

Environmental Management Accounting (EMA) Workbook

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Ministry of Economy, Trade and Industry

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Introduction

Significance and Overview of Environmental Management Accounting (EMA)

0.1 Significance of Environmental Management Accounting

In a three-year plan spanning between 1999 and 2001, the Ministry of Economy, Trade and Industry commissioned the Japan Environmental Management Association for Industry, within which an Environmental Accounting Committee (for a list of committee members, refer to the end of this workbook) was set up, to conduct investigative research. A report on the results from this investigative research has been summarized in this document, which is entitled “Environmental Management Accounting Workbook.”

Environmental accounting can be classified broadly into external environmental accounting, in which information is disclosed outside of a company, and internal environmental accounting, which contributes to business management within a company. In recent years, internal environmental accounting has also come to be referred to as environmental management accounting (EMA), and in this document, the term “environmental management accounting” will be used.

There are various views regarding the scope of environmental management accounting, but in “Environmental Management Accounting: Procedures and Principles” published by the United Nations Division for Sustainable Development, the tools for environmental management accounting are classified into monetary EMA and physical EMA, and further into past oriented tools and future oriented tools. The following graph summarizes these classifications.

Environmental Management Accounting (EMA)			
Monetary EMA (MEMA)		Physical EMA (PEMA)	
Past oriented tools	Future oriented tools	Past oriented tools	Future oriented tools
Annual environmental expenditure or costs, transition from bookkeeping and cost accounting	Monetary environmental budgeting and investment appraisal	Material, energy and water flow balances	Physical environmental budgeting and investment appraisal
	Calculating costs, savings and benefits of projects	Environmental performance evaluation and indicators, benchmarking	Setting quantified performance targets
External disclosure of environmental expenditures, investments and liabilities		External environmental reporting and other reporting to agencies and authorities	Design and implementation of environmental management systems, cleaner production, pollution prevention, design for environment, supply chain management, etc.

Source: United Nations. *Environmental Management Accounting Procedures and Principles*, 2001, p. 9.

The leading environmental management accountants in Europe. M. Bennett and P. James, stipulate in “The Green Bottom Line” that the purpose of environmental management accounting is to provide information and support for the decision-making process that is affected by environmental factors, and also state that specifically, it is useful in the following ways.

- (1) Clarifies the impact that environmental activities have on income statements and balance sheets.

- (2) Makes opportunities for cost reduction and other improvements clear.
- (3) Determines the order of priority for environmental activities.
- (4) Supports the determination of product prices, product mixes, and product development.
- (5) Increases customer value.
- (6) Supports investment decisions that take the future into consideration, as well as other decisions that are associated with long-term results.
- (7) Supports sustainable corporate activities.

In such a way, environmental management accounting, including physical environmental management accounting, is, by definition, perceived as covering a broad scope that incorporates means for externally disclosing information. However, with regard to physical environmental management accounting, there is already a substantial accumulation of research findings in areas other than environmental accounting, as represented by environmental impact assessment and life cycle assessment, and even external disclosure of environmental accounting information can also be perceived as neighboring, individual areas for external environmental accounting.

Accordingly, the area that should be uniquely defined as environmental management accounting is monetary environmental management accounting, as well as the area that is useful for internal management of companies. These are the central areas of environmental management accounting.

In Japan, ever since the Ministry of the Environment issued “Guidelines for Introducing an Environmental Accounting System” (hereinafter referred to as “MOE Guidelines”), environmental accounting oriented towards external disclosure of information, or rather, external environmental accounting, has been at the center of environmental management accounting. This is due to the fact that the purpose of the MOE Guidelines was not for environmental accounting information to be used for internal management of companies, but rather to place major emphasis on disclosure based on environmental reports.

It is unnecessary to repeat here that external disclosure of environmental accounting information is extremely important from the perspective of environmental accountability. However, in the same way that financial accounting (external accounting that emphasizes disclosure of information) and management accounting (internal accounting that emphasizes business management) are essential to the field of traditional accounting, development where harmony between external environmental accounting and environmental management accounting (internal environmental accounting) is reached is strongly desired in the field of environmental accounting.

The current situation for environmental accounting practices in Japan is one where rapid developments in environmental accounting oriented towards external disclosure of information based on efforts by the Ministry of the Environment can be seen, but it is undeniable that the field of environmental management accounting is at a stage where developments are greatly delayed. Environmental management accounting is an essential tool for corporate management that strives for environmental conservation, as a means for aiming to realize cost reduction and acquire earnings, while executing environmental conservation activities.

Companies cannot carry out sustainable environmental conservation activities with only environmental management tools (the ISO 14000 family is not associated with environmental activities of companies) that are separate from economic activities, as companies are organizations that pursue commercial gain. A mechanism that links environmental conservation to economic activities is necessary. Environmental management accounting provides this mechanism.

0.2 International Trends Surrounding Environmental Management Accounting

Environmental accounting is a mechanism that is applied mainly within companies, but from its public attributes, government agencies in various countries around the world have exercised tremendous efforts for development and popularization of this mechanism. In relation to this development and popularization, intergovernmental organizations such as the United Nations and the European Commission have also been carrying out various projects. There are also influential private research institutions that are conducting research centering on environmental management accounting. It is important to progress with research on environmental management accounting in Japan by coordinating with these trends. Major international trends are introduced below.

(1) United States

In the United States, the Environmental Protection Agency (EPA) has been implementing the “Environmental Accounting Project” since 1992. This represents the earliest approach made towards environmental management accounting, and its mission is “to encourage and motivate business to understand the full spectrum of their environmental costs, and integrate these costs into decision making” (<http://www.epa.gov.opptintr/acctg/eaproject.htm>).

In the initial stages of the EPA’s Environmental Accounting Project, a large amount of efforts were concentrated towards development of a total cost assessment method as a method for assessing investments in environmental facilities, and there were presentations of numerous findings relating to the fundamental concept and method for total cost assessment (TCA). In particular, the classification of environmental costs that serves as the basis for TCA is used for classifying costs for environmental management accounting in many countries.

In addition to case studies of large-scale companies such as Green Accounting at AT&T and Full Cost Accounting at Ontario Hydro, the EPA is vigorously conducting case studies related to environmental management accounting for medium and small companies, such as environmental accounting for the printing industry. Recently, the EPA has also been implementing research projects on the relationship between green supply chains and environmental accounting, and is aiming for the cultivation of a new area. The green supply chain is an attempt at reducing environmental burdens through the overall supply chain.

The EPA has also launched the Environmental Management Accounting Research and Information Center (EMARIC), and in the future, the EPA’s environmental accounting projects are planned to be transferred to the EMARIC. The EMARIC is hosted by the Tellus Center, and has a Web page that gathers a broad array of information on environmental management accounting from around the world (<http://www.emawebsite.org>).

(2) Europe

In Europe, a large-scale survey project on environmental management accounting was implemented by the European Commission (EC) at the end of the 1990s, and afterwards, research and development trends for environmental management accounting were promoted. This survey was referred to as ECOMAC (Eco-Management Accounting as a Tool of Environmental Accounting), and was conducted during the period from 1996 to 1998. In concrete terms, surveys were conducted on 84 companies in Europe and the United States, in addition to case studies on environmental management accounting for 15 companies in Germany, Italy, the Netherlands, England, and Ireland were implemented, and a framework for environmental management accounting was advocated. The name “Eco-Management Accounting” that was used during the time that this survey project was carried out was later changed to “Environmental Management Accounting,” and came to be known by this name.

The ECOMAC project ended as the surveys ended, but the Environmental Management Accounting Network-Europe (EMAN-EU) was established through financial support by the EU for the purpose of maintaining a network for research on environmental management accounting, and a meeting is held every year (<http://www.eman-eu.net>).

In terms of unique approaches by each country, the trends in Germany are particularly important. In Germany, the Federal Environment Ministry and the Federal Environment Agency published the “Environmental Cost Accounting Handbook.” In addition, the German Federal Environment Ministry and Federal Environment Agency are currently collaborating with DIN (German Institute for Standardization), IÖW (Institute for Ecological Economy Research), and IMU (Institute for Management and the Environment) to plan for the publication of guidelines relating to environmental cost management. These guidelines are expected to strengthen orientation towards internal management more than the handbook published in 1996.

In Germany and Austria, research relating to environmental accounting by private research institutes such as the abovementioned IMU and IÖW, as well as the Wuppertal Institute for Climate, Environment and Energy, is being conducted actively. In particular, the material flow cost accounting that was developed by IMU is taken up as a major item in this survey project.

In England, activities are also being carried out for introduction and popularization of environmental management accounting, mainly by the Environment Agency. The Environment Agency of England has created a manual for the introduction of an environmental accounting

system into government agencies and corporations, and is making efforts to popularize environmental accounting through supporting the holding of seminars, etc.

(3) Asia and the Pacific

In Asia and the Pacific, Japan and Australia are leading the way in environmental accounting. With regard to approaches by government agencies regarding environmental management accounting in countries other than Japan, Korea has received support from the World Bank and the Ministry of the Environment in Korea has published a report on research related to environmental accounting systems. In this report, several case studies of Korean companies and environmental accounting guidelines are described. In China, a project for introducing environmental accounting to Japanese-Chinese joint ventures is underway, as part of the “3E (Energy Environment Economy) Project,” which is a joint collaboration between Keio University and Tsinghua University.

In the Philippines, developments in an education program for environmental management accounting are being made, in addition to efforts to introduce the methods developed by the US EPA.

Based on these developments in environmental accounting in Asia and the Pacific, the Environmental Management Accounting Network – Asia Pacific (EMAN-AP) was formed in 2001 (<http://www.eman-ap.net>).

(4) United Nations

With regard to efforts by the United Nations regarding environmental management accounting, as it was cited in the beginning of this chapter, the activities carried out by the United Nations Division of Sustainable Development (UNSD) are important (<http://www.un.org/esa/sustedev/>). The UNSD started a research project on activities carried out by governments to promote environmental management accounting by companies in 1999. The findings from this research are publicized in 2 workbooks, “Environmental Management Accounting: Procedures and Principles,” and “Environmental Management Accounting: Policies and Linkages.” Upon gathering their findings in these two workbooks, the UNSD has halted activities, but there are plans for moving further ahead with the project.).

0.3 Process for the Development of Environmental Management Accounting Methods in Japan

There are a wide variety of concrete methods for environmental management accounting, and a tendency for expansion is also apparent. This is because for companies, if further environmental consciousness is sought after, the field of environmental management accounting expands in response. However, on the other hand, environmental management accounting must be established as a means for providing appropriate information in regards to concrete management decision-making problems.

In Japan, there is rapid popularization of a system for aggregating environmental costs for corporate activities overall, due to efforts by the Ministry of the Environment. What is necessary next is the establishment of an environmental management accounting method that is useful for individual management decision-making purposes. With this in mind, it has been decided to take up the three areas below, which were broadly classified from the perspective of the possibility of developing concrete methods and their importance as an environmental management accounting method.

- (1) Environmentally conscious investment appraisal
- (2) Environmentally conscious cost management
- (3) Environmentally conscious performance evaluation

The environmentally conscious investment appraisal is a method for decision-making that takes impacts on the environment by business investments into consideration. As previously mentioned, this is a theme on which research has been conducted for a long period of time by the US EPA in the form of an environmental accounting project, and the findings of this research have been established as total cost assessment.

However, it is clear that with the method for business investment decisions, there are large discrepancies for each country. In the US, a method for decision-making that involves discounting future cash flows based on business investments to the current value is popular, but this method is not as popular in Japan. In this American method, only the economics of environmental business investment are emphasized, and there are limitations such that the effects on the environment are not sufficiently incorporated into the method.

Using this method developed in the US as a reference, a working group was set up in Japan in 2000 to review environment-conscious business investment decisions methods that can be applied to Japanese corporations.

As the term implies, environmentally conscious cost management aim for overall cost management relating to the environment, and since this cost management extends over a wide range, it was decided to carry out reviews through the following four classifications: environmental quality cost accounting system, environmentally conscious target costing, material cost accounting, and life cycle costing.

Starting in 2000, it was decided to review environmental quality cost accounting systems and environmentally conscious target costing together as environmentally conscious cost management in one working group. The environmental management accounting method related to these fields is undergoing a stage of dramatic developments on a global scale, but by developing these tools, they can be helpful in analyzing the efficiency of environmental cost budget management expenditures, and it is also expected for the provision of environmental accounting information, which supports environmentally conscious decision-making in the development design of products, to become possible.

There has been relative progress with research on material flow cost accounting and life cycle costing on a global scale; a working group was established for each, and research has been carried out. The working group for material flow cost accounting was established in 2000, and the working group for life cycle costing was established in 2001.

Material flow cost accounting is a method that accurately captures the flow of quantities and money in the production process, and clarifies the inefficiency of the manufacturing process in monetary units and quantities. Life cycle costing is a cost accounting method that takes costs related to the product usage, recycle, and disposal stages into consideration. Both methods clarify the environmental problems that are otherwise not made clear with traditional cost accounting, in terms of monetary amounts.

The last method, or the environmentally conscious performance evaluation, is a method that introduces information on environmental performance into the system for performance evaluation of companies. To promote environmental administration, it is most effective to introduce an environmental aspect into a system that is the core foundation of companies, and the environmentally conscious performance evaluation is a means to do so. In 2000, a working group was set up and examinations were conducted to handle this issue.

In the examination process, it was found that with regard to environmentally conscious performance evaluation, it is preferable at the present stage to refer to a case example where a system was introduced into a corporation, and have each company take approaches with a method that is suitable for each, rather than developing a standard method for all companies, since the performance evaluation system itself varies greatly according to each company.

Therefore, research was conducted on a case example using an advanced company that had implemented environmentally conscious performance evaluation, and results from this research were gathered. In the future, additional examinations are deemed as being necessary, as after this research was conducted, there was an increase in the number of companies implementing environmentally conscious performance evaluation, and companies that had already been implementing environmentally conscious performance evaluation made various improvements.

The fields of environmental management accounting that are described here do not cover all the fields of environmental management accounting, but can be applied to management of environmental conservation costs, cost-benefit analysis of environmental measures, and decision-making in business management for efficient environmental investments and environmental consciousness.

Chapter 1 Outline of Environmental Management Accounting Methods

1.1 Introduction

In reviewing environmental management accounting methods, a total of 5 working groups were set up, and each working group carried out reviews and developments on different environmental management accounting methods. As it was mentioned in the introductory chapter, in Japan, environmental accounting that is oriented towards external reporting that takes advantage of the MOE Guidelines is taking the lead and becoming widespread. However, it cannot be said that there can be sufficient understanding of environmental accounting simply by looking at each of these various methodologies for environmental accounting individually. In this chapter, before describing concrete details of each method, the positional relationships between each method and the MOE Guidelines is organized, and its overall picture is presented.

1.2 Outline of Environmental Management Accounting Methods

1.2.1 Fundamental Attributes of Environmental Management Accounting Methods

The first and foremost aspect that is important as an attribute of environmental management accounting methods is that each method is fundamentally independent. Although in this chapter statements are made that link the methods reciprocally so that the orientation of each method can be clarified, and there may be cases where the methods are actually related to each other, as methods, they are separate from each other. In other words, they are not characterized such that without implementing one method, it is impossible to implement another method.

Each company should apply these methods by sorting out the methods and selecting one that is suitable to their actual conditions. That is, it is not necessary for all companies to implement the methods mentioned here in a uniform way, and it is assumed that each company will adopt a method that is adapted to their purpose.

It should be pointed out that the effectiveness of each method depends on the philosophy and intentions of the company that adopts the method. As stated below, all of the methods described in this chapter serve the purpose of either achieving or adjusting a balance in some form or another between goals for environmental conservation and managerial needs. However, the contents of environmental conservation activities and expected standards, which are the premises for achieving or adjusting this balance, are, in general, guided by the philosophies and visions of each company, and come from outside of the frame for environmental management accounting. Accordingly, the results that can be obtained by applying each method differ depending on how each company perceives environmental problems, and what kind of targets each company sets.

1.2.2 Relation of Each Method

The six methods that are described in this workbook all have the intention of achieving or adjusting a balance in some form or another between goals for environmental conservation and managerial needs, but the target items to which each method can be applied can be sorted out as shown in Figure 1.1. First of all, both the environmentally conscious target costing and life cycle costing are methods that supplement consideration to the environment from the aspect of costs on the level of products. The differences between these two methods consist mainly of the range of the costs and the implementation period. The environmentally conscious investment appraisal is a method that aims for a combination or balance between considerations from an environmental aspect and economic efficiency when making decisions on business investments. The target in material flow cost accounting is mainly the material flow in the production process. The targets for the environmental cost matrix method and environmentally conscious performance evaluation are fundamentally general environmental conservation activities, and there may be the possibility that in addition to operating costs, environmentally conscious product design, business investment amounts, and the effects of such investments may also be targets.

Product-by-product	Environmentally conscious target costing Life cycle costing	Environmental cost matrix	Environmentally conscious performance evaluation
Investments	Environmentally conscious investment appraisal		
Processes for production, logistics, etc.	Material flow cost accounting		

Figure 1-1 Classification of Methods Based on Applicable Targets

Next, it is possible to present the relation of each method in business processes as an illustration such as the one shown in Figure 1-2. Of course, business processes vary widely depending on the industry sector and business type, but in order to present the relation of each method in an understandable method here, the general business process has been simplified to product planning, design, and procurement/production/logistics of materials and raw materials, and in addition, from the perspective of burdens on the environment, the process up until use and disposal of the product is also taken into consideration. The environmentally conscious target costing and life cycle costing are methods that are used during the design stage. However, the implementation period of these methods differ, as the environmentally conscious target costing is implemented during the conceptual design stage, and life cycle costing is implemented after detailed designs are fixed; the scope of the costs that are considered differ as well, as shown in the figure. The environmentally conscious investment appraisal has an impact in the years following its implementation, in terms of cost depreciation and environmental conservation. This is represented as depth in the figure. For material flow cost accounting, the process from procurement to production and logistics of materials and raw materials is the applicable scope. In a narrow sense, these kinds of business investments can also be conducted in the planning and design stage, etc., but to make the figure simple, they are presented only in the manufacturing stage. The environmental cost matrix is a tool that is used when establishing a budget and comprehending performance, and it is difficult to orient this method precisely in the figure in relation to a time period; in the figure, however, this method is presented in terms of an applicable range of costs. The environmentally conscious performance evaluation is not mapped in this figure, but this is because the target of business appraisals generally consists of periods such as fiscal years, and such periods vary depending on appraisal items and companies. However, for methods other than the environmentally conscious performance evaluation, it is possible to capture their rough positional relationships from the figure below.

