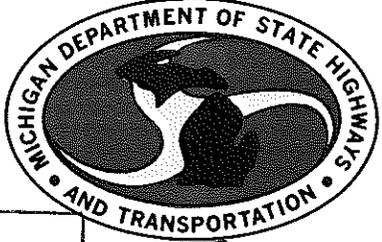


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BRIGHTNESS STUDY AND SPECIFICATION
COMPLIANCE SURVEY OF
ARROW-BAR TRAFFIC CONTROL SIGNS



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TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

**BRIGHTNESS STUDY AND SPECIFICATION
COMPLIANCE SURVEY OF
ARROW-BAR TRAFFIC CONTROL SIGNS**

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**Research Laboratory Section
Testing and Research Division
Research Projects 76 TI-361
and 76 TI-373
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**Michigan State Highway Commission
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Vice-Chairman, Hannes Meyers, Jr., Weston E. Vivian
John P. Woodford, Director
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INTRODUCTION

The study reported here resulted from a complaint by Stanley Huey, a truck driver for Wolverine Express Company of Muskegon. He stated that the flashing arrow sign was too bright at night for truck drivers. Mr. Huey said that the truckers' approximate height of 9 ft above the pavement positions them more directly in line with the main beams of the arrow-bar lamps than is the case for automobile drivers.

In order to ascertain the extent, if any, of glare caused by the arrow-bar sign, one of the two units assigned to the Research Laboratory (Unit No. 12-5024) was selected for photometric evaluation. The unit was a Type A arrow-bar sign, 48 by 96 in. with a bottom height of 7 ft. The 15 lamps mounted in the sign were No. 4412A automotive sealed beam fog lamps with amber lenses.

Prior to conducting the photometric study the Laboratory's units were checked for compliance with the specifications. This check disclosed many hardware and performance discrepancies. After discussion with M. N. Clyde and K. A. Allemeier, it was decided that the Laboratory would undertake a survey of the Department's arrow-bar units to determine the degree of specification compliance and the possible need for acceptance testing and/or continuing inspection.

This report is, therefore, divided into two separate sections. The first reports the results of a photometric evaluation of one, typical arrow-bar sign and the second, the results of a survey of the operation and hardware of over one-half of the Department's 102 arrow-bar signs. The photometric evaluation was conducted by the Laboratory's Photometry Group and the survey by the Instrumentation and Data Systems Group.

BRIGHTNESS STUDY OF ARROW-BAR TRAFFIC CONTROL SIGN IN NIGHT PHASE

Before evaluating the subject arrow-bar sign, specification deficiencies were corrected as necessary. Inspection showed that it was necessary to replace one burned-out lamp and to rewire another unlighted lamp. Operation of the left and right arrow showed that the lamp in the arrow shaft adjacent to each arrow head remained lighted. Standard Specification 6.31.02h, Lighted Arrow, Types A and B, 1976, requires that the lamps next to the arrow heads not be lighted when the arrow heads are flashing.

TABLE 1
GLARE FROM LEFT AND RIGHT ARROW

Range	Driver Position (With Respect to Center of Sign)				Glare in ft.-L at Lamp Voltage			
	Distance, ft		Angular Distance, deg		5.7	6.5	8.4	12.0
	Vertical	Horizontal	Vertical	Horizontal				
50	0	0	0	0	4.19	7.17	18.60	67.9
50	0	7.0 right	0	8 right	2.12	3.62	9.40	34.3
75	0	0	0	0	2.82	4.82	12.50	45.8
100	1 up	0	0.6 up	0	1.06	1.82	4.72	17.2
100	0	0	0	0	1.51	2.58	6.70	24.5
100	0	3.5 right	0	2 right	1.28	2.18	5.66	20.7
100	0	7.0 right	0	4 right	1.31	2.23	5.79	21.2
100	1 down	0	0.6 down	0	1.29	2.20	5.71	20.9
100	2 down	0	1.1 down	0	0.86	1.47	3.83	14.0
100	3 down	0	1.7 down	0	0.53	0.90	2.34	8.6
100	4 down	0	2.3 down	0	0.26	0.44	1.15	4.2

The control switches in the arrow-bar sign under test, Unit No. 12-5024 were single-throw switches. Double pole, double-throw switches instead are necessary to ensure that the lamps adjacent to the arrow heads are not lighted when the double arrow lamps are lighted. The switches should be wired into the circuit as shown on the shop drawings (September 24, 1971) for a Type A arrow-bar sign. The sign unit was instead wired similarly to the circuit shown in the shop drawing (September 24, 1971) for a Type B sign (nominal 36 by 64 in.).

