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16. Abstract

The increase in fatal accidents involving maintenance personnel in construction zones prompted research into making working personnel easier to detect by motorists. Two approaches were taken to this problem. Improved safety vests were sent to various regions in Texas to evaluate their utility, and different types of driver communication devices were tested for effectiveness. Criteria were also established for "special use" garments for courtesy patrol personnel: to increase conspicuity and identifiability. The recommended safety vest has brilliant yellow-green (BYG) fluorescent/reflective material in a "W" shape on a red-orange fluorescent mesh background with strap and loop ties. Since the Changeable Message Paddle (CMP) is readily understood, light and manageable, and requires little training to use as a driver communication device, the feasibility of producing it in some form should be explored. A uniform of light colored shirt, dark trousers, shoulder patch with department logo, and safety vests should be worn by Courtesy Patrol Personnel.

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PROTECTION OF PERSONNEL IN MAINTENANCE AND CONSTRUCTION ZONES

by

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and

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Research Report 330-1
Research Study Number 2-20-84-330
Protection of Personnel in Maintenance and Construction Zones

Sponsored by

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College Station, Texas

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Safety Vests, Safety Garment, Personnel Safety, Work Zones, Construction Zones, Driver Communication Devices, Changeable Message Paddle (CMP), High Visibility Garment.

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ABSTRACT

Protection of Personnel in Maintenance
and Construction Zones

The increase in fatal accidents involving maintenance personnel in construction zones prompted research into making working personnel easier to detect by motorists. Two approaches were taken to this problem. Improved safety vests were sent to various regions in Texas to evaluate their utility, and different types of driver communication devices were tested for effectiveness. Criteria were also established for "special use" garments for courtesy patrol personnel: to increase conspicuity and identifiability. The recommended safety vest has brilliant yellow-green (BYG) fluorescent/reflective material in a "W" shape on a red-orange fluorescent mesh background with strap and loop ties. Since the Changeable Message Paddle (CMP) is readily understood, light and manageable, and requires little training to use as a driver communication device, the feasibility of producing it in some form should be explored. A uniform of light colored shirt, dark trousers, shoulder patch with department logo, and safety vests should be worn by Courtesy Patrol Personnel.

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1.0 INTRODUCTION

The hazards associated with working adjacent to moving traffic have been highlighted recently by fatal accidents involving maintenance personnel. This is an emotionally charged problem that demands the attention it has received in the past few years. That attention has focused on developing methods for controlling traffic through work zones and on finding effective ways to provide positive barriers. Also, an effort has been made to devise means of making working personnel easier to detect by motorists. This effort resulted in the development of a modified traffic control vest enhanced with brilliant yellow-green (BYG) fluorescent and reflective stripes. This garment represents just one of many possible configurations of a high visibility garment.

Limited field testing of prototype vests was accomplished. However, a larger distribution and longer testing were considered necessary before a change could be recommended to the State Department of Highways and Public Transportation (SDHPT). A full field evaluation needed to be conducted to ensure the garment performed satisfactorily in terms of acceptability and durability.

During the course of the development of the traffic control vest, reflective garments of various types were collected. Few of these garments were practical for the widespread usage required of the vests, but some did have potential for specialized, limited, distribution purposes. One particular duty that was considered to have such a need was that of the courtesy patrol.

Courtesy patrols are operated on the freeway systems of several large metropolitan cities. Patrol members, in addition to keeping the highways clear of debris, provide assistance to motorists with disabled vehicles. They often perform these services in heavy traffic and in hours of darkness. In that environment it would be useful for them to be wearing some type of high visibility garment. It would also be useful if the garment could be used to readily identify the wearer as a member of the Department. An in-depth evaluation of the requirements of courtesy patrol members for special garments was recommended as an outgrowth of the previous work in developing traffic control vests.

Another aspect of work zone activity, tangentially related to personnel protection, is the use of flags or other devices to communicate with passing motorists. Previous research has indicated that when standard signals are used, the stop/slow paddles are more effective than red flags in terms of their ability to transmit certain information.(4) However, these devices have undesirable size, weight and other characteristics that limit their utility. They also do not seem to have the attention value of the more commonly used flags. An investigation of how these communication devices might be improved was included as part of this study.

1.1 OBJECTIVES

The work activity of this project had three distinct objectives.

1. To distribute two versions of the improved safety vests to various climatic regions in Texas and evaluate their utility.
2. To establish the criteria for and to evaluate "special use" garments for possible use by courtesy patrol personnel.
3. To compare the existing driver communication devices and to recommend improvements where necessary.

The following sections briefly outline the approach taken to accomplish these objectives and present the results and conclusions. Each section deals independently with a specific objective. The recommendations for all three project efforts are summarized in the last section.

2.0 FIELD EVALUATION OF IMPROVED TRAFFIC CONTROL VESTS

The Department requires that Traffic control or safety vests be worn by all flagpersons while on duty and by any employee whose duties cause them to be on the road surface when not in a properly signed and barricaded area. (1) The purpose of these vests is to alert motorists to the presence of the personnel wearing them so they can be heeded and avoided. In order for these vests to adequately perform their function, they must be highly visible against a variety of backgrounds under all illumination conditions.

The vests currently in use by the department are fabricated with orange fluorescent mesh enhanced with white reflective stripes (see Figure 2.1). These vests are somewhat inadequate, in terms of attracting attention, when viewed against the construction orange colors present in work zones. This is especially true during periods of twilight. Personnel who wear vests regularly report that they retain heat during the summer months and have a tendency to create a glare on the face. There have even been a few cases of sunburn and rashes attributed to them.

An improved vest, using some of the recently introduced fluorescent-reflective materials, was developed under research study No. 2-18-79-262. This report includes a review of the literature and discusses the criteria used to develop the vest which were related to the conspicuity and comfort of the wearer.(2) Several versions of this improved vest underwent limited field testing. The test results indicated that the improvements were beneficial, however, further evaluation was recommended in order to determine that the changes would be acceptable to the Department personnel in general, and to determine if the vest would stand up under a variety of working conditions.

The full field evaluation involved two versions of the improved vests (see Figures 2.2 and 2.3). These vests employed a red-orange fluorescent mesh for the basic garment but differed in the pattern of the BYG reflective material, their cut, and in the types of fasteners used. The vest in Figure 2.2 was called the "11" vest after the two parallel strips of reflective material on its front. This vest has a chevron of reflective material on the back. It also has a V-shaped front scoop and a rounded-off back scoop with the shoulder straps held together by a strap of black webbing. The adjustable side straps are made using black webbing and overlapping "D"-rings.

The second vest was called the "W" vest after the W-shaped pattern of reflective material located on its front and back sides (see Figure 2.3). It is cut with a deep squared-off scoop in front and a shallower scoop in back. Side adjustment is accomplished by means of hook and loop tape. Both vests are fastened in the front by hook and loop tape.

During the last week of September 1983, copies of the "11" vest were distributed to maintenance personnel of the Department in two

