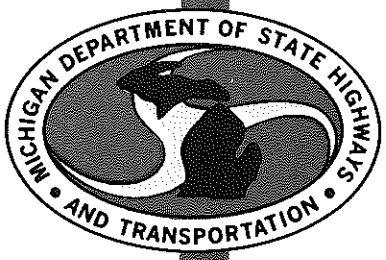
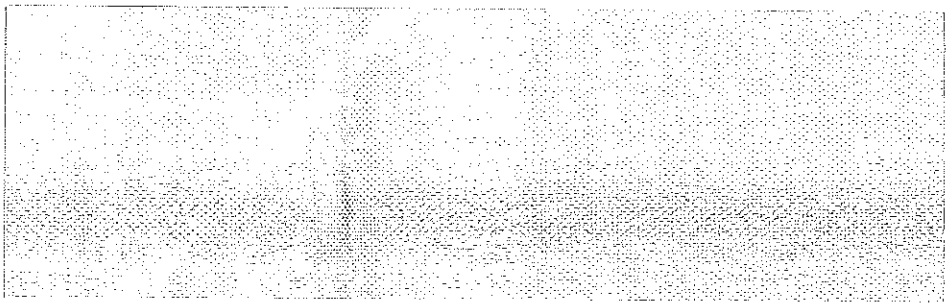
REFLECTORIZED TRAFFIC REGULATOR VESTS

Progress Report



TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION



TH7970.R4 J36 1980 c. 2
Reflectorized traffic
regulator vests : progress
report

REFLECTORIZED TRAFFIC REGULATOR VESTS

Progress Report

M. H. Janson
G. M. Smith
J. D. Truax

Research Laboratory Section
Testing and Research Division
Research Project 77 G-229
Research Report No. R-1135

Michigan Transportation Commission
Hannes Meyers, Jr., Chairman; Carl V. Pellonpaa,
Vice-Chairman; Weston E. Vivian, Rodger D. Young,
Lawrence C. Patrick, Jr., William C. Marshall
John P. Woodford, Director
Lansing, April 1980

In response to the Department's request of January 25, 1977, concerning the pattern shape and reflectorized color for traffic regulator apparel the NAC Subcommittee on Construction and Maintenance recommended additional experimentation. Departmental Report No. R-1021, dated September 1976, which was submitted with the request had recommended a yellow 'stick man' reflectorized pattern. In a November 1, 1977 letter to J. P. Woodford, R. E. Conner of the Office of Traffic Operations, FHWA, transmitted an Official Ruling Cn-35 and recommended that a proposal for further research be submitted with the consideration that:

"1. Your previous research has been static testing only.

2. The introduction of yellow into the construction zone would be a significant departure from the currently recognized color code.

3. Your 'stick man' figure was never night tested against a fully reflectorized vest. This should be a major focus on further research, regardless of the fact that the fully reflectorized vest may have less daytime visibility."

Consequently, on March 1, 1978, our Engineering Operations Committee approved a proposal entitled, "Proposal for a Research Study for Further Research on Reflectorized Flagman's Vests," Research Project 77 G-229.

Because the "currently recognized color code" (2 above) as mandated by the Federal Manual on Uniform Traffic Control Devices (MUTCD) is orange, and because the traffic regulator vest in use in Michigan and in many other states is a fluorescent yellow-orange or 'blaze orange,' a search for an available fluorescent reflectorized material was conducted.

The search continued for more than a year when it was learned that the Reflexite Corp. (199 Whiting St., New Britain, CT, 06051) had developed a fluorescent and reflectorized material. The material was fluorescent yellow-orange under daylight illumination and showed an acceptable reflected yellow-orange color under headlight illumination. Sufficient material to fabricate two vests was received in September 1979. The results were expected to substantiate previous observer data on pattern preference from static tests, to investigate preferences for pattern vs. non-pattern vests, to evaluate brightness preferences, and to establish a basis for a series of tests.

In this initial test it was decided to use the fluorescent yellow-orange color but a nonfluorescent orange vest was included to obtain a luminance

difference at twilight. The tests were conducted at night and at twilight but weather circumstances permitted conducting an additional test at night during an extremely heavy fog. Patterns on vests were varied and luminance was varied by controlling exposed areas. Observers in moving vehicles recorded their preferences from paired comparisons of six orange vests.

Results indicate that the brighter the vest the better, and that a distinctive pattern is preferred. This report is intended to describe initial test procedures and materials along with the results obtained in testing orange traffic regulator vests.

Test Procedures

Materials and procedures were developed for the nighttime evaluations first because reflectorized pattern effects were considered the primary concern. On the basis of previous test procedures side-by-side presentations of vests but separated by a regulator sign were planned. The Reflexite vest as received was easily adapted to become the front half of two vests that could be presented flat to emphasize the patterns with little or no differences in reflectorized color or brightness. Masks that were prepared to control brightness and to reveal the various patterns were matte black and, therefore, would not be noticeable or considered during nighttime observations.

Because of lack of ventilation in the vest as tested, it is very important to note that a full tunic fluorescent reflectorized vest made from the Reflexite material would require the uniform reduction of exposed area in order to obtain a practical traffic regulator's vest, i.e., one which would be comfortable to wear.

