PURCHASE SPECIFICATION
LIGHT EMITTING DIODE (LED) SIGNAL MODULES

This specification is for the purchase of light emitting diode (LED) Traffic Signal Modules (herein referred to as modules) in the following configurations: the 300 mm circular sections, the 200 mm circular sections, the 300 mm arrow sections, bicycle sections, programmable visibility sections, and lane control sections.

All devices must meet the general specifications of the Transportation Electrical Equipment Specifications (TEES), Chapter 1--General Specifications, as well as the following specification. Incase of conflict, this specification shall govern over the TEES, Chapter 1.

1 Glossary

Wherever the following terms or abbreviations are used, the intent and meaning shall be interpreted as follows:

AlInGaP	Aluminum indium gallium phosphorus material used in the production of the LED
Cd	Candela. Unit of measurement of light intensity.
Chromaticity	The property of color of light
Conflict monitor	Model 210. A device used to prevent conflicting green phases in conjunction with a Model 170 controller. (see TEES)
Controller unit	Model 170 Traffic Signal Controller that is standard equipment on Caltrans maintained signalized intersections. (see TEES)
GaN	Gallium nitride material used in the production of the LED.
ITE	Institute of Traffic Engineers
LED	Light Emitting Diode.
Load switch	Series of devices used to switch power to signal indicators
MUTCD	Manual on Uniform Traffic Control Devices
METS	Material Engineering and Testing Services of the Translab.
NEMA	National Electrical Manufacturers Association
Power factor	The ratio of the real power component to the total (complex) power component.
PV	Programmable Visibility Head. A traffic signal indication that can be "programmed" to limit the visible area of the indication.
Rated power	The power consumption that the module was designed and tested for at ambient temperature (25C or 77F). See Design Qualification Testing.
TEES	Traffic Electrical Equipment Specifications. A package of standard specifications for traffic electrical equipment to be used on State Highways. This document is compiled by Caltrans Traffic Operations Program.
THD	Total Harmonic Distortion. The amount of higher frequency power on the power line
Type 1 module	LED module that is designed to be mounted in the place of the existing lens of a traffic signal.
Type 2 module	LED module that is designed to be mounted in the place of the incandescent lamp of a traffic signal utilizing the existing lens and lamp socket.
VTCSH	Vehicle Traffic Control Signal Head

2 General

2.1 Each module shall consist of an assembly that utilizes LEDs as the light source in lieu of an incandescent lamp for use in traffic signal sections.

2.2 The LEDs utilized in the modules shall be AlInGaP technology for red, amber and yellow indications, or GaN for green indications, and shall be the ultra bright type rated for 100,000 hours of continuous operation from -40°C to +74°C.

2.3 The modules shall be rated for a minimum useful life of 48 months. All modules shall meet all parameters of this specification during this period.

2.4 The individual LEDs shall be wired such that a catastrophic loss or the failure of one LED will not result in the loss of the entire module.

2.5 Electrical

2.5.1 Power Consumption

2.5.1.1 Maximum power consumption for LED modules is per Table 2-1.

2.5.1.2 LED modules will have EPA Energy Star compliance ratings, if applicable to that shape, size and color.

2.5.2 Operation Voltage

2.5.2.1 The modules shall operate from a 60 HZ ±3 HZ AC line over a voltage ranging from 95 volts to 135 volts. The fluctuations of line voltage shall have no visible effect on the luminous intensity of the indications.

2.5.2.2 Operating voltage of the modules shall be 120 VAC. All parameters shall measured at this voltage.

2.5.3 Power Factor
The LED signal module shall have a power factor of 0.90 or greater.

2.5.4 THD
Total harmonic distortion (current and voltage) induced into an AC power line by a LED signal module shall not exceed 20 percent.

2.5.5 Surge Suppression
The signal module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients as stated in Section 2.1.6 of NEMA Standard TS-2, 1992.

