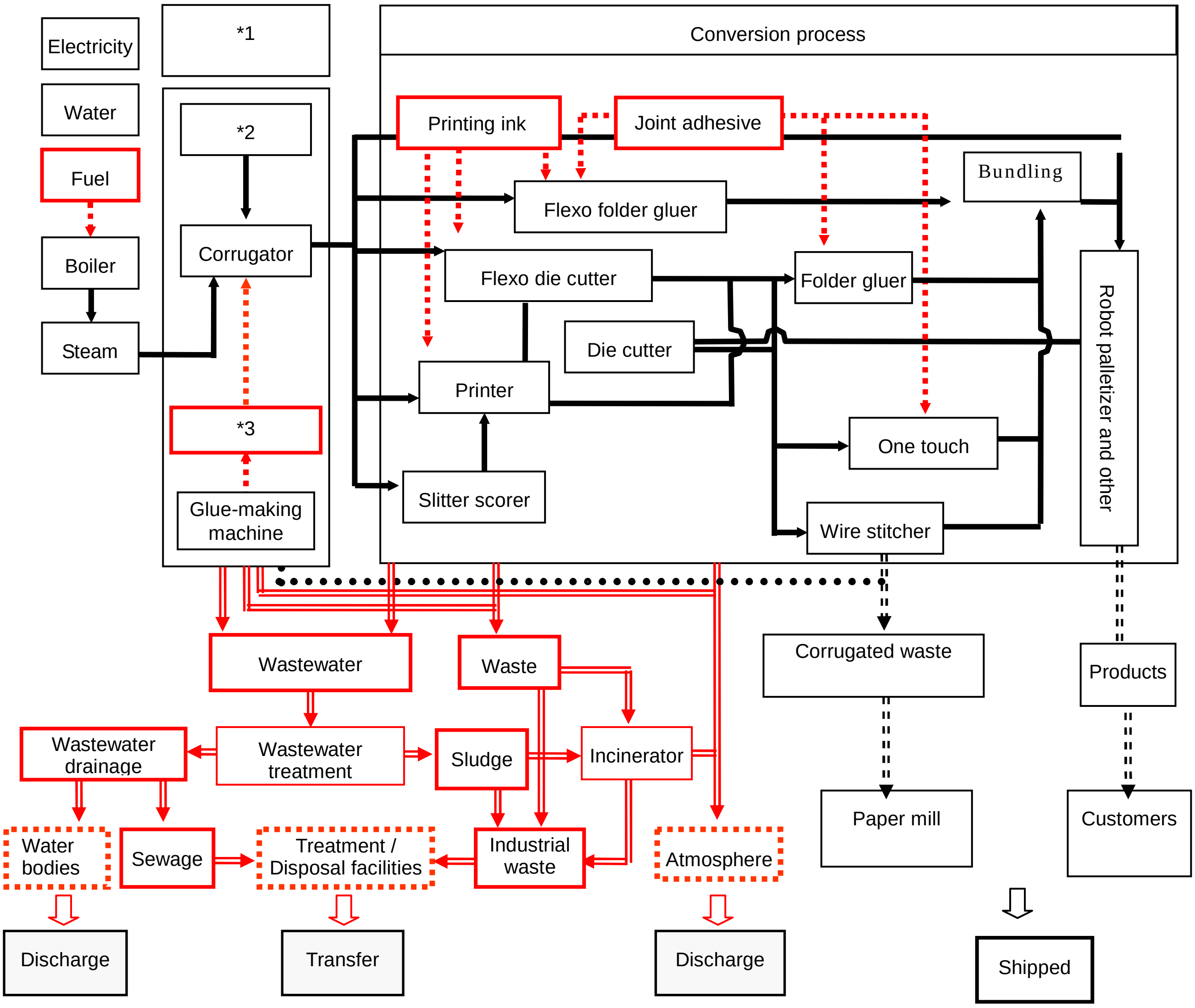
24.Corrugated Packaging Industry

1. Outline of Manufacturing Process and Materials Utilized

The manufacture of corrugated packaging can be roughly classified into two processes: the containerboard combining process, which glues one or more sheets of fluted corrugating medium to one or more flat facings of linerboard; and the box manufacturing process, which is used to assemble the corrugated sheets into boxes. Figure 1 depicts the typical manufacturing process flow and the auxiliary facilities that are used at a corrugated packaging plant.

Figure 1 Overview of Manufacturing Process Flow for Corrugated Packaging



The discharge of all Class I Designated Chemical Substances, at the points indicated by the dotted boxes [graphic], are subject to reporting.

*1 Containerboard combining process *2 Containerboard *3Adhesives for combining

1) Primary Materials and Energies Utilized in the Corrugated Packaging Industry

(1) Containerboard (linerboard, corrugating medium)
(2) Adhesives for combining (starch = corn starch, caustic soda, borax / boric acid)
(3) Printing ink (flexo ink, quick drying ink, OP varnish)
(4) Joint adhesives (vinyl acetate emulsion adhesives)
(5) Energy sources (electricity, gas / heavy oil / kerosene, water)
(6) De-oxygenating agent for boiler, neutralizer
(7) Bundling materials (PP bands, stretch film, baling twine, etc.)
(8) Other materials (water treatment agents, lubricating oils, paints)

2) Details of Primary Materials Utilized for the Manufacture of Corrugated Board and Corrugated Boxes

(1) Containerboard

In general, paper that has a greater basis weight and thickness than that of regular paper is collectively referred to as paperboard. Among all the types of paperboard, those that are utilized particularly for the manufacture of corrugated packaging are referred to as containerboard. This containerboard is classified, as shown in Table 1, in accordance with the statistics and classifications specified by the Ministry of Economy, Trade and Industry - Classification Table for Paperboard Types.

Table 1 Extracted from the Classification Table for Paperboard Types

Paperboard Type	Description of Cardboard Types
Containerboard	
Linerboard *1	
Kraft Linerboard	Containerboard made primarily from kraft pulp, that is used for the top and bottom surfaces of corrugated boards. For use as shipping container for corrugated boxes.
Jute Linerboard	A top layer, made of kraft pulp, is laminated to a middle layer and a bottom layer, which are both composed of waste paper. Utilized for both top and bottom surfaces of corrugated boards. For use as

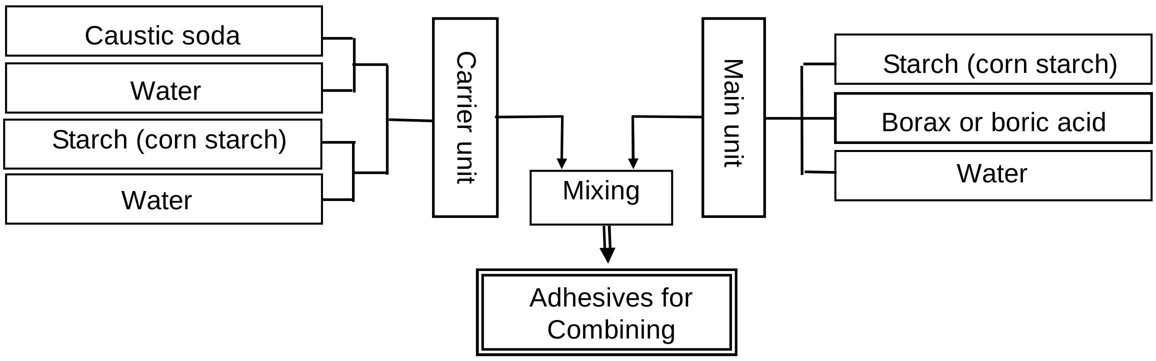
		shipping container for corrugated boxes.
	Recycled Linerboard	Primarily composed of waste paper, it does not possess sufficient strength to meet JIS standards. Utilized mainly for inner boxes and inner partitions for corrugated packaging.
Corrugating Medium [*2]		
	Semi-chemical corrugating medium	Primarily composed of pulp and utilized for "flutes" within corrugated boards.
	Recycled corrugating medium	Primarily composed of waste paper and utilized for "flutes" within corrugated boards.

[*1]: Linerboard for outer packing is regulated under JIS P 3902. However, there are no classifications that differentiate between kraft linerboard and jute linerboard. Linerboard is only classified by strength, into classes AA, A, B and C.