Masks complicated twilight procedures because the black mask did not uniformly reduce daytime brightness and the outline shape of the mask did not have the appearance of a traffic regulator vest. Preliminary daylight observations showed that the exposed nighttime pattern areas were not conspicuous. Arbitrarily, it was decided to double the daytime pattern areas using a non-reflective fluorescent material. From the figures it can be seen that the pattern shapes were altered slightly but retained their identification.

Daylight brightness control was limited to the use of fluorescent or nonfluorescent colors and, therefore, material with an orange color similar to construction orange was used for one of the vests to be observed at twilight. Since twilight observations were made with low-beam headlights on, brightness effects obtained from the reflectorized and fluorescent material as retro-reflective brightness competed with daylight diffuse reflective brightness.

Six vests were constructed as follows:

Vest A - Consisted of fluorescent and reflective material, shaped as a tunic and presented a reflective area of 568 sq in. The front half of the vest was mounted flat on plywood (Fig. 1).

Vest B - Consisted of a masonite mask containing 1-3/4 in. holes bored in such a pattern that when the mask was placed in front of Vest A the vest had approximately 2/3 the reflective intensity of Vest A. The vest presented a reflective area of 342 sq in. (Fig. 2).

Vest B_t - Consisted of a fluorescent traffic regulator's vest as supplied from the Department's Central Warehouse, Item No. 5750-8535. The vest was shaped as a tunic like Vest A but was non-reflective. The vest was used in the twilight presentations.

Vest C - Consisted of a masonite mask containing 1-3/4 in. holes bored in such a pattern that when the mask was placed in front of Vest A, the vest had approximately 1/3 the reflective intensity of Vest A. The vest presented a reflective area of 185 sq in. (Fig. 3).

Vest C_t - Consisted of highway orange colored material as obtained from Department coveralls, Central Warehouse, Item No. 4412-7122. The vest was tunic shaped like Vest A, was non-reflective, nonfluorescent, and was used in the twilight presentations.

Vest D - Consisted of a mask such that when it was placed in front of Vest A the pattern of a 'stick man' was seen. A reflective area of 210 sq in. was presented.

Vest D_t - Consisted of Vest D with an expanded figure made of fluorescent material with a total fluorescent area of 383 sq in. Vest D_t was used in the twilight presentation (Fig. 4).

Vest E - Consisted of a mask with the pattern such that when the mask was placed in front of Vest A a reflectorized double chevron was seen by the observer. A reflective area of 211 sq in. was presented.

Vest E_t - Consisted of Vest E plus an expanded fluorescent pattern with a total of 400 sq in. This vest was used in the twilight presentation (Fig. 5).

Vest F - Consisted of a mask with a pattern such that when the mask was placed in front of Vest A a pattern of three horizontal bars was presented to the observer. A reflective area of 210 sq in. was presented.

