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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS AND ON THE GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION AND LABELLING OF CHEMICALS

Sub-Committee of Experts on the Transport of Dangerous Goods
(Twenty-first session, 1-10 July 2002 agenda item 11(b))

Sub-Committee of Experts on the Globally Harmonized System of Classification and Labelling of Chemicals
(Third session, 10-12 July 2002)

GLOBAL HARMONIZATION OF SYSTEMS OF CLASSIFICATION AND LABELLING OF CHEMICALS

Transmitted by the expert from the United States of America

1. At the previous sessions of the Sub-Committee of Experts on the Transport of Dangerous Goods (TDG) and the Sub-Committee of Experts on the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), the expert from the United States of America indicated that he had initiated a study to evaluate the GHS red diamond border pictograms and their impact on the effectiveness of transport regulations, transport emergency response, transport safety, compliance and enforcement (see also the report of the TDG Sub-Committee ST/SG/AC.10/C.3/40, paras. 113-117 and GHS Sub-Committee ST/SG/AC.10/C.3/4, para.12). This initiative was presented and explained to both Sub-Committees and constructive comments were provided to the expert from the United States of America by various participants. On the basis of the comments, the methodology of the study has been amended and comprehensibility testing will begin in April so that results can be presented at the July sessions of both Sub-Committees.

2. A discussion of our research to date including a statement of the perceived problem, a literature review, an explanation of the methodology and a research plan are provided as Annex to this document. The methodology is consistent with the approach outlined in the instrument that was developed for the International Labour Office (ILO) Working Group on Hazard Communication that provides a methodology for the assessment of the comprehensibility of labels and Safety Data Sheets (SDS's) for chemical hazards (see ST/SG/AC.10/C.4/2001/27).

3. The research study will be conducted to determine whether workers and emergency responders are able to differentiate the transport and other sector GHS pictograms so that safety and the appropriateness of their responses are not adversely affected. The study will also attempt to evaluate the impact of training. The results of the study should be used to evaluate the comprehensibility of the GHS pictograms and the impact on the current transport system. The results will be available by the July 2002 TDG and GHS Sub-Committee meetings**.** The timing of the results will allow adjustments to be made to the GHS, if necessary, before final adoption of the GHS on the basis of scientific evidence. The United States of America has been an active participant in the development of the GHS, and strongly supports its goals, and wide implementation of it around the world to accomplish those goals. It is our objective to ensure a protective, effective GHS, and to provide objective evidence that addresses the comprehensibility of the GHS pictograms.

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Annex

Proposal for comprehensibility testing of Global Harmonization System (GHS) pictograms and Transport of Dangerous Goods (TDG) labels

1.0 Introduction:

The United Nations Sub-Committee of Experts on the Globally Harmonized System (GHS) of Classification and Labelling of Chemicals is considering the adoption of a comprehensive hazard classification and communication system that can be used for communicating the hazards associated with chemical substances and mixtures world-wide. A final draft of the GHS was submitted by the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) Coordinating Group for the Harmonization of Chemical Classification Systems (CG/HCCS) in December 2001.

The intent of the GHS is to communicate the hazards posed by chemicals for all sectors. The proposed GHS includes pictograms that are intended to communicate information on the physical, health, and environmental hazards of chemicals through the use of alerting and informative text and through the use of symbols in an effort to be understandable to the widest possible audience around the world. In developing this system, the CG/HCCS included a harmonized set of pictograms for chemical hazards, incorporating graphic elements from existing international chemical hazard labelling systems including those used for the transport of dangerous goods. The CG/HCCS has also proposed two new pictograms. A concern has been raised, however, that the proposed GHS pictograms may cause confusion when used with existing pictograms (transport labels) used to indicate hazards associated with chemicals that are regulated for transport (referred to as dangerous goods). The acute dangers posed by dangerous goods are indicated internationally by graphically based transport hazard labels that share similar features with the proposed GHS pictograms. The research proposal presented below is designed to assess the nature and consequences of this potential confusion through an evaluation of the comprehensibility of the GHS pictograms when presented within the same context as transport labels.

