



Office of Roadway Engineering
Traffic Engineering Manual (TEM)
July 16, 2021 Revision

As of July 16, 2021 this publication has been revised.

The revision involves updates of the Title Sheet, preface materials, and Parts 1, 2, 3, 4, 6, 7, 11, 12 and 13.

The updated manual and the separate revision package, which includes a Revision Log, are available from the **ODOT Design Reference Resource Center**, or from the **Office of Roadway Engineering's website**.

Per ODOT policy, revisions will only be available via the web pages noted above.

For questions, comments, or concerns please contact:

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Office of Roadway Engineering
Traffic Engineering Manual (TEM)
Revision Log

July 16, 2021 Revision (of the October 2002 Edition)

The following is list of the changes made in the Preface Materials, and Parts 1, 2, 3, 4, 6 , 7, 11, 12, and 13 of the TEM as of July 16, 2021:

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
<p>* Key for Revision Type: Change - change in a standard, new information, revising text to provide clarification, updating references, or correcting a mistake in the text, more than simple editorial change; Deletion - deleting a section, form, table or figure; Editorial - correcting a simple typing or drawing mistake, simple editorial changes such as rephrasing a statement or making a format change.</p>				
Preface Materials				
Title Sheet	i - ii	i - ii	Editorial	Updated to reflect the July 16, 2021 date for this revision.
Preface & Mission Statement	iii - iv	iii - iv		No change.
Pub. Record	v – xvii	v – xviii	Editorial	Updated per this revision.
Table of Contents	xvii – xlvi	xix – xlvi	Editorial	Updated per this revision.
Part 1, General				
	1-1 – 1-4	1-1 - 1-4		Table of Contents. Updated per this Revision
120-4	1-23 – 1-26	1-23 – 1-26	Change	Traffic Control Devices and Materials, Patented or Proprietary Materials, Specifications or Processes. Complete rewrite of section including addition of subsections.
	1-27 – 1-29	1-27 – 1-30		Text shifted.
120-7	1-30	1-31	Change	Traffic Control Devices and Materials, Alternative Bids for Traffic Control and Lighting Items. In Subsection 120-7.3, Procedure , added a new first sentence to first paragraph, “Refer to L&D Volume 3, Section 1307.”
	1-31 – 1-32	1-32		Text shifted.
196	1-57	1-57	Change	Forms Index. Deleted previous form, ORE Publications Order Form.
	1-58	1-58		Included as part of the Revision Set.

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
196-1	1-59	1-59	Change	Form 196-1, ORE Publication Order Form. Deleted. Form is now "Reserved for Future Information".
	1-60	1-60		Included as part of the Revision Set.
Part 2, Signs				
	2-17	2-17		Included as part of the Revision Set.
201-14	2-18	2-18	Change	Regulatory Signs, Traffic Law Photo-Monitoring Signs (R10-18), Automated Traffic Enforcement and Surveillance Devices. In last paragraph, added new last sentence, "R10-18 signs shall not be installed on interstates or freeways maintained by ODOT."
209-7	2-69	2-69	Change	Freeway & Expressway Distance & Destination Signs, Signs for Option Lanes. Deleted next-to-last paragraph re. the use of two slanting down arrows on adjacent signs pointing to the same lane, per 2012 OMUTCD. In new next-to-last paragraph, added "or sign upgradings" after "highway construction" in first sentence.
	2-70	2-70		Included as part of the Revision Set.
210-4	2-71	2-71	Change	Miscellaneous Signs, Soil and Water Conservation District Signing. New section.
	2-72	2-72		Included as part of the Revision Set.
Part 3, Markings				
	3-1 – 3-4	3-1 – 3-4		Table of Contents. Updated per this Revision
	3-7	3-7		Text shifted.
301-6	3-8 – 3-9	3-8 - 3-9	Change	Pavement and Curb Markings, Crosswalk Markings. In Subsection 301-6.1 , revised second sentence in first paragraph to include reference to new SCD TC-74.10. In Subsection 301-6.3, Basis of Payment , replaced text. Added new subsection, Subsection 301.6.4, High Visibility Patterns.
	3-10 – 3-28	3-10 – 3-28		Text shifted.
Part 4, Signals				
	4-1 – 4-8	4-1 – 4-8		Table of Contents. Updated per this Revision
401-9	4-17	4-17	Change	Traffic Control Signals – General, Americans with Disabilities Act (ADA) Requirements. In first paragraph, revised "requirements" (second instance) to "elements", and "effect" to "affect". In last paragraph added a reference to the Office of Roadway Engineering's "ADA Design Resources".
	4-18	4-18		Text shifted.
403-1	4-25	4-25	Change	Traffic Control Signal Features and Operation, General. Deleted second paragraph re. dual-arrow signal sections.
	4-26 – 4-27	4-26 – 4-27		Included as part of the Revision Set.

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
403-6	4-28	4-28	Change	Traffic Control Signal Features and Operation, Emergency-Vehicle Preemption Control Systems. In Subsection 403-6.2, Procedures , deleted second paragraph re. Federal/State funds and initial Emergency Vehicle preemption control system.
403-10	4-33	4-33	Change	Traffic Control Signal Features and Operation, Railroad Preemption Control Systems. In Subsection 403-10.2, Controller Functionality . Added new item 12 re. pushbutton requirement and removal of pedestrian recall, and renumbered subsequent items.
	4-34 - 4-39	4-34 - 4-39		Text shifted.
403-12	4-40 – 4-41	4-40 – 4-41	Change	Traffic Control Signal Features and Operation, Centrally Controlled Arterial Traffic Signal System (new title). In Subsection 403-12.1, Engineering Background and Subsection 403-12.2, Guidelines and Review , revised “Central Signal System Control Station” (or “CSSCS”) to “Centrally Controlled Arterial Traffic Signal System”; added new Subsection 403-12.4, Construction .
403-13	4-41	4-41	Change	Traffic Control Signal Features and Operation, Traffic Signal System with Transit Priority. Added “Item 809” to beginning of first paragraph.
404-2	4-42	4-42	Change	Pedestrian Control Features, Pushbuttons. Deleted “regular” in first sentence of second paragraph; added “accessible” before “pedestrian pushbuttons” in second line and added a reference to Section 404-3. Added “accessible” in two places in third paragraph. In last paragraph added information re. curb ramp requirements.
404-3	4-42	4-42	Change	Pedestrian Control Features, Accessible Pedestrian Signals and Locator Tones. In first paragraph, second line, replaced “requirements” with “elements”. Revised second paragraph text; now two paragraphs. Added new item 6 re. training of visually impaired users.
	4-43	4-43		Text shifted.
404-4	4-44	4-44	Change	Pedestrian Control Features, Leading Pedestrian Interval (LPI). Revised last paragraph to include “with a new or reconstructed traffic signal” and changed “shall” to “should”.
407-2	4-47 – 4-48	4-47 – 4-48	Change	Other Electrical Devices, PREPARE TO STOP WHEN FLASHING Signs (W3-H4a). In Subsection 407-2.2, Criterial for Removal reworded justification for removal text; in item 2 revised 0.5 mile to 1 mile; Subsection 407-2.3, Procedure / Reviewing Other Countermeasures , revised reference in item 8 from 420-4.11 to 420-4.12.

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
420-4	4-53 – 4-55	4-53 – 4-55	Change	Materials and Signal Hardware, Vehicular Signal Heads. In Subsection 420-4.1, General , added a paragraph referencing SCD TC-81.22 & ODOT's installation preference. Added new Subsection 420-4.4, Number of Signals on an Approach and renumbered subsequent subsections. Various other changes to Subsections 420-4.6 and 420-4.7. In 420-4.12 revised 20% (truck percentages) to 10%.
420-5	4-56 – 4-57	4-56 – 4-57	Change	Materials and Signal Hardware, Detection. In Subsection 420-5.1, General , added a new second paragraph re. approaches 45 mph or greater. In Subsection 420-5.3, Video Detection Prohibited for Dilemma Zone Applications , reworded last sentence re. ODOT's standard detection.
	4-58	4-58		Included as part of the Revision Set.
440-3	4-63	4-63	Change	Design Information, Single-Arm Overhead Signal Support. Added text indicating ODOT's preferred signal support.
	4-64	4-64		Included as part of the Revision Set.
440-8	4-67 – 4-68	4-67 – 4-68	Change	Design Information, ADA Requirements on Traffic Signal Projects. In Subsection 440-8.2, Accessible Pedestrian Signals and Locator Tones , replaced "signals and locator tones" in first sentence with "pushbuttons" and added "when pedestrian facilities are provided" in second line of sentence; in last paragraph replaced "accessible to the disabled" with "accessible to all" and added "unobstructed" before "paved pathway". In Subsection 440-8.3, Curb Ramps , replaced text with new text.
	4-81	4-81		Included as part of the Revision Set.
442-20	4-82	4-82	Change	Plan Notes, 809 ATC Controller, As Per Plan (new title). Removed "V6.24" from section title.
	4-91	4-91		Included as part of the Revision Set.
442-44	4-92	4-92	Change	Plan Notes, 632 Signal Support Foundation. Added new sentence to Designer Note re. Plan Note 442-42.
	4-111	4-111		Included as part of the Revision Set.
450-10	4-112	4-112	Change	Construction, Signal Equipment and Wiring. In Subsection 450-10.4, Vehicular Signal Heads and Wiring , in item 14 revised reference to Section 420-4.10 to Section 420-4.11. In Subsection 450-10.5, Optically Programmed Signal Heads , revised reference to Section 420-4.6 in first paragraph to Section 420-4.7.
450-11	4-119	4-119	Change	Construction, Signal Performance Tests and System Checks. In Subsection 450-11.8, Final Signal Installation Check , replaced the 12 numbered items with a paragraph that refers to OTO Traffic Signal Resources page.
	4-120	4-120		Text shifted.
	4-121	4-121		Included as part of the Revision Set.

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
460-3	4-122 – 4-123	4-122 – 4-123	Change	Maintenance / Operations. In Subsection 460-3.2, Traffic Control Signals and Intersection Control Beacons , reworded last paragraph, adding text re. “inspections and maintenance history”. In table, revised the two “End of Life” replacement periods shown to 10 years (UPS Inverter) and 15 years (Detection). Added * item below table re. max. life of signal supports.
	4-124	4-124		Included as part of the Revision Set.
Part 5, Low-Volume Roads				
Part 6, Temporary Traffic Control				
	6-1 – 6-12	6-1 – 6-12		Table of Contents. Updated per this Revision
	6-87	6-87		Included as part of the Revision Set.
640-5	6-88 – 6-89	6-88 – 6-89	Change	Design Information, Use of Shoulders. In Subsection 640-5.3, Emergency Pull-Offs , revised/expanded previous section text, including when emergency pull-offs should be considered; references new Plan Insert Sheet.
	6-90 – 6-105	6-90 – 6-105		Text shifted.
	6-106	6-106		Included as part of the Revision Set.
641-35	-	6-135	Change	Plan Preparation / Production, Emergency Pull-Offs (PIS 2010350) . New section that describes new Plan Insert Sheet, Emergency Pull-Offs.
	6-136	6-136		Included as part of the Revision Set.
	6-151	6-151		Included as part of the Revision Set.
642-35	6-152	6-152	Editorial	Plan Notes, Item 614, Work Zone Crossover Lighting System . In first paragraph, revised 625.04 to 625.06.
	6-153	6-153		Included as part of the Revision Set.
642-39	6-154	6-154	Change	Plan Notes, Lighting . In the second paragraph, second sentence, added “an 8000-lumen LED,” after “...by using”
Part 7, Zones and Studies				
	7-11	7-11		Included as part of the Revision Set.
796-1	7-12 – 7-13	7-12 – 7-13	Change	Form 796-1, Agreement for School Signs with Beacons . Replaced form.
	7-14	7-14		Included as part of the Revision Set.
Part 8, Rail Grade Crossings				
Part 9, Bicycles				
Part 10, Reserved for Future Use				
Part 11, Highway Lighting				
	11-1 – 11-8	11-1 - 11-8		Table of Contents. Updated per this Revision
1101	11-11	11-11	Change	District System Lighting Plan (DSLPL) . In first paragraph, added a new third sentence re. maintenance of DSLP.
	11-12	11-12		Included as part of the Revision Set.

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
1103-2	11-13	11-13	Change	Warrants and Guidelines, Warrants for Highway Lighting. In first paragraph, second sentence, added “ODOT-specific warrants” after “are”, and added “and modified by ODOT” after “derived”, and inserted “1984” before “AASHTO”.
	11-14	11-14		Included as part of the Revision Set.
1103-6	11-15 11-16	11-15 – 11-16	Change	Warrants and Guidelines, Special Locations. In Subsection 1103-6.2, Intersections , added a new second paragraph. Revised new third paragraph. In new fifth paragraph, revised “should” to “may” in first sentence. In Subsection 1103-6.3, Pedestrian Walkways , added “AC or 48 volts DC” after “(120 volts” in third line. In Subsection 1103-6.8, Sign Lighting , deleted sentence “It is common practice to power the luminaires for sign lighting from the roadway lighting circuits.”
	11-29	11-29		Included as part of the Revision Set.
1130-4	11-30	11-30	Change	Planning / Programming, State Participation. In item 3, deleted “as established by ANSI”.
1130-6	11-30	11-30	Change	Planning / Programming, Light Fixtures. Deleted first paragraph. In new first paragraph, deleted “Federal” (two places). Added “official, published” before “City” (fourth line).
1140-3	11-33 – 11-38	11-33 – 11-38	Change	Design Information, Lighting Theory. In Subsection 1140-3.1, General , item 1, revised “Distance” to “Distant”. In Subsection 1140-3.2.1, Illuminance, General , added a new second paragraph. In Subsection 1140-3.3.1, Luminance, General , replaced last word in first paragraph (footcandle) with “candela per meter squared (cd/m ²)”; added a new third paragraph re. Luminance-Based Design. In Subsection 1140-3.3.2, Luminance, Small Target Visibility , replaced second paragraph with “ODOT does not use the Small Target Visibility method for design.” In Subsection 1140-3.4, Headlamps , replaced “STV” in third paragraph with “visibility”. In Subsection 1140-3.6.2, Illumination Criteria, Average Illumination , added a new sixth sentence re. net LLF. In previous sentence, revised “lamp” to “LED”. In Subsection 1140-3.6.3, Illumination Criteria, Uniformity , deleted last sentence in second and third paragraphs.
1140-4	11-38 - 11-40; 11-42- 11-46	11-38 – 11-40; 11-42 – 11-45	Change	Design Information, Luminaires and Sources. Numerous changes to Subsections 1140-4.2.1, Luminaire Placement, General; 1140-4.2.2, Luminaire Placement, High-Mast Lighting; 1140-4.3.2, Conventional, Mounting Height and Wattage; 1140-4.3.3, Conventional, Spacing; 1140-4.3.4.1, Pole Location, Lateral Placement; 1140-4.3.4.2, Pole Location, Bracket Arm Length; 1140-4.4.1, Partial Lighting, Interchange – General Information; 1140-4.4.4, Partial Lighting, Intersection; 1140-4.4.5, Partial Lighting, Combination Supports; 1140-4.5.1, Full Lighting, Interchange; 1140-4.6.2, Specific Cases, Intersections; and 1140-4.6.3, Specific Cases, Bridges Over Highways.

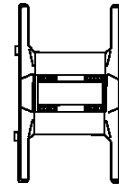
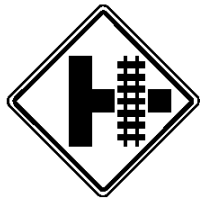
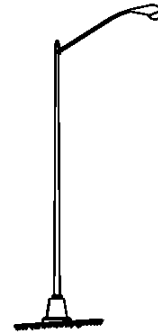
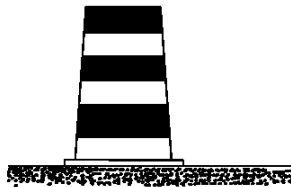
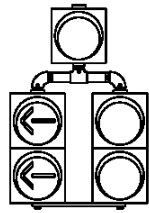
Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
	11-41; 11-46 – 11-50	11-41; 11-46 – 11-49		Text shifted.
1140-5	11-51 – 11-52; 11-54	11-50 – 11-51; 11-54	Change	Design Information, Circuit Design. Numerous changes to 1140-5.2.1, 1140-5.2.2, 1140-5.3.1, 1140-5.3.2, 1140-5.4.2, 1140-5.9.2
	11-52 – 11-54	11-52 – 11-53		Text shifted.
1140-6	11-55 – 11-56	11-55	Change	Design Information, Foundations. In Subsection 1140-6.1.1.2, General, Conventional, Drilled Shaft , added a new first paragraph. In Subsection 1140-6.1.2.1, General, High Mast, General , revised “are usually” to “should be” in first sentence.
	11-57 – 11-61	11-56 – 11-60		Text shifted.
	11-63	11-63		Included as part of the Revision Set.
1141-3	11-64	11-64	Change	Plan Preparation / Production, Plan Composition. Revisions to 1141-3.7.1, Special Details, Required Special Details for Underpass Lighting , and 1141-3.9 Tower Cross Sections .
1142-5	11-71	11-71	Change	Plan Notes, Luminaire, High Mast, As Per Plan. Added “(This Plan Note is obsolete but is retained for historical reference.)” after section title.
1142-6	11-71	11-71	Change	Plan Notes, Luminaire, Low Mast, As Per Plan. Added “(This Plan Note is obsolete but is retained for historical reference.)” after section title.
1142-7	11-71	11-71	Change	Plan Notes, 625, Luminaire, Conventional, As Per Plan. Added “(This Plan Note is obsolete but is retained for historical reference.)” after section title.
1142-8	11-72	11-72	Change	Plan Notes, 625, Luminaire, Post-top, As Per Plan. Added “(This Plan Note is obsolete but is retained for historical reference.)” after section title.
1142-9	11-72	11-72	Change	Plan Notes, 625, Luminaire, Underpass, As Per Plan. Added “(This Plan Note is obsolete but is retained for historical reference.)” after section title.
1142-10	11-72	11-72	Change	Plan Notes, 625, Luminaire, Installation Only, As Per Plan. Added “(This Plan Note is obsolete but is retained for historical reference.)” after section title.
1142-11	11-72	11-72	Change	Plan Notes, Lamps. Added “(This Plan Note is obsolete but is retained for historical reference.)” after section title.
	11-73 – 11-78	11-73 – 11-78		Text shifted.
1142-27	11-85	11-85	Change	Plan Notes, Decorative Teardrop Luminaire, Solid-State (LED), Refractive Glass, 3000K, Black Finish. In fourth paragraph (page 85) replaced 4 luminaire mfr’s/models with 3 new ones (LED).
	11-86	11-86		Included as part of the Revision Set.
1150-2	11-87	11-87	Change	Construction, Materials. Revisions to Subsections 1150-2.1, General and 1150-2.2, Qualified Products List .

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
1150-3	11-88 – 11-89	11-88 – 11-89	Change	Construction, Luminaires. Numerous revisions to Subsections 1150-3.1, General; 1150-3.2, Conventional Luminaire; 1150-3.3, Side-Mount Roadway Luminaire; 1150-3.4, High-Mast Luminaire; 1150-3.5, Low-Mast Luminaire; 1150-3.6, Underpass Luminaire.
1150-4	11-89	11-89	Change	Construction, Lamps. Added “(Obsolete. Retained for historical reference only.)” after section title.
	11-90	11-90		Included as part of the Revision Set.
1150-5	11-91	11-91	Change	Construction, Supports. In Subsection 1150-5.2.3, Inspection of Support Components, Compliance with Shop Drawings , added a new first paragraph re. AASHTO criteria.
	11-92	11-92		Text shifted.
1150-7	11-93	11-93	Change	Construction, Pull Boxes. Deleted “(Manholes)” from section title.
1150-8	11-93	11-93	Change	Construction, Junction Boxes. Deleted “(Handholes)” from section title.
1150-10	11-94	11-94	Change	Construction, Trench. Deleted last paragraph re. caution tape.
1150-12	11-95	11-95	Change	Construction, Grounding. In Subsection 1150-12.4, Structure Grounding , added “(Standard Construction Drawing HL-50.22)” after section title.
	11-96 – 11-97	11-96 – 11-97		Included as part of the Revision Set.
1150-14	11-98	11-98	Change	Construction, Connections. In Subsection 1150-14.3, Compression Connections , deleted “Crimped” from section title.
	11-99	11-99		Included as part of the Revision Set.
1150-17	11-100	11-100	Change	Construction, Documentation Requirements. In item 1.a., replaced “lamp” with “lumen output”.
	11-101	11-101		Included as part of the Revision Set.
1160-8	11-102	11-102	Change	Maintenance / Operations, Recommended Preventive Maintenance. In the first paragraph added “Any” before “sodium”.
	11-103	11-103		Included as part of the Revision Set.
1160-12	11-104 – 11-106	11-104 – 11-106	Change	Maintenance / Operations, Troubleshooting Lamps. In Subsection 1160-12.1, General , added a new first sentence. In Subsection 1160-12.2, Lamp Will Not Start , added “HPS” to beginning of section title. In Subsection 1160-12.3, Short Lamp Life , added “HPS” after “Short” in section title. In Subsection 1160-12.6, Lamp Light Output Low , added “HPS” to beginning of section title. In Subsection 1160-12.7, Lamp Starts Slowly , added “HPS” after “Lamp” in section title. In Subsection 1160-12.8, Blackened Arc Tube , added “HPS” after “Blackened”. In Subsection 1160-12.9, Abnormal Lamp Color Difference , added “HPS” after “Abnormal”.
	11-107	11-107		Text shifted.
	11-108	11-108		Included as part of the Revision Set.

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
1197-1	11-111	11-111	Change	Table 1197-1, Suggested Data for the District System Lighting Plan. In first column, fifth row, added "(HPS), Lumen Output (LED)" after "Wattage". In first column, sixth row, added "(HPS only)" after "Ballast".
	11-112	11-112		Included as part of the Revision Set.
1198-3	11-125	11-125	Change	Figure 1198-3, Typical Luminaire Placement Partial Interchange Lighting (PIL). Added a fifth note re. intersections with marked crosswalks.
	11-126	11-126		Included as part of the Revision Set.
1198-7	11-129	11-129	Change	Figure 1198-7, Intesection Lighting Examples. Replaced schematics for 2- and 4-Lane Roads.
	11-130	11-130		Included as part of the Revision Set.
1198-12	11-133	11-133	Change	Figure 1198-12a, Voltage Drop Study – Cable Sizing Calculation Notes. Added a general note before item 1.
	11-134	11-134		Included as part of the Revision Set.
Part 12, Zones and Traffic Engineering Studies				
	12-1 – 12-4	12-1 – 12-4		Table of Contents. Updated per this Revision
1203-1	12-5	12-5	Editorial	Speed Zones, General. In first sentence of first paragraph replaced "geometric and traffic characteristic study" or "an engineering and traffic investingation," with "an engineering study". In first sentence of second paragraph, revised/corrected "2B.11" to "2B.13". Various revisions to third, fifth and seventh paragraphs.
1203-2	12-6 – 12-9	12-6 – 12-9	Change	Speed Zones, Procedures for Requesting and Authoriing Speed Zones. Various revisions to the following subsections: Subsection 1203-2.2, State Highways within ODOT's Jurisdiction – General Procedure (new title); Subsection 1203-2.3, Highways within Local Jurisdictions – General Procedure (new title); Subsection 1203-2.4, Split Jurisdictions , Subsection 1203-2.6, Narrow and Low-Volume Rural Roads (Form 1296-1) ; and Subsection 1203.2.7, Unimproved Highways and Residential and Commercial Subdivision Streets (Form 1296-15) .
	12-10 – 12-12	12-10 – 12-12		Text shifted.
1203-3	12-13 – 12-17	12-13 – 12-17	Change	Speed Zones, Speed Zone Studies. Various revisions to the following subsections: Subesection 1203-3.1, General ; Subsection 1203-3.2, Field Review ; Subsection 1203-3.4.1; Speed Zone Warrant Sheet (Form 1296-2), General ; Subsection 1203-3.4.2, Information Used in Completing Form 1296-2 ; and Subsection 1203.5, Add'l Information/Considerations . Added new Subsection 1203-3.6, Approved Speed Limit .
	12-18 – 12-22	12-18 – 12-22		Text shifted.

Revision Involves:			Type *	Section Title & Revision Description
Chapter / Section	Page	New Page		
1213-2	12-41	12-41	Editorial	Other Traffic Engineering Studies, Determining Curve Advisory Speeds. In Subsection 1213-2.3, Calculation Method to Determine Curve Advisory Speed , extended square root symbol in formula to include “15R”.
	12-42	12-42		Included as part of the Revision Set.
1296	12-45	12-45	Change	Forms Index. Revised text for Form 1296-1 and 1296-5.
	12-46	12-46		Included as part of the Revision Set.
1296-1	12-47 – 12-48	12-47 – 12-48	Change	Form 1296-1, Speed Zone Request for Narrow and Low-Volume Rural Roads. Replaced sheets 1 and 2.
1296-2	12-51 – 12-52	12-51 – 12-52	Change	Form 1296-2, Speed Zone Warrant Sheet. Replaced sheets 1 and 2.
1297	12-73	12-73	Change	Tables Index. Revised text for Table 1297-2; deleted item 1297-3, Speed Zone Warrant Analysis – Roadway Features.
	12-74 – 12-75	12-74 – 12-75		Included as part of the Revision Set.
1297-2	12-76	12-76	Change	Table 1297-2. Speed Zone Warrant Analysis – Highway Development. Replaced descriptions to match those on Form 1296-2
1297-3	12-77	12-77	Change	Table 1297-3. Speed Zone Warrant Analysis – Roadway Features. Deleted table; now, “Reserved for Future Information”.
	12-78-12-79	12-78 – 12-79		Included as part of the Revision Set.
1297-6	12-80	12-80	Change	Table 1297-6, Speed Zone Warrant Analysis – Roadway Characteristics. Revised “Description” info. for all alphabetic values except DIV.
Part 13, Intelligent Transportation Systems				
	13-1 – 13-2	13-1 – 13-2		Table of Contents. Updated per this Revision
	13-15	13-15		Included as part of the Revision Set.
1303-4	13-16	13-16	Change	Freeway Management System on ODOT-Maintained Highways, Communication. In items 7 and 8 replaced references to “fiber optic” with “communication”.
	13-31	13-31		Included as part of the Revision Set.
1342-10	13-32	13-32	Change	Plan Notes, Communication Cable Marker (new title). Revised “Fiber Optic” in title to “Communication”.
1397-1	13-41	13-41	Change	Table 1397-1, Exempt, Low-Risk and High-Risk ITS Projects. In “Low-Risk” part of table, moved “Adaptive Traffic Signal Control system.” item to “High-Risk” part of table. (To match text in TEM Section 1301-2.3.)
	13-42	13-42		Included as part of the Revision Set.
Part 14, Miscellaneous				
Part 15, Appendix				

Traffic Engineering Manual



October 23, 2002 Edition
(Includes revisions through July 16, 2021.)

Ohio Department of Transportation
Office of Roadway Engineering

Revisions of this Manual are published on a quarterly basis, as needed. They are published only on-line, at the Office of Roadway Engineering (ORE) and DRRC websites noted below.

**Ohio Department of Transportation
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Web addresses:

ODOT: <https://www.transportation.ohio.gov/wps/portal/gov/odot/>

Office of Roadway Engineering (ORE):

<http://www.dot.state.oh.us/Divisions/Engineering/Roadway/Pages/default.aspx>

Office of Traffic Operations (OTO):

<http://www.dot.state.oh.us/divisions/Operations/traffic/>

ODOT Publications (Design Reference Resource Center (DRRC)):

<http://www.dot.state.oh.us/drrc/Pages/default.aspx>

Traffic Engineering Manual (TEM) website:

<http://www.dot.state.oh.us/Divisions/Engineering/Roadway/DesignStandards/traffic/TEM/Pages/default.aspx>

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PREFACE

The **Traffic Engineering Manual (TEM)** has been developed to assure uniformity in application of **ODOT** traffic engineering policies, guidelines, standards and practices. The **OMUTCD** establishes the basic, minimum traffic control standards for any street, highway, bikeway or private road open to public travel in **Ohio**, and all supplemental **ODOT** traffic engineering design, construction and operations related information is either contained in the **TEM** or referenced from it.

This Manual contains standards, policies, etc. established for use in **ODOT** work; however, various situations will present themselves where engineering knowledge, experience and judgment will have to be used to determine how to apply the information included herein to specific situations. Comments, questions and proposed revisions should be submitted to the **ODOT Office of Roadway Engineering, Design Standards Section**, at the address noted on page ii. Email and telephone contact information is also available on the **Contacts for Traffic Standards Publication web page**.

**Ohio Department of Transportation
MISSION STATEMENT**

To provide easy conveyance of people and goods from place to place, we will:

- Take care of what we have
- Make our system work better
- Improve safety
- Enhance capacity

PUBLICATION RECORD

2002 October 23, 2002 Edition, effective December 2, 2002

New edition, updating and consolidating information previously published in the ODOT Traffic Control Application Standards Manual, the Traffic Control Design Information Manual, the Construction Guidelines for Traffic Control Devices and various separate policies, guidelines and procedures.

2003 January 17, 2003 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet, Publication Record, and Table of Contents;**
- **in Part 1**, a revised Table 197-1;
- **in Part 2**, a revised Section 208-3, and editorial changes in Section 205-2.3.1;
- **in Part 3**, a revised Table of Content, revised Sections 304-2, 342-2, 342-3, 342-4, 342-5 and 343, and editorial changes in Sections 301-1, 301-3, 302-1, 304-1, 304-3, 304-6, 306, 307, 320-4, 320-5, 340-1, 340-2, 340-3 and 350-2;
- **in Part 4**, a revised Table of Content, revised Sections 442-3, 442-5, 442-9, 442-10, 442-11, 442-15, 442-16 and 442-19, deleted Sections 442-14, 442-17 and 442-18, and editorial changes in Sections 401-1, 403-1, 404-1, 420-1, 421-1, 441-9, 442-4, 442-6, 442-7, 442-8, 442-12, 442-13, 443, 450-3.2 thru 450-3.6, 450-4.1, 450-4.3, 450-4.4, 450-6.2, 450-6.3, 450-8.2, 450-8.5, 450-8.7, 450-8.8, 450-9, 450-10.2 thru 450-10.7 and 450-11.1 thru 450-11.8;
- **in Part 6**, a revised Table of Content, a new Section 605-8.4, revised Sections 605-6.5, 607-40, 607-41, 640-14, 640-24.1, 641-8.4, 641-10.5, 642-3, 642-9, 642-16, 642-17, 642-19, 642-20, 642-21, 642-24, 642-25, 642-26, 642-27, 642-28, 642-30, 642-31, 642-32, 642-35, 642-39, 642-41, 670-7 and Figure 698-3a, and editorial changes in Sections 605-2.1, 605-7.3, 605-11.3, 605-11.4.1, 605-11.5, 605-11.10.2, 606-2, 606-12, 606-14, 606-15, 607-1, 620-3, 620-6.1, 620-6.2, 620-6.3, 640-1, 640-8, 640-11.3, 640-11.6, 640-11.7, 640-18.2, 640-21, 640-22, 641-2.6, 641-5.1 thru 641-5.4, 641-5.6, 641-6.1 thru 641-6.5, 641-7.2, 641-8.5, 641-9.6, 641-9.7, 641-10.4, 641-10.8, 641-11, 641-12, 641-13, 641-14, 641-15, 641-16, 641-17, 641-19, 642-2, 642-4, 642-5, 642-6, 642-9, 642-10, 642-12, 642-18, 642-22, 642-29, 642-33, 642-34, 642-36, 642-37, 642-38 and 642-40;
- **in Part 11**, a revised Table of Content, revised Sections 1141-3.1, 1142-2 thru 1142-19, 1142-21 thru 1142-23, 1142-26, 1142-31, 1142-32 and 1142-34, and editorial changes in Sections 1142-20, 1142-24, 1142-25, 1142-27 thru 1142-30, 1142-33, 1142-35 and 1143;
- **in Part 12**, a revised Table of Content and revised Section 1215; and
- **in Part 14**, the Index was revised.

2003 April 18, 2003 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- new **Cover Sheet, Publication Record and Table of Contents;**
- **in Part 2**, revised Section 201-8 and Table 297-9;
- **in Part 3**, revised Sections 302-3 and 343; and editorial corrections in Section 302-2 and Table 397-1;
- **in Part 4**, new Sections 442-17, 442-18 and 442-19; a revised Table of Contents and revised Sections 442-1 thru 442-16 and Figures 498-3 and 498-5;
- **in Part 6**, a revised Table of Contents, and revised Sections 602-5.3, 605-10.2, 642-1 thru 642-32 and Table 697-9; and editorial changes in Sections 605-11.4.1, 640-12.2, 640-20, 640-23.3.4, 640-23.5, 641-7.4, 641-15, 642-9, 642-36;
- **in Part 11**, new Sections 1150-1 thru 1150-21 and 1160-11 thru 1160-14; a revised Table of Contents; and editorial changes in Section 1100-1, 1140-4.3.5, 1140-5.6.2, 1140-5.7.2, 1140-7.3, 1141-4.2.3, 1142-16, 1142-17 and 1142-18; and
- **in Part 12**, revised Section 1202-1.

2003 October 17, 2003 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet and Table of Contents**, and an updated **Publication Record;**
- **in Part 1**, a revised Table of Contents, and revised Sections 100-2, 100-5, 101-1, 101-2, 101-3.2, 101-3.3, 101-3.4, 101-4, 101-5, 102-2, 102-3.2, 102-3.4, 102-3.5, 102-5, 103-3.1, 103-3.3, 103-3.8, 103-4, 103-5, 104-1, 104-2, 105-1, 106-2, 106-3, 130-2.1, 130-2.3, 140-2.6, 194-9, 197 and 198, and Form 196-3, Tables 197-1, 197-2, 197-3, 197-9 and 197-10, and Figures 198-1a, 198-1b, 198-1c and 198-2; deleted Section 106-4 and Figure 198-1d; editorial changes in Sections 100-1.4 and 103-3.4; and general editorial/formatting changes;
- **in Part 3**, a new Section 301-14; revised and renumbered Sections 301-12.4 and 301-12.5 (now Sections 301-12 and 301-13, respectively); a revised Table of Contents, and revised Sections 301-1, 301-4 through 301-11, 302-1, 303-1, 303-2, 304-1, 304-3, 304-5, 304-6, 305, 306 and 310, and Figures 398-1, and 398-3 through 398-5; deleted Sections 301-12.1 through 301-12.3; editorial changes in Sections 301-2 and 320-1; and general editorial/ formatting changes;
- **in Part 4**, new Sections 401-6 through 401-8, 402-3.5, 403-7, 408-2, 440-5 and 440-6, and Forms 496-8 through 496-18; a revised Table of Contents, and revised Sections 400-1, 401-1, 401-3, 401-4, 402-1, 402-3.1 through 402-3.4, 403-1 through 403-3, 403-5, 403-6.1, 404-1 through 404-3, 405-1, 406-1 through 406-3, 407-2, 408-1, 420-4.1 through 420-4.4, 420-4.7, 420-4.8, 421-1, 441-3, 450-10.4, 450-10.6, 496 and 497, and Table 497-3; and general editorial/reformatting changes;
- **in Part 5**, revised Sections 500 and 595;
- **in Part 7**, a revised Table of Contents, and revised Sections 700, 701, 702-1 through 702-5, 702-7 and 704; and general editorial/reformatting changes;
- **in Part 8**, a revised Table of Contents, and revised Sections 800, 801-1, 801-2.2, 802-1, 802-2, 803, and 804; and general editorial/reformatting changes;
- **in Part 9**, a revised Table of Contents and revised Section 900; and general editorial/ reformatting changes;
- **in Part 10**, revised Sections 1000 and 1095; and
- **in Part 11**, a revised Table of Contents, and Sections 1100-1, 1103-6.8, 1140-4.6.2, 1142-14, 1142-15, 1142-25, 1160-6 and 1160-8; and an editorial change in Section 1160-13.

2004 January 16, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 2**, a revised Table of Contents, and revised Sections 200-1, 201-1 through 201-3, 201-5, 201-7, 201-8, 201-10 through 201-13, 202-1, 202-4 through 202-7, 203-1, 203-2, 204-1 through 204-4, 205-1, 205-2.1, 205-2.3.3, 205-3, 206-1, 206-3 through 206-15, 207, 207-1, 207-2.1, 207-3.1, 207-4, 207-5, 207-6.1, 207-6.3, 207-6.4, 207-7, 208-1, 208-2, 208-3, 208-4, 208-6, 209-1, 209-2.2, 209-2.3, 209-3, 209-4, 209-5, 210-2, 211-1, 212-1, 220-7, 240-2.3, 240-3, 250-3.1, 295-2, 297 and 298, and Tables 297-1 and 297-4, and Figures 298-1, 298-2, 298-4a, 298-4b, 298-5a through 298-5d, 298-6a, 298-6b, 298-7, 298-22 and 298-24; deleted Sections 201-6, 206-2 and 295-3, and Figure 298-6c; and general editorial/formatting changes;
- in **Part 3**, editorial corrections in Section 398;
- in **Part 6**, new Sections 605-5.12 through 605-5.15, 606-19, 606-20, 640-26, 642-42 through 642-45, 670-6.1 through 670-6.3; a revised Table of Contents, and revised Sections 601-1, 602-4.1, 602-4.4.4, 602-5.1 through 602-5.6, 602-5.8, 602-6, 602-7, 603, 604, 605-1 through 605-3, 605-4.2, 605-4.3, 605-5.1 through 605-5.11, 605-6, 605-7, 605-8, 605-9605-10.1, 605-10.2, 605-11.1 through 605-11.9, 605-11.10.1, 605-11.11 through 605-11.13, 605-12, 605-13, 605-14.1, 605-14.2, 605-14.5, 605-15.1, 605-15.2.2, 605-15.2.3, 605-16 through 605-20, 606-1 through 606-18, 607-1 through 607-15, 620-3, 620-6.1, 640-4, 640-5.3, 640-12.1, 640-12.4, 640-18.2, 640-20, 640-22, 641-5.2, 641-5.3, 641-6.3, 641-6.5, 641-7.3, 641-8.3, 641-9.3, 641-9.6, 641-10.3, 641-10.4, 641-11 through 641-13, 641-15, 641-17, 641-19, 642-24, 642-27, 642-31 through 642-34, 660-2, 670-6 through 670-8, 695-2, 697, 698, and Tables 697-5 through 697-9, and Figures 698-1 through 698-4; deleted Sections 605-6.1 through 605-6.5, 605-9.1 through 605-9.3, 605-10.3, 605-11.14, 607-16 through 607-44, 670-9, 670-10, and Tables 697-10 through 697-14, and Figures 698-5 through 698-49; editorial corrections in Sections 620-2.2, 642-5, 642-30; and general editorial/formatting changes.
- in **Part 11**, revised Section 1141-3.1;
- in **Part 12**, a revised Table of Contents, and revised Sections 1210, 1211, 1212-1, 1212-2.2, 1212-2.3, 1213-1, 1213-2, 1213-3, 1214, 1215, 1220-3, 1220-5.1, 1230-2.1 and 1230-6.13; and editorial corrections in Sections 1220-5.7 and 1230-6.9.
- in **Part 13**, a revised Table of Contents, and revised Sections 1301-2, 1301-3, 1305, 1312 and 1399, and general editorial/formatting changes.

