

# On Upgrading the Industrial Standards of Rubber and Rubber Wood Products on par with International Standards

## Executive Summary



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Rubber and rubber wood product industries are important for Thailand's economy. They generate export income of more than 10 billion USD every year. The main factor supporting the export is Thailand's advantage as the raw material source of upstream natural rubber and rubber woods. In fact, Thailand ranks first as the world's producer of natural rubber. In 2010, Thailand produced approximately 3.25 million tons of natural rubber. Despite this fact, export is still mainly in the form of primary processed rubber amounting to 7,896.03 million USD or 86 percent of the total natural rubber production. The remaining 14 percent is the export of finished products amounting to 6,433.96 million USD. Moreover, rubber woods were exported as raw materials more than finished products. Therefore, if the rubber and rubber woods are increasingly used as raw materials to produce downstream products, the value added to the products and the income to the country will be greatly enhanced.

However, the rubber and rubber wood product industries in Thailand are not well developed because most producers are SMEs. Their manufacturing efficiency is low and they lack product testing standard. As a result, their product quality does not meet international standards. Furthermore, high negotiating powers are imposing non-tariff barriers such as Product Standard, Environment Standard, Sanitary Standard, etc. Therefore, it is necessary for Thai producers to recognize the importance of the development of product quality, upgrading of the product standards and manufacturing to increase competitiveness in the world market, and the development of network of rubber and rubber wood product standards in Thailand. In parallel, the government's support is needed for the accelerated standard definitions and testing standards and upgrading the standards of products and production so that the rubber and rubber wood products are competitive in the global market.

On Upgrading the Industrial Standards of Rubber and Rubber Wood Products on par with International Standards the Project focuses on the guidelines to define the standards of rubber and rubber wood products and to develop the management skills of the manufacturers. Office of Industrial Economics, Ministry of Industry, was allocated the budget in 2013 and Thailand Productivity Institute conducted the Project. The Project is divided into two main activities as follows:

Main activity 1: Study of guidelines to define standards of rubber and rubber wood products to support the product standard definitions by Thai Industrial Standards Institute (TISI).

Main activity 2: Enhancement of management ability to increase efficiency and productivity of the rubber and rubber wood products by following the Thailand Quality Award (TQA) guidelines for rubber and rubber wood product industry.

## MAIN ACTIVITY 1:

Study Of Guidelines To Define Standards Of Rubber And Rubber  
Wood Products To Support The Product Standard Definitions  
By Thai Industrial Standards Institute (TISI)

## ACTIVITY 1

### Study of Guidelines to Determine Industrial Standards for Rubber Products

This is a report on the project called “Study of Guidelines to Determine Industrial Standards for Rubber Products” and aims to support the determination of industrial standards of Thai Industrial Standards Institute (TISI).

#### **1. Introduction**

Rubber Industry is very important to the Thai economy. It contributes to export income of more than 10,000 million US\$ each year. The major factor supporting the export of the industry is Thailand’s strength as the source of raw material of natural rubber. Thailand ranks first in the world as the natural rubber producer. In 2010, Thailand produced 3.25 million tons of rubber. However, 86% of natural rubber is exported as primary products, amounting to 7,896.03 million US\$. The remaining 14% is exported as secondary products but with export income about 6,433.96 US\$, which is almost the same amount as the primary products. Therefore, with the increased use of natural rubber in the production of downstream products, it will substantially increase value added to the rubber products and income earning from export.

However, most rubber companies in Thailand are small and medium enterprises. Most of them use out-of-date technologies with no industrial standards to control the quality of their products. Thus, the quality of their products does not meet the international standards. At present, Thailand’s manufacturers of rubber products are facing with non-tariff barriers that they cannot negotiate such as industrial product standards, environmental standards, and health standards. From this point of view, it is vital to develop manufacturing processes and product quality of Thai rubber industry to meet international standards. This includes improvement and development of networking, industrial standards, and product testing. Consequently, Thailand’s rubber product industry can compete in the global market.

## 2. Study of Guidelines to Determine Industrial Standards for Rubber Product Industry

### 2.1 Primary information

#### 2.1.1 Criteria for selection of rubber products to study

A study of guidelines to determine industrial standards of rubber product industry started with collecting and analyzing information on economic issues from 2006 to 2012. This information was used as criteria for selection of rubber products. The criteria includes the products that are important to the economy such as export value, consumption of natural rubber used in production, and potential of other products (Figures 1 – 4, respectively).

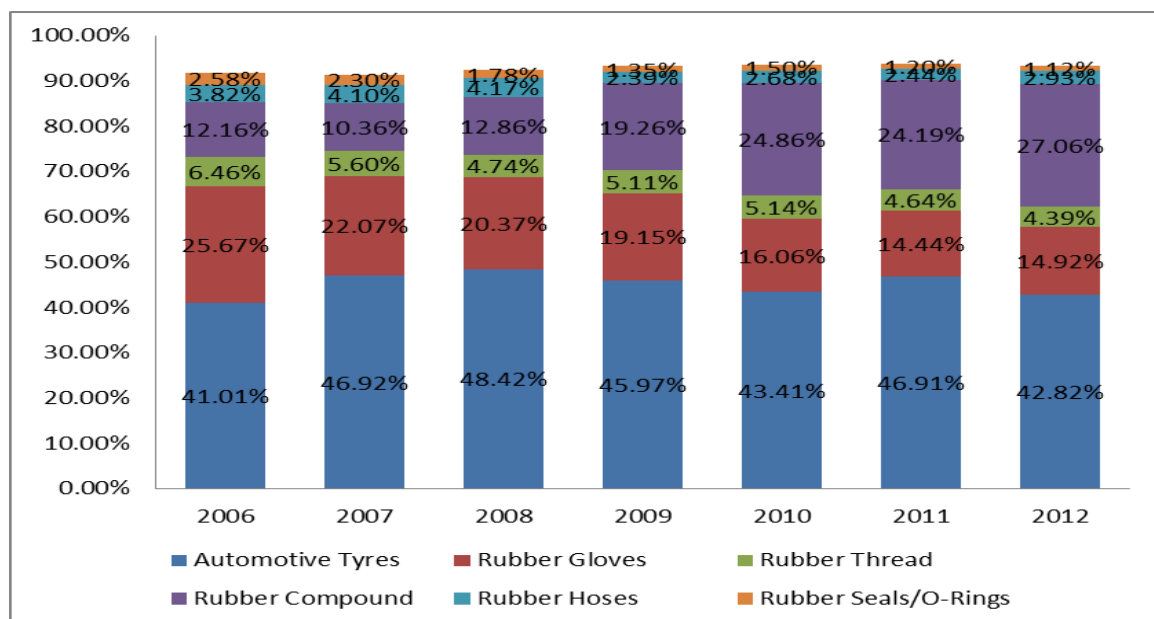


Figure 1 Rubber products with highest export incomes in sequence and combined export incomes of more than 80% of the total export incomes from 2006 – 2012 (excluding other rubber products)

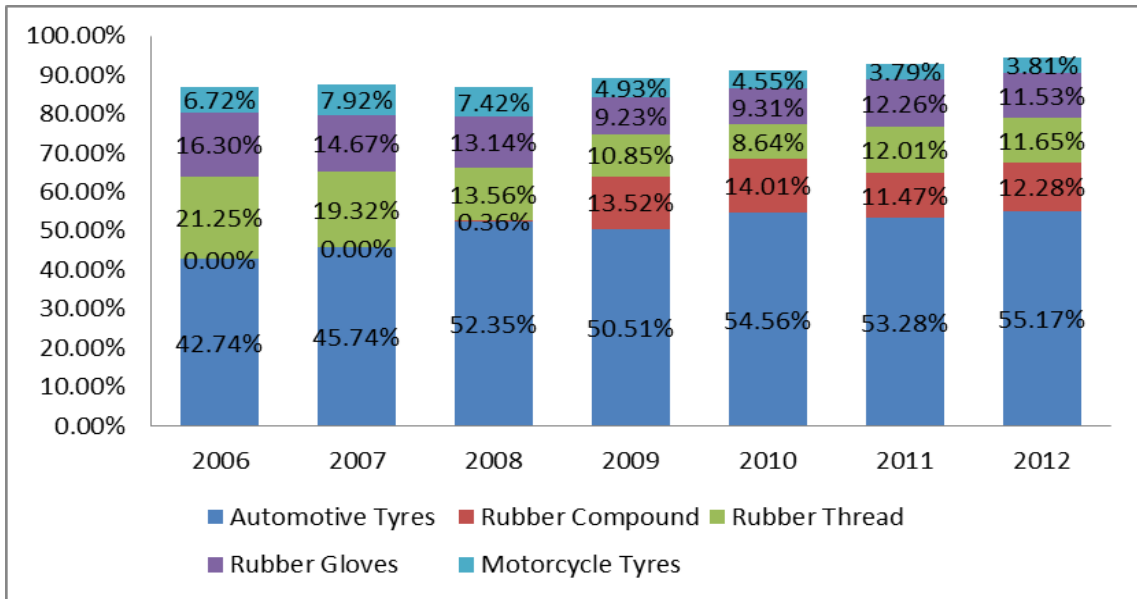


Figure 2 The top five rubber products with the highest consumption of natural rubber and the combined consumption of natural rubber of more than 80% of the total consumption of natural rubber in Thailand (Statistical data of the consumption of rubber compound was not collected by any organization between 2006 and 2007).

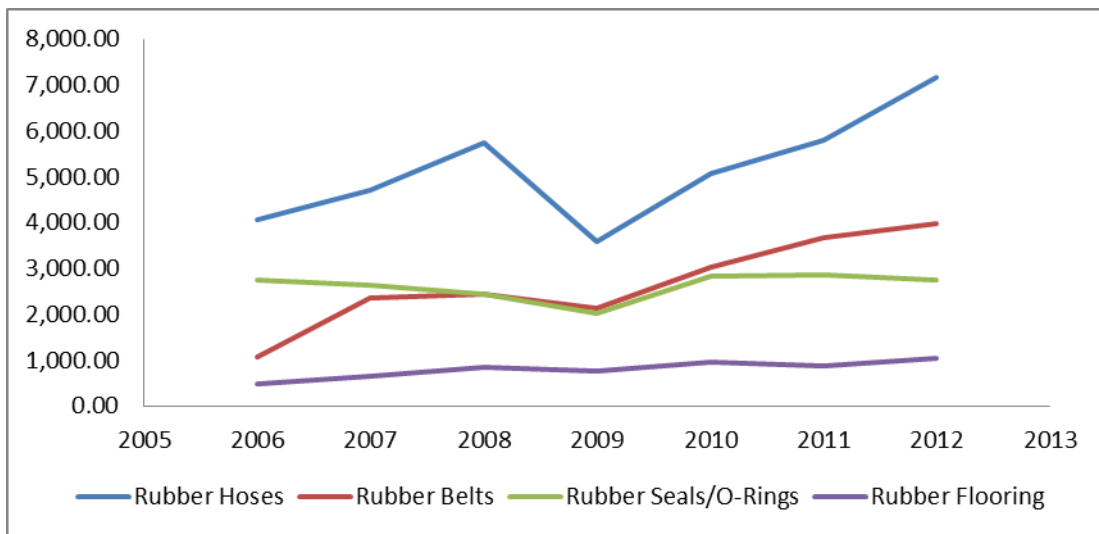


Figure 3 Growth trends of rubber products used in engineering and construction in terms of export incomes from 2006 – 2012 (Statistical data of other rubber products used in engineering and construction was not collected individually.)