2.0 Statement of the problem:

The proposed GHS pictograms use an overall diamond shape, outlined with a red border, and incorporate black iconic symbols depicted on a white background within the red border. These pictograms are proposed to be a part of the overall GHS pictogram that will be applied to packages containing chemical substances and mixtures that have been classified according to the GHS criteria for acute and chronic health hazards, environmental hazards, and physical hazards. Allowances are made within the GHS for the use of the existing transport labels in cases where a chemical substance is being transported that poses a hazard covered by the transport sector, such as flammable liquids, toxic substances and corrosive substances. In many cases the GHS pictogram will appear on inner packages (e.g. pesticide bottle) that will not be visible to transport workers or emergency responders unless there is an incident where the inner packages escape form the outer package. However, in some circumstances, GHS pictograms may be applied to the outer package. This would apply when the chemical is transported in a single packaging such as a bag or drum where no inner package(s) are provided. In other circumstances a GHS pictogram may appear on a packaging due to the fact that the transport regulations provide exceptions from labeling (e.g. packagings transported as limited quantities or consumer commodities). One of the potential problems perceived by some in the transport sector is that GHS pictograms will be applied to packages where they will be visible to transport workers and emergency responders, and this may lead to confusion and have an adverse affect on safety.

Like the GHS pictograms, transport labels also use an overall diamond shape (although the border is usually black) and many use the same or similar iconic symbols within the diamond. The similarities shared by the transport labels and the GHS pictograms are part of the overall GHS design. The intent of the similarities is to generate harmonization among the pictograms used to signal chemical hazards. Under the GHS, diamond shaped pictograms are intended to be an international signal of a chemical hazard.

The differences that exist between the two types of pictograms were intentionally developed by the crafters of the GHS to make it clear to the viewer which chemicals are transport regulated and therefore represent a hazard covered by the transport regulatory system, and which represent a hazard that is not covered by the transport regulatory system. The red borders, the white internal backgrounds, and the centered prominent placement of the black iconic symbols are unique features of the GHS pictograms that are intended to distinguish them from the transport pictograms.

The efforts of the GHS Sub-Committee are welcomed throughout the transport industry and by other groups, such as first responders, who rely on package hazard labels to warn of potential chemical hazards. Transport workers and emergency responders are currently trained to understand that the presence of a diamond-shaped pictogram (label) signals the presence of transport regulated dangerous goods that require immediate attention and specific mitigation procedures in the event of a spill (e.g., evacuation of a community, do not use water to suppress a fire involving a water reactive material). With the implementation of the GHS, the fact that a label bears a diamond shaped border will no longer necessarily mean that the package contains transport regulated dangerous goods. Rather, additional cognitive steps will be required in which the diamond shape is first detected and then the color of the border will need to be considered in order to differentiate GHS pictograms from transport labels. Additional training will be required to help these workers make the proper discriminations and to take the appropriate actions (e.g. rejection of the shipment because it is not authorized for transport by passenger aircraft, segregation of dangerous goods packages for shipping, or appropriate precautions taken by first responders).

Difficulty in discriminating between GHS and transport pictograms could potentially result in one of two problems (i.e., a reduction in the current effectiveness of the transport labels at signaling a hazard covered in the transport sector, or an undesirable increase in sensitivity to the possibility of the presence of dangerous goods). In other words, those who must respond appropriately to the presence of dangerous goods may either become less concerned about them due to the increase in the number of diamond shaped pictograms that would be present in the world, or they may become overly cautious and treat every diamond shaped pictogram they see as if the package contained transport regulated dangerous goods.

3.0 Literature review

There are a number of literature and data sources that are relevant to this study. These literature sources provide information useful in assessing the stated problem. A review of the human factors research on warnings reveals a mixture of results that unfortunately raise as many questions as answers. Many studies of warnings have focused on specific design features such as the role of colors (e.g., Braun, Greeno, Silver, 1998), or the role of graphical elements (e.g., Young, 1997). Deppa & Martin (1997) provide a review of the ANSI Z535.3 Label Standard for Safety Symbols in which they summarize key elements for designing sets of safety symbols. According to their review, an internal consistency within the set (i.e., harmonization) is critical for users to recognize different symbols as belonging to the set. However, maximum discrimination between symbols within a set on critical features is also desirable so that users can easily tell the differences between different symbols.