2004 April 16, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, a new Section 140-7; and revised Tables 197-1 and 197-10;
- in **Part 2**, a new Section 240-8; a revised Table of Contents and Sections 240-1 and 295-2;
- in **Part 3**, a new Section 350-3; a revised Table of Contents, revised Sections 301-1, 301-2, 301-14, 302-2 thru 302-4, 304-4, 320-1, 320-5, 340-2 thru 340-4, 342-2, 343 and 397, and revised Table 397-1; deleted Sections 342-3 thru 342-5; and a minor editorial correction in Section 301-10;
- in **Part 4**, a new Section 440-7; a revised Table of Contents and Section 440-1;
- in **Part 6**, new Sections 630-5, 641-23 and 642-46, and Figures 698-5 through 698-9; a revised Table of Contents, revised Sections 606-16, 606-17, 607-10, 607-12, 607-13, 607-15, 630-1, 640-12.1, 640-12.4, 640-23.3.1 and 698; and editorial corrections/changes in Sections 640-2, 642-44 and 642-45

2004 July 16, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, a revised Table of Contents and Sections 101-1.3, 100-5, 101-3.3, 101-4, 101-5, 102-3.1, 102-3.2, 102-3.3, 102-5, 103-4, 103-5, 104-3, 140-2.3, 140-2.4, 140-7, 150-1, 160, 193-10.2, 194-14 and 198, and Figures 198-1a and 198-2; deleted Figures 198-1b and 198-1c; and editorial corrections/changes in Sections 100-1.1, 100-1.4, 100-6, 101-2, 101-3.2, 101-3.4, 102-1, 102-2, 102-3.6, 103-1, 140-2.2, 140-2.5, 140-2.6, 193-10.1, 193-11, 193-12, 194-3, 194-6, 194-9, 194-10, 194-11 and 194-17.
- in **Part 2**, five renamed sections: existing Sections 205-2, 205-3, 205-3.1, 205-3.2 and 209-1.1 are now 205-3, 205-4, 205-4.1, 205-4.2 and 211-3, respectively; new Sections 202-8, 205-2, 205-5, 206-16, 207-8, 209-6, 209-7 and 211-2, and Figures 298-28 thru 298-36; a revised Table of Contents, and Sections 200-1, 201-1, 201-4, 201-5, 201-7, 201-8, 202-4 thru 202-7, 203-1, 203-2, 204-1 thru 204-4, 205-1, 205-2.1, 205-2.2, 205-2.3.2, 205-2.3.3, 206-1, 206-3, 206-4, 206-5.1, 206-5.2, 206-5.5, 206-6, 206-7.2, 206-7.3, 206-8, 206-14, 206-15, 207-1, 207-2.1 thru 207-2.3, 207-3.1, 207-5.2, 207-5.3, 207-6.2, 207-6.3, 207-7, 208-1 thru 208-4, 208-6, 209-1, 209-2.1, 209-2.2, 209-3, 209-4.1, 209-4.2, 209-5, 210-2, 211-1, 211-2, 212-1 thru 212-3, 220-4 thru 220-7, 220-8.2, 220-8.3, 220-8.5, 221-1, 240-2.1, 240-2.2, 240-3, 240-4.3, 240-4.5, 240-4.7 thru 240-4.9, 240-5.3, 240-5.6, 240-5.7, 240-6.3, 240-6.4, 240-7.1 thru 240-7.3, 240-8, 241-1, 241-3, 241-7, 242-1 thru 242-4, 250-2, 250-3.1, 250-4.3, 250-5.3, 250-5.7, 250-8.1, 260-1, 260-4.2, 260-4.3, 260-6.1 and 298, and Tables 297-1 and 297-6, and Figures 298-5a thru 298-5d and 298-22; and editorial corrections/changes in Sections 200-3, 201-2, 201-3, 201-10 thru 201-13, 202-1, 205-2.4, 206-7.1, 206-7.4, 207-2, 207-4.2, 207-4.4, 207-5.1, 207-6.1, 207-6.4, 209-2.3, 209-2.5, 209-2.6, 220-8.4, 221-5, 240-7.5 thru 240-7.7, 241-2, 241-6, 242-5, 250-3.2, 250-3.3, 250-4.1, 250-4.2, 250-4.6, 250-5.2 and 250-6.2, and Tables 297-2, 297-4, 297-9, 297-11.
- in **Part 3**, four renamed sections: existing Sections 340-2, 340-3, 340-4 and 340-5 are now 341-2, 341-3, 341-4 and 341-5, respectively; new Sections 340-2, 341, 341-1, 350-4, 360-1, 360-2 and 360-3; a revised Table of Contents and revised Sections 301-14.1, 302-1, 340-1, 350-3 and 360; and a minor editorial corrections/changes in Sections 300-1 and 301-14.4;
- in **Part 4**, new Sections 442-20, 442-21, 442-22 and 442-23; a revised Table of Contents and Sections 401-6 and 440-7, and Form 496-13; and editorial corrections/changes in Sections 442-1, 442-3, 442-4, 442-5, 442-6, 442-7, 442-8, 442-9, 442-10, 442-11, 442-12, 442-13, 442-14, 442-15, 442-16 and 442-19;
- in **Part 6**, new Sections 630-6 and 640-27, and Form 696-1; a revised Table of Contents, revised Sections 605-4.3, 605-5.3, 605-5.12 thru 605-5.15, 605-11.3, 630-4, 630-5, 640-12.2, 642-24, 642-27, 642-33, 696 and 698, and Figures 698-3a, 698-3b and 698-4; and editorial corrections/changes in Sections 607-10, 607-13, 607-15, 640-18.2, 642-14, 642-15, 642-42 and 642-46.

- in **Part 11**, new Sections 1141-3.7 thru 1141-3.9; a revised Table of Contents and Sections 1140-6.1.1.4, 1140-6.1.2.2, 1141-2, 1141-3.1 thru 1141-3.6 and 1141-4; and an editorial corrections in Section 1142-35.
- in **Part 14**, a revised listing.

2004 October 22, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, a revised Table of Contents and Section 103-3.2; and editorial corrections/changes in Sections 100-3.3 and 140-7;
- in **Part 4**, editorial corrections/changes in Sections 442-20, 442-21 and 442-23; and
- in **Part 6**, new Section 642-47; a revised Table of Contents, revised Sections 605-11.3, 640-18.2, 641-5.1, 641-6.1, 642-9, 642-19 and 642-24.

2005 January 21, 2005 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised **Preface** and an updated **Cover Sheet, Revision Record and Table of Contents**;
- in **Part 1**, new Sections 194-21 and 194-22; a revised Table of Contents and Sections 100-3, 100-4, 101-3.3, 102-1, 102-3.4, 103-3.1, 103-3.2, 103-3.4, 103-3.7, 103-5, 105-1, 105-3, 120-1 thru 120-3, 140-7, 193-3, 193-10.1, 193-14, 193-15, 194-1, 194-2, 194-13, 194-15, 194-16 and 194-19, Tables 197-2, 197-8 and 197-9, and Figure 198-1; editorial corrections or changes in Sections 101-2, 101-4, 101-5, 102-2, 102-3.2, 102-3.5, 102-3.6, 102-4, 103-4, 104-1 thru 104-3, 106-1, 106-3, 130-2.3, 130-3, 130-4, 130-6, 140-1, 140-2.4, 140-2.6, 140-2.7, 140-5, 150-1, 150-2, 160, 193-5, 193-10.2, 193-12, 193-20, 194-5, 194-9 thru 194-11, 195-1, 196, 197 and 198, Forms 196-1 thru 196-4, Tables 197-3 thru 197-6, 197-7 and 197-10; and minor format changes.
- in **Part 2**, new Sections 205-6 and 210-3; revised Table of Contents and Sections 205-4, 209-4 and 240-8, and Table 297-7;
- in **Part 4**, new Forms 496-19 and 496-20, and Table 497-6; a revised Table of Contents, revised Sections 403-5, 403-6, 403-6.1, 403-6.4, 403-7, 440-3, 440-5 thru 440-7, 441-2, 441-3, 441-8, 441-11, 496 and 497, and revised Forms 496-3 and 496-4; editorial corrections in Form 496-6; and deleted Section 403-6.5; and
- in **Part 6**, a revised Table of Contents, revised Sections 605-4.3, 605-10.1, 642-21, 642-28, 642-30 thru 642-32 and 642-44; and editorial corrections or changes in Sections 642-33, 642-34, 642-36, 642-37, 642-40 thru 642-43, 642-45 and 642-47, and Tables 697-3 thru 697-5 .

2005 April 15, 2005 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, revised Tables 197-2 and 197-3;
- in **Part 3**, a revised Table of Contents, revised Sections 301-1, 301-7, 301-14.4, 302-2, 302-6, 307-2, 310, 320-1, 320-4, 341-1, 342-2 and 343, and Table 397-2; and minor editorial/format changes;
- in **Part 4**, a revised Table of Contents, Sections 401-6, 401-7, 404-2, 442-20, 442-21, 442-22 and 442-23, Form 496-2, and Table 497-5; deleted Forms 496-12 through 496-18; editorial revisions in Forms 496-8 through 496-11, and 496-19, Table 497-6, and Figure 498-37; and minor editorial/format changes;
- in **Part 6**, a revised Table of Contents, revised Sections 630-4, 630-5, 640-23.4, 640-23.5, 641-9.6, 641-23, 642-46 and Form 696-1; and minor editorial/format changes;
- in **Part 11**, a revised Section 1142-30;
- in **Part 12**, a revised Section 1220-5.6; and
- in **Part 13**, added copies of ODOT Policies 16-004(P), 22-007(P), 25-005(P), 122-002(P), 322-002(P), 512-002(P), and Standard Procedures 122-004(SP) and 510-005(SP); revised Sections 1301-2, 1310, 1312, 1314 and 1399; and minor editorial/format changes.

2006 January 20, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Preface, Publication Record and Table of Contents**;
- in **Part 1**, a new Section 193-11; deleted Section 193-14; three renumbered Sections (Sections 193-11 thru 193-13 are now Sections 193-12 thru 193-14); a revised Table of Contents, Sections 101-2, 101-3.2 thru 101-3.4, 101-4, 101-5, 102-2, 102-3.4 thru 102-3.6, 102-4, 103-3, 103-3.4 thru 103-3.6, 103-4, 103-5, 104-4, 106-1 thru 106-3, 120-1, 120-2, 130-2.2, 130-2.3, 140-2.3, 140-2.4, 193-4 thru 193-7, 193-9, 193-15 thru 193-18, 194-1 thru 194-3, 194-6 thru 194-8, 194-19, Chapter 197, Forms 196-1 thru 196-4, Tables 197-1 thru 197-3 and 197-5 thru 197-10, and Figures 198-1 and 198-2; and editorial revisions in Sections 100-1.2, 100-1.4, 100-4 thru 100-6, 101-3.1, 102.3.1 thru 102-3.3, 102-5, 103-3.2, 104-2, 105-1, 120-3, 130-1, 130-2.1, 130-5, 140-1, 140-2.6, 140-2.7, 140-3, 140-4, 140-5, 140-7, 193-1, 193-2, 193-10, 194-4, 194-21 and 195-1, and Chapters 160 and 180;
- in **Part 5**, revised Chapters 500 and 595;
- in **Part 7**, revised Chapter 704, Sections 702-5, 702-6, 705-1, 705-2 and 705-4; and editorial revisions to the Table of Contents, Chapters 795 and 796, and Forms 796-4 and 796-5;
- in **Part 8**, revised Chapters 803, 805 and 840, Sections 801-2.2, 801-2.3, 802-1, 802-2, 880-2, 895-1, 895-2, 895-3, and 895-4; and editorial revisions to Chapters 850 and 860, Sections 830-1 880-1;
- in **Part 9**, a new Section 995-4; revised Table of Contents, Chapters 900, 930, 940 and 950, and Sections 995-1 and 995-2; and
- in **Part 10**, revised Chapters 1000 and 1095

2006 April 21, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 2**, a new Figure 298-37; deleted Figure 298-5d; a revised Table of Contents, Chapter 243, Sections 200-1, 201-1 thru 201-4, 201-8, 201-10 thru 201-13, 202-5, 202-7, 202-8, 203-2, 204-1, 204-2, 205-2, 205-4 thru 205-6, 206-1, 206-3, 206-4, 206-5.2, 206-6, 206-7.2, 206-8, 206-10 thru 206-12, 206-14, 206-15, 207-1, 207-4.4, 207-5.1, 207-6.1, 207-6.3, 207-6.4, 207-7, 208-1, 208-2, 208-4 thru 208-6, 209-1, 209-4.1, 209-5 thru 209-7, 211-1 thru 211-4, 212-1, 212-3, 220-4, 220-5, 221-2, 221-4, 240-2.2, 240-3, 240-4.1, 240-4.2, 240-4.6, 240-4.8, 240-4.9, 240-5.3 thru 240-5.5, 240-6.2, 240-7.2, 240-7.3, 240-7.6, 240-7.7, 241-5, 242-4, 250-2, 250-2, 250-3.1 thru 250-3.4, 250-4.2 thru 250-4.6, 250-5.2 thru 250-5.8, 250-6.2, 250-6.4, 250-6.5, 250-7.1, 250-7.2, 250-7.4 thru 250-7.6, 250-8.1, 250-8.2, 260-4.2, 260-4.3, 260-5, 260-6.1, 260-6.2, 295-1 thru 295-4, Figure Index, Figures 298-4a and 298-5a thru 298-5c; and editorial revisions in Chapter 230, Sections 200-2, 201-5, 201-9, 202-1, 202-4, 202-6, 203-1, 204-4, 205-1, 206-2, 206-5.1, 206-7.1, 207-2.2, 207-2.3, 207-3.1, 207-3.2, 207-3.3, 207-5.2, 207-5.3, 209-2.5, 209-4.2, 210-1, 210-3, 220-1, 220-7, 220-9, 221-1, 221-3, 221-5, 240-1, 240-2.1, 240-4.3, 240-4.5, 240-4.7, 240-5.7, 240-6.3, 240-7.4, 240-7.5, 240-8, 241-1, 241-6, 241-7, 242-1, 250-4.1, 250-5.1, 250-6.1, 250-6.3, 260-1, 260-4.1 and Figure 298-22; and minor editorial/format changes;
- **in Part 3**, new Sections 304-7, 341-6, 342-3 thru 342-5, and 350-5 thru 350-8; deleted Section 360-3; a revised Table of Contents, a revised title for Chapter 303, revised Chapters 310 and 343, Sections 300-1, 300-3, 301-1 thru 301-4, 301-6 thru 301-12, 301-14.1, 301-14.2, 301-14.4, 301-14.5, 302-1, 302-5, 303-1, 303-3, 304-2, 304-6, 307-2, 320-1, 320-4, 341-2, 341-5, 342-2, 360-1 and 360-2, Form 396-1, Figures Index, and Figures 398-2 thru 398-5; and editorial revisions to the Tables Index, Sections 300-2, 301-13, 303-4, 304-3, 340-1, 340-2, 341-1, 341-4, 342-1, 350-3 and 350-4, Chapters 330, 370 and 380, and Table 397-1; and minor editorial/format changes; and
- **in Part 4**, new Sections 442-24 thru 442-29, revised Table of Contents, Chapter 443, Sections 400-1, 401-2, 401-3, 401-6, 403-2, 403-7, 404-2, 404-3, 406-2, 407-2.2 thru 407-2.4, 420-4.2, 420-4.8, 440-6, 441-7, 441-8, 442-3, 442-13, 442-17 thru 442-19, 450-1, 450-3.2 thru 450-3.5, 450-6.2, 450-6.3, 450-8.4, 450-8.5, 450-10.2 thru 450-10.7, 450-11.2, 450-11.5 thru 450-11.8, 460-3.4, 495-1, Forms Index, Table 497-5, Figures Index, and Figures 498-7, 498-23 and 498-27; and editorial revisions to Chapters 430, 470 and 480, Sections 400-2, 400-3, 401-4, 402-1, 402-2, 402-3.1 thru 402-3.3, 402-4, 403-1, 403-3, 403-5, 403-6.1, 403-6.2, 404-1, 406-1, 407-1, 408-1, 408-2, 420-2, 420-4.1, 420-4.4, 420-4.5, 420-5, 440-1 thru 440-3, 440-5, 440-7, 441-1, 441-2, 441-5, 441-10, 441-11, 442-1, 450-5, 450-6.1, 450-8.1, 450-10.1, 460-5, 460-7, 460-8, 460-9.2, 460-9.3, and Forms 496-2, 496-6 and 496-7; and minor editorial/format changes.

2006 July 21, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 4**, new Section 450-12; a revised Table of Contents and Section 420-4.6;
- **in Part 6**, new Sections 600-6, 606-21, 606-22, 642-48 thru 642-52, and Table 697-10; deleted Section 605-14.5; a revised Table of Contents, Sections 601-2, 602-3, 602-5.1, 602-5.3, 602-5.6, 602-5.7, 603-2, 603-3, 604-2, 604-3, 604-6, 605-1, 605-2.1 thru 605-2.3, 605-4.3, 605-5.1, 605-5.2, 605-5.5 thru 605-5.7, 605-5.9 thru 605-5.15, 605-6, 605-7.2, 605-7.3, 605-8.4, 605-9, 605-10.1, 605-10.2, 605-11.1 thru 605-11.13, 605-12.1 thru 605-12.5, 605-13.1, 605-14.1, 605-14.2, 605-14.4, 605-15.1, 605-16 thru 605-18, 605-20, 606-1, 606-3, 606-6 thru 606-9, 606-11 thru 606-20, 607-1, 607-6, 607-10, 607-13, 607-15, 620-3, 620-5, 630-5, 640-2, 640-5.2, 640-9, 640-12.1, 640-13.2, 640-18.1, 640-18.2, 640-22, 640-24.1, 640-24.2, 640-25, 640-26, 641-5.4, 641-5.6, 641-6.4, 641-8.4, 641-9.6, 641-10.6, 641-11 thru 641-14, 641-18, 641-23, 642-4, 642-6, 642-17, 642-21, 642-24, 642-25, 642-27, 642-39, 642-44, 642-46, 670-5 and Tables Index; and editorial revisions in Chapter 643, Sections 600-1 thru 600-5, 602-1, 602-5.8, 602-6, 602-7.1, 602-7.3, 602-8, 603-1, 604-1, 604-4, 605-3.1, 605-4.1, 605-4.2, 605-5.8, 605-7.1, 605-8.1, 605-8.3, 605-13.2, 605-15.2, 605-19, 606-2, 606-5, 606-10, 607-4, 607-7, 607-11, 607-12, 620-1, 630-1, 630-3, 630-4, 640-1, 640-3, 640-4, 640-5.1, 640-6, 640-7.1, 640-8, 640-11.3, 640-11.5, 640-13.1, 640-14, 640-16, 640-17, 640-19 thru 640-21, 640-23.1, 640-23.3, 640-23.4, 641-1, 641-2.1, 641-2.3, 641-2.5, 641-2.7, 641-2.8, 641-3, 641-4, 641-5.1 thru 641-5.3, 641-6.1 thru 641-6.3, 641-6.5, 641-7.1, 641-7.3, 641-8.1, 641-8.3, 641-9.3, 641-10.1, 641-10.3, 641-10.7, 641-15 thru 641-17, 641-19, 642-1, 642-10, 642-30, 642-43, 642-47, 650-1, 660-1, 660-2, 670-1, 670-2, 670-6.2, 695-1, 695-2, 695-5, 695-6 and Table 697-1d; and minor editorial/format changes;
- **in Part 11**, deleted Section 1142-32; a revised Table of Contents, Chapter 1150, Sections 1104-3, 1130-5, 1140-4.2, 1140-4.4, 1140-4.6, 1140-5.7, 1140-5.9, 1140-7.3, 1141-3.6, 1142-14, 1142-15, 1142-24, 1160-2, 1160-3.1 and Figures Index; editorial revisions in Chapter 1195, Sections 1100-1, 1100-2, 1100-3, 1103-6.6, 1103-6.8, 1104-1, 1104-2, 1105-1 thru 1105-3, 1106-2.2, 1107-3, 1120-3, 1130-2, 1130-3.1, 1130-4, 1140-1, 1140-3.2, 1140-3.3, 1140-3.5, 1140-4.3, 1140-4.7, 1140-5.3 thru 1140-5.6, 1140-5.8, 1140-6.1, 1140-6.2, 1140-8, 1141-1, 1141-2, 1141-3.1 thru 1141-3.3, 1141-4.1 thru 1141-4.5, 1142-8, 1142-13, 1142-25, 1142-28, 1142-31, 1142-35, 1160-1, 1160-4, 1160-13.5, the Tables Index, Tables 1197-4 thru Table 1197-7 and Figure 1198-4; and minor editorial/format changes.

2006 September 5, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**; and
- **in Part 6**, deleted Table 697-6; a revised Table of Contents, Sections 605-8.4, 605-12.2, 605-15.2, 606-10, 606-16, 607-10, 630-5, 640-5.1, 640-9, 641-5, 641-6.2, 641-6.4, 641-11, 641-18, 641-19, 642-10, 642-42, Tables Index, and Figures 698-6 and 698-8; and editorial revisions in Sections 601-2, 630-4, 630-6, and Table 697-10; and minor editorial/format changes.

2006 October 20, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 3**, revised Form 396-1;
- **in Part 4**, revised Section 420-4.2;
- **in Part 6**, a revised Table of Contents and Sections 642-26, 642-50 and 642-51;
- **in Part 8**, revised Chapter 805; and
- **in Part 12**, new Sections 1215-1 thru 1215-5 and 1230-7, Form 1296-13, Table 1297-5 and Figures 1298-17 thru 1298-40; a revised Table of Contents, Chapters 1210 and 1211, Sections 1201-1 thru 1201-5, 1202-1, 1212-2, 1212-3, 1213-1, 1213-2, 1220-2, 1220-6, 1230-1 thru 1230-3, 1230-6, 1250-2, Forms Index, 1296-1, 1296-2, 1296-11, 1296-12, Tables Index,

Figures Index and Figures 1298-2, 1298-6, 1298-7, 1298-10, 1298-11, 1298-12, 1298-15, 1298-16; and editorial revisions in Chapters 1200, 1214, 1280 and 1295, Sections 1212-1, 1212-4, 1213-3, 1220-1, 1220-3 thru 1220-5, 1250-1; and minor editorial/format changes.

2007 January 19, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 1**, revised Figure 198-1;
- **in Part 2**, new Sections 202-9, 202-10, 204-5, 204-6, 220-10 and 221-6, Tables 297-12 and 297-13, and Figures 298-38 through 298-44; a revised Table of Contents, Sections 201-1, 201-3, 202-7, 203-1, 205-3, 208-1 and 221-5, Tables Index, Figures Index, Figure 298-6, 298-14, 298-15 and 298-27; editorial corrections in Sections 200-1, 201-5, 201-7, 204-4, 207-5, 207-6, 240-4, 250-4, 250-7 and 260-5, Table 297-4, and Figures 298-26 and 298-28 through 298-32; and minor editorial/format changes;
- **in Part 4**, new Sections 442-30, 442-31 and 442-32, and Figures 498-39, 498-40, 498-41 and 498-42; a revised Table of Contents and Figures Index; editorial corrections in Sections 407-2 and 450-10, and Figure 498-1; and minor editorial/format changes;
- **in Part 6**, a new section 620-7; a revised Table of Contents and Sections 605-1, 605-2, 605-11, 620-2, 620-4, 640-18, 642-24, 642-27, 642-33 and 642-34; editorial corrections in Sections 605-4, 605-5, 620-1, 641-17 and 641-19; and minor editorial/format changes; and
- **in Part 7**, revised Chapter 704.

2007 April 20, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 1**, revised Sections 103-3, 103-4, 104-2 and 104-3, Table Index, and Tables 197-1 through 197-3, and 197-5 through 197-10;
- **in Part 2**, a revised Table of Contents, Section 207-4, Figures 298-15 and 298-22; and editorial corrections in Figures 298-12, and 298-13 ;
- **in Part 4**, new Sections 402-5 and 402-6, and Tables 497-7 and 497-8; a revised Table of Contents, Forms Index, Forms 496-12 and 496-13, and Tables Index; editorial corrections in Sections 402-3, 404-2, 404-3 and 450-8, and Figures 498-6 through 498-8, 498-21, 498-26, and 498-28 through 498-35; and minor editorial/format changes;
- **in Part 6**, new Sections 641-24 and 642-53, a revised Table of Contents and Sections 602-2, 605-14, 607-12, 607-13, 640-1, 640-12, 641-23, 642-9, 642-21, 642-22, 642-30, 642-31, 642-44 and 642-48; editorial corrections in Sections 640-2, 641-6, 641-7, 641-19, 642-10, 642-11, 642-16 and 642-42; and minor editorial/format changes;
- **in Part 11**, revised Section 1140-5; and
- **in Part 12**, a revised Table of Contents and Section 1220-3.

2007 July 20, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 1**, new Sections 120-7, 150-3, 195-3 through 195-7 and Figures 198-3 through 198-6; revised Table of Contents, Chapters 106, 160, 180 and 195, Sections 100-1, 100-4, 101-2, 101-5, 102-1 through 102-3, 120-1 through 120-6, 130-2, 140-7, 193-9 and 195-1, Forms 196-1 and 196-3, Tables 197-2, 197-3, 197-9 and 197-10, and Figures Index; editorial corrections in Sections 193-7, 193-10, 193-15 and 193-16; and minor editorial/format changes;
- **in Part 2**, a revised Table of Contents and Sections 220-2, 220-3, 240-4, 260-4 and 295-2;
- **in Part 3**, revised Sections 320-2 and 320-3;
- **in Part 4**, new Sections 401-9 and 440-8; a revised Table of Contents and Sections 401-2, 404-3, 420-2, 420-3 and 420-4;
- **in Part 6**, new Chapter 608, Section 695-7, Forms 696-2 through 696-9, and Figure 698-10; a revised Table of Contents, Sections 600-4, 600-6, 601-2, 602-3, 602-5, 605-3, 605-14, 605-17, 605-19, 606-14, 606-20, 630-4, 630-5, 640-12 through 640-14, 640-18, 641-2, 641-24, 642-35, 642-51, 642-52, 695-6, Forms Index, Form 696-1 and Figures Index; editorial corrections in Sections 607-13, 620-7, 630-1, 630-6, 640-23, 640-26, 641-6 and Figure 698-1; and minor editorial/format changes;
- **in Part 8**, revised Chapter 805;
- **in Part 11**, a revised Table of Contents and Sections 1120-3 through 1120-5;
- **in Part 12**, new Chapters 1203, 1204 and 1205, a revised Table of Contents, Chapters 1200, 1201, 1202, 1210, 1211, 1212, 1213, 1220, 1250, 1280, Forms Index, Form 1296-1, Tables Index, Figures Index, and Figures 1298-1, 1298-3 through 1298-5, 1298-21 and 1298-24; deleted Chapters 1213 through 1215, and 1230; editorial corrections in Form 1296-2 and Figures 1298-21 and 1298-24; and minor editorial/format changes;
- **in Part 13**, new title, Table of Contents and Chapters replaced existing text, which was relocated Part 15;
- **in Part 14**, new title, Table of Contents, Chapters 1400, 1401, 1402, 1415, 1420, 1430, 1450, 1480, 1495, Forms Index, and Form 1496-1; and deleted the index; and
- added **Part 15**.

2007 October 19, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 1**, revised Table of Contents, Section 120-4, and Tables 197-1 and 197-2; an editorial correction in Sections 101-2; and minor editorial/format changes;
- **in Part 2**, revised Figures 298-10 and 298-29 through 298-32; editorial corrections in Section 240-4 and Figures 298-8, 298-9, 298-11 and 298-26; and minor editorial/format changes;
- **in Part 3**, an editorial correction in Table 397-1;

- **In Part 4**, a revised Table of Contents and Section 406-3; deletion of Section 402-6; and an editorial correction in Section 401-9;
- **in Part 6**, revised Table of Contents and Sections 641-12, 641-13, 641-14, 641-15, 642-30, 642-39 and 642-41;
- **in Part 11**, a revised Table of Contents; and editorial corrections to Chapters 1103 and 1120, and Section 1150-3;
- **in Part 13**, a revised Section 1301-3, Forms Index, and Form 1396-1.

2008 January 18, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 4**, new Section 460-10 and Table 497-9; a revised Table of Contents, Sections 440-4, 442-13, 442-17, 442-24, and Tables Index; and minor editorial/format changes;
- **in Part 6**, new Form 696-6; renamed Forms 696-1 through 696-9 (now Forms 696-1a, 696-1b, 696-2a, 696-2b, 696-3a, 696-3b, 696-4a, 696-4b and 696-5); a revised Table of Contents, Sections 605-2, 605-9, 605-13, 605-14, 605-18, 606-6, 606-16, 630-5, 640-2, 640-12, 640-19, 641-9, 641-10, 642-18, 642-39, 642-44 and 695-7, and Forms Index; editorial corrections in Sections 606-1, 640-11, 641-1, 641-12 through 641-15, and Figure 698-3a; and minor editorial/format changes; and
- **in Part 13**, revised Sections 1301-1 and 1301-2, Forms 1396-1 and 1396-2, and Table 1397-1.

2008 April 18, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 1**, revised Tables 197-2 and 197-9; ;
- **in Part 2**, revised Table of Contents and Sections 240-4 through 240-6; and minor editorial/format changes;
- **in Part 3**, revised Table of Contents, Sections 342-3, 350-7 and 350-8; and minor editorial/format changes;
- **in Part 4**, new Section 401-10; a revised Table of Contents, Chapter 443, Sections 403-6, 403-7, 440-2, 440-6, 441-6, 441-9, 442-1, 442-3, 442-6, 442-11, 442-17 through 442-19, 442-24, 450-3, 450-8, 450-10, 450-11, 460-4, 460-7, 460-8, Forms Index, Forms 496-14, 496-15, 496-19, Tables 497-1, 497-4, and Figures 498-10, 498-22, 498-25, 498-34 and 498-37; editorial corrections in Section 442-32, the Figures Index and Figure 498-37; and minor editorial/format changes;
- **in Part 6**, new Section/Plan Note 642-54; a revised Table of Contents, Sections 605-9, 605-11, 605-13, 620-6, 640-2, 641-10, 642-39; and minor editorial/format changes; and;
- **in Part 7**, new Chapter 742 with new Sections 742-1 and 742-2; a revised Table of Contents, and Section 702-4; and minor editorial/format changes
- **in Part 11**, editorial correction in Section 1142-25; and minor editorial/format changes;
- **in Part 13**, deleted Form 1396-2; revised Table of Contents, Section 1301-1, Forms Index and Figures Index; and minor editorial/format changes.

2008 July 18, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 2**, new Section 206-17 and Table 297-14; a revised Table of Contents and Sections 201-6, 240-4, 260-5, the Table Index and Figure 298-18; and minor editorial/format changes;
- **in Part 3**, revised Table of Contents; deleted Sections 341-6, 342-4 and 342-5;
- **in Part 4**, new Section 440-9; a revised Table of Contents and Section 440-3;
- **in Part 6**, new Section 604-21, a revised Table of Contents, Sections 605-11, 605-18, 605-20, 607-15, 640-2, 642-24, 642-39, 642-41 and 642-50; and minor editorial/format changes;
- **in Part 7**, revised Table of Contents and Section 702-4; and minor editorial/format changes; and
- **in Part 12**, new Forms 1296-14 through 1296-16, and Table 1297-6; revised Table of Contents, Chapters 1201 and 1202, Sections 1203-1 through 1203-5, the Forms Index, Forms 1296-1, 1296-3, 1296-4, 1296-11, the Tables Index, the Figures Index, Figures 1298-3 through 1298-5; and minor editorial/format changes.

2008 October 17, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 2**, new Section 201-14; a revised Table of Contents and Section 210-3;
- **in Part 3**, new Table 397-5; revised Table of Contents, Section 350-2 and Tables 397-1, 397-3 and 397-4; deleted Figure 398-6; editorial changes in Sections 301-13, 302-2, 303-3, 307-2, 320-4, 350-6, 350-7, 350-8, the Tables Index and the Figures Index; and minor editorial changes;
- **in Part 4**, a revised Table of Contents, Chapter 430, and Sections 401-3, 442-26, 442-28, 460-2 and 460-2; editorial changes in Sections 401-10 and 403-3; and minor editorial changes;
- **in Part 6**, a revised Table of Contents, Sections 605-13, 605-20, 620-6, 640-18, 640-23, 641-23, 642-24, 642-25, 642-48 and 642-50; editorial changes in Sections 602-6, 605-2, 605-9, 605-10, 605-11, 605-19, 608-2, 620-3, 620-7, 641-9, 641-10, 641-24, 642-21, 642-27, 642-41, 642-54 and 670-6; and minor editorial/format changes;
- **in Part 7**, revised Table of Contents; and an editorial change in Section 702-2;
- **in Part 11**, revised Figure 1198-12;
- **in Part 12**, new Section 1213-6; revised Table of Contents, Chapter 1210, Section 1213-1 and Forms 1296-1 and 1296-14; editorial changes in Section 1212-10; and minor editorial/format changes; and
- **in Part 13**, new Figures 1398-2 and 1398-3; revised Table of Contents, Sections 1301-1, 1301-2, 1301-3, Form 1396-1 and Table 1397-3; and editorial changes in the Forms Index and the Figures.

2009 January 16, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;

- in **Part 2**, a revised Table of Contents and Sections 201-3 and 240-5; and minor editorial/format changes;
- in **Part 3**, new Section 342-4; and a revised Table of Contents;
- in **Part 4**, new Sections 442-33 through 442-39; a revised Table of Contents, Sections 403-5, 440-3, 440-4 and 450-8, Tables Index, Tables 497-4 and 497-5, Figures Index and Figures 498-3 through 498-5, 498-12, 498-35 and 498-37; editorial change for Section 401-10; and minor editorial changes;
- in **Part 6**, new Section 641-19 and renumbered existing Sections 641-19 through 641-24, a revised Table of Contents, Sections 603-2, 605-5, 605-11, 605-13, 640-6, 640-22, 640-24, 640-25, 641-9, 641-10, new 641-21 (formerly 641-20), new 641-22 (formerly 641-21), 642-4, 642-6, 642-14, 642-15, 642-35, 642-38 and 642-39; editorial change in Section 642-41; and minor editorial/format changes; and
- in **Part 13**, new Section 1301-4 and Form 1396-2; deleted Figure 1398-1 and renumbered Figures 1398-2 and 1398-3; revised Table of Contents, Sections 1301-1 through 1301-3, Forms Index, Form 1396-1, Tables Index, Table 1397-1, and the Figures Index; editorial corrections in Table 1397-3; and minor editorial/format changes.

2009 March 6, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents; and
- in **Part 2**, a revised Section 240-4.

2009 April 17, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents; and
- in **Part 2**, new Tables 297-15, 297-16, 297-17 and 297-18; a revised Table of Contents, Sections 206-8, 206-13, 207-2, 207-3, 240-4, the Tables Index, and Figures 298-5a and 298-5b; editorial change in Section 207-4; and minor editorial/format changes;
- in **Part 3**, new Sections 301-15 and 341-6; and a revised Table of Contents and Sections 301-10, 302-1 and 341-4; and editorial changes in Chapters 350, 360, 370, 380, 395 and Table 397-2;
- in **Part 4**, a revised Table of Contents, Chapter 443, Sections 401-7, 403-2, 440-3, 440-6, 442-7, 442-8, 442-13, 442-17, 442-18, 442-25 and 442-32, and Figure 498-5; editorial changes for Sections 442-20 and 442-22; and minor editorial changes;
- in **Part 6**, new Section 604-5 and renumbered existing Sections 604-5 and 605-6, new Section 640-28, and new Section 641-19 and renumbered existing Sections 641-19 through 641-25, and new Figures 698-11 and 698-12; a revised Table of Contents, Sections 601-2, 605-2, 605-5, 605-11, 605-14, 605-19, 606-10, 620-4, 640-9, 640-11, 640-12, 640-19, 640-22, 640-23, 641-5, 641-6, 641-9, 641-10, 641-17, 641-18, new 641-20 through 641-22 (formerly 641-19 through 641-21), new 641-24 through 641-26 (formerly 641-23 through 641-25), 642-6, 642-14, 642-15, 642-18, 642-30, 642-31 642-36, 642-37, 642-44, 642-46, 642-50, 642-53, and 642-54, the Tables Index, and the Figures Index; editorial changes in Sections 641-8 and 642-24, and Form 696-1a; and minor editorial/format changes;
- in **Part 9**, new Sections 940-1 and 940-2, and a new Chapter 942, with new Sections 942-1 and 942-2; a revised Table of Contents and Chapter 940;
- in **Part 12**, a new Section 1213-7; a revised Table of Contents, Chapter 1210, Sections 1203-2, 1203-3, 1213-1, the Forms Index, Form 1296-2 and Form 1296-14; editorial changes in Sections 1203-1 and Form 1296-1; and minor editorial/format changes;
- in **Part 13**, a revised Table of Contents, Sections 1301-1, 1301-2, 1301-3 and 1301-4, and Form 1396-1; and minor editorial/format changes; and
- in **Part 15**, a revised Table of Contents, Chapter 1505, and Section 1501-3; and minor editorial/format changes.

2009 July 17, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, new Section 195-8, a revised Table of Contents, Chapter 106, Sections 100-1, 100-4, 100-5, 101-4, 101-5, 102-1, 102-3 through 102-5, 103-1, 103-3 through 103-5, 104-1 through 104-4, 105-1, 120-3, 120-6, 130-2, 130-4 through 130-6, 140-7, 193-7, 193-11, 194-1, 194-17, 194-18, 195-3 through 195-6, Forms Index, Forms 196-1 and 196-3, Tables Index, Tables 197-1 through 197-3, Tables 197-9 and 197-10, and Figure 198-2; editorial changes in Section 140-2 and Figure 198-6; and minor editorial/format changes;
- in **Part 2**, new Sections 202-11 and 242-6; a revised Table of Contents, Sections 201-3, 201-6, 201-8, 201-11, and Section 295-2; editorial changes in Sections 202-6 and 206-11; and minor editorial/format changes;
- in **Part 3**, revised Chapter 343, Sections 302-5, 304-3, 320.1, 320-5, and Form 396-1; editorial changes in Sections 301-3, 301-7, 301-10, 301-14, 350-7 and Table 397-1; and minor editorial changes;
- in **Part 4**, new Section 403-8; a revised Table of Contents, Chapter 443; Sections 402-2, 402-3, 408-2, 420-1, 421-1, 421-2, 440-3, 440-8, 441-7, 442-27, 442-29, 450-1, 460-7, 460-9, and the Forms Index; editorial changes in Sections 440-4, 442-5, 442-22, 442-32 and 442-33; and minor editorial changes;
- in **Part 6**, a revised Table of Contents, Sections 600-4, 605-4, 605-11, 605-13, 605-14, 608-4, 608-11, 608-12, 620-3, 620-7, 640-9, 641-3, 641-4, 641-10, 642-50, 650-2, 650-3, 660-3, 670-3, 695-2, 695-4, 695-6, and 695-7; editorial changes in Sections 601-2, 604-5, 605-9, 605-10, 608-2, 608-4, 630-4, 630-5, 640-23, 640-26, 642-43, 642-44, and the Forms Index; and minor editorial/format changes;
- in **Part 13**, revised Sections 1301-3 and 1301-4, the Forms Index, and the Tables Index; editorial change in Section 1301-1; and minor editorial/format changes.

2009 October 16, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, new Section 140-8, a revised Table of Contents; revised Sections 120-4 and 193-19, and Table 197-2; and minor editorial/format changes;

- in **Part 3**, a revised Section 342-2;
- in **Part 4**, a revised Table of Contents, Sections 420-5, 440-7, 450-10, 450-11, Forms 496-4 and 496-6, the Figures Index, and Figures 498-3 through 498-5, 498-23, 498-27, 498-29, 498-30 and 498-33; an editorial correction in Sections 420-4; and minor editorial changes;
- in **Part 11**, a revised Table of Contents; revised Sections 1140-4, 1142-24 and 1142-26, and Figure 1198-12; editorial corrections in Sections 1140-6, 1140-8, 1142-25; and minor editorial/format changes.

2010 January 15, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, revised Section 101-5, Forms 196-3 and 196-4, and Table 197-2;
- in **Part 2**, new Sections 202-12, 202-13 and 260-7, a revised Table of Contents and Sections 201-8 and 240-2;
- in **Part 3**, new Section 301-16, and a revised Table of Contents, Section 301-14 and Table 397-2;
- in **Part 4**, a revised Table of Contents and Section 440-3; and minor editorial changes.

2010 April 16, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, new Sections 130-7 and 140-9; a revised Table of Contents and Sections 140-8, 195-2, and Tables 197-2 and 197-9; and an editorial correction in Section 130-6;
- in **Part 4**, new Sections 403-9, 403-10, 442-40, 442-41 and 442-42; a revised Table of Contents and Sections 402-3, 403-3, 403-6 and 420-5; and minor editorial/format changes;
- in **Part 8**, new Sections 804-1 through 804-4, 830-3, 830-4, 840-1 through 840-4, 895-5, a new Forms Index and Form 896-1, and a new Figures Index and Figure 898-1; a revised Table of Contents, Chapters 804 and 840, Section 830-1; and minor editorial/format changes; and
- in **Part 10**, a revised Chapter 1000.

2010 May 14, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 6**, new Section 660-4 and new Figures 698-13 and 698-14; a revised Table of Contents and Section 660-1, and a revised Figures Index; editorial corrections in Sections 601-2, 608-4, 608-6, 608-8, 630-4, 630-5, 640-1, 640-13, 640-14, and Figure 698-1; and minor editorial/format changes.

2010 July 16, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents and Sections 202-4, 202-12, 202-13 and 205-3, Tables 297-1, 297-4, 297-12, 297-13 and 297-17, and Figures 298-20, 298-22 and 298-28; editorial corrections in the Figures Index and Figure 298-10; and minor editorial/format changes;
- in **Part 3**, a revised Table of Contents and Sections 301-1, 301-8 and 301-15; and an editorial correction in Section 301-16;
- in **Part 4**, a revised Table of Contents and Sections 440-3, 442-25, 442-26, 442-27, 442-28, 442-29, 442-31, 442-40, 442-41 and 450-8;
- in **Part 6**, a revised Table of Contents and Sections 605-6, 605-8, 642-41, 642-44 and 670-4, Table 697-1b, and Figure 698-3b;
- in **Part 7**, a revised Section 742-2; and
- in **Part 9**, new Chapters 901 and 902; a revised Table of Contents and Chapter 900, and Sections 940-1 and 940-2.

2010 October 15, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents; ;
- in **Part 1**, a revised Table of Contents and Sections 140-7 and 195-8, and Table 197-9;
- in **Part 2**, a revised Table of Contents and Sections 209-2, 211-1 through 211-4 and 240-8; editorial corrections in Tables 297-16 and 297-17; and minor editorial/format changes;
- in **Part 3**, revised Chapter 343, Sections 302-1, 304-1, 304-3, 307-1, 320-5, 341-2, 350-3, 350-6 and 350-8; and minor editorial changes;
- in **Part 4**, a revised Figure 498-21;
- in **Part 6**, a revised Table of Contents and Sections 602-8, 605-11, 606-16, 607-10, 640-12, 641-9, 641-21, 641-25 and 695-4; an editorial correction in Section 640-18; and minor editorial changes; and
- in **Part 9**, a revised Table of Contents and Chapter 930 (replacing the existing text with new Sections 930-1 and 930-2).

2011 January 21, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents and Sections 212-1 through 212-3, 240-4 , 240-7, 250-4, 250-5, 250-7 and 250-8; and minor editorial/format changes;
- in **Part 3**, revised Table of Contents and Section 301-9, the Figures Index, and Figure 398-1;
- in **Part 4**, a revised Table of Contents and Sections 403-6, 420-4, 440-2, 440-5, 440-7, 442-27, 442-29, Tables 497-1 and 497-6; and an editorial change in Figure 498-38;

- in **Part 6**, a revised Table of Contents and Sections 605-19, 605-20, 607-10, 642-50 and 642-51 and Figures 698-3a and 698-3b,
- in **Part 8**, a revised Section 804-4; and
- in **Part 11**, a revised Table of Contents and Chapter 1142, deleting fourteen Plan Notes, while renumbering and revising the others.

