An Operations Improvement in an Incoming Materials Inspection Department

By

Mr. Watit Kasempremchit

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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Project Title	An Operations Improvement in an Incoming Materials Inspection Department
Name	Watit Kasempremchit
Project Advisor	Dr. Chamnong Jungthirapanich
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

Approval Committee:

(Dr. Chamnong Jufitli bpanich)
Dean and Advisor

(Prof.Dr.Srisakdi Charmonman)
Chairman

oftts,a4' 91Y;r•sx.ra

(Assist.Prof.Dr.Boonmark Sirinaovakul)
Member

(Dr. Prapon Phasukyud)
Member

(Assoc.Prof.Somchai Thayarnyong)
MUA Representative

July 1999

ABSTRACT

The purpose of this project is to recommend improvements to the incoming inspection process flow. Major steps in this project are analyzing the existing process flow, recommending the proposed process flow, and evaluating the proposed process flow.

A process chart is used to analyze the existing process flow and identify areas for improvement. Then, the proposed process flow is designed with the method of work simplification in order to improve the existing process flow. Finally, the proposed process flow and the existing process flow are compared to verify whether there is improvement with the proposed process flow. The cycle time of both process flows will be measured and compared. The net present value is also used to compare the benefit and cost of the proposed process flow.

Based on the evaluation result, there is a significant improvement and the benefit gain with the proposed flow.

ACKNOWLEDGEMENTS

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I. INTRODUCTION

Nowadays, most businesses are in the competitive market. Only companies that are able to produce their products with the highest cost-effectiveness will survive in the current market situation. Processes are the most essential part that affects the cost-effectiveness. If the process is not well designed, there will be many steps or operations that do not add any value to the product. Such operations are considered to be a waste that will result in higher production cost. Therefore, the continuous process improvement is an important issue that the company needs to consider in order to gain competitive advantage over competitors as it helps the company to analyze and eliminate wastes from the processes. It does not only improve productivity but also reduce the production cost.

In manufacturing facilities, there are many operations from receiving incoming materials to shipping finished products. The incoming materials inspection is one of these operations that assure the quality of incoming materials or detect the materials' problem before using them. This operation is performed prior to loading materials onto the production line.

This project aims at improving the existing incoming materials inspection process flow, which starts from receiving materials, preparing materials for inspection, performing inspection, recording the inspection data, packing materials into their original boxes and/or packages, and returning materials to the warehouse. The scope of this project includes analyzing the existing incoming materials inspection process flow, identifying areas where improvements can be made, and recommending appropriate improvements to the process flow.

II. LITERATURE REVIEW

2.1 Continuous Process Improvement

The continuous process improvement is a method to constantly improve the current work. The benefit of the continuous process improvement will result in many areas, which includes reducing scrap and rework, reducing cycle time, reducing waste, reducing inventory, providing significant short-term return on investment, introducing long-term profit and productivity gains, identifying and eliminating non-value-adding, nonessential work from processes, and improving and polishing processes. Various tools may be applied to help improve the process such as process chart, Pareto chart, and cause and effect diagram (Robson 1991).

The General steps to make improvements to any system and/or correct the existing problem in the current system include (Termer and Freivalds 1992)

(1) Defining problem.

(2) Identifying and documenting process.

(3) Measuring performance.

(4) Understanding why.

(5) Developing and testing idea.

(6) Implementing and evaluating.

The purpose of the first step is to define the problem in the existing system and to limit the scope of the system to be improved and/or corrected. After the area to be improved is selected, the current system needs to be understood. The existing process will be documented so that it helps analysts to understand the process. There are many tools that can be used, such as process chart, worker-machine chart, and cause and effect diagram or Fishbone diagram. Then, the existing system will be measured for its performance. Then, the proposed system may be developed to improve the existing system and/or to correct the problem in the existing system. However, before an implementation of the proposed system, the proposed system must be tested to ensure that the proposed system can actually improve the existing system and/or correct the problem in the current system. To test the proposed system, the proposed system will be measured and its performance will be compared with the performance of the existing system, which is measured in the third step. There are also a number of tools that can be used to measure the current and the proposed system such as time measurement, Pareto chart, and control chart. If the test result shows that the proposed system can improve the current system, the proposed system can be fully implemented (Tenner and Freivalds 1992).

Waste is a major focus to improve the current process. There are a number of wastes existing in processes and work environments. If these wastes are eliminated, the cost of production will be lower because, for example, number scraped, cycle time, and inventory can be reduced. However, people tend to focus on adding something into the process that adds value rather than focus on eliminating something from the process that erodes value. As a result, opportunities for improvement are sometimes overlooked. Fujio Cho of Toyota defines waste as "anything other than the minimum amount of equipment, materials, parts, space, and worker's time, which are absolutely essential to add value to the product." Later, Toyota had done various improvement activities and classified wastes into seven categories called "Seven Wastes" as follows (Suzaki 1987):

(1) Waste from over production: This is the waste when the company produces goods over the amount required by the market. It creates the unnecessary consumption of raw material, labor cost, and inventory cost. However, to reduce this over production problem, we need to understand that it is not

necessary to make machines and operators fully utilized as long as market demands are met.

(2) Waste of waiting time: This waste is easily identified. It happens when operators stay idle and wait for the machine to complete the work.

(3) Transportation waste: Transportation is considered to be wasted because it does not add anything to the product but, rather, it creates the hidden cost. This waste is commonly observed in many factories. It can be reduced or eliminated by improving the layout, transportation methods, and housekeeping.

(4) Processing waste: This waste is created by ill-designed processing method. Additional time will be required to complete the work when the processing method is not well designed. It can be eliminated by the use of proper fixtures or automation.

(5) Inventory waste: This is the waste of holding excess inventory. It can be reduced by line balancing, producing in small lots, and organizing workplace.

(6) Waste of motion: Unnecessary motion is considered to be wasted if it does not add value to the product.

(7) Waste from product defects: This is the waste when the process produces the defect. To reduce this waste, a system must be developed to identify defects or the conditions that produce defects so that anyone can take immediate corrective action.

The basic improvement idea is to make the work easier, faster, cheaper, better, and safer. These can be done by four basic approaches as follows (Suzaki 1987):

(1) Simplifying: This approach focuses on changing the new method to do the work so that the work becomes easier. This may be done by using automation, using better fixture to hold the part, or designing an easier way to complete the work.

(2) Combining: This approach focuses on combining two or more steps of doing work into a single step. The redundant steps may be combined into one step.

(3) Eliminating: This approach focuses on eliminating the unnecessary step. However, the elimination of unnecessary step must not affect the quality of work output.

(4) Changing sequence: This approach focuses on rearranging sequence of steps or the work flow to complete the work in order to make the process flows more smoothly.

2.2 A Process Chart

A process chart is a chart used to represent the actions occurred in a process, which includes operations, transportations, inspections, delays, storages, and its sequence. Some useful information may be added to help in analysis such as time required and distance moved. There are two types of process charts as follows (The American Society of Mechanical Engineers 1980):

(a) The material type which is used to display the process in terms of the events which occur to the material(s) being processed.

(b) The person type which is used to display the process in terms of the activities of a person(s) performing steps of the process.

In the process chart, each action in the process flow will be categorized into five actions or activities, which are operations, transportations, inspections, delays, and storages, each of which can be represented in symbol as follows (The American Society of Mechanical Engineers 1980):

(1) Operation rm _-): An operation is the action of an intentional change on an object in any of its physical or chemical characteristics, is assembled or disassembled from another object, or is arranged or prepared for another operation, transportation, inspection, or storage. The operation can be the action when the information is given or received or when planning or calculating takes place. (Symbol: Circle)

(2) Transportation *: A transportation is the action of an object's movement from one location to another. It is excluded when such movement is a part of the operation or is caused by the operator at the workstation. (Symbol: Arrow)

(3) Inspection : An inspection is the action of examining or verifying an object for quality or quantity in any of its characteristics. (Symbol: Square)

(4) Delay 3: A delay is the action when an object or person waits for the next planned action. (Symbol: D)

(5) Storage V : A storage is the action when an object is kept and protected against unauthorized removal. (Symbol: Inverted triangle)

The process chart is a simple but effective method to display the entire process graphically. In the actual application, the process chart help us to (Robson 1991)

(a) Simplify complex processes.

(b) Magnify areas that are normally overlooked for the improvement.

(c) Identify key actions in the process.

(d) Identify critical areas for the improvement.

(e) Identify nonessential and non-value-adding action.

2.3 Time Study

The Time study or work measurement is a common method that is used to measure each work in factory. It determines the time necessary for a qualified worker to perform a particular task. It can also be applied to compare the cycle time between the process flow before an improvement and the process flow after an improvement to verify the time improvement between two flows. The typical output of the time study is the standard time. There are several techniques to perform time study as follows (Dilworth 1993):

(1) Stop watch time study. This technique is performed by observing and timing an operator directly when he/she performs his/her work. Then, the standard time is derived from the calculation of observed times. It is suitable for the work that is repetitive or routine where the same workflow is performed. It presents the most accurate standard time.

(2) Elemental time files. In this technique, the historical data of the same work element, which is kept in the company database or file, is used as the standard data to determine the time required to complete the work.

(3) Predetermined motion times. In this technique, the predetermined motion time for basic motions, which is the standard table created by the MTM Association for Standards and Research, is used as the standard data to determine the time required to complete the work.

(4) Work sampling. This technique is also performed by observing the operator when he/she performs his/her work. However, it does not require a stop watch to record the time. Instead, the standard time is derived from taking a large number of observations randomly and the percentage of time that the operator performs work activities.

Before timing the operator at work with the stop watch time study technique, the number of cycles to time and the sampling dates and times must be determined. There are various techniques to determine the number of cycles in order to get an acceptable result. If the distribution of sample times is assumed to be normally distributed, the number of cycles can be statistically determined from the equation below (Dilworth 1993).

$$n = \left(\frac{Zs}{Ax} \right)^2$$

where n = number of cycles

Z = standardized normal deviate that has (1-confidence)/2 as the area remaining in the distribution beyond Z

s = sample standard deviation

= the average job cycle time

A = accuracy desired expressed as decimal fraction of the true value

However, from an economist standpoint, sometimes, the analyst may not be able to complete the timing for a specified sample size, which is calculated statistically. Therefore, the General Electric Company studied and established the recommended number of observation cycles for the varied cycle time, which is shown in Table 2.1 (Niebel and Freivalds 1999).

In order to make sure that dates and times to perform the stop watch timing is random, the random table may be used to determine dates and times. The random table is shown in Table A.1 in the appendix. There are various approaches to code the date and time in order to get random dates and times from the random table. In one approach, five numbers in random table may be selected, the first digit may represent the day, the second digit may represent the shift, and the last three consecutive digits may represent minutes after the shift is started, for example the number 12333 represents the first day or Monday, second shift, and 333 minutes after the shift is started. In another approach, five numbers in random table may also be selected, the first digit may represent the day, but the last four consecutive digits may represent the hour and minute, for example the number 10900 represents the first day or Monday, and 09:OOAM. If the number received from the table is not valid such as 3333 for the hour and minute, that number will be discarded and the new number will be selected from the table in sequence until the valid number is received. (Niebel and Freivalds 1999).

Table 2.1. Recommended Number of Observation Cycles (Niebel and Freivalds 1999).

Cycle Time in Minutes	Recommended Number of Cycles
0.10	200
0.25	100
0.50	60
0.75	40
1.00	30
2.00	20
2.00-5.00	15
5.00-10.00	10
10.00-20.00	8
20.00-40.00	5
40.00-above	3

2.4 Benefit and Cost Analysis

The benefit and cost analysis is the method to evaluate whether the given alternative, which may be the proposed project or the proposed machine, is worthy to be invested. However, in the analysis, benefit and cost from different time period cannot be compared directly because the value of money changes when time changes. To compare the money at the different time period, the equivalent money value has to be calculated. The money value at a future time can be discounted to be equivalent to the money value at the present time by using the equation below (Blank and Tarquin 1989).

$$\mathbf{P} = \frac{\mathbf{F}}{[1 + 1r}$$

where P = Equivalent money value

F = Money value at a future time

i = interest rate per interest period; months, years, etc.

n = number of interest periods; months, years, etc.

There are various approaches to compare the benefit and cost as follows (Blank and Tarquin 1989):

(1) Net present value: In this approach, costs and benefits from every time period will be discounted to the present time. Then, the total cost, or the summation of every cost at the present time, will be subtracted from the total benefit, or the summation of every cost at the present time. If the result of the subtraction, which is called net present value or net present worth, is positive, the given alternative is considered to be worthy because the result of the subtraction represents the equivalent money gained at the present time.

(2) Equivalent uniform annual value: This approach is similar to the net present value approach. However, instead of considering costs and benefits at the present time, costs and benefits are considered over the specified time interval with equal money, e.g. 100 baht/year for 5 years. Similarly, the total cost will be subtracted from the total benefit. If the result of subtraction, which is called equivalent uniform annual value or equivalent uniform annual worth is positive, the given alternative is considered to be worthy because the result of subtraction represents the equivalent equal money gained over the specified time interval.

(3) Rate of return: This approach is different from other approaches. Instead of calculating the total cost and total benefit, the rate of return of the alternative is calculated. The rate of return is similar to the interest rate in the sense that it considers the time value of money. However, the difference between the rate of return and interest rate is that the rate of return is the rate which makes the overall cash flow, net present value or equivalent uniform annual value, equal to zero. If the rate of return is higher than the minimum attractive rate of return (MARR), the alternative is considered to be worthy.

(4) Benefit/Cost ratio: This approach is similar to the first approach and the second approach. However, instead of subtracting the total cost from the total benefit, the total benefit will be divided by the total cost. If the result of the division, which is called benefit/cost ratio, is more than one, the given alternative is considered to be worthy. However, the result does not represent the money gained. This method is usually used in the government project.

III. RESEARCH METHODOLOGY

3.1 Overview

In this project, the Head Gimbal Assembly (HGA) raw material incoming inspection process is selected to recommend improvements. The HGA, which is used to receive the signal from the computer and to perform reading/writing function on the disk media, is one of the components in the hard disk drive. There are three major direct raw materials to be assembled into the HGA, which include a slider or a read/write head, a flexure or a suspension, and a Flex On Suspension (FOS) or a flex circuit used to connect slider to hard disk drive controller.

Every HGA incoming material has the same inspection process flow as the incoming inspection department. Their differences in the inspection process are the inspection criteria and magnification of the inspection microscope. Therefore, the incoming inspection flow of the slider, which is the most critical material of the HGA, is selected to represent all incoming materials inspection flow in recommending improvements to the existing process flow.

The overall research methodology in this project includes the following steps:

(1) Existing process flow analysis

(2) Proposed process flow recommendations

(3) Proposed process flow evaluation

3.2 Existing Process Flow Analysis

In the existing process flow analysis step, the existing process flow will be analyzed with the use of process chart. The process chart of the existing process flow will be drawn and each action or step in the process chart will be discussed on how and/or why the action is performed.

3.3 Proposed Process Flow Recommendations

In the proposed process flow recommendation step, the proposed process flow will be designed in order to improve the existing process flow. Basic concepts of work simplification are used to eliminate non-value-adding works from the existing process flow. Then, the process chart will be used to display the proposed process flow. Again, each action or step in the process chart will be discussed on how and/or why the action is performed.

3.4 Proposed Process Flow Evaluation

At the incoming inspection process, there is no scrap and rework problem to be considered because the process itself does not create the defective part. Therefore, the cycle time is selected to be a measure of the proposed process flow improvement.

The method to measure the cycle time in this project is the stop watch time study technique because it is the most accurate method to measure the cycle time of the repetitive process flow.

The time study will be performed on the existing process flow and the proposed process flow. Then, the cycle time of the existing process flow and the proposed process flow will be calculated and compared to evaluate whether there is the improvement on the proposed process flow. Steps for the proposed system evaluation are

(1) Determine the number of cycles to perform the time study for the existing process flow and the proposed process flow. The number of cycles will be determined according to the recommended number of observation cycles, which is established by the General Electric Company, shown in Table 2.1 of the literature review section.

(2) Determine dates and times to perform the time study for the existing process flow and the proposed process flow. Dates and times will be determined by using the random number table. The total number of dates and times to perform the time study will equal to the total number of cycles determined in the first step.

(3) Perform the time study for the existing process flow and the proposed process flow according to the dates and the times determined in the second step.

(4) Calculate cycle times of the existing process flow and the proposed process flow. The standard time will not be calculated because the purpose of this time study is only to compare the average time used in the existing process flow and the average time used in the proposed process flow.

(5) Compare the cycle times of the existing process flow and the proposed process flow to check whether there is an improvement with the proposed process flow.

(6) Perform the benefit and cost analysis. The net present value method will be used in the analysis because it represents the impact on the actual money gained or lost.

IV. EXISTING PROCESS FLOW ANALYSIS

4.1 Overview

The existing incoming inspection department employs one Incoming Quality Assurance supervisor (IQA supervisor) and three Incoming Quality Assurance operators (IQA operators) per shift. The normal working hour for each shift is 7 hours/day and 6 days/week. The total number of shift is 3 shifts/day.

The main purpose of performing incoming inspection is to ensure that materials received from suppliers meet the standard quality level. However, in the incoming inspection, only a visual inspection is performed because the incoming inspection department has no capability to perform a functional inspection or test on incoming materials. The slider incoming inspection consists of a 30x inspection and a 100x inspection according to the requirement of the engineering specification. This inspection must be done in the cleanroom in order to keep the materials clean.

The incoming inspection uses the 0.65%AQL level II of Military Standard 105D sampling plan as a reference to select the number of materials to be inspected for each shipment and to select the number of total rejected materials to accept/reject the inspected shipment. The sample size according to this sampling plan varies according to the quantity of the incoming lot or the incoming shipment. Because of the limitation of IQA operators, the incoming inspection department sets the incoming inspection flow to include both Skip Inspection flow and Perform Inspection flow. Therefore, there will be both inspected shipment, which the incoming inspection will be performed, and skipped inspection shipment, which the incoming inspection will be skipped. When the first shipment of materials arrive, the inspection will be performed on every shipment until three consecutively accepted shipments are met. Then, the inspection will be skipped for six shipments. After that, a seventh shipment will be inspected. If this shipment is accepted, the inspection will be skipped for another six shipments. However, if this shipment is rejected, the inspection will be performed on the next shipment until three consecutively accepted shipments are met. The flow chart of the perform/skip inspection is illustrated in Figure 4.1.

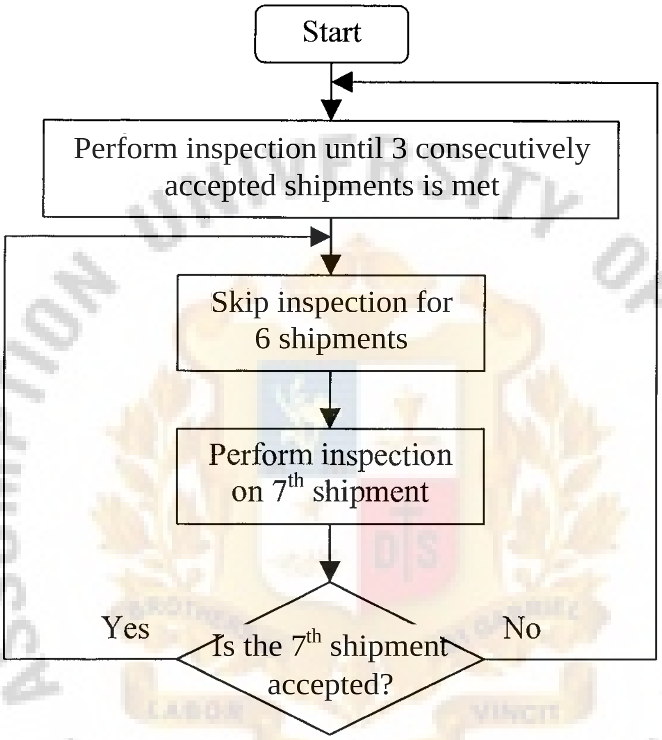

Figure 4.1. Perform Inspection / Skip Inspection Flow.