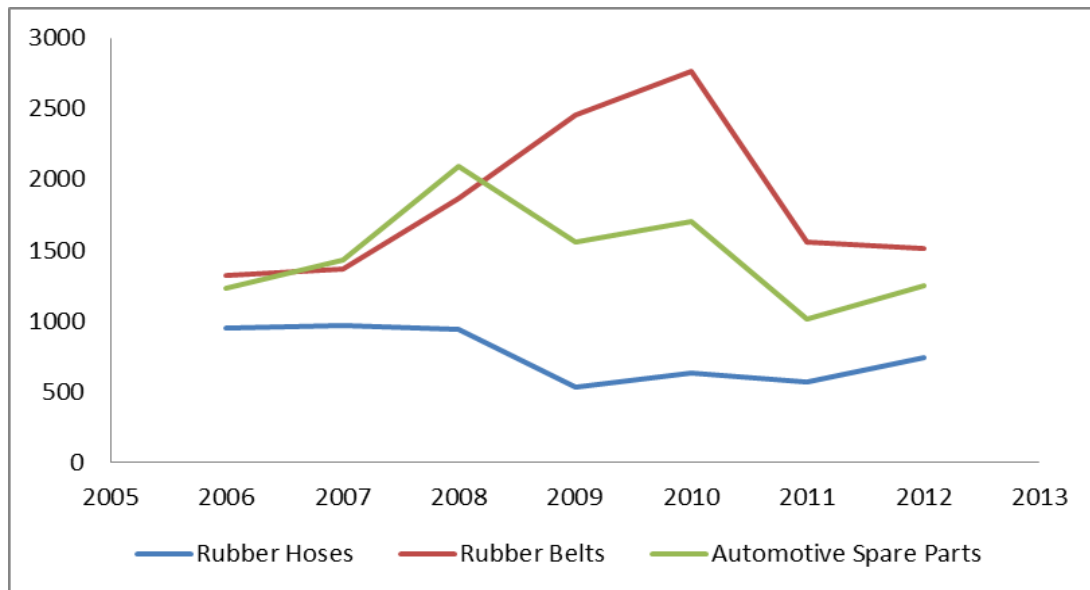


Figure 4 Growth trends of the consumption of natural rubber divided by the types of rubber products used in engineering and construction from 2006 – 2012 (Statistical data of other rubber products used in engineering and construction was not collected individually).

In addition to export incomes, consumption of natural rubber used to produce rubber products, and growth of rubber products used in engineering, the factors that need to take into account are environment impact and customer safety. For instance, the use of reclaimed rubber to produce rubber products can reduce wastes into environment. Therefore, if there are industrial standards to regulate the reclaimed rubber, the manufacturers will increasingly use reclaimed rubber to produce their products. This results in better environment.

Furthermore, it can be seen from Figures 1 and 2 that automotive tyres had the highest values regarding export incomes and quantities of natural rubber used to produce the products. Automotive tyres are the products that involve customer safety. For this reason, if industrial standards are regulated for automotive tyres, they will increase customer safety.

Therefore, in considering export incomes, quantities of natural rubber used to produce the products, growth opportunities, environmental and customer safety, there were nine rubber products that need to have industrial standards to be determined as the following:

- 1) Automotive tyres (outer tubes for automotive tyres, solid tyres, and retreaded tyres)
- 2) Inner tubes for automotive tyres
- 3) Rubber gloves
- 4) Rubber threads
- 5) Rubber compound



- 6) Rubber hoses
- 7) Rubber seals/O-rings
- 8) Rubber belts
- 9) Reclaimed rubber

## 2.1.2 Review of Thai Industrial Standards of Rubber Products

Thai Industrial Standards (TIS) of the nine selected rubber products were summarized in Table 1.

**Table 1 Thai industrial standard of the selected rubber products**

Product Type	Standard Number	Standard Name
Automotive tyres	TIS 367-2532	Automotive tyres
	TIS 682-2540	Motorcycle Tyres outer tubes
	TIS 571-2528	Bicycle Tyres outer tubes
Solid Tyres	-	
Retreaded Tyres	-	
Vehicle Inner Tubes	TIS 651-2535	Automotive Tyres inner tubes
	TIS 683-2530	Motorcycle Tyres inner tubes
	TIS 652-2532	Bicycle Tyres inner tubes
Rubber Gloves	TIS 1056-2548	Single-use medical examination gloves – Specification for gloves made from rubber latex or rubber solution
	TIS 538-2548	Single-use sterile rubber surgical gloves
	TIS 2476-2552	Household rubber gloves
	TIS 2505-2553	Rubber gloves for food industry
Rubber Threads	TIS 570-2528	Rubber threads
Rubber Compound	TIS 2478-2552	Rubber tread compound for hot(conventional) retreading of commercial automotive tyres
Rubber Hoses	TIS 642-2529	Rubber hoses for pressure systems
	TIS 658-2551	Rubber hoses and tubing for cooling systems for internal-combustion engines
	TIS 746-2551	Rubber hoses for water suction and supply
	TIS 839-2532	Hydraulic hoses and tubing for vehicles and motorcycles: rubber hoses
Rubber Belts	TIS 124-2518	Banded belt drives
	TIS 146-2536	V-belt drive
	TIS 147-2530	Conveyor belts
	TIS 811-2531	V-belt drives for vehicles
Rubber seals/O-rings	TIS 237 - 2520	Rubber ring for water pipes
Reclaimed rubber	-	

### 2.1.3 International Standards

International standards that involve the nine selected rubber products were investigated from trading partners of Thailand during 2006 – 2012. The top five trading partners of each rubber product and their international standards were shown in Table 2. This information was compared with TIS and then used to improve TIS or to draft new TIS for the rubber products that do not have any TIS regulations. In the case that the trading partners do not have industrial standards for any product, standards of the American Society of Testing Materials (ASTM), European standards or standards of the International Standard Organization (ISO) will be used for the comparison.

**Table 2 Trading partners of Thailand and their industrial standards for the nine selected rubber products**

Product Type	Trading Partners	Industrial Standards
Automotive tyres outer tubes	USA, Japan	FMVSS 109, New Pneumatic and Certain Specialty tires FMVSS 119, New Pneumatic Tires for Motor Vehicles with a GVWR of More Than 4536 kg FMVSS 139, New Pneumatic Radial Tires for Light Vehicles JIS D 4202/JIS D 4230, Automobile Tyres -- Designation and Dimensions JIS K 6366, Motorcycles Tyres JIS K 6302, Cycles -- Tyres ISO 10191, Passenger Car Tyres -- Verifying Tyre Capabilities -- Laboratory Test Methods ECE R30, Uniform Provisions Concerning the Approval of Pneumatic Tyres for Motor Vehicles and their Trailers ECE R75, Uniform Provisions Concerning the Approval of Pneumatic Tyres for Motor Cycles and Mopeds ECE R117, Uniform Provisions Concerning the Approval of Tyres with Regard to Rolling Sound Emissions and to Adhesion on Wet Surfaces and/or to Rolling Resistance EC R1222, The Labeling of Tyres with respect to Fuel Efficiency and other Essential Parameters
Solid Tyres	USA, Japan, Australia, Malaysia	N/A
Retreaded Tyres	Japan, Malaysia	JIS K 6329, Retreaded tyres MS 224, Specification for Retreading of Pneumatic

Product Type	Trading Partners	Industrial Standards
		Rubber Tyres for Passenger Car and Commercial Vehicles
Vehicle Inner tubes	Myanmar, Cambodia, Japan	JIS D 4231, Inner Tubes for Automobile Tyres JIS K 6367, Inner Tubes for Motorcycle Tyres JIS K 6304, Inner Tubes for Bicycles Tyres
Rubber Gloves	USA	ASTM D 4679-02, Standard Specification for Rubber General Purpose, Household or Beautician Gloves ASTM D3578-05, Standard Specification for Rubber Examination Gloves BS EN 455-1, Medical gloves for Single Use: Requirements and Testing for Freedom from Holes BS EN 455-2, Medical Gloves for Single Use: Requirements and Testing for Physical Properties BS EN 420, Protective Gloves: General Requirements and Test Methods ISO 10282, Single-Use Sterile Rubber Surgical Gloves – Specification
Rubber Thread	Vietnam, China, Hong Kong	BS 7141 part 5, Narrow fabrics Specification for woven elastic webbings containing natural rubber BS 7141 part 5, Narrow Fabrics Specification for Elastic Flat Braids Containing Natural Rubber
Rubber Compound	China	ISO 9026, Raw Rubber or Unvulcanized Compounds -- Determination of Green Strength ISO 9924-1, Rubber and Rubber Products -- Determination of the Composition of Vulcanizates and Uncured Compounds by Thermogravimetry -- Part 1: Butadiene, Ethylene-Propylene Copolymer and Terpolymer, Isobutene-Isoprene, Isoprene and Styrene-Butadiene Rubbers BS 1154, Natural Rubber Compounds. Specification BS 903 PART A62, Physical Testing of Rubber Part A62 Method for Determination of Green Strength of Raw Rubber of Unvulcanized Compounds BS 1154, Natural Rubber Compounds. Specification MS 1097, Rubber Tread Compound for Hot (Conventional) retreading of Passenger Car and Commercial Automotive tyres – Specification (Second Revision)
Rubber Hoses	USA, Japan	SAE J20, Coolant System Hoses JIS K 6338, Rubber Hoses for Water Suction JIS D 2601, Automotive Parts - Brake Hose Assemblies for Hydraulic Braking Systems Used with

Product Type	Trading Partners	Industrial Standards
		<p>Non-Petroleum-Base Brake Fluid</p> <p>JIS D 2602, Rubber - Coolant Hoses and Tubing for Use on Private Cars and Light Commercial Vehicles – Specification</p> <p>JIS B 8381, Pneumatic System -- Flexible Tubes -- Tube Fittings</p> <p>BS 2952, Specification for rubber hose for i. c. engine cooling systems</p> <p>BS EN 1765, Rubber Hose Assemblies for Oil Suction and Discharge Services: Specification for the Assemblies</p>
Rubber Belts	Singapore, Japan, Vietnam, Malaysia	<p>JIS K 6368, Narrow V-belts for Power Transmission</p> <p>JIS B 8808, Portable Belt Conveyors</p> <p>MS 774, Industrial V-Belts</p> <p>MS 475, Specification for Automotive V-Belt Drives</p> <p>BS 3790, Specification for Belt Drives. Endless Wedge Belts, Endless V-belts, Banded Wedge Belts, Banded V-belts and their Corresponding Pulleys</p> <p>BS ISO 9981, Belt Drives: Pulleys and V-ribbed Belts for the Automotive Industry, PK Profile, Dimensions</p> <p>BS ISO 9982, Belt Drives: Pulleys and V-ribbed Belts for Industrial Applications, PH, PJ, PK, PL and PM Profiles, Dimensions</p>
Rubber Seals/O-rings	Japan, Singapore, USA	<p>JIS B 2401, Standard O-ring Size</p> <p>BS 7417, Specification for Interface Dimensions of Flat Face 'O'-ring Seal Hydraulic Couplings</p> <p>ISO 3601-1, Fluid Power Systems -- O-rings -- Part 1: Inside Diameters, Cross-sections, Tolerances and Designation Codes</p> <p>ISO 3601-3, Fluid Power Systems — O-rings — Part 3: Quality Acceptance Criteria</p> <p>ISO 3601-4, Fluid Power Systems -- O-rings -- Part 4: Anti-extrusion Rings (back-up rings)</p>
Reclaimed Rubber	Malaysia, China, Vietnam	<p>JIS K 6313, Reclaimed Rubbers</p> <p>IS 6306, Methods of Test for Reclaimed Rubber PCD 13: Rubber and Rubber Products</p>

Remark: As Singapore, Hong Kong, China, Cambodia, Vietnam and Myanmar do not have their own standards for the selected rubber products, ISO, BS, or JIS were used.