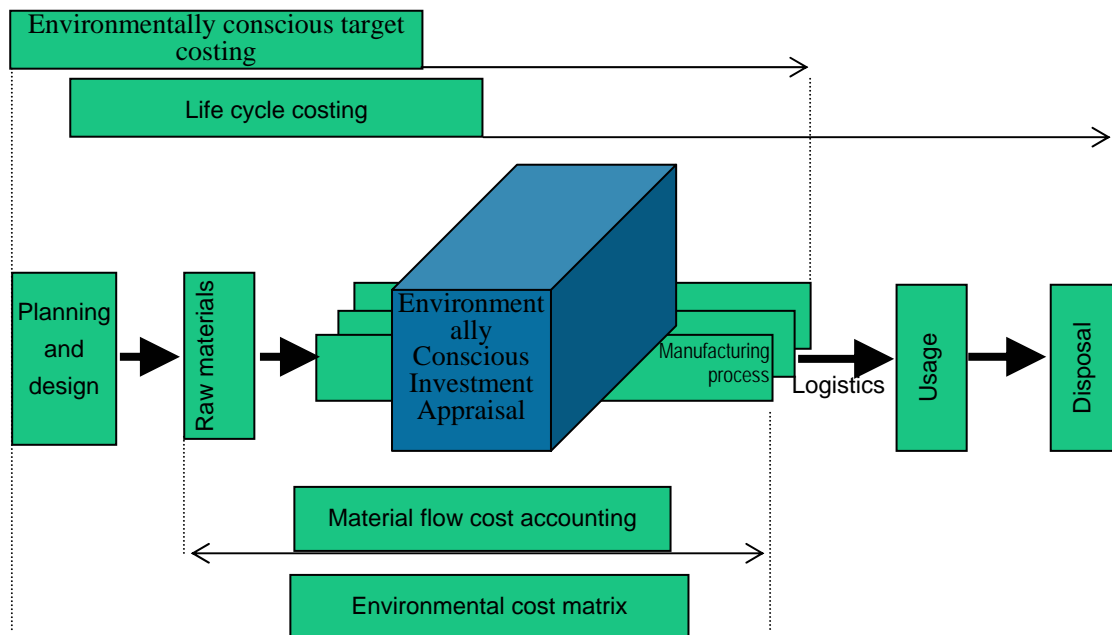


Figure 1-2 Relation of Each Method and their Applicable Scopes in the Business Process

Chapter 4 Material Flow Cost Accounting (MFCA)

4.1 What Is Material Flow Cost Accounting?

Explained in a simple manner, material flow cost accounting is as follows. (For details, refer to Japan Environmental Management Association for Industry, “Report on Investigative Studies Regarding the Promotion of Developments in Environmental Business (Environmental Accounting) 2000, commissioned by the Ministry of Economy, Trade and Industry.”)

The materials (collective term for all materials, without any classifications such as main raw materials or subsidiary materials) that are input are to be comprehended in terms of physical amounts, and the path of such materials within the company or within the manufacturing process are also to be traced. As the targets to be measured in doing so, focus is placed on the loss (waste) that does not constitute good products, rather than the material that constitutes final (good) products, and material flow cost accounting is a method that tries to evaluate value by recording the name and quantity of the materials that were input according to each area where losses are generated. This loss is referred to as “material loss,” and the ultimate purpose is to simultaneously achieve a reduction in environmental burdens and a lowering of costs by reducing material losses.

The most important cost elements in material cost accounting are the 3 elements of “material costs,” “system costs,” and “delivery/disposal costs.” If the manufacturing process is to be made a target area for material flow cost accounting, the manufacturing costs are to be classified according to these 3 elements.

Material costs are the most important costs, and refer to all of the raw materials that are input into the manufacturing process. Each raw material is tracked in terms of physical amounts, from the starting point for input until the final point. This physical amount is then multiplied by the unit price, and the material cost for each raw material that is input is calculated for each location.

By tracking quantities, it becomes clear that there is a flow of material objects towards good products, and that there is a flow of material objects towards material losses. The purpose of material flow cost accounting is to make this material loss clear; material losses are calculated in the procedure below.

Mass balance, which appears frequently in environmental management accounting, is also incorporated. Mass balance is a comparison chart that grasps and lists the material objects that are generally input into a company from the outside by the name and quantity of the material object, and at the same time grasps and lists the material objects that are output from companies to the outside in relation to the input. In other words, mass balance is a chart that lists the material expenditures, focusing on companies. Such a mass balance is based on the law of conservation of mass in physics, and boils down to whether to stock the input materials within a company or to discharge the materials outside of a company, without reducing the input materials in terms of mass.

In such a way, mass balance is introduced into the in-company process, and in addition to comprehending and recording the flow and stock of material objects, their value is also evaluated. Consequently, it is necessary to set up measurement points within the in-company process in order to obtain a mass balance by, for example, setting up a single manufacturing process to be the measurement point for the mass balance. In material flow cost accounting, this measurement point is referred to as a quantity center, and the inputs, outputs, and stock (inventory at the beginning of a period and the end of a period, or an in-process inventory) in relation to this quantity center is comprehended and recorded in terms of physical amounts and according to each material. Then, material losses are calculated using the following concept.

$$\begin{aligned} & (\text{Materials input} + \text{starting inventory}) - (\text{materials comprising good products} + \text{ending inventory}) \\ & = \text{Difference (material loss)} \end{aligned}$$

Using this concept, the physical amounts of input, output, stock, and material loss according to each material and for each quantity center can be comprehended, and by multiplying these amounts by the unit price, their value can be evaluated.

By expanding material flow cost accounting to the entire in-company process, and measuring and recoding the data for costs for each quantity center, further consistency in the overall data can

be obtained. Concrete results for this can be seen in the case example for Nitto Denko in section 4.2 “Overview of Surveys and Activities in 2000.”

Incidentally, system costs are the costs remaining after material costs and delivery/disposal costs for waste materials are subtracted from manufacturing costs, and mainly refer to processing costs such as depreciation costs and labor costs. System costs are comprehended and recorded for each quantity center. In material flow cost accounting, these system costs are distributed proportionally to good products and material losses, principally on the basis of quantity. By doing so, material flow cost accounting aims to clearly specify the manufacturing costs of material losses.

Delivery and disposal costs are generally made up of delivery costs and waste disposal costs that are related to waste materials. If the applicable scope for material flow cost accounting is expanded to cover the overall company or the supply chain, it is necessary to consider delivery costs including general logistics costs.

Energy-related costs, such as electric power and fuel, are also included in material costs, but in this project, they are comprehended and noted individually.

The cost notation system for material flow cost accounting is distinctive, and an explanation will be provided. In material cost accounting, the flow and stock of material objects is comprehended and value is assessed, but the purpose is no calculations for added value of products, such as with general cost accounting. The primary purpose does not lie in adding the cost data and presenting the overall costs for material losses, but rather in providing the constituents for material losses according to raw materials and a cost table for each of these constituent raw materials.

4.2 Overview of Surveys and Activities in 2000

Examinations started with an actual visit to the IMU (Institut für Management und Umwelt, Augsburg) in Germany, in order to understand the concept behind and a concrete method for implementing material cost accounting, which is an environmental management method that was developed and introduced by the IMU. The purpose was to experimentally implement material cost accounting in Japanese companies as based on this understanding, comprehend specific procedures for material flow cost accounting, and verify the effectiveness of this method in terms of environmental management.

In Germany, there is an accumulation of examples where material cost accounting has been implemented, as principle concepts and methods are clear. However, the creation of a theoretical system as a method for environmental management, and an environmental business method that is adapted to business routines are incomplete and are still in the stages of development. Consequently, while making the IMU’s material flow cost accounting a basis, material flow cost accounting was experimentally implemented through trial and error.

Specifically, cooperation from Nitto Denko Corporation (hereinafter referred to as “Nitto Denko”) was obtained, and an implementation experiment was conducted at the Toyohashi Plant, with the targets being 1 production line for 1 product family of adhesive tapes, for a period of one month (November 2000).

The material flow cost accounting that was executed in 2000 was composed of the 3 elements of (1) material costs (costs of resources and raw materials, etc.), (2) system costs (labor costs, cost depreciation, etc.) and (3) delivery/disposal costs, but since this was the first implementation experiment, the scope of implementation was limited to (1) material costs, rather than attempting to implement all aspects of material flow cost accounting. System costs and delivery/disposal costs were not applicable; a portion of energy costs were also confined to simply being taken into consideration, and were treated as an issue in 2001.

From the results of the experiment for implementing material flow cost accounting at Nitto Denko, it was clear that material flow cost accounting can be an effective environmental management method for companies.

What is particularly important was that material flow cost accounting pursues the flow of materials and the flow of the system from the start until the end, and views waste products in the sense of “**secondary product = negative product.**” Conventionally, in cost accounting, the materials that add value to a product (waste) are not recognised in terms of costs, and even if costs for treating waste in the end are recognised, the costs of materials that constitute waste are not

systematically recognised. In material flow cost accounting, however, processing costs and indirect costs that are included in waste (= system costs, etc.) are also taken into account, and calculations for costs are made in such a way that waste is regarded as a product. In other words, by pursuing materials that would conventionally be treated as yield and omitted until the very end, the overall picture of the impact and output of the materials in terms of quantity was able to be comprehended, making recognition of total losses possible, and companies were able to clarify the issue of the manufacturing process.

For example, in the case of Nitto Denko, each quantity center consisted of a processing process, and as it was possible to clearly specify good products and losses according to material for each process in terms of quantity and monetary amounts, what could only be known roughly in the past is now made clear. Concretely, it was clear simply by visual observations that the greatest losses were being generated at the quantity center for “cutting” from among all of the processes, but the monetary amount of these losses became clear and it also became possible to estimate a pertinent investment amount and review concrete improvement measures. In 2001, material flow cost accounting was expanded, the points for improvement that were discovered with the aid of material flow cost accounting were reconfirmed, and approaches for a management process in which actual decisions are made on improvement proposals were taken. Decision-making, however, was confined to how decisions can be made in terms of business practices, and naturally, the actual selection and implementation of decisions was left up to Nitto Denko.

From the experiment conducted in 2000, it was acknowledged that material flow cost accounting is an effective method for manufacturers of materials and components such as Nitto Denko, but it was perceived that this effectiveness differs according to the industry sector and business category. Accordingly, in 2001, the number of companies in which this method was implemented was increased, and multifaceted verification was carried out regarding its effectiveness.

4.2.1 Measurement Method for Material Flow Cost Accounting — Using the Case Example of Nitto Denko —

The 3 companies that started participating in 2001 (Tanabe Seiyaku Co., Ltd., hereinafter referred to as “Tanabe Seiyaku;” Takiron Co., Ltd., hereinafter referred to as “Takiron;” and Canon Inc., hereinafter referred to as “Canon”) started implementing material flow cost accounting using the 2000 case example of Nitto Denko as a reference. This concrete implementation of material flow cost accounting at Nitto Denko, and in particular, the setting up of quantity centers and the procedure for establishing mass balance at quantity centers, were effective in terms of understanding specific operations for material flow cost accounting. Accordingly, an explanation regarding the specific series of operations for material flow cost accounting is given below.

For concrete measurement for material flow cost accounting, it is necessary to be ingenious on a case-by-case basis, according to the company, industry sector, and product characteristics. However, it can be perceived that the way in which material flow costs were measured in this project can sufficiently be used as a reference for the foundation in implementing material flow cost accounting. The way in which material flow costs were measured is summarized once again below, in a simple and specific manner.

First, a simple explanation of the product and manufacturing process will be given. The applicable product was adhesive tape used for electronics, and was formed from a 3-layer structure consisting of base material, adhesive compound, and a separator. With regard to the manufacturing process, a flow chart that incorporates data is presented at the end of this section. As shown in this flow chart, in the “dissolution” and “batch formulation” processes, the adhesive compound was created, and in the “coating/drying” process, a sheet with a construction such that the adhesive compound is placed between the base material and separator is created. This sheet is cut into a tape form in the “cutting” process, and the product is considered complete after the “inspection/packaging” process. In relation to quantity centers, since temporary stock is generated during the “coating/drying” and “cutting” processes, a quantity center called “original sheets (stock)” was set up, and in addition, a quantity center called “product warehouse” was set up for the finished product.

The area for revision in the examinations conducted in 2000 is the establishment of this quantity center for “original sheets (stock).” When Dr. M. Strobel from the IMU, who is the developer behind material flow cost accounting, visited Japan in April 2001, the findings from the examinations conducted in 2000 were announced at the Nitto Denko Toyohashi Plant. At this time, high marks were received, as it was declared that in approaches at Nitto Denko, material flow cost accounting was being experimentally implemented in an accurate manner. However, it was recommended to establish a quantity center between “coating/drying” and “cutting” to represent stock of materials.

The method in which mass balance was set up at each quantity center for Nitto Denko is explained below.

(1) Overview of Gathered Data

[Input Resources]

• Dissolution process

Type	Input amount (weight)	Unit price	Money amount
Solvent	8,400kg	50 yen	420,000 yen
Polymers	2,100kg	180 yen	378,000 yen

• Batch formulation process

Type	Input amount (weight)	Unit price	Money amount
Solvent	1,042.643kg	50 yen	52,132.15 yen
Monomers	27.513kg	350 yen	9,629.55 yen
Cross-linking agent A	18.32kg	400 yen	7,328.00 yen
Cross-linking agent B	10.992kg	350 yen	3,847.20 yen

- Coating/drying process

Type	Input amount (length)	Unit price (yen/m)	Money amount
Base material	38,850m	30 yen	1,165,500 yen
Separator	42,160m	30 yen	1,264,800 yen

• Cutting process

Type	Input amount (rolls)	Unit price	Money amount
Winding core made from plastic	912 rolls	Depends on product specifications (width)	541,681.52 yen

• Packaging process

Type	Input amount	Unit price	Money amount
Various packaging materials (details omitted)	Omitted, as there are many varieties	Omitted, as there are many varieties	172,900.70 yen

[Production Quantity]

• Dissolution process

Type	Quantity
Polymer solution	1,374.924kg (actual measurement)

• Batch formulation process

Type	Quantity
Adhesive compound	Refer to the explanation on the dissolution/batch formulation process to be given hereinafter

• Coating/drying process

Type	Quantity
Coated original sheets	38,095m

• Cutting process

Product specifications	Quantity
Tape A	379 rolls
Tape B	96 rolls
Tape C	94 rolls
Tape D	48 rolls
Tape E	244 rolls
Tape F	12 rolls
Tape G	39 rolls
Total	912 rolls

[Stock]

• Coating/drying process

Type	Quantity
Starting inventory of coated original sheets	15,840m
Ending inventory of coated original sheets	10,355m

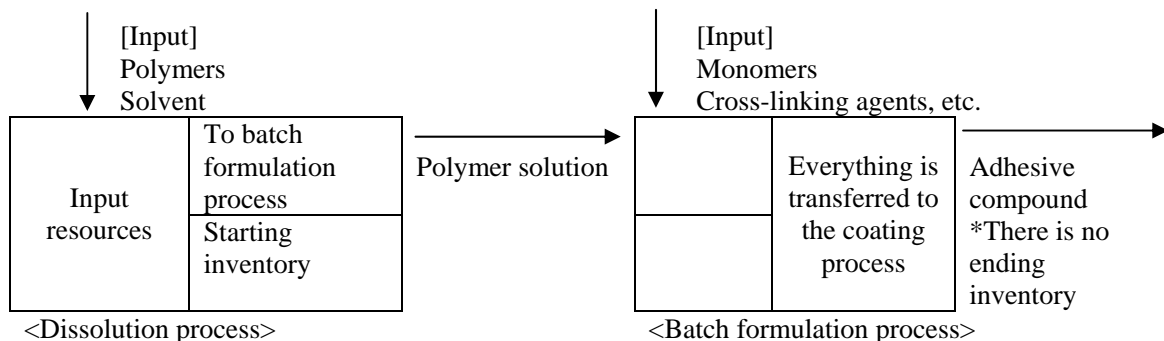
• Cutting process

Product specifications	Starting inventory	Ending inventory
Tape A	500 rolls	12 rolls
Tape B	9 rolls	2 rolls
Tape C	39 rolls	1 roll
Tape D	21 rolls	1 roll
Tape E	86 rolls	2 rolls
Tape F	0 rolls	0 rolls
Tape G	44 rolls	0 rolls
Total	699 rolls	18 rolls

(2) Calculation of Material Costs

[Dissolution/Batch Formulation Process]

To be precise, the dissolution/batch formulation process can be thought of by dividing it into a dissolution process and a batch formulation process. In the dissolution process, polymers and solvents are input. The polymer solution that is created here is then sent to the batch formulation process, where cross-linking agents, etc., are input, and a final adhesive compound is produced.



First of all, in the dissolution process, polymers are dissolved using a solvent, but rather than performing this individually for each product lot, this polymer solution is created in large batches and stored. Consequently, in order to think of the mass balance for the input and output in this dissolution process, there is no meaning unless all products that are produced from this polymer

solution, and not only the model product used in this examination, are taken into account. In this examination, calculations are made for only the model product, and it was assumed that the necessary solution was supplied from the dissolution process to the subsequent batch formulation process without any waste, and that there were no losses.

The amount of polymer solution that was transferred from the dissolution process to the subsequent batch formulation process was actually measured to be 1,374.924 kg, and when this amount was distributed proportionally based on a composition ratio for the total input amount (solvent: 8,400 kg, polymers: 2,100 kg), it was possible to calculate the amount input into the model product as shown in the chart below.

<Dissolution process>

Breakdown of resources	Unit	Input amount	Unit cost	Money amount
Solvent	kg	1,099.9392	50	54,996.96 yen
Polymers	kg	274.9848	180	49,497.26 yen
Total	kg	1,374.924		104,494.22 yen

Next, by mixing a cross-linking agent into the polymer solution that was created in the dissolution process, an adhesive compound can be produced, but at this stage, the compound deteriorates in a few hours and cannot be stockpiled for a long period of time. For this reason, a cross-linking agent is mixed by batch processing for each product lot. In regards to the batch formulation process, therefore, only the parts corresponding to the model product for this examination were able to be made subject to calculations. Fundamentally, as this compound cannot be stockpiled, there is no starting stock, and since all of this compound is considered to be transferred to the coating process, there is no ending stock either. During the period in between, the flow amount consists of the entire amount of adhesive compound that is created by batch formulation, which is the total of the amount input from the preceding dissolution process and the total amount of materials that is newly input in the batch formulation process. The amount that is newly input in the batch formulation process is presented below. The portion that remains unused in the subsequent coating process is considered a loss in relation to the adhesive compound.

<Batch formulation process>

Breakdown of resources	Unit	Input amount	Unit cost	Money amount
Solvent	kg	1,042.643	50	52,132.15 yen
Monomers	kg	27.513	350	9,629.55 yen
Cross-linking agent A	kg	18.32	400	7,328.00 yen
Cross-linking agent B	kg	10.992	350	3,847.20 yen
Total	kg	1099.468		72,936.90 yen

In summarizing the above, the total amount of adhesive compound and monetary amount that is input from the dissolution/batch formulation process to the subsequent coating/drying process is as follows.

