APPROPRIATE LABEL COMBINATION FORMATS FOR INCREASING READER'S RESPONSE AND COMPREHENSION OF CHEMICAL CONTAINERS

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Supakpong Charoenpornpanich
18 February 2005

APPROPRIATE LABEL COMBINATION FORMATS FOR INCREASING READER'S RESPONSE AND COMPREHENSION OF CHEMICAL CONTAINERS

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ABSTRACT

Good labeling is essential for the safe handling of chemicals. The purpose of this quasi-experimental research is to find out which are the best label combination formats for chemical containers and also increasing the reader's response and comprehension. This knowledge will improve the hazard communication program and the improved labels will also comply with local requirements about hazardous material substances. Thus, eighteen combination formats were designed based on three variables of label sizes, the adding of signal words and pictograms, and the application of color codes. The objective was to increase the reader response and comprehension. The random subjects were 422 manufacturing staff of GM Thailand who were tested with one of the eighteen combination formats to check the response time and comprehension scores.

Results of the study illustrated that the best average of both response time and comprehension scores were for labels of 4" X 6" size in which signal words and color codes were added. All variables had significant correlation with the subject's comprehension but only the pictograms application had no significant correlation with response time. The comparison showed that the 4"X6" label size with signal words, pictograms and color codes application format had better average response time and comprehension scores than the existing label format. Therefore, this is the format which is recommended for use.

KEY WORDS: LABEL /COMBINATION FORMAT /CHEMICAL CONTAINER / RESPONSE TIME / COMPREHENSION
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การผสานรูปแบบฉลากผลิตภัณฑ์เคมีที่เหมาะสมเพื่อเพิ่มความไวในการตอบสนองและความเข้าใจ ของผู้อ่าน (APPROPRIATE LABEL COMBINATION FORMATS FOR INCREASING READER'S RESPONSE AND COMPREHENSION OF CHEMICAL CONTAINERS)

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บทคัดย่อ

การติดฉลากผลิตภัณฑ์เป็นสิ่งสำคัญในการจัดการกับสารเคมี การศึกษาครั้งนี้เป็นการวิจัยกึ่งทดลองเพื่อคัดเลือก การผสานรูปแบบฉลากที่เหมาะสมที่สุดที่จะใช้ติดลงบนบรรจุภัณฑ์สารเคมีเพื่อเพิ่มความไวในการตอบสนองและความเข้าใจของผู้อ่าน ความรู้ที่ได้จะช่วยปรับปรุงโครงการสื่อสารอันตราย อีกทั้งยังช่วยให้สอดคล้องกับข้อกำหนดของไทยเรื่องสารเคมีและวัตถุอันตราย ดังนั้นการดำเนินการศึกษาวิจัย จึงได้มีการออกแบบฉลากผลิตภัณฑ์ขึ้นมาทั้งสิ้น 18 แบบจากการผสานตัวแปรที่สำคัญ 3 ตัวคือ ขนาดของฉลาก, การใช้คำเตือนและรูปภาพสัญลักษณ์ ตลอดจนการใช้สัญลักษณ์สี โดยพนักงานฝ่ายผลิตจำนวนทั้งสิ้น 422 คนของบริษัท เจนเนอรัลมอเตอร์สประเทศไทย ได้ถูกสุ่มให้ทดสอบฉลากผลิตภัณฑ์เคมีจำนวน 1 แบบจากทั้งสิ้น 18 แบบเพื่อประเมินความไวในการตอบสนองและคะแนนความเข้าใจของแต่ละบุคคล

ผลการศึกษาวิจัยแสดงให้เห็นว่าค่าเฉลี่ยของความไวในการตอบสนองรวมถึงคะแนนความเข้าใจของผู้อ่านมีแนวโน้มที่ดีที่สุดเมื่อทดสอบกับฉลากขนาด 4 X 6 นิ้ว, ฉลากที่มีการใช้คำเตือนและฉลากที่มีการใช้สัญลักษณ์สี ผลการศึกษายังพบว่าทุกตัวแปรมีค่าสัมประสิทธิ์ สหสัมพันธ์ที่มีนัยสำคัญต่อความเข้าใจของผู้อ่าน แต่เมื่อพิจารณาเฉพาะความไวในการตอบสนองของผู้อ่านพบว่าทุกตัวแปรยกเว้น การใช้ภาพสัญลักษณ์ เท่านั้นที่มีค่าสัมประสิทธิ์สหสัมพันธ์ที่มีนัยสำคัญ และเมื่อทำการทดสอบเปรียบเทียบ พบว่าผู้ทดสอบฉลากผลิตภัณฑ์ขนาด 4 X6 นิ้ว มีการใช้คำเตือน รูปภาพสัญลักษณ์ และใช้ สัญลักษณ์สี จะมีความไวในการตอบสนองและความเข้าใจ ดีกว่า ผู้ทดสอบฉลากผลิตภัณฑ์ที่ใช้อยู่ในปัจจุบัน ดังนั้น นี่จึงเป็นรูปแบบฉลากผลิตภัณฑ์เคมีที่แนะนำเพื่อการใช้งาน

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CHAPTER I
INTRODUCTION

1.1 Backgrounds and Rationale

Some of safety and environmental professions may still understand that "Hazard communication program" should focus only on safety training about how their employees identify and protect themselves from chemical hazards in the work areas. They sometime skip to review the effectiveness of their existing hazard communication methods or do not develop, implement and maintain the written hazard communication program to describe how material safety data sheet, labeling, and employee information and training requirements will be met.

Not only General Motors (GM) facilities in USA, but also other GM facilities worldwide including Thailand have to develop and implement the chemical hazard communication program regarding GM and United Auto Workers (UAW) hazard communication guidance. [1,2] Six months before the first product launched in May 2000 at GM Thailand (GMTh), a hazard communication program was partially introduced to their employees by Environment and chemical section. During implementation they found that there were some differences in detail between the guidance and local requirements and also question about its effectiveness, which they have to review and improve very soon.

GM Thailand has a plan to review the effectiveness of their chemical hazard communication program on a periodical basis. In September 2002, the Environment and chemical section conducted an annual survey relating to the customer satisfaction on their service programs e.g. Environmental Management Program (EMS), Water and wastewater treatment operation, Waste management, Laboratory analysis, Chemical inventory management and Chemical hazard communication program by sending 100 self-administered questionnaires to all group areas in manufacturing department. Some

part of the results indicated that 70.45 % of the respondents satisfied with the overall performance and effectiveness of existing hazard communication program. But 47.73 % of the respondents identified that our standard chemical warning label is difficult to understand or cannot well communicate on hazard of the chemical material inside.

When studied more deeply by interviewing about the satisfaction on each component of our existing label, the result could be indicated as following;

The sizing of existing chemical warning label (4" X 6")

Suitable = 54.55 % *Unsuitable (Too big/small) = 45.45 %*

The sizing of font & message shown on the label

Suitable = 63.64 % *Unsuitable (Too big/small) = 36.36 %*

The color contrast & background of the label

Suitable = 90.91 % *Unsuitable = 9.09 %*

The comprehension will be increased when the pictograms are added into the label

Agree = 100 % *Disagree = 0 %*

The information that should be shown on the chemical warning label for hazard communication purpose is as follows;

	% Agree	*% Disagree*
5.1 Product name	100	0
5.2 Direction for use	100	0
5.3 Receiving/Expiration date	100	0
5.4 Special instruction/precaution	100	0
5.5 Packaging type	100	0
5.6 Gross weight/volume	100	0
5.7 Emergency call/Spill control team	100	0
5.8 Hazard identification	100	0
5.9 First aid instruction	100	0
5.10 Manufacturer name	90.91	9.09
5.11 GM approver number	90.91	9.09
5.12 Batch number	72.73	27.27

The average comprehension score of each term shown on the label is as follows;

	% Accuracy of the answer	*% Non-accuracy of the answer*
6.1 Chemical identification on the label	100.00	0
6.2 Instruction in case of spillage	90.91	9.09
6.3 Storing precaution	90.91	9.09
6.4 Indicating the chemical major hazard	81.82	18.18
6.5 Health hazard rating	63.64	36.36
6.6 Fire hazard rating	54.55	45.45
6.7 GM approver number	54.55	45.45
6.8 Special instruction/precaution	45.45	54.55
6.9 Reactivity rating	45.45	54.45
6.10 Batch number	9.09	90.91

The average comprehension score for the existing GMTh's label show an unsatisfied performance (63.64 % correct) especially on the items of hazard identification (Health, Fire and Reactivity hazards rating system) and also the instruction and precaution to prevent the chemical hazards. This indicated that the label is not easy to understand when compare against the rough guideline of American National Standards Institute (ANSI) and International Organization for Standardization (ISO), which the appropriate comprehension score for safety signs should be higher than 66 % and 85 % respectively.

Therefore, this bring to their concern that how they could improve their existing chemical warning label and/or other elements in hazard communication program to increase the comprehension of the employee and the effectiveness of chemical risk prevention program as well as to improve their customers satisfaction with specific focus on this following aspects;

A. Format of chemical warning label

1. The size of the label
2. The quantity of information contents shown on the label
3. The adding of the signal words/pictograms
4. The use of color codes

B. Comprehension of the readers against these following items;

1. Indicating the chemical major hazard
2. Health hazard rating
3. Fire hazard rating
4. Reactivity rating
5. Special instruction

1.2 Terms and Definition

Some technical terms and definitions that could be found in this study are identified as following;

Chemical warning Label: Chemical warning label is an appropriate group of written, printed or graphic information elements concerning a hazardous product, which furnished by the manufacturer of a chemical material to identify its hazards.
The label should describe the name of the product, hazard warnings, and the name and address of manufacturer/distributor.

Response time: means the time that elapses between a stimulus and the response to it. For this study, response time will refer to the length of time for the individual to read a chemical warning label, and the reader must have the information in order to manage or control dangerous situation.

Comprehension: means the quality of comprehensible language or thought. For this study, comprehension will refer to the ability of the individual reading a chemical warning label to understand the information sufficiently to take the desired action.

Symbol: A symbol means a graphical element intended to succinctly convey information.

Pictogram: A pictogram means a composition that includes a symbol plus other graphic elements, such as a border, background pattern or color that is intended to convey specific information.

Signal word: means a word used to indicate the relative level of severity of hazard and alert the reader to a potential hazard on the label. Three signal words, which were mostly found on the label, are “Danger”, “Warning”, and “Caution”

> *Danger* indicates an immediately hazardous situation, which if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.
> *Warning* indicates a potentially hazardous situation, which if not avoided, could result in death or serious injury.
> *Caution* indicates a potentially hazardous situation, which if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

Color code: means a color used as a background on each part of the content to convey specific information.

Precautionary statement: means a phrase (and/or pictogram) that describes recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to a hazardous product, or improper storage or handling of a hazardous product.

Hazard Level: This is the term used to describe the level of hazard i.e. oral acute toxicity has five hazard levels, flammable liquid has four hazard levels and carcinogen has three levels.

Hazard statement: means a phrase allocated to the hazard classification criteria that describes the hazards of hazardous products, including where appropriate, the degree of hazard.

Hazard warning: Any words, pictures, symbols or combination thereof appearing on label or other appropriate form of warning which convey the hazard(s) of the chemical(s) in the container(s)

Physical hazards: means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

Health hazards: means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes.

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Chemical Name: Chemical name can mean an acronym or shorthand abbreviation if a across- reference between the fully written chemical name and its associated short name is posted in the work area.

Chemical material: Chemical material is often used interchangeable with hazardous material. A chemical material covered by hazard communication program is any liquid, gas, emulsion, pellet, paste, dust, chip, fiber or powder. Purchased parts such as casting that are machined in-house are chemical materials. Purchased items that are not machined but which are coated with a chemical material, are also covered by the program. Example include lubricating oils, greases, metal working fluids, cleaners, paint, adhesives, welding rods, fuel, refractory, grinding wheels, refrigerants, and laboratory chemicals. Chemical materials that are not covered by this program are

medical supplies, food, tobacco, earthen substances such as rock or gravel (unless used for blasting), finished items that do not undergo any further processing at the plant and which are not coated with a rust inhibitor, and other specific items as determined by the GM-Hazardous Material Control Committee (HMCC) Administrator

Hazardous material: A chemical material that has some type of hazard associated with it. This hazard might be a health affect that could result from employee use, a transportation hazard and/or an environmental hazard. The hazard may not be obvious to most employees. Hazards are a function of chemical composition, toxicity, method of use, and exposure potential

GM: General Motors Corporation

UAW: United Auto Workers

GMTh: General Motors (Thailand) Limited

Material Safety Data Sheet (MSDS): This is a document furnished by the manufacturer of a chemical material. The MSDS describes the potential hazards of the product and precautionary measures to be followed.

Safe Use Instruction (SUI): Safe Use Instructions are documents developed by the United Auto Workers (UAW) and GM for the purpose of communicating potential hazards to users of hazardous materials.

HMCC (Hazardous Material Control Committee): The individual with primary responsibility for hazardous material management. At General Motors Thailand (GMTh), this function is assigned to an “Environment and Chemical Manager” to be a chairperson.

Category of materials: The categorization of specific safe use instruction by United Auto Workers (UAW) and GM for the chemical materials into twenty groups as follows;

1. Halogenated Solvents
2. Solvents – Flash point less than or equal to 100 ^{o}F
3. Solvents – Flash point greater than 100 ^{o}F
4. Metal working fluids and lubricants
5. Adhesives – Solvent based polyurethane, Epoxies, Sealers
6. Adhesives, Sealers – General
7. Compresses gas – Toxic
8. Metals, Metal salts, Solders, Power metals
9. Corrosives – Concentrated acids – pH less than 4
10. Corrosives – Acid/Base – Powder, flake, and salt
11. Corrosives – Concentrate base – pH greater than 10
12. Compress gas – Flammable
13. Compress gas – Inert
14. Compress gas – Oxidizing
15. Compress gas – Corrosive
16. General use – Minimal health risk
17. Other/Unique hazard
18. Respirable/Reactive fibers and Particulates
19. Biocides, Pesticides
20. Oxidizing materials

Container: Any bag, barrel, bottle, box, can, cylinder, drum, reaction vessel, storage tank, or the like that contains a hazardous chemical.

Label Size: The physical magnitude of the label.(how big it is) For this study, the interested label sizes are 4.0 ”X6.0 ”, Half A4 and A4 Size

Content: What a communication that is about something is about on the label.

Combination: A collection of things that have been combined for a specific purpose.

1.3 Research Objectives

1.3.1 General Objective

To develop and find out the most appropriate chemical warning label for increasing reader's response and comprehension, this new chemical warning label will strengthen the success of hazard communication program and comply with both local and global requirements for chemical warning label.

