

Cost Accounting Assumptions for Waste to be Revisited

In Readiness for the 60th Anniversary of the Cost Accounting Standards

Yuka KOIZUMI

Abstract

In readiness for the 60th anniversary of the Japanese Cost Accounting Standards next year, this article revisits the fundamentals of “waste” (e.g., how to calculate waste in terms of equivalent units), together with related formulas. This is shown by following the established practice of converting the “Process Cost Component Chart” to the “Equivalent Units Chart”.

This article then deals with the WIP Conversion Coefficient using an example of crafting a tote bag out of a leather sheet, and draws attention to the convention of setting an upper limit of one (100%) onto the production progress rate for the E-WIP, and argues that this practice would lead to erroneous outcomes.

Finally, the article presents the general formula of Process Costing using the FIFO and Method of Non-Neglect and offers an alternative method for computing “Costs of Waste Occurring from the B-WIP”, where conventional assumptions are disappplied.

The research method employed in this article is conceptual and deductive, stemming from academic theories and practices observed in the field of cost accounting.

Key word

The Cost Accounting Standards, First-In, First-Out Method (FIFO), Method of Non-Neglect, Conversion Coefficient, Waste

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Introduction

The Japanese Cost Accounting Standards (*Genka Keisan Kijun*), hereinafter referred to as the “Standards”, were established by the Business Accounting Council of the Ministry of Finance in 1962. They have, therefore, been in existence for almost 60 years and remain the norms for the cost accounting system in Japan without any revisions since the introduction (Moroi 2012).

When the Standards were established, Japan was on her way for the subsequent high economic growth period, but there were no computers nor electric calculators readily available. The technologies used in manufacturing and accountancy were basic.

Against this background, it was not surprising that the Standards allowed simplified costing methods which adopted certain assumptions to be made in relation to the production activities. However, the ultimate goal of Cost Accounting, being mapping the actual situations of production activities with accuracy, remains unchanged as set out in the Standards. Continuous efforts should be made in the practical applications of the Standards to accommodate the ongoing sophistication of production processes in light of technological advancements.

With the 60th anniversary of the Standards approaching and starting a new round of a life (*Kanreki*), having completed all yearly combinations under the 10 stems and 12 branches of the Japanese and Chinese calendar cycles, it is an opportune time to review the Standards and the practices which followed the Standards and explore further refinements where possible.

This article presents alternative concepts, computation methods and procedures to be considered and highlights the issues and problems that are yet to be examined. It is an amalgamation of numerous discussions which the writer has had with colleagues in the academic arena, including the research presentation the writer delivered at Southern Oregon University in the US in 2014, though the writer is solely accountable for its contents. The research method employed in this article is conceptual and deductive, stemming from academic theories and practices observed in the field of cost accounting.

To be more specific, this article examines the appropriate allocation of the losses of materials which have been added to the manufacturing process but have subsequently become “wasted” and have no values (Waste), and aims to revisit certain assumptions which have been largely taken for granted by the academics and practitioners in this field.

In essence, the conventional process costing theories and practices generally adopt the assumption that no Waste has occurred from the Beginning Work-in-Process (B-WIP) and that such Waste has only occurred in the materials which were newly added to the production system in the current period.

In this respect, the Standards provide, in essence, that the Waste should be dealt with in the same manner as with Spoilage (*Shisonji*) and that Spoilage should generally be allocated to the finished goods in the period and the Ending Work-in-Process (E-WIP) (Section 27). The Standards, therefore, indirectly provide a support to the said assumption.

The assumption is also endorsed in many leading literatures, such as Bamba (1963) and Okamoto (2000). It is also widely noted that adopting the assumption would mean a departure from the widely observed practice of the “First-In First-Out Method (FIFO)”.

The justification usually cited for adopting the assumption is that the material components of the B-WIP tend to be small in comparison to the volumes and values of the newly added materials during the current period, and therefore the differences which would arise from adopting this assumption is considered to be insignificant.

For example, Professor Bamba, the authoritative scholar in this field, stated, “The reason why it is assumed that waste losses occur from the batches started in the current period ... is because doing so would cause no serious harms.” (translated by the writer) (Bamba 1963, p273).

Professor Okamoto, the other authoritative scholar, stated, “...most factories do not question about how much of the normal waste came from the B-WIP of the month and how much from the batches commenced in the present month. As such, given that the volume of the present month’s commencement far exceeds that of the B-WIP of the month, it is common that the normal waste derive from the current month’s new batches.” (translated by the writer) (Okamoto 2000, p311).

