

**Original**

## **Job safety analysis and hazard identification for work accident prevention in para rubber wood sawmills in southern Thailand**

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**Abstract: Objective:** We utilized job safety analysis (JSA) and hazard identification for work accident prevention in Para rubber wood sawmills, which aimed to investigate occupational health risk exposures and assess the health hazards at sawmills in the Trang Province, located in southern Thailand. **Methods:** We conducted a cross-sectional study which included a walk-through survey, JSA, occupational risk assessment, and environmental samplings from March through September 2015 at four Para rubber wood sawmills. **Results:** We identified potential occupational safety and health hazards associated with six main processes, including: 1) logging and cutting, 2) sawing the lumber into sheets, 3) planing and re-arranging, 4) vacuuming and wood preservation, 5) drying and planks re-arranging, and 6) grading, packing, and storing. Working in sawmills was associated with high risk of wood dust and noise exposure, occupational accidents injuring hands and feet, chemicals and fungicide exposure, and injury due to poor ergonomics or repetitive work. **Discussion:** Several high-risk areas were identified from JSA and hazard identification of the working processes, especially high wood dust and noise exposure when sawing lumber into sheets and risk of occupational accidents of the hands and feet when struck by lumber. All workers were strongly recommended to use personal protective equipment in any working processes. Exposures should be controlled using local ventilation systems and reducing noise transmission. We recommend that the results from the risk assessment performed in this study be used to create an action plan for

reducing occupational health hazards in Para rubber sawmills.

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**Key words:** Health hazards, Job safety analysis, Occupational health, Para rubber wood, Sawmill

### **Introduction**

In Thailand, Para rubber wood is one of the most important export products. Thailand is the leading exporter of natural rubber and related products, accounting for 40 percent of the world's rubber production<sup>1</sup>. Southern Thailand is the major area of Para rubber production, making up one-third of the total rubber production in Thailand<sup>2</sup>. Para rubber wood is one of the most important recycled natural resources in wood industries. It is used to make furniture, furniture parts, and other wood-based products. These exported products have significantly contributed to Thailand's economy. Since 1985, exported Para rubber wood products have resulted in approximately US \$1 billion per year<sup>3</sup>. In addition, Thailand is a leader of wood's log exporter with 1.6 million m<sup>3,4</sup>. Para rubber wood is a desirable product because it is light, easy to machine, and can be harvested in an environmentally friendly, sustainable way<sup>5</sup>.

Previous studies of occupational wood dust exposures have reported negative health effects such as decline of pulmonary function, alveolitis allergy, asthma, chronic bronchitis, rhinitis, mucous membrane irritation, contact dermatitis and nasal cancer<sup>6,8</sup>. Skin irritation and skin sensitization have also occurred as a result of contact with the wood itself, dust, bark, and wood sap<sup>8</sup>. Wood dust exposure has demonstrated effects on the respiratory system

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including rhinitis from nasal symptoms, sneezing, eye symptoms such as soreness, watering and conjunctivitis, and asthma, including cough, wheeze, and dyspnea<sup>4</sup>). Specifically, a cross-sectional analysis of workers' compensation claim data in Trang Province has shown that Para rubber wood sawmills were the industry with the highest percentage of all workers' compensation claims overall (26.4%)<sup>9</sup>). However, there are few studies reporting on occupational health and safety in Para rubber wood industries.

The main objective of this study was to assess and inspect each step of work process and identify existing potential risk hazards in sawmills. We will use results from this study to design and implement specific control measures to prevent occupational health hazards and minimize occupational exposure risks in logging factories.

## Material and Methods

### *Working Process in Para rubber Wood Sawmills*

Managers from 20 different Para rubber wood sawmills were invited to participate in this study. Each factory was chosen due to similar work environments based on the number of workers, working procedures, size of factories, and other characteristics observed in the site visits. Of these 20, only four sawmills agreed to participate, including three large sawmills and one medium-sized sawmill. All factories had a similar working procedure and routine work<sup>22</sup>). We obtained signed consent forms from managers in these sawmills.