Research that focused on testing methodology was similarly mixed. Typical comprehensibility studies focus on how people comprehend the meaning of individual symbols. Braun and Shaver (1999), for example, used a magnitude estimation task to assess the level of risk depicted in different warnings. Other research, such as that conducted by Wolgalter and Usher (1999) focused more on behavioral compliance with warnings. In this particular study, the results indicated that as a person's cognitive demands increase their tendency to comply with warnings decreases.
The influence of training on the comprehension of warning symbols was directly studied by Brelsford, Wolgalter, and Scoggins (1994). In this study, the comprehension of warning signals was improved following a brief training session and performance was sustained up to one week following the training. Additionally, the training had the largest effect on symbols that were poorly comprehended prior to the training.

Frantz, Rhoades, Young & Schiller (1999) provide a broader perspective on the role of warnings by looking at both 'intra-product issues' as well as 'inter-product issues'. While many studies of warnings focus on the potential benefits of particular features of warning labels, these primarily are concerned with the value of the warning to a specific product. However, when the proliferation of warnings is considered across many different products, these authors argue that too many warnings are likely to have a negative effect. Complacency about warnings as well as over sensitivity to warnings are both likely outcomes. Chen, Gilson, and Mouloua (1997) provide direct empirical support for the notion that as additional warnings are added, the effectiveness of the warnings becomes diluted.

This research proposal attempts to address many different questions relative to the influence of the two different sets of pictograms on each other. First, the comprehensibility of the two sets of pictograms will be assessed to determine what people believe to be the meaning of the pictograms. The transport versus GHS distinction is important for comprehending the hazards that are addressed by the current transport system and the new all encompassing GHS system. However, the distinction is less important when considering the fact that both represent potential chemical hazards. By addressing this question, this research will assess how well the specific design elements of the GHS pictograms both harmonize and differentiate chemical hazard signals. A second question to be considered will be the effect of training on the comprehension of the pictograms. Of particular concern is whether the differences between the pictograms can be easily distinguished with minimal error through training, allowing workers and responders to differentiate the hazards communicated by GHS pictograms that are not covered in the transport sector from those which are covered in transport. A third question to be addressed will be an evaluation of whether the harmonization intended in the GHS design has the unintended effect of diluting the effectiveness of the transport labels.

4.0 Research plan:

Data will be collected on two distinct tasks that represent approximations to real world situations. One task, referred to here as the Transport Task, will approximate a package sorting task in which individual packages are evaluated for the presence of transport regulated dangerous goods. The second task, referred to here as the First Responder Task, approximates the conditions sometimes found in an emergency involving a vehicle or a facility that could potentially contain large quantities of dangerous goods. Both tasks will include training for the research subjects on the meaning of the pictograms involved in the task as well as an explanation of the intent of the GHS.

4.1 Research participant selection:

Participants will be recruited for the study from populations appropriate to the specific research tasks. In the transport task, workers familiar with loading dock procedures will be recruited. In the first responder task, both professional and volunteer fire fighters and first responders will be recruited.

Prior to participation in the study, research participants will receive a vision screening consisting of Snellen acuity test, Ishihara color vision test, and Pelli-Robson or related test for contrast sensitivity. Passing criteria of 20/20 normal or corrected to normal with no apparent color vision deficiencies in at least one eye will be required for participation. Contrast sensitivity will be recorded.

Demographic data will be collected on the following dimensions:

- Age
- Ethnicity
- Education level (number of years)
- Occupation and experience

These data will serve as a means of comparing the performance of the participants in this study with the data collected in other studies.

4.2 Transport task description:

Subjects will view 100 photographs of packages that have been prepared for transport. Eighty five of the packages will be packages having no indication of the presence of transport regulated dangerous goods. The remaining 15 packages will have a label indicating the presence of transport regulated dangerous goods. Of the eighty five non-transport regulated packages 45 will have GHS pictograms representing hazards that are not covered by transport regulations or in a couple of cases GHS pictograms that would apply if the transport label was not required (e.g. in the case of a transport regulation exception such as in the case of a limited quantity packaging). The subjects will be required to examine each photograph and determine, based only on the appearance, whether dangerous goods that are regulated for transport are present. The frequency of occurrence of these packages (i.e., 15%) was determined following consultation with air and ground freight companies in the United States of America. The frequency of transport regulated dangerous goods varies by mode of transport. The occurrence of the transport labels within the 100 photographs represents a ‘signal’ to be detected in the presence of the ‘noise’ generated by the other packages. The frequency of 15 transport regulated packages represents a high, but not unrealistic volume throughout the transport industry.