[*2]: Corrugating medium are regulated under JIS P 3904. However, there are no classifications that differentiate between pulp coreag

The adhesive for combining is a bonding agent used to adhere the wave-shaped flutes to the front and back linerboard. The main ingredient of this type of glue is starch. As described within this document, caustic soda is used to reduce the gelatinizing temperature of the starch. Either borax or boric acid is used to add viscosity and to increase adhesion at the time of initial application.

Figure 2 Typical Adhesives for Combining Ingredients and Glue Manufacture Process Flow



□ Printing Inks

Printing for corrugated packaging has evolved from the use of oil-based inks to quick drying inks and now to flexo inks, which are most common. The use of oil-based inks has almost completely ceased and even quick drying inks are now utilized only occasionally. The special characteristics of each type of ink are shown in Table 2.

Table 2 Characteristics of Printing Inks Used for Corrugated Packaging

		Oil-based inks	Quick drying inks	Flexo inks
Ink Characteristics				
	Composition of vehicle	Contains dissolved drying oils and synthetic resins	Contains dissolved glycol and synthetic resins	Alkali aqueous solution of synthetic resins, emulsion
	Drying mechanism	Oxygen polymerization	Absorption and permeation	Absorption and evaporation
	Drying time	4 – 5 hours	20 – 30 minutes	0.5 – 1 second
	Ink viscosity	100 – 200 poises	100 – 200 poises	2 – 3 poises
Characteristics of Printed Material				
	Film thickness	8-10 microns	5-8 microns	4 – 6 microns
	Resistance to light	Good – Excellent	Good – Excellent	Good – Excellent
	Gloss	Excellent	Excellent – Good	Good
	Abrasion resistance	Excellent	Good	Good

□ Joint Adhesives

Figure 4 depicts the methods used to glue the joint when manufacturing the most common type of general-purpose corrugated box, as shown in Figure 3 (type 02 – refer to JIS Z 1507). Currently, of the methods shown below, an extremely efficient gluing method (glue joint method) employing high strength adhesive is most widely utilized.

The machines that are used to form boxes with this glue joint method are called “folder gluers”. Folder gluer machines generally utilize vinyl acetate emulsion adhesives, in particular, those adhesives containing di-n-butyl-phthalate and xylene (or toluene), in order to improve heat resistance, cold resistance and drying speed. However, new adhesives have recently been introduced to the market, which contain significantly reduced amounts of di-n-butyl-phthalate in order to meet the standards prescribed under the PRTR Law. Therefore, it is expected that, in the near future, the adhesives used shall make the transition to substances that no longer employ Class I Designated Chemical Substances.

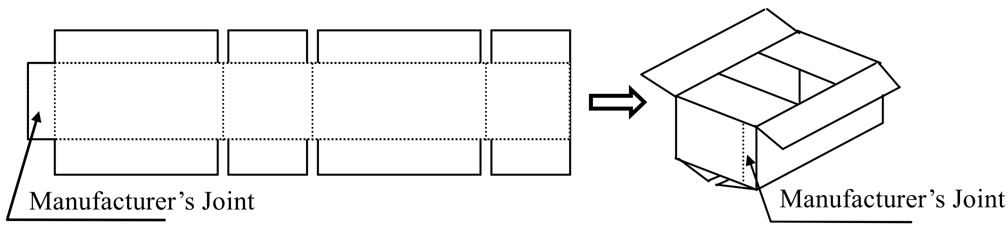


Figure 3 Forming of a Corrugated Box

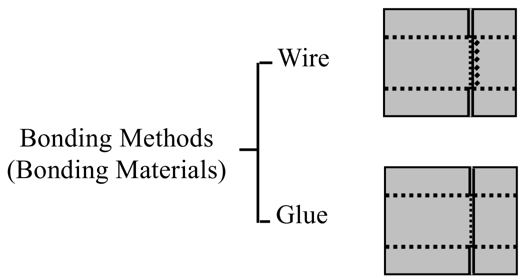
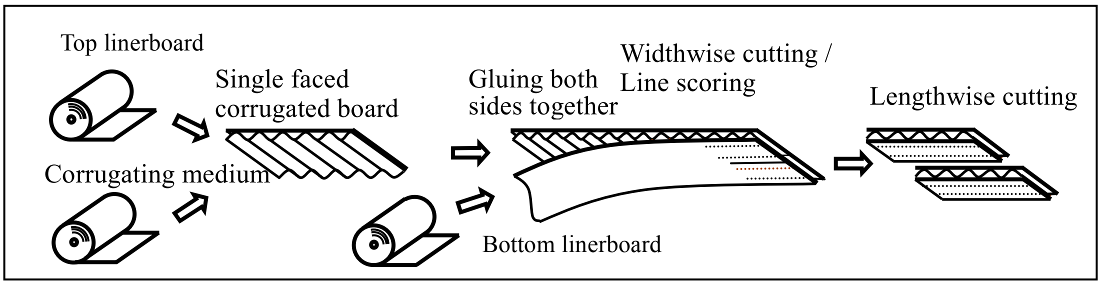


Figure 4 Method of Forming of a Corrugated Box

3) Manufacturing Processes

(1) Containerboard combining Process — The process by which corrugated boards are made, using a machine called a corrugator-

A corrugating medium is pressed into a wave-like shape (flutes), then is glued to both a top sheet and a bottom sheet of linerboard. The corrugated boards are then dried, scored, cut and loaded.

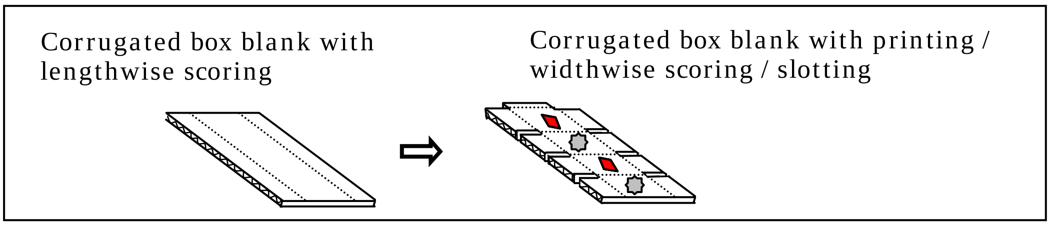


(2) Box Manufacturing Process

- Printing / Punching / Forming / Bundling / Palletizing –

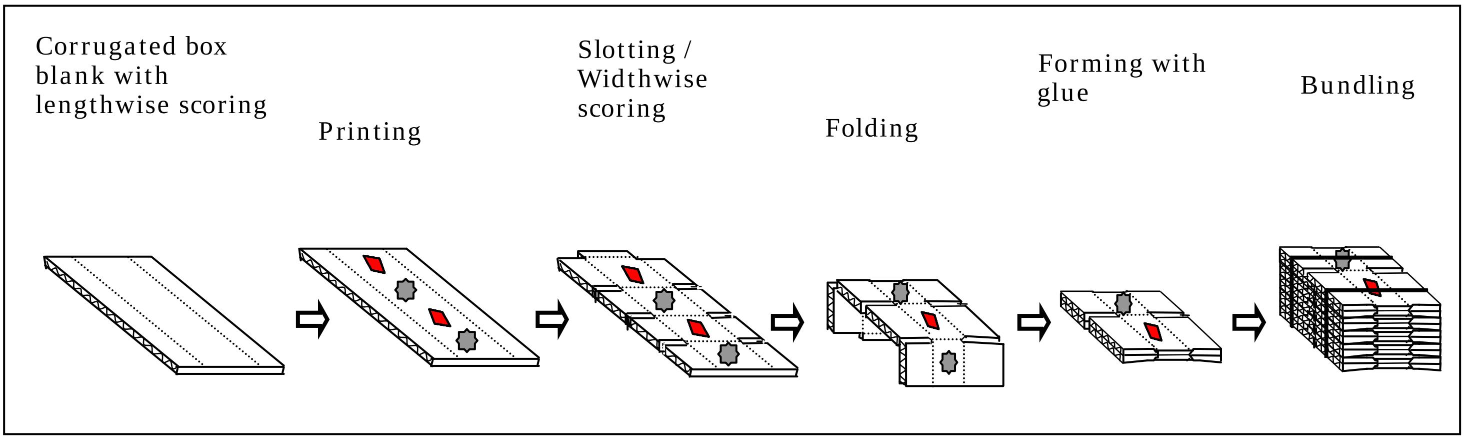
Printing is performed on corrugated box blanks that have been formed, scored and cut by a corrugator. The box blanks are subsequently cut or die-cut into specific shapes for further forming into finished boxes. Before the bundling process, a combination of several box manufacturing machines are utilized to process box blanks into different types of corrugated boxes. The typical procedures involved in each of these processes are shown below. However, the only processes that may possibly use materials containing Class I Designated Chemical Substances are processes in which the machines used contain either printing units or forming units that employ adhesives.