2.5.6 The LED circuitry shall prevent perceptible flicker to the unaided eye over the voltage range specified above.

2.5.7 All wiring and terminal blocks shall meet the requirements of Section 13.02 of the ITE Publication: Equipment and Material Standards, Chapter 2 (Vehicle Traffic Control Signal Heads).

2.5.8 Compatibility
The modules shall be operationally compatible with currently used controller assemblies (solid state load switches, flashers, and conflict monitors). Review TEES Chapters 3 and 6 for specifications on these devices.

2.5.8.1 When a current of 20 mA AC (or less) is applied to the unit, the voltage read across the two leads shall be 15 VAC or less.

2.5.9 The modules and associated on-board circuitry must meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

2.6 Photometric Requirements

2.6.1 The minimum initial luminous intensity values for the modules shall be as stated in Table 2-2 and/or Table 2-4 at 25°C.

2.6.1.1 The modules (excluding yellow) shall meet or exceed the illumination values as shown in Table 2-3 and/or Table 2-5, throughout the useful life based on normal use in a traffic signal operation over the operating temperature range.

2.6.1.2 Yellow modules shall meet or exceed the illumination values as shown in Table 2-3 and/or Table 2-5, throughout the useful life based on normal use in a traffic signal operation at 25°C.

2.6.2 The measured chromaticity coordinates of the modules shall conform to the chromaticity requirements of Table 2-6, throughout the useful life over the operating temperature range.

2.7 Physical and Mechanical Requirements

LED traffic signal modules shall be designed as retrofit replacements for existing optical units of signal indications and shall not require special tools for installation. See appropriate sections for Type 1 and Type 2 modules.

2.8 Environmental Requirements

2.8.1 The LED signal module shall be rated for use in the operating temperature range of -40°C (-40°F) to +74°C (+165°F). The modules shall meet all specifications throughout this range.

2.8.2 The LED signal module shall be protected against dust and moisture intrusion per the requirements of NEMA Standard 250-1991 for Type 4 enclosures to protect all internal components.

2.9 Construction

2.9.1 The LED signal module shall be a single, self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing. The power supply for the module shall be integral to the unit.

2.9.2 The circuit board and power supply shall be contained inside the module. Circuit boards shall conform to Chapter 1, Section 6 of the "Transportation Electrical Equipment Specifications".

2.9.3 The assembly and manufacturing process for the LED signal assembly shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

2.10 Materials

2.10.1 Material used for the lens and signal module construction shall conform to ASTM specifications for the materials.

2.10.2 Enclosures containing either the power supply or electronic components of the signal module shall be made of UL94VO flame retardant materials. The lens of the signal module is excluded from this requirement.

2.11 Module Identification

2.11.1 Each module shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked on the back of the module.

2.11.2 The following operating characteristics shall be permanently marked on the back of the module: rated voltage and rated power in Watts and Volt-Ampere.

2.11.3 Each module shall have a symbol of the type of module (i.e. circle, arrow, etc.) in the color of the module. The symbol shall be one inch (25.4 mm) in diameter. Additionally, the color shall be written out in ½ in letters next to the symbol.

2.11.4 If a specific mounting orientation is required, each module shall have prominent and permanent marking(s) for correct indexing and orientation within a signal housing. The markings shall consist of an up arrow, or the word "UP" or "TOP".

3 Type 1 Traffic Signal Module

The following specification requirements apply to the Type 1 module only. All general specifications apply unless specifically superceded in this section.

3.1 Type 1 modules can be manufactured under this specification for the following faces:

3.1.1 300 mm circular

3.1.2 200 mm circular

3.1.3 300 mm arrow

3.1.4 Bicycle indication (future)

3.1.5 Lane Control (future)

3.2 Physical and Mechanical Requirements

3.2.1 The module shall fit into existing traffic signal section housings built to the specifications detailed in ITE Publication: Equipment and Material Standards, Chapter2 (Vehicle Traffic Control Signal Heads).