### 2.1.4 Manufacturer Survey

Manufacturer survey was done by using questionnaires, interviews and meeting with the manufacturers producing the selected rubber products. The meeting was held on 22 August 2013 at Golden City Hotel, Rayong province. Information getting from the manufacturer survey was industrial standards that the manufactures used for selling their rubber products locally and abroad, the problems they were facing, the recommendations they proposed and their readiness.

Based on the manufacturer survey, it can be concluded that all manufacturers are ready to follow the TIS, trading partners' standards and international standards with the exception of tyre manufacturers as there are no laboratories ready for testing automotive tyres following the UN/ECE R117 and UN/ECE R1222.

### 2.1.5 Thai Industrial Standards Compared with International Standards

Thai industrial standards were compared with international standards in terms of testing and technical knowledge about the standards. The comparison informed us the differences between those standards that could be used as guidelines for improving TIS or drafting new TIS in order to regulate the selected rubber products. As a result of this, TIS will be comparable to international standards. This helps rubber manufacturers to improve their manufacturing processes and product qualities to overcome trade barriers.

### 2.1.6 Laboratory Readiness

Laboratory Readiness was shown in Table 3.

**Table 3 Laboratory readiness for TIS and international standards**

Product Type	Standard Number	Standard Name	Laboratory available
Automotive tyres Outer Tubes	TIS 367-2532	Automotive tyres	Tyre Test Laboratory, Mahidol University (Salaya campus); Thailand Automotive Institute
	TIS 682-2540	Motorcycle Tyres	Tyre Test Laboratory, Mahidol University (Salaya campus); Thailand Automotive Institute
	TIS 571-2528	Bicycle Tyres	Tyre Test Laboratory, Mahidol University (Salaya campus) *Endurance test needs provision of additional rim standard
	FMVSS109	New Pneumatic and Certain Specialty tyres	Tyre Test Laboratory, Mahidol University (Salaya campus)

Product Type	Standard Number	Standard Name	Laboratory available
	FMVSS 119	New Pneumatic Tires for Motor Vehicles with a GVWR of More Than 4,536 kg	Tyre Test Laboratory, Mahidol University (Salaya campus)
	FMVSS139	New Pneumatic Radial Tires for Light Vehicles	Tyre Test Laboratory, Mahidol University (Salaya campus)
	JIS D 4202/JIS D 4230	Automobile Tyres -- Designation and Dimensions	Tyre Test Laboratory, Mahidol University (Salaya campus)
	JIS K 6366	Motorcycles Tyres	Tyre Test Laboratory, Mahidol University (Salaya campus)
	JIS K 6302	Cycles -- Tyres	Tyre Test Laboratory, Mahidol University (Salaya campus) *Endurance test needs provision of additional rim standards *Bead unseating resistance test needs special load block
	ISO 10191	Passenger Car Tyres -- Verifying Tyre Capabilities -- Laboratory Test Methods	Tyre Test Laboratory, Mahidol University (Salaya campus)
	ECE R30	Uniform Provisions Concerning the Approval of Pneumatic Tyres for Motor Vehicles and their Trailers	Tyre Test Laboratory, Mahidol University (Salaya campus)
	ECE R75	Uniform Provisions Concerning the Approval of Pneumatic Tyres for Motor Cycles and Mopeds	Tyre Test Laboratory, Mahidol University (Salaya campus)
	ECE R117	Uniform Provisions Concerning the Approval of Tyres with Regard to Rolling Sound Emissions and to Adhesion on Wet Surfaces and/or to Rolling Resistance	N/A *Needs standard test track (ISO 10844) and equipments for rolling sound emissions and adhesion on wet surface test
	EC R1222	The Labeling of Tyres with respect to Fuel Efficiency and other Essential Parameters	N/A *Needs standard test track (ISO 10844) and equipments for rolling sound emissions and adhesion on wet surface test

Product Type	Standard Number	Standard Name	Laboratory available
Retreaded tyres	JIS K 6329	Retreaded tyres	N/A
	MS 224	Specification for Retreading of Pneumatic Rubber Tyres for Passenger Car and Commercial Vehicles	N/A
Vehicle Inner tubes	TIS 651-2535	Automotive rubber inner tubes	Technical Service at MTEC; Technical Service at Mahidol University (Salaya campus) *Mechanical testing only
	TIS 683-2530	Motorcycle rubber inner tubes	Technical Service at Mahidol University (Salaya campus); Thailand Automotive Institute *Mechanical testing only
	TIS 652-2532	Bicycle rubber inner tubes	Technical Service at MTEC; Technical Service at Mahidol University (Salaya campus) *Mechanical testing only
	JIS D 4231	Inner Tubes for Automobile Tires	Technical Service at MTEC; Technical Service at Mahidol University (Salaya campus) *Mechanical testing only
	JIS K 6367	Inner Tubes for Motorcycle Tires	Technical Service at MTEC; Technical Service at Mahidol University (Salaya campus) *Mechanical testing only
	JIS K 6304	Inner Tubes for Bicycles Tyres	Technical Service at MTEC; Technical Service at Mahidol University (Salaya campus) *Mechanical testing only
Solid Tyres	TIS (draft)	Solid Tyres	Tyre Test Laboratory, Mahidol University (Salaya campus)
Rubber Gloves	TIS 1056-2548	Single-use medical examination gloves – Specification for gloves made from rubber latex or rubber solution	Department of Science Service (except sterile test); Department of Medical Service
	TIS 538-2548	Single-use sterile rubber surgical gloves	Department of Science Service (except sterile test); Department of Medical Service
	TIS 2476-2552	Household rubber gloves	Department of Science Service; Department of Medical Service

Product Type	Standard Number	Standard Name	Laboratory available
	TIS 2505-2553	Rubber gloves for food industry	Department of Science Service; Department of Medical Service
	ASTM D 4679-02	Standard Specification for Rubber General Purpose, Household or Beautician Gloves	Department of Science Service; Department of Medical Service
	ASTM D3578-05	Standard Specification for Rubber Examination Gloves	Department of Science Service; Department of Medical Service
	BS EN 455-1	Medical gloves for Single Use: Requirements and Testing for Freedom from Holes	Department of Science Service; Department of Medical Service
	BS EN 455-2	Medical Gloves for Single Use: Requirements and Testing for Physical Properties	Department of Science Service; Department of Medical Service
	BS EN 420	Protective Gloves: General Requirements and Test Methods	N/A
	ISO 10282	Single-Use Sterile Rubber Surgical Gloves – Specification	Department of Science Service (except sterile test); Department of Medical Service
Rubber thread	TIS 570-2528	Rubber thread	Department of Science Service
	BS 7141 part 4	Narrow fabrics Specification for woven elastic webbings containing natural rubber	Department of Science Service (except mass per unit area which can be tested at Thailand Automotive Institute; Rubber count is not found to be tested at any laboratory)
	BS 7141 part 5	Narrow Fabrics Specification for Elastic Flat Braids Containing Natural Rubber	Department of Science Service (except mass per unit area which can tested at Thailand Automotive Institute; Rubber count is not found to be tested at any laboratory)
Rubber Compound	TIS 2478-2552	Rubber tread compound for hot(conventional) retreading of commercial automotive tyres	Department of Science Service; Technical Service at Mahidol University (Salaya campus)
	ISO 9026	Raw Rubber or Unvulcanized Compounds - - Determination of Green	Department of Science Service; Technical Service at Mahidol University (Salaya campus) (except



Product Type	Standard Number	Standard Name	Laboratory available
		Strength	IRDH hardness test)
	ISO 9924-1	Rubber and Rubber Products -- Determination of the Composition of Vulcanizates and Uncured Compounds by Thermogravimetry -- Part 1: Butadiene, Ethylene-Propylene Copolymer and Terpolymer, Isobutene-Isoprene, Isoprene and Styrene-Butadiene Rubbers	Department of Science Service; Technical Service at Mahidol University (Salaya campus)
	BS 1155	Natural rubber compounds for extrusion. Specification	Department of Science Service; Technical Service at Mahidol University (Salaya campus)
	BS 903 PART A62	Physical Testing of Rubber Part A62 Method for Determination of Green Strength of Raw Rubber of Unvulcanized Compounds	Department of Science Service; Technical Service at Mahidol University (Salaya campus)
	BS 1154	Natural Rubber Compounds. Specification	Department of Science Service; Technical Service at Mahidol University (Salaya campus) (except IRDH hardness test)
	MS 1097	Rubber Tread Compound for Hot (Conventional) retreading of Passenger Car and Commercial Automotive tyres – Specification (Second Revision)	Department of Science Service; Technical Service at Mahidol University (Salaya campus)
Rubber Hoses	TIS 642-2529	Rubber hoses for pressure system	Department of Science Service
	TIS 658-2551	Rubber hoses and tubing for cooling systems for internal-combustion engines	Department of Science Service
	TIS 746-2551	Rubber hoses for water suction and supply	Department of Science Service
	TIS 839-2532	Hydraulic hoses and tubing for vehicles and	Department of Science Service

Product Type	Standard Number	Standard Name	Laboratory available
		motorcycles: rubber hoses	
	SAE J20	Coolant System Hoses	N/A
	JIS K 6338	Rubber Hoses for Water Suction	Department of Science Service
	JIS D 2601	Automotive Parts - Brake Hose Assemblies for Hydraulic Braking Systems Used with Non-Petroleum-Base Brake Fluid	Department of Science Service
	JIS D 2602	Rubber - Coolant Hoses and Tubing for Use on Private Cars and Light Commercial Vehicles – Specification	Department of Science Service
	JIS B 8381	Pneumatic System -- Flexible Tubes -- Tube Fittings	Department of Science Service
	BS EN 1765	Rubber Hose Assemblies for Oil Suction and Discharge Services: Specification for the Assemblies	N/A
	BS 2952	Specification for rubber hose for i. c. engine cooling systems	N/A
Rubber Belts	TIS 124-2518	Banded belt drives	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	TIS 146-2536	V-belt drives	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	TIS 147-2530	Conveyor belts	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	TIS 811-2531	V-belt drives for vehicles	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)

