Chapter 4
Improvement of Incoming Inspection

This chapter discusses actions that have been taken as well as those planned to be taken in the future in order to improve effectiveness of the incoming inspection process.

Referred to Table 3.3 in chapter 3, it was concluded that the following areas should be improved to attain a better incoming inspection process.

1. **Specifications** – revising of the existing specifications to ensure correct characteristics critical to material quality are being focused and tested.
2. **Inspection and testing methods** – establishment of standardized procedures for materials inspection and testing based on the new set of specifications.
3. **Organization setting** – changing of the organization setting so that quality issues are managed more effectively.
4. **Equipment-** calibration and repair plan to ensure equipment is in good condition and purchasing of necessary equipment.
5. **People-** Inspectors, purchaser and other users of incoming materials and their specifications must be trained and educated to understand materials' properties and specifications.

4.1 Review and modification of the existing specifications

A task force consisting of representatives from these departments was set up to improve the material specifications.

1. R&D: Manager and one lab scientist
2. Production: Production Manager and one senior supervisor
3. Purchasing: Purchasing Manager and the raw material purchaser

The Factory Manager acted as the adviser for this project. We will refer to this working group as "the Team" later throughout this chapter.

The existing specifications were examined in details and modification was made to attain a new set of specifications with the following qualities.

1. Reasonable specifications that are relevant to the ultimate product requirements, or specification that are set up with full understanding of the material properties and how these properties impact the final product and production process.
2. Specifications that can be understood by all departments concerned or affected by the specifications
3. Specifications that can be understood and followed by suppliers of choice.

4.2 Setting up appropriate testing and inspecting methods

After the issues of specification had been settled, the team went on to work out an inspection plan. This task was a collaboration of R&D, purchasing and production departments.

4.2.1 Quality Characteristics to be tested

The first step was to list out the quality characteristics to be tested or inspected These are characteristics that the Team deems most important for each kind of materials The characteristics selected for testing inspecting for each material are summarized in Table 4 1 together with supporting reasons.

4.2.1 Type of and Amount of Inspections to be Performed

Regarding the type of testing/ inspection and the amount of inspection to be performed for each material, the Team considered the following issues:

- Cost of Inspection (if all necessary equipments are ready for carrying out the inspections/ test)
- Ease of Inspection
- Damage and costs incurred for using substandard material

- Ease of detection for defects after material is received – it will not be possible to detect defects in some items after they enter production. These items, therefore, should receive more careful inspection at the receipt.

- Quality History of the Material - the amount of inspection necessary for each material also depends on its past history about quality. A long consistently good quality history normally justifies less amount of inspection.

Table 4.1 below summarized discussions on these issues.

Criteria	MMA	Masking Paper	Pigment/ Dye	Additives	Glass
Cost of Inspection	Very High (many chemical properties)	Low	High (a sample must be made for checking color shade)	Very High (many chemical properties)	Very High
Ease of Inspection	Difficult	Easy	Difficult	Difficult	Difficult
Cost incurred if unsatisfactory items are used	Very High (the whole lot will be defective, costing millions of Baht)	Medium (masking paper can be removed)	High	Medium (if found defective, production can stop using that material in other lots)	Very High (low quality glass will result in thousands of bad sheets throughout its useful life)
Ease of detecting defective items after passed to production	Very difficult	Easy	Difficult	Very Difficult	Very Difficult
Quality History	Very good	Poor	Poor	Very Good	Very Good
Readiness of Necessary Equipment	-	O.K.	O.K. (After purchasing the spectrophotometer)	-	-

Table 4.1 Considerations for the Type of Inspection

From Table 4.1, despite their critical importance and enormous effects if defective items are accepted and used, the company at the moment did not have the equipment necessary to carry out chemical testing for MMA, additives and complex testing of glass. In addition, these materials/ products have a very consistently good quality history showing very rare problems. As a result, for the sake of this initial inspection plan, the Team agreed to trust the information provided by the suppliers who have been proven to be trustworthy. Most of inspections for these materials thus rely on suppliers' Certificate of Analysis (COA) at this initial stage. However, the management will have to consider investing in some equipment for testing of some critical characteristics. This equipment issue is discussed in section 4.4.