1.3.2 Specific Objectives

1.3.2.1 To evaluate and compare the appropriateness among the label design variables (focusing on label sizes and the quantity of the information contents, the adding of signal word and pictogram, and the use of color code), which may affect to the reader's response time, and comprehension testing scores

1.3.2.2 To evaluate the improvement of the reader's response time and comprehension score when applying with the appropriate chemical warning label and comparing with the existing label.

1.4 Research Hypothesis

1.4.1 There are any significant correlations among these factors:- "the label size with various quantity of information contents", "the adding of signal words and pictograms", "the use of color code" may give some significant effects on "the response time, comprehension testing scores" of the readers.

1.4.2 The large label size (A4) with most information contents has better response time, comprehension testing scores than the small (4"X6") and medium label (Half A4) sizes.

1.4.3 The response time and comprehension testing scores of the designed label with "signal words and pictograms" and "Color codes" are better than label without them.

1.5 Studied Variables

1.5.1 Independent Variables

1.5.1.1 The size of chemical warning label and the quantity of information contents

a. Small – 4.0”X6.0”, with rough information contents

b. Medium – Half of A4 size, with moderate information contents

c. Large – A4 size, with detailed information content

1.5.1.2 The adding of signal words and pictograms

a. With both signal words and pictograms

b. With signal words only

c. With pictograms only

1.5.1.3 The use of color code

a. With color code

b. Without color code

1.5.2 Dependent Variables

1.5.2.1 Response time - The time taken to answer the questions

1.5.2.2 Comprehension testing score - The accuracy of the answer of each question

1.5.3 Controlled Variables

To assume that all GM subjects are homogeneous under this study, some important variables such as Educational level, working experiences and the experience with GM’s hazard communication program and etc. were being controlled as following;

1.5.3.1 Education level (Not higher than high vocational level)

1.5.3.2 Working experience with GM Thailand (At least 0.5 year)

1.5.3.3 Experience with GM’s hazard communication program (The hazard communication system (HCS) knowledge will be reviewed by watching HCS VDO before testing)

1.5.3.4 Font characteristic and size (12-point of Tahoma font with 2-point size difference between the signal word and the main body will be used for this research)

1.5.4 Exclusion criteria

Experience with chemical accident will be screened and separated during interviewing by the questionnaire. The reason of this screening due to the fact that the workers who have the past experience with the chemical accident will alert and familiar with the chemical precaution better than normal people who have no experience.

1.6 Scope of Study

1.6.1 This research is aimed to design and find out the most effective chemical warning label system for implementation regarding local and global hazard communication standards.

1.6.2 The research will be taken place at "Chevrolet assembly center – General Motors Thailand, Rayong province.

1.6.3 Reference labeling systems are most well known and acceptable systems e.g. GHS-Global harmonized system, NFPA-National Fire Protection Association system and HMIS- Hazardous Material Information System.

1.6.4 Subjects in the research are manufacturing workers who already passed the orientation training of "Hazardous material awareness" or "Brush up course" not longer than 0.5 year, The workers of Environmental and Chemical section or the workers with education higher than grade 12 or the workers having experience with chemical accident before will be excluded from this study.

1.6.5 The subjects of this study will be tested by designed test with 18 label formats (See table 1-1) and interviewed by using the testing record form, which will be designed by the researcher (See Appendix D)

Table 1-1: Design of tested labels by various combination

Variables	Number of Patterns	Codes	Tested Labels
1. Label Sizes	3	S = 4" X 6" M = Half A4 size L = A4 size	Total combination = 18 **Combination codes for 3X3X2 tested labels** (SAY, SAN, SBY, SBN, SCY, SCN, MAY, MAN, MBY, MBN, MCY, MCN, LAY, LAN, LBY, LBN, LCY, LCN)
2. The adding of Signal words and Pictograms	3	A = Both Signal words and Pictograms B = Signal words only C = Pictograms only	
3. The use of color codes	2	Y = Yes N = No	

Each combination code came from each variable and assigned for each tested label as following examples; "SAY" means the designed label in "4 X 6" size with the adding of both Signal words and Pictograms, and color codes. "LBN" means the designed label in A4 size with the adding of Signal words only, and without color code.

1.7 Benefit from the study

1.7.1 The risk of non-compliance with local regulations about working with hazardous chemical and/or hazard communication will be reduced.

1.7.2 The result from the study could be used as guidance for designing an appropriate chemical warning label format to increase the reader's response and comprehension by selecting the recommended variable combinations.

1.7.3 The effectiveness of hazard communication program by using chemical warning label will be increased after improving the worker's response time and comprehension.

1.7.4 The chemical warning label format will be standardized for implementing hazard communication program among Thailand automotive industries and/or within the GM Corporation.

CHAPTER II
LITERATURE REVIEW

2.1 OSHA Hazard communication (29 CFR 1910.1200)

The hazard communication standard [3] was developed to inform workers who exposed to hazardous chemical and the risks associated with those chemicals by the Occupational Safety and Health Administration (OSHA). The purpose of the standard is to ensure that; the hazards of all chemicals produced or imported are evaluated, and information concerning chemical hazards is transmitted to employers and employee.

This US-OSHA hazard communication standard [3] contains ten basis requirements designed to protect the health and safety of employee.

1. Hazards determination
2. Material Safety Data Sheets (MSDSs) composing
3. Providing customers with MSDSs and warning labels
4. Providing MSDS for every hazardous chemical
5. MSDS accessibility
6. Label application on the packaging/containers
7. Label maintaining
8. Employee information
9. Employee training
10. Written hazard communication program preparation

The standard of labels and other forms of warning, was described in the "f" section which was purposed to ensure that the hazards of all chemicals produced or imported are evaluated, and that information concerning their hazards is transmitted to employers and employees. This transmission of information is accomplished by means of comprehensive hazard communication programs, which are to include container labelling and other forms of warning, material safety data sheets and employee training.

(f)(1)

The chemical manufacturer, importer, or distributor shall ensure that each container of hazardous chemicals leaving the workplace is labelled, tagged or marked with the following information:

(f)(1)(i)

Identity of the hazardous chemical(s);

(f)(1)(ii)

Appropriate hazard warnings; and

(f)(1)(iii)

Name and address of the chemical manufacturer, importer, or other responsible party.

(f)(2)

(f)(2)(i)

For solid metal (such as a steel beam or a metal casting), solid wood, or plastic items that are not exempted as articles due to their downstream use, or shipments of whole grain, the required label may be transmitted to the customer at the time of the initial shipment, and need not be included with subsequent shipments to the same employer unless the information on the label changes;

(f)(2)(ii)

The label may be transmitted with the initial shipment itself, or with the material safety data sheet that is to be provided prior to or at the time of the first shipment; and,

(f)(2)(iii)

This exception to requiring labels on every container of hazardous chemicals is only for the solid material itself, and does not apply to hazardous chemicals used in conjunction with, or known to be present with, the material and to which employees handling the items in transit may be exposed (for example, cutting fluids or pesticides in grains).

(f)(3)

Chemical manufacturers, importers, or distributors shall ensure that each container of hazardous chemicals leaving the workplace is labeled, tagged, or marked in accordance with this section in a manner which does not conflict with the

requirements of the hazardous Materials Transportation Act (49 U.S.C. 1801 et seq.) and regulations issued under that Act by the Department of Transportation.

(f)(4)

If the hazardous chemical is regulated by OSHA in a substance-specific health standard, the chemical manufacturer, importer, distributor or employer shall ensure that the labels or other forms of warning used are in accordance with the requirements of that standard.

(f)(5)

Except as provided in paragraphs (f)(6) and (f)(7) of this section, the employer shall ensure that each container of hazardous chemicals in the workplace is labeled, tagged or marked with the following information:

(f)(5)(i)

Identity of the hazardous chemical(s) contained therein; and,

(f)(5)(ii)

Appropriate hazard warnings, or alternatively, words, pictures, symbols, or combination thereof, which provide at least general information regarding the hazards of the chemicals, and which, in conjunction with the other information immediately available to employees under the hazard communication program, will provide employees with the specific information regarding the physical and health hazards of the hazardous chemical.

(f)(6)

The employer may use signs, placards, process sheets, batch tickets, operating procedures, or other such written materials in lieu of affixing labels to individual stationary process containers, as long as the alternative method identifies the containers to which it is applicable and conveys the information required by paragraph (f)(5) of this section to be on a label. The written materials shall be readily accessible to the employees in their work area throughout each work shift.

(f)(7)

The employer is not required to label portable containers into which hazardous chemicals are transferred from labelled containers, and which are intended only for the immediate use of the employee who performs the transfer. For purposes of this

section, drugs which are dispensed by a pharmacy to a health care provider for direct administration to a patient are exempted from labelling.

(f)(8)

The employer shall not remove or deface existing labels on incoming containers of hazardous chemicals, unless the container is immediately marked with the required information.

(f)(9)

The employer shall ensure that labels or other forms of warning are legible, in English, and prominently displayed on the container, or readily available in the work area throughout each work shift. Employers having employees who speak other languages may add the information in their language to the material presented, as long as the information is presented in English as well.

(f)(10)

The chemical manufacturer, importer, distributor or employer need not affix new labels to comply with this section if existing labels already convey the required information.

(f)(11)

Chemical manufacturers, importers, distributors, or employers who become newly aware of any significant information regarding the hazards of a chemical shall revise the labels for the chemical within three months of becoming aware of the new information. Labels on containers of hazardous chemicals shipped after that time shall contain the new information. If the chemical is not currently produced or imported, the chemical manufacturer, importers, distributor, or employer shall add the information to the label before the chemical is shipped or introduced into the workplace again.

2.2 Thailand Hazard Communication Standards

2.2.1 Requirement related with MSDS

2.2.1.1 Ministerial Regulation No.3 issued under Factory Act B.E. 2535 (Clause 6)

2.2.1.2 Ministry of Interior's Notification about Safety working with Chemicals.

2.2.1.3 Hazardous substance Act B.E. 2535

The factory which produces, stores or uses dangerous substance, shall have to prepare Material Safety Data Sheet concerning the nature of harm according to the property of such material

2.2.2 Requirement for Labels

2.2.2.1 The Factory Act B.E. 2535 (1992)

A. Label must be in Thai

B. Label must include the following details

a. Chemical or scientific name of harmful chemical

b. Quantity and composition of harmful chemical

c. Symbol indicating harm

d. Hazardous characteristics

e. Signal words “Harmful chemical” or “Poisonous substance”

f. Warning concerning storage, use, and transport

g. Method of first-aid treatment and advice to send the patient to the medical officer

h. Hazard symbols e.g. Explosive substances, Toxic substances, Flammable substances, Corrosive substances, Substance that contribute to combustion, Hazardous substances and etc.

2.2.2.2 Ministry of Interior’s Notification about Safety working with hazardous materials

Not allow the employer transport, handling or store the hazardous materials into the organization unless the appropriate label had been posted on every packaging. The label should have following information as following;

a. The pictogram and signal word of “Hazardous material” or “Toxic substance” or any other words relate with its hazard would be identified obviously in red or black.

b. Chemical name or scientific name of the hazardous material.

c. Quantity and ingredient of the hazardous material.

d. Hazards and symptoms from the hazardous material.

e. Instruction for safety storing, handling, transporting application, disposal and packaging methods

f. Instruction for first aid

2.2.2.3 Consumer Protection Act B.E. 2522 (1979)

The controlled products under this regulation would be labelled and identified this following information to the consumers;

a. Name and trade make of the manufacturer

b. The manufacturer or importer address

c. Product identification and the countries which the product was imported from

d. Instruction or warning information and expiry date

e. Any essential health and safety information

2.2.3 Chemical labelling system

Many chemical products in the workplace are packed as consumer products. Because of this there are no many formal labelling systems applied. Instead, there are some straightforward warning about hazards associated with the products (e.g. Flammable, Keep away from fire or flame, Do not swallow or inhale). The workers may see these labelling systems on containers and on the Material Safety Data Sheets. (MSDS) However, in addition to the manufacturer's labels, there are four common labelling systems that may come across:

1. National Fire Protection Association (NFPA) Diamond
2. Hazardous Material Information System (HMIS) Label
3. American National Standard Institute (ANSI) Standard Z129.1
4. Global Harmonised Chemical Classification and Labelling System (GHS)

The NFPA (National Fire Protection Association) Diamond – Figure 2.1 and HMIS (Hazardous Material Information System) – Figure 2.2 are visual systems of ***colors*** and ***numbers*** that identify a chemical's inherent hazards, including both ***health hazards*** and ***physical hazards***, and their ***severity***, or degree of hazard but the ANSI (American National Standard Institute) system recommends the use of signal word such as caution, warning and danger to convey the degree of hazard. [4] (See HMIS numerical rating, and HMIS PPE symbols in appendix A-B).

Figure 2-1: NFPA Diamond

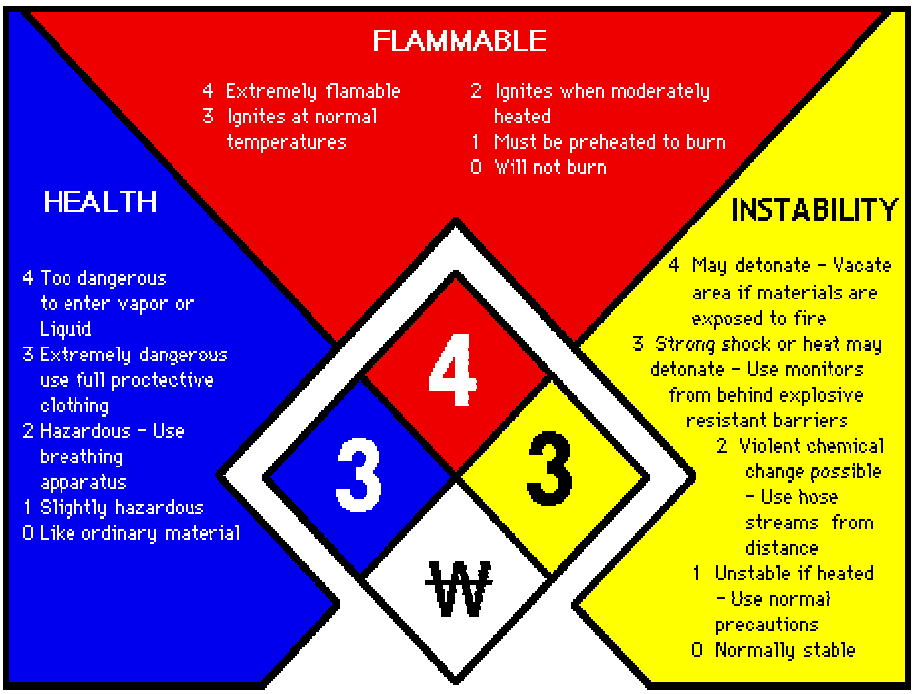
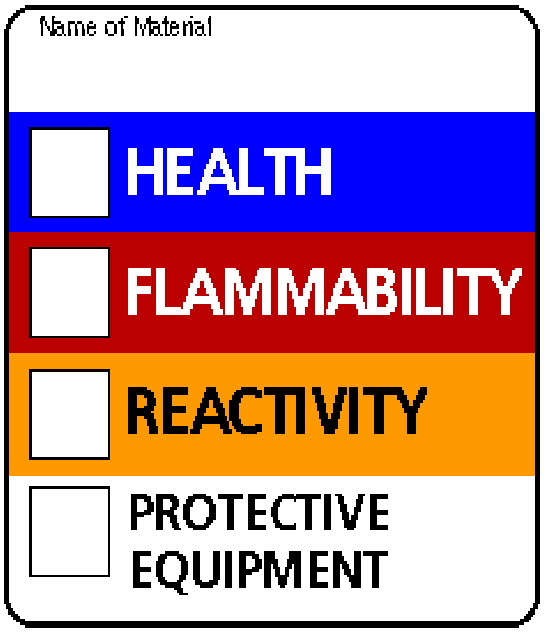


Figure 2-2: HMIS Label



There are some differences between the NFPA and HMIS (Hazard Labelling System) which was summarized as following;

Similarities

1. Both systems have three color-coded fields to indicate the flammability (red), health (blue), and reactivity (yellow) hazards associated with the material.