Product Type	Standard Number	Standard Name	Laboratory available
	JIS K 6368	Narrow V-belts for Power Transmission	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	JIS B 8808	JIS B 8808, Portable Belt Conveyors	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	MS 774	Industrial V-Belts	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	MS 475	Specification for Automotive V-Belt Drives	Department of Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	BS 3790	Specification for Belt Drives. Endless Wedge Belts, Endless V-belts, Banded Wedge Belts, Banded V-belts and their Corresponding Pulleys	Department Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	BS ISO 9981	Belt Drives: Pulleys and V-ribbed Belts for the Automotive Industry, PK Profile, Dimensions	Department Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
	BS ISO 9982	Belt Drives: Pulleys and V-ribbed Belts for Industrial Applications, PH, PJ, PK, PL and PM Profiles, Dimensions	Department Science Service; Technical Service at Mahidol University (Salaya campus); Technical Service (MTEC)
Rubber Seals/O-rings	TIS 237 - 2552	Runner ring for water pipes	Department of Science Service
	JIS B 2401	Standard O-ring Size	N/A
	BS 7417	Specification for Interface Dimensions of Flat Face 'O'-ring Seal Hydraulic Couplings	Department of Science Service
	ISO 3601-1	Fluid Power Systems -- O-rings -- Part 1: Inside Diameters, Cross-sections, Tolerances and Designation	Department of Science Service

Product Type	Standard Number	Standard Name	Laboratory available
		Codes (DIAMETER, CROSECTION, TOLERANCE)	
	ISO 3601-3	Fluid Power Systems — O-rings — Part 3: Quality Acceptance Criteria	Department of Science Service
	ISO 3601-4	Fluid Power Systems -- O-rings -- Part 4: Anti-extrusion Rings (back-up rings)	Department of Science Service
Reclaimed rubber	JIS K 6313	Reclaimed Rubber	Department of Science Service; Technical Service at Mahidol University (Salaya campus)
	IS 6306	Methods of Test for Reclaimed Rubber PCD 13: Rubber and Rubber Products	Department of Science Service; Technical Service at Mahidol University (Salaya campus)

### 2.1.7 Advantages and Disadvantages

Improvement of TIS of rubber products to be comparable to international standards will increase customer confidence so that export incomes will be boosted and trade barriers will be overcome. However, the improvement must be done with high consideration of manufacturer and laboratory readiness. Some TIS can be improved instantly because manufacturers and laboratories are ready to follow the standards such as standards for solid tyres and retreaded tyres. On the contrary, some standards need longer time to regulate because unreadiness of manufacturers and laboratories, for example, TIS following UN/ECE R117 and TIS following UN/ECE R1222 standards. These standards involve regulation of tyre rolling resistance, tyre noise and tyre wet grip. If the standards are immediately enforced, most Thai tyre manufacturers will be unable to manufacture their tyres to meet specifications of the standards. They also have to apply their products to be tested abroad for standard certification. Therefore, possibility of tyre standard development is to meet with tyre manufacturers and laboratory representatives to find out what they need to meet the standard specifications such as basic knowledge, equipment, technicians, and duration. Then, TIS following UN/ECE R117 and UN/ECE R1222 can be developed in suitable time period.

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## 2.2 Determination of Industrial Standards for Rubber Products

Based on export incomes, the quantities of natural rubber used to produce the products and growth opportunities were considered altogether, the rubber products urgently needed to improve or develop their industrial standards were automotive tyres, solid tyres, retreaded tyres, and rubber gloves. They contributed to the export incomes equal to 64.02% of the total export incomes of rubber products and used natural rubber equal to 62.97% of the total natural rubber used to produce rubber products.

For rubber hoses, even though the export incomes continued to increase, they were not considered as the urgent products to improve or develop their industrial standards. Their average export income was very low. It was equal to 3.22% (5,160,724 million baht) of the total export incomes of rubber products. Furthermore, the natural rubber used to produce these products decreased gradually.

For rubber compound, it contributed to the export incomes nearly equal to that of rubber gloves. Export incomes of rubber compound and rubber gloves were 18.67% and 18.95% respectively of the total export incomes of rubber products. However, rubber compound is a low-valued product compared with rubber gloves (Sectoral Industrial Policy 2, Office of Industrial Economics, “Technology and Market: alternatives to intervene in rubber”). From this point of view, rubber compound was not considered as an urgent product needed to improve or develop its industrial standards.

For rubber threads, although in average they used natural rubber to produce them more than rubber gloves did, they contributed 4-time less export incomes than that of rubber gloves. Therefore, rubber threads were not considered urgent for industrial standard improvement or development.

In addition, rubber threads, rubber belts and rubber seals/O-rings were not considered as urgent products to improve or develop their industrial standards because their export incomes and the quantities of natural rubber used to produce them were very low. The average export incomes of rubber threads, rubber belts and rubber seals/O-rings were 5.15% (8,423.839 million baht), 1.57% (2,661.61 million baht), and 1.69% (2,614.331 million baht) respectively of the total export incomes of rubber products. The average quantities of natural rubber used to produce rubber threads and rubber belts were 13.18% (60,540 metric tons) and 0.40% (1,834 metric tons) respectively of the total quantities of natural rubber used to produce rubber products. In case of rubber seals/O-rings, there was no statistical information of quantities of natural rubber used to produce them. Therefore, the urgent products needed to improve or develop their industrial standards were automotive tyres, retreaded tyres, solid tyres, and rubber gloves as shown in Table 4.

**Table 4 Rubber products needed to improve or develop their industrial standards (arranging from high to low importance according to export incomes, quantities of natural rubber used to produce rubber products and growth opportunities)**

Order	Product Types	Additional consideration
1	Automotive tyres	Need TIS following UN/ECE R117 and R1222 of European standards
2	Retreaded tyres	No TIS regulated
3	Solid tyres	No TIS and international standards regulated
4	Rubber Gloves	Rubber Gloves are higher value-added products compared with rubber compound (Sectoral Industrial Policy 2, Office of Industrial Economics)

When concerning environmental impact and customer safety, reclaimed rubber and automotive inner tubes were considered. As tubeless tyre technologies increase rapidly, the use of tyre inner tubes tend to decrease. Therefore, automotive inner tubes were not urgent products to improve or develop their industrial standards.

However, it is very important to develop industrial standards for reclaimed rubber. As reclaimed rubber is cheaper than virgin rubber, most manufacturers prefer to mix it with virgin rubber in order to reduce their cost of materials. Reclaimed rubber is made from different kinds of rubber products such as natural rubber products and synthetic rubber products. In addition, mechanical properties and chemical contents in reclaimed rubber are very different, such as tensile strength, elasticity, carbon black content, %PAH and volatile contents. These affect final properties of rubber products that made from reclaimed rubber. As a result, development of industrial standards for reclaimed rubber, for example, rubber types, mechanical properties and quantities of chemical contents, will aid manufacturers to better select appropriate reclaimed rubber for their products. They can control the types and quantities of reclaimed rubber used to produce their products so that their product properties can meet the specifications of standards. This will promote using reclaimed rubber to reduce cost of materials and also to reduce rubber waste into environment as unused rubber products can be recycled to produce reclaimed rubber.

In conclusion, when the criteria were export incomes, the quantities of natural rubber used to produce rubber products, growth opportunities, environmental concern and customer safety, rubber products needed to improve and develop their industrial standards were:

- 1) Automotive tyres
- 2) Retreaded tyres
- 3) Solid tyres
- 4) Rubber gloves
- 5) Reclaimed rubber

The important issues have to be determined to improve or develop industrial standards for the rubber products were shown in Table 5.

**Table 5 Important issues have to be determined to improve or develop industrial standards of rubber products**

Product Type	Test Issue	Standard Values	Referent Standard
Automotive Tyres	% PAH	See Table 2.9 of Appendix 2	EU REACH Annex XVII
	Performance at low inflation pressure	After test, inflation pressure must not less than 95% of the initial inflation pressure	FMVSS 139
	Rolling Resistance	See Table 2.1 of Appendix 2	UN/ECE R117
	Noise	See Table 2.2 – 2.4 of Appendix 2	UN/ECE R117
	Wet Grip	See Table 2.5 of Appendix 2	UN/ECE R117
	Labeling	See Table 2.6 – 2.8 of Appendix 2	UN/ECE R1222
Retreaded Tyres	% PAH	See Table 2.9 of Appendix 2	EU REACH Annex XVII
	Carcass examination	See Table 2.12 – 2.14 of Appendix 2	MS 224:1983
	Retreaded tyre process	1. Buffing: clean, no impurity, no unacceptable defects after buffing 2. Cementing: spray with cement solution not more than 8 hours after finishing buffing process and no impurity after cementing 3. Building: tread rubber must be of crown, base and gauge dimensions as required in which the tyre is to be cured and shall provide a minimum of 1.587 mm undertread in the case of uncured tread retreading. 4. Curing: cure the uncured retreaded tyre after building process at appropriate temperature, pressure and duration by using mold for hot retreading or bladder for cold retreading	MS 224:1983
	Defect examination	No pile separation and trapped air (examine when the tyre still in hot condition)	MS 224:1983
	Performance test	No defects after performance test under load, inflation pressure, temperature and duration (depending on tyre types and sizes)	TIS 367

Product Type	Test Issue	Standard Values	Referent Standard
	Tensile strength (tread)	Tread must have tensile strength not less than 11.8 MPa	JIS K 6329
	Elongation (tread)	Tread must have elongation not less than 300%	JIS K 6329
	Peel Strength	Tread must have peel strength not less than 3.2 N/mm Carcass must have peel strength not less than 3.2 N/mm	JIS K 6329
	Marking	1. "RETREAD" at sidewall 2. manufacture date (month and year) and trade mark or company name	MS 224:1983 JIS K 6329
Solid Tyres	% PAH	See Table 2.9 of Appendix 2	EU REACH Annex XVII
	Endurance Test	No defect after endurance test with 100% maximum load at speed of 10 km/hr for 90 minutes	-
	Marking or labeling	Size Product code / Manufacture date Tread ware indicator Manufacturer name / company name	-
Rubber Gloves			
Single-use sterile rubber surgical gloves	Protein Content	50 $\mu\text{g}/\text{dm}^2$	EN 455-3
Rubber gloves for food industry	RoHS	Cd not more than 0.01% w/w Pb, Hg, Cr6+, PBB, PBDE not more than 0.1% w/w	Restriction of Hazardous Substances Directive 2002/95/EC
Protective gloves against chemicals and micro-organisms	Liquid Proof	Liquid Permeation not more than 1/2 of the thickness of the glove at the thinnest area	BS EN 374-1
	Penetration	No chemical leak	
	Permeation	Chemical Permeation from one side to the other not less than 30 min (Level 2)	
	Abrasion (cycle)	Level 0 > 100 Level 1 =100 Level 2 =500 Level 3 =2000	BS EN 388