We conducted walk through surveys for the four assigned sawmills from March 1 through September 30, 2015. In rubber wood sawmills, there are six major steps in the processing of wood: 1) logging and cutting, 2) sawing the lumber into sheets, 3) planing and re-arranging, 4) vacuuming and wood preservation, 5) drying and planks re-arranging, and 6) grading, packing, and storing. In addition, these processes also required blade sharpening and boiling (boiler control system) [Fig. 1]. First, logs were cut into the required length and then sorted and stored in dry area. In cutting process, the logs were cut into boards by a band saw. Afterwards, boards were flattened, leveled and smoothed using an industrial planer. Next, sorted sheets were sent to a vacuum tank for preservative treatment where they were impregnated with fungicide, mainly boric acid and borax. After impregnation, the sheets were stored to dry before shipping or further processing including cutting, additional planing, laminating, and sanding. In these working areas, exhaust ventilation systems were provided primarily to prevent the accumulation of wood dust and air pollutants. Finally, workers performed a cleanup process at the end of each day, which involved blowing compressed air and dry sweeping to remove wood dust.

### *Reviewing Annual Reports*

The authors reviewed the fiscal reports of occupational accidents and injuries of each factory. The physical exams or health records were also reviewed if they were provided. In addition, the annual occupational health and safety plan for each factory was examined. There were two case reports of a worker being hit by a forklift<sup>10,11</sup>).