2. Both use a system of five numbers, ranging from 0 to 4, to indicate the severity of hazard, with 0 being the least and 4 being the most hazardous.

Differences

1. They differ in layout (NFPA uses four diamonds, but HMIS uses vertically stacked bars.

2. They differ in interpretation of the fourth, white field (special handling in the NFPA system; protective equipment in the HMIS system).

Possibly the most significant difference, however, has to do with the intended audience for each of the systems. The HMIS was devised as a Hazard communication system (HCS) compliance tool, and employees must handle hazardous chemicals in the workplace as the intended audience. The NFPA system was designed to alert fire fighters arriving on the scene of a fire to the hazards associated with materials presented at that location. Therefore, the numbers assigned in the NFPA system assume that a fire is present. No such assumption holds in the HMIS system. For this reason, the numbers that are assigned to the flammability, health, and reactivity hazards may differ between the NFPA and HMIS systems, even for the exact same chemical.

Although the NFPA, HMIS and ANSI labelling systems are widely used worldwide, but there are many efforts to harmonize the hazard communication to be a global system for solving the confusion problem. The Internal Labour Office (ILO) is one of the dominant organizations that have the major roles on protecting the health of the workers who work related with hazardous chemicals. ILO had set the working group to propose the harmonization of chemical hazard communication [5] in the globally harmonized system (GHS) since 1992. The working group has proposed the draft GHS labelling comprising at least 5 elements as listed below;

1. Hazard level
2. GHS Hazard Symbols i.e. Flame, Flame over circle, Exploding bomb, Corrosion, Skull and crossbones, Exclamation mark, Fish and tree, and etc. (see examples in appendix B)
3. Hazard Pictograms (The pictogram should be diamond in shape)
4. Signal word
5. Hazard statement

The goals of the globally harmonised classification and labelling system (GHS) are to enhance protection of mankind and the environment by;

1. Providing an internationally comprehensible system for hazard communication.
2. Providing a recognised framework for those countries without an existing system.
3. Facilitating international trade in chemicals whose hazards have been properly assessed and identified on an international basis.
4. Reducing the need for testing and evaluation of chemicals.

A set of principles for globally harmonised classification and labelling system (GHS) had been developed as following;

1. The overall level of protection should not be reduced

2. The hazard classification process should refer only to the intrinsic properties of the chemicals

3. A building block approach should be used: the appropriate elements relevant to means of transport, consumer, worker and environmental protection should be selected from a common and coherent basis for chemical hazard classification and communication.

4. Harmonization should include both hazard classification criteria and hazard communication tools. e.g. labelling and chemical safety data sheet

5. The comprehension of chemical hazard communication tools should be addressed.

6. Hazard communication programs should be designed to protect the health, safety and environment for operators, consumers and the general public, whilst respecting suppliers confidentially.

The harmonised hazard communication system included labelling, safety data sheets and easily understanding symbols. The hazard communication is based on the classification criteria for physical, health and environmental hazards. The harmonized system for labelling of hazardous chemical uses these following key points to achieve its GHS objectives;

1. Signal words for indicating the severity of the hazard and alert the reader to its potential. Two signal words are used
   a. Danger: - To describe the more severe hazard categories
   b. Warning: - To describe the less severe hazard categories
2. Symbols
3. Pictograms
4. Hazard statements
5. Precautionary information
6. Product identifiers
7. Ingredients (In the case of mixtures)
8. Colour

Although the GHS will be a non-mandatory recommendation available to the countries to implement and the goal is to have the system implemented in at least 2 countries in each of the five regions of the world in year 2008, this global hazard communication program will be the guidance to design an appropriate chemical warning label in this study.

For GM Thailand' existing standard chemical warning label, its was first launched in the mid of year 1999 at the size of 4" X 6" with HMIS labelling system. All chemical material delivered to the site will be replaced by this label before distributing to the point of use. The pattern of this label especially the information to be communicated was influenced by GM-UAW hazard communication program,

which was found later that it did not fully comply with our local requirement yet. (See the comparison in table 2-1)

Table 2-1: The comparison of GM Thailand - existing chemical warning label with 3 concerned standards on acceptable hazard warning design requirements

Requirement/Expectation	GM Thailand Label	Annc.of Ministry of Interior (hazardous chemical)	GM-UAW Hazard communication	OSHA Hazard communication
1. Hazard symbol or context of "Hazardous material" or "Toxic substance" in Red or Black		✔	✔	✔
2. Chemical name or Scientific name	✔	✔	✔	✔
3. Quantity & ingredient of hazardous chemical		✔		
4. Physical and health hazards	✔	✔ (may documented separately)	✔	✔
5. Instruction/Precaution for handling, storing and disposal methods.	✔	✔ (may documented separately)	✔	
6. First aid procedure/instruction		✔ (may documented separately)		

The obvious difference among the existing labeling elements used in GM Thailand which need to be improved for complying with local regulation, OSHA Hazard communication standard, GHS labeling system and also GM-UAW Hazard communication program is the lack of “hazard symbol” and “Signal word”, so this will be the first element which have to be study more before design the new label for use in the company.

Figure 2-3: GM Thailand - Existing chemical warning label

GM แผนกเคมีและสิ่งแวดล้อม เบอร์ 4264, 4266	**ชื่อผลิตภัณฑ์** น้ำมันเบรค Break Fluid Dot 4 ESL	**ผู้จำหน่าย/ผลิต** บ.เชลล์ ประเทศไทย จำกัด
1 ระดับอันตรายต่อสุขภาพ 1 ระดับความไวไฟ 0 ระดับความไม่เสถียรในการเกิดปฏิกิริยา ซึมผ่านได้	**หมายเลขประจำการผลิต** 1140420	**ทะเบียนสารเคมีที่ได้รับอนุญาต** **GM 000094**
	วัตถุประสงค์การใช้งาน ใช้เติมลงในระบบเบรครถยนต์	**วันที่ตรวจรับสินค้า** 04-02-03
		ข้อชี้แนะพิเศษ เก็บในที่แห้งและเย็น ปิดฝาให้สนิท
หมายเลขติดต่อกรณีฉุกเฉิน Security 1911 Medical 2519 Safety 2507	ลักษณะบรรจุภัณฑ์ ถังโลหะ	**น้ำหนักสุทธิ** 200 ลิตร

So, it may conclude that for compliance with both GM requirement and local requirement (Announcement of Ministry of Interior about working with hazardous chemical [6] and Hazardous material Acts by Ministry of Industry [7]), new improved label should have at least 6 elements as shown below;

1. Generic name of chemical material
2. Hazard symbol and Signal word such as “Danger-Hazardous material”, “Caution-Toxic substance” or etc.
   (Need to be added)
3. Statement of hazards (both physical & health hazards)
4. Precautionary measures
5. Quantity and ingredient of hazardous chemical
   (Need to be added)
6. Instruction in case of contact, exposure etc.
   (Need to be added)

2.3 Communication and Visual Perception Theories

Acceptable design of label should consider these following factors, which may relay critical information since they relate to consumer safety in the reasonable and foreseeable use of the product. [8]

2.3.1 Label visibility

2.3.1.1 Viewing distance and warning placement

In 1985, OSHA proposed an amendment to 1910.145, "Specification for accident prevention signs and tags," requiring that accident prevention tag be readable from a distance of at least five feet.

2.3.1.2 Viewing angle

Labels are most effective if they are read from directly in front (0^o angle)

2.3.1.3 Time to view

The required time to perceive information in one symbol or word is generally in the range of 0.5 sec. Alternatives to words, when viewing is at a premium, are pictures or symbols. A symbol is most easily perceived when it represents a familiar object.

2.3.1.4 Light level

Light level affects sign readability, when the available light is low or severe shadows are apparent, it is necessary to use the larger label and type. If glare is a problem, the sign should be printed using non-reflective materials.

2.3.1.5 Light sensitivity

Regarding the guideline for lighted visual warnings, color is important because of convention (e.g. red for danger, yellow for caution)

2.3.1.6 Durability

Labels form a durable bond with the base material and shall show no appreciable loss of adhesion during weather exposure or exposure to oil or gasoline. Following normal cleaning procedures, the label shall show no appreciable fading, discoloration, cracking, crazing, blistering, or dimensional change. Also, labels should not curl at the edges.

2.3.1.7 Color and color contrast

Regarding the color contrast theory, the appropriate color combinations were recommended as below;

Signal word	Color code
Danger	White letters on red background
Warning	Black letters on orange background
Caution	Black letters on yellow background
Notice	White letters on blue background

2.3.1.8 Color codes for Signs (By OSHA Regulation 1910.145)

Classification	Color designation
Danger	White letters on red background surrounded by black border, message in black letters on white background below.
Caution	Yellow letters on black background, message in black letters on yellow background below.
Notice	White letters on blue background, message in black letters on white background below.
Safety instruction	White letters on green background, message in black letters on white background below

2.3.1.9 Location and orientation of Label

Labels should be placed where they can be seen or arrange label close to the component being identified and make sure two different labels are not so close together that they appear to be a continuation of each other. Labels should be placed consistently either above or below each component identified. Above is preferred choice. Place labels horizontally. Vertically orientations can be used in rare cases where the label is needed only for familiarization purposes. Curved patterns of label should not be used.

Orient all labels horizontally to the expected line of sight.

2.3.2 Label legibility

2.3.2.1 Stroke width

Stroke width normally expressed as the ratio of the thickness of the stroke to the weight of the characters or numbers. In general, the following character ratios are recommended for acceptable good design:

Color of character	Stroke width : Height ratio
Black on white	1 : 6 – 1 : 8
White on black	1 : 8 – 1 : 10

2.3.2.1 Width : Height ratio

Description	*Daylight*	*Tran illumination*
W 55 % of H	*Poor*	*Poor*
W 70 % of H	*Optimum*	*Acceptable*
W 85 % of H	*Optimum*	*Acceptable*
W 100 % of H	*Acceptable*	*Optimum*

2.3.3 Label readability

Label readability normally refers to the recognition of the information content of the materials; this includes words, sentences, text, or other meaningful grouping of words or alphanumeric characters.

2.3.3.1 Type specification (Font)

Recommended font on label and signs for optimum readability are "Helvetica, Euro style, Oracle Bold II and Avant Garde Gothic "Type form (Capital, lowercase, boldface, italics, etc.)

The instruction message should appear in lowercase letters, a full word might be set in uppercase letters for emphasis.

2.3.3.2 Contrast

See item 2.3.1.7

2.3.4 Pictograms

The pictograms are beneficial in warning label design as a supplement to the written message. This is particularly true when the user has a limited grasp of the written English language. Pictograms should be used to supplement and reinforce the warning message.

When the pictograms are utilized in a visual display, they must be graphically arranged properly to be effective. These following basic guidelines are being used for designing effective visual displays;

1. Clear figure/ground articulation is essential.
2. A contrast boundary, essentially a solid shape, is preferred to a line boundary of a figure.
3. The boundary of a symbol should be clear, usually portrayed in bold lines, with no words or numerals outside this boundary.
4. The simplest figure should be chosen, consistent with the inclusion of any features that are necessary to get the message across.
5. Symbols should be unified as possible.

2.4 Related researches

As the result of the first internal survey indicated that 47.73 % of the respondents identified that GMTh's standard chemical warning label is difficult to understand or do not well communicate on hazard for the chemical material inside. However the average comprehension score for all parts of the existing label show that the readers can answer the question correctly for 63.64 % from the second survey result.

Mark R. Lehto has recommended in his research that the effective warning sign and label should have comprehension score > 85 %, so the existing score should be improved in this research by choosing the most effective variables such as label sizes, the adding of signal words and pictograms, and the use of color codes and etc for further improvement.

Anyway, after doing literature review, there are many factors related with the reader responding and comprehension toward the label, which may be the variables for this research.

2.4.1 Label format (Size, style, location, and etc)

The experiment of J.Paul Frantz, 1993, indicated that the presentation format did not affect overall label effectiveness [9] and the result was confirmed by Mark R. Lehto, 1998, that label format did not strongly impact subject performance on speed and accuracy of finding requested information as much as the content of the label. [10]

Regarding the above finding, this research will design three label sizes with different content for testing separately from other label format. This study will reconfirm whether the label format impacts the subject performance on the reader's response or not.

2.4.2 Signal word

Michael S. Wogalter et.al.,1999, found that the presence of warning using signal word on the front label increase participant's perceptions of a product hazard. (11) Moreover, J.Paul Frantz, 1993, also found that substantially more subjects read and complied with warning that appeared in the "Directions for use" than "Precautions" section, ANSI Z535.4-1991 entitled "Product safety signs and label" indicates when the following signal words should be used: Danger, Warning and Caution" (9)

Therefore, in this research, all three recommended signal words such as Danger, Warning and Caution will be used for testing compliance with hazard communication program.

2.4.3 The provision of symbol/pictogram on a label

Joseph P. Ryan, P.E.,1990 indicate in his book (Design of warning labels and instruction) that the symbol and pictogram will help the reader more understand the hazard. (8) The results are similar to the experiment of J. Paul Frantz, James M. Miller and Mark R. Lehto,1991, found that the context will be less important when applying the generic safety symbols.(12)

The addition of symbol/pictogram on a label will be one of the variables tested the impact to the reader's responding and comprehension.