2011 April 15, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, revised Forms 196-3, 196-4 and 197-9, and Figure 198-1;
- in **Part 2**, revised Sections 241-6;
- in **Part 4**, a revised Sections 440-5, 441-7, 441-10, 442-10, 460-2 and 460-3; editorial changes in Sections 440-3, 440-8, 441-3, 441-5, 441-6, 442-12 and 442-14; and other minor editorial/format changes;
- in **Part 6**, new Section 650-4; a revised Table of Contents and Sections 600-2, 602-6, 602-8, 603-3, 605-2, 605-14, 605-15, 608-5, 608-8, 620-7, 640-4, 640-11, 640-12, 640-13, 640-17, 640-18, 641-2, 641-5, 641-6, 641-7, 641-8, 641-9, 641-25, 642-6, 642-24, 642-26, 642-30, 642-31, 642-33, 642-48, and 650-3, the Tables Index, and Table 697-7; editorial changes to Sections 600-5, 602-4, 602-5, 602-7, 604-5, 605-4, 605-5, 605-6, 605-7, 605-11, 605-13, 605-17, 605-18, 605-19, 605-20, 606-6, 606-7, 606-9, 607-10, 630-5, 640-2, 640-5, 640-25, 640-28, 641-10, 641-12 through 641-17, 641-19, 641-20, 641-21, 641-26, 642-9, 642-10, 642-15, 642-16, 642-19, 642-21, 642-25, 642-27, 642-28, 642-34, 642-35, 642-39, 642-40, 642-41, 642-50 through 642-54, 670-6 and 695-4, Tables 697-1c, 697-2, 697-4, 697-8 and 697-9, and the Figures Index; and other minor editorial/format changes;
- in **Part 8**, a revised Section 804-4.
- in **Part 12**, new Forms 1296-6b, 1297-7b, 1296-17, 1296-18 and 1296-19; a revised Table of Contents, Chapter 1250, Sections 1203-1, 1203-2, 1203-3, 1203-4, 1203-5, 1204-2, 1204-5, the Forms Index, Forms 1296-6a, 1296-7a and 1296-16, the Tables Index, Table 1297-7, the Figures Index and Figure 1298-1; and editorial changes in Forms 1296-2, 1296-4, 1296-11 and 1296-12; and other minor editorial/format changes; and
- in **Part 14**, a revised Table of Contents, the Chapter 1415 title and Sections 1401-1, 1401-2, 1401-3, 1401-6, 1402-1, 1415-1, 1415-2, 1415-3; editorial changes in Sections 1401-4 and 1401-5, the Form Index, and Form 1496-1; and other minor editorial/format changes.

2011 July 15, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents and Section 206-5;
- in **Part 4**, an editorial change in Section 460-8; and
- in **Part 11**, a revised Table of Contents, Section 1140-4, the Figure Index, and Figure 1198-6; and other minor editorial/format changes.

2011 October 21, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents;
- in **Part 3**, revised Sections 301-5 and 350-4; and other minor editorial changes;
- in **Part 4**, revised Sections 420-4 and 450-8; and other minor editorial changes;
- in **Part 6**, revised Sections 642-37 and 642-41; and a minor editorial correction; and
- in **Part 11** a revised Table of Contents; revised Section 1120-5; deleted Section 1142-15; and other minor editorial changes.

2012 January 20, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, revised Forms 196-3 and 193-4, and Table 197-3; and made editorial corrections in Sections 100-1 100-4, 101-4, 101-5, 102-4, 102-5, 103-1, 103-4, 103-5, 104-1 104-3, 104-4, 105-1, 106, 195-3, 195-5, 195-6, 195-8, 196-1, 196-2, 196-3, and 196-4;
- in **Part 3**, revised Chapters 305, 306, and 310, Sections 300-1, 301-1, 301-4, 301-5, 301-6, 301-7, 301-8, 301-9, 301-10, 301-11, 301-12, 301-14, 303-1, 303-2, 304-1, 304-3, 304-5, 304-6, 341-2, 342-2, 342-4, 350-3, 350-5, 350-6, 350-7, 350-8, Table 397-2, and Figures 398-2, and 398-3;
- in **Part 4**, a revised Table of Contents; Sections 400-1, 401-7, 403-2, 403-6, 403-10, 404-3, 405-1, 406-1, 406-3, 407-2, 408-1, 408-2, 420-4, 420-5, 421-1, 441-3, 450-10, Table 497-3; and deleted Section 403-7;
- in **Part 5**, revised Chapter 500;
- in **Part 6**, revised Sections 602-5, 602-6, 604-5, 604-6, 604-7, 605-3, 605-5, 605-6, 605-7, 605-9, 605-10, 605-11, 605-12, 605-13, 605-14, 606-15, 605-17, 605-18, 605-21, 606-14, 606-18, 606-19, 606-21, 606-22, 607-1, 607-2, 620-6, 640-18, 640-26, 641-5, 641-7, 641-8, 641-9, 641-10, 641-12, 641-13, 641-14, and 641-15;
- in **Part 8**, a new Part Title; a revised Table of Contents, Chapters 800, 803 and Sections 802-1, 804-1, 804-2, 804-3, 830-3, 840-2, 840-3, and 840-4;
- in **Part 9**, revised Chapter 900;
- in **Part 10**, contents have been incorporated into Part 8; Part 10 now reserved for future use; and
- in **Part 11**, a revised Table of Contents, and Section 1141-4.

2012 April 20, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;

- **in Part 1**, a revised Table of Contents; revised Sections 101-2, 101-3, 101-4, 102-2, 102-3, 102-5, 103-2, 103-3, 103-5, 120-4, 120-6, 120-7, 130-6, 140-7, 193-7, 193-15, 193-19, 194-6, 194-10, 194-14, 195-3, and 195-4; revised Tables 197-1, 197-2, 197-9, 197-10; and revised Figures 198-1, 198-5 and 198-6.
- **in Part 2**, a revised Table of Contents; new Sections 202-14 and 242-7; revised Sections 200-1, 201-1, 201-2, 201-3, 201-5, 201-6, 201-7, 201-8, 201-10, 201-11, 201-12, 201-13, 202-1, 202-4, 202-5, 202-6, 202-7, 202-9, 202-10, 202-11, 202-12, 203-1, 203-2, 204-2, 204-3, 204-4, 205-1, 205-2, 205-3, 205-4, 205-5, 205-6, 206-1, 206-3, 206-4, 206-5, 206-6, 206-7, 206-8, 206-10, 206-11, 206-12, 206-14, 206-15, 206-16, 206-17, 207-1, 207-2, 207-3, 207-4, 207-5, 207-6, 207-7, 207-8, 208-1, 208-2, 208-3, 208-4, 208-5, 209-1, 209-2, 209-3, 209-4, 209-5, 209-6, 209-7, 210-3, 211-1, 211-2, 211-3, 211-4, 212-1, 212-2, 220-5, 220-6, 220-7, 220-10, 221-1, 221-2, 221-3, 221-4, 221-5, 221-6, 240-2, 240-3, 240-4, 240-5, 240-6, 240-7, 240-8, 241-5, 242-3, 242-4, 242-5, 242-6, 250-3, 250-4, 250-5, 250-6, 250-7, 260-2, 260-4, 260-5, 295-2; deleted Section 210-2; revised Tables 297-1, 297-2, 297-8f, 297-9, 297-10, 297-12; and deleted Table 297-13; revised Figures Index, revised Figures, 298-4a, 298-4b, 298-5a, 298-5b, 298-7, 298-9, 298-11, 298-12, 298-13, 298-15, 298-18, 298-29, 298-30, 298-31, 298-32, 298-42; and deleted Figure 298-10
- **in Part 3**, a revised Table of Contents, new Section 342-5; revised Sections 301-4, 301-9, 301-10, 301-13, 301-14, 302-6, 304-4, 304-5, 304-6, 340-2, 341-2, 342-2, and 350-8; revised Chapter 305, deleted Chapter 303; and other minor editorial/format changes.
- **in Part 4**, a revised Table of Contents, new Sections 442-43 and 442-44; revised Sections 401-7, 402-2, 402-3, 403-2, 404-2, 404-3, 407-2, 420-1, 420-4, 421-1, 440-3, 440-7, 441-6, 441-8, 442-5, 442-9, 442-19, 442-21, 442-25, 442-29, 442-36, 442-39, 442-40, 442-41, 450-3, 450-6, 450-8, 450-10, 460-3; revised Forms 496-2 and 496-5; revised Table 497-3, revised Figures Index, and revised Figures 498-1, 498-3, 498-4, and 498-5; and other minor editorial/format changes.
- **in Part 6**, a revised Table of Contents, revised Chapter 643; revised Sections 602-4, 602-8, 605-10, 606-7, 607-1, 607-15, 620-7, 640-21, 640-26, 640-28, 641-5, 641-6, 641-9, 641-17, 642-41, 650-2, 660-2, and 660-3; and revised Figures 698-13 and 698-14.
- **in Part 11**, a revised Table of Contents; and deleted Section 1142-4.

2012 July 20, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 1**, a revised Table of Contents; revised Chapter 106; revised Sections 100-1, 100-4, 100-5, 100-6, 101-4, 102-4, 102-5, 103-1, 103-3, 103-4, 105-1, 105-2, 120-5, 193-1, 193-3, 194-1, 194-22, 195-1, and 195-2; revised Form 196-3; revised Tables Index; deleted Tables 197-1 and 197-2 (with subsequent Tables renumbered).
- **in Part 2**, a revised Table of Contents; new Section 241-8; revised Sections 202-14, 240-4; and Revised Figures 298-5b, 298-6a, 298-6b, 298-6c, 298-6d, 298-7, 298-8, 298-9, 298-22, 298-28, 298-29, 298-30, 298-31, 298-32, 298-33, 298-34, 298-35, 298-36, 298-39, 298-40, 298-41, 298-42, and 298-43.
- **in Part 3**, a revised Table of Contents; new Section 341-6; revised Sections 301-8, 301-12, 301-14, 302-6, 304-4, 304-5, 304-6, and 307-2, revised Figures Index; deleted Section 341-5; and deleted Figure 398-1 (with subsequent Figures renumbered).
- **in Part 4**, a revised Table of Contents; new Sections 403-7, 442-45, 442-46, and 442-47; revised Sections 440-3, 442-4, 442-21, and 442-44; and deleted Section 442-42.
- **in Part 6**, a revised Table of Contents; new Section 642-46; revised Chapters 643, and 695: revised Sections 604-5, 605-14, 605-18, 605-19, 605-20, 608-10, 620-1, 620-7, 630-5, 640-2, 640-6, 640-19, 640-28, 641-5, 641-6, 641-9, 641-10, 641-13, 641-17, 641-19, 641-20, 641-21, 642-26, 642-35, 642-41, 642-45, 642-50, 660-2, and 660-4; revised Table 697-5; revised Forms Index; revised Figures Index; deleted Form 696-5: and deleted Figures 698-11 and 698-12 (with subsequent Figures renumbered).
- **in Part 7**, a revised Table of Contents; new Section 702-8; revised Chapters 701 and 704; revised Sections 702-2, 702-3, 702-4, 702-5, 702-6, 702-7, 705-1, 705-2 and 705-4; revised Forms Index 796; revised Forms 796-2 and 796-3; and an editorial correction in Table 797-1.
- **in Part 11**, a revised Table of Contents; and revised Sections 1140-5, 1140-6, 1142-10, 1142-12, 1142-16 and 1142-18.
- **in Part 12**, a revised Table of Contents; revised Chapter 1202; revised Sections 1211-1, 1211-4, 1211-10, 1212-1, 1212-8, 1212-10, 1213-6, and 1213-7; revised Forms Index; deleted Form 1296-13; revised Tables Index; deleted Table 1297-5; and an editorial correction in Table 1297-4.

2012 October 19, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 2**, revised Sections 207-7, 208-6, 220-8 and 242-6; an editorial correction in Section 208-4;
- **in Part 3**, revised Section 302-5; and editorial corrections in Sections 301-16 and 341-6;
- **in Part 4**, a revised Table of Contents; a new Figure 498-43; revised Chapter 443, Sections 401-8, 403-3, 403-6, 403-8, 403-9, 404-2, 407-2, 420-1, 420-4, 421-1, 421-2 and 450-10, the Forms Index, and the Figures Index; and an editorial correction in Section 440-3;
- **in Part 6**, a revised Table of Contents; revised Sections 605-5, 606-6, 641-3, 641-4 and 642-37; and
- **in Part 12**, revised Sections 1213-6 and 1213-7.

2013 January 18, 2013 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover, Title Sheet and an updated Publication Record and Table of Contents;
- **in Part 2**, a revised Table of Contents; new Sections 240-9 and 242-8; revised Sections 240-4, 241-7, 242-5 and Table 297-4; and an editorial correction in Section 240-8;
- **in Part 4**, a revised Table of Contents; new Sections 405-3, 442-48, 442-49 and 442-50; revised Chapter 443; revised Sections 403-9, 420-1, 420-5, 421-1, 440-3, 440-5, 440-7, 442-44, 450-3, 450-6, 450-8 and 450-10; and miscellaneous minor editorial/format corrections;
- **in Part 6**, revised Sections 642-41 and 670-6;
- **in Part 9**, a revised Table of Contents; and revised Section 902-2; and

- **in Part 11**, a revised Table of Contents; revised Sections 1103-6 and 1140-4; and an editorial correction in Section 1120-5.
- 2013 April 19, 2013** – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):
- a revised Title Sheet, Publication Record and Table of Contents; and
 - **in Part 6**, revised Table of Contents; revised Sections 642-41 and 642-46, and deleted Section 642-45.
- 2013 July 19, 2013** - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):
- a revised Title Sheet, Publication Record and Table of Contents;
 - **in Part 4**, revised Section 403-10; and an editorial correction in Section 442-32;
 - **in Part 6**, revised Table of Contents; added new Figure 698-11; revised Sections 601-2, 602-5, 603-2, 605-2 – 605-5, 605-7, 605-11 – 605-14, 605-17 – 605-19, 606-10, 606-11, 606-13, 606-16, 606-17, 607-1, 607-7, 607-10, 607-12, 607-13, 607-15, 608-6 thru 608-11 (now 608-5 thru 608-10), 608-13 (now 608-11), 620-3, 620-4, 620-7, 630-4, 630-5, 640-2, 640-5, 640-6, 640-9, 640-11 thru 640-13, 640-15, 640-18, 640-19, 640-22, 640-25, 640-26, 640-28, 641-2 – 641-19, 641-21 – 641-26, 642-6, 642-14, 642-15, 642-21, 642-24, 642-30, 642-31, 642-34, 642-44, 642-53, 650-3, 660-2, 660-4, 670-3, 670-6, 670-7, 695-2 and 695-4; 695-7 (now 605-6); revised Forms Index; revised Tables Index, Table 697-5 and renumbered Tables 697-8 – 697-10 (now 697-6 – 697-8); revised Figures Index, revised and renumbered Figures 698-3a and 698-3b (now 698-2), and renumbered Figures 698-4 and 698-6 thru 698-12 (now 698-3 thru 698-11); deleted Sections 608-5, 608-12, 650-4, 695-6, Form 696-5 (now Figure 698-11), Tables 697-6 and 697-7, and Figures 698-2 and 698-5; editorial corrections in Sections 600-1, 600-2, 600-5, 605-6, 606-14, 607-3, 640-8 and 640-24; and miscellaneous minor editorial/format corrections;
 - **in Part 7**, revised Table of Contents; revised Chapters 701 and 704, Sections 702-6, 705-2, 705-4, 742-1 and 742-2; deleted Chapter 795; editorial corrections in Sections 702-3, 702-4, 702-5 and 705-1, and Form 796-2; and miscellaneous minor editorial/format corrections;
 - **in Part 9**, revised Table of Contents; revised Chapters 900, 901 and 950, Sections 902-1, 930-1, 930-2, 940-1, 942-2, 995-1, 995-2 and 995-4 (now 995-3); deleted Chapter 980 and existing Section 995-3; and miscellaneous minor editorial/format corrections; and
 - **in Part 12**, revised Form 1296-17.
- 2013 October 18, 2013** - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):
- a revised Title Sheet, Publication Record and Table of Contents;
 - **in Part 3**, revised Sections 302-1 and 302-3;
 - **in Part 4**, revised Table of Contents; revised Chapter 443, Sections 401-4, 442-13, 442-17, 442-30, 442-31, 442-45, 460-2, 460-3 and 460-7; deleted existing Sections/Plan Notes 442-18, 442-33 – 442-38; editorial corrections in Sections/Plan Notes 442-4 – 442-6, 442-9 – 442-11, 442-14, 442-16, 442-41, 442-43, 442-44 and 442-46 – 442-49; and miscellaneous minor editorial/format corrections;
 - **in Part 6**, revised Table of Contents; revised Sections 605-5, 605-20, 641-11, 641-19; editorial corrections in Sections 641-18; and miscellaneous minor editorial/format corrections;
 - **in Part 12**, revised Table of Contents; revised Sections 1213-1, 1213-2, 1213-4 (now 1213-3), 1213-6 (now 1213-4), 1213-7 (now 1213-5), the Forms Index, Forms 1296-11, the Figures Index, and Figure 1298-2; deleted Chapters 1220, 1250, 1280 and 1295, Sections 1213-3 and 1213-5, and Form 1296-12; editorial corrections in Form 1296-13; and miscellaneous minor editorial/format corrections; and
 - **in Part 14**, revised Table of Contents; new Chapter 1416 and Section 1416-1; revised Chapter 1400, Sections 1401-1 through 1401-6, 1415-1 – 1415-3, 1415-5 (now 1415-4); deleted Chapters 1402, 1420, 1430, 1450, 1480, 1495, Section 1415-4, the Forms Index and Form 1496-1; and miscellaneous minor editorial/format corrections.
- 2014 January 17, 2014** - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):
- a revised Title Sheet, Publication Record and Table of Contents;
 - **in Part 2**, revised Table of Contents; new Figures 298-45 through 298-47; revised Sections 201-9, 207-2, 207-3, 209-7, 240-7, 242-6, 242-7, 250-2 and 250-8, Tables 297-17 and 297-18, the Figure Index and Figure 298-18; deleted existing Plan Note 242-7; editorial corrections in Chapter 243, Sections 240-5 and 250-7, and Figures 298-6b, 298-31 and 298-32; and miscellaneous minor editorial/format corrections;
 - **in Part 3**, revised Table of Contents; revised Sections 301-1, 301-4, 301-12, 301-13, 301-15, 304-7, 341-2, 350-3, 350-4 and 350-8; editorial corrections in Sections 301-3, 301-8, 301-9, 301-10, 301-11, 301-14, 304-1, 304-2, 304-3, 304-5, 304-6, 341-1, 341-3 and 350-2; and miscellaneous minor editorial/format corrections;
 - **in Part 4**, revised Sections 402-3, 420-4, 450-3, 450-8 and 450-10; editorial changes in Sections 420-1, 450-4 and 450-9; and miscellaneous minor editorial/format corrections;
 - **in Part 6**, revised Table of Contents; revised Sections 604-5, 605-14, 605-19, 605-21 (now 605-20), 608-3, 608-6 through 608-8, 640-21, 640-27, 641-19, 641-21, 641-26, 641-46, 642-51 through 642-53, 650-1, 650-3 (now 650-2), 660-1, 660-4 (now 660-3), 670-4, Table 697-8, Figures 698-4 and 698-6, and the Figures Index; deleted existing Sections 605-20, Plan Notes 642-26 and 642-50, and Sections 650-2 and 660-3; editorial corrections in Chapter 643, Sections 605-18, 608-1, 608-10, 640-5, 640-20, 640-26, 641-17, 641-20, 641-25, 642-27 through 642-29, 642-33 through 642-38, 642-41, 642-43, 642-44, 642-48, 642-49, 642-55, 670-2 and 695-4; and miscellaneous minor editorial/format corrections;
 - **in Part 8**, revised Table of Contents; new Chapter 843; revised Chapters 800, 803 and 805, Sections 801-2, 804-3, 804-4, 830-1, 895-3 (now 895-1), 895-4 (now 895-2), 895-5 (now 895-3), the Forms Index, the Figures Index and Figure 898-1; deleted Chapters 850, 860 and 880 and Sections 895-1 and 895-2; editorial corrections in Sections 802-1, 802-2, 804-2, 830-4 and 840-2; and miscellaneous minor editorial/format corrections; and

- in **Part 13**, revised Table of Contents; new Figures 1398-3 through 1398-5; revised Chapter 1300, Sections 1301-1, 1301-3, 1303-1 through 1303-4, 1303-6 through 1303-10, the Forms Index, Forms 1396-1 and 1396-2, the Tables Index, Tables 1397-2 and 1397-3, the Figures Index and Figures 1398-1 and 1398-2; editorial corrections in Sections 1301-2, 1301-4 and 1303-5; and miscellaneous minor editorial/format corrections.

2014 April 18, 2014 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- in **Part 13**, a new Form 1396-3, a revised Table of Contents, revised Sections 1301-1, 1301-2, 1301-3 and 1301-4, and a revised Forms Index, Tables Index and Table 1397-1.

2014 July 18, 2014 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 2**, revised Table of Contents; revised Sections 201-1, 201-3, 201-7, 201-8, 202-13, 203-1, 204-2, 205-6, 206-7, 206-8, 206-11, 207-2, 207-3, 211-2, 211-4, 220-7, 220-8, 221-3, 240-7, 242-1 through 242-5, 260-2 and 295-2, the Forms Index, Form 296-3, the Tables Index, Tables 297-1 and 297-3, the Figures Index, and Figures 298-3, 298-4a-b, 298-5a-c and 298-6a-c; deleted Form 296-5; editorial corrections in Sections 200-3, 202-9, 220-1, 221-1, 221-6, 240-1, 240-2, 240-4 through 240-6, 241-1, 241-7, 250-2 through 250-8, Table 297-10, and Figures 298-38a, 298-38b and 298-46; and miscellaneous minor editorial/format corrections;
- in **Part 3**, revised Table of Contents; revised Sections 301-1, 301-2, 301-7, 301-14, 340-2, 341-2, 342-2, 350-3, 350-4 and 350-8; deleted Chapter 303; editorial corrections in Chapter 305, 310 and 343, Sections 300-3, 302-1 through 302-3, 302-6, 307-1, 307-2, 320-1, 320-4, 320-5, 341-4, 341-6, 342-1, 350-5, 350-6, the Tables Index and Tables 397-1, 397-3, and Figures 398-1 through 398-4; and miscellaneous minor editorial/format corrections;
- in **Part 4**, revised Table of Contents; new Section 403-11; revised Sections 401-4, 401-7, 401-9, 402-2, 403-7, 407-2, 408-2, 440-3, 440-7, 442-14, 442-20, 442-43, 442-48, 460-8, 495-2, the Form Index, Forms 496-3, 496-5 and 496-7, and Figures 498-3 through 498-5, 498-12, 498-13, 498-16 through 498-20, 498-23, and 498-36 through 498-38; deleted Section/Plan Note 442-50 and Forms 496-16, 496-17 and 496-18; revised/renumbered Form 496-19 to 496-16, and Form 496-20 to 496-17; editorial changes in Chapter 443, Sections 400-3, 401-1, 403-1, 403-9, 404-1, 420-4, 420-5, 421-1, 421-2, 440-1, 440-2, 440-4 through 440-6, 441-1, 441-3, 441-8 through 441-11, 442-1, 442-4, 442-5, 442-6, 442-9 through 442-13, 442-17 through 442-19, 442-21, 442-32, 442-41, 442-44, 442-46, 450-1, 450-3, 450-6, 450-8, 450-10 and 450-11, Forms 496-4, 496-6, and 496-8 through 496-11, the Table Index, Tables 497-4 and 497-8, and Figure 498-31; and miscellaneous minor editorial/format corrections;
- in **Part 6**, revised Table of Contents; new Section 641-27; revised Sections 607-10, 620-7, 641-5, 641-6, 641-9, 641-10, 641-17, 641-21, 641-25, 642-6, 642-21, 642-37 and 642-44; editorial corrections in Sections 600-3, 605-2, 605-9, 605-11, 605-14, 605-15, 607-1, 607-13, 607-15, 620-3, 620-6, 630-1, 640-1, 640-2, 640-11, 640-18, 641-1, 641-2, 641-8, 641-16, 642-1, 642-2, 642-5, 642-9, 642-12 642-20 and 642-24; and miscellaneous minor editorial/format corrections;
- in **Part 8**, editorial corrections in Section 802-2;
- in **Part 9**, revised Table of Contents; revised Sections 940-2 and 942-2; editorial corrections in Section 942-1; and miscellaneous minor editorial/format corrections;
- in **Part 11**, revised Table of Contents; revised Sections 1106-2, 1120-5, 1140-4, 1141-1, 1141-3, 1141-4, 1142-14, 1160-6 and 1160-8, and Figure 1198-11; editorial corrections in Chapter 1143, Sections 1100-1, 1100-3, 1103-6, 1130-4, 1130-5, 1140-3, 1140-5 through 1140-8, 1142-2, 1142-3, 1142-5 through 1142-8, 1142-13, 1142-17, 1142-18, 1142-20, 1150-2, 1150-5, 1150-6, 1150-10, 1150-13, 1160-4, 1160-11, 1160-13, Tables 1197-3 through 1197-7, and Figure 1198-4; deleted Chapters 1170, 1180 and 1190; and miscellaneous minor editorial/format corrections; and
- in **Part 14**, editorial corrections in Sections 1415-1 and 1415-2; and miscellaneous minor editorial/format updates.

2015 January 16, 2015 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 2**, revised Table of Contents; new Sections 206-18 and 240-10; revised Section 240-9; and miscellaneous minor editorial/format corrections;
- in **Part 3**, revised Sections 301-6 and 302-2, and Table 397-1; and miscellaneous minor editorial/format corrections;
- in **Part 4**, revised Table of Contents; new Sections 440-10, 440-11, 440-12 and 442-50, new Form 496-18, and new Figures 498-44, 498-45 and 498-46; revised Chapter 443, Sections 402-2, 403-8, 420-5, 440-1, 440-3, 440-7, 442-3, 442-7, 442-8, 442-12, 442-13, 442-17, 442-18, 442-21, 442-22, 442-23, 442-24, 442-39, 442-41, 442-43, 442-44, 442-48, 442-49, 450-10, the Forms Index, Forms 496-3, 496-4, 496-5 and 496-16, Table 497-6, the Figures Index, and Figures 498-13, 498-21, 498-36 and 498-37; editorial changes in Figures 498-4, 498-12 and 498-38; and miscellaneous minor editorial/format corrections;
- in **Part 6**, revised Table of Contents; new Section 641-28; revised Chapter 643, Sections 605-4, 605-14, 605-17, 640-2, 640-9, 640-12, 640-18, 640-19, 641-11, 642-24, 642-26, 642-41, 642-55 and 660-2, and Table 697-5; and miscellaneous minor editorial/format corrections;
- in **Part 7**, revised Sections 705-4 and 742-2;
- in **Part 8**, editorial corrections in Chapter 843;
- in **Part 11**, revised Table of Contents; new Sections 1142-22 and 1142-23; revised Section 1140-6; and miscellaneous minor editorial/format corrections;
- in **Part 12**, revised Table of Contents; revised Chapter 1211 and Sections 1203-2, 1203-3, 1203-5 and 1204-5, the Forms Index (1296), Forms 1296-1, 1296-2, 1296-6b, 1296-7b, 1296-14, 1296-16, 1296-17 and 1296-18, the Tables Index (1297), Table 1297-7, the Figures Index (1298), and Figures 1298-1a through 1298-1c, and 1298-6 through 1298-22; an editorial correction in Chapter 1202; deleted Chapter 1212 and Figures 1298-23 through 1298-40; and miscellaneous minor editorial/format corrections;
- in **Part 13**, revised Table of Contents; new Chapter 1343; and miscellaneous minor editorial/format corrections; and
- in **Part 14**, revised Table of Contents; revised Sections 1415-1 and 1415-3; and miscellaneous minor editorial/format updates.

2015 July 17, 2015 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- **in Part 1**, revised Table of Contents; revised Chapters 104, 106, 160, 180, 193, 194 and 195; revised Sections 100-1 through 100-5, 101-1, 101-3, 101-4 and 101-5, 102-2 through 102-5, 103-1 through 103-5, 105-3, 120-1, 120-2, 120-4, 120-6, 120-7, 130-2, 130-4, 130-5, 140-2, 140-7, 150-1 through 150-3; deleted existing Forms 196-1, 196-2 and 196-4, and renumbered 196-3 to 196-1; revised Table 197-1, deleted Tables 197-3 through 197-6, and renumbered and revised Tables 197-7 and 197-8 to 197-3 and 197-4, respectively; revised Figures 198-4 through 198-6; made editorial changes to Chapter 170, Sections 101-2, 102-1, 105-1, 105-2, 120-3, 130-3, 130-6, 130-7, 140-6, the Forms Index, the Tables Index, the Figures Index, and Figures 198-1 through 198-3; and miscellaneous minor editorial/format corrections;
- **in Part 2**, revised Table of Contents; new Sections 201-15 and 202-15; revised Sections 201-3, 201-6, 202-8, 202-11, 206-16, 207-2, 209-2, 240-6, 242-5, 242-6 and 242-7; made editorial changes to Chapters 202, 205 through 209, 241, 242 and 243, and Sections 201-5, 201-10 through 201-14, 240-5, 240-9 and 298-20; and miscellaneous minor editorial/format corrections;
- **in Part 3**, revised Table of Contents; revised Section 301-12 and Table 397-1; made editorial changes in Sections 301-13 through 301-15 and 304-3; deleted Section 304-7; and miscellaneous minor editorial/format corrections;
- **in Part 4**, revised Table of Contents; revised Sections 401-1 through 401-3, 403-1, 407-2, 420-4, 420-5, 440-1, 440-3, 440-7, 440-8, 440-10, 441-1, 442-14, 442-33, 442-44, 442-45, 442-46, 442-48, 442-49, 450-6, 450-8, 450-10, 450-11, 495-2, the Forms Index, Forms 496-3 through 496-5, 496-10, 496-16 and 496-17, Table 497-1, the Figures Index, and Figures 498-2, 498-3, 498-5, 498-9 and 498-15; editorial changes in Chapter 408, 421, 441, 443, Sections 403-2, 403-3, 420-1, 440-4, 440-5, 440-12, 442-39, 442-43, Forms 496-8, 496-9, 496-11, and 496-18, the Tables Index, Table 497-4, Figures 498-12, 498-13, 498-37 and 498-45; and miscellaneous minor editorial/format corrections;
- **in Part 6**, revised Table of Contents; Sections 601-2, 602-3, 605-1, 605-3, 605-4, 605-6, 605-14, 605-15, 606-14, 607-1, 608-7, 608-8, 620-2, 630-4 through 630-6, 640-5, 640-13, 640-14, 640-18, 641-2, 642-5, 642-21, 642-27, 642-30, 642-31, 642-35, 642-41, 695-2 and 695-6, and Figure 698-2; editorial changes in Chapters 602, 605, 606, 607, 608, 620, 630, 640, 641, 642, 643 and 695 and miscellaneous minor editorial/format corrections;
- **in Part 7**, revised Section 705-4 and editorial changes to Chapter 705;
- **in Part 11**, revised Table of Contents; new Section 1120-8; revised Sections 1120-2, 1140-4, 1140-6; editorial changes in Chapter 1141, and Sections 1120-5, 1140-5, 1140-7, 1140-8; and miscellaneous minor editorial/format corrections;
- **in Part 12**, revised Table of Contents; revised Sections 1203-1, 1203-3, 1203-5, 1204-5, 1213-4, and Forms 1296-6a, 1296-6b, 1296-7a, 1296-7b, 1296-14; and an editorial change in Section 1203-2;
- **in Part 13**, revised Table of Contents; new Chapters 1340, 1342 and 1395, and Tables 1397-4 through 1397-9; revised Chapter 1343; revised Sections 1303-1, 1303-3 through 1303-7, 1303-10; editorial changes in Chapters 1300 and 1301, and Sections 1303-2, 1303-8, 1303-9, the Forms Index, the Tables Index, Tables 1397-1 and 1397-3, and Figures 1398-1 through 1398-5; and miscellaneous minor editorial/format corrections; and
- **in Part 15**, revised Table of Contents; revised Chapter 1599, and Sections 1501-1 through 1501-3 and 1505-1; editorial changes in Sections 1505-2 and 1505-3; deleted Chapters 1510 through 1514 and 1596; and miscellaneous minor editorial/format updates.

2015 October 16, 2015 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- an updated Title Sheet, Preface, Publication Record and Table of Contents;
- **in Part 6**, revised Table of Contents; new Section 641-29; revised Sections 605-3, 605-6, 640-17, 640-18, 640-26, 641-5 through 641-9, 642-24 and 642-26; editorial changes in Sections 605-4, 605-7, 640-19, 640-22, 640-24, 640-25, 640-28, 641-2, 641-10 through 641-28; and miscellaneous minor editorial/format corrections; and
- **in Part 12**, revised Table of Contents; revised Sections 1203-4, 1203-5; revised Forms Index and Forms 1296-6a, 1296-6b, 1296-7b, 1296-16, 1296-17, 1296-18; revised Tables Index and Table 1297-7; revised Figures Index and Figures 1298-1a, 1b and 1c; editorial changes in Sections 1203-1 and 1203-2; and miscellaneous minor editorial/format corrections.

2016 January 15, 2016 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- **in Part 2**, a revised Table of Contents; new Section 221-7; new Figure 298-48; revised Sections 201-9 and 209-2; revised Table 297-4; revised Figures Index and Figure 298-48; and editorial changes in Section 221-6 and Figure 298-47;
- **in Part 3**, a revised Forms Index;
- **in Part 4**, a revised Table of Contents; revised Sections 402-3, 404-2, 420-4, 420-5, 440-7, 441-5, 441-8, 442-13, 442-18, 442-19, 442-21, 442-41, 450-3, 450-6, 450-10, 460-3, 460-7; revised Table 497-6; and revised Figures 498-12, 498-13 and 498-36;
- **in Part 6**, a revised Table of Contents and revised Section 641-17;
- **in Part 11**, a revised Table of Contents; revised Sections 1140-4, 1142-6, 1142-7, 1150-9, and revised Figure 1198-12; and
- **in Part 13**, revised Sections 1303-3, 1303-6, and 1340-2; and revised Tables 1397-5 and 1397-6.

2016 July 15, 2016 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- **in Part 1**, a revised Form 196-1 and revised Table 197-4;
- **in Part 2**, a revised Table of Contents; revised Sections 202-5, 202-14, 205-2, 211-1, 211-2, 211-3, 211-4, 240-8, 242-6 and 260-5;
- **in Part 3**, a revised Table of Contents, revised Sections 301-4, 301-15, 302-6, 304-4, and 304-5; a revised Table 397-1, revised Figures Index and Figure 398-1; and deleted Figures 398-3 and 398-4;

- in **Part 4**, a revised Table of Contents; new Section 403-12; revised Sections 402-2, 442-20, 442-45, and 460-3; and deleted Section 442-23;
- in **Part 6**, a revised Table of Contents; new Sections 601-3, 641-7, 641-10, 641-20, 641-23, 641-24 and 642-57; revised Sections 601-2, 602-5, 605-11, 605-13, 605-14, 605-19, 606-14, 606-16, 607-12, 607-13, 607-15, 608-4, 608-7, 630-4, 630-5, 640-2, 640-5, 640-9, 640-13, 640-14, 640-18, 640-24, 640-28, 640-29, 641-2, 641-12, 642-24, 642-30, 642-31, 642-35, and 642-38; revised Forms 696-1a, 696-1b, 696-3a and 696-3b; revised Tables Index; and revised Table 697-1c.
- in **Part 11**, a revised Section 1142-21 and revised Table 1197-3;
- in **Part 12**, revised Sections 1203-2, 1203-3, and 1204-1; revised Forms 1296-2, 1296-5, 1296-8 and 1296-9; and revised Table 1297-6;
- in **Part 13**, revised Section 1303-4 and revised Table 1397-7; and
- in **Part 15**, revised Chapter 1599 and new Standard Procedure 123-001(SP).

2017 January 20, 2017 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 1**, revised Section 120-4;
- in **Part 2**, a revised Table of Contents; new Section 242-9; revised Sections 202-2 and 242-8;
- in **Part 3**, a revised Table of Contents; new Sections 301-17, 301-18, 301-19 and 307-3; revised Section 342-4;
- in **Part 4**, a revised Table of Contents; revised Sections 403-2, 403-3, 420-4, 442-24, 442-33, and 442-45; and revised Table 497-1;
- in **Part 6**, a revised Table of Contents; new Sections 642-58 and 642-59; new Figure 698-12; revised Sections 605-6, 605-7, 605-12, 605-14, 605-15, 605-16, 606-16, 607-15, 620-7, 630-5, 640-8, 640-12, 640-18, 640-26, 640-29, 641-5, 641-6, 641-11, 641-34, 642-8, 642-24, 642-43, and 642-57;
- in **Part 7**, revised Form 796-4;
- in **Part 9**, revised Section 902-2;
- in **Part 11**, a revised Table of Contents; new Section 1142-4; revised Sections 1140-5 and 1141-4;
- in **Part 14**, revised Sections 1415-1, 1415-2, and 1415-3.

2017 July 21, 2017 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 1**, a revised Table of Contents; revised Sections 120-4 and 140-7; revised Form 196-1; revised Tables Index; deleted Table 197-4; and revised Figure 198-1;
- in **Part 2**, revised Section 242-9 revised Table 297-17; and revised Figure 298-29;
- in **Part 3**, a revised Table of Contents; new Sections 301-20, 301-21, 302-7, 307-4 and 342-6; revised Sections 301-2, 301-13 and 350-7; revised Tables Index; new Table 397-6; and revised Table 397-1; revised Figures Index; an editorial change in Figure 398-1; and deleted Figure 398-4.
- in **Part 4**, a revised Table of Contents; revised Sections 402-1, 403-2, 403-12, 440-6, 442-20 and 460-6;
- in **Part 6**, a revised Table of Contents; revised Sections 605-11, 605-19, 606-13, 630-5, 640-2, 640-12, 640-18, 640-29, 641-5, 641-6, 641-9, 641-11, 641-12, 641-14, 641-15, 641-16, 641-17, 641-19, 641-26, 641-30, 642-20, 642-32, 642-44, 642-48, 642-49, 642-51, 642-57, and 642-58; an editorial change in Section 642-8; deleted Section 642-46; revised Form 696-1a; revised Table 697-4; revised Figures 698-5 and 698-7;
- in **Part 7**, revised Form 796-4;
- in **Part 8**, revised Form 896-1;
- in **Part 11**, a revised Table of Contents; new Section 1142-24; revised Sections 1120-6, 1140-5, and 1160-8; revised Table 1197-3; and revised Figure 1198-11.
- in **Part 12**, revised Section 1203-1; and
- in **Part 13**, a revised Table of Contents; revised Sections 1303-6, and 1342-7; deleted Section 1342-12; and revised Form 1396-3;

2018 January 19, 2018 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents, and revised Sections 201-14, 202-2, 240-9, 240-10 and 242-8;
- in **Part 3**, revised Section 301-4;
- in **Part 4**, a revised Table of Contents; revised Sections 403-5, 405-3, 420-5, 440-6, 440-11, 442-4, 442-13, 442-15, 442-16, 442-25 and 442-50;
- in **Part 6**, a revised Table of Contents; revised Sections 600-1, 605-11, 605-12, 640-2, 640-9, 640-19, 641-30, 641-33, 642-18, 642-36, 642-37, 642-55, 642-56 and 642-59; and revised Table 697-3;
- in **Part 9**, a revised Table of Contents; new Sections 901-1 and 901-2, and deleted Section 995-3.
- in **Part 11**, a revised Table of Contents; revised Sections 1103-6, 1107-4, 1120-5, 1140-3, 1140-4, 1140-8, 1141-3, 1142-22, 1142-23 and 1160-3; and revised Tables 1197-3, 1197-5 and 1197-6;
- in **Part 12**, revised Section 1203-2; and
- in **Part 13**, a revised Table of Contents; revised Sections 1303-4, 1303-5, 1342-3, 1342-7 and 1342-12; and revised Table 1397-5, and 1397-9.

2018 July 20, 2018 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 1**, a revised Table of Contents; new Section 100-6; and renumbered Section 100-7;

- in **Part 2**, a revised Table of Contents; revised Sections, 202-15, 206-8, 240-9, 240-10 and 242-8; a revised Tables Index; and deleted Table 297-17.
- in **Part 3**, a revised Table of Contents; new Sections 343-1 and 343-2; revised Sections 301-6 and 342-4;
- in **Part 4**, a revised Table of Contents; new Section 442-43; revised Sections 401-1, 402-3, 403-1, 403-2, 403-3, 403-12, 404-2, 405-3, 407-2, 420-1, 420-4, 420-5, 440-3, 440-11, 442-13, 442-20, 442-24, 442-25, 442-49, 443, 460-6, and 495-2; editorial changes in Sections 400-3 and 442-19;
- in **Part 6**, a revised Table of Contents, new Sections 608-12 and 640-23, revised Sections 605-11, 605-16, 605-19, 608-1, 608-2, 608-3, 608-5, 608-7, 608-9, 608-11, 630-5, 640-2, 640-5, 640-12, 641-18, 641-22, 642-24, 642-41, 642-44, 642-45, 642-51, 642-52, 642-55, 642-57, and 642-59; an updated Forms Index; new Forms 696-5, 696-6, 696-7; revised Forms 696-1a, and 696-1b; revised Figures Index; revised Figure 698-11; and an editorial change in 641-20.1;
- in **Part 11**, a revised Table of Contents; revised Sections 1102, 1120-1, 1120-4, 1120-5, 1120-6, 1120-8, 1140-1, 1141-3, 1141-4, 1142-16; an editorial change in Section 1100-3; revised Table 1197-4; and revised Figure 1198-11;
- in **Part 12**, a revised Table of Contents; revised Section 1203-2; and revised Forms Index;
- in **Part 13**, a revised Table of Contents; new Sections 1303-12, 1303-13, and 1342-13; revised Sections 1301-2, and 1342-12; and
- in **Part 14**, a revised Table of Contents; and deleted Section 1401.