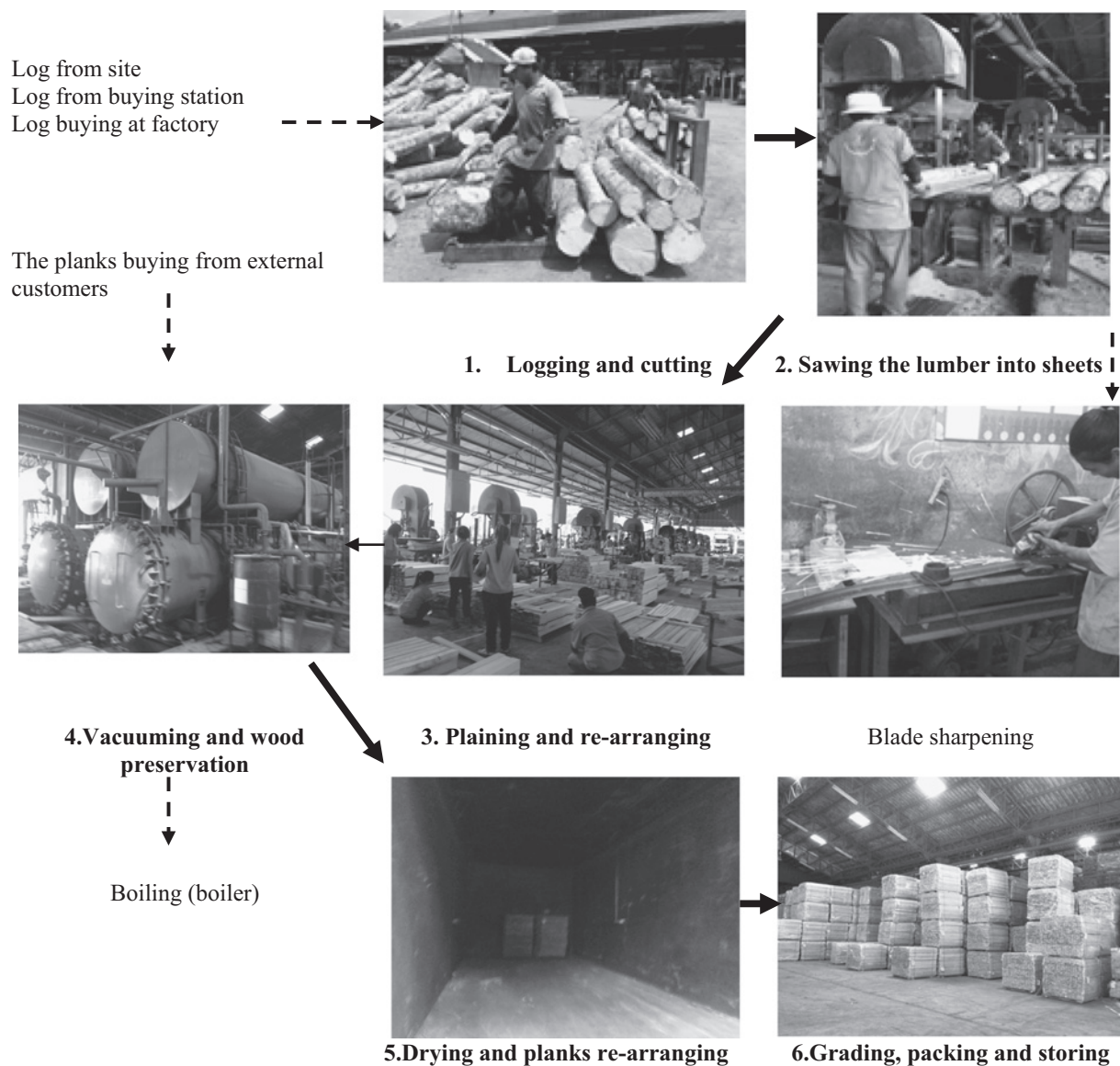
### *Noise and Wood Dust Samplings*

Noise exposure and wood dust samplings were conducted between December 10, 2015 and January 28, 2016. Equivalent continuous noise exposure level (Leq) was measured using a sound level meter (NL-21; Rion, Inc., Kyoto, Japan) for different areas of the sawmills during specific steps of wood processing. Personal noise measurements were conducted using noise dosimeters (Casella, Cel320; Casella CEL, Inc., NY, USA). In each department, all employees were randomly assigned a specific time of day to wear their personal noise dosimeter 41 times during the study. All study participants received clear explanation of study purposes and procedures. All participants gave signed, written informed consent prior to participation in the study.

Wood dust samplings were conducted using a portable personal air sampling pump (SKC Inc, Aircheck 2000, Valley View Road, PA USA). The gravimetric measurement method, NIOSH Method 0500, was used in dust measurements<sup>12</sup>). To collect the sample, a pump was placed on a worker working in a randomly selected point at the workplace and the flow rate was set at 2 l/minute. A total of 27 respirable dust and 5 total dust measurements were conducted for randomly selected workers using tared 5- $\mu$ m Polyvinyl chloride (PVC) filter with closed faced 37-mm Millipore samplers (NIOSH method 0500) whereas respirable dust using tared 5-PVC membrane with aluminum cyclone (NIOSH method 0600)<sup>12</sup>). Selected sawmill workers in each department received clear explanation of study purposes and samplings. They also gave signed, written informed consent prior to participation in the study.

We also conducted job safety analysis (JSA) by identifying, analyzing, and recording: 1) the steps involved in performing a specific task or working procedure, 2) the existing or potential safety and health hazards associated with each step, and 3) the recommended actions at each procedure that can help eliminate or minimize potential health hazards and the risk of a workplace injury or illness<sup>13</sup>).

Before performing JSA, we outlined the potential hazards of the wood processing. While conducting the JSA, we identified suspected health effects of each hazard including: 1) blunt force injury due to falling or flying objects; 2) penetration by sharp objects; 3) being caught in or between stationary/moving object(s); 4) falls from an elevated work platform, ladders or stairs; 5) muscu-



**Fig. 1.** Para rubber wood sawmills processing (Main process no. #1-6 (an arrow shape); all pictures have been released under the permission)

loskeletal injury due to excessive lifting, twisting, pushing, pulling, reaching, or bending; and 6) repetitive motion injuries. We also documented specific hazards that could lead to a wide variety of occupational injuries including: vibrating power tools, excessive noise, excessive heat, harmful levels of gases, vapors, fungicide, fumes, and wood dusts, electrical hazards, lack of or too much light, among others.

This study was approved by the ethical committee of Chulalongkorn University Review Board (COA No.237/2558; research project 210.1/58). We obtained permission from the manager of the factory and participating workers to present pictures of the working procedures and health risk hazards at sawmills.