Product Type	Test Issue	Standard Values	Referent Standard
		Level 4 =8000 Level 5 = -	
	Cut resistance (factor)	Level 0 < 1.2 Level 1 = 1.2 Level 2 = 2.5 Level 3 = 5 Level 4 = 10 Level 5 = 20	
	Tearing resistance (Newton)	Level 0 < 10 Level 1 = 10 Level 2 = 25 Level 3 = 50 Level 4 = 75 Level 5 = -	
	Puncture resistance (Newton)	Level 0 < 20 Level 1 = 20 Level 2 = 60 Level 3 = 100 Level 4 = 150 Level 5 = -	
Reclaimed rubber	% PAH	See Table 2.9 of Appendix 2	EU REACH Annex XVII
	Specific Gravity (g/cm <sup>3</sup> )	AN = 1.20 max AI = 1.20 max BT = 1.18 max BP = 1.25 max C1 = 1.35 max C2 = 1.55 max	JIS K 6313 AN = reclaim rubber made from natural rubber inner tubes AI = reclaim rubber made from IIR inner tubes BT = reclaim rubber made from truck or bus tyres BP = reclaim rubber made from passenger car tyres C1 = reclaim rubber made from other rubber products (Grade A) C2 = reclaim rubber made from other rubber products
	Mooney Viscosity	AN = 50 max AI = 80 max BT = 70 max BP = 70 max C1 = 80 max C2 = 80 max	
	Ash Content (%)	AN = 20 max AI = 15 max BT = 15 max BP = 20 max C1 = 40 max C2 = 40 max	
	Tensile Strength (MPa)	AN = 80 min AI = 70 min	

Product Type	Test Issue	Standard Values	Referent Standard
		BT = 80 min BP = 60 min C1 = 40 min C2 = 30 min	(Grade B)
	Elongation (%)	AN = 400 min AI = 450 min BT = 300 min BP = 200 min C1 = 150 min C2 = 120 min	
	Retention rate of tensile strength	AN = 70 min AI = - BT = 60 min BP = 60 min C1 = 45 min C2 = 40 min	
	Acetone Extraction	AN = 15 max AI = 20 max BT = 25 max BP = 25 max C1 = 20 max C2 = 20 max	
	Carbon black Content	report	IS 6306
	Volatile Content	report	

### 2.3 Guidelines for Development of Industrial Standards for Rubber Products

Guidelines for development of industrial standards can be done by meeting with the manufacturers who produce the selected rubber products which are automotive tyres, retreaded tyres, solid tyres, rubber gloves, and reclaimed rubber. Then, comparison between TIS and international standards are examined in order to find out what issues need to be put into the TIS for improvement and development. In the case that there are no TIS for any products such as retreaded tyres and reclaimed rubber, international standards should be selected as guidelines for development of new TIS standards. However, if there are no TIS and international standards for any products such as solid tyres, TIS need to be newly developed. The issues needed to be put in the newly developed TIS can be taken from the meeting with manufacturers. Sampling of the selected rubber products sold in markets is necessary so that their qualities can be tested against the specifications defined in the standards. If their qualities can meet all specifications, then the improved or newly

developed TIS can be regulated at once. On the other hand, if their qualities do not meet all specifications, the enforcement of the improved or newly developed TIS should be delayed and regulated in appropriate duration. This will give manufacturers more time to prepare themselves to manufacture their products to meet the specifications.

The procedures of improved or newly developed TIS as above will give high benefits to the manufacturers. It will also increase customer confidence in product qualities and increase trade opportunity because the products that have TIS certificates will also meet international standards. Thai manufactures do not need to apply their products to foreign laboratories for international standard certificates. This also reduces the cost of testing for the manufacturers.

However, improvement or new development of TIS must be done with laboratory readiness. New laboratories may need to set up to fulfill manufacturer needs or to test rubber products as defined in the improvement or new development of TIS. Furthermore, there should be cooperation between Thai Industrial Standards Institute (TISI) and academic organizations to generate knowledge behind the standards and to test the products according to the standard specifications. TISI should also have information about TIS and related laboratories on website to support manufacturers when they need to apply their product for testing.

Finally, it needs to consider export incomes and growth opportunities of rubber products. If any products have high export incomes or high growth opportunities, improved or new developed TIS can be enforced at once. However, if any products have low export incomes or low growth opportunities, the enforcement of improved or new developed TIS should be delayed. Manufacturers can apply for the standards certificates by willingness until the increase in their export incomes or growth opportunities is reached

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## Study of Guidelines to Determine Industrial Standards for Rubber Wood Products

### 1. Introduction

This report is based on the project to study the guidelines to determine the industrial standards for the rubber wood products to support the standardization of Thai Industrial Standards Institute (TISI). Currently, Thailand's furniture and wood industry uses rubber wood as the main raw material. The areas for rubber plantations cover about 16.9 million Rai, mostly in the South with 11,339,658 Rai, by which Surat Thani province has the most rubber plantations of 1,871,907 Rai. When the rubber trees become old (20-25 years), latex output would decrease and investment not worthwhile. They will be cut down for replantation. Normally, companies dealing in rubber wood logs will purchase by auction from rubber plantation farmers. Then, they will fell the rubber trees and sell them. Large tree trunks will be sold to manufacturers of wood processing and furniture whereas cheaper small trunks and twigs will be sold to manufacturers of plywood and fiberboard. The production process needs to be controlled or operated under conditions of industrial standards or regulations imposed by the state authorities or even with the partner countries.

At present, the production of wood processing for export is mainly rubber wood processing accounting for 97% or 21,023,834,857 baht. According to Thailand's international trade, the export of rubber wood furniture and wooden parts had the highest value since 2009-2012. The wooden furniture with the highest export value in 2012 was bedroom furniture (HS 940350) worth 2,812.2 million baht. Therefore, it is important for researchers to define standards in the bedroom furniture such as cabinets, beds, tables, chairs etc. In most cases, wood product and wood furniture industry will be directly affected by the market/consumer as well as voluntary measures. They are considered products with problems of product standards. The most important regulations at present are the laws relating to the emission of harmful substances from products, particularly formaldehyde.

Based on this reason, there are important issues that stimulate the producers to produce environmentally-friendly products to meet the customer's needs and an opportunity to access to new markets. The measures of the wood furniture industry are likely to be defensive in response to the requirements/requests from customers with documentation according to the requirements of customers. They are therefore requested by the producers and consumers to set up standards.

This study reviewed the industrial product standards based on the category of the main raw material used in the production of rubber wood which is defined in only one single standard: rubber wood sawn timber (TIS 2423-2552). This standard sets the

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specification of processed rubber wood derived from timber processing machinery, drying and/or wood treatment with boron, taking into account the properties of rubber wood usage to enter into the next production process. In addition to the industrial standards, there are also rubber wood product community standards which cover the products made from rubber wood as the main raw material. They do not however cover rubber wood, toys made of rubber wood and wood products already announced as community standards as well as the green label project, the determination of which varies according to the type and impact of environmental issues that are caused by the products. The green label requirements relating to industrial products made from rubber wood are green label for products made from rubber wood (TGL-22-R1-11) which cover only finished products made from rubber wood or board made from rubber wood.

In terms of economic importance such as high production and export value, the standard setting will cause the economic benefits. It is found that the production of wood processing for export is at present mainly rubber wood processing amounting to 97% or 21,023,834,857 baht as there is no source of timber elsewhere with sufficient volume to feed the industry. The rubber wood export market with the highest proportion is China accounting for 97% (20,403,498,684 baht). The current standard is defined by the rubber wood sawn timber (TIS 2423-2552). The wood furniture product with the highest export value in 2012 was bedroom furniture (HS 940350) worth 2,812.2 million baht. Therefore, researchers give priority to the standardization of the bedroom furniture such as cabinets, beds, tables, and chairs and which may be used as the guidelines to determine the standards of industrial products, functional sizes of domestic furniture (TIS 662-2530), standard test methods for furniture (TIS 1015 volume 1-2533), stability of tables etc.

The rubber wood product is the product or system undergoing change in international standards. Therefore, it is necessary to align the Thai standards with the international standards. As they are the products with the problems of product standards, the establishment of standard will serve as framework guidelines to promote and control quality as well as the products required by the private sector and the consumers to set up standards.

## 2. Objectives

Based on the reason and the significance discussed above, the project is set up to study the guidelines to determine industrial standards for rubber wood products to support the standardization of Thai Industrial Standards Institute (TISI). The objective is to evaluate the present capabilities of Thai industrial standards so as to ensure that the producers are aware of their own capabilities of rubber wood product standards. The

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information gained can also be used to determine the standards of the rubber wood products to meet the needs of producers.

### 3. Methods

Quantitative research, in the form of survey research, is conducted by collecting data in field areas of sampling establishments and through questionnaires. Research was studied with the sample of 56 establishments taken from 100% Thai producers using rubber wood as the main raw material in the production or no less than 51% of Thai shareholders located in Bangkok Metropolitan area consisting of Bangkok, Nonthaburi, Pathumthani, Samutprakan, Ayutthaya, Saraburi and the Eastern region consisting of Chonburi, Chachoengsao, and Rayong, with the total of 70 factories.

### 4. Results

According to the survey of 51 sampling establishments or 86.4% of the total number of sampling establishments, the main results of the operation of the project are summarized as follows:

#### 4.1 The availability of testing process, tools and test equipments

Most producers test the various properties of the raw material which is rubber wood and finished products through agencies or laboratories belonging to their own establishment or plant, including the testing inside their own establishment or plant but not considered laboratories.

(1) The majority of small enterprises have not yet set standards to test the properties of the raw material and rubber wood products. The result of this research study has shown that the establishment owners need the laboratory standards and the laboratories of the domestic private sector to test various properties of the rubber wood products.

(2) Medium and large enterprises have raw materials and finished products tested by external agencies whether public or private.

(2.1) Examples of the agencies listed to test the properties of the raw material which is rubber wood and finished products are as follows:

(2.2) Department of Forest Products, Faculty of Forestry, Kasetsart University

(2.3) WU-NRCT University Technology Center on Wood and Wood Products

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(2.4) Laboratory of Industrial Wood Processing Standard, Scientific Equipment Center, Prince of Songkla University

(2.5) Thailand Institute of Scientific and Technological Research

(2.6) ELF Enterprise Co., Ltd

(2.7) Intertek Testing Services (Thailand) Co., Ltd

## **4.2 Positive impacts, negative impacts, and feasibility**

### **4.2.1 Positive impacts**

(1) The standards related to the products using rubber wood as a main raw material are direct requirements from the establishments.

(2) The channel to drive the establishments to upgrade the quality of their rubber wood products.

(3) Rubber wood products have the standards which are in accordance with international standards.

(4) Increase the opportunities and channels to export more rubber wood products.

(5) Increase the value of rubber wood products.

