## ABSTRACT

## TACTILE HAZARDOUS MATERIAL INFORMATION SYSTEM (THMIS)

**by**

**Alejandro Ruiz**

In today's work environment, many dangers exist around that can harm workers who are not aware of the hazards in their environment. If these workers happen to be visually impaired, then identifying those hazards with the present labeling systems would be difficult. The Hazardous Material Information System (HMIS) was chosen to be adapted with tactile patterns and numbers. The tactile patterns and numbers would not change the layout and intent of the HMIS, but enhance its effectiveness.

Five tactile patterns and five tactile numbers were designed to be recognizable and simple. The patterns and numbers were tested and observed to learn if they could be recognized without being mistaken for another pattern. Twenty subjects volunteered, 14 males and 6 females, to participate in the experiment. The twenty subjects were provided two different sizes of the patterns making a total of 2000 observations. The three most recognizable tactile patterns were chosen out of the five and assigned a color consistent with the HMIS.

# TACTILE HAZARDOUS MATERIAL INFORMATION SYSTEM (THMIS)

by
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**APPROVAL PAGE**

**TACTILE HAZARDOUS MATERIAL INFORMATION SYSTEM (THMIS)**

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This thesis is dedicated to
my beautiful wife Michele and my wonderful parents, Diego F. and Rosalba.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Objective

The objective of this thesis is to develop a system to inform workers that are blind or visually impaired of the hazards in their work environments. The current system of hazard identification caters to workers who can visually identify such information in the form of signs, placards and warning labels. To maintain compliance with OSHA's (Occupational Safety and Health Administration) Hazard Communication Standard (HCS) a few systems for the display of information were adopted. Two of the systems adopted for HCS were the NFPA (National Fire Prevention Administration) Hazard Diamond and the HMIS (Hazardous Material Information System). At least one of these two systems would have to be adapted to aid workers who could not visually identify the hazards.

The end result desired would be to adapt a system of hazard identification without changing the original intent and/or target audience, but expand it to include visually impaired individuals. To achieve this goal a different form of delivering the information to the worker would have to be established. One such form could be auditory. However, this form of information would be impractical since the majority of the hazardous information would be on labels. Another form of delivering information would be in tactile form. Tactile information is interpreted through the sense of touch. The tactual representation of information is nothing new for the blind and visually impaired. Braille, Raised Letter and detectable warning products have been used as a form of tactile information in providing accessibility for the visually impaired, as mandated by ADA (Americans with Disabilities Act) for buildings designed for public accommodations.

NFPA Hazard Diamond and HMIS, use the same colors (blue, red, yellow and white) and numbers (0,1,2,3 and 4) a standardized tactile pattern would have to be established for each color and number. For this thesis, the design for the colors and numbers are already standardized according to the HCS. This is a criterion that has been maintained to assure the compliance of labeling with OSHA requirement. To determine the patterns needed, a few different patterns have been developed and tested to compare their ability to be recognized without being confused for another pattern. It would be key to recognize the tactile information without making an error, as the purpose of information would be to properly identify the correct hazards. This thesis is not meant to test the memory of a worker on the ability to recall information, rather to design patterns that would be simple to be recognized even if the labels were different sizes.

Workers that are not visually impaired would also benefit from the tactile information. In the event the work area has poor lighting or even if the lights were off the information would still be able to be interpreted. These tactile patterns would be simple; the acuity of the worker's sense of touch would not be challenged.

## 1.2 Background

### 1.2.1 Information Systems

The OSHA Hazard Communication Standard (HCS) requires all chemicals in a workplace to be labeled in a manner that warns of any hazards the chemical may present. The actual format and method of labeling is not specified, so several different formats are in use. The NFPA hazard diamond is one such method. Two other HCS compliance systems that are very similar to one another are described here.

#### 1.2.1.1 HMIG and HMIS

The Hazardous Material Identification Guide (HMIG) is a labeling system developed and sold through Lab Safety Supply, Inc. The Hazardous Material Information System (HMIS) is a labeling system developed by the National Paint and Coatings Association (NPCA) and sold through Labelmaster, Inc. Both systems use a label with four color bars and a space at the top where the name of the chemical should be written (see Figure 1.1). The blue, red, and yellow colored bars indicate, respectively, the health, flammability, and reactivity hazard associated with the material. These three bars use a numbering scale ranging from 0 to 4. A value of zero means that the material poses essentially no hazard; vs. a rating of four, which would indicate extreme danger. Although the details of how numbers are assigned vary somewhat between the systems, it is essentially the same overall scheme as is used in the NFPA system (in a later section the differences between NFPA and HMIG are noted). A discussion of health hazards and the terminology used to describe them are given in Appendix B (OSHA Hazard Communication Standard 29 CFR 1910.1200).


**Figure 1.1** Typical HMIS/HMIG label

The fourth, white bar is marked "protective equipment" in the HMIG system, and "personal protection" in the HMIS system. Both systems (HMIG and HMIS) place a letter in this bar to indicate the kind(s) of personal protective equipment (PPE) that should be used in order to handle the material safely (see Figure 1.2). The letters used are A - K and X. Meanings of the letters are the same in both systems, and both systems augment the letter code with icons or pictograms showing the kinds of PPE to be used.

A significant difference between the HMIG and HMIS systems is that the recently (NPCA 1995) revised HMIS system now includes a second box on the blue (health hazard) bar. If this second box holds an asterisk (*), then the health hazard associated with the material has a chronic (long-term) effect.

| Symbol | Personal Protective Equipment (PPE) Required |
|---|---|
| A | Safety Glasses  |
| B | Safety Glasses<br>Gloves  |
| C | Safety Glasses<br>Gloves<br>Apron  |
| D | Face Shield<br>Gloves<br>Apron  |
| E | Safety Glasses<br>Gloves<br>Dust Respirator  |
| F | Safety Glasses<br>Gloves<br>Apron<br>Dust Respirator  |
| G | Safety Glasses<br>Gloves<br>Vapor Respirator  |
| H | Splash Goggles<br>Gloves<br>Apron<br>Vapor Respirator  |
| I | Safety Glasses<br>Gloves<br>Dust and Vapor Respirator  |
| J | Splash Goggles<br>Gloves<br>Apron<br>Dust and Vapor Respirator  |
| K | Air Line Hood or Mask<br>Gloves<br>Full Suit<br>Boots  |
| X | Ask supervisor or safety specialist for handling instructions. |

**Figure 1.2** (PPE Symbols Copyright © 1987, Lab Safety Supply Co.)

### 1.2.1.2 NFPA Hazard Diamond

The NFPA and HMIS/HMIG Hazard Labeling Systems may be used to comply with the labeling requirement of the OSHA Hazard Communication Standard (HCS). These systems, although similar, differ in some important respects.

Similarities:

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

- They differ in layout as NFPA uses four diamonds and HMIG/HMIS uses vertically stacked bars.
- They differ in interpretation of the fourth, (white) field as it signifies special handling in the NFPA system and protective equipment in the HMIG system.
- Possibly the most significant difference, however, has to do with the intended audience of each system. The HMIG (or HMIS) was devised as an HCS compliance tool. Employees who must handle hazardous chemicals in the workplace are it's intended audience. The NFPA system was designed to alert fire fighters arriving on the scene of a fire as to the hazards associated with materials present at that location. Therefore, the numbers assigned in the NFPA system assume that a fire is present. No such assumption holds in the HMIG/HMIS system. For this reason, the numbers that are assigned to the flammability, health, and reactivity hazards may differ between the NFPA and HMIG systems, even for the exact same chemical.

### 1.2.2 Hazard Communication (Hazcom)

The Occupational Safety and Health Act of 1970 established the Occupational Safety and Health Administration (OSHA) within the US Department of Labor. The original Act included language to the effect that employees should be apprised of all hazards to which will be exposed to the job. In the early 80's, OSHA implemented this instruction by enacting the Hazard Communication Standard (HCS) as 29 CFR 1910.1200, which became effective in 1986. The fundamental premise of the HCS is that employees who could be exposed to hazardous chemicals in the workplace have the right to know about the hazards and how to protect themselves. For this reason, the HCS is sometimes referred to as the Worker Right-to-Know Legislation, or more often just as the Right-to-Know law. Although the original HCS applied only to the manufacturing industry, subsequent court challenges have modified the scope of the law so that today the HCS applies to nearly all sectors of the work force.

The Hazard Communication Standard sets forth guidelines and requirements in six areas:

1.Chemical Labeling 29 CFR 1910.1200 (f)

Requires that all chemicals in the workplace be labeled. The information, which must be present, includes the name of the chemical and warnings about any hazards the material may present. This requirement may be implemented in a variety of ways. Two of the most popular systems are the NFPA and HMIG.

2.Material Safety Data Sheets (MSDS) 29 CFR 1910.1200 (g)

An MSDS is a document that gives detailed information about a material, including any hazards associated with the material. MSDSs must be immediately

available to employees at locations where hazardous materials are used. The Hazard Communication Standard sets forth certain responsibilities in regards to MSDSs:

- It is the responsibility of the manufacturer of a material (1) to determine what hazards are associated with the material, (2) to prepare an MSDS for the material, and (3) to provide the MSDS to any recipients of the material.
- It is the responsibility of an employer to provide training and clarification on MSDSs to the employees. MSDSs for hazardous materials must be immediately available in the workplace.
- It is the responsibility of the employees to read and understand the MSDSs for any and all chemicals used on the job.

OSHA specifies that each MSDS must include, at a minimum, the information listed in the twelve sections below.

OSHA Mandated MSDS Information

Item I: Chemical Identity

The chemical identity as listed on the label, the material's chemical and common names, and a list of all hazardous ingredients.

Item II: Physical Data

Physical and chemical characteristics, such as vapor pressure, flash point, density, boiling point, etc.

Item III: Physical Hazards

Fire data, explosion data and reactivity data. These usually appear as two separate sections on the actual MSDS.

Item IV: Health Hazards

Signs and symptoms of exposure, and any medical conditions generally recognized as being aggravated by exposure to the material.

Item V: Primary Route(s) of Entry

The route(s) the material would most likely take to enter the body.

Item VI: Exposure Limits

Legal exposure limits (OSHA and other recommended limits). This frequently includes toxicity information.

Item VII: Whether the Material is Carcinogenic

States whether the material has been found to be carcinogenic.

Item VIII: Precautions for Safe Handling and Use

Any precautions for safe handling and use known to the party preparing the MSDS, such as appropriate hygienic practices, protective measures required during handling of contaminated equipment, and procedures for clean-up of spills and leaks.

Item IX: Control Measures

Any control measures known to the party preparing the MSDS, such as engineering controls, work practices, or personal protective equipment.

Item X: Emergency and First-Aid Measures

Self-explanatory.

Item XI: Revision Data

Date of preparation of the MSDS, and the date of the last change to it.

Item XII: Manufacturer Contact Information

Name, address and telephone numbers of the party who can provide additional information about the material if necessary.

Beyond that, OSHA does not specify the exact format of the MSDS, nor even how the information should be broken into sections. MSDSs prepared by different manufacturers tend to look different and contain different information. Even MSDSs for the same chemical can be quite different, if different manufacturers have prepared them.

3.Hazard Determination 29 CFR 1910.1200 (d)

Says that the employer must identify and maintain a list of all hazardous chemicals used in the workplace.

4.Written Implementation Program 29 CFR 1910.1200 (e)

Mandates that the employer develop a written plan, the Hazard Communication Program, detailing how the employer implements the requirements of the HCS.

5.Employee Training 29 CFR 1910.1200 (h)

Requires that the employer provide to the employees training including handling of hazardous materials, use and interpretation of both MSDSs and hazcom labels, and information about the HCS.

6.Trade Secrets 29 CFR 1910.1200 (i)

Sets forth the conditions under which a manufacturer may withhold information about a material, and the conditions under which such information must be divulged to health care providers.

### 1.3 Other Tactile Warning Label

Early in 1992, a blind diabetic contacted Ed Bryant of the Diabetes Action Network of the National Federation of the Blind (NFB 1992). The blind diabetic informed him that he and others with his condition were perfectly capable of accurately drawing up their insulin, but had no reliable way to distinguish between insulin types. All the types of

insulin either fast-, intermediate- or long-acting, could only be told apart by reading the print on the label. This placed blind diabetic patients in grave danger of vial misidentification.

A national survey was conducted on whether insulin vials should have tactile markings to help blind diabetics, those losing vision, the hurried, elderly, young, busy medical professionals, overworked pharmacists, and everyone else. Survey results were conclusive that tactile information on insulin vials was much needed and desired (NFB 1992).

Ed Bryant wrote letters to U.S. insulin manufacturers and the Food and Drug Administration (FDA). Many nurses and other medical professionals also wrote in support, acknowledging the print was so small they had trouble reading it, and that misdosage's were made in hospitals and Pharmacies.

The FDA called a meeting of interested participants: Insulin manufacturers, diabetes educators, drug packaging/labeling firms, diabetes associations and organizations of the blind. The first meeting took place on October 19, 1995, at FDA headquarters in Rockville, Maryland. At that meeting, participants agreed that non-sighted insulin vial identification was a necessity, and that such coding should be factory-applied, durable, and sufficiently prominent that blind diabetics with neuropathy could use it. The insulin manufacturers were to come to the next meeting with both short-term prototypes and long-term proposals.

The next meeting was held on April 10, 1996. By the close of that meeting, Eli Lilly and Co. and the FDA were ready to agree on a set of one through four tactile bars that would be placed on the label, as a means of distinguishing insulin classes.

At a June meeting, the insulin manufacturers presented their test findings. Lilly related how their researchers had sought out blind diabetics with differing degrees of neuropathy (mild, moderate, and severe), then tested their success in distinguishing dot codes, vertical lines, and horizontal lines on the vial label. Lilly found that although a few individuals had neuropathy too severe to recognize any system, a series of wide horizontal bars provided greatest accuracy: over 98% successful tactile recognition. This finding mirrors the consensus of ALL consumer groups present at the meeting.

When the question of tactile-label durability was raised, Lilly related how they had tested the bars under a wide variety of conditions, including long-term immersion in alcohol, and experienced no failures. A representative from CCL Label, a national company that makes vial labels for pharmaceuticals, confirmed that his company could guarantee durable tactile bars on vial labels. It was pointed out that even if there were a rare label failure, the system would be more reliable than at present, where blind insulin users are using rubber bands or tape to identify insulin. The FDA was satisfied with the system. All organizations present with the exception of Novo Nordisk accepted the four-bar system as presented. The FDA stated that once they had completed the approval process, one company would be able to proceed without waiting for consensus from its competitors.

Below is a description of the system of four horizontal tactile bars to be used on the insulin vial label:

1. One bar = fast-acting insulins such as Humalog;
2. Two bars = Regular insulins
3. Three bars = any mixed insulin (70/30 or 50/50)
4. Four bars = longer-acting insulins.

Once final approval is granted, Lilly estimates it will take between six and 18 months for the tactile-marked insulin vials to reach pharmacists' shelves. Insulins have a shelf life of two years from date of manufacture, so it may be as long as two years from the start of tactile-labeled insulin production before all the older, unmarked vials are off pharmacists' shelves, though the bulk will be replaced far sooner.

### 1.4 Choosing a Hazard Information System

In choosing the Hazard Information System that could be adapted with the tactile patterns many aspects were considered. First how should the numbers and patterns be situated so they can be easily recognized? In the case of the NFPA diamond, this would be a difficult task considering the location of the number in the diamonds. The diamonds themselves, no matter what the color being red, blue, yellow or white, have the number value inside of them (see Figure 1.3). Trying to put a tactile pattern surrounding the tactile value of the number would make the information too complex to understand.

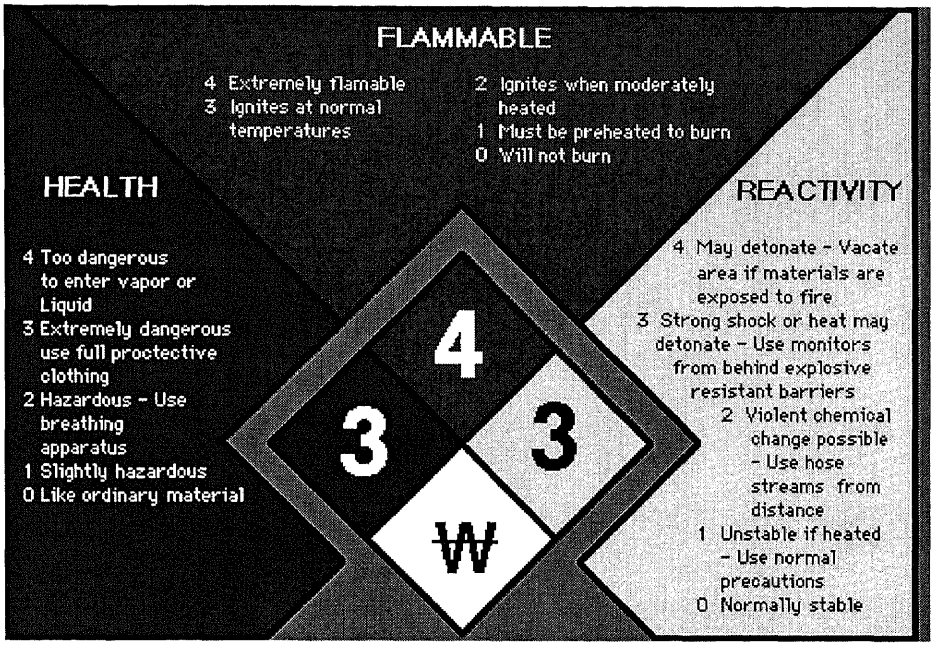



**Figure 1.3** Typical NFPA Diamond (NFPA)

Another reason for not choosing the NFPA Diamond would be the intended audience of the label itself. The NFPA system was designed to alert fire fighters arriving on the scene of a fire to the hazards associated with materials present at that location. Since the chances of a visually impaired worker getting to close enough to actually feel the tactile information on the label would be very unlikely in the event of a fire in the area. These were enough reasons to forego the adaptation of the NFPA Diamond.

Another option would be the HMIS/HMIG. Since both of these systems have the same layout and use the same number scales whatever is adapted for one could be used for the other. The layout of the HMIS caters very well to the idea of adding tactile information. First, the value numbers on the labels are located all the way to one side, leaving a field for the color and the text saying it's hazard (i.e. a blue field with the text HEALTH). All of the colors are setup the same with the exception of the white field. The white field has the pictorial representations of the PPE (Personal Protective

Equipment) needed. The PPE value system would be arranged with different value scales, to be discussed later.

The main reason one would choose to use HMIS is that it is a standard well used throughout industry. There would be no need to train workers with a whole new system. The only difference would be one additional item on the labels used at their worksites. Since employers are required to train all their employees on the hazard they are exposed to, adding one additional item to this training would not be costly or increase training time significantly.

# CHAPTER 2

# DESIGNING THE PATTERNS AND NUMBERS

## 2.1 Design Stage

The main idea in designing the patterns was to help keep the information as simple as possible. If the patterns were too complex the needed information would not be interpreted the way it should. This could be very dangerous if the hazard is interpreted incorrectly. To minimize the potential hazard of misidentification, it was decided to design five patterns that would be simple to distinguish and identify. To identify the pattern without having to think too hard would be one of the elements of the design. The other element would be the ability to differentiate among various patterns. The size of the pattern and the sizes of the cuts would make the difference. The depth and the width of the cuts needed to be determined. If the cuts were too wide and deep then they would not be practical for label, but if the cuts were too narrow and shallow then they would be to difficult to identify. The two-point threshold, the smallest distance between two pressure points at which the points are perceived as separate was a median of 2 millimeters (Vollbo and Johansson, 1978). In the patterns designed the minimum width of a cut would be very close to 2 millimeters. The depth of the cuts would also have a minimum depth very close to 2 millimeters.

That final size of the label would also need to be determined. Keeping everything symmetrical and square would be the easiest way of insuring that the patterns and numbers could be interchangeable and easily located. Once again the HMIS lends itself to easy adaptation, as the label is a square with four equally sized rectangles, one for every color. The numbers in each rectangle take up approximately 25% of the rectangle.

This would be the final dimension of the labels X being the width of the square label (see Figure 2.1). So the if the X was one inch, the tactile pattern for the hazard would be 0.25" x 0.75" and the numbers would be 0.25" x 0.25".

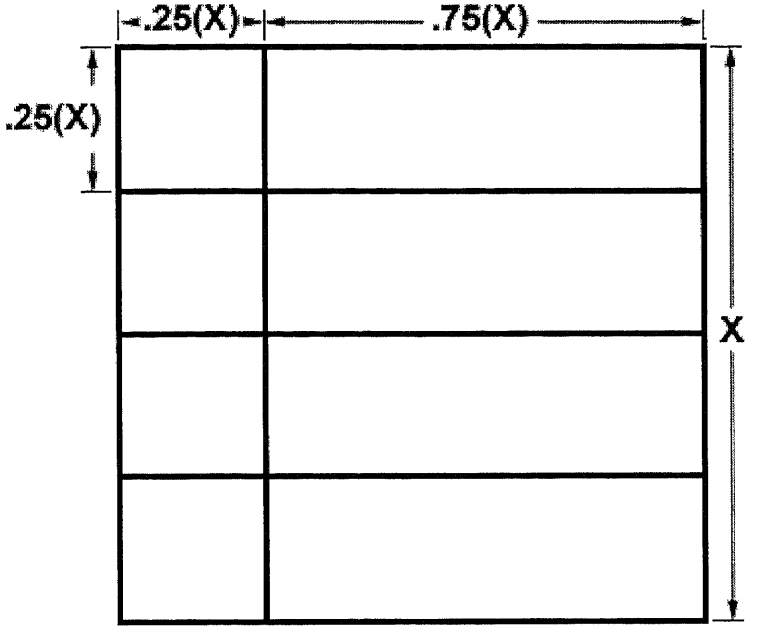



**Figure 2.1** Tactile label lay out.

## 2.2 Making the Designs

In producing the patterns, blanks would be made out of wax and sculpted in to the desired patterns (see Figure 2.2). It proved to be more cost effective to make a pattern out of wax and test it, than to design it and have it milled on a machine and possible find out it really wasn't expected. The wax patterns were then coated with latex to make a mold that would make a reproducible pattern (see Figure 2.3). Pouring plaster of Paris into the molds would then produce multiple samples of the same pattern. Ultimately six patterns were chosen for developing into prototypes. The patterns were named P1, P2, P3, P4, P5 and P6 to help identify them easier.