 Printing Process – Printer Slotter -
The printer slotter performs printing, scoring and slotting. There are two types of printer slotter: one type that utilizes flexo inks and another type that utilizes quick drying inks.



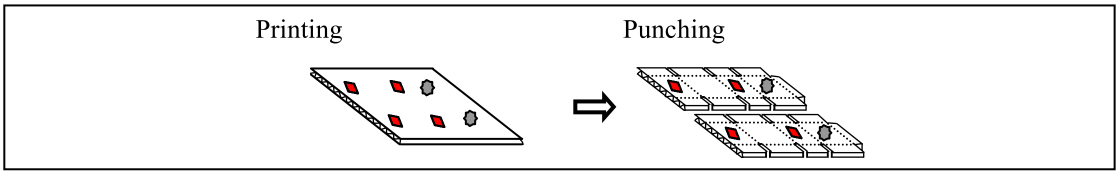
②Printing and Forming Processes – Flexo Folder Gluer -

The flexo folder gluer first performs printing onto the surface of box blanks that have been scored lengthwise. Next, the machine performs slotting and widthwise scoring, finally gluing the manufacturer's joints together to form boxes.



③ Punching Process- Die Cutter –

The die cutter utilizes cutting dies to punch out specific shapes from printed box blanks. Rotary die cutters and platen die cutters are most commonly utilized, however, die cutters are also used in combination with flexo printing machines.



4) Wastewater Treatment Process

(1) Discharge Routes for Wastewater and Wastes

Although actual discharge routes for wastewater and wastes from the containerboard combining process (corrugator) and the box-manufacturing process (printing / gluing processes only) will vary, depending upon the facilities and geographic conditions available to each particular corrugated packaging manufacturer (discharge into rivers or sewers), a typical flow is

shown in Figure 5.

Figure 5　Discharge Routes for Wastewater and Wastes

* “Glue balls” are lumps of gelatinized combining adhesive within the glue vat, caused by excessive ambient heat.

(2) Wastewater Treatment Methods

The wastewater generated by plants that manufacture corrugated packaging can be classified into the following categories: household wastewater / domestic wastewater; rainwater; wastewater from clean up of combining adhesive (corrugator and glue making machine) and wastewater from clean up of printing ink and joint adhesive. Household wastewater / domestic wastewater and wastewater from processes containing substances designated by the PRTR system, except for rainwater, are generally treated through a combination of several methods listed in Table 3.

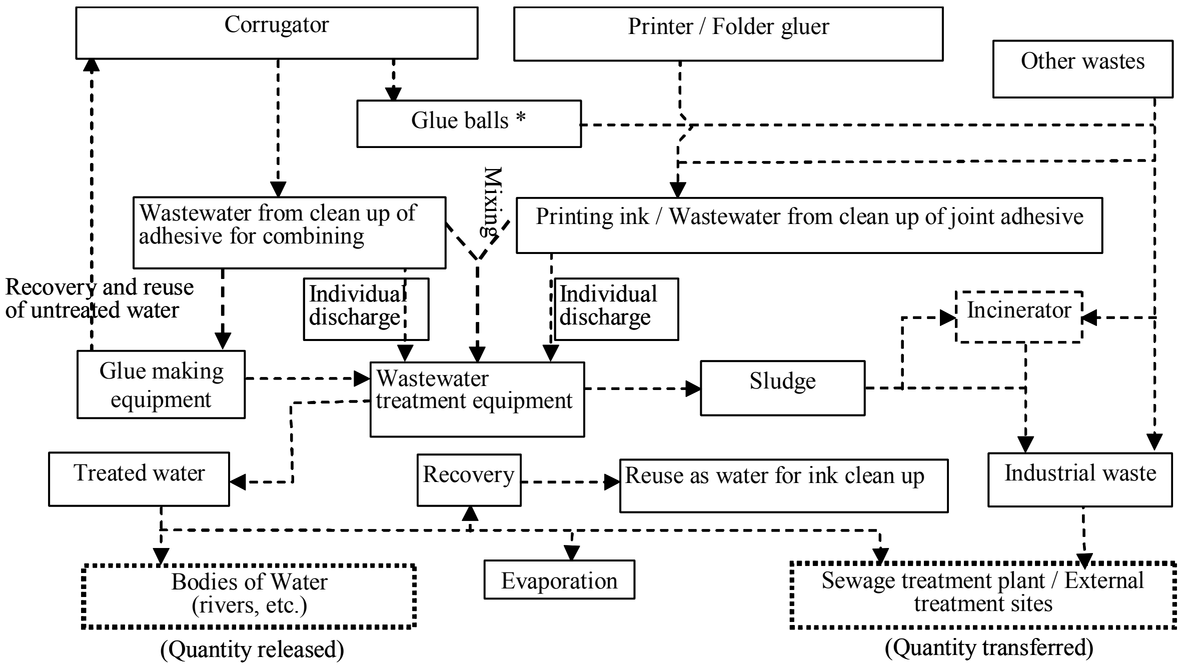


Table 3　Types of Wastewater Treatment Methods

Pretreatment	Primary Treatment	Secondary Treatment	Tertiary Treatment
pH adjustment Addition of Coagulant Oil Separation	Pressure floatation Coagulant precipitation	Filter press Centrifugal separation	Activated sludge Activated carbon Drying (dryer)
pH adjustment	Pressure reduction / Concentration	Drying (dryer)	-
-	Drying (dryer)	-	-

2. Class I Designated Chemical Substances Contained within Materials and Energies Utilized in the Corrugated Packaging Industry

Table 4 indicates the major Class I Designated Chemical Substances contained in the materials and energies utilized for the manufacture of corrugated packaging, which have been investigated by the member companies of Japan Corrugated Case Association (JCCA).

Table 4 Major Class I Designated Chemical Substances Contained in Materials and Energies

Cabinet Order Number	Name of Chemical Substance	Product Name	Primary Usage
1	Water-soluble zinc compounds	Flexo inks	Crosslinking agents for resins
16	2-aminoethanol	De-oxygenating agents	Rust prevention
43	Ethylene glycol	Quick drying inks	Solvents (as a vehicle)
63	Xylene	Joint adhesives / kerosene	Drying accelerants for adhesives / fuel additives
66	Glutaraldehyde	Antiseptic / antifungal agents	Antiseptic / antifungal agents for laminating glues
134	1,3-dichloro-2-propanol	Waterproofing agents	Enhancing water resistance of laminating glues
179	Dioxins	Exhaust gases, incinerated ash	Wastes from incineration
199	Tetrachloro-isophthalonitrile	Antiseptic / antifungal agents	Antiseptic / antifungal agents for laminating glues
227	Toluene	Joint adhesives	Drying accelerants for adhesives
253	Hydrazine	De-oxygenating agents	Rust prevention
270	Di-n-butyl-phthalate	Joint adhesives	Plasticizer
304	Boron and its compounds	Borax, boric acid	Viscosity stabilizer for laminating glues
309	Poly (oxyethylene) = nonyl phenyl ether	Flexo inks	Surfactants
310	Formaldehyde	Antiseptic / antifungal agents	Antiseptic / antifungal agents for laminating glues
346	Molybdenum and its compounds	Flexo inks	Pigments, lubricating oil additives

3. Corresponding Class I Designated Chemical Substances

The list of Class I Designated Chemical Substances shown in Table 5, below, was prepared from the general usage examples obtained as a result of an investigation conducted at 121 of JCCA member companies' plants. These chemical substances comprise 1% or greater of the particular product, which itself is handled in annual quantities that may exceed 1 ton. In addition, these chemical substances may result in the release of dioxins from designated facilities, as stipulated by the Law Concerning Special Measures against Dioxins (for corrugated packaging plants, such designated facilities would be small incinerators). For chemical substances other than those listed in the table, the MSDS should be obtained, in order to confirm whether such chemical substances are subject to reporting.