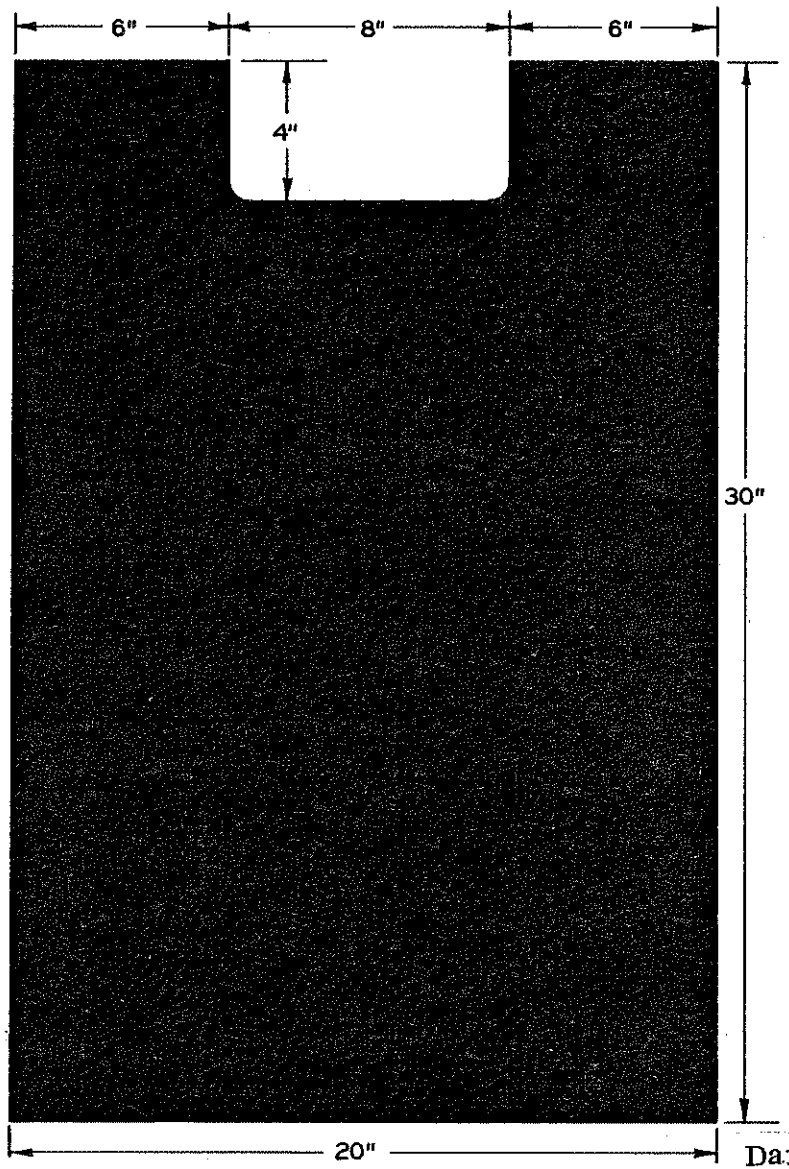
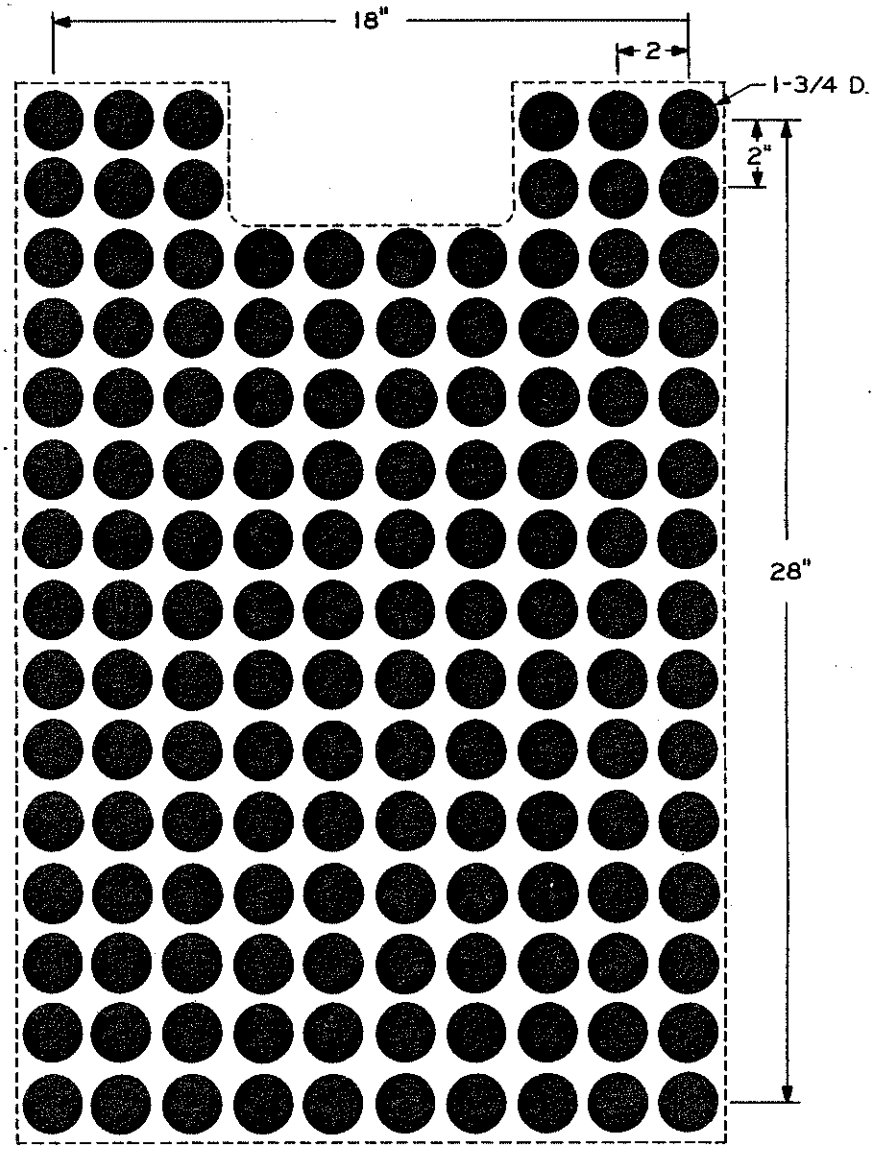
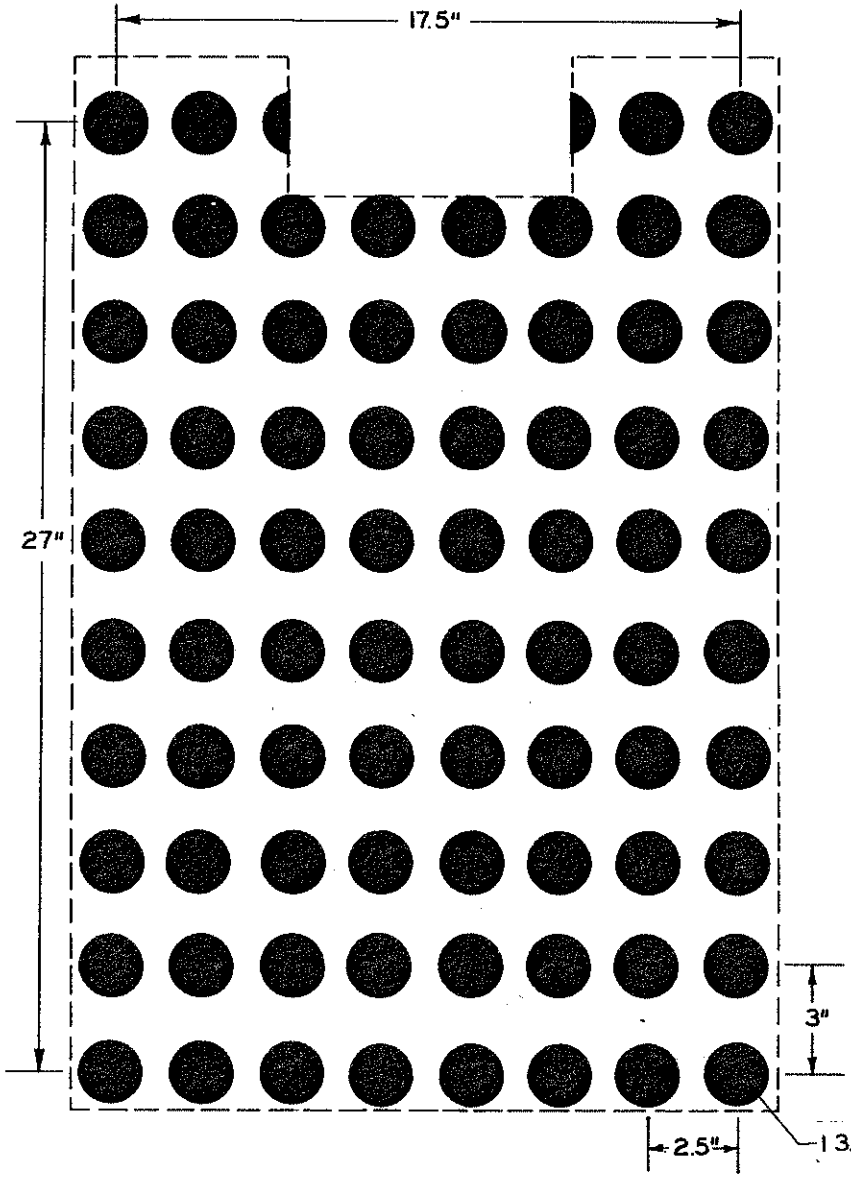