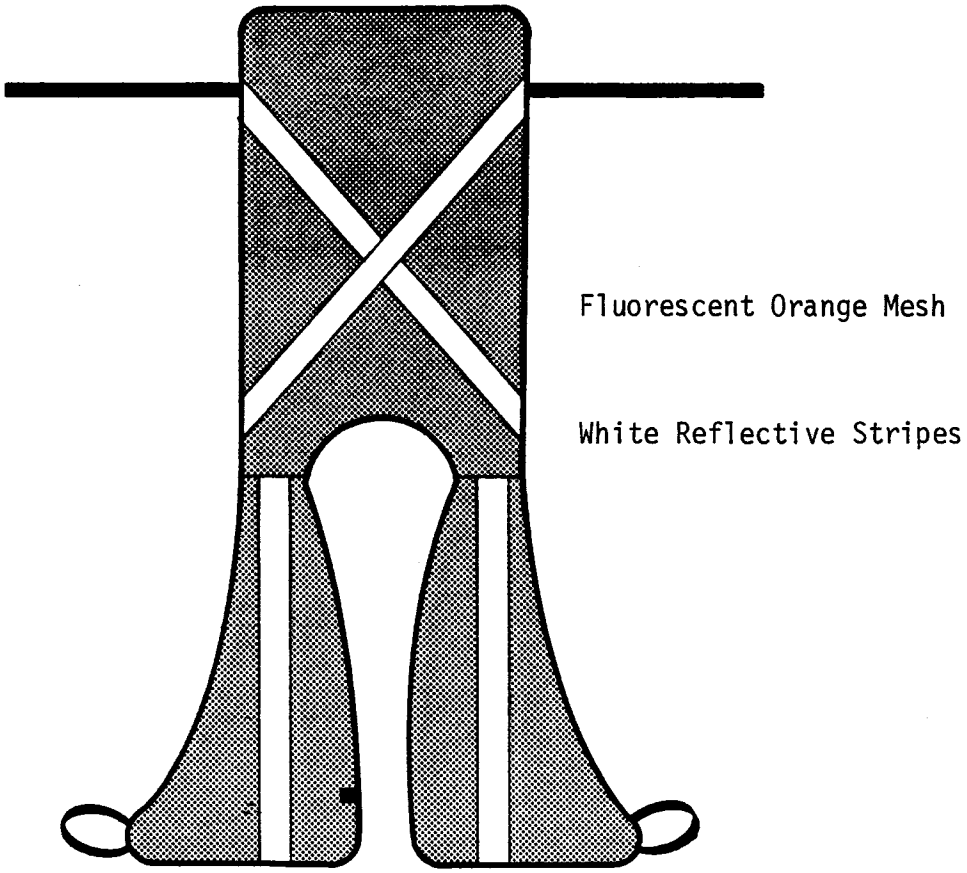


FIGURE 2.1 Traffic Control Vest
in Current Use

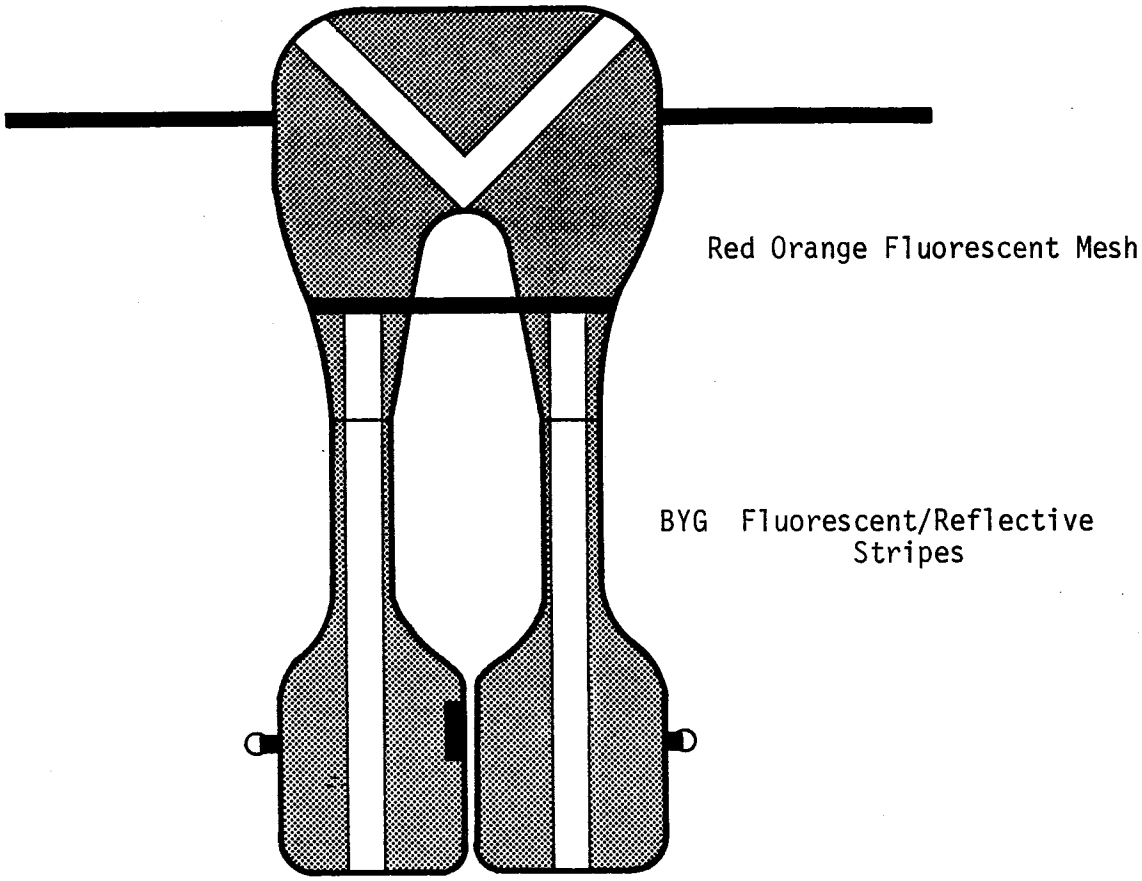


FIGURE 2.2 Improved "11" Style Vest

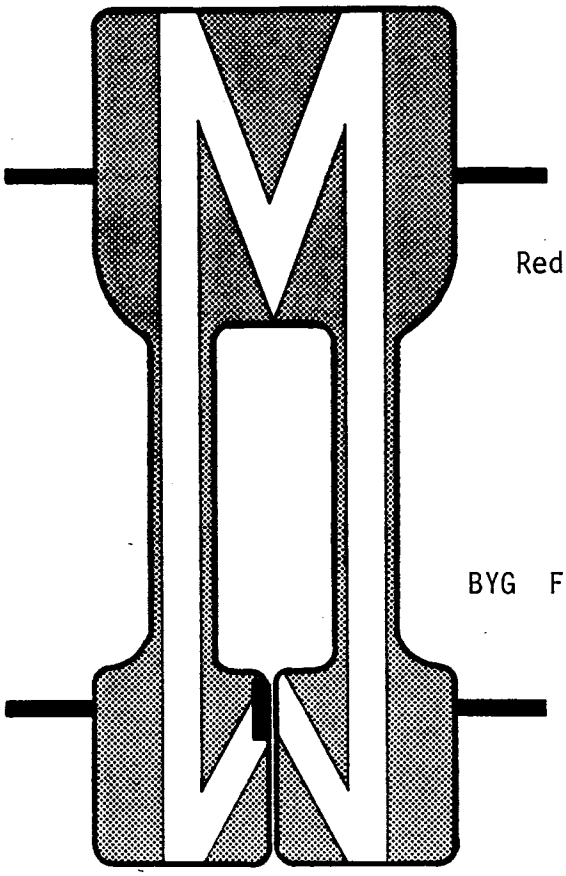


FIGURE 2.3 Improved "W" Style Vest

areas: Amarillo (District 4), and Brownsville (District 21). The "W" version of the vest was distributed to personnel in Houston (District 2) and Odessa (District 6) areas at the same time. Approximately fifty vests were given out in each area. After a three month trial period, the areas exchanged vests. Thus personnel in each area had the opportunity to wear each vest type for three months. At the end of each three month period, vest evaluation surveys were conducted in each area. Participants in these surveys were asked to compare the visibility, comfort and durability of the new vests with the old style vest. The comparison at the end of the first three months was between a single new type vest with the old style vests. The six month comparison was among both types of new vest and the old style vest. The evaluation instruments used in each of these surveys are included in the Appendix.

2.1 RESULTS

The survey conducted at the end of the first three months of vest usage prepared the personnel taking part in the vest evaluation for the questions asked after they had worn both the "11" and the "W" vest. It also served as a means of overcoming or defusing some of the natural resistance to the introduction of a new piece of equipment by affording personnel an opportunity to express general dissatisfaction. Although the results of this survey are not of primary interest, they were not inconsistent with the result of the final survey. They are presented in the Appendix as supplemental information.

The results of the survey conducted after all personnel had had experience with both types of new vests are presented according to the major topic areas of visibility, comfort, and durability in Tables 2.1, 2.2, and 2.3 respectively. In addition, a miscellaneous section is used to summarize comments (Table 2.4).

2.2 CONCLUSIONS

Since more than 90% of the personnel responded to the questions concerning greater day and nighttime visibility by selecting one of the new vests, and since these vests both make use of BYG fluorescent/reflective stripes, it can be concluded that this material is thought to be an improvement over that used on the old style vest. This conclusion is supported by comments received from supervisors in the field. The fact that the new vest with the "W" stripe pattern was selected by almost 70% of the personnel would indicate that those responding felt that the more BYG material present, the better the visibility. This too is consistent with comments from the field.

The results from the questions addressing the issue of comfort of safety vests were mixed. Although over 90% of the personnel responding selected one of the two new vests as the most comfortable, they were also selected as hotter. In addition, over 25% felt that the vests were binding and over 85% complained that the straps slipped off the shoulders when working.

Table 2.1 Visibility

1. Which vest is most visible during the day?

	"11" Vest	"W" Vest	Old Vest
Amarillo	6	18	0
Midland/Odessa	9	24	0
South Texas	8	25	2
Houston	14	18	1
TOTAL	37	85	3
Percent(N=123)	30.08	69.11	2.44*

2. Which vest is most visible after dark?

	"11" Vest	"W" Vest	Old Vest
Amarillo	4	20	0
Midland/Odessa	8	21	0
South Texas	8	25	2
Houston	8	19	1
TOTAL	28	85	3
Percent(N=123)	22.76	69.11	2.44

*Percentage can be greater than or less than 100% because some subjects did not respond and some selected more than one option.