3.2.2 Each Type 1 module shall be designed to be installed in the doorframe of a standard traffic signal housing. The Type 1 module shall be sealed in the doorframe with a one-piece EPDM (ethylene propylene rubber) gasket.

3.2.3 The maximum weight of a Type 1 module shall be 1.8 kg (4 lbs.).

3.2.4 Each Type 1 module shall be a sealed unit to include all parts necessary for operation (a printed circuit board, power supply, a lens and gasket, etc.), and shall be weather proof after installation and connection.

3.2.5 Conductors
Two secured, color coded, 600 V, 20 AWG minimum, jacketed wires, conforming to the National Electric Code, rated for service at +105°C, are to be provided for electrical connection for each Type 1 LED signal module. Conductors for Type 1 modules shall be 1-m in length, with quick disconnect terminals attached and shall conform to Section 86-4.01C, "Electrical Components," of the Standard Specifications.

3.2.6 If specified in the purchased order, the module will be equipped with an adapter that will screw into the medium base, lamp socket. The adapter shall be able to accept the quick disconnect terminals at the end of the conductors for the module. The electrical contacts of the adapter shall be made of brass.

3.3 Lens

3.3.1 The lens of the Type 1 module shall be integral to the unit, shall be convex with a smooth outer surface and made of plastic or of glass.

3.3.2 The lens may be tinted or may use transparent film or materials with similar characteristics to enhance ON/OFF contrasts.

3.3.2.1 The use of tinting or other materials to enhance ON/OFF contrasts shall not affect chromaticity and shall be uniform across the face of the lens.

3.3.3 The LED signal module lens shall be UV stabilized and shall be capable of withstanding ultraviolet (direct sunlight) exposure for a minimum period of 60 months without exhibiting evidence of deterioration.

3.3.4 If a polymeric lens is used, a surface coating or chemical surface treatment shall be used to provide front surface abrasion resistance.

4 Type 2 Traffic Signal Module

The following specification requirements apply to the Type 2 module only. All general specifications apply unless specifically superceded in this section.

4.1 Type 2 modules can be manufactured under this specification for the following faces:

4.1.1 300 mm circular

4.1.2 200 mm circular

4.1.3 300 mm arrow

4.1.4 Programmed Visibility (red, yellow, green)

4.2 Physical and Mechanical Requirements

4.2.1 The module shall fit into existing traffic signal section housings built to the specifications detailed in the ITE Publication: Equipment and Material Standards, Chapter 2 (Vehicle Traffic Control Signal Heads), with the existing lens, reflector and lamp socket remaining in place, and without modification to the housing.

4.2.2 Each Type 2 module shall be designed to mount in the standard lamp socket normally used with an incandescent lamp.

4.2.3 The maximum weight of a Type 2 module shall be 1.4 kg (3 lbs.).

4.2.4 Type 2 modules shall be a sealed unit containing all components necessary for operation.

4.3 The installation of a Type 2 module shall not require any removal of, or modification to the standard lamp socket or reflector. The installation of a Type 2 module shall not require special tools.

5 300 mm Arrow

The following specification requirements apply to the 300 mm arrow module only. All general specifications apply unless specifically superceded in this section.

5.1 The arrow module shall meet specifications stated in Section 9.01 of the ITE Publication: Equipment and Material Standards, Chapter 2 (Vehicle Traffic Control Signal Heads) for arrow indications.

5.2 The LEDs shall be spread evenly across the illuminated portion of the arrow area.

6 300 mm Bicycle

The following specification requirements apply to the 300 mm bicycle module only. All general specifications apply unless specifically superceded in this section.

6.1 The bicycle module shall approximate shape and size specifications as shown in Figure 6-1 for bicycle signal face. Caltrans shall make the final determination as to the conformance to the intent of the specification.