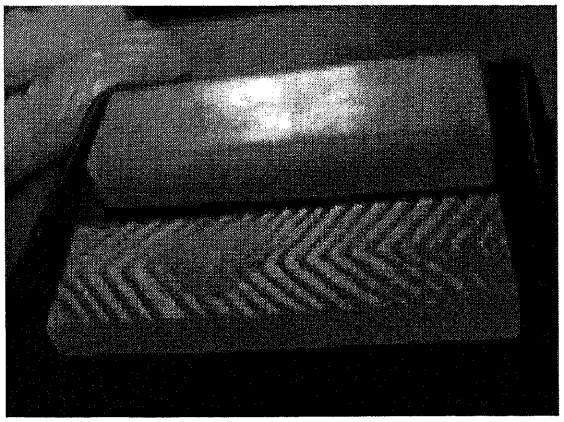


**Figure 2.2** Wax blank and a pattern P1

**Figure 2.3** Molds of P3 and P4

Most of the patterns were variations of knob designs (Sanders and McCormick, 1993) with the exception of P1 and P4. The first pattern called P1 (see Figure 2.2) would be a representation of caution tape, with the arrangement of repeated lines forming arrows. P1 also had a tire tread look to it. Two of the patterns were a representation of knob designs (Bradley, 1967) they were P2 and P3. P2 has a rectangular knurled surface texture and P3 (see Figure 2.4) has the diamonded knurled surface texture. The design of P4 (see Figure 2.4) came out of being tired of seeing all the squares and straight lines of the other patterns. P4 is the only pattern with out any corners or sharp edges. P5's design was a variation of a knob design (Jenkins, 1947) that has a pyramid style to it. P5 resembles three rows of pyramids. A blank piece of wax was used to produce a smooth pattern (see Figure 2.2).

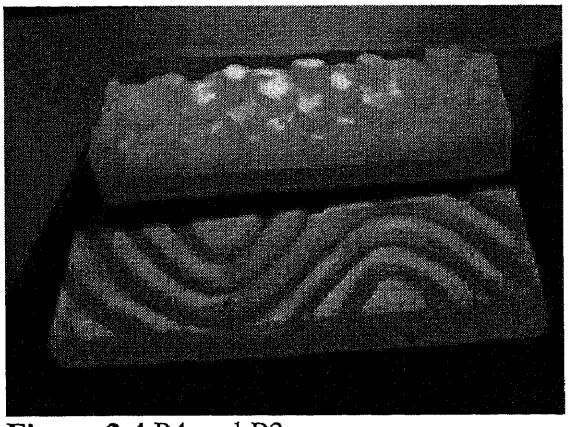


**Figure 2.4** P4 and P3

The designs of the numbers were done the same way the patterns were. They first would be done in wax (see Figure 2.5), and a mold (see figure 2.6) would then be generated and finally a plaster prototype would be made. The numbers are a simple combination of raised dots that are equal to the value of the hazard. If the hazard value was four, then four dots would be displayed as a pattern.

i.e. 0 = , 1 = , 2 = , 3 = , 4 =

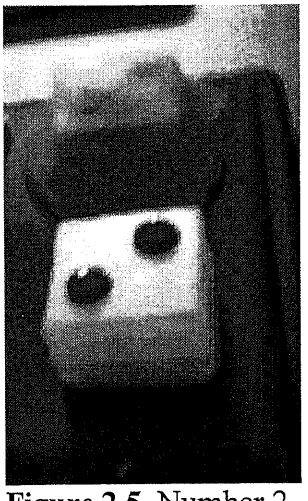


**Figure 2.5** Number 2

**Figure 2.6** Latex on molds

The patterns would resemble Braille in the way that the dots are used but could not be thought of as Braille since Braille uses six dots. It would have to be explained to the intended audience that the dots are a number representation for this label and not

Braille. This is not expected to become a problem since the workers would be trained about the system.

## 2.3 Manufacturing the Designs

Once all the desired patterns were made, the plaster reproductions were used as visual aids to redesign them on a computer so they could be milled. Cutting the patterns out of wax by hand reduced the accuracy of the depth and width of the cuts. A consistent depth and width in every cut would be needed to maintain uniformity among all the patterns. In the computer model the width and depth of the cuts could be adjusted to the scale the pattern. With the wax, only one size could be made, but on the computer the pattern could be scaled to different sizes. The sizes chosen to be tested were X = 4" (see Figure 3.7) and X = 2" (see Figure 2.8). The smaller scaled patterns are the exact copy of the larger pattern but in size. The different sizes would help in determining if the pattern, which looks simple at a large size, would be ideal at a smaller size. Also the 4-inch label would be common on most containers and the 2-inch label would be common on smaller containers.

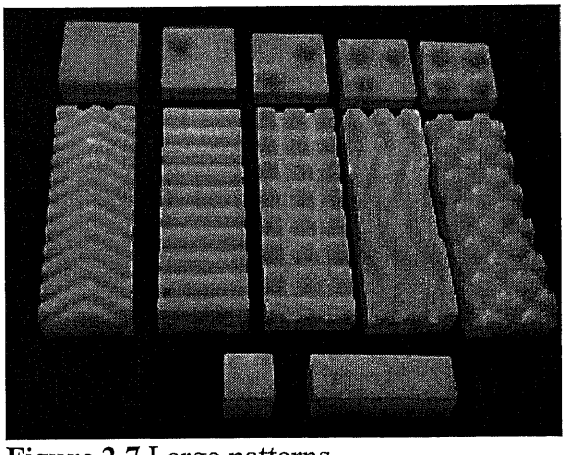


**Figure 2.7** Large patterns

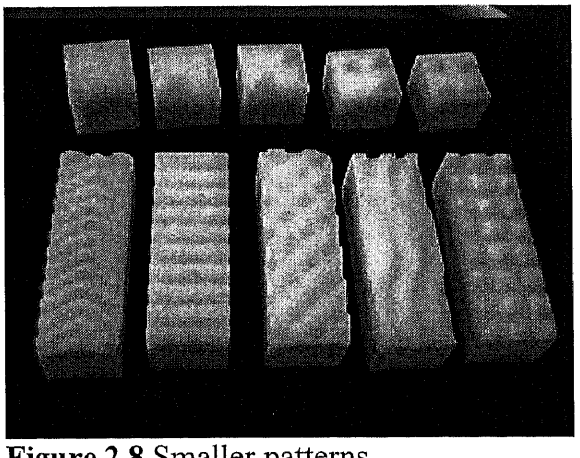


**Figure 2.8** Smaller patterns

The dimensions of the each pattern and number are as follows:

**Table 2.1** Pattern and number sizes

| | Larger Pattern | | Smaller Pattern | |
|---|---|---|---|---|
| | Length | Width | Length | Width |
| P1 | 3 in | 1 in | 1.5 in | 0.5 in |
| P2 | 3 in | 1 in | 1.5 in | 0.5 in |
| P3 | 3 in | 1 in | 1.5 in | 0.5 in |
| P4 | 3 in | 1 in | 1.5 in | 0.5 in |
| P5 | 3 in | 1 in | 1.5 in | 0.5 in |
| 0 | 1 in | 1 in | 0.5 in | 0.5 in |
| 1 | 1 in | 1 in | 0.5 in | 0.5 in |
| 2 | 1 in | 1 in | 0.5 in | 0.5 in |
| 3 | 1 in | 1 in | 0.5 in | 0.5 in |
| 4 | 1 in | 1 in | 0.5 in | 0.5 in |
| 5 | 1 in | 1 in | 0.5 in | 0.5 in |

The dimensions of the depth and width of each cut are as follows:

**Table 2.2** Width and depth cuts

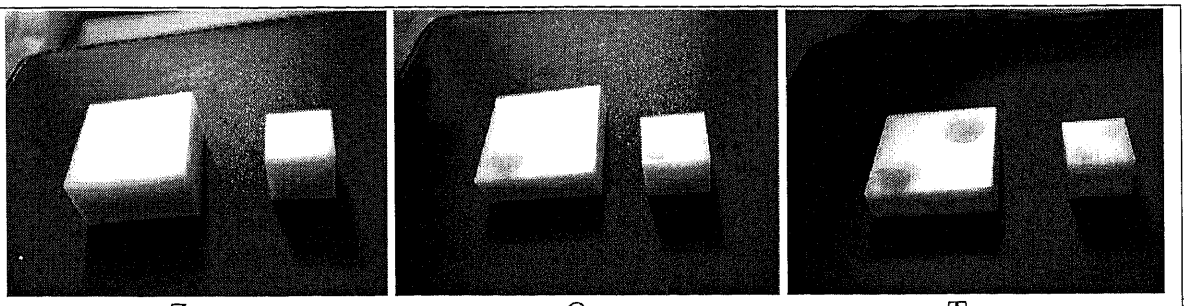
| | Larger Pattern | | Smaller Pattern | |
|---|---|---|---|---|
| | Depth | Width | Depth | Width |
| P1 | 1.5mm | 1.5mm | 3mm | 3mm |
| P2 | 1.8mm | 2.36mm | 3.66mm | 4.7mm |
| P3 | 1.5mm | 2.36mm | 3.94mm | 4.8mm |
| P4 | 2.28mm | 2.28mm | 4.7mm | 4.7mm |
| P5 | 1.9mm | 5mm | 4.3mm | 10mm |

For the numbers the depths of the cuts are 3.5mm.

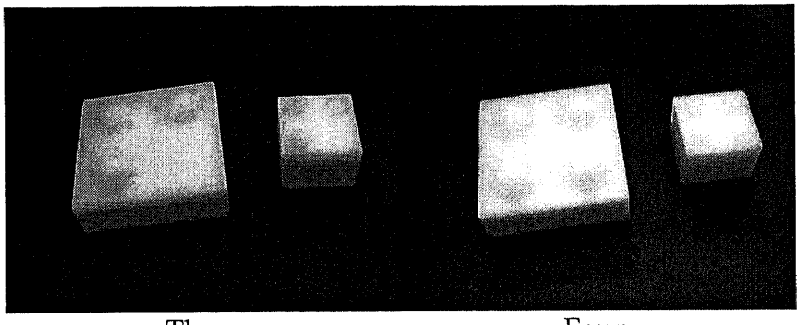
**Table 2.3** Parts List

| | Large | Small |
|---|---|---|
| | Quantity | Quantity |
| P1 | 2 | 2 |
| P2 | 2 | 2 |
| P3 | 2 | 2 |
| P4 | 2 | 2 |
| P5 | 2 | 2 |
| P6 | 1 | 2 |
| 0 | 5 | 4 |
| 1 | 4 | 4 |
| 2 | 4 | 4 |
| 3 | 4 | 4 |
| 4 | 4 | 4 |
| 5 | 4 | 4 |

For testing the patterns they were milled out of plastic. The plastic used was a plastic called acetyl and white in color. The plastic would last longer than the plaster original and it would be an easier material to mill. Every pattern and number has more than one of each and made this produced two sets just in case something would happen to the first set. Table 2.3 shows the parts list of each set and Figure 2.9 and 2.10 shows the final look of the patterns and numbers.



Zero One Two



Three Four

**Figure 2.9** The tactile number in both sizes large and small

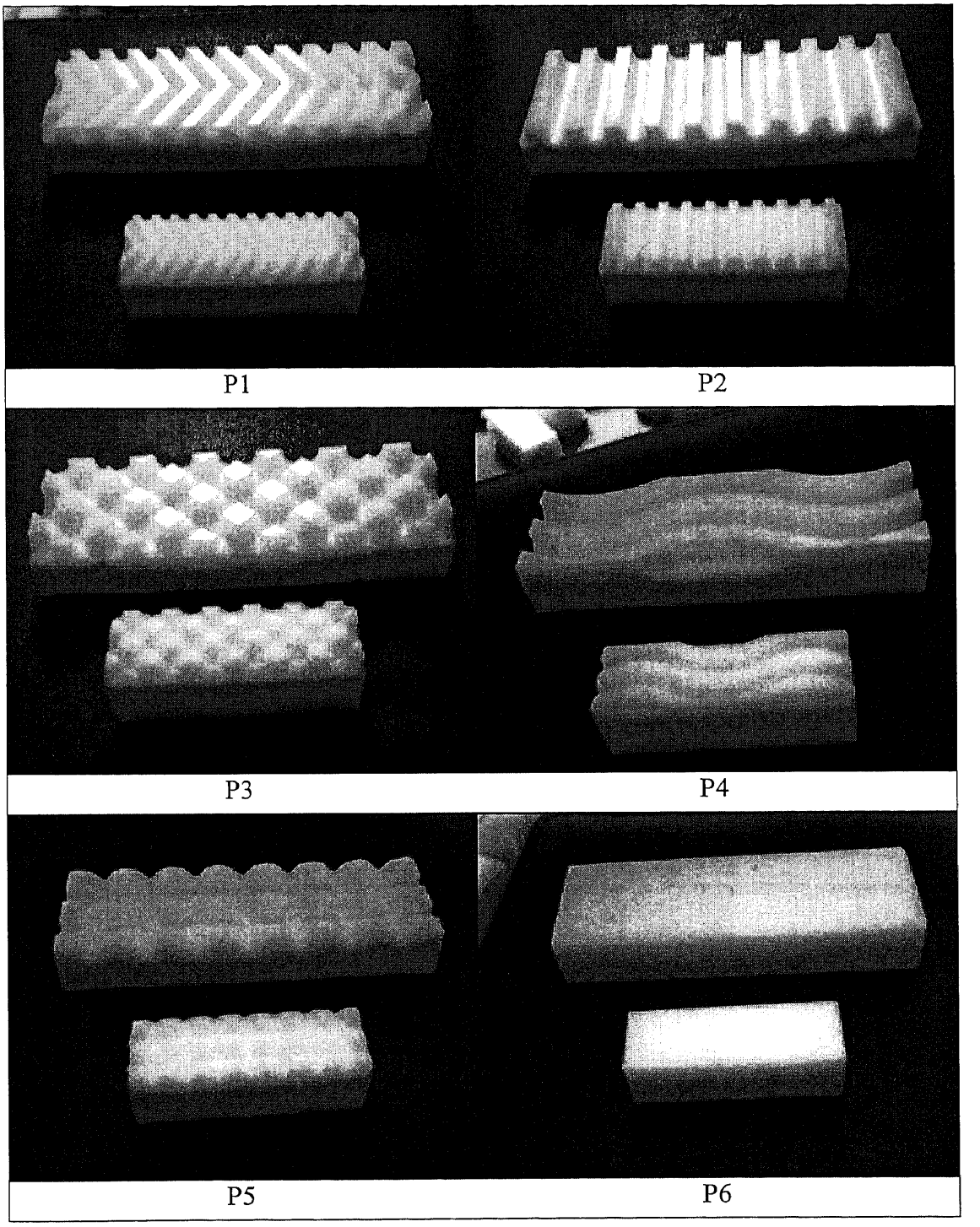



**Figure 2.10** The six patterns in both sizes large and small

# CHAPTER 3

# METHODOLOGY OF EXPERIMENT

## 3.1 Research Objective

This study compared the recognition of the tactile patterns and numbers presented to the subjects. The subjects' response to the patterns in the study would help determine if a tactile pattern was easily recognizable or not and which tactile pattern would it most likely be confused for.

There were 5 tactile patterns and one smooth pattern used in the study. The smooth pattern (P6) was removed since it did not have a pattern to recognize. The smooth surface would add a false identification of a hazard since the smooth field may not be differentiated from the smooth surface of the container being labeled. In this case the smooth pattern would act as the white field on the label. This leaves the three other fields (red, blue and yellow) and five other patterns to be tested.

The numbers were included in the study to test for recognition, and to help randomize the tactile patterns. The subject had a chance to memorize the patterns since there were only five. Also with the numbers attached to the tactile pattern this increased the amount of observations that were unique (i.e. 5 patterns x 5 numbers = 25 combinations). There were 25 combinations for each size, the large set and the small set. Each sets' combinations were doubled, so the total amount of combinations would be 50 for the large set and 50 for the small set.

A questionnaire was given to the subjects in order to record their experience and thoughts on the tactile pattern. The results of the study helped to determine the best

possible combinations of patterns and also to find if the small tactile patterns were recognizable.

### 3.2 Selection of Subjects

Twenty individuals, 14 males and 6 females volunteered for the experiment. The experiment took between 50-60 minutes. The subjects were briefed about their role in the experiment and when to observe the patterns. Every participant received a post-experimental questionnaire (see figure 3.1), in order to categorize them by age, sex, education, occupation and ethnicity.

**Questionnaire**

Subject # _____ Date _____

Purpose: The purpose of this questionnaire is to determine if the tactile patterns are recognizable.

Name: _____ Age: _____

Gender: _____ Education: _____ Occupation: _____ Ethnicity: _____

Are you visually impaired?

Are you familiar with warning labeling systems i.e. HMIS or NFPA 704?

Have you had Hazardous Communication training before?

Do you work in an environment that uses warning systems?

Are your fingers Fatigued?

If fatigued, when did you start noticing trouble recognizing the patterns?

Were any of the patterns harder to recognize? If yes which ones.

Which of the pattern were easier to decipher?

Did the size matter? And if it did which size did you prefer?

If the pictures were removed would you be able to recognize the patterns?

Of the samples showed what colors would you recommend for each, choices of colors are red, blue and yellow?
Sample 1 _____
Sample 2 _____
Sample 3 _____
Sample 4 _____
Sample 5 _____

**Figure 3.1** Post-Experimental questionnaires.

### 3.3 Information Gathered

With the questionnaire completed, the information was then separated into categories and laid out in a spreadsheet (MS Excel 2000). The spreadsheet helped in the compiling of all the data that was generated by the 20 subjects.

### 3.4 Data Analysis

The information will have to be extrapolated out of the experimental observations and the questionnaire. Some of the information gathered off the questionnaire was subjective due to the subjects' tactile pattern likes and dislikes. This was compared to the experimental observations to find out if the subjects preference for patterns actually differed. The color preference for the patterns would also be subjective since the only color to choice from would be red, blue and yellow. The colors were matched to the three best patterns to determine a final layout for the HMIS.

### 3.5 Taking the Observations

In making the observation, the subject was presented with the tactile pattern and number according to an established order. The combination of a pattern and number was presented in an enclosed barrier so that the subject could not see the combination. This was done with both the large and small set. A picture of the complete set was placed in their view so the subject had a reference of the patterns and numbers. The subjects were not asked to memorize the sets in this study.

The subjects used their index finger to feel the combinations in the enclosure and responded with their observations. There were no time limits on the observations to prevent any misidentification do to time pressure.

In figure 3.2 the subject used the index finger to feel a tactile pattern/number combination. A total of 100 observations by the same finger were done on both sets.

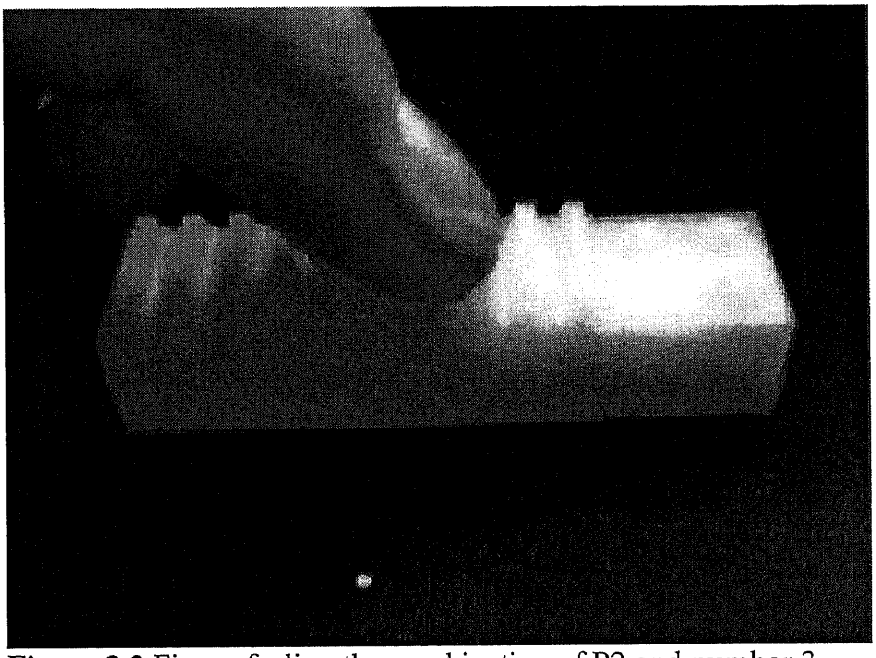


**Figure 3.2** Finger feeling the combination of P2 and number 3

# CHAPTER 4

# RESULTS

## 4.1 Observation Results

A total of 2000 observations were taken in this study. Each subject made 50 observations for the large set and 50 for the small set. In setting up the randomizations of each set, they were put in to 10 repetitions of 5 tactile patterns in which no repetitions had the same order of tactile pattern. The numbers were combined with the tactile pattern with different orders of the 5 tactile numbers of each repetition. Table 4.1 shows the final order of the observations has each combination of pattern and number observed twice.

The observations were given to the subjects in the order of 1 through 50 for the large set. For the small set they were started at the half waypoint, 25 through 50 and then 1 through 25 so the subject would not memorize the order. When a pattern was misidentified the response given was noted. This information was used to determine the final error rate and misidentifications of both large and small sets.

The larger set had a recognition rate of 100% for both the tactile Patterns and tactile numbers. There were no misidentified patterns or numbers in the all of the 50 combinations. For the smaller set only the tactile number had a 100% recognition rate. The tactile pattern had a total of 8 misidentified patterns out of the 1000 patterns shown. Twenty subjects were given 50 patterns equal to a total of 1000 patterns. This gave the smaller set a 0.8% error rate of recognition of the tactile patterns. To give the best possible combination of three tactile patterns, the 8 misidentified tactile patterns were later statistically compared to the patterns they were mistaken for.