Table 2.2 Comfort

1. Which vest is more comfortable?

	"11 Vest"	"W" Vest	Old Vest
Amarillo	13	7	7
Midland/Odessa	7	23	1
South Texas	20	24	0
Houston	10	16	1
TOTAL	50	70	9
Percent(N=123)	40.65	56.91	7.32

2. Which vest is hotter?

	"11" Vest	"W" Vest	Old Vest
Amarillo	10	7	7
Midland/Odessa	7	23	1
South Texas	20	24	0
Houston	10	16	1
TOTAL	47	70	9
Percent(N=123)	38.21	56.91	7.32

3. Which vest cuts into you?

	"11" Vest	"W" Vest	Old Vest
Amarillo	3	2	2
Midland/Odessa	3	6	0
South Texas	4	4	0
Houston	8	3	0
TOTAL	18	15	2
Percent(N=123)	14.63	12.20	1.63

4. Does any vest cause a rash or sunburn?

	"11" Vest	"W" Vest	Old Vest
Amarillo	2	0	1
Midland/Odessa	4	3	0
South Texas	3	3	0
Houston	5	0	0
TOTAL	14	6	1
Percent(N=123)	11.38	4.88	0.81

5. Do the shoulder straps fall down?

	"11" Vest	"W" Vest	Old Vest
Amarillo	2	8	1
Midland/Odessa	18	23	0
South Texas	12	17	1
Houston	11	15	2
TOTAL	43	63	4
Percent(N=123)	34.96	51.22	3.25

Table 2.3 Durability

1. Did any vest fall apart?

	"11" Vest	"W" Vest	Old Vest
Amarillo	5	0	0
Midland/Odessa	9	19	0
South Texas	10	11	1
Houston	10	3	1
TOTAL	35	33	2
Percent(N=123)	27.64	26.83	1.63

2. Which vest comes unfastened?

	"11" Vest	"W" Vest	Old Vest
Amarillo	10	4	2
Midland/Odessa	17	17	1
South Texas	6	20	1
Houston	10	9	1
TOTAL	43	50	5
Percent(N=123)	34.96	40.65	4.07

Table 2.4 Miscellaneous

1. Do vests need to be different sizes?

	Yes	No
Amarillo	21	2
Midland/Odessa	26	4
South Texas	19	13
Houston	26	3
TOTAL	92	22
Percent(N=123)	74.79	17.88

2. Additional Comments

	Number
a. Need improvement and/or more adjustable fasteners	20
b. Shoulder straps fall down	5
c. Make more durable	6

The loose shoulder straps can be directly attributed to the scooped neck design of the new vests and indirectly attributed to the "single size" issue. Since the same size vest was made available to all personnel, the shoulder straps would fall off the shoulders of the smaller individuals while the side adjustment straps would tend to bind the underarms of some of the larger. Comments from the field were quite numerous concerning these problems. As can be seen in the miscellaneous section of the survey results, over 74% of the personnel responding felt the vest should come in different sizes.

The scooped neck design was incorporated into the new vests to reduce heat retention and glare. Since more personnel selected one of the new vests as having these problems it must be concluded that these designs failed in their intended purpose. It should also be noted that less than 18% of the personnel responded to the question regarding sunburns and rashes. Comments from the field would suggest that the major problem is that of heat retention and heat rash rather than sunburn from glare off the front of the vest.

There were some definite problems with the durability of the new vests. In most cases, these problems could be attributed to the fastening devices sewn on each side of the vests. These straps, the only means of adjusting size, tended to fray on the "11" style vest that used the D-rings. The hook and loop fasteners on the "W" style vests were too short. When larger personnel tried to extend them to fit their size they would not hold. There were few comments concerning the durability of the major portion of the vests.

In summary, the results of the survey indicated that the use of the BYG striping improved visibility, but there were serious problems with the design of the new vests. These problems are related to falling shoulder straps and poor fastener location and durability. The results also indicated that the scooped neck did not solve the heat retention problem. Although the newer vests were selected for comfort more frequently than the old style vest, it was probably an expression of a desire to keep the striping material rather than a vote of satisfaction for the new designs.

3.0 SPECIAL USE SAFETY GARMENTS

The SDHPT operates courtesy patrols on the freeways of some of the larger urban areas around the state. These patrols assist motorists who experience breakdowns on the freeway system. Patrol members perform minor vehicle repairs, provide small amounts of gasoline, emergency traffic control, and communications with tow truck services. The operators of courtesy patrol vehicles are often required to perform their services in heavy traffic, in adverse weather, and under poor lighting conditions. This operational environment makes it necessary for patrol personnel to be as conspicuous as possible to reduce the potential of being struck by passing vehicles. In addition, it would be advisable that courtesy patrol operators be readily identifiable so that stranded motorists do not misconstrue their intentions.

The introduction of new fluorescent and reflective materials has, in recent years, led to the development of garments that have potential for use in such a specialized setting. To determine what type of garment, if any, might satisfy the requirements of courtesy patrol personnel, it was necessary to find out more about the courtesy patrol operation and what was currently being used in the field. It was also necessary to develop a set of idealized requirements for a special use garment for the courtesy patrols, then compare what was currently being used to the idealized requirements and make a recommendation for further action.

3.1 RESULTS

A list of courtesy patrol operators was obtained by contacting the offices of the 25 district engineers. Supervisors from the four districts operating courtesy patrols were then contacted to inventory current policies and practices. It was determined that there are approximately 36 courtesy patrol personnel (not including supervisory staff), providing service during peak traffic periods. These periods include some hours of daylight, twilight, and darkness.

Ft. Worth's courtesy patrol consists of 12 to 14 people. They work from 4:00 p.m. to 8:00 a.m., Monday through Thursday. On Fridays work begins at 4:00 p.m. and continues until 8:00 a.m. Monday morning. Patrol personnel wear street clothes and safety vests.

San Antonio has a patrol consisting of two vehicles and ten men. They work from 5:00 p.m. to 8:00 a.m., Monday through Thursday. On the weekends they work in four shifts from 5 p.m. Friday to 8 a.m. Monday. San Antonio has a standardized uniform made up of a grey workshirt with an identifying arm patch and nametag. They also wear a baseball cap with the same patch as the shirt. Patrol members are required to wear safety vests when out of their vehicles.

Houston's patrol has ten men. Their shift is from 3:30 p.m. to midnight, Monday through Thursday and on weekends from Friday at 11:30 a.m. to Monday at 8:00 a.m. This patrol uses the same uniform as the crew members that operate the ferries, a white shirt with

nametag and armpatch and dark blue pants. They are also required to wear safety vests and hardhats.

Corpus Christi has a patrol of two men: one patrolling during the day, the other patrolling at night. The service runs five days a week, Monday through Friday. Their shifts concentrate on the peak traffic periods, 6:45 to 8:45 a.m. and 3:30 to 5:30 p.m., Monday through Friday and all day (24 hours) on state holidays. The personnel wear street clothes with the standard issue safety vest and hardhat.

The consensus of opinion of the personnel contacted was that some type of uniform would be desirable, not only from safety and morale standpoints, but to clearly identify to motorists that they are representatives of the SDHPT.

The information obtained from courtesy patrol operators was combined with the experience and human factors expertise of the staff to produce a list of garment requirements. These requirements suggest that the garments used by courtesy patrol personnel should be:

1. Conspicuous-during daylight, twilight, and nighttime hours.
2. Identifiable-readily associated with SDHPT and standardized across all districts.
3. Acceptable to users in terms of aesthetic value, thermal comfort, and fit comfort.
4. Of low cost - low initial purchase price, easily maintainable (washable), and durable (long-lived).

Companies that manufacture or sell safety garments were identified from safety and emergency medical service magazines and catalogues. These companies were contacted and asked to supply information and materials that might be considered appropriate for the special-use garment under study. The companies contacted include: HUB Equipment Co., LEM Products Southwest, AG Manufacturing, Harold Taft, Inc., Edith Sullivan, Inc., Southwest Gloves and Safety Equipment Co., Dyna-Med, Inc., Direct Safety Co., 3M Products, Universal Safety Concepts, and several retail outlets.

The inventory of courtesy patrol operators and contacts with manufacturers and suppliers allowed the development of alternative garments that are or could be used by courtesy patrol personnel. These alternatives were then subjectively evaluated by the project staff using the garment requirements as criteria. The evaluation involved rating each alternative for each criterion using the broad categories of Good (1), Fair (2), or Poor (3). In terms of cost, the number 1 indicates low cost (under $15), 2 is moderate ($15-$30) and 3 is high (over $30). The results of this evaluation are presented in Table 3.1.