<Totals for the dissolution/batch formulation process>

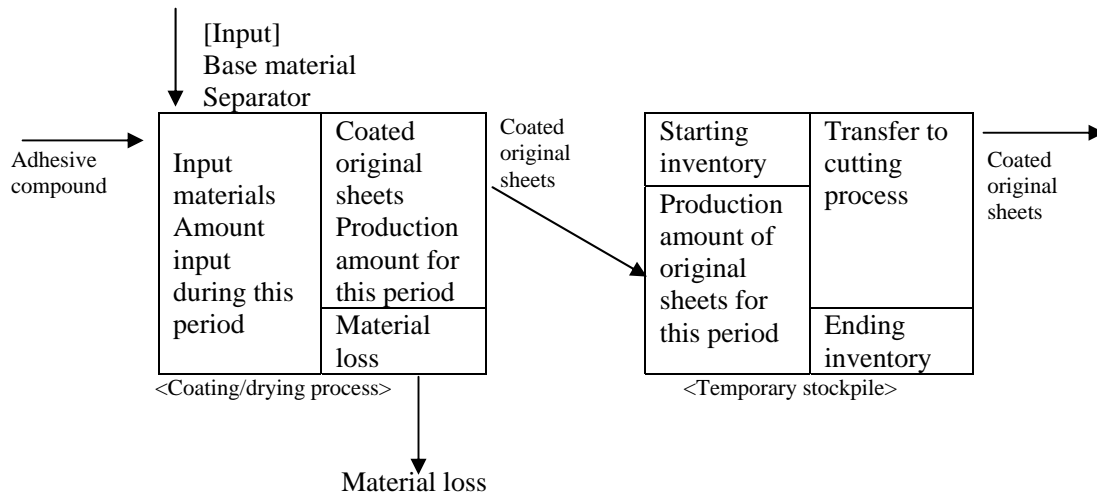
Process	Unit	Input amount	Unit cost	Money amount
Dissolution process	kg	1,374.924		104,494.22 yen
Batch formulation process	kg	1099.468		72,936.90 yen
Total	kg	2474.392		177,431.12 yen

[Coating/Drying Process]

In the coating/drying process, the base material and separator are newly input, and an original sheet is produced by coating the adhesive compound that is input from the preceding process. Coating and drying are a series of processes, and cannot be comprehended separately. In this process, there is no starting or ending inventory in the form of resources or raw materials, and there are also no work-in-progress products. However, as all of the input resources do not become

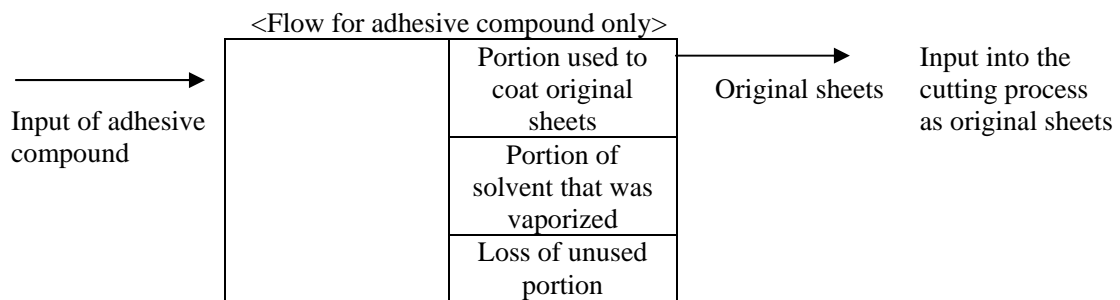
interim products, a fixed loss is generated. It is therefore necessary to make calculations by dividing material flow into interim products and losses.

There is starting and ending inventory of coated original sheets, but put in accurate terms, such sheets are products after output from this process, and form a temporary stockpile for before progressing to the subsequent cutting process. Consequently, the production amount of original sheets during the applicable period is 38,095m, but it can be thought that the amount of the difference after adjustments are made to the starting and ending inventory is sent to the subsequent cutting process, rather than the entire production amount.



As stated previously, losses are generated in this process, but its contents can be divided into two kinds of losses: (1) the portion of adhesive compound that remains unused, and (2) losses for the base material and separator at the beginning and end of coating.

(1) Firstly, with regard to the adhesive compound, a batch is formulated for each product lot, and this compound cannot be stockpiled, which means that the unused portion becomes a loss. In addition, during the drying process, all of the solvent that is contained in the adhesive compound vaporizes through drying. It is therefore necessary to divide the adhesive compound that is input into three categories of losses: unused portion, vaporized solvent, and adhesive compound that is applied to the original sheets.



There are two methods for calculating the materials flow for this adhesive compound. The first method is to use the amount of adhesive compound that is applied per 1m² of the product (mass balance) to calculate the total amount of adhesive compound that is applied as coating, and calculate the unused portion of the adhesive compound and the solvent that is vaporized based on the amount of difference. The second method is one where the total amount of the adhesive compound that remains unused is actually measured. With the first method, the theoretical value of the amount of adhesive compound (g) per 1m² of the product can be obtained based on product specifications for the product, but there is a fixed allowable range for this, with an upper limit and lower limit. In this examination in particular, a sample of a portion was taken and actual measurements were performed. The results of these measurements were, as expected, within the allowable range for theoretical values, but it is not necessarily true that this is the average value of

the product produced in this examination. Fundamentally, it is perceived that the usual concept is to make calculations by carrying out sampling several times and obtaining a numerical value that is thought to be close to the average value, but it is understood that in this case, marginal errors cannot be avoided.

In this examination, there were actual measurements relating to the portion of the adhesive compound that remained unused, and it was decided to use the second method for calculating the materials flow. The amount of unused adhesive compound for the model product was 186.272kg. The actual measurement value of the unused portion was subtracted from the total amount of the adhesive compound that was input from the dissolution/batch formulation process as calculated in [Input Resources], and the money amount was distributed proportionally, resulting in the figures below. In this case, the ratio of components for the unused portion and the portion used for coating are thought to be uniform, and the money amounts are divided proportionally based purely on weight ratios.

<Flow of adhesive compound to original sheets and unused portion>

	Input amount	Unused portion (actual measurements)	Difference (portion of adhesive compound used for coating)
Quantity (weight)	2,474.392kg	186.272kg	2,288.12kg
Money amount (calculations based on proportional distribution)	177,431.12 yen	13,357.00 yen	164,074.12 yen

Next, it is necessary to classify the portion of the adhesive compound that was used for coating the product and the portion of the adhesive compound of which the solvent vaporized. To do so, the ratio of components that has already been calculated is used to calculate how much solvent is in the adhesive compound, and the following figures were obtained.

<Content ratio of solvent in the adhesive compound>

	Total amount	Solvent	Components other than solvent
Weight of batch formulation	2,474.392	2,142.5822kg	331.8098kg
Content ratio	1	0.865902492	0.134097508

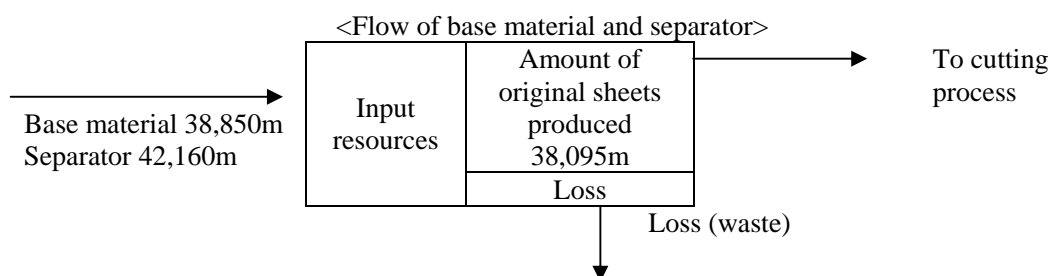
By perceiving that the solvent vaporizes completely, and that all other components in the adhesive compound remain in the base material, it is possible to use the content ratio given above to divide the adhesive compound that was applied once as coating into a solvent portion that vaporized and the remaining portion without this solvent. In this case, since the unit price differs according to the components, the money amount for the solvent portion was first calculated using a unit price of 50.00 yen for the solvent, and the money amount for the portion without the solvent (portion of adhesive compound coating the original sheets) was calculated by subtracting the amount for the solvent portion from the total amount.

<Flow of solvent portion of adhesive compound that vaporized and portion remaining on original sheets>

	Total amount used as coating on product	Solvent	Components other than solvent
Content ratio	1	0.865902492	0.134097508
Amount used as coating on product	2,288.12kg	1,981.29kg	306.83kg
Converted to money amount	164,074.12 yen	99,064.5 yen	65,009.62 yen

(2) Next, with regard to the base material and separator that is newly input during this process, since there is some time in the coating process between when coating using the adhesive

compound begins until it stabilizes, losses in a longitudinal direction are generated. As presented beforehand on the page for gathered data, the production amount of original sheets in this process is 38,095m, and it is possible to calculate losses using the by subtracting this from the amounts of base material and separator that are input.



When the input amount of the base material is distributed to the flow of original sheets and losses, the following figures are obtained.

<Flow of base material to original sheets and losses>

	Input amount	Production amount for original sheets	Difference (loss)
Quantity (length)	38,850m	38,095m	755m
Money amount (30 yen/m)	1,165,500 yen	1,142,850 yen	22,650 yen

In the same way as for the separator, when the input amount is distributed to the flow of original sheets and losses, the following figures are obtained.

<Flow of separator to original sheets and losses>

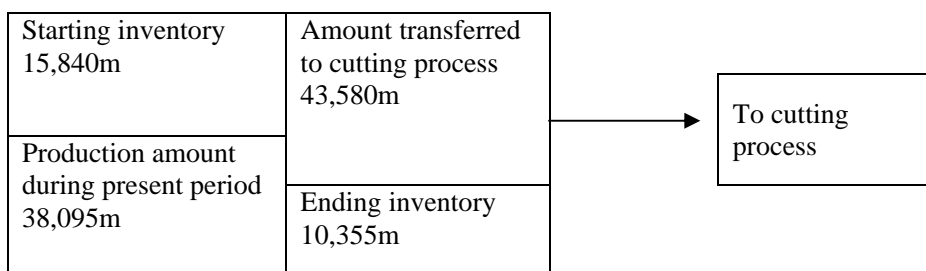
	Input amount	Production amount for original sheets	Difference (loss)
Separator (length)	42,160m	38,095m	4,065m
Money amount (30 yen/m)	1,264,800 yen	1,142,850 yen	121,950 yen

When the above results are narrowed down to the flow of materials to interim products, the flow of materials to the original sheets that were produced during the coating/drying process in the period under examination and its costs are as follows.

<Material flow to the original sheets produced in this period>

Material	Quantity	Money amount
Base material	38,095m	1,142,850 yen
Separator	38,095m	1,142,850 yen
Adhesive compound	306.83kg	65,009.62 yen

From the above, the material flow for the production of original sheets during the coating/drying process in the period under examination becomes clear, but as it was mentioned beforehand, there is starting inventory and ending inventory of coated original sheets. It is then necessary to calculate the material costs for the original sheets that are sent to the cutting process that follows. As shown on the page with gathered data, the starting inventory of original sheets was 15,840m, and the ending inventory was 10,355m. By making calculations through subtractions as shown below, it is possible to calculate the amount of original sheets transferred to the cutting stage as being 43,580m.



* Amount transferred to cutting process = Starting inventory + Production amount during present period – Ending inventory

$$= 15,840 + 38,095 - 10,355$$

$$= 43,580$$

When the adhesive compound, base material, and separator contained in the starting and ending inventories are calculated, the following figures are obtained. These results are listed by setting up a quantity center called “original sheets (stock)” in between the quantity centers for “coating + drying” and “cutting.” As this is solely temporary stock, though, there is no special warehouse. However, in material flow cost accounting, a quantity center that represents the stock is established, enabling for consistency between quantity centers, and for consistency and reliability to be established overall as well.

	Starting inventory	Ending inventory
Adhesive compound	27,032 yen	17,671 yen
Base material	475,200 yen	310,650 yen
Separator	475,200 yen	310,650 yen

If it is assumed that there is no change between the starting inventory and the production amount during the period under review for mass balance of the original sheets and for the unit price of the materials, by multiplying the materials flow of the original sheets for the amount produced in the period under review as calculated previously by (43,580/38,095), it is possible to calculate the materials flow of original sheets sent to the cutting process in the following way.

<Materials flow for original sheets to be input in the cutting process>

Material	Quantity	Money amount
Base material	43,580m	1,307,400 yen
Separator	43,580m	1,307,400 yen
Adhesive compound	351.01kg	74,370.26 yen

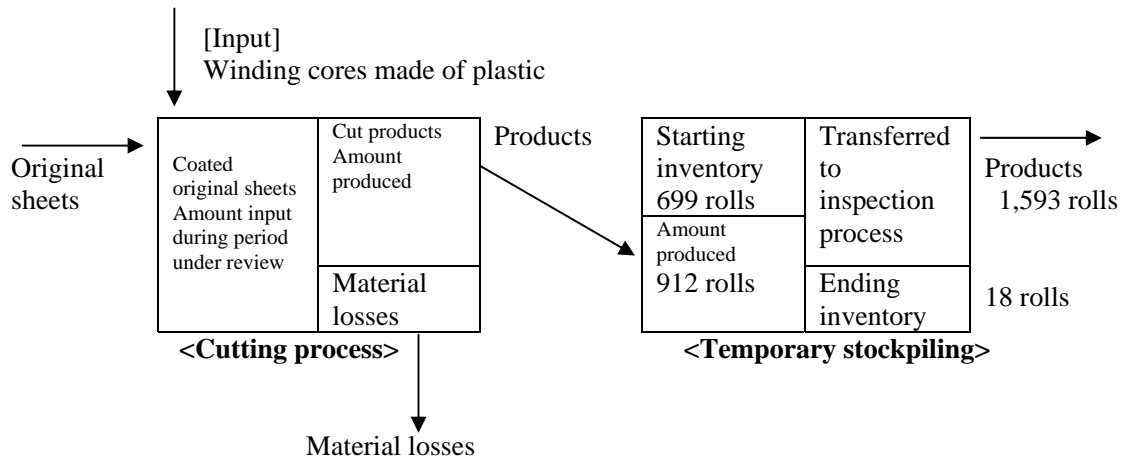
For example, the quantity and money amount of adhesive amount contained in the original sheets to be input into the cutting process can be obtained using the following formula if it is assumed that they have the same production amount for the period under review.

$$\text{Quantity of adhesive compound} = 306.83\text{kg} \times \frac{43,580\text{m}}{38,095\text{m}} = 351.01\text{kg} (74,370.26 \text{ yen})$$

[Cutting Process]

In the cutting process, the coated original sheets that are input from the preceding process are cut to a length and width that comply with product specifications, and are brought to completion as a product in the form of tape. In doing so, losses in the width direction are incurred, due to the relationship between the width of the original sheets and the width of the product. As it was mentioned earlier, in this process, cutting is performed by winding the original sheet around a plastic winding core, and at this point, a sensor is used to check defective products. Accordingly, in this process, additional losses are incurred in the form of defective products. In this process, plastic winding cores are newly input as material, but as these cores represent the product width, and only an amount for the number of products is provided, no losses are generated. All of the materials input into this process are cut, and there is no stock in terms of work-in-progress products.

There is product inventory at the beginning and end of the period, but this stock consists of items that are generated after outputs are made from this process, and is temporary stockpiled before they are sent to the inspection/packaging process that follows. As presented on the page with gathered data, the number of products after cutting during the period under review was 912 rolls, the starting inventory was 699 rolls, and the ending inventory was 18 rolls. This is comprised of products of different types, with differing specifications, and it is necessary to take heed of this when calculating material flow. If only the number of pieces is simply counted, however, then it is determined that the difference of 1,593 rolls was input into the inspection/packaging process that follows.



As stated above, the total quantity of products after cutting that serve as outputs from the cutting process is 912 rolls, and material losses can be calculated as the difference between this total quantity and the quantity of original sheets that were input in the beginning of this process. However, the total quantity of 912 rolls consists of the total number of products with various differing specifications, and cannot be simply totaled. As a result, calculations are made by converting the original sheets and products into surface area. With regard to the original sheets that were input, the width of the base material was 570m, and the width of the separator was 650m, enabling for the following kinds of calculations to be made.

<Surface areas of the base material and separator used in the original sheets that were input>

	Amount (length)	Width	Area
Base material	43,580m	570m	24,840.6m ²
Separator	43,580m	650m	29,327.0m ²

With regard to the products, the width of the tape differs according to the product specifications, and the production amount for the period under review is converted into area as shown below, rather than making calculations using width x length x number of pieces. Based on calculations, the total area for the products that were produced in the cutting process was 17,541.5m².

<Conversion of produced products to area>

Product specification	Production quantity	Area
Tape A	379 rolls	9,131m ²
Tape B	96 rolls	1,728m ²
Tape C	94 rolls	1,551m ²
Tape D	48 rolls	840m ²
Tape E	244 rolls	3,660m ²
Tape F	12 rolls	144m ²
Tape G	39 rolls	487.5m ²
Total	912 rolls	17,541.5m ²

When the materials flow and losses in the cutting process are calculated in terms of area, based on the relationship between the quantity input into the cutting process and the production amount as shown above, the figures shown in the diagram below are obtained.

<Materials flow for the cutting process>

Input amount		Production amount	
Base material	24,840.6m ²	Products	17,541.5m ²
Separator	28,327m ²	Losses	
		Base material	7,299.1m ²
		Separator	10,785.5m ²

Next, based on this relationship, the following figures are obtained when material costs are calculated separately for the base material, separator, and adhesive compound.

<Material cost for the base material in the cutting process>

	Input amount	Product	Difference (losses)
Area	24,840.6m ²	17,541.5m ²	7,299.1m ²
Money amount	1,307,400 yen	923,236.82 yen	384,163.18 yen

<Material cost for the separator in the cutting process>

	Input amount	Product	Difference (losses)
Area	28,327m ²	17,541.5m ²	10,785.5m ²
Money amount	1,307,400 yen	809,607.68 yen	497,792.32 yen

<Material cost for the adhesive compound in the cutting process>

	Input amount	Product	Difference (losses)
Area of base material	24,840.6m ²	17,541.5m ²	7,299.1m ²
Amount of adhesive compound	351.01kg	247.87kg	103.14kg
Money amount	74,370.26 yen	52,517.47 yen	21,852.79 yen

Calculations for the material flow in the cutting process are now complete. As it was previously mentioned, inventory exists in the beginning and end of a period even in the cutting process, but this is stock in the form of tape after it has been cut, and relates to post-outputs from the cutting stage. This stock is simply waiting to undergo inspection, and is not related to losses. Calculations pertinent to this stock are omitted here.

[Inspection/Packaging Process]

As it was mentioned above, in the inspection stage, there were no defective products for the model product for this examination. Therefore, there were no losses in this process. There were also no losses in the packaging process. Accordingly, in this process, the input resources are simply added to the product costs. There are actually numerous kinds of packaging materials, but only the total money amount will be presented here, and the breakdown for packaging materials will be omitted.