4.2 The Process Chart of the Existing Process Flow

In the analysis of the existing incoming inspection flow, the process chart is used to analyze and present the existing incoming inspection flow. The existing process flow is illustrated in Figure 4.2. With some conditions, which will be described below, the inspection flow can be classified into four major flows as follows:

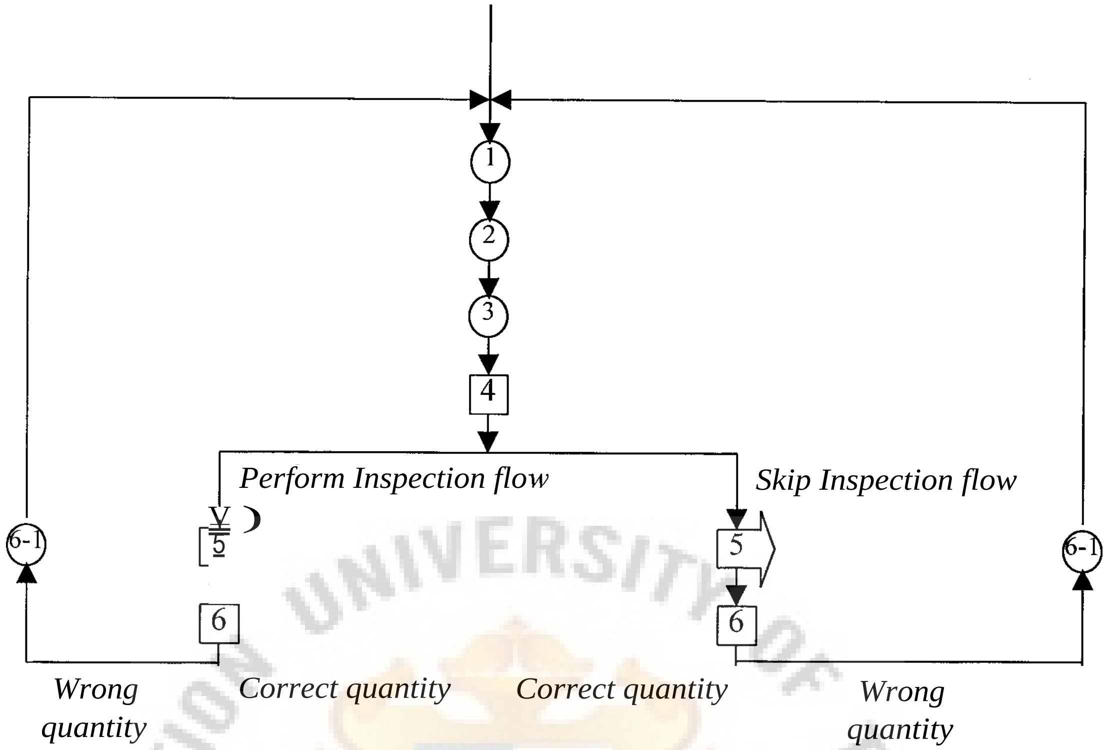

Figure 4.2. The Existing Incoming Inspection Process Flow.

Figure 4.2. The Existing Incoming Inspection Process Flow. (Continued)

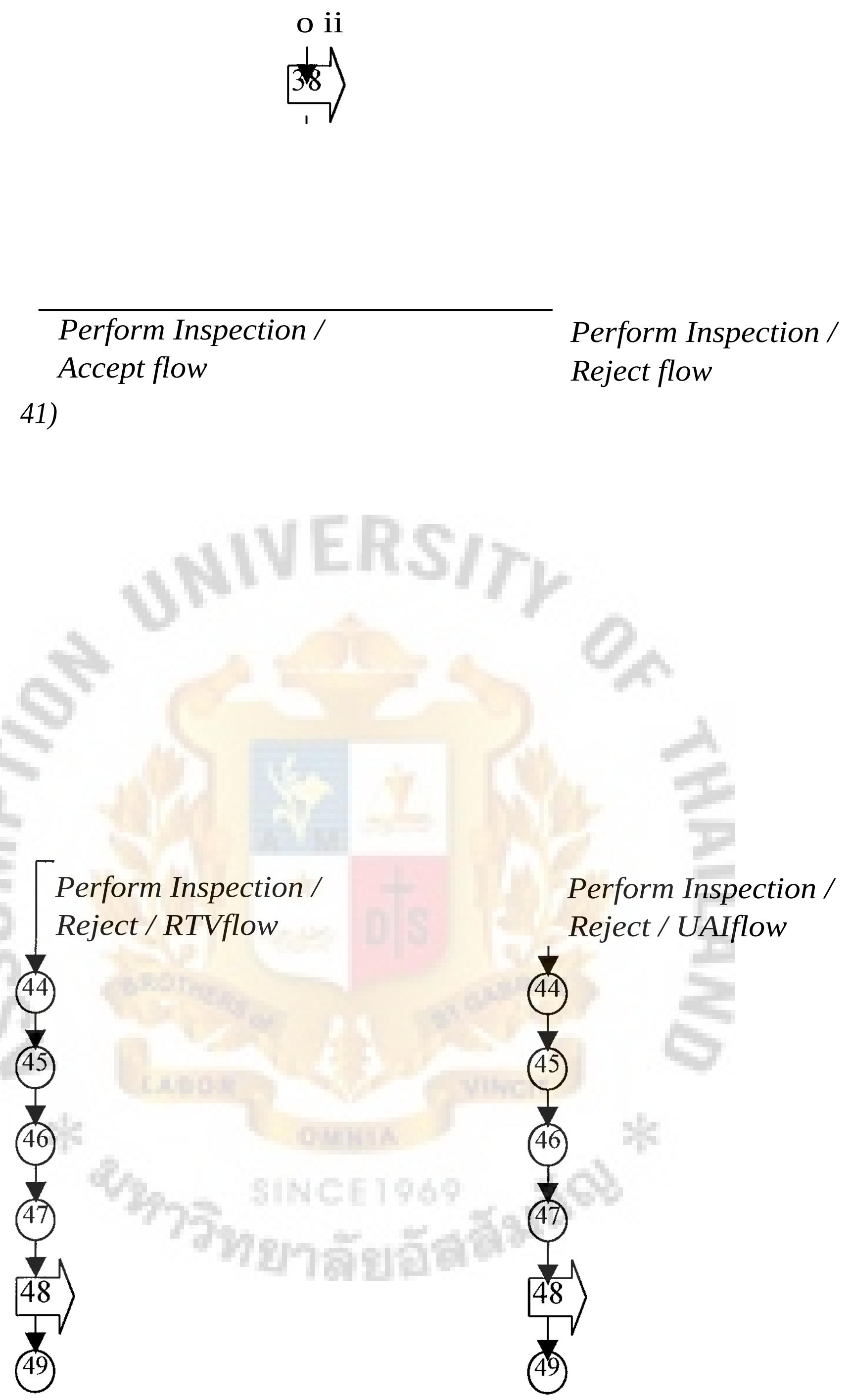

Figure 4.2. The Existing Incoming Inspection Process Flow. (Continued)

(1) Skip Inspection flow

(2) Perform Inspection / Accept flow

(3) Perform Inspection / Reject / Return To Vendor (RTV) flow

(4) Perform Inspection / Reject / Use As Is (UAI) flow.

Every inspection process flow starts when the IQA operator receives the Receipt Traveler (RT) slip, or shipment slip, and its copy from the warehouse staff. This RT slip will be returned to the warehouse department whereas its copy will be kept at the incoming inspection department. Detailed steps of each process flow can be described in following sub-sections. The existing layout of the warehouse area and the incoming inspection department can be drawn as shown in Figure 4.3.

4.2.1 Steps in the Skip Inspection Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)" step, is the Skip Inspection. In this flow, there will be no inspection performed. The detail of each step in this flow is as follows:

Step 1 "Record the time when the RT slip and its copy are received and sign the receiver name." In this step, the IQA operator records the time in the form provided by the warehouse staff and signs her name in the form. The purpose of this step is to be able to trace back the time when the incoming inspection department receives the shipment.

Step 2 "Assign the Receiving Inspection Report (RIR) number to the incoming shipment on the database." In this step, the IQA operator creates the new RIR form on the database; fills in the RT number, the shipment number, the shipment quantity, the part number of received material, the vendor code, and the wafer code; and saves the new RIR form on the database.

Step 3 "Write the RIR number on the RT slip and its copy." After the new RIR form created in Step 3 is saved, the RIR number will be assigned to the RIR form automatically. In this step, the IQA operator writes the RIR number, which is automatically assigned by database, on the RT slip and its copy. The purpose of this step is to be able to trace back the inspection result of the shipment.

Step 4 "Check the inspection flow (Inspect or Skip)." In this step, the IQA operator sorts the RIR in database by the part number and the supplier. Then, the IQA operator checks whether the received shipment will be inspected or skipped inspection. Conditions that the inspection has to be performed are as follow otherwise the inspection will be skipped.

(a) The part number and the supplier of the received shipment are the new part number and/or supplier and the inspection has not been performed until three consecutively accepted shipments are met.

(b) The part number and the supplier of the received shipment has been skipped for six shipments.

(c) The part number and the supplier of the received shipment were rejected and the inspection has not been performed until three consecutively accepted shipment are met.

Step 5 "Go to the warehouse." In this step, the IQA operator walks to the warehouse area with the calculator and the "Skip" stamp in order to perform Steps 6-10.

Step 6 " Check the actual total quantity on boxes with the RT slip." In this step, the IQA operator has to find boxes of the material shipment in a specific warehouse area. Material boxes of every shipment will be placed together in the specific area after he/she checked the shipment and quantity. Then, the IQA operator counts the number of boxes, and sums the total number of materials of every box from the box label. If the total number of materials matches with the RT slip, the IQA operator proceeds Step 7 otherwise the RT slip will be returned to the warehouse for correction and the RIR will be voided as in Step 6-1 of Figure 4.2.

Step 7 "Write the RIR number on every box." In this step, the IQA operator reads the RIR number from the RT slip, which is written in Step 3, and writes this number on every box in order to identify that the box belongs to this RIR. This is done to avoid mixing boxes that have different RIR number because the same shipment number may contain various part numbers and each part number may be shipped from different shipments.

Step 8 "Stamp "Skip" on the RT slip and its copy." In this step, the IQA operator stamps "Skip" on the RT slip and its copy. The warehouse staff uses this stamp as a reference in order to store material boxes after the IQA operator returns the RT slip to the warehouse. For Skip, Accept, and UAI RT slip, the warehouse staff will move material boxes into the material storage area. For the RTV RT slip. The warehouse staff will keep the RT slip for reference only.

Step 9 "Stamp "Skip" on every box." In this step, the IQA operator stamps the "Skip" on every material box. This step is to identify boxes that already pass the incoming inspection flow to the warehouse staff.

Step 10 "Return the RT slip to the warehouse." In this step, the IQA operator places the RT slip at the warehouse counter in order to notify the warehouse staff that this shipment has already passed the incoming inspection flow.

Step 11 "Go back to the incoming gage room." In this step, the IQA operator walks back to incoming gage room to perform the remaining steps.

Step 12 "Update the disposition as "Skip" on the database." In this step, the IQA operator opens the RIR on the database, updates the disposition of the shipment as "Skip", and saves the completed RIR on the database.

Step 13 "Keep the copy of the RT slip in the file." In this step, the IQA operator keeps the copy of the RT slip in the file for reference.

4.2.2 Steps in the Perform Inspection / Accept Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)" step, is Perform Inspection and the result of the visual inspection is accepted. The detail of each step in this flow is as follows:

Steps 1 — 4 is the same as Steps 1 — 4 in the existing Skip Inspection flow.

Step 5 "Go to warehouse." In this step, the IQA operator walks to the warehouse area with the platform truck and the RT slip in order to bring material boxes to the incoming gage room.

Step 6 is the same as Step 6 in the existing Skip Inspection flow.

Step 7 "Load boxes onto the platform truck." In this process, the IQA operator moves material boxes in the warehouse area onto the platform truck.

Step 8 "Move boxes to the incoming gage room." In this process, the IQA operator transfers material boxes by the platform truck from the warehouse area to the "material under inspection" area in the incoming gage room in order to prepare sample materials to perform inspection.

Step 9 "Unload boxes from the platform truck." After material boxes are moved from the warehouse to the incoming gage room, the IQA operator will move material boxes from the platform truck to the "material under inspection" area.

Step 10 is the same as Step 7 in the existing Skip Inspection flow.

Step 11 "Check the number of sample size to be inspected." In this step, the IQA operator checks the number of sample size to be inspected from 0.65%AQL of Military Standard 105D table. The number of sample size to be inspected varies by the total quantity of materials in the shipment. However, most operators can remember the number of sample size as she performs the inspection everyday.

Step 12 "Open boxes and take sample packages into the bag." In this step, the IQA operator opens material boxes and takes sample packages into the bag in order to move them to the cleanroom because material boxes are not allowed to be taken into the cleanroom. The IQA operator also has to write the box number on boxes and sample packages from each box to identify from which box the sample package is taken.

Step 13 "Move the bag to the pass box in front of the cleanroom." To move sample materials into the cleanroom, materials have to be placed in the pass box because the operator has to stand in the air shower room for ten seconds before entering the cleanroom. It is not convenient for the operator to hold sample materials in her hand while waiting for the air shower to turn off. In this step, the IQA operator walks to the pass box in front of the cleanroom, opens the pass box, puts the bag into the pass box, and closes the pass box.

Step 14 "Wear the cleanroom suit." Before entering the cleanroom, the IQA operator has to wear the cleanroom suit to avoid contamination from human skin. The suit includes a pair of booties (shoe cover), a head cover, a mount cover, a head smock, a body smock, a heel strap, a wrist strap, and a pair of nitrite glove.

Step 15 "Enter the cleanroom." In this step, the IQA operator walks into the air shower room, stands in the air shower area to reduce the level of particles attached on the cleanroom suit, and then enters the cleanroom. The air shower will turn on automatically for 10 seconds when the entrance door is opened. After the air shower is turned off automatically, the IQA operator walks out of the room from the different side of the door, which is connected to the cleanroom.

Step 16 "Move the bag from the pass box to the 30X scope." In this step, the IQA operator transfers the bag that contains sample materials from the pass box to the 30X scope workbench.

Step 17 "Connect the wrist strap to the workbench for grounding." In this step, the IQA operator connects the wire from the workbench to the wrist strap on her wrist for grounding. Each workbench is grounded to avoid Electro Static Discharge (ESD) problem that can functionally damage materials.

Step 18 "Take sample packages from the bag." In this step, the IQA operator takes sample packages out of the bag.

Step 19 "Open the 30x scope." In this step, the IQA operator turns on the switch of the 30x scope, which is located under the workbench.

Step 20 "Open the sample package and tray." A material tray is in a material package. In this step, the IQA operator opens the sample package and, then, opens the tray inside the package.

Step 21 "Separate sample materials to be inspected." Normally, in a tray, five sample materials will be inspected. In this step, the IQA operator separates five sample materials to be inspected into a free slot in the same tray. The purpose of this step is to ensure that the IQA operator inspects only separated sample materials and the same materials are inspected under the 30x scope and the 100x scope.

Step 22 "Inspect materials under the 30x scope." In this step, the IQA operator performs the visual inspection under the 30x scope. She flips all sides of the material by the tweezers to inspect.

Step 23 "Close the sample tray and package." The IQA operator will completely inspect materials under the 30x scope before moving to the 100x scope. Therefore, before moving to the 100x scope, the sample tray has to be closed and returned to the original package to avoid the problem of mixing trays and particle contamination attached to the materials.

Remark: Steps 20-23 are repeated until the number of the specified sample size is inspected under the 30x scope.

Step 24 "Close the 30x scope." After the 30x inspection is done, the IQA operator turns off the switch of the 30x scope, which is located under the workbench.

Step 25 "Disconnect the wrist strap." In this step, the IQA operator removes the wire of the workbench from the wrist strap on her wrist.

Step 26 "Move to the 100x scope." In this step, the IQA operator transfers sample materials from the 30x scope to the 100x scope, which is located in the opposite side of the workbench, by moving sample materials to the opposite side of the workbench and walks around the workbench to the 100x scope.

Step 27 "Connect the wrist strap to the workbench for grounding." This step is the same as Step 17 but it is done in the 100x scope area.

Step 28 "Open the 100x scope." In this step, the IQA operator turns on the switch of the 100x scope, which is located at the side of the scope on the workbench.

Step 29 "Open the sample package and tray." This step is the same as Step 20 but it is done in the 100x scope area.

Step 30 "Inspect materials under the 100x scope." In this step, the IQA operator performs the visual inspection under the 100x scope. In contrast to the 30x inspection, the 100x inspection is performed on 1 side of the material only. Therefore, no material flipping is needed in this step.

Step 31 "Close the sample tray and package." In this step, the IQA operator closes the sample tray and puts the tray back to the original package.

Remark: Steps 29-31 are repeated until the number of the specified sample size is inspected under the 100x scope.

Step 32 "Close the 100x scope." After the 100x inspection is done, the IQA operator turns off the switch of 100x scope, which is located at the side of the scope on the workbench.

Step 33 "Disconnect the wrist strap." This step is the same as Step 25 but it is done in the 100x scope area.

Step 34 "Record the inspection result in the cleanroom paper." In this step, the IQA operator writes the shipment information, the RIR number, the number of sample size, the number of rejected, and the rejected criteria (if any) in the inspection result form which is copied in the cleanroom paper.

Step 35 "Return sample packages to the bag." In this step, the IQA operator puts all sample packages on the workbench back to the bag.

Step 36 "Exit the cleanroom." In this step, the IQA operator carries the bag and walks out of the cleanroom through the exit door and places the bag on the table outside the cleanroom.

Step 37 "Take off the cleanroom suit." In this step, the IQA operator takes off the cleanroom suit, throws away a pair of booties (shoe cover) and a pair of nitrite glove, and puts a head cover, a mount cover, a head smock, a body smock, a heel strap, and a wrist strap back to the smock bag.

Step 38 "Move the bag to the incoming gage room." In this step, the IQA operator carries the bag and walks to the incoming gage room.

Step 39 "Return sample packages into boxes." In this step, the IQA operator sorts sample packages by the box number written in Step 12 and puts them back according to the box number.

Step 40 "Staple the copy of RT slip with the inspection result." In this step, the IQA operator staples the copy of RT slip with the inspection result before keeping them together in the record.

Step 41 "Update the inspection result and disposition on the database." In this step, the IQA operator opens the RIR on the database, input the number of sample size, the number of rejected, and the rejected criteria (if any), then, updates the disposition of the shipment as "Acc", and saves the completed RIR on the database.

Step 42 "Stamp "Acc" on the RT slip and its copy." In this step, the IQA operator stamps the "Ace" on the RT slip and its copy.

Step 43 "Stamp "Ace" on every box." In this step, the IQA operator stamps the "Ace" on every material box.

Step 44 "Load boxes onto the platform truck." In this step, the IQA operator moves material boxes onto the platform truck before transferring them back to the warehouse area.

Step 45 "Transfer boxes and return the RT slip to the warehouse." In this step, the IQA operators transfers material boxes by the platform truck from the incoming gage room to the warehouse area, unloads material boxes in the warehouse area, places the RT slip in the specified cavity on the warehouse counter, and walks back to the incoming gage room.

Step 46 "Keep the copy of RT slip and inspection result in the file." In this step, the IQA operator keeps the copy of the RT slip, which is stapled with the inspection result in the cleanroom paper, in the file for reference.

4.2.3 Steps in the Perform Inspection / Reject / Return To Vendor (RTV) Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)" step, is Perform Inspection, the result of the visual inspection is rejected, and the shipment is disposed as Return To Vendor (RTV). The detail of each step in this flow is as follows.

Steps 1 — 40 are the same as Steps 1 — 40 in the existing Perform Inspection / Accept flow.

Step 41 "Update the inspection result on the database." In this step, the IQA operator opens the RIR on the database, inputs the number of sample size, the number of rejected, and the rejected criteria, and then, saves the RIR on the database. There is no disposition input to the database in this step because the disposition of the rejected shipment will be known after engineering meeting.

Step 42 "Issue the Multi Purpose Quality Report (MPQR)." When the shipment is rejected, the MPQR will be issued to Supplier Quality Engineer and the meeting among Manufacturing Engineer, In Process Quality Engineer, Manufacturing Supervisor, Material Planner, and Purchasing Supervisor will be set up to dispose the shipment whether it will be Return To Vendor or Use As Is. In this step, the IQA operator issues the MPQR on the database by clicking the "Create the MPQR" button, after clicking this button, all information will be copied from the RIR to the MPQR. The MPQR will be saved and sent to Supplier Quality Engineer via e-mail.

Step 43 "Hold boxes at IQA for further disposition". In this step, material boxes will be held at specified location at the IQA area until the disposition of the shipment is made.

Step 44 "Update the disposition as "RTV" on the database." In this step, the IQA operator opens the RIR on the database, updates the disposition of the shipment as "RTV", and saves the completed RIR on the database.