Figure 1. Vest A (nighttime), dark area.



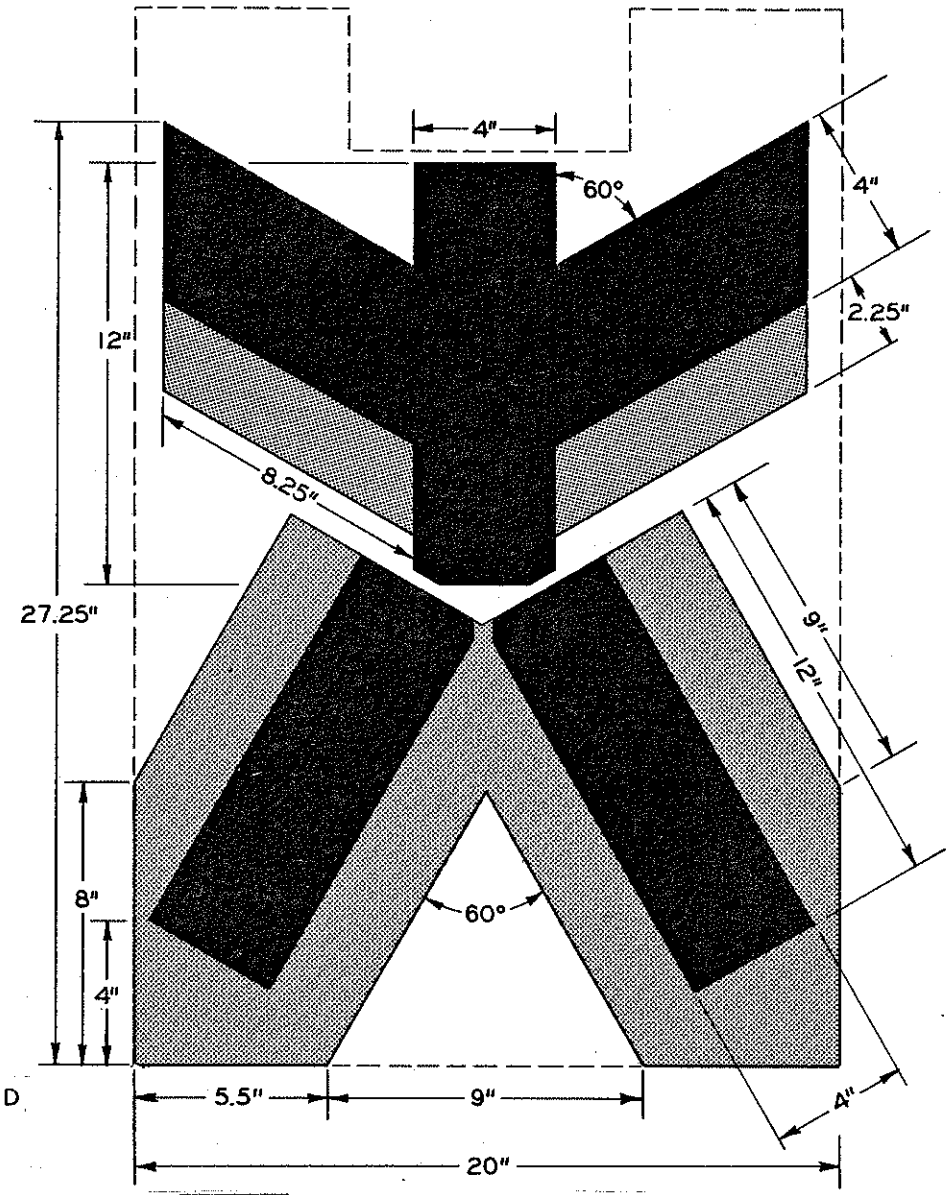
Dark area: fluorescent and reflectorized.