The voltages applied to the lamps were also checked. A photocell operated switch introduced resistors into the circuit at night to drop the voltage to the lamps. The nighttime operating voltage, specified as 5.7 to 6.5 v, was actually 8.1 to 8.4 v as shown below:

	Left Arrow	Right and Left Arrow	Specification
Night voltages	8.4	8.1	5.7 to 6.5
Day voltages	11.0	10.6	12, minimum

Glare

Glare measurements from the lighted left and right arrow modes of the sign were taken at 100, 75, and 50-ft distances from the sign. The glare measurements were maximized, i. e., 15 lamps were lighted instead of the normal 13 lamps and the Pritchard Photometer was aimed directly at the sign rather than at the pavement. A prudent driver would probably avoid looking directly at the sign as he approached the 100 ft or shorter distances. Table 1 shows the disability veiling brightness, or glare, for various observer positions and for a range of applied voltages at the lamps.

Maximum glare for a truck driver was found at a distance of 50 ft from the sign and opposite the center of the sign; however, it would be very unlikely for a driver to be in this position and still be capable of passing the sign safely.

A glare greater than the practical maximum glare (15 vs 13 lamps) that may be experienced by a truck driver is listed in the second row of Table 1 where the truck driver is 50 ft from the sign and about 7 ft to the right of the sign center. With the lamps operating at the maximum specified nighttime voltage of 6.5, the glare at this driver position is 3.6. Note that the left and right arrow glare would increase more than 2.5 times if the sign were incorrectly operated at 8.4 v such as the laboratory sign evaluated.

The maximized glare level of 3.6 ft-L that a truck driver at a 9-ft eye level above the pavement could experience in viewing the left plus right arrow indication with the lamps at 6.5 v is a higher glare level than normally encountered on the roadway from advertising signs and streetlights. The glare level for each of the left arrow, right arrow, or bar displays would of course be proportionately less or at least half. As mentioned above, the driver may not always be looking directly at the sign at distances less than 100 ft from the sign and therefore would experience much less glare than shown in Table 1.

An automobile driver would experience much less glare than would the average trucker. From Table 1 an automobile driver at 100 ft from the sign and 4 ft below the sign center (most drivers' eye level would be at least 4 ft below the 9 ft sign center) the measured glare was 0.44 ft-L.

Distribution of Light Intensity

A single lamp from the arrow sign was tested for light intensity distribution. It was found to conform generally to the requirements for candela distribution in the SAE Standard for Fog Lamps, J583C. The most intense beams emanate from the fog lamps in a broad, nearly horizontal plane. Intensity of the light rays above and below the horizontal decrease rapidly. It was noted from the intensity distribution, that a truck driver at the height of the sign center, 9 ft above the pavement, may receive as much as six times the light from the lighted arrow sign as the typical automobile driver would receive.

INVENTORY OF ILLUMINATED ARROW-BAR SIGN OPERATION AND HARDWARE

A survey of the operating condition and hardware of State owned Type A Illuminated Arrow-Bar Signs was conducted. In the course of this survey, 54 of the Department's 102 illuminated arrow-bar signs were inspected. The signs were manufactured by ATC, Inc. (1), Bemis (44), and Coffman (9). None were found which would totally comply with Department Standard Specifications 6.31.02 and 6.31.04 (July 1976) and Standard Plan VI-125C (October 1973).