3.2 CONCLUSIONS

Several comments are necessary concerning portions of the evaluation table. For instance, standardization and recognition are interrelated, therefore a set uniform used within a district's

TABLE 3.1

GARMENT EVALUATION

CRITERIA	Street Clothes	Street Clothes With Vest	White or Grey Shirt	White or Grey Shirt With Vest	Fluor. Red Paper-Alls	Blue Paper-Alls	Orange Cotton Coverall-LS	Orange Cotton Coverall With Vest	Orange Poplin Jumpsuit-SS	Orange Poplin Jumpsuit With Vest	Red Reflect. Coveralls
Conspicuity											
Day	*2	1	2	1	1	1	1	1	1	1	2
Twilight	2	1	2	1	1	2	2	1	2	1	2
Night	3	1	3	1	2	2	2	1	2	1	1
Acceptability											
Aesthetics	1	1	1	1	3	3	1	1	1	1	1
Thermal	1	1	1	1	1	1	2	2	1	1	2
Fit	1	1	1	1	2	2	1	1	1	1	2
Identification											
Recognition	3	3	1	1	1	1	1	1	1	1	1
Standardized	3	3	1	1	1	1	1	1	1	1	1
Cost											
**Initial	1	2	2	2	2	2	2	2	2	2	3
Maintenance	1	2	1	1	3	3	1	1	1	1	2
Durable	1	2	1	1	3	3	1	1	2	2	1
TOTAL	19	18	17	12	20	21	15	13	15	13	17

* Good - 1, Fair - 2, Poor - 3

** Unit Cost Under $15=1, $15-$30=2, Over $30=3

courtesy patrol would eventually be associated with the SDHPT. To a large degree, the safety vest provides standardization. If this vest were worn over some type of uniform shirt or coverall that had a distinctive arm patch with the SDHPT logo on it, there would be little doubt as to the affiliation of patrol personnel. In addition, the safety vest satisfies the conspicuity requirements for most illumination conditions. This is particularly true for the newer vests with the BYG fluorescent/reflectorized stripes. Since the courtesy patrols operate almost exclusively on urban freeways where supplemental lighting is present, additional reflectorized enhancement of the vest is not required.

The criterion of acceptability on the table was an estimate by the staff using the knowledge gained from interviews with courtesy patrol personnel. The districts now using a uniform seemed to be satisfied with them. This is due in large measure to the fact that they are provided by the Department along with a laundry allowance.

4.0 COMPARISON OF COMMUNICATION DEVICES USED BY FLAGGERS

Flaggers (flagpersons) serve a vital function on roadways. They are utilized primarily to move traffic safely and appropriately through and around roadway work areas.(3) In addition to moving traffic safely, flagpersons also serve to protect the work crew in work zones by diverting traffic away from them.

Flaggers usually use red flags and hand signals or STOP and SLOW paddles to guide motorists through work zones. There are three basic messages that are communicated: stop, slow or alert, and proceed. As simple as these messages appear, they are sometimes misunderstood. In a recent study of the signals recommended in the 1973 and 1980 versions of the Texas Manual of Uniform Traffic Control Devices, Richards et al (1981) found that with a trained flagger, 91% of the test subjects correctly interpreted the flag signal to stop, 100% understood the signal to proceed but only 31% understood the signal to slow down. The STOP and SLOW paddles were understood by 100% of the subjects when displaying the message to stop, 93% of the subjects when displaying the message to proceed and 96% when displaying the slow message.(4) These somewhat high levels of understanding were achieved using a trained flagger in an idealized situation. Unfortunately, in actual practice, flagging operations are performed under less than ideal circumstances, usually by the newest or least productive members of the work crew who have had little training in the appropriate procedures. Consequently, a much higher level of misunderstanding of these messages would be expected in the actual work environment.

The more frequently used combination of flag and hand signals is part of a coded system that requires a high degree of interpretation on the part of motorists. The STOP and SLOW paddles, while not attracting as much attention as the moving flag, are more readily interpreted and understood. However, the paddle has the problem of displaying two messages at the same time, which may create confusion in certain circumstances.

Both communication devices have other problems associated with their usage besides occasional low comprehension. The use of flags can become very difficult if strong winds are present. The short-handled SLOW and STOP paddles are often not very popular with work crews because of their weight and wind resistance. Long-handled STOP and SLOW paddles that rest on the ground are cumbersome to use and store.

In addition, as Richards pointed out, it would be useful if the communication devices were capable of presenting messages that conveyed a requirement to change lanes, change directions, detour, and use shoulders.

What is needed is a communication device that is highly effective at conveying many messages with the least amount of training, that is not greatly decreased in efficiency by

environmental conditions like strong winds, and is not excessively heavy. It is also necessary that a communication device be designed such that more possible messages can be displayed.

A new communication device that was thought to meet the above-mentioned criteria was developed. Since the device was designed in the shape of a paddle and with the feature of message interchangeability, it was named the changeable message paddle (CMP).

To ensure that the new CMP would be light in weight, it was constructed of aluminum tubing. Figure 4.1 gives an illustration of the basic frame of the CMP. No dimensions are given because the device, as tested, did not satisfy the size requirements for either a stop and slow paddle or a flag. It was smaller than either and was considered to be a prototype of a device that could be produced in any shape or size.

A fabric sleeve (or "pillow case") was used to cover the tubing of the paddle (see Figure 4.2). The sleeve can be easily replaced if damaged since it is attached by hook and loop tape to the paddle. The sleeve was red on one side and orange on the other. The red side was used as a stop sign, and the orange side as a slow sign. As Figure 4.2 illustrates, there are four hook and loop fasteners on each side of the fabric sleeve. It is at these points that the paddle's various messages will be attached. Since the messages can be easily applied and taken off, the CMP has the feature of flexibility. When messages are not being used, they can be stored inside the sleeve.

It was determined that the messages which the CMP should display were: 'STOP' (white letters on red background), 'SLOW' (black letters on orange background), and a directional arrow (black arrow on orange background). These various messages are illustrated in Figure 4.3. The CMP can also be utilized as an alerting device by simply using the sleeve without any attached messages.

An arrow was selected to indicate changes in direction (e.g., change lanes, detour, exit) since it was contended that this geometric shape would just as readily convey directional information as would a more specifically worded sign. It was also considered important to not "overload" the flagger with too many possible messages.

The cost to fabricate the CMP is relatively low. It was determined that the approximate cost of each paddle was $10.00. However, this does not include labor costs.

In order to determine how well the CMP functioned, it was compared with the use of flags and paddles in their ability to convey messsages to motorists. A survey at a local shopping mall was designed for this purpose. A videotape of a flagperson using the three types of communication devices was shown to subjects with valid Texas drivers licenses. The first device was the most commonly used on the work site, the flag. The flag consists of a square piece of red fluorescent material attached by one side to a wooden handle. The

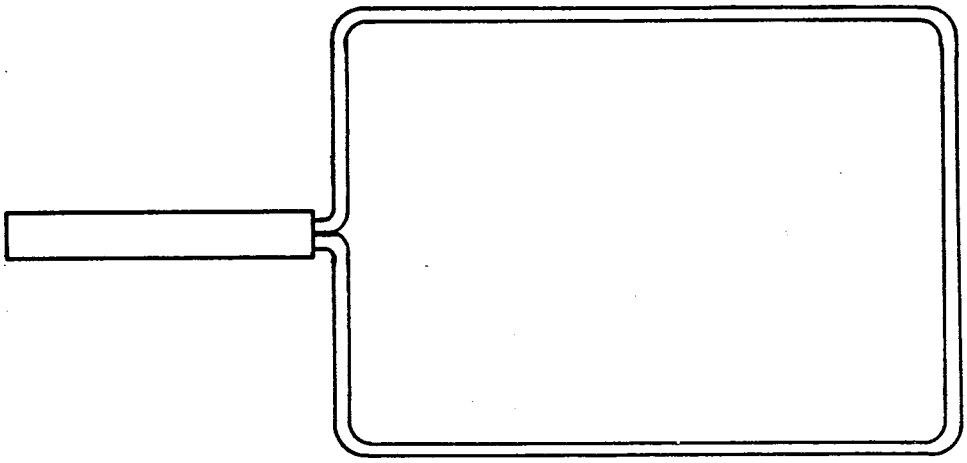


FIGURE 4.1 Frame of Changeable Message Paddle (CMP)