*Measuring and Calculating Risk Levels*

In this study, the authors conducted a walk-through survey and then inspection for each working procedure of wood processing throughout the factories. Observations from these activities were used to identify occupational health hazards and estimate the risk of occupational health events (i.e., injuries). We used JSA, hazard identification, risk assessment, and what if analysis<sup>13)</sup>. JSA methodology was adapted from Job Hazard Analysis, OSHA Publication 3071<sup>18)</sup>. Risk levels were assessed using the following steps: 1) an operational issue or occupational health problem was identified during inspection, reported and recorded, which required the attention of occupational safety personnel and the managers of each factory; 2) the researchers and occupational safety personnel

**Table 1.** Levels of chance and severity of occupational health events

Level (degree)	Description Criteria for Chance of Occupational Health Event	Description Criteria for Severity of Occupational Health Event
1	Rare (very low incidence rate)	Incident or accident can be managed by a first aid (minimal risk)
2	Low (once every 5-10 years)	Incident or accident can be treated by medical treatment and healthcare team (moderate risk)
3	Moderate (once per year)	Incident or accident causes severe illnesses or injuries (high risk)
4	High (once per month)	Incident or accident causes death or life threatening (severe risk)

**Table 2.** Description of total scores for occupational health event risk level

Total Score <sup>a</sup>	Description Criteria for Risk Level
1-2	Minimal risk
3-7	Acceptable risk; Need to review working procedure and control of hazard
8-11	High risk; Needs to manage and control
12-16	No acceptable risk or tolerance; Need to stop and provide a control method or procedure in order to restart

<sup>a</sup>Total score calculated by multiplying “chance of occupational health event” by “severity of occupational health event”

analyzed the nature of the work procedures necessary to carry out the repair or minimize occupational hazards and risks; 3) all potential hazards were identified, including physical, chemical, biological, ergonomic, psychosocial hazards, possible mechanisms of injury and possible damage to others and/or equipment. When potential hazards were identified, we calculated a “Total Score” for occupational health event by multiplying “chance of occupational health event (Table 1)” and by “severity of occupational health event (Table 2)”<sup>13</sup>. The “total score” for occupational health event risk was divided into the following categories: minimal risk (score 1-2); acceptable risk (score 3-7); high risk (score 8-11); and no acceptable risk levels or tolerance (score 12-16) (Table 2).

#### Statistical Analysis

The data analyses were conducted using SPSS version 19 for Windows (Chicago, IL, USA). Descriptive results included means and standard deviations (SDs) of demographic characteristics, and frequencies and percentages of relevant categorical variables. All JSA worksheets and raw data were analyzed qualitatively.

#### Results

We identified and assessed potential and actual occupational health hazards associated with each wood processing task. We documented specific health hazards and risks associated with each wood processing (Table 3). We have included a more detailed summary of occupational health risks we identified (Table 3).

#### Logging and Cutting

In logging and cutting procedures, the working proc-

esses consisted of log re-arranging and drying, log transportation, and log weighing. The occupational safety and health hazards at this step included moving logs, hooks used to pick up the logs, wood dust, fungi and molds, slippery and wet floors, high heat, poor ergonomics, traffic injury due to forklift hitting, and heavy lifting. The occupational health hazards with high risk levels included wood dust exposure (score = 8), and traffic injury from forklift (score= 9) (Table 3). We also reviewed one case report of a worker being hit by a forklift<sup>10</sup>.

#### Sawing the Lumber into Sheets

For the process of sawing the lumber into sheets, occupational safety and health hazards included sharp blade, logs, wood dust, scraps of wood, splinter of wood, fungi and molds, noise, poor ergonomics, heavy lifting, electricity, and fire. Hand and arm injuries caused by the saw blade were at a relatively high risk level (score = 9). Wood chip and splinters flying into eyes, causing eye irritation and injuries, were also at a high risk level (score = 8). The sawmill workers were exposed to wood dust at maximum levels of 2.500 mg/m<sup>3</sup> for respirable dust and 2.083 mg/m<sup>3</sup> for total dust, respectively (Table 4). In addition, we detected high noise exposures, including a maximum of 94.4 dBA (score = 9) (Table 5). We identified case reports for occupational health injuries including wood chips splashing into eyes (3 cases), hands and arms injured during sawing (5 cases) in the past year and noise-induced hearing loss (6 cases) within two years, respectively<sup>10,11</sup>.