Table 5 List of Corresponding Class I Designated Chemical Substances

Cabinet Order Number	Name of Chemical Substance	Product Name	Primary Usage
43	Ethylene glycol	Quick drying inks	Solvents (as a vehicle)
63	Xylene	Joint adhesives / kerosene	Drying accelerants for adhesives / fuel additives
179	Dioxins	Exhaust gases, incinerated ash	Wastes from incineration
227	Toluene	Joint adhesives	Drying accelerants for adhesives
270	Di-n-butyl-phthalate	Joint adhesives	Plasticizer
304	Boron and its compounds	Borax, boric acid	Viscosity stabilizer for laminating glues

In addition, there are certain types of flexo inks (currently, flexo inks are utilized most commonly) that contain approximately 2% of the Class I Designated Chemical Substances shown in the aforementioned Table 4. However, as the quantities of these particular inks used (10 kg and less) are far less than the quantities specified by the law (1 t or more), these flexo inks are not subject to reporting. Quick drying inks have been designated as products that are subject to reporting. Regardless of the particular type or color of these inks, they all contain a relatively large percentage of ethylene glycol, which is a Class I Designated Chemical Substance, as a primary ingredient in the solvent. In addition, there is a strong possibility that the annual quantities handled will exceed 1 ton.

4. Fundamental Data for Calculating the Quantities of Corresponding Class I Designated Chemical Substances Released / Transferred

In general, the quantities of corresponding Class I Designated Chemical Substances released and transferred can be calculated using either the actual values or the measured values, as obtained by each company. However, in the event that these numeric values are difficult to determine, then it is acceptable to utilize either: industry average values, nominal values or the standard values set by machine manufacturers (the numeric values in red font), as listed in Table 6. (The particular values utilized must be clearly stated.)

Table 6 Fundamental Data for Calculating the Quantities of Corresponding Class I Designated Chemical Substances Released / Transferred

Item	Industry average values / Nominal values
Production volume of corrugated boards (m^2 / year)	Actual quantity for each company
Quantity of corrugated waste sold (t / year)	Actual quantity for each company
Average weight (average mass of corrugated boards, per square meter) (g / m^2)	647 g/m^2 (industry average value)
Quantity of adhesives for combining applied (units of starch) (g / m^2)	9g/m^2 (industry average value)
Borax content of laminating glue *1 (as a percentage content of starch) (%)	2% (nominal value)
Quantity of glue balls produced (kg / day)	12 kg/day (industry average value)
Solids content of glue balls (%)	35% (industry average value)
Boron content of wastewater *2 (mg / 1)	Measured quantity for each company
Production volume of glue joint type (including joints made by "one touch gluer") corrugated boxes (m^2 / year)	Actual quantity for each company
Percentage loss of glue joint type (including joints made by "one touch gluer") corrugated boxes (%)	1% (industry average value)
Quantity of joint adhesive applied (glue joint type including those made by "one touch gluer") (g / m^2)	0.75 g/m^2 (industry average value)
Di-n-butyl-phthalate content of joint adhesive (%)	MSDS
Xylene or toluene content of joint adhesive (%)	MSDS
Xylene content of kerosene (%)	MSDS
Decomposition rate in combustion equipment (e.g. boiler) ※3 (%)	99.5% (METI's Manual for Estimating Quantities of Released and Transferred Chemical Substances)
Ethylene glycol content of quick drying inks (%)	MSDS
Quantity of ink discarded from each type of printing machine and for each type of ink -After ink is cleaned from the machine, industrial waste treatment is outsourced to an external company (quantity of ink discarded, per color, per cleaning operation) -Treatment of waste fluids is outsourced to an external company (quantity of ink discarded, per color, per cleaning operation) -Treated by wastewater treatment equipment (quantity of ink discarded, per color, per cleaning operation)	(Standard values set by machine manufacturers) 350 g / color, per cleaning operation 50 g / color, per cleaning operation 126 g / color, per cleaning operation
Quantity of exhaust gas released from incinerators (m^3N / h)	For each company, numeric values to be reported to the government (normal value)

Measured quantities of dioxins within exhaust gas / incinerated ash	Actual quantities for each company

Note: Actual quantities for each company must be utilized for the following: quantities of wastewater produced from other processes (m^3 / day); quantities of materials handled (such as adhesives and ink); number of days of operation; and number of print color change operations.

*1 : Borax shall be calculated using $Na_2B_4O_7 \cdot 10\ H_2O$ (boron content: 11.3%) as standard.

When utilizing either $Na_2B_4O_7 \cdot 5\ H_2O$ (boron content: 14.8%) or boric acid H_3BO_3 (boron content: 17.5%), conversion to borax $Na_2B_4O_7 \cdot 10\ H_2O$ (boron content: 11.3%) must be performed, in accordance with the formulae shown below.

$Na_2B_4O_7 \cdot 10\ H_2O = (14.8 / 11.3) \times Na_2B_4O_7 \cdot 5\ H_2O$ (borax)
$Na_2B_4O_7 \cdot 10\ H_2O = (17.5 / 11.3) \times H_3BO_3$ (boric acid)

Example: If 4 tons of boric acid (H_3BO_3) and 5 tons of borax have been handled, then what is the total quantity of boron handled?

Conversion of boric acid to borax: $Na_2B_4O_7 \cdot 10\ H_2O = (17.5 / 11.3) \times H_3BO_3$ (boric acid)

$= 1.55 \times 4\ t = 6.2\ t$

Thus, 4 tons of boric acid is equivalent to 6.2 tons of borax. Therefore; after conversion, the quantity of borax equivalent is calculated as: 5 t + 6.2 t = 11.2 t and the total quantity of boron handled is calculated as: 11.2 t × 0.113 = 1.266 t = 1,266 kg.

*2: Regarding Boron Content in Wastewater after Wastewater Treatment has been Performed (reference)

- The effluent standard specified by the Water Pollution Control Law: boron content in wastewater shall be no more than 10 mg / l.

- Example of boron measurement at a corrugated packaging manufacturer (total quantity of wastewater discharged during manufacturing processes: 10 m^3 / day): Over the weekend, the wastewater derived from the cleaning of glue vats was combined with wastewater derived from the clean up of ink. Flocculants and similar coagulating agents were then added to this mixture at the beginning of the subsequent week. Lastly, the sludge within this mixture was separated out through pressure floatation and filter press techniques. The wastewater was analyzed and the boron content was found to range between 1.8 - 7.8 mg / l, with an average concentration of 4.4 mg / l.

- Normally, the wastewater derived from the clean up of ink is discharged every time that the ink color is changed, during printer operation. However, glue vats and other parts of the corrugator are cleaned no more than once a day, even at factories that perform frequent cleaning. Factories that do not perform frequent cleaning may clean these parts only once each week. During these thorough cleaning operations, overall boron concentrations are greater due to the discharge of wastewater that contains laminating glue. Therefore, this example of actual quantities measured shows a situation in which wastewater containing a significant amount of laminating glue was discharged. Therefore, with consideration for previous examples of actual measured concentrations, it is estimated that annual average boron concentrations will actually be approximately 1 - 2 mg / l, which is less than one-half of the average concentration measured in this example.

- Precautions Prior to Sampling
The actual concentration of boron can vary greatly, depending upon the adhesives for combining content of the wastewater derived from clean up operations. Therefore, it is desirable to preset the effluent condition standards, then to perform 2 – 3 point sampling in chronological order.

*3: Regarding the Decomposition Rate of Xylene in Combustion Equipment (such as boilers)

- The process of combustion will cause 99.5% of the xylene present to decompose into water and carbon dioxide. The remaining 0.5% is not decomposed and is released unchanged to atmosphere. (Cited from page 241 in the "*Manual for Estimating Quantities of Released and Transferred Chemical Substances*" prepared by the Ministry of Economy, Trade and Industry and the Ministry of the Environment, in March 2001.)

Note: Actual quantities for each company must be utilized for items that are not described, including: quantities of wastewater produced from other processes (m^3 / day); quantities of materials handled (such as adhesives and ink); number of days of operation; and number of print color change operations.