2018 January 18, 2019 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents; revised Sections 201-3 and 202-10; a revised Tables Index; and new Table 297-3;
- in **Part 3**, a revised Table of Contents; and revised Section 301-6;
- in **Part 4**, a revised Table of Contents; new Section 404-4; revised Sections 403-2, 404-1, 442-24, 442-46; deleted Section 442-14; a revised Forms Index; and new Form 496-19;
- in **Part 6**, a revised Table of Contents; revised Sections 605-15, 608-4, 608-5, 608-7, 630-4, 640-24, 641-20, 641-26, 642-4, 642-5, 642-6, 642-29, 642-52 and 642-59; revised Tables Index 697; revised Tables 697-1d and 697-1e;
- in **Part 11**, a revised Table of Contents; new Sections 1104-4, 1142-25, and 1142-26, revised Sections 1104-3, 1120-8, 1140-4, 1143; and revised Table 1198-11;
- in **Part 12**, a revised Table of Contents; revised Sections 1203-1 and 1203-3; and revised Form 1296-6a.

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- in **Part 2**, a revised Table of Contents; and revised Sections, 201-9 and 210-2;
- in **Part 4**, a revised Table of Contents; revised Sections 402-3, 403-2, 403-7, 403-10, 404-7, 440-7, 442-20, 442-24, 442-25, 460-6; a revised Forms Index; revised Forms 496-3 and 496-4; a revised Figures Index; and revised Forms 496-36, 496-37 and 496-38;
- in **Part 6**, revised Section 630-4; and an editorial change in 642-24;
- in **Part 11**, revised Section 1141-3;
- in **Part 12**, revised Section 1202; and
- in **Part 13**, a revised Table of Contents, new Sections 1342-8 and 1342-15; revised Sections 1303-3, 1303-4, 1303-7, 1342-7, 1342-9, 1342-11, 1342-12, 1342-13, and 1342-14; revised Tables 1397-4, 1397-5a, 1397-6, 1397-7 and 1397-8.

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- in **Part 3**, revised Table 397-1;
- in **Part 14**, a revised Table of Contents; and revised Sections 1415-1 and 1415-3;

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- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents; and revised Sections 201-3, 201-16, 206-5, 210-3 and 242-8;
- in **Part 3**, a revised Table of Contents; and revised Sections 301-3, 301-6, 301-10, 342-4, 342-5, 350-2, 350-6, revised Tables Index; revised Table 397-1, and deleted Tables 397-3, 397-4, 397-5; ;
- in **Part 4**, a revised Table of Contents; revised Sections 402-2, 402-3, 403-6, 403-8, 404-5, 405-2, 441-12, 442-16, 442-20, 442-21, 442-22, 442-25, 442-29, 442-45, and 460-3; and deleted Section 442-24;
- in **Part 6**, a revised Table of Contents; and revised Sections 605-14, 641-15, 641-29, and 642-27;
- in **Part 8**, a revised Table of Contents; and revised Sections 804-2, 804-4, 830-3, 840-2, and 843;
- in **Part 11**, a revised Table of Contents; new Section 1142-27; and revised Sections 1142-25 and 1142-26;
- in **Part 13**, a revised Table of Contents; new Section 1303-14; revised Sections 1300, 1301, 1303-1, 1303-7, 1303-11, 1303-12, 1303-13, 1397; deleted Section 1342-5; deleted Table 1397-8 and
- in **Part 14**, revised Section 1415-3.

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- **in Part 1**, revised Sections 103-2 and 120-4;
- **in Part 2**, a revised Table of Contents; revised Sections 221-1, 240-2, 240-4, 241-7, 242-3, 250-3, 250-4, 250-5, and 250-7; revised Table 297-7; revised Figures 298-12, 298-18, 298-20, and 298-21;
- **in Part 4**, a revised Table of Contents; revised Sections 401-1, 403-1, 420-1, 421-1, 440-3, 440-4, 440-5, 440-10, 441-8, 441-10, 442-10, 442-11, 442-12, 442-43, 442-45, 442-46, 450-3, 450-6, and 450-8; revised Table 497-4 and revised Figure 498-37;
- **in Part 6**, a revised Table of Contents; revised Sections 605-14, 640-5, 640-12, 641-29, 642-8 and 642-58.

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- **in Part 2**, a revised Table of Contents; new Section 201-17; revised Sections 206-8, 210-3, 212-2, 220-6, and 221-6 ; revised Table 297-6; and revised Figure 298-21;
- **in Part 3**, a revised Table of Contents; and revised Section 320-4;
- **in Part 4**, a revised Table of Contents; revised Sections 403-6, 403-7, 403-10, 421-1, 440-4, 442-21, 442-22, 442-25, 442-26, 442-27, 442-28, 442-29, 442-41, 442-42, 442-48, and 442-49; deleted Sections 442-13 and 442-45; an editorial change in 404-4; revised Table 497-1; and revised Figure 498-38;
- **in Part 13**, a revised Table of Contents; revised Sections 1303-3, 1303-5, 1303-6, 1303-10, 1303-11, and 1340-1; deleted Section 1395-2; and revised Table 1397-9.

2020 October 16, 2020 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

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- **in Part 1**, revised Sections 120-4 and 140-7;
- **in Part 2**, revised Section 206-10; an editorial change in Section 202-14;
- **in Part 3**, revised Form 396-1;
- **in Part 4**, editorial changes in Table 497-1 and Figure 498-44.
- **in Part 6**, a revised Table of Contents; revised Sections 601-2, 601-3, 630-4, 640-13, 640-29 and 642-32;
- **in Part 11**, a revised Table of Contents; revised Section 1140-5;
- **in Part 13**, editorial changes in Tables 1397-3 and 1397-7;
- **in Part 15**; revised Section 1599; revised Policy 21-008(P); and revised Standard Procedure 123-001(SP).

2021 January 15, 2021 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- **in Part 3**, a revised Table of Contents; new Sections 301-21 (replaces deleted Section 301-21) and 341-7; revised Sections 301-10, 307-1, 307-2, 307-4, 342-4, 350-7, and 350-8; and deleted Section 342-6;
- **in Part 4**, a revised Table of Contents; new Sections 403-13 and 420-6; revised Sections 401-9, 402-1, 403-6, 403-10, 404-4, 407-2, 440-1, 440-8, 440-10, 442-42, 442-43, and 450-4, deleted Section 401-8; revised Table 497-1; revised Figures Index; and deleted Figure 498-9;
- **in Part 6**, a revised Table of Contents; new Section 642-18; new Figure 698-13; and revised Sections 601-3, 605-11, 608-4, 630-4, 640-19, 640-24, 641-5, 641-6, 641-7, 641-29, 642-47, 642-55; and revised Figures Index;
- **in Part 11**, a revised Table of Contents; new Section 1120-7 (replaces deleted Section 1120-7); and revised Sections 1103-6, 1140-4 and 1141-4;
- **in Part 13**, a revised Table of Contents; revised Sections 1303-2, 1303-3, 1303-5, 1303-6, 1303-11, 1342-7, and 1342-8; and
- **in Part 14**, a revised Table of Contents; and revised Sections 1415-2 and 1415-3.

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- a revised Title Sheet, Publication Record and Table of Contents;
- **in Part 1**, a revised Table of Contents; revised Sections 120-4 and 120-7; a revised Forms Index; and revised Form 196-1;
- **in Part 2**, a new Section 210-4; and revised Sections 201-14 and 209-7;
- **in Part 3**, a revised Table of Contents; and revised Section 301-6;
- **in Part 4**, a revised Table of Contents; and revised Sections 401-9, 403-1, 403-6, 403-10, 403-12, 403-13, 404-2, 404-3, 404-4, 407-2, 420-4, 420-5, 440-3, 440-8, 442-20, 442-44, 450-10, 450-11 and 460-3;
- **in Part 6**, a revised Table of Contents; new Section 641-35; revised Sections 640-5 and 642-39; and an editorial change in 642-35;
- **in Part 7**, a revised Form 796-1;

- **in Part 11**, a revised Table of Contents; revised Sections 1101, 1103-2, 1103-6, 1130-4, 1130-6, 1140-3, 1140-4, 1140-5, 1140-6, 1141-3, 1142-5, 1142-6, 1142-7, 1142-8, 1142-9, 1142-10, 1142-11, 1142-27, 1150-2, 1150-3, 1150-4, 1150-5, 1150-7, 1150-8, 1150-10, 1150-12, 1150-14, 1150-17, 1160-8, and 1160-12; revised Table 1197-1; and revised Figures 1198-3, 1198-7, and 1198-12;
- **in Part 12**, a revised Table of Contents; revised Sections 1203-2 and 1203-3; an editorial change in Sections 1203-1 and 1213-2; a revised Forms Index; revised Forms 1296-1 and 1296-2; a revised Tables Index; and revised Tables 1297-2, 1297-3 and 1297-6;
- **in Part 13**, a revised Table of Contents; revised Sections 1303-4 and 1342-10; and revised Table 1397-1.

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120 TRAFFIC CONTROL DEVICES AND MATERIALS**120-1 General**

In general, only traffic control devices addressed in the **OMUTCD** are approved for use on public highways, and private roads open to public travel. However, new devices are being developed regularly and the fact that they are not addressed specifically in the **OMUTCD** is not intended to exclude them from use. **OMUTCD Section 1A.10** states that "Design, application, and placement of traffic control devices other than those adopted in this Manual shall be prohibited unless the provisions of this Section are followed." **OMUTCD Section 1A.10** then describes the review and approval processes for experimentation, interim approval, interpretation and changes related to traffic control devices. **TEM Section 120-3** provides additional details regarding **ODOT's** procedures for reviewing and evaluating new products.

In general, information about traffic control materials is located within each **TEM** Part according to the type of material involved. Information that addresses more than one type of material, such as the guidelines for handling patented or proprietary materials, or the process whereby local agencies can purchase traffic control materials and equipment using Federal funds, is addressed in **TEM Part 1**.

120-2 Specifications

Per **ODOT Policy 16-004(P)**, **Standard Procedure 122-004(SP)**, **Development of Standards and Specifications**, describes the procedures for development, approval, distribution and implementation of all new and revised **ODOT** specifications. For further information on **ODOT** specifications in general, see **Chapter 105** of this Manual. Information on specific types of traffic control devices are addressed in the individual **TEM** Parts related to the particular types of traffic control.

120-3 New Products

Per **ODOT Policy 27-014(P)**, **Standard Procedure 515-001(SP)** establishes the process by which new products are evaluated and approved/disapproved for use. Information about the **ODOT** new products program is available on-line from the [Office of Materials Management's New Products web page](#). Also see **OMUTCD Section 1A.10**.

120-4 Patented or Proprietary Materials, Specifications or Processes

Patented or proprietary materials, specifications, or processes shall not be included in a construction contract unless one of the following conditions applies:

1. The item is to be purchased or obtained through competitive bidding with equally suitable items. In which case, the Plans shall specify a minimum of two acceptable items and include the phrase "or approved equal."
2. No equally suitable alternate exists.
3. The item is essential for compatibility with existing highway facilities. The owner must explain how the proprietary item is essential based on ONE of the following:
 - a. **FUNCTION**- the proprietary item is an engineering requirement for the satisfactory operation of the existing facility.
 - b. **AESTHETICS**- the proprietary product is necessary to match the visual appearance of existing facilities that are directly adjacent to the proposed construction. Aesthetics is not an engineering function and ODOT strives to minimize the amount of Federal and State funds expended on aesthetic details that have no inherent engineering purpose.
 - c. **LOGISTICS**- the proprietary product is interchangeable with products in an agency's maintenance inventory. In general, ODOT considers the Logistics justification met when greater than 50% of the agency's inventory consists of the

proposed item. Convenience for the maintaining agency is not justification for a proprietary bid item, but the ability to rapidly maintain roadway items that serve an important safety function is an important consideration.

4. The item is used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes.
5. There is a determination by the District Deputy Director (DDD) that it is in the best public interest to specify one such item to the exclusion of any other acceptable alternate.
6. The proprietary item is funded with 100% local funds or an ODOT-administered funding source that specifically allows the use of proprietary bid items for aesthetic purposes. The Plans shall reflect the local funding split.

A request and justification shall be submitted by the maintaining agency to the **Office of Roadway Engineering (ORE)** with a copy to the appropriate District. A web-based submittal tool and instructions to assist maintaining agencies make a Proprietary Product Request is found at the ODOT Office of Local Programs website. It is very important that each item is requested separately and that each request includes:

1. The model and/or manufacturer of the item.
2. An engineering justification that details why the proprietary item is necessary.
3. A complete list of the agency's existing inventory of that item, including the model requested. EVPE (Emergency Vehicle Preemption) requests should contain the functional classification of the intersecting roadways at each intersection.

ORE shall evaluate the request, coordinate with other **ODOT Offices** and **FHWA** if appropriate, and subsequently notify the requesting agency of the disposition of the request. All requests for traffic signal control equipment shall include a table listing all signalized intersections under the agency's jurisdiction, the brand of equipment installed at each and the date of installation. A separate submittal is generally needed for each item and must clearly state one or more engineering reasons for each Proprietary Product Request.

Requests shall be submitted in a timely manner, in accordance with the Project Development Process (PDP) or the Local-let procedures, whichever is applicable.

Where research or experimentation is proposed, it will also be necessary to set up an evaluation program per the **New Product Development Policy 27-014(P)**.

Should a Proprietary Product Request be denied, ORE will inform the requesting agency they may consider alternate bidding procedures and that Federal-aid participation will be based on the lowest price so established.

120-4.1 Alternate Bid Items

In lieu of proprietary bids for aesthetically designed items including signal, sign or lighting supports, decorative coatings, many streetscape items, alternate bids are permitted. Alternate bids shall use at least two brands of similar aesthetically designed items for the generic bid and an alternate bid for the local agency's preferred choice. The local agency shall pay the cost difference if the alternate bid item price exceeds the generic bid item.

The generic and alternate bid items shall be separated in the plan Summary or Summaries appear in the Plans as Alternate A, B, ..., or 1, 2, ..., etc. The Office of Estimating can provide assistance to designers on including alternate bid items in the Plans.

120-4.2 Proprietary Traffic Signal Items

In the case of traffic signals, the majority of alternate bid requests are made for controller items or emergency vehicle preemption. Proprietary bids shall be considered instead of alternate bids when:

1. The signal controllers are an extension of an existing arterial coordinated signal system. Typically, the number of controllers being added is less than the number of existing controllers in the system.
2. Greater than fifty percent of the agency's controllers are of a single brand.
3. Greater than fifty percent of the agency's signalized intersections operate with a single brand of emergency vehicle preemption equipment. Alternatively, for agencies with 40 or more signalized intersections, the same fifty percent criterion may be applied to the subset of signalized intersections located on roadways with Functional Classification Minor Arterial, Principal Arterial or Expressway. The extension of preemption equipment on an existing preempted arterial will not be a basis for approval of proprietary bid items for preemption equipment.
4. Greater than fifty percent of the agency's signalized intersections operate with a single brand of video detection equipment.
5. Greater than fifty percent of the agency's signalized intersections operate with a single brand of spread spectrum radio equipment. Proprietary bid items will be considered if the spread spectrum radios are an extension of an existing coordinated signal system and the number of radios being added is less than the number of existing radios in the system.
6. Greater than 50% of the agency's signalized intersections operate with a single brand of UPS equipment.

There should be no upgrading of the existing equipment (controllers, preemption, video detection, spread spectrum radio, etc.), or the upgraded existing equipment will be evaluated as new/added equipment.

Items provided to an agency at any price below normal fair market value shall not be included as part of the proprietary item calculation. Documentation may be requested verifying purchase at fair market value.

If at least fifty percent of the agency's controllers are of a single brand, central control software upgrades may be considered. The single brand controllers do not have to be currently connected to the central control. Upgraded existing controllers will be evaluated as new/added controllers.

The addition of an interconnection card to an existing controller is not considered an upgrade to the controller.

For signal supports, if two brands of the generic item are not specified, the generic bid shall be a standard ODOT signal support with black coating meeting **ODOT Supplemental Specification 916**, which shall be cited in the alternate bid note and Title Page of the Plan set. Any support with a coating other than black coatings meeting SS 916 shall be alternate bid.

120-4.3 Proprietary Roadway Lighting Items

Unless meeting one of the criteria in 120-4 above, proprietary items for aesthetically designed luminaries and lighting supports shall not be considered because of the numerous manufacturers of similar support designs.

For light supports, if two brands of the generic item are not specified, the generic bid shall be a standard ODOT light support with black coating meeting **ODOT Supplemental Specification 916**, which shall be cited in the alternate bid note and Title Page of the Plan set. Any support with a coating other than black coatings meeting SS 916 shall be alternate bid.

120-4.4 Proprietary Roadway Sign Items

Unless meeting one of the criteria in 120-4 above, proprietary items for aesthetically designed sign supports shall not be considered because of the numerous manufacturers of similar support designs.

For sign supports, if two brands of the generic item are not specified, the generic bid shall be a standard ODOT sign support with black coating meeting **ODOT Supplemental Specification 916**, which shall be cited in the alternate bid note and Title Page of the Plan set. Any support with a coating other than black coatings meeting SS 916 shall be alternate bid.

120-5 Cooperative Purchasing Program

Under the Cooperative Purchasing Program, political subdivisions may purchase machinery, materials, supplies and other articles from the **ODOT** Annual Term Contracts and the **ODOT** Single Purchase Contracts with their own funds. A copy of the program may be obtained from the **ODOT Office of Contracts, Purchasing Services (see Table 197-1)**.

120-6 Alternative Purchasing Program for Local Agencies

120-6.1 General

ODOT also sponsors another program with respect to the purchase of traffic control materials for installation and use by local government agencies. In this program, funding for the purchase of traffic control materials for installation and use by a requesting local governmental agency is allocated by **ODOT** to the local governmental agency and does not involve the use of **ODOT** term purchase contracts. This method was developed primarily for traffic control materials but can encompass the purchase of other roadway appurtenances such as roadway lighting, signing and street beautification items.

This purchase order procedure was originally created to provide local agencies with a means of purchasing traffic signal materials with Federal project funds. The procedure has also been used to purchase signing materials and can be expanded to include other roadway appurtenances. All materials acquired using this procedure are to be installed by the local agency without cost to **ODOT**.

If traffic signal material is involved, data must be submitted for evaluation of traffic signal warrants as contained in **OMUTCD Part 4**. The signal warrant data shall be evaluated and approved by the **District**. Assistance is available from **ORE** upon request. Only the intersections with **District** approved signal warrants are eligible for Federal funding of traffic signal materials.

The following procedure has been the process to be followed in procuring materials and equipment for purchase order contracts. These functions are also shown as a flow chart in **Figure 198-3**. The steps shown in **Sections 120-6.7 through 120-6.10** are initiated concurrently.

120-6.2 Programming and Funding

The **District** shall prepare and submit the programming package to the **Office of Systems Planning and Program Management**. Any State or Federal funds allocated to the agency that are eligible may be utilized, except for nontraditional transportation funds. Funds shall be sufficient to encompass the material costs, plus preliminary and construction engineering if requested. Any additional cost in the procurement of materials due to increased costs, or to ensure a completed installation, shall be the agency's responsibility unless changes are approved in advance and funds are available.

The agency's cost participation, the local share, whether due to normal project funding splits or 100 percent local cost items, shall be based on the estimate as provided by the agency in **Section 120-6.6(2a)**.

120-6.3 Alternate Bids

Alternate bids cannot be used in the automated purchase order system. There must be only one bid item for each item.

120-6.4 Proprietary Bids (also see Section 120-4)

The purchasing regulations allow a vendor to supply a comparable item for any proprietary brand listed in the bid package. There are two ways to purchase approved proprietary items:

1. Appear before the **State Controlling Board** and request an exemption from the **Department of Administrative Services** purchasing regulations.
2. Have the agency use their own purchasing system to purchase the approved proprietary items. **ODOT** utilizes a "Pass Through of Federal Funds" account in the **Office of Accounting** so that the agency does not have to use their own funds in the purchase. The agency submits the invoices from the vendors to the **District** for payment. This process requires that all preliminary engineering documents and approvals be processed as if **ODOT** were the sole purchasing agent.

120-6.5 Prequalification of Materials

The agency can prequalify a number of manufacturers of a purchase order item. A minimum of three brands should be listed and the supplied item must be one of these specified brands. The agency must document the procedure or reasons for limiting bidding.

120-6.6 Bid Documents Package

The agency shall prepare the bid documents package and submit it to the **District**. The **District** shall coordinate and consolidate review comments and respond to the agency. The bid documents package shall include the following information as required:

1. Preliminary Plans or Sketches.
 - a. For traffic signal projects, plans or sketches should depict existing and proposed signal operation and equipment locations. The complexity of the detail drawings will be determined by the **District** based on the extent of the signal work involved.
 - b. If the work is not signal related, the drawings shall show the locations of all proposed items and any existing conditions that will be affected. Roadway lighting work may require an illumination review to determine the effect the proposed lighting will have on the roadway. Based on the scope of the roadway lighting, the **District** will determine if this review is necessary.
 - c. Plans and sketches shall show right-of-way.
2. Summary of Estimated Quantities and Cost Estimate.
 - a. Detailed sub-summaries with item descriptions and quantities shall be prepared. They shall be subdivided by each intersection and separately subtotaled for any funding splits.
 - b. Two general summaries shall also be submitted; one with the cost estimate included for **ODOT's** use and the other without the cost estimate. The general summary without the cost estimate is used in the bid package that will be sent to the vendors and will provide places for the bid prices to be stated by the vendors.
 - c. Usually, the project must be separated into multiple bid packages in order to group similar items so that the various vendors can bid on only the item group that they can supply.
3. Material Specifications.
 - a. [ODOT's Construction and Material Specifications \(C&MS\)](#) and [Supplemental Specifications](#) shall be used where feasible, but may be supplemented by the agency's requirements, as necessary.

- b. **ODOT** does not review and approve shop drawings or catalog sheets. If the agency wants to review and approve these items, this requirement must be included in the material specifications.
- 4. Miscellaneous Documentation.
 - a. Assurance that all pavement markings, signing and signal installations within the project area are, or will be, in compliance with the [OMUTCD](#). This should be accomplished by a field inspection by **District** and agency personnel, with any deficiencies documented.

The deficiencies shall be corrected by the agency prior to completion of their installation of the purchased materials. By performing this inspection early in the project development, materials can be included in the bid package to correct the deficiencies.
 - b. Assurance that all work is within the right-of-way.
 - c. A proposal for disposition of removed equipment.
 - d. Justification of any proprietary items or specialized equipment.
 - e. A schedule of the agency's installation work, based on equipment delivery dates. This should also be referenced in the agreement.
 - f. Maintenance of Traffic standards which will govern the agency's work.

All plans and documents in the bid document package shall be on 8 ½ x 11 inch sheets, and the agency shall submit all computerized plans and document files to the **District** by disk or by electronic file transfer.

After the agency provides the **District** with the final, **District** approved, version of the bid documents package, the **District** will provide **ORE** with the originals of the bid documents package.

120-6.7 Requisitions

The **District** or the **Office of Accounting** will enter the project into the automated purchasing system. The **ORE Administrator** shall be added as a required authorization on the requisition.

120-6.8 Agreement

ORE will send to the **District** an agreement to be forwarded to the agency for signature.

The agreement will be reviewed by the agency, signed by the agency's contractual officer, and returned to the **District** for the **Deputy Director** to sign.

The **District** will keep the original of the executed agreement and provide copies to the agency and **ORE**.

If the agency is responsible for a share of the project costs:

1. A check shall accompany the agreement when returned to the **District**.
2. The **District** shall forward the check to the **Office of Payroll and Project Accounting** and that office will ensure that the agency's check is properly credited to the project and processed. The **District** will furnish **ORE** with a copy of the check transmittal letter.

120-6.9 Federal Approval

If Federal funding is involved, **ORE** will submit a bid document package, excluding the agreement, to the **Office of Payroll and Project Accounting** to obtain PS&E approval from **FHWA**.

120-6.10 Pass Through of Federal Funds

If a “Pass Through of Federal Funds” process is used, as described in **Section 120-6.4**:

ORE will request that the **Office of Accounting** establish the account and create the requisition for the agency's items. The **Office of Accounting** shall add the **ORE Administrator** as a required authorization on the requisition.

120-6.11 Approval and Invitation to Bid

When all of the concurrently initiated actions in **Sections 120-6.7 through 6.10** are finalized, **ORE** will:

1. Approve the electronic requisitions so they proceed to **Purchasing Services** in the [ODOT Office of Contracts](#);
2. Forward the bid documents package to **Purchasing Services** to process an Invitation to Bid; and
3. Advise the agency to proceed with their purchase process if a “Pass Through of Federal Funds” process is used (*see Section 120-6.4*).

120-6.12 Recommendation for Award of Bids

After the bids have been received and reviewed by **Purchasing Services**, they will be tabulated and sent to **ORE**. **ORE** shall process the bids as follows:

1. Discuss the bids with the **District** and the agency and make award recommendations.
2. In the case of Federal projects with active Federal oversight, obtain **FHWA's** concurrence with the award recommendations.
3. Forward award recommendations to **Purchasing Services** for further processing.

120-6.13 Purchase Order

Purchasing Services will create the purchase orders to be issued to the supplier. The purchase order shall include:

1. A “Shop Drawing” note indicating that material catalog sheets or data sheets shall be submitted to the agency before any material is shipped; and
2. A note that all invoices are to be mailed directly to the **District** and materials shipped to the agency.

For those items requiring certified test data as determined by the **District**, the Purchase Order shall also indicate that submissions are required to be submitted to the **District** by the supplier. This would include any submissions which contain a material composition analysis which must be in accordance with a recognized standard.

120-6.14 Catalog Sheets, Certified Test Data and Testing

If specified in the project specifications, catalog sheets shall be received and reviewed by the agency. The agency will indicate comments on the catalog sheets as to the acceptability of the submitted items and their compliance with the material specifications. The submittal shall be marked “Approved,” “Approved as Noted,” or “Not Approved,” and will be transmitted to the various affected parties.

The agency shall notify the material supplier as to the acceptability of the submitted product, thus enabling them to commence fabrication and/or shipping in the case of an approval, or to make other arrangements in the case of disapproval. The supplier will be advised to send invoices to the **District**.

Certified test data shall be received by the agency with material shipment. It shall be sent to the **District** for review and retention.

Submittals requiring testing shall be conveyed to the **District Highway Management Administrator** and the **Office of Materials Management** for review and approval.

120-6.15 Inspection of Material Received

Upon receipt of materials, the agency shall contact the **District** to arrange for the inspection of the materials and completion of the necessary **Receiving Forms (MR-541)** and **Field Inspection Report (TE-30)** if required. If only **Receiving Forms (MR-541)** are necessary, the **District** may direct the agency to fulfill this function.

120-6.16 Invoice Payment

The following shall be submitted to the **District** for payment: invoice, **Invoice Coding Strip (AU-60)**, **Receiving Form (MR-541)**, **Field Inspection Report (TE-30)** if required, and certified test data if required.

120-6.17 Project Completion

Upon project completion, the agency shall contact the **District** to arrange a final field inspection. If Federal funding was used and the project has direct Federal oversight, **FHWA** shall be included in the process and its representative should be given copies of all approved certified test data submittals.

After completion of the inspection and correction of any deficiencies, the **District** will document that **ODOT** accepts the physical work as performed by the agency. The **District** will also document that any deficiencies identified in the engineering phase of project development have been corrected.

The **District** shall formally advise the **Office of Payroll and Project Accounting** when the project is completed and acceptable to **ODOT** and **FHWA**. With this information the **Office of Payroll and Project Accounting** will seek final Federal reimbursement of project funds. This process will finalize the project.

120-7 Alternate Bids for Traffic Control and Lighting Items

120-7.1 General

The alternate bid procedure has been established to permit a local agency to obtain a specific brand, feature or design of traffic control or lighting device for use on a project.

Some of the generalized uses of the procedure are as follows:

1. To obtain a specific brand and model of equipment, which is expected to simplify maintenance and operation or reduce operating costs.
2. To obtain supports which include architectural features or designs used exclusively within the jurisdiction of the local agency, and which are more expensive than the support designs normally used in **ODOT** plans. This may include items in local areas with historic or theme backgrounds.
3. To obtain a specialized design feature which is patented or manufactured by only one supplier, and which the agency expects will improve maintenance or operation.

4. To obtain devices which are not presently justified for efficient use on the project or are not acceptably justified by agreed future conditions, but which the local agency believes will be necessary at some future time.
5. To obtain items whose extra costs are not justified when lower cost items can provide acceptable results.

120-7.2 Eligibility

The local agency should inquire from the **District Planning and Engineering Administrator** as to whether or not an item is eligible for normal project participation. In many cases where a precedent has not been established, the request is reviewed with **FHWA** (when Federal funds are involved) and a decision is rendered. This request may be made informally or in writing depending on the nature of items involved and precedents already established. If it is determined that alternate bids are necessary, the local agency shall submit a request in writing through the appropriate **District** that alternate bids be taken. **Figure 198-5** shows a sample letter which may be used by local authorities to request alternate bids.

Each request must include the following information:

1. Specific brand (and model) or design features desired.
2. Reasons why the local agency desires the product or feature in question.
3. Locations for use on the project under consideration.
4. Past history or experience with the product where applicable.
5. Confirmation that the local agency understands the procedures of the alternate bid process (**Section 120-7.3**).
6. Name and telephone number or email address of the responsible authority within the local agency to be contacted after the bid opening to determine the disposition of the alternate bids.

120-7.3 Procedure

Refer to L&D Volume 3, Section 1307. The alternate bid procedure consists of adding a second bid item (alternate bid) for each general (generic) bid item which is affected by the local agency's special requirements. The generic bid item reflects the customary item that is sufficient to meet the needs of the project and is eligible for normal project participation. The alternate bid item describes a similar item that will satisfy the same needs of the project but also contains the local agency's special requirements. After bid opening, **ODOT** compares the costs of generic versus alternate bids for the affected bid items. In the event the generic items are bid at a higher price than the alternate items by the successful bidder, the award will normally be made on the basis of the alternate items with no additional cost incurred by the local agency. In the event the alternate items are bid at a higher price than the generic items, the maintaining agency will have the opportunity to either reject the alternate bids or to agree to accept the alternate bids with the understanding that local agency funds will pay the entire cost differential between the alternate bid and the generic bid.

A representative of the **District** will contact the responsible authority of the maintaining agency (**see Section 120-7.2, item 6**) by telephone or email and furnish unit prices and total bids for the generic and alternate bid items involved, including cost differentials for the apparent low bidder. Where the alternate bid process involves more than one item description, alternate bids can be selectively accepted or rejected; however, similar equipment types should be grouped together, such as all controller bid items or all preemption bid items. Only a limited period of time (one or two days) will be available for the maintaining agency to make known their preference by return telephone call or email (if time is needed to deliberate the preference) and to forward a letter with written confirmation to the **District**.

The apparent low bidder for the project will be determined solely on the lowest bid prices submitted. The cost differential presented to the local agency will be based only upon generic and alternate bid prices submitted by the apparent low bidder. Alternate bid prices submitted by other bidders will not be considered when determining the local agency's added costs.

The project must be awarded or rejected within ten days of the bid opening; therefore, **ODOT** must receive the local agency's written acceptance of the alternate bids within the time period or **ODOT** may award the project on the basis of the lowest bids. If the local agency refuses the alternate bids, written confirmation is still required for **ODOT** documentation. The letter of confirmation must be sent directly to the **District Planning and Engineering Administrator**. The letter shall also include a statement of willingness of the maintaining agency to pay the entire difference in cost, if the local choice is alternate bids involving a higher cost than that for generic bid items. The letter shall be signed by the contractual officer for the local agency. **Figure 198-6** shows a sample letter that may be used by local authorities to acknowledge acceptance or rejection of the alternate bids.

196 FORMS INDEX

196-1 Reserved for Future Information

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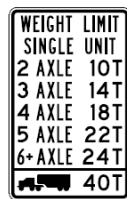
Form 196-1. Reserved for Future Information

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A municipal corporation can regulate the use of its streets and can restrict the type of vehicles that travel over those streets pursuant to **ORC Section 4511.07**. However, **ORC Sections 4511.06 and 4513.33** restrict the use of that power for trucks traversing designated State or U.S. Routes. Thus, a municipal corporation may establish its own truck weight limits for streets and highways within its jurisdiction that differ from those established in **ORC Chapter 5577** and must post signs notifying the traveling public. However, when such weight limits involve State or U.S. Routes, **ORC 4513.33** requires the approval of the **Director** to alter them. Otherwise, the ordinance may conflict with **ORC Sections 4511.06 and 4513.33** and be found ineffective.

Weight Limit signs are discussed in **OMUTCD Section 2B.59**, and the **ODOT Bridge Design Manual (BDM)** also addresses this signing in **BDM Section 919.3**.

BDM Section 919.7 addresses EMERGENCY VEHICLE WEIGHT LIMIT (R12-H7) signing. A bridge posted with a Weight Limit sign (e.g., R12-H5) shall not be signed simultaneously with the R12-H7 sign.



R12-H5



R12-H7

201-10 Lane-Use Control Signs

OMUTCD Sections 2B.19 through 2B.22 address Lane-Use Control signs and show some of them. However, there are many more of these signs that have been designed and assigned code numbers than could practically be shown in the **OMUTCD**. For reference purposes, **Table 297-1** provides a listing of them with their standard sizes and **Figure 298-22** provides illustrations of them.

201-11 YIELD Signs (R1-2)

OMUTCD Sections 2B.04, 2B.08, 2B.09 and 2B.10 discuss YIELD signs. **OMUTCD Section 3B.16** addresses Yield Lines. The maintenance responsibilities of STOP and YIELD signs at **County and Township** road intersections with state highways is addressed in **Section 260-6**.

A YIELD sign shall be erected at the point where the vehicle is to stop if necessary to yield the right-of-way. Except where unusual intersection geometrics exist, YIELD signs should not be placed further than 50 feet from the intersected roadway. Where there is a marked or unmarked crosswalk, the sign should be erected approximately 4 feet in advance of the crosswalk edge nearest to approaching traffic (see **OMUTCD Figure 2A-3**).

201-12 DO NOT ENTER Signs (R5-1)

OMUTCD Section 2B.37 discusses the DO NOT ENTER sign.

In accordance with **OMUTCD Section 2B.10**, when a DO NOT ENTER sign is mounted back-to-back with a STOP sign, the DO NOT ENTER sign should stay within the edges of the STOP sign. If necessary, the size of the STOP sign should be increased so that the DO NOT ENTER sign installed back-to-back with the STOP sign remains within the edges of the STOP sign.

201-13 KEEP RIGHT (LEFT) Signs (R4-7, R4-8)

OMUTCD Section 2B.32 discusses KEEP RIGHT (LEFT) signs.

On a median, the KEEP RIGHT (LEFT) sign should be mounted not more than 50 feet beyond the
(July 16, 2021)

approach end of the island. To facilitate guidance of left-turning traffic entering from a cross street, the KEEP RIGHT (LEFT) sign may be erected at an angle of up to 45 degrees with the cross street.

201-14 Traffic Law Photo-Monitoring Signs (R10-18), Automated Traffic Enforcement and Surveillance Devices

Among other conditions on the use of traffic law photo-monitoring devices to detect or enforce traffic law violations set out in **Senate Bill 342, 130th General Assembly, Ohio Revised Code Section 4511.094** imposes certain conditions on any local authority for placement or use of traffic law photo-monitoring devices:

1. Erect R10-18 signs on every highway that is not a freeway that is part of the state highway system and that enters the local authority to inform inbound traffic that the local authority utilizes traffic law photo-monitoring devices to enforce traffic laws.
2. Beginning on March 23, 2015, erect signs at each fixed system location informing motorists that a traffic law photo-monitoring device is present at the location.
3. The sign shall be erected within the first three hundred feet of the boundary of the jurisdiction or within three hundred feet of the fixed system location, as applicable. If the signs cannot be located within the first three hundred feet of the boundary of the local authority or within three hundred feet of the fixed system location, the local authority shall erect the signs as close to that distance as possible. If a particular highway enters and exits the jurisdiction multiple times, the local authority shall erect the signs at the locations in each direction of travel where inbound traffic on the highway first enters the jurisdiction.
4. All signs erected must conform in size, color, location, and content standards contained in the **OMUTCD** and shall remain in place for as long as the local authority uses traffic law photo-monitoring devices to enforce any traffic law.
5. All required R10-18 signs shall be maintained and replaced as needed so that at all times at least ninety percent of the required signs are in place and functional.
6. The local authority shall annually document and, upon request, certify compliance with provision 5 of this Section.
7. At all intersections where traffic law photo-monitoring devices are placed, which are controlled by traffic signals, the operation of the yellow change lights and arrows must be timed so that the steady yellow interval exceed by one second the minimum yellow change interval determined in accordance with **Section 403-2**.

No traffic law photo-monitoring, automated enforcement or surveillance device (including, but not limited to red light cameras, speed cameras, license plate readers (LPRs) and electronic surveillance devices) shall be installed at any intersection or on any highway maintained by **ODOT**. R10-18 signs shall not be installed on interstates or freeways maintained by **ODOT**.

201-15 KEEP RIGHT EXCEPT TO PASS Sign (R4-16)

ORC Section 4511.351 requires **ODOT** to erect the KEEP RIGHT EXCEPT TO PASS (R4-16) sign on Interstate highways with three or more lanes in the same direction. The purpose of the sign is to direct drivers to stay in the right-hand lane except when passing another vehicle.

The KEEP RIGHT EXCEPT TO PASS sign would be expected to have the greatest benefit in rural areas with a higher percentage of long distance traffic and greater spacing between interchanges. The message will be less relevant in urban areas with complex freeway designs and a higher percentage of relatively local traffic. For this reason, the sign is not recommended for installation within the outerbelt of major metropolitan areas, but should be installed on the outerbelt itself where,

These requirements may not present any particular problems when used at isolated locations. However, problems may arise in cases where a mainline exit from an option lane is followed shortly thereafter by a ramp split, especially where the ramp split also contains an option lane, or where interchanges are closely spaced. Both of these situations are prevalent on Ohio freeways.

OMUTCD Figures 2E-4, 2E-5 and 2E-6 provide examples regarding the use of Arrow-per-Lane signs for multi-lane exits and splits that have an option lane, but do not have a subsequent ramp split. **Figure 2E-34** provides examples of guide signing for ramp splits beyond the mainline exit, but where there is no mainline option lane or ramp option lane. There are no examples in the **OMUTCD** showing guide signing arrangements for multi-lane exits with an option lane followed by a ramp split. There are also no examples for multi-lane exits with an option lane for closely spaced interchanges.

For major highway reconstruction or sign upgradings, efforts should be made to follow the **OMUTCD** to the greatest extent practical. This includes working with the highway design team to develop highway entrance and exit ramp configurations and interchange spacings that will be conducive to the application of the signing design principals in the **OMUTCD**.

Besides the figures included in the **OMUTCD**, *TEM Figures 298-33 through 298-36, and 298-45 through 298-47* should be referred to when designing interchange guide signing.

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210 MISCELLANEOUS SIGNS**210-1 General**

This Chapter addresses miscellaneous signs not in the **OMUTCD**.

210-2 National Park Service Signing

ORC Section 5511.10 describes signing requirements for an area that is part of the National Park System. A list of such areas in Ohio can be found here nps.gov/state/oh/index.htm.

Signs erected prior to June 30, 2017 are not required to display the arrowhead symbol of the National Park Service. New signs installed after that date, or signs installed prior to that date and being replaced, shall display the arrowhead symbol.

210-3 Decorative Signs in State Right-of-Way

Decorative signs have been recategorized as Community Gateway Monuments and guidance can be found in the Location and Design Manual, Volume 1, Section 904.

210-4 Soil and Water Conservation District Signing

Soil and Water Conservation District signs do not fall under the guidelines for local community signs (TEM 210-3 - decorative signs) and are not considered jurisdictional signs which fall under the OMUTCD General Information Sign category. Soil and Water Conservation District signs do not provide pertinent information to highway maintenance crews, emergency responders, or drivers to enable them to perform their driving task. Per Section 2H.04, these signs do not provide specific reasons for orienting the road users or identifying control points for activities that are clearly in the public interest and therefore should not be installed in ODOT right-of-way.

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"Request by, and approval of, the legislative authority of a **Village**" shall be in the form of **ODOT Form No. MR-689** (available from the **Office of Maintenance Operations** website) and shall describe the state highway extensions covered by the Ordinance. All such maintenance ordinances (**MR-689**) shall be filed in the office of the **District Deputy Director**.

The pavement markings shall be maintained by the **District** in conformance with the **OMUTCD** and shall be applied in the course of regularly scheduled pavement marking work. An inventory of these markings shall be maintained in the **District**.

The placing of auxiliary markings shall not be **ODOT's** responsibility, but may be included in a contract administered by **ODOT**. The **Village** shall bear all project costs of such auxiliary markings.

Auxiliary markings shall be defined as all markings described in **C&MS 641.08**, except center lines (note that center lines include two-way left-turn striping and the outline of left-turn islands), lane lines, edge lines and channelizing lines. However, channelizing line segments of 200 feet or less shall be considered auxiliary markings.