Total money amount for packaging materials	172,900.70 yen
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[Input Energy] (Reference)

In this examination, only the fuel costs and power costs associated with the coating equipment and cutting equipment were estimated through proportional distributions using operating time as the standard. The results of these estimations are shown below. The calculation process is omitted.

	Power costs	Fuel costs
Coating equipment	27,619.2 yen	44,496 yen
Cutting equipment	5,364.9 yen	0 yen

[Summary and Review of Calculation Results]

The following flow chart (Figure 4-1) represents the results of calculations for the year 2000, and the money amounts in terms of the material flow model for revisions that were made to some parts of these results. The flow chart for 2001 was altered in order to standardize the pattern with that of other companies, and the flow chart that is presented here uses the format for the flow chart from 2000.

4.3 Overview of Surveys and Activities in 2001

Based on the results of implementing material flow cost accounting at Nitto Denko in 2000, the applicable period for material flow cost accounting at the same model manufacturing department at Nitto Denko was extended from 1 month to 5 months, and it was decided to carry out experimental implementation continuously. It was also decided to broaden the scope of costs for material flow cost accounting to cover not only material costs, but full flow costs, including system costs and delivery/disposal costs, as well. It was also decided to refer to the 3 cost elements of material flow cost accounting using the collective term “full flow costs.”

Since the applicable target was 1 manufacturing line for 1 product family, the point from which materials are input into the target manufacturing line until the point when finished products are produced was determined to be applicable to material flow cost accounting. Accordingly, delivery/disposal costs refer to delivery costs related to disposal of waste materials and costs incurred from waste disposal itself. For example, if an entire company or a logistics system is included in the applicable range for material flow cost accounting, it is necessary to include general delivery costs and conduct examinations.

From the results of material flow cost accounting at Nitto Denko in 2000, however, several points for improvement in the process were discovered. It was therefore verified based on data over a 5-month period whether these points for improvement could be generalized, rather than being applied temporarily, and attempts were made to concretely implement environmental improvement management activities that are based on material flow cost accounting. Specifically, since it is necessary to reexamine the manufacturing process and raw materials, and also to make decisions in accordance with investments, it was decided to fundamentally aim for building theoretical/virtual procedures.

It was also possible to concretely test improvement activities to a maximum extent, with cooperation from companies that participated in these examinations. This represents substantial cooperation from participating companies as well as expectations for material flow cost accounting, and it can be appreciated that there is a positive attitude on the part of participating companies as companies that are advanced in environmental management, as well as towards understanding these examinations.

Consequently, the success of these examinations largely depended on cooperation by participating companies. However, as the purpose of these examinations was to verify whether material flow cost accounting is an effective method in terms of practical business affairs, and whether material flow cost accounting has potential, the most significant result was that all participating companies responded, in regards these points, that material flow cost accounting is an effective environmental management method. In addition, from the viewpoint of whether concrete decision-making was able to be tested, it is perceived that specific effectiveness towards companies was exhibited through material flow cost accounting. This point will be explained in the case studies on each company.

In 2001, it was decided to increase the number of case examples of companies implementing material flow cost accounting, in addition to expanding and elaborating the case study for Nitto Denko. Studying one company is insufficient for understanding material flow cost accounting in a practical manner, as well as for systemizing it as a concrete environmental management method. It is also necessary to study more case examples of implementation of material flow cost accounting in companies in order to clarify the fundamental parts of material flow cost accounting and the parts that require changes depending on company characteristics, such as the industry sector, as well as to provide useful environmental management methods.

As a result, starting in 2001, Tanabe Seiyaku, Takiron, and Canon also participated in implementing material flow cost accounting. The key points regarding the implementation project carried out in 2001 and that are common to the 4 companies are as follows.

- (1) Full flow costs, which include material costs, system costs, and delivery/disposal costs, are the target. Theoretically, energy costs, such as electrical power costs and fuel costs, are included in material costs. However, in this project, the consumption amount and costs for electricity, fuel, etc., are comprehended for each quantity center, and are displayed individually rather than being grouped under materials.

- (2) The premise for calculations regarding allocation of system costs is ABC (activity-based costing), and allocation bases are to be allocated using activity bases to an extent as allowable as possible. Allocation of system costs to non-defective products and material losses at quantity centers are also to be based on a principle of weight ratios.
- (3) The target for material flow cost accounting is 1 manufacturing line for 1 product family.
- (4) In implementing material flow cost accounting, data that already exists at companies is fundamentally to be used, rather than making new investments for the purpose of gathering data, etc.

With the above kinds of premises, it was actually possible to test the implementation of material flow cost accounting adapted to each company based on the company's circumstances and characteristics.

4.4 Overview of Case Examples of Implementation in Companies in 2001

As previously mentioned, the 3 companies that started participating in 2001 began implementation of material flow cost accounting using the 2000 case example for Nitto Denko as a reference. In order to understand concrete operations for material flow cost accounting, it was found to be useful to concretely carry out the material flow cost accounting implemented at Nitto Denko in 2000, and in particular, the setting up of quantity centers and procedures for establishing mass balance at the quantity centers. For information on the series of concrete operations for material flow cost accounting, refer to section 4.1.1. For the case examples of the companies that participated in 2001, since these companies fundamentally expanded on the case example of Nitto Denko, details on the characteristics of each company will be explained, rather than explaining the overall case example.

The characteristics for each of the example companies in implementing material flow cost accounting can be summarized as follows.

For example, in the case of Nitto Denko, the theme was to clarify how the company should execute improvement measures based on material flow cost accounting, and what kinds of information (including modes of information) is necessary to make decisions on such improvement measures.

For Tanabe Seiyaku, since there was also the fact that the period for implementation of SAP/R3 (an ERP system by the German company SAP), which is a type of ERP (Enterprise Resource Planning) system, overlapped with the period during which material flow cost accounting was implemented, consideration was given to the relationship between material flow cost accounting and the ERP system, which is perceived to be common in Germany, and focus was placed on the possibilities for the ERP system and the role of ERP in managing material flow cost accounting. Results from material flow cost accounting show that it is possible to comprehend waste disposal costs according to location, and it was also determined that costs generated at particular quantity centers were large. In addition, based on these results, concrete improvement methods are under review.

In the case of Takiron, the target for material flow cost accounting was a manufacturing line that almost fully achieves zero emission due to recycling. In accordance with this, the recycling system was evaluated from an environmental and economical perspective based on material flow cost accounting. Consideration was given to evaluation methods for the in-company recycling system based on material flow cost accounting, and the purpose of examinations was to concretely evaluate the recycling system at Takiron.

Lastly, for Canon, the target was the engineering process for camera lenses. Since this process consists of cutting glass material into the shape of lenses and coating these lenses, the main material loss is polishing sludge from glass (glass shavings). In addition to reducing material loss in this process, the purpose was to clarify how much and in which processes discharge from closed waste disposal processing, such as of effluent, was being generated. The production system was recently changed so that it is specialized according to processes, transforming it from a system for processing into a cell method system where one manufacturing department carries out production an integrated manner, from the starting point when raw materials are processed, until the final point. After this change was made, there was also a focus on evaluating the cell method, including analysis of the present state, to determine whether production is being conducted

efficiently between manufacturing processes, so that smooth production activities could be established. By doing so, attempts were made to clarify whether evaluation of structural specifications based on material flow cost accounting is possible, and what kind of ingenuity is necessary to make such evaluation possible.

Material flow cost accounting is effectively used as a tool for analyzing the present state of each company in the abovementioned kinds of ways. To use a metaphor, material flow cost accounting is a checkup tool used in conducting a health check for a company, and can be considered as having a role similar to a CT scan that gives a cross-sectional view of the inside of a human body. Based on analysis results, future improvement measures are established, and such measures are taken up by placing belief in the findings of environmental management. Material flow cost accounting is a tool that analyzes the current state within a company and detects any problems that may exist. The discovery of concrete problems and pursuit of improvement measures depends on the party receiving the information, and material flow cost accounting is not a tool that resolves problems if it is implemented. Although hints for creating a systematic management system extending from analysis of the present state based on material flow cost accounting to the execution of concrete improvement activities can be found in the case examples for this project, this remains a future challenge.

Efforts were made to make the format of the flow charts uniform between each company, but there are minor differences between each flow chart that derive from characteristics of each company. Explanations for the charts are given in the section for the flow charts for each company, including explanations on these differences. There are 4 types of flow charts common to each company, and these 4 types are as follows.

- (1) Flow chart relating to materials
- (2) Flow chart relating to system costs
- (3) Flow chart relating to waste disposal and utilities such as electricity and fuel
- (4) Flow cost matrix that generalizes the above 3 flow charts

(Note) All of the data does not represent the actual data, and has been edited for disclosure. Efforts have been made, however, so that percentages, etc., conform to explanations of the present state as much as possible.

4.4.1 Case Example at Nitto Denko

As of 2001, Nitto Denko was in its second year of implementing material flow cost accounting. Even in 2001, the target for material flow cost accounting was the same product/manufacturing process as based on results from 2000, and the primary purpose was to verify what kinds of concrete improvement activities are possible. Put differently, the purpose was to concretely verify how information obtained from material flow cost management can be applied to corporate environmental management.

First of all, the main differences in terms of calculations for material flow costs between the years 2000 and 2001 for material flow cost accounting are the following 2 points.

- Full flow costs, including system costs and delivery/disposal costs, were aggregated, rather than just material costs.
- The period for data aggregation was extended from one month (November 2000) to 5 months (November 2000 to March 2001).

Based on the results of systematic material flow cost accounting, a concrete scenario for process improvements was tested.

(1) Company overview

The company overview is available at <http://www.nitto.com>.

Chart 4-1 Environmental budget and actual results for Nitto Denko

(Units: millions of yen/month)

Categories	Fiscal 2000 budget	Fiscal 2000 results
Sales value of own products	16594.6	17093.3
Total sales	17995.0	18534.2
Environmental conservation costs		
General and administrative overhead	66.9	80.0
Disposal for industrial waste	68.7	79.1
External services for environmental management	20.2	19.2
Personnel	43.1	43.5
Depreciation	58.3	93.2
R&D&E	118.3	92.9
Total	375.5	407.9
Environmental impact costs		
Value of industrial waste	2645.1	2913.9
Energy	309.7	326.3
Organic solvents	150.0	141.1
Water	21.7	18.9
Total	3126.5	3400.2
Ratio of environmental impact costs*	17.4%	18.3%

(*: Ratio of environmental impact costs in relation to total sales) Source: Nitto Denko "Environmental Report 2001," p. 12.

(2) Targets and scope of implementation

The targets and scope of implementation are the same manufacturing line for the same product family as in 2000 (adhesive tape for electronics). Full flow costs that include system costs and delivery/disposal costs were aggregated, rather than only material costs. The data aggregation period was also extended from 1 month (November 2000) to 5 months (November 2000 to March 2001).

The reason why this period was extended was to test continuous implementation of material flow cost accounting, and because it was thought that in order to make decisions regarding improvements in the process based on material flow cost accounting, it would be necessary to review results from a 5-month period and then create and decide on improvement measures.

(3) Implementation structure: Creating a material flow model and establishing quantity centers

In 2001, changes were made to the quantity centers established in 2000. In 2000, the input for the quantity center for "cutting" and the output from the preceding quantity center "coating/drying" is noted as being a consecutive process. However, after "coating/drying," a temporary stop is put on the products completed during this process. Consequently, a quantity center for "original sheets (stock)" was established to represent a temporary warehouse between these two processes. This does not mean, however, that "stock" always exists.

In general, information relating to the amount of input and the amount of output for a certain period, the amount of starting and ending inventories, and the amount of losses is recorded in this "stock."

In addition, the project team below was organized to implement this project.

Plant: A model manufacturing department, Production Management and Information Department, Environment Department, Accountant and Materials Purchaser for the model manufacturing department, and Quality Assurance Department
 Headquarters: Environmental Headquarters, Accounting Department

(4) Gathering of data

The information gathered over the course of 1 month in the project implemented in 2000 was expanded to cover a 5-month period.

(5) Calculation of material costs, system costs, and delivery/disposal costs

The material costs were the same as those for 2000, and consisted of an adhesive compound and a separator that are formed from multiple materials, and some subsidiary materials. For details, refer to section 4.2.1, “Measurement Method for Material Flow Cost Accounting —Using the Case Example of Nitto Denko—,” in this document.

System costs, energy costs, and delivery/disposal costs were calculated as follows, based on various control data.

Costs	Allocation Base	Allocation Type
Personnel	Man-hour	Allocation on base of real data
Depreciation	Operating time	Allocation on base of monthly data
Other management costs	Expenditure	(Explanation below)
Electricity	Consumption	Allocation on base of monthly data (correctly as possible)
Fuel	Consumption	Allocation on base of monthly data (correctly as possible)
Waste disposal costs	Real costs	Calculated by actually measuring the weight

In addition, repair and inspection costs for the abovementioned manufacturing process and costs for consumables and tools, etc., were aggregated as “other management costs.” Such costs are not grasped for each quantity center, however, and were noted only as other system costs.

(6) Creating a flow chart that contains data

1) Flow chart (Figure 4-2: Material costs)

The top row, which is entitled “Raw materials/Base material/Separator,” represents new inputs made into the abovementioned manufacturing process.

The second row, entitled “Adhesive compound/Base material/Separator/Subsidiary materials,” reflect changes in the respective amount of materials. Accordingly, the numbers on the right side of this row represent the components for completed products.

The row underneath the quantity centers represents material losses. The reason why “Non-input losses” appears in front of the quantity center for “coating/drying” is because there remains some adhesive compound that was not completely used for coating in the preceding process. This remaining portion cannot be stored well. The solvent contained in this adhesive compound is also assumed to volatilize 100% at this quantity center, and this portion is symbolized by “Deodorizing furnace.”

2) Flow chart (Figure 4-3: System costs)

The top row marked “System costs” represents the system costs at each quantity center, with their totals shown underneath.

The row underneath the quantity centers represents the amounts where system costs have been distributed proportionally to non-defective products and material losses based on weight ratios for the materials. As mentioned above, the losses for the adhesive agent at the quantity center for “coating/drying” consist of the portion that was not used for coating. When thinking about system losses, therefore, it is appropriate to calculate the losses for the system costs (accumulated total) from the preceding quantity center. The losses at the quantity center for “coating/drying” (133,453 yen) were also distributed proportionally based on the weight ratio for the base material and separator, excluding the solvent that vaporizes completely.

3) Flow chart (Figure 4-4: Items related to utilities and waste disposal)

The money amounts in the top row represent the utility costs input at each quantity center. Underneath, in the row above and below the quantity centers, the amounts obtained upon proportionally distributing these utility costs to non-defective products and material losses based on weight ratios for the materials are given. The quantity center for “coating/drying” is treated the same way as for calculations for system costs.

For waste disposal costs, a unit cost for disposal in terms of weight in relation to the remaining adhesive agent is established. For adhesive tapes that are comprised of 3 layers, unit costs for disposal in terms of weight in relation to the adhesive agent, base material, and separator are also established, and calculations are made by determining each of their respective weights from the overall weight of waste.

4) Flow cost matrix (Figure 4-5)

Inputs are thought of as inputs into the applicable manufacturing line, and do not represent the flow of material objects. At the quantity center for “original sheets (stock),” it is necessary to presume that a portion of the stock that is carried over from the previous period is used as new input in the period under examination, if there is less starting inventory than ending inventory. This input amount is therefore listed as well.

Using the aggregation results, percentages such as the ones shown below were calculated. This represents an analysis of overall material losses and the quantity center for “cutting,” where material losses were the greatest.

Material flow cost percentage (Percentage of total amount of losses in relation to total costs): 29.8%

Cutting loss cost percentage (Percentage of total cost of “cutting” losses in relation to total costs): 23.6%

Cutting loss percentage (Percentage of the total cost of “cutting” losses in relation to the total loss costs): 79.2%

From these results, it is clear that the quantity center for “cutting” is the most important point for improvement, where the amount of losses is approximately 5.4 million yen.

Flow Chart (Material Costs)

Nitto Denko (Adhesive tape for electronics: 4,785 rolls)