5. Calculation Procedures and Examples for Typical Processes

1) Boron and its compounds

Name of Substance	Boron and its compounds		
Cabinet Order Number	304	Product Name	Borax / boric acid
Usage	Increasing viscosity and adhesion of adhesives for combining (primary ingredient: starch)		

- Figure 6 depicts the flows involved with the release and transfer of boron contained within adhesives for combining, during the processes of glue making, combining and wastewater treatment. The quantities of boron released and transferred can be calculated by following the procedures described below.
- The borax utilized in these processes (i.e., boron and its compounds) reacts with caustic soda to produce sodium borate, which itself reacts with starch to form borate ester. As well, when boric acid is utilized, it reacts with caustic soda to produce borax. Thus, boron is transformed into a variety of chemical compounds, depending upon the processes in which it is utilized. However, for calculating the quantities released and transferred, the overall quantity should be understood in terms of the mass of elemental boron.
- With respect to boron, the amount that will eventually be discharged into raw wastewater is equivalent to the difference between the quantity handled and the quantity shipped out in the form of finished product and corrugated waste. The wastewater treatment process then separates the raw wastewater into wastewater (treated water) and waste. Measurements are then performed to calculate the quantity of boron in the wastewater (treated water). The quantity of boron transferred in waste is equivalent to the difference between the quantity of boron discharged into raw wastewater and the quantity of boron measured in the wastewater (treated water).

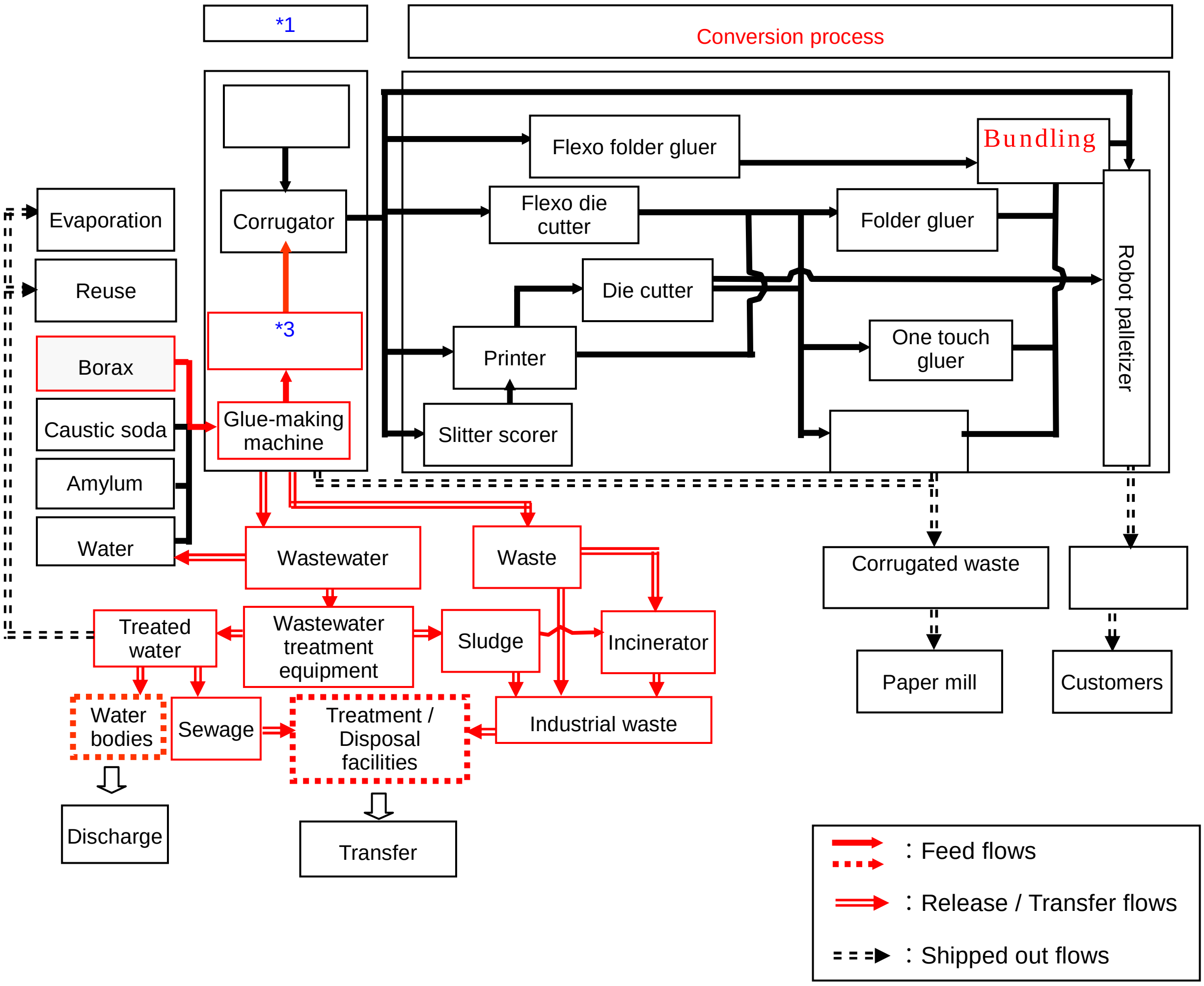


Figure 6　Boron Release / Transfer Flows

*1 Containerboard combining process　*2 Containerboard　*3Adhesives for combining

[Calculation Procedures]

□Annual quantity handled　□Annual quantity released and transferred

① Annual quantity of boron handled = annual quantity of borax handled × boron content

② Quantity of boron in the product = production volume of corrugated boards × quantity of adhesives for combining applied × borax content of adhesives for combining × boron content of borax

③ Quantity of boron in corrugated waste = quantity of corrugated waste sold ÷ average basis weight * × quantity of adhesives for combining applied × borax content of adhesives for combining × boron content of borax

④ Quantity of boron in raw wastewater (untreated) released to the wastewater treatment process = ① − (② + ③ + ⑦)

⑤ Quantity of boron released to bodies of water = quantity of boron in wastewater released from the wastewater treatment process = measured quantity × quantity of water released.

⑥ Quantity of boron in the sludge discharged from the wastewater treatment process = ④ − ⑤.

⑦ Quantity of boron in glue balls = quantity of glue balls produced × solids content × number of days of operation × borax content of adhesives for combining × boron content of borax

⑧ Quantity of boron transferred in waste = ⑥ + ⑦

Table 7 Quantities of Boron Released / Transferred for Each Method of Wastewater Treatment

Wastewater Treatment Method	Quantity Released to Bodies of Water	Quantity Transferred in Waste
a. Pressure floatation + filter press method, etc.	⑤ (Quantity transferred in sewage)	⑧ = ⑥ + ⑦
b. Concentration / evaporation method or evaporation method		⑧ = ⑥ + ⑦
c. Recovery and reuse method		⑦

[Calculation Examples]

<Input Data for Calculations>

Note: Figures in red font represent industry average values / nominal values

- Production volume of corrugated boards: 49,000,000 m^2 / year
- Quantity of corrugated waste sold: 3,000 t / year = 3,000,000 kg / year
- Average basis weight: 647 g / m^2 = 0.647 kg / m^2
- Annual quantity of borax ($Na_2B_4O_7 \cdot 10\ H_2O$) handled: 10,000 kg / year
- Boron content: 11.3%
- Quantity of adhesives for combining applied: 9 g / m^2 = 0.009 kg / m^2
- Borax content of adhesives for combining : 2%
- Quantity of glue balls produced: 12 kg / day
- Solids content of glue balls: 35%

- Number of days of operation: 20 days × 12 months / year
- Quantity of clean up water discharged: 10 m^3 / day
- Wastewater treatment facility: pressure floating + filter press method
- Released to: bodies of water
- Quantity of boron in treated wastewater: 4.4 mg / l = 0.0044 kg / m^3

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<Calculation Results>

① Annual quantity of boron handled = 10,000 kg / year × 0.113 = 1,130 kg / year
(Annual quantity of borax handled × boron content)

② Quantity of boron in the product (corrugated boards) = 49,000,000 m^2 / year × 0.009 kg / m^2 × 0.02 × 0.113 = 996.7 kg / year
(Production volume of corrugated boards × quantity of adhesive applied × borax content of adhesives for combining × boron content of borax)

③ Quantity of boron in corrugated waste
= 3,000,000 kg / year ÷ 0.647 kg / m^2 × 0.009 kg / m^2 × 0.02 × 0.113
= 94.3 kg / year
(Quantity of corrugated waste sold ÷ basis weight × quantity of adhesive applied × borax content of adhesives for combining × boron content of borax)

④ Quantity of boron in raw wastewater released to the wastewater treatment process
= 1,130 − (996.7 + 94.3 + 2.3) = 36.7 kg / year
{① − (② + ③ + ⑦)}

⑤ Quantity of boron released to bodies of water
=quantity of boron in wastewater released to bodies of water from the wastewater treatment process
= 0.0044 kg / m^3 × 10 m^3 / day × 240 days = 10.6 kg / year
(Measured quantity × quantity released (daily output × number of days of operation))

⑥ Quantity of boron in the sludge discharged from the wastewater treatment process = 36.7−10.6= 26.1 kg / year
(④ − ⑤)

⑦ Quantity of boron in glue balls = 12 kg / day × 0.35 × 240 days / year × 0.02 × 0.113 = 2.3 kg / year
(Quantity of glue balls produced × solids content × number of days of operation × borax content of adhesives for combining × boron content of borax)

⑧ Quantity of boron transferred in waste = 26.1 kg / year + 2.3 kg / year
= 28.4 kg / year

(⑥ + ⑦)

2) Xylene

Name of Substance	Xylene		
Cabinet Order Number	63	Product Name	Joint adhesives (vinyl acetate emulsion adhesives) / kerosene
Usage	Drying accelerator for joint adhesives (vinyl acetate emulsion adhesives), kerosene additives, etc.		