The writer, however, is of a view that such justification may not hold persuasive in certain circumstances, in particular, where a large amount of the materials needs to be added to the earlier phases of the production, with its production period being relatively long. This view will be advanced in the following three steps.

First, the basic concept of Waste and the formulas associated with it will be explained in Section 1. Then, in the conventional cost accounting, the production progress rate or degree of completion of WIP (the conversion coefficient) is commonly thought not to exceed one (100%), and the adequacy of this treatment will be revisited in Section 2. Finally, in Section 3, it will be illustrated that there will be certain circumstances where the conventional assumption would lead to erroneous outcomes. This article will then present an alternative theoretical model of process costing using the FIFO and Method of Non-Neglect.

1. Basic Concept of Waste and the Related Formulas

1.1. Concept and Definition of “Waste”.

The Japanese Cost Standards do not contain a definition for “waste” but give a certain illustration thereof as “loss of materials arising from evaporation, powder spreading, gasification, turning into smokes, etc.” (translated by the writer) (Section 27).

Professor Bamba gave a slightly broader description, “evaporations, leakages, spillages, gasification, turning into exhaust fumes, effluents, refuses, breakages, etc., which arise in processing hydrated compounds, liquid substances, oils, grains, ceramics.” (translated by the writer) (Bamba 1963, p256).

Furthermore, Professor Okamoto referred to waste in contrast to spoilage, and stated that “waste” means “diminishment of materials which occur in the production processes such as evaporation, powder spreading, gasification, turning into smokes, or occurrence of a certain part of materials which are not turned into products and are of no value”, whereas “spoilage” means “defective products which did not meet the required quality standards or specifications.” (translated by the

writer) (Okamoto 2000, p288).

Taking into consideration certain variations as above, the writer submits that, in its narrow sense, “waste” refers to intangible diminishment or disappearance of materials caused by gasification, evaporation, etc., where such diminished or disappeared portions are no longer identifiable in a tangible manner.

On the other hand, in its wider sense, “waste” also includes leftovers or residues of the materials after the completion of the production process, which has no “scrap” values. An illustration of the latter would be remaining parts of fabrics after cutting for making clothes, on the basis that they have no value.

In this categorization, it is recognized that the distinction between “waste” and “scrap” is based largely on external factors, such as market values and disposal costs, which tend to fluctuate from time to time. Arguably, this could be considered inconsistent with the fundamental accounting principle of continuity, but a discussion on this point is outside the scope of this article.

The above categorization is illustrated in Fig. 1 below.

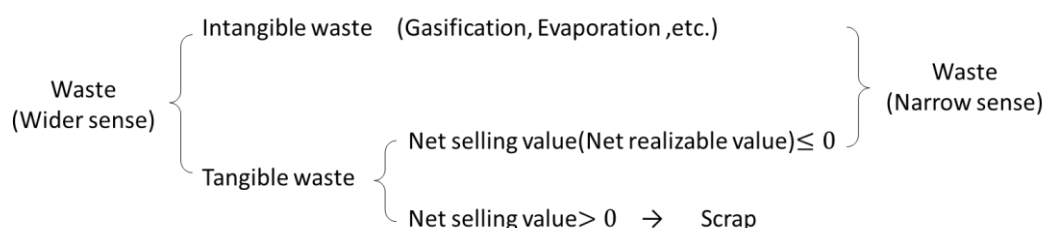


Fig. 1 Classification of “Waste” and “Scrap”

In this connection, it is noted that one of the leading literatures in the US, Horngren et al 2012, adopts a different classification, which does not expressly cover the Intangible waste (Gasification, evaporation, etc.) as described above. Furthermore, it refers to “Scrap” as “residual material that results from manufacturing a product” and cites examples, such as “short lengths from woodworking operations, edges from plastic molding operations, and frayed cloth and end cuts from suit-making operations”. Additionally, it states that “Scrap can sometimes be sold for relatively small amounts” (p645). This indicates that, in classifying as Scrap, Horngren makes no distinction about whether it has a positive or negative value. Notwithstanding the different terminologies, in this article, the term “Waste” is used in its narrow sense as shown in Fig. 1 above.