6.2 The LEDs shall be spread evenly across the illuminated portion of the bicycle area.

7 300 mm Programmed Visibility (PV)

The following specification requirements apply to the 300 mm PV module only. All general specifications apply unless specifically superceded in this section.

7.1 The module shall be a Type 2 module designed and constructed to be installed in a programmed visibility (PV) signal housing with out modification to the housing.

7.2 The LEDs shall be spread evenly across the module.

8 300 mm Lane Control

The following specification requirements apply to the 300 mm lane control module only. The lane control module is a single, combination module with both a red X and green arrow. All general specifications apply unless specifically superceded in this section.

8.1 The lane control module shall approximate shape and size specifications as shown in Figures 8-1 and 8-2 for lane control modules. Caltrans shall make the final determination as to the conformance to the intent of the specification.

8.2 Three secured, color coded, 600 V, 20 AWG minimum, jacketed wires, conforming to the National Electric Code, rated for service at +105°C, are to be provided for electrical connection for each lane control LED signal module. Conductors for this module shall be 1-m in length, with quick disconnect terminals attached and shall conform to Section 86-4.01C, "Electrical Components," of the Standard Specifications. The color code is as follows:

Function	Color
neutral	white
red X	red
green arrow	brown

8.3 The LEDs shall be spread evenly across the illuminated portions of this module.

9 Quality Assurance

9.1 The modules shall be manufactured in accordance with a manufacturer quality assurance (QA) program. The QA program shall include two types of quality assurance: (1) design quality assurance and (2) production quality assurance. The production quality assurance shall include statistically controlled routine tests to ensure minimum performance levels of The modules built to meet this specification, and a documented process of how problems are to be resolved.

9.2 QA process and test results documentation shall be kept on file for a minimum period of seven years.

9.3 LED signal module designs not satisfying design qualification testing and the production quality assurance testing performance requirements described below shall not be labeled, advertised, or sold as conforming to this specification.

9.4 Design Qualification Testing

9.4.1 Design Qualification Testing shall be performed by the manufacturer or an independent testing lab hired by the manufacturer on new LED module designs, and when a major design change has been implemented on an existing design.
A major design change is defined as a design change (electrical or physical) which changes any of the performance characteristics of the module, results in a different circuit configuration for the power supply, or changes the layout of the individual LED's in the module.

9.4.2 A quantity of two units for each design shall be submitted for Design Qualification Testing.

9.4.2.1 Test units shall be submitted to Caltrans after the manufacturer's testing is complete.

9.4.2.2 Manufacturer's testing data shall be submitted with test units for Caltrans verification of Design Qualification Testing data.

9.4.3 Burn In.
The sample modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of +74°C (+165°F) before performing any design qualification testing.

9.4.4 Any failure of the module, which renders the unit non-compliant with the specification after burn-in, shall be cause for rejection.

9.4.5 For Design Qualification Testing, all specifications will be measured including, but not limited to:

9.4.5.1 Rated Initial Luminous Intensity.
Measured at +25°C.

9.4.5.2 Chromaticity (Color).
Measured at +25°C.

9.4.5.3 Electrical.
All specified parameters shall be measured and used for quality comparison of production quality assurance on production modules. (rated power, etc)

9.4.5.4 Equipment Compatibility.
Modules shall be tested for compatibility with the controller unit, conflict monitor, and load switch. Each signal module shall be connected to the output of a standard load switch connected to an AC voltage supply between the values of 95 and 135 VAC with the input to the load switch in the "off" position. The AC voltage developed across each LED signal module so connected shall not exceed 10 Vrms as the input AC voltage is varied from 95 Vrms to 135 Vrms.

9.4.5.5 Mechanical vibration testing shall be as per MIL-STD-883, Test Method 2007, using 3 four minute cycles along each x, y, and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 HZ to 120 HZ. The loosening of the lens, of any internal components, or other physical damage shall be cause for rejection.