#### Planing and Re-arranging

The planing and re-arranging step includes planing, planing pre-vacuum, and planing after wood preservative.

**Table 3.** Occupational health risks and hazards assessment after evaluation in working procedures in Para rubber sawmills

Working Procedure/ area	Task	Identified Hazard and Risk	Definitions	Risks by Chance	Rating (event severity)	Total Score	Risk Level
Logging and cutting	Re-arrange logs into wooden pallet	Logs	Falling objects (logs) to feet and hands	4	1	4	Acceptable
			Slippery and fall caused head injury	4	1	4	Acceptable
		Hook	Body parts injured by hook	4	1	4	Acceptable
		Wood dust	Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
		Fungi	Fungicide exposure caused respiratory symptoms and irritation and allergy	4	1	4	Acceptable
		Wet floor	Slippery floor conditions	3	1	3	Acceptable
		High heat	Heat exhaustion and faintness	4	1	4	Acceptable
		Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Urgent on demand work	Work stress and caused occupational injury and accident	3	1	3	Acceptable
		Truck	Accident on car crash	2	2	4	Acceptable
		Forklift	Accident on forklift hit or crash	3	3	9	High
		Heavy lifting	Heavy and repetitive work caused musculoskeletal disorders	3	2	6	Acceptable
		Sawing the lumber into sheets*	Saw blade		Hands and arms injuries caused by saw blade	3	3
	Lack belt caused body parts injured			2	3	6	Acceptable
Logs			Falling logs to feet, hands, and shoulder, slippery and fall caused head injury	4	1	4	Acceptable
Wood chip and slivers			Splashing of wood particles into eyes causing irritation and eye injury	4	2	8	High
Wood dust			Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
Planks			Falling planks caused feet injury	4	1	4	Acceptable
Scrap of wood			Hands stabbing by wood scrap	4	1	4	Acceptable
Splinter of wood			Hands stabbing by splinter	4	1	4	Acceptable
Fungi			Fungicide exposure caused respiratory symptoms and irritation and allergy	4	1	4	Acceptable
Noise			Hearing defects and noise-induced hearing loss	3	3	9	High
Ergonomics or repetitive work			Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
Heavy lifting			Heavy and repetitive work caused musculoskeletal disorders	4	1	4	Acceptable
Electricity			Short circuit caused fire	1	4	4	Acceptable
Fire			Planks and wood dust caused fire	1	4	4	Acceptable
Urgent on demand work			Work stress and caused occupational injury and accident	3	1	3	Acceptable

\*The logs were cut into boards by a band saw.

Occupational safety and health hazards included planks, wood dust and splinter of wood, excessive noise, forklift injuries, poor ergonomics, fire, poor lighting and sheet pile. Occupational health hazards with a high risk level included: exposures to wood dust (score = 8) (Table 4), high noise (Table 5), accidents from hitting (score = 9), and crashing by forklift (score = 9).

#### *Vacuuming and Wood Preservation*

The vacuuming and wood preservation procedure included wood preservation and chemical and fungicide mixing. Occupational safety and health hazardous concerns associated with this step were chemical exposure, slipping on wet floors in mixing areas, danger of electric shock, and fire. Tasks at a high risk level for this step in-

**Table 3.** Occupational health risks and hazards assessment after evaluation in working procedures in Para rubber sawmills (continued)