“Waste” may occur in a variety of manners and at varying timings and, for the ease of understanding, this article principally envisages the following simplified situation:

- Materials are added to the production process in the preceding cost period (t-1);
- At the time of such addition, the accounting status of the added materials changes from “materials” to “WIP”;
- Such WIP will remain largely unchanged in a physical sense and will be recognized as the E-WIP of that cost period (t-1), which in turn will become the B-WIP in the current cost period (t); and
- In the current cost period (t), the materials included in the B-WIP reach a point in the production process (the Waste Occurrence Point or WOP) upon which a certain proportion will become “wasted” and lose values.

1.2. Formulas relating to Waste and its Computations

The amount of Cost Component “i” (C_i) added to the production process can be shown as its price obtained (p_i), multiplied by the quantity so placed and consumed (q_i), thus

$$C_i = p_i q_i \quad (1)$$

The total quantity consumed per finished good (u_i) can be shown as the consumption quantity (q_i) divided by the quantity of the finished goods (Q), thus

$$u_i = \frac{q_i}{Q} \quad (2)$$

This can also be shown as:

$$q_i = u_i Q \quad (3)$$

Accordingly, Cost Component (C_i) can be calculated by the following Formula (4).

$$C_i = p_i u_i Q \quad (4)$$

For a particular Cost Component (i), the sum of its costs in the B-WIP (C_{Bi}) and its costs added during the period (C_{Ii}) must always equal to the sum of (a) its costs in the Finished Goods in the period (C_{Gi}), (b) costs in the spoilage in the period (C_{Di}), (c) costs wasted in the period (C_{wi}), and (d) costs in the E-WIP (C_{Ei}), as shown in the following Formula (5) below.

$$C_{Bi} + C_{Ii} = C_{Gi} + C_{Di} + C_{wi} + C_{Ei} \quad (5)$$

The same relationship applies to its consumption quantity as shown in the following Formula (6):

$$q_{Bi} + q_{Ii} = q_{Gi} + q_{Di} + q_{wi} + q_{Ei} \quad (6)$$

A similar relationship applies when measured in terms of the finished goods (Q), except that q_{wi} (consumption quantity of a Cost Component (i) which has become waste during a period) should have a nil value and should not exist, because it is impossible to measure it in terms of the finished goods (Q), as it has been “wasted” from the perspective of the finished goods (Q), thus Formula (6) becomes:

$$Q_B + Q_I = Q_G + Q_D + Q_E \quad (7)$$

We now expand Formula (2), so that it can be used for the WIP quantity, and to this end, a concept of θ_i is introduced, which is “a degree of completion measured in equivalence to the costs of the finished goods”, ranging from 0 to 100%. (This is also called the “Conversion Coefficient” in this article.) This is used to replace “ Q ” in Formula (2) with “ $Q\theta_i$ ” as shown below.

Formula (2) becomes:

$$u_i = \frac{q_i}{Q\theta_i} \quad (8)$$

Formula (3) becomes:

$$q_i = u_i Q \theta_i \quad (9)$$

Formula (4) becomes:

$$C_i = p_i u_i Q \theta_i \quad (10)$$

Even where FIFO is used in the conventional method, the weighted average method is essentially used for the works commenced in the current period, and thus it can be assumed that its consumed price (p_i) remains constant (Koizumi, 2019).

On this basis, the Cost Component (C_i) can be allocated in accordance with consumption quantity (q_i) as shown in the following formula.

$$C_i = C(q_i) \quad (11)$$

The chart below illustrates the production activities of the process, which is the actual figure of production activities expressing the real condition of input and output of materials as they are. The horizontal axis is the quantity of the finished goods and the vertical axis is "the amount used per unit of the finished goods multiplied by the Conversion Coefficient θ_i ". The area " q_i " represents the quantity of the resources and services used in the finished goods.

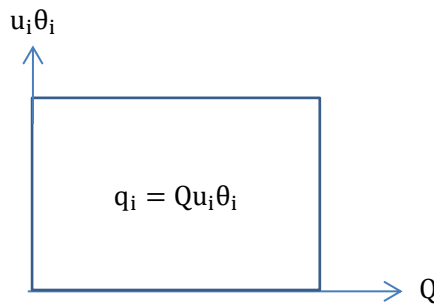


Fig.2 Basic Process Cost Component Chart

The area shown in Fig. 2 above can be divided into four separate blocks, representing finished goods (q_{Gi}), spoilage (q_{Di}), The E-WIP (q_{Ei}) and those wasted (q_{Wi}) as shown in Fig. 3 below.