Figure 2. Vest B (nighttime), dark area.



Dark area: fluorescent and reflectorized.

Figure 3. Vest C (nighttime), dark area.



fluorescent and reflectorized

fluorescent but not reflectorized

Figure 4. Vest D (nighttime), dark area; Vest D_t (twilight), dark area and gray area.

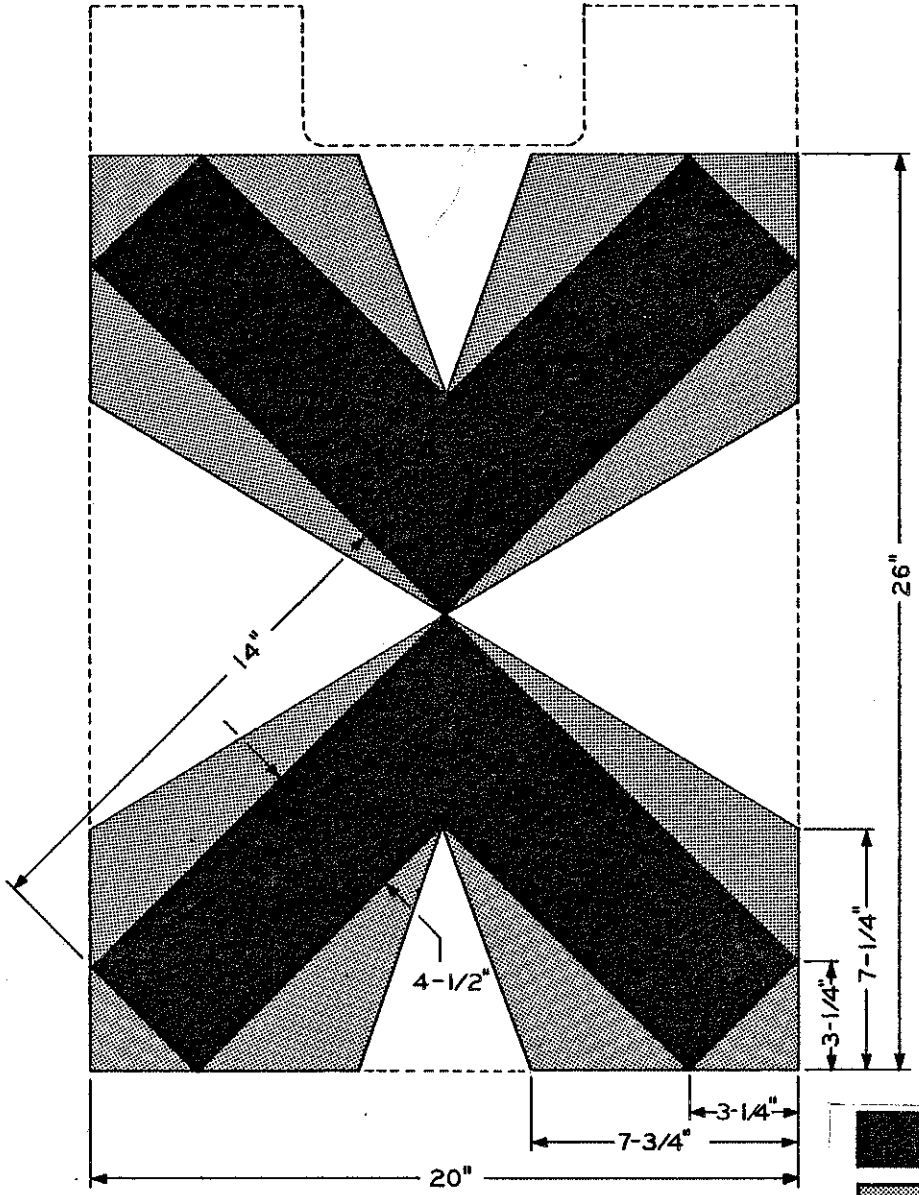


Figure 5. Vest E (nighttime), dark area; Vest E_t (twilight), dark area and gray area.