4.3 New Organization Setting

The company has recruited a new manager to set up and take care of the QA department. The new organization chart is shown in Figure 4.1. This new organization chart was created based on work performed by each department rather than key people as the previous one.

The new QA department is divided into 3 subdivisions.

1. Incoming Material Quality Control: responsible for inspecting and controlling the quality of incoming materials from suppliers, also collaborates with R&D in setting up material specifications and testing methods.
2. Process Control: This subdivision is responsible for monitoring the process to ensure it is under control.
3. Finished Product Quality Control: the main task is to inspect finished products and keep records for reference and analysis for causes.

4.3.1 Responsibility and Authority of the new QA department

As pointed in chapter 3, one problem was that the authority and responsibility of QA department was not clear. We therefore tried to define clearly authority and responsibility for the newly set up QA department.

- **Responsibility**

1. Responsible for monitoring, and controlling quality of product and production process, keep record of nonconforming and actions taken to correct them.
2. Responsible for the setting specifications for purchased materials and products, as well as measuring/ testing equipments.
3. Responsible for collecting quality data and analyzing of these data to attain proper solution, and providing feedback on quality to suppliers.
4. Responsible for assessing sample of new products or sample lots from new suppliers.

- **Authority**

1. Has the authority to monitor, prevent, and correct nonconforming product and process, and keep those records.
2. Authorized to suggest the purchases of measuring and testing equipment within the approval of factory manager.
3. Authorized to stop the delivery of nonconforming products, and calling back of such items.