**Table 4.1** Order of the combinations

**Observation Order**

| Order | Repetition | Pattern | Number | Order | Repetition | Pattern | Number |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 3 | 26 | 6 | 2 | 4 |
| 2 | 1 | 4 | 2 | 27 | 6 | 3 | 3 |
| 3 | 1 | 3 | 1 | 28 | 6 | 4 | 1 |
| 4 | 1 | 2 | 4 | 29 | 6 | 1 | 2 |
| 5 | 1 | 5 | 0 | 30 | 6 | 5 | 0 |
| 6 | 2 | 3 | 4 | 31 | 7 | 4 | 2 |
| 7 | 2 | 2 | 0 | 32 | 7 | 1 | 3 |
| 8 | 2 | 5 | 3 | 33 | 7 | 5 | 4 |
| 9 | 2 | 1 | 2 | 34 | 7 | 2 | 1 |
| 10 | 2 | 4 | 1 | 35 | 7 | 3 | 0 |
| 11 | 3 | 5 | 2 | 36 | 8 | 5 | 1 |
| 12 | 3 | 1 | 1 | 37 | 8 | 2 | 2 |
| 13 | 3 | 4 | 4 | 38 | 8 | 3 | 4 |
| 14 | 3 | 3 | 0 | 39 | 8 | 4 | 3 |
| 15 | 3 | 2 | 3 | 40 | 8 | 1 | 0 |
| 16 | 4 | 2 | 2 | 41 | 9 | 1 | 4 |
| 17 | 4 | 5 | 5 | 42 | 9 | 5 | 2 |
| 18 | 4 | 1 | 1 | 43 | 9 | 2 | 3 |
| 19 | 4 | 4 | 4 | 44 | 9 | 3 | 1 |
| 20 | 4 | 3 | 3 | 45 | 9 | 4 | 0 |
| 21 | 5 | 4 | 3 | 46 | 10 | 3 | 2 |
| 22 | 5 | 3 | 2 | 47 | 10 | 4 | 4 |
| 23 | 5 | 2 | 1 | 48 | 10 | 1 | 1 |
| 24 | 5 | 5 | 4 | 49 | 10 | 5 | 3 |
| 25 | 5 | 1 | 0 | 50 | 10 | 2 | 0 |

The errors were arranged in which repetition the error happened and which pattern the subject responded with. In the data calculated "$S_n$" will equal the subject with "n" being the subject number. The pattern misidentification will be "Pd $\rightarrow$ Pr", with "Pd" being the original pattern displayed and "Pr" being the subjects pattern response. The "$R_m$" will be the repetition and "m" will be in which the error happen. They are in the order of subject, which does not add any value to the error.

1. $S_3 = P2 \rightarrow P5 \ @ \ R_{10}$
2. $S_7 = P3 \rightarrow P5 \ @ \ R_7$
3. $S_7 = P2 \rightarrow P1 \ @ \ R_{10}$
4. $S_{12} = P3 \rightarrow P1 \ @ \ R_3$
5. $S_{14} = P5 \rightarrow P3 \ @ \ R_6$
6. $S_{15} = P5 \rightarrow P3 \ @ \ R_6$
7. $S_{16} = P1 \rightarrow P4 \ @ \ R_1$
8. $S_{16} = P5 \rightarrow P3 \ @ \ R_1$

P1 was misidentified 1 time and mistaken for another 2 times

P2 was misidentified 2 times and mistaken for another 0 times

P3 was misidentified 2 times and mistaken for another 3 times

P4 was misidentified 0 times and mistaken for another 1 times

P5 was misidentified 3 times and mistaken for another 2 times

A total of 10 combinations using three patterns could be generated by the 5 unique patterns.

$$\frac{5!}{3! \text{ X } (5\text{-}2)!} = 10$$

The ten possible combinations and their potential error value are as follows:

1. (P1, P2, P3) = 5
2. (P1, P2, P4) = 3
3. (P1, P2, P5) = 6
4. (P1, P3, P4)= 3
5. (P1, P3, P5) = 6
6. (P1, P4, P5) = 4
7. (P2, P3, P4) = 4
8. (P2, P3, P5) = 7
9. (P2, P4, P5) = 5
10. (P3, P4, P5) = 5

The error value is calculated by adding up the number of times each pattern was misidentified in each combination. The two sets with the lowest error value are the combinations of set 2 and set 4 with and error of 3.

## 4.2 Results from the Questionnaire

The questionnaire results were separated into three parts: subjects' information, subjects' experience and subjects opinions.

### 4.2.1 Subjects' Information

Of the 20 subjects, 14 were male and 6 were female. The average age of the subjects was 22.7 years old with a standard deviation of 2.23 years. There were a wide range of occupations, but the majority of the subjects were students. One of the subjects has a high school education and the rest have a college education. The occupational break down for the 20 subjects are in Table 4.2. None of the subjects were visually impaired.

**Table 4.2** Occupational Break down

| Occupation | Subjects |
|---|---|
| Student | 8 |
| Computer | 3 |
| Finance | 2 |
| Teacher | 2 |
| Office | 1 |
| Police | 1 |
| Chemical | 1 |
| Safety field | 1 |
| Lab | 1 |

### 4.2.2 Subjects' Experience

The subjects were asked if they had any experience with hazard information systems and if they had any training in Hazcom. The results can be seen in Figure 4.1.

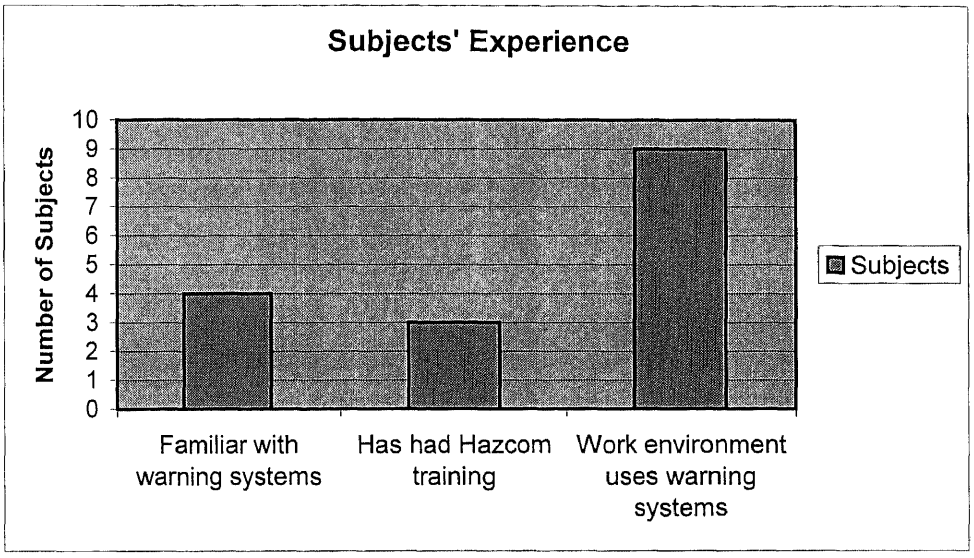



**Figure 4.1** Subject Experience

### 4.2.3 Subjects' Opinion

In this part of the questionnaire the subjects were asked their thoughts on the patterns. They were also asked if their fingers felt fatigued from participating in the experiment. None of the subjects felt fatigued based on the report of the questionnaire.

The subjects were also asked to put down the pattern that they thought were harder and easier to identify (see Figure 4.2). This helped in the comparison of the objective results and the subjective results. The preference of choice was only on the five tactile patterns not the tactile number since the numbers themselves are a tactile representation of the number value.

The choice of preferred color to help associate the tactile pattern to a color was also asked. Since there were only three colors to choose from and five patterns to give a color to the same colors were be given to more than one pattern. The choices for the colors were biased by the subject's opinions. Which was fine if most of the other subject share those opinions. Figure 4.3 shows the preferred colors for each pattern.

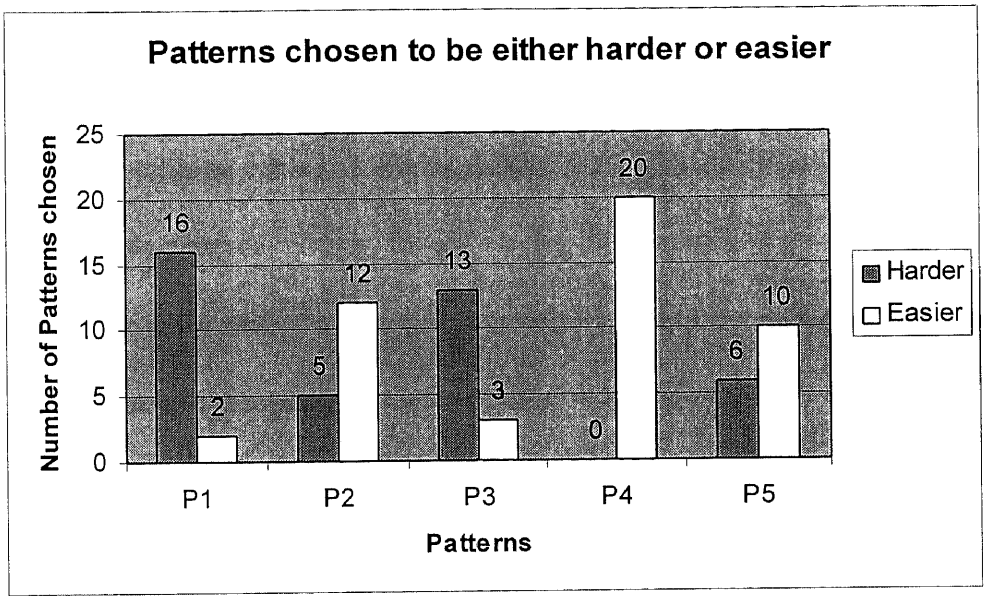



**Figure 4.2** Pattern chosen to be harder or easier

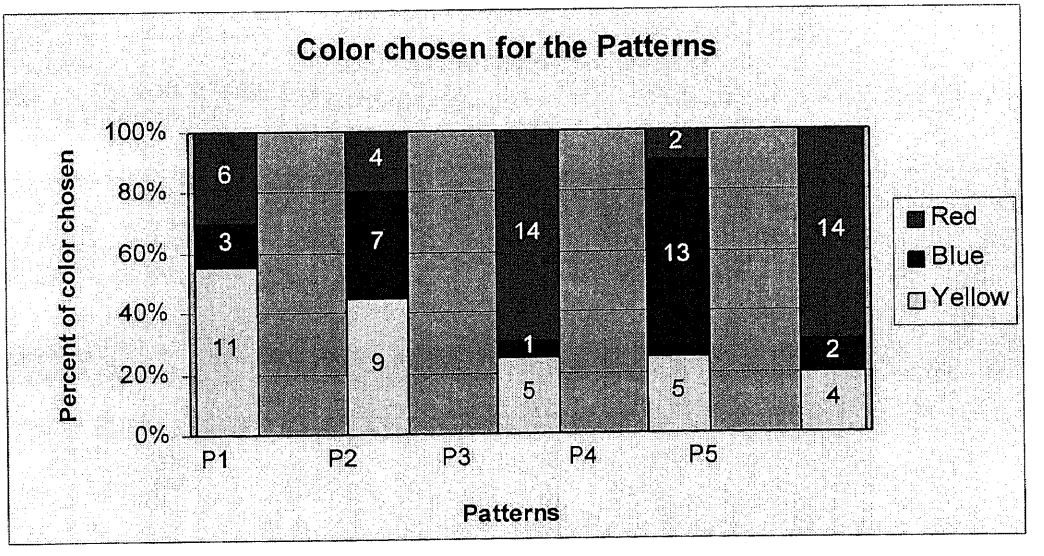



**Figure 4.3** Color chosen for the Patterns

Finally the subjects were asked if the picture of the patterns were removed would they still be able to identify the patterns, Seventeen out of the 20 subjects replied yes, and commented that the patterns were different enough to identify without the picture.

### 4.3 Combining the Results

Once the error value was calculated for each combination set, the two best sets were chosen. A chi-squared distribution was done with the subject's choices of colors. This helped to determine the best combinations of pattern to the strongest association with color for each pattern. With $\chi^2$ for set 4 being 28.20 which is greater than the table value of $\chi^2_{4,.05} = 9.488$ and $\chi^2_{4,.01} = 13.28$ gave it a higher association between the patterns and the colors compared to set 2 with a $\chi^2 = 10.85$.

**Table 4.3** The chi-squared calculation of combination sets 4 and 2.

| Set 4 | P1 | P3 | P4 | Total |
|---|---|---|---|---|
| Yellow | 11 | 5 | 5 | 21 |
| Blue | 3 | 1 | 13 | 17 |
| Red | 6 | 14 | 2 | 22 |
| Total | 20 | 20 | 20 | 60 |
| Expected Y | 7.00 | 7.00 | 7.00 | |
| Expected B | 5.67 | 5.67 | 5.67 | |
| Expected R | 7.33 | 7.33 | 7.33 | |

Chi-Square = 28.20 for Set 4

| Set 2 | P1 | P2 | P4 | Total |
|---|---|---|---|---|
| Yellow | 11 | 9 | 5 | 25 |
| Blue | 3 | 7 | 13 | 23 |
| Red | 6 | 4 | 2 | 12 |
| Total | 20 | 20 | 20 | 60 |
| Expected Y | 8.33 | 8.33 | 8.33 | |
| Expected B | 7.67 | 7.67 | 7.67 | |
| Expected R | 4.00 | 4.00 | 4.00 | |

Chi-Square = 10.85 for Set 2

# CHAPTER 5

# DISCUSSION AND CONCLUSIONS

## 5.1 Discussion

HMIS has proven to be a reliable labeling system for hazard warning. The development of a tactile adaptation to it would enhance its versatility and also add a needed sense of touch to reemphasize the warning. The tactile patterns were initially designed to be simple and easy to identify. The final outcome showed that this was accomplished. Designing these distinct patterns has showed that keeping the tactile patterns less cluttered or complex would make it easy to recognize.

The larger tactile pattern and tactile numbers had a 100% recognition rate. This may be due to the larger size, which made it to easier for the subject to recognize the patterns and numbers. The outcome of the smaller tactile patterns and numbers compared well. The recognition rates for the smaller tactile numbers only that were half the size of the larger tactile numbers were also 100%. The smaller tactile patterns did have 8 misidentified patterns out of 1000. Making the recognition rate of the smaller tactile patterns 99.2%. This rate also shows that the designed tactile pattern even at a smaller size can still be recognized.

The subjects gave their opinions on the hardest and easiest tactile patterns to recognize and this was compared to the actual observations taken during the study. The subjects picked the patterns set (P2, P4, P5) the easiest to recognize. Since P1 and P3 were considered by the subjects to be the hardest patterns to identify, they were eliminated from the potential set. The set of (P2, P4, P5) were given the colors the subjects preferred, the preferred results being: yellow for P2, blue for P4, and red for P5.

The HMIS already has a standard format based on the above colors. The tactile pattern would be situated in the label according to their assigned color (see Figure 5.1).

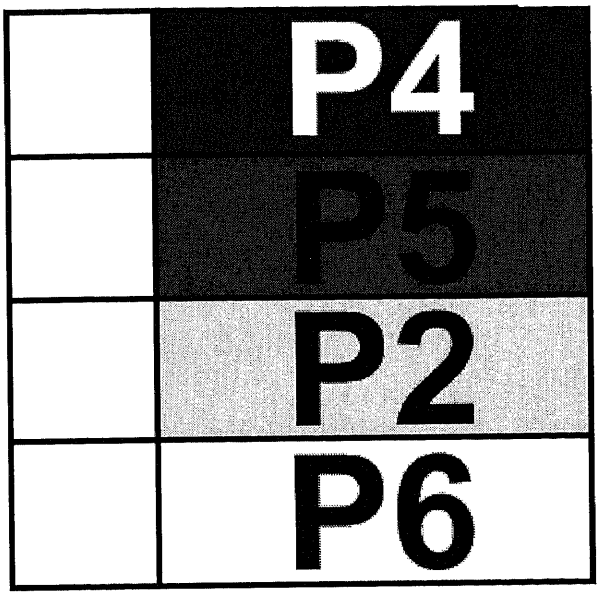



**Figure 5.1** Final layout according to the subjects opinions

The observed results differ from the opinions of the subjects. According to the error value of each combination of patterns, the combination set chosen by the subjects opinions is (P2, P4, P5) = 5. There are four other combinations that resulted in a lower error value (P1, P2, P4) = 3, (P1, P3, P4) = 3, (P1, P4, P5) = 4 and (P2, P3, P4) = 4. This results in a problem of which set to choose, an observation based layout. If the sets with the best error value were chosen, the remaining set were (P1, P2, P4) and (P1, P3, P4) which both had a error value of 3. To decide the final combination set, the subjects color preferences were used. Since the combination of (P1, P2, P4) had a color preference of yellow for P1, yellow for P2 and blue for P4 it would make it difficult to choose which pattern would be assigned yellow. For the combination set of (P1, P3, P4) the preferred color actually work out with yellow for P1, red for P3 and blue for P4 (see

figure 5.2). This was also worked out with a chi-square distribution. The outcome gave the combinations set of (P1, P3, P4) the best association between the color and pattern.

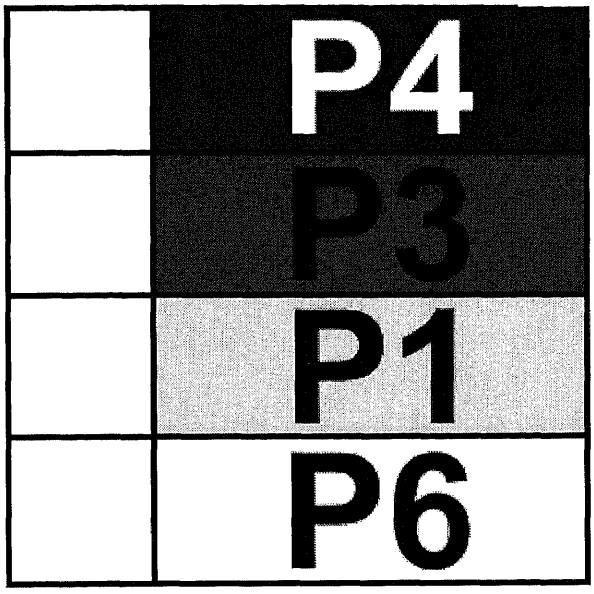



**Figure 5.2** Final layout according to the observations

This leaves the question of why did the opinions of the subjects determine a combination of a greater error rate when the observation dictated a different combination. One reason could be that the patterns P1 and P3 were the hardest to identify not because of difficulty, but because it was the ones that the subjects personally disliked. The other reason could be that liked the way P2 and P5 felt. The goal was not to design patterns to feel good to the touch, but to inform the intended user of the potential hazard. The patterns with the best recognition rate happened to have textures that were not as comfortable to the touch.

### 5.2 Proposed Tactile Hazardous Material Information System (THMIS)

The Hazardous Material Information System (HMIS) is a labeling system developed by the National Paint and Coatings Association (NPCA) and sold through Labelmaster Inc. The system uses a label with four color bars and a space at the top where the name of the chemical is written. The blue, red, and yellow colored bars indicate, respectively, the health, flammability, and reactivity hazard associated with the material. These three bars use a numbering scale ranging from 0 to 4. A value of zero means that the material poses essentially no hazard; a rating of four indicates extreme danger.

The fourth, white bar is marked "personal protection" in the HMIS system. The System (HMIS) places a letter in this bar to indicate the kind(s) of personal protective equipment (PPE) that should be used in order to handle the material safely. The letters used are A - K and X. Meanings of the letters in the system augment the letter code with icons or pictograms showing the kinds of PPE to be used.

The Tactile Hazardous Material Information System (THMIS) (see figure 5.3) will provide the same information as the HMIS with the addition of tactile patterns for the hazards and tactile numbers for there respected hazard value. The THMIS will also have a representative value for the personal protective equipment in the white bar. Using a tactile numbering scale as seen in Figure 5.4, the appropriate PPE will be represented.

As with any information system proper training will have to be provided by the employer according to the meet compliance with OSHA's Hazard Communication Standard (HCS). This will ensure that the workers have the proper training in how to interpret the tactile information displayed.

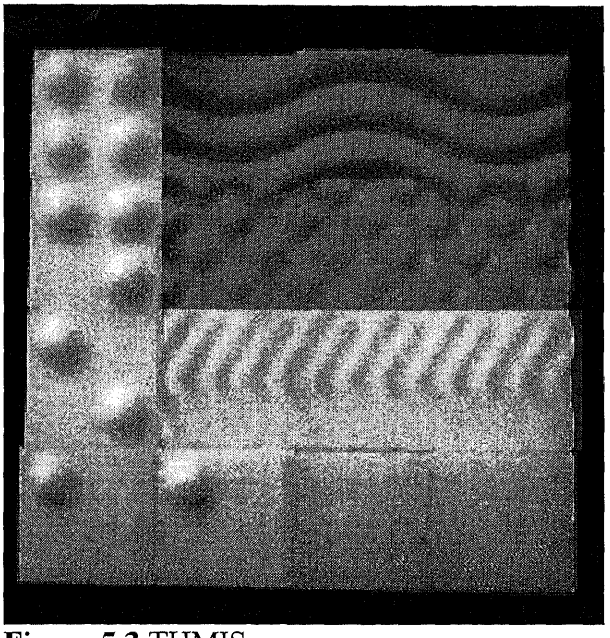


**Figure 5.3** THMIS

The THMIS will be the same size as the HMIS and be laid out the same as well. The colors of the tactile patterns will be the same as they are on the HMIS. The tactile number will have the text version printed on them so that they could be read also. For the PPE, a blank field was left on the white section so that the letter code with icons or pictograms showing the kinds of PPE can be used. This system will help with interpreting the hazards and proper PPE to use. The exception between HMIS and THMIS is providing the chemical's identity. This will have to force the workers to ask what the identity of the chemical is if they are alarmed by the hazard felt on the label. Possibly Braille or another system of text can be provided to enhance the THMIS.

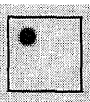
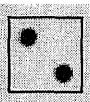
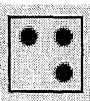
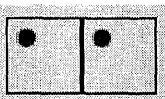
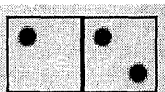
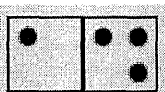
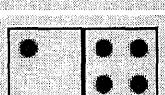
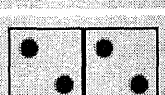
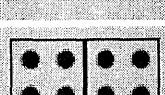
| Tactile Number | Symbol | Personal Protective Equipment (PPE) Required |
|---|---|---|
|  | A | Safety Glasses |
|  | B | Safety Glasses<br>Gloves |
|  | C | Safety Glasses<br>Gloves<br>Apron |
|  | D | Face Shield<br>Gloves<br>Apron |
|  | E | Safety Glasses<br>Gloves<br>Dust Respirator |
|  | F | Safety Glasses<br>Gloves<br>Apron<br>Dust Respirator |
|  | G | Safety Glasses<br>Gloves<br>Vapor Respirator |
|  | H | Splash Goggles<br>Gloves<br>Apron<br>Vapor Respirator |
|  | I | Safety Glasses<br>Gloves<br>Dust and Vapor Respirator |
|  | J | Splash Goggles<br>Gloves<br>Apron<br>Dust and Vapor Respirator |
|  | K | Air Line Hood or Mask<br>Gloves<br>Full Suit<br>Boots |
|  | X | Ask supervisor or safety specialist for handling instructions. |

**Figure 5.4** Tactile numbering value (PPE Symbols Copyright © 1987, Lab Safety Supply Co.)

### 5.3 Future Research Direction

Finally, it would be recommended that further research be conducted after this study. Test could be expanded to include the effects of climate conditions on the hand and its sense of touch. One direction would be to test whether the cold makes any difference in the ability to recognize the tactile patterns. In addition, would the dexterity of gloves make differences in how the tactile patterns might be effective? Further research on the effects of contours of the labels, being on a round bottle as opposed to a flat box are necessary. Also, can the gaps (currently 2mm) be reduced; can the depth be reduced? What is an acceptable error rate for tactile warning labels? Lastly, testing of the label's material should be performed for durability. In conclusion, this study would not only help the visually impaired, but also the workers who would appreciate the tactile labels in unexpected situations.