Working Procedure/ area	Task	Identified Hazard and Risk	Definitions	Risks by Chance	Rating (event severity)	Total Score	Risk Level	
Planing and re-arranging*	Planks	Planks	Falling planks caused feet injury	4	1	4	Acceptable	
		Wood dust	Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High	
	Splinter of wood	Splinter of wood	Hands stabbed by splinters	4	1	4	Acceptable	
		Noise	Hearing defects and noise-induced hearing loss	3	3	9	High	
	Forklift	Forklift	Accident on forklift hit or crash	3	3	9	High	
	Ergonomics or repetitive work	Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable	
	Fire	Fire	Planks and wood dust caused fire	1	4	4	Acceptable	
	Planks/sheets planing after vacuum/wood preservative	Chemicals	Chemicals	Skin rash and irritations	4	1	4	Acceptable
		Splinter of wood	Splinter of wood	Hands stabbed by splinters	4	1	4	Acceptable
		Sheet pile	Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable
		Forklift	Forklift	Accident on forklift hit or crash	3	3	9	High
		Ergonomics or repetitive work	Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Fire	Fire	Planks and wood dust caused fire	1	4	4	Acceptable
		Planks/sheets planing after drying	Splinter of wood	Splinter of wood	Hands stabbed by splinter	4	1	4
Wood dust	Wood dust		Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High	
Light	Light		Dimness and darkness resulted in eye strain, causing eye pain and dizziness	3	1	3	Acceptable	
Forklift	Forklift		Accident on forklift hit or crash	3	3	9	High	
Sheet pile	Sheet pile		Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable	
Vacuuming and wood preservation	Chemical mixing	Chemicals	Chemical inhalation caused respiratory symptoms, nausea and vomiting	4	2	8	High	
		Chemicals	Skin rash and irritations	4	1	4	Acceptable	
		Chemicals	Eye irritation and pain	4	1	4	Acceptable	
	Wet floor	Wet floor	Fall and slippery	4	1	4	Acceptable	
	Electricity	Electricity	Short circuit caused fire	1	4	4	Acceptable	
	Fire	Fire	Planks and wood dust caused fire	1	4	4	Acceptable	
Drying and planks re-arranging	Transfer wood chips to stove	Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable	
		High heat	Body dehydration and fainting	2	1	2	Minimal	
Grading, packing and storing	Packing	Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable	
		Splinter of wood	Hands stabbed by splinter	4	1	4	Acceptable	
		Light	Dimness and darkness resulted in eye strain, causing eye pain and dizziness	3	1	3	Acceptable	
		Ergonomics or repetitive work	Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Forklift	Forklift	Accident on forklift hit or crash	3	3	9	High
	Storage	Sheet pile	Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable
		Fire	Fire	Planks and wood dust caused fire	1	4	4	Acceptable

clude chemical mixing for wood preservation (score = 8) (Table 3).

**Table 3.** Occupational health risks and hazards assessment after evaluation in working procedures in Para rubber sawmills (continued)

Working Procedure/ area	Task	Identified Hazard and Risk	Definitions	Risks by Chance	Rating (event severity)	Total Score	Risk Level
Blade sharpening	Sharpening	Blade	Hands and arms injury	3	3	9	High
		Splash from blade sharpening	Eye irritation, pain and may cause blindness	4	1	4	Acceptable
		Noise	Hearing defects and noise-induced hearing loss	3	3	9	High
		Fume/mist	Inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
		Electricity	Short circuit caused fire	1	4	4	Acceptable
	Fire	Splash from blade sharpening caused fire	1	4	4	Acceptable	
Boiling (boiler)	Transferring wood chip as fuel	Splinter of wood	Hands stabbed by splinter	4	1	4	Acceptable
		High heat	Heat exhaustion and faintness	4	1	4	Acceptable
		Dust and smoke	Total dust and smog inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
	Controlling boiler	Ball valve obstruction	Water decreased, caused explosion	1	4	4	Acceptable
		Valve defect	High pressure increased, caused valve defect and explosion	1	4	4	Acceptable
		Controlling meter defect	Water decreased and valve controlling controller malfunctioned, caused explosion	1	4	4	Acceptable
		Gage/switch defect	Boiler controlling system failure caused explosion	1	4	4	Acceptable
	Crack pipe/leakage	High pressure and decreasing high heat caused explosion	1	4	4	Acceptable	