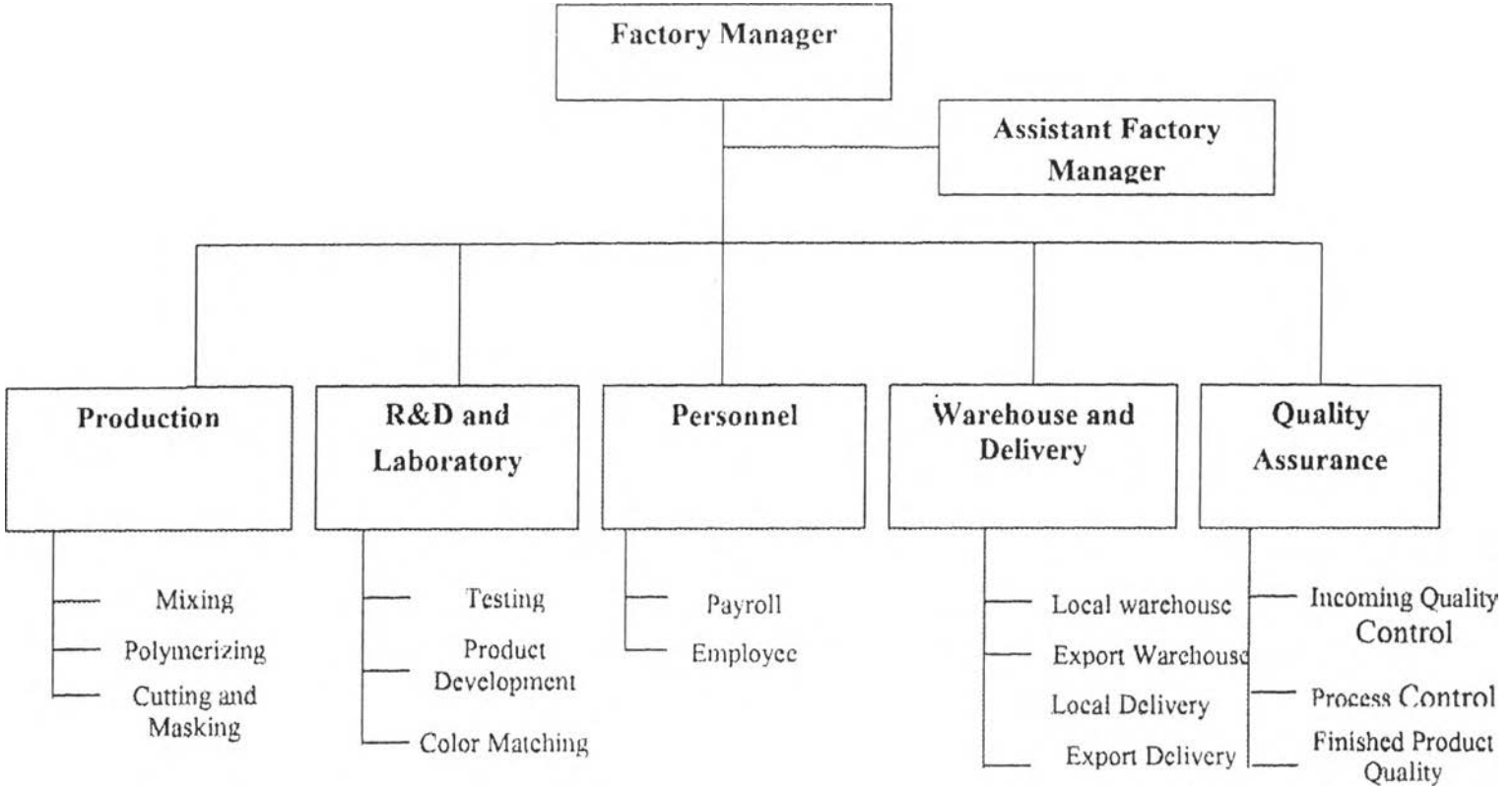

Figure 4.1 New organization chart after adding the new QA department

4.4 Equipment Maintenance and Purchasing of new equipment

Equipment must always be kept and maintained in good condition so that it can produce accurate and reliable result. As a result, a regular schedule for calibrating and checking equipment condition is needed.

In the new system, the history of each equipment such as the date of purchase, name of manufacturer must be recorded for reference. In addition, they have to be calibrated and checked regularly to ensure they are functioning properly. Repair history is also recorded.

Engineering department is responsible for calibrations / repair that can be done in-house. For those that cannot be fixed/ calibrated in-house, they will be sent to external certify calibrating companies. Certificate/ Report of calibration or repair will be kept for reference. Samples of forms used in keeping calibration/ repair record can be seen in Appendix B.

In addition to maintenance and calibration of existing equipment, R&D together with QC have also worked out a proposal for purchase of some equipments that are probably useful to the improvement of inspection efficiency. These are as follows:

1. **Spectrophotometer** – This is equipment used to measure color accurately. The machine measures a color and express it in numbers representing the color value and brightness. In short, it can provide an accurate, numerical assessment of a color, the quality that cannot be attained by eyes. The management has agreed and approved purchase of such equipment since January 2002.

2. **Digital thickness gauge** – A digital thickness gauge is suggested to be bought in for use in measuring glass thickness which is crucial to the surface properties of the final acrylic sheets.

3. **Lab Oven**: In testing the properties of additives and catalysts, a sample standard sheet has to be made using these materials required to be tested. In order to really perceive the effect of these materials, other factors other than materials must be kept constant. However, under current practice without a good lab oven, after the mixture

of MMA and additives are ready, the lab people will put the mixture in the same oven that is used in actual production. The problem is the temperature in this main oven is not constant, rather adjusted all the time to suit sheets for different thicknesses, adding another variable to the test. For more accurate test result, the company thus needs to purchase a new quality oven for use in the lab.

A proposal for purchasing new equipment was submitted to the management and is waiting for approval. Below shows rough estimates for the price of these sets of equipment.