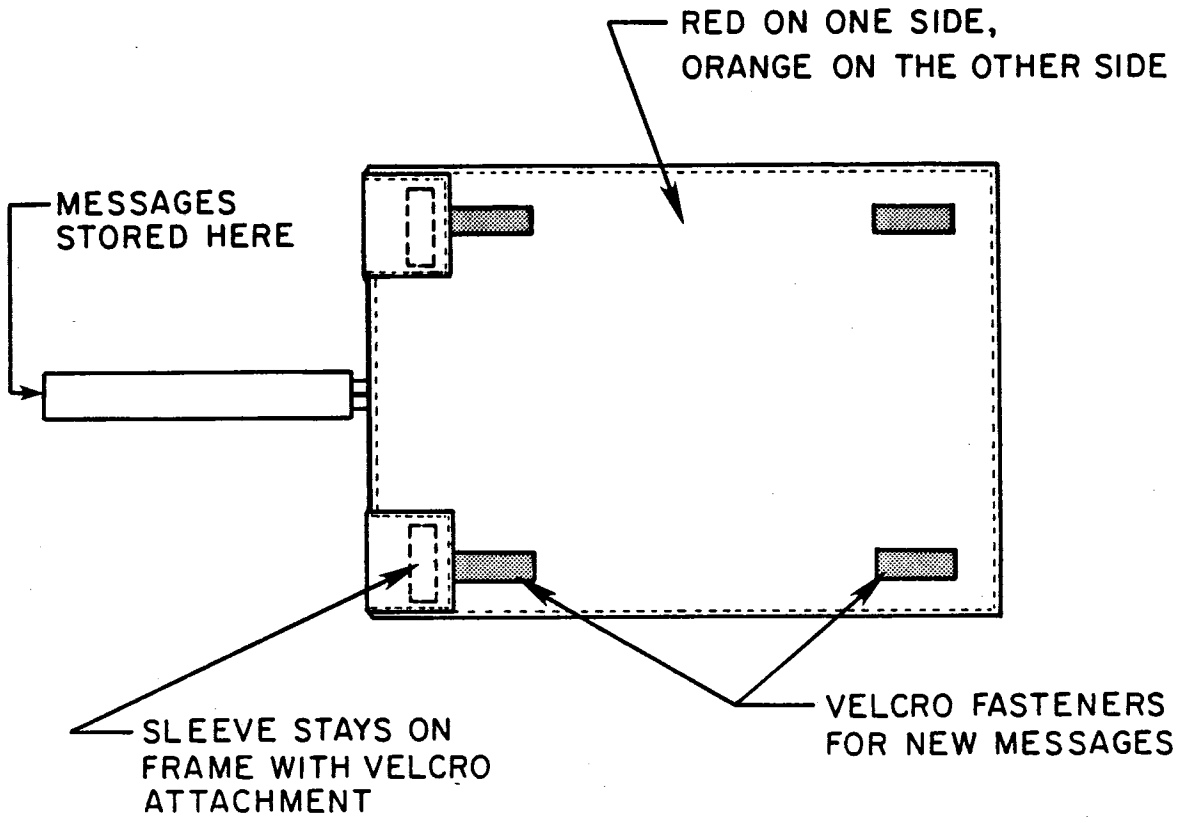
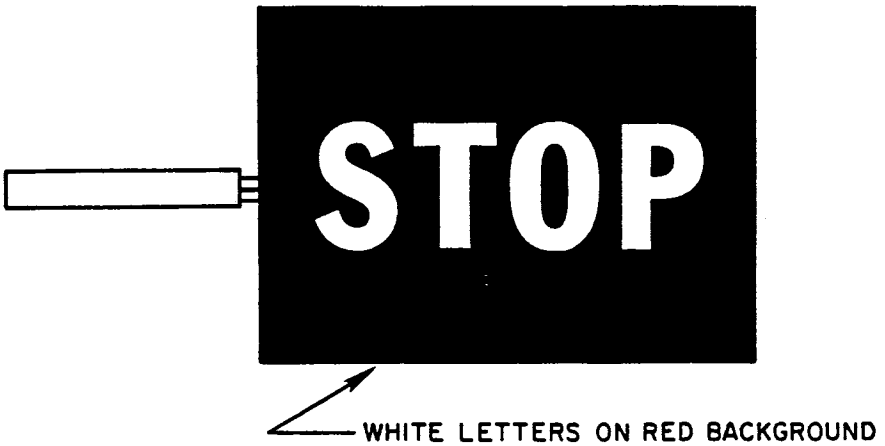
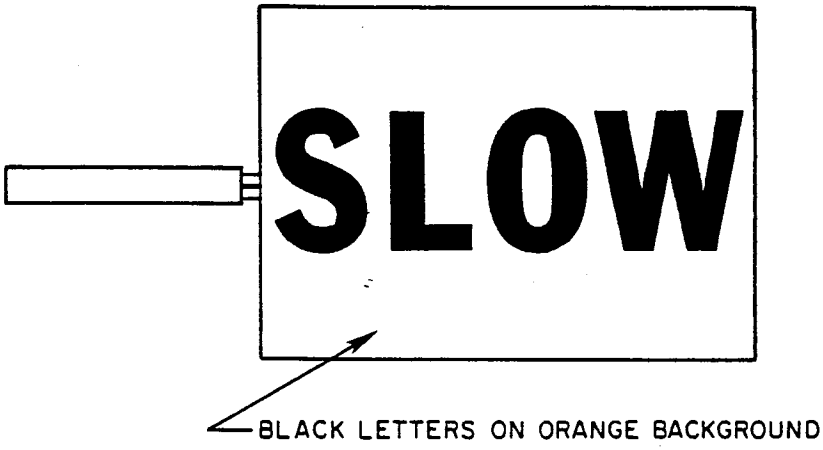


FIGURE 4.2 CMP "Pillow Case" Covering





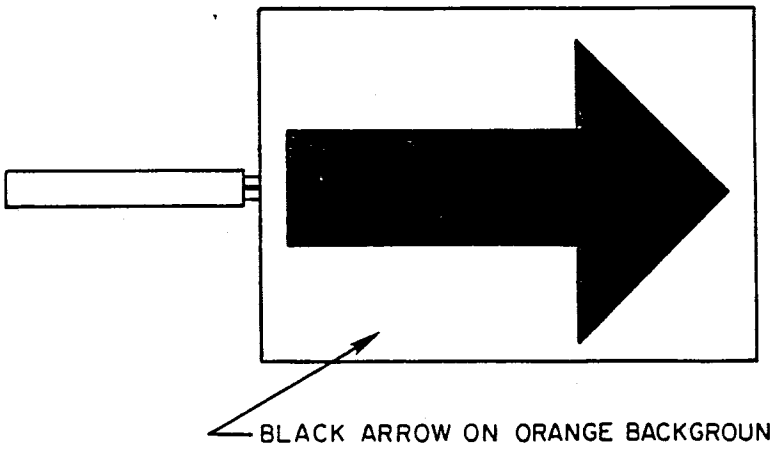


FIGURE 4.3 CMP Messages

fluorescent material is about 18 inches square. The second device was the Stop and Slow paddle. The Stop and Slow paddle is 18 inches square with a red stop sign on one side and an orange slow sign on the other. The third device was a prototype CMP.

There were four conditions: the flagperson using only the flag, using only the paddle, using both the flag and paddle, and using the CMP. Four messages were attempted to be conveyed: stop, slow, change direction, and proceed. In the first three conditions the flagperson used flagging procedures set out in the Manual on Uniform Traffic Control Devices (1978). In the CMP condition the flagperson used similar procedures where applicable.

The subjects were told that they would see a videotape of a flagperson and that they were to write down the message that the flagperson was trying to convey. Each subject was shown one condition. The videotape showed the flagperson from a distance and then zoomed in as if approaching him. At the closest point the zoom stopped and held for 15 seconds after which the blank screen was shown. The blank screen remained until the subject finished writing, then the next message was shown.

4.1 RESULTS

Each subject's response to each of the treatment conditions was compared to what the flagger's intended meaning was. The percent correct was calculated for each communication strategy and the percent for the most common misunderstandings.

The highest percentage correct for the stop signal was in the paddle condition with 94.1%, followed by the CMP with 92.3%, the flag and paddle with 83.8%, and the flag alone the lowest with 65.5% (see Table 4.1). Considering the differences in the sample sizes, the differences in the percentages between the paddle and the CMP are not significant. Both performed significantly better than either the flag and paddle or the flag alone. The most common incorrect interpretation of this message was to go left.

The highest percentage correct for the slow signal was the CMP with 96.2% followed by the paddle alone with 91.2%, the flag and paddle with 90.3%, and the flag alone, which was the lowest with 41.4% (see Table 4.2). The CMP performed better than any of the traditional communication devices. The CMP, the paddle alone, and the flag and paddle were not significantly different but were much better than the flag alone.