Shown below are the flows for the xylene released. Xylene is contained in the joint adhesives used during the conversion process and is also used as an additive for boiler fuel. The quantity released can be calculated by following the procedures described below.

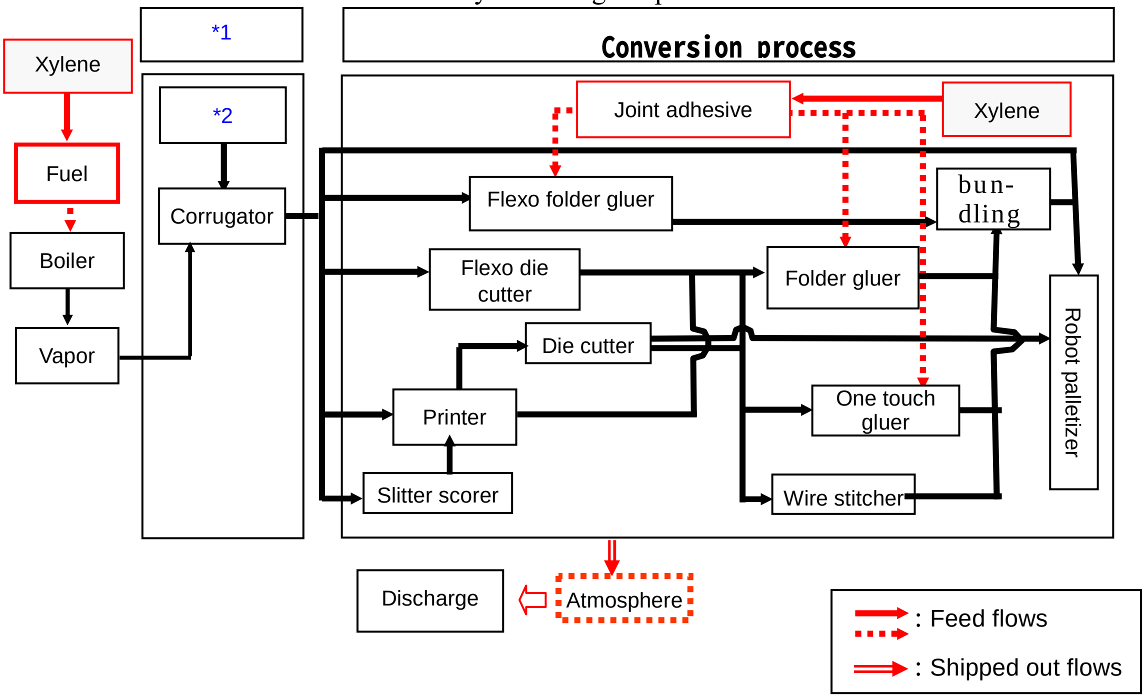

Figure 7 Flows for Xylene Released

*1 Containerboard combining process *2 Containerboard *3Adhesives for combining

[Calculation Procedures]

Annual quantity handled Annual quantity released or transferred

① Annual quantity of xylene handled

= annual quantity of kerosene handled × density × xylene content + annual quantity of joint adhesive handled × xylene content

Note: 99.5% of xylene contained in kerosene is decomposed through combustion. The entire quantity of xylene contained in joint adhesives for combining is released to the atmosphere during the drying process.

② Quantity of xylene released to atmosphere = Quantity of xylene in kerosene × + non-decomposition rate + annual quantity of joint adhesives handled × xylene content

[Calculation Examples]

<Input Data for Calculations>

Annual quantity of kerosene handled: 1,050 kl / year	Average density of kerosene: 0.8g/cm^3
Average xylene content of kerosene: 1.1%	Decomposition rate in combustion equipment: 99.5%
Quantity of xylene in kerosene: 1,050 × 0.8 × 0.011 = 9.24 t / year = 9,240* kg/year	
Annual quantity of joint adhesive handled: 22,000 kg / year	Xylene content of joint adhesive: 5%

<Calculation Results>

① Annual quantity of xylene handled = 9,240* + 22,000 × 0.05 = 10,340 kg

② Quantity of xylene released to atmosphere = 9,240 × 0.005 + 22,000 kg / year × 0.05
= 1,146 kg / year

3) Toluene

Name of Substance	Toluene		
Cabinet Order Number	227	Product Name	Joint adhesives (vinyl acetate emulsion adhesives)
Usage	Drying accelerator for joint adhesives (vinyl acetate emulsion adhesives)		

- The flow of toluene released from joint adhesives used during the conversion process is the same as the flow of xylene described in section 2, above).

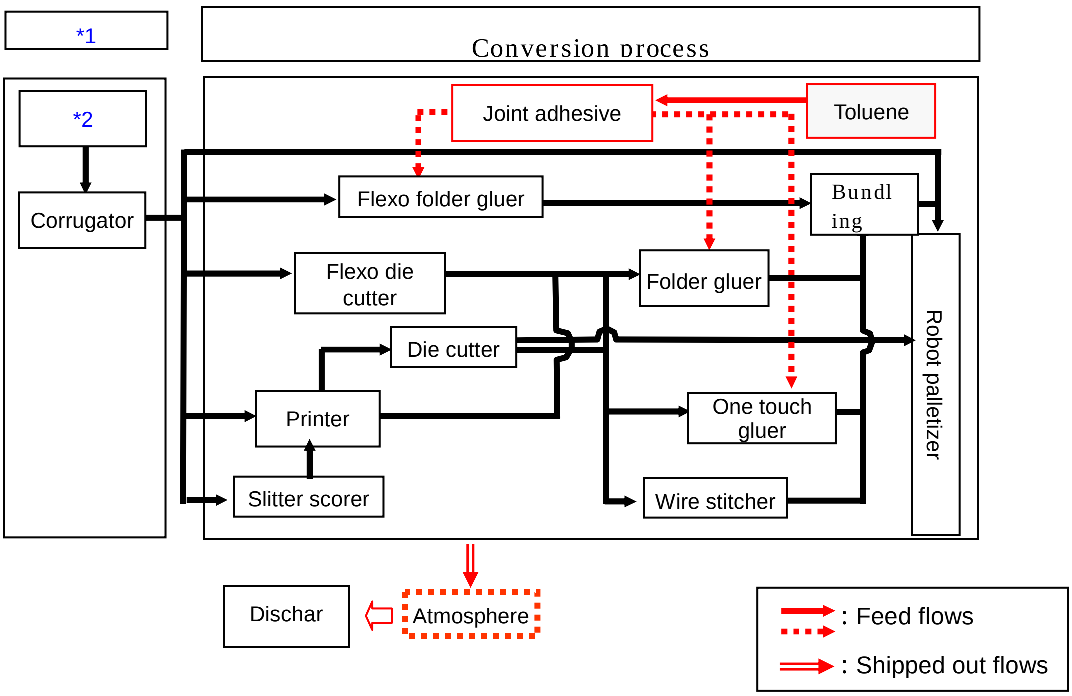

Figure 8 Flows for Toluene Released

[Calculation Procedures]

☐Annual quantity handled ☐Annual quantity released or transferred

[Calculation Procedures]

① Annual quantity of toluene handled = ② Quantity released to atmosphere
= Annual quantity of joint adhesive handled × Toluene content

[Calculation Examples]

<Input Data for Calculations>

Annual quantity of joint adhesive handled: 22,000 kg / year
Toluene content in joint adhesive: 5%

<Calculation Results>

① Annual quantity of toluene handled = 22,000 kg / year × 0.05 = 1,100 kg / year =1.1 t / year

② Quantity of toluene released to atmosphere = 22,000 kg / year × 0.05 = 1,100 kg / year = 1.1 t / year

4) Di-n-butyl-phthalate

Name of Substance	Di-n-butyl-phthalate		
Cabinet Order Number	270	Product Name	Joint adhesives (vinyl acetate emulsion adhesives)
Usage	Plasticizer for joint adhesives (vinyl acetate emulsion adhesives)		

- Shown below are the flows for the release and transfer of di-n-butyl-phthalate. Di-n-butyl-phthalate is contained in the joint adhesive used during the conversion process and is present in wastewater subject to treatment. The quantity transferred can be calculated by following the procedures described below.