Equipment	Usage	Price range (Baht)
Digital Thickness gauge	Measure thickness of Glass/ paper	50,000-100,000
Lab Oven	For making sample Sheet to test effects of additives	100,000-200,000

4.5 Educating and Training personnel

The new system acknowledges the development of people's knowledge and skill as vital to overall performance. To increase the effectiveness of inspection process, it is therefore necessary to raise the standard of our inspectors/ supervisors.

The job to educate/ train inspectors and supervisors are assigned to QC/ R&D departments. Every new inspector must undergo formal training for a period of time and pass a test before being allowed to start working. Working inspectors also have to be periodically tested and updated with new knowledge as well as testing techniques. The purchaser, as the person who frequently uses the specifications in communicating with suppliers, must also attend the training to ensure correct understanding.

Sample sheets for training record of employees can be seen in Appendix B. A training program is set up to provide inspectors with necessary knowledge to conduct

testing and inspection correctly. The training program is designed and organized jointly by the R&D and QC departments.

Following topics are included in the training program.

1. Basic knowledge about acrylic sheet and its properties.
2. Explanation about manufacturing process
3. Importance of quality and its impact on the company's profitability.
4. Importance of inspection as a means to support product quality
5. Inspection method for each key raw material.

After completing the training session, the employee must attend an examination to assess their learning. The result from assessment will be included in the employer's file for reference.

4.6 The Inspection Plan for Initial Stage

After the inspection methods to be used and the amount of inspection had been considered as discussed in section 4.2, the inspection plan was created as shown in Table 4.3. The inspection method, inspection frequency, responsible persons as well as equipment to be used are shown in the table. It should be noted that this inspection plan was the first to be created in this organization thus is subjected to future change or modification to be more appropriate. The inspection plan for each type of material may be tightened or reduced in the future according to QA manager's judgment based on established quality history of that material obtained after the new evaluation system has been used for a certain period of time.

Material Type	Function	Properties to be tested/ inspected	Reason
MMA	Main raw material (monomer)	1. Color 2. Purity 3. Water Content 4. Inhibitor	1. Pure MMA must be colorless 2. Affects quality of the sheet 3. Causes defects 4. Affects the process time
Pigment (Paste)	Adds color to acrylic sheet	Mixing of pigment and solvent Color shade	The pigment must be thoroughly mixed Affects color of the final sheet
Pigment (Powder)	Adds color to acrylic sheet	1. Color. appearance 2. Color shade	Must be in good condition Affects color of the final sheet
Masking Paper	Protects acrylic sheet against scratches	1. Width 2. Texture 3. Weight per sq.m.	1. Check size 2. Compare to ordered type 3. Check density and approximate thickness
UV-absorber	Absorbs UV to protect the sheet against photo-degradation	1. Melting Point 2. Insolubility	1. This is a way to check whether there is filled material or contamination 2. The material must be well dissolved to take effect
DOP	Acts as plasticizer	1. Specific gravity 2. Purity 3. Moisture 4. Color	1. To check the content of material 2. Purity affects sheet quality 3. Moisture can cause defects 4. Affects sheet color
ABNR	Acts as process initiator for sheet with 1.0-3.0 mm. thickness	1. Cleanliness 2. Effectiveness (by comparing time needed for sample sheet to solidity	1. Must contain no visible impurity 2. To ensure the material is still useable.
ABNV	Acts as process initiator for sheet with thickness over 3 mm.	1.Cleanliness 2. Effectiveness (by comparing time needed for sample sheet to solidify	1. Must contain no impurity 2. To ensure the material is still useable