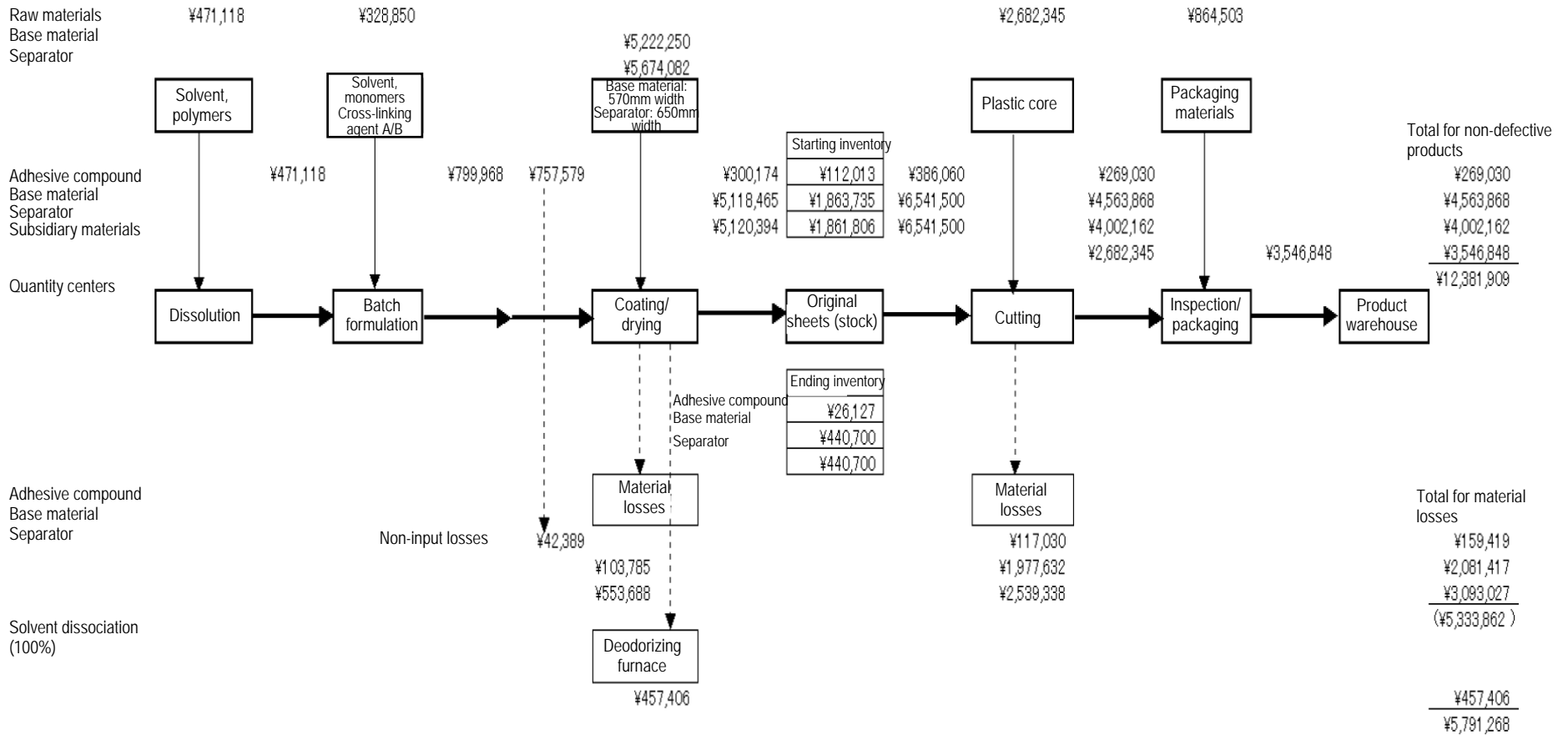
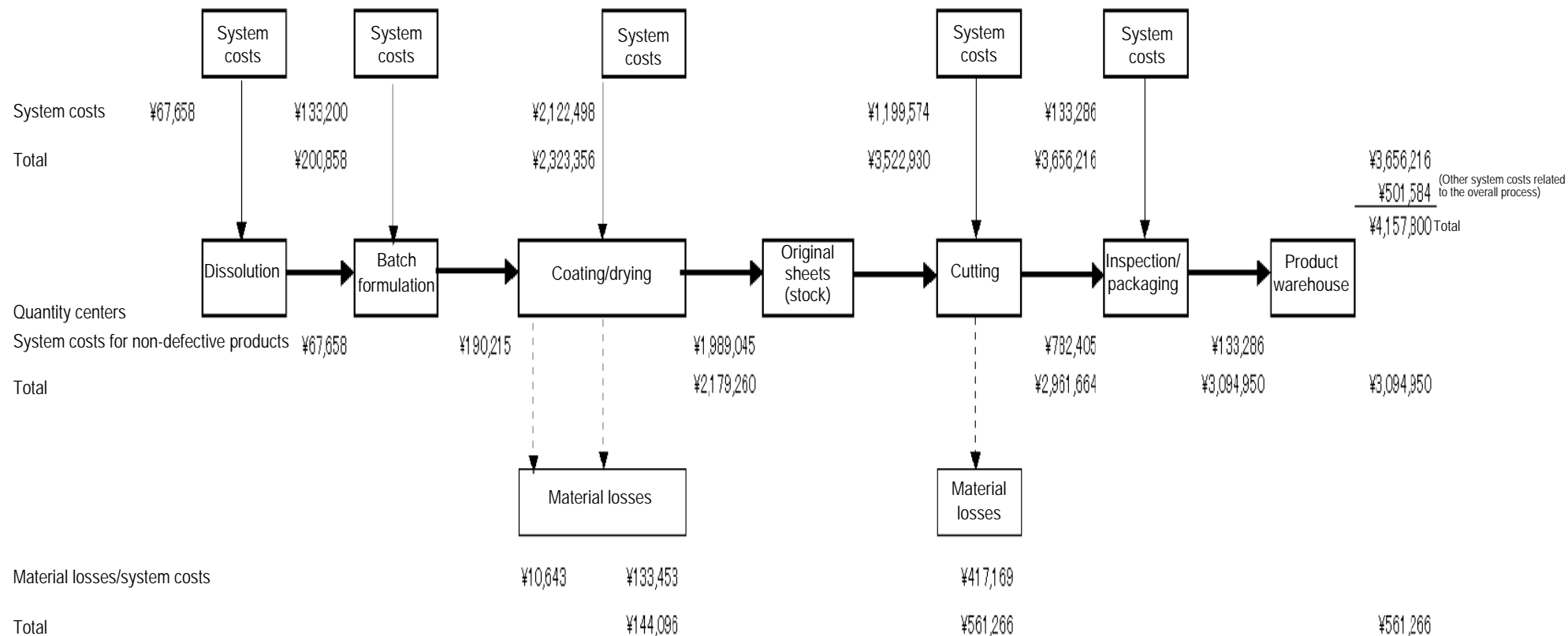


Figure 4-2 Nitto Denko Flow Chart for Material Costs

Flow Chart (System Costs)

Nitto Denko

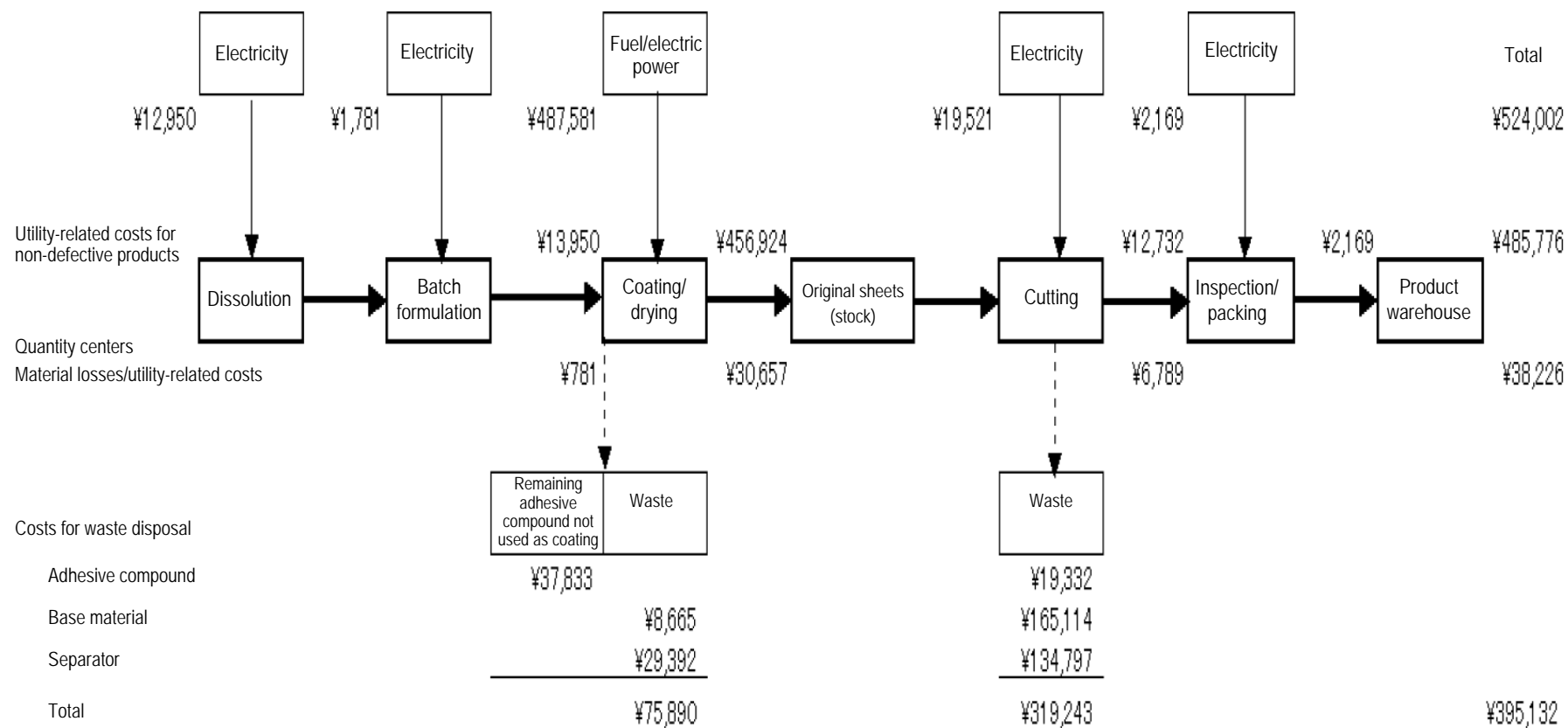


Losses related to the adhesive compound at the quantity center "Coating/drying" represent the portion that was not used as coating. When thinking of system losses, it is therefore appropriate to calculate the losses in relation to the system costs (total) for the preceding quantity center. The losses at the quantity center "Coating/drying" (133,453 yen) were distributed proportionally based on the weight ratios for the base material and separator, excluding the solvent that vaporizes completely.

Figure 4-3 Nitto Denko Flow Chart for System Costs

Flow Chart (Items related to Utilities and Waste Disposal)

Nitto Denko



Unit costs in terms of weight were established for each, each waste product was converted to weight as necessary, and this weight was multiplied by the unit cost.

Figure 4-4 Nitto Denko Flow Chart for Items Related to Utilities and Waste Disposal

Flow Cost Matrix

Nitto Denko

Quantity centers	Dissolution	Batch formulation	Coating/drying	Original sheets (stock)	Cutting	Inspection/packaging	Product warehouse		
Input									
Material costs	¥471,118	¥328,850	¥10,886,332	¥2,930,028	¥2,682,345	¥864,508	¥0	¥18,173,177	
System costs	¥67,658	¥133,200	¥2,122,498	¥0	¥1,198,574	¥133,286	¥0	¥3,656,216	
Utility-related costs	¥1,2950	¥1,781	¥467,581	¥0	¥19,521	¥2,169	¥0	¥524,002	
Subtotal	¥551,726	¥463,831	¥13,506,411	¥2,930,028	¥3,901,440	¥999,958	¥0	¥22,353,395	
Material losses									
Material losses	¥0	¥0	¥42,389	¥1,114,879	¥4,634,000	¥0	¥0	¥5,791,268	
System costs	¥0	¥0	¥10,643	¥133,453	¥417,169	¥0	¥0	¥561,266	
Utility-related costs	¥0	¥0	¥781	¥30,657	¥6,789	¥0	¥0	¥38,226	
Waste disposal costs			¥37,833	¥38,057	¥319,243			¥395,132	
Subtotal	¥0	¥0	¥91,646	¥1,317,046	¥5,377,201	¥0	¥0	¥6,785,882	

For the input of materials at the quantity center "Original sheets (stock)" there is less starting inventory than ending inventory for the period under examination, and the difference between these inventories was considered as being the input amount for this period.

	Material costs	System costs	Waste disposal costs	Subtotal
Non-defective products	¥12,381,909	¥3,580,726	0	¥15,962,635
Material losses	¥5,791,268	¥599,492	¥395,132	¥6,785,892
Subtotal	¥18,173,177	¥4,180,218	¥395,132	¥22,748,527

Material loss cost percentage 29.8% (Percentage of total amount of losses in relation to total costs)
 Cutting loss cost percentage 23.6% (Percentage of total amount of "cutting" losses in relation to total costs)
 Cutting loss percentage 79.2% (Percentage of the total amount of "cutting" losses in relation to the total loss costs)

Figure 4-5 Nitto Denko Flow Cost Matrix

(7) Evaluation as a company implementing material flow cost accounting: Discovery of points for improvement and improvement activities

Based on the aggregation of material flow cost accounting over the course of a 5-month period in 2001, although the money amounts and results from material flow cost accounting are naturally larger than those obtained in 2000 (when material flow cost accounting was implemented over the course of 1 month), the relative ratios between the quantity centers were found to be the same. It was therefore perceived that the points for improvement that were discovered based on the results of material flow cost accounting in 2000 could be universalized. Based on this, activities to reduce losses in detailed areas in the quantity center for “coating/drying” were carried out first. An experiment to improve separator losses in the quantity center for “cutting” was then implemented, and the width was altered to the minimum limit. Through improvements in these processes, material losses have currently improved by approximately 7%. In addition, reexaminations on the base material, including new equipment for the manufacturing of base materials, are being conducted in order to improve the losses that stem from base materials.

This kind of management decision-making is carried out by top management, based on judgments regarding new investments, etc. Accordingly, it is necessary to create and present a report on the results of material flow cost accounting to the top management in order for improvement measures to be adopted. For example, Figure 4-6, which was used within Nitto Denko (altered for public disclosure) shows quantities and money amounts in one chart, and is an extremely useful chart for clearly reporting what the points for improvement are to the top management, who have knowledge on the manufacturing process to some extent. In the future, it is necessary to concretely survey and research what kind of format should be used and to what extent reports on material flow cost accounting should be made, to which management level, and for what kinds of issues, so that such reports can be useful.

Material Flow Accounting (Summary)

Model manufacturing section:
 Product: Adhesive tape for electronics (912 rolls)
 Period: November 1, 2000 to November 30, 2000 (1 month)

First row: Adhesive compound (red)
 Middle row: Base material (blue)
 Bottom row: Separator (green)

→ Flow towards finished products
 - - - → Flow towards waste products

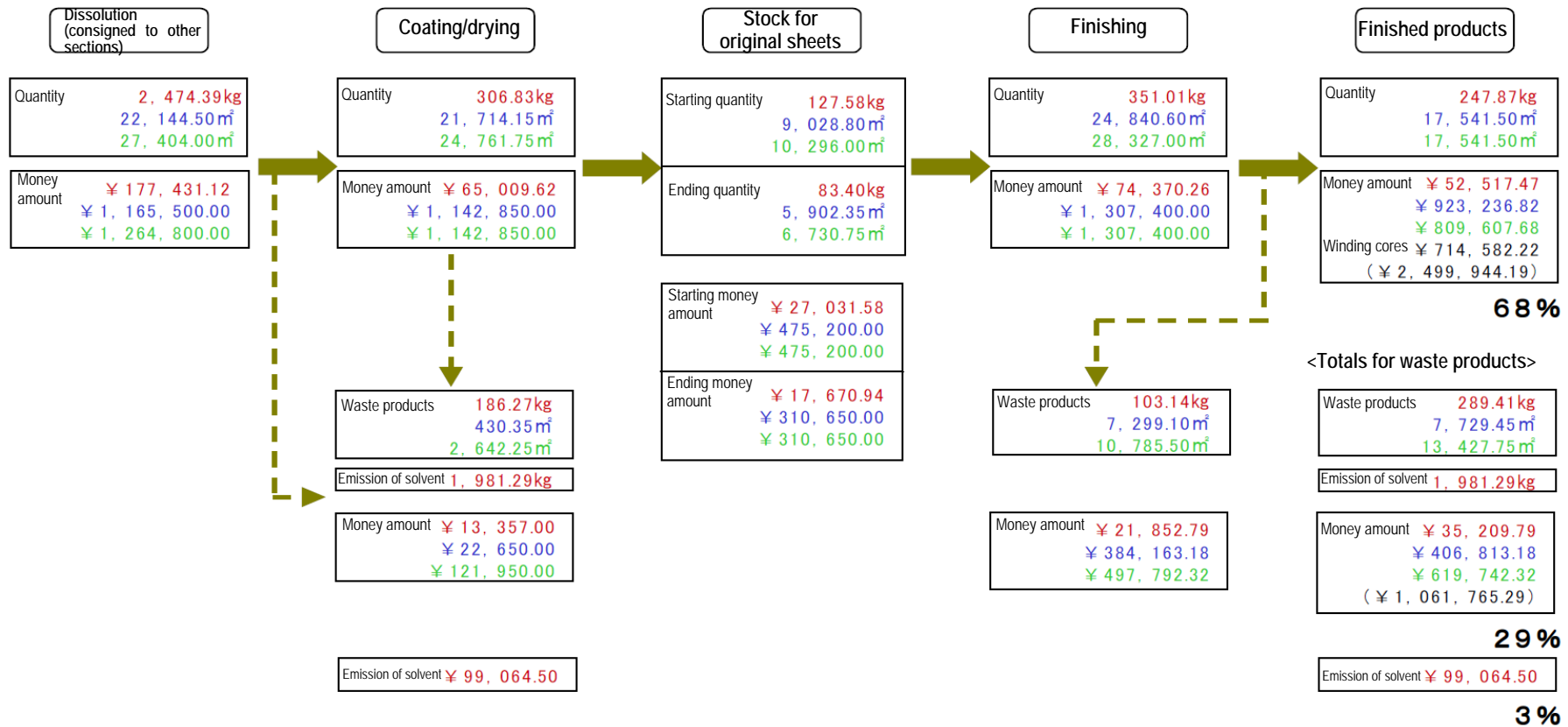


Figure 4-6 Example of Summary Used for Reports

4.4.2 Case Example at Tanabe Seiyaku

Tanabe Seiyaku is a company that started cooperating in the implementation of material flow cost accounting in 2001. The main characteristics in this case example are given below.

For example, case examples for implementation of material flow cost accounting based on Germany's IMU are explained in relation to its linkage with the ERP (Enterprise Resource Planning) system. However, for Japanese companies, there are a comparatively large number of cases where an information system developed in-house is used, which is one of the differences in the case examples for implementation of material flow cost accounting between Germany and Japan. In German case examples, there are many instances where material flow cost accounting is explained and developed as premised on the ERP system. It was conjectured that in Japan, there are not many opportunities to concretely verify the usefulness and linkage method between material flow cost accounting and the ERP system.

However, Tanabe Seiyaku has been undergoing preparations for starting system operation with SAP R/3 in April 2002, and it was also decided to take this opportunity to experimentally implement material flow cost accounting during this same period. Material flow cost accounting was therefore to be implemented, keeping its systemization with SAP in mind. One of the purposes was also to verify what kind of role the ERP system plays in implementation of material flow cost accounting.

A systematic association between the ERP system and material flow cost accounting was made, and attempts are made to link this with in-house cost accounting systems. In comparison with the other 3 case examples where material flow cost accounting was confined to partial implementation or implementation in the manner of a project similar to special cost studies, the aspect of this case example where a connection is made between product cost accounting systems and material flow cost accounting is regarded as being an approach that contributes to a valuable experience.

(1) Company overview

The company overview is available at <http://www.tanabe.co.jp/english/index.shtml/>.