2.4.4 The context for more explanation

Naiphaporn Augsornpeug, 2001, Mahidol University, Thesis M.Sc. (Industrial hygiene and safety) found that the comprehensive scores of the safety signs for the construction site were increased when adding text and pictures. (13)

2.4.5 The difficulty of technical word/content

Akihiko Seki et.al.,2000, found this problem when studying about MSDSs, the most difficult words from their studies were CAS number, sensitisation and mutagenicity, which made the MSDSs were unsatisfied due to the difficulty in understanding and interpreting the MSDS content.. (14)

2.4.6 Knowledge of the reader, Working experience in industry, and/or Experience with chemical warning label or MSDS

Carles C. Phillips et.al., 1999, summarized their finding about MSDSs and worker acceptability that education level, number of chemicals used, and working years did not affect the usefulness of the MSDS, [15] which contrast with the finding by Mark R. Lehto, 1998, and Araya Rumpakaporn 1996, that either education level, past exposure to similar chemical labels or industrial experience with chemicals gave the significant higher understanding of label. [9, 16]

Education level, past exposure to similar chemical labels, industrial experience with chemical or chemical accident will be controlled in this research.

2.4.7 Type of fonts and size

Braun and Silver, 1992, summarized their finding that participants were more likely to read the warning in "Helvetica type" than that in "Time or Goudy types" and the main body with 10-point size (compared with 8-point size), 2-point size difference between the signal word and the main body of the warning produced a great likelihood of reading warning over 4-point size difference [17], but Silver, Kline and Braun, 1994 found there was greater perceived readability and perceived hazard when the signal word was printed in 14-point. [18]

14-point of Helvetica font with 2-point size difference between the signal word and the main body will be applied on all tested labels for this research. Anyway, due to Helvetica font could not support Thai format. So, Tahoma font, the most similar style with Helvetica will be applied instead in the research.

2.4.8 Shape of labels and Color

Rectangular shapes are predominately used because of their simplicity; Young, 1993 summarized his research result that warning containing a pictorial, color, or and icon had significantly faster response times than warnings without them and the additional of border did not improve response times, [19] Braun, Sansing, and Silver, 1994 suggested in their finding that red color conveyed the highest level of perceived hazard followed by orange, black, green and blue. [20]

Color codes will be used as a variable for testing the improvement of response times of the readers in this research.

CHAPTER III
MATERIALS AND METHODS

This research is an experimental study designed with combinations of 3 factors as 3 X 3 X 2 = 18 labeling designs. The reader's response time in seconds and comprehension score (%) were the tested outcome according to the labels. Each chemical warning label will be designed with or without signal words and pictograms, the use of color codes and the various sizes and contents regarding the factorial design concept.

3.1 Target Populations, Sample Size, and Sampling Technique

3.1.1 Target populations are typical group of GM Thailand's employee in Manufacturing, Engineering and Quality Control departments, who used or consumed the chemicals both directly and indirectly. The subjects were asked about their educational background, working experiences, and the experiences with chemical accident by answering the question 7-10 in section 1 of the testing record form. Finally, all screened subjects in the group were assumed as homogeneous with an educational background not higher than high vocational school, had at least 0.5 year working experience with GM Thailand, and had no experiences with the chemical accident before.

3.1.2 Sample size (n) estimation [21] was calculated from the formula below;

$$n = \frac{(Z)^2 pq}{d^2}$$

p = Proportional of the answer in the correct decision. (The study result in the year 2002, the average comprehension of the existing label = 63.64 % or 0.64)

q = Proportional of the answer in the wrong direction, (1-p) or 0.36

d = Maximum error that allow to be happened, (0.05)

When $Z_{\alpha/2} = 1.96$, d = 0.05, p = 0.64, q =0.36, therefore..

$$n = \frac{1.96^2 \text{ X } 0.64 \text{ X } 0.36}{0.05^2}$$

n = 354 subjects

3.1.3 Although the sample size from the calculation is only 354 subjects when the total population is 2,300 people (at September 2003), therefore the sampling ratio is 2300/354 = 6.5 However, when considering the safety factor and the sampling error that may occurred, the sampling ratio would be adjusted to 5.0 for this study. Finally, the approximate population structure of the Manufacturing department of GM Thailand could be compare with the sampling size as below;

	N	n
Press & Body Shop	700	140
Paint Shop	500	100
General Assembly Shop	800	160
Quality Control and Other	300	60
Total	**2,300**	**460**

The subjects were sampled by simple random sampling technique in advance 1 month before the testing started. They were allowed to register and get in the group only once (totally 25 groups with 20 subjects per group) as per their convenience. Each subject received one designed label by simple random technique for testing his response time and comprehension score toward his handled label.

3.2 Research Materials

3.2.1 Testing record form

The testing record form used in this research was composed of three essential parts as following;

Part 1: General Information

There were 10 questions in this part which asking the subjects about their general characteristic e.g. sex, ages, department and their working location. The rest of questions asked them about their educational background, working experiences with GM Thailand, the experiences with chemical accident and the familiarity with GM Thailand's hazard communication program for screening the subjects.

Part 2: Reader's response time testing

This part had 15 multiple choices questions to test the subjects about their response time. The subjects would find the information from their assigned label and answer this part as fast as they could. The questions asked the subjects about the quick information shown on the label such as chemical name, hazard rating, the routes of entry of that chemical, the appropriate personal protective equipment (PPE), First aid instruction and etc. Each subject would record his individual duration (second) to complete this part after finishing 15 questions immediately.

Part 3: Reader's comprehension score testing

The subjects read the label and completed this part within 15 minutes. The questions asked the subjects about their comprehension on the chemical hazards, how to do when this chemical spilled or fired, how to do first aid and handle the chemical, what are the meaning of each color code and pictogram, and etc. Anyway, for preventing the subjects did part 2 by overlooking the accuracy of their answers. Thus, the comprehension scores of the subjects were collected from

both part 2 (15 questions) and part 3 (12 questions) as a total score.

3.2.2 Collecting Data and Supporting Instruments

A. Stop watch for checking the time taken to complete 15 questions in Part 2 of the testing record form.

B. Hazard communication system (HCS) VDO which was used for reviewing the knowledge of all subjects about the HCS documents e.g. Material Safety Data Sheet (MSDS), Safe Use Instruction (SUI), Chemical warning label, Hazard warning by NFPA rating system, Chemical safety instruction and etc. All subjects had to watch this 15 minutes VDO before start the test.

3.2.3 Testing procedure

A. After registering to the group as scheduled, the subjected were explained about the research purposes, objectives and testing procedure for 10 minutes by the researcher.

B. Then, the Hazard communication system (HCS) VDO was opened for reviewing and adjusting their knowledge about GM's hazard communication program.

C. Each selected subject received one randomize label together with one testing record form after the HCS VDO ended. They could fulfill the general information in Part 1 immediately but could not start the testing for Part 2 and Part 3 until receiving the allowance from the researcher.

D. All subjects started doing Part 2 testing as soon as the researcher allowed and started the stop watch. When the subjects finished Part 2, they would raise their hand up individually then the researcher assistant recorded each duration time immediately before allowing them to continue Part 3 without time keeping.

E. After completing all parts in the testing record forms, the subjects returned the forms and label to the researcher for checking the completion of the test.

3.3 Tested Labels

Tested labels were designed base on three main variables as following.

3.3.1 Three sizes of chemical warning label and the quantity of information contents

a. Small – 4.0”X6.0”, with rough information contents
b. Medium – Half A4 size, with moderate information contents
c. Large – A4 size, with detailed information contents

3.3.2 The adding of signal words and pictograms

a. With both signal words and pictograms
b. With signal words only
c. With pictograms only

3.3.3 The use of color codes

a. With color codes
b. Without color code

Total designed labels = No. of sizes X No. of options to add Signal words and pictograms X No. of option to use Color codes

= 3 X 3 X 2

= 18 designed labels

Not only considering on main three variables, but all eighteen labels were also considering the compliance with both local and international hazard communication standards, the communication and visual perception theories. Some examples of the eighteen labels for this study could be shown as following;

Figure 3-1: Designed label with Signal Words, Pictograms and Color codes (SAY, MAY, LAY)

Design No 1: Tested label code "SAY"

Design No 7: Tested label code "MAY"

Design No 13: Tested label code "LAY"

S = Label in 4" X 6" size

M= Label in Half A4 size

L = Label in A4 size

A = Adding both Signal words & Pictograms

Y = With Color codes

Figure 3-2: Designed label with Signal Words and Pictograms but has no Color code (SAN, MAN, LAN)

Design No 2: Tested label code "SAN"

Design No 8: Tested label code "MAN"

Design No 14: Tested label code "LAN"

S = Label in 4" X 6" size

M= Label in Half A4 size

L = Label in A4 size

A = Adding both Signal words & Pictograms

N = Without Color code

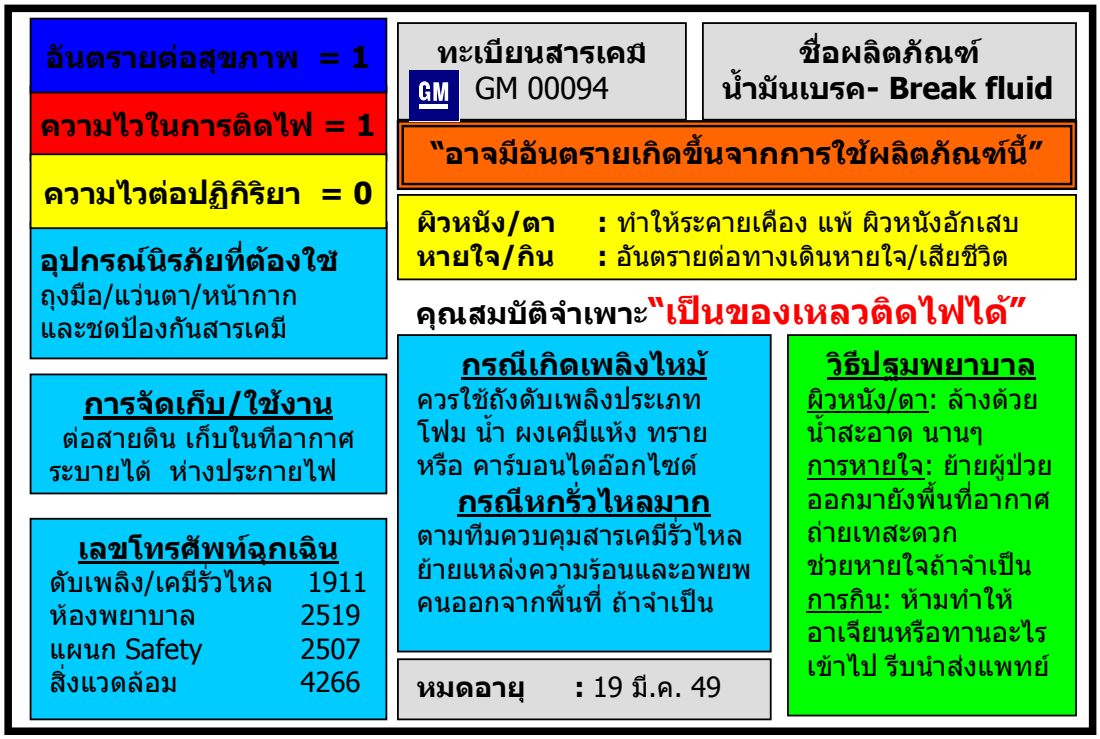


Figure 3-3: Designed label with Signal Words and Color codes but has no Pictogram (SBY, MBY, LBY)

Design No 3: Tested label code "SBY"

Design No 9: Tested label code "MBY"

Design No 15: Tested label code "LBY"

S = Label in 4" X 6" size

M= Label in Half A4 size

L = Label in A4 size

B = Adding Signal words only

Y = With Color codes

Figure 3-4: Designed label with Signal words but has no Pictogram and Color code (SBN, MBN, LBN)

Design No 4: Tested label code "SBN"

Design No 10: Tested label code "MBN"

Design No 16: Tested label code "LBN"

S = Label in 4" X 6" size

M= Label in Half A4 size

L = Label in A4 size

B = Adding Signal words only

N = Without Color code

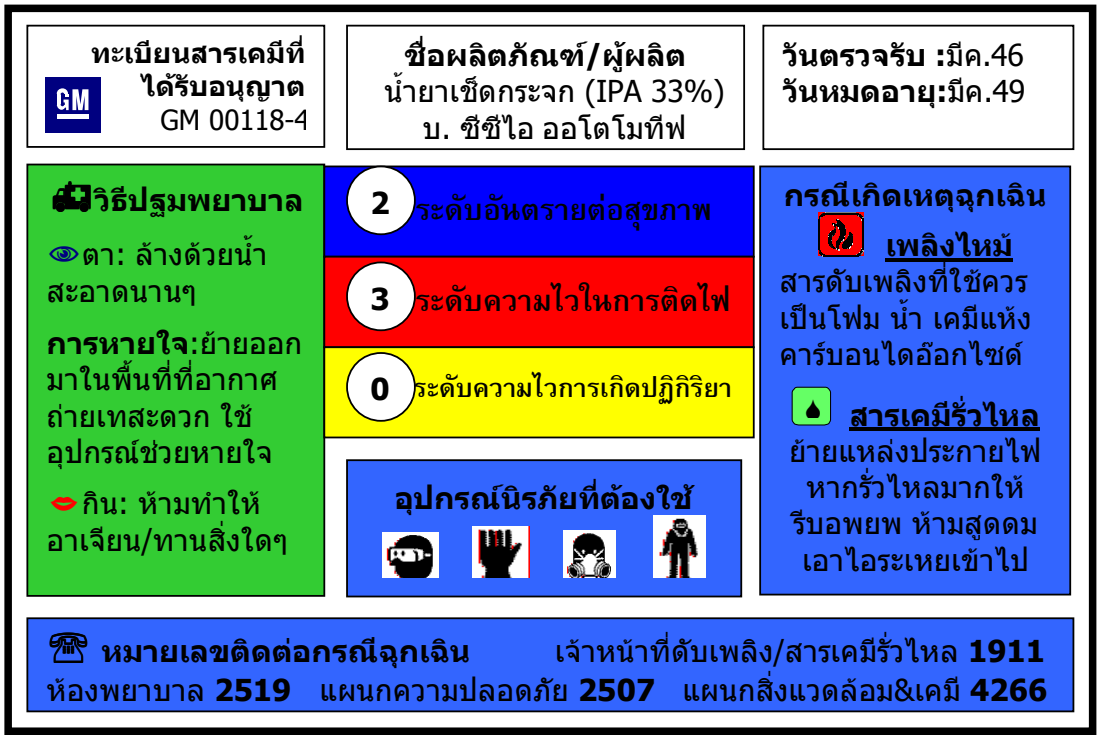


Figure 3-5: Designed label with Pictograms and Color codes but has no Signal word (SCY, MCY, LCY)

Design No 5: Tested label code “SCY”

Design No 11: Tested label code “MCY”

Design No 17: Tested label code “LCY”

S = Label in 4” X 6” size

M= Label in Half A4 size

L = Label in A4 size

C = Adding Pictograms only

Y = Without Color code

Figure 3-6: Designed label with Pictograms but has no Signal word and Color code (SCN, MCN, LCN)

Design No 6: Tested label code “SCN”

Design No 12: Tested label code “MCN”

Design No 18: Tested label code “LCN”

S = Label in 4” X 6” size

M= Label in Half A4 size

L = Label in A4 size

C = Adding Pictograms only

N = Without Color code

3.4 Research Activities

The research activities were designed, planned, reviewed, tested, evaluated and interpreted almost 15 months from June 2003. The activities summarization could be shown and explained by the table 3-1

Table 3-1: Research activities summarization

Activities	Year 2003							Year 2004							
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1. Labels design	◄►														
2. Develop testing record form		◄►													
3. Pre-testing (Trial)			◄►	◄►											
4. Adjustification or modification				◄►											
5. Testing and data collecting					◄	►									
6. Evaluation and Interpretation													◄	►	

3.4.1 Design 18 tested warning labels

As indicated in item 3.3 that all labels were designed base on three variables of the label sizes, the use of signal words, pictograms and color codes. All tested labels had to comply with the hazard communication programs and also the local requirements for the chemical warning label. The labels were printed 3 copies in the actual sizes and color as designed for the test.