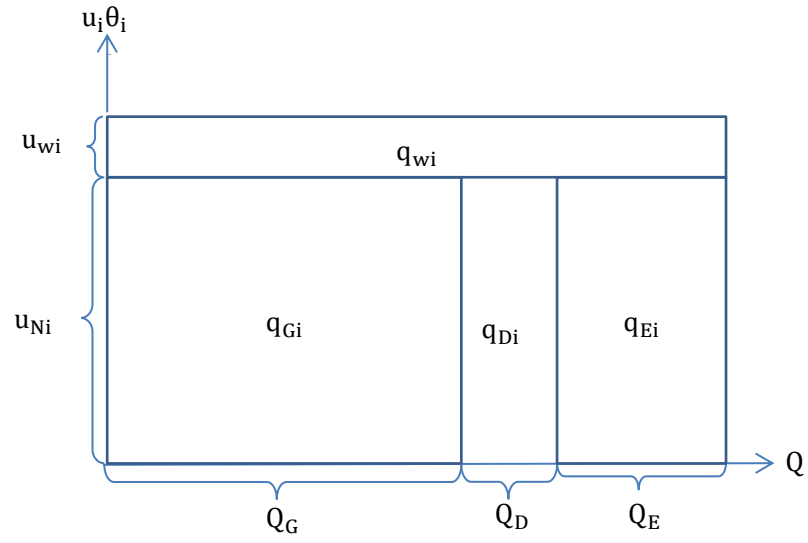


Fig.3 Process Cost Component Chart

In order to compute in terms of equivalent units, we follow the established practice of converting “Process Cost Component Chart” (Fig.3) to the “Equivalent Units Chart” (Fig.4) below with the horizontal axis being the equivalent units and the vertical axis being the net quantity per unit of finished goods. Throughout this article, net quantity consumed per finished good is “ u_N ” whereas waste quantity occurred per finished good is “ u_w ”.

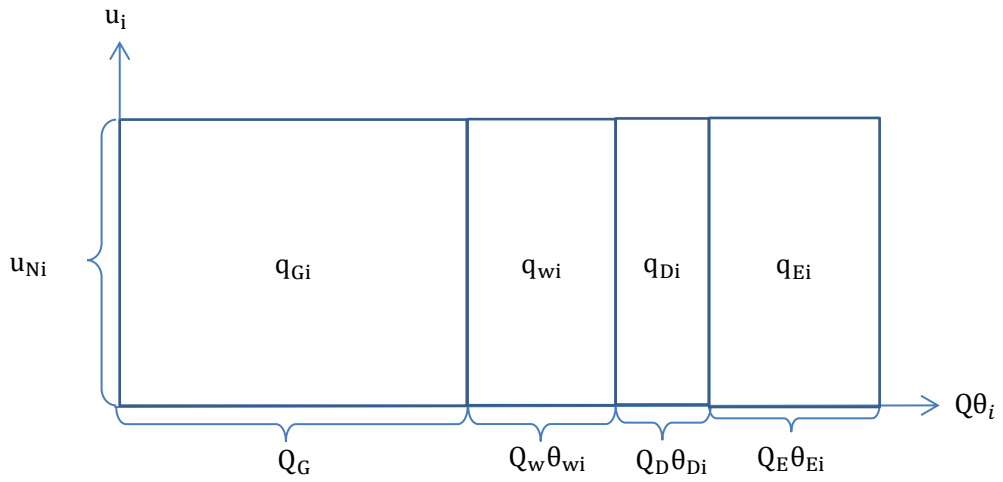


Fig.4 Equivalent Units Chart

Conceptually this conversion is achieved by moving the horizontal area “ q_{wi} ” to the position between the “ q_{Gi} ” and “ q_{Di} ” areas with the same height as others, as shown in Fig.4, without changing its amount. Thus, individual cost is computed in proportion to the equivalent units (Koizumi, 2014).

2. Revisiting the WIP Conversion Coefficient

For us to calculate the waste element of WIP, we need to calculate the costs of WIP itself accurately.

In the conventional method, the upper limit of the production progress rate (Conversion Coefficient) of the direct materials of the E-WIP will automatically be set to one (100%), regardless of whether or not it has reached its WOP.