301-4 Longitudinal Markings

Longitudinal markings are center lines (which include two-way left-turn striping, excluding the arrows, and the outline of left-turn islands), lane lines, edge lines and channelizing lines.

For ODOT-maintained facilities, the standard width for center lines, lane lines, edge lines and channelizing lines shall be as follows:

ODOT-Maintained Facility	Center Line	Lane Line	Edge Line	Channelizing Line
Interstates	N/A	6"	6"	12"
Freeways and Expressways	N/A	6"	6"	12"
Multilane Divided Highway	N/A	6"	6"	12"
Multilane Undivided Highway	4"	6"	6"	12"
Two Lane Highway – Rural	4"	N/A	6"	8"
All Other Highways	4"	4"	4"	8"

However, wide lines may be used for additional emphasis, and **OMUTCD Section 3A.06** defines a wide line as at least twice the width of a normal line with the width of the line indicating the degree of emphasis.

Center lines, lane lines and edge lines shall be placed as follows:

- Edge line – Center of the edge line shall be applied 6 inches from the edge of pavement.
- Lane line – Nearest edge of the lane line shall be applied 2 inches to the left of the construction joint. Broken lines shall be in a 40-foot cycle consisting of a 10-foot dash with a 30-foot gap between the lines.
- Center line – Nearest edge of the center line shall be applied 2 inches to the left of the construction joint. Broken lines shall be in a 40-foot cycle consisting of a 10-foot dash with a 30-foot gap between the lines.

301-5 Stop Lines

The general standards for Stop Lines are addressed in **OMUTCD Section 3B.16**. For **ODOT**-maintained highways, Stop Lines shall be 24 inches wide. They should be used at all signalized intersections. They should also be used to supplement STOP signs where it is important to indicate the point behind which vehicles are required to stop, typically the point at which motorists have the optimum cross-corner sight distance. They are not typically located adjacent to the STOP sign.

301-6 Crosswalk Markings

301-6.1 General

The general standards for Crosswalk Markings are addressed in **OMUTCD Section 3B.18**. For **ODOT**-maintained highways, the standard patterns and line widths are addressed in **SCD TC-74.10**.

As noted in **OMUTCD Section 3B.18**, warning signs should be installed for non-intersection pedestrian crossings.

NCHRP Web-Only Document 208 provides design guidance for channelized right-turn lanes. The report recommends a consistent practice for crosswalk location to help enable those with vision impairment to safely traverse the channelized right-turn lane. This document is available on-line at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w208.pdf.

301-6.2 Aesthetic Treatments

Brick pavers and colored decorative pavement treatments that simulate brick or other patterns may be used between the white crosswalk lines.

Such colored decorative pavements shall be devoid of retroreflective properties and not diminish the effectiveness of the legally required markings. They should also not use colors or patterns that might be mistaken by road user as a traffic control application.

Examples of acceptable treatments include brick lattice patterns, paving bricks, paving stones, setts, cobbles, or other resources designed to simulate such paving. Acceptable colors for these materials would be red, rust, brown, burgundy, clay, tan or similar earth tone equivalents. All elements of pattern and color for these treatments are to be uniform, consistent, repetitive, and expected so as not to be a source of distraction.

Murals or other similar crosswalk art shall not be used. Examples of such unacceptable treatments include, but is not limited to, random or unsystematic patterns, pictographs, symbols, multiple color arrangements, text or other attempts to communicate with any roadway user, etc.

301-6.3 Basis of Payment

Crosswalk lines, whether transverse or longitudinal, are measured and paid for by the foot. Transverse lines are 12 inches wide and longitudinal lines used in the longitudinal bar pattern are 24 inches wide.

For example, bid items for Heat-Fused Preformed Thermoplastic crosswalk lines include:
Crosswalk Line, Type B125, 12"
Crosswalk Line, Type B125, 24"

301-6.4 High Visibility Patterns

High-visibility crosswalks, which come in three different patterns known as "longitudinal bars", "perpendicular" and "double-paired", have been shown to increase safety by improving visibility to approaching motorists and better emphasizing pedestrian crossing areas than the basic parallel transverse line crosswalks.

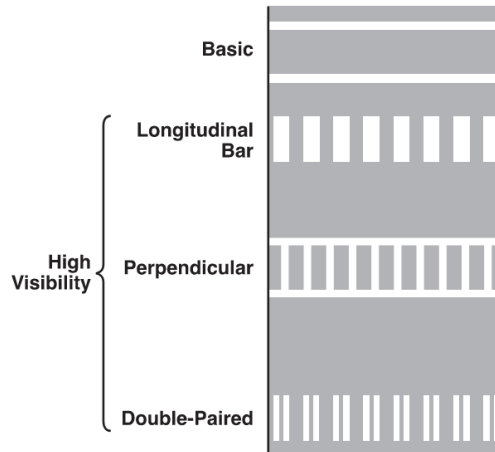
The longitudinal bar crosswalk is the default high visibility pattern for ODOT maintained highways.

Where the determination has been made to install crosswalk markings on ODOT maintained highways, the longitudinal bar crosswalk should be used in the following situations:

1. At intersections where at least one approach has a speed limit of 35 mph or higher
2. At all established midblock pedestrian crossings and with appropriate signing accompaniment

Other locations with high pedestrian volumes or with characteristics that may reduce visibility of pedestrian paths such as poor lighting conditions, obstructions like parked cars, or roadway curvature should also be considered for installation of high-visibility crosswalks.

See Standard Construction Drawing TC-74.10 for details on placement of longitudinal bars.



301-7 Parking Space Markings

The general standards for parking space markings are addressed in **OMUTCD Section 3B.19**. For **ODOT** facilities, the standard width for parking space lines shall be 4 inches.

When parking spaces reserved for persons with disabilities are provided, in addition to the required signing (**OMUTCD Section 2B.46**), the International Symbol of Accessibility (wheelchair symbol) shall be used to further identify the reserved stall(s). Unless there is a need for additional emphasis, the standard size pavement marking symbol shall be used (see **OMUTCD Figure 3B.22** and **TEM Table 397-2**).

The **Americans with Disabilities Administrative Guidelines (ADAAG)** issued by the **U.S. Access Board** include requirements regarding the number and design of parking spaces reserved for the handicapped. This information is available from the **Access Board** at www.access-board.gov. A bulletin specifically addressing accessible parking is also available from the **Access Board** website.

301-8 Pavement Marking Words and Symbols

All pavement marking words (letters and numerals) and symbols should be in conformance with **FHWA's Pavement Markings Alphabets and Symbols** (see **OMUTCD Figures 3B-22 through 3B-26, 3B-28 through 3B-30, and Appendix F of the Sign Designs and Markings Manual**).

OMUTCD Section 3B.20 establishes general standards for pavement marking words, symbols and arrows, and **Traffic SCD TC-71.10** establishes placement standards, as well as providing additional design detail information. Some standard applications of pavement marking words and symbols are illustrated in **OMUTCD Figures 3B-27**. As noted in **Section 301-1**, additional markings information specifically related to School Areas, Highway-Rail Grade Crossings and Bicycle Facilities are addressed in **OMUTCD and TEM Parts 7, 8 and 9**, respectively.

The optional narrow elongated arrow design mentioned in the note in **OMUTCD Figure 3B-24** should not be used on **ODOT**-maintained highways unless needed to match similar arrows used by another jurisdiction in the same area.

Lane-Use Arrow pavement markings should be used in all right-turn and left-turn bays. Signs or arrow markings should be repeated as necessary to prevent entrapment and to help the road users

select the appropriate lane early. When used, there should be a minimum of two arrows in each turn bay.

The **ONLY** word marking may be used only when engineering judgment indicates a need for it.

When used, spacing between the arrows, and arrow and **ONLY** word markings, should be not more than ten times the height of the characters.

TEM Table 397-2 shows the marking area in square feet for various words and symbols.

301-9 Two-Way Left-Turn Arrows

OMUTCD Sections 3B.03 and 3B.20, and Figures 3B-7 and 3B-24 establish standards for the design and placement of pavement markings for two-way left-turn only (TWLTO) lanes. For uniformity and consistency, the following additional guidelines have been established for spacing two-way left-turn arrows within a TWLTO lane.

As shown in **OMUTCD Figure 3B-7** and **Traffic SCD TC-71.10**, these left-turn arrows, when used, should be spaced 8 to 16 feet apart, tip to tip. The “wing tips” of the arrows should be placed 4 inches from the center of the lane.

The arrow sets should be longitudinally spaced at intervals of 500 to 1000 feet for speeds up to 40 miles per hour, and at intervals of 1000 to 1500 feet for speeds over 40 miles per hour. In addition, an arrow set should be placed 100 to 200 feet from the near edge of an intersecting roadway or inside both ends of TWLTO lanes, to remind road users that they are approaching a TWLTO lane in the middle.

Signing for TWLTO facilities is addressed in **OMUTCD Section 2B.24**.

301-10 Speed Measurement Markings

301-10.1 General

Speed Measurement Markings (**see OMUTCD Section 3B.21 and Figure 3B-10**) are used to establish Air Speed Check Zones to assist in the enforcement of speed regulations.

As noted in OMUTCD Section 3B.1, advisory signs may be used in conjunction with these markings. The use of **SPEED ENFORCED BY AIRCRAFT (R2-H15)** or **AREA PATROLLED BY AIRCRAFT (D12-H15a)** is acceptable.

301-10.2 Procedure

Use the following procedure to initiate, maintain or abolish an Air Speed Check Zone:

1. Local **Ohio State Highway Patrol (OSHP) Posts** shall submit requests for establishing, maintaining or abolishing Air Speed Check Zones on the Air Speed Check Zone Request Form (Form 396-1) to the **OSHP Aviation Section Commander** at Ohio State Highway Patrol, Aviation Section, 2829 W. Dublin-Granville Rd., Columbus, Ohio 43235.
2. The **Aviation Section Headquarters** shall determine the necessity of establishing, maintaining or abolishing an Air **Speed Check Zone**.
3. **If the Aviation Section Commander** approves the request, it shall be forwarded to the appropriate **ODOT District Highway Management Administrator**.
4. The **ODOT District** shall evaluate the practicality of establishing or maintaining the zone. If the request is determined to be practical, the **District** shall complete the requested work. A registered surveyor shall lay out the markings (when originally established and when replaced after resurfacing).

5. Upon completion of the requested work, the **District** shall:
 - a. Update its records, including its Air Speed Check Zone inventory,
 - b. Complete the **ODOT** portion of the request form, and
 - c. Return the completed request form to the **OSHP Aviation Section Commander**, at the address listed in item 2.
6. If for some reason the request is not practical, the **District** shall return the request to the **OSHP Aviation Section Commander** (at the address noted in item 2) explaining the reason for not complying with the request.
7. If the request was to abolish an existing Air Speed Check Zone, the **District** shall:
 - a. Update its records,
 - b. Complete the **ODOT** portion of the request form,
 - c. Return the completed request form to the **OSHP Aviation Section Commander**, and
 - d. Allow the markings to wear out.

301-10.3 Installation

Each Speed Measurement Marking shall consist of one white transverse 24-inch line measured in the direction of travel and 4 feet in length. The markings shall be placed at one-quarter mile intervals for a minimum of 1 mile along the roadway, at locations as shown in the plans or as directed by the Engineer. Speed Measurement Markings should avoid being located in the vicinity of a taper, entrance ramp or exit ramp.

On multilane highways with shoulder widths of at least 6 feet, center the Speed Measurement Marking entirely on the shoulder. If the shoulder width is less than 6 feet, center the marking on the edge line such that it extends 2 feet on either side. To assure visibility of the markings and reduce parallax errors, for each direction utilizing an Air Speed Check Zone, a set of two markings (left and right side) shall be used at each one-quarter mile interval.

On two-lane roadways, one marking should be used at each one-quarter mile interval and installed across the center line such that it extends 2 feet on either side.

See **TEM Section 342-4 (Plan Note 342-4)** when Speed Measurement Markings are included in a plan.

301-11 Railroad Approach Markings

The general standards for railroad approach markings are addressed in **OMUTCD Sections 8B.27, 8B-28 and 8B.29, and Figures 8B-6, 8B-7 and 8B-8**. Additional railroad approach markings information is provided in **TEM Section 802** and **Traffic SCD TC-71.10**.

301-12 Speed Hump Markings

Speed humps are “wave-shaped” paved humps/bumps in the street, spread over about 12 feet with a maximum height in the middle of about 3 inches. They are considered a design feature, rather than a traffic control device. **ODOT** does not have an official policy or standard on the design or use of speed humps.

Drivers may respond to these humps/bumps with alarm or surprise, which could result in loss of control of the vehicle. The humps can also cause problems for ambulances and other emergency

vehicles. Therefore, their use should be limited and we do not recommend their use on through public highways. However, since they can be a cost-effective traffic-calming measure for reducing speeds on existing residential streets, local jurisdictions periodically inquire about them. Signing and pavement markings standards for speed humps are addressed in [OMUTCD Sections 2C-29, 3B.25 and 3B.26](#). Examples of pavement markings for speed humps are shown in [OMUTCD Figures 3C-29 and 3C-30](#). It is recommended that any jurisdiction considering speed humps establish guidelines for their design and use. Sample guidelines are available from the [Institute of Transportation Engineers \(ITE\)](#) and various local jurisdictions (e.g., the [City of Columbus](#)).

301-13 Dotted Lines

The general standards for Dotted Lines at exit and entrance ramps are addressed in [OMUTCD Section 3B.04](#), [OMUTCD Figures 3B-8, 3B-9 and 3B-10](#), and [Traffic SCD TC-72.20](#).

For ODOT-maintained highways, Dotted Lines at exit and entrance ramps shall consist of white line segments that are 6 inches wide and are 3 feet in length, separated by 9-foot gaps.

The general standards for Dotted Lines through intersections are addressed in [OMUTCD Section 3B.08](#) and [OMUTCD Figure 3B-13](#).

Dotted lines through intersections are optional and may be used when engineering judgment indicates a need for it.

For ODOT-maintained highways, Dotted Lines through intersections shall consist of line segments that are 2 feet in length, separated by 6-foot gaps. The standard width and color shall match the width and color of the existing adjacent lane line or center line.

301-14 Chevron and Diagonal Crosshatch Markings

301-14.1 General

[OMUTCD Section 3B.24](#) discusses Chevron Crosshatch Markings and Diagonal Crosshatch Markings. These markings are 24 inches wide and placed at approximately 45 degrees to the longitudinal lines that they intersect.

Chevron Crosshatch Markings are used in paved areas that separate traffic flows in the same general direction and shall be white with the point of each chevron facing toward approaching traffic.

Diagonal Crosshatch Markings are used in paved areas that separate opposing directions of traffic and shall be yellow and slant away from traffic in the adjacent travel lanes.

CROSSHATCH MARKINGS SPACING TABLE

FROM*	TO	CROSSHATCH MARKINGS SPACING
0 feet	48 feet	12 feet on center
49 feet	96 feet	24 feet on center
97 feet	Greater than 97 feet	48 feet on center

* measured from the theoretical gore

301-14.2 Entrance and Exit Ramps

Chevron Crosshatch Markings should be used to mark neutral areas of exit ramps at freeway to freeway interchanges and lane drop exits, and when engineering judgment indicates a need for them. As noted in [OMUTCD Section 3B.24](#), they may also be used to mark neutral areas of entrance ramps. When used for those situations, the spacing of markings shall be as noted

in **Section 301-14.1**. Also see [Traffic SCD TC-72.20](#), Freeway Entrance and Exit Pavement Markings, for a typical layout.

301-14.3 Obstructions

When there is an obstruction within the paved roadway, Chevron Crosshatch Markings or Diagonal Crosshatch Markings should be used as shown in [OMUTCD Figure 3B-15](#) in the neutral area formed by the required approach markings, per **OMUTCD Section 3B.10**.

301-14.4 Island Markings

"Painted" islands, including turn lane markings, more than 6 feet in width at their widest part shall include Diagonal Crosshatch Markings in the open area in order to discourage use as a travel lane or parking space. Such markings shall not be used in the open area of islands that are less than 6 feet in width, except when engineering judgment indicates a need for them. The spacing of the markings shall be as shown in the table in **Section 301-14.1**; however, if the island separates opposing traffic, the 12-foot spacing begins at both ends of the island. Also see [Traffic SCD TC-71.10](#), Word and Symbol Pavement Markings, for a typical island layout.

301-14.5 Shoulders

Highways with paved shoulders may experience operational problems due to vehicles misusing the shoulder (e.g., using the shoulder as a travel lane). Diagonal Crosshatch Markings may be used to discourage shoulder misuse where such problems exist.

When such markings have been placed, appropriate signing (e.g., R4-17, DO NOT DRIVE ON SHOULDER) should be erected.

301-15 Elongated Route Shield Symbol Markings

301-15.1 General

The general standards for Elongated Route Shield Symbol Markings are addressed in OMUTCD Section 3B-20, Figure 3B-25 and Figure 3C-14.

301-15.2 Marking Materials

Installation of elongated route shield symbol and cardinal direction markings shall be in accordance with Supplemental Specification 814 - Heat-Fused Preformed Thermoplastic Shield Pavement Marking.

Installations of elongated route shield symbols using Traffic Paint (Item 642), Polyester (Item 643), Thermoplastic (Item 644), Preformed Thermoplastic (Item 645), Epoxy (item 646) and Spray Thermoplastic (Item 648) pavement marking materials shall not occur.

Approved materials can be found on the ODOT Approved List.

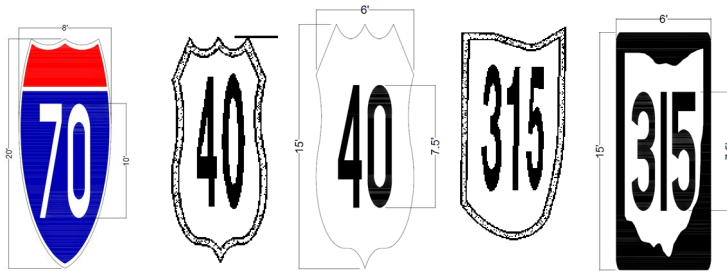
301-15.3 Size of Elongated Route Shield Symbol Markings

The size of the elongated shield symbol and size of the letters shall be according to the Ohio **Sign Designs and Markings Manual (SDMM)** Appendix F as follows:

1. On Interstate Routes the Shield Symbol shall be 8' x 20' with 10' number size.
2. On US Routes the Shield Symbol shall be 6' x 15' with 7.5' number size.
3. On State Routes the Shield Symbol shall be 6' x 15' with 7.5' number size.

301-15.4 Color of Elongated Route Shield Symbol Markings

The Interstate Elongated Route Shield Symbol Markings are available in red/white/blue. US Route and State Route Shield Symbol Markings are available in black/white.

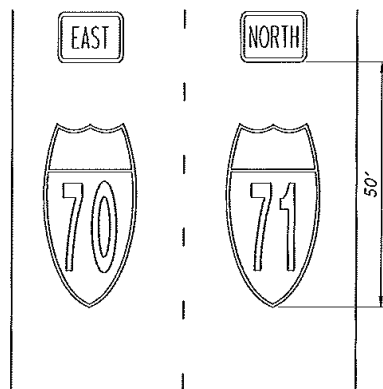
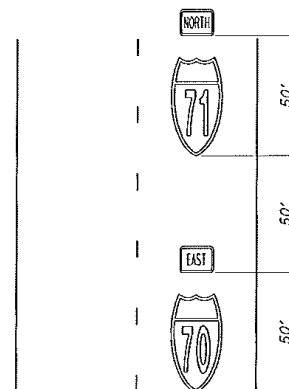
**301-15.5 Cardinal Direction (NORTH, SOUTH, WEST & EAST) Markings**

The size and spacing for the cardinal direction (NORTH, SOUTH, WEST & EAST) markings is based on OMUTCD Section 3B-20. *See Figure 398-1* for size and spacing information.

301-15.6 Placement of Elongated Route Shield Symbol and Cardinal Direction Markings

The distance from the bottom of the elongated route shield to the bottom of the cardinal direction marking should be 50 feet. The spacing between multiple route shields should be 100 feet from the bottom of the first route shield to the bottom of the next route shield.

The elongated route shield and cardinal direction markings should be centered in the lane.

Single Shield Per Lane**Vertical Stacked Shields****301-16 Guidelines to Apply Pavement Markings over Chip Seal Surface or Chip Seal Surface Covered with Fog Seal****301-16.1 General**

Fog sealing is a process using a diluted emulsion to cover the chip seal surface that fills in the voids in the chip seal.

301-16.2 Surface Prep

The surface shall be swept to remove loose chips prior to pavement marking application.

301-16.3 Work Zone Pavement Markings

Place Work Zone pavement markings per **C&MS 614.11**, except Class I pavement markings should be used instead of Class II. After the project is completed, **C&MS 642** permanent pavement markings shall be placed per **C&MS 614.11**. This will increase the application thickness for the pavement markings allowing for the extra absorption of pavement marking material into the cover aggregate.

301-16.4 Striping Materials

Apply permanent pavement markings on chip seal or chip seal with fog seal surfaces as follows:

1. Use Item 642 Traffic Paint to install the permanent pavement markings. Monitor line wear as a second application of permanent pavement markings prior to winter may be needed.
2. Maintain permanent pavement markings using either Item 642 Traffic Paint or Item 643 Polyester Pavement Marking.

Thermoplastic and epoxy pavement marking materials are not recommended for striping long line markings on routes with 2500 or less ADT since these materials must be removed before a chip seal coat can be applied to the pavement.

301-17 Wrong-Way Arrows

OMUTCD Section 3B.20 and **Figure 3B-24** establish standards for the design of wrong-way arrow pavement markings.

For uniformity and consistency, additional guidelines have been established for placing the wrong-way arrows on exit ramps. Wrong-way arrow(s), when used, should be placed as follows:

1. On ramps where lane-use arrows are not used, place the first wrong-way arrow 10 to 30 feet in advance of the stop line. Place the second wrong-way arrow according to engineering judgment.
2. On ramps where lane-use arrows are used, place the wrong-way arrow in advance of first traffic control arrow at a spacing equal to or greater than the spacing between the lane-use arrows.
3. On multi-lane ramps, a wrong-way arrow should be placed in each lane, side-by-side.

Basic signing arrangements for wrong-way traffic control at exit ramps is addressed in **OMUTCD Sections 2B.38, 2B.41** and **Figure 2B-18**.

Traffic SCD TC-73.20 (Enhanced Wrong-Way Traffic Control for Ramps) provides details where additional wrong-way traffic control will be used. The decision on where to apply the enhanced treatments should be made based on an engineering study or engineering judgment, taking into consideration the number of documented wrong way movements, crash data, geometric design, interchange complexity, and any other factors that could potentially contribute to wrong way movements.

SCD TC-73.20 is intended to be used at select locations and is not intended to be used at all interchange ramps.

Funding for enhanced treatments and guidance on selecting appropriate location for the enhancements may be requested from the **Division of Planning's** State Highway Safety Program.

301-18 Lane-Reduction Arrows

OMUTCD Section 3B.20 and **Figures 3B-14** and **3B-24** establish standards for the design and placement of lane-reduction arrow pavement markings. For uniformity and consistency, the following additional guidelines have been established for placing the lane-reduction arrows in the lane-reduction lanes.

As shown in **OMUTCD Figures 3B-14, 3B-24** and **Traffic SCD TC-71.10**, lane-reduction arrows, when used, should be placed as follows:

1. Place the first lane-reduction arrow 100 feet in advance of the "Begin Taper Point".
2. Place the second lane-reduction arrow at $\frac{3}{4}d$ (d = advance warning sign distance).

Lane-reduction signing is addressed in **OMUTCD Section 2C-42** and **Figure 2C-8**.

301-19 Guidelines to Apply Contrast Markings (Black and White)

301-19.1 General

OMUTCD Section 3A.05 briefly discusses Contrast Markings.

Many concrete and heavily oxidized asphalt pavements are so light in color that during day time, white pavement markings appear to blend in with the pavement surface.

To improve the visibility of white lane line pavement markings on light-colored pavements, contrast pavement markings may be applied as an option.

301-19.2 Marking Materials

The following pavement marking materials may be used for contrast markings (black and white) on the concrete pavements:

1. Item 642 Traffic Paint
2. Item 645 Preformed Thermoplastic
3. Item 646 Epoxy
4. Item 647 Heat-Fused Preformed Thermoplastic

For Item 642 Traffic Paint and Item 646 Epoxy, apply the black marking material that is recommended by the manufacturers.

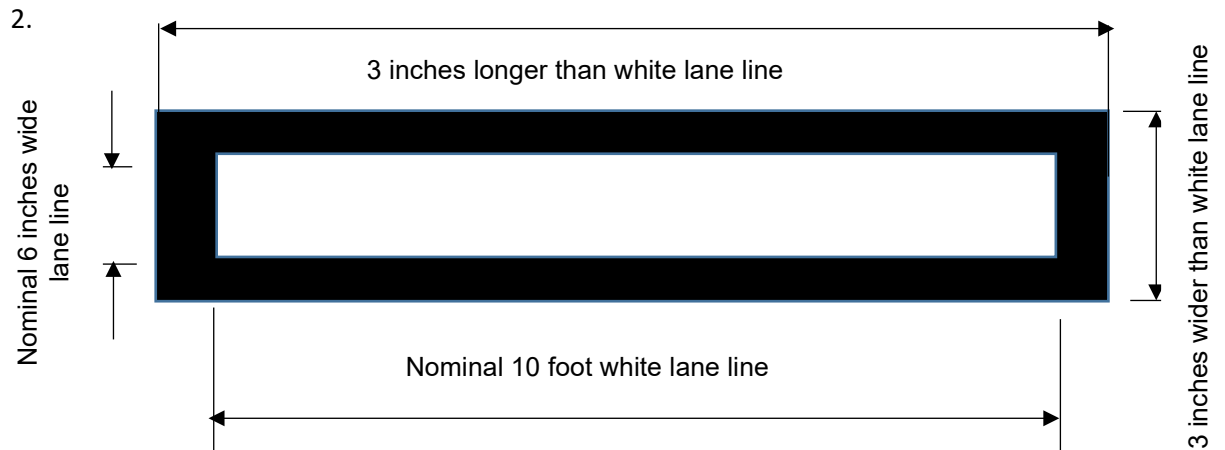
When contrast markings are applied, black is not considered a marking color, but only a contrast-enhancing system for the markings.

301-19.3 Contrast Marking Application

1. Apply white lane line markings over the top of a compatible black marking material or
2. Apply a ten foot white lane line marking and a ten foot black marking end-to-end and then provide a twenty foot gap

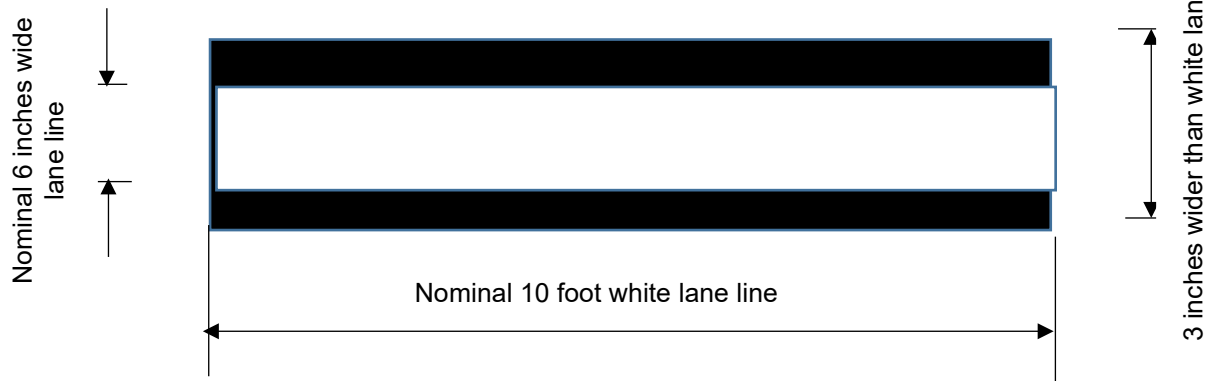
301-19.4 Contrast Marking Application Guidelines for Item 642 and 646

1. First, apply the black pavement marking on the pavement. Second apply the white pavement marking on top of the black marking after the black marking has cured according to manufacturer's recommendations. The black contrast marking and the white lane line marking shall be placed according to the following diagram:

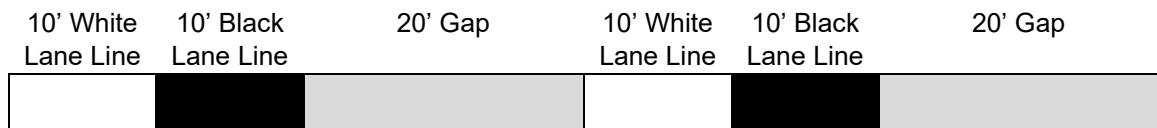


The white lane line shall be centered on the black marking such that there will be a 1.5 inch black border on either side of the white lane line. The white lane line shall be centered within the black paint area with black on both the leading and trailing edges.

3. As an alternate to the above, apply contrast marking without leading or trailing edges according to the following diagram:



1. Apply a ten-foot white lane line marking and a ten-foot black marking end-to-end and then provide a twenty-foot gap according to the following diagram:



301-19.5 Contrast Marking Application Guidelines for Item 645 and 647

Item 645 Preformed Thermoplastic and Item 647 Heat-Fused Preformed Thermoplastic contrast markings (black and white) shall be installed as recommended by the manufacturers.

301-19.6 Basis of Payment

Item 642 and 646

The quantity of black contrast pavement marking will be paid for at the contract unit price for the pay item as included in the contract.

The white intermittent or white solid markings will be paid for separately at the contract unit price for the pay item as included in the contract.

Item 645 and 647

The quantity of black and white contrast pavement marking will be paid for at the contract unit price for the pay item as included in the contract.

301-20 Guidelines to Install Bicycle Facility Markings with Heat-Fused Preformed Thermoplastic Pavement Marking Material (Item 647)

301-20.1 General

OMUTCD Section 9C.03 discusses Shared-Use Path markings.

OMUTCD Section 9C.04 discusses Bicycle Lane markings.

OMUTCD Section 9C.07 discusses Shared Lane markings.

301-20.2 Marking Materials

Approved materials for Heat-Fused Preformed Thermoplastic Pavement Marking can be found on the ODOT Approved List.

In CMS Item 647, Heat-Fused Preformed Thermoplastic Pavement Marking, the following type of marking materials are available:

Pre-heated Tape

Type A90 (90 mil thickness)

Type A125 (125 mil thickness)

Post-heated Tape

Type B90 (90 mil thickness)

Type B125 (125 mil thickness)

301-20.3 Marking Material Selection

When the bicycle facility markings are installed with Heat-Fused Preformed Thermoplastic Marking material (Item 647), the tape thickness (90 mil vs 125 mil) should be specified in accordance with the following guidelines:

1. Shared-Use Path Markings

Marking Item	Item 647 Material Thickness
Auxiliary Symbol Markings	90 mil thick
Long Line Markings	90 mil thick

2. Bicycle Lane Markings

Marking Item	Item 647 Material Thickness
Auxiliary Symbol Markings	90 mil thick
Long Line Markings	125 mil thick

3. Shared Lane Markings

Marking Item	Item 647 Material Thickness
Auxiliary Symbol Markings	125 mil thick
Long Line Markings	125 mil thick

301-21 Recessed Wet Reflective (R-WR) Pavement Markings**301-21.1 General**

Numerous studies have shown that recessed markings last longer and wet reflective (WR) markings improve safety. There are large glass beads or ceramic elements collectively called "Wet Reflective Optics" that provide this WR performance. Plowing operations impact the performance of any bead or optic. To protect the WR Optics and extend the life of the pavement marking, the WR markings should be placed in grooves to recess them below the pavement surface. The cost to add WR Optics and grooving to pavement markings is significant. However, the expected benefits of reduced crashes, especially on interstate and multilane highways, outweigh the anticipated costs making R-WR markings an effective safety treatment.

301-21.2 Implementation

All resurfacing and reconstruction projects on ODOT-maintained interstate and multilane highways should receive R-WR markings as their eventual final permanent long line pavement markings as defined in the C&MS 641.08 (e.g., edge line, lane line, center line, and channelizing lines over 200 feet). This includes the corresponding entrance and exit ramps. Cities and other jurisdictions are not required to implement R-WR markings. For information on wet reflective work zone pavement markings see 605-11.11.1.

Timing of when each project gets the R-WR marking is dependent on the completion date of the project. It is recommended not to include the R-WR marking in the resurfacing/reconstruction plan itself if it has a late summer or fall completion date. Rather, those projects should include a lower cost standard marking (not R-WR) that will last through the winter and until the District Wide R-WR Pavement Marking plan installs the permanent R-WR markings.

For R-WR marking determination, a multilane highway is considered a highway with more than one lane moving in the same direction and has a basic cross-section comprised of two or more through lanes in one or both directions. It includes divided and undivided highways with at-grade intersections. It does not include intersections that widen to multi-lane approaches and does not include three lane highways with a center dual left turn lane.

If most of the route is an ODOT-maintained interstate or multilane highway but happens to cross through a small portion of one or more jurisdictions, then the entire length of the route should receive R-WR markings. Unless otherwise specified by the jurisdiction in question, do not change from R-WR markings to standard markings going through the other jurisdictions.

On local let projects that include ODOT-maintained interstates or multilane highways, if the majority of the interstate or multilane highway is maintained by ODOT then the entire contiguous interstate or multilane highway in the plans should receive R-WR markings.

301-21.3 Pavement Maintenance Surfaces

With the grooving depth only a maximum of 150 mils (0.15") deep, it is expected that grooving on pavement maintenance surfaces such as Item 421 Microsurfacing, Item 422 Chip Seal, Item 424 Fine Graded Polymer AC (i.e., Smoothseal), and Supplement Specification 860 Thinlay Asphalt Concrete on interstates and multilane highways should not be an issue and therefore the R-WR pavement marking should be applied.

Grooving is not intended for bridge deck epoxy overlays.

301-21.4 Bridges

R-WR markings will also be applied to bridges if they are included in resurfacing or reconstruction projects on interstates and multilane highways. Separate bridge rehabilitation projects are not required to include R-WR markings.

Supplemental Specification 850 describes the limitations of the groove placement on bridge decks. Grooving is not intended for bridge deck epoxy overlays.

Binders that traditionally adhere better to concrete (e.g., epoxy, etc.) should be used. Preformed pavement markings with wet reflective qualities are also available and listed on the Qualified Product List (QPL) and could be used.

301-21.5 Grooving

Supplemental Specification 850 (SS850) describes the requirements for grooving operations.

When grooving for center line markings, a separate groove should be installed for each 4" line comprising the center line. For example, a double yellow center line will have two 5" grooves to accommodate the two 4" lines. Each groove will be paid for separately.

301-21.6 Lifecycle

By recessing the WR markings in a groove it is estimated that the life span of the pavement marking will increase 2 to 4 years depending on the binder type.

Initial installation of R-WR markings will occur on new pavement surfaces where the expected life of the pavement will exceed the expected life of the marking. As the original R-WR pavement marking wears down and it becomes necessary to reapply the marking, a binder type with a projected lifespan close to the remaining life of the pavement should be used. A WR optic should be used in whichever binder type is selected as the restriping material.

302 RAISED PAVEMENT MARKERS**302-1 General**

Raised Pavement Markers (RPMs) are a special form of pavement markings described in **OMUTCD Sections 3B.11 through 3B.14**. Plowable RPMs were developed for use in states that typically have to deal with snow. **C&MS Item 621** and **C&MS 721** establish the specifications for RPMs and **Supplement 1062** addresses testing procedures. Information about the proper installation of RPM castings and reflectors, and inspection guidelines are provided in **Chapters 350 and 360**, respectively.

As noted in **OMUTCD Sections 3B.12 through 3B.14**, RPMs may be used as positioning guides, or to supplement or substitute for the standard pavement markings. **ODOT's** RPM program basically uses them as positioning guides.

Temporary raised pavement markers are addressed in **Section 605-11.12** and **Traffic SCD MT-99.30. Supplement 1056** specifies the Prequalification Procedure for Work Zone Raised Pavement Markers.

302-2 Guidelines and Placement Standards

RPMs should be used on **ODOT**-maintained highways. They should be included in new construction and resurfacing projects on **ODOT**-maintained highways. They may also be included in the plans at other locations.

Traffic SCDs TC-65.10 and 65.11 detail the placement standards and guidelines for RPMs used with center lines, lane lines, edge lines and channelizing lines in general. Various specific typical situations, such as one-lane bridges, stop approaches, curves, two-way left-turn lanes and intersections are also addressed in these **SCDs**.

Except for edge lines on one-lane bridges (**see SCD TC-65.11**), RPMs shall not be installed on bridges less than 400 feet in length on tangent alignments. For bridges longer than 400 feet in length on tangent alignments, RPMs shall be installed at twice the normal spacing. For any length bridge in a curve, RPMs shall be installed at the normal spacing.

Each **District** should periodically inspect their RPMs to determine if nighttime retroreflectivity is still adequate. Reflectors that are cracked, abraded, missing or have marginal optical performance should be scheduled for maintenance. Cracked or loose castings should be removed and replaced as soon as practicable. Systematic replacement of RPM reflectors should be scheduled on a two to four year cycle. A statewide average reflector maintenance rate of 33 percent per year is expected.

302-3 Administrative Responsibilities

Responsibilities for this program are as follows:

1. The **Office of Roadway Engineering (ORE)** shall:
 - a. Develop specifications and standards;
 - b. Evaluate new RPM materials; determine the method of RPM installation, maintenance and replacement;
 - c. Administer the term purchase contract for RPM materials; and
 - d. Conduct Quality Assurance Reviews (QARs) at least every two years in each **District**.
2. The **District** shall:
 - a. Carry out the RPM program in a manner to install 100 percent of the RPMs on all eligible **ODOT**-maintained highways;

- b. Replace RPMs that are removed/disturbed, for whatever reason, as soon as practicable;
- c. Maintain a roadway inventory of all RPMs; and
- d. Systematically replace RPM prismatic reflectors.

302-4 Maintenance

To be effective, RPMs must be properly maintained to keep prismatic reflectors and castings in good condition. Proper maintenance can be best accomplished by a program which emphasizes replacement of removed/disturbed RPMs as soon as practicable in conjunction with a systematic replacement of RPM reflectors on a two to four year cycle. The length of the replacement cycle would be dependent upon factors such as traffic volumes, traffic composition and environmental conditions. Most highways should have reflectors replaced on a three year cycle. A four year replacement cycle might prove to be adequate for low-volume highways; while heavily traveled freeways and expressways with high volumes of truck traffic might need reflector replacement based on a two-year cycle.

RPMs shall be removed prior to resurfacing and disposed of by the contractor.

302-5 Raised Pavement Markers in Villages

The **District** may install RPMs on state highway extensions in **Villages**, upon request by and approval of the legislative authority of a **Village**. "Request by, and approval of, the legislative authority of a **Village**" shall be in the form of **ODOT Form No. MR-689** (available on-line at <http://portal.dot.state.oh.us/Divisions/Operations/MaintAdmin/Pages/MandR.aspx>, a web page maintained by the **Office of Maintenance Administration**) and shall describe the state highway extensions covered by the Ordinance. All such maintenance ordinances (**MR-689**) shall be filed in the office of the **District Deputy Director**. The installation of RPMs upon request of a **Village** does not obligate **ODOT** to maintain them.

302-6 Narrow and One-Lane Bridges

RPMs shall be installed in accordance with **Traffic SCD TC-65.11** at narrow and one-lane bridges. The center line pavement marking shall be stopped 150 feet in advance of a one-lane bridge. **Figure 398-2** illustrates signing and markings guidelines for narrow and one-lane bridges. Additional information is also provided in **Sections 202-5, 202-14.2 and 304-5**.

302-7 Fire Hydrant Markers

OMUTCD Section 3B.11 states that blue raised pavement markers may be used to mark the position of fire hydrants.

In 1983, **FHWA** issued a memorandum on the use of blue retroreflective pavement markers to help identify fire hydrants and water supply locations. They also provided a good set of guidelines that had been developed by the **California Traffic Control Devices Committee** in consultation with fire officials. Over the years this information has been made available to local jurisdictions in response to inquiries on the topic. Copies of the information are available from the **Office of Roadway Engineering**. Generally, this is an urban issue and has been left to local jurisdictions to address as needed.

The blue pavement markers are, of course, subject to the same problems as our standard raised pavement markers (RPMs) in areas subject to snowfall. It has been noted that, if the primary concern is to attract attention quickly to a nearby hydrant, there are other methods that can be used, such as small signs, retroreflective tape or paint. For example, **District 12** has had to address the problem of identifying fire hydrants locations. The hydrants were going to be hidden by a sound barrier. Access holes were provided in the barrier wall and small signs (12 x 6 inches) were mounted on the wall above the access points to identify them, using a local numbering system.

304 DELINEATORS**304-1 General**

OMUTCD Chapter 3F establishes standards and guidelines for the design and use of delineators. Additional design and application information is provided herein, and in **Traffic SCD TC-61.10, C&MS Item 620 and C&MS 720**. Delineator reflector and flexible post color shall match that of the nearest edge line.

304-2 Delineator Types

For identification purposes, **C&MS 620.02** designates the following color of each type of delineator: Type C, rectangular white; Type D, rectangular yellow; and Type E, rectangular red.

304-3 Application Guidelines

In accordance with the provisions of **C&MS 620.02**, on **ODOT**-maintained routes, only flexible delineator posts on the [Qualified Products List](#) shall be installed for roadside delineation (see Reflector Items).

On **ODOT**-maintained freeways and expressways, delineators shall be used except as noted below.