### **4.2.2 Negative impact**

(1) The establishment may require modifications to the method of production, including how to test various standards of the products when the rubber wood product industry standards are published.

(2) The establishments may have to bear product testing costs when the rubber wood product industry standards are published.

### **4.2.3 Feasibility**

If the standard has been modified as the standard for products directly using rubber wood as a raw material, the research result can predict the feasibility to set the industrial standards of the rubber wood products. However, the methods and the testing processes may need to be modified to align with the published standards.

## **4.3 The rubber wood product standardization that needs to be set**

The study results demonstrate the needs of enterprises that need to standardize rubber wood product standards by setting the standard that should be set using the recommended values as follows:

### 1. Category and type of rubber wood product in the group of furniture and parts : chairs and/or chair parts, tables and/or table parts, and beds and/or bed parts

Standards that must be set	Standards and values that should apply or introduce	Testing laboratory to certify standard
<p><b><u>Standards of mechanical properties of rubber wood</u></b></p> <ul style="list-style-type: none"> <li>- The moisture percentage standard of rubber wood</li> <li>-The modulus of rupture standard of rubber wood</li> <li>- The hardness standard of rubber wood</li> </ul>	<ul style="list-style-type: none"> <li>- Dried rubber wood must have a moisture content not exceeding 12% (TIS 2423-2552)</li> <li>- The modulus of rupture of rubber wood has a value not less than 86 MPa (average modulus of rubber wood)</li> <li>- The hardness of rubber wood has a value not less than 4,030 N (average hardness value from rubber wood)</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Laboratory of Industrial Wood Processing Standard, Scientific Equipment Center, Prince of Songkla University</li> </ul>
<p><b><u>Standards of physical properties of rubber wood</u></b></p> <ul style="list-style-type: none"> <li>- Standards of durability, resistance to fungus and bacteria of rubber wood</li> <li>- Standards of compatibility with the adhesive of rubber wood</li> <li>- Standard of capability of bending the curve of rubber wood</li> </ul>	<ul style="list-style-type: none"> <li>- High durability and resistance to fungus and bacteria with treatment</li> <li>- Compatible with the adhesive industry such as adhesive resins (phenolic resin and amino plastic)</li> <li>- Standard-sized rubber wood thickness of 25 mm must have capability of bending the curve of the stick with the constant radius curve of more than 500 mm.</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Laboratory of Industrial Wood Processing Standard, Scientific Equipment Center, Prince of Songkla University</li> </ul>
<p><b><u>Industrial standards of rubber wood product industry in accordance with international standards, measures, regulations, rules of trading partners</u></b></p> <ul style="list-style-type: none"> <li>- Safety standards of the chemicals in the product</li> <li>- Environmental standards on pollution discharge of organic vapors into the environment</li> <li>- Standards and requirements for the import of rubber wood</li> </ul>	<ul style="list-style-type: none"> <li>- Formaldehyde Maximum Emission Level 0.07 ppm. (Formaldehyde Emission EU Standard)</li> <li>- Formaldehyde Maximum Emission Level 0.05 ppm. (Formaldehyde Emission Japanese Standard )</li> <li>- Formaldehyde Maximum Emission Level 0.05 ppm. (Formaldehyde Emission USA Standard )</li> <li>- The maximum limits of quantities, relieving the substance formaldehyde products not exceeding 0.124 mg/m<sup>3</sup>. (ISO 12460-</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- ELF Enterprise Co., Ltd</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Thailand Institute of Scientific and Technological Research (TISTR)</li> </ul>



Standards that must be set	Standards and values that should apply or introduce	Testing laboratory to certify standard
product into the market of the trading partners	1) (Reference Chamber Method) - Formaldehyde emissions $\leq 0.12$ mg from the Hyde/m <sup>3</sup> . (GB 18580-2001 Standard)	
<b><u>Requirements for product standards based on foreign standard system of wood products and the international standard system for wood products</u></b> - Emissions control standards for formaldehyde - The test standard for quantity of formaldehyde - The test standard for quantity of pentachlorophenol	- Contains formaldehyde in wood no more than 8 mg/100 of dry wood chips (TGL-22-99) - Formaldehyde releasing from a piece of dry wood must not exceed 1.5 mg/l. (TGL-22-99) - No pentachlorophenol in product (TGL-22-99)	- WU-NRCT University Technology Center on Wood and Wood Products - Intertek Testing Services (Thailand) Co., Ltd. - Department of Forest Products, Faculty of Forestry, Kasetsart University - Thailand Institute of Scientific and Technological Research (TISTR)

## 2. The category and type of rubber wood products in construction materials: wood floors, wood walls and doors

Standards that must be set	Standards and values that should apply or introduce	Testing laboratory to certify standard
<b><u>Standards of mechanical properties of rubber wood standards</u></b> - The moisture percentage standard of rubber wood - The modulus of rupture standard of rubber wood - The hardness standard of rubber wood	- Dried rubber wood must have a moisture content not exceeding 15% (TIS 192-2549) - The modulus of rupture of rubber wood has a value not less than. 86 MPa (average modulus of rubber wood) - The hardness of rubber wood has a value not less than 4,030 N (average hardness values from rubber wood)	- WU-NRCT University Technology Center on Wood and Wood Products - Intertek Testing Services (Thailand) Co., Ltd. - Department of Forest Products, Faculty of Forestry, Kasetsart University - Laboratory of Industrial Wood Processing Standard, Scientific Equipment Center, Prince of Songkla University
<b><u>Standards of physical properties of rubber wood</u></b> - Standards of durability, resistance to fungus and bacteria of rubber wood - Standards of compatibility with the adhesive of rubber wood - Standard of capability of	- High durability and resistance to fungus and bacteria with treatment - Compatible with the adhesive industry, such as adhesive resins (phenolic resin and amino plastic) - Bending strength of joint must not be less than 40 MPa	- WU-NRCT University Technology Center on Wood and Wood Products - Intertek Testing Services (Thailand) Co., Ltd. - Department of Forest Products, Faculty of Forestry, Kasetsart University

Standards that must be set	Standards and values that should apply or introduce	Testing laboratory to certify standard
bending the curve of rubber wood		- Laboratory of Industrial Wood Processing Standard, Scientific Equipment Center, Prince of Songkla University
<p><b><u>Industrial standards of rubber wood products in accordance with international standards, measures, regulations, rules of trading partners</u></b></p> <ul style="list-style-type: none"> <li>- Safety standards of the chemicals in the product</li> <li>- Environmental standards on pollution discharge of organic vapors into the environment</li> <li>- Standards and requirements for the import of rubber wood products into the market of trading partners</li> </ul>	<ul style="list-style-type: none"> <li>- Formaldehyde Maximum Emission Level 0.07 ppm. (Formaldehyde Emission EU Standard)</li> <li>- Formaldehyde Maximum Emission Level 0.05 ppm. (Formaldehyde Emission Japanese Standard )</li> <li>- Formaldehyde Maximum Emission Level 0.05 ppm. (Formaldehyde Emission USA Standard )</li> <li>- The maximum limits of quantities, relieving the substance formaldehyde products not exceeding 0.124 mg/m<sup>3</sup>. (ISO 12460-1) (Reference Chamber Method)</li> <li>- Formaldehyde emissions ≤ 0.12 mg from the Hyde/m3. (GB 18580-2001 Standard)</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- ELF Enterprise Co., Ltd</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Thailand Institute of Scientific and Technological Research (TISTR)</li> </ul>
<p><b><u>Requirements for product standards based on foreign standard system of wood products and the international standard system for wood products</u></b></p> <ul style="list-style-type: none"> <li>- Emissions control standards for formaldehyde</li> <li>- The test standard for quantity of formaldehyde</li> <li>- The test standard for quantity of pentachlorophenol</li> </ul>	<ul style="list-style-type: none"> <li>- Contains formaldehyde in wood no more than 8 mg/100 of dry wood chips (TGL-22-99)</li> <li>- Formaldehyde releasing from a piece of dry wood does not exceed 1.5 mg/l. (TGL-22-99)</li> <li>- No pentachlorophenol in product (TGL-22-99)</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Thailand Institute of Scientific and Technological Research (TISTR)</li> </ul>

### 3. The category and type of rubber wood products in construction materials: wooden wall panels for interior and external decorations, internal molding walls

Standards that must be set	Standards and values that should apply or introduce	Testing laboratory to certify standard
<p><b><u>Standards of mechanical properties of rubber wood</u></b></p> <ul style="list-style-type: none"> <li>- The moisture percentage standard of rubber wood</li> <li>-The modulus of rupture standard of rubber wood</li> <li>- The hardness standard of rubber wood</li> </ul>	<ul style="list-style-type: none"> <li>- Dried rubber wood must have a moisture content not exceeding 15% (TIS 192-2549)</li> <li>- The modulus of rupture of rubber wood has a value not less than 86 MPa (average modulus of rubber wood)</li> <li>- The hardness of rubber wood has a value not less than 4,030 N (average hardness values from rubber wood)</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Laboratory of Industrial Wood Processing Standard, Scientific Equipment Center, Prince of Songkla University</li> </ul>
<p><b><u>Standards of physical properties of rubber wood</u></b></p> <ul style="list-style-type: none"> <li>- Standards of durability, resistance to fungus and bacteria of rubber wood</li> <li>- Standards of compatibility with the adhesive of rubber wood</li> <li>- Standards of capability of bending the curve of rubber wood</li> </ul>	<ul style="list-style-type: none"> <li>- High durability and resistance to fungus and bacteria with treatment</li> <li>- Compatible with the adhesive industry, such as adhesive resins (phenolic resin and amino plastic)</li> <li>- Bending strength of joint must not be less than 40 MPa</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Laboratory of Industrial Wood Processing Standard, Scientific Equipment Center, Prince of Songkla University</li> </ul>
<p><b><u>Industrial standards of rubber wood products in accordance with international standards, measures, regulations, rules of trading partners</u></b></p> <ul style="list-style-type: none"> <li>- Safety standards of the chemicals in the product</li> <li>- Environmental standards on pollution discharge of organic vapors into the environment</li> <li>- Standards and requirements for the import of rubber wood product into the market of trading partners</li> </ul>	<ul style="list-style-type: none"> <li>- Formaldehyde Maximum Emission Level 0.07 ppm. (Formaldehyde Emission EU Standard)</li> <li>- Formaldehyde Maximum Emission Level 0.05 ppm. (Formaldehyde Emission Japanese Standard )</li> <li>- Formaldehyde Maximum Emission Level 0.05 ppm. (Formaldehyde Emission USA Standard )</li> <li>- The maximum limits of quantities, relieving the substance formaldehyde products not exceeding 0.124 mg/m<sup>3</sup>. (ISO 12460-1) (Reference Chamber Method)</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- ELF Enterprise Co., Ltd</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Thailand Institute of Scientific and Technological Research (TISTR)</li> </ul>

Standards that must be set	Standards and values that should apply or introduce	Testing laboratory to certify standard
	<ul style="list-style-type: none"> <li>- Formaldehyde emissions <math>\leq 0.12</math> mg from the Hyde/m<sup>3</sup>. (GB 18580-2001 Standard)</li> </ul>	
<p><b><u>Requirements for product standards based on foreign standard system of wood products and the international standard system for wood products</u></b></p> <ul style="list-style-type: none"> <li>- Emissions control standards of formaldehyde               <ul style="list-style-type: none"> <li>- The test standard of the quantity of formaldehyde</li> <li>- The test standard of the quantity of pentachlorophenol</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>- Contains formaldehyde in wood no more than 8 mg/100 of dry wood chips (TGL-22-99)</li> <li>- Formaldehyde releasing from a piece of dry wood does not exceed 1.5 mg/l. (TGL-22-99)</li> <li>- Non pentachlorophenol in product (TGL-22-99)</li> </ul>	<ul style="list-style-type: none"> <li>- WU-NRCT University Technology Center on Wood and Wood Products</li> <li>- Intertek Testing Services (Thailand) Co., Ltd.</li> <li>- Department of Forest Products, Faculty of Forestry, Kasetsart University</li> <li>- Thailand Institute of Scientific and Technological Research (TISTR)</li> </ul>

Most requirements of the establishments consist of setting the industrial standards of the rubber wood products specifically the standards of rubber wood as a raw material since the raw material is a major factor in product processing.

