device	80	(0)	70	(0)	0	(0)	0	(0)
Microbial decomposing device	70	(0)	70	(30)	0	(0)	60	(40)
Membrane filter	100	(0)	100	(0)	0	(0)	0	(0)
Activated carbon adsorber	10	(0)	10	(0)	20	(0)	80	(0)