The independent variable in this task will be the presence or absence of the new GHS pictograms in the series of photographs. One group of subjects will see a series of photographs containing 15 transport packages with transport labels affixed. A second group will see photographs of 40 packages containing substances not subject to the GHS with no GHS pictograms, 15 packages with transport labels, and 45 packages with the new GHS pictograms. Several research controls will be used in this study. They are listed below:

- The 15 packages with transport labels will include at least one representation of each of the nine transport classes, as well as 3 containing multiple transport labels to depict the situation where a chemical requires primary and subsidiary hazard labels. Two of the 15 packages will also contain one transport label and one GHS pictogram representing the case of a product that poses a

transport hazard and a hazard that is covered under the GHS but not for transport (e.g. a flammable liquid that is a carcinogen).

- The 45 GHS packages will primarily depict classifications of skin irritants, eye corrosivity, and carcinogen hazards. Three of the packages will include two GHS pictograms (e.g., irritant and carcinogen). Two of the packages will include GHS corrosive labels (represents a substance that is corrosive to eyes under the GHS but not to skin according to transport regulations) and two more will contain GHS pictograms to depict a category 4 acute toxicity hazard. These will represent chemicals that are not required to be labeled according to the transport regulatory system.

- The photographs of the packages with transport labels will include a variety of appropriate packages, such as fiberboard boxes, steel drums, bags and plastic jerricans. The photographs will include other packaging marks such as the orientation arrows and fragile mark.

- The product identifiers, pictograms, hazard statements, signal words, and precautionary statements presented on the GHS pictograms will be derived from published chemical reference data (e.g., Pohanish, 2002). Specific chemicals will be chosen that are not currently regulated for transport but that meet the criteria of the GHS classification system. Although time does not allow for a more thorough investigation of each chemical chosen, this approach at a minimum ensures that realistic candidates have been chosen that may eventually be considered for classification in the GHS. Appendix A provides a list of examples that may be used.

- All of the packages used in the study will represent those commonly found in transport and worker environments.

The table below provides a break down of the packages that will be used in this study.

Table 1

Package types	**Condition 1**	**Condition 2**
	Study transport labels only	**Study transport labels and GHS pictograms**
Packages without transport labels	85	85
Packages with transport labels	15	15
Packages with GHS pictograms	0	45

4.2.1 Transport task training:

Subjects will receive training on transport and GHS pictograms before participating in the comprehensibility testing procedure. The training will consist of the following components:

1. Pretest on knowledge of transport and GHS pictograms. Subjects will be tested on their recognition of the pictograms, their understanding of the meaning of the pictograms, their perception of the hazard(s) indicated, and any action that is indicated or required by the pictogram.

2. Explanation of the hazards posed by dangerous goods regulated for transport and other chemicals covered by the GHS system.

3. Explanation of the GHS classification system
4. Means of detecting hazards covered in the transport and non-transport sectors in accordance with the GHS: color, symbol, shape/border discrimination

5. Explanation of job aid poster containing transport and GHS pictograms and other package markings (e.g., orientation arrows).

6. Final exam following the training sessions to ensure and validate the effectiveness of the training.

4.2.2 Transport task procedure:

Subjects will receive training approximately one week prior to the comprehensibility testing. One week later, they will be subjected to the comprehensibility testing. At the beginning of the testing they will be given instructions. They will view each of the photographs in series. Each photograph will be viewed in isolation on a computer screen. Subjects will press a button down to view each photograph. Subjects will be asked to determine whether the package contains dangerous goods that are regulated for transport. Measurements of the accuracy and error rates will be recorded relevant to the subject's responses to the question regarding the presence of transport regulated dangerous goods. After viewing 100 photographs, subjects will be given a follow-up questionnaire. Questions will focus on their interpretation of the meanings of the transport and GHS pictograms, their preference for different elements of the transport and GHS pictograms, and on whether the similarities between transport and GHS pictograms caused confusion.