The study of the project to determine the guidelines to set the industrial standards of rubber wood products to support the standardization of Thai Industrial Standards Institute (TISI) has the objective of preparing and evaluating the operational capabilities of Thai industrial standards. The producers are aware of their own operational capabilities of rubber wood product standards. It can also be used to plan the determination of standard criteria of rubber wood products to meet the needs of producers. The demand from most establishments tends toward the standardization of the raw material since the raw material is a major factor of product processing. The need of standardization also covers the control of chemicals in the rubber wood and the chemicals in the rubber wood products mostly finished furniture and furniture parts which is consistent with the export value of furniture. This group of product mostly uses rubber wood as raw material and had the highest export value in 2012. The study results reveal the following issues:

- Category and type of products using rubber wood as a raw material that is consistent with the establishments' needs of standardization; they are also the group with the highest export value in the industry.

- Standards related to the products using rubber wood as a raw material in consistence with the establishments' needs of standardization.

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- Process and methods that the establishments use to test products using rubber wood as a raw material, including the current standards that the establishments use with the products made from rubber wood as raw material.

## **5. Guidelines to drive for the setting up of rubber wood product standards**

The study results through the recommendations of the producers reveal the following information:

5.1 The standardization of rubber wood products needs the documents on the standards of rubber wood products to be disseminated to the producers and to be announced throughout all factories.

5.2 Seminar to disseminate the information on the standardization of rubber wood products to the producers.

## **6. Problems, obstacles and recommendations**

6.1 Information received from the study really reflects the standardization of the rubber wood products. The study results should be used to set standards, regulations and disseminate to the establishments.

6.2 The enforcement of rubber wood processing standards in sawmills and wood drying factories or the standards set in parallel so that the establishments can produce more according to applied standards.

6.3 The standardization of finished furniture and furniture parts should be launched as the group had the highest export value.

6.4 The standardization of finished furniture and furniture parts should focus on the standardization of the control of chemicals on raw material and rubber wood products as it is the main need of the establishments.

6.5 There should be development on top of the standardization of the rubber wood products so as to upgrade the standardization of rubber wood products to a higher level.

6.6 The enforcement of standards should take into account the current situation with the applied standards in compliance with international standards, measures, and regulations.

## MAIN ACTIVITY 2:

Enhancement Of Management Ability To Increase Efficiency  
And Productivity Of The Rubber And Rubber Wood Products  
By Following The Thailand Quality Award (TQA) Guidelines  
For Rubber And Rubber Wood Product Industry.

## MAIN ACTIVITY 2

Enhancement of management ability to increase efficiency and productivity of the rubber and rubber wood products was conducted following the TQA guidelines for rubber and rubber wood product industries.

### 1. Target

The production of Thailand’s rubber and rubber wood products meets international standards

### 2. Target group

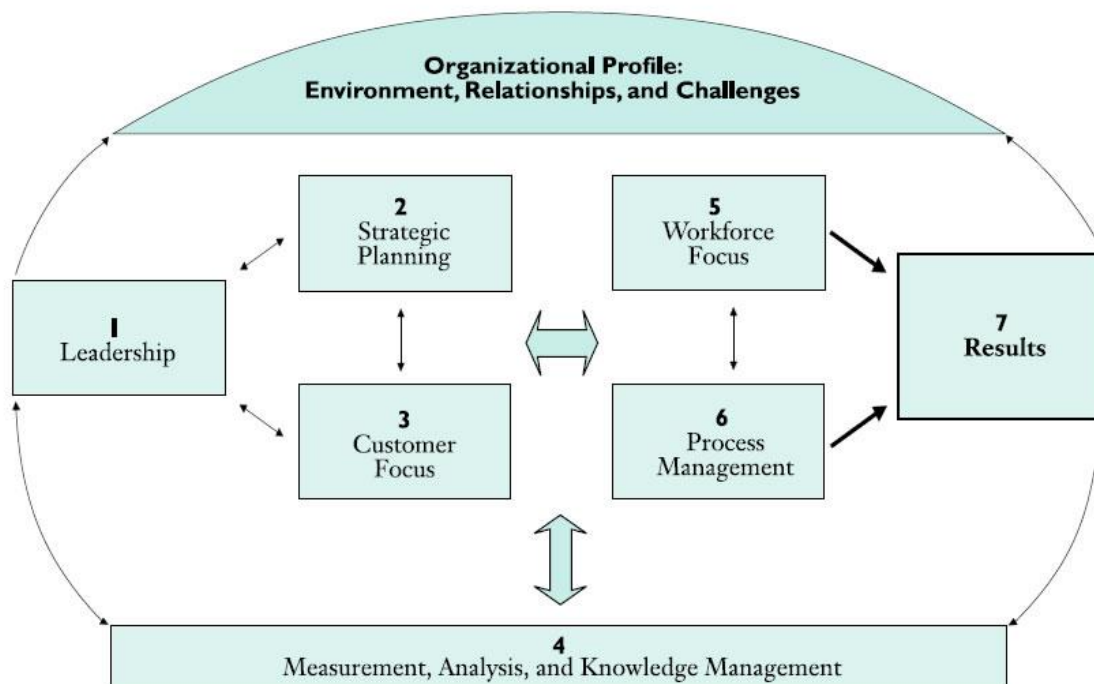
Rubber and rubber wood manufacturers in Thailand

### 3. Output

Twelve Manufacturers apply to participate in the project

### 4. Outcome

The development of rubber and rubber wood manufacturers is enhanced and their management standards upgraded to increase productivity, following the Thailand Quality Award (TQA) guidelines for rubber and rubber wood product industries.



**TQA criteria consist of the following:****Organizational Profile**

1. Type of organization
2. Situation of organization

**Category 1: Leadership**

- 1.1 Senior Leadership
- 1.2 Monitoring of organization and social responsibilities

**Category 2: Strategic Planning**

- 2.1 Strategic preparation
- 2.2 Strategic implementation

**Category 3: Customers**

- 3.1 Voice of customers
- 3.2 Customer attachment

**Category 4: Measurement, Analysis, Knowledge Management**

- 4.1 Measurement, analysis, and improvement of organizational performance
- 4.2 Management of information, knowledge, and information technology

**Category 5: Human Resource**

- 5.1 Workforce environment
- 5.2 Workforce attachment

**Category 6: Process Management**

- 6.1 Work Systems
- 6.2 Work Processes

**Category 7 Outcome**

- 7.1 Product and Process Outcome
- 7.2 Customer-Focused Outcome
- 7.3 Workforce-Focused Outcome
- 7.4 Leadership and Organizational Monitoring Outcome
- 7.5 Financial and Marketing Outcome

**5. Background of Thailand Quality Award (TQA)**

Upon signing the agreement between the Foundation of Thailand Productivity Institute (FTPI) and the National Science and Technology Development Agency (NSTDA) on September 5, 1996, a study on how to establish the Thailand Quality Award (TQA) was initiated. With the government's recognition of the importance of this award, Office of the National Economic and Social Development Board inserted TQA into the National Productivity Development Plan, as part of the 9<sup>th</sup> National Economic and Social



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Development Plan. FTPI has been the main organization in supporting the productivity and services sectors to adopt TQA criteria as an essential tool to improve their management capability. Organizations in Thailand with best practices and performance excellence can apply to be nominated to receive the Thailand Quality Award, as a role model for other organizations to follow. As the number of Thailand Quality Award increases, the overall Thailand competitiveness at the world level should increase as well.

Thailand Quality Award is considered a world-class award. The fundamental of the technical and decision-making processes are identical to the Malcolm Baldrige National Quality Award (MBNQA) of the United States of America, which is the model of national quality award adapted by more than 70 countries worldwide.

### **Objectives of Thailand Quality Award**

The “Thailand Quality Award” is widely recognized as the most prestigious quality award in Thailand and the symbol of the world-class performance excellence.”

#### Objectives

1. Encouraging organizations to implement TQA criteria to improve their competitiveness
2. Providing recognition to the TQA winners who attain the world-class standards
3. Stimulating organizational learning and sharing of best practices
4. Demonstrating the country’s commitment to pursue world-class management and performance excellence

## **6. Activities/Methodology**

For the manufacturers to understand and enhance management standards to increase efficiency following the TQA guidelines, the manufacturers are categorized into four levels as follows:

### **Level 1: Firefighting approach**

The operation looks like activities more than processes, and mainly meets the requirements or solves immediate problems with lack of good objective setting.

### **Level 2: Early Systematic approach**

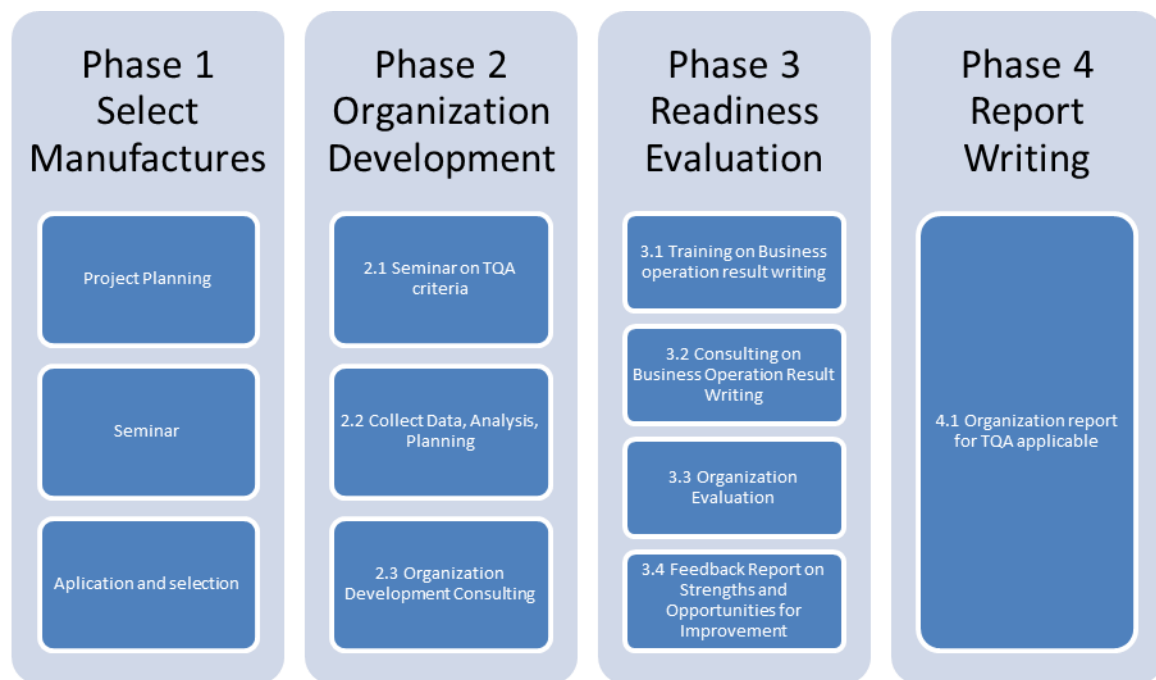
The organization is at the early stage of operation of repeatable processes with evaluation and improvement. It starts some coordination with other departments within the organization. Strategies and qualitative objectives are defined.