Step 45 "Stamp "RTV" on the RT slip and its copy." In this step, the IQA operator stamps the "RTV" on the RT slip and its copy.

Step 46 "Stamp "RTV" on every box." In this step, the IQA operator stamps the "RTV" on every material box.

Step 47 "Load boxes onto the platform truck." In this step, the IQA operator moves material boxes onto the platform truck before transferring them to the RTV area.

Step 48 "Transfer boxes to RTV location and return the RT slip to the warehouse." In this step, the IQA operator transfers material boxes by the platform truck from the incoming gage room to the RTV area, unloads material boxes at the RTV area, walks to the warehouse counter, and place the RT slip in the specified cavity on the warehouse counter and walks back to the incoming gage room.

Step 49 "Keep the copy of RT slip and inspection result in the file." This step is the same as Step 46 in the existing perform inspection / Accept flow.

4.2.4 Steps in the Perform Inspection / Reject / Use As Is (UAI) Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)" step, is Perform Inspection, the result of the visual inspection is rejected, and the shipment is disposed as Use As Is (UAI). The detail of each step in this flow is as follows.

Steps 1 — 43 are the same as Steps 1 — 43 in the existing Perform Inspection / Reject / Return To Vendor (RTV) flow.

Step 44 "Update the disposition as "UAI" on the database." In this step, the IQA operator opens the RIR on the database, updates the disposition of the shipment as "UAI", and saves the completed RIR on the database.

Step 45 "Stamp "UAI" on the RT slip and its copy." In this step, the IQA operator stamps the "UAI" on the RT slip and its copy.

Step 46 "Stamp "UAI" on every box." In this step, the IQA operator stamps the "UAI" on every material box.

Step 47 "Load boxes onto the platform truck." This step is the same as Step 44 in the Perform Inspection / Accept flow.

Step 48 "Transfer boxes return the RT slip to the warehouse." This step is the same as Step 45 in the existing Perform Inspection / Accept flow.

Step 49 "Keep the copy of RT slip and inspection result in the file." This step is the same as Step 46 in the existing Perform Inspection / Accept flow.

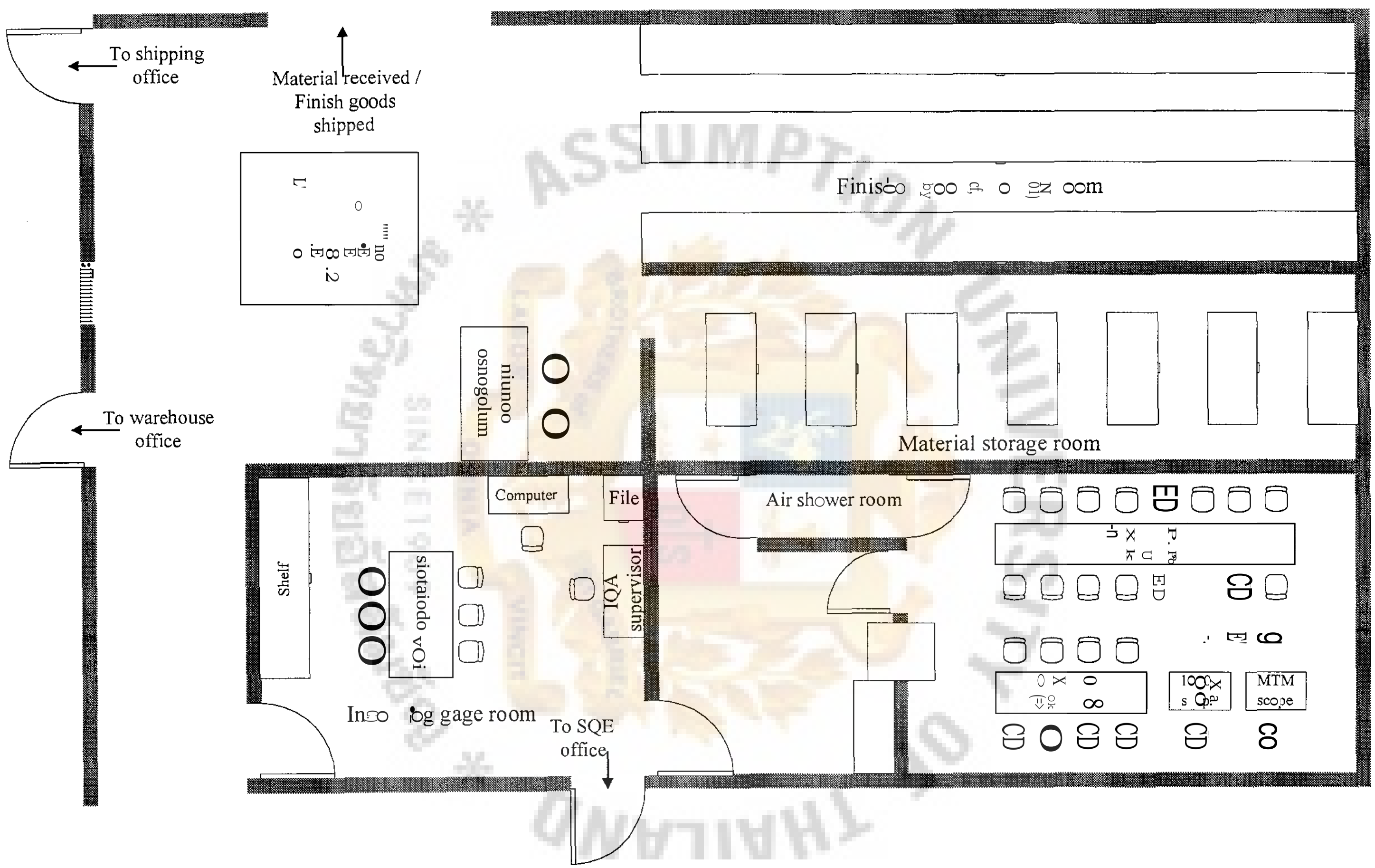

Figure 4.3. The Existing Room Layout.

V. PROPOSED PROCESS FLOW RECOMMENDATIONS

5.1 Overview

The overall incoming inspection organization and the reference sampling plan for the proposed process flow will be the same as the existing process flow. Differences between the proposed process flow and the existing process flow are changes in workflow, change in equipment arrangement, and introduction of the conveyor to transfer material boxes between the warehouse department and the incoming inspection department.

In designing the proposed process flow, some methods of work simplification, which includes simplifying, combining, eliminating, and changing sequence, are applied to correct and improve the existing process flow. Then, the figure of proposed process flow will be drawn.

5.2 Observations and Improvement Recommendations

After reviewing the existing process flow, there are four observations that are found to be areas where improvements can be made as follows.

(1) For every incoming inspection flow, the IQA operator has to go to the warehouse area and search for material boxes of the shipment. (Steps 5 and 6 in the existing process flow). These steps result in more than one minute additional time required.

(2) For every incoming inspection flow, the IQA operator has to stamp the disposition on the copy of the RT slip. In fact, the disposition of the copy of RT slip is used for the incoming inspection department only and there is no need to stamp the disposition on the copy of RT slip because the disposition of the shipment can be referred to on the database. (Step 8 in the existing Skip Inspection flow, Step 42 in the existing Perform Inspection / Accept

flow, and Step 45 in the existing Perform Inspection / RTV flow and the existing Perform Inspection / UAI flow) This step results in few seconds additional time required.

(3) For every incoming inspection flow, the IQA operator has to stamp the disposition on every box. This stamp is used as a reference at the warehouse department in order to identify the disposition of material boxes. In fact, the disposition of the shipment is already stamped on the RT slip. Therefore, the stamp on the RT slip can be used as reference for the disposition of each material box by using the RIR number as identifier. (Step 9 in the existing Skip Inspection flow, Step 43 in the existing Perform Inspection / Accept flow, and Step 46 in the existing Perform Inspection / RTV flow and the existing Perform Inspection / UAI flow) This step results in few seconds to more than a minute additional time required.

(4) For the Performing Inspection flow, sample packages and trays have to be closed and opened twice and the wrist strap also has to be connected and disconnected twice because the 30x scope and 100x scope are placed on opposite sides. (Steps 27, 29, 31, and 33 in the existing perform inspection flow). These steps result in half a minute to more than ten minutes additional time required

From each observation, the improvement can be recommended as follows.

(1) For the first observation, a conveyor is recommended to be set up in order to transfer material boxes between the warehouse area and the incoming gage room. When the conveyor is set up, the warehouse staff can immediately transfer material boxes to the incoming inspection department after checking for the shipment and quantity. Therefore, the IQA operator

does not need to waste time to walk to the warehouse area and search for material boxes. This recommendation corresponds to the work simplification approach because it helps the operator to complete work easier.

(2) For the third observation, stamping the disposition on the copy of RT slip is considered to be unnecessary work. Therefore, this step is recommended to be eliminated. This recommendation corresponds to the work elimination approach because it eliminates the unnecessary work.

(3) For the second observation, stamping the disposition on material boxes is considered to be unnecessary work. Therefore, this step is recommended to be eliminated. This recommendation corresponds to the work elimination approach because it eliminates the unnecessary work.

(4) For the fourth observation, the 30x scope and the 100x scope is recommended to be placed next to each other so that when the IQA operator completes the 30x inspection, she can perform the 100x inspection without closing the sample tray and package and disconnecting the wrist strap from the workbench. This recommendation corresponds to the work combining approach because it combines the redundant work to be performed at one time.

5.3 The Process Chart of the Proposed Process Flow

When four improvement recommendations, discussed in the earlier section, are implemented, steps in the existing process flow will be revised. The process chart of the proposed process flow can be drawn as shown in Figure 5.1. In the figure, the name of steps written in numbers represent the same step numbers in the existing process flow whereas the name of the steps written in block letter represents the new steps introduced to the proposed process flow. The number of eliminated step is not used in the proposed process flow.

With the proposed process flow, the inspection process flow starts when the IQA operator receives the RT slip and its copy from the warehouse with material boxes from the conveyor. Since most of the steps are the same as the existing process flow, only the new steps in the proposed process flow will be described. Anyway, the proposed process flow is still classified into four major flows. Detailed steps of each process flow can be described in following sub-sections. After the improvement is recommended, the layout of the incoming inspection department and the warehouse area is proposed as shown in Figure 5.2. The change in layout includes:

(1) Adding the conveyor to transfer material boxes between the incoming gage room and the warehouse area.

(2) Rearranging the position of 30x scope and 100x scope.

5.3.1 Steps in the Skip Inspection Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)" step, is the skip inspection. Again, there will be no inspection performed in this flow. The detail of the new steps in this flow are as follows:

Step A "Unload the RT slip, its copy, and material boxes from the conveyor." In this step, the IQA operator unloads the RT slip, its copy, and material boxes from the conveyor to the incoming gage room.

Step B "Check the actual total quantity on boxes with the RT slip." In this step, the IQA operator counts the number of boxes and sums the total number of every material boxes from the box label. If the total number of materials match with the RT slip, the IQA operator proceeds the Step 3 otherwise the

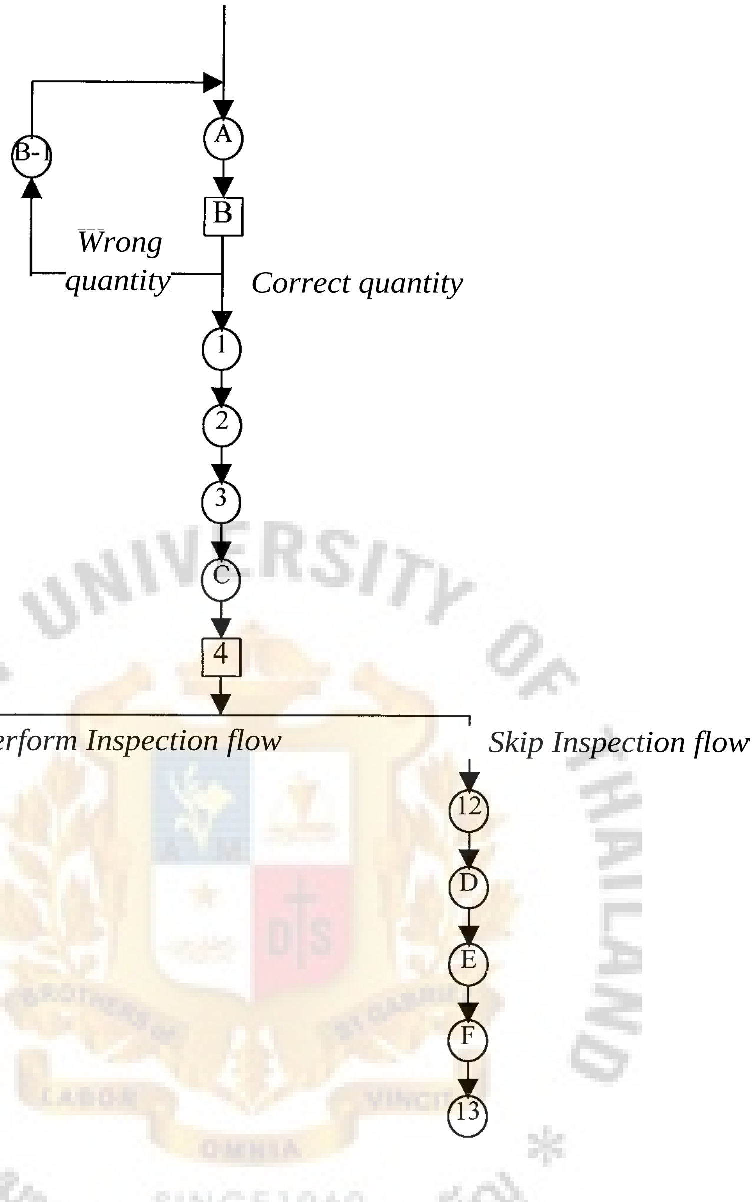

Figure 5.1. The Proposed Incoming Inspection Process Flow.

22

30

6

38

Perform Inspection / ccept flow

Perform Inspection / eject flow

ii

Figure 5.1. The Proposed Incoming Inspection Process Flow. (Continued)

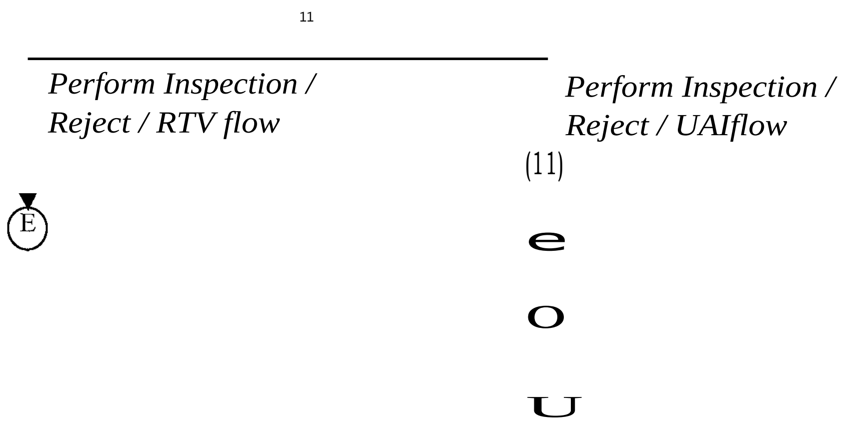

Figure 5.1. The Proposed Incoming Inspection Process Flow. (Continued)

RT slip, its copy, and material boxes will be returned to the warehouse for correction through the conveyor as in Step B-1.

Step C "Write the RIR number on every box." This step is the same as Step 7 in the existing Skip Inspection flow.

Step D "Stamp "Skip" on the RT slip." This step is the same as Step 8 in the existing Skip Inspection flow except the IQA operator does not need to stamp "Skip" on the copy of the RT slip.

Step E "Load boxes and the RT slip onto the conveyor." In this step, the IQA operators load material boxes and the RT slip onto the conveyor.

Step F "Return the RT slip and boxes to the warehouse by the conveyor." In this step, the IQA operator operates the conveyor to return the RT slip and boxes to the warehouse area.

5.3.2 Steps in the Perform Inspection / Accept Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)" step, is Perform Inspection and the result of the visual inspection is accepted. The detail of the new steps in this flow are as follows:

Steps A, B, and C are the same as Steps A, B, and C in the proposed Skip Inspection flow.

Step D "Move the sample tray to 100x scope." In this step, the IQA operator immediately moves the sample tray that she just completes the 30x inspection from the 30x scope to the 100x scope in order to perform inspection at 100x scope without closing the tray and package because, with the proposed process flow, the 100x scope is placed next to the 30x scope.

Remark: Steps 20, 21, 22, D, 30, and 31 are repeated until the number of sample size is inspected under the 30x scope and the 100x scope.

Step E. "Stamp "Acc" on the RT slip." This step is the same as Step 42 in the existing Perform Inspection / Accept flow except the IQA operator does not need to stamp the "Acc" on the copy of the RT slip.

Step F "Load boxes and the RT slip onto the conveyor." In this step, the IQA operator loads material boxes and the RT slip onto the conveyor.

Step G "Return the RT slip and boxes to the warehouse by the conveyor." In this step, the IQA operator operates the conveyor to return the RT slip and boxes to the warehouse area.

5.3.3 Steps in the Perform Inspection / Reject / Return To Vendor (RTV) Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)", step is Perform Inspection, the result of the visual inspection is rejected, and the shipment is disposed as Return To Vendor (RTV). The detail of the new steps in this flow are as follows:

Steps A, B, C, and D are the same as Steps A, B, C, and D in the proposed Perform Inspection / Accept inspection flow, which is mentioned in earlier sub-section, respectively.

Step E "Stamp "RTV" on the RT slip." This step is the same as Step 45 in the existing Perform Inspection / Reject / Return To Vendor (RTV) flow except the IQA operator does not need to stamp the "RTV" on the copy of RT slip.

5.3.4 Steps in the Perform Inspection / Reject / Use As Is (UAI) Flow

This process flow will be applied when the result from Step 4, "Check the inspection flow (Inspect or Skip)" step, is Perform Inspection, the result of the visual inspection is rejected, and the shipment is disposed as Use As Is (UAI). The detail of the new steps in this flow are as follows:

Steps A, B, C, and D are the same as Steps A, B, C, and D in the proposed Perform Inspection / Accept inspection flow.

Step E "Stamp "UAI" on the RT slip." This step is the same as Step 45 in the existing Perform Inspection / Reject / Use As Is (UAI) flow except the IQA operator does not need to stamp the "UAI" on the copy of the RT slip.

Step F "Load boxes and the RT slip onto the conveyor." This step is the same as Step 36 in the proposed Perform Inspection Accept flow.

Step G "Transfer boxes and return the RT slip to the warehouse by the conveyor." This step is the same as Step 36 in the proposed Perform Inspection Accept flow.