<Environmental accounting for Tanabe Seiyaku>

Scope: 3 locations for Tanabe Seiyaku (in Onoda, Kashima, and Toda), and Tanabe Seiyaku Yoshiki Factory Co., Ltd. (which is a consolidated subsidiary)

Period: April 1, 2000 to March 31, 2001

Environmental Conservation Costs Units: Millions of yen

Environmental conservation costs				
Category		Main contents of approaches	Investment amount	Costs
1. Environmental conservation costs to control environmental burdens generated within the business area due to production and service activities (business area costs)			103	694
Breakdown	(1) Pollution control costs	New construction/operation and maintenance of equipment to reduce emission of air pollutants and drainage treatment facilities Analysis and measurements for air, water quality, etc.	82	390
	(2) Global environmental conservation costs	Installation of energy-saving air conditioners	4	—

	(3) Resources recycling costs	Renewal/operation and maintenance of facilities for disposal of industrial wastes Treatment and disposal of industrial wastes	17	304
2. Costs to control environmental burdens generated on the upstream or downstream in accordance with production/service activities (upstream/downstream costs)		Promotion of green procurement Expenses for commissioning recommercialization of containers and packaging	—	6
3. Environmental conservation costs for management activities (management activities costs)		Environmental education for employees Operation of EMS that complies with ISO 14001 Personnel costs for Environmental Affairs Department	—	213
4. Environmental conservation costs for research and development activities (R&D costs)		Research and development of environment-conscious products (Costs related to research and development at product technology research laboratories)	3	134
5. Environmental conservation costs for social activities (social activities costs)		Maintenance and management of green areas within the site Donations to organizations that carry out environmental conservation Creation and publication of environmental reports Pollution load levy based on Law Concerning Pollution-Related Health Damage Compensation and Other Measures	—	26
6. Costs for responding to environmental damage			—	—
Total			106	1073

Item	Amount (millions of yen)
Total investment amount for period under examination	3,625
Total R&D costs for period under examination	19,816

Environmental Conservation Effects

		Amount of environmental burdens reduced	Amount of environmental burdens (for 2000)
(1) Pollution prevention	SOx	-0.0t	0.1t
	NOx	0.6t	15.1t
	Total amount of drainage water	540,000m ³	6,320,000m ³

	Amount of BOD burdens	7.1t	42.4t
	Amount of COD burdens	1.6t	51.0t
(2) Conservation of global environment	Amount of CO ₂ emissions	2100t	41,500t
	Amount of energy used	49,000GJ	937,000 GJ
(3) Resources recycling	Total amount of waste discharged	506t	2,731t
	Final waste incineration and disposal amount	869t	5,901t

Economic Effects Associated with Environmental Conservation Measures

Details of effects	Amount (millions of yen)
Reductions in costs in association with energy-saving activities	88
Reduction of waste disposal costs in association with recycling	17
Income obtained through recycling (profits from selling collected items)	68
Total	173

(2) Targets and scope of implementation

The target for implementation was a manufacturing process for 1 product family for a medicinal drug that is produced at the Onoda plant. In this manufacturing process, multiple raw materials are input into a synthesis process, after which these synthesized products are purified. After completing purification, the products are then input into the next process and pharmaceutical chemicals are manufactured. After these pharmaceutical chemicals are weighed, they undergo the drug formulation process, are packaged in various capacities and containers, and form a finished product. Material losses are generated from each process, but are divided into those that are recovered and returned to the preceding process or their own process, and those that directly undergo disposal as emission (waste).

For the scope of costs for material flow cost accounting, the full flow costs of “material costs,” “system costs,” and “delivery/disposal costs” were aggregated, and the overall manufacturing cost for this target product was categorized into these 3 types of costs. Data was gathered for a period of one year, from April 2000 to March 2001.

Regardless that this was the first year that material flow cost accounting was being implemented, the reason why the data collection period was set to 1 year was because Tanabe Seiyaku already had a simulation system for manufacturing costs that they themselves had developed (data on costs of raw materials, labor costs, and quantities), and also because since Tanabe Seiyaku had already made approaches so that data could be gathered in conjunction with the introduction of SAP/R3 (An ERP system by SAP) in 2002, it was determined that it would be comparatively easier to deal with data from a period of 1 year.

With this case example, if an ERP system based on an integrated database is implemented, aggregation of 1 year’s worth of data relating to material flow cost accounting is, naturally, a great deal easier than performing calculations by hand. Also, if the period for implementation of the ERP system overlaps with the period for implementation of material flow cost accounting, it is possible to reflect a system design that is in accordance with material flow cost accounting in the ERP system, which can be considered good opportunity to systematically introduce material flow cost accounting.

However, it is necessary to review the aspect of how to incorporate material flow cost accounting into the ERP system. For example, if material flow cost accounting is directly incorporated into the ERP system, extreme amounts of time (including energy) and costs become necessary in general, in the sense that the ERP system itself has to be customized. Accordingly, it

is necessary to make considerations by including the building of a secondary system where data is extracted from the REP system and processed into material flow cost accounting as one of the choices. In addition, it was made clear exactly what the necessary data was in regards to material flow cost accounting, and a design for obtaining this data through the ERP system was reviewed within Tanabe Seiyaku. It was not possible, however, to review a concrete design during this examination. Furthermore, future issues remain, such as the issue of how a system that integrates the ERP system and material flow cost accounting operates, and the issue of the ERP system not operating at all times.

(3) Implementation structure: Making a material flow model and setting quantity centers

To explain material flow cost accounting to the staff at the plant where it was to be implemented, and to tour the plant and view the products (manufacturing process), a visit was made to the Onoda plant in July 2001.

From this visit, it was decided that the target for material flow cost accounting would be a manufacturing process for 1 product family, and the attached flow charts were created.

To execute this project, the project team (total of 15 people) described below was organized.

Headquarters (4 people): Financial Accounting Department (in charge of cost accounting and SAP R/3)—1 person

Environmental Affairs Department (in charge of environmental accounting)—1 person

Information Systems Department (in charge of cost accounting and SAP R/3)—2 people

Plant (11 people): General Affairs Department (in charge of accounting)—3 people

Environment Affairs Office—2 people

Production Management Department—1 person

Quality Assurance Office—1 person

Pharmaceuticals Department—1 person

Drug Formulation Department—1 person

Energy Management—2 people

(4) Gathering of data

For quantity data on materials (raw materials) and labor costs, it was possible to easily obtain data using the simulation system for manufacturing costs that was developed by Tanabe Seiyaku. Data related to other costs was also gathered from data in financial accounting.

Concretely, the information materials used as data for quantities and money amounts included a list that shows actual performance values according to process for each material if a finished product that is labeled as being 100kg is converted into 100kg (for the year 2000), an analysis master that shows a cost accounting chart for 2000 and theoretical figures for each process, and a standard cost accounting chart for 2000.

Since the data for a period of 1 year was taken from while SAP was under implementation, data was still gathered even if a part of the data had to be calculated by hand. Based on this, it was possible to calculate the mass balance independently for each quantity center, but it was not possible to achieve consistency between the quantity centers. Since the input amounts for each quantity center were actually measured, however, the mass balance for each quantity center reflects accurate data that was actually measured. It is conceivable that after SAP put in operation, however, it would be possible to obtain consistency between the quantity centers, and there are plans for making such approaches.

(5) Calculation of material costs, system costs, and delivery/disposal costs

With regard to the use and production of materials (raw materials) in each manufacturing process, there are theoretical figures, standard values, and actual performance figures, and these 3 types of figures are applied towards the calculation of material losses.

It was determined to recognize material costs as the difference between actual performance figures and theoretical figures, which are based on calculations of molecular weight. In other words, there are theoretical figures that are attained chemically, standard values that are based on past data and serve as performance goals for management, and performance figures for actual performance; in terms of business, there are material losses that incorporate the relationships

between these three types of figures, and the analysis of these material losses is considered to be effective for management. However, this topic was considered to be a future issue, and in this project, material losses were considered to be the difference between the abovementioned theoretical figures and actual performance figures. Those that result in monetary losses, however, were directly grasped individually. Examples include cardinal remedies, auxiliary materials, subsidiary materials, and solvents. For packaging materials, losses were recognized through theoretical yields used in calculating losses for cardinal remedies in the packaging process.

For utilities (water, electricity, steam) costs, after usage costs for each department were allocated to quantity centers (processes) using machine-hours, losses were calculated based on weight ratios for raw materials.

$$\text{Machine-hours} = (\text{Standard machine-hours per lot}) \times (\text{Number of production lots})$$

The usage of machine-hours is to make the information materials be comparable to analysis materials pertaining to after SAP R/3 is implemented in April 2002. Another reason why machine-hours is used is because the allocation of machine-hours is perceived to be more suitable than the present allocation of man-hours.

“System costs” and “delivery/disposal costs” were calculated as follows.

- Labor costs:

Man-hours were acknowledged for each quantity center (process), and losses were output through weight ratios for raw materials.

- Equipment costs:

Depreciation costs and repair costs for machine equipment are applicable. Cost centers for total existing depreciation were modified after SAP R/3 was introduced, and equipment costs were allocated in machine-hours according to quantity centers (processes). Afterwards, losses were output using the following calculation formula.

$$(\text{Amount of energy for each quantity center}) \times (1 - (\text{Machine-hour} / 24 \text{ hours} \times 365 \text{ days}))$$

- Other:

Labor costs, depreciation costs, and other expenditures other than those for the manufacturing department represent amounts that are adjusted through allocation, and are not distributed to losses, since they have strong components in the form of fixed costs. Amounts that are adjusted through allocation refer to the amount of differences obtained when allocation standards after implementation of SAP R/3 are applied to energy costs and equipment costs.

- Delivery/disposal costs:

Waste disposal costs were added up for each quantity center. As explained previously, general delivery costs were not included.

(6) Making a flow chart that includes data

1) Flow chart (Figure 4-7: Material costs)

As it has been explained already, the mass balance for quantity centers has been obtained independently in this examination, but there is no consistency between the quantity centers. Accordingly, there are two arrows between the quantity centers to signify output from a quantity center and input into the following quantity center. The row above the quantity centers represents input data, and the numbers above the arrows represent output of good products or input from the preceding process. The material losses for this production process that appear in the row below the quantity centers are represented as material losses that did not directly become good products. Underneath, arrows from “Material losses” indicate the material losses that are generated from re-input into the recovery process or back into their own process, and the material losses that directly become final emission (waste).

2) Flow chart (Figure 4-8: System costs)

The system costs that are input are divided into 2 groups: system costs that are comprised of labor costs and equipment costs, and other system costs as mentioned above. The system costs that

are comprised of labor costs and equipment costs are proportionally distributed towards good products and losses and are presented. Other system costs are calculated as follows.

$$(\text{Total amount of overhead costs}) - (\text{Labor costs} + \text{equipment costs} + \text{utility costs} + \text{disposal fees}) = \text{Other system costs}$$

The total amount of overhead costs are those from 2000, and are calculated using a conventional calculation method, but since the equipment costs and utility costs are calculated using calculation standards that are in accordance with SAP, the total amount and its machine elements, though part of the same formula, are calculated using different calculation standards. Consequently, at the present moment, other system costs are adjusted amounts of differences, and may be negative depending on the situation (expressed in parentheses for quantity centers for “Synthesis” and “Recovery I.”) SAP was implemented starting in April 2002, and the calculation method for overhead costs was changed as shown below.

		Labor costs	Equipment costs	Utility costs
Total amount: Conventional method	March 2002 and earlier	Man-hours	Man-hours	Man-hours
System costs: SAP method	April 2002 and later	Man-hours	Machine-hours	Machine-hours

3) Flow chart (Figure 4-9: Items related to utilities and waste disposal)

The rows above the quantity centers represent costs related to utilities and the amount of money that is input into each quantity center, and the costs for good products where this input amount is proportionally divided among good products and losses is shown above the arrows between the quantity centers. Underneath these arrows, the losses for utility-related costs are shown. The arrows pointing down from the quantity centers represent disposal of final emission (waste), and the disposal costs for each final waste product is also given.

4) Flow cost matrix (Figure 4-10)

The material costs, system costs, and utility-related costs that are shown in the top row under “Input” represent the amounts that are input into each quantity center, but as there are no new inputs into the manufacturing process that is under review, these figures represent the flow of substances from the preceding process. The figures for the quantity center for “packaging” are therefore the total input manufacturing costs that are calculated based on the final products for the period. Though it has already been mentioned, since mass balances have been obtained under the premise that each quantity center is independent, all values are displayed as new inputs towards quantity center for the sake of the documented materials.

The material losses in the lower row all represent individual losses generated at each quantity center. The total for these losses is indicated on the right side of the chart. As it has been explained above, since material losses are comprised of those that are returned to the recovery process or their own process, and those that directly become final emission (waste), the amounts displayed are those that have been proportionally distributed into such categories. System costs represent the money amount for material losses overall (those recovered and those that become final emission (waste)) for each quantity center. It is necessary to divide these amounts proportionally into the portion that is collected and the portion that becomes final emission (waste), but in this examination, this was not carried out due to time constraints.

Since aggregations were made independently for each quantity center, there is no consistency overall, but since the inputs and outputs (including losses) at each quantity center have actually been calculated, the data obtained contains, for example, accurate figures that reflect actuality. Consequently, the following kinds of percentages, for example, can be analyzed.

- Material loss cost percentage: 47.6%

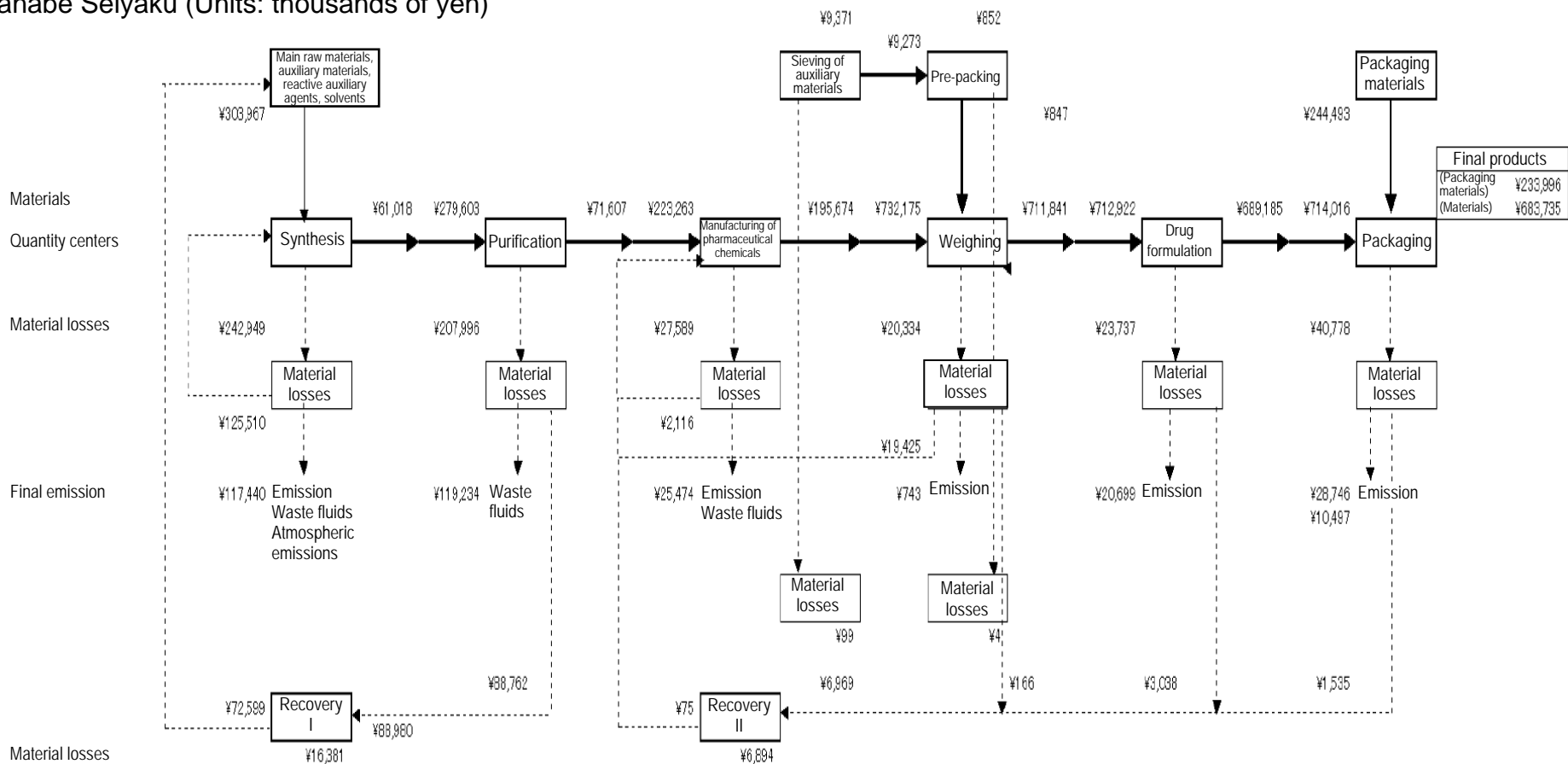
(The percentage of material losses for materials that did not directly become good products in relation to the overall input costs)

- Percentage of final waste product costs: 17.5%

(The percentage of final emission (waste) in relation to the overall input costs)

Flow Chart (Material Costs)

Tanabe Seiyaku (Units: thousands of yen)

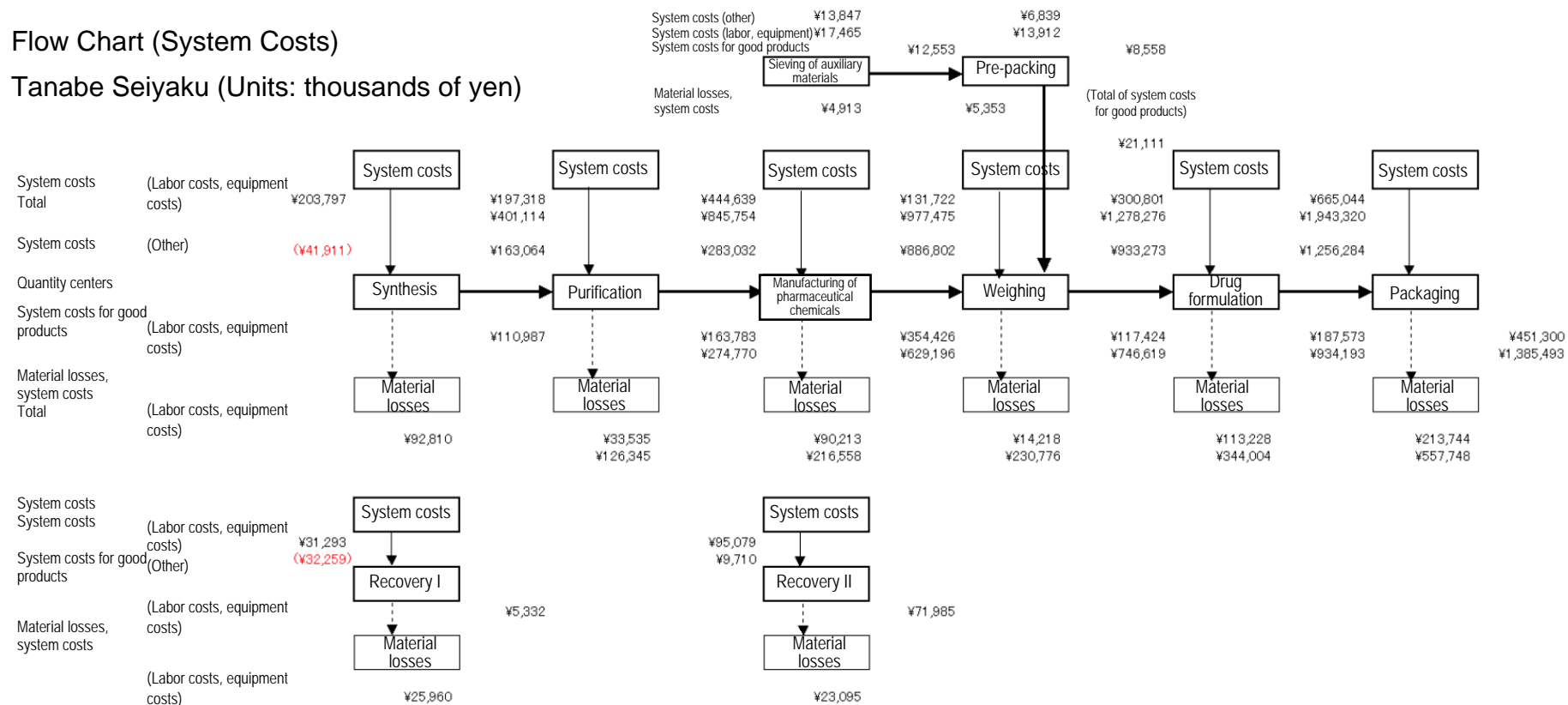


(Note) Due to an enormous amount of data and restrictions on the data processing system at the present moment, the purpose of this case example is to obtain the mass balance for each quantity center, but there is no consistency between the quantity centers. Accordingly, inputs and outputs are measured focusing on the quantity centers. Errors between quantity centers represent inventory, but figures for these inventories have not been precisely measured in this examination.