# APPENDIX A

## EXPERIMENTAL DATA

The data is tabulated using Microsoft Excel 2000. The experiment consisted of a total of 2000 observations, a100 observations per subject. In the observations zero was put down if no error happen. If an error was observed then the pattern it was mistaken for was noted.

The questionnaire was also tabulated using Microsoft Excel 2000.

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|---|---|---|---|---|---|---|---|---|---|---|
| LR1P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | S11 | S12 | S13 | S14 | S15 | S16 | S17 | S18 | S19 | S20 |
|---|---|---|---|---|---|---|---|---|---|---|
| LR1P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR1P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR2P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR3P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR4P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR5P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR6P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR7P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR8P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR9P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LR10P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|---|---|---|---|---|---|---|---|---|---|---|
| SR1P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR1P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR1P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR1P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR1P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P3 | 0 | 0 | 0 | 0 | 0 | 0 | **P5** | 0 | 0 | 0 |
| SR7P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P2 | 0 | 0 | 0 | 0 | **P5** | 0 | **P1** | 0 | 0 | 0 |
| SR10P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | S11 | S12 | S13 | S14 | S15 | S16 | S17 | S18 | S19 | S20 |
|---|---|---|---|---|---|---|---|---|---|---|
| SR1P1 | 0 | 0 | 0 | 0 | 0 | **P4** | 0 | 0 | 0 | 0 |
| SR1P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR1P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR1P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR1P5 | 0 | 0 | 0 | 0 | 0 | **P3** | 0 | 0 | 0 | 0 |
| SR2P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR2P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P3 | 0 | **P1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR3P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR4P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR5P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR6P5 | 0 | 0 | 0 | **P3** | **P3** | 0 | 0 | 0 | 0 | 0 |
| SR7P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR7P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR8P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR9P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SR10P5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | 22 | 22 | 21 | 21 | 20 | 23 | 22 | 20 | 22 | 22 |
| Gender | M | F | M | M | M | M | F | M | M | M |
| OccStud | Y | Y | Y | Y | Y | Y | | | Y | |
| OccComp | | | | | | | Y | Y | | Y |
| OccFina | | | | | | | | | | |
| OccTeach | | | | | | | | | | |
| OccOffice | | | | | | | | | | |
| OccPolice | | | | | | | | | | |
| OccChem | | | | | | | | | | |
| OccSafety | | | | | | | | | | |
| OccLab | | | | | | | | | | |
| EduHS | | | | | | | | | | |
| EduColl | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| VisImpair | | | | | | | | | | |
| WarnSys | | | | | | | | | | |
| Hazcom | | | | | | | | | | |
| EnvirWarn | Y | Y | Y | | | Y | | Y | Y | |
| Fatigue | | | | | | | | | | |
| FatigTime | | | | | | | | | | |
| HardP1 | Y | Y | Y | Y | Y | Y | | | | Y |
| HardP2 | | Y | | Y | | Y | | | | |
| HardP3 | | | Y | Y | Y | | Y | Y | Y | Y |
| HardP4 | | | | | | | | | | |
| HardP5 | | | | Y | Y | | Y | Y | Y | |
| EasyP1 | | | | | | | | Y | Y | |
| EasyP2 | Y | | Y | | Y | | Y | Y | Y | |
| EasyP3 | | Y | | | | Y | | | | |
| EasyP4 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| EasyP5 | | Y | Y | | | Y | | | | Y |
| SizeMatt | | Y | | Y | | Y | Y | Y | | |
| Sizelike | Y | Y | Y | Y | | Y | Y | Y | Y | |
| Recognize | Y | Y | Y | Y | Y | Y | | Y | Y | |
| ColorP1Y | | Y | | | Y | | Y | | Y | |
| ColorP1B | | | | | | Y | | Y | | |
| ColorP1R | Y | | Y | Y | | | | | | Y |
| ColorP2Y | Y | Y | | Y | | | | Y | | |
| ColorP2B | | | Y | | Y | | Y | | | |
| ColorP2R | | | | | | Y | | | Y | Y |
| ColorP3Y | | Y | | | | Y | | | | Y |
| ColorP3B | | | | | | | | | | |
| ColorP3R | Y | | Y | Y | Y | | Y | Y | Y | |
| ColorP4Y | | | Y | | | | Y | Y | | |
| ColorP4B | Y | Y | | Y | Y | | | | Y | Y |
| ColorP4R | | | | | | Y | | | | |
| ColorP5Y | | | Y | Y | | Y | | | | Y |
| ColorP5B | | | | | | | | | | |
| ColorP5R | Y | Y | | | Y | | Y | Y | Y | |

| | S11 | S12 | S13 | S14 | S15 | S16 | S17 | S18 | S19 | S20 |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | 19 | 23 | 23 | 26 | 25 | 22 | 28 | 25 | 24 | 24 |
| Gender | M | F | F | M | M | F | F | M | M | M |
| OccStud | Y | | | | | | | | | |
| OccComp | | | | | | | | | | |
| OccFina | | Y | | | | | | | | Y |
| OccTeach | | | | | | Y | Y | | | |
| OccOffice | | | Y | | | | | | | |
| OccPolice | | | | | Y | | | | | |
| OccChem | | | | | | | | | Y | |
| OccSafety | | | | | | | | Y | | |
| OccLab | | | | Y | | | | | | |
| EduHS | | | | Y | | | | | | |
| EduColl | Y | Y | Y | | Y | Y | Y | Y | Y | Y |
| VisImpair | | | | | | | | | | |
| WarnSys | Y | | | | | | | Y | Y | Y |
| Hazcom | Y | | | | | | | Y | Y | |
| EnvirWarn | Y | | | | | | | Y | Y | |
| Fatigue | | | | | | | | | | |
| FatigTime | | | | | | | | | | |
| HardP1 | Y | Y | Y | Y | | Y | Y | Y | Y | Y |
| HardP2 | | | | Y | | Y | | | | |
| HardP3 | Y | | Y | | Y | | Y | | Y | Y |
| HardP4 | | | | | | | | | | |
| HardP5 | | | | | Y | | | | | |
| EasyP1 | | | | | | | | | | |
| EasyP2 | Y | | Y | | | | Y | Y | Y | Y |
| EasyP3 | | | | | | | | Y | | |
| EasyP4 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| EasyP5 | Y | | | Y | | | Y | Y | Y | Y |
| SizeMatt | Y | Y | | | Y | | Y | Y | | Y |
| Sizelike | Y | Y | | Y | Y | Y | Y | Y | | Y |
| Recognize | Y | Y | Y | Y | Y | Y | | Y | Y | Y |
| ColorP1Y | Y | Y | | Y | Y | | | Y | Y | Y |
| ColorP1B | | | | | | | Y | | | |
| ColorP1R | | | Y | | | Y | | | | |
| ColorP2Y | | | | | Y | | Y | Y | Y | Y |
| ColorP2B | | Y | Y | Y | | Y | | | | |
| ColorP2R | Y | | | | | | | | | |
| ColorP3Y | Y | | | | | | | Y | | |
| ColorP3B | | Y | | | | | | | | |
| ColorP3R | | | Y | Y | Y | Y | Y | | Y | Y |
| ColorP4Y | | | Y | | | Y | | | | |
| ColorP4B | Y | | | Y | Y | | Y | Y | Y | Y |
| ColorP4R | | Y | | | | | | | | |
| ColorP5Y | | | | | | | | | | |
| ColorP5B | | | Y | | | Y | | | | |
| ColorP5R | Y | Y | | Y | Y | | Y | Y | Y | Y |

## APPENDIX B

## OSHA HAZARD COMMUNICATIONS STANDARD

### OSHA Regulations (Standards – 29 CFR)
### Hazard Communication. – 1910.1200

**Standard Number**: 1910.1200
**Standard Title:** Hazard Communication.
**SubPart Number:** Z
**SubPart Title:** Toxic and Hazardous Substances
**Applicable Standard:** Applicable Standard:

**(a)**

"Purpose."

**(a)(1)**

The purpose of this section is 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 transmittal of information is to be accomplished by means of comprehensive hazard communication programs, which are to include container labeling and other forms of warning, material safety data sheets and employee training.

**(a)(2)**

This occupational safety and health standard is intended to address comprehensively the issue of evaluating the potential hazards of chemicals, and communicating information concerning hazards and appropriate protective measures to employees, and to preempt any legal requirements of a state, or political subdivision of a state, pertaining to this subject. Evaluating the potential hazards of chemicals, and communicating information concerning hazards and appropriate protective measures to employees, may include, for example, but is not limited to, provisions for: developing and maintaining a written hazard communication program for the workplace, including lists of hazardous chemicals present; labeling of containers of chemicals in the workplace, as well as of containers of chemicals being shipped to other workplaces; preparation and distribution of material safety data sheets to employees and downstream employers; and development and implementation of employee training programs regarding hazards of chemicals and protective measures. Under section 18 of the Act, no state or political subdivision of a state may adopt or enforce, through any court or agency, any requirement relating to the issue addressed by this Federal standard, except pursuant to a Federally-approved state plan.

**(b)**

"Scope and application."

**(b)(1)**

This section requires chemical manufacturers or importers to assess the hazards of chemicals which they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program, labels and other forms of warning, material safety data sheets, and information and training. In addition, this section requires distributors to transmit the required information to employers. (Employers who do not produce or import chemicals need only focus on those parts of this rule that deal with establishing a workplace program and communicating information to their workers. Appendix E of this section is a general guide for such employers to help them determine their compliance obligations under the rule.)

**(b)(2)**

This section applies to any chemical which is known to be present in the workplace in such a manner that employees may be exposed under normal conditions of use or in a foreseeable emergency.

**(b)(3)**

This section applies to laboratories only as follows:

**(b)(3)(i)**

Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced;

**(b)(3)(ii)**

Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible during each workshift to laboratory employees when they are in their work areas;

**(b)(3)(iii)**

Employers shall ensure that laboratory employees are provided information and training in accordance with paragraph (h) of this section, except for the location and availability of the written hazard communication program under paragraph (h)(2)(iii) of this section; and,

**(b)(3)(iv)**

Laboratory employers that ship hazardous chemicals are considered to be either a chemical manufacturer or a distributor under this rule, and thus must ensure that any containers of hazardous chemicals leaving the laboratory are labeled in accordance with paragraph (f)(1) of this section, and that a material safety data sheet is provided to distributors and other employers in accordance with paragraphs (g)(6) and (g)(7) of this section.

**(b)(4)**

In work operations where employees only handle chemicals in sealed containers which are not opened under normal conditions of use (such as are found in marine cargo handling, warehousing, or retail sales), this section applies to these operations only as follows:

**(b)(4)(i)**

Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced;

**(b)(4)(ii)**

Employers shall maintain copies of any material safety data sheets that are received with incoming shipments of the sealed containers of hazardous chemicals, shall obtain a material safety data sheet as soon as possible for sealed containers of hazardous chemicals received without a material safety data sheet if an employee requests the material safety data sheet, and shall ensure that the material safety data sheets are readily accessible during each work shift to employees when they are in their work area(s); and,

**(b)(4)(iii)**

Employers shall ensure that employees are provided with information and training in accordance with paragraph (h) of this section (except for the location and availability of the written hazard communication program under paragraph (h)(2)(iii) of this section), to the extent necessary to protect them in the event of a spill or leak of a hazardous chemical from a sealed container.

**(b)(5)**

This section does not require labeling of the following chemicals:

**(b)(5)(i)**

Any pesticide as such term is defined in the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136 et seq.), when subject to the labeling requirements of that Act and labeling regulations issued under that Act by the Environmental Protection Agency;

**(b)(5)(ii)**

Any chemical substance or mixture as such terms are defined in the Toxic Substances Control Act (15 U.S.C. 2601 et seq.), when subject to the labeling requirements of that Act and labeling regulations issued under that Act by the Environmental Protection Agency;

**(b)(5)(iii)**

Any food, food additive, color additive, drug, cosmetic, or medical or veterinary device or product, including materials intended for use as ingredients in such products (e.g. flavors and fragrances), as such terms are defined in the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 et seq.) or the Virus-Serum-Toxin Act of 1913 (21 U.S.C.151 et seq.), and regulations issued under those Acts, when

they are subject to the labeling requirements under those Acts by either the Food and Drug Administration or the Department of Agriculture;

**(b)(5)(iv)**

Any distilled spirits (beverage alcohols), wine, or malt beverage intended for nonindustrial use, as such terms are defined in the Federal Alcohol Administration Act (27 U.S.C. 201 et seq.) and regulations issued under that Act, when subject to the labeling requirements of that Act and labeling regulations issued under that Act by the Bureau of Alcohol, Tobacco, and Firearms;

**(b)(5)(v)**

Any consumer product or hazardous substance as those terms are defined in the Consumer Product Safety Act (15 U.S.C. 2051 et seq.) and Federal Hazardous Substances Act (15 U.S.C. 1261 et seq.) respectively, when subject to a consumer product safety standard or labeling requirement of those Acts, or regulations issued under those Acts by the Consumer Product Safety Commission; and,

**(b)(5)(vi)**

Agricultural or vegetable seed treated with pesticides and labeled in accordance with the Federal Seed Act (7 U.S.C. 1551 et seq.) and the labeling regulations issued under that Act by the Department of Agriculture.

**(b)(6)**

This section does not apply to:

**(b)(6)(i)**

Any hazardous waste as such term is defined by the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6901 et seq.), when subject to regulations issued under that Act by the Environmental Protection Agency;

**(b)(6)(ii)**

Any hazardous substance as such term is defined by the Comprehensive Environmental Response, Compensation and Liability ACT (CERCLA) (42 U.S.C. 9601 et seq.) when the hazardous substance is the focus of remedial or removal action being conducted under CERCLA in accordance with the Environmental Protection Agency regulations.

**(b)(6)(iii)**

Tobacco or tobacco products;

**(b)(6)(iv)**

Wood or wood products, including lumber which will not be processed, where the chemical manufacturer or importer can establish that the only hazard they pose to employees is the potential for flammability or combustibility (wood or wood products which have been treated with a hazardous chemical covered by this

standard, and wood which may be subsequently sawed or cut, generating dust, are not exempted);

**(b)(6)(v)**

Articles (as that term is defined in paragraph I of this section);

**(b)(6)(vi)**

Food or alcoholic beverages which are sold, used, or prepared in a retail establishment (such as a grocery store, restaurant, or drinking place), and foods intended for personal consumption by employees while in the workplace;

**(b)(6)(vii)**

Any drug, as that term is defined in the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 et seq.), when it is in solid, final form for direct administration to the patient (e.g., tablets or pills); drugs which are packaged by the chemical manufacturer for sale to consumers in a retail establishment (e.g., over-the-counter drugs); and drugs intended for personal consumption by employees while in the workplace (e.g., first aid supplies);

**(b)(6)(viii)**

Cosmetics which are packaged for sale to consumers in a retail establishment, and cosmetics intended for personal consumption by employees while in the workplace;

**(b)(6)(ix)**

Any consumer product or hazardous substance, as those terms are defined in the Consumer Product Safety Act (15 U.S.C. 2051 et seq.) and Federal Hazardous Substances Act (15 U.S.C. 1261 et seq.) respectively, where the employer can show that it is used in the workplace for the purpose intended by the chemical manufacturer or importer of the product, and the use results in a duration and frequency of exposure which is not greater than the range of exposures that could reasonably be experienced by consumers when used for the purpose intended;

**(b)(6)(x)**

Nuisance particulates where the chemical manufacturer or importer can establish that they do not pose any physical or health hazard covered under this section;

**(b)(6)(xi)**

Ionizing and nonionizing radiation; and,

**(b)(6)(xii)**

Biological hazards.

**I**

"Definitions."

"Article" means a manufactured item other than a fluid or particle: (i) which is formed to a specific shape or design during manufacture; (ii) which has end use function(s) dependent in whole or in part upon its shape or design during end use; and (iii) which under normal conditions of use does not release more than very small quantities, e.g., minute or trace amounts of a hazardous chemical (as determined under paragraph (d) of this section), and does not pose a physical hazard or health risk to employees.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee. "Chemical" means any element, chemical compound or mixture of elements and/or compounds.

"Chemical manufacturer" means an employer with a workplace where chemical(s) are produced for use or distribution.

"Chemical name" means the scientific designation of a chemical in accordance with the nomenclature system developed by the International Union of Pure and Applied Chemistry (IUPAC) or the Chemical Abstracts Service (CAS) rules of nomenclature, or a name which will clearly identify the chemical for the purpose of conducting a hazard evaluation.

"Combustible liquid" means any liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except any mixture having components with flashpoints of 200 deg. F (93.3 deg. C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Commercial account" means an arrangement whereby a retail distributor sells hazardous chemicals to an employer, generally in large quantities over time and/or at costs that are below the regular retail price.

"Common name" means any designation or identification such as code name, code number, trade name, brand name or generic name used to identify a chemical other than by its chemical name.

"Compressed gas" means:

j A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg. C) regardless of the pressure at 70 deg. F (21.1 deg. C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 deg. C) as determined by ASTM D-323-72.

"Container" means any bag, barrel, bottle, box, can, cylinder, drum, reaction vessel, storage tank, or the like that contains a hazardous chemical. For purposes of this section, pipes or piping systems, and engines, fuel tanks, or other operating systems in a vehicle, are not considered to be containers.

"Designated representative" means any individual or organization to whom an employee gives written authorization to exercise such employee's rights under this section. A recognized or certified collective bargaining agent shall be treated automatically as a designated representative without regard to written employee authorization.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

"Distributor" means a business, other than a chemical manufacturer or importer, which supplies hazardous chemicals to other distributors or to employers.

"Employee" means a worker who may be exposed to hazardous chemicals under normal operating conditions or in foreseeable emergencies. Workers such as office workers or bank tellers who encounter hazardous chemicals only in non-routine, isolated instances are not covered.

"Employer" means a person engaged in a business where chemicals are either used, distributed, or are produced for use or distribution, including a contractor or subcontractor.

"Explosive" means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"Exposure or exposed" means that an employee is subjected in the course of employment to a chemical that is a physical or health hazard, and includes potential (e.g. accidental or possible) exposure. "Subjected" in terms of health hazards includes any route of entry (e.g. inhalation, ingestion, skin contact or absorption.)

"Flammable" means a chemical that falls into one of the following categories:

**j** "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) "Gas, flammable" means: (A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of thirteen (13) percent by volume or less; or (B) A gas that, at ambient temperature and pressure, forms a

range of flammable mixtures with air wider than twelve (12) percent by volume, regardless of the lower limit;

(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 deg. F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. F (37.8 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) "Solid, flammable" means a solid, other than a blasting agent or explosive as defined in 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

j Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24-1979 (ASTM D 56-79)) for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7-1979 (ASTM D 93-79)) for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)). Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

"Foreseeable emergency" means any potential occurrence such as, but not limited to, equipment failure, rupture of containers, or failure of control equipment which could result in an uncontrolled release of a hazardous chemical into the workplace.

"Hazardous chemical" means any chemical which is a physical hazard or a health hazard.

"Hazard warning" means any words, pictures, symbols, or combination thereof appearing on a label or other appropriate form of warning which convey the specific physical and health hazard(s), including target organ effects, of the chemical(s) in the container(s). (See the definitions for "physical hazard" and "health hazard" to determine the hazards which must be covered.)

"Health hazard" 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. Appendix A provides further definitions and explanations of the scope of health hazards covered by this section, and Appendix B describes the criteria to be used to determine whether or not a chemical is to be considered hazardous for purposes of this standard.

"Identity" means any chemical or common name which is indicated on the material safety data sheet (MSDS) for the chemical. The identity used shall permit cross-references to be made among the required list of hazardous chemicals, the label and the MSDS.

"Immediate use" means that the hazardous chemical will be under the control of and used only by the person who transfers it from a labeled container and only within the work shift in which it is transferred.

"Importer" means the first business with employees within the Customs Territory of the United States which receives hazardous chemicals produced in other countries for the purpose of supplying them to distributors or employers within the United States.

"Label" means any written, printed, or graphic material displayed on or affixed to containers of hazardous chemicals.

"Material safety data sheet (MSDS)" means written or printed material concerning a hazardous chemical which is prepared in accordance with paragraph (g) of this section.

"Mixture" means any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.

"Organic peroxide" means an organic compound that contains the bivalent –O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"Physical hazard" 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.

"Produce" means to manufacture, process, formulate, blend, extract, generate, emit, or repackage.

"Pyrophoric" means a chemical that will ignite spontaneously in air at a temperature of 130 deg. F (54.4 deg. C) or below.

"Responsible party" means someone who can provide additional information on the hazardous chemical and appropriate emergency procedures, if necessary.

"Specific chemical identity" means the chemical name, Chemical Abstracts Service (CAS) Registry Number, or any other information that reveals the precise chemical designation of the substance.

"Trade secret" means any confidential formula, pattern, process, device, information or compilation of information that is used in an employer's business, and that gives the employer an opportunity to obtain an advantage over competitors who do not know or use it. Appendix D sets out the criteria to be used in evaluating trade secrets.

"Unstable (reactive)" means a chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

"Use" means to package, handle, react, emit, extract, generate as a byproduct, or transfer.

"Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

"Work area" means a room or defined space in a workplace where hazardous chemicals are produced or used, and where employees are present.

"Workplace" means an establishment, job site, or project, at one geographical location containing one or more work areas.

**(d)**

"Hazard determination."

**(d)(1)**

Chemical manufacturers and importers shall evaluate chemicals produced in their workplaces or imported by them to determine if they are hazardous. Employers are not required to evaluate chemicals unless they choose not to rely on the evaluation performed by the chemical manufacturer or importer for the chemical to satisfy this requirement.