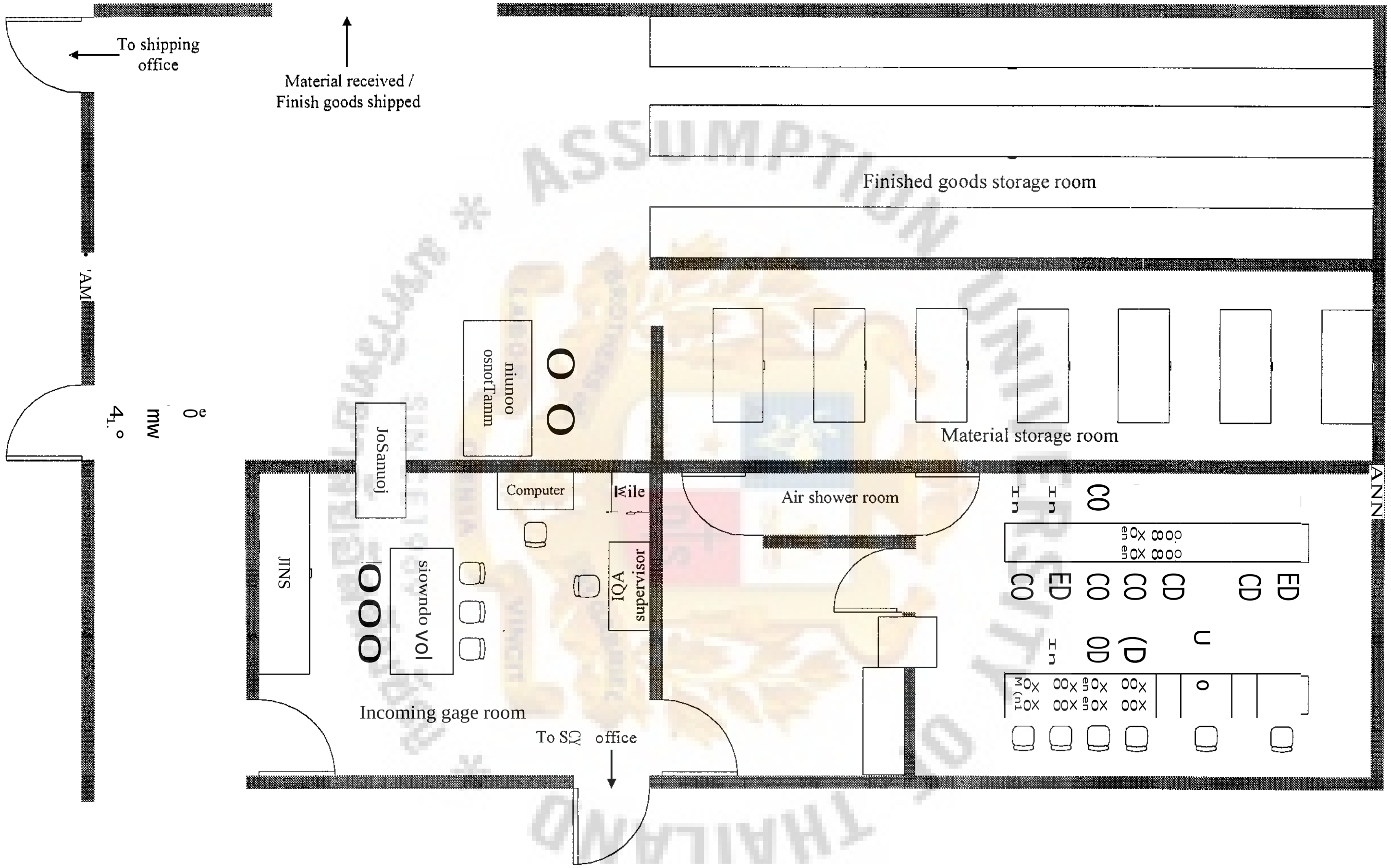

Figure 5.2. The Proposed Room Layout.

VI. PROPOSED PROCESS FLOW EVALUATION

6.1 Overview

The purpose of the evaluation is to ensure that the proposed process flow can improve the existing process flow. The technique used in the evaluation is the stop watch time study. After the time study is performed, the cycle time of the proposed process flow and the existing process flow will be calculated and compared to check for improvement with the proposed process flow. The steps of the evaluation process are described in the research methodology section.

6.2 Cycle Time Measurement

In this section, Steps 1-4 of the evaluation process, which are mentioned in the research methodology, will be performed.

From observations when the IQA operator perform each process flow, the estimated cycle time of each process flow is shown in Table 6.1. The recommended number of cycles to time the operator at each process flow according to Table 2.1, which is established by the General Electric Company, is also shown in Table 6.1. The total cycle number to time the operator is 55 cycles.

After the number of cycle is received, dates and times to perform the time study will be determined from the random number table, Table A.1 in Appendix A. The total number of days to perform the time study is 18 working days, or 3 weeks. The data and time is coded by six digit numbers. The first two digits represent the day to perform the time study which varies from 01 to 18. The second two digits represent the hour of the clock which varies from 00 to 23. The last two digits represent the minute of the clock which varies from 00 to 59. For example, the code 012233 represents the first day at the time of 22:33.

Table 6.1. Estimated Cycle Time and Number of Observation for each Process Flow.

Process Flow	Estimated Cycle Time	Number of Observations
Existing Skip Inspection flow	7 minutes	10
Existing Perform Inspection / Accept flow	35 minutes	5
Existing Perform Inspection / Reject / RTV flow	40 minutes	5
Existing Perform Inspection / Reject / UAI flow	40 minutes	5
Proposed Skip Inspection flow	4 minutes	15
Proposed Perform Inspection / Accept flow	25 minutes	5
Proposed Perform Inspection / Reject / RTV flow	30 minutes	5
Proposed Perform Inspection / Reject / UAI flow	30 minutes	5

From the random numbers table, Table A.1, dates and times can be determined as follows.

(1) For the first date and time code,

10 represents the 10th day.

27 cannot represent the hour so this number will be discarded.

53 cannot represent the hour so this number will be discarded.

96 cannot represent the hour so this number will be discarded.

23 represents the hour of 23 o'clock.

71 cannot represent the minute so this number will be discarded.

50 represents the 50th minute.

Therefore, the first date and time code is 102350, which represents the 10th day at the time of 23:50.

(2) For the second date and time code,

54 cannot represent the day so this number will be discarded.

36 cannot represent the day so this number will be discarded.

23 cannot represent the hour so this number will be discarded.

54 cannot represent the hour so this number will be discarded.

31 cannot represent the hour so this number will be discarded.

04 represents the 4th day.

82 cannot represent the hour so this number will be discarded.

98 cannot represent the hour so this number will be discarded.

04 represent the time of 4 o'clock.

14 represent the 14th minute.

Therefore, the second date and time code is 040414, which represent the 4th day at the time of 04:14.

The same method will be done until 55 date and time codes are received. The 55 date and time codes from the above method are 102350, 040414, 121509, 180556, 091134, 021918, 030524, 072323, 110853, 071518, 131620, 091453, 170101, 130825, 080637, 011948, 182027, 160008, 180204, 050203, 170155, 120634, 091629, 012353, 092307, 121411, 151436, 150342, 101152, 070448, 062212, 040617, 160257, 070906, 141317, 111228, 161425, 011643, 022013, 140112, 132230, 021604, 182351, 082056, 110813, 091724, 172001, 051837, 151448, 060047, 080246, 170239, 030656, 171423, and 010102. Then, the date and time will be sorted according to the day to perform the time study. The result of these 55 date and time codes and their interpretation into the date and time after sorting is shown in Table 6.2.

In timing the operator, the first 25 cycles is used to time the existing process flow while the last 30 cycles is used to time the proposed process flow. For the existing process flow, 1st-10th cycle, llth- -th cycle, 16th-20th cycle, and 21st-25th cycle are used to perform Skip Inspection flow, Perform Inspection / Accept flow, Perform Inspection / Reject / RTV flow, and Perform Inspection / Reject / UAI flow respectively. For the proposed process flow, 1st-15th cycle, 16th-20th cycle, 21st-25th cycle, and 26th-30th cycle are used to perform Skip Inspection flow, Perform Inspection / Accept flow, Perform Inspection / Reject / RTV flow, and Perform Inspection / Reject / UAI flow respectively.

Table 6.2. Date and Time to Perform Time Study.

No.	Date and Time Code	Day Number	Time
1	010102	1	01:02
2	011643	1	16:43
3	011948	1	19:48
4	012353	1	23:53
5	021604	2	16:04
6	021918	2	19:18
7	022013	2	20:13
8	030524	3	05:24
9	030656	3	06:56
10	040414	4	04:14
11	040617	4	06:17
12	050203	5	02:03
13	051837	5	18:37
14	060047	6	00:47

Table 6.2. Date and Time to Perform Time Study. (Continued)

No.	Date and Time Code	Day Number	Time
15	062212	6	22:12
16	070448	7	04:48
17	070906	7	09:06
18	071518	7	15:18
19	072323	7	23:23
20	080246	8	02:46
21	080637	8	06:37
22	082056	8	20:56
23	091134	9	11:34
24	091453	9	14:53
25	091629	9	16:29
26	091724	9	17:24
27	092307	9	23:07
28	101152	10	11:52
29	102350	10	23:50
30	110813	11	08:13
31	110853	11	08:53
32	111228	11	12:28
33	120634	12	06:34
34	121411	12	14:11
35	121509	12	15:09
36	130825	13	08:25

Table 6.2. Date and Time to Perform Time Study. (Continued)

No.	Date and Time Code	Day Number	Time
37	131620	13	16:20
38	132230	13	22:30
39	140112	14	01:12
40	141317	14	13:17
41	150342	15	03:42
42	151436	15	14:36
43	151448	15	14:48
44	160008	16	00:08
45	160257	16	02:57
46	161425	16	14:25
47	170101	17	01:01
48	170155	17	01:55
49	170239	17	02:39
50	171423	17	14:23
51	172001	17	20:01
52	180204	18	02:04
53	180556	18	05:56
54	182027	18	20:27
55	182351	18	23:51

Normally, the morning shift, the afternoon shift, and the night shift start at 06:00, 14:00, and 22:00 respectively. The operator break time for the morning shift, the afternoon shift, and the night shift are 08:00-09:00, 17:00-18:00, and 00:00-01:00 respectively. Some of the time in Table 6.2 falls in the operator break time, near the operator break time, or near the end of the shift. In these cases, the first cycle after breaking or starting of the next shift will be timed instead.

After 55 cycles is timed, the result of each process flow can be summarized in Table 6.3-6.10. The time unit in the table is second. However, the comparison cannot be done directly because the time in some steps is varied by the number of boxes or the number of sample trays. Therefore, the table has to be adjusted so that each cycle of those steps has the same base, i.e. time based on performing on one material box or one sample tray. The number of boxes and sample trays for each of the 55 cycles is shown in Table 6.11. After adjusting, the time for each step can be revised as in Table 6.12-6.19. The step that has to be adjusted in each process flow includes:

(1) For the existing Skip Inspection flow.

(a) The time in Steps 7 and 9 have to be divided by the total number of boxes.

For time in Step 7,

Cycle 1: Time must be adjusted to 107/ 20 = 5.4 seconds.

Cycle 2: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 3: Time must be adjusted to 13/2 = 6.5 seconds.

Cycle 4: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 5: Time must be adjusted to 203/36 = 5.6 seconds.

Cycle 6: Time must be adjusted to 32/6 = 5.3 seconds.

Cycle 7: Time must be adjusted to 7/1 = 7.0 seconds.

Cycle 8: Time must be adjusted to 12/2 = 6.0 seconds.

Table 6.3. Cycle Times of the Existing Skip Inspection Flow.

Step Number	Cycle (Seconds)									
	1	2	3	4	5	6	7	8	9	10
1	4	5	4	4	3	5	4	5	4	6
2	73	67	74	71	77	73	70	75	69	72
3	14	11	12	11	14	13	14	12	11	13
4	5	4	3	4	4	3	4	5	4	5
5	19	21	22	18	20	17	19	20	21	18
6	113	91	98	95	89	96	101	108	105	97
7	107	6	13	6	203	32	7	12	28	11
8	7	5	6	6	5	7	8	6	7	8
9	37	2	3	2	68	10	2	3	9	3
10	5	8	6	7	9	8	6	8	7	8
11	17	20	22	20	17	18	21	18	20	21
12	39	32	31	36	35	42	37	40	38	35
13	18	21	27	24	19	23	21	18	25	22
Cycle time	458	293	321	304	563	347	314	330	348	319

Cycle 9: Time must be adjusted to 28/5 = 5.6 seconds.

Cycle 10: Time must be adjusted to 11/2 = 5.5 seconds.

For time in Step 9,

Cycle 1: Time must be adjusted to 37/20 = 1.9 seconds.

Cycle 2: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 3: Time must be adjusted to 3/2 = 1.5 seconds.

Table 6.4. Cycle Times of the Existing Accept Flow.

Step Number	Cycle (Seconds)				
	1	2	3	4	5
1	5	4	4	5	3
2	70	72	69	71	75
3	11	12	11	13	11
4	5	3	4	4	5
5	20	22	21	18	20
6	95	102	97	106	94
7	3	4	3	9	3
8	21	19	18	22	23
9	3	4	4	8	3
10	6	11	5	29	7
11	3	4	2	4	4
12	21	40	24	108	19
13	16	17	19	15	18
14	162	172	167	169	164
15	18	19	19	17	18
16	5	6	5	6	6
17	6	5	5	6	5
18	8	7	8	7	9
19	3	4	5	4	5
20	104	168	106	266	26
21	128	205	126	328	34

Table 6.4. Cycles Time of the Existing Accept Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
22	554	881	587	1,379	135
23	114	176	115	283	28
24	4	3	3	5	4
25	5	6	5	5	4
26	9	10	12	9	10
27	5	5	4	6	5
28	4	2	3	3	2
29	108	172	108	265	27
30	301	465	298	752	75
31	112	181	114	284	30
32	2	3	3	2	4
33	5	6	4	5	6
34	108	99	113	105	110
35	9	11	8	13	7
36	6	8	7	8	7
37	117	123	121	119	124
38	15	13	15	14	16
39	20	36	19	95	17
40	8	7	8	8	9
41	45	42	44	46	40
42	7	5	6	7	6

Table 6.4. Cycles Time of the Existing Accept Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
43	2	4	2	9	2
44	4	4	3	10	3
45	56	62	59	64	57
46	23	18	22	24	19
Cycle time	2,356	3,242	2,405	4,735	1,299

Table 6.5. Cycles Time of the Existing RTV Flow.

Step Number	Cycle (Seconds)				
	1	2	3	4	5
1	4	5	5	4	6
2	69	67	75	73	70
3	11	11	13	12	13
4	4	5	4	3	4
5	21	19	23	20	17
6	97	93	107	102	105
7	3	4	17	3	4
8	19	18	22	20	22
9	4	3	14	4	4
10	5	6	57	6	7
11	5	3	3	4	5

Table 6.5. Cycles Time of the Existing RTV Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
12	20	18	205	21	20
13	15	18	17	16	15
14	158	170	169	172	161
15	16	18	18	17	19
16	7	5	6	7	7
17	6	5	4	6	7
18	8	6	8	8	7
19	4	3	5	4	4
20	169	25	412	106	112
21	210	32	506	129	135
22	859	138	2,222	555	546
23	176	29	445	114	118
24	4	3	3	5	4
25	5	6	5	5	6
26	9	8	11	10	11
27	6	5	5	4	6
28	2	2	3	2	4
29	163	27	409	107	110
30	461	74	1195	309	313
31	178	28	442	119	121
32	2	3	2	3	3

Table 6.5. Cycles Time of the Existing RTV Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
33	5	5	4	6	5
34	124	107	109	113	104
35	10	8	12	9	8
36	7	6	7	8	6
37	108	127	120	116	121
38	16	14	15	13	14
39	19	18	174	17	18
40	7	9	7	8	7
41	64	70	67	62	69
42	25	22	23	20	24
43	-	-	-	-	-
44	36	35	34	32	37
45	5	6	7	7	6
46	2	2	17	2	3
47	4	3	16	4	3
48	58	53	62	54	57
49	29	31	26	28	32
Cycle time	3,239	1,373	7,132	2,469	2,500

Remark: No time in Step 43 since this step does not involve the IQA operator's activity.

Table 6.6. Cycles Time of the Existing UAI Flow.

Step Number	Cycle (Seconds)				
	1	2	3	4	5
1	4	5	4	6	5
2	72	73	68	70	72
3	12	13	11	11	12
4	4	4	3	4	2
5	19	18	20	19	22
6	98	101	93	96	105
7	11	3	8	4	3
8	18	20	19	22	20
9	10	3	7	3	4
10	28	5	16	7	6
11	4	3	4	2	3
12	98	21	62	21	22
13	17	18	16	18	17
14	163	166	175	169	167
15	17	18	16	17	18
16	7	6	6	5	7
17	6	7	5	5	6
18	8	9	8	10	9
19	4	5	5	3	5
20	260	104	268	161	25
21	320	129	329	200	34

Table 6.6. Cycles Time of the Existing UAI Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
22	1,410	556	1,392	871	138
23	286	113	279	184	28
24	5	4	4	5	4
25	6	7	7	6	8
26	10	11	9	8	10
27	5	6	8	6	7
28	3	4	3	4	2
29	259	108	263	172	27
30	762	301	731	483	76
31	289	111	284	190	29
32	3	2	3	4	3
33	5	6	5	7	6
34	120	121	115	108	112
35	11	8	12	10	8
36	8	7	8	6	7
37	120	116	125	107	113
38	16	13	15	16	14
39	81	19	54	18	17
40	9	8	7	8	7
41	69	67	61	65	62
42	21	24	26	22	25

Table 6.6. Cycles Time of the Existing UAI Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
43	-	-	-	-	-
44	31	32	35	34	32
45	7	6	5	6	7
46	9	2	5	3	2
47	11	4	8	3	2
48	54	57	62	61	55
49	31	27	29	25	22
Cycle time	4,821	2,471	4,698	3,285	1,387

Remark: No time in Step 43 since this step does not involve the IQA operator's activity.

Cycle 4: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 5: Time must be adjusted to 68/36 = 1.9 seconds.

Cycle 6: Time must be adjusted to 10/6 = 1.7 seconds.

Cycle 7: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 8: Time must be adjusted to 3/2 = 1.5 seconds.

Cycle 9: Time must be adjusted to 9/5 = 1.8 seconds.

Cycle 10: Time must be adjusted to 3/2 = 1.5 seconds.

(2) For the existing Perform Inspection / Accept flow.

(a) The time in Steps 7, 9, and 44 has to be divided by 2 times the total number of boxes because the operator can load/unload 2 boxes at a time.

Table 6.7. Cycle Times of the Proposed Skip Inspection Flow.

Step Number	Cycle (Seconds)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	4	3	3	4	27	4	7	3	10	3	4	3	4	7	3
B	7	4	3	3	43	6	11	2	16	7	6	2	7	14	3
1	4	5	4	4	5	6	4	5	3	4	4	5	4	6	4
2	70	68	72	75	73	70	74	67	73	71	70	72	75	69	71
3	13	11	10	11	14	12	13	10	13	14	11	13	14	12	13
C	11	6	5	5	82	12	17	6	29	12	11	5	12	23	6
4	3	4	4	3	4	5	5	3	4	5	4	3	4	4	5
12	34	37	38	31	37	32	35	41	38	34	37	30	35	33	32
D	3	4	3	5	4	4	3	5	3	4	4	5	4	3	4
E	3	4	5	3	25	3	7	4	12	3	3	3	4	8	3
F	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
13	19	22	24	25	23	21	19	20	23	22	20	18	21	17	19
Cycle time	176	173	176	174	342	180	200	171	229	184	179	164	189	201	168

(b) The time in Steps 10, 12, 39, and 43 has to be divided by the total number of boxes.

(c) The time in Steps 20, 21, 22, 23, 29, 30, and 31 has to be divided by the total number of sample trays, which is equal to the number of sample size divided by 5 because, in a tray, five units of the material have to be inspected.

Table 6.8. Cycle Times of the Proposed Accept Flow.

Step Number	Cycle (Seconds)				
	1	2	3	4	5
A	3	4	3	4	4
B	3	2	3	6	3
1	4	5	6	4	4
2	74	70	71	73	69
3	11	13	14	12	13
C	5	6	6	11	6
4	5	4	5	3	4
11	4	2	3	4	3
12	22	24	20	42	19
13	16	18	17	16	19
14	173	170	168	164	169
15	19	17	18	16	18
16	5	6	5	7	6
17	6	4	6	6	5
18	7	8	7	9	8
19	6	5	5	4	6
28	3	4	2	4	3
20	104	107	25	170	108
21	129	128	33	203	134
22	561	571	141	856	564
D	50	53	13	80	53

Table 6.8. Cycle Times of the Proposed Accept Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
30	292	288	73	470	297
31	112	116	28	184	115
24	5	6	4	5	4
32	3	3	2	4	2
33	6	6	5	7	6
34	99	103	110	104	108
35	10	8	8	11	9
36	6	8	7	6	8
37	120	116	121	124	119
38	15	13	14	13	12
39	18	19	15	33	17
40	7	8	8	9	7
41	44	41	45	43	47
E	3	5	3	4	3
F	4	3	3	5	3
G	5	5	5	5	5
46	22	23	27	19	24
Cycle time	1,981	1,992	1,049	2,740	2,004

Table 6.9. Cycles Time of the Proposed RTV Flow.

Step Number	Cycle (Seconds)				
	1	2	3	4	5
A	3	10	3	4	4
B	3	15	2	2	6
1	5	4	5	3	4
2	73	68	76	75	71
3	12	11	12	13	11
C	6	32	5	6	13
4	5	4	3	4	3
11	4	3	4	4	3
12	21	118	18	22	43
13	15	17	16	18	17
14	175	162	171	167	163
15	18	17	17	18	16
16	6	7	6	5	6
17	5	6	7	5	7
18	7	9	6	8	7
19	4	5	4	6	5
28	3	4	3	2	3
20	170	272	26	106	164
21	209	321	32	130	200
22	884	1,414	141	554	850
D	80	126	12	49	78

Table 6.9. Cycles Time of the Proposed RTV Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
30	451	728	73	301	474
31	181	296	28	120	185
24	5	7	6	5	6
32	4	2	3	3	4
33	5	6	6	5	4
34	116	114	121	108	111
35	9	12	8	9	10
36	8	7	7	6	7
37	119	117	122	113	120
38	14	16	13	15	14
39	20	114	18	17	37
40	9	8	7	8	7
41	68	62	61	65	60
42	23	26	22	24	21
43	-	-	-	-	-
44	32	34	35	30	31
E	4	3	4	5	4
47	4	8	3	2	3
48	55	60	53	50	57
49	29	27	30	26	31
Cycle time	2,864	4,272	1,189	2,113	2,860

Remark: No time in Step 36 since this step does not involve the IQA operator's activity.