The CMP had the highest percentage of correct responses for the change direction signal at 100% correct (see Table 4.3). The paddle alone was second with 97.1%, followed by the flag and paddle at 93.5%, and the flag alone at 93.1%. As in the stop signal, the differences in the sample sizes make the differences in the percentages of the CMP and the paddle alone non-significant. Both, however, are better than both the flag alone and the flag and paddle together.

TABLE 4.1 Response to the Stop Signal

	Flag	Paddle	Flag & Paddle	CMP
Stop	65.5%	94.1%	83.8%	92.3%
Stop, Go Left	6.9%	0	9.7%	0
Stop, Go Slow	3.4%	0	0	0
Slow	3.4%	0	3.2%	0
Go Left	20.7%	5.9%	3.2%	7.7%
SUBJECTS	29	34	31	26

TABLE 4.2 Response to the Slow Signal

	Flag	Paddle	Flag & Paddle	CMP
Slow	41.4%	91.2%	90.3%	96.2%
Proceed	6.9%	0	0	0
Stop	27.6%	2.9%	0	0
Go to Left	24.1%	2.9%	3.2%	3.8%
Other	0	2.9%	6.5%	0
SUBJECTS	29	34	31	26

TABLE 4.3 Response to the Change Direction Signal

	Flag	Paddle	Flag & Paddle	CMP
Change Direction	93.1%	97.1%	93.5%	100%
Other	6.9%	2.9%	6.5%	0
SUBJECTS	29	34	31	26

TABLE 4.4 Response to the Proceed Signal

	Flag	Paddle	Flag & Paddle	CMP
Proceed	100%	100%	87.1%	96.2%
Other	0	0	12.9%	3.8%
SUBJECTS	29	34	31	26

The flag alone and the paddle alone both had 100% correct for the proceed signal. The CMP is next with 96.2%, followed by the flag and paddle with 87.1% (see Table 4.4). There is no significant difference between the flag alone, the paddle alone, and the CMP. Only the flag and paddle combination was significantly poorer than the flag or the paddle.

For all messages, the CMP had slightly higher levels of correct interpretations than the paddle alone at 96.2% correct to 95.6% which is not significantly different. The flag and paddle together had 88.7% correct and the flag alone was the lowest with 75% correct.

4.2 CONCLUSIONS

The most commonly used communication device on roadway construction sites is the flag alone. Present research has shown that the percentage of correct understanding of what the flagperson is trying to communicate is only 75%. Indeed on some of the most commonly used signals, stop and slow, understanding can be lower than 50%. This is an indication that the flag alone is not the best communication device. It should be noted that only the communications aspect of the flag was tested, not its attention getting value. In addition, there has been some indication that the communication ability of the flag can be increased by using non-standard hand signals or other gestures.(5)

The CMP and the traffic paddle were the best communication devices. It may be questioned if it is advisable to spend the money for the CMP when the already existing traffic paddle is just as good at communicating to motorists. In response, it must be remembered that there are other problems with the traffic paddle. Workers complain that it is too heavy. When working in a strong wind it is unmanageable. Because of these problems, the traffic paddle is seldom used; when it is used it is usually used improperly. Many reported that instead of holding it, they would place the handle in traffic cones and stand beside it. This causes more motorist confusion.

The CMP was designed with these problems in mind. It is relatively light in weight, made of aluminum tubing. In strong winds it is much more manageable than either the traffic paddle or the flag. For this reason workers are more likely to use the paddle properly. It has the advantage that the message can be changed to fit the situation.

5.0 RECOMMENDATIONS

The following recommendations are based on the results of the work conducted during the course of this project. They are presented in an order that corresponds to the objectives to which they apply.

5.1 FIELD EVALUATION OF IMPROVED TRAFFIC CONTROL VESTS

1. The BYG fluorescent/reflective material should be used on all traffic control vests.

2. The pattern of striping on traffic control vests should be the "W" style used on the vest seen in Figure 2.3.

3. Production of the old style vest should be resumed with some changes. The first change is the use of the BYG material in the "W" pattern. The second change is the use of the same red-orange fluorescent mesh used in making the improved vests. The third change is the production of vests of two sizes. The dimensions of the recommended sizes of large and small vests are presented in Figures 5.1 and 5.2. If a single size vest is to be produced, the recommended dimensions are presented in Figure 5.3.

5.2 SPECIAL USE SAFETY GARMENTS

1. A standard issue uniform consisting of a light colored shirt and dark trousers is recommended for use by courtesy patrol personnel. There is no need for special fluorescent or reflectorized clothing (see item 2).

2. For purposes of conspicuity and identification, personnel should always wear traffic control vests, preferably those with BYG fluorescent/reflective stripes. When jackets are worn, these vests should be worn over them.

3. Additional identification can be provided by shoulder patches with the Department logo. Name tags, if worn, should be in the form of arm patches as well to keep them from being covered by safety vests.

4. Decisions concerning the use of baseball caps or hard hats by courtesy patrol personnel should follow current Department policy.

5.3 COMPARISON OF COMMUNICATION DEVICES USED BY FLAGGERS

1. It should be re-emphasized that this study was not designed to evaluate the overall effectiveness of the stop and slow paddle versus the flag; to do so would require a detailed comparison of attention value, communication ability in various configurations, and a survey of utility (cost, training time, use rate, etc.). It would also require an in-depth field study to validate experimental findings. What was attempted was the development of a new device that incorporated the best characteristics of each. These characteristics were determined subjectively using human factors engineering