The following items were checked on each sign to determine its compliance with Department requirements:

- 1) Nominal size (48 in. by 96 in.)
- 2) Minimum bottom height above pavement (7 ft)

- 3) Master on-off switch
- 4) Operation mode (LA, RA, LA & RA, and Bar)
- 5) Indicators for operation modes
- 6) Visor configuration and orientation
- 7) Lamp spacing and orientation
- 8) Photoelectric day-night switching
- 9) Daytime voltage at the lamp (12 v)
- 10) Nighttime voltage at the lamp (5.7 to 6.5 v)
- 11) Proper lamps for each operation mode
- 12) Flash rate (25 to 35 flashes per minute)
- 13) Dwell time (40 to 60 percent)

All of the 54 signs inspected conformed with the first four items listed; therefore, those items are excluded from Table 2 which details the inspection findings. The most serious discrepancy uncovered is in the operating voltage at the lamps, where only seven of the inspected signs conformed with both daytime and nighttime voltage levels. It was also found that 14 of the signs had defective photoelectric circuits, and would not automatically switch lamp voltage between daytime and nighttime levels. The one sign manufactured by ATC, Inc. was not even equipped with a photoelectric switching circuit.

Other important discrepancies were found in the flash rate where 19 signs had an improper flash rate and three would not flash at all. Also, 18 signs had lamps which were oriented incorrectly including two 1976 Bemis models which had all 15 lamps upside down.

A less serious discrepancy, although indicative of the magnitude of noncompliance, was that 49 of the 54 signs had incorrect lamp usage in the various modes. Of these, 40 simply used seven lights in the light bar mode instead of the five specified in the Standard Specifications (contradicting the Standard Specifications, A&E specification 96.800, July 1975, requires seven lights to be illuminated in the 'Bar' mode of operation).

The operation of the photoelectric switching circuit (Item 8) was determined; however, the ambient light levels necessary for its actuation were not checked due to the lack of necessary light sources and instrumentation. Also, the electrical rating of the operation mode and master on-off switches were not checked due to the major disassembly which would have been required.

TABLE 2
ARROW-BAR INSPECTION SURVEY FINDINGS

Illuminated Arrow-Bar Sign Inventory										
MDSHT Unit Number	Year and Manufacturer	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13
		Mode Indicator(s) Inoperative	Improper Visor Configuration	Improper Lamp Orientation	Photoelectric Circuit Inoperative	Day Mode Lamp Voltage L = Low H = High	Night Mode Lamp Voltage L = Low H = High	Improper Lamp Usage in Operating Modes	Improper Flash Rate	Improper Dwell
12-0002	1976 ATC		X		X	L	L	X		
12-0004	1976 Bemis		X					X		
12-0006	1976 Bemis		X			L	L	X	X	
12-0007	1976 Bemis		X					X	X	
12-0008	1976 Bemis		X			Flash Inoperative		X	Flash Inoperative	
12-0009	1976 Bemis		X	X		L		X		
12-0010	1976 Bemis		X					X		
12-0011	1976 Bemis	X	X	X		L	L	X	X	
12-0012	1976 Bemis		X			L	L	X		
12-0013	1976 Bemis		X			L	L	X		
12-0014	1976 Bemis		X			L	L	X		
12-0015	1976 Bemis		X			L	L	X		
12-0018	1976 Bemis		X				H	X		
12-0019	1976 Bemis		X	X				X		
12-0020	1976 Bemis		X			L	L	X		
12-0021	1976 Bemis		X			L	L	X		
12-0022	1976 Bemis		X					X		
12-0023	1976 Bemis		X					X		
12-0110	1969 Coffman			X		L	L	X	X	
12-0113	1969 Coffman	X		X		L	L		X	
12-0114	1969 Coffman	X		X	X	L	H	X	X	
12-0115	1969 Coffman			X			H		X	
12-0119	1969 Coffman			X		L	L		X	
12-0120	1969 Coffman				X	L	H	X	X	
12-0128	1969 Bemis		X		X	L	H	X		
12-0132	1969 Bemis	X	X			L	L	X		
12-0138	1969 Bemis		X			(Completely Inoperative)				