Figure 4-7 Tanabe Seiyaku Flow Chart for Material Costs

Flow Chart (System Costs)

Tanabe Seiyaku (Units: thousands of yen)



System costs (other): (Total amount of overhead costs) – (Labor costs + equipment costs + utility costs + disposal fees), refers to adjusted amounts of differences at the present moment.

SAP was implemented starting in April 2002, and the calculation method for overhead costs changed from the one used conventionally. The overhead costs here are the total overhead costs for 2000 and have been calculated using the conventional method.

However, in calculating system costs, the calculation method based on SAP has been used, so that it is possible to compare such calculations those of 2002. As a result, the system costs (other) are the adjusted amounts.

		Labor costs	Equipment costs	Utility costs
Total amount: Conventional method	March 2002 and earlier	Man-hours	Man-hours	Man-hours
System costs: SAP method	April 2002 and later	Man-hours	Machine-hours	Machine-hours

Figure 4-8 Tanabe Seiyaku Flow Chart for System Costs

Flow Chart (Items related to Utilities and Waste disposal)

Tanabe Seiyaku (Units: thousands of yen)

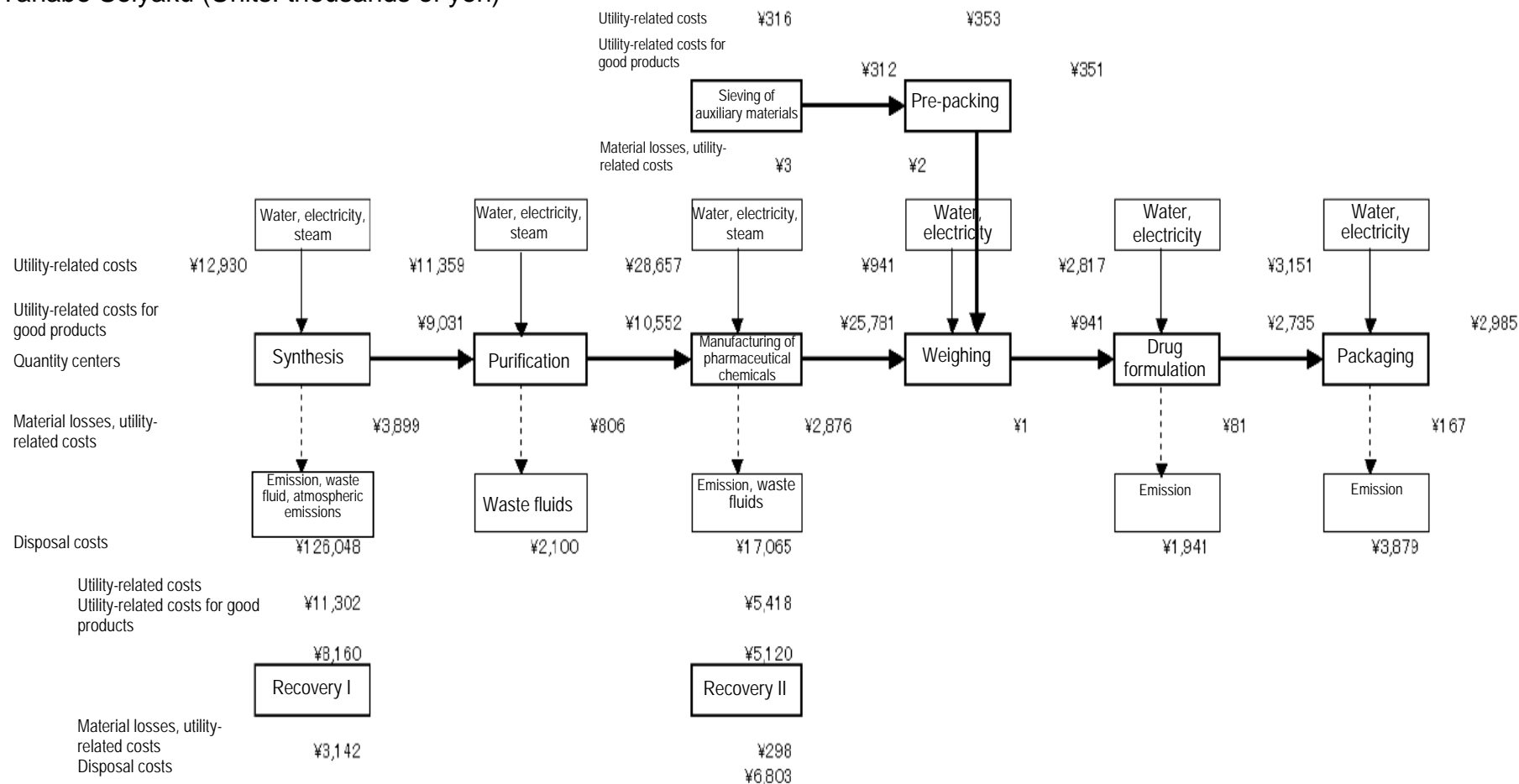


Figure 4-9 Tanabe Seiyaku Flow Chart for Items Related to Utilities and Waste disposal

Flow Cost Matrix

Tanabe Seiyaku (Units: thousands of yen)

Quantity centers	Synthesis	Purification	Manufacturing of pharmaceutical chemicals	Weighing	Drug formulation	Packaging	Sieving of auxiliary materials	Pre-packing	Recovery I	Recovery II	
Input											
Material costs	¥ 303,867	¥ 279,603	¥ 223,263	¥ 732,175	¥ 712,922	¥ 958,509	¥ 9,371	¥ 852	¥ 68,980	¥ 6,969	
System costs	¥ 161,586	¥ 560,382	¥ 727,671	¥ 1,018,524	¥ 1,234,074	¥ 1,921,328	¥ 31,312	¥ 20,751	¥ -966	¥ 104,789	
Utility-related costs	¥ 12,330	¥ 11,359	¥ 28,657	¥ 941	¥ 2,817	¥ 3,151	¥ 316	¥ 353	¥ 11,302	¥ 5,418	
Subtotal	¥ 478,783	¥ 651,344	¥ 979,592	¥ 1,751,641	¥ 1,949,813	¥ 2,882,989	¥ 40,999	¥ 21,956	¥ 99,316	¥ 117,176	
Material losses											
Material losses	¥ 242,343	¥ 207,896	¥ 27,589	¥ 20,334	¥ 23,737	¥ 40,778	¥ 99	¥ 4	¥ 16,381	¥ 6,594	¥ 586,761
Of which are from recovery process	(¥ 125,510)	(¥ 88,782)	(¥ 2,116)	(¥ 19,591)	(¥ 3,038)	(¥ 1,535)	¥ -	¥ -	¥ -	¥ -	(¥ 240,551)
Of which eis emission (waste)	(¥ 117,440)	(¥ 119,234)	(¥ 25,474)	(¥ 743)	(¥ 20,699)	(¥ 39,243)	(¥ 99)	(¥ 4)	(¥ 16,381)	(¥ 6,594)	(¥ 346,210)
System costs	¥ 92,510	¥ 33,535	¥ 90,213	¥ 14,218	¥ 113,228	¥ 213,744	¥ 4,813	¥ 5,353	¥ 25,960	¥ 23,085	¥ 617,070
Utility-related costs	¥ 3,599	¥ 806	¥ 2,676	¥ 1	¥ 61	¥ 167	¥ 3	¥ 2	¥ 3,142	¥ 298	¥ 11,276
Waste disposal costs	¥ 126,043	¥ 2,100	¥ 17,065	¥ 1,941	¥ 1,941	¥ 3,879	¥ -	¥ -	¥ -	¥ 6,803	¥ 157,836
Subtotal	¥ 465,706	¥ 244,437	¥ 137,744	¥ 34,553	¥ 138,967	¥ 258,568	¥ 5,015	¥ 5,359	¥ 45,483	¥ 37,089	¥ 1,372,942

	Material costs	System costs	Disposal costs	Subtotal
Good products	¥ 371,748	¥ 1,296,194	0	¥ 1,667,943
Material losses	¥ 586,761	¥ 628,945	¥ 157,836	¥ 1,372,942
Final emission (waste)	(¥ 346,210)	-	(¥ 157,836)	(¥ 504,046)
Subtotal	¥ 992,309	¥ 1,924,480	¥ 157,836	¥ 3,040,225

Material loss cost percentage 47.6%
 Percentage of final emission (waste) costs 17.5%

Figure 4-10 Tanabe Seiyaku Flow Cost Matrix

(7) Evaluation as a company implementing material flow cost accounting: Finding of points for improvement and improvement activities

Based on the results from experimental implementation at the Onoda plant, 2 problematic areas were found, and the following kinds of measures were considered.

<Problem 1>

In the manufacturing process (synthesis), the waste disposal costs related to chlorinated solvents used in reactions are large.

[Examination & Solution]

With the purpose of reducing waste disposal costs related to chlorinated reaction solvent, R&D, activities to make process management more appropriate, and equipment investments are to be carried out, and an increase in the amount that is recovered and reused, together with a reduction in the amount of waste are to be promoted to plan for reduction of fuel and personnel costs that are required in waste disposal of this chlorinated reaction solvent.

(Economic effects: Approximately 30 million yen/year)

Either R&D or equipment investments as described below will be adopted as a countermeasure.

(1) Research and development

- Conduct reviews on chlorinated reaction solvents, and replace the chlorinated reaction solvent with one that has a high rate for recovery and reuse, and low waste disposal costs. (Currently under review)

Reference example: The solvent used in the Beston manufacturing process was changed to one that has little environmental burdens.

(Planned to be implemented at Taiwan Tanabe Seiyaku Co., Ltd., which is a consolidated subsidiary of Tanabe Seiyaku, after October 2002)

- Carry out appropriate management and improvements in reaction conditions (reaction temperature, reaction time, etc.) for the amount of solvent used, and make process management more appropriate. (Currently under review)

(2) Equipment investments

- Make equipment investments centering around chlorinated reaction solvent, such as the installation of equipment for exhaust gas treatment/recovery, increase in the condensation and cooling rate during collection, etc.

(Currently under review, investments in recovery equipment are planned)

<Problem 2>

There are large material losses in the drug formulation process.

[Examination & Solution]

As measures for reducing material losses related to raw materials, reaction solvents, etc., R&D or equipment investments are to be carried out, and efficient usage of resources are to be promoted in order to reduce material losses.

(1) Research and development

- Aim for increase in the amount of the target chemical compound acquired, or a reduction in the amount of auxiliary materials and reaction solvents used, by changing the physical conditions, such as reaction temperature and reaction time, rather than changing the raw materials or reaction solvents.
- Conduct fundamental reexaminations of the synthesis method used for acquiring the target chemical compound, review the reaction conditions such as those for raw materials and reaction solvents, and aim to establish highly-selective reactions and secure high yields.

The following kinds of developments are also planned for the future.

1) Systemization of material flow cost accounting

Incorporate the concepts for material flow cost accounting into the SAP R/3 system, and carry out systemization.

2) Expansion of scope of implementation for material flow cost accounting

As experimental implementation, material flow cost accounting is implemented for a manufacturing process for 1 product family at the Onoda plant, but after systemization is complete,

the implementation scope for material flow cost accounting is planned to be expanded to other plants, in addition to the Onoda plant (main plant).

3) Detailed comprehension of energy losses

In relation to energy, calculations for energy losses are to be elaborated by newly installing measurement meters such as for electricity, and establishing appropriate theoretical figures.

4.4.4 Case Example at Canon

Canon is another company that started participating in experimental implementation in 2001. In the manufacturing process for camera lenses, glass materials (that have been made into the shape of lenses to some extent) that are externally purchased are first polished, and are then processed into a shape and thickness that is appropriate for the required lenses. After centering, in which the focal point that is required for the lens is established, coating is applied, and the lens is finished. Even when actually looking at the manufacturing line, there are no waste (glass materials, etc.) that can visibly be seen. Material losses can be thought of as being composed of breakages or damaged products that cannot be re-processed, and polishing sludge that results from polishing the glass (glass shavings). As it will be explained hereinafter, there are very little damaged products. If raw materials that do not become finished products are considered as material losses, then it can be deemed that if there are no damaged products, production is carried out without any losses in terms of the number of lenses. However, from the standpoint of material flow cost accounting, this polishing sludge is considered to be material loss. Polishing sludge is generated as waste. Even for cases where the quantity of materials input is directly transformed into an equivalent quantity of finished products, it was decided to conduct examinations as to whether improvement points can be discovered through implementation of material flow cost accounting.

In order to suppress environmental burdens to a minimum, the water that is used for polishing and its effluent undergo closed treatment inside the plant. While this leads to extremely significant effects in terms of waste processing, such disposal treatment incurs large costs. In the past, the magnitude of these costs was viewed in relation to the plants themselves, but in this experimental implementation of material flow cost accounting, though the manufacturing line was a single line, the purpose was to clarify the waste disposal costs for this line for each process (quantity center). By tracking what kinds of substances flow from the manufacturing process to the waste disposal system at the level of quantities, and by clarifying the costs of the substances themselves (in terms of material flow cost accounting) and waste disposal costs, such information can be useful for future improvements.

(1) Company overview

The company overview is available at <http://www.canon.com/>.

(2) Targets and scope of implementation

At the Utsunomiya Plant, the target was 1 manufacturing line for 1 camera lens model. Starting in 2000, a structural form based on cells, where the entire manufacturing process is implemented in one cell, has been adopted, rather than the conventional structure that is divided according to each process. The scope of costs for material flow cost accounting is the full flow costs consisting of “material costs,” “system costs,” and “delivery/disposal costs.” The period for gathering data was also set to one month (in 2000).

As detailed explanations on the manufacturing process include parts that are corporate secrets, a general explanation is given instead. The purchased glass that is to be formed into lenses are grinded and polished to the required thickness and shape at the quantity centers from “rough grinding” until “polishing,” and are then coated in “coating.” This is a relatively simple process, where lens glass, which is the raw material, is input at the starting point for manufacturing and processed, and subsidiary materials are input during the process according to necessity.

In the disposal of waste (waste fluid, waste oil), for example, water is used during processing for polishing. However, water, polishing sludge (glass shavings), and subsidiary materials are contained in the waste fluid. Water undergoes closed treatment within the company, and is circulated and reused.

(3) Implementation structure: Making a material flow model and setting quantity centers

To explain material flow cost accounting to the staff at the plant, and to tour the plant where material flow cost accounting was to be implemented and view the products (manufacturing process), a visit was made to the Utsunomiya Plant in July 2001.

To execute this project, the team below was organized.

Utsunomiya Plant: Centering around the Environmental Management Department; other related departments, such as Manufacturing, Production Technology, Production Management, and Facilities.

(4) Gathering of data

An 8-page MS-Excel spreadsheet for the quantity centers (rough grinding, fine grinding, polishing, washing and inspection, centering, washing, and coating) and “materials,” which represents the totals for the quantity centers, was created. This spreadsheet is set up so that for each of the 13 part numbers that flow through the manufacturing line, the following items can be recorded on a daily basis.

Parts marked with “?” are represented by actual numbers on the actual data materials, but due to corporate confidentiality, they have been withheld here.

(1) Man-hours (minutes)	(8) Number of revisions	Processing costs (yen) (1) x (3) x (5)
(2) Labor costs	(9) Disposal costs for damaged products	
(3) Rate	(10) Man-hours for making preparations (minutes)	
(4) Personnel	(11) Number of times preparations were made	
(5) Number input	(12) Time for making preparations (10) x (11)	
(6) Number complete	(13) Amount of electricity used (kwh)	
(7) Number of products returned from preceding process	(14) Amount of sludge ?g x (5)	

As subtotals for each quantity center, settings are made so that the items below are recorded.

Depreciation costs (yen)
Machinery (1)
Machinery (2)
Machine utilization rate (%) (1)+ (2) x 100
(1) Actual utilization time (Hr)
(2) Base time (Hr) 2 shifts

Amount used on electricity (yen) (1) x (2)
(1) Amount used (Kwh) 200V
(2) Unit cost [? yen/kwh]
Amount used on water (yen) (3) + (6)
(1) Amount of filtrate water used (m ³)
(2) Unit cost (? yen/m ³)
(3) Money amount used (1) x (2)

Waste oil disposal costs (yen) (3) + (6)
Product name [] (1) Amount (Kg)
(2) Unit cost for disposal
(3) Money amount for disposal
Product name [] (4) Amount (Kg)
(5) Unit cost for disposal
(6) Money amount for disposal
Waste fluid disposal costs (yen) (3) + (6)
Product name [Sewage dryer] (1) Amount (liters)

(4) Amount of pure water used (m ³)
(5) Unit cost (? yen/m ³)
(6) Money amount used (4) x (5)
Amount used on air (yen) (1) x
(1) Amount used (Nm ³)
(2) Unit cost (yen/ Nm ³)

Amount used on subsidiary materials (yen)
(1) Subsidiary materials A Amount used (liters)
(2) Unit cost (yen/liter)
(3) Money amount (yen) (1) x (2)
(4) Subsidiary materials B Amount used (liters)
(5) Unit cost (yen/liter)
(6) Money amount (yen) (4) x (5)

(2) Unit cost for disposal
(3) Money amount for disposal
Product name [Dried sewage] (1) Amount (liters)
(5) Unit cost for disposal
(6) Money amount for disposal
Sludge disposal costs (yen)
Product name [Glass shavings] (1) Amount (Kg)
(2) Unit cost for disposal

In addition to the above, there is also a chart for damaged products and a chart for changes in weight (not available for all of the quantity centers at the present time) for each part number, and flow charts were created based on these charts.

(5) Calculation of material costs, system costs, and delivery/disposal costs

Material costs consist of the purchased lens glass (a piece of glass for a lens unit), as well as other subsidiary materials (approximately 20 different kinds). For the lens glass, a unit cost is set up for each of the 13 part numbers. As the process is one where lens glass is cut to form a lens, there is fundamentally no waste generated in terms of the number of pieces of lenses, other than when the lenses become chipped or cracked (damaged products). However, in this examination, both polishing sludge (glass shavings) and damaged products were recognized as material losses. Damaged products are recorded for each quantity center and the number of damaged products (Damaged Products Chart), but for polishing sludge, there are only theoretical values for each part number at the point in time when “rough grinding” and “centering” are complete. Therefore, material losses were determined as being the value obtained by subtracting these theoretical figures for the point in time when processing is complete from the weight of the purchased lens glass (values for purchasing specifications). The measurement of material losses based on polishing at quantity centers other than two mentioned above was overlooked in this examination. At the other quantity centers, however, the amounts of polishing sludge were extremely small.