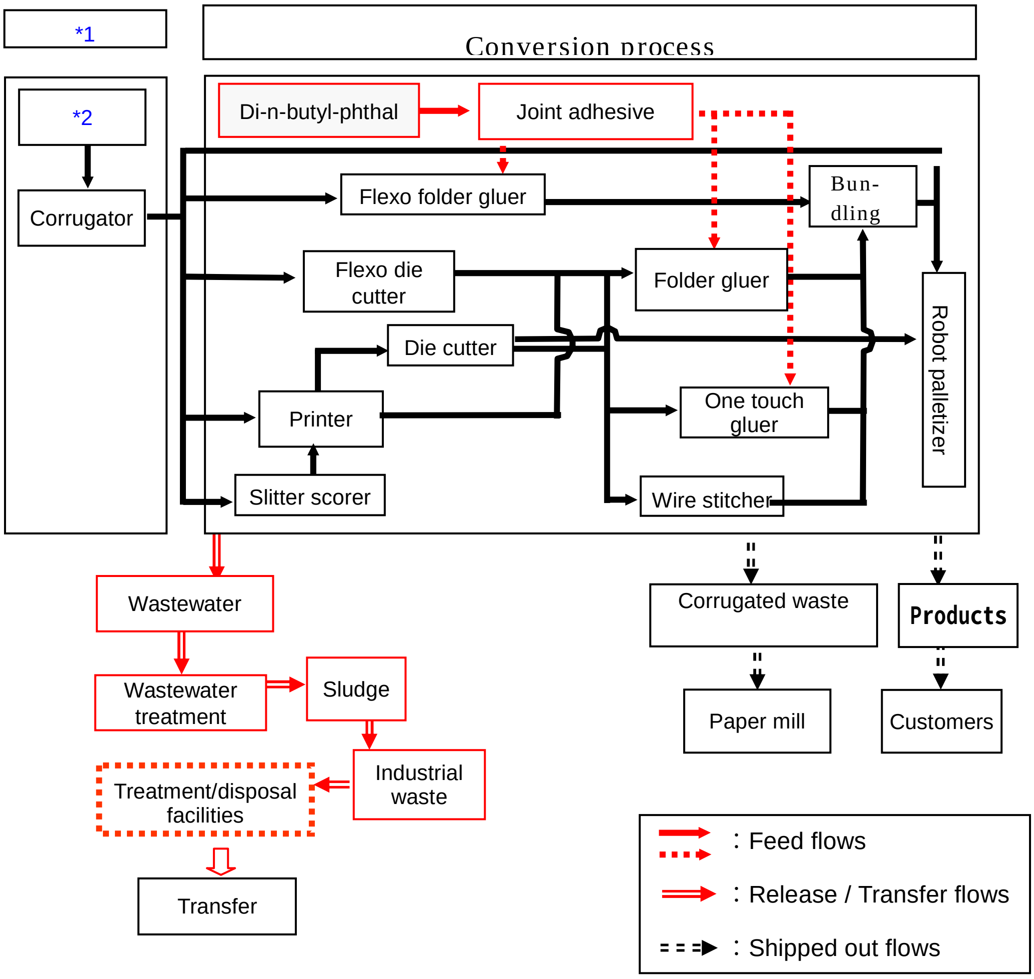

Figure 9 Flows for Di-n-butyl-phthalate Released and Transferred

Annual quantity handled Annual quantity released or transferred

[Calculation Procedures]

① Annual quantity of di-n-butyl-phthalate handled

= annual quantity of joint adhesive handled × di-n-butyl-phthalate content

② Quantity of di-n-butyl-phthalate in the product
= production volume of glue joint type corrugated × quantity of joint adhesive applied × di-n-butyl-phthalate content of joint adhesive

③ Quantity of di-n-butyl-phthalate in corrugated waste
= production volume of glue joint type corrugated × quantity of joint adhesive applied × percentage loss during the conversion process (glue joint type) × di-n-butyl-phthalate content of joint adhesive

④ Quantity of di-n-butyl-phthalate from raw wastewater released from the wastewater treatment process = ① − (② + ③)

* As the solubility of di-n-butyl-phthalate is extremely low (0.003 g / 100g), the quantity released to wastewater (treated water) is effectively determined to be "0".

⑤ Quantity of di-n-butyl-phthalate in the sludge discharged from the wastewater treatment process = ④

⑥ Quantity of di-n-butyl-phthalate transferred in waste = ⑤.

[Calculation Examples]

<Input Data for Calculations>
Note: Figures in red font represent industry average values / nominal values

Production volume of glue joint type corrugated:
17,859,000 m^2 / year
Percentage loss during the conversion process (glue joint type): 1%
Annual quantity of joint adhesive handled: 13,800 (kg / year)
Di-n-butyl-phthalate content of joint adhesive: 7.3%
Quantity of joint adhesive applied (glue joint type only, including one-touch gluer):
0.75 g / m^2 = 0.00075 kg / m^2

<Calculation Results>

① Annual quantity of di-n-butyl-phthalate handled: 13,800kg / year × 0.073 =1,007.4 kg / year

(Annual quantity of joint adhesive handled × di-n-butyl-phthalate content)

② Quantity of di-n-butyl-phthalate in the product
= 17,859,000 m^2 / year × 0.00075 kg / m^2 × 0.073 = 977.8 kg / year

(Production volume of glue joint type corrugated × quantity of joint adhesive applied × di-n-butyl-phthalate content of joint adhesive)

③ Quantity of di-n-butyl-phthalate in corrugated waste
= 17,859,000 m^2 / year × 0.00075 kg / m^2 × 0.01 × 0.073 = 9.8 kg / year

(Production volume of glue joint type corrugated × quantity of joint adhesive applied × percentage loss during the conversion process × di-n-butyl-phthalate content of joint adhesive)

④ Quantity of di-n-butyl-phthalate from raw wastewater released during the wastewater treatment process = 1,007.4 − (987.6) = 19.8 kg / year

{① − (② + ③)}

⑤ Quantity of di-n-butyl-phthalate in the sludge discharged from the wastewater treatment process = ④

⑥ Quantity of di-n-butyl-phthalate transferred in waste = ⑤ = 19.8 kg / year

5) Ethylene Glycol

Name of Substance	Ethylene Glycol		
Cabinet Order Number	43	Product Name	Quick drying ink
Usage	Quick drying ink solvent (as a vehicle)		

- Shown below are the flows for the release and transfer of ethylene glycol. Ethylene glycol is contained in the quick drying inks used during the conversion process and is present in wastewater subject to treatment. The quantities both released and transferred can be calculated by following the procedures described below.