9.4.5.6 Temperature cycling shall be performed as per MIL-STD-883, Test method 1010. The temperature range shall be per "Environmental Requirements". A minimum of 20 cycles shall be performed with a 30 minute transfer time between temperature extremes and a 30 minute dwell time at each temperature. Module(s) being tested shall be energized and functioning throughout the duration of the test. Failure of a module to function properly or any evidence of cracking of the module lens or housing after temperature cycling shall be cause for rejection.

9.5 Production Quality Control Testing.

9.5.1 The following Production Quality Assurance tests shall be performed on each new module prior to shipment. Failure to meet requirements of any of these tests shall be cause for rejection. Test results shall be retained by the manufacturer for seven years.

9.5.2 Burn-in period shall consist of each signal module being energized at rated voltage for a 30 minute stabilization period before the measurement is made (except for yellow modules).

9.5.3 Each module shall be tested for rated initial intensity after burn-in.

9.5.3.1 A single point measurement, with a correlation to the intensity requirements of Table 2-2 for circular modules, may be used.

9.5.3.2 The ambient temperature for this measurement shall be +25°C (+77°F).

9.5.3.3 Each module not meeting minimum luminous intensity requirements per Table 2-2 or Table 2-4 shall be cause for rejection.

9.5.4 Each module shall be tested for required power factor after burn-in.

9.5.5 Each module shall be measured for current flow in amperes after burn-in. The measured current values shall be compared against rated values resulting from design qualification measurements under "Design Qualification Testing". The current flow shall not exceed the rated value.

9.5.6 Each module shall be visually inspected for any exterior physical damage or assembly anomalies. Careful attention shall be paid to the surface of the lens to ensure there are no scratches (abrasions), cracks, chips, discoloration, or other defects. Any such defect shall be cause for rejection.

9.6 Caltrans Quality Assurance Testing. (random sample testing)

9.6.1 Caltrans may perform random sample testing on all shipments.

9.6.2 Random sample testing should be completed within than 30 days after delivery to the specified location on the purchase order.

9.6.3 Circular modules shall be tested according to California Test No. 604, and as described herein.

9.6.4 PV, bicycle and arrow modules shall be tested as per California Test 3001 and as described herein.

9.6.5 All optical testing shall be performed with the module mounted in a standard traffic signal section without a visor or hood attached to the section or housing.

9.6.6 The number of units tested (sample size) shall be determined by the quantity of each model in the shipment. The sample size shall conform to ANSI/ASQC Z1.4. The Caltrans METS shall determine the sampling parameters to be used for the random sample testing.

9.6.7 All parameters of the specification may be tested on the shipment sample.

9.6.8 Acceptance/Rejection of the shipment shall conform to ANSI/ASQC Z1.4 for random sampled shipments.

10 Warranty

In addition to meeting the performance requirements for the minimum period of 48 months, the manufacturer shall provide a written warranty against defects in materials and workmanship for the modules for a period of 60 months after acceptance of the modules. Replacement modules shall be provided promptly after receipt of modules that have failed at no cost to the State. All warranty documentation shall be given to the TransLab prior to random sample testing.

TABLES

Table 2-1 Maximum PowerConsumption (in Watts)

	Red		Yellow		Green	
Temperature	25°C	74°C	25°C	74°C	25°C	74°C
300 mm circular	11	17	22	25	15	15
200 mm circular	8	13	13	16	12	12
300 mm arrow	9	12	10	12	11	11
Bicycle indication	11	17	22	25	15	15
PV indication	11	17	22	25	15	15
Lane Control (X)	9	12	n/a	n/a	n/a	n/a
Lane Control (Arrow)	n/a	n/a	n/a	n/a	11	11

Table 2-2 Minimum Initial Intensities for Circular Indications (in cd)