Table 6.10. Cycles Time of the Proposed UAI Flow.

Step Number	Cycle (Seconds)				
	1	2	3	4	5
A	3	4	11	3	4
B	2	4	13	3	2
1	3	4	5	4	5
2	69	72	70	74	68
3	12	10	14	11	12
C	6	11	34	6	5
4	4	5	3	4	5
11	3	4	4	3	4
12	22	41	125	20	18
13	17	19	16	18	17
14	170	161	168	172	164
15	19	16	18	17	18
16	7	6	5	7	6
17	6	7	5	6	5
18	7	9	10	8	9
19	5	7	4	6	5
28	4	2	3	2	3
20	102	162	269	102	26
21	128	201	332	135	34
22	571	897	1,408	550	136
D	51	80	134	53	13

Table 6.10. Cycles Time of the Proposed UAI Flow. (Continued)

Step Number	Cycle (Seconds)				
	1	2	3	4	5
30	288	464	728	302	75
31	114	181	291	115	28
24	6	5	7	5	4
32	3	4	2	4	3
33	5	6	5	7	6
34	113	116	109	117	110
35	8	11	13	9	7
36	7	6	6	8	7
37	120	117	121	125	122
38	15	16	14	13	16
39	19	35	112	17	19
40	7	10	9	7	8
41	65	70	62	60	63
42	25	23	20	21	23
43	-	-	-	-	-
44	34	30	33	35	31
E	3	4	4	3	4
F	3	3	8	4	3
G	5	5	5	5	5
49	26	23	29	25	30
Cycle time	2,077	2,851	4,229	2,086	1,123

Remark: No time in Step 36 since this step does not involve the IQA operator's activity.

Table 6.11. Number of Boxes and Sample Trays for each Cycle.

Cycle No.	Number of Boxes	Number of Sample Trays
1	20	-
2	1	-
3	2	-
4	1	-
5	36	-
6	6	-
7	1	-
8	2	-
9	5	-
10	2	-
11	1	16
12	2	25
13	1	16
14	5	40
15	1	4
16	1	25
17	1	4
18	10	63
19	1	16
20	1	16
21	5	40
22	1	16

Table 6.11. Number of Boxes and Sample Trays for each Cycle. (Continued)

1 Cycle No.	Number of Boxes	Number of Sample Trays
23	3	40
24	1	25
25	1	4
26	2	-
27	1	-
28	1	-
29	1	-
30	15	-
31	2	-
32	3	-
33	1	-
34	5	-
35	2	-
36	2	-
37	1	-
38	2	-
39	4	-
40	1	-
41	1	16
42	1	16
43	1	4
44	2	25

Table 6.11. Number of Boxes and Sample Trays for each Cycle. (Continued)

Cycle No.	Number of Boxes	Number of Sample Trays
45	1	16
46	1	16
47	6	25
48	1	40
49	1	16
50	2	4
51	1	25
52	2	40
53	6	4
54	1	16
55	1	25

For time in Step 7,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 9/3 = 3.0 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step 9,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 3: Time must be adjusted to 4/1 = 4.0 seconds.

Table 6.12. Adjusted Cycle Times of the Existing Skip Inspection Flow.

Step Number	Cycle (Seconds)										
	1	2	3	4	5	6	7	8	9	10	Avg
1	4	5	4	4	3	5	4	5	4	6	4.4
2	73	67	74	71	77	73	70	75	69	72	72.1
3	14	11	12	11	14	13	14	12	11	13	12.5
4	5	4	3	4	4	3	4	5	4	5	4.1
5	19	21	22	18	20	17	19	20	21	18	19.5
6	113	91	98	95	89	96	101	108	105	97	99.3
7	5.4	6.0	6.5	6.0	5.6	5.3	7.0	6.0	5.6	5.5	5.9
8	7	5	6	6	5	7	8	6	7	8	6.5
9	1.9	2.0	1.5	2.0	1.9	1.7	2.0	1.5	1.8	1.5	1.8
10	5	8	6	7	9	8	6	8	7	8	7.2
11	17	20	22	20	17	18	21	18	20	21	19.4
12	39	32	31	36	35	42	37	40	38	35	36.5
13	18	21	27	24	19	23	21	18	25	22	21.8
Cycle time	321	293	313	304	300	312	314	323	318	312	311.0

Cycle 4: Time must be adjusted to 8/3 = 2.7 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step 44,

Cycle 1: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 2: Time must be adjusted to 4/1 = 4.0 seconds.

Table 6.13. Adjusted Cycle Times of the Existing Accept Flow.

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
1	5	4	4	5	3	4.2
2	70	72	69	71	75	71.4
3	11	12	11	13	11	11.6
4	5	3	4	4	5	4.2
5	20	22	21	18	20	20.2
6	95	102	97	106	94	98.8
7	3.0	4.0	3.0	3.0	3.0	3.2
8	21	19	18	22	23	20.6
9	3.0	4.0	4.0	2.7	3.0	3.3
10	6.0	5.5	5.0	5.8	7.0	5.9
11	3	4	2	4	4	3.4
12	21.0	20.0	24.0	21.6	19.0	21.1
13	16	17	19	15	18	17.0
14	162	172	167	169	164	166.8
15	18	19	19	17	18	18.2
16	5	6	5	6	6	5.6
17	6	5	5	6	5	5.4
18	8	7	8	7	9	7.8
19	3	4	5	4	5	4.2
20	6.5	6.7	6.6	6.7	6.5	6.6
21	8.0	8.2	7.9	8.2	8.5	8.2

Table 6.13. Adjusted Cycles Time of the Existing Accept Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
22	34.6	35.2	36.7	34.5	33.8	35.0
23	7.1	7.0	7.2	7.1	7.0	7.1
24	4	3	3	5	4	3.8
25	5	6	5	5	4	5.0
26	9	10	12	9	10	10.0
27	5	5	4	6	5	5.0
28	4	2	3	3	2	2.8
29	6.8	6.9	6.8	6.6	6.8	6.8
30	18.8	18.6	18.6	18.8	18.8	18.7
31	7.0	7.2	7.1	7.1	7.5	7.2
32	2	3	3	2	4	2.8
33	5	6	4	5	6	5.2
34	108	99	113	105	110	107.0
35	9	11	8	13	7	9.6
36	6	8	7	8	7	7.2
37	117	123	121	119	124	120.8
38	15	13	15	14	16	14.6
39	20.0	18.0	19.0	19.0	17.0	18.6
40	8	7	8	8	9	8.0
41	45	42	44	46	40	43.4
42	7	5	6	7	6	6.2

Table 6.13. Adjusted Cycles Time of the Existing Accept Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
43	2.0	2.0	2.0	1.8	2.0	2.0
44	4.0	4.0	3.0	3.3	3.0	3.5
45	56	62	59	64	57	59.6
46	23	18	22	24	19	21.2
Cycle time	1,024	1,038	1,042	1,056	1,033	1,038.6

Table 6.14. Adjusted Cycles Time of the Existing RTV Flow.

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
1	4	5	5	4	6	4.8
2	69	67	75	73	70	70.8
3	11	11	13	12	13	12.0
4	4	5	4	3	4	4.0
5	21	19	23	20	17	20.0
6	97	93	107	102	105	100.8
7	3.0	4.0	3.4	3.0	4.0	3.5
8	19	18	22	20	22	20.2
9	4.0	3.0	2.8	4.0	4.0	3.6
10	5.0	6.0	5.7	6.0	7.0	5.9
11	5	3	3	4	5	4.0

Table 6.14. Adjusted Cycles Time of the Existing RTV Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
12	20.0	18.0	20.5	21.0	20.0	19.9
13	15	18	17	16	15	16.2
14	158	170	169	172	161	166.0
15	16	18	18	17	19	17.6
16	7	5	6	7	7	6.4
17	6	5	4	6	7	5.6
18	8	6	8	8	7	7.4
19	4	3	5	4	4	4.0
20	6.8	6.3	6.5	6.6	7.0	6.6
21	8.4	8.0	8.0	8.1	8.4	8.2
22	34.4	34.5	35.3	34.7	34.1	34.6
23	7.0	7.3	7.1	7.1	7.4	7.2
24	4	3	3	5	4	3.8
25	5	6	5	5	6	5.4
26	9	8	11	10	11	9.8
27	6	5	5	4	6	5.2
28	2	2	3	2	4	2.6
29	6.5	6.8	6.5	6.7	6.9	6.7
30	18.4	18.5	19	19.3	19.6	19.0
31	7.1	7.0	7.0	7.4	7.6	7.2
32	2	3	2	3	3	2.6

Table 6.14. Adjusted Cycles Time of the Existing RTV Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
33	5	5	4	6	5	5.0
34	124	107	109	113	104	111.4
35	10	8	12	9	8	9.4
36	7	6	7	8	6	6.8
37	108	127	120	116	121	118.4
38	16	14	15	13	14	14.4
39	19.0	18.0	17.4	17.0	18.0	17.9
40	7	9	7	8	7	7.6
41	64	70	67	62	69	66.4
42	25	22	23	20	24	22.8
43	-	-	-	-	-	-
44	36	35	34	32	37	34.8
45	5	6	7	7	6	6.2
46	2.0	2.0	1.7	2.0	3.0	2.1
47	4.0	3.0	3.2	4.0	3.0	3.4
48	58	53	62	54	57	56.8
49	29	31	26	28	32	29.2
Cycle time	1,112	1,108	1,145	1,120	1,136	1,124.2

Remark: No time in Step 43 since this step does not involve the IQA operator's activity.

Table 6.15. Adjusted Cycles Time of the Existing UAI Flow.

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
1	4	5	4	6	5	4.8
2	72	73	68	70	72	71.0
3	12	13	11	11	12	11.8
4	4	4	3	4	2	3.4
5	19	18	20	19	22	19.6
6	98	101	93	96	105	98.6
7	3.7	3.0	4.0	4.0	3.0	3.5
8	18	20	19	22	20	19.8
9	3.3	3.0	3.5	3.0	4.0	3.4
10	5.6	5.0	5.3	7.0	6.0	5.8
11	4	3	4	2	3	3.2
12	19.6	21.0	20.7	21.0	22.0	20.9
13	17	18	16	18	17	17.2
14	163	166	175	169	167	168.0
15	17	18	16	17	18	17.2
16	7	6	6	5	7	6.2
17	6	7	5	5	6	5.8
18	8	9	8	10	9	8.8
19	4	5	5	3	5	4.4
20	6.5	6.5	6.7	6.4	6.3	6.5
21	8.0	8.1	8.2	8.0	8.5	8.2

Table 6.15. Adjusted Cycles Time of the Existing UAI Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
22	35.3	34.8	34.8	34.8	34.5	34.8
23	7.2	7.1	7.0	7.4	7.0	7.1
24	5	4	4	5	4	4.4
25	6	7	7	6	8	6.8
26	10	11	9	8	10	9.6
27	5	6	8	6	7	6.4
28	3	4	3	4	2	3.2
29	6.5	6.8	6.6	6.9	6.8	6.7
30	19.1	18.8	18.3	19.3	19.0	18.9
31	7.2	6.9	7.1	7.6	7.3	7.2
32	3	2	3	4	3	3.0
33	5	6	5	7	6	5.8
34	120	121	115	108	112	115.2
35	11	8	12	10	8	9.8
36	8	7	8	6	7	7.2
37	120	116	125	107	113	116.2
38	16	13	15	16	14	14.8
39	16.2	19.0	18.0	18.0	17.0	17.6
40	9	8	7	8	7	7.8
41	69	67	61	65	62	64.8
42	21	24	26	22	25	23.6

Table 6.15. Adjusted Cycles Time of the Existing UAI Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
43						
44	31	32	35	34	32	32.8
45	7	6	5	6	7	6.2
46	1.8	2.0	1.7	3.0	2.0	2.1
47	3.7	4.0	4.0	3.0	2.0	3.3
48	54	57	62	61	55	57.8
49	31	27	29	25	22	26.8
Cycle time	1,131	1,138	1,138	1,114	1,119	1,128.0

Remark: No time in Step 43 since this step does not involve the IQA operator's activity.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 10/3 = 3.3 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step 10,

Cycle 1: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 2: Time must be adjusted to 11/2 = 5.5 seconds.

Cycle 3: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 4: Time must be adjusted to 29/5 = 5.8 seconds.

Cycle 5: Time must be adjusted to 7/1 = 7.0 seconds.

For Step 12,

Cycle 1: Time must be adjusted to 21/1 = 21.0 seconds.

Cycle 2: Time must be adjusted to 40/2 = 20.0 seconds.

Table 6.16. Adjusted Cycle Times of the Proposed Skip Inspection Flow.

Step Number	Cycle (seconds)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Avg
A	4	3	3	4	3	4	4	3	3	3	4	3	4	4	3	3.4
B	4	4	3	3	3	3	4	2	3	4	3	2	4	4	3	3.1
1	4	5	4	4	5	6	4	5	3	4	4	5	4	6	4	4.5
2	70	68	72	75	73	70	74	67	73	71	70	72	75	69	71	71.3
3	13	11	10	11	14	12	13	10	13	14	11	13	14	12	13	12.3
C	6	6	5	5	5	6	6	6	6	6	6	5	6	6	6	5.6
4	3	4	4	3	4	5	5	3	4	5	4	3	4	4	5	4.0
12	34	37	38	31	37	32	35	41	38	34	37	30	35	33	32	34.9
D	3	4	3	5	4	4	3	5	3	4	4	5	4	3	4	3.9
E	3	4	5	3	3	3	4	4	4	3	3	3	4	4	3	3.5
G	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5.0
13	19	22	24	25	23	21	19	20	23	22	20	18	21	17	19	20.9
Cycle time	167	173	176	174	180	171	174	171	178	175	171	164	180	166	168	172.5

Cycle 3: Time must be adjusted to 24/1 = 24.0 seconds.

Cycle 4: Time must be adjusted to 108/5 = 21.6 seconds.

Cycle 5: Time must be adjusted to 19/1 = 19.0 seconds.

For Step 43,

Cycle 1: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 2: Time must be adjusted to 4/2 = 2.0 seconds.

Cycle 3: Time must be adjusted to 2/1 = 2.0 seconds.

Table 6.17. Adjusted Cycle Times of the Proposed Accept Flow.

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
A	3.0	4.0	3.0	4.0	4.0	3.6
B	3.0	2.0	3.0	3.0	3.0	2.8
1	4	5	6	4	4	4.6
2	74	70	71	73	69	71.4
3	11	13	14	12	13	12.6
C	5.0	6.0	6.0	5.5	6.0	5.7
4	5	4	5	3	4	4.2
11	4	2	3	4	3	3.2
12	22	24	20	21	19	21.2
13	16	18	17	16	19	17.2
14	173	170	168	164	169	168.8
15	19	17	18	16	18	17.6
16	5	6	5	7	6	5.8
17	6	4	6	6	5	5.4
18	7	8	7	9	8	7.8
19	6	5	5	4	6	5.2
28	3	4	2	4	3	3.2
20	6.5	6.7	6.3	6.8	6.8	6.6
21	8.1	8.0	8.3	8.1	8.4	8.2
22	35.1	35.7	35.3	34.2	35.3	35.1
D	3.1	3.3	3.3	3.2	3.3	3.2

Table 6.17. Adjusted Cycles Time of the Proposed Accept Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
30	18.3	18.0	18.3	18.8	18.6	18.4
31	7.0	7.3	7.0	7.4	7.2	7.2
24	5	6	4	5	4	4.8
32	3	3	2	4	2	2.8
33	6	6	5	7	6	6.0
34	99	103	110	104	108	104.8
35	10	8	8	11	9	9.2
36	6	8	7	6	8	7.0
37	120	116	121	124	119	120.0
38	15	13	14	13	12	13.4
39	18.0	19.0	15.0	16.5	17.0	17.1
40	7	8	8	9	7	7.8
41	44	41	45	43	47	44.0
E	3	5	3	4	3	3.6
F	4.0	3.0	3.0	5.0	3.0	3.6
G	5	5	5	5	5	5.0
46	22	23	27	19	24	23.0
Cycle time	811	808	814	831	812	811.0

Table 6.18. Adjusted Cycles Time of the Proposed RTV Flow.

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
A	3.0	3.3	3.0	4.0	4.0	3.5
B	3.0	2.5	2.0	2.0	3.0	2.5
1	5	4	5	3	4	4.2
2	73	68	76	75	71	72.6
3	12	11	12	13	11	11.8
C	6.0	5.3	5.0	6.0	6.5	5.8
4	5	4	3	4	3	3.8
11	4	3	4	4	3	3.6
12	21.0	19.7	18.0	22.0	21.5	20.4
13	15	17	16	18	17	16.6
14	175	162	171	167	163	167.6
15	18	17	17	18	16	17.2
16	6	7	6	5	6	6.0
17	5	6	7	5	7	6.0
18	7	9	6	8	7	7.4
19	4	5	4	6	5	4.8
28	3	4	3	2	3	3.0
20	6.8	6.8	6.5	6.6	6.6	6.7
21	8.4	8.0	8.0	8.1	8.0	8.1
22	35.4	35.4	35.3	34.6	34.0	34.9
D	3.2	3.2	3.0	3.1	3.1	3.1

Table 6.18. Adjusted Cycles Time of the Proposed RTV Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
30	18.0	18.2	18.3	18.8	19.0	18.5
31	7.2	7.4	7.0	7.5	7.4	7.3
24	5	7	6	5	6	5.8
32	4	2	3	3	4	3.2
33	5	6	6	5	4	5.2
34	116	114	121	108	111	114.0
35	9	12	8	9	10	9.6
36	8	7	7	6	7	7.0
37	119	117	122	113	120	118.2
38	14	16	13	15	14	14.4
39	20.0	19.0	18.0	17.0	18.5	18.5
40	9	8	7	8	7	7.8
41	68	62	61	65	60	63.2
42	23	26	22	24	21	23.2
43	-	-	-	-	-	-
44	32	34	35	30	31	32.4
E	4	3	4	5	4	4.0
47	4.0	2.7	3.0	2.0	3.0	2.9
48	55	60	53	50	57	55.0
49	29	27	30	26	31	28.6
Cycle time	968	949	955	932	938	948.3

Remark: No time in Step 36 since this step does not involve the IQA operator's activity.

Table 6.19. Adjusted Cycles Time of the Proposed UAI Flow.

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
A	3.0	4.0	3.7	3.0	4.0	3.5
B	2.0	2.0	2.2	3.0	2.0	2.2
1	3	4	5	4	5	4.2
2	69	72	70	74	68	70.6
3	12	10	14	11	12	11.8
C	6.0	5.5	5.7	6.0	5.0	5.6
4	4	5	3	4	5	4.2
11	3	4	4	3	4	3.6
12	22.0	20.5	20.8	20.0	18.0	20.3
13	17	19	16	18	17	17.4
14	170	161	168	172	164	167.0
15	19	16	18	17	18	17.6
16	7	6	5	7	6	6.2
17	6	7	5	6	5	5.8
18	7	9	10	8	9	8.6
19	5	7	4	6	5	5.4
28	4	2	3	2	3	2.8
20	6.4	6.5	6.7	6.4	6.5	6.5
21	8.0	8.0	8.3	8.4	8.5	8.3
22	35.7	35.9	35.2	34.4	34.0	35.0
D	3.2	3.2	3.4	3.3	3.3	3.3

Table 6.19. Adjusted Cycles Time of the Proposed UAI Flow. (Continued)

Step Number	Cycle (Seconds)					
	1	2	3	4	5	Avg
30	18.0	18.6	18.2	18.9	18.8	18.5
31	7.1	7.2	7.3	7.2	7.0	7.2
24	6	5	7	5	4	5.4
32	3	4	2	4	3	3.2
33	5	6	5	7	6	5.8
34	113	116	109	117	110	113.0
35	8	11	13	9	7	9.6
36	7	6	6	8	7	6.8
37	120	117	121	125	122	121.0
38	15	16	14	13	16	14.8
39	19.0	17.5	18.7	17.0	19.0	18.2
40	7	10	9	7	8	8.2
41	65	70	62	60	63	64.0
42	25	23	20	21	23	22.4
43	-	-	-	-	-	-
44	34	30	33	35	31	32.6
E	3	4	4	3	4	3.6
F	3.0	3.0	2.7	4.0	3.0	3.1
G	5	5	5	5	5	5.0
49	26	23	29	25	30	26.6
Cycle time	901	900	897	908	889	898.9

Remark: No time in Step 36 since this step does not involve the IQA operator's activity.