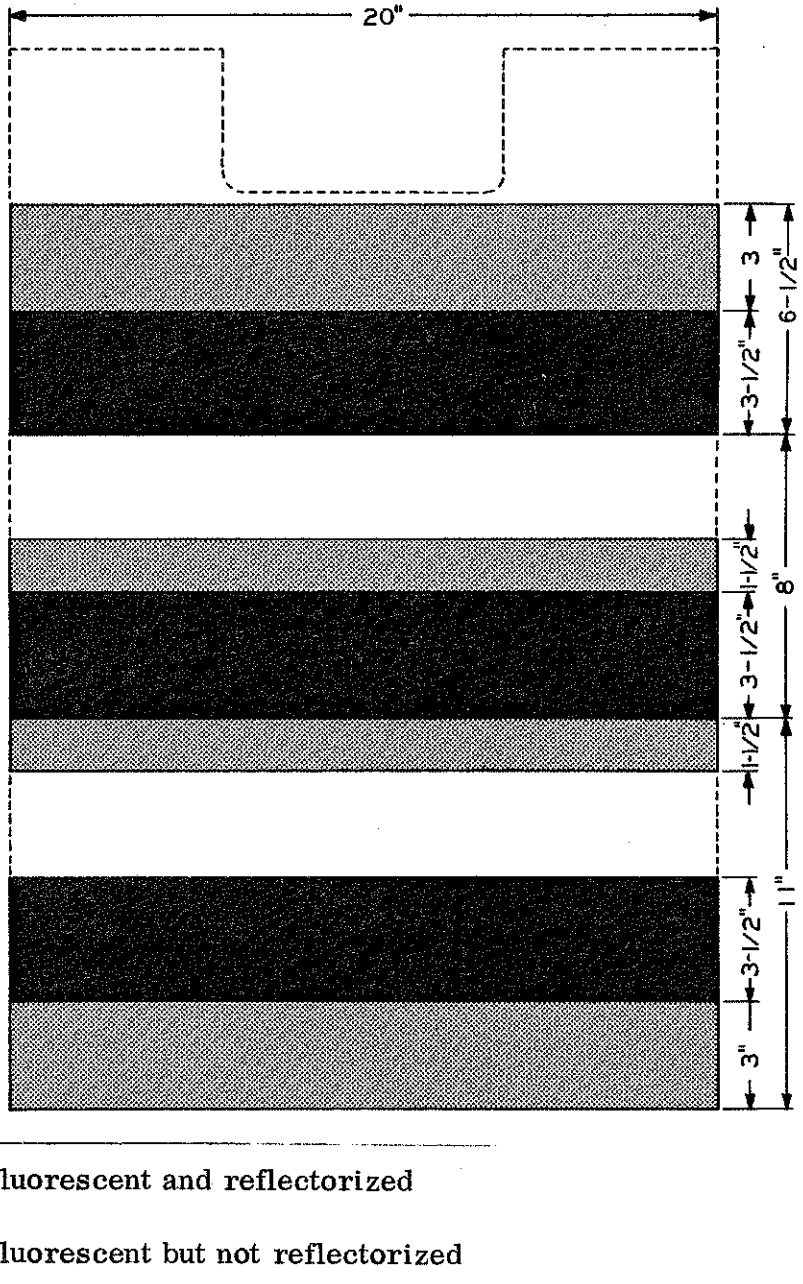


Figure 6. Vest F (nighttime), dark area; Vest F_t (twilight), dark area and gray area.

Vest F_t - Consisted of Vest F plus an expanded fluorescent pattern with a total of 390 sq in. This vest was used in the twilight presentation (Fig. 6).

The vests were separated into two groups of six vests each. Group 1 (A, B, C, D, E, F) was used at night while Group 2 (A, B_t, C_t, D_t, E_t, F_t) was used at twilight.

Vest Evaluation

The vests were presented to the observer in a series of 15 pairs such that each one of the six vests was compared with every one of the other five vests. For each pair presentation, the observer was asked to indicate which vest he considered to be the better vest. A criterion for the comparison was the question: "Which vest would you feel safer wearing on a dark night?" The observers were also asked to choose the better vest using the criteria: attention-getting, recognizability, and conspicuity. Each pair of vests were spaced 4 ft apart. A 24-in. diameter stop sign with an 8-in. legend standing at a 6-ft bottom height was located midway between the vests. The pair presentation order was randomized for each group of 8 to 12 observers.

The observer-driver was requested to drive toward the vests at about 45 mph using lower beam headlamps and starting at a distance of 1,500 ft. All observers were requested to make their choices at a 700-ft distance and again at 450 ft. These distances were selected because it was judged that the driver should be able to detect the flagman before and certainly soon after the "FLAGMAN, 500 FT" sign required by the MUTCD.

Three to four observers were seated in each of three vehicles. The seating positions were driver, front right, rear right and left. Drivers of following observer vehicles were instructed to initiate their run after the preceding observer car was out of sight so that possible taillight effects would be eliminated.

The tests were run at night in a rural area on one side of an unopened section of Interstate highway, with a median in excess of 50 ft. There was a small amount of traffic using the opposing lanes, which did not affect the test. Three orange reflectorized construction signs were placed on the right shoulder at 1,000, 500, and 250 ft from the vests. The observer vehicle's headlamps were aimed visually in accordance with the 1974 SAE Standard No. J599c.