However, where materials are added at the beginning of the process, waste occurs at a particular point in the process, and the E-WIP has not reached the WOP in the current period, it is inappropriate to set the upper limit of the Conversion Coefficient to one.

According to Professor Kataoka (1978, p178), the Conversion Coefficient is "the ratio of the quantity of goods or services represented by a cost component input into the WIP (u_i) to its net input in the finished goods (u_{Ni})". This can be shown using the following formula:

$$\theta_{Ei} = \frac{u_i}{u_{Ni}} = \frac{u_{Ni} + u_{Wi}}{u_{Ni}} \geq 1 \quad (12)$$

As shown in formula (12), the material quantity included in the E-WIP that has not reached WOP includes the waste portion that will become wasted at WOP in the future. Therefore, only the waste portion is larger than the material quantity included in the finished goods. Accordingly, the Conversion Coefficient, in this case, exceeds one.

To illustrate this more concretely, let us imagine that we are crafting a tote bag out of a flat leather sheet. Such crafting may entail the following operations:

Operations:

1. Check the quality of the leather sheet.
2. Remove any dirt, dust and stains, and give other treatments as required.
3. Select the applicable pre-drawn template patterns.
4. Stick the template on the leather using masking tapes.
5. Punch holes at the places shown in the template.
6. Adjust the cutting tools according to the condition of the leather.
7. Cut the leather according to the patterns.
8. Apply the leather dye to the parts.
9. Stitch the parts with thread and a needle.
10. Add buttons, straps, trademarks and accessories.
11. Conduct a visual check of the product.
12. Place the product into a protective cover and send it to the inspection department.

In the above example, although Operation 5 (punching holes) produces small pieces of the leather, the bulk of the waste of the leather occurs at Operation 7, which will be the WOP.

The same can be observed from the perspective of cost accounting as follows (see Fig. 5 below):

1. Material is added at the beginning of the production process, and the waste occurs at a subsequent point (WOP) in the production process.
2. From a leather sheet weighing 10 kg, a rectangle-shaped piece weighing 8 kg will be cut out, leaving a 2-kg-waste (this waste is assumed not to have any value).
3. Costs of the finished goods (related to the leather) are \$10,000 per 10-kg-sheet.
4. A total of 10 sheets are added to the production process during the cost period. Therefore, the Direct Material Costs ($i=1$) added in the cost period are \$100,000 ($C_{11}^t = \$100,000$).
5. Production Quantity Data: the finished goods are 6 bags from 6 sheets, the E-WIP is 4 sheets.
6. WOP occurs at the middle point of the production process $\hat{\theta}_{w1}=0.5$ (50%).
7. As at the E-WIP, 30% of the production process takes place at the close of the cost period, thus $\theta_{E2} = 0.3$ (30%).

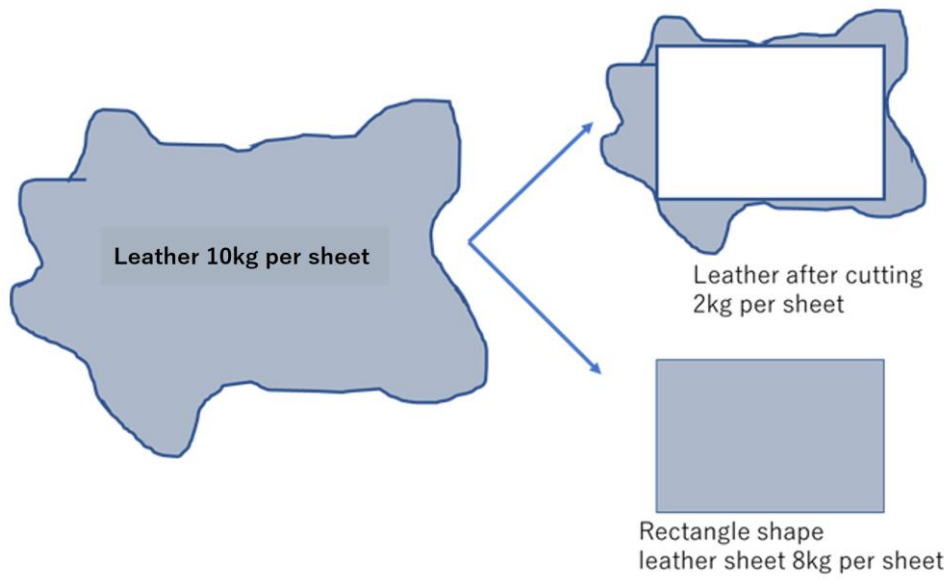


Fig.5 Cutting Out Leather

The above rationale can be described using the following formula:

Quantity of the material contained in 1 finished good:

$$q_{G1} = u_{N1} Q_G = 8 \text{ kg} \cdot 1 \text{ sheet} = 8 \text{ kg} \quad (13)$$

Quantity of Waste:

$$q_{w1} = u_{w1} Q_G = 2 \text{ kg} \cdot 1 \text{ sheet} = 2 \text{ kg} \quad (14)$$

By applying Formula (12), where there is 10 kg of leather introduced and 8 kg of leather consumed in the finished goods, the Conversion Coefficient of 1.25 is derived.

$$\theta_{E1} = \frac{u_1}{u_{N1}} = \frac{u_{N1} + u_{w1}}{u_{N1}} = \frac{10\text{kg}}{8\text{kg}} = 1.25 \quad (15)$$

Accordingly, the conventional assumption that the B-WIP would not be wasted and that the Conversion Coefficient would not exceed one does not necessarily display the accurate states of the manufacturing process and production costs. This finding is of significant importance when the production cost is calculated as shown below:

First, the above example will be graphically displayed in the format of “Process Cost Component Chart” as shown below, which corresponds to Fig.3 above.

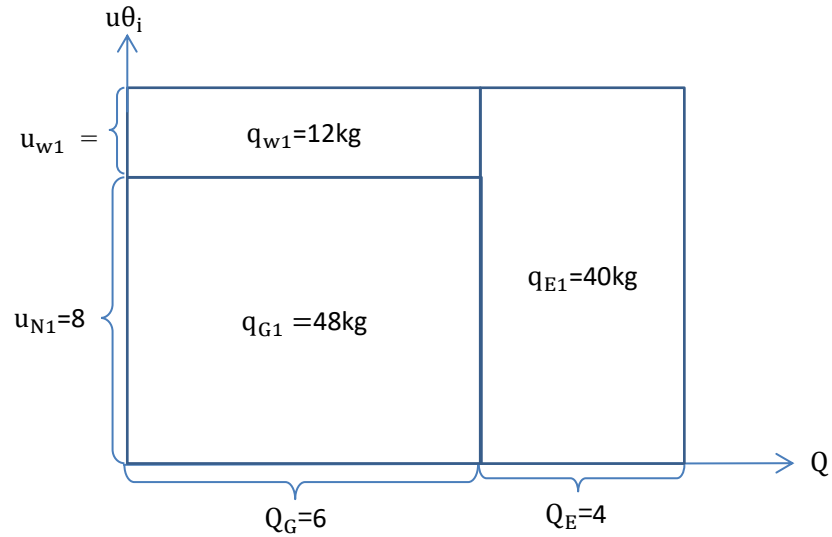


Fig.6 Process Cost Component Chart
(the y-axis is “kg” and the x-axis is “sheets”)

In order to calculate on the basis of equivalent units, Fig.6 will be turned into the “Equivalent Units Chart (Fig.7)” as shown below, which corresponds to Fig.4 above.

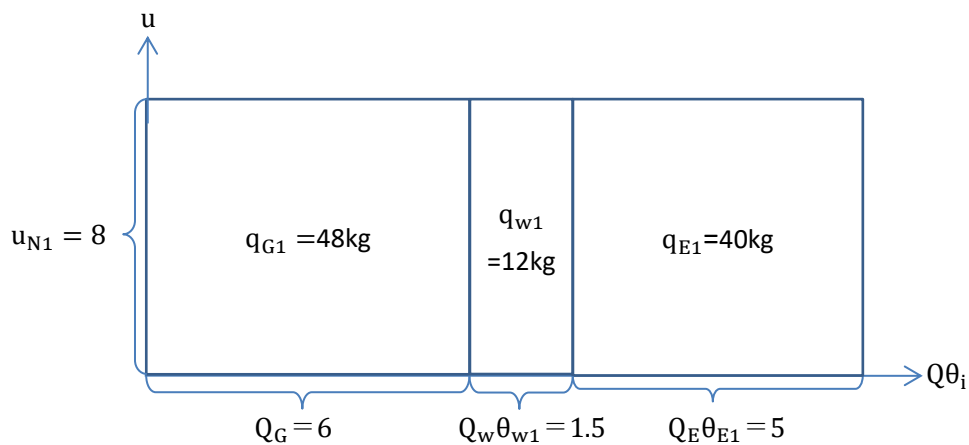


Fig.7 Equivalent Units Chart
(the y-axis is “kg” and the x-axis is “sheets”)