Cycle 4: Time must be adjusted to 9/5 = 1.8 seconds.

Cycle 5: Time must be adjusted to $^{2}/_{1}$ = 2.0 seconds.

For Step 20,

Cycle 1: Time must be adjusted to 104/16 = 6.5 seconds.

Cycle 2: Time must be adjusted to 168/25 = 6.7 seconds.

Cycle 3: Time must be adjusted to 106/16 = 6.6 seconds.

Cycle 4: Time must be adjusted to 266/40 = 6.7 seconds.

Cycle 5: Time must be adjusted to26/4 = 6.5 seconds.

For Step 21,

Cycle 1: Time must be adjusted to 128/16 = 8.0 seconds.

Cycle 2: Time must be adjusted to 205/25 = 8.2 seconds.

Cycle 3: Time must be adjusted to126/16 = 7.9 seconds.

Cycle 4: Time must be adjusted to 328/40 = 8.2 seconds.

Cycle 5: Time must be adjusted to 34/4 = 8.5 seconds.

For Step 22,

Cycle 1: Time must be adjusted to 554/16 = 34.6 seconds.

Cycle 2: Time must be adjusted to 881/25 = 35.2 seconds.

Cycle 3: Time must be adjusted to 587/16 = 36.7 seconds.

Cycle 4: Time must be adjusted to 1,379/40 = 34.5 seconds.

Cycle 5: Time must be adjusted to 135/4 = 33.8 seconds.

For Step 23,

Cycle 1: Time must be adjusted to 114/16 = 7.1 seconds.

Cycle 2: Time must be adjusted to 176/25 = 7.0 seconds.

Cycle 3: Time must be adjusted to 115/16 = 7.2 seconds.

Cycle 4: Time must be adjusted to 283/40 = 7.1 seconds.

Cycle 5: Time must be adjusted to 28/4 = 7.0 seconds.

For Step 29,

Cycle 1: Time must be adjusted to 108/16 = 6.8 seconds.

Cycle 2: Time must be adjusted to 172/25 = 6.9 seconds.

Cycle 3: Time must be adjusted to 108/16 = 6.8 seconds.

Cycle 4: Time must be adjusted to 265/40 = 6.6 seconds.

Cycle 5: Time must be adjusted to 27/4 = 6.8 seconds.

For Step 30,

Cycle 1: Time must be adjusted to 301/16 = 18.8 seconds.

Cycle 2: Time must be adjusted to 465/25 = 18.6 seconds.

Cycle 3: Time must be adjusted to 298/16 = 18.6 seconds.

Cycle 4: Time must be adjusted to 752/40 = 18.8 seconds.

Cycle 5: Time must be adjusted to 75/4 = 18.8 seconds.

For Step 31,

Cycle 1: Time must be adjusted to 112/16 = 7.0 seconds.

Cycle 2: Time must be adjusted to 181/25 = 7.2 seconds.

Cycle 3: Time must be adjusted to 114/16 = 7.1 seconds.

Cycle 4: Time must be adjusted to 284/40 = 7.1 seconds.

Cycle 5: Time must be adjusted to 30/4 = 7.5 seconds.

(3) For the existing Perform Inspection / Reject / RTV flow.

(a) The time in Steps 7, 9, and 47 has to be divided by 2 times the total number of boxes.

(b) The time in Steps 10, 12, 39, and 46 has to be divided by the total number of boxes.

(c) The time in Steps 20, 21, 22, 23, 29, 30, and 31 has to be divided by the total number of sample trays, which is equal to the number of sample size divided by 5.

For Step 7,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to $^4/_1$ = 4.0 seconds.

Cycle 3: Time must be adjusted to 17/5 = 3.4 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to $^4/_1$ = 4.0 seconds.

For Step 9,

Cycle 1: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 2: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 3: Time must be adjusted to 14/5 = 2.8 seconds.

Cycle 4: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 5: Time must be adjusted to 4/1 = 4.0 seconds.

For Step 47,

Cycle 1: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 2: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 3: Time must be adjusted to 16/5 = 3.2 seconds.

Cycle 4: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step 10,

Cycle 1: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 2: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 3: Time must be adjusted to 57/10 = 5.7 seconds.

Cycle 4: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 5: Time must be adjusted to 7/1 = 7.0 seconds.

For Step 12,

Cycle 1: Time must be adjusted to 20/1 = 20.0 seconds.

Cycle 2: Time must be adjusted to 18/1 = 18.0 seconds.

Cycle 3: Time must be adjusted to 205/10 = 20.5 seconds.

Cycle 4: Time must be adjusted to 21/1 = 21.0 seconds.

Cycle 5: Time must be adjusted to 20/1 = 20.0 seconds.

For Step 39,

Cycle 1: Time must be adjusted to 19/1 = 19.0 seconds.

Cycle 2: Time must be adjusted to 18/1 = 18.0 seconds.

Cycle 3: Time must be adjusted to 174/10 = 17.4 seconds.

Cycle 4: Time must be adjusted to 17/1 = 17.0 seconds.

Cycle 5: Time must be adjusted to 18/1 = 18.0 seconds.

For Step 46,

Cycle 1: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 2: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 3: Time must be adjusted to 17/10 = 17.7 seconds.

Cycle 4: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 5: Time must be adjusted to 3/1 = 2.0 seconds.

For Step 20,

Cycle 1: Time must be adjusted to 169/25 = 6.8 seconds.

Cycle 2: Time must be adjusted to 25/4 = 6.3 seconds.

Cycle 3: Time must be adjusted to 412/63 = 6.5 seconds.

Cycle 4: Time must be adjusted to 106/16 = 6.6 seconds.

Cycle 5: Time must be adjusted to 112/16 = 7.0 seconds.

For Step 21,

Cycle 1: Time must be adjusted to 210/25 = 8.4 seconds.

Cycle 2: Time must be adjusted to 32/4 = 8.0 seconds.

Cycle 3: Time must be adjusted to 506/63 = 8.0 seconds.

Cycle 4: Time must be adjusted to 129/16 = 8.1 seconds.

Cycle 5: Time must be adjusted to 135/16 = 8.4 seconds.

For Step 22,

Cycle 1: Time must be adjusted to 859/25 = 34.4 seconds.

Cycle 2: Time must be adjusted to 138/4 = 34.5 seconds.

Cycle 3: Time must be adjusted to 2,222/63 = 35.3 seconds.

Cycle 4: Time must be adjusted to 555/16 = 34.7 seconds.

Cycle 5: Time must be adjusted to 546/16 = 34.1 seconds.

For Step 23,

Cycle 1: Time must be adjusted to 176/25 = 7.0 seconds.

Cycle 2: Time must be adjusted to 29/4 = 7.3 seconds.

Cycle 3: Time must be adjusted to 445/63 = 7.1 seconds.

Cycle 4: Time must be adjusted to 114/16 = 7.1 seconds.

Cycle 5: Time must be adjusted to 118/16 = 7.4 seconds.

For Step 29,

Cycle 1: Time must be adjusted to 163/25 = 6.5 seconds.

Cycle 2: Time must be adjusted to 27/4 = 6.8 seconds.

Cycle 3: Time must be adjusted to 409/63 = 6.5 seconds.

Cycle 4: Time must be adjusted to 107/16 = 6.7 seconds.

Cycle 5: Time must be adjusted to 110/16 = 6.9 seconds.

For Step 30,

Cycle 1: Time must be adjusted to 461/25 = 18.4 seconds.

Cycle 2: Time must be adjusted to 74/4 = 18.5 seconds.

Cycle 3: Time must be adjusted to 1,195/63 = 19.0 seconds.

Cycle 4: Time must be adjusted to 309/16 = 19.3 seconds.

Cycle 5: Time must be adjusted to 313/16 = 19.6 seconds.

For Step 31,

Cycle 1: Time must be adjusted to 178/25 = 7.1 seconds.

Cycle 2: Time must be adjusted to 28/4 = 7.0 seconds.

Cycle 3: Time must be adjusted to 442/63 = 7.0 seconds.

Cycle 4: Time must be adjusted to 119/16 = 7.4 seconds.

Cycle 5: Time must be adjusted to 121/16 = 7.6 seconds.

(4) For the existing Perform Inspection / Reject / UAI flow.

(a) The time in Steps 7, 9, and 47 has to be divided by 2 times the total number of boxes.

(b) The time in Steps 10, 12, 39, and 46 has to be divided by the total number of boxes.

(c) The time in Steps 20, 21, 22, 23, 29, 30, and 31 has to be divided by the total number of sample trays, which is equal to the number of sample size divided by 5.

For Step 7,

Cycle 1: Time must be adjusted to 11/3 = 3.7 seconds.

Cycle 2: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 3: Time must be adjusted to 8/2 = 4.0 seconds.

Cycle 4: Time must be adjusted to $^4/_1$ = 4.0 seconds.

Cycle 5: Time must be adjusted to $^3/_1$ = 3.0 seconds.

For Step 9,

Cycle 1: Time must be adjusted to 10/3 = 3.3 seconds.

Cycle 2: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 3: Time must be adjusted to 7/2 = 3.5 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to 4/1 = 4.0 seconds.

For Step 47,

Cycle 1: Time must be adjusted to 11/3 = 3.7 seconds.

Cycle 2: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 3: Time must be adjusted to 8/2 = 4.0 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to 2/1 = 2.0 seconds.

For Step 10,

Cycle 1: Time must be adjusted to 28/5 = 5.6 seconds.

Cycle 2: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 3: Time must be adjusted to 16/3 = 5.3 seconds.

Cycle 4: Time must be adjusted to 7/1 = 7.0 seconds.

Cycle 5: Time must be adjusted to 6/1 = 6.0 seconds.

For Step 12,

Cycle 1: Time must be adjusted to 98/5 = 19.6 seconds.

Cycle 2: Time must be adjusted to 21/1 = 21.0 seconds.

Cycle 3: Time must be adjusted to 62/3 = 20.7 seconds.

Cycle 4: Time must be adjusted to 21/1 = 21.0 seconds.

Cycle 5: Time must be adjusted to 22/1 = 22.0 seconds.

For Step 39,

Cycle 1: Time must be adjusted to 81/5 = 16.2 seconds.

Cycle 2: Time must be adjusted to 19/1 = 19.0 seconds.

Cycle 3: Time must be adjusted to 54/3 = 18.0 seconds.

Cycle 4: Time must be adjusted to 18/1 = 18.0 seconds.

Cycle 5: Time must be adjusted to 17/1 = 17.0 seconds.

For Step 46,

Cycle 1: Time must be adjusted to 9/5 = 1.8 seconds.

Cycle 2: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 3: Time must be adjusted to 5/3 = 1.7 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to 2/1 = 2.0 seconds.

For Step 20,

Cycle 1: Time must be adjusted to 260/40 = 6.5 seconds.

Cycle 2: Time must be adjusted to 104/16 = 6.5 seconds.

Cycle 3: Time must be adjusted to 268/40 = 6.7 seconds.

Cycle 4: Time must be adjusted to 161/25 = 6.4 seconds.

Cycle 5: Time must be adjusted to 25/4 = 6.3 seconds.

For Step 21,

Cycle 1: Time must be adjusted to 320/40 = 8.0 seconds.

Cycle 2: Time must be adjusted to 129/16 = 8.1 seconds.

Cycle 3: Time must be adjusted to 329/40 = 8.2 seconds.

Cycle 4: Time must be adjusted to 200/25 = 8.0 seconds.

Cycle 5: Time must be adjusted to 34/4 = 8.5 seconds.

For Step 22,

Cycle 1: Time must be adjusted to 1,410/40 = 35.3 seconds.

Cycle 2: Time must be adjusted to 556/16 = 34.8 seconds.

Cycle 3: Time must be adjusted to 1,392/40 = 34.8 seconds.

Cycle 4: Time must be adjusted to 871/25 = 34.8 seconds.

Cycle 5: Time must be adjusted to 138/4 = 34.5 seconds.

For Step 23,

Cycle 1: Time must be adjusted to 286/40 = 7.2 seconds.

Cycle 2: Time must be adjusted to 113/16 = 7.1 seconds.

Cycle 3: Time must be adjusted to 279/40 = 7.0 seconds.

Cycle 4: Time must be adjusted to 184/25 = 7.4 seconds.

Cycle 5: Time must be adjusted to 28/4 = 7.0 seconds.

For Step 29,

Cycle 1: Time must be adjusted to 259/40 = 6.5 seconds.

Cycle 2: Time must be adjusted to 108/16 = 6.8 seconds.

Cycle 3: Time must be adjusted to 263/40 = 6.6 seconds.

Cycle 4: Time must be adjusted to 172/25 = 6.9 seconds.

Cycle 5: Time must be adjusted to 27/4 = 6.8 seconds.

For Step 30,

Cycle 1: Time must be adjusted to 762/40 = 19.1 seconds.

Cycle 2: Time must be adjusted to 301/16 = 18.8 seconds.

Cycle 3: Time must be adjusted to 731/40 = 18.3 seconds.

Cycle 4: Time must be adjusted to 483/25 = 19.3 seconds.

Cycle 5: Time must be adjusted to 76/4 = 19.0 seconds.

For Step 31,

Cycle 1: Time must be adjusted to 289/40 = 7.2 seconds.

Cycle 2: Time must be adjusted to 111/16 = 6.9 seconds.

Cycle 3: Time must be adjusted to 284/40 = 7.1 seconds.

Cycle 4: Time must be adjusted to 190/25 = 7.6 seconds.

Cycle 5: Time must be adjusted to 29/4 = 7.3 seconds.

(5) For the proposed Skip Inspection flow.

(a) The time in Steps A and E has to be divided by 2 times the total number of boxes.

(b) The time in Steps B and C has to be divided by the total number of boxes.

For Step A,

Cycle 1: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 2: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 5: Time must be adjusted to 27/8 = 3.4 seconds.

Cycle 6: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 7: Time must be adjusted to 7/2 = 3.5 seconds.

Cycle 8: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 9: Time must be adjusted to 10/3 = 3.3 seconds.

Cycle 10: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 11: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 12: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 13: Time must be adjusted to $^4/_1$ = 4.0 seconds.

Cycle 14: Time must be adjusted to 7/2 = 3.5 seconds.

Cycle 15: Time must be adjusted to 3/1 = 3.0 seconds.

For Step E,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to $^4/_1$ = 4.0 seconds.

Cycle 3: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to 25/8 = 3.1 seconds.

Cycle 6: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 7: Time must be adjusted to 7/2 = 3.5 seconds.

Cycle 8: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 9: Time must be adjusted to 12/3 = 4.0 seconds.

Cycle 10: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 11: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 12: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 13: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 14: Time must be adjusted to 8/2 = 4.0 seconds.

Cycle 15: Time must be adjusted to 3/1 = 3.0 seconds.

For Step B,

Cycle 1: Time must be adjusted to 7/2 = 3.5 seconds.

Cycle 2: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to 43/15 = 2.9 seconds.

Cycle 6: Time must be adjusted to 6/2 = 3.0 seconds.

Cycle 7: Time must be adjusted to 11/3 = 3.7 seconds.

Cycle 8: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 9: Time must be adjusted to 16/5 = 3.2 seconds.

Cycle 10: Time must be adjusted to 7/2 = 3.5 seconds.

Cycle 11: Time must be adjusted to 6/2 = 3.0 seconds.

Cycle 12: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 13: Time must be adjusted to 7/2 = 3.5 seconds.

Cycle 14: Time must be adjusted to 14/4 = 3.5 seconds.

Cycle 15: Time must be adjusted to 3/1 = 3.0 seconds.

For Step C,

Cycle 1: Time must be adjusted to 11/2 = 5.5 seconds.

Cycle 2: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 3: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 4: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 5: Time must be adjusted to 82/15 = 5.5 seconds.

Cycle 6: Time must be adjusted to 12/2 = 6.0 seconds.

Cycle 7: Time must be adjusted to 17/3 = 5.7 seconds.

Cycle 8: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 9: Time must be adjusted to 29/5 = 5.8 seconds.

Cycle 10: Time must be adjusted to 12/2 = 6.0 seconds.

Cycle 11: Time must be adjusted to 11/2 = 5.5 seconds.

Cycle 12: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 13: Time must be adjusted to 12/2 = 6.0 seconds.

Cycle 14: Time must be adjusted to 23/4 = 5.8 seconds.

Cycle 15: Time must be adjusted to 6/1 = 6.0 seconds.

(6) For the proposed Perform Inspection / Accept flow.

(a) The time in Steps A and F has to be divided by 2 times the total number of boxes.

(b) The time in Steps B, C, 12, and 39 has to be divided by the total number of boxes.

(c) The time in Steps 20, 21, 22, D, 30, and 31 has to be divided by the total number of sample trays, which is equal to the number of sample size divided by 5.

For Step A,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 5: Time must be adjusted to 4/1 = 4.0 seconds.

For Step F,

Cycle 1: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 2: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step B,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 6/2 = 3.0 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step C,

Cycle 1: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 2: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 3: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 4: Time must be adjusted to 11/2 = 5.5 seconds.

Cycle 5: Time must be adjusted to 6/1 = 6.0 seconds.

For Step 12,

Cycle 1: Time must be adjusted to 22/1 = 22.0 seconds.

Cycle 2: Time must be adjusted to 24/1 = 24.0 seconds.

Cycle 3: Time must be adjusted to 20/1 = 20.0 seconds.

Cycle 4: Time must be adjusted to 42/1 = 21.0 seconds.

Cycle 5: Time must be adjusted to 19/1 = 19.0 seconds.

For Step 39,

Cycle 1: Time must be adjusted to 18/1 = 18.0 seconds.

Cycle 2: Time must be adjusted to 19/1 = 19.0 seconds.

Cycle 3: Time must be adjusted to 15/1 = 15.0 seconds.

Cycle 4: Time must be adjusted to 33/2 = 16.5 seconds.

Cycle 5: Time must be adjusted to 17/1 = 17.0 seconds.

For Step 20,

Cycle 1: Time must be adjusted to 104/16 = 6.5 seconds.

Cycle 2: Time must be adjusted to 107/16 = 6.7 seconds.

Cycle 3: Time must be adjusted to 25/4 = 6.3 seconds.

Cycle 4: Time must be adjusted to 170/25 = 6.8 seconds.

Cycle 5: Time must be adjusted to 108/16 = 6.8 seconds.

For Step 21,

Cycle 1: Time must be adjusted to 129/16 = 8.1 seconds.

Cycle 2: Time must be adjusted to 128/16 = 8.0 seconds.

Cycle 3: Time must be adjusted to 33/4 = 8.3 seconds.

Cycle 4: Time must be adjusted to 203/25 = 8.1 seconds.

Cycle 5: Time must be adjusted to 134/16 = 8.4 seconds.

For Step 22,

Cycle 1: Time must be adjusted to 561/16 = 35.1 seconds.

Cycle 2: Time must be adjusted to 571/16 = 35.7 seconds.

Cycle 3: Time must be adjusted to 141/4 = 35.3 seconds.

Cycle 4: Time must be adjusted to 856/25 = 34.2 seconds.

Cycle 5: Time must be adjusted to 564/16 = 35.3 seconds.

For Step D,

Cycle 1: Time must be adjusted to 50/16 = 3.1 seconds.

Cycle 2: Time must be adjusted to 53/16 = 3.3 seconds.

Cycle 3: Time must be adjusted to 13/4 = 3.3 seconds.

Cycle 4: Time must be adjusted to 80/25 = 3.2 seconds.

Cycle 5: Time must be adjusted to 53/16 = 3.3 seconds.

For Step 30,

Cycle 1: Time must be adjusted to 292/16 = 18.3 seconds.

Cycle 2: Time must be adjusted to 288/16 = 18.0 seconds.

Cycle 3: Time must be adjusted to 73/4 = 18.3 seconds.

Cycle 4: Time must be adjusted to 470/25 = 18.8 seconds.

Cycle 5: Time must be adjusted to 297/16 = 18.6 seconds.

For Step 31,

Cycle 1: Time must be adjusted to 112/16 = 7.0 seconds.