3.4.2 Development of the testing record form

The testing record form was developed for collecting the subject's personal information and the reader's response time and comprehension at the same time. Therefore, each question was developed base on the mandatory requirement regarding all involve hazard communication program and regulations. The information needed to fulfill in the testing record form could be found from the tested labels.

3.4.3 Pre-Testing (Trail)

The pre-testing (trail) was performed with the pilot group (22 staffs of new comers) on August 18, 2004. This trial was done for testing the validity of the questionnaire and observed any errors or obstructions that could be occurred during the test.

3.4.4 Adjustification or modification

Some modifications on the testing questionnaire were done after the completion of the pre-testing with the pilot group. The wording and vocabularies were simplified more clearly for the subjects.

3.4.5 Testing and data collection

Regarding the higher production volume occurred at GM Thailand during the final quarter of the year 2003, that made the subjects could not come to participate. Therefore, three classes per month or totally 25 classes were prepared for all the selected subjects to join as their convenience. Each test was taken only 1 hour per class (15 minutes for reviewing the hazard communication VDO, 10 minutes for the researcher to explain the objectives and the methods of testing and also collecting the personal information, and the rest 35 minutes were available for the label testing)

3.4.6 Evaluation and interpretation

All required information e.g. personal information, the time taken for completing the test, and the comprehension scores and etc. were recorded in each individual testing record form. Each record form was

interpreted and coded for further analyses by SPSS program against the research's objectives and hypothesis.

3.5 Data Analysis and Statistical Testing

3.5.1 Data Analysis

The testing record forms, after being edited were coded into numerical information. The data were recorded into 3.5 diskette ready for computerized by the software "Statistical Package of the Social Sciences" (SPSS)

3.5.2 Statistical Testing

3.5.2.1 Descriptive statistics were used to described the studied variables of the subjects characteristics and some testing results in Percentage(%), Mode, Arithmetic Mean(X), Standard deviation (SD), and coefficient of variation (%)

3.5.2.2 Pearson's Product Moment Correlation was used to evaluate the correlation level among the variables and also used for testing the hypothesis

3.5.2.3 Analysis of Variance (ANOVA) was used to evaluate and test the main effects and the interaction between-subjects effects among the variables toward the tested outcomes.

3.5.2.4 Paired t-Test was used to compare the significant changes of the tested outcomes between the existing chemical warning label and the appropriated warning label combination which derived from the test.

CHAPTER IV
RESULTS

After eight months of label testing at General Motors Thailand, the results of the study are presented in seven parts as the following;

Part 1: The demographic characteristics of the subjects i.e. gender, ages, educational background, number of service years in the company and working locations.

Part 2: The average reader's response times to complete the label testing toward each option of label sizes, signal words and pictograms adding, and the use of color codes.

Part 3: The average reader's comprehension score toward each option of label sizes, signal words and pictograms adding, and the use of color codes.

Part 4: The correlation coefficients among label sizes, the adding of signal words and pictograms, and the use of color codes towards reader's response time and comprehension.

Part 5: Test of reader's response time between-subjects effects among label sizes, the adding of signal words and pictogram, and the use of color codes.

Part 6: Test of reader's comprehension between-subjects effects among label sizes, the adding of signal words and pictogram, and the use of color codes.

Part 7: Independent t-test between the existing label and the most appropriate label toward reader's response time and comprehension scores.

4.1 Demographic characteristics of the subjects

The 449 employees were randomly selected from members of General Motors Thailand employed at Chevrolet Assembly Center in Rayong Province. Totally, 27 subjects were not qualified with the research conceptual framework identified in chapter 1, item 1.5.3 (23 subjects graduated Bachelor degree level and 4 subjects have experienced with chemical accidents before)

The majority of the subjects were male (93.36%), their ages varied from 18 to 37 years, with a mean of 24.29 years and standard deviation of 3.16 years. Most subjects (67.30 % and 31.52 %) graduated from senior high school/vocation level and high vocational level, respectively. Service year of the subjects varied from 0.5 to 5 years but most subjects had only 0.5 service years with the company. Most subjects (72.27 %) were newly hired employees who have not passed the probation period yet. All subjects were manufacturing staffs who worked regularly at Press and Body Shop (36.02 %), General Assembly Shop (33.17 %) and Paint Shop (19.67 %) respectively. The numbers of the subjects selected from each department were reflecting the real figure of the population ratio. (See detail in table 4-1)

Table 4-1: General characteristics of the subjects.

Characteristics	N = 422	Percentage
1. Gender		
Male	394	93.36
Female	28	6.64
2. Age		
18 – 22 years	129	30.57
23 – 27 years	236	55.92
28 – 32 years	50	11.85
33 years up	7	1.66
$\bar{X}$ = 24.29 years, SD = 3.16		
3. Educational Background		
Junior High School	5	1.18
Senior High School/Vocational	284	67.30
High Vocational	133	31.52
4. Service years in GM Thailand		
0-1 year	366	86.73
1-2 years	16	3.79
2-3 years	21	4.98
3-4 years	16	3.79
4-5 years	3	0.71
Mode = 0.5 years		
5. Working Location		
Press & Body Shop	152	36.02
Paint Shop	83	19.67
General Assembly shop	140	33.17
Quality Control and others	47	11.14

4.2 Average of the reader's response time

Test result among eighteen labels showed that the average of the reader's response time varied from 236.00 to 379.96 seconds. The subjects tested with the label code"SAN" (Label in 4.0" X 6.0" size with Signal words and Pictograms but without Color code) had the lowest response times at 236.00 seconds with C.V. of 32.14 % but when they tested the label code "LCN" (Label in A4 size with Pictograms but without Color code), they had the highest response times at 379.96 seconds with C.V. of 29.30 %

When classified by the group of variables, the information presented in table 4-2, 4-3 and the figure 4-1 indicated that all subjectes tested with the label in 4" X 6" size had lowest average of reader's response time (286.97 seconds with C.V. of 25.76 %) when all subjects tested with the label in A4 size had highest average of response time (333.65 seconds with C.V. of 27.05 %)

Table 4-2: Average of the reader's response times (seconds) classified by Label codes toward main factors and levels.

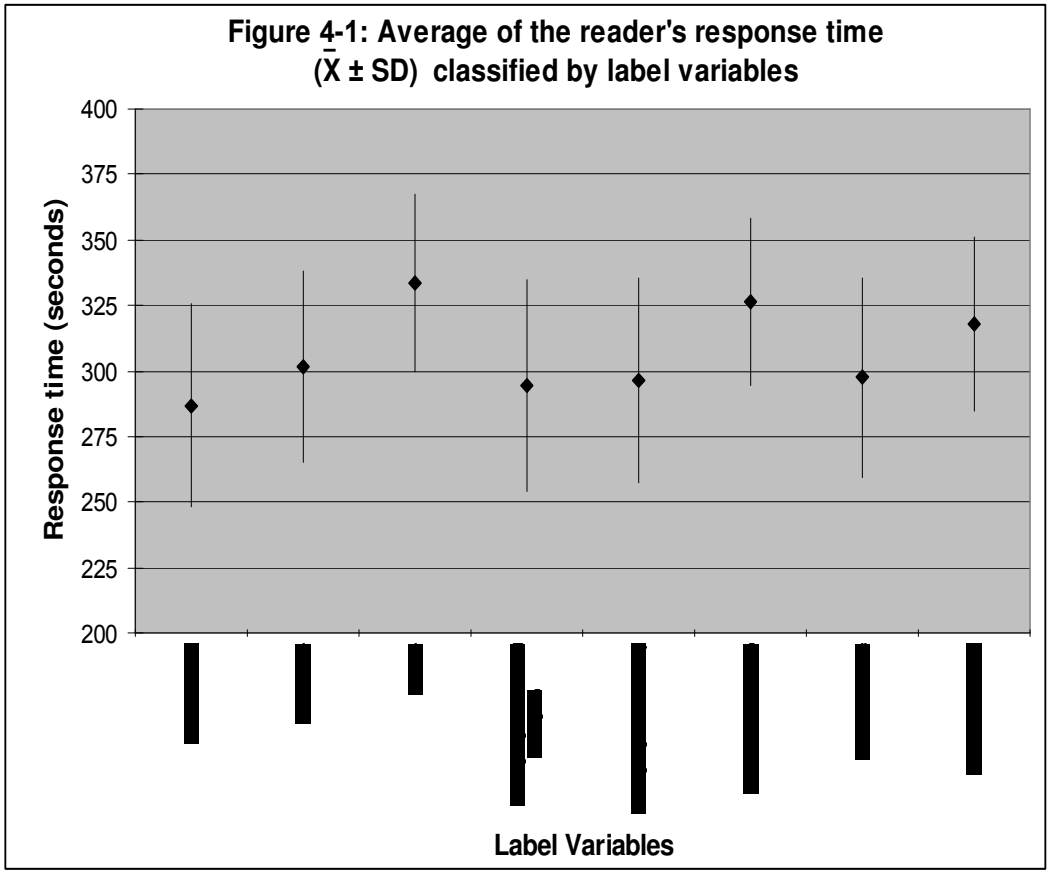
Response times to complete the label testing (seconds)				
Label Codes	Mean	S.D.	C.V. (%)	No of subjects
SAY – Label in 4.0" X 6.0" size with signal words, pictograms and color codes	279.00	89.66	32.14	21
SAN – Label in 4.0" X 6.0" size with signal words, pictograms but without color code	240.58	39.47	16.41	19
SBY – Label in 4.0" X 6.0" size with signal words and color codes	307.22	76.72	24.97	23
SBN – Label in 4.0" X 6.0" size with signal words but without color code	277.00	63.59	22.96	24
SCY – Label in 4.0" X 6.0" size with pictograms and color codes	284.59	57.02	20.04	37
SCN – Label in 4.0" X 6.0" size with pictograms but without color code	324.92	89.95	27.68	24

Table 4-2: Average of the reader's response times (seconds) classified by Label codes toward main factors and levels. (Continue)

Response times to complete the label testing (seconds)				
Label Codes	Mean	S.D.	C.V. (%)	No of subjects
MAY – Label in half A4 size with signal words, pictograms and color codes	236.00	54.97	23.29	24
MAN – Label in half A4 size with signal words, pictograms but without color code	352.65	98.78	28.01	20
MBY – Label in half A4 size with signal words and color codes	305.32	71.81	23.52	22
MBN – Label in half A4 size with signal words but without color code	263.44	87.36	33.16	18
MCY – Label in half A4 size with pictograms and color codes	312.74	67.42	21.56	27
MCN – Label in half A4 size with pictograms but without color code	337.87	71.30	21.10	23
LAY – Label in A4 size with signal words, pictograms and color codes	332.41	74.04	22.27	22
LAN – Label in A4 size with signal words, pictograms but without color code	328.61	96.92	29.49	23
LBY – Label in A4 size with signal words and color codes	283.80	86.47	30.47	25
LBN – Label in A4 size with signal words but without color code	336.78	78.12	23.20	23
LCY – Label in A4 size with pictograms and color codes	344.17	68.88	20.01	24
LCN – Label in A4 size with pictograms but without color code	379.96	111.31	29.30	23

Table 4-3: Average of the reader's response times (seconds) classified by main label variables.