In this example, if one uses the conventional method, it assumes that the Conversion Coefficient of the E-WIP is always one, and it is a common ground that the E-WIP is shown as follows (Okamoto 2000, pp313-315):

$$C_{E1} = \frac{C_{I1} Q_E \theta_{E1}}{(Q_G - Q_B \theta_{B1}) + Q_{Iw} \theta_{Iw1} + Q_E \theta_{E1}} = \frac{100,000 \times 4 \times 1}{6 + 1.5 + 4 \times 1} = \$34,783 \quad (16)$$

But if we use the method proposed in this article and adopt the Conversion Coefficient of 1.25, then the Formula (15) should be adopted to produce the correct result.

$$C_{E1}^* = \frac{C_{I1} Q_E \theta_{E1}}{(Q_G - Q_{BG} \theta_{B1}) + Q_{IG} \theta_{Iw1} + Q_E \theta_{E1}} = \frac{100,000 \times 4 \times 1.25}{6 + 1.5 + 4 \times 1.25} = \$40,000 \quad (17)$$

“*” indicates the method proposed by the writer.

The two results are significantly different, and this begs a question about adopting the conventional assumption which will be examined in more detail below.

3. Process Costing using the FIFO and Method of Non-Neglect

3.1. The implication of the Assumption: Volume of WIP and Length of Production Period

We will consider two cases, which reflect different production characters.

In Case A, the B-WIP (q_{Bi}) is small and they will be turned into the finished goods relatively quickly. In this scenario, the portion of the B-WIP which will become “wasted” should be small and one could argue that it would not matter at which time point such a small proportion became wasted because virtually all of the B-WIP had turned into the finished goods (except such possible wasted portion). One could, therefore, argue that the waste occurred in the costs period (q_{wi}) could safely be assumed to have arisen from the materials added to the production system in the current year (q_{Ii}). This argument would support the conventional assumption.

In Case B, on the other hand, the B-WIP is significant (q_{Bi}) and, due to a long production period, it has taken a considerable time to turn them into the finished goods (q_{Gi}). The addition of the new materials (q_{Ii}) took place late in the costs period, and none of them had turned into the finished goods. In this case, the conventional assumption that no waste had occurred from the B-WIP does not match the mode of production and fails to display the reality.

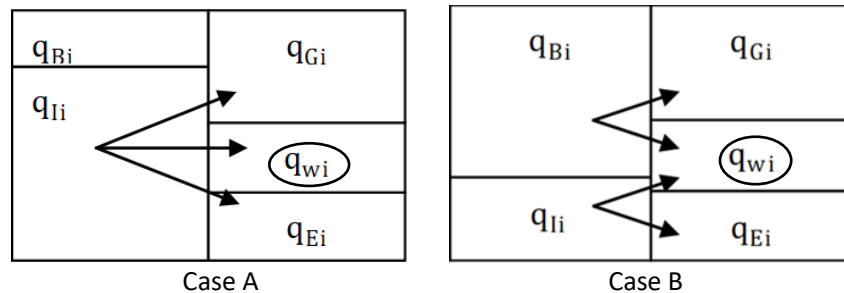


Fig.8 WIP Account Chart

3.2. Calculation of Equivalent Units of Waste

It is the writer's point of view that the quantity of the materials wasted should be shown directly by the material quantity wasted (q_{wi}) itself. However, under the conventional method, because it is computed in terms of the equivalent units, it will be shown indirectly using $Q_w \theta_{wi}$ (Koizumi, 2005). This will be briefly explained below.

Where the quantity of material added and the quantity of waste occurred are both expressed in terms of the finished goods, such as weight (e.g., kg), the quantity of material waste will be expressed as follows:

$$q_{wi} = Q_w \theta_{wi} u_{Ni} \quad (18)$$

In other cases, however, we need to convert " q_{wi} " to " $Q_w \theta_{wi}$ " by using the following conversion formula:

$$Q_w \theta_{wi} = \frac{q_{wi}}{u_{Ni}} \quad (19)$$

In this connection, it should be noted that the concept of "progress in processing" does not apply to waste. This is because waste is not something "processed". Similarly, the concept of "degree of completion" does not apply to waste because, once it occurs, it cannot be further turned into a finished good.