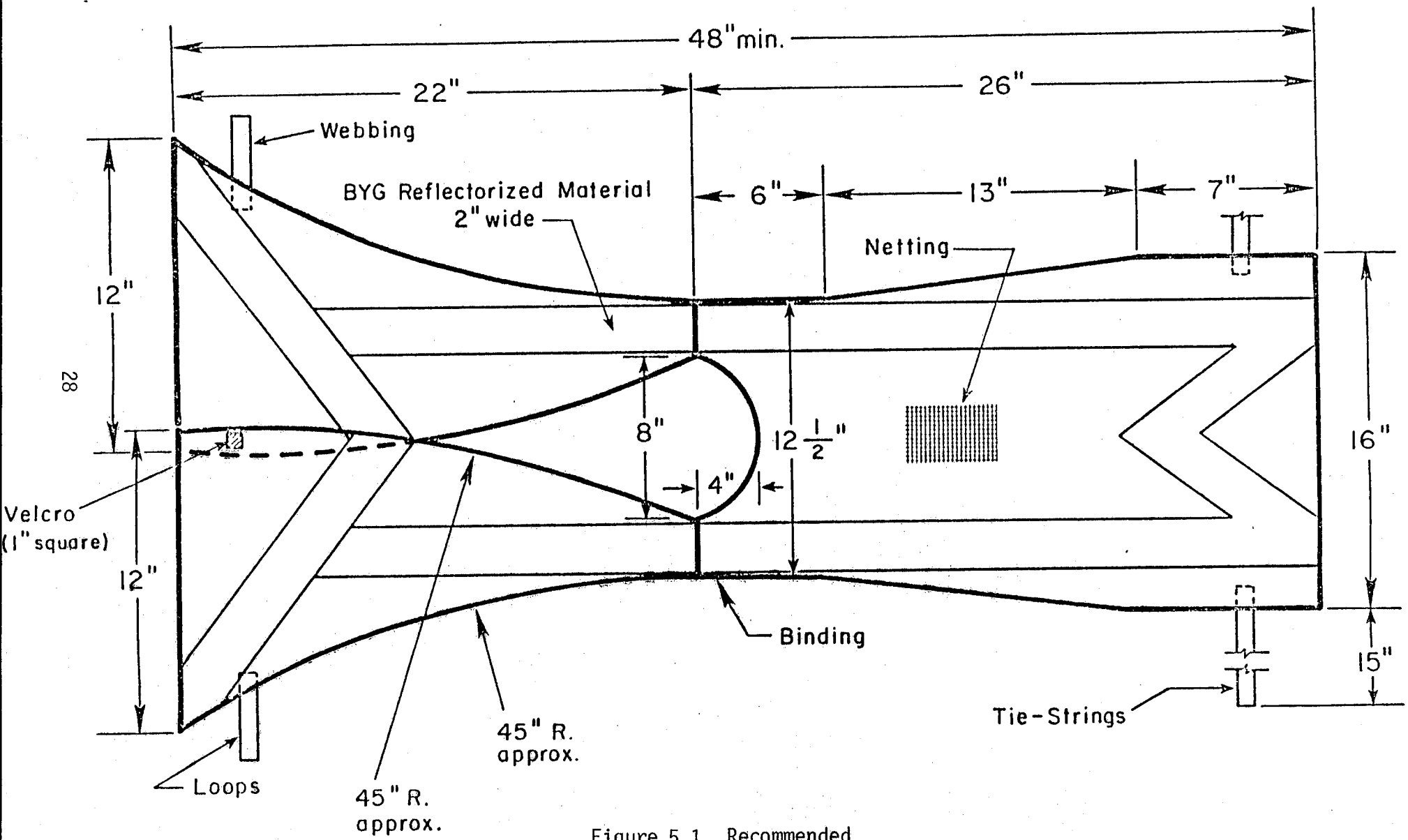


Figure 5.1 Recommended

SAFETY VEST

LARGE

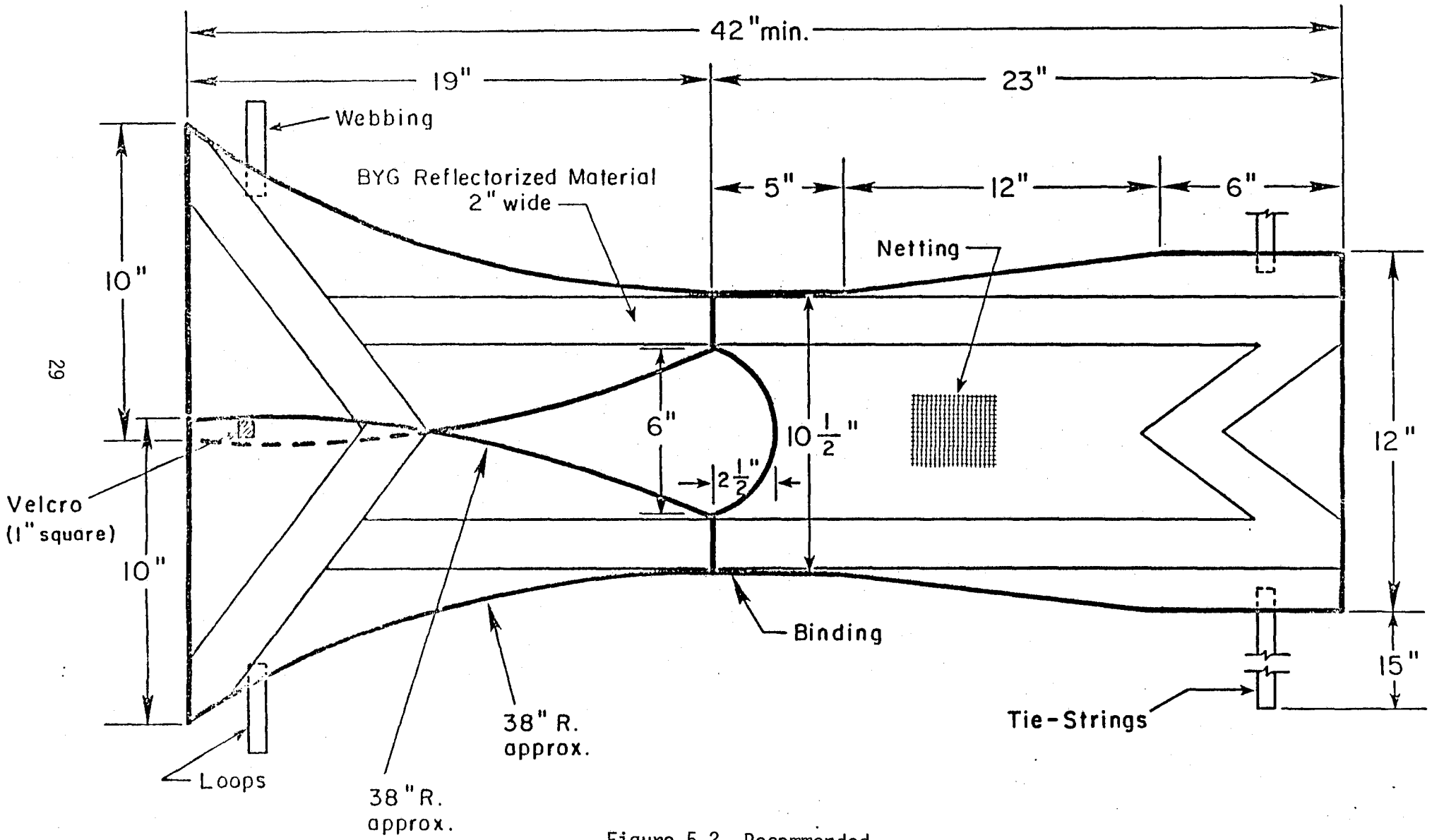


Figure 5.2 Recommended

SAFETY VEST

SMALL

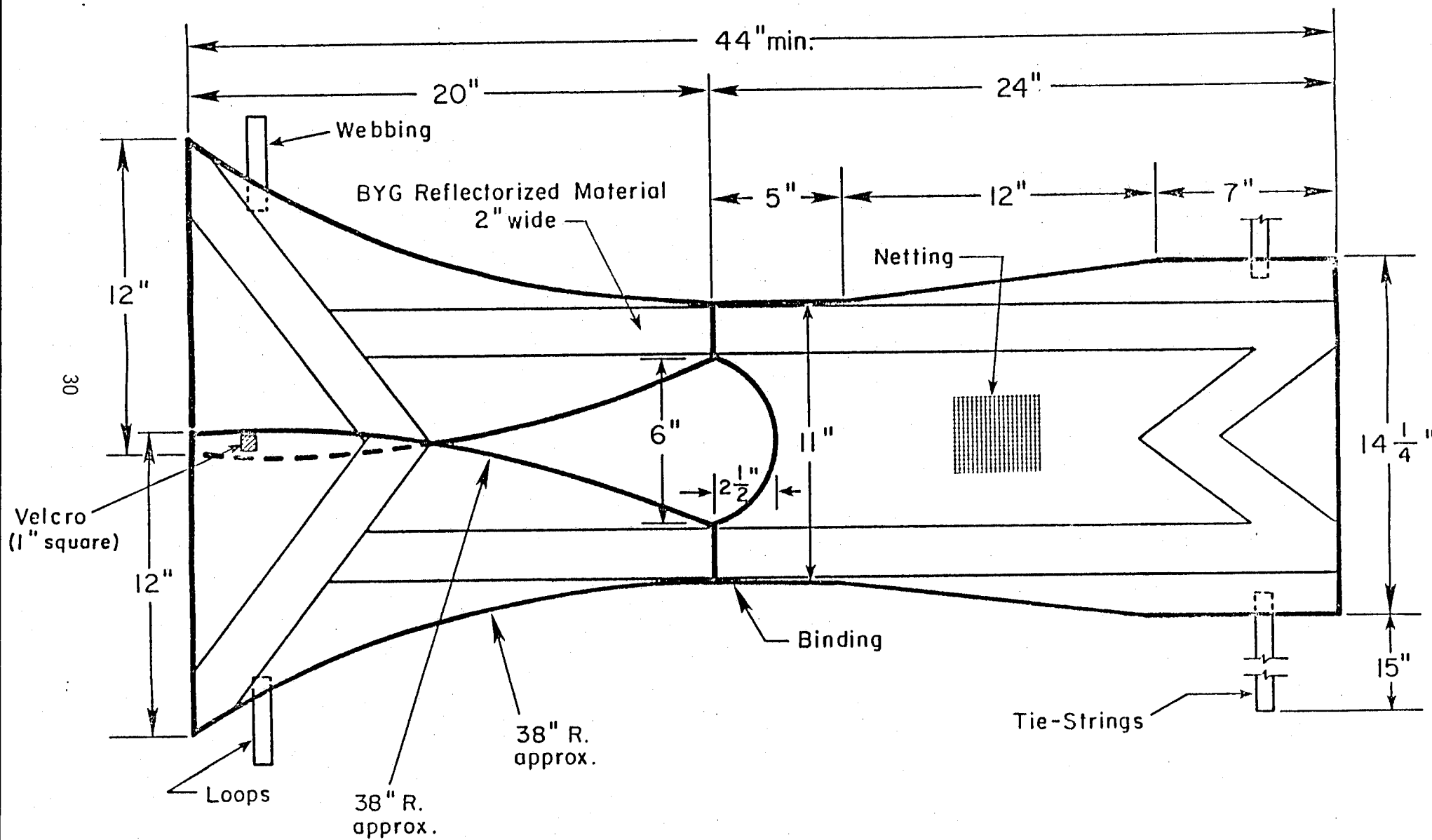


Figure 5.3 Recommended

SAFETY VEST

SINGLE SIZE

criteria. The single dimension of communications ability, using mostly standard messages and gestures, was used to determine if the new concept warranted further consideration.