		200 mm			300 mm	
Angle (v,h)	Red	Yellow	Green	Red	Yellow	Green
2.5, ±2.5	157	314	314	399	798	798
2.5, ±7.5	114	228	228	295	589	589
2.5, ±12.5	67	133	133	166	333	333
2.5, ±17.5	29	57	57	90	181	181
7.5, ±2.5	119	238	238	266	532	532
7.5, ±7.5	105	209	209	238	475	475
7.5, ±12.5	76	152	152	171	342	342
7.5, ±17.5	48	95	95	105	209	209
7.5, ±22.5	21	43	43	45	90	90
7.5, ±27.5	12	24	24	19	38	38
12.5, ±2.5	43	86	86	59	119	119
12.5, ±7.5	38	76	76	57	114	114
12.5, ±12.5	33	67	67	52	105	105
12.5, ±17.5	24	48	48	40	81	81
12.5, ±22.5	14	29	29	26	52	52
12.5, ±27.5	10	19	19	19	38	38
17.5, ±2.5	19	38	38	26	52	52
17.5, ±7.5	17	33	33	26	52	52
17.5, ±12.5	12	24	24	26	52	52
17.5, ±17.5	10	19	19	26	52	52
17.5, ±22.5	7	14	14	24	48	48
17.5, ±27.5	5	10	10	19	38	38

Table 2-3 Maintained Minimum Intensities for Circular Indications (in cd)

		200 mm			300 mm	
Angle (v,h)	Red	Yellow	Green	Red	Yellow	Green
2.5, ±2.5	133	267	267	339	678	678
2.5, ±7.5	97	194	194	251	501	501
2.5, ±12.5	57	113	113	141	283	283
2.5, ±17.5	25	48	48	77	154	154
7.5, ±2.5	101	202	202	226	452	452
7.5, ±7.5	89	178	178	202	404	404
7.5, ±12.5	65	129	129	145	291	291
7.5, ±17.5	41	81	81	89	178	178
7.5, ±22.5	18	37	37	38	77	77
7.5, ±27.5	10	20	20	16	32	32
12.5, ±2.5	37	73	73	50	101	101
12.5, ±7.5	32	65	65	48	97	97
12.5, ±12.5	28	57	57	44	89	89
12.5, ±17.5	20	41	41	34	69	69
12.5, ±22.5	12	25	25	22	44	44
12.5, ±27.5	9	16	16	16	32	32
17.5, ±2.5	16	32	32	22	44	44
17.5, ±7.5	14	28	28	22	44	44
17.5, ±12.5	10	20	20	22	44	44
17.5, ±17.5	9	16	16	22	44	44
17.5, ±22.5	6	12	12	20	41	41
17.5, ±27.5	4	9	9	16	32	32

Table 2-4 Minimum Initial Intensities for Arrow and PV Indications (in cd/m2)

	Red	Yellow	Green
Arrow Indication	5,500	11,000	11,000
Bicycle Indication	5,500	5,500	5,500
PV Indication	future	future	future
Lane Control (X)	5,500	n/a	n/a
Lane Control (Arrow)	n/a	n/a	11,000

Table 2-5 Minimum Maintained Intensities for Arrow and PV Indications (in cd/m2)

	Red	Yellow	Green
Arrow Indication	5,500	11,000	11,000
Bicycle Indication	5,500	5,500	5,500
PV Indication	future	future	future
Lane Control (X)	5,500	n/a	n/a
Lane Control (Arrow)	n/a	n/a	11,000

Table 2-6 Chromaticity Standards (CIE Chart)
Section 8.04 of

Red	Y: not greater than 0.308, or less than 0.998 - x
Yellow	Y: not less than 0.411, nor less than 0.995 - x, nor less than 0.452
Green	Y: Not less than 0.506 -.519x, nor less than 0.150 + 1.068x, nor more than 0.730 - x