**(d)(2)**

Chemical manufacturers, importers or employers evaluating chemicals shall identify and consider the available scientific evidence concerning such hazards. For health hazards, evidence which is statistically significant and which is based on at least one positive study conducted in accordance with established scientific principles is considered to be sufficient to establish a hazardous effect if the results of the study meet the definitions of health hazards in this section. Appendix A shall be consulted for the scope of health hazards covered, and Appendix B shall be consulted for the criteria to be followed with respect to the completeness of the evaluation, and the data to be reported.

**(d)(3)**

The chemical manufacturer, importer or employer evaluating chemicals shall treat the following sources as establishing that the chemicals listed in them are hazardous:

**(d)(3)(i)**

29 CFR part 1910, subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA); or,

**(d)(3)(ii)**

"Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment," American Conference of Governmental Industrial Hygienists (ACGIH) (latest edition). The chemical manufacturer, importer, or employer is still responsible for evaluating the hazards associated with the chemicals in these source lists in accordance with the requirements of this standard.

**(d)(4)**

Chemical manufacturers, importers and employers evaluating chemicals shall treat the following sources as establishing that a chemical is a carcinogen or potential carcinogen for hazard communication purposes:

**(d)(4)(i)**

National Toxicology Program (NTP), "Annual Report on Carcinogens" (latest edition);

**(d)(4)(ii)**

International Agency for Research on Cancer (IARC) "Monographs" (latest editions); or

**(d)(4)(iii)**

29 CFR part 1910, subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration.

Note: The "Registry of Toxic Effects of Chemical Substances" published by the National Institute for Occupational Safety and Health indicates whether a chemical has been found by NTP or IARC to be a potential carcinogen.

**(d)(5)**

The chemical manufacturer, importer or employer shall determine the hazards of mixtures of chemicals as follows:

**(d)(5)(i)**

If a mixture has been tested as a whole to determine its hazards, the results of such testing shall be used to determine whether the mixture is hazardous;

**(d)(5)(ii)**

If a mixture has not been tested as a whole to determine whether the mixture is a health hazard, the mixture shall be assumed to present the same health hazards as do the components which comprise one percent (by weight or volume) or greater of the mixture, except that the mixture shall be assumed to present a carcinogenic hazard if it contains a component in concentrations of 0.1 percent or greater which is considered to be a carcinogen under paragraph (d)(4) of this section;

**(d)(5)(iii)**

If a mixture has not been tested as a whole to determine whether the mixture is a physical hazard, the chemical manufacturer, importer, or employer may use whatever scientifically valid data is available to evaluate the physical hazard potential of the mixture; and,

**(d)(5)(iv)**

If the chemical manufacturer, importer, or employer has evidence to indicate that a component present in the mixture in concentrations of less than one percent (or in the case of carcinogens, less than 0.1 percent) could be released in concentrations which would exceed an established OSHA permissible exposure limit or ACGIH Threshold Limit Value, or could present a health risk to employees in those concentrations, the mixture shall be assumed to present the same hazard.

**(d)(6)**

Chemical manufacturers, importers, or employers evaluating chemicals shall describe in writing the procedures they use to determine the hazards of the

chemical they evaluate. The written procedures are to be made available, upon request, to employees, their designated representatives, the Assistant Secretary and the Director. The written description may be incorporated into the written hazard communication program required under paragraph (e) of this section.

**(e)**

"Written hazard communication program."

**(e)(1)**

Employers shall develop, implement, and maintain at each workplace, a written hazard communication program which at least describes how the criteria specified in paragraphs (f), (g), and (h) of this section for labels and other forms of warning, material safety data sheets, and employee information and training will be met, and which also includes the following:

**(e)(1)(i)**

A list of the hazardous chemicals known to be present using an identity that is referenced on the appropriate material safety data sheet (the list may be compiled for the workplace as a whole or for individual work areas); and,

**(e)(1)(ii)**

The methods the employer will use to inform employees of the hazards of non-routine tasks (for example, the cleaning of reactor vessels), and the hazards associated with chemicals contained in unlabeled pipes in their work areas.

**(e)(2)**

"Multi-employer workplaces." Employers who produce, use, or store hazardous chemicals at a workplace in such a way that the employees of other employer(s) may be exposed (for example, employees of a construction contractor working on-site) shall additionally ensure that the hazard communication programs developed and implemented under this paragraph (e) include the following:

**(e)(2)(i)**

The methods the employer will use to provide the other employer(s) on-site access to material safety data sheets for each hazardous chemical the other employer(s)' employees may be exposed to while working;

**(e)(2)(ii)**

The methods the employer will use to inform the other employer(s) of any precautionary measures that need to be taken to protect employees during the workplace's normal operating conditions and in foreseeable emergencies; and,

**(e)(2)(iii)**

The methods the employer will use to inform the other employer(s) of the labeling system used in the workplace.

**(e)(3)**

The employer may rely on an existing hazard communication program to comply with these requirements, provided that it meets the criteria established in this paragraph (e).

**(e)(4)**

The employer shall make the written hazard communication program available, upon request, to employees, their designated representatives, the Assistant Secretary and the Director, in accordance with the requirements of 29 CFR 1910.1020 (e).

**(e)(5)**

Where employees must travel between workplaces during a workshift, i.e., their work is carried out at more than one geographical location, the written hazard communication program may be kept at the primary workplace facility.

**(f)**

"Labels and other forms of warning."

**(f)(1)**

The chemical manufacturer, importer, or distributor shall ensure that each container of hazardous chemicals leaving the workplace is labeled, 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 labeled 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 labeling.

**(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.

**(g)**

"Material safety data sheets."

**(g)(1)**

Chemical manufacturers and importers shall obtain or develop a material safety data sheet for each hazardous chemical they produce or import. Employers shall have a material safety data sheet in the workplace for each hazardous chemical which they use.

**(g)(2)**

Each material safety data sheet shall be in English (although the employer may maintain copies in other languages as well), and shall contain at least the following information:

**(g)(2)(i)**

The identity used on the label, and, except as provided for in paragraph (i) of this section on trade secrets:

**(g)(2)(i)(A)**

If the hazardous chemical is a single substance, its chemical and common name(s);

**(g)(2)(i)(B)**

If the hazardous chemical is a mixture which has been tested as a whole to determine its hazards, the chemical and common name(s) of the ingredients which contribute to these known hazards, and the common name(s) of the mixture itself; or,

**(g)(2)(i)I**

If the hazardous chemical is a mixture which has not been tested as a whole:

**(g)(2)(i)I(1)**

The chemical and common name(s) of all ingredients which have been determined to be health hazards, and which comprise 1% or greater of the composition, except that chemicals identified as carcinogens under paragraph (d) of this section shall be listed if the concentrations are 0.1% or greater; and,

**(g)(2)(i)I(2)**

The chemical and common name(s) of all ingredients which have been determined to be health hazards, and which comprise less than 1% (0.1% for carcinogens) of the mixture, if there is evidence that the ingredient(s) could be released from the mixture in concentrations which would exceed an established OSHA permissible exposure limit or ACGIH Threshold Limit Value, or could present a health risk to employees; and,

**(g)(2)(i)I(3)**

The chemical and common name(s) of all ingredients which have been determined to present a physical hazard when present in the mixture;

**(g)(2)(ii)**

Physical and chemical characteristics of the hazardous chemical (such as vapor pressure, flash point);

**(g)(2)(iii)**

The physical hazards of the hazardous chemical, including the potential for fire, explosion, and reactivity;

**(g)(2)(iv)**

The health hazards of the hazardous chemical, including signs and symptoms of exposure, and any medical conditions which are generally recognized as being aggravated by exposure to the chemical;

**(g)(2)(v)**

The primary route(s) of entry;

**(g)(2)(vi)**

The OSHA permissible exposure limit, ACGIH Threshold Limit Value, and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the material safety data sheet, where available;

**(g)(2)(vii)**

Whether the hazardous chemical is listed in the National Toxicology Program (NTP) Annual Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest editions), or by OSHA;

**(g)(2)(viii)**

Any generally applicable precautions for safe handling and use which are known to the chemical manufacturer, importer or employer preparing the material safety data sheet, including appropriate hygienic practices, protective measures during repair and maintenance of contaminated equipment, and procedures for clean-up of spills and leaks;

**(g)(2)(ix)**

Any generally applicable control measures which are known to the chemical manufacturer, importer or employer preparing the material safety data sheet, such as appropriate engineering controls, work practices, or personal protective equipment;

**(g)(2)(x)**

Emergency and first aid procedures;

**(g)(2)(xi)**

The date of preparation of the material safety data sheet or the last change to it; and,

**(g)(2)(xii)**

The name, address and telephone number of the chemical manufacturer, importer, employer or other responsible party preparing or distributing the material safety

data sheet, who can provide additional information on the hazardous chemical and appropriate emergency procedures, if necessary.

**(g)(3)**

If no relevant information is found for any given category on the material safety data sheet, the chemical manufacturer, importer or employer preparing the material safety data sheet shall mark it to indicate that no applicable information was found.

**(g)(4)**

Where complex mixtures have similar hazards and contents (i.e. the chemical ingredients are essentially the same, but the specific composition varies from mixture to mixture), the chemical manufacturer, importer or employer may prepare one material safety data sheet to apply to all of these similar mixtures.

**(g)(5)**

The chemical manufacturer, importer or employer preparing the material safety data sheet shall ensure that the information recorded accurately reflects the scientific evidence used in making the hazard determination. If the chemical manufacturer, importer or employer preparing the material safety data sheet becomes newly aware of any significant information regarding the hazards of a chemical, or ways to protect against the hazards, this new information shall be added to the material safety data sheet within three months. If the chemical is not currently being produced or imported the chemical manufacturer or importer shall add the information to the material safety data sheet before the chemical is introduced into the workplace again.

**(g)(6)**

**(g)(6)(i)**

Chemical manufacturers or importers shall ensure that distributors and employers are provided an appropriate material safety data sheet with their initial shipment, and with the first shipment after a material safety data sheet is updated;

**(g)(6)(ii)**

The chemical manufacturer or importer shall either provide material safety data sheets with the shipped containers or send them to the distributor or employer prior to or at the time of the shipment;

**(g)(6)(iii)**

If the material safety data sheet is not provided with a shipment that has been labeled as a hazardous chemical, the distributor or employer shall obtain one from the chemical manufacturer or importer as soon as possible; and,

**(g)(6)(iv)**

The chemical manufacturer or importer shall also provide distributors or employers with a material safety data sheet upon request.

**(g)(7)**

**(g)(7)(i)**
Distributors shall ensure that material safety data sheets, and updated information, are provided to other distributors and employers with their initial shipment and with the first shipment after a material safety data sheet is updated;

**(g)(7)(ii)**
The distributor shall either provide material safety data sheets with the shipped containers, or send them to the other distributor or employer prior to or at the time of the shipment;

**(g)(7)(iii)**
Retail distributors selling hazardous chemicals to employers having a commercial account shall provide a material safety data sheet to such employers upon request, and shall post a sign or otherwise inform them that a material safety data sheet is available;

**(g)(7)(iv)**
Wholesale distributors selling hazardous chemicals to employers over-the-counter may also provide material safety data sheets upon the request of the employer at the time of the over-the-counter purchase, and shall post a sign or otherwise inform such employers that a material safety data sheet is available;

**(g)(7)(v)**
If an employer without a commercial account purchases a hazardous chemical from a retail distributor not required to have material safety data sheets on file (i.e., the retail distributor does not have commercial accounts and does not use the materials), the retail distributor shall provide the employer, upon request, with the name, address, and telephone number of the chemical manufacturer, importer, or distributor from which a material safety data sheet can be obtained;

**(g)(7)(vi)**
Wholesale distributors shall also provide material safety data sheets to employers or other distributors upon request; and,

**(g)(7)(vii)**
Chemical manufacturers, importers, and distributors need not provide material safety data sheets to retail distributors that have informed them that the retail distributor does not sell the product to commercial accounts or open the sealed container to use it in their own workplaces.

**(g)(8)**

The employer shall maintain in the workplace copies of the required material safety data sheets for each hazardous chemical, and shall ensure that they are readily accessible during each work shift to employees when they are in their work area(s). (Electronic access, microfiche, and other alternatives to maintaining paper copies of the material safety data sheets are permitted as long as no barriers to immediate employee access in each workplace are created by such options.)

**(g)(9)**

Where employees must travel between workplaces during a workshift, i.e., their work is carried out at more than one geographical location, the material safety data sheets may be kept at the primary workplace facility. In this situation, the employer shall ensure that employees can immediately obtain the required information in an emergency.

**(g)(10)**

Material safety data sheets may be kept in any form, including operating procedures, and may be designed to cover groups of hazardous chemicals in a work area where it may be more appropriate to address the hazards of a process rather than individual hazardous chemicals. However, the employer shall ensure that in all cases the required information is provided for each hazardous chemical, and is readily accessible during each work shift to employees when they are in in their work area(s).

**(g)(11)**

Material safety data sheets shall also be made readily available, upon request, to designated representatives and to the Assistant Secretary, in accordance with the requirements of 29 CFR 1910.1020(e). The Director shall also be given access to material safety data sheets in the same manner.

**(h)**

"Employee information and training."

**(h)(1)**

Employers shall provide employees with effective information and training on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new physical or health hazard the employees have not previously been trained about is introduced into their work area. Information and training may be designed to cover categories of hazards (e.g., flammability, carcinogenicity) or specific chemicals. Chemical-specific information must always be available through labels and material safety data sheets.

**(h)(2)**

"Information." Employees shall be informed of:

**(h)(2)(i)**

The requirements of this section;

**(h)(2)(ii)**

Any operations in their work area where hazardous chemicals are present; and,

**(h)(2)(iii)**

The location and availability of the written hazard communication program, including the required list(s) of hazardous chemicals, and material safety data sheets required by this section.

**(h)(3)**

"Training." Employee training shall include at least:

**(h)(3)(i)**

Methods and observations that may be used to detect the presence or release of a hazardous chemical in the work area (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

**(h)(3)(ii)**

The physical and health hazards of the chemicals in the work area;

**(h)(3)(iii)**

The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used; and,

**(h)(3)(iv)**

The details of the hazard communication program developed by the employer, including an explanation of the labeling system and the material safety data sheet, and how employees can obtain and use the appropriate hazard information.

**(i)**

"Trade secrets."

**(i)(1)**

The chemical manufacturer, importer, or employer may withhold the specific chemical identity, including the chemical name and other specific identification of a hazardous chemical, from the material safety data sheet, provided that:

**(i)(1)(i)**

The claim that the information withheld is a trade secret can be supported;

**(i)(1)(ii)**

Information contained in the material safety data sheet concerning the properties and effects of the hazardous chemical is disclosed;

**(i)(1)(iii)**

The material safety data sheet indicates that the specific chemical identity is being withheld as a trade secret; and,

**(i)(1)(iv)**

The specific chemical identity is made available to health professionals, employees, and designated representatives in accordance with the applicable provisions of this paragraph.

**(i)(2)**

Where a treating physician or nurse determines that a medical emergency exists and the specific chemical identity of a hazardous chemical is necessary for emergency or first-aid treatment, the chemical manufacturer, importer, or employer shall immediately disclose the specific chemical identity of a trade secret chemical to that treating physician or nurse, regardless of the existence of a written statement of need or a confidentiality agreement. The chemical manufacturer, importer, or employer may require a written statement of need and confidentiality agreement, in accordance with the provisions of paragraphs (i)(3) and (4) of this section, as soon as circumstances permit.

**(i)(3)**

In non-emergency situations, a chemical manufacturer, importer, or employer shall, upon request, disclose a specific chemical identity, otherwise permitted to be withheld under paragraph (i)(1) of this section, to a health professional (i.e. physician, industrial hygienist, toxicologist, epidemiologist, or occupational health nurse) providing medical or other occupational health services to exposed employee(s), and to employees or designated representatives, if:

**(i)(3)(i)**

The request is in writing;

**(i)(3)(ii)**

The request describes with reasonable detail one or more of the following occupational health needs for the information:

**(i)(3)(ii)(A)**

To assess the hazards of the chemicals to which employees will be exposed;

**(i)(3)(ii)(B)**

To conduct or assess sampling of the workplace atmosphere to determine employee exposure levels;

**(i)(3)(ii)I**

To conduct pre-assignment or periodic medical surveillance of exposed employees;

**(i)(3)(ii)(D)**

To provide medical treatment to exposed employees;

**(i)(3)(ii)(E)**

To select or assess appropriate personal protective equipment for exposed employees;

**(i)(3)(ii)(F)**

To design or assess engineering controls or other protective measures for exposed employees; and,

**(i)(3)(ii)(G)**

To conduct studies to determine the health effects of exposure.

**(i)(3)(iii)**

The request explains in detail why the disclosure of the specific chemical identity is essential and that, in lieu thereof, the disclosure of the following information to the health professional, employee, or designated representative, would not satisfy the purposes described in paragraph (i)(3)(ii) of this section:

**(i)(3)(iii)(A)**

The properties and effects of the chemical;

**(i)(3)(iii)(B)**

Measures for controlling workers' exposure to the chemical;

**(i)(3)(iii)I**

Methods of monitoring and analyzing worker exposure to the chemical; and,

**(i)(3)(iii)(D)**

Methods of diagnosing and treating harmful exposures to the chemical;

**(i)(3)(iv)**

The request includes a description of the procedures to be used to maintain the confidentiality of the disclosed information; and,

**(i)(3)(v)**

The health professional, and the employer or contractor of the services of the health professional (i.e. downstream employer, labor organization, or individual employee), employee, or designated representative, agree in a written confidentiality agreement that the health professional, employee, or designated representative, will not use the trade secret information for any purpose other than

the health need(s) asserted and agree not to release the information under any circumstances other than to OSHA, as provided in paragraph (i)(6) of this section, except as authorized by the terms of the agreement or by the chemical manufacturer, importer, or employer.

**(i)(4)**

The confidentiality agreement authorized by paragraph (i)(3)(iv) of this section:

**(i)(4)(i)**

May restrict the use of the information to the health purposes indicated in the written statement of need;

**(i)(4)(ii)**

May provide for appropriate legal remedies in the event of a breach of the agreement, including stipulation of a reasonable pre-estimate of likely damages; and,

**(i)(4)(iii)**

May not include requirements for the posting of a penalty bond.

**(i)(5)**

Nothing in this standard is meant to preclude the parties from pursuing non-contractual remedies to the extent permitted by law.

**(i)(6)**

If the health professional, employee, or designated representative receiving the trade secret information decides that there is a need to disclose it to OSHA, the chemical manufacturer, importer, or employer who provided the information shall be informed by the health professional, employee, or designated representative prior to, or at the same time as, such disclosure.

**(i)(7)**

If the chemical manufacturer, importer, or employer denies a written request for disclosure of a specific chemical identity, the denial must:

**(i)(7)(i)**

Be provided to the health professional, employee, or designated representative, within thirty days of the request;

**(i)(7)(ii)**

Be in writing;

**(i)(7)(iii)**

Include evidence to support the claim that the specific chemical identity is a trade secret;

**(i)(7)(iv)**

State the specific reasons why the request is being denied; and,

**(i)(7)(v)**

Explain in detail how alternative information may satisfy the specific medical or occupational health need without revealing the specific chemical identity.

**(i)(8)**

The health professional, employee, or designated representative whose request for information is denied under paragraph (i)(3) of this section may refer the request and the written denial of the request to OSHA for consideration.

**(i)(9)**

When a health professional, employee, or designated representative refers the denial to OSHA under paragraph (i)(8) of this section, OSHA shall consider the evidence to determine if:

**(i)(9)(i)**

The chemical manufacturer, importer, or employer has supported the claim that the specific chemical identity is a trade secret;

**(i)(9)(ii)**

The health professional, employee, or designated representative has supported the claim that there is a medical or occupational health need for the information; and,

**(i)(9)(iii)**

The health professional, employee or designated representative has demonstrated adequate means to protect the confidentiality.

**(i)(10)**

**(i)(10)(i)**

If OSHA determines that the specific chemical identity requested under paragraph (i)(3) of this section is not a "bona fide" trade secret, or that it is a trade secret, but the requesting health professional, employee, or designated representative has a legitimate medical or occupational health need for the information, has executed a written confidentiality agreement, and has shown adequate means to protect the confidentiality of the information, the chemical manufacturer, importer, or employer will be subject to citation by OSHA.

**(i)(10)(ii)**

If a chemical manufacturer, importer, or employer demonstrates to OSHA that the execution of a confidentiality agreement would not provide sufficient protection against the potential harm from the unauthorized disclosure of a trade secret specific chemical identity, the Assistant Secretary may issue such orders or impose such additional limitations or conditions upon the disclosure of the

requested chemical information as may be appropriate to assure that the occupational health services are provided without an undue risk of harm to the chemical manufacturer, importer, or employer.

**(i)(11)**

If a citation for a failure to release specific chemical identity information is contested by the chemical manufacturer, importer, or employer, the matter will be adjudicated before the Occupational Safety and Health Review Commission in accordance with the Act's enforcement scheme and the applicable Commission rules of procedure. In accordance with the Commission rules, when a chemical manufacturer, importer, or employer continues to withhold the information during the contest, the Administrative Law Judge may review the citation and supporting documentation "in camera" or issue appropriate orders to protect the confidentiality of such matters.

**(i)(12)**

Notwithstanding the existence of a trade secret claim, a chemical manufacturer, importer, or employer shall, upon request, disclose to the Assistant Secretary any information which this section requires the chemical manufacturer, importer, or employer to make available. Where there is a trade secret claim, such claim shall be made no later than at the time the information is provided to the Assistant Secretary so that suitable determinations of trade secret status can be made and the necessary protections can be implemented.

**(i)(13)**

Nothing in this paragraph shall be construed as requiring the disclosure under any circumstances of process or percentage of mixture information which is a trade secret.