Delineators should be used on freeway and expressway tangent sections in snowbelt areas (i.e., **District 12** and the northern portions of **Districts 3 and 4**). In other areas of the **State**, roadside delineators shall not be placed on roadway tangent sections of expressways, freeways and other multi-lane divided highways when all the following conditions are met:

1. Raised pavement markers (RPMs) are used continuously on lane lines throughout all curves and on all tangents to supplement pavement markings.
2. Where whole routes or substantial portions of routes have large sections of tangent alignment (where, if roadside delineators were not required on tangents, only short sections of curved alignment would need delineators).
3. Roadside delineators are used to lead into all curves as shown in **OMUTCD Figure 3F-1**.

Once delineators are installed, they shall be maintained. Periodic reviews shall be conducted to assure that good appearance and effectiveness are maintained.

304-4 Narrow and One-Lane Bridges

Type C (white rectangular) delineators should be erected 50 feet apart along both sides of each approach to narrow and one-lane bridges in accordance with **OMUTCD Chapter 3F** and **Traffic SCD TC-61.10. TEM Figure 398-2** illustrates the signing and markings guidelines for narrow and one-lane bridges. Additional information is also provided in **Sections 202-5, 202-14.2 and 302-6**.

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305 COLORED PAVEMENTS

The use of colored pavement as a traffic control device is addressed in **OMUTCD Chapter 3G**.

Information regarding green colored pavement for bike lanes is addressed in **Plan Note 342-5 (Section 342-5)** and **Traffic Plan Insert Sheet (PIS) 207000**.

306 BARRICADES AND CHANNELIZING DEVICES

The use of barricades and channelizing devices in Temporary Traffic Control Zones is addressed in **OMUTCD Part 6** and **Part 6** of this manual. Use of channelizing devices in other situations is addressed in **OMUTCD Chapter 3H**. We do not currently have any additional **ODOT**-specific standards related to this use of these devices.

307 BARRIER REFLECTORS**307-1 General**

Although not considered traffic control devices, barrier reflectors are used to help mark guardrail, cable barrier, and concrete barriers, including bridge parapets. Specifications for these reflectors are covered in **C&MS Item 626** and **C&MS 726**.

Once barrier reflectors are installed, they should be maintained in good condition.

307-2 Application on ODOT-Maintained Highways

Barrier reflectors shall be erected on all new or reconstructed guardrail, new or reconstructed cable barrier, new concrete barrier and new or reconditioned bridge parapets. This applies to all State and/or federally funded projects regardless of the presence of edge lines, retroreflectorized glare screens, RPMs or highway lighting.

These reflectors may be used in highlighting the curb ends of medians.

Barrier Object Markers (**Section 202-14.4**) may also be considered for use in highlighting the curb ends of medians.

307-3 Reflector Color

The color of a barrier reflector shall match that of the nearest edge line.

One-way and bi-directional barrier reflectors shall be used in accordance with the following guidelines:

BARRIER REFLECTORS COLOR & DIRECTION	One-Way Reflector		Bi-Directional Reflector	
	Left Edge	Right Edge	Left Edge	Right Edge
Two-Lane, Two-Way			NA	White/White
Interchange Ramp			Yellow/Red**	White/Red
Multilane Undivided			NA	White/White
Multilane Divided with median barrier*		White	Yellow/Yellow	
Multilane Divided without median barrier	NA	White		

- * concrete wall, guardrail or cable rail
- ** if median concrete wall is present

Barrier reflectors shall also be used on temporary traffic barriers in work zones (see **Section 605-19**). Although they are paid for under **C&MS Item 614**, these reflectors are identical to those described in **C&MS Item 626**.

Systematic replacement of barrier reflectors should be on a five-year cycle.

307-4 Reflector Types

The following six types of Barrier Reflectors are detailed in the **C&MS Item 726.01**:

1. Type 1 barrier reflector is for concrete barriers, retaining walls and bridge rails or bridge parapets.
2. Types 2 to 5 barrier reflectors are for guardrail blockouts.
3. Type 6 cable barrier reflector.

The selection of a particular guardrail blockout reflector (Types 2-5) as described in C&MS Item 726.01 is a District preference based on engineering judgement and environmental conditions.

Approved Barrier Reflectors can be found on the ODOT Qualified Product List (QPL) at the following link:

<http://www.odotonline.org/materialsmanagement/qpl.asp?specref=726.01>

310 ISLANDS

OMUTCD Chapter 3I addresses the functions, end protection and approach treatments for traffic control islands. As noted in **OMUTCD Section 1A.13, item 102**:

Island - a defined area between traffic lanes for control of vehicular movements, for toll collection, or for pedestrian refuge. Within an intersection area, a median or an outer separation is considered to be an island.

L&D Manual Volume 1 Section 300 includes additional information about medians and curbs.

Also see **Sections 301-14.4** and **307-2** for additional information about marking islands.

320 MATERIALS AND HARDWARE

320-1 General

The **Office of Materials Management** maintains the Qualified Product List (QPL) for raised pavement markers, delineators and barrier reflectors and the Approved List for pavement marking materials. The QPL and the Approved List are available on that office's web page. The list is available on-line at www.dot.state.oh.us/divisions/constructionmgt/materials/pages/default.aspx.

Specifications and testing procedures for markings materials are addressed in **Chapter 343. Section 350-2** addresses work zone performance evaluations.

C&MS information may be viewed on-line at www.odotonline.org/cmsportal/.

320-2 Patented or Proprietary Materials, Specifications or Processes

The use of patented or proprietary materials, specifications or processes is discussed in **Section 120-4**.

320-3 Purchasing Materials for Installation and Use by Local Agencies

To help encourage uniformity and provide a method whereby local agencies can buy traffic control materials and equipment using Federal funds. **Sections 120-5 and 120-6** describe processes that have been established whereby local agencies can purchase such items through **ODOT**.

320-4 Use of Type G and Type J Sheeting

Type G retroreflective sheeting (**see C&MS 730.19**) shall be used on cones and tubular markers used at night, barricades and drums, delineators, guardrail anchor assemblies, and impact attenuators. Information about guardrail anchor assemblies and impact attenuators is provided in **the L&D Manual Volume 1, Section 603**. Information about the use of Type J, ASTM D 4956 Type XI, sheeting on guardrail anchor assemblies and impact attenuators is found in **Plan Notes R-112, R-113 and R-123 (see L&D Manual Volume 1, Appendix B)**.

Type J, ASTM D 4956 Type XI retroreflective sheeting (**see C&MS 730.193**) shall be used on permanent object markers and end-of-roadway markers.

320-5 Barrier Reflectors

There is not a testing procedure for barrier reflectors; however, the following approval process has been established:

Barrier reflectors shall be purchased only from companies on the QPL maintained by the **Office of Materials Management**. The manufacturer shall submit to **ODOT** a sample of the reflector along with a catalog description showing recommended installation procedures and certified test data from an independent test laboratory. **ODOT** will evaluate these samples to determine conformance with **C&MS 726**. Reflectors meeting the specifications will be included on the QPL maintained by the **Office of Materials Management**. Poor field performance or a change in materials will be cause for removal from the prequalified list. Substitutes will not be accepted.

The QPL is available on-line at:

www.dot.state.oh.us/Divisions/ConstructionMgt/Materials/Pages/QPL.aspx).

330 PLANNING / PROGRAMMING

This Chapter has been reserved for information regarding planning/programming information related to traffic control markings.

340 DESIGN INFORMATION

340-1 General

Chapter 140 provides general background regarding design information for **ODOT** projects, including the three-stage review process typically used for traffic control plans. This Chapter provides additional design information specific to markings.

Additional plan preparation information specific to markings is provided in **Chapter 341**. Plan Notes for marking-related items are addressed in **Chapter 342**, and marking specifications and testing information are addressed in **Chapter 343**.

340-2 Stage 2 and 3 Plan Submittals

The following information has been provided here as checklists for Stage 2 and 3 plan submittals.

1. Stage 2 Plan Requirements:

- a. On most projects, markings should be shown on the same plan sheets as the signing. If a separate marking plan is determined to be necessary, the following shall apply:
 - i. Base plan drawn at a scale of 1:200 or 1:100 continuous for the entire project.
 - ii. A second base plan drawn at a minimum scale of 1:50 for all interchanged crossroads and mainline intersections, and for other critical at-grade intersections in urban areas.
 - iii. All proposed roadways and connections to existing construction shall be shown.
 - iv. On some projects, particularly in urban areas, it may be more efficient to show the entire project on one plan drawn at a scale of 1:50 or 1:20.
- b. Location of pavement edges, number of lanes, speed change lanes, transitions, raised medians and all structures. Lane widths if other than 12 feet.
- c. Directional arrows (one per lane) indicating the number of lanes.
- d. Pavement marking at merging, diverging or intersecting roadways. Show painted gores for merging and diverging roadways. Show auxiliary markings.

2. Stage 3 Plan Requirements:

- a. General Notes
- b. Estimated quantities.
- c. Special details.
- d. Delineator locations (Table).
- e. Raised Pavement Marker locations (Table).
- f. Barrier Reflector locations (Table).

341 PLAN PREPARATION / PRODUCTION**341-1 General**

The **L&D Manual Volume 3** and **TEM Chapter 140** generally describe **ODOT** plan preparation and production guidelines. Additional information is provided in this Chapter and **Chapters 340 (markings plans), 342 (Plan Notes) and 343 (Specifications)**.

341-2 Pavement Marking

In a pavement marking plan the following information should be included:

1. All markings on the main roadway, ramps, cross streets and new street intersections, where needed and the type of material to be used (see **Sections 301-2 and 320**).
2. Special details should be shown in the plans for markings not covered by typical layouts included on **Traffic SCDs TC-71.10 and TC-72.20**. These should be drawn to appropriate scale for the contractor to properly place the markings.
3. Subsummary tabulations shall be made of the various markings, as required in the **Construction and Materials Specifications (C&MS)** (i.e., **C&MS Items 642, 643, 644, 645, 646, 647 and 648**). All measurements shall be the length of the completed line, including the gaps, intersections and other sections of pavement not normally marked. Station limits and totals for each item shall be shown as follows:
 - a. Edge line (white)
 - b. Edge line (yellow)
 - c. Lane line
 - d. Dotted line, ___ inch
 - e. Center line: solid, double
 - f. Center line: broken, double
 - g. Center line: broken, single
 - h. Center line: broken and solid, double
 - i. Channelizing line
 - j. Stop line
 - k. Crosswalk line
 - l. Transverse/Diagonal line (white)
 - m. Transverse/Diagonal line (yellow)
 - n. Curb marking (white)
 - o. Curb marking (yellow)
 - p. Island marking (white)
 - q. Island marking (yellow)
 - r. Parking lot stall marking
 - s. Lane arrow
 - t. Word on pavement, ___ inch
 - u. Railroad symbol marking
 - v. School symbol marking, ___ inch
 - w. Handicap symbol marking
 - x. Chevron Markings
4. Payment for all pavement marking items in the General Summary shall be carried as **C&MS Items 642, 643, 644, 645, 646, 647 and 648** on a unit bid basis (no lump sum) as follows:

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The agreement is a standard agreement developed by the **Departments Chief Legal Counsel** that cannot be modified. This agreement must be signed and returned to this office along with the proper payment no later than 30 days from receipt of this letter.

Failure to return the signed signal agreement and payment may result in the **District** performing a traffic engineering study of the subject location which could lead to the removal of the existing traffic signal.

401-7.9 Removal of Signal / Termination of Agreement

If failure to receive payment either due to refusal or inability to pay by the private entity or inability to locate the private entity by the **District** the following options should be pursued:

Notify the private entity(s) of pending signal (or signal phase) removal by letter with copies to all property tenants 30 days in advance of any removal action.

Post SIGNAL UNDER STUDY FOR REMOVAL signs (only if complete signal is proposed for removal) for two weeks with the signal in Stop-and-Go operation. Portable Changeable Message Signs (PCMS) may also be utilized.

Place signal on flash and follow signal removal process.

401-8 Reserved for Future Use

401-9 Americans with Disabilities Act (ADA) Requirements

The **ADA** requirements are issued and regulated by the **US Justice Department**. Generally, there are four major **ADA** elements that affect traffic signal projects:

1. Curb Ramps
2. Truncated Domes (Tactile Bumps on the Curb Ramp)
3. ADA-Compliant Pushbuttons Located per OMUTCD 4E.08
4. Accessible/Audible Pedestrian Pushbuttons (Locator Tones)

See **Sections 404-3 and 440-8** for details on these requirements. Web addresses for **ADA Accessibility Guidelines** information are shown in **Table 197-1**. An additional resource to review is the **Office of Roadway Engineering's** ADA Design Resources.

401-10 Special or Off-Duty Law Enforcement Officer Operation of ODOT Traffic Signal Procedures

Before a special or off-duty law enforcement officer (LEO) can operate an **ODOT** traffic control signal, authorization shall be obtained from **ODOT**.

Applications for permission to operate an **ODOT** traffic control signal (**Form 496-14**) by a special or off-duty LEO shall be submitted to the **District Deputy Director** a minimum of 21 days prior to the event for which the permit is being requested. If it is determined that the operation is acceptable, a permit for the operation of the traffic control signal shall be issued (**Form 496-15**).

Application shall be made by the private employer hiring the special or off-duty LEO. Application by the special or off-duty LEO is unacceptable.

The operation of the traffic control signal by the special or off-duty LEO shall conform to the **Ohio**

Manual of Traffic Control Devices (OMUTCD).

Examples of events requiring a permit are church services, football or basketball games, midnight madness sales, farm science reviews and county fairs.

403 TRAFFIC CONTROL SIGNAL FEATURES AND OPERATION**403-1 General**

OMUTCD Chapter 4D presents information on the design, location and use of traffic control signals. Construction details are shown on [Traffic SCDs TC-81.11 through TC-85.22](#) as well as applicable ITS SCDs. Traffic signal equipment is specified in [C&MS Items 632 and 633](#), [C&MS 732 and 733](#), and [Supplemental Specification 809](#).

403-2 Yellow Change and Red Clearance Intervals

The vehicle change interval (or phase change interval) described in **OMUTCD Section 4D** consists of the yellow change interval and the red clearance interval. A yellow signal indication shall be displayed following every CIRCULAR GREEN or GREEN ARROW signal indication. The function of the yellow change interval (Y) is to warn traffic of an impending change in the right-of-way assignment. For **ODOT**-maintained signals, the yellow change interval should be followed by a red clearance interval (R) of sufficient duration to permit traffic to clear the intersection before conflicting traffic movements are released. The durations of the yellow change interval and the red clearance interval shall be predetermined.

Make the yellow and red clearance intervals the same for all phases that may terminate concurrently to ensure the clearance intervals end at exactly the same time for both movements.

The length of the phase change interval can be determined using the following equations:

$$Y = t + \frac{1.47V_y}{2a + 64.4g}$$

$$R = \frac{W + L}{1.47V_R} - 1$$

Y = yellow change interval (s)

R = red clearance interval (s)

t = perception/reaction time of driver (s) [typically 1s]

a = deceleration rate (ft/s²) [typically 10 ft/s²]

V_y = approach speed (mph); yellow change interval (see tables below)

V_R = approach speed (mph), all red interval (see tables below)

g = approach grade

average of approaching 400 feet using 100 ft increments (percent of grade divided by 100; negative for downgrade)

W = width of intersection (ft)

measured from the approach movement stop-line to the far side of the intersection as defined by the extension of curb line, outside edge of the farthest travel lane, or the far side of the pedestrian cross-walk *

L = length of vehicle (ft) [typically 20 ft]

* A pedestrian crossing equipped with pedestrian signals on a receiving lane should not be considered unless the nearest crossing line is 40 feet or more from the extension of the farthest edge of the farthest conflicting traffic lane. If this condition exists, the intersection width should be measured from the back/upstream edge of the approaching movement stop line to the nearest pedestrian crossing lane.

Yellow change intervals should be between three and six seconds. Red clearance intervals should be between one and six seconds. Clearance intervals should be rounded to the nearest tenth of a second. See below for guidance if the maintaining agency has a rounding preference to the nearest whole or half second.

Yellow change interval approach speeds:

Movement	Speed study available	Speed study not available
Through	85 th percentile speed	Posted speed limit + 7 mph
Left Turn	85 th percentile speed	Posted speed limit – 5 mph

Red clearance interval approach speeds:

Movement	Speed study available	Speed study not available
Through	85 th percentile speed	Posted speed limit + 7 mph
Left Turn	85 th percentile speed of vehicles executing the left turn movement	25 mph

If engineering judgement determines that the approach speeds defined above are not representative of real-world conditions, alternate speeds may be used in the yellow change and red clearance interval equations.

For opposing approaches with differing speed limits or 85th percentile speeds, use the higher speed approach to evaluate clearance intervals. Make the yellow and all red clearance intervals the same for all phases that may terminate concurrently to ensure the clearance intervals end at exactly the same time for both movements.

Modern digital traffic controllers are capable of programming values to one-tenth of a second (0.1s) for any interval; therefore, the timings for the yellow change and red clearance intervals can be calculated in tenths of a second. Using the equations to calculate the yellow change and red clearance interval durations, the resulting values should be rounded to the nearest 0.1 seconds. Values ending in 0.01 to 0.04 should be rounded down to the nearest tenth of a second whereas values ending in 0.05 to 0.09 should be rounded up to the nearest tenth of a second.

If an existing agency policy rounds these values to the nearest half-second (0.5s), then the following methodology is suggested:

- Values ending in 0.0 to 0.1 should be rounded down to the nearest whole number;
- Values ending in 0.2, 0.3, and 0.4 should be rounded up to the half-second;
- Values ending in 0.6 should be rounded down to the half-second; and
- Values ending in 0.7, 0.8, and 0.9 should be rounded up to the nearest whole number.

403-3 Flashing Operation of Traffic Control Signals

OMUTCD Sections 4D.28, 4D.29 and 4D.30 list requirements for flashing operations. When an ODOT-owned stop-and-go traffic signal is in flashing operation, red indications shall be used for all approaches. The **Office of Traffic Operations (OTO)** may approve special cases in which yellow indications can be used for major street approaches and red indications for all others.

ODOT-owned stop-and-go traffic signals shall not be placed in flash during off-peak hours.

403-4 Approach Monitoring

All **ODOT**-maintained traffic signals shall be designed to use an approach monitoring concept.

Approach monitoring makes use of the dual indication monitoring capabilities of the **NEMA** plus or

NEMA extended monitor. The approach monitoring concept will not function if the “plus” features in the monitor are disabled or not available. Intersections designed for approach monitoring permit the “plus” monitor to detect total loss of a signal color indication on an approach basis rather than a per phase basis. With approach monitoring, the loss of all green, yellow or red indications on an approach place the intersection into flash. **ODOT’s** primary intent however is to catch the red out.

To detect a “no load” signal condition, a basic signal design is necessary. The approach monitoring design requires each approach to be wired separately. Each has its own load switch and its own monitor channel. The final equipment requirement is a **NEMA** plus monitor programmed to accommodate the approach monitor design.

403-5 Traffic Law Photo Monitoring, Automated Traffic Enforcement and Surveillance Devices

Senate Bill No. 342 (130th General Assembly), effective March 23, 2015, imposed certain conditions and responsibilities on local authorities who choose to use traffic law photo monitoring devices. **Section 201-14** addresses the local authority’s duties, which include assuring that the yellow change interval exceeds by 1 second the yellow change interval determined in accordance with **Section 403-2**.

As noted in **Section 201-14**, no traffic law photo-monitoring, automated enforcement or surveillance device (including, but not limited to, red light cameras, speed cameras, license plate reader (LPRs) and electronic surveillance devices) shall be installed at any intersection or on any highway maintained by **ODOT**.

403-6 Emergency-Vehicle Preemption Control Systems

403-6.1 General

As noted in **OMUTCD Section 4D.27**, preemption systems are used to give certain vehicles control over traffic signals. These systems use devices located on an approaching vehicle to preempt the normal operation of signalized intersections. This Section provides a consistent method for funding traffic control signal preemption systems if needed.

The intent of this Section is to cover priority control which involves equipping the vehicle with a preemption emitter and equipping the signalized intersection with preemption receivers. These systems tend to use proprietary equipment, and once a local governmental agency installs the equipment, the agency is restricted to the same brand and type of preemption equipment in order to have emitters and receivers work together.

Vehicle-activated systems can use light (optics), sound or radio signals (includes GPS systems) to activate a receiver at the intersection.

The decision to install and maintain a preemption control system shall be made by the maintaining agency. The cost for the installation and maintenance of a preemption control system at existing **ODOT** signals shall be assumed by the requesting agency.

For **ODOT** or Local intersections having preemption installed, pushbuttons shall be installed at all pedestrian crossings and pedestrian recall shall be removed.

403-6.2 Procedures

Emergency Vehicle preemption control systems are the only type of priority control to be installed at any **ODOT** traffic signal. The movement of equipment or unauthorized use by a Local agency to use other vehicles (i.e.—snowplow trucks, non-emergency service vehicles) to receive priority control is strictly prohibited. Violation of this requirement may result in the disconnection or removal of the preemption equipment.

Before an Emergency Vehicle preemption control system can be installed at an **ODOT** signal, the requesting agency shall have a signed maintenance agreement with the **District** that places operations and maintenance responsibilities of the system to the Local agency, along with adhering to all requirements of the TEM, especially preventing the Yellow Trap (see **Section 403-9**) and providing a proposed phasing diagram and controller settings. Additionally, during the initial installation or any regular maintenance, an approved Permit shall be acquired by the Local agency to perform work at the traffic signal.

The use of Federal/State funds will be considered for the expansion of an Agency's existing preemption system or the replacement of preemption equipment only at project intersections as further defined below:

For new preemption system equipment, at a new signalized intersection or at a signal rebuild and the existing equipment is over 15 years old **ODOT** will participate at the normal project participation rate in the acquisition and installation of a generic preemption system, that is approved on the Traffic Authorized Product List, as determined by the lowest contract bid price. In addition to obtaining generic bids, a local governmental agency may request alternate bids if they desire a specific brand of preemption equipment and agree to pay any extra cost above the generic bid price. A Plan Note specifying three different preemption systems by manufacturer and model is equivalent to a generic bid item.

At a signal rebuild, if the existing equipment is less than 15 years old, it should be transferred to the new signal. The Local has the option to fund a replacement using Local funds.

When a municipality adds intersections to its existing preempt system, it can obtain the same type of equipment by either the use of alternate bids or, if justified, proprietary bids.

For proprietary bids to be considered justified, the existing preempt system must control an appreciable part of the municipality's intersections before it can be considered to represent the municipality's standard. As a measure of this standard, the existing system must constitute at least fifty percent of the signalized intersections of a municipality. If this test is met, a proprietary bid requested by the municipality will be given consideration. Otherwise, alternate bids may be used to limit **State** and **Federal** participation to the generic system costs.

403-6.3 Preemption Emitters

The quantity of vehicle hardware provided with the system shall be as determined by the municipality, but should not exceed four emitters for each signalized intersection which will be equipped with preemption as a part of the project. Only fire, emergency medical, police and transit vehicles are eligible to be equipped. If alternate bids are used and the desired system utilizes vehicle-mounted emitters, the cost of this hardware shall be included in the alternate bid cost for comparison to the generic bids.

403-6.4 Local Maintaining Agency Policies

As a requirement for inclusion of vehicle preemption equipment in the contract, the local governmental agency shall have policies for the use of preemption. For safety forces, the policies shall specify the types of emergency calls for which preemption may be employed and shall define any use of preemption when lights and sirens are not simultaneously employed. For transit vehicles, the policies shall define when and under what conditions the preemption may be employed.

When possible, municipalities are strongly encouraged to develop signal preemption policies which coordinate with surrounding **City**, **County** and **Township** forces. They should take into account mutual aid agreements, access to hospitals and transit where a vehicle operates

preemption plan is activated and the Preemption Clearance phase(s) are green.

7. Each controller railroad preemption plan should be capable of inhibiting Flashing Yellow Arrow operation during the Preemption Clearance interval. If a phase opposing the preemption clearance phases or phases is currently displaying flashing yellow arrow and Yellow Trap Prevent is not enabled, the flashing yellow arrow display shall continue through the preemption clearance phase(s) even though it would be inhibited had it not already been displaying a flashing yellow arrow.
8. Using the options in 4 – 8 above, when a railroad preemption plan is activated, the normal sequence shall terminate and transition to a programmed phase or phases for Preemption Clearance. The programmed values for any trailing overlap Green Extension preceding the Preemption Clearance (if used) should be timed, Yellow Change and Red Clearance shall be used during the transition. If no phases are programmed, the normal sequence shall advance to All-Red or flashing red programmable by phase and overlap. Every overlap shall be capable of being forced to red, green, flashing yellow or flashing red during the Preemption Clearance interval subject to programmed ring and barrier sequence rules.
9. A timed interval (with a minimum range of 0 – 99 seconds) shall be provided for the minimum Preemption Clearance interval. This interval shall time in its entirety if a lower priority preemption plan is activated and the current preemption plan request is terminated before transitioning to the lower priority preemption plan. This interval shall immediately terminate if a higher priority preemption plan is activated, regardless of the activation request for the current plan.
10. A per-unit Advance Pedestrian Preempt (APP) input shall be provided in addition to the 6 railroad plans; generally, this is another preempt input (e.g., Preempt 11), but may also be implemented using a dedicated controller logic input. APP may be implemented through a preemption plan. When activated, APP shall immediately terminate any active Pedestrian Walk movement currently being serviced and begin the normal Pedestrian Change interval for the phase(s). APP will also prevent (omit) any new pedestrian service from starting. Any pedestrian calls for service shall be stored, and processed APP is de-activated. Vehicle phases shall continue to time and sequence normally during APP.
11. Ability to inhibit pedestrian service per phase during each railroad preemption plan.
12. For ODOT or local intersections having preemption installed, pushbuttons shall be installed at all pedestrian crossings and pedestrian recall shall be removed.
13. In the event the controller unit is operating under manual control and any railroad preemption plan becomes active, the manual control shall be inhibited, and the railroad sequence shall govern. Once the railroad preemption is deactivated and the manual control input remains active, manual control operation shall be restored.
14. In the event the controller unit is operating in soft flash or off-duty flash and any railroad preemption plan becomes active, the flashing operation shall terminate normally and the sequence shall advance to the active railroad preemption plan.
15. Any controller unit proposed for use on an ODOT-maintained project where railroad preemption is required shall be furnished to the **ODOT** signal shop for testing prior to acceptance.

403-10.3 Cabinet Functionality

In order to properly implement railroad preemption operation, design specifications have been developed which describe both the traffic signal controller cabinet and railroad warning system interconnection (*see Section 804-4*).

403-11 Conflict Monitors

403-11.1 General

Modern conflict monitors for traffic signals incorporate many useful features in addition to their basic functions of: 1) looking for incompatible signal display conflicts; 2) monitoring 24V cabinet power supply (using two independent inputs); and 3) monitoring the Controller Watchdog signal (**Caltrans**). Prequalification procedures for conflict monitors used with 2070 controllers are addressed in **Supplement 1076**, testing of conflict monitors on construction projects is addressed in **Section 450-10**; and maintenance of this device is discussed in **Sections 460-2 and 460-3**.

Section 403-11 addresses common conflict monitor features that should be enabled by default for each channel, unless specific operating conditions for a traffic signal require them to be disabled. Slight variations of option selection methods can be expected between particular models of conflict monitors, but the most important features are discussed herein and should provide guidance for setting features on all monitors.

ODOT uses both **NEMA** and **Caltrans** traffic signal equipment. Recommended settings for conflict monitors for both **Caltrans** 2010ECL Conflict Monitor Units (CMUs) and **NEMA** TS2 Malfunction Management Units (MMUs) are addressed.

As a general rule, **ODOT**-maintained conflict monitors and MMUs shall be set in the “most restrictive” manner, meaning that as many of the available monitoring features as possible are enabled. This assures that the traffic signal operation is monitored for the greatest number of potential fault conditions. The monitor parameters **should not** just be set restrictive enough to “get the signal out of flash.” Instead, a conflict monitor should be set up in a very restrictive state as recommended below and features selectively changed only as directed by the “Engineer,” which for purposes of this Section is intended to refer to the **District** traffic engineer responsible for the design and operation of signals.

403-11.2 Settings for a (Caltrans) Model 2010ECL Conflict Monitor

The following are recommended settings for a **Caltrans** Model 2010ECL conflict monitor:

- **Red Fail** – is designed to assure that there is at least one active field input (R, Y, G) on a channel at all times. This feature puts the intersection into flash if all the field terminals on a given channel are dark when they should be lit. An obvious exception is a permissive left turn channel on a five-section head, whose channel has no red signal head. The Red Enable input to the monitor controls the Red Fail operation of all channels. **ODOT**-spec cabinets should be wired to assert the Red Enable input pin to the conflict monitor (by applying 120VAC), which enables the Red Fail feature for all channels that have not had Red Fail individually disabled by other means. In a **Caltrans** 33x cabinet, the Red Enable input is connected to the Load Switch Signal Bus. In this way, the Red Enable input signals to the CMU that the load switches are currently driving the field terminals. Red Fail is generally disabled by the monitor during flashing operation (via the EE input pin).

There is no on-board 2010ECL monitor switch or jumper setting associated with the Red Enable input to the monitor. The information in the above paragraph is for support only. This pin is generally driven by the cabinet wiring through the red enable cable, so it is essential that the red enable be installed at all times.

- **RFSSM (Red Fail per SSM) DIP Switch should be OFF** – On **Caltrans** monitors (e.g., 2010ECL), this feature is enabled/disabled on a per-channel basis by the SSM switches only if the RFSSM (“Red Fail per SSM”) DIP switch is ON. The most restrictive operation occurs when Red Fail monitoring is enabled by default on all channels. **Therefore, the RFSSM DIP switch should be OFF.** When the RFSSM switch is off, channels that do not have a load switch installed must have the corresponding Red Interface Board (RIB) channel jumper set in the “AC+” position.
- **RF (Red Fail) 2010 DIP Switch should be ON** – Timing of the Red Fail condition is affected by the “RF 2010” switch on the CMU (typically switch #1 of SW3). **The “RF 2010”**

DIP switch should be set in the ON position. This corresponds to the 2010 Standard value of 1350 ms. In the OFF position, the Red Fail time is set to the 210E Standard value of 850 ms. 1350 ms is not the most restrictive setting, but is considered appropriate for ODOT signals.

- **Red Fail Monitoring of Pedestrian Displays** – Red Fail monitoring can be used for Pedestrian displays if the Red Interface Board (RIB) jumper for that channel routes the load switch output to the monitor by placing it in the “LS” position. This is the most restrictive condition and should be used unless directed otherwise by the Engineer. The Engineer may determine that putting the entire intersection into flash from a failed Pedestrian DONT WALK display is not desirable. If it is desired NOT to monitor pedestrian displays for Red Fail, then the corresponding RIB jumper should be set to the “AC+” position.
There is no on-board 2010ECL monitor switch or jumper setting associated with this display, the information in the above paragraph is for support only.
- **G-Y-R Dual Indication** – detects the simultaneous display of more than one active field terminal on the same channel. This function is enabled and disabled on a per-channel basis in **Caltrans** monitors. There is also a related “G-Y Enable” switch (see below). The G-Y-R Dual Indication feature is enabled/disabled on a per-channel basis by the SSM DIP switches. **Therefore, unless directed otherwise by the Engineer, the SSM DIP switch should be enabled (“ON”) for all channels that display red, yellow and green**
- **G-Y Enable** – is a subset of G-Y-R Dual Indication Monitoring applies only to channels for which red monitoring has been disabled. It ignores R-Y and R-G duals. The paragraph above requires the use of per-channel G-Y-R monitoring on any channel that contains a red display, so the state of the G-Y Enable DIP switch is irrelevant in those cases. However, for a channel without a red display (e.g., permissive left turn on a five-section head), having G-Y Enable set causes the monitor to check for G-Y duals while ignoring the red. This is the most restrictive operation. Therefore, it is recommended that G-Y enable be set for all monitors. **Unless directed otherwise by the Engineer, the G-Y Enable DIP switch should be set to the “ON” position.**
- **Short Yellow (Clearance)** – times each channel’s yellow change interval to assure it is displayed for a certain minimum time (nominal 3 seconds). The **OMUTCD** sets an absolute minimum of 3.0 seconds for yellow change intervals on vehicle signals. Pedestrian signals have no yellow display, so this function is typically disabled for pedestrian signal channels only. **Caltrans** conflict monitors use programming cards that allow per-channel disabling of the short yellow function. On **Caltrans** monitors (e.g., 2010ECL), the short yellow feature is enabled/disabled on a per-channel basis by the SSM switches, as well as by the jumpers on the Programming Card. **Therefore, unless directed otherwise by the Engineer, the SSM DIP switch should be enabled (“ON”) for all vehicle and pedestrian channels. The preferred method for disabling short yellow monitoring on pedestrian channels is to have the programming card YELLOW DISABLE jumpers installed.**
- **Watchdog Monitoring** – looks for a signal from the Controller Unit that indicates to the monitor that the controller is operating. This is a logic-level signal that turns on and off at a 100-ms rate, generated by an interrupt service routine in the signal controller software. If the controller has a “computer glitch” that causes a malfunction, it is very likely that this routine would not be executed consistently, and the watchdog signal sensed by the monitor would stop changing state properly. For example, the controller could “hang” in a particular phase display and never advance, and as long as no conflicts were present, the monitor would not trip. Thus, the signal would remain in a sort of “stop time” state until a trouble call was reported and addressed. The resulting running of reds by motorists is considered to be more dangerous than going into monitor flash; therefore, it is required that watchdog monitoring be enabled to put the signal into flash any time the controller watchdog signal is not valid. On **Caltrans** monitors (e.g., 2010ECL), watchdog monitoring is a basic feature that can be enabled/disabled by a switch (called “WDT Enable”) on the monitor printed circuit board. **The Watchdog (WD) Enable Toggle Switch should be in the “WD**

ENABLE” position.

- **Watchdog Latch Select** – is available on **Caltrans** monitors only (2010ECL). It is a jumper that selects whether a power-restore after AC brownout will latch or not latch the controller Watchdog Fault (WDT) that sometimes occurs during a brownout condition. A latching WDT fault would hold the intersection in flash until the monitor is manually reset, and this is the most restrictive condition. If the WDT LATCH jumper (SEL1) is installed, this fault is latched. **Therefore, unless directed otherwise by the Engineer, the WDT LATCH Jumper (SEL1) should be installed.**
- **Recurrent Pulse** – is a proprietary feature of **EDI** brand monitors. It is basically an integrator that adds up the width of a series of very short fault pulses on a given channel. These pulses are too short to individually cause a fault using **Caltrans** or **NEMA** specified timing thresholds, but taken collectively can represent an equipment problem or a display fault. The Recurrent Pulse (RP) feature can be disabled by DIP switches labeled “RP DISABLE.” Having Recurrent Pulse monitoring enabled is the more restrictive condition, so it should not be disabled. **Unless directed otherwise by the Engineer, the RP DISABLE DIP switch should be in the OFF position.**
- **LED-Specific Voltage Threshold Levels** – is a feature that sets voltage thresholds differently than the **Caltrans** (TEES) and **NEMA** (TS1, TS2) specifications. These revised thresholds match closely the **ITE** requirements for LED traffic signals, and at the same time are quite suitable for incandescent lamps as well. **ODOT** only uses LED signals; therefore, this feature should be enabled on all conflict monitors. On **EDI** brand 2010ECL monitors a DIP switch on the monitor board has a position labeled “LEDGuard.” **Unless directed otherwise by the Engineer, the LEDGuard internal DIP switch should be set to the ON position.**
- **Minimum Flash Time** – is a setting for the minimum amount of time the conflict monitor will hold in a flashing state after an AC power up. This should not be set too short for two main reasons: 1) to give the controller and other slow-booting devices time to safely begin their operation; and 2) to give a period of flashing operation for drivers using a previously dark signal to become aware that the signal is now powered and may begin stop-and-go operation soon. **ODOT** recommends that the longest available minimum flash time be used, up to a value of about 16 seconds. In **Caltrans** spec monitors (e.g., 2010ECL), there is no default minimum flash time, but a minimum flash time jumper (SEL2) is available to assure that the flash time is a minimum of 6 to 10 seconds. **Unless directed otherwise by the Engineer, the Minimum Flash Time select jumper (SEL2) should be installed.**
- **Configuration Change Fault Select** – is available on **Caltrans** monitors only (2010ECL). The jumper (SEL3) determines whether a detected change in the programming card configuration will cause the cabinet to enter a fault condition (flash) or to continue in stop-and-go operation while logging the Configuration Change Fault. Given the importance of programming card information, **ODOT** recommends that any change in the card detected by the monitor should immediately be brought to the attention of the maintaining agency. This is done by causing the intersection to enter a monitor fault flashing condition. **Therefore, unless directed otherwise by the Engineer, the Configuration Change Fault Select Jumper (SEL3) should be installed.**
- **Red Interface Cable Fault Select** – is available on **Caltrans** monitors only (2010ECL). It determines whether or not the monitor will trip if the Red Enable Cable is not installed, after the cabinet door is closed. Note that **ODOT**-spec **Caltrans** cabinets are wired such that the monitor output relay is bypassed when the door is open, allowing the signal to continue stop-and-go operation without the monitor installed. If the monitor is not installed when the door is shut, the intersection will go into flash. Given the importance of the Red Interface Cable, it is recommended that the monitor be set to trip into flash if the door is shut without the cable installed. **Therefore, unless directed otherwise by the Engineer, the Red Interface Cable Fault Select Jumper (SEL4) should be installed.**

- **AC Brownout Select** – is available on **Caltrans** monitors only (2010ECL). It selects between two brownout dropout voltage levels. The more restrictive brownout voltage settings occur when the jumper SEL5 is installed. **Therefore, unless directed otherwise by the Engineer, the AC Brownout Select jumper (SEL5) should be installed**
- **EE Input Polarity Select** – selects the polarity of the EE input to the monitor that corresponds to a flashing condition in the cabinet. For standard **Caltrans** cabinet operation (Flash Transfer Relays and MC energized during flash), this jumper should be left in the open position. **ODOT-spec Caltrans** cabinets operate in this manner; therefore, **the EE Input Polarity Select jumper (SEL9) should be open.**
- **Watchdog Timing Option** – changes the default timing the monitor uses to sense a watchdog fault. This is selectable between 1.0 and 1.5 seconds, via OPTIONS switch SW3. In **ODOT's** experience, the setting of this parameter is not critical, but occasionally the setting of 1.5 seconds may be required for certain controllers. The more conservative option is to select the 1.0 second timing parameter. **Therefore, the OPTIONS DIP switch SW3, labeled "WD 1.0 SEC" should be set to the ON position by default.**
- **Special Function #1 Polarity** – should be left in its factory-default position of OFF. Special Function #1 is an input to the monitor that is very rarely used. **Therefore, SF#1 POLARITY DIP switch should be set to the OFF position.**
- **SEL6–SEL16 Jumpers.** SELECT JUMPER PROGRAMMING – The Signal Monitor also provides jumper options to modify the monitor operation. The select jumpers are labeled SEL1 through SEL16. **SEL6 through SEL16 are reserved for EDI configuration programming and should not be modified except by the factory.**

The following list summarizes the recommended settings as described in this Section. Every 2010ECL (and similar models such as 2010KCL, 2018ECL, etc.) should be set in a similar manner. FYA switches are only used when Flashing Yellow Arrow operation is required.