4.3 First responder task description:

Subjects will view 100 images of multiple photographs of packages that have been arranged in a 3 x 5 grid. Eighty five of the photographs will not contain photographs of packages that are labeled with transport hazard warnings. The remaining 15 will include one photograph of a package containing a transport regulated dangerous goods. GHS pictograms will be included on 45 of the package photographs. The specific combinations of transport and GHS pictograms is provided in Table 2. Each of the photographs used in this study will be degraded visually to represent the conditions that may be present during an emergency. Further, many of the packages in the photographs will have the pictograms oriented in non-upright directions as often happens in a spill scenario. The subjects will be required to examine each photograph and determine, based only on the appearance, whether dangerous goods are present.

The table below provides a break down of the packages that will be used in this study.

Table 2

Number of Trials	Number of transport labels in the image	Number of GHS pictograms in the image
5	1	0
5	1	1
5	1	2
5	0	1
5	0	2
5	0	3
70	0	0
100 TOTAL		

4.3.1 First responder task training:

Subjects will receive training on transport regulated dangerous goods and the GHS before participating in the data collection procedure. The training will be conducted by a professional trained in GHS and transport labeling, emergencies and fire fighting and will consist of the following components:

Subjects will receive training on transport and GHS pictograms before participating in the comprehensibility testing procedure. The training will consist of the following components:

1. Pretest on knowledge of transport and GHS pictograms. Subjects will be tested on their recognition of the pictograms, their understanding of the meaning of the pictograms, their perception of the hazard(s) indicated, and any action that is indicated or required by the pictogram.

2. Explanation of the hazards posed by dangerous goods regulated for transport and other chemicals covered by the GHS system.

3. Explanation of the GHS classification system

4. Instruction on detecting hazards covered in the transport and non-transport sectors in accordance with the GHS: color, symbol, shape/border discrimination

5. Explanation of job aid poster containing transport and GHS pictograms and other package markings (e.g., orientation arrows).

6. Final exam following the training sessions to ensure and validate the effectiveness of the training.

4.3.2 First responder task procedure:

Subjects will receive training approximately one week prior to the comprehensibility testing procedure. One week later, they participate in comprehensibility testing exercise. At the beginning of the exercise they will be given instructions. They will view each of the photographs in series. Each photograph will be viewed in isolation on a computer screen.
Subjects will press a button to view the image and start a timer. Subjects will be asked to determine whether the package contains dangerous goods that are regulated for transport.

Measurements of the accuracy and error rates will be recorded relevant to the subject's response to the question regarding the presence of transport regulated dangerous goods. After viewing 100 photographs, subjects will be given a follow-up questionnaire. Questions will focus on their interpretation of the meanings of the transport and GHS pictograms, their preference for different elements of the transport and GHS pictograms, and on whether the similarities between transport and GHS pictograms caused confusion.

5.0 Analysis:

The data gathered in the comprehensibility testing procedures detailed in section 4 above will be analyzed to assess the nature of the interaction between the GHS and transport pictograms. An evaluation of the pretest data from both research tasks will provide an understanding of how the GHS and transport pictograms are initially comprehended by these two target groups of participants. This procedure is consistent to previous studies of signal comprehensibility that seek to identify what symbols mean to

people. Extending the analysis to the post test data will indicate whether the GHS harmonized design is effective at both grouping symbols for indicating chemical hazards and simultaneously insuring discrimination between transport hazards and hazards that are not covered by transport regulations.

The post test results, along with the accuracy data from the two tasks will provide a measure of the effectiveness of the training. A high degree of accuracy following the training will be an indicator of the effectiveness of training, especially if the pretest scores are low.

Performance with the different types of pictograms in the two tasks will also be an indicator of how much the GHS and transport pictograms interact with each other. If mistakes are made with the transport labels when viewed in the context of GHS pictograms, but not when the GHS pictograms are absent, then this result will indicate the potential influence of the GHS pictograms on the interpretation of the transport labels. Alternatively, if the pictures and images with the GHS pictograms are incorrectly identified as indicating the presence of transport regulated dangerous goods, then this result will indicate the potential influence of the transport labels on the interpretation of the GHS pictograms. It is also possible that there will be synergistic effects in which the GHS and transport pictograms complement each other and performance actually improves when they are combined.

6.0 References:

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APPENDIX A
GHS Chemical name examples

Chemical name	**Transport regulation**	**Potential GHS classification**
2-Ethyl-3-Propyl Acrolein	None	Irritant
Allyl Propyl Disulfide	None	Irritant
Cyclophosphamide	None	Carcinogen
Glycerin (Mist)	None	Irritant
Hexylene Glycol	None	Irritant