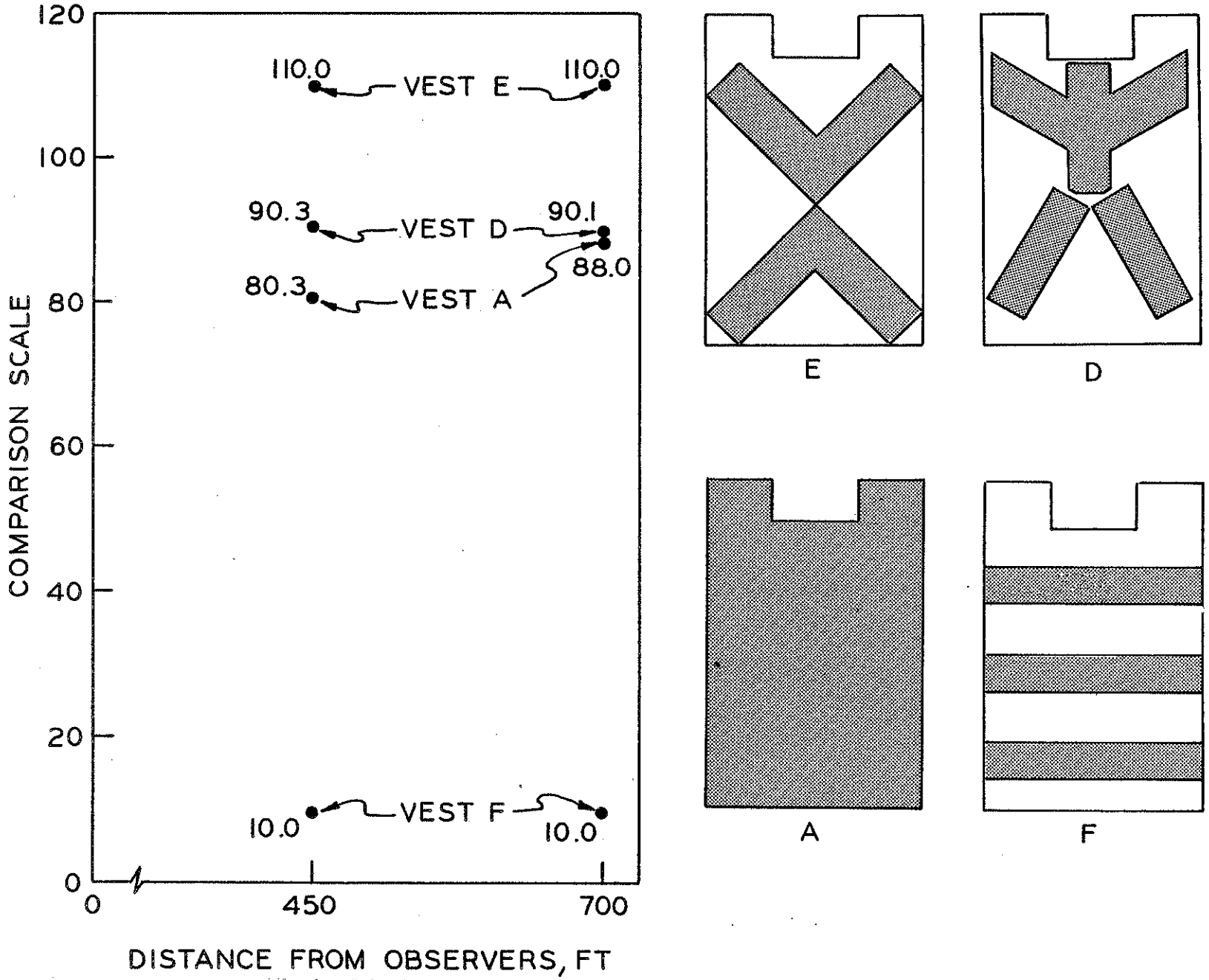


Figure 7. Relative observer responses at night to vests A, D, E, and F in pair comparison tests.

Average vest luminances in foot-Lamberts (ft-L) as measured by a Model 1980 Pritchard telephotometer from the driver's eyes position were as follows:

Distance from Vest, ft	Luminance, ft-L	
	Left Vest	Right Vest
450	2.6	4.1
700	2.1	3.1
*	0.8	1.8

* Average vest luminance in dense fog at 130 ft.

Because low beams were used the vest on the right was brighter. Each vest appeared an equal number of times on the left and on the right. The vest luminances at twilight at 450 ft ranged as follows:

Vest Material	Luminance, ft-L
Reflectorized	32.0 - 2.6
Fluorescent Tunic	22.0 - 0.9
Orange Coveralls	6.1 - 0.3

The twilight observations began 15 minutes before sunset. The natural illumination on the vests from the twilight sky (measured by International Light Research Photometer Model IL710A) ranged from 7.6 to 0.25 foot-candles (ft-c). Below 0.25 ft-c, observer responses became similar to those made at night.

Results

Nighttime - The observer choices of pattern shape were scaled according to a statistical pair comparison method. The results are shown in Figure 7. In this method, the vertical scale is arbitrary, the values being dimensionless. However, the relative positions and spacing of the vests on the scale are significant. Vest E (Fig. 5) is clearly preferred over the other vests. The 'stick man' Vest D (Fig. 4) is next, followed closely by the fully reflectorized Vest A (Fig. 1). The fully reflectorized vest has a higher relative preference at 700 ft where the patterns are less distinctive.

Table 1 shows the percent of total choices made by 35 observers for each vest for the nighttime study.

TABLE 1
OBSERVER RESPONSES IN NIGHTTIME

Viewing Distance, ft	Percent of Total Responses						
	Comparison of Vest Pattern				Comparison of Vest Luminance		
	A	D	E	F	A	B	C
700	28.6	29.5	37.1	4.8	59.0	38.1	2.9
450	26.7	28.1	35.7	9.5	60.0	32.4	7.6

The comparison of vest pattern shape in Table 1 confirms the results shown in Figure 7, viz, that vest pattern E (Fig. 5) was preferred. Vest A with approximately three times the reflective area of Vests D, E, and F was third-most preferred.