Response times to complete the label testing (seconds)				
Main label variables	Mean	S.D.	C.V. (%)	No of subjects
4.0" X 6.0" size	286.97	73.92	25.76	148
Half A4 size	301.43	84.00	27.87	134
A4 size	333.65	90.25	27.05	140
Adding signal words and pictograms	294.71	89.87	30.49	129
Adding signal words only	296.40	79.58	26.85	135
Adding pictograms only	326.22	82.21	25.20	158
With color codes	297.55	76.32	25.65	225
Without color code	317.90	92.82	29.20	197



4.3 Average of the reader's comprehension score

In the same way, test result among eighteen labels showed that the average of the reader's comprehension scores varied from 37.32 to 61.51 % The subjects tested with the label code"SCN" (Label in 4.0" X 6.0" size with Pictograms but without Color code) had the lowest comprehension score at 37.32 %, SD. = 10.72 The subjects tested with the label code "SBY" (Label in 4.0" X 6.0" size with Signal words and with Color codes) had the highest average comprehension score of 61.51 % , SD. = 11.00

When classified by the group of variables, the information presented in table 4-4, 4-5 and the figure 4-2 indicated that all subjects tested with the label of 4" X 6" size had highest average of reader's comprehension scores (52.14 %, SD. = 13.56) when all subjects tested with the label with Pictograms only had lowest average of comprehension scores (41.79 %, SD. = 9.86)

Table 4-4: Average of the reader's comprehension scores (%) classified by Label codes toward main factors and levels

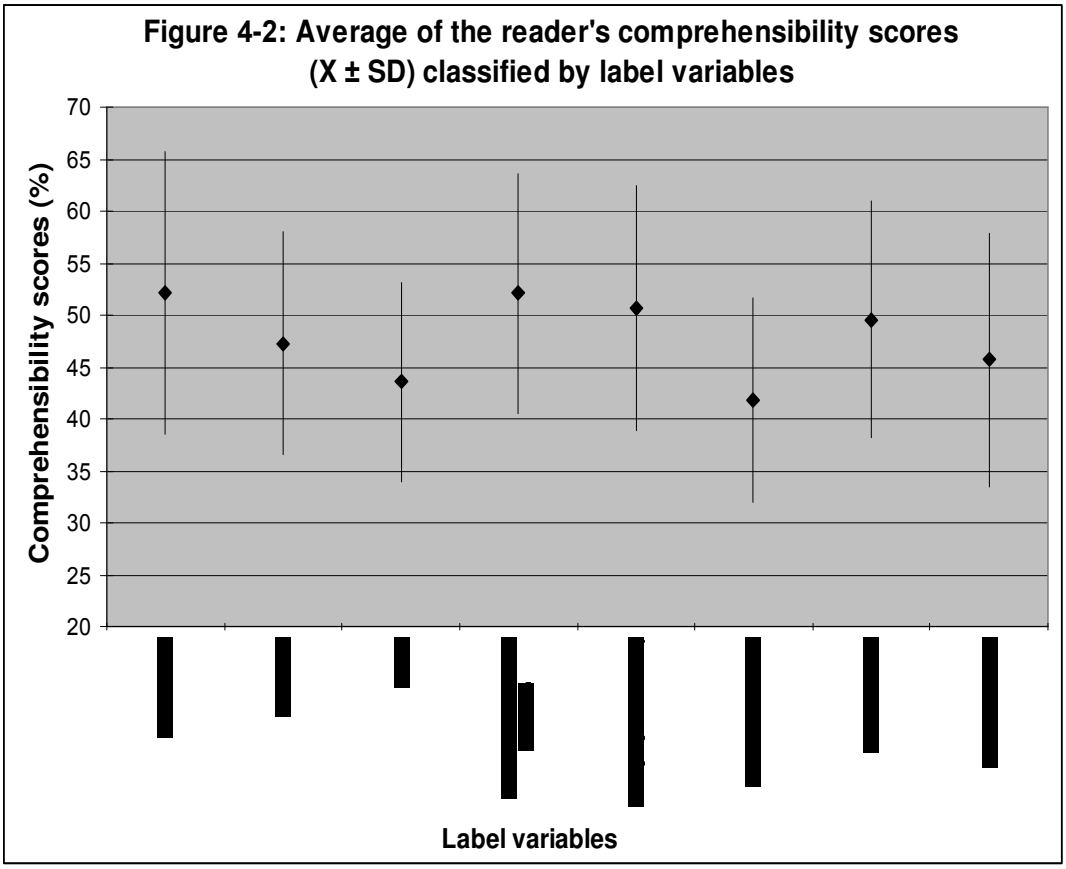
Comprehension score (%)			
Label Codes	Mean	S.D.	No of subjects
SAY – Label in 4.0" X 6.0" size with signal words, pictograms and color codes	61.07	11.22	21
SAN – Label in 4.0" X 6.0" size with signal words and pictograms but without color code	57.82	10.15	19
SBY – Label in 4.0" X 6.0" size with signal words and color codes	61.51	11.00	23
SBN – Label in 4.0" X 6.0" size with signal words but without color code	57.05	9.04	24
SCY – Label in 4.0" X 6.0" size with pictograms and color codes	44.75	9.57	37
SCN – Label in 4.0" X 6.0" size with pictograms but without color code	37.32	10.72	24

Table 4-4: Average of the reader's comprehension scores (%) classified by Label codes toward main factors and levels (Continue)

Comprehension score (%)			
Label Codes	Mean	S.D.	No of subjects
MAY – Label in half A4 size with signal words, pictograms and color codes	53.43	10.84	24
MAN – Label in half A4 size with signal words and pictograms but without color code	46.91	10.42	20
MBY – Label in half A4 size with signal words and color codes	50.40	9.86	22
MBN – Label in half A4 size with signal words but without color code	46.65	11.41	18
MCY – Label in half A4 size with pictograms and color codes	44.39	9.39	27
MCN – Label in half A4 size with pictograms but without color code	42.07	9.24	23
LAY – Label in A4 size with signal words, pictograms and color codes	49.40	8.42	22
LAN – Label in A4 size with signal words and pictograms but without color code	44.63	10.30	23
LBY – Label in A4 size with signal words and color codes	44.82	6.63	25
LBN – Label in A4 size with signal words but without color code	42.52	10.71	23
LCY – Label in A4 size with pictograms and color codes	41.85	7.61	24
LCN – Label in A4 size with pictograms but without color code	38.30	10.77	23

Table 4-5: Average of the reader's comprehension scores (%) classified by main label variables.

Comprehension score (%)			
Main label variables	Mean	S.D.	No of subjects
4.0" X 6.0" size	52.14	13.56	148
Half A4 size	47.28	10.68	134
A4 size	43.55	9.61	140
Adding signal words and pictograms	52.05	11.62	129
Adding signal words only	50.60	11.82	135
Adding pictogram only	41.79	9.86	158
With color codes	49.58	11.46	225
Without color codes	45.66	12.24	197



4.4 Correlation coefficients among label design variables and the reader's response time and comprehension scores

When classified the range of the reader's response time and comprehension score in table 4-6, the Pearson's Product Moment Correlation coefficient (r) between "Label sizes" toward "Reader's response time" = 0.226 ($p<0.0001$), there were negative correlation coefficients ($r = -0.175$ and -0.120) between "Signal words" and "Color codes" toward "Reader's response time" with statistical significant ($p<0.0001$ and $p<0.05$ respectively). Calculation also revealed the moderate and low correlation coefficients between "Signal words" and "Color codes" toward "Reader's comprehension" ($r = 0.385$ and 0.163) with statistical significant ($p<0.0001$ and $p<0.005$), other negative correlation coefficients included those between "Label sizes" and "Pictograms" toward "Comprehension score" ($r = -0.297$ and -0.164) with statistical significant, $p<0.0001$ and $p<0.005$ respectively.

Table 4-6: Pearson's Product Moment Correlation coefficient among Label variables toward reader's response time, and comprehension score.

Label variables (N = 422)	Response Time (seconds)				Comprehension Score (%)			
	<251	251-300	>300	N	<41	41-50	>50	N
Label sizes								
- 4.0" X 6.0" Size	51	73	24	148	28	36	84	148
- Half A4 Size	36	65	33	134	40	45	49	134
- A4 Size	22	65	53	140	41	73	26	158
	r = 0.226				**r = -0.297**			
	p-value <0.0001				**p-value < 0.0001**			
Signal words								
- With Signal words	23	83	52	158	67	64	27	158
- Without Signal word	86	120	58	264	42	90	132	264
	r = -0.175				**r = 0.385**			
	p-value < 0.0001				**p-value < 0.0001**			
Pictograms								
- With Pictograms	40	63	32	135	24	45	66	135
- Without Pictogram	69	140	78	287	85	109	93	287
	r = 0.086				**r = -0.164**			
	p-value = 0.077				**p-value = 0.001**			
Color codes								
- With color codes	49	89	59	197	60	74	63	197
- Without color code	60	114	51	225	49	80	96	225
	r = -0.120				**r = 0.163**			
	p-value = 0.014				**p-value = 0.001**			

4.5 Test of reader's response time between-subjects effects among label design variables

The ANOVA of the main effects and interaction are presented in table 4-7, there were statistical significant for the main effects toward the reader's response time with three independent variables as following; Label sizes ($p < 0.0001$), Signal words ($p < 0.0001$) and Color codes ($p < 0.05$)

Further, there were no statistical significant for almost interactions among the label variables toward the reader's response time except the group of independent variables as following; the group of label sizes, signal words and color codes ($p < 0.005$), the group of label sizes, pictograms and color codes ($p < 0.0001$)

Table 4-7: Test of reader's response time between-subjects effects among Label sizes, the adding of Signal words and Pictogram, and the use of Color codes.

	Dependent Variables	Df	Variance Ratio	P - Value
Label sizes	Response Time	2	11.554	<0.0001
Signal words	Response Time	1	14.767	<0.0001
Pictograms	Response Time	1	0.006	0.941
Color codes	Response Time	1	4.083	0.044
Label sizes and Signal words	Response Time	2	0.242	0.785
Label sizes and Pictograms	Response Time	2	2.803	0.062
Label sizes and Color codes	Response Time	2	2.055	0.129
Signal words and Color codes	Response Time	1	0.230	0.632
Pictograms and Color codes	Response Time	1	2.616	0.107
Label sizes and Signal words and Color codes	Response Time	2	7.641	0.001
Label sizes and Pictograms & Color codes	Response Time	2	11.289	<0.0001

4.6 Test of reader's comprehension between-subjects effects among label design variables

The same as section 4.5, the ANOVA of the main effects and interaction showed there were statistical significant for the main effects among Label sizes, Signal words, and Color codes toward the reader's comprehension score ($p < 0.0001$) as presented in table 4-8

However, there were no significant interactions found between groups of independent variables except the group of "Label sizes and Signal words" which has high significant effects to reader's comprehension score ($p < 0.001$), and the interaction between the group of "Label sizes and Signal words and Pictogram" and the group of "Label sizes, Pictogram, and Color codes" which have high significant effects to reader's comprehension score ($p \leq 0.001$ and $p < 0.001$) respectively.

Table 4-8: Test of reader's comprehension between-subjects effects among Label sizes, the adding of Signal words & Pictogram, and the using of Color codes.

	Dependent Variables	df	Variance Ratio	P – Value
Label sizes	Comprehension	2	29.153	<0.0001
Signal words	Comprehension	1	83.125	<0.0001
Pictograms	Comprehension	1	1.981	0.160
Color codes	Comprehension	1	17.291	<0.0001
Label sizes and Signal words	Comprehension	2	10.569	<0.0001
Label sizes and Pictograms	Comprehension	2	0.582	0.559
Label sizes and Color codes	Comprehension	2	0.434	0.648
Signal words and Color codes	Comprehension	1	0.030	0.862
Pictograms and Color codes	Comprehension	1	0.301	0.584
Label sizes and Signal words and Color codes	Comprehension	2	0.051	0.950
Label sizes and Pictograms & Color codes	Comprehension	2	0.273	0.761

4.7 Independent t-test between the existing label and the most appropriate label toward reader's response time and comprehension score

To ensure that the results of label testing are applicable to every kind of chemical products, thus the most desirable label was redesigned for other chemicals (Exxon Thinner) to compare the reader's response and comprehension score with the existing label again. The most appropriate label from the study result is the label code "SAY" or the label designed in 4"X6" size with Signal word, Pictograms and Color codes.

This comparison was being done in August 2004 with the pilot group of manufacturing department of General Motors Thailand. The testing result showed that the reader's response time of the most appropriate label was better than existing label significantly at p-value < 0.005 and the reader's comprehension score of the most appropriate label was also better than the existing label significantly at p-value < 0.0001 as presented in Table 4-9

Table 4-9: Independent t-test between the existing label and the most appropriate label toward the reader's response time, and comprehension score.

	Mean	S.D.	t-statistic	p-value
Response Time				
Existing label	204.13	48.78	4.139	0.001
Most appropriate label	168.69	37.55		
Comprehension Score				
Existing label	54.69 %	8.04	-6.574	<0.0001
Most appropriate label	67.46 %	5.83		

4.8 Results of the Hypothesis testing

There are three hypotheses being set for this study as following;

Hypothesis 1: There are any significant correlations among "The size with vary quantity of information contents", "The adding of signal word and pictogram", "The use of color code" toward "The response time, comprehension testing scores" of the readers.

The hypothesis testing results could be concluded as following;

- Label size has a low correlation coefficient with the reader's response time, r = 0.226, p-value < 0.0001
- Signal word has a negative low correlation coefficient with the reader's response time, r= -0.175, p-value < 0.0001
- Color code has a negative low correlation coefficient with the reader's response time, r= -0.120, p-value < 0.05

- Pictogram has no statistical significant correlation coefficient with the reader's response time, r = 0.086, p-value = 0.077
- Label size has a negative low correlation coefficient with the reader's comprehension score, r = -0.297, p-value < 0.0001
- Signal word has a moderate correlation coefficient with the reader's comprehension score, r = 0.385, p-value < 0.0001
- Color code has a low correlation coefficient with the reader's comprehension score, r = 0.163, p-value < 0.005
- Pictogram has a negative low correlation coefficient with the reader's comprehension score, r = -0.164, p-value < 0.005

Hypothesis 2: The large label size (A4) with most information contents has better response time, comprehension testing scores than the small (4"X6") and medium label (Half A4) sizes.

The hypothesis testing results could be concluded as following;

- The average of reader's response time of each variable was ranked from the fastest to the slowest as following;

  4 "X 6" size = 286.97 ± 73.92 seconds

  Half A4 size = 301.43 ± 84.00 seconds

  A4 size = 333.65 ± 90.25 seconds

  Average response time: *4" X 6" Size < Half A4 Size < A4 Size*

  Therefore, this hypothesis could not be accepted.

- The average of reader's comprehension score was ranked from the highest to the lowest as following;

  4" X 6" size = 52.14 ± 13.56 %

  Half A4 size = 47.28 ± 10.68 %

  A4 size = 43.55 ± 9.61 %

  Average comprehension score: *4" X 6" Size > Half A4 Size > A4 Size*

Therefore, this hypothesis could not be accepted.

Hypothesis 3: The response time and comprehension testing scores of the designed label with "adding of signal word and pictogram" and "color code" are better than label without adding.

The hypothesis testing results could be concluded as following;

- The average of reader's response time among the adding options of signal word and pictogram are as following;

  Adding both Signal word & Pictogram = 294.71 ± 89.87 seconds

  Adding Signal word only = 296.40 ± 79.58 seconds

  Adding Pictogram only = 326.22 ± 82.21 seconds

  Average response time: *Adding both Signal word & Pictogram < Adding Signal word only < Adding Pictogram only*

- The average of reader's response time among the use of color codes are as following;

  With color code = 297.55 ± 76.32 seconds

  Without color code = 317.90 ± 92.82 seconds

  Average response time: *With color code < Without color code*

  Therefore, this hypothesis could be accepted.

- The average of reader's comprehension score among the adding options of signal word and pictogram are as following;

  Adding both Signal word & Pictogram = 52.05 ± 11.62 %

  Adding Signal word only = 50.60 ± 11.82 %

  Adding Pictogram only = 41.79 ± 9.86 %

  Average comprehension score: *Adding both Signal word & Pictogram > Adding Signal word only > Adding Pictogram only*

- The average of reader's comprehension score among the use of color codes are as following;

  With color code = 49.58 ± 11.46 %

  Without color code = 45.66 ± 12.24 %

  Average comprehension score: *With Color codes > Without color code*

  Therefore, this hypothesis could be accepted.