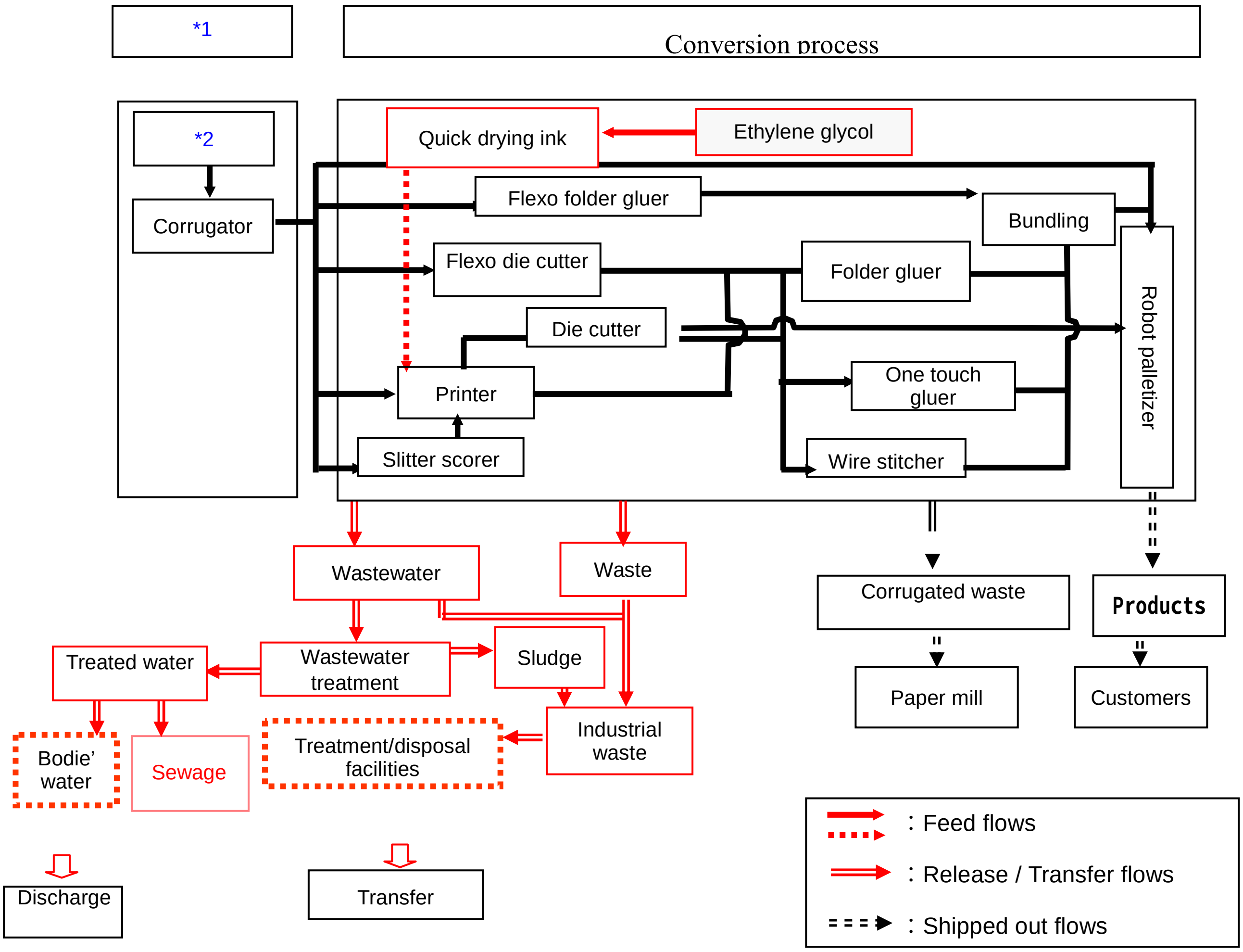

Figure 10 Flows for Ethylene Glycol Released and Transferred

☆ The methods used for the cleaning and final treatment of printers that utilize quick drying inks will vary, depending upon the characteristics of the inks and the specifications of each machine. Therefore, the various treatment methods are classified as shown in (1) - (3), below.

(1) Wipe-off Method: used for conventional roll transfer type printers and conventional spray type printers. After excess ink has been wiped off the printers with waste cloths, the materials used for cleaning are disposed of as industrial waste.

(2) Industrial Waste Treatment Method for Waste Liquids: the waste inks resulting from color change processes and the wastewater from ink clean up are stored in drums, then disposed of as industrial waste, as is.

(3) Wastewater Treatment Method: the printing process utilizes washable quick drying inks. After wastewater is treated by a standard wastewater treatment system, the wastewater is separated into liquid wastewater and solid waste. In the event that an activated sludge treatment is performed as a tertiary treatment, then the wastewater will be fully broken down into water and carbon dioxide. Therefore, the quantity of ethylene glycol released will be "0".

□Annual quantity handled □Annual quantity released or transferred

[Calculation Procedures]

① Quantity of ethylene glycol handled = annual quantity of quick drying ink handled × ethylene glycol content

② Wipe-off Method: quantity of ethylene glycol transferred in waste= quantity of waste per color / cleaning operation × number of daily color changes× number of days of operation

③ Industrial Waste Treatment Method for Waste Liquids: quantity of ethylene glycol transferred in waste = quantity of waste per color / cleaning operation × number of daily color changes× number of days of operation

④ Wastewater Treatment Method: quantity of ethylene glycol released to wastewater = quantity of waste per color / cleaning operation × number of daily color changes × number of days of operation

[Calculation Examples]

<Input Data for Calculations>
Note: Figures in red font represent industry average values / nominal values

- Quantity of ink handled: 6,000 kg / year (wipe-off type: 3,500 kg / year)
- Ethylene glycol content: 30%
- Quantity of ink per disposal, per color: ② 350 g / disposal; ③ 50 g / disposal; ④ 126 g / disposal
- Number of color changes: 40 changes / day (wipe-off type: 20 changes / day)
- Number of days of operation: 20 days × 12 months = 240 days / year

<Calculation Results>

① Quantity of ethylene glycol handled = 6,000 kg / year × 0.3 (3,500 × 0.3) = 1,800 kg / year (1,050 kg / year)

② Wipe-off Method: quantity of ethylene glycol transferred in waste = (350 / 1,000) × 0.3 × 20 × 20 × 12 = 504 kg / year

③ Industrial Waste Treatment Method for Waste Liquids: quantity of ethylene glycol transferred in waste = (50 / 1,000) × 0.3 × 40 × 20 × 12 = 144 kg /year

④ Wastewater Treatment Method: quantity of ethylene glycol released to wastewater = (126 / 1,000) × 0.3 × 40 × 20 × 12 = 363 kg /year

Note: In the event that the wastewater from procedure ④, above, receives tertiary treatment using an activated sludge treatment method, then complete decomposition would occur. Therefore, the quantity of ethylene glycol released would be determined as "0". If the wastewater is not treated using an activated sludge treatment method, then a slight amount of ethylene glycol will be transferred along with the residual water, to the dehydrated waste (although most of the ethylene glycol is released to the wastewater itself). This miniscule quantity of transferred ethylene glycol is difficult to measure and is estimated as being only a few % of the entire quantity released. Therefore, for the purposes of the calculations above, the entire quantity of ethylene glycol is considered as being released to the wastewater, with none of it being transferred to the dehydrated waste.

6) Dioxins

Name of Substance	Dioxins	
Cabinet Order Number	179	
Usage	Unintentional byproducts from incinerators (exhaust gases / incinerated ashes, etc.)	

[Calculation Procedures]

① Annual quantity of dioxins in exhaust gases released
= quantity of exhaust gases* × measured quantity of dioxins in exhaust gases × number of daily hours operation × number of days operation

② Annual quantity of dioxins in incinerated ashes transferred
= quantity of incinerated ashes released × measured quantity of dioxins in incinerated ashes

[Calculation Examples]

<Input Data for Calculations>

Quantity of exhaust gases	1,180 Nm^3 / h
Measured quantity of dioxins in exhaust gases (Dioxins in exhaust gases)	2.0ng−TEQ/Nm^3 = 2.0×10^{-6} mg−TEQ/Nm^3
Number of daily hours of operation	8h/day
Number of days of operation (days / month) × 12 months	240 days/year
Quantity of incinerated ashes released	21 t/year = 21×10^6 g/year
Measured quantity of dioxins in incinerated ashes	1.1 ng−TEQ/g = 1.1×10^{-6}mg−TEQ/g

*TEQ: As a variety of different dioxins are produced, the quantity of dioxins has been converted to the toxic equivalence specified by 2,3,7,8 tetrachlorinated dibenzo-para-dioxin.

<Calculation Results>

① Annual quantity of dioxins in exhaust gases released
$= 1{,}180 \times 2.0 \times 10^{-6} \times 8 \times 20 \times 12 = 4.53$ mg − TEQ / year

② Annual quantity of dioxins in exhaust gases released
$= 21 \times 10^6 \times 1.1 \times 10^{-6} = 23.1$ mg − TEQ / year