The concept of the changeable message paddle developed in the course of this study has certain advantages. Aside from the flexibility of displaying many messages, the CMP is more readily understood than the commonly used flag, and more manageable and lighter than the STOP and SLOW paddle. It also requires little training for its use. It is recommended that the potential of this device be further explored to determine the feasibility of producing it in its present or some alternative configuration.

6.0 REFERENCES

1. Handbook of Safe Practices, SDHPT, Insurance Division.

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3. Manual on Uniform Traffic Control Devices for Streets and Highways, U.S. DOT, FHWA, Washington, D.C., 1978.

4. Richards, S.H., Huddleston, N.D., Bowman, J.D., Driver Understanding of Work Zone Flagger Signals and Signaling Devices, Research Report 228-3. Texas Transportation Institute and Texas State Department of Highways and Public Transportation, College Station, Texas, January 1981.

5. Richards, S. H., Wunderlich, R. C., Dudek, C. L., and Brackett, R.Q., Improvements and New Concepts For Traffic Control In Work Zones, Final Report #DTFH61-81-C-00102. Federal Highway Administration, December 1983.

7.0 APPENDIX

7.1 First Vest Questionnaire

7.2 Second Vest Questionnaire

7.3 Summary of Results of First Questionnaire

7.1 FIRST VEST QUESTIONNAIRE

Please answer the following questions.

1. How many years have you worked with the Texas SDHPT?

2. What type of job with the SDHPT do you perform most often?

3. What is your sex?

4. What is your age?

---

1. Which safety vest can be seen the easiest during the day? Circle your answer.

New Trial Vest  or Vest you used up to now

2. Which safety vest can be seen the easiest after dark? Circle your answer.

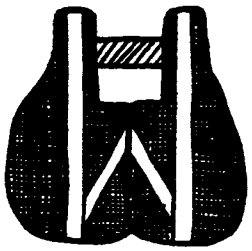
New Trial Vest  or Vest you used up to now

3. Did either safety vest fall apart? Check ( ) yes, or ( ) no. If you checked yes, which vest was it? Circle your answer.

New Trial Vest  or Vest you used up to now

4. Which safety vest is more comfortable to wear? Circle your answer.

New Trial Vest



or

Vest you used up to now

5. Which safety vest is hotter to wear? Circle your answer.

New Trial Vest

or

Vest you used up to now

6. Does either safety vest cut into you anyplace? Check either ( ) yes, or ( ) no. If yes, which one? Circle your answer.

New Trial Vest

or

Vest you used up to now

Where does it cut?_____

7. Does either safety vest come unfastened? Check either ( ) yes, or ( ) no. If yes, which one? Circle your answer.

New Trial Vest

or

Vest you used up to now

8. Does either safety vest cause you to get a rash or sunburn? Check either ( ) yes, or ( ) no. If you checked yes, which vest is it? Circle your answer.

New Trial Vest  or Vest you used up to now

9. Do the shoulder straps on either safety vest fall down? Check either ( ) yes, or ( ) no. If yes, which one? Circle your answer.

New Trial Vest  or Vest you used up to now

---

10. Do you think that the vests need to be different sizes?

11. Do you have any additional comments?

7.2 SECOND VEST QUESTIONNAIRE

Please answer the following questions.

1. How many years have you worked with the Texas SDHPT?
2. What type of job with the SDHPT do you perform most often?
3. What is your sex?
4. What is your age?

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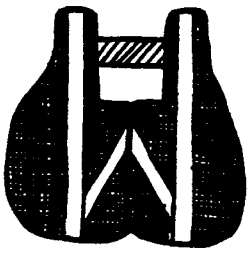
1. Which safety vest can be seen the easiest during the day? Circle your answer.

Trial Vest 'll'

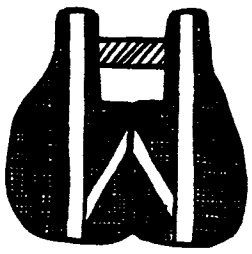


Trial Vest 'W'

Vest you wore before the experiment began.

2. Which safety vest can be seen the easiest after dark? Circle your answer.

Trial Vest 'll'



Trial Vest 'W'

Vest you wore before the experiment began.

3. Did either safety vest fall apart? Check ( ) yes, or ( ) no. If you checked yes, which vest was it? Circle your answer.

Trial Vest 'll'

Trial Vest 'W'

Vest you wore before the experiment began.

4. Which safety vest is more comfortable to wear? Circle your answer.

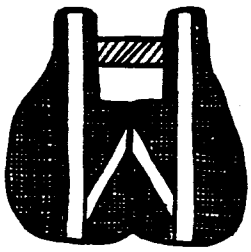
Trial Vest 'll'

Trial Vest 'W'

Vest you wore before the experiment began.

5. Which safety vest is hotter to wear? Circle your answer.

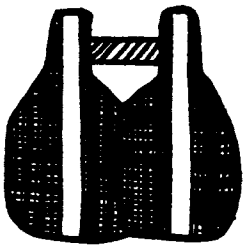
Trial Vest 'll'



Trial Vest 'W'

Vest you wore before the experiment began.

6. Does either safety vest cut into you anyplace? Check either ( ) yes, or ( ) no. If yes, which one? Circle your answer.



Trial Vest 'll'

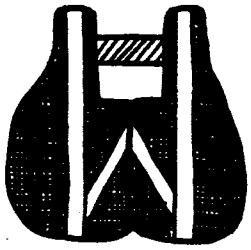
Trial Vest 'W'

Vest you wore before the experiment began.

Where does it cut?_____

7. Does either safety vest come unfastened? Check either ( ) yes, or ( ) no. If yes, which one? Circle your answer.

Trial Vest 'll'



Trial Vest 'W'

Vest you wore before the experiment began.

8. Does either safety vest cause you to get a rash or sunburn? Check either ( ) yes, or ( ) no. If you checked yes, which vest is it? Circle your answer.

Trial Vest 'll'

Trial Vest 'W'

Vest you wore before the experiment began.

9. Do the shoulder straps on either safety vest fall down? Check either ( ) yes, or ( ) no. If yes, which one? Circle your answer.

Trial Vest 'll'

Trial Vest 'W'

Vest you wore before the experiment began.

---

10. Do you think the vests need to be different sizes?

11. Do you have any additional comments?

TEXAS A&M UNIVERSITY
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COLLEGE STATION TEXAS 77843

HUMAN FACTORS DIVISION

February 14, 1984

MEMO

TO: 2330 Project Staff

FROM: Mark Stuart

SUBJECT: Summarization of the Safety Vest Questionnaire Results

QUESTION	AMARILLO (VEST '11') TRIAL	AMARILLO (VEST '11') OLD	MIDLAND (VEST 'W') TRIAL	MIDLAND (VEST 'W') OLD	SOUTH TEXAS (VEST '11') TRIAL	SOUTH TEXAS (VEST '11') OLD	HOUSTON (VEST 'W') TRIAL	HOUSTON (VEST 'W') OLD
1. Most Visible during the day?	16	0	33	6	40	6	16	0
2. Most Visible at night?	12	1	31	3	41	2	10	1
3. Did either vest fall apart?	3	1	18	1	27	9	1	0
4. Which is more comfortable?	16	0	6	30	20	23	8	5
5. Which vest is hottest?	0	14	15	8	19	14	4	11
6. Did either vest cut in anyplace?	3	4	12	3	9	5	1	7
7.Did either vest come un-fastened?	4	3	18	5	20	8	5	5
8. Did either vest cause a rash or sunburn?	2	2	6	3	4	3	1	0
9. Did the shoulder straps on either vest fall down?	4	3	27	4	31	1	11	0

OUTLINE FOR FINAL REPORT FOR PROTECTION OF PERSONNEL IN MAINTENANCE AND CONSTRUCTION ZONES

I. INTRODUCTION

A. BACKGROUND
   1. Discussion of all three topic areas

B. OBJECTIVES
   1. To distribute two versions of the improved safety vests to various climatic regions in Texas and evaluate their utility.
   2. To establish the criteria for and to evaluate "special use" safety garment.
   3. To compare special devices, such as stop and go paddles with the standard flagging procedures in terms of their ability to communicate with motorists.

C. ORGANIZATION OF REPORT

II. FIELD EVALUATION OF IMPROVED SAFETY VESTS

A. APPROACH
   1. Tasks

B. RESULTS

C. CONCLUSIONS

III. SPECIAL USE GARMENT EVALUATION

A. APPROACH
   1. Tasks

B. RESULTS

C. CONCLUSIONS

IV. EVALUATE COMMUNICATION DEVICES USED BY FLAGPERSONS

A. APPROACH
   1. Tasks

B. RESULTS

C. CONCLUSIONS

V. RECOMMENDATIONS

A. FOR VESTS

B. FOR GARMENTS

C. FOR FLAGS