**(j)**

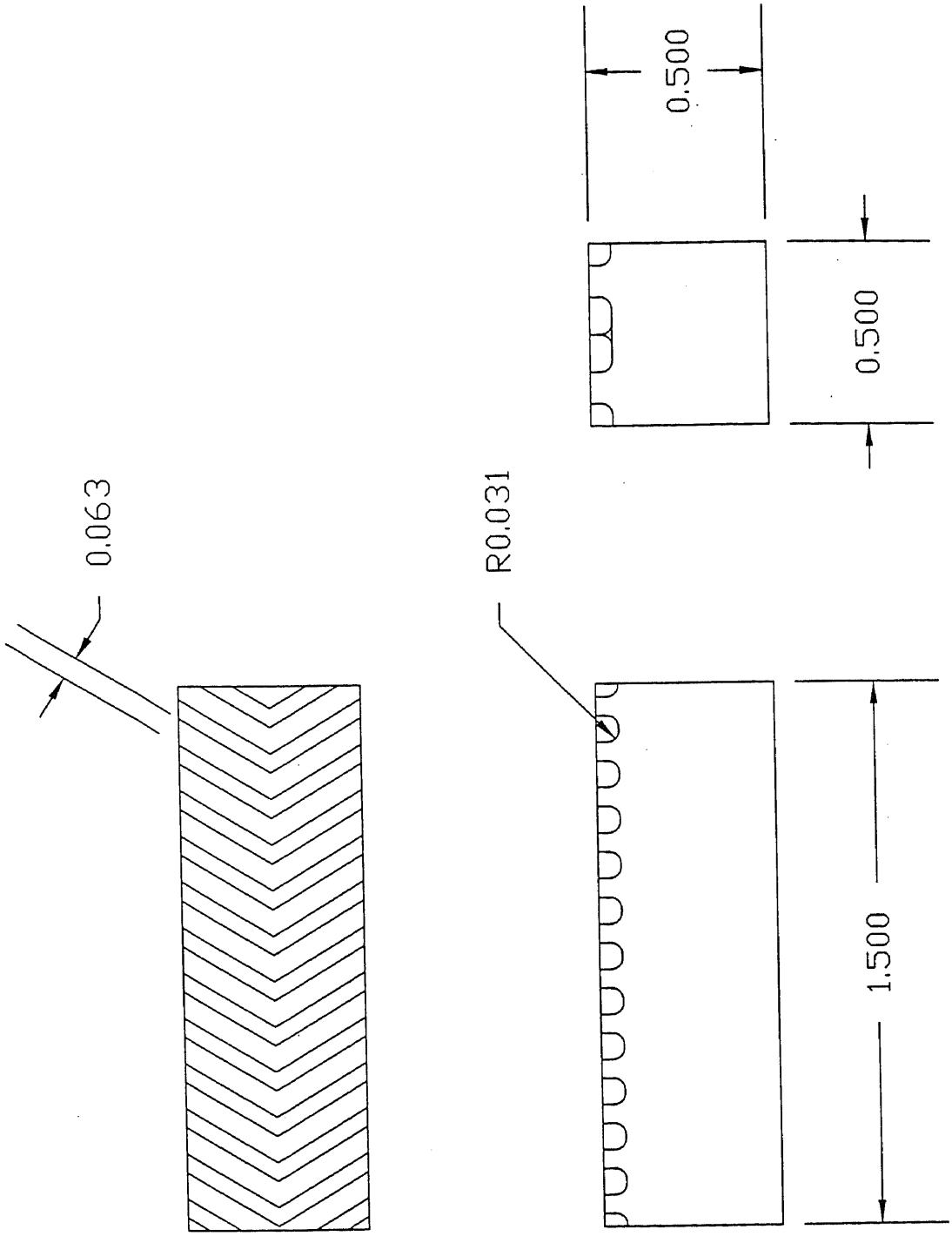
"Effective dates." Chemical manufacturers, importers, distributors, and employers shall be in compliance with all provisions of this section by March 11, 1994.

Note: The effective date of the clarification that the exemption of wood and wood products from the Hazard Communication standard in paragraph (b)(6)(iv) only applies to wood and wood products including lumber which will not be processed, where the manufacturer or importer can establish that the only hazard they pose to employees is the potential for flammability or combustibility, and that the exemption does not apply to wood or wood products which have been treated with a hazardous chemical covered by this standard, and wood which may be subsequently sawed or cut generating dust has been stayed from March 11, 1994 to August 11, 1994.

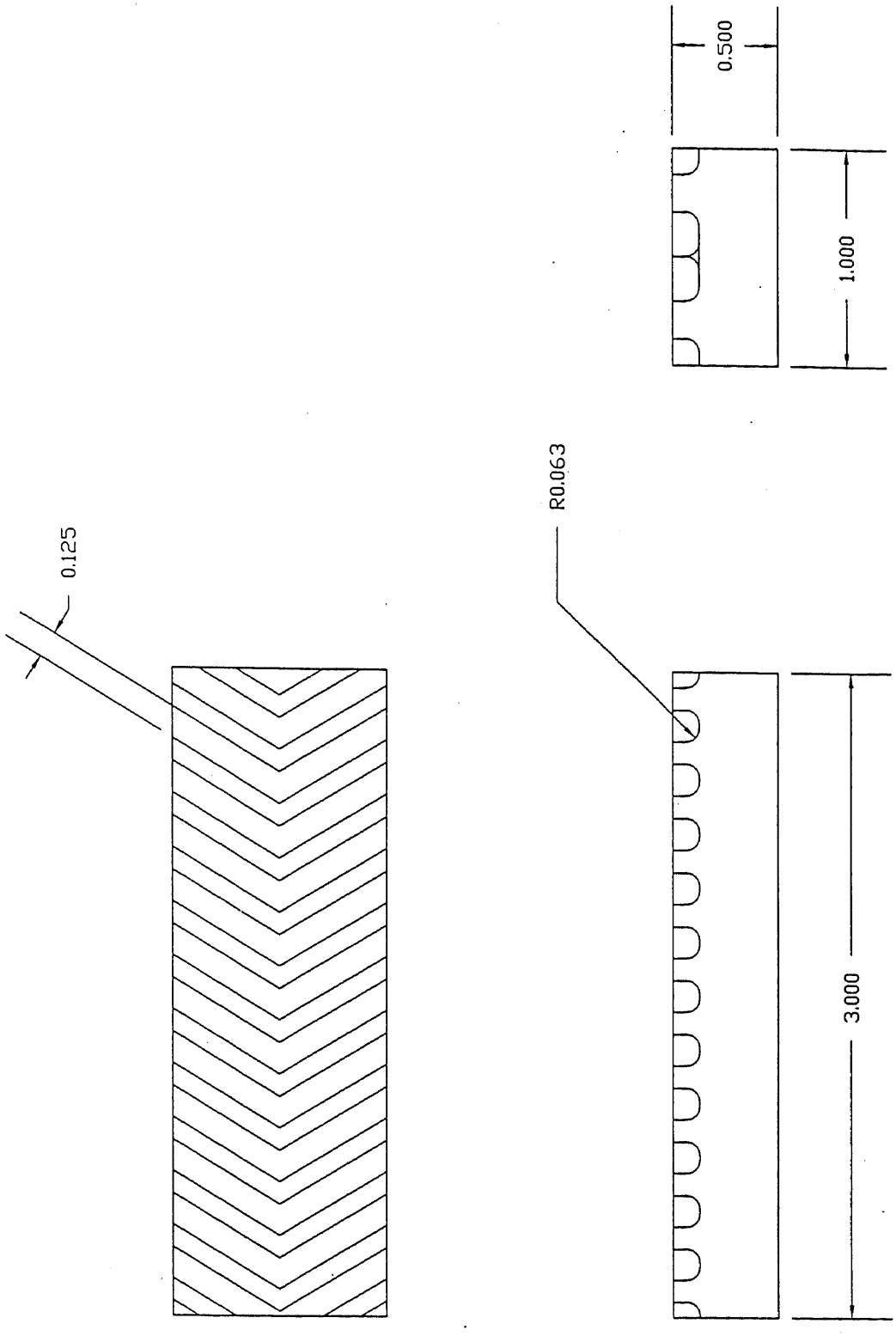
# APPENDIX C

## DRAWINGS FOR THE TACTILE PATTERNS AND NUMBERS

**Small Tactile Pattern P1**



## Large Tactile Pattern P1



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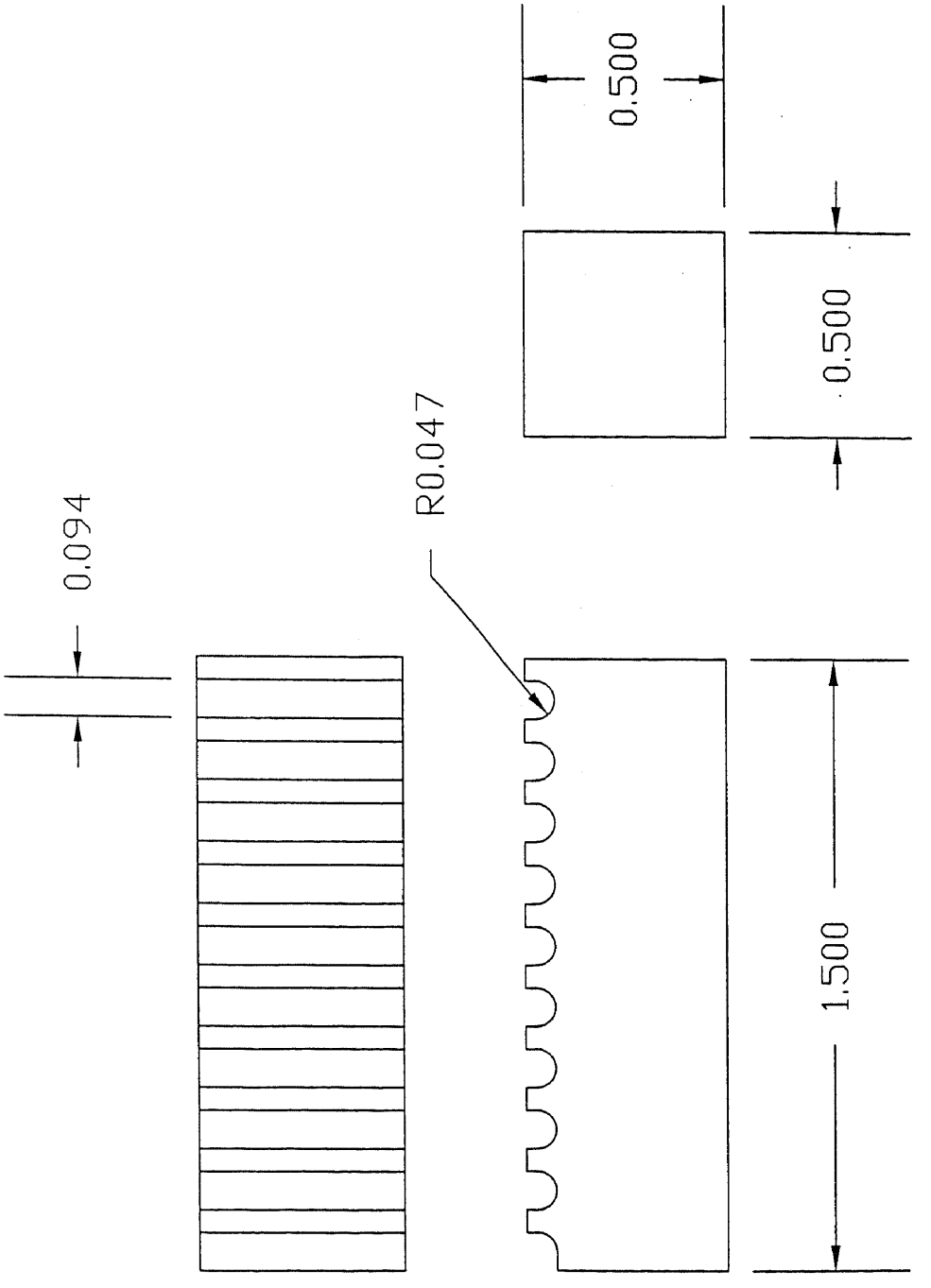

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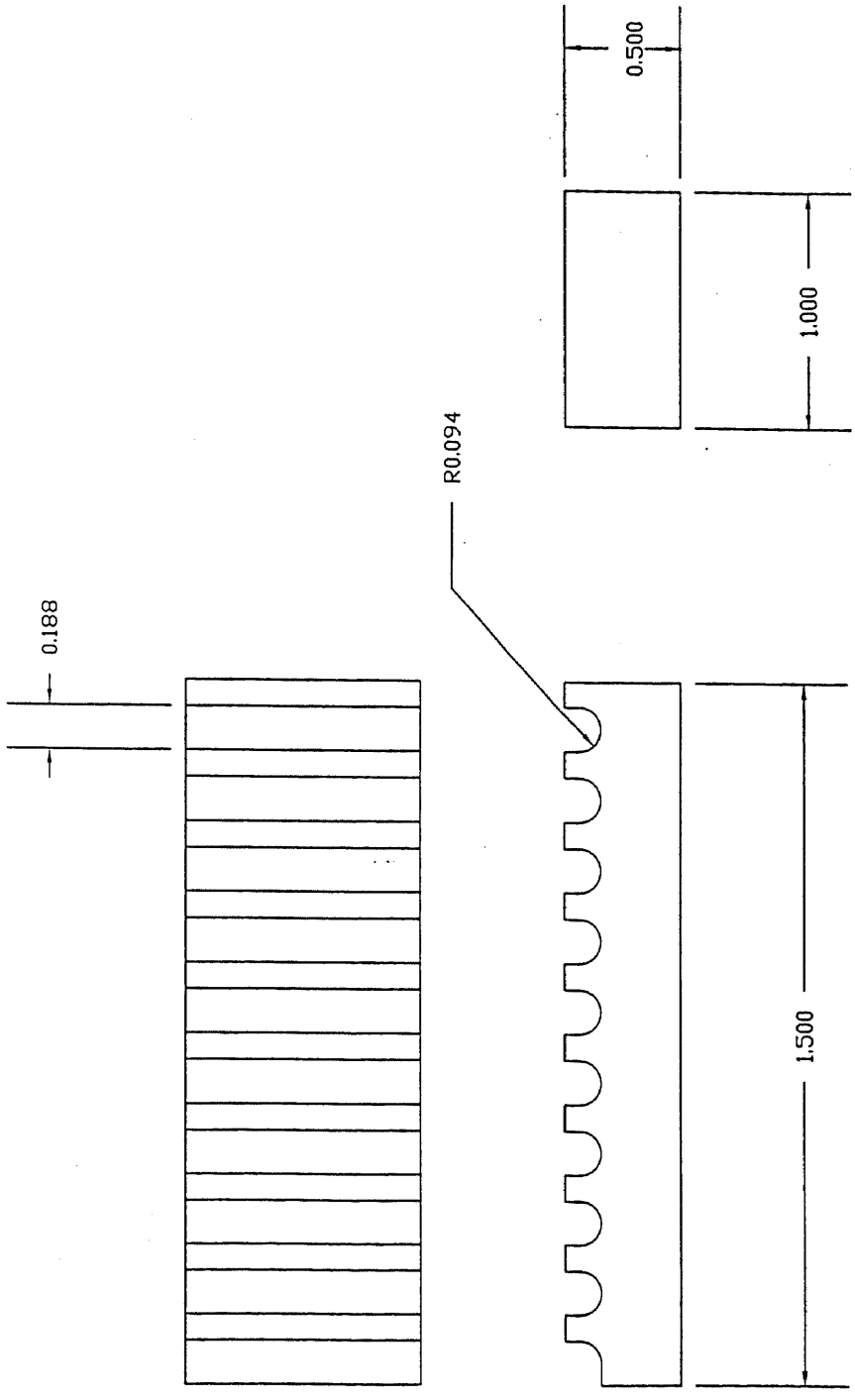

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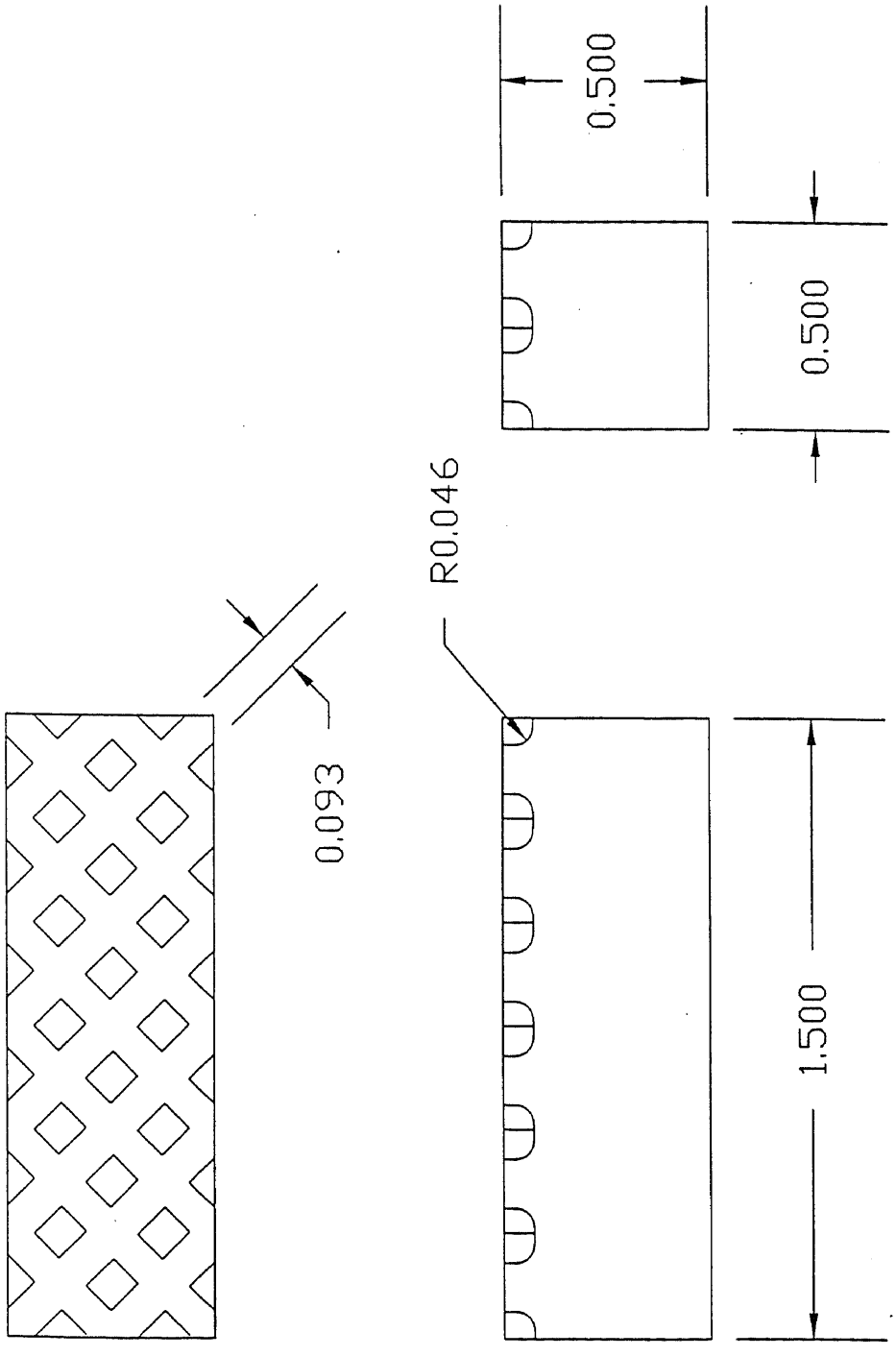

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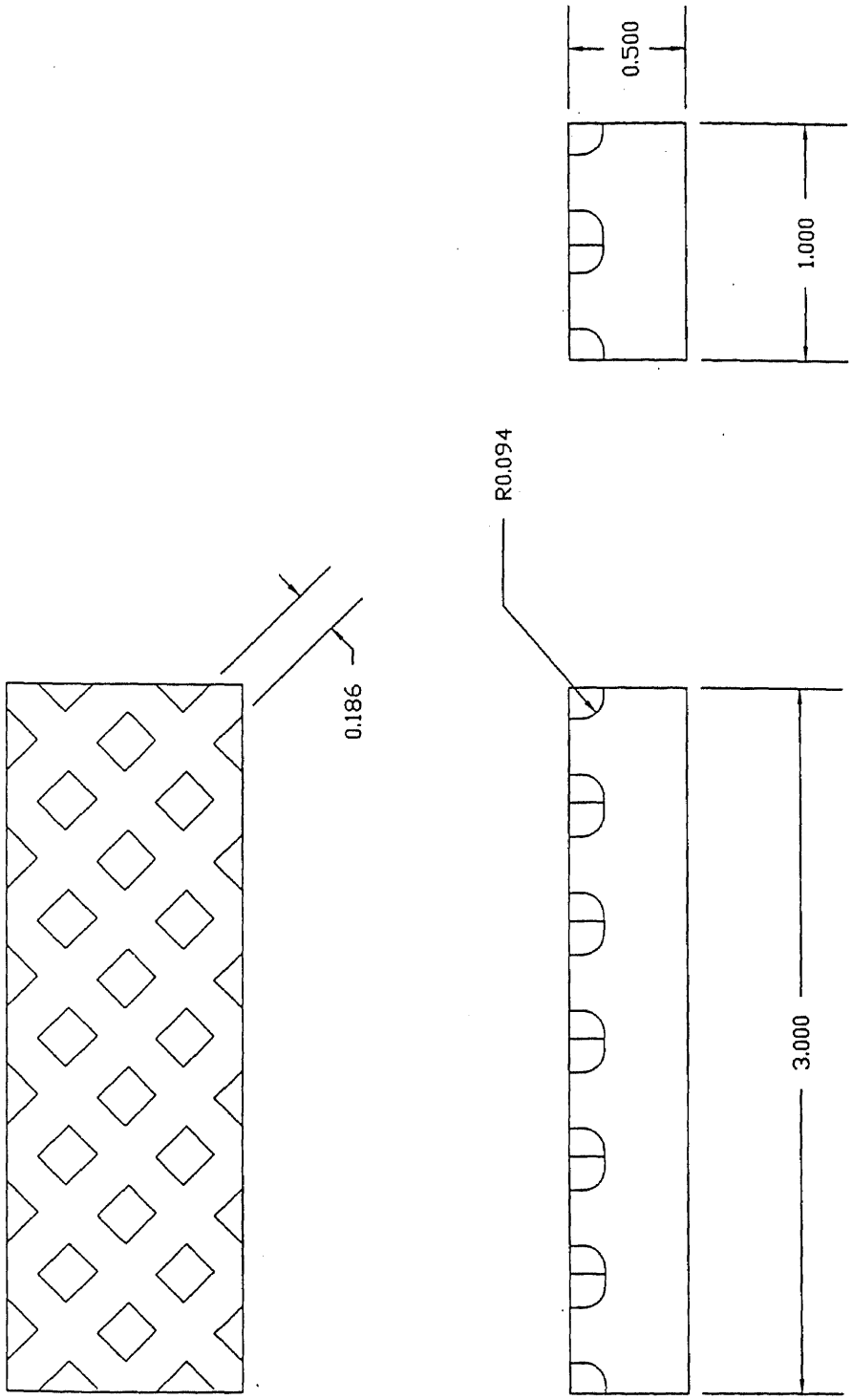