The comparison of vest luminances shows that Vest A, the brightest, is predominantly preferred while Vest C, which was roughly 1/3 the luminance of Vest A, was chosen a very small percentage of the time. Even at 700 ft from where it was difficult to distinguish pattern shape, the observers preferred pattern shape E over the fully reflectorized Vest A.

The differences between patterned vests and a non-patterned fully reflectorized vest become more pronounced when Vest C was compared with Vests D, E, and F, below in Table 2. Vest C, while unpatterned, had the same reflective area as either Vests D, E, or F.

TABLE 2
PERCENT OF TOTAL RESPONSES

Viewing Distance, ft	Comparison of Vest Pattern			
	C	D	E	F
700	4.8	36.2	42.8	16.2
450	4.8	34.3	41.4	19.5

Fog - Table 3 lists the results of the nighttime fog study in which nine observers participated. The vest was invisible at 700 ft.

TABLE 3
OBSERVER RESPONSES IN NIGHTTIME FOG

Viewing Distance, ft	Percent of Total Responses						
	Comparison of Vest Pattern				Comparison of Vest Luminance		
	A	D	E	F	A	B	C
450	44.4	33.3	22.2	0.0	63.0	37.0	0.0

Fully reflectorized Vest A attracted the greatest percent of choices with the 'stick man' pattern next. Observers remarked that pattern shapes were indistinct, and that pattern A was somewhat brighter than D, E, and F.

Twilight - Table 4 shows the observer responses in twilight. Twelve observers took part.

TABLE 4
OBSERVER RESPONSES IN TWILIGHT

Viewing Distance, ft	Percent of Total Responses						
	Comparison of Vest Pattern				Comparison of Vest Luminance		
	A	D	E	F	A	B_t	C_t
700	40.3	29.2	26.4	4.2	66.7	33.3	0.0
450	38.9	30.6	25.0	5.6	66.7	33.3	0.0

Fluorescent tunic (shape identical to Vest A).
Orange coveralls (shape identical to Vest A).

Vest pattern A was judged superior. Some observers said that the vest patterns in twilight appeared relatively formless just as they had in the nighttime fog test. As the vest illumination fell below 0.25 ft-c (natural illumination) the observer responses reverted to nighttime responses.

The comparison of luminances in Table 4 demonstrated that a vest which was both fluorescent and reflectorized, Vest A, was strongly preferred over a vest which was fluorescent only, Vest B.

Questionnaire

All observers were surveyed prior to beginning their observations. The questions and answers of the 45 persons who responded to our questionnaire are shown in Figure 8. Most of the observers were very familiar with traffic regulator use. Twenty-six had worked in traffic, 16 as traffic regulators.

Those that have worked in traffic preferred vest patterns D and E over the fully reflectorized Vest A. Those observers who had not worked in traffic preferred by a small margin, the fully reflectorized Vest A over the three patterned Vests D, E, and F and those persons experienced with traffic operations preferred a reflectorized vest pattern with an identifiable shape. Some comments from the experienced observers indicated that a pattern shape was necessary to distinguish the traffic regulator's vest from other lights in the field of view such as headlights.

Conclusions and Recommendations

Results of this initial test indicate that:

1. For nighttime and twilight use, vest pattern E (Fig. 5) is preferred. Even though a fully reflectorized vest was the observer choice in twilight, vest pattern E is recommended since vest pattern E is fluorescent as well as reflectorized and will lend a fully fluorescent appearance to the vest. Thus, in twilight, vest pattern E appeared to be the same size as the fully reflectorized vest and had nearly as much luminance.

The results of this study, with observers riding in vehicles, verified previous Department studies with stationary observers.

2. Other factors that should be investigated are:

   a) vest color - orange, white, yellow, and red,
   b) observers viewing vests against on-coming headlights,
   c) vests turned through various angles, and
   d) urban situation.

3. The Reflexite material should undergo field trials of up to one year on construction projects to determine feasibility and durability.

4. The effect of reflectorized gauntlets, leglets, and hats in addition to the reflectorized vest should be investigated.

QUESTIONNAIRE

Please answer the following questions:

Question	Number of Observers Answering
1. Do you think it is more important to notice the flagger's vest or the STOP sign held by the flagger.	
a) Flagger's Vest	13
b) Stop Sign	9
c) Equal Importance	19
2. Should the flagger's vest appearance be unique?	
Yes	36
No	5
3. Do you think that the flagger's vest should have the same appearance day and night?	
Yes	31
No	10
4. Have you ever worked in traffic?	
Yes	26
No	15
As a traffic regulator?	
Yes	16
No	25

Figure 8.

5. The stop sign luminance should be increased and ideally the stop sign should be internally illuminated; however, this should be investigated. Most observers said they had not seen the stop sign even though they considered stop signs important.

6. Fabrication of the vests should be investigated to determine the most economical procurement.

7. It should be re-emphasized that fully reflectorized Vest A is not practical because it would be too warm for extended use by a traffic regulator. Removing a substantial amount of the material to provide ventilation may be necessary.