TABLE 2 (Cont.)
ARROW-BAR INSPECTION SURVEY FINDINGS

Illuminated Arrow-Bar Sign Inventory										
MDSHT Unit Number	Year and Manufacturer	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13
		Mode Indicator(s) Inoperative	Improper Visor Configuration	Improper Lamp Orientation	Photoelectric Circuit Inoperative	Day Mode Lamp Voltage L = Low H = High	Night Mode Lamp Voltage L = Low H = High	Improper Lamp Usage in Operating Modes	Improper Flash Rate	Improper Dwell
12-0139	1969 Bemis	X	X				H	X	X	
12-0141	1970 Bemis		X	X	X	L	H	X		
12-0142	1970 Bemis	X	X			L	H	X	X	
12-0143	1970 Bemis		X			L	H	X		
12-0144	1970 Bemis	X	X			L	H	X		
12-0147	1970 Bemis	X	X	X	X	L	H	X		X
12-0149	1970 Bemis		X	X		L		X	X	
12-0152	1970 Bemis		X	X		L		X	X	
12-0154	1971 Bemis		X			L	L	X		
12-0155	1971 Bemis	X	X			L	L	X		
12-0157	1971 Bemis		X		X	Flash Inoperative		X	Flash Inoperative	
12-0159	1971 Bemis	X	X	X		L	L	X		
12-0162	1971 Bemis	X	X	X		L	L	X		
12-0163	1972 Bemis	X	X	X	X	L		X		
12-0164	1972 Bemis	X	X			L	L	X		
12-0165	1973 Bemis		X				H	X	X	
12-0168	1973 Bemis		X			L	L	X		
12-0172	1973 Bemis		X	X		L	L	X		
12-0175	1973 Bemis		X		X	L	L	X		
12-0176	1973 Bemis		X			L		X		
12-0177	1974 Coffman	X			X	L	H	X		
12-0178	1974 Coffman					L				
12-0183	1974 Coffman	X		X	X		H	X	X	
12-0190	1975 Bemis		X		X	L		X	X	
12-0193	1975 Bemis		X		X	L		X	X	
12-0194	1975 Bemis		X	X				X	X	
12-0195	1975 Bemis		X		X	L		X	X	

A survey of contractor owned signs was not conducted since there are essentially only two arrow-bar manufacturers in Michigan. Therefore, it would be a reasonable conclusion that their signs would exhibit similar performance and hardware conditions as do those of the Department.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Glare can be expected with the operation of warning devices; however, drivers apparently do tolerate high glare levels and do learn to drive through such areas. For example, the amber indication from a 12-in. vehicular traffic signal or intersection flasher subjects truck drivers and passenger car drivers to at least as much glare as the combined left and right arrow indications but complaints are not known to be associated with the signal operation. The comparison is not intended to justify arrow-bar glare, because that glare could be reduced or the time that a driver is exposed to the glare could be reduced. However, reducing glare by substantial reductions in operating voltage in order to decrease light output or changing light sources could affect the desired arrow-bar warning message. In addition, recommending immediate basic sign changes to satisfy this complaint may be premature because it is highly unlikely that the trucker's complaint is related to an arrow-bar which was operating within specification requirements. Visual field inspections of eight arrow-bar signs revealed that six of the eight arrow-bars in service were unsatisfactory. It was not unusual to see arrow-bars with discrepancies similar to those noted on the laboratory's sign.

The results of the large sample of signs studied in this survey indicate a high probability that all of the Department's arrow-bars, and probably those of the contractors, are out of specification.

Recommendations

- 1) A program should be initiated to inspect all the Department's and contractor's arrow-bar signs.
- 2) A program of modification and repair should be implemented to bring all of the Department's arrow-bar signs into compliance with specifications.
- 3) All contractors should be directed to bring their arrow-bar signs into full compliance with specifications.

4) An on-going program of arrow-bar sign acceptance testing should be initiated.

5) An arrow-bar field operation inspection program should be initiated to assure continued proper operation of the units throughout their lives.

6) A thorough review should be undertaken of the specifications being furnished to arrow-bar sign fabricators, by the Department or contractors, to minimize or eliminate inconsistencies, errors, or improper modification authorizations.

7) The currently specified nighttime voltage of 6.5 to 5.7 v should be retained to allow for day-to-day equipment variations. When adjustments are made, the voltage should be set near the 5.7 v limit.

8) Should complaints continue after it is certain that the arrow-bars are operating as specified, then a project is recommended for developing a suitable replacement arrow-bar sign.