Subsidiary materials were all considered to be material losses due to character of this manufacturing process.

The system costs for quantity centers were calculated by summing the processing costs at each quantity center (man-hours (min.) x labor cost rate x number input) with the depreciation costs for the applicable machinery equipment. The basis for the money amounts were all extracted from financial records, and for processing costs, a labor cost rate per minute was established, whereas depreciation costs were established by researching the purchase price even for equipment with a book value of “0,” and then using the straight-line depreciation method. Distribution to good products and material losses were done so proportionally based on the weight ratio for the lens glass.

For delivery/disposal costs, unit costs were established for each item that is listed in the chart below, and delivery/disposal costs were calculated by multiplying these unit costs with the quantity of each waste. The unit costs represent per unit averages of actual costs.

Waste costs	Units	Unit cost	Production water	Units	Unit cost
Polishing sludge	kg		Closed water	m ³	
Sewage dryer	kg		Pure water	m ³	
Dried sewage	kg	?			
Waste oil	kg	?			
Damaged glass rubbish	kg	?			
Waste fluid A	kg	?			
Waste solvent	kg	?			
Waste fluid B	kg	?			
Refuse from coating	kg	?			
Blast residue	kg	?			

(6) Making a flow chart that includes data

1) Flow chart (Figure 4-16: Material costs)

The rows above the quantity centers represent materials that are newly input into the manufacturing line under examination. The numbers above the arrows between the quantity centers indicate the flow of materials towards good products, and are the input from the preceding quantity center into each quantity center. The figures below the quantity center for “polishing” are for work-in-process products, and the figures below “coating” refer to returns to the preceding process as a result of problems. In this examination, it was decided to express only numerical figures for the products returned to the preceding process.

Material losses consist of losses of glass materials, which are the main raw materials; polishing sludge (shavings) and damaged products are divided and indicated. Since weight data (theoretical figures) for products that have completed the process are only available for “rough grinding,” “polishing,” “centering,” and “coating,” material losses were calculated using only these quantity centers. The number of damaged products was comprehended concretely through the number of pieces.

Subsidiary materials were all considered as losses due to the character of the manufacturing process.

2) Flow chart (Figure 4-17: System costs)

The top row shows the system costs that were generated at each quantity center and their totals. The numbers below the arrows between each quantity center are all system costs towards good products, and are proportionally distributed into losses based on the weight ratios of the materials.

3) Flow chart (Figure 4-18: Items related to utilities and waste disposal)

The top row indicates the money amounts input into electricity for machines, electricity for lighting, water, and air at each quantity center. These amounts are distributed proportionally into good products and losses based on the weight ratios of materials, and the amounts for good products are shown above the arrows in between the quantity centers.

The costs that are incurred in relation to wastes are also shown in the bottom row, indicated by the type of costs and the money amount.

4) Flow cost matrix (Figure 4-19)

The upper rows represent new inputs into the manufacturing line under examination. The lower rows indicated material losses according to each quantity center. Based on these results, the following kinds of percentages were calculated.

- Material loss cost percentage (Percentage of the total amount of losses in relation to the total amount of costs): 32.0%
- Percentage of rough grinding loss costs (Percentage of the amount of losses related to “rough grinding” in relation to the total amount of costs): 25.1%
- Percentage of rough grinding losses (Percentage of the amount of losses related to “rough grinding” in relation to the total amount of losses): 67.2%

Flow Chart (Material Costs)

Canon

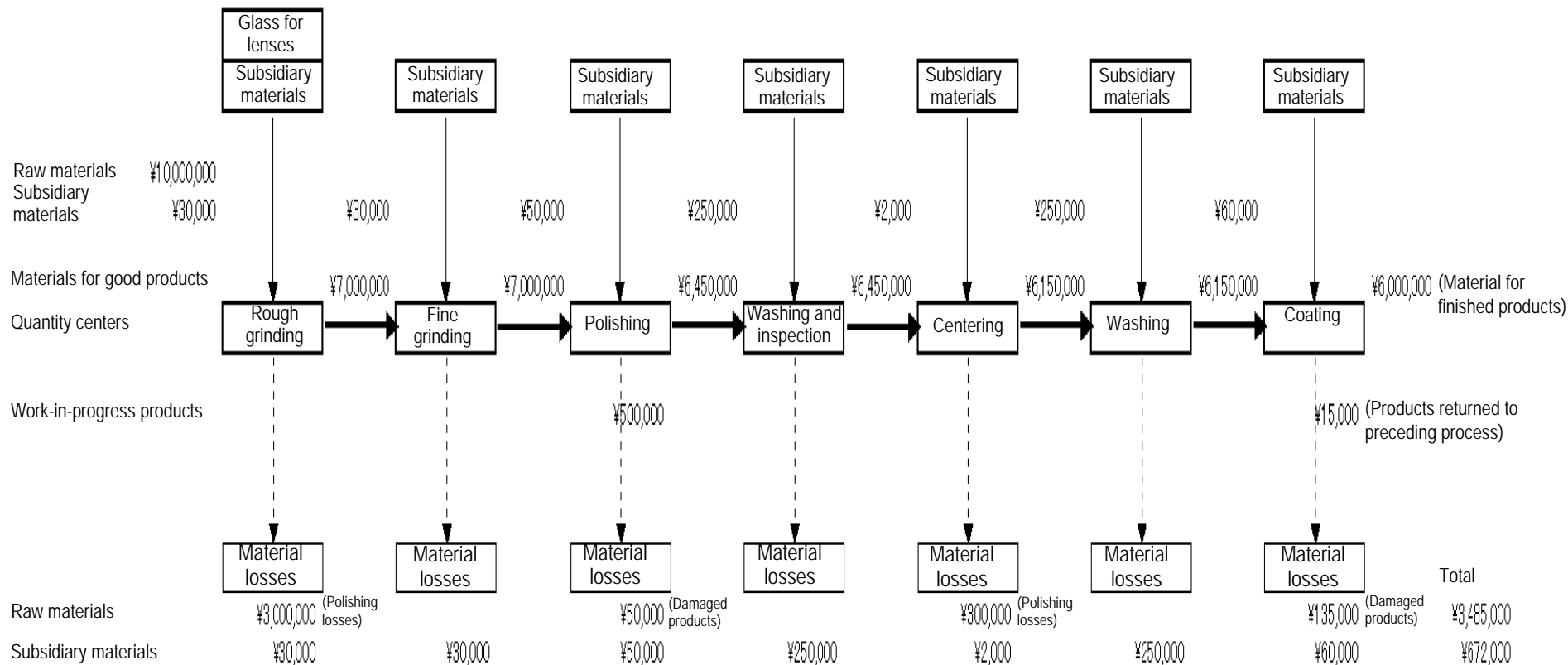


Figure 4-16 Canon Flow Chart for Material Costs

Flow Chart (System Costs)

Canon

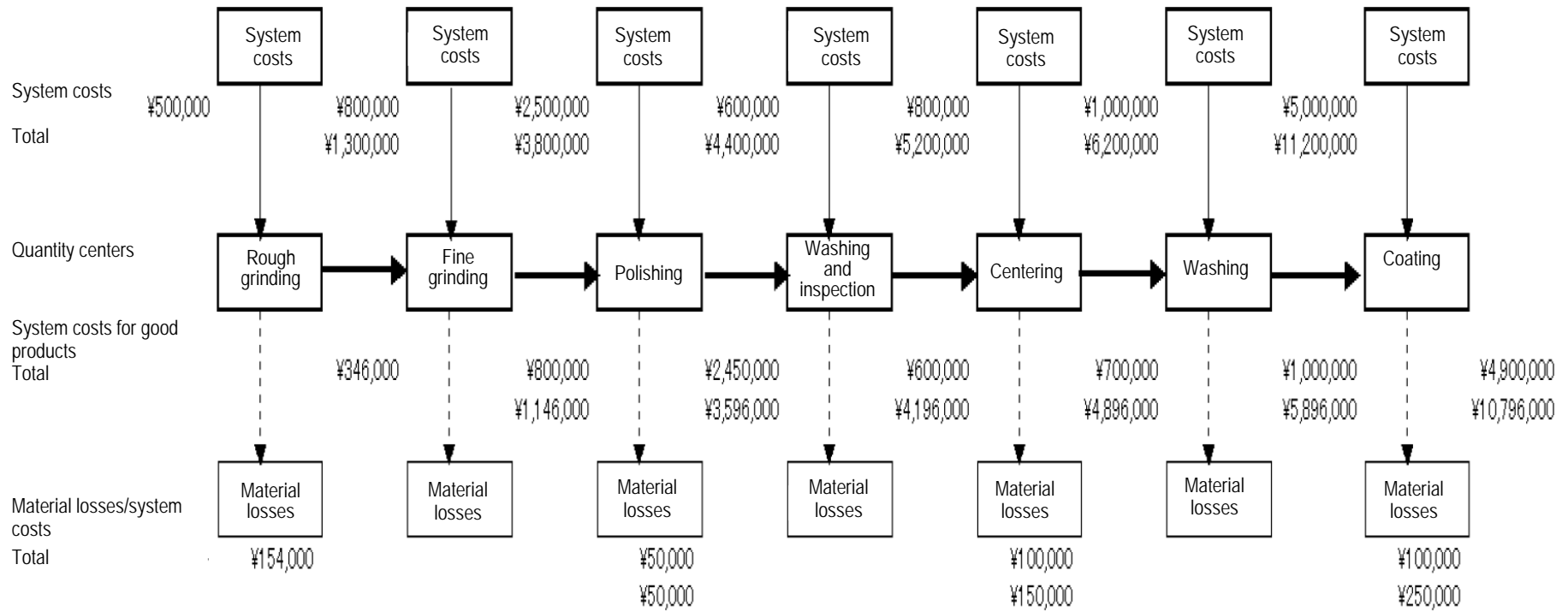


Figure 4-17 Canon Flow Chart for System Costs

Flow Chart (Items Related to Utilities and Waste Disposal)

Canon

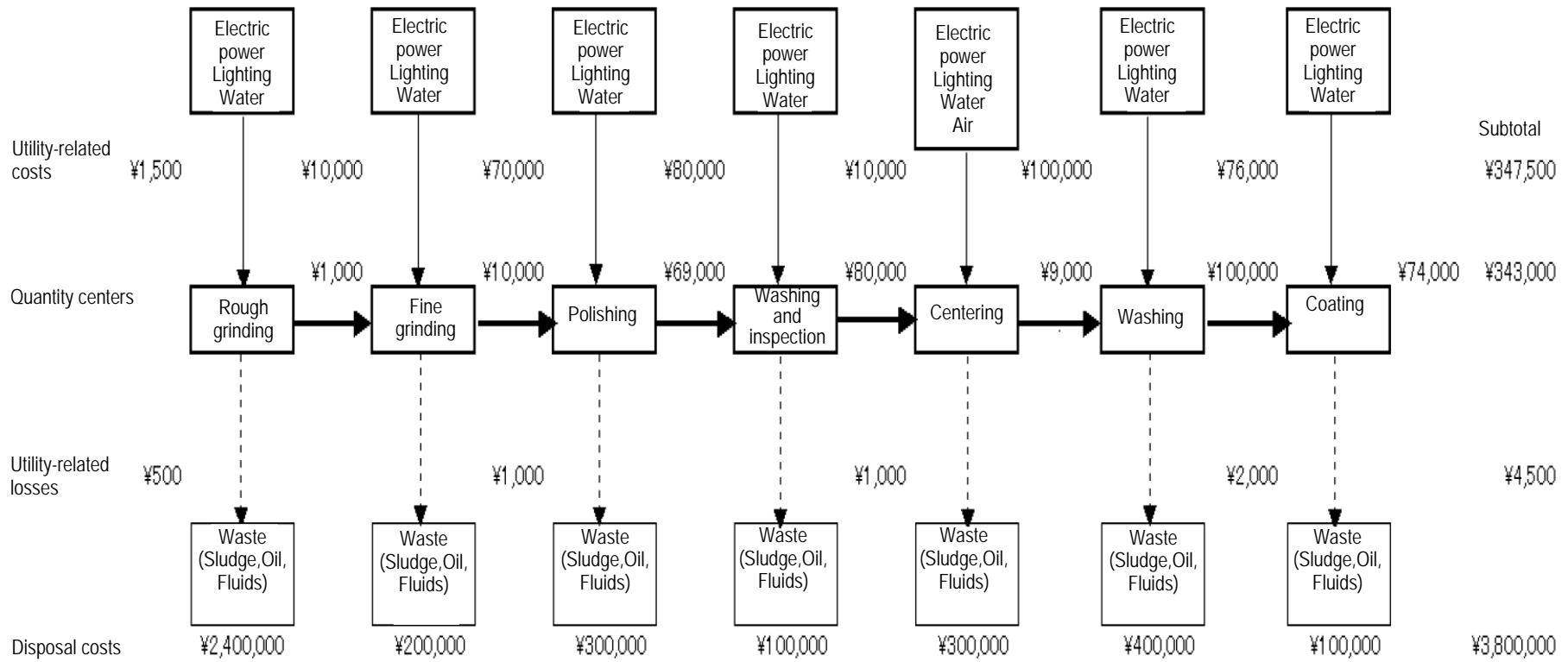


Figure 4-18 Canon Flow Chart for Items Relating to Utilities and Waste Disposal

Flow Cost Matrix

Canon

Quantity centers	Rough grinding	Fine grinding	Polishing	Washing and inspection	Centering	Washing	Coating	Total
Input								
Material costs	¥10,030,000	¥30,000	¥50,000	¥250,000	¥2,000	¥250,000	¥60,000	¥10,672,000
System costs	¥500,000	¥800,000	¥2,500,000	¥600,000	¥800,000	¥1,000,000	¥5,000,000	¥11,200,000
Utility-related costs	¥1,500	¥10,000	¥70,000	¥80,000	¥10,000	¥100,000	¥76,000	¥347,500
Subtotal	¥10,531,500	¥840,000	¥2,620,000	¥930,000	¥812,000	¥1,350,000	¥5,136,000	¥22,219,500
Material losses								
Material losses	¥3,030,000	¥30,000	¥50,000	¥250,000	¥302,000	¥250,000	¥195,000	¥4,107,000
System costs	¥154,000	¥0	¥50,000	¥0	¥100,000	¥0	¥100,000	¥404,000
Utility-related costs	¥500	¥0	¥1,000	¥0	¥1,000	¥0	¥2,000	¥4,500
Disposal costs	¥2,400,000	¥200,000	¥300,000	¥100,000	¥300,000	¥400,000	¥100,000	¥3,800,000
Subtotal	¥5,584,500	¥230,000	¥401,000	¥350,000	¥703,000	¥650,000	¥397,000	¥8,315,500

	Material costs	System costs	Disposal costs	Subtotal
Good products	¥6,565,000	¥11,139,000	0	¥17,704,000
Material losses	¥4,107,000	¥408,500	¥3,800,000	¥8,315,500
Subtotal	¥10,672,000	¥11,547,500	¥3,800,000	¥26,019,500

Material loss cost percentage: 32.0% (Percentage of the total amount of losses in relation to the total amount of costs)

Percentage of rough grinding loss costs: 25.1% (Percentage of the amount of losses for "Rough grinding" in relation to the total amount of costs)

Percentage of rough grinding losses: 67.2% (Percentage of the amount of losses for "Rough grinding" in relation to the total amount of losses)

Figure 4-19 Canon Flow Cost Matrix

(7) Evaluation as a company implementing material flow cost accounting: Finding of points for improvement and improvement activities

As it has already been explained, lenses are fundamentally handled in units of numbers of pieces. As material losses in terms of numbers of pieces, damaged products are generated at the quantity centers for “polishing” and “coating,” but the number of damaged products with respect to the overall number of products that undergo processing is less than 3%, which can be considered as being relatively small compared to the material losses resulting from polishing at the quantity center for “rough grinding.” The point that is focused on first is therefore the material losses resulting at the quantity center for “rough grinding;” as shown in the flow cost matrix, the percentage of the material losses from “rough grinding” in relation to the total cost is approximately 25%, and further, the amount of monetary losses from “rough grinding” constitute almost 70% of the total amount of losses. In addition, in relation to the total amount of monetary losses being 8.3 million yen, the losses from “rough grinding” are approximately 5.6 million yen, of which material losses comprise 3 million yen, and waste disposal costs comprise approximately 2.4 million yen, which is considered to be an extremely large amount per month.

The material losses from “rough grinding” and waste disposal are the main factors behind polishing sludge from lenses, but by considering how reductions will be made such areas where cutbacks are possible, large achievements can be made in improvement effects. For example, by considering that the shape of the purchased glass material can be made to one that is closer to the shape of products that have undergone rough grinding, in simple terms, if the material losses from “rough grinding” are “0,” then there is potential for a cost reduction of almost 9 million yen/month, which can also lead to an achievement in the reduction of environmental burdens.

4.5 Conclusion — Outcomes of the Implementation —

Through actual implementation in companies over the course of 2 years, concrete effectiveness of material flow cost accounting and future challenges are becoming clear.

From these case examples, it is clear that management information based on material flow cost accounting enables for analysis inside the company from a new perspective. Based on where “negative products” (emission (waste)), which represent the flow of raw materials that do not become products (good products), are generated, and on systematic information relating to the costs of such “negative products,” the flows and stocks of material objects within a company are made transparent, and it is possible to analyze corporate activities from a perspective that is different from one of the past, which was based on added value information centering on good products. By hypothesizing that “generation of emission (waste)” is production of emission (waste), and thinking of the manufacturing process as a manufacturing process for 2 kinds of products—“good products” and “emission (waste)” —, it is possible to use information on their quantities and calculation of their costs as information for reduction of environmental burdens. As can be seen with the case examples of the 4 companies, material flow cost accounting can be applied effectively as a method for simultaneously achieving reduction of environmental burdens as well as economic improvements based on cost reductions.

However, at the present moment, “economic improvements” is only a matter for speculation, and it is necessary to verify concrete improvement measures and their economic effects in the future. Also, from a theoretical aspect on material flow cost accounting, there is still not enough concrete examinations on the rights and wrongs of, for example, always comprehending materials at the point when they are input, in a manufacturing process where materials are processed into something that differs completely in composition and quality from those of the raw materials at the time when they are input. It has also become clear that material flow cost accounting is effective in the materials industry, but there still remain many issues that need to be examined in the future, such as whether material flow cost accounting can be expanded towards, for example, the fabricating industry and the supply chain.

At the same time, it is clear that the usability of material flow cost accounting as an environmental management method is high, and as there is a wide range of extensibility in terms of business management information, it is desired for material flow cost accounting to become improved in the future through concrete implementation and popularization, and to be perfected as a management method.