Table 4.2 Material properties selected for inspection/ testing

Material	Property	Spec.	Testing Equipment	Inspection/ Testing Methods	Frequency	Responsible Person	Reaction Plan (In case of nonconformance)	Detailed Inspection Plan
MMA	Color	Must be colorless	-	Visual inspection	Take 1 kg. Sample from every incoming tanker	Receipt inspector	Inform QA manager	-
	Purity	>99%	-	Check COA	Every lot	Receipt inspector	Inform QA manger	
	Water Content	<0.01%	-	Check COA	Every lot	Receipt inspector	Inform QA manager	
	% Inhibitor	4-10 ppm	-	Check COA	Every lot	Receipt inspector	Inform QA manger	
	Conformance to COA	-	-	Send sample to be tested by recognized testing body	Every two months or requested by factory	Lab	Inform QA manager, Purchasing	
Pigment Paste	General appearance	Thoroughly mixed, no separation	-	Visual inspection	Every drum	Receipt Inspector	Inform QA manager	See Appendix C
	Color Deviation from agreed sample (dE)	DE< 0.8	Spectrophoto - meter	Make sample sheet using the incoming pigment then compare to standard sheet	Take sample from each color from the incoming lot	Lab	Inform QA manager and purchasing (to make claim or return)	
Pigment Powder/ Dye	General Appearance	Thoroughly mixed, no separation	-	Visual inspection	Every drum	Receipt inspector	Inform QA manager	See Appendix C
	dE	DE<0.4	Spectrophoto meter	Make sample sheet using the incoming powder/dye then compare to standard sheet	Take sample from each color from the incoming lot	Lab	Inform QA manager and purchasing (to make claim or return)	
Masking Paper	Width	Plus or minus 2% from P.O.	Standard tape, yardstick	Measure the width of paper roll	1 rolls for each carton (10 rolls)	Receipt inspector	100% inspection, reject those of wrong size.	See Appendix C

Table 4.3 Inspection Plan for Key Raw Materials

	Unit Weight	Plus or minus 4% from spec. (depending on paper type)	Digital balance	Measure the weight of 1piecie of 1 sq.m paper	Take 1 sq.m. sample from each carton	Receipt inspector	100% inspection, reject those of wrong size	See Appendix C
	Texture	Same as agreed sample	-	Compare to agreed sample	One roll every carton	Receipt inspector	Inform QA manager	
UV absorber	Melting Point	103-104.3 degree Celsius	-	Check COA	Every lot	Receipt inspector	Inform QA manager	-
DOP	% Insolubility	<0.04%	-	Check COA	Every lot	Receipt inspector	Inform QA manager	-
	Specific Gravity	0.99 plus or minus 0.01	-	Check COA	Every lot	Receipt inspector	Inform QA manager	
ABNR	Purity	>98%	-	Check COA	Every lot	Receipt inspector	Inform QA manager	See Appendix C
	Moisture	<0.04%	-	Check COA	Every lot	Receipt inspector	Inform QA manager	
	Color	Must be clear	-	Visual inspection	Every drum	Receipt inspector	Inform QA manager	
	Effectiveness	Standard 3 mm. sheet must be solidified with 3 hours plus or minus 10 minutes	Standard clock	Randomly take 40 g of ABNR from one lot for making a standard sheet.	40 g. per lot	Lab	Inform QA manager and purchasing (to make claim or return)	

Table 4.3 Inspection Plan for Key Raw Materials (Continued)

Material	Property	Spec.	Testing Equipment	Inspection/ Testing Methods	Frequency	Responsible Person	Reaction Plan (In case of nonconformance)	Detailed Inspection Plan
ABNV	Color	Must be clear	-	Visual inspection	Every drum	Receipt inspector	Inform QA manager	See Appendix C
	Impurity	No visible impurity	-	Visual inspection	Every drum	Receipt inspector	Inform QA manager	
	Effectiveness	Standard 3 mm. sheet must be solidified with 3 hours plus or minus 10 minutes	Standard clock	Randomly take 40 g of ABNR from one lot for making a standard sheet.	40 g. per lot	Lab	Inform QA manager and purchasing (to make claim or return)	

Table 4.3 Inspection Plan for Key Raw Materials (Continued)