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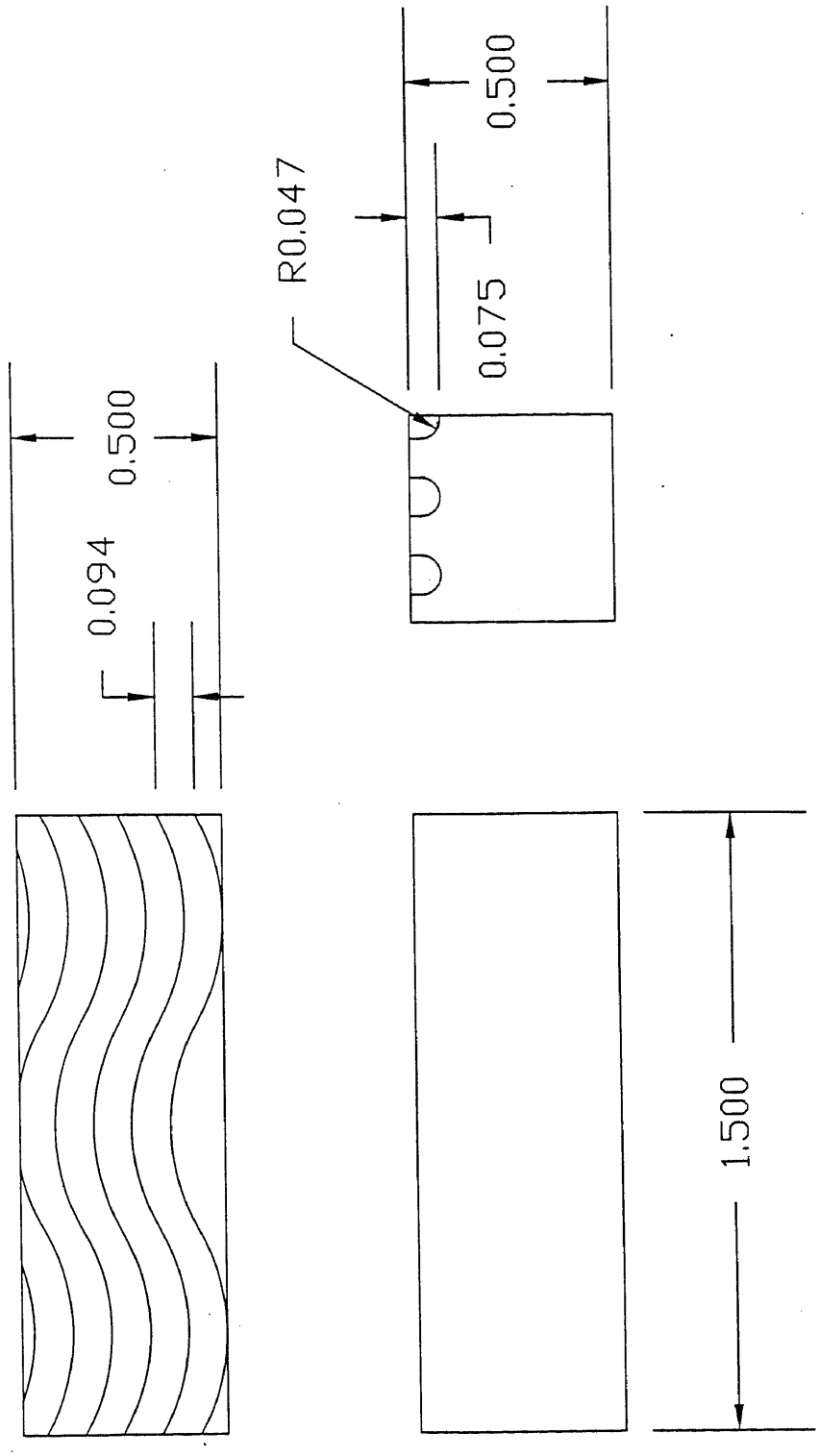

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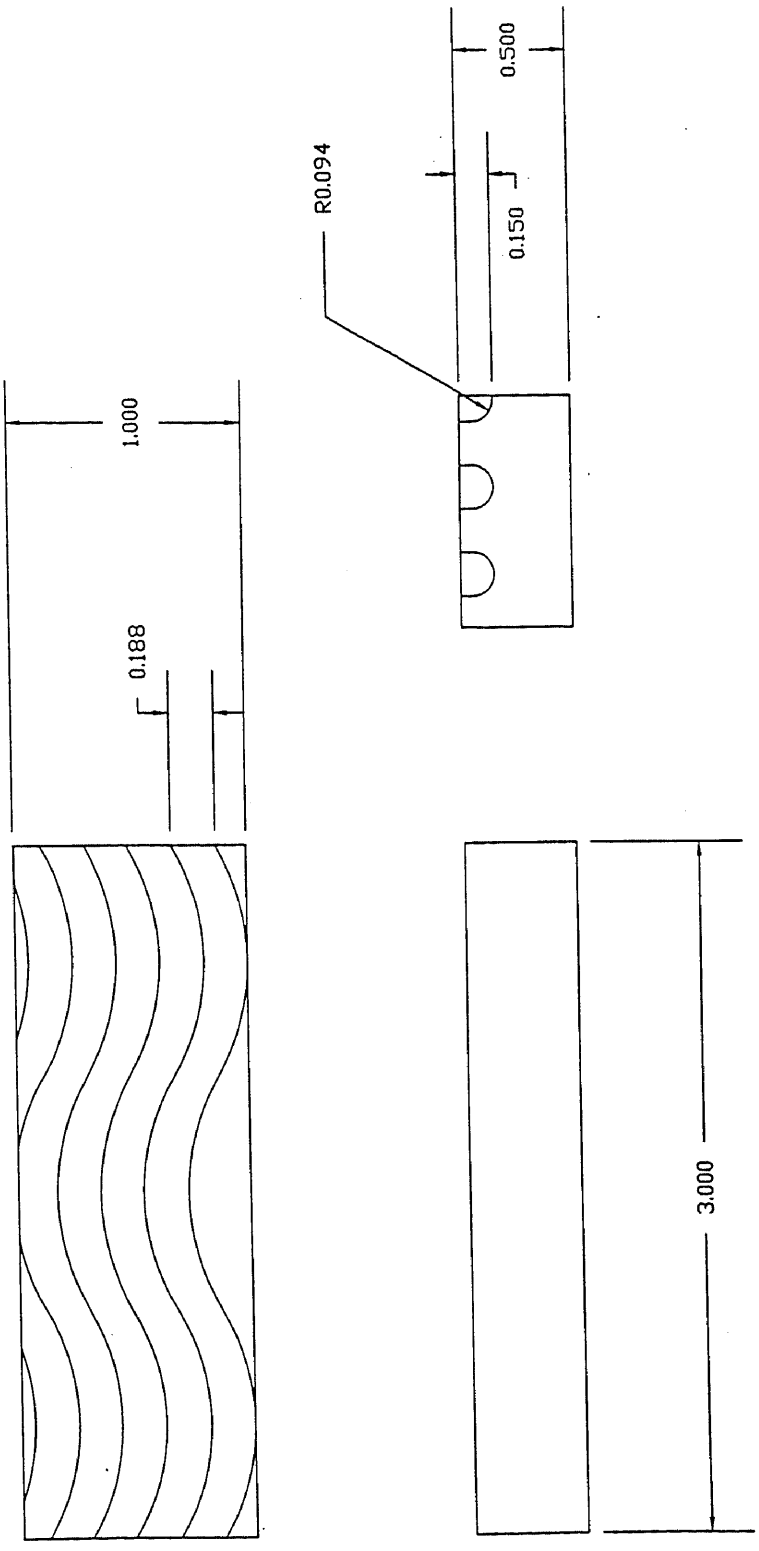

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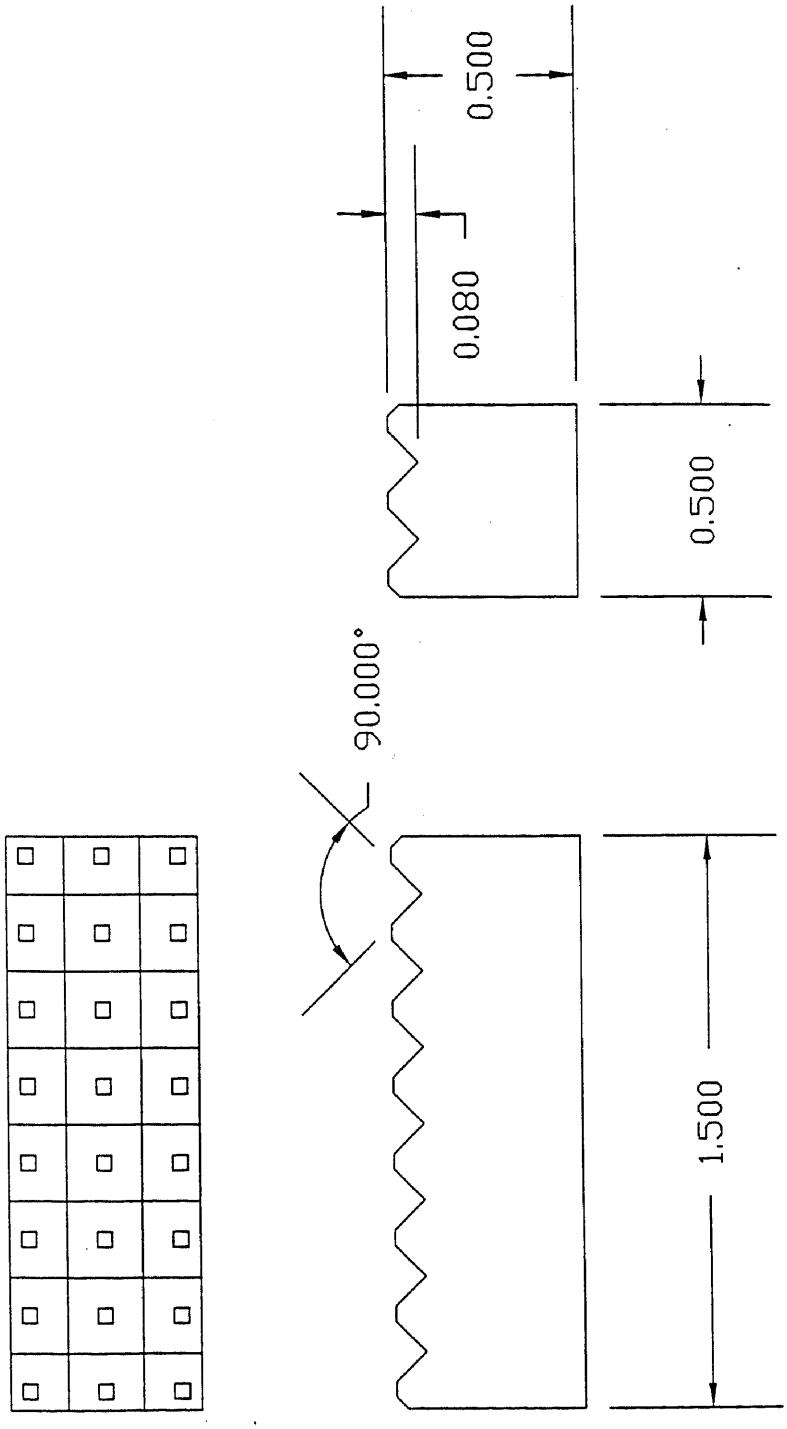

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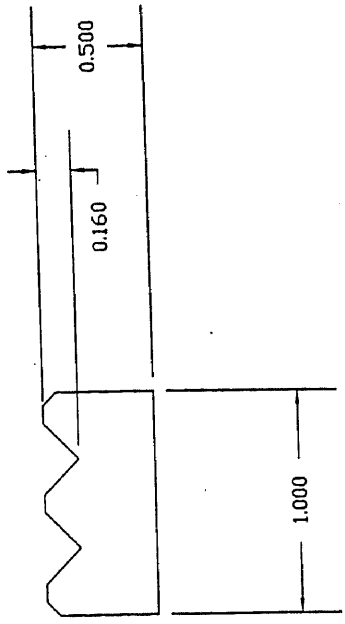


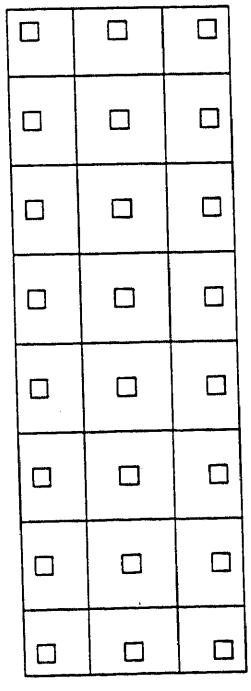

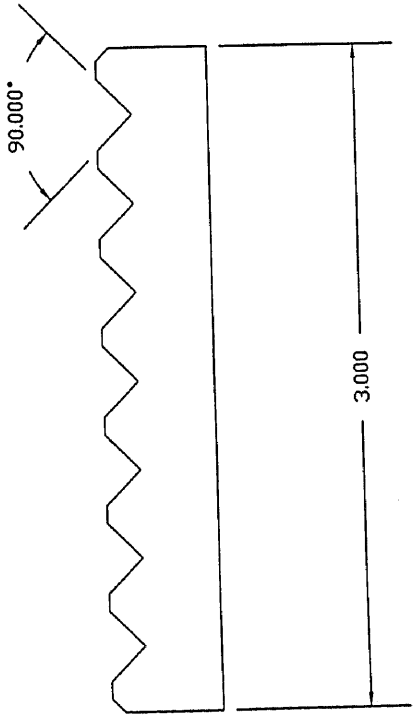

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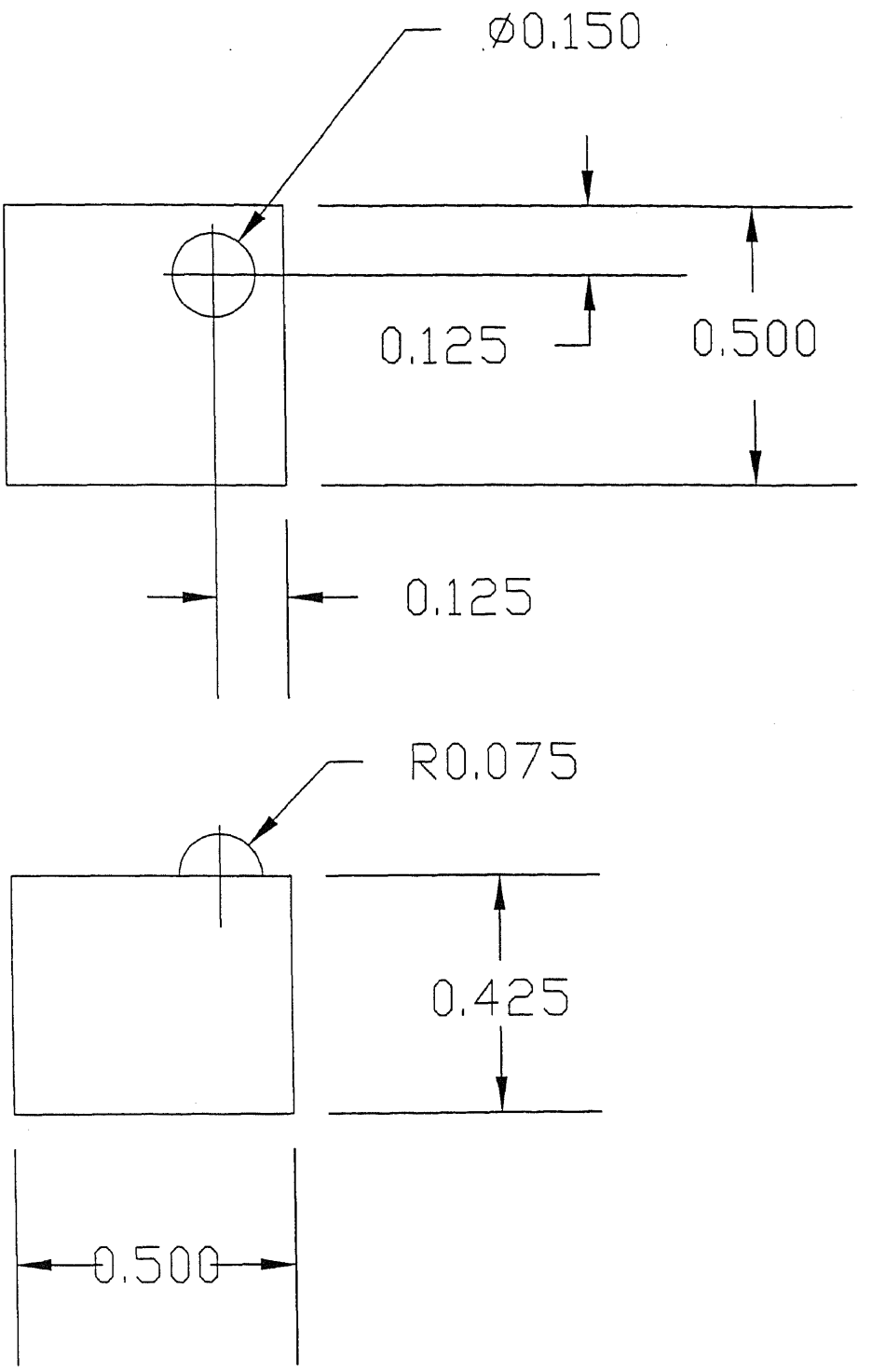

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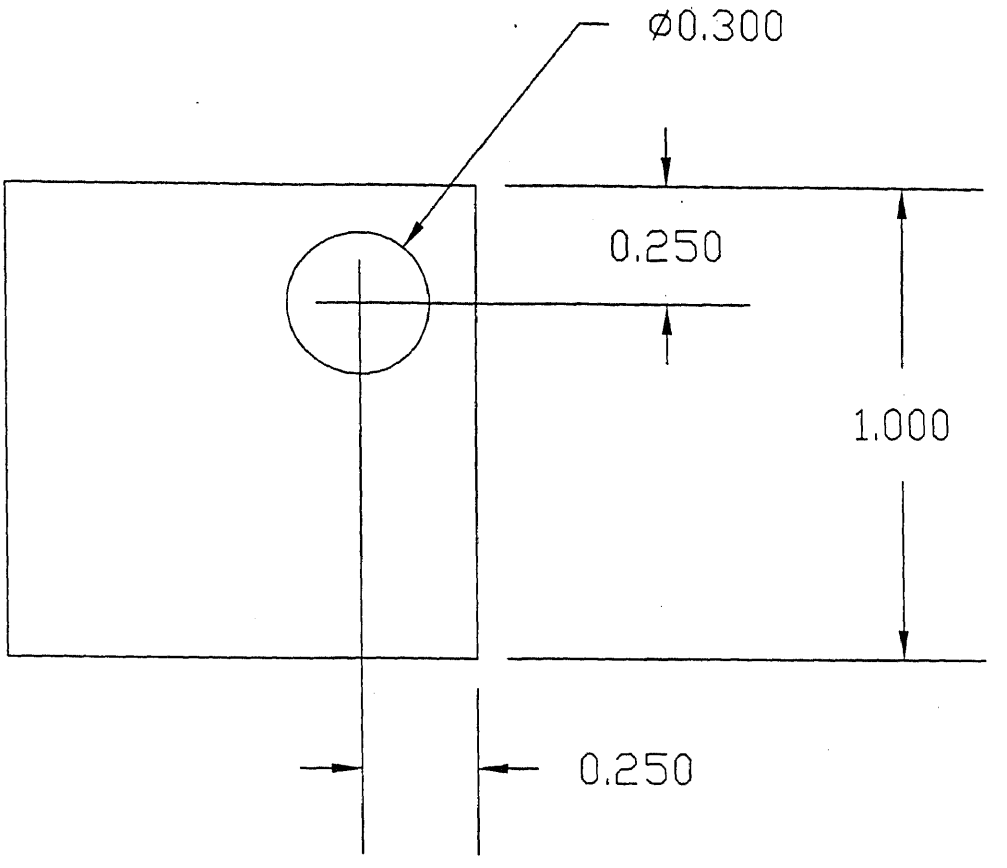


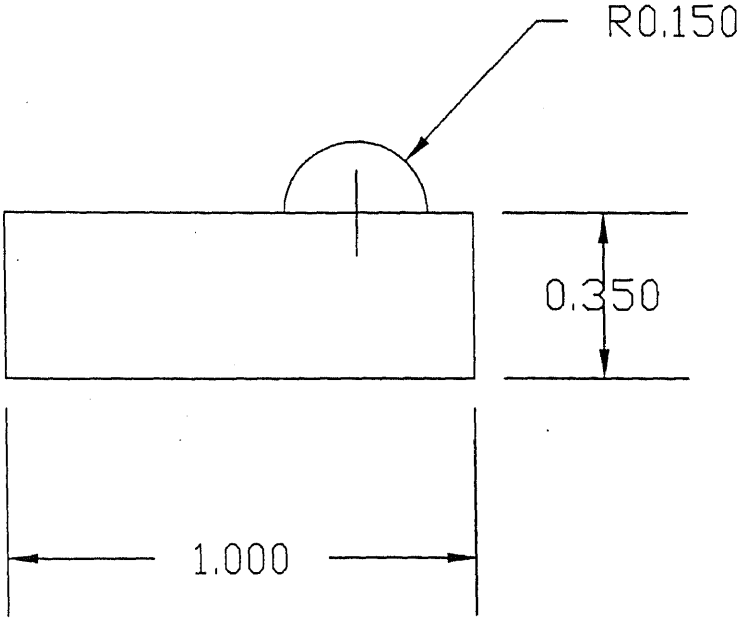

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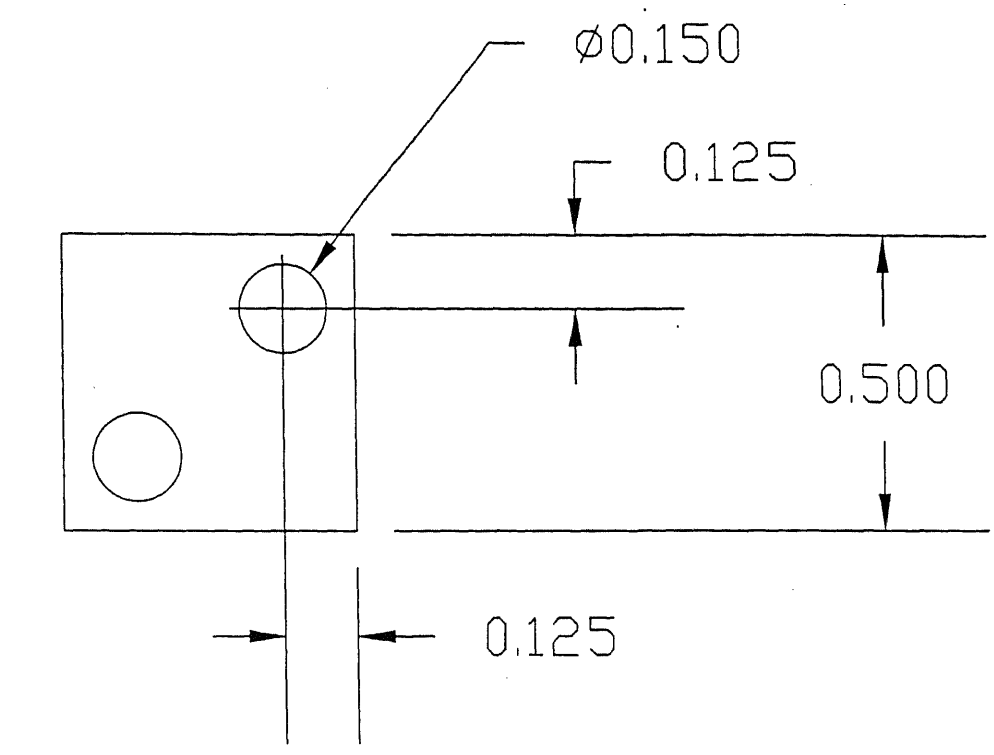