CHAPTER V
DISCUSSION

After completed testing the reader's response time and comprehension scores toward each designed label as the result show in chapter IV, there are some concerns on this research that would be discussed here about the study design and the study result as following;

5.1 Discussion on the study design

In this study, eighteen combination formats were designed based on the variables of label size, the adding of signal words, pictograms and color codes. The subjects are 422 Manufacturing team members who have been working with General Motors Thailand at least 6 months. Mean of the reader's response time and comprehension score of each designed label were compared and tested for the correlation among each variable. The effects from each variable were also tested for evaluating their effects and its interaction. Although there is preparedness before starting the study, the error might be occurred as the list below;

5.1.1 Systematic Bias

A. Personal Respondent

The measurement on subjective data may be occurred from personal variation either from the researcher or the subjects. However, this study was conducted and controlled by the researcher alone. Thus, the data collection procedures and testing methods could be ensured that they were performed in the same pattern and environment.

B. Method Bias

This kind of bias may be occurred from either data collection or analytical method. To ensure that the subjects in each group have the same characteristics, the workers were selected from manufacturing department only. All subjects in this study were also screened not only their educational background which not higher than high vocational degree, but also their service years in General Motors

Thailand would be in 0.5 – 5 years. All of them had to view the fifteen minutes of Hazard communication VDO prior to start the label testing. The same design of eighteen labels was applied for every groups tested without changing during the study. All subjects saw and tested the labels in the same position and same distance and same viewing angle. No one of the subjects had abnormal result in the color vision due to the assessment screening process before the employment.

C. Instrumental Bias

To minimize and control the instrumental bias, the eighteen chemical warning labels were designed base on both local and international related standards and requirements such as NFPA (National Fire Protection Association), HMIS (Hazardous Material Information System), ANSI (American National Standard Institute), GHS (Global Harmonized System), GM-UAW (General Motors and United State Automotive Workers), OSHA (Occupational Health and Safety Association), and Thailand – Ministry of Industry. Not only the label contents and structure, but also the font type and font size, all label designs criteria would also be controlled in this study for the most compliance with all above requirements. As the result from the literature review, one recommended font on the label for the optimum readability is “Tahoma” with “2-points size difference” between the signal word and its main body context. The color and color contrast were also applied regarding the color contrast theory and the appropriate visual colors combination recommended for communication. All designed labels and the testing questionnaire were examined and tested their validity by performing the pretest with the pilot group in General Motors Thailand. Some improvement for more simplicity, precision, and reliability had been done later for the final designed labels and testing questionnaire. The researcher worked as the timekeeper during the test for every group by using the same stopwatch without changing.

5.1.2 Randomization

The increase of the sample size may reduce the random error. Thus, almost 120 team members (almost 30%) were selected and tested more in this study whereas the calculated sample size from the approximated formula were only 354 team members. The study was conducted in the same environmental condition for each designed label such as the testing place and testing length (1.0 hour). All team members were nominated from all departments then they were assigned into each group by random sampling method. Eighteen labels were randomly distributed to each team member in each group for testing his response time and comprehension score.

5.1.3 Effect of Extraneous Variable

From the literature review, the major factor that would affect to the reader's response time and comprehension score is "the past experiences with the chemical accident." Therefore, the testing results of the team members who experienced with the chemical accident before, were screened out by the testing record form and were excluded from the study. All subjects in this study were randomly selected for the most homogeneity by limiting their working experiences with General Motors Thailand, the educational level, and the experiences with GM's hazard communication program.

5.2 Discussion on the study result

5.2.1 Characteristics of the subjects

It was normally found the number of male employees more than female in the automotive industries in Thailand, so did the ratio of male per female in this study. GM Thailand was a young organization regarding their operation just started up in the mid of year 2000. Thus, the average age of the subjects was only 24.29 years and nobody has serviced for the company longer than 5 years. The workers qualification for the manufacturing staffs identified that they must graduate at least junior high school or Mathayom 3, but it was found that some workers were overqualified for this position. Anyway, 23 subjects with bachelor degree were already excluded from the study. The subjects characteristics found in this study are the same figures

with other GM facilities worldwide, except the educational background. The study of Teresa M. Lynch during 1969-1995 found the percentage of US automotive workers without high school diploma was declined continuously and found only 12 % in the year 1995 [22] which still higher than the finding in this study (1.18 %)

5.2.2 Average of the reader's response time

When compared the average response time among the group of label sizes, the result showed that the average response time of the readers who tested the labels in 4" X 6" size was better than who tested the labels in Half A4 size and A4 size respectively. This may cause by the label in 4" X 6" size has the shortest contents and information shown on the label and the subjects used less time to retrieve the information after their first reading. This finding showed the same result as the experiment of J.Paul Frantz which indicated that the presentation format did not affect overall label effectiveness and also the finding of Mark R. Lehto, that label format did not strongly impact subject performance on speed and accuracy of finding requested information as much as the content of the label.

Except the label sizes, the average response time of the reader who were tested with the labels with pictograms only was the highest. This may assume that the subjects took too much time to interpret or find out more supporting information on the label. There were little differences among the average response time of the readers who were tested with the label with adding both signal word and pictogram and who were tested with the label with adding signal word only and who were tested with the label with the use of color codes. From the figure 4.1, we could summarize that the label in A4 size and the label with adding pictogram only and the label without color code use are the labels that were not support the shorten of the reader's response time as well as the rest of other variables did.

5.2.3 Average of the reader's comprehension score

The average reader's comprehension score of the subjects who tested the label in 4"X6" size is higher than those tested with the labels in Half A4 size and A4 size respectively. This trend was also found in the same way with the average of reader's response time. It was shown that the larger size of the label with more information content would not support the increasing of the reader's

comprehension, which we may assume that too much information contents will make the reader more confusing with the instructions appeared.

The use of pictogram alone in the label did not help improvement of the reader's response time and also comprehension score. This may cause from the subjects did not understand or interpret the meaning of the pictograms well because each pictogram was not included any explanation text and had no briefing about the pictogram meaning in the VDO orientation. Another reason was that the Pictograms applied in the test were referring from the HMIS system, which were not the same pictures used in the company's safety sign.

5.2.4 The correlation coefficient between label design variables and the reader's response time and comprehension

The Pearson's Product Moment Correlation coefficient showed that there was no significant correlation coefficient only between the pictogram adding and the reader's response. This may cause by the readers could not understand or interpret the meaning of the pictograms used on the tested labels as explained in the previous item. The testing also indicated that there was a low correlation coefficient ($r = 0.226$) between "Label Sizes" and "Reader's response time" with statistical significant ($p<0.001$), which mean that much larger label and much more information contents will convey much longer time to find out information on the label. Further, negative correlations coefficients ($r = -0.175$ and -0.120) between "Signal words" and "Color codes" toward "Reader's response time" presented with statistical significant ($p<0.001$ and $p<0.05$) respectively. In other words, the applying of "Signal words" and "Color codes" will convey much less time to retrieve the information from the label. Analysis also revealed the moderate and low correlations coefficients between "Signal words" and "Color codes" toward "Comprehension score" ($r = 0.385$ and 0.163) with statistical significant ($p \leq 0.001$), other significant correlation coefficients included those between "Label sizes" and "Pictograms" toward "Comprehension score" ($r = -0.297$ and -0.164) These correlation, coefficients respectively, indicated that the subjects were answer the question more correctly when applied Signal words and Color codes or when used a small label size or when did not apply the pictograms.

The finding from this study showed the same result as Joseph P. Ryan, P.E.,1990 indicated in his book (Design of warning labels and instruction) that the symbol and pictogram would help the reader more understand the hazard. The results were similar to the experiment of J. Paul Frantz, James M. Miller and Mark R. Lehto,1991, which found that the context would be less important when applying the generic safety symbols.

5.2.5 Test of reader's response time between-subjects effects among label design variables

There were significant effects from all individual variables except the use of pictograms toward the reader's response time. This testing was in line with the result of correlation testing between the use of pictogram and the reader's response time, which showed that there was no correlation existed. Anyway, the effects from mixed variables, which included the use of pictogram, showed that there were the significant effects toward the reader's response time. This may result from other dominant variables included in the group such as label sizes or the use of color codes.

5.2.6 Test of reader's comprehension between-subjects effects among label design variables

The use of pictograms was only one variable that had no significant effect to the reader's comprehension. However, there were no significant effects among all groups of variables toward the reader's comprehension although there were significant effects from individual variables such as label sizes, signal words and color codes. This may cause from the restriction of ANOVA testing by the SPSS program when analyzed with more than two variables.

5.2.7 Independent t-test between the existing label and the most appropriate label toward reader's response time and comprehension

Both of the reader's response time and comprehension score of the most appropriate label were significantly improved when comparing with the existing label. Response times of the readers were improved 17.36 % with statistical significant. The final comprehension score of the most appropriate label resulted at 67.46 %, which higher than the appropriate comprehension score for safety signs (higher than 66 %) as guided by ANSI (American National Standards Institute) but

lower than 85 % as guided by ISO (International Organization for Standardization)

5.2.8 Recommendation for the appropriate label combinations for increasing reader's response and comprehension

The results from this study could be used as a recommendation for designing an appropriate label to increase the reader's response and comprehension as following;

a. Label Size; 4.0" X 6.0" will be appropriate for the hazard communication but the label size half of A4 and A4 would be more appropriate for identifying the hazards on the bigger container/packaging size.

b. The appropriate label would have Signal words, Color code and Pictogram. However, the application of pictogram will increase the reader response time and comprehension when the explanation text is also applied.

c. Font should be Tahoma with at least 12 point size and has at least 2 point size different for the signal word (at least 14 point size)

CHAPTER VI
CONCLUSION

This study is aimed to find out the most appropriate label combination formats for further implementing in General Motors Thailand and other companies in the automotive industry. That improved label would induce the increasing of the reader's response time and comprehension scores compared with the existing label design. This study took almost 8 months to complete testing with 422 manufacturing's team members of General Motors Thailand, Rayong. The conclusion from the study would be discussed as following;

6.1 Conclusion of the study result

Eighteen combinations of chemical warning labels were designed based on the three main variables of label sizes, the adding of signal words and pictograms, and the use of color codes. Some conclusion on the study results and recommendations could be identified as below items;

1. **Average of the reader's response time (seconds)**

   The designed label, which has best reader's response time, is "Label code – MAY (Half A4 size with signal word, pictograms and color codes)

   The average of the reader's response time of each variable may be ranked from the fastest to the slowest as following;

Variables	Mean ± SD
1. 4 "X 6" size	286.97 ± 73.92
2. Adding both signal words & pictograms	294.71 ± 89.87
3. Adding signal words only	296.40 ± 79.58
4. With color codes	297.55 ± 76.32
5. Half A4 size	301.43 ± 84.00

6. Without color code	317.90 ± 92.82
7. Adding pictograms only	326.22 ± 82.21
8. A4 size	333.65 ± 90.25

Comparing the average of the reader's response time among the sizes are as following;

4" X 6" size < Half A4 size < A4 size

Comparing the average of the reader's response time among the adding options of signal words and pictograms are as following;

Adding both signal word & pictogram < Adding signal word only < Adding pictogram only

Comparing the average of the reader's response time among the use of color codes are as following;

With color code < Without color code

2. Average of the reader's comprehension score (%)

The designed label, which has best reader's comprehension score, is "Label code – SBY (4" X 6" size with signal word and color code but no adding of pictogram). The average of reader's comprehension of each variable may be ranked from the highest to the lowest as following;

Variables	**Mean ± SD**
1. 4 "X 6" size	52.14 ± 13.56
2. Adding both signal word & pictogram	52.05 ± 11.62
3. Adding signal word only	50.60 ± 11.82
4. With color codes	49.58 ± 11.46
5. Half A4 size	47.28 ± 10.68
6. Without color code	45.66 ± 12.24
7. A4 size	43.55 ± 9.61
8. Adding pictogram only	41.79 ± 9.86

Comparing the average of the reader's comprehension score among the label sizes are as following;

4" X 6" size > Half A4 size > A4 size

Comparing the average of the reader's comprehension score among the adding options of signal words and pictograms are as following;

Adding both signal words & pictograms > Adding signal words only > Adding pictograms only

Comparing the average of the reader's comprehension score among the use color codes are as following;

With color codes > Without color code

3. **The correlation coefficient between the label design variables and the reader's response time.**
   - 3.1 Label size has a low correlation with the reader's response time with statistical significant at p-value < 0.0001
   - 3.2 Signal word has a negative low correlation with the reader's response time with statistical significant at p-value < 0.0001
   - 3.3 Color code has a negative low correlation with the reader's response time with statistical significant at p-value < 0.05
   - 3.4 Pictogram has no statistical significant correlation with the reader's response time
4. **The correlation coefficient between the label design variables and the reader's comprehension score.**
   - 4.1 Label size has a negative low correlation with the reader's comprehension score with statistical significant at p-value < 0.0001
   - 4.2 Signal word has a moderate correlation with the reader's comprehension score with statistical significant at p-value < 0.0001
   - 4.3 Color code has a low correlation with the reader's comprehension score with statistical significant at p-value < 0.005
   - 4.4 Pictogram has a negative low correlation with the reader's comprehension score with statistical significant at p-value < 0.005

5. The effects from the label design variables toward the reader's response time.

5.1 There is a statistical significant effect from label size toward the reader's response time at p- value < 0.0001

5.2 There is a statistical significant effect from signal word toward the reader's response time at p- value < 0.0001

5.3 There is a statistical significant effect from color code toward the reader's response time at p- value < 0.05

5.4 There is no statistical significant effect from pictogram toward the reader's response time

5.5 There is a statistical significant combined effect from label size and signal word and color code toward the reader's response time at p- value < 0.005

5.6 There is a statistical significant combined effect from label size and pictogram and color code toward the reader's response time at p- value < 0.0001

6. The effects from the label design variables toward the reader's comprehension score.

6.1 There is a statistical significant effect from label size toward the reader's comprehension score at p- value < 0.0001

6.2 There is a statistical significant effect from signal word toward the reader's comprehension score at p- value < 0.0001

6.3 There is a statistical significant effect from color code toward the reader's comprehension score at p- value < 0.0001

6.4 There is no statistical significant effect from pictogram toward the reader's comprehension score

6.5 There is a statistical significant combined effect from label size and signal word toward the reader's comprehension score at p- value < 0.0001

7. **The comparison of the reader's response time between the existing chemical warning label and the most appropriate chemical warning label.**

   The most appropriate chemical warning label (4" X 6" size with signal word, pictogram and color code) has statistical significant mean of the reader's response time better than the existing design label at p-value < 0.005

8. **The comparison of the reader's comprehension score between the existing chemical warning label and the most appropriate chemical warning label.**

   The most appropriate chemical warning label (4" X 6" size with signal word, pictogram and color code) has statistical significant mean of the reader's comprehension score better than the existing design label at p-value < 0.0001

6.2 Recommendations

6.2.1 Recommendation from this study

- The reader's response time and comprehension score had been improved with the smallest label size, or when adding both signal word and pictogram together and/or when applying the color code on the label. Although, the use of pictogram has no correlation with the reader's response time but has a correlation with the reader's comprehension. Therefore, the most appropriate chemical warning label from this study to do final testing to compare with existing design label and will be used in the future at General Motors Thailand is "The label size 4" X 6" with signal word, pictogram and color code"
- The use of pictogram alone on the label will not affect nor has any relation with the improvement of the reader's response time and comprehension score. This may cause from the subjects could not understand or interpret the meaning of the pictogram well. Thus, the use of pictogram together with the explanation text would be recommended to use instead of the pictogram alone.