**Table 4.** Para rubber wood dust exposure level in sawmills\*\*

Department	Total dust (mg/m <sup>3</sup> )*				Respirable (dust mg/m <sup>3</sup> )*			
	Median	SD	Max	Min	Median	SD	Max	Min
Sawing the lumber into sheets (n=5)	1.458	0.439	2.083	1.111	1.670	0.918	2.500	0.556
Planing and re-arranging (n=4)	N/A	N/A	N/A	N/A	0.453	0.263	0.556	<0.001
Vacuuming and wood preservation (n=4)	N/A	N/A	N/A	N/A	<0.001	<0.001	<0.001	<0.001
Drying and planks re-arranging (n=4)	N/A	N/A	N/A	N/A	1.111	0.000	1.111	1.111
Grading, packing and storing (n=4)	N/A	N/A	N/A	N/A	0.681	0.786	1.111	<0.001
Maintenance/forklift (n=2)	N/A	N/A	N/A	N/A	0.412	0.393	0.556	<0.001
Office (n=4)	N/A	N/A	N/A	N/A	<0.001	<0.001	<0.001	<0.001

\*ACGIH=American Conference of Governmental Industrial Hygienists, 2011

\*\*Permissible exposure limit for wood dust exposure: respirable dust; size less than 10 um TWA 5 mg/m<sup>3</sup> and total dust TWA 15 mg/m<sup>3</sup><sup>22)</sup>

N/A no data available

#### Drying and Planks Re-arranging

During the drying and planks re-arranging process, the planks or sheets were prepared for drying. Occupational safety and health hazards at this step were sheet pile and high heat exposure. The risk level of these hazards was

acceptable or minimal (Table 3).

#### Grading, Packing and Storing

At the warehouse, the work procedures were grading, packing, and storing wood. Occupational safety and

**Table 5.** Noise level measurements in Para rubber wood sawmills\*\*\*

Department	Area sampling (dBA)*	Personal sampling (dBA)**			
		Median	SD	Max	Min
Sawing the lumber into sheets (n=16)	88.4	92.7	1.5	94.4	89.2
Planing and re-arranging (n=12)	87.8	90.2	0.8	91.1	89.1
Vacuuming and wood preservation (n=4)	86.4	88.6	0.2	88.9	88.4
Grading, packing and storing (n=4)	86.0	88.9	0.4	89.4	88.4
Blade sharpening/ maintenance/forklift (n=5)	87.2	92.4	4.5	93.0	82.5

\*Area sampling using sound level meter, a single measurement

\*\*Personal sampling using noise dosimeter

\*\*\*Permissible exposure limit for 85 dB (A) during an 8- hour workday<sup>22)</sup>

health hazards of this step were splinter of wood, repetitive work, forklift, sheet pile and fire. The task at a high risk level at this step included being hit by forklift (score = 9) (Table 3).

#### Blade Sharpening

For blade sharpening, occupational safety and health hazards included blade injuries, noise, fume exposure from sharpening, and fire. Hands and arm injuries from blade cutting (score = 9), inhalation of fume and mist (score=8) and high level of noise exposure at maximum level of 93.0 dBA (score=9) (Table 5) were at high risk level.

#### Boiling

Monitoring the boiler includes controlling heat and obtaining fuel materials. Occupational safety and health hazards associated with this step includes flying splinter of wood, high heat, dust and smoke exposure, gage or switch defect (Table 3). Exposure to dust from fumes were at a high risk level (score =8) (Table 3).

## Discussion

The results from this study of Para rubber wood sawmills in southern Thailand demonstrated that the workers in sawmills were exposed to wood dust and noise above permissible exposure limits, especially in process of sawing the lumber into sheets, and planing and re-arranging, respectively (Table 4 and 5). The dust level measurements were similar to previous studies of dust exposure to processing of Para rubber tree lumber<sup>14,15)</sup>. It should be noted, however, that these previous studies were conducted at the Para rubber furniture factories, not sawmills. This study found similar results for dust and/or noise exposure levels in lumber mill as the study of Koehncke et al.<sup>16)</sup>. The results of our study demonstrate the need for further efforts to minimize hazardous exposures to occupational wood dust and noise.

The authors and occupational health safety personnel

of four sawmills conducted JSA and hazard identifications for each work procedure for the purpose of establishing proper task procedures to minimize or eliminate the occupational hazards. Previous studies showed utilizing JSA for improving task procedures in sawmills reduced costs and related unnecessary expenses resulting from lower occupational injury rates, employee absenteeism and workers' compensation, and also lead to increased performance and productivity<sup>17,18)</sup>.