Cycle 2: Time must be adjusted to 116/16 = 7.3 seconds.

Cycle 3: Time must be adjusted to 28/4 = 7.0 seconds.

Cycle 4: Time must be adjusted to 184/25 = 7.4 seconds.

Cycle 5: Time must be adjusted to 115/16 = 7.2 seconds.

(7) For the proposed Perform Inspection / Reject / RTV flow.

(a) The time in Steps A and 47 has to be divided by 2 times the total number of boxes.

(b) The time in Steps B, C, 12, and 39 has to be divided by the total number of boxes.

(c) The time in Steps 20, 21, 22, D, 30, and 31 has to be divided by the total number of sample trays, which is equal to the number of sample size divided by 5.

For Step A,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 10/3 = 3.3 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to $^4/_1$ = 4.0 seconds.

Cycle 5: Time must be adjusted to $^4/_1$ = 4.0 seconds.

For Step 47,

Cycle 1: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 2: Time must be adjusted to 8/3 = 2.7 seconds.

Cycle 3: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 4: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step B,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 15/6 = 2.5 seconds.

Cycle 3: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 4: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 5: Time must be adjusted to 6/2 = 3.0 seconds.

For Step C,

Cycle 1: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 2: Time must be adjusted to 32/6 = 5.3 seconds.

Cycle 3: Time must be adjusted to 5/1 = 5.0 seconds.

Cycle 4: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 5: Time must be adjusted to 13/2 = 6.5 seconds.

For Step 12,

Cycle 1: Time must be adjusted to 21/1 = 21.0 seconds.

Cycle 2: Time must be adjusted to 118/6 = 19.7 seconds.

Cycle 3: Time must be adjusted to 18/1 = 18.0 seconds.

Cycle 4: Time must be adjusted to 22/1 = 22.0 seconds.

Cycle 5: Time must be adjusted to 43/2 = 21.5 seconds.

For Step 39,

Cycle 1: Time must be adjusted to 20/1 = 20.0 seconds.

Cycle 2: Time must be adjusted to 114/6 = 19.0 seconds.

Cycle 3: Time must be adjusted to 18/1 = 18.0 seconds.

Cycle 4: Time must be adjusted to 17/1 = 17.0 seconds.

Cycle 5: Time must be adjusted to 37/2 = 18.5 seconds.

For Step 20,

Cycle 1: Time must be adjusted to 170/25 = 6.8 seconds.

Cycle 2: Time must be adjusted to 272/40 = 6.8 seconds.

Cycle 3: Time must be adjusted to 26/4 = 6.5 seconds.

Cycle 4: Time must be adjusted to 106/16 = 6.6 seconds.

Cycle 5: Time must be adjusted to 164/25 = 6.6 seconds.

For Step 21,

Cycle 1: Time must be adjusted to 209/25 = 8.4 seconds.

Cycle 2: Time must be adjusted to 321/40 = 8.0 seconds.

Cycle 3: Time must be adjusted to 32/4 = 8.0 seconds.

Cycle 4: Time must be adjusted to 130/16 = 8.1 seconds.

Cycle 5: Time must be adjusted to 200/25 = 8.0 seconds.

For Step 22,

Cycle 1: Time must be adjusted to 884/25 = 35.4 seconds.

Cycle 2: Time must be adjusted to 1,414/40 = 35.4 seconds.

Cycle 3: Time must be adjusted to 141/4 = 35.3 seconds.

Cycle 4: Time must be adjusted to 554/16 = 34.6 seconds.

Cycle 5: Time must be adjusted to 850/25 = 34.0 seconds.

For Step D,

Cycle 1: Time must be adjusted to 80/25 = 3.2 seconds.

Cycle 2: Time must be adjusted to 126/40 = 3.2 seconds.

Cycle 3: Time must be adjusted to 12/4 = 3.0 seconds.

Cycle 4: Time must be adjusted to 49/16 = 3.1 seconds.

Cycle 5: Time must be adjusted to 78/25 = 3.1 seconds.

For Step 30,

Cycle 1: Time must be adjusted to 451/25 = 18.0 seconds.

Cycle 2: Time must be adjusted to 728/40 = 18.2 seconds.

Cycle 3: Time must be adjusted to 73/4 = 18.3 seconds.

Cycle 4: Time must be adjusted to 301/16 = 18.8 seconds.

Cycle 5: Time must be adjusted to 474/25 = 19.0 seconds.

For Step 31,

Cycle 1: Time must be adjusted to 181/25 = 7.2 seconds.

Cycle 2: Time must be adjusted to 296/40 = 7.4 seconds.

Cycle 3: Time must be adjusted to 28/4 = 7.0 seconds.

Cycle 4: Time must be adjusted to 120/16 = 7.5 seconds.

Cycle 5: Time must be adjusted to 185/25 = 7.4 seconds.

(8) For the proposed Perform Inspection / Reject / UAI flow.

(a) The time in Steps A and F has to be divided by 2 times the total number of boxes.

(b) The time in Steps B, C, 12, and 39 has to be divided by the total number of boxes.

(c) The time in Steps 20, 21, 22, D, 30, and 31 has to be divided by the total number of sample trays, which is equal to the number of sample size divided by 5.

For Step A,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 4/1 = 4.0 seconds.

Cycle 3: Time must be adjusted to 11/3 = 3.7 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to 4/1 = 4.0 seconds.

For Step F,

Cycle 1: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 2: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 3: Time must be adjusted to 8/3 = 2.7 seconds.

Cycle 4: Time must be adjusted to $^{4}/_{1}$ = 4.0 seconds.

Cycle 5: Time must be adjusted to 3/1 = 3.0 seconds.

For Step B,

Cycle 1: Time must be adjusted to 2/1 = 2.0 seconds.

Cycle 2: Time must be adjusted to 4/2 = 2.0 seconds.

Cycle 3: Time must be adjusted to 13/6 = 2.2 seconds.

Cycle 4: Time must be adjusted to 3/1 = 3.0 seconds.

Cycle 5: Time must be adjusted to 2/1 = 2.0 seconds.

For Step C,

Cycle 1: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 2: Time must be adjusted to 11/2 = 5.5 seconds.

Cycle 3: Time must be adjusted to 34/6 = 5.7 seconds.

Cycle 4: Time must be adjusted to 6/1 = 6.0 seconds.

Cycle 5: Time must be adjusted to 5/1 = 5.0 seconds.

For Step 12,

Cycle 1: Time must be adjusted to 22/1 = 22.0 seconds.

Cycle 2: Time must be adjusted to 41/2 = 20.5 seconds.

Cycle 3: Time must be adjusted to 125/6 = 20.8 seconds.

Cycle 4: Time must be adjusted to 20/1 = 20.0 seconds.

Cycle 5: Time must be adjusted to 18/1 = 18.0 seconds.

For Step 39,

Cycle 1: Time must be adjusted to 19/1 = 19.0 seconds.

Cycle 2: Time must be adjusted to 35/2 = 17.5 seconds.

Cycle 3: Time must be adjusted to 112/6 = 18.7 seconds.

Cycle 4: Time must be adjusted to 17/1 = 17.0 seconds.

Cycle 5: Time must be adjusted to 19/1 = 19.0 seconds.

For Step 20,

Cycle 1: Time must be adjusted to 102/16 = 6.4 seconds.

Cycle 2: Time must be adjusted to 162/25 = 6.5 seconds.

Cycle 3: Time must be adjusted to 269/40 = 6.7 seconds.

Cycle 4: Time must be adjusted to 102/16 = 6.4 seconds.

Cycle 5: Time must be adjusted to 26/4 = 6.5 seconds.

For Step 21,

Cycle 1: Time must be adjusted to 128/16 = 8.0 seconds.

Cycle 2: Time must be adjusted to 201/25 = 8.0 seconds.

Cycle 3: Time must be adjusted to 332/40 = 8.3 seconds.

Cycle 4: Time must be adjusted to 135/16 = 8.4 seconds.

Cycle 5: Time must be adjusted to 34/4 = 8.5 seconds.

For Step 22,

Cycle 1: Time must be adjusted to 571/16 = 35.7 seconds.

Cycle 2: Time must be adjusted to 897/25 = 35.9 seconds.

Cycle 3: Time must be adjusted to 1,408/40 = 35.2 seconds.

Cycle 4: Time must be adjusted to 550/16 = 34.4 seconds.

Cycle 5: Time must be adjusted to 136/4 = 34.0 seconds.

For Step D,

Cycle 1: Time must be adjusted to 51/16 = 3.2 seconds.

Cycle 2: Time must be adjusted to 80/25 = 3.2 seconds.

Cycle 3: Time must be adjusted to 134/40 = 3.4 seconds.

Cycle 4: Time must be adjusted to 53/16 = 3.3 seconds.

Cycle 5: Time must be adjusted to 13/4 = 3.3 seconds.

For Step 30,

Cycle 1: Time must be adjusted to 288/16 = 18.0 seconds.

Cycle 2: Time must be adjusted to 464/25 = 18.6 seconds.

Cycle 3: Time must be adjusted to 728/40 = 18.2 seconds.

Cycle 4: Time must be adjusted to 302/16 = 18.9 seconds.

Cycle 5: Time must be adjusted to 75/4 = 18.8 seconds.

For Step 31,

Cycle 1: Time must be adjusted to 114/16 = 7.1 seconds.

Cycle 2: Time must be adjusted to 181/25 = 7.2 seconds.

Cycle 3: Time must be adjusted to 291/40 = 7.3 seconds.

Cycle 4: Time must be adjusted to 115/16 = 7.2 seconds.

Cycle 5: Time must be adjusted to 28/4 = 7.0 seconds.

Another column, which is the average time of each step, is added in the adjusted table, Tables 6.12-6.19, to show the average time used in each step. This column is calculated by taking the average of every cycle.

6.3 Process Flows Comparison

From the adjusted cycle time tables, Tables 6.12-6.19, the average cycle time of the existing process flows and proposed process flows and percentage of time improvement with the proposed process flows can be summarized as shown in Table

6.20. The unit of the cycle time in Table 6.20 is in second. However, these average cycle times are based on one material box and one inspected tray. Therefore, before calculating the percentage of time improvement, the average cycle time has to be based on the average number of material box and the average number of inspected tray.

Table 6.20. Average Cycle Times based on One Material Box and One Inspected Tray.

Process Flow	Average Cycle Time of the Existing Flow (Seconds)	Average Cycle Time of the Proposed Flow (Seconds)
Skip Inspection	311.0	172.5
Perform Inspection / Accept	1,038.6	811.0
Perform Inspection / Reject / RTV	1,124.2	948.3
Perform Inspection / Reject / UAI	1,128.0	898.9

In the actual flow, the average number of material box is three boxes per shipment and the average number of inspected tray is 21 trays per shipment. These numbers have to be added back to the average cycle time, which is based on one material box and one inspected tray, in reverse to the calculation of adjusted cycle time as follows.

(1) For the adjusted time in the existing Skip Inspection flow.

(a) The time in Steps 7 and 9 must be multiplied by the average number of boxes.

From Table 6.12,

The time in Step 7 must be revised to 5.9 x 3 = 17.7 seconds

The time in Step 9 must be revised to 1.8 x 3 = 5.4 seconds.

Therefore, the average cycle time of the existing Skip Inspection flow must be revised to

311.0 — 5.9 — 1.8 + 17.7 + 5.4 = 326.4 seconds.

(2) For the existing Perform Inspection / Accept flow.

(a) The time in Steps 7, 9, and 44 must be revised to be two times the adjusted time because three material boxes can be loaded/unloaded by two times.

(b) The time in Steps 10, 12, 39, and 43 must be multiplied by the average number of boxes.

(c) The time in Steps 20, 21, 22, 23, 29, 30, and 31 must be multiplied by the average number of inspected trays.

From Table 16.13,

The time in Step 7 must be revised to 3.2 x 2 = 6.4 seconds.

The time in Step 9 must be revised to 3.3 x 2 = 6.6 seconds.

The time in Step 44 must be revised to 3.5 x 2 = 7.0 seconds.

The time in Step 10 must be revised to 5.9 x 3 = 17.7 seconds.

The time in Step 12 must be revised to 21.1 x 3 = 63.3 seconds.

The time in Step 39 must be revised to 18.6 x 3 = 55.8 seconds.

The time in Step 43 must be revised to 3.5 x 3 = 10.5 seconds.

The time in Step 20 must be revised to 6.6 x 21 = 138.6 seconds.

The time in Step 21 must be revised to 8.2 x 21 = 171.2 seconds

The time in Step 22 must be revised to 35.0 x 21 = 735.0 seconds

The time in Step 23 must be revised to 7.1 x 21 = 149.1 seconds

The time in Step 29 must be revised to 6.8 x 21 = 142.8 seconds

The time in Step 30 must be revised to 18.7 x 21 = 392.7 seconds

The time in Step 31 must be revised to 7.2 x 21 = 151.2 seconds

Therefore, the average cycle time of the existing Perform Inspection / Accept flow must be revised to

1,038.6 - 3.2 - 3.3 - 3.5 -5.9-21.1 - 18.6 - 3.5 - 6.6 - 8.2 - 35 - 7.1 - 6.8 - 18.7 - 7.2 + 6.4 + 6.6 + 7 + 17.7 + 63.3 + 55.8 +10.5+138.6+171.2+735+149.1+142.8+392.7+151.2

= 2,937.8 seconds

(3) For the existing Perform Inspection / Reject / RTV flow.

(a) The time in Steps 7, 9, and 47 must be revised to be two times the adjusted time because three material boxes can be loaded/unloaded by two times.

(b) The time in Steps 10, 12, 39, and 46 must be multiplied by the average number of boxes.

(c) The time in Steps 20, 21, 22, 23, 29, 30, and 31 must be multiplied by the average number of inspected trays.

From Table 16.14,

The time in Step 7 must be revised to 3.5 x 2 = 7.0 seconds.

The time in Step 9 must be revised to 3.6 x 2 = 7.2 seconds.

The time in Step 47 must be revised to 3.4 x 2 = 6.8 seconds.

The time in Step 10 must be revised to 5.9 x 3 = 17.7 seconds.

The time in Step 12 must be revised to 19.9 x 3 = 59.7 seconds.

The time in Step 39 must be revised to 17.9 x 3 = 53.7 seconds.

The time in Step 46 must be revised to 2.1 x 3 = 6.3 seconds.

The time in Step 20 must be revised to 6.6 x 21 = 138.6 seconds.

The time in Step 21 must be revised to 8.2 x 21 = 172.2 seconds

The time in Step 22 must be revised to 34.6 x 21 = 726.6 seconds

The time in Step 23 must be revised to 7.2 x 21 = 151.2 seconds

The time in Step 29 must be revised to 6.7 x 21 = 140.7 seconds

The time in Step 30 must be revised to 19.0 x 21 = 399.0 seconds

The time in Step 31 must be revised to 7.2 x 21 = 151.2 seconds

Therefore, the average cycle time of the existing Perform Inspection / Reject / RTV flow must be revised to

1,124.2 - 3.5 - 3.6 - 3.4 - 5.9 - 19.9 - 17.9 - 2.1 - 6.6 - 8.2 - 34.6 - 7.2 - 6.7 - 19 - 7.2 + 7 + 7.2 + 6.8 + 17.7 + 59.7 + 53.7 + 6.3 + 138.6 + 172.2 + 726.6 + 151.2 + 140.7 + 399 + 151.2

= 3,016.3 seconds

(4) For the existing Perform Inspection / Reject / UAI flow.

(a) The time in Steps 7, 9, and 47 must be revised to be two times the adjusted time because three material boxes can be loaded/unloaded by two times.

(b) The time in Steps 10, 12, 39, and 46 must be multiplied by the average number of boxes.

(c) The time in Steps 20, 21, 22, 23, 29, 30, and 31 must be multiplied by the average number of inspected trays.

From Table 16.15,

The time in Step 7 must be revised to 3.5 x 2 = 7.0 seconds.

The time in Step 9 must be revised to 3.4 x 2 = 6.8 seconds.

The time in Step 47 must be revised to 3.3 x 2 = 6.6 seconds.

The time in Step 10 must be revised to 5.9 x 3 = 17.7 seconds.

The time in Step 12 must be revised to 20.9 x 3 = 62.7 seconds.

The time in Step 39 must be revised to 17.6 x 3 = 52.8 seconds.

The time in Step 46 must be revised to 2.1 x 3 = 6.3 seconds.

The time in Step 20 must be revised to 6.5 x 21 = 136.5 seconds.

The time in Step 21 must be revised to 8.2 x 21 = 172.2 seconds

The time in Step 22 must be revised to 34.8 x 21 = 730.8 seconds

The time in Step 23 must be revised to 7.1 x 21 = 149.1 seconds

The time in Step 29 must be revised to 6.7 x 21 = 140.7 seconds

The time in Step 30 must be revised to 18.9 x 21 = 396.9 seconds

The time in Step 31 must be revised to 7.2 x 21 = 151.2 seconds

Therefore, the average cycle time of the existing Perform Inspection / Reject / UAI flow must be revised to

1,128 - 3.5 - 3.4 - 3.3 - 5.9 - 20.9 - 17.6 - 2.1 - 6.5 - 8.2 - 34.8 - 7.1 - 6.7 - 18.9 - 7.2 + 7 + 6.8 + 6.6 + 17.7 + 62.7 + 52.8 + 6.3 + 136.5 + 172.2 + 730.8 + 149.1 + 140.7 + 396.9 + 151.2

= 3,019.2 seconds

(5) For the proposed Skip Inspection flow.

(a) The time in Steps A and E must be revised to be two times the adjusted time because three material boxes can be loaded/unloaded by two times.

(b) The time in Steps B and C must be multiplied by the average number of boxes.

From Table 6.16,

The time in Step A must be revised to 3.4 x 2 = 6.8 seconds.

The time in Step E must be revised to 3.5 x 2 = 7.0 seconds.

The time in Step B must be revised to 3.1 x 3 = 9.3 seconds

The time in Step C must be revised to 5.6 x 3 = 16.8 seconds

Therefore, the average cycle time of the proposed Skip Inspection flow must be revised to

172.5 - 3.4 - 3.5 - 3.1 - 5.6 + 6.8 + 7 + 9.3 + 16.8

= 196.8 seconds

(6) For the proposed Perform Inspection / Accept flow.

(a) The time in Steps A and F must be revised to be two times the adjusted time because three material boxes can be loaded/unloaded by two times.

(b) The time in Steps B, C, 12, and 39 must be multiplied by the average number of boxes.

(c) The time in Steps 20, 21, 22, D, 30, and 31 must be multiplied by the average number of inspected trays.

From Table 6.17,

The time in Step A must be revised to 3.6 x 2 = 7.2 seconds.

The time in Step F must be revised to 3.6 x 2 = 7.2 seconds.

The time in Step B must be revised to 2.8 x 3 = 8.4 seconds.

The time in Step C must be revised to 5.7 x 3 = 17.1 seconds.

The time in Step 12 must be revised to 25.4 x 3 = 76.2 seconds.

The time in Step 39 must be revised to 17.1 x 3 = 51.3 seconds.

The time in Step 20 must be revised to 6.6 x 21 = 138.6 seconds.

The time in Step 21 must be revised to 8.2 x 21 = 172.2 seconds

The time in Step 22 must be revised to 35.1 x 21 = 737.1 seconds

The time in Step D must be revised to 3.2 x 21 = 67.2 seconds

The time in Step 30 must be revised to 18.4 x 21 = 386.4 seconds

The time in Step 31 must be revised to 7.2 x 21 = 151.2 seconds

Therefore, the average cycle time of the existing Perform Inspection / Accept flow must be revised to

811.0 - 3.6 - 3.6 - 2.8 - 5.7 - 25.4 - 17.1 -6.6-8.2-35.1 - 3.2 - 18.4 - 7.2 + 7.2 + 7.2 + 8.4 + 17.1 + 76.2 + 51.3 + 138.6 + 172.2 + 737.1 +67.2+386.4+ 151.2

= 2,494.2 seconds

(7) For the proposed Perform Inspection / Reject / RTV flow.

(a) The time in Steps A and 47 must be revised to be two times the adjusted time because three material boxes can be loaded/unloaded by two times.

(b) The time in Steps B, C, 12, and 39 must be multiplied by the average number of boxes.

(c) The time in Steps 20, 21, 22, D, 30, and 31 must be multiplied by the average number of inspected trays.

From Table 6.18,

The time in Step A must be revised to 3.5 x 2 = 7.0 seconds.

The time in Step 47 must be revised to 2.9 x 2 = 5.8 seconds.

The time in Step B must be revised to 2.5 x 3 = 7.5 seconds.