3.3. Modified General Formula to Compute the Cost of Waste Occurring from the B-WIP

Below is the conventional Revised FIFO or Pure FIFO formula (Method of Non-Neglect), which is commonly acknowledged in this field. This is a general formula in the sense that it accommodates any cost component, whether materials or services. It is noted in this formula that the costs of finished goods are calculated by separating the costs of finished goods in the current period from the costs of finished goods in the previous period.

$$C_{BGi} = C_{Bi} + \frac{C_{Li} Q_B (1 - \theta_{Bi})}{(Q_G - Q_B \theta_{Bi}) + Q_w \theta_{wi} + Q_E \theta_{Ei}} \quad (20)$$

However, in order to remove the assumption as presented by the writer, we will need to modify this general formula specifically for computing direct material costs. To this end, we will separate the "waste costs occurring from the B-WIP" element from C_{BGi} , and allocate C_{Bi} to the two separate items using the ratio of $Q_B \theta_{B1}$ and $Q_B \theta_{BBW1}$.

In doing so, for the sake of simplification, only the Cost Component 1 (direct material: $i=1$) will be dealt with in the formulas.

Costs of Goods commenced in the previous period and finished in the current period:

$$C_{BG1}^* = \frac{C_{B1} Q_B \theta_{B1}}{Q_B \theta_{B1} + Q_B \theta_{BBw1}} \quad (21)$$

Costs of Waste occurring from the B-WIP:

$$C_{BW1}^* = \frac{C_{B1} Q_B \theta_{BBw1}}{Q_B \theta_{B1} + Q_B \theta_{BBw1}} \quad (22)$$

It is submitted that the conventional assumption may be removed and, where this is done, the costs of goods and costs of waste will be captured with accuracy using the above amended formulas.

4. Summary

In this article, the basic concept of waste (e.g. how to calculate in terms of equivalent units) was introduced, together with related formulas, and this was shown by following the established practice of converting the “Process Cost Component Chart” to the “Equivalent Units Chart” (Section 1).

This article then touched the WIP Conversion Coefficient using an example of crafting a tote bag out of a leather sheet, and highlighted that the practice in the conventional method of setting an upper limit of one (100%) to the progress completion of the E-WIP would lead to erroneous outcomes (Section 2).

The article then revisited the general formula of Process Costing using the FIFO and Method of Non-Neglect and offered an alternative version to compute “Costs of Waste occurring from the B-WIP”, where the conventional assumptions are disapplied (Section 3).

5. Concluding Remarks

The Japanese Cost Standards were introduced in the era when accountants used primarily pens, papers and abacus. Similarly, there was no comprehensive tracking mechanism used in the ordinary production lines, and no tracing information of the materials was available. Under such circumstances, it is unsurprising that the cost accounting was performed by adopting a number of assumptions to achieve its aim within the limitations.

The situation has, however, changed significantly over the last 60 years. Most manufacturers now use sophisticated IT systems to monitor the entire production process, of which cost accounting is an integral part. Furthermore, various attempts have been made, such as the “Just-in-Time” system, “Fab-Less” and digital transformation (DX), in order to improve production efficiencies. Additionally, we have also witnessed the situations where unexpected changes in the availability of essential materials, such as IC chips for cars, could easily halt the production.

In this regard, the aim of cost accounting used to be to grasp the production costs accurately *ex-post*. But the writer believes that cost accounting should be more dynamic in the sense that it should be more future-oriented. For example, it should be capable of providing reliable information to the management on the ongoing production costs in response to the unexpected changes and even threats that the manufacturers may encounter.

This paradigm shift should also apply to the fields of materials waste, scraps, byproducts and spoilages, which occur during the course of manufacturing. This will be of particular importance in light of the Sustainable Development Goals (SDGs) as currently advocated globally.

The writer is of a view that the established practices in cost accounting, such as the assumptions dealt with in this article, should be revisited carefully with fresh eyes, for a better understanding of what cost accounting can offer to the industry and society. It is submitted that such continuous revisits will be instrumental in preserving the freshness of the Japanese Cost Standards and carrying its values forward into the future.

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