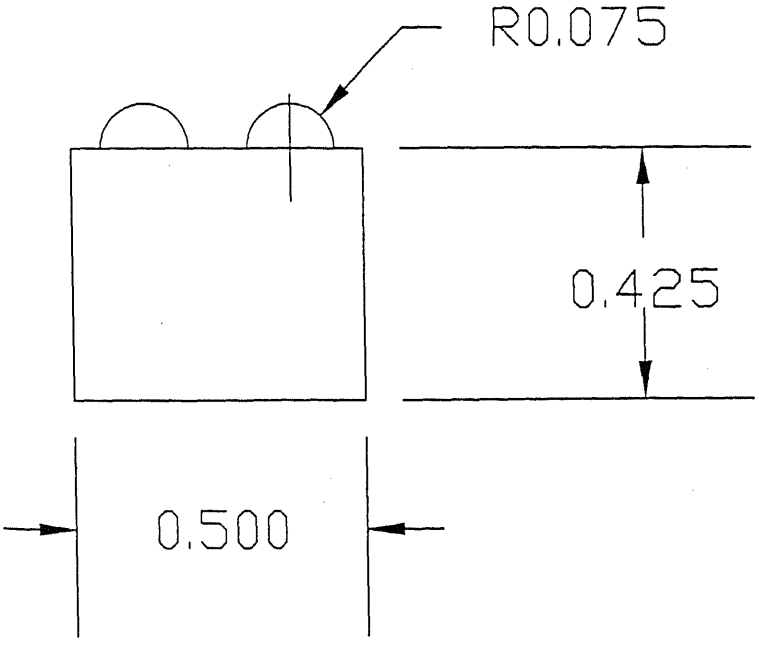

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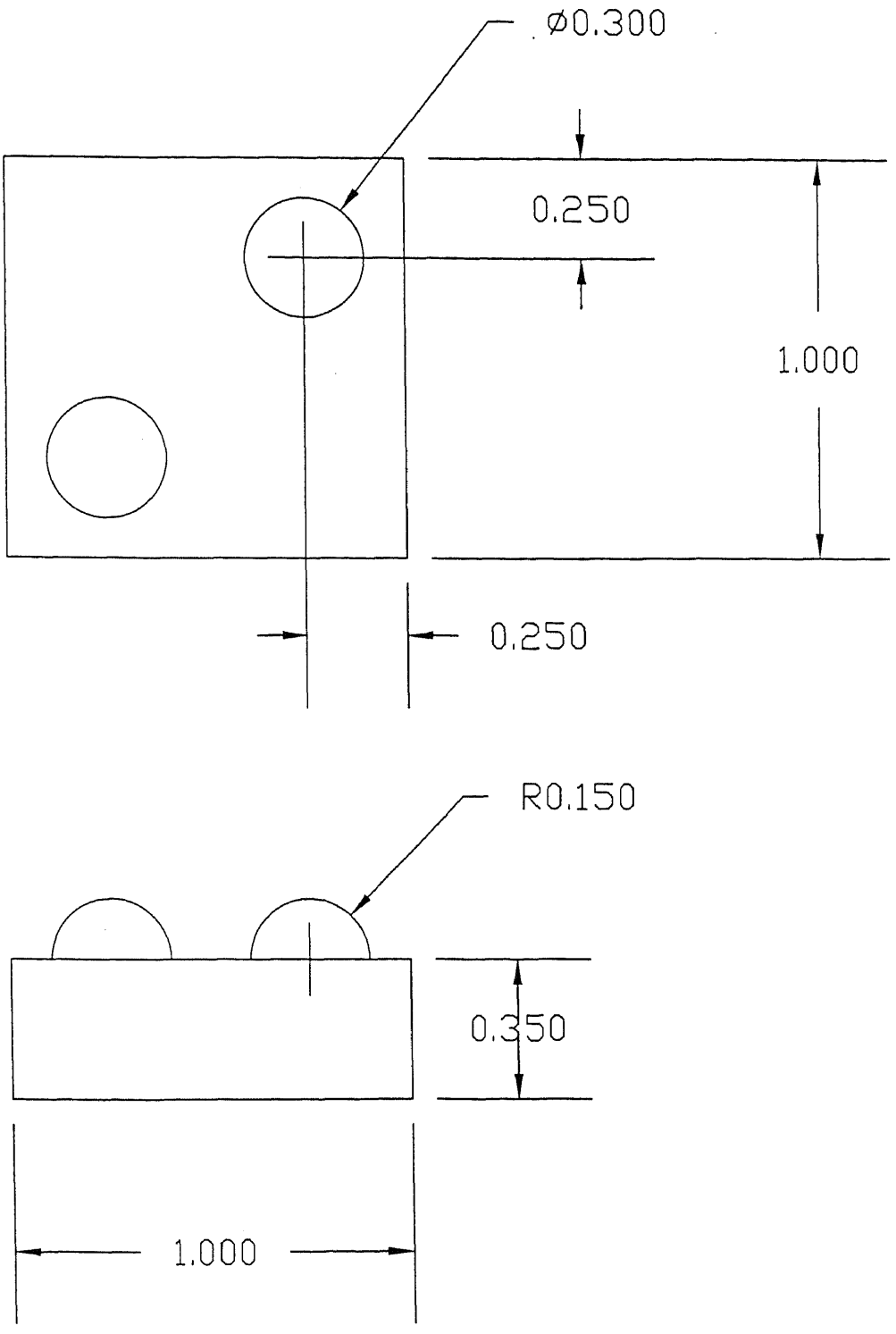

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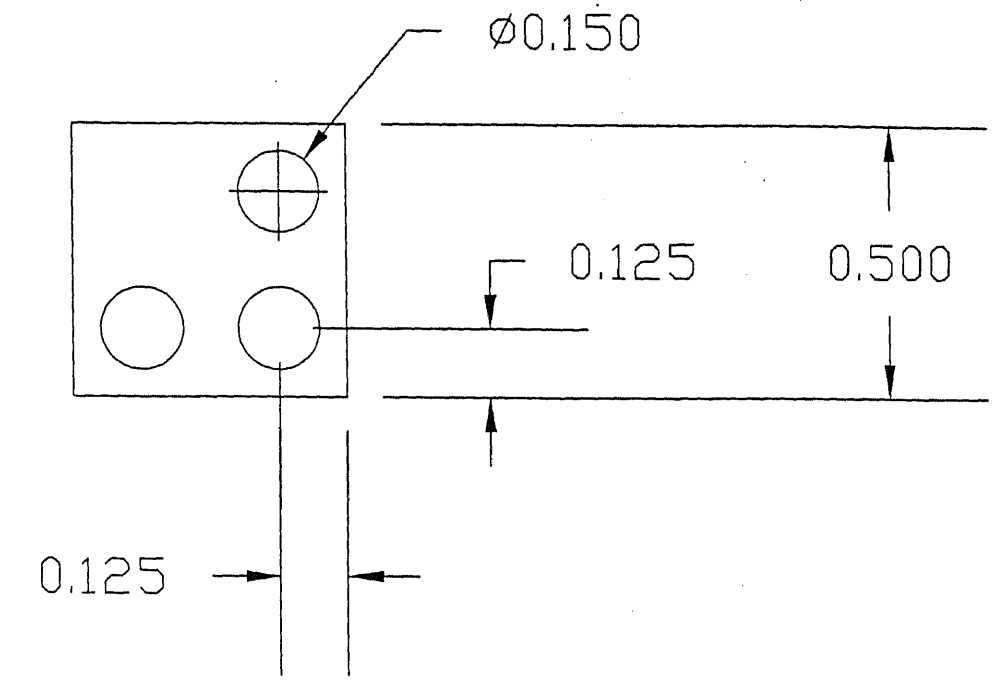


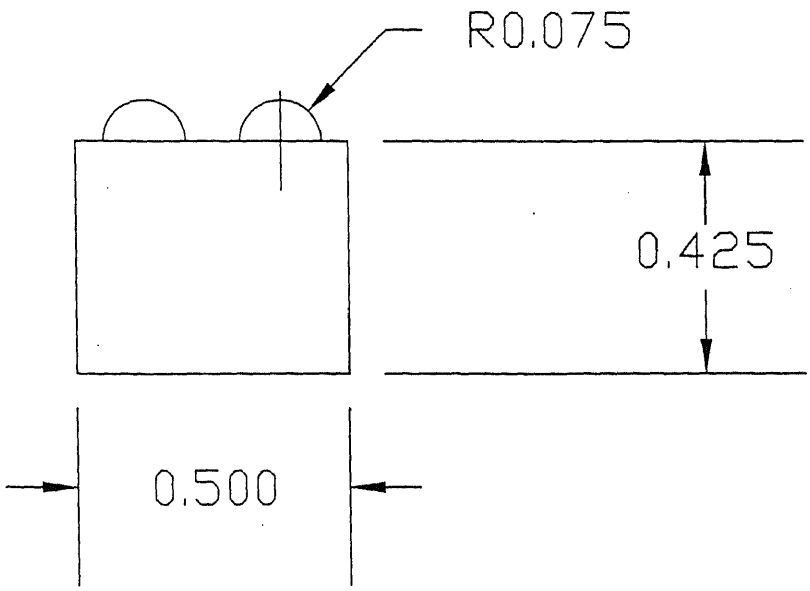

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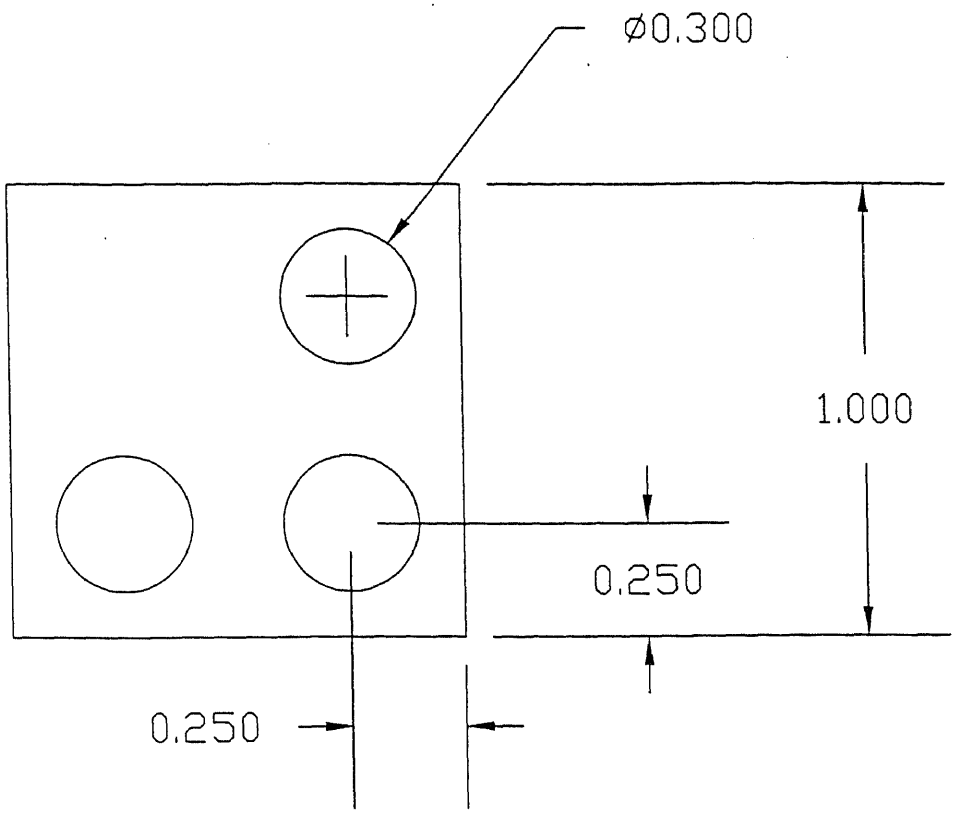


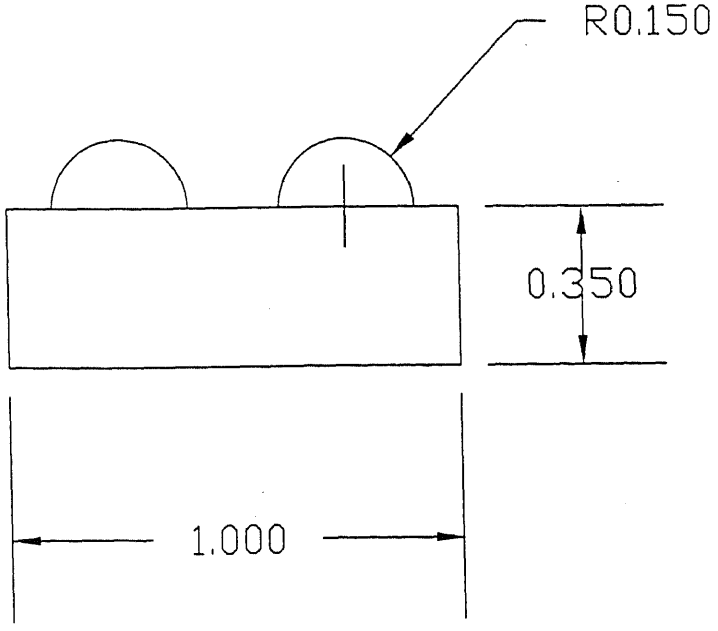

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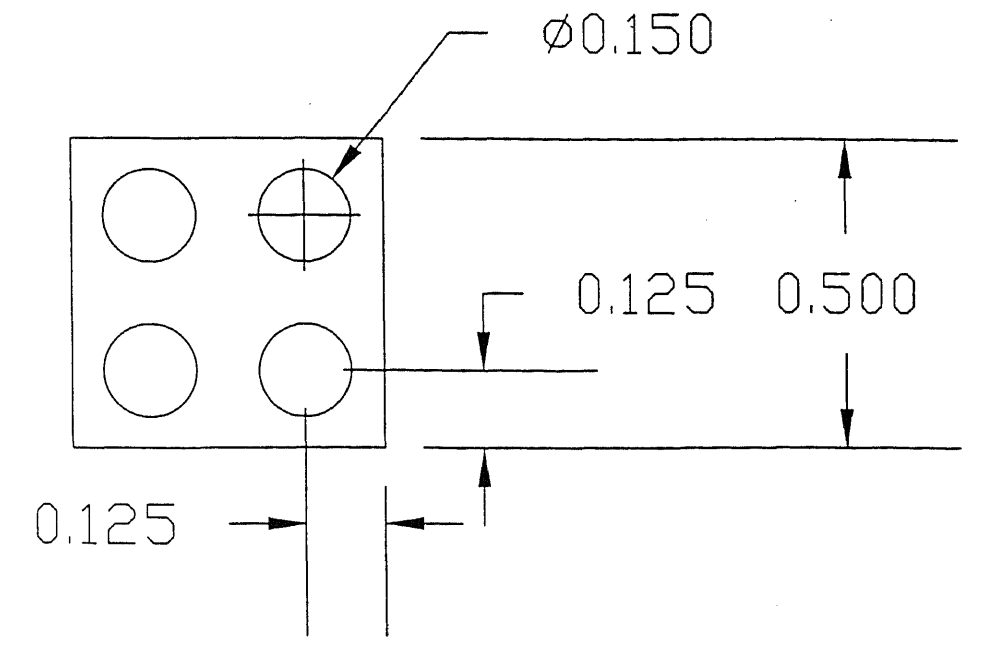


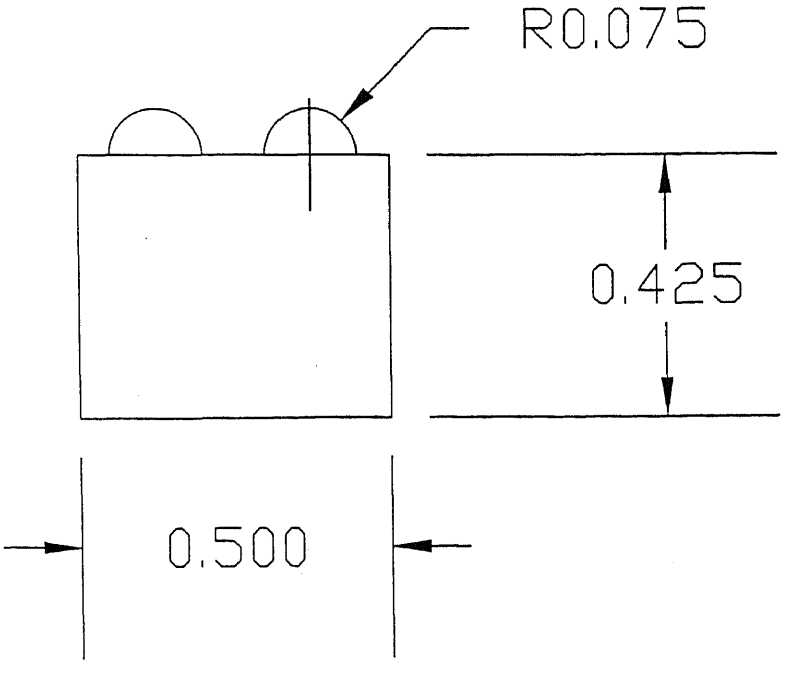

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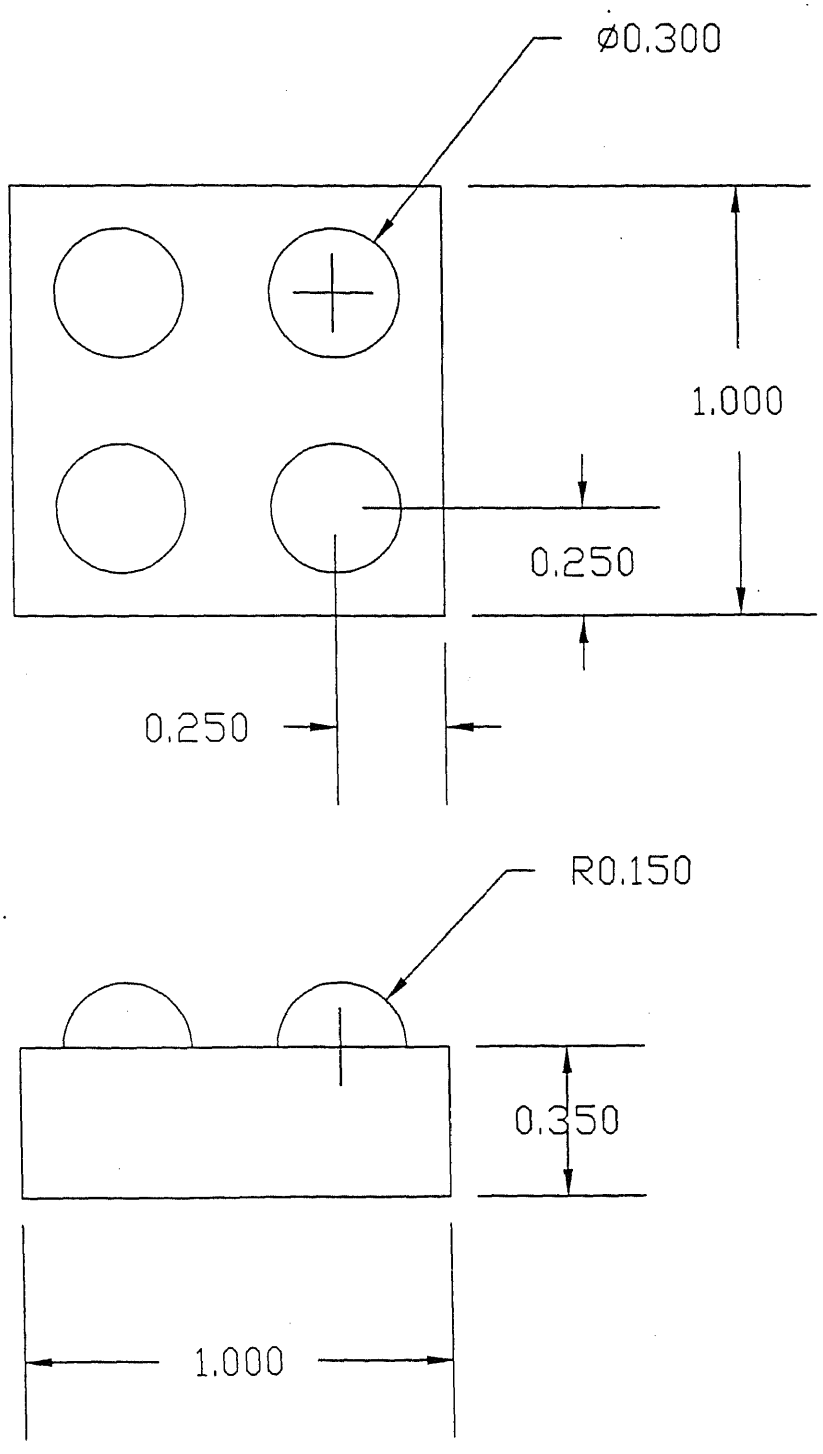

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