The time in Step C must be revised to 5.8 x 3 = 17.4 seconds.

The time in Step 12 must be revised to 20.4 x 3 = 61.2 seconds.

The time in Step 39 must be revised to 18.5 x 3 = 55.5 seconds.

The time in Step 20 must be revised to 6.7 x 21 = 147.7 seconds.

The time in Step 21 must be revised to 8.1 x 21 = 170.1 seconds

The time in Step 22 must be revised to 34.9 x 21 = 732.9 seconds

The time in Step D must be revised to 3.1 x 21 = 65.1 seconds

The time in Step 30 must be revised to 18.5 x 21 = 388.5 seconds

The time in Step 31 must be revised to 7.3 x 21 = 153.3 seconds

Therefore, the average cycle time of the proposed Perform Inspection / Reject / RTV flow must be revised to

948.3 - 3.5 - 2.9 - 2.5 - 5.8 - 20.4 - 18.5 - 6.7 - 8.1 -34.9- 3.1-18.5-7.3+ 7 + 5.8 + 7.5 + 17.4 + 61.2 + 55.5 + 140.7 + 170.1 + 732.9 + 65.1 + 388.5 + 153.3

= 2,621.1 seconds

(8) For the proposed Perform Inspection / Reject / UAI flow.

(a) The time in Steps A and F must be revised to be two times the adjusted time because three material boxes can be loaded/unloaded by two times.

(b) The time in Steps B, C, 12, and 39 must be multiplied by the average number of boxes.

(c) The time in Steps 20, 21, 22, D, 30, and 31 must be multiplied by the average number of inspected trays.

From Table 6.19,

The time in Step A must be revised to 3.5 x 2 = 7.0 seconds.

The time in Step F must be revised to 3.1 x 2 = 6.2 seconds.

The time in Step B must be revised to 2.2 x 3 = 6.6 seconds.

The time in Step C must be revised to 5.6 x 3 = 16.8 seconds.

The time in Step 12 must be revised to 20.3 x 3 = 60.9 seconds.

The time in Step 39 must be revised to 18.2 x 3 = 54.6 seconds.

The time in Step 20 must be revised to 6.5 x 21 = 136.5 seconds.

The time in Step 21 must be revised to 8.3 x 21 = 174.3 seconds

The time in Step 22 must be revised to 35.0 x 21 = 735.0 seconds

The time in Step D must be revised to 3.3 x 21 = 65.1 seconds

The time in Step 30 must be revised to 18.5 x 21 = 388.5 seconds

The time in Step 31 must be revised to 7.2 x 21 = 151.2 seconds

Therefore, the average cycle time of the proposed Perform Inspection / Reject / UAI flow must be revised to

898.9 - 3.5 - 3.1 - 2.2 - 5.6 - 20.3 - 18.2 - 6.5 - 8.3 - 35 - 3.3 -18.5-7.2+7+6.2+6.6+16.8+60.9+54.6+136.5+ 174.3 + 735 + 65.1 + 388.5 + 151.2

= 2,569.9 seconds

The percentage of time improvement is calculated from the time reduced with the proposed flow, which comes from the cycle time of the existing system minus the cycle time of the proposed system, divided by the average cycle time of the existing flow.

For Skip Inspection flow,

The time reduced with the proposed flow is equal to 326.4 - 196.8

= 129.6 seconds

Therefore, the percentage of time improvement is equal to 129.6/326.4*100

= 39.71%

For Perform Inspection / Accept flow,

The time reduced with the proposed flow is equal to 2,937.8 - 2,494.2

= 443.6 seconds

Therefore, the percentage of time improvement is equal to

443.6/2,937.8*100

= 15.10%

For Perform Inspection / Reject / RTV flow,

The time reduced with the proposed flow is equal to 3,016.3 — 2,621.1

= 395.2 seconds

Therefore, the percentage of time improvement is equal to

395.2/3,016.3*100

= 13.10%

For Perform Inspection / Reject / UAI flow,

The time reduced with the proposed flow is equal to 3,019.2 — 2,569.9

= 449.3 seconds

Therefore, the percentage of time improvement is equal to

449.3/3,019.2*100

= 14.88%

After the average cycle times were adjusted to be based on the average number of material boxes, Table 6.21 represents the comparison of the average cycle times based on the average number of material boxes and inspected trays and their percentage of time improvement for each proposed process flow. The unit of average cycle time in Table 6.21 is in seconds.

From the comparison of the existing process flows and the proposed process flows, we can conclude that there is significant improvement in cycle time reduction for the proposed process flows. For the Skip Inspection flow, 39.71% of time improvement is observed and the number of steps in the flow is reduced from 13 steps to 12 steps.

For the Perform Inspection / Accept flow, 15.10% of time improvement is observed and the number of steps in the flow is reduced from 46 steps to 38 steps. For Perform Inspection / Reject / RTV flow, 13.10% of time improvement is observed and the number of steps in the flow is reduced from 49 steps to 41 steps. For Perform Inspection / Reject / UAI flow, 14.81% of time improvement is observed and the number of steps in the flow is also reduced from 49 steps to 41 steps.

Anyway, the benefit and cost analysis will be calculated to check whether there is a cost impact or a cost saving. The net present value method is selected to be used in this benefit and cost analysis. The calculation of benefit in this analysis is based on the incoming inspection flow of the slider only so the actual benefit may be higher than the benefit calculated in this analysis because the summation of cost saving due to time reduction in every material inspection flows will be higher. Assumptions in the analysis are as follows:

(a) The interest rate is 10% per year because the Minimum Retailed Rate (MRR) in June 1999 is about 9.25% and it is expected to increase a little during the next five years.

(b) The estimated gravity conveyor life time is 5 years.

(c) The average labor cost, the IQA operator cost, is 190 baht per day in the year 2000 (year 1) and increases at the rate of 10 baht per year.

The calculation of the total cost, the total benefit, and the net present value is shown below.

(1) Cost of the proposed process flow: Additional costs of the proposed process flow are the conveyor cost and the layout preparation cost. These costs are one-time cost. The selected type of conveyor is the gravity conveyor because the transported distance is only about 5 metres so there is no

Table 6.21. Average Cycle Times Based on the Average Number of Material Boxes and Inspected Trays.

Process Flow	Average Cycle Time of the Existing Flow (Seconds)	Average Cycle Time of the Proposed Flow (Seconds)	Percentage of Time Improvement
Skip Inspection	326.4	196.8	39.71%
Perform Inspection / Accept	2,937.8	2,494.2	15.10%
Perform Inspection / Reject / RTV	3,016.3	2,621.1	13.10%
Perform Inspection / Reject / UAI	3,019.2	2,569.9	14.88%

operating cost of the conveyor. Two gravity conveyors are needed, one is used to transfer material boxes from the warehouse area to the incoming gage room, the other is used to transfer material boxes from the incoming gage room back to the warehouse area.

The cost of a gravity conveyor and the installing cost is about 13,000 baht. The layout preparation cost is estimated to be 5,000 baht. Therefore,

Total cost = (2 conveyors x 13,000 baht) + 5,000 baht

= 31,000 baht

(2) Benefit of the proposed process flow: The benefit of the proposed process flow is the cost saving due to time reduction. To calculate the cost saving due to time reduction, the time saving per day and the labor cost per day are needed.

Based on the actual incoming shipment, the average number of incoming slider shipments is 60 shipments per day. About 70% of them are the skipped inspection shipments and about 30% of them are the accepted shipments whereas less than 0.5% is the rejected shipments. Therefore, only the time reduction from Skip Inspection flow and Perform Inspection / Accept flow will be calculated because 0.5% is so small that it can be ignored.

Based on information from above paragraph, the number of skipped inspection shipments per day is equal to 60 x 0.7 = 42 shipments and the number of accepted shipments per day is equal to 60 x 0.3 = 18 shipments. From the calculation of the cycle time reduction above, the estimated cycle time reduction for a Skipped Inspection flow and a Perform Inspection / Accept flow are 129.6 seconds and 443.6 seconds respectively. Therefore, the estimated time reduction per day is equal to

(42 x 129.6) + (18 x 443.6)

= 13,428 seconds or 3.73 hours

There are 292 working day in a year and 21 hours in a working day. Therefore, the total time reduction in a year is equal to

3.73 x 292

= 1,089.16 hours or 51.86 working days

The estimated labor cost per day during the years 1999 — 2003 is shown below

Year 1999: 190 baht/day

Year 2000: 200 baht/day

Year 2001: 210 baht/day

Year 2002: 220 baht/day

Year 2003: 230 baht/day

Therefore the annual cost saving during the years 1999 — 2003 is calculated by multiplying the annual time reduction to the labor cost as shown below.

Year 1999: 190 x 51.86 = 9,853.4 baht

Year 2000: 200 x 51.86 = 10,372 baht

Year 2001: 210 x 51.86 = 10,890.6 baht

Year 2002: 220 x 51.86 = 11,409.2 baht

Year 2003: 230 x 51.86 = 11,927.8 baht

Since the cost saving during each year will be accumulated to the end of that year, for the cost saving of the year 1999 is considered as year 1, of the year 2000 is considered as year 2, of the year 2001 is considered as year 3, of the year 2002 is considered as year 4, and of the year 2003 is considered as year 5.

To calculate the net present value, the future values or the values in yearl — year 5 must be converted to the present value or year 0 by the equation below

$P = F / (1+i)^{\circ}$

where i = interest rate which equal to 10% or 0.1

n = year number

P = Present value

F = Future value

From above cost and benefit information,

Total cost in year 0 is equal to 31,000 baht

Total benefit in year 0 is equal to

$9,853.4/(1+0.1)^1 + 10,372/(1+0.1)^2 + 10,890.6/(1+0.1)^3 +$

$11,409.2/(1+0.1)^4 + 11,927.8/(1+0.1)^5$

= 40,910.67 baht

Therefore, the net present value is calculated by using the equation below

Net present value = Total benefit in year 0 — Total cost in year 0

= 40910.67 — 31,000

= 9,910.67 baht

From the benefit and cost analysis, there is no cost impact but, instead, there is a net benefit gain due to the cost saving from the time reduction in the proposed process flow.

VII. CONCLUSION

The incoming inspection process, which involves the verification of incoming materials before loading into the production line, is selected to recommend improvements to the existing process flow. The process flow can be classified into four major flows, which include Skip Inspection flow, Perform Inspection / Accept flow, Perform Inspection / Reject / Return To Vendor flow, and Perform Inspection / Reject / Use As Is flow.

The process chart is used to analyze the existing process flow. After the existing flow is analyzed, four observations are found to be areas where improvements can be made, which includes the wasted time due to operator going to the warehouse and searching for material boxes, the unnecessary stamp of the shipment disposition on the copy of the RT slip, the unneccessary stamp of the shipment disposition on material boxes, and the double step of opening/closing material tray and connecting/ disconnecting the wrist strap.

Recommendations to the above observations are installing the conveyor to transfer material boxes between the warehouse area and the incoming inspection area, eliminating unnecessary stamp on the copy of the RT slip and material boxes, and rearranging 30x and 100x microscope to place them next to each other.

To verify whether the above recommendations can improve the incoming inspection process, the cycle time of the existing process flow and the proposed process flow is measured and compared. The cycle time must be compared based on the same base, i.e. the same number of material boxes and the same number of inspected trays. Therefore, the average number of material boxes and the average number of inspected trays are selected to be the base of comparison. The comparison result shows that there is significant improvement on cycle time with the proposed process flow. The percentage of time improvement for the Skip Inspection flow, Perform Inspection / Accept flow, Perform Inspection / Reject / Return To Vendor flow, and Perform Inspection / Reject / Use As Is flow are 39.71%, 15.10%, 13.10%, and 14.88% respectively. The number of steps to complete the Skip Inspection flow is reduced from 13 steps to 12 steps. The number of steps to complete the Perform Inspection / Accept flow is reduced from 46 steps to 38 steps. The number of steps to complete the Perform Inspection / Reject / Return To Vendor flow is reduced from 49 steps to 41 steps. The number of steps to complete the Perform Inspection / Reject / Use As Is flow is reduced from 49 steps to 41 steps. The benefit and cost is also analyzed with the net present value method. The result of analysis shows that the net present value of the proposed process flow is 9,910.67 baht.

This result of this project proves that work simplification approach can improve the existing process. Although, in this project, this approach is only applied to the incoming inspection process, it is believed that the work simplification approach can also be applied to other areas.

APPENDIX A

THE TABLE OF RANDOM NUMBERS

Table A.1. Random Numbers

10 27 53 96 23	71 50 54 36 23	54 31 04 82 98	04 14 12 15 09	26 78 25 47 47
28 41 50 61 88	64 85 27 20 18	83 36 36 05 56	39 71 65 09 62	94 76 62 11 89
34 21 42 57 02	59 19 18 97 48	80 30 03 30 98	05 24 67 70 07	84 97 50 87 46
61 81 77 23 23	82 82 11 54 08	53 28 70 58 96	44 07 39 55 43	42 34 43 39 28
61 15 18 13 54	16 86 20 26 88	90 74 80 55 09	14 53 90 51 17	52 01 63 01 59
91 76 21 64 64	44 91 13 32 97	75 31 62 66 54	84 80 32 75 77	56 08 25 70 29
00 97 79 08 06	37 30 28 59 85	53 56 68 53 40	01 74 39 59 73	30 19 99 85 48
36 46 18 34 94	75 20 80 27 77	78 91 69 16 00	08 43 18 73 68	67 69 61 34 25
88 98 99 60 50	65 95 79 42 94	93 62 40 89 96	43 56 47 71 66	46 76 29 67 02
04 37 59 87 21	05 02 03 24 17	47 97 81 56 51	92 34 86 01 82	55 51 33 12 91
63 62 06 34 41	94 21 78 55 09	72 76 45 16 94	29 95 81 83 83	79 88 01 97 30
78 47 23 53 90	34 41 92 45 71	09 23 70 70 07	12 38 92 79 43	14 85 11 47 23
87 68 62 15 43	53 14 36 59 25	54 47 33 70 15	59 24 48 40 35	50 03 42 99 36
47 60 92 10 77	88 59 53 11 52	66 25 69 07 04	48 68 64 71 06	61 65 70 22 12
56 88 87 59 41	65 28 04 67 53	95 79 88 37 31	50 41 06 94 76	81 83 71 16 33
02 57 45 86 67	73 43 07 34 48	44 26 87 93 29	77 09 61 67 84	06 69 44 77 75
31 54 14 13 17	48 62 11 90 60	68 12 93 64 28	46 24 79 16 76	14 60 25 51 01
28 50 16 43 36	28 97 85 58 99	67 22 52 76 23	24 70 36 54 54	59 28 61 71 96
63 29 62 66 50	02 63 45 52 38	67 63 47 54 75	83 24 78 43 20	92 63 13 47 48
45 65 58 26 51	76 96 59 38 72	86 57 45 71 46	44 67 76 14 55	44 88 01 62 12
39 65 36 63 70	77 45 85 50 51	74 13 39 35 22	30 53 36 02 95	49 34 88 73 61
73 71 98 16 04	29 18 94 51 23	76 51 94 84 86	79 93 96 38 63	08 58 25 58 94
72 20 56 20 11	72 65 71 08 86	79 57 95 13 91	97 48 72 66 48	09 71 17 24 89
75 17 26 99 76	89 37 20 70 01	77 31 61 95 46	26 97 05 73 51	53 33 18 72 87
37 48 60 82 29	81 30 15 39 14	48 38 75 93 29	06 87 37 78 48	45 56 00 84 47
68 08 02 80 72	83 71 46 30 49	89 17 95 88 29	02 39 56 03 46	97 74 06 56 17
14 23 98 61 67	70 52 85 01 50	01 84 02 78 43	10 62 98 19 41	18 83 99 47 99
49 08 96 21 44	25 27 99 41 28	07 41 08 34 66	19 42 74 39 91	41 96 53 78 72
78 37 06 08 43	63 61 62 42 29	39 68 95 10 96	09 24 23 00 62	56 12 80 73 16
37 21 34 17 68	68 96 83 23 56	32 84 60 15 31	44 73 67 34 77	91 15 79 74 58
14 29 09 34 04	87 83 07 55 07	76 58 30 83 64	87 29 25 58 84	86 50 60 00 25
58 43 28 06 36	49 52 83 51 14	47 56 91 29 34	05 87 31 06 95	12 45 57 09 09
10 43 67 29 70	80 62 80 03 42	10 80 21 38 84	90 56 35 03 09	43 12 74 49 14
44 38 88 39 54	86 97 37 44 22	00 95 01 31 76	17 16 29 56 63	38 78 94 49 81
90 69 59 19 51	85 39 52 85 13	07 28 37 07 61	11 16 36 27 03	78 86 72 04 95
41 47 10 25 62	97 05 31 03 61	20 26 36 31 62	68 69 86 95 44	84 95 48 46 45
91 94 14 63 19	75 89 11 47 11	31 56 34 19 09	79 57 92 36 59	14 93 87 81 40
80 06 54 18 66	09 18 94 06 19	98 40 07 17 81	22 45 44 84 11	24 62 20 42 31
67 72 77 63 48	84 08 31 55 58	24 33 45 77 58	50 45 67 93 82	75 70 16 08 24
59 40 24 13 27	79 26 88 86 30	01 31 60 10 39	53 58 47 70 93	85 81 56 39 38
05 90 35 89 95	01 61 16 96 94	50 78 13 69 36	37 68 53 37 31	71 26 35 03 71
44 43 80 69 98	46 68 05 14 82	90 78 50 05 62	77 79 13 57 44	59 60 10 36 66
61 81 31 96 82	00 57 25 60 59	46 72 60 18 77	55 66 12 62 11	08 99 55 64 57
42 88 07 10 05	24 98 65 63 21	47 21 61 88 32	27 80 30 21 60	10 92 35 36 12
77 94 30 05 39	28 10 99 00 27	12 73 73 99 12	49 99 57 94 82	96 88 57 17 91
78 83 19 76 16	94 11 68 84 26	23 54 20 86 85	23 86 66 99 07	36 37 34 92 09
87 76 59 61 81	43 63 64 61 61	65 76 36 95 90	18 48 27 45 68	27 23 65 30 72
91 43 05 96 47	55 78 99 95 24	37 55 85 78 78	01 48 41 19 10	35 19 54 07 73
84 97 77 72 73	09 62 06 65 72	87 12 49 03 60	41 15 20 76 27	50 47 20 29 16
87 91 60 76 86	44 88 96 07 80	83 05 83 38 96	73 70 66 81 90	30 56 10 48 59

APPENDIX B

DOCUMENT FORMS USED IN INCOMING INSPECTION PROCESSES

Multi - Purpose Quality Report **No.**

Status:

Document detail

Disposition :	Part No :	Recv Date:
Vendor :	Desc :	Shpt# :
Lot QTY :	Sample size :	Acc/Rej:

Item	Qty	Defect Code	Defect description
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Supervisor' s comment:
SQE Comment:

Signature

	Manufacturing Engineer 's	**Inprocess Quality Engineer 's**	**Supplier Quality Engineer 's**
Name			
Signature			
	Manufacturing Supervisor 's	**Material Control 's**	**Purchasing Supervisor 's**
Name			
Signature			

Last Modify :

Figure B.2. The Multi-Purpose Quality Report (MPQR) Form.

SLIDER INSPECTION RESULT

LOT DETAIL

RECV DATE : ____________________

RIR# __________ LOT SIZE : __________

P/N :

MODEL

SHIP #

VENDOR : ( ) STTH (STPG-S (STIP ( ) STRH

VISUAL INSPECTION DETAIL

( ) NORMAL INSP. ( ) MONITOR ( ) 1005 INSP.

AQL 5 : ( ) 0.10 ( ) 0.15 ( ) 0.25 (0.40 (0.65

SAMPLE SIZE : ________ ACC/REJ : ____/____

PER (AQL)

REJECTED SLIDER ________

MPQRS ________

LOT DISP : ( )ACC (81AI (IRTV ((OTHER

MAGNIFICATION	DEFECT	NUMBER OF REJECTED SLIDER (QTY)
100X ABS Alumina and pole tip area	1. Crack on pole tip	
	2.Scratch on pole tip	
	3.	
	4.	
	5.	
30X All slider area	1.Breakaway	
	2.Chip	
	3.Contamination	
	4.Crack	
	5.Mix type slider	
	6.Scratch on ABS	
	7.Wrong wafer code	
	8.	
	9.	
	10.	
	11.	
	12.	
	13.	
	14.	
	TOTAL	

Figure B.3. Slider Inspection Result Form.

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