When logs were cut and loaded as raw materials, tasks at a high risk level included wood dust exposure and traffic injuries by forklift hits. This agrees with other studies that have reported high exposure to wood dust and symptoms of the upper respiratory system due to inhalation, as well as accidents caused by forklift crashes<sup>10,11)</sup>. From our review on occupational accident records, the incidence of forklift hits showed, on average, two cases each year for four different factories. The authors recommended that the sawmill safety officer create a clearer and separate commute path for transferring lumber sheets by using signs and marking the path with a luminous line and reflective paint. The authors also recommended that wood dust exposure be reduced by providing workers with personal protective breathing masks and by installing and maintaining a hood duct to provide better ventilation and removal of wood dust from the work area.

For the procedure of sawing lumber into sheets, tasks at high risk level included hand and arm injury by saw blade, eye injury due to wood dust, wood chip or sliver splash into eyes, and high noise level exposure. From reviewing occupational accidents and injuries and annual reports, we found that there was an average of one case per year in which a worker was cut by a saw blade resulting in hand and arm injury<sup>10,11)</sup>. Almost half of sawmill workers did not use or rarely used gloves because they felt uncomfortable carrying logs into the saw chain wearing gloves and worried about slippery gloves<sup>19,20)</sup>. The authors strongly recommend for use of gloves to prevent injury. Wood chips flying into eyes caused eye irritation and injuries<sup>10,11)</sup>. We recommended using goggles for eye



protection. Noise levels were presently at a maximum of 94.4dBA (Table 5). Less than half of workers regularly wore ear plugs or any kinds of hearing protection<sup>19,20)</sup>. Hearing defects and noise-induced hearing loss were reported among Para rubber tree sawmill workers in previous studies<sup>10,11)</sup>. We continue to recommend that workers use hearing protection.

In planing and re-arranging procedure, high levels of wood dust exposure, high noise levels, and accidents by forklift hit or crash were found. We provided similar recommendations to the ones we issued for handling planks. We suggested the creation and ongoing maintenance of the use of personal masks to prevent inhalation of wood dust, the installation of a hood duct to reduce wood dust levels, hearing protection use by workers, and a clearly marked commute driveway for transporting wood.

During the vacuuming and wood preservation procedure, the highest risk activities for workers concerned chemicals (Table 3). Chemicals use can cause respiratory symptoms, nausea and vomiting, skin and eye irritations<sup>21)</sup>. We suggest the workers use both protective masks and chemical resistant gloves to reduce chemical exposure.

During the drying and planks re-arranging procedure, there was also the risk of falling wooden planks and sheets. These falling items can cause injuries to workers' feet and hands. There is also risk of injury when workers transfer wood chips to the stove. Even though we found the relative low risk for high heat exposure (Table 3), exposure to high heat can still cause workers to become dehydrated and faint.

During the grading, packing and storing procedure, workers are most vulnerable to accidents from traffic injuries by forklift crashing. As we have mentioned previously, clearly marked pathways for transporting wood may help significantly reduce incidence of this type of injury.

For blade sharpening, workers are at high risk levels of hands and arms injury due to blade and hearing loss from high noise levels. Fume and mist exposure may cause respiratory symptoms<sup>22)</sup>. At the boiling station, tasks at high risk level include exposure to high wood dust levels and smoke inhalation, resulting in problems of the upper respiratory system.

In conclusion, occupational health risk assessment and risk identification of steps in Para rubber wood processing found high levels of wood dust in logging and cutting, sawing lumber into sheets, planing and re-arranging procedures, and high noise exposure in sawing lumber into sheets, planing and re-arranging and blade sharpening procedures. JSA and hazard identification on working processes in sawmills identified several high risk areas: Occupational accidents of the hands and feet are caused by being struck or injured by lumber, especially during the planing step; During the vacuuming and wood pre-

servative section, workers were exposed chemicals. All workers were strongly recommended to use personal protective equipment in any working processes. Exposures should be controlled using local ventilation systems and reducing noise transmission. We recommend that the results from the risk assessment performed in this study be used to create an action plan for reducing occupational health hazards in Para rubber sawmills.

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