Figure 6-1 Bicycle module symbol

Figure 8-1 Lane Control X symbol

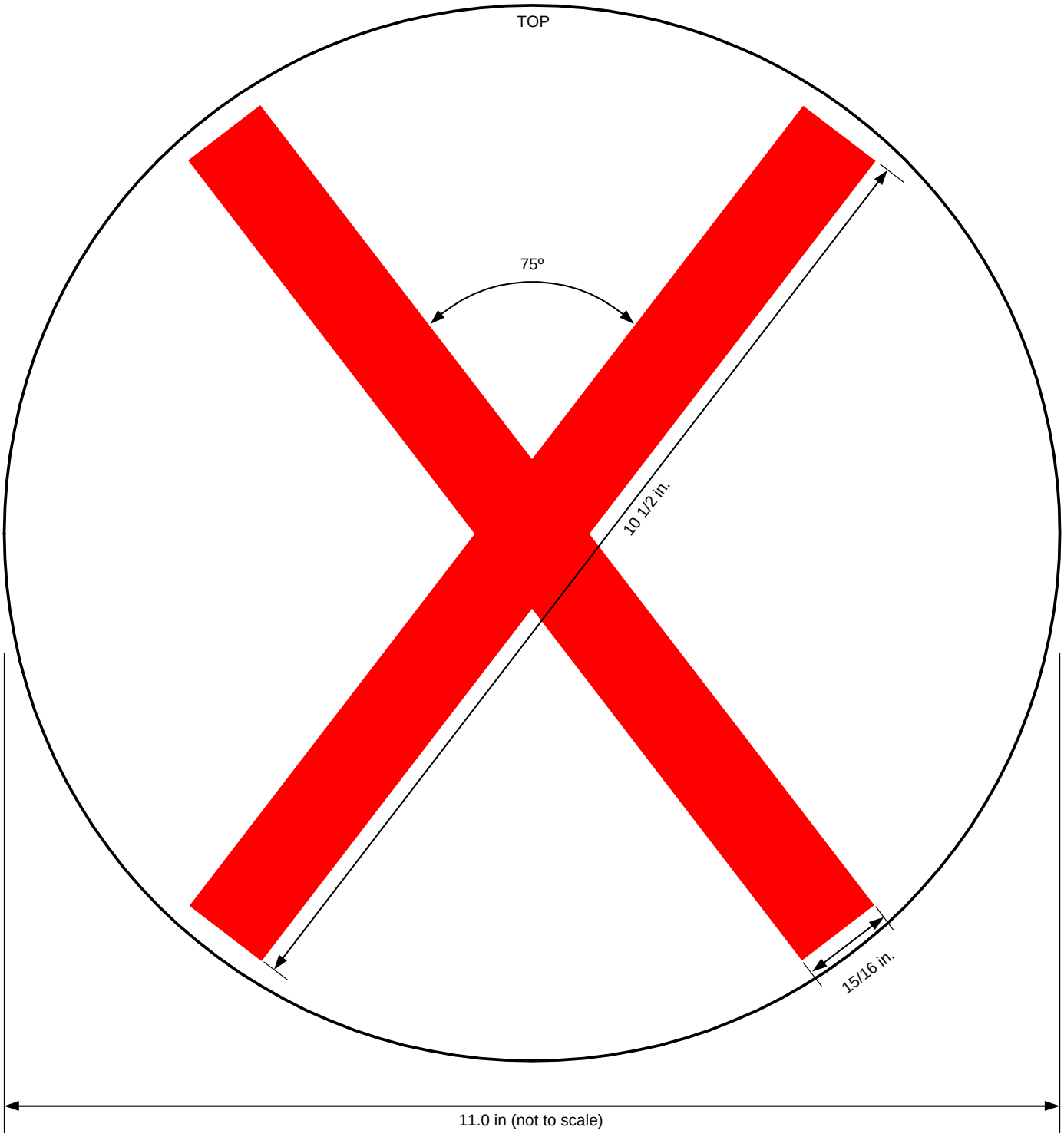

Figure 8-2 Lane Control Arrow symbol