OPTION DIP SWITCHES:

RF 2010	ON
RP DISABLE	OFF
WD 1.0 SEC	ON
GY ENABLE	ON
SF#1 POLARITY	OFF
LEDguard	ON
RF SSM	OFF

FYA DIP SWITCHES:

FYA COMPACT	OFF
FYA1-9	OFF
FYA3-10	OFF
FYA5-11	OFF
FYA7-12	OFF

SSM DIP SWITCHES:

ALL CHANNELS	ON
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SEL JUMPERS:

SEL1	INSTALLED
SEL2	INSTALLED
SEL3	INSTALLED
SEL4	NOT INSTALLED
SEL5	INSTALLED
SEL6-16	AS DELIVERED FROM FACTORY

WD ENABLE TOGGLE SWITCH: ON

YELLOW DISABLE (ON PROGRAMMING CARD):

CH13	INSTALLED IF PEDESTRIAN DISPLAY USED
CH14	INSTALLED IF PEDESTRIAN DISPLAY USED
CH15	INSTALLED IF PEDESTRIAN DISPLAY USED
CH16	INSTALLED IF PEDESTRIAN DISPLAY USED

403-11.3 Settings for a NEMA Malfunction Management Unit (MMU)

The following are recommended settings for **Caltrans** Model 2010ECL conflict monitors:

- **Red Fail** – is designed to assure that there is at least one active field input (R, Y, G) on a channel at all times. This feature will put the intersection into flash if all the field terminals on a given channel appear inactive when they should be active. An obvious exception is permissive left turn channel on a five-section head, whose channel has no red signal head. The Red Enable input to the monitor controls the Red Fail operation of all channels. **ODOT**-spec cabinets should be wired to assert (by applying 120VAC) the Red Enable input pin to the MMU, which enables the Red Fail feature by for all channels that have not had Red Fail individually disabled by other means. In a **NEMA** cabinet, the Red Enable input is connected to the coil of the Main Contactor and is intended to signal to the monitor that the load switches are currently driving the field terminals. On **NEMA** Malfunction Management Units, Red Fail monitoring is enabled for all channels when Red Enable is active. Red Fail monitoring shall be used for Pedestrian displays. This is the most restrictive condition and should be used unless directed otherwise by the Engineer. If it is desired NOT to monitor Pedestrian displays for Red Fail, then individual per-channel Red Fail disables are available on most MMUs to do so. Some MMUs allow per-channel enable/disable of Red Fail through front panel menus and/or software interface to a laptop computer; however, **unless directed otherwise by the Engineer, per-channel disabling of Red Fail (if available) should not be done. Instead, any unused red inputs should be connected to AC+ using spade lug jumpers in the load switch slot, and the corresponding Field Check/Dual Enable switch should be disabled.**
- **Field Check Monitoring** – Field Check monitoring is used in TS2 Type 1 cabinets and ensures that the field signal states sensed by the MMU at the field terminals match the output state set by the Controller Unit. When any field signal state (R, Y or G) does not match the output state of the Controller Unit **and** the MMU is not in the Fault mode, then a cabinet hardware, or field hardware, failure has occurred. When all the field signal states (R, Y or G) do match the output state of the Controller Unit **and** the MMU is in the fault mode, then the Controller Unit has caused the fault (CU programming), or the MMU programming is not compatible with CU or cabinet configuration. **For channels that display red, yellow and green, unless directed otherwise by the Engineer, Field Check Monitoring should not be disabled. On channels which do not display a red, the Field Check/Dual Enable Switch should be disabled.**
- **G-Y-R Dual Indication** – On **NEMA** Malfunction Management Units, dual indication is enabled/disabled on a per-channel basis. On some models, this is done using the front panel FIELD CHECK/DUAL ENABLE DIP switches. On other models, the front panel menu and/or laptop interface is used. Note that on models with hardware switches, each switch affects both Dual Enable and Field Check functions. (See above paragraph on Field Check monitoring for more information.) **Therefore, unless directed otherwise by the Engineer, the FIELD CHECK/DUAL ENABLE function should be enabled (“ON”) for all channels that display red, yellow and green.**
- **G-Y Dual Indication** – Applies to any channel for which G-Y-R Dual Indication monitoring has been disabled, such as Pedestrian display channels. **The G-Y Enable DIP switch should be set to the “ON” position. If this DIP switch is not present, each channel should be programmed by front panel or software for G-Y dual indication monitoring.**
- **Clearance (Short or Skipped Yellow)** – Clearance monitoring times each channel’s yellow change interval to ensure that it is displayed for the minimum time of 3.0 seconds on vehicle

signals, as required by **OMUTCD**. Pedestrian channels have no yellow, so it is common to disable this feature. On **NEMA** Malfunction Management Units short yellow monitoring is disabled on a per-channel basis using the Minimum Yellow Change Disable (MYCD) jumpers on the programming card. **MYCD jumpers on the Programming Card should not be installed except for Pedestrian channels or if directed by the Engineer.**

- **Controller Voltage Monitoring (CVM)** – On **NEMA** Malfunction Management Units the steady-state CVM signal (see below) has a similar function to the oscillating controller watchdog signal specified by **Caltrans**. There is no way to disable the CVM feature, although some monitor options exist that affect how a CVM fault is handled when it occurs (see CVM Latch Enable and CVM Log Disable below).
- **CVM Latch Enable** – is available on **NEMA** MMUs only (e.g., MMU-16E, MMU-16LE, MMU-1600). Recall that the CVM input to the monitor originates in the controller. If the controller is operating normally, this pin is asserted by being driven to 0VDC. If the controller is shut down or has some other malfunction, this monitor input will be pulled high (nominally 24VDC) and a CVM fault will occur. For example, at startup the controller will not assert its CVM output until all phase outputs are being actively driven. Like most monitor faults, CVM will latch the intersection into the fault state (flashing) until the Reset button is pushed. However, some CVM faults can be self-recovering, so the option exists to select between latching and non-latching operation. This is done using a jumper on the programming card. Enabling CVM latch is generally regarded as the more conservative option; therefore, **unless directed otherwise by the Engineer, the CVM Latch Enable jumper should be installed.**
- **CVM Log Disabling** – is a feature on **EDI** brand MMUs. It is generally used only when the signal is designed to go repeatedly into a programmed flash (such as nighttime flashing). As mentioned above, CVM can be thought of as a sort of DC-level controller watchdog circuit. If the controller is shut down or has some other malfunction, this monitor input will be pulled high (nominally 24VDC) and a CVM fault will occur. A controller can execute a nightly programmed flash by de-asserting its CVM output at the appointed hour and re-asserting it when returning to stop-and-go operation. By setting the “CVM LOG DISABLE” DIP switch to ON, logging of all CVM fault events is disabled. Very few **ODOT** signals operate by scheduled program flash. Also, disabling logging of CVM faults can impair troubleshooting of controller problems for signals that do not use scheduled flash operation. **Therefore, unless directed otherwise by the Engineer, the “CVM LOG DISABLE” DIP switch should be set to the OFF position.**
- **External Watchdog** – Although no controller watchdog feature is used in **NEMA** cabinets, **NEMA** MMUs do have available an **external** watchdog monitoring input called “External Watchdog” that can be enabled/disabled by a front panel DIP switch. It can be used to monitor a critical external device other than the controller (e.g., a modem, master controller, etc.). Note that external watchdog failure state will put the monitor into a Fault condition (intersection in monitor Flash). **Therefore, EXTERNAL WATCHDOG DIP switch should not be enabled unless: 1) connected to a critical device; and 2) directed by the Engineer.**
- **Recurrent Pulse** – is a proprietary feature of **EDI** brand monitors. It is basically an integrator that adds up the timing of a series of very short fault pulses on a given channel. These pulses are too short to individually cause a fault using **NEMA** specified timing thresholds, but taken collectively can represent an equipment problem or a display fault. The Repetitive Pulse feature can be enabled/disabled by a front panel DIP switch. **Unless directed otherwise by the Engineer, the RP DISABLE DIP switch should be in the OFF position.**
- **LED Voltage Threshold Option** – On **EDI** brand MMUs, a DIP switch on the front panel has a position labeled “LEDGuard.” On **Reno** brand MMUs, a DIP switch on the front panel has a position labeled “LED THRESHOLDS.” **The LEDGuard front panel DIP switch on EDI MMUs should be set to the ON position unless directed by the Engineer. Unless directed otherwise by the Engineer, the LED THRESHOLDS front panel DIP switch on Reno MMUs should be set to the ON position.**

- **24V Latch Enable** – is a selectable option only on some **NEMA** conflict monitors and all MMUs. **NEMA** TS2 requires the MMU programming card to have a jumper labeled “24V LATCH ENABLE.” When a jumper is soldered into this position, any fault on either of the two 24V cabinet power supply inputs will cause a latching fault that must be reset by an assertion of the RESET button. If the jumper is not in place, then the CVM fault is non-latching. Enabling 24V latch is generally regarded as the more conservative option; therefore, **the 24V Latch Enable jumper should be installed on the Programming Card unless directed by the Engineer.**
- **Minimum Flash Time** – is a setting for the minimum amount of time the conflict monitor will hold in a flashing state after an AC power up. This should not be set too short for two main reasons: 1) to give the controller and other slow-booting devices time to safely begin their operation; and 2) to give a period of flashing operation for drivers using a previously-dark signal to become aware that the signal is now powered and may begin stop-and-go operation soon. The longest available minimum flash time should be used, up to a value of about 16 seconds. On **NEMA** MMUs, the Minimum Flash Time is typically set on the Programming Card using four available jumpers that select a range of 6 to 16 seconds. **Unless directed otherwise by the Engineer, all four programming jumpers for Minimum Flash Time should be installed on the Programming Card, to give a flash time of 16 seconds.**

403-12 Centrally Controlled Arterial Traffic Signal System

403-12.1 Engineering Background

Note that controllers and interconnect may have to be updated to be compatible with the proposed Centrally Controlled Arterial Traffic Signal System..

403-12.2 Guidelines and Review

Any proposed state or federally-funded Centrally Controlled Arterial Traffic Signal System installation must be reviewed and approved by the Administrator of the Office of Traffic Operations (OTO).

The request must come from the Local maintaining agency while in the Project Development Process (PDP). If approved, submit a Systems Engineering Review Form (SERF) or Systems Engineering Analysis (SEA) through the MPO/District for any project with state or federal funds. Additionally, once approved, it will be added to the Statewide ITS Architecture.

The following criteria should be met currently or after completion of the proposed project for a Central Signal System Control Station to be approved:

- a. A minimum of fifty (50) signalized intersections as an individual jurisdiction, or achieved through a partnership with adjacent jurisdiction(s)
- b. 50% or greater signalized intersections with functioning interconnection
- c. All interconnected controllers shall be compatible with the proposed Centrally Controlled Arterial Traffic Signal System.
- d. Dedicated engineering and/or traffic signal operations staff (internal or external)

Any proposed **ODOT** or federally-funded Centrally Controlled Arterial Traffic Signal System installation must be reviewed and approved by the Office of Traffic Operations (OTO).

403-12.3 Required Documentation

Required information to be sent to OTO for review and approval may include:

- a. Intersection list
 1. Controller make, model, and firmware version at each intersection
 2. Connectivity to ODOT corridor or Interstate
- b. Means of interconnect per intersection

1. Ability to maintain communications—fiber, modems, high-speed radios (internal or external)
 - a. Copy of active contract between Local and contractor (if external)
- c. Names and qualifications of dedicated staff responsible for daily operations
 1. Copy of active contract between Local and Consultant (if using external)

403-12.4 Construction

Contractor responsibility and materials requirements of the system shall meet one of the Signal Equipment options noted in 809.10 and 909.13. One of the following items shall be used:

- a. 809E66000 Closed Loop Arterial Traffic Signal System
- b. 809E66010 Centrally Controlled Arterial Traffic Signal System
- c. 809E66020 Highway Rail/Traffic Signal Pre-emption
- d. 809E66030 Traffic Signal System with Emergency Vehicle Pre-emption
- e. 809E66040 Traffic Signal System with Transit Priority
- f. 809E66050 Adaptive Traffic Signal Control System

Additionally, item 809 Training is an optional item that can be added to the plans for additional training for an ITS device.

403-13 Traffic Signal System with Transit Priority

Item 809 Transit priority is the act of modifying traffic signal phasing or timing to accommodate transit vehicles. Transit priority may be achieved through passive or active strategies.

1. Passive priority. Passive priority involves closed loop systems or centrally controlled signal systems designed to improve traffic flow and progression for all vehicles along routes and direction with significant transit use.
2. Active priority. Active priority involves the detection of transit and subsequent change in normal traffic signal operation to give signal priority to the transit vehicle. This can include giving an early green indication or holding green time for the desired direction of transit movement, whether a through or turning movement.

An active priority system should consider detection of transit vehicles, prediction of transit arrival times based on schedules or signal system information, and volumes of other traffic at the signalized intersection and within the traffic signal system.

One simplified method of active priority is to only give transit priority if a transit vehicle is running late.

Transit priority benefits can be improved with geometric conditions such as dedicated transit lanes and far-side transit stops.

Transit priority may increase delay for all other vehicles within the transit priority system include vehicles traveling in the same direction as well as cross street traffic. If transit priority in more than one direction at the same time may result in less effective priority systems without a high degree of planning and analysis.

System planning, required hardware, and communication systems must be coordinated with the roadway maintaining agency and the transit agency

404 PEDESTRIAN CONTROL FEATURES**404-1 General**

Pedestrian signal indications (see **OMUTCD Figure 4E-1**) are special types of traffic signal indications intended for the exclusive purpose of controlling pedestrian traffic. Pedestrian signals are discussed in **OMUTCD Chapter 4E** and **4F**. Construction mounting details are shown on **Traffic SCD TC-85.10**, and pedestrian signal equipment is specified in **C&MS Item 632** and **C&MS 732**.

404-2 Pushbuttons

OMUTCD Section 4E.08 addresses pedestrian detection, usually accomplished using pushbuttons.

On actuated signal phases, if there is a reasonable expectation of pedestrian use, the phase shall be equipped with accessible pedestrian pushbuttons (see **Section 404-3**) to provide access to all corners of the intersection with sufficient time to safely cross the highway; and countdown pedestrian heads, marked crosswalks, applicable signs and ADA ramps shall be provided.

This is especially important on side-street phases where the signal green time is usually based on a short initial green interval with the green time extended by signal actuations. The initial green interval is usually not long enough to allow a pedestrian to cross the mainline. The accessible pedestrian pushbutton will initiate a guaranteed crossing time without input from vehicular traffic. The accessible pushbutton will also provide the pedestrian with a means to cross the mainline when there is no side-street traffic to initiate the signal phase for the pedestrian crossing.

See Curb Ramp requirements in **Section 404-8**. If accessible pushbuttons are provided, countdown pedestrian signal heads and marked crosswalks shall be required. Additionally, they shall be compliant with all **PROWAG** and **OMUTCD 4E.08-4E.13** requirements including, but not limited to: curb cuts/ramps and slopes, crosswalk markings, countdown pedestrian signal heads, pushbutton access, and pushbutton installation locations. When accessible pushbuttons are provided, they should allow pedestrians to reach all corners of the intersection. Designers should be aware of this requirement and consider the possible future location of crosswalks when locating stop lines and stop line detectors at signals that do not presently include pedestrian facilities.

404-3 Accessible Pedestrian Signals and Locator Tones

As noted in **Section 401-9**, use of accessible pedestrian signals and locator tones are major **ADA** elements that affect traffic signals. Accessible Pedestrian Signals supplement visual WALK indications and are designed to aid visually impaired pedestrians; and Locator Tones enable pedestrians who have visual disabilities to locate the pushbutton.

All requirements of **OMTUCD 4E.08-4E.13** shall be met when installed. The installation of Accessible Pedestrian Signals and/or Locator Tones shall be required at **ODOT**-maintained traffic signals when a new signalized intersection is being built or an existing traffic signal is being rebuilt, which work includes, but is not limited to, new supports, curb ramps, pedestals, or pedestrian equipment upgrades.

To retrofit an existing crossing with Accessible Pedestrian Accomodation, an engineering study which considers the factors specified in **OMUTCD Sections 4E.09** and **4E.10** shall be conducted and the following minimum conditions are met:

1. The proposed intersection must be signalized.
2. The audible devices should be retrofittable to the existing traffic signal hardware.

3. The signalized intersection should be equipped with pedestrian pushbuttons.
4. The selected crosswalk must be suitable for the installation of Accessible Pedestrian Signals and/or Locator Tones, in terms of surrounding land use and traffic patterns.
5. There must be a demonstrated need for the audible devices in the form of a request from an individual or a group that would use the audible signal.
6. The individual or group requesting the device should agree to train the visually impaired users in the use of the Accessible Pedestrian Signals and/or Locator Tones, as appropriate.

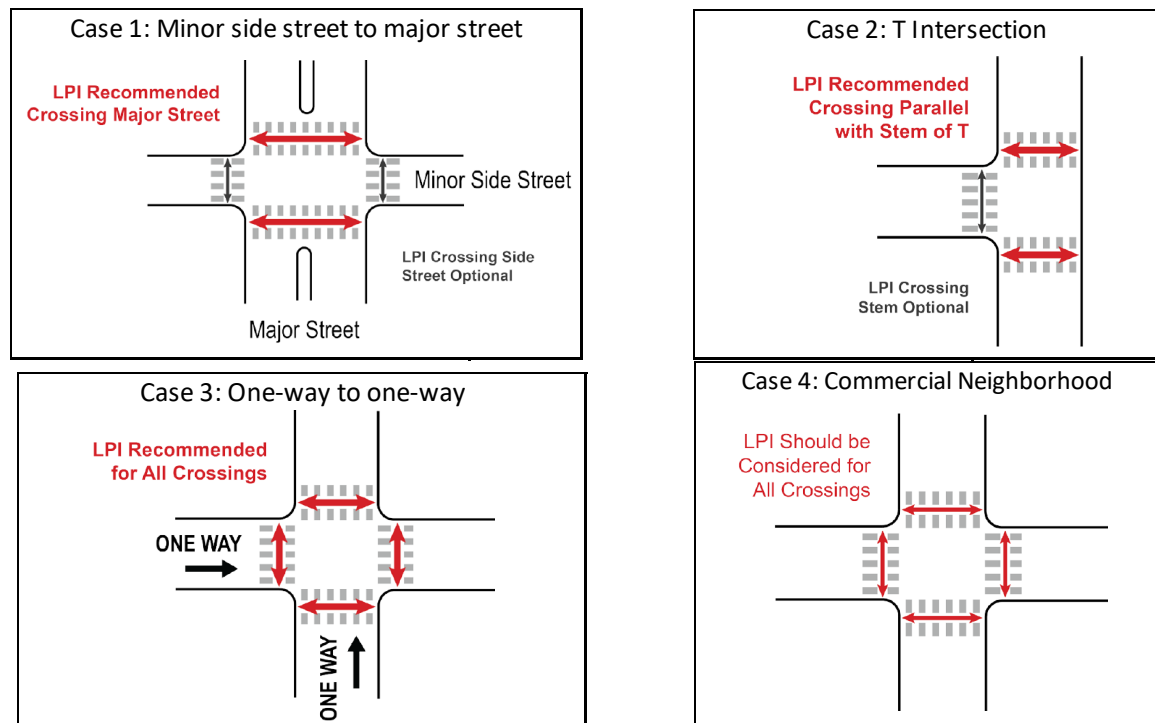
Additional guidance is available in **OMUTCD Part 4**.

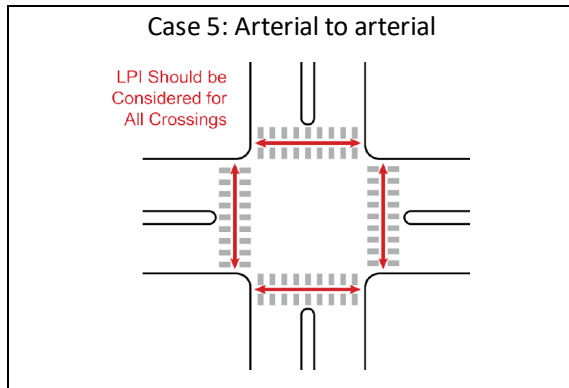
404-4 Leading Pedestrian Interval (LPI)

Leading Pedestrian Interval typically gives pedestrians a 3-7 second head start when entering an intersection with a corresponding green signal in the same direction of travel. To calculate the LPI timing, reference the Signal Design Reference Packet (SDRP) Clearance Interval spreadsheet. LPIs enhance the visibility of pedestrians in the intersection and reinforce their right-of-way over turning vehicles, especially in locations with a history of conflict.

LPI should be considered where there are pushbuttons and a high potential for pedestrian traffic, in the following intersection configurations and cases:

- Desired LPI phase(s) have permissive movements only (no protected, no protected/permissive lefts, no split phasing)
- Desired LPI phase(s) have protected left movements in the same direction
- Desired LPI phase(s) is part of a split phase





LPI should not be implemented where the desired LPI phase has protected/permissive left in the same direction due to possible vehicle/pedestrian conflict.

Where LPI is implemented with a new or reconstructed traffic signal, it should have accessible/audible pedestrian pushbuttons.

404-5 Pedestrian Hybrid Beacons

OMUTCD Section 4F addresses the Pedestrian Hybrid Beacon (PHB), formerly known as a HAWK signal, for its application, design, and operations.

As noted in the OMUTCD, an engineering study shall be done to justify the PHB installation. As part of the study, it shall evaluate all aspects noted in **Form 496-19** along with completing the form.

The study and completed form shall be sent to the Office of Traffic Operations for review and approval of the proposed PHB that will be ODOT owned and maintained. Additionally, in cases with Federal and State funding, the Office of Traffic Operations shall review the study and justification.

PHB installations shall have the CROSSWALK, STOP ON RED, PROCEED ON FLASHING RED WHEN CLEAR (R10-23a) sign which meets the requirement of the OMUTCD as the required sign instead of the CROSSWALK, STOP ON RED (R10-23) sign. See 201-16 for more details.

407 OTHER ELECTRICAL DEVICES**407-1 General**

This Chapter is used to address other traffic control electrical devices, including active signs, used on **ODOT**-maintained highways.

407-2 PREPARE TO STOP WHEN FLASHING Signs (W3-H4a)**407-2.1 General**

The PREPARE TO STOP WHEN FLASHING (PTSWF) sign (W3-H4a) is used to provide drivers approaching a traffic signal with additional information concerning the changing of the traffic signal indication from green to yellow. Drivers who are past the dilemma zone will usually decide to continue through the intersection when the yellow indication is displayed, while drivers who have not yet entered the dilemma zone will decide to stop. This sign can also be used to provide advance information when the geometric design of the intersection approach prevents the signal display from being seen in time to stop.

ODOT has been actively removing PTSWF signs since the 2010s in response to crash trends that exhibit an increase in high-speed serious injury/fatality crashes including red light running and angle crashes. Data shows that these types of crashes have decreased where proper removal procedures have been followed.

Additional data to support the PTSWF removals along with an explanation of the technology being installed can be found on ODOT's Traffic Signals website under *Additional FAQs*: <https://www.transportation.ohio.gov/wps/portal/gov/odot/programs/traffic-operations/resources/01-signals>.

407-2.2 Criteria for Removal

If the stopping sight distance to the traffic signal meets or exceeds L&D requirements, any one of the following characteristics can be used as justification for removal of a PTSWF assembly:

1. When the stopping sight distance to the traffic signal meets or exceeds L&D requirements
2. When there are two or more signalized intersections on the same route and the spacing between each signal is 1 mile or less
3. When a signal becomes part of a coordinated system
4. When the posted speed limit is reduced to less than 45 miles per hour
5. Upon mitigation of the condition that caused the sight distance limitation where the PTSWF sign is installed

Prior to removal of the PTSWF signs, the signs shall be covered and flashers disconnected for a minimum of ten days.

407-2.3 Procedure / Reviewing Other Countermeasures

In the event of crashes caused by failure to stop, the following progressive application of countermeasures should be utilized:

1. Inspection and confirmation of the following:
 - a. **OMUTCD**-compliant intersection signal display configurations
 - b. Updated controller timing and coordination timing (if applicable) functionality, including properly functioning detection and simultaneous gap out

- c. Proper controller functionality, including functioning detection and simultaneous gap out
 - d. Clearance Intervals calculated per **Section 403-2** and programmed correctly
2. Installation of a single Signal Ahead (W3-3) sign properly spaced from other signs/devices
3. Dual W3-3 signs properly spaced from other signs/devices
4. Oversized, dual W3-3 signs properly spaced from other signs/devices
5. Backplates on signal heads
6. W3-3 signs with continuously flashing beacons properly spaced from other signs/devices
7. Advanced Dilemma Zone Radar Detection
8. Auxiliary Traffic Signal Heads (See **Section 420-4.12**)
9. PTSWF (W3-H4a) signs, timed concurrently with the yellow (Y) and Red (R) clearance intervals
10. PTSWF signs, with advance warning time as calculated using **Section 407-2.6** with Advanced Dilemma Zone Radar Detection at or upstream of the PTSWF sign

Generally, the PTSWF sign should be used only where conventional traffic control devices have been tried and found ineffective in reducing crashes, or where operational problems related to rear-end, or other crashes caused by failure to stop have occurred.

407-2.4 Alternatives to Removal

If existing PTSWF installations with advance warning time are to remain in place, the advance warning time should be eliminated. In this approach, signal operation is simplified by driving the PTSWF beacons concurrently with the associated phase yellow clearance and red clearance intervals. This is equivalent to reducing the PTSWF advance warning time to zero. The preferred zero-warning-time implementation shall use a separate load switch and/or flasher module to activate the PTSWF flasher using a wire of the yellow and red load switch outputs.

Older PTSWF installations with timing based on earlier **TEM** formulas should have the advanced warning time reduced to comply closely with the new formula (See **Section 407-2.6**). If a **District** decides that the early warning time of the PTSWF must be maintained, then the detection zone of the signal shall be extended to a minimum of 100 feet upstream from the PTSWF sign, along with Advance Radar detection installed at the signal, to assure that no vehicles between the PTSWF sign and the next downstream detector are caught in the Dilemma Zone at the end-of-green.

407-2.5 Applications

Any proposed **ODOT** or federally-funded PTSWF sign installations must be reviewed and approved by the [Office of Traffic Operations \(OTO\)](#). Installation of the PTSWF sign should only be implemented upon failure of the progressive application of countermeasures described in **Section 407-2.3**. The following are typical applications for PTSWF signs:

1. A location where stopping sight distance to the traffic signal is less than L&D requirements.
2. A location (usually four-lane divided) with approach speed of 45 miles per hour or greater, a high rear-end accident rate, and evidence of rear-end conflicts (skid marks) at the intersection.
3. A remote rural location with approach speed of 45 miles per hour or greater where the presence of a signal is unexpected.
4. A location with approach speeds of 45 miles per hour or greater and diminished signal sight

420 MATERIALS AND SIGNAL HARDWARE**420-1 General**

Construction details are shown on [Traffic SCDs TC-81.11 through TC-85.20](#) as well as applicable ITS SCDs. Traffic signal equipment is specified in [C&MS Items 632 and 633](#), [C&MS 732 and 733](#), and [Supplemental Specification 809](#).

420-2 Patented or Proprietary Materials, Specifications or Processes

The use of patented or proprietary materials, specifications or processes is addressed in **Section 120-4**.

420-3 Purchasing Materials for Installation and Use by Local Agencies

To help encourage uniformity and provide a method whereby local agencies can buy traffic control materials and equipment using Federal funds, **Sections 120-5 and 120-6** describe processes that have been established whereby local agencies can purchase such items through **ODOT**.

420-4 Vehicular Signal Heads**420-4.1 General**

Standards related to vehicular signal heads are addressed generally in [OMUTCD Chapter 4D](#).

For any project using **State** or **Federal** funds, louvered reflective backplates in accordance with **C&MS 732.22** are required for all new signal heads (backplates are required for both mast-arm and span-wire installations).

ODOT prefers mast arm installations per **Traffic SCD TC-81.22** with rigid mounted polycarbonate signals to eliminate the potential for swinging heads, better lateral and vertical placement, and better aesthetics that help eliminate visual clutter. Additionally, as noted in **OMUTCD 4D.11**, locating primary signal faces on the far side of the intersection, as opposed to diagonally on spans, has been shown to provide safer operation.

If strain poles are used, the signal heads shall be polycarbonate plastic and be tethered per **Traffic SCD TC-85.21** to minimize sway for span-wire type configurations. A signal support analysis should be performed on all existing strain poles to insure they are structurally adequate for the proposed changes. If span-wire supports are found deficient for backplates in all directions, then the intersection should be analyzed for mainline or East/West backplates only. Written documentation and calculations are required if the proposed additions/changes cannot be implemented.

420-4.2 Signal Head Color

In **ODOT**-maintained traffic signal installations, the vehicular signal head housings and the outside of the visors shall be highway yellow or black. The two colors shall not be mixed within an intersection.

420-4.3 Vehicular Signal Indications

Vehicular signal indications shall be 8 inches or 12 inches in diameter, depending on the provisions of **OMUTCD Section 4D.07**. For **ODOT**-maintained traffic signal installations, they shall be LED modules and they should be 12 inches in diameter. The 8-inch size is typically used only for low-speed, urban applications.

420-4.4 Number of Signal Faces on an Approach

In addition to meeting the minimum number of vehicular signal heads per approach set forth in **OMUTCD 4D.11**, there may be circumstances that lead to installing additional signal heads.

See guidelines for Auxiliary or side-mounted traffic signal heads in **Section 420-4.12**.

If side-mounted signal heads have been installed at an intersection and crash trends continue to increase, consideration may be given to installing one overhead traffic signal per lane.

See the Signal Design Reference Packet (SDRP) for typical signal head placements.

420-4.5 Location of Five-Section Signal Heads for Protected/Permissive Turns

OMUTCD Sections 4D.17 through 4D.20 contain the requirements for signal head use for protected/permissive left turns. In protected/permissive signal phasing, the left (or right) turns can be made in both a protected (green arrow) and a permitted (circular green) signal phase.

“Shared” five-section signal face:

Because the circular signal indications in this five-section signal head apply to both the through and turning vehicles, the signal head should be located on an extension of the Channelizing Line that separates the through and turn lanes. The “shared” type of five-section signal face is used extensively throughout **Ohio**.

Left-turn lanes on four-lane highways with wide medians are often separated from the through lanes by a large painted channelizing island in order to provide good alignment and sight distance for opposing left-turn vehicles. In this case, the five-section head should be located in front of the left-turn lane with an R10-12 sign, LEFT TURN YIELD ON GREEN, next to the signal head. Two additional three-section signal heads should be provided for the through-traffic lanes. The maintaining agency should monitor accidents for this type of operation with the wide median. **ODOT's** experience in some parts of the **State** showed that left-turning drivers were not yielding on the circular green and the phase operation had to be converted to “protected only.”

420-4.6 Aluminum versus Polycarbonate

Vehicular signal heads are manufactured in either aluminum or polycarbonate plastic. The choice of which material to use will be made by the maintaining agency. Many urban jurisdictions prefer the use of polycarbonate, because they are much lighter and easier to handle. Because of the lighter weight, they are often used when adding left-turn signal heads to an existing signal support system. Polycarbonate signal heads are most often associated with rigid-mounted signal heads on mast arms where wind sway will not be a factor.

In **ODOT**-maintained traffic signal installations, polycarbonate signal heads should be used rigid mounted to mast arms or span-wire attached with tether.

420-4.7 Programmable Signal Heads

A programmable signal head utilizes a special optical lens that can be “programmed” to provide the signal display to only desired portions of the roadway. The programming is accomplished by steerable LED arrays behind the lens. Applications for the use of programmable heads may be severely skewed roadways where the signals may be visible from more than one approach and closely spaced intersections, or closely spaced intersections.

Because the lens is programmed to be visible from certain areas, the signal head should be rigid mounted or tethered. Programmable signal heads are much more expensive than a regular signal head and, if programmed incorrectly, can create an unsafe condition. Signal

designers should give careful thought to their use and provide plan sheets clearly showing the desired visibility cutoffs.

See **Section 450-10.5** for additional details on optically programmable signal heads.

420-4.8 Signal Indications on the Stem of a T-Intersection

For through traffic, a minimum of two signal faces shall be provided and shall be continuously visible per the requirements of [OMUTCD Section 4D.11](#).

On the stem of a T intersection, where there is no through traffic, at least one of the turning movements shall be provided with dual indications. If two three-section heads are used, one with a left-turn green arrow and the other with a right-turn green arrow, the approach does not meet the minimum requirements of the **OMUTCD**. Two circular greens are sufficient, or two circular greens with one or two arrows (four-section heads) are acceptable. The purpose of providing dual indications is to ensure that if one lamp fails, a second lamp will be provided to the predominant movement.

420-4.9 Signal Head Clearance

[OMUTCD Section 4D.15](#) requires that the bottom of the signal housing and any related attachments to a vehicular signal face located over a roadway shall be at least 15 feet above the pavement. The top of the signal housing of a vehicular signal face located over a roadway shall not be more than 25.6 feet above the pavement. For new construction using mast arm overhead attachment, [Traffic SCD TC- 85.20](#) requires a clearance of 17 to 19 feet above the pavement elevation at the center of the roadway. For new construction using span wire overhead attachment, [Traffic SCD TC-85.22](#) requires a clearance of 17 to 19 feet (including tether attachment) above the pavement elevation at all points of the roadway. If the installation cannot be adjusted to the proper clearance, the engineer, in consultation with the maintaining agency, may direct the use of drop pipes or waive the maximum clearances requirement for each head.

420-4.10 Use of Balance Adjusters Prohibited

Balance adjusters shall not be used on signal installations with backplates. Experience has shown that balance adjusters allow enough twisting motion in the signal head to produce tether wire fatigue at the tether attachment point.

420-4.11 Dual-Arrow Signal Section (Bi-Modal Arrow)

[OMUTCD Section 4D.06](#) allows for the use of a dual-arrow alternative display, also referred to as a bi-modal display, of a GREEN ARROW and a YELLOW ARROW. However, these dual-arrow signal sections shall not be used on **ODOT**-maintained highways.

420-4.12 Auxiliary Traffic Signal Heads

Approaches to traffic signals with high truck percentages (10% or greater) and/or high approach speeds (45 mph posted or greater) should include one or more auxiliary signal heads. Typical placement is on the near-side right side signal support. Auxiliary heads improve signal indication visibility for motorists approaching the signal when one or more high trucks (e.g., tractor-trailers) are stopped at or are approaching the intersection. Motorists following high trucks often have their view of overhead signal indications blocked by the truck.

Installations with lower approach speeds and lower truck volumes should be considered on a case-by-case basis for auxiliary heads, especially in situations with sight distance restrictions due to horizontal or vertical curves, roadside or overhead obstructions.

420-5 Detection

420-5.1 General

At ODOT-owned/maintained intersections, Radar Detection (809) is the standard means of detection unless specific reasons exist that would prohibit it. Examples of prohibited sites include at a curve or roadway where geometrics do not allow proper coverage, or where an overpass/ obstruction blocks the view.

For all approaches 45 mph or greater, Advance Radar Detection/Dilemma Zone Detection (Item 809E69000) is required to provide extension of vehicles. In cases where the speed limit is less than 45 mph but prevailing speeds and crash patterns suggest that Advance Radar Detection/Dilemma Zone Detection is beneficial, it is encouraged to be installed.

For in-pavement loops, **Figures 498-3 through 498-5** illustrate suggested loop placements for traffic control signals in the following situations: Mainline vs. Large-Volume Side Street, Mainline vs. Ramp/T Intersection, and Mainline vs. Low-Volume Side Street, respectively. **Section 450-10.7** provides additional detail information about loop placement and wiring.

These are intended only as suggestions for detector placement and a naming convention. Actual placement will depend on individual conditions and **District** practices. Electronic copies of the drawings are available upon request.

420-5.2 Detection of Motorcycles and Bicycles

For any project using **State** or **Federal** funds, all stop line detection zones shall reliably detect motorcycles and bicycles, and all dilemma zone detectors shall reliably detect motorcycles. To assist the traffic signal designer, the following information is provided:

1. Motorcycles and bicycles are more easily detected by inductance loop detectors (ILDs) when traveling over a wire that is parallel or skewed to the direction of travel. Most loop configurations have a bicycle/motorcycle dead zone at their center.
2. Stop Line Radar Detection (Item 809E69100) provides very good bicycle and motorcycle detection and its use is encouraged for new design. For ODOT traffic signals, Radar Detection is the standard detection.
3. Video stop line detection is usually a reliable detection system for motorcycles and bicycles. The detection zone at the stop line should be kept small so that motorcycles and bicycles will impact a larger percentage of the detection zone. Other detection zones may be added in advance of the stop line detection zone to provide large area detection. Locking of detection calls is prohibited, especially during nighttime hours, especially at unlighted intersections.
4. An 8-foot wide rectangle or square ILD in a lane of 12 feet or less in width places the wires too close to the edge of pavement or adjacent lane to be considered a traveled path for motorcycles. A 6-foot wide ILD in a 12-foot wide lane will position the wires closer to the traveled path, increase sensitivity in the center of the zone, and allow the detector unit sensitivity setting to be increased while minimizing adjacent lane false calls.
5. The long rectangular stop line ILD is not a reliable detector of small vehicles. While the commonly used rectangular ILD has good detection of high-bed vehicles, the center dead zone does not reliably detect motorcycles and bicycles. Increasing sensitivity to a level that will detect motorcycles and bicycles may cause false calls in the adjacent lane.
6. For dilemma zone detection, the commonly used 6-foot diamond, square, or rectangle shape may not reliably detect motorcycles traveling in the center of the lane over the ILD corners. The Angular Design Detection (ADD) loop shown on [Traffic SCD TC-82.10](#) will provide more reliable detection.
7. To provide large area ILD detection at stop lines:
 - a. The Powerhead configuration provides both motorcycle/bicycle and large area

detection with a single loop. Shorter Powerhead loops (e.g., 6 x 20 feet) provide the best performance, with a maximum permissible length of 35 feet.

- b. A short quadrupole (10 feet or less) with 3-6-3 wire configuration can be used at the stop line for the detection of motorcycles and bicycles, with a longer rectangular or ADD ILD in advance of the quadrupole to detect other vehicles including high-bed vehicles. This arrangement provides better performance than a single Powerhead loop, but requires more detector module channels.
- c. A series of 6-foot rectangular ILDs can be used to provide a zone of coverage in advance of the stop line with the ILD at the stop line being either a short Powerhead or a short parallel quadrupole.
- d. The stop line ILD shall not be wired to any other loops and shall have its own detector channel.
- e. System loops may be 6 x 6 foot square or diamond shapes.

At locations of high bicycle use or where the outline of the ILD is not visible on the pavement, signing and pavement marking ([OMUTCD Section 9B.13](#) and [Figure 9C-7](#)) may be used to denote the location on the ILD for the most reliable detection area after testing with a bicycle.

All stop line detection zones shall be tested for a bicycle target, and all dilemma detection zones tested for a motorcycle target for reliable detection. See [Figure 498-27](#) for the **ODOT** standard vehicle test targets. See [Traffic SCD TC-82.10](#) for bicycle-specific ILD's.

420-5.3 Video Detection Prohibited for Dilemma Zone Applications

Video detection shall not be used for advance (Dilemma Zone) detection on any approach with a posted or prevailing speed of 35 mph or greater. Video detection is suitable for stop line applications only. Within 200 feet of the stop line, video detection may be employed for (green) extension detection. Beyond 200 feet, extension detection shall be provided by Advance Radar Detection, section (809), which is ODOT's standard detection or inductive pavement loops.

420-5.4 Second-Car Detection

420-5.4.1 Background

The use of second-car detection eliminates timing of the associated protected left-turn phase when only one vehicle is waiting for service. This amounts to an "early return" of the opposing green through movement equal to the minimum duration for the left turn. In general, left turns have minimum times similar to those below, to be used for this example calculation:

- 1. Minimum Green: 7 seconds
- 2. Yellow Change: 4 seconds
- 3. All-Red Clearance: 1 second

The total for this minimum phase time is 12 seconds. The queue clearance time (QCT) in seconds is given by:

$QCT = 4 + 2n$ (where n = the number of vehicles clearing from queue past the stop line).

Rearranging, we can calculate the number of vehicles (per opposing through lane) that move into the intersection during this interval: $n = 0.5 (QCT - 4)$.

For the typical left-turn phase timings above, this gives: $n = 0.5 (12 - 4) = 4$.

Thus, only an additional four vehicles per lane are cleared in the opposing through phase by eliminating the protected left-turn movement using second-car detection. The signal designer is advised to consider this minor increase in through-phase service volume

relative to the safety considerations associated with eliminating the protected left-turn interval.

420-5.4.2 Use of Second-Car Detection

The deliberate placement of protected/permmissive left-turn presence loops and detection zones at locations with their trailing edge more than one vehicle length behind the stop line is sometimes used by signal designers. The rationale for this placement is the perceived increased efficiency obtained by skipping the associated left-turn phase if only one vehicle is present at the stop line, forcing that vehicle to make a permissive turn at some point during the adjacent green through phase. Such operation yields its greatest mainline efficiency benefit under moderate through-volume conditions. However, under heavy-volume conditions, the permissive left turn often cannot be made until the opposing phase termination. For higher-speed, multi-lane, divided highways, offset-left approaches and other conditions, this can be a dangerous vehicular movement, contributing to angular collisions.

For the reason noted above, left-turn second-car detection should not be used at **ODOT**-maintained signals under (but not limited to) the following conditions unless engineering judgment indicates such operation is acceptable.

1. Posted or prevailing speeds greater than 35 miles per hour.
2. More than two opposing through lanes regardless of approach speeds. Median-divided highways.
3. Offset left-turn lanes.
4. Left-turn lanes with permitted U-turns.
5. An intersection with PREPARE TO STOP WHEN FLASHING advance warning flashers.
6. High-skew or other geometrics or conditions with limited visibility.

420-6 Cabinets

When developing plans for upgrading or replacing signalized intersections, planning for future technologies that could be housed in the cabinet is recommended. Project funds should be used to install the latest model cabinets that are available to agencies. ODOT strives to enhance the technology used statewide, which is the reason that NEMA TS-1 cabinet specifications have been removed from the TEM and CM&S. In the event that an older type cabinet is desired (i.e., NEMA TS-1), it may be justified following 23 CFR 940 recommendations, which is explained in more detail in Section 1301-2, by noting it is an expansion of an old system and apply a Misc. item and note, which abides by the published NEMA TS-1 standards.

be as much as four feet in diameter. With allowance for construction tolerance, ODOT recommends a minimum clear space of two feet beyond the foundation extent for reliable placement of the foundation and construction of radial conduits without affecting adjacent buried utilities.

When the guidance above and the designer's assigned tolerance for the buried utility position indicate interference, then a Level A SULS may be required. Because Level A SULS is not incidental to most design contracts, the Designer shall immediately notify ODOT of the situation and the responsible parties shall coordinate a response.

The designer may wish to have appropriate survey markers placed as part of the Level A SULS effort for later use during construction.

Here is a summary statement for Designers: when proposed construction items and existing utilities, both properly toleranced, indicate potential interference, then a Level A SULS may be required to locate and mark the existing utilities with high accuracy.

440-2 Electrical Power for Traffic Signals

Each signalized location should, whenever possible, be powered from a separate, independent power source point arranged with the power company. This should be a 120-volt (two-wire) service of adequate ampacity for the predicted loads. A 120/240 volt, three-wire, service should only be considered when it will also be used to power a few roadway luminaries at the intersection, and in this case, disconnects shall be arranged so that it is possible to disconnect the lighting circuit for repairs without disturbing signal operation.

[Traffic SCD TC-83.10](#) addresses pole mountings for controllers and power service. ODOT-maintained signals shall use padlocks at all times to prevent unauthorized disconnect operation.

Provision of traffic signal power service will cover the same general considerations as designated for separate independent sign lighting power services (**Section 240-7.7, 1 and 3**). The availability of power at various locations in the intersection may tend to make some locations more favorable for the controller mounting.