- Label size has a positive correlation with the reader's response time (Larger label will take more time), and has a negative correlation with the reader's comprehension score. (Larger label will induce lower score) So, the big label such as A4 size is the most inappropriate label size from this study for improving the reader's response time and comprehension score. This is because the larger label will take more time for the reader to read and retrieve and understand the information from the label.
- Both signal word and color code have a negative correlation with the reader's response time (Their application will reduce the time to response) and they have a positive correlation with the reader's comprehension score. (Their application will induce higher score)
  Therefore, the application of signal word and color code would be recommended to use on the label for strengthen the effectiveness of hazard communication program.
- Mean of the reader's response time and comprehension score from the most appropriate label testing are 168.69 seconds and 67.46 % or 17.37 % and 23.35 % improvement from the existing label. The recommended guidance by ANSI (American National Standards Institute) was used for comparing the reader's comprehension but there was no guidance found for the recommended response time.
- There are six criteria to be considered as following when design the warning label for hazard communication purpose;

  1. Minimum contents on the label.

     To comply with Thai and International Hazard communication standard, the contents on the label should have this information as a minimum requirement.

     1.1 Generic name of chemical material

     1.2 Hazard symbol and Signal word such as "Danger or Hazardous material", "Caution-Toxic substance" or other hazards identifications.

     1.3 Statement of hazards (both physical & health hazards)

1.4 Precautionary measures

1.5 Quantity and ingredient of hazardous chemical

1.6 Instruction in case of contact, exposure etc.

2. Label size and context.

For a quick response as a safety or emergency response purpose, the smaller label size e.g. 4" X 6" with brief information/context would be suitable because it could communicate only the essential information required to the reader within a few minutes. However, this label size will not be suitable when posted on the bigger container or packaging such as 200 litres drum or when the reader need to know the detailed information. This situation could be solved by the application of bigger label in Half of A4 and A4 Size.

3. Color code

The color code could help conveying the information to the reader more efficiently when the meaning of each color had been trained or communicated properly. Anyway, there are some recommendations for the color combinations as below;

Danger	White letters on red background surrounded by black border, message in black letters on white background below.
Caution	Yellow letters on black background, message in black letters on yellow background below.
Notice	White letters on blue background, message in black letters on white background below.
Safety instruction	White letters on green background, message in black letters on white background below

4. Pictogram

Although the application of pictogram on the warning label are helpful for the hazard communication purpose, there are reasons for applying pictogram with the explanation context for better

communication and prevention of the misunderstanding or misinterpreting its meaning. Also in the near future (Year 2007 or 2008), the GHS (Global Harmonised Globally Harmonized System of Classification and Labelling of Chemicals) will be launched internationally. Therefore, the recommended pictogram from this guideline would be used as a guideline for applying a hazard communication purpose as well as other recommendation from ANSI or others.

5. Font size and style

   Not only the mandatory requirement to use local language for communicating the hazards to the local workers, but also the fonts on the label that would be considered for the best visual perception. The 14-point of Tahoma font with 2-point size difference between the signal word and the main body will be applied on hazard communication labels. The font size could be increased when applied on the bigger label size regarding the visual perception theory.

6. The combination for the label

   It is recommended for the warning label design that would consider the combination opportunity among the label sizes, the adding of signal word and pictogram, the use of color code and etc. for the most successfulness of the hazard communication program implementation within the organization.

6.2.2 Recommendation for further study

- The pictograms, which were tested in this study, are the standard pictograms without any explanation text. Further study about the effect of pictogram with explanation text toward both the reader's response time and comprehension score could be designed and tested for the influence from this addition.

- The label size from this study was designed into three sizes (4" X 6" and Half A4 and A4 Size) based on the capability of the available label printers in Thailand. There is the opportunity left for designing another sizes of the label for further study about the most appropriate label sizes.
- This study was a factorial design study with many variable options (2X3X3=18 options) that was difficult to do statistical analysis in some options together e.g. the between-subjects effects testing, due to the limitation of program capability. Therefore, the design with less options and less complication would be better improvement for further study.

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APPENDIX

APPENDIX A

Key to the HMIS Label Numerical Rating

Health

4 Deadly: even the slightest exposure to this substance would be life threatening. Only specialized protective clothing should be worn.

3 Extremely Danger: Serious injury would result from exposure to this substance. Do not expose any body surface to these materials. Full protective measures should be taken.

2 Dangerous: Expose to this substance would be hazardous to health. Protective measures are indicated.

1 Slight Hazard: Irritation or minor injury would result from exposure to this substance. Protective measures are indicated.

0 No Hazard: Exposure to this substances offers no significant risk to health.

Flammability

4 Flash point below 73 ^{o}F and Boiling point below 100 ^{o}F: This substance is very flammable, volatile or explosive. Extreme caution should be used in handling/storing these materials.

3 Flash point below 100 ^{o}F: Flammable, volatile or explosive under almost all normal temperature conditions. Exercise great caution in storage and handling of these materials.

2 Flash point below 200 ^{o}F: Moderately heated conditions may ignite this substance. Caution procedures should be employed in handling.

1 Flash point above 200 ^{o}F: This substance must be preheated to ignite. Most combustible solids would be in this category.

0 Will not burn: Substance will not burn.

Reactivity

4 May detonate: Substances that are readily capable of detonation or explosion at normal temperatures and pressures. Evacuate area if exposed to heat or fire.

3 Explosive: Substances that are readily capable of detonation or explosion by a strong initiating source (heat, shock, water) Monitor from behind explosion resistant barrier.

2 Unstable: Violent chemical changes are possible at normal or elevated temperature and pressures. Potentially violent or explosive reaction may occur when mixed with water. Monitor from a safe distance.

1 Normal stable: Substances that may become unstable at elevated temperature and pressure or when mixed with water. Approach with caution.

0 Stable: Substances will remain stable when exposed to heat, pressure or water.

APPENDIX B

PPE Symbols used by the HMIS

In the HMIS systems, the fourth, white bar is used to indicate what Personal Protective Equipment (PPE) must be used in order to handle the material safely. A letter, often supplemented by icons or pictograms, is used to indicate what set of PPE should be used.

Symbol	Personal Protective Equipment (PPE) Required
A	 Safety Glasses
B	 Safety Glasses Gloves
C	 Safety Glasses Gloves Apron
D	 Face Shield Gloves Apron
E	 Safety Glasses Gloves Dust Respirator
F	 Safety Glasses Gloves Apron Dust Respirator
G	 Safety Glasses Gloves Vapor Respirator

H	 Splash Goggles Gloves Apron Vapor Respirator
I	 Safety Glasses Gloves Dust and Vapor Respirator
J	 Splash Goggles Gloves Apron Dust and Vapor Respirator
K	 Air Line Hood or Mask Gloves Full Suit Boots
X	Ask supervisor or safety specialist for handling instructions.

APPENDIX C

Example of Special Precaution Symbols


Flammable!


Explosive!


Corrosive!


Poison!


Radioactive!


Compressed Gas!

APPENDIX D

Testing Record Form of Reader's Response and Comprehension toward Chemical Warning Labels

Instruction:

1. Please choose the right answer or fulfill the information in the blanks as your understanding
2. This testing questionnaire has 3 parts. You have to do each part carefully after instructed by the researcher.

Part 1: General Information (10 questions)

Coding

1. Your sex is...

( ) 1. Male ( ) 2. Female [ ]

2. Now, your ages are ____ years ____ months [ ]

3. Your highest educational background is... [ ]

( ) 1. Primary school ( ) 2. Junior high school
( ) 3. Senior high school ( ) 4. Diploma or High vocational
( ) 5. Bachelor or higher

4. Your department is... [ ]

( ) 1. Manufacturing ( ) 2. Engineering
( ) 3. Quality Control ( ) 4. Other, Please identify _____

5. Your main working location/area is ... [ ]

( ) 1. Press Shop ( ) 2. Body Shop
( ) 3. Paint Shop ( ) 4. General Assembly Shop
( ) 5. Utility Building ( ) 6. Other Areas, Please identify _____

6. You have been working with the company for ____ years ____ months

7. Have you experienced with any chemical accident before? [ ]

( ) 1. Never ( ) Yes, please identify Chemical name _____

8. At GMTh, have you trained on Chemical hazards communication program? [ ]

( ) 1. Never ( ) 2. Yes, please identify (You can choose more than 1 answer)

( ) 2.1 Via the training by EC Section

( ) 2.2 Via the handbook or newsletter

( ) 2.3 Instructed by my colleagues or supervisor

( ) 2.4 Other methods, please identify

_____

9. Have you ever seen or read chemical warning label which was posted in your working area? [ ]

( ) 1. Never ( ) 2. Yes, Please identify chemical name _____

10. Have you ever experienced with any other Chemical warning label? [ ]

( ) 1. Never ( ) 2. Yes, Please identify chemical name _____

Part 2: Reader's response time testing (Total 15 questions)

****Very important****

This part will do time keeping. Thus, please start testing after finished the explanation from the researcher.

Test designed label no: _____ [ ]

Start time: _____ End time: _____

Total time was taken: ____ Min ____ Sec [ ]

1. Which chemical was identified on the label? [ ]

( ) 1. Break fluid ( ) 2. Diesel fuel ( ) 3. Isopropyl Alcohol

( ) 4. Sulfuric acid ( ) 5. Others, Please identify

_____

2. Do this chemical harmful? If yes, please identify it's dominant hazard [ ]

( ) 1. Not harmful ( ) 2.1 Fire hazard ( ) 3. I don't know

( ) 2.2 Health hazard

( ) 2.3 Reactivity hazard

( ) 2.4 Corrosion hazard

3. Do this chemical has a health hazard to the user? [ ]

( ) No health hazard

( ) Has a health hazard, acknowledged from

( ) Pictogram ( ) Signal words ( ) Color coding

( ) I don't know

4. What is a health hazard rating for this chemical ? [ ]

( ) 0 ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) I don't know

5. Do this chemical have a fire hazard to the user? [ ]

( ) No fire hazard

( ) Has a fire hazard, acknowledged from

( ) Pictogram ( ) Signal words ( ) Color coding

( ) I don't know

6. What is a fire hazard rating for this chemical? [ ]

( ) 0 ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) I don't know

7. Do this chemical has a reactivity hazard to the user? [ ]

( ) No reactivity hazard

( ) Has a reactivity hazard, acknowledged from

( ) Pictogram ( ) Signal words ( ) Color coding

( ) I don't know

8. What is a reactivity hazard rating for this chemical? [ ]

( ) 0 ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) I don't know

9. What is the route of entry of this chemical to the user? [ ]

(You can choose more than 1 answer)

( ) Skin ( ) Eye ( ) Breathing ( ) Eating ( ) I don't know

10. What is the required personal protective equipments when use this chemical? [ ]

(You can choose more than 1 answer)

( ) Chemical mask ( ) Ear plug/muff ( ) Goggle

( ) Full cover all ( ) Rubber glove ( ) Face shield

( ) Safety glass ( ) Safety shoe ( ) Apron

( ) Other, please identify _____

11. What is the telephone number of GMTh-medical service center? [ ]

( ) 1911 ( ) 2519 ( ) 2507 ( ) 4266

12. What will you do first when your colleague inhale this chemical vapor accidentally? [ ]

( ) Take his clothing off ( ) Giving artificial respiration

( ) Induce vomiting ( ) Remove him to fresh air area

( ) Cleaning with fresh water for a long time

13. Do the color codes help you finding the information on the chemical warning label faster than no use? [ ]

( ) Faster ( ) May helpful ( ) Did not helpful

14. Do the pictograms help you finding the information on the chemical warning label faster than no use? [ ]

( ) Faster ( ) May helpful ( ) Did not helpful

15. How easy to find all required information on this tested label? [ ]

( ) Very easy ( ) Take some time ( ) Use a long time

( ) Very difficult

****When you finish this part, please ask the researcher to stop your time keeping****

<u>Part 3: Reader's comprehension testing (Total 12 questions, 15 minutes)</u>

1. What are the potential hazards when you work with this chemical?

1.1 Short-term _____

1.2 Long-term _____

1.3 Target organs _____

2. What will you explain to your colleague on how to avoid the health hazards when he was assigned to work with this chemical?

_____

_____

_____

_____

_____

_____

_____

3. What is the “dominant hazard” of this chemical?

_____

_____

4. How can you do first aid to the injured person from this chemical?

_____

_____

_____

5. What will you do when you found this chemical spilled in your working area?

_____

_____

_____

6. Which kind of fire extinguisher could be used to stop the fire from this chemical?

_____

_____

7. What is the meaning or guidance by these color code?

7.1 Red color _____

7.2 Orange color _____

7.3 Yellow color _____

7.4 Green color _____

7.5 Blue color _____

8. What are the meanings of these pictograms?

 _____  _____  _____  _____

_____ _____ _____ _____

_____ _____ _____ _____

9. What is the signal word identified on your tested chemical warning label?

_____

_____

_____

10. Could you explain these following terms as your understanding?

10.1 Health hazard rating _____

_____

10.2 Fire hazard rating _____

_____

10.3 Reactivity hazard rating _____

_____

11. How can you store and handle this chemical safely?

_____

_____

_____

_____

_____

_____

12. How well you understand this tested chemical warning label?

( ) Understand all parts of the label

( ) Some parts are understood, Please identify the part that you did not understand _____

( ) Did not understand all parts of the label

BIOGRAPHY

NAME	Mr. Supakpong charoenpornpanich
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INSTITUTIONS ATTENDED	Mahidol University, 1993: Bachelor of Science (Public Health) Major Sanitary Science Mahidol University, 2005: Master of Science (Industrial hygiene and Safety)
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