**Level 3 One Way direction approach**

The operation is repeatable processes with regular evaluation and improvement. Knowledge is shared in the organization and coordination among departments within the organization. The processes meet the organization’s main strategies and objectives.

**Level 4 Integrated approach**

The operation is repeatable processes with regular evaluation and improvement by cooperating with affected departments. The analysis, innovation, and the sharing of information and knowledge result in the efficient interdepartmental performance. The approach uses processes and key indicators to follow up on the progress of strategic objectives and important work operation. Due to the categories, the project approach focuses on the level of management on efficiency and productivity to serve customer requirements according to the TQA guidelines. The approach also includes consulting on TQA application for feedback report on the organization development references. The approach consists of four phases as follows:



The organizations initially qualified to participate in the project will be divided into two groups according to the level of management by referring to the above categories as follows:

Group 1: the organizations at the early stage of the development of organizational management

The organizations with standard production process and standard certification but still lack integrated management such as the needs and expectations of customers, management of negative impact on the society, and human resource management.

Group 2: the organizations with systematic organizational management in major processes

- The organizations with standard production process and continuous improvement on productivity, and probably with major standard certification or award in organizational management.

- The organizations with focus on the total or some integrated management system involving manufacture, requirements and expectations of customers, management on negative impact on the society, and human resource management.

- The organizations with awards that have similar criteria as TQA such as Prime Minister Award, SME National Award (by Office of Small and Medium Sized Enterprises Promotion), or Thailand Franchise Quality Award (by Department of Business Development, Ministry of Commerce), etc.

**The list of participating organizations is as follows:**Group 1: the organizations at the early stage of the development of organizational management

No.	Organization Name	Product type	Location
1	Chaiwatchara Rubber	Automotive Parts	Samutsakorn
2	G.I.F. Engineering	Automotive Parts and rubber products	Bangkok
3	Rebirth Industry	Rubber Furniture	Rayong
4	P.I. Industry	Rubber compound	Rayong
5	Creative Polymer	Rubber compound	Rayong
6	Thai Chin Wood	Rubber Wood Kitchen Furniture	Samutprakarn
7	Thai Eastern Innovation	Premier compound	Chonburi
8	N.Y. Rubber	Concentrated latex	Chonburi

Group 2: the organizations with systematic organizational management in major processes

No.	Organization Name	Product type	Location
9	Thai Eastern Rubber	Concentrated latex	Chonburi
10	Rockworth	Office Furniture	Bangkok/Chonburi
11	Suretech	Condom	Suratthani
12	Siam Rubber	Truck Tire	Sumutsakorn

## 6.1 The activities of organizational development according to the TQA guidelines :

### (1) Organizational development

(1.1) Training on TQA criteria for the organisations to understand TQA background, guidelines, and the linkage between TQA and Malcolm Baldrige National Quality Award (MBNQA).

(1.2) Business diagnosis such as Organizational Management, Quality Process Management according to the TQA guidelines on organizational evaluation.

(1.3) Consulting on organizational improvement and development to align with TQA criteria by coaching the organizations in report writing and best practice study as well as the period to apply for the Award.

### (2) Readiness Evaluation

(2.1) Training on report writing for TQA application such as Business Environment, Strategy Context, Process Improvement System

(2.2) Coaching on business performance for TQA application for each organization

#### (2.3) Organizational Business Evaluation

(2.3.1) Consulting on organization operation index that reflects organizational efficiency improvement according to TQA guidelines such as efficiency index, effectiveness index, cost management index, capacity index, quality ratio, delivery ratio, breakdown index, WIP index, etc.

(2.3.2) Evaluation on business result of the organizations following TQA guideline by expert TQA consultants

(2.3.3) Summary of the project and evaluation on readiness of the organizations, by providing the organizations' strengths and weaknesses that need improvement in the form of report with recommendations, cooperation with the organizations to chart short-, medium-, and long-term plans to conduct organizational development according to the TQA guidelines.

### **(3) Preparation of Manual and Report**

Production of 300 copies of TQA application manuals to disseminate the information to rubber and rubber wood manufacturers to stimulate and support them in the understanding of management according to the TQA guidelines. This will encourage the organizations to develop and enhance their quality to meet international standards and The development of the overall rubber and rubber wood product industries

## **7. The example of TQA assessment activities**

7.1 Consultants diagnosed the information of the organizations, by interviewing high-level management and the project team members. In the beginning.

7.2 Consultants described the project in detail and elaborated on TQA criteria's for further improvement. The consultants studied manufacturing processes of the selected organizations in terms of organization strategies, marketing strategies, manufacturing strategies, human resource strategies, strategic planning and survey on management indicators such as process indicators, production efficiency indicators, voice of customer indicators, management type, ethics, environment, marketing and customer focus, production information analysis, knowledge management, IT, productivity activities and standard certificates.

7.3 The consultants advised the organizations to improve on business management for TQA application with application procedures, the application period, TQA criteria, qualifications of the applicants, benefits, self-assessment, recommendations on establishing improvement team and information preparation for reporting writing .

The example of TQA assessment

Category 1 Leadership

Category 2 Strategic Planning

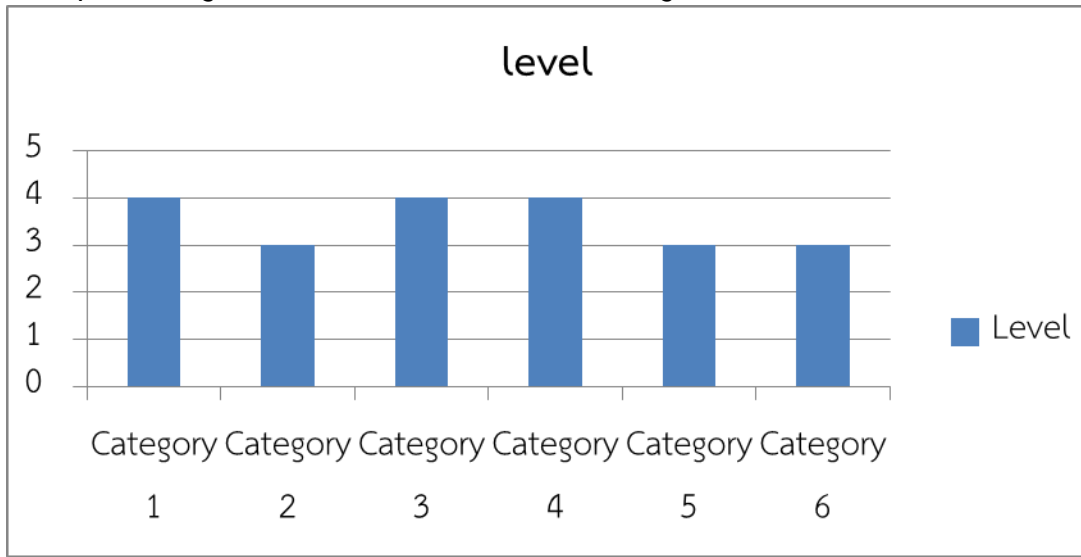
Category 3 Customers

Category 4 Measurements, Analysis, Knowledge Management.

Category 5 Human Resource

Category 6 Process Management

The Example of Organizational Score Level according to TQA Guidelines



Definition of Level of Organizational Evaluation

level	Definition
1 (10%) The system starts to be applied in some areas	Have basic guidelines in some areas
2 (20%) The system starts in the areas important to achieve the vision	Have basic guidelines
3 (30%) Business expansion	Systematic guidelines (continuous improvement and effectiveness)
4 (40%) Product development by themselves	Progressive guidelines, more alignment with other departments with shared goals
5 (50%)	Progressive guidelines in the same industry

The criteria of organizational evaluation applied from TQA are divided into five levels as the above table. The assessment therefore focuses on organizational improvement.

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#### 7.4 Consulting on Report Writing of Operation Performance to apply for TQA Award for Each Participating Organization

Consultants studied the document prepared by each organization and coached to improve business operation report writing to align with TQA framework. The details of report writing such as number of report pages must not exceed 100 pages of A4 size with category 1 not exceeding 10 pages. It also needs to convert category 7 (the highest score) into visual information (graphs) as well as benchmarking information.

In process categories (Category 1 to Category 6), the report should demonstrate the improvement in systematic approach. The improvement process must be consistency and well deployment. Learning and development must be continuous Efficiency across-function and integration in the same direction

Category 7 means output and outcome with the following four factors:

1. **Level** means present results
2. **Trend** means improvement of business results or maintaining of good business results
3. **Comparison** means the comparison of business results with similar organisations
4. **Integration** means KPIs and important indicators such as major customers, products, marketing, process, operating plans, and outcomes with integrated major work process

The report writing project team should separate each category to the respective team for writing and have an editor to review the report that needs to be in the same direction. Moreover, writing the report might help the management and the working team to know about the present situation of the organization.

### 8. Application of the TQA Framework for Organizational Improvement

8.1 Organizations should study more on TQA procedures and criteria and best practice

8.2 Establishing TQA self-assessment team, the members will create guidelines that deal with changing situations.

8.3 Development planning: this is an opportunity for improvement as planning is an important part for improvement activities. An activity needs to look into the detail such as KPI, strategy, human resource, operation, financial, customers, stakeholders, social impact, environment, leadership, benchmarking according to the vision and the missions.

8.4 Repeat self-assessment at deeper level, prepare roadmap for further level of development, and reduce opportunity gap for business excellence.

8.5 Readiness evaluation is also essential for TQA application with complete application documents. If organizational improvement working team and management agree that organizational business process and management is good enough for TQA application, the working team will make a complete report that covers all key areas for TQA. However, the main purpose of TQA criteria is to improve business operation management toward business operation excellence. Therefore, the organizations should educate their employees on TQA.