Plan Note 442-2 (see Section 442-2) should be included on projects with traffic signals. The name and address of the power company and the voltage to be supplied shall be specified in the appropriate blanks.

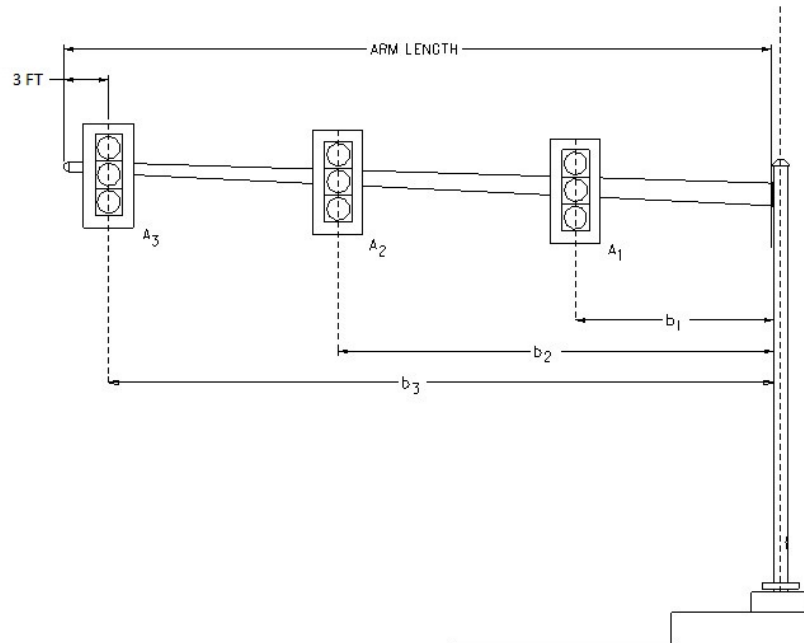
440-3 Single-Arm Overhead Signal Support

Various types of overhead signal supports are depicted in **Table 497-4**. In designing a single-arm overhead signal support, ODOT's preferred signal support (see **Section 420-4.1**), the following instructions are used in conjunction with [Traffic SCD TC-81.22](#) for new supports:

1. Determine the approximate arm length as the horizontal distance from the pole flange plates to a point 3 feet beyond the center of the most remote signal attachment, or 1 foot beyond the furthest edge of the most remote sign attachment.
2. Locate each signal or sign on the arm. Select the proper area for each signal head from **Table 497-5**, and for a sign.
3. Calculate the area moment design factor (K) by multiplying each area (A) by the distance (b) from its attachment point to the pole centerline and add the products.

$$K = b_1A_1 + b_2A_2 + b_3A_3$$

See figure shown on next page. Area moment for standard luminaires and bracket arms may be calculated as $3L$, where L = length of bracket arm in feet.



4. For a new support, select the proper design based on maximum arm length (from [TC-81.22](#)) and area moment design factor (K) from the design chart shown below.

Design No.	2	4	12	13	14
K	787.5	1575	1995	2380	2641
Max Arm Length (ft)	32	38	48	60	70

5. As long as the K value is not exceeded, it is acceptable to exceed the "Maximum Design Area" shown on [TC-81.22](#).
6. When an existing [TC-81.20](#) (see [SCD Archive](#)) support is to be retrofitted with backplates and/or rigid-mounted signals, the following design chart shall be used.

Design No.	1	2	3	4	11	12
K	318.5	378	412.5	825	845.5	1045
Max Arm Length (ft)	25	32	38	38	45	48

7. The value should not exceed that listed for the selected design number. If the values are exceeded, the designer shall be responsible for determining the support size required.
8. Any mast arm length greater than 59 feet is required to have a wind damping system.
9. If the design numbers for the supports at a particular intersection are similar (for example, 2 design number 11 and 2 design number 12 at the same intersection), then the smaller supports may be changed to the larger design number in the plans.

440-3.1 Non-Standard Signal Support Design Criteria

The designer shall submit detailed structural calculations showing the adequacy of any proposed non-standard or aesthetic signal support design. The proposed design shall include the foundation. The plan designer shall include a **Plan Note** reflecting the non-standard signal

- i. Pavement marking pertinent to the signal operation.
 - j. Signal phasing diagram (*see Figure 498-46*), method of addressing yellow trap (where applicable) or field hook-up chart (*Form 496-16*) and signal timing. See the [Signal Design Reference Packet \(Section 495-2\)](#) for typical signal timing charts and the field hook-up chart template (*Form 496-16*). Sample field hook-up charts are shown in *Figure 498-47*.
 - k. Handicap ramp locations.
 - l. Right-of-Way lines.
 - m. Corporation lines.
 - n. Any existing features to be incorporated into the new signal. Any decision to reuse equipment must be based on a field check of the structural integrity and condition of the devices and agreement with the maintaining agency.
 - o. Other physical features within the intersection and sidewalk area which may conflict with traffic flow, pedestrian flow or sight distance.
 - p. **Synchro** files on CD.
 - q. **SWISS** files on CD.
2. Stage 3 Plan Requirements:
- a. General Notes.
 - b. Estimated quantities.
 - c. Special details.
 - d. Pole orientation chart.
 - e. Wiring diagram. It shall indicate the type of cable and number of conductors connecting each signal head, pedestrian head, detector, push button, etc. See *Figure 498-45* for a sample diagram.
 - f. Coordination timing. All coordination timings shall be in seconds.

The Traffic Signal Stage 3 check list is given in *Form 496-2*.

440-8 ADA Requirements on Traffic Signal Projects

440-8.1 General

As noted in *Section 401-9*, there are generally four major **ADA** requirements that affect traffic signal projects:

- 1. Curb Ramps
- 2. Truncated Domes (Tactile Bumps on the Curb Ramp)
- 3. ADA-Compliant Pushbuttons Located per OMUTCD 4E.08
- 4. Accessible/Audible Pedestrian Pushbuttons (Locator Tones)

440-8.2 Accessible Pedestrian Signals and Locator Tones

Section 404-3 covers the requirement of accessible pedestrian pushbuttons at **ODOT**-maintained traffic signals when pedestrian facilities are provided. On traffic signal projects, local governmental agencies may install these devices at their intersections if it is part of their local policy/standards.

A common mistake made at rural type intersections is to provide a pedestrian pushbutton on a pole that is located far back from the roadway. When provided, pedestrian pushbuttons shall be accessible to all. This may mean providing an unobstructed paved pathway back to the pushbutton. Alternatively, a pedestal can be provided to put the pushbutton near the intersection.

440-8.3 Curb Ramps

Generally, curb ramps are needed whenever a sidewalk or other pedestrian walkway crosses a curb. Where a traffic signal is installed or upgraded in which the upgrade affects the access, circulation, or use of the roadway, the intersection shall be provided with ADA-compliant curb ramps where the sidewalk or pedestrian facility crosses the curb. Example projects that would require curb ramp upgrades include reconstruction, widening, resurfacing (see USDOJ-FHWA technical assistance dated 6-28-13 for additional clarification), and signal installation. If the existing curb ramps are physically disturbed, the disturbed curb ramps must be updated to meet ADA compliance.

Refer to **Location and Design Manual, Volume 1, Section 306** for basic guidelines for pedestrian facilities (curb ramps and sidewalks) and the **Office of Roadway Engineering's** ADA Design Resources.

440-8.4 Truncated Domes (TDs)

TDs are raised "bumps" used by people with vision impairments to be able to feel where the ramps are. All new, existing or upgraded curb ramps shall have truncated domes upon completion of a traffic signal project.

[Roadway Engineering's SCD BP-7.1](#) addresses new ramps. For guidance in the use of this drawing, contact the [Office of Roadway Engineering](#).

440-9 Paying Locals with Project Funds

On some projects, the local authorities desire to have one of their employees in attendance when the contractor is working in their traffic signal controller cabinets. This is a legitimate request and the plans should include a general note requiring the contractor to inform the local authorities prior to working in their traffic signal controller cabinets. The cost of providing the local employees shall be borne by the local authorities. Project funds shall not be used to pay the local representative's salary, either straight or overtime pay.

440-10 Span-Mounted Traffic Signal Support Structures

440-10.1 General

Various rigid span-mounted (non-cantilevered) traffic signal support structures may be used when required. These are not standard **ODOT** designs, but must be designed specifically for each instance. Such structures shall be designed according to **AASHTO LRFDLTS**. A typical use of these structures is to support traffic signals above the roadway on a SPUI (Single-Point Urban Interchange).

These applications often involve placing the span-mounted signal support on an overpass or similar roadway structure. The rather concentrated base loads transferred into the roadway structure by the signal support structure must be considered early on in the design of the roadway structure. They differ from the usual bridge design loads. Because of their size, complexity, and potential for dynamic interaction with the supporting roadway structure, the designer must carefully consider a number of factors. These include but are not limited to:

- Width of signal support span.
- Size of signal support span members.

The guarantee shall cover the following items of the traffic control system: controller, cabinet, uninterruptible power supply, vehicle detection equipment, LED lamp units, network and communication/interconnect equipment.

Customary manufacturer's guarantees for the foregoing items shall be turned over to the state or the maintaining agency following acceptance of the equipment.

The cost of guaranteeing the traffic control system will be incidental to and included in the contract unit price of the various items making up the system.

Designer Note: See **Section 441-11**.

442-16 633 Alternate Bid Item

633 Cabinet, Type ____

(Example of a standard bid item)

633 Cabinet, Type ____, (Acme Brand) (Alternate 1)

The cabinet shall be a Model xx-99 as manufactured by Acme Cabinet Company, Santoy, Ohio and shall be furnished with all the design features, auxiliary equipment, accessories, and prewired cabinet features as required in the standard bid item.

Payment will be at the contract unit price for each, in place, all connections made and wiring completed, tested and accepted.

(Example of an alternate bid item)

Designer Note: See **Section 441-12**.

442-17 Reserved – Existing Note Deleted

The Plan Note for “632 Vehicular Signal Head, Color, Material, By Type (with Backplate), As Per Plan” is outdated and has been deleted; however, the number has been reserved for future information.

442-18 632 Pedestrian Signal Head (LED), (Countdown), Type D2, As Per Plan

In addition to the requirements of C&MS 632 and 732 the following shall apply:

1. Signal heads and visors shall be constructed of black polycarbonate plastic and meet ITE specifications.
2. Proper exterior colors shall be obtained by use of colored plastic material rather than painting.
3. Pipe, spacers and fittings constructed of polycarbonate plastic may be used in lieu of galvanized steel or aluminum.
4. The pedestrian signal head shall be of the LED countdown type.
5. New attachment hardware and fittings shall be used
6. The light emitting diode (LED) modules shall meet the requirements of C&MS 732.04-C. The Contractor shall provide ODOT, in writing, with the LED manufacturer name, serial number, part number, description of lamp, and date of manufacture for all led units that are to be used in the signal head prior to installation, for acceptance and warranty purposes.

Payment for item 632 Pedestrian Signal Head (LED), (Countdown), Type D2, As Per Plan

shall be made for the number of complete signal head furnished and installed, including all labor, equipment, materials and new attachment hardware.

442-19 632 Relamp Existing Signal Section with LED Module, By Lens Type, As Per Plan

This item of work shall consist of replacing the 12-inch lens and incandescent lamp in an existing signal head section with a 12-inch LED module.

The light emitting diode (LED) modules shall meet the requirements of C&MS 732.04-C. An LED module shall be furnished and installed for the type of signal lens specified in the bid item description. [The existing reflector unit and lens shall be removed and returned to the maintaining agency. The existing incandescent lamp shall be disposed of by the contractor.]

The Department will measure "Relamp Existing Signal Head with LED Modules, By Lens Type, As Per Plan" by the number of complete units furnished and installed, and will include all hardware and lamps as specified.

Designer Note: Since maintaining agencies will use different combinations of LED/incandescent lamp and aluminum/polycarbonate signal sections, this note will allow the designer to choose the various options that will provide the maintaining agency with features that they prefer. Items that are enclosed in brackets [] should be carefully considered and retained or deleted based on maintaining agency preferences. Care should be taken not to include duplicate requirements for the same item.

442-20 809 ATC Controller, As Per Plan

The controller unit shall be furnished and installed per SS 809 and be listed on the Traffic Authorized Products (TAP) List.

The controller shall be an Econolite Cobalt and compatible with the Cabinet type being installed.

Designer Note: This note shall be used at all locations to be owned and maintained by ODOT. ODOT has Statewide Proprietary approval for Econolite controllers.

442-21 633 Cabinet, Type 33x, As Per Plan

The cabinet shall be furnished and installed according to CMS 633 and 733 and be listed on the Traffic Authorized Products List (TAP).

The cabinet shall be furnished with an EDI Monitor as allowed on the TAP/Approved Products List.

The contractor shall not reassign the cabinet detector inputs in order to reduce the number of 2-channel detector units supplied and shall use the standard Caltrans Input File designations following Plan Insert Sheet 203324.

Payment for item 633 Cabinet, Type 33x, As Per Plan will be at the contract bid price per each complete and in place including all connections tested and accepted.

Designer Note: This note shall be used at ODOT maintained intersections in Caltrans Districts. Designate in the Note and Item which cabinet Type: 332 or 336. ODOT has Statewide Proprietary Approval for EDI Monitors.

442-22 633 Cabinet, Type TS-2, As Per Plan

The cabinet shall be furnished and installed according to CMS 633 and 733 and be listed on

support locations are to be approved by the Engineer.

The work will include backfilling, compacting, and restoration of the excavation to the site's original condition.

Excavations shall not be left open overnight.

Payment for this item shall be at the unit price bid per each Item 632 Test Hole Performed to be used at the direction of the Engineer.

Designer Note: The note and contingency quantity can be included if it is anticipated that utility conflicts may exist.

Designers must understand that this Note provides for contingency quantities during Construction. It does not represent a Subsurface Utility Location Services (SULS) Test Hole, which is usually performed during the Preliminary Engineering step of project Design. See **TEM Section 440**.

442-43 632 Auger-In Foundation, 8-inch Diameter by (Depth in Feet)

This item consists of supplying and installing a pole foundation in undisturbed soil by use of a power rotary drill rig ("Kelly drive"), at the location specified in the Plans. Provide an auger-in foundation of 8-inch minimum outside diameter and shaft length as specified in the item description. Integral cableway cutouts of 2-inch by 8-inch (minimum) shall be present on opposite sides of the shaft beginning at 30-inch depth. Provide a shaft and all hardware hot-dip galvanized finished per ASTM A153. Assure the base plate can accommodate 12-3/4-inch to 17-inch bolt circles as shown on Standard Construction Drawings HL-10.13, TC-83.20, and TC-21.21.

Install per manufacturer's instructions, with frequent checking and adjustment during auguring, to assure a plumb pole installation. Auger in the foundation until the top of the base plate is at the final grade elevation. Align the base plate side parallel to the roadway and align cableway cutouts with underground conduits shown in the Plans. If no conduits appear in the Plans, then install the cableway cutouts parallel to the roadway. Clean the inside of the installed foundation of soil and debris to the bottom of the cableway cutouts.

Dig conduit trench by hand using a trenching shovel within 2 feet of the installed foundation. If machine-trenching is performed within 2 feet of the foundation, re-install the auger-in foundation a short distance away, as directed by the Engineer, or replace with a cast-in-place concrete 632 Pedestal Foundation. Foundation and conduit relocation and/or replacement foundations necessitated by machine-trenching too close to the original foundation are performed at the Contractor's expense.

Provide an auger-in foundation meeting these specifications and manufactured by AB Chance, Millerbernd, Pelco, or an approved equal.

Payment for this item is for each unit specified at the unit bid price, complete and in place.

Designer Note:

Use this specification in place of Item 632 Pedestal Foundation only when necessary, such as for knockdown replacement and similar situations that require a quick installation. The concrete 632 Pedestal Foundation item is standard for new design, but the Auger-In Foundation is suitable for maintenance installations. The minimum specified length is five feet (60 inches) in urban areas and 6 feet (72 inches) in rural areas. For maintenance purposes, these two sizes are generic. Generally, the designer also specifies a breakaway Transformer Base as part of the complete assembly. The designer shall perform basic 90mph design wind speed overturning moment calculations for all sign, signal, or light pole assemblies mounted on auger-in bases using the **AASHTO LRFDLTS-1**, with parameters per TC-81.22. Use this design overturning moment and

local soils data to determine the required foundation dimensions using the Drilled Shaft Foundation Design Spreadsheet provided by the Office of Roadway Engineering (ORE); the spreadsheet is available for download from the ORE website.

District approval is required before using this item in construction plans; provide copies of the spreadsheet and soils data to the District.

442-44 632 Signal Support Foundation

Prior to ordering the signal supports, the Contractor shall contact OUPS to have all the utilities located in the field then meet with the Project Engineer to locate the proposed support locations to insure there are no conflicts with utilities. If there are issues, the Project Engineer shall provide guidance as to the relocation of the support poles.

Payment will be at the contract unit price and will be full compensation for all labor, materials, tools, equipment and other incidentals necessary for each support furnished, in place, complete and accepted.

Designer Note: This note should be used when any new signal supports are to be installed. If note **442-42 Test Hole Performed** is used, this note can be deleted.

442-45 Reserved – Existing Note Deleted

442-46 632 Signal Support, (By Type), As Per Plan

In addition to provisions of the ODOT C&MS, furnish and install signal poles as specified in the plans.

The signal support designer shall provide drawings of a signal support with structural aspects of the design and materials in compliance with the **AASHTO LRFDLTS-1**.

Submit, to the Engineer prior to incorporation: two copies of the signal support drawings and shop drawings, which identify and describe each manufactured signal support and signal support item which is being incorporated into the construction. The signal support drawings and shop drawings shall each be reviewed, sealed, stamped, and dated by two Ohio registered Professional Engineers.

Payment for Item 632 "Signal Support, (By Type), As Per Plan" shall be made at the contract unit price per each complete and in place, and shall include all signal support design, labor, materials, and equipment necessary to complete the work.

Designer Note: This note is required on all projects where non-standard signal supports are included in the plans.

442-47 632 Signalization, Misc.: Unlash and Relash Messenger Wire

The Contractor shall remove existing messenger wire lashing rods and reinstall them as necessary for the installation of any new cables on the existing intersection signal spans. The cables shall enter the existing strain pole through the pole cable entrance fitting and use the existing conduit system to get to the controller cabinet. The new cables shall be supported by a new cable support assembly at the top of the strain pole.

The new signal cables shall be bid by separate bid items.

Payment for Item 632 "Signalization Misc.: Unlash and Relash Messenger Wire" shall be made at the contract unit price per foot and shall include all labor, materials, cable support assemblies and equipment to install new cables on existing signal span wire installations.

they should be lashed or restrained so that they do not interfere with the access to equipment, including terminal blocks or buses. The harnesses should be of sufficient length and should be easily traced through the cabinet. All conductors should be stranded, with labeled spade type terminals or plug connectors. The wiring should be color coded, with solid white for the AC common, black for the AC line side power (AC+), and solid green or white with green stripes for the safety ground.

14. Incoming cable and wire should be identified by tags or bands ([C&MS 632.05](#)). The size, material and method of tag or band identification should be in accordance with [C&MS 725.02](#), except that marking may be by indelible pen on plastic tags instead of embossed letters. The identification on the tags or bands should conform to the wiring diagram for the cabinet and its intersection, with typical abbreviations in accordance with **C&MS Table 632.05-1**, which has been reproduced in this Manual as **Table 497-2**.
15. Two copies of the schematic and wiring diagram for each cabinet and its intersection should be furnished by the contractor. The diagrams are to be updated to reflect any changes made during construction. The diagrams should be neat and legible, on durable paper, and folded in a moisture-proof envelope fastened to the cabinet interior.

450-10.3 Cable and Wire Identification

As noted in [C&MS 632.05](#), cables and wires shall be identified as shown in **C&MS Table 632.05-1**, which has been reproduced in this Manual as **Table 497-2**.

450-10.4 Vehicular Signal Heads and Wiring

Illustrations of the signal head visors and wiring discussed herein are presented in **Figure 498-21** and [Traffic SCD TC-85.21](#).

1. Signal heads shall conform to the plans, [C&MS 732.01](#), and [Traffic SCDs TC-85.20 and TC-85.22](#). Signal heads shall be made up of the correct number of optical sections (one, three, four or five). Sections shall be of the correct module size, i.e., 8 or 12 inches, color and ball or arrow configuration. Arrow modules shall be the 12-inch size. It should be noted that arrow modules are made in Rights, Lefts and Throughs (up). The use of the proper arrow module should be checked.
2. Modules shall be aligned properly in their frames so their optical configuration directs most of the light to the forward sector.
3. As noted in **Section 420-4.2**, signal heads shall have a yellow or black finish, unless otherwise specified in the plan.
4. Cutaway type visors ([C&MS 732.01](#)) shall be fastened to each optical section, unless open bottom tunnel visors or other types are specified, and the interior finish of the visors shall be flat black.
5. Signals should be clean and the assembly tight. Gaskets should be in good condition and module door hinges and latches should be in good working order. All openings not used for mounting purposes shall be closed by waterproof caps.
6. Five-section faces, arranged in accordance with [Traffic SCDs TC-85.20 and TC-85.22](#) and the plans, are to use galvanized pipe, elbows and tubular hardware, painted to match the signal head.
7. Swinging signals shall be installed in a plumb condition.
8. Swinging signals suspended from a mast arm shall be fitted with a universal hanger permitting swinging in both longitudinal and transverse directions.

9. When specified by the plans, disconnect hangers shall be used with signal heads.
10. Drop pipes, 1 1/2-inch diameter galvanized pipe, are a source of trouble and are aesthetically unattractive; therefore, they are intended to be used only when they are necessary. Signals supported by span wire, with sag required between 3 and 5 percent ([Traffic SCD TC-84.20](#)), shall be brought to proper clearance by adjusting the attachment height of the span wire to the poles.
11. Backplates shall be fitted to signal heads, unless specified otherwise.
12. Signal cable shall be routed into the interior of heads through the entrance fitting using a grommet. The cable shall be routed to each face's terminal block, which is typically in the yellow indication section. Conductors shall be fitted with spade type terminals and shall be fastened securely to the correct terminal points. Conductors shall be identified according to the wiring diagram. Signal cable shall not be spliced, either between signals or in signal face interiors.
13. External signal cable shall to be fashioned into a drip loop extending at least 6 inches below the entrance fitting but shall not chafe on the signal.
14. Lamps shall be light emitting diode (LED) ([C&MS 732.04\(C\)](#)). All vehicular signal lamps shall be prequalified in accordance with [C&MS 732.04\(C\)](#). As noted in **Section 420-4.11**, although [OMUTCD 4D.06](#) allows for an alternative dual-arrow (bi-modal) display of a GREEN ARROW and a YELLOW ARROW, these dual-arrow signal sections shall not be permitted on **ODOT**-maintained highways.
15. Each face of a signal head shall be oriented to its approach of traffic and its locking device securely tightened. Orientation or aiming of standard signals should be done so that the maximum light intensity from a standard signal is directed slightly below the horizontal center; thus, on a level approach, the face of the signal should be essentially vertical. When an approach to a signal is on a grade, the signal may be tilted slightly to point the signal axis parallel to the grade of the approach. Horizontal aiming should orient the axis of signal display parallel to the centerline of the approach for straight approaches when the signal is over the roadway. When the approach roadway is curved, or when a signal is not over the roadway, the axis should be directed at a point on the approach which is 175 to 625 feet in advance of the intersection, the distance being dependent on the speed of approaching traffic. For convenience, [OMUTCD Table 4D-2](#) has been reproduced as **TEM Table 497-3**.
16. When a vehicular traffic signal head has been erected and faces approaching traffic, it shall either be in operation as a stop-and-go signal or a flasher, or it shall be covered or bagged. This is an **OMUTCD** requirement ([OMUTCD Section 4D.01](#)) and cannot be ignored. Typically, the plans will contain an item for "Covering of Vehicular Signal Heads" which will require the contractor to cover, maintain the covering, and subsequently remove the covering when the signal is ready to commence operation.
17. Normally, the plans will provide the "covering" item for each new signal head, but will not provide them for any existing heads which are to be removed. The intent is that "covering" will be necessary for the new heads until they and their associated controller and wiring have been checked by circuit testing (**see Section 450-11**), while any existing signals at the intersection will continue to control traffic. When the new signals are uncovered and placed in operation, the existing signals can be quickly removed. Specific maintenance of traffic requirements in any plan may require a different means to assure the unused signals are not exposed to traffic.

450-10.5 Optically Programmed Signal Heads

Programmed heads (**see Section 420-4.7**) shall conform to certified drawings, [C&MS 732](#), and

error should be noted during the ten-day performance test.

After successful completion of the ten-day performance test, and after a partial or final acceptance of a project, the contractor is to turn over to the engineer all manuals, diagrams, instructions, guarantees and related material, as required by **C&MS 632.05**. It is recommended that the engineer list this material in the project diary as a permanent record of the transfer. The engineer should transfer the material to the maintaining agency. For **ODOT**-maintained signals the material should be given to the **District Roadway Services Manager**.

After a traffic control system project has been accepted by **ODOT**, the engineer should immediately notify the maintaining agency that as of a certain exact time and date, the agency is responsible for the operation and maintenance of the system.

450-11.7 Ten-Day Performance Test

Before acceptance of the traffic control system, the contractor shall furnish all personnel and equipment required to successfully operate the system continuously for ten consecutive days without major malfunction or failure (**C&MS 632.28(G)**).

At least seven days prior to the beginning of the performance test, the contractor shall notify the engineer of the starting date. The engineer will notify the maintaining agency (**C&MS 632.28(G)**).

The contractor shall arrange with the utility supplying the power for purchase of the energy required to conduct the test. All costs of personnel, equipment, electrical energy and incidentals required to perform the test are to have been included in the contract unit prices for the respective items tested.

Minor failures such as lamps, a single detector or an individual signal head, etc. shall be immediately replaced or repaired and will not cause restart of the test.

A major malfunction or failure, such as a master or local controller, interconnect equipment, etc. will cause termination of the test, and after replacement or repair of the malfunctioning or failed equipment, the beginning of a new ten-day test.

Items which have been repaired or which are replacements are to be monitored by the contractor for a period of ten days to provide assurance of their reliability.

The complete test results are to be furnished to the engineer on test reporting forms in accordance with **C&MS 625.19**. The contractor is to record in the test results the beginning and end of the test, and the method and date of the correction of each fault.

The engineer should record the following events in the project diary: the date of the beginning of the ten-day performance test, a day-by-day record of faults as they occur during the test, and the date of the successful completion of the performance test.

450-11.8 Final Signal Installation Check

After all wiring is completed and all testing completed and accepted, a final inspection of the traffic control system should be performed to assure a neat and workmanlike appearance.

From OTO's Traffic Signal Resources page, the Construction Final Inspection checklist shall be completed.

450-12 Controller Change Orders

Once a project is bid with 2070, **NEMA** or 170 controller technologies, it is not permissible to switch to a different technology after the project bids.

This is not allowed even if it is a no cost change order. This practice circumvents the competitive bidding practice and could lead to legal action being taken against **ODOT** by suppliers who were not afforded the opportunity to bid on the replacement technology type.

These types of change orders are not allowed even if the local maintaining agency requests it. They need to make their preference for controller technology known during the design so that it can be competitively bid.

460 MAINTENANCE / OPERATIONS**460-1 General**

Because traffic signals by their very nature provide positive guidance to conflicting traffic movements, it is imperative that they be maintained in order for them to function reliably. The mean time before failure of a traffic signal installation can be dramatically reduced through proper maintenance practices. The consequences of poor maintenance practices are a reduction in safety to road users and an unnecessarily large exposure to liability claims. **District Roadway Services** personnel and signal maintenance contractors are required to perform maintenance on traffic signals according to a preset schedule.

460-2 Responsibilities

The **Office of Traffic Operations (OTO)** shall:

1. Staff and maintain a central repair facility for the purpose of repairing components of electrical traffic control devices.
2. Assist **Districts** in maintaining reasonable stock levels of all major electrical items, and their appurtenances, required for new installations and maintenance through the management of annual term contracts and spot purchase contracts.
3. Assist the **Districts**, through procedure manuals, training programs, inspections, and other methods, in providing quality maintenance.

The **OTO Signal Shop** shall:

1. Repair, check and make serviceable for installation all signal controllers, signal relays, detectors, flashers, conflict monitors and other associated items.
2. Provide the loop detectors and other miscellaneous parts to custom wire as per plan new controller cabinets purchased by the **Districts** or rewire/refurbish existing controller cabinets.
3. Periodically provide the **Districts** with technical information concerning old and new equipment, such as: a list of outdated equipment that will not be repaired by the **Signal Shop**, changes, problems, software updates and etc. for any equipment owned by **ODOT**, and other tips or tricks that may help the **District** personnel.
4. Distribute to the **Districts**, at least once per calendar year, a list of all equipment, parts, and services available from the **Signal Shop**.

Each **District** shall:

1. Maintain a stock of traffic control equipment and other spare parts sufficient for normal preventive maintenance and emergency field repairs.
2. Have a plan to support the extraordinary (i.e., severe storm damage) traffic control equipment needs of the **District**.
3. Evaluate, authorize and maintain records of all changes in the location or operation of electrical traffic control devices.
4. Transport defective controllers, detector relays, detectors, conflict monitors, etc., to the **OTO Signal Shop** (or approved contractor/vendor) for service, maintenance and repair, along with a **Signal Shop Order** and a tag indicating the exact type of malfunction. These units shall at all times be properly cushioned to prevent physical damage during shipping and handling.

5. Generate an “as built” drawing for each electrical traffic control device installation, including each new or upgraded intersection control beacon, school flasher or signal. The drawing shall be in MicroStation V8 or later format and shall include the following, if appropriate:
 - a. Geometrics of the intersection.
 - b. Materials list.
 - c. Layout and location of the detectors, poles, pull boxes, cable runs, span wire, signal and pedestrian heads, controller, power service, phase diagram, detector operation, date of installation, revision block, and any other information which shows the intended operation.
 - d. Changes which affect the geometrics of the intersection and/or the operation of the signal shall be added to the drawing as revisions.

These electronic files shall be accessible to the **Central Office** in a read-only mode. Signal drawings which exist in a raster or single element format and cannot be modified shall be digitized or converted by other means when revisions become necessary.

6. Perform appropriate engineering studies, as needed, upon which revisions in signal operations, e.g., phasing may be based. When such revisions are required, an engineering report and necessary supporting data shall be submitted for approval to the appropriate **District** staff person.

Some signalized intersections and/or signalized corridors may be eligible to apply for, and participate in, the Systematic Signal Timing & Phasing Program (SSTPP). See **Section 1213-6** for more information about this program.

460-3 Preventive Maintenance

460-3.1 General

ODOT-maintained traffic signal installations shall be inspected a minimum of one time annually. In addition to the annual traffic signal inspection, the following routine scheduled maintenance shall be performed by either **District Roadway Services** section personnel or a signal maintenance contractor.

460-3.2 Traffic Control Signals and Intersection Control Beacons

Every eight years, all standard-warranty (5-yr) LED traffic control signal lamps and intersection control beacons should be replaced. A twelve-month compliance interval should apply to this process such that no device should be in service for more than eight years or if LEDs are performing well, longer than expected, closely monitor biannually for performance degradation.

Every eighteen years, all extended warranty (15-yr) traffic control signals and intersection control beacons should be replaced. A twelve-month compliance interval should apply to this process such that no device should be in service more than eighteen years or if LEDs are performing well, longer than expected, closely monitor biannually for performance degradation.

Every twelve months the conflict monitor shall be tested with an automatic conflict monitor tester.

Conflict monitors that are over ten years old need to be removed from service.

The recommended replacement periods for traffic signal equipment are listed below, which does not preclude replacement of deficient items identified during periodic inspections. Additionally, devices may be in operation longer if inspections and maintenance history show

the item is functioning properly.

Item	Replacement Period (years)	Item	Replacement Period (years)
UPS Inverter	10	LED Lamp Modules (5-yr/15-yr warranty)	8/18
UPS Batteries	8	Ped./Veh. Signal Heads/ Blank-Out Signs	15
Monitor	10	Wiring	30
Controller Unit	15	Messenger/Tether Wire	30
Communication Equip.	15	Strain Poles/Mast Arms	30 *
Cabinet	30	Detection (Radar/ Video/Pavement Loops)	15

- * Signal supports may be in use for longer periods, subject to annual inspection, with a maximum life cycle of 45 years.

When rebuilding a signal, do not reuse equipment that is beyond the replacement period.

460-3.3 Other Electrical Traffic Control Devices

For School Flashers, flashing and illuminated signs, and other electrical traffic control devices:

- Incandescent lamps shall no longer be used.
- Every four years mercury vapor lamps shall be replaced, and all reflectors, lenses, tubes and /or lamps shall be cleaned.

460-3.4 Signal Support Inspection

All signal supports shall be inspected at a maximum five-year interval. New signal supports shall be inspected at the time of construction. Refer to **Section 421-2** for additional information on signal support inspections.

460-4 As Required Maintenance

The following maintenance shall be conducted as required:

At signalized intersections, and for School Flashers and Intersection Control Beacons (overhead flashers):

1. Replace premature failure of lamps. Clean all reflectors, lenses, tubes and/or lamps.
2. Repaint painted steel poles, controller housings and signal heads as necessary to maintain good appearance and protection.
3. If required by local conditions of smoke, smog, etc., clean all reflectors, tubes and/or lamps using a mild detergent.

At flashing signs, illuminated signs, and other electrical traffic control devices:

1. Replace premature failure of lamps. Clean all reflectors, lenses, tubes and/or lamps.
2. Maintain and replace all other items as required.

Maintain all signs and pavement markings directly associated with any of these devices.

460-5 Malfunction Response

Each **District** shall seek the cooperation of the **Ohio State Highway Patrol (OSHP)**, local law enforcement, and **ODOT** work crews in reporting outages and malfunction of electrical traffic control devices. The **District** shall provide directions for reporting malfunctions twenty-four hours a day.

Upon becoming aware of a traffic signal malfunction (i.e., single red or yellow outage, power outage, signal on flash, and other malfunctions or damage as deemed necessary), the **District** shall be reasonably prompt in responding at all times, including outside normal working hours. Other repairs, especially green outages, may be made when practicable.

The **District** shall establish procedures for addressing malfunction responses. At a minimum these shall include:

1. If necessary, notify the **OSHP** or other appropriate law enforcement agencies, and ask for immediate assistance with traffic control until operation can be restored to a safe condition.
2. Assure that the signal is examined by a signal electrician or other qualified individual to verify that the signal was not damaged by the outage.
3. When a response is made to a reported traffic signal malfunction, the nature and time of malfunctions and corrective action taken shall be recorded.
4. All maintenance of traffic operations shall follow the requirements of the **OMUTCD** and **Part 6** of this Manual.

460-6 Record Retention

The **District** shall be responsible for retaining records on all traffic signal maintenance, installations, upgrades, transfers, and removals. These records shall be retained according to DAS record retention Schedule Number 17701678, which is viewable at the [website](#). These records shall include:

1. A description of all other signal maintenance, repairs, and inspections performed.
2. A current phasing diagram, current “as-built” plan, and current programming chart for coordination if necessary.
3. Documentation to reflect the history of the signals, shall also be maintained for each location. Copies of the original installation and each revision shall be retained either in paper or electronic form or both.
4. A recording of serial/unique number of controller and monitor, along with date the monitor was tested.

A current signal timing chart, current “as-built” plan, current programming chart for coordination if necessary, cabinet wiring diagram, and special function device diagrams in each controller housing and in the **District** office. If laptop computers are used instead of paper copies, a plan for updating all the signal electrician’s laptops shall be developed by the **District**.

460-7 Training

The **District** shall be responsible for training its personnel. The **Office of Training** and the **Office of Traffic Operations**, in cooperation with the **Districts**, will make the necessary classes and training available.

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temporary. Any of these could be considered as an individual step if the designer finds a need for specifically identifying the set up.

On complex, multi-year Maintenance of Traffic (MOT) Plans consideration may be given to identifying project stages, phases and/or steps.

640-4 Lane Closure

Roadway construction often requires a reduction in the number of available lanes. This may require only a reduction in lane width or it may require complete lane closure. Lane closure may be required not only of the lane in which the activity is taking place, but also an adjacent lane in order to provide a barrier or a buffer between the workers and the vehicular traffic.

When there is a need to perform roadway maintenance or reconstruction in the interior lane of a freeway, an adjacent lane shall be closed in addition to the lane in which the maintenance or reconstruction is necessary. This additional lane may serve to provide access to construction traffic or equipment, or it may serve as a lateral buffer, see [OMUTCD Figures 6H-37 and 6H-38](#). Caution is advised in the use of **Figure 6H-38**. Although this figure may be used to determine proper signing for splitting directional through movement, it does not provide for closure of the additional lane. Interior lane closure on **ODOT** projects shall be modified accordingly.

Before incorporating lane closures into the design of the MOT Plan, the effect of the lane closure on the traffic flow must be analyzed to insure that delay to the road users is kept within an acceptable range (*see Section 640-13*).

A minimum distance between adjacent lane closures should be provided. Suggested minimum distances are 2 miles in high-volume locations and 1 mile in low-volume locations. If the suggested distance cannot be provided, it is suggested that the lane closure be extended between the adjacent locations to form one continuous lane closure.

640-5 Use of Shoulders

640-5.1 General

Many maintenance of traffic situations require the use of either the full width or part-width of the paved shoulder as a traffic lane. Capacity, traffic characteristics, bridge width, work area location and existing shoulder characteristics all play a role in determining the extent of modifications and use of paved shoulders.

Any shoulder use for maintaining traffic requires evaluating the integrity of the shoulder pavement. The District Pavement Engineer and District Work Zone Traffic Manager shall be consulted in this evaluation. Engineering judgment should be used in making this evaluation. The designer should consider the percentage of truck traffic, duration of shoulder use, and the existing pavement condition, including the composition.

[Traffic SCDs MT-102.10, 102.20 and 102.30](#) are examples of use of the shoulder as a traffic lane.

640-5.2 Provisions for Use of Shoulders

When a shoulder is to be used as a traffic lane certain provisions shall be made:

1. Lane width, in accordance with **Section 640-2**, shall be maintained. This may require widening the existing shoulder.
2. The designer shall evaluate the strength of the shoulder and consider strengthening it or replacing it with temporary pavement.
 - a. Shoulders used for maintaining traffic, which are determined to be of insufficient

- strength, should be completely removed and replaced in accordance with the requirements of [L&D Manual Volume 1, Section 301.2](#) and the [Pavement Design Manual](#) (see *TEM Section 194-9*).
- b. Shoulders used for maintaining traffic, which are determined to be structurally sufficient, should also provide smooth travel. Provisions should be made to recondition shoulder surfaces that are rutted, raveled or otherwise insufficient.
 3. The designer shall examine structures to ensure that sufficient width and height are maintained.
 4. The designer should evaluate the roadside for obstacles which may require protection. Temporary protection may be required at obstructions that were not previously protected. In such a situation, the clear zone values for the facility under normal conditions ([L&D Manual Volume 1, Figure 601-1](#)) may be reduced by 12 feet, but shall never be reduced to less than 2 feet.

During any sequence of operations where traffic is to be maintained within 2 feet of the edge of the paved shoulder, the graded shoulder area adjacent to the paved shoulder should be strengthened. Item 411 aggregate placed a minimum of 6 inches deep, or a composition with similar structural characteristics, should be specified for 2 feet beyond the edge of the temporary traveled lane. This treatment should be placed in conjunction with final graded shoulder treatments when such shoulder use is required on final surface course pavements. This treatment may be left in place. When included, these items shall have separate notes and/or details as well as separate pay items.

Part-width use of shoulders may be required when either work or channelizing devices encroach upon the traveled lane adjacent to the shoulder.

Minimum clearance from existing obstructions may be reduced by 12 feet when traffic is shifted onto the shoulder.

640-5.3 Emergency Pull-Offs

The traffic control plan should address the need for emergency pull-offs throughout the work zone. This is important for all work zones, but is particularly critical on freeways, expressways, and multi-lane highways where access is limited. When shoulders are used to maintain traffic over long distances, consideration shall be given to providing emergency pull-off areas in order to minimize capacity reduction due to vehicle malfunction and provide space for work zone enforcement.

Emergency pull-offs shall be considered in work zones with a length of 3 miles or more without an interchange within the project limits, or in work zones with a length of 5 or more miles with an interchange within project limits. Emergency pull-offs may also be considered in work zones that do not meet the minimum specified criteria for length or interchanges. Signing for pull-offs shall be erected in order to provide advance notice to the road user of the emergency pull-offs. These signs should be rectangular in shape, with black legend on orange background.

In terms of work zone enforcement, emergency pull-offs shall be considered in work zones that are in close proximity to an airport. Airports can act as a conflict to the Air Speed Check Zones specified in **Section 642-47**. In work zones where Air Speed Check Zones are not possible due to conflicts with airport flight paths, emergency pull-offs can provide space for ground enforcement.

In addition to the number of emergency pull-offs per phase of a project, consideration should be given to the relocation of an emergency pull-off during the project as necessary to accomplish construction activities.

Acceptable locations for emergency pull-offs on freeways, expressways, and multi-lane highways with limited access shall be designed into the plans and laid out in accordance to the minimum requirements in PIS 2010350. See **Section 641-35** for additional information on PIS

2010350.

640-5.4 Existing Rumble Strips on Shoulders

Permanent, longitudinal rumble strips are often provided on freeway shoulders to alert the road user who diverts from the travel lane. Longitudinal rumble strips create a dilemma when providing lane-shifts in temporary traffic control zones. It may be necessary to remove or resurface longitudinal rumble strips when providing lane shifts. Or, if the temporary lanes can be aligned such that the wheels of the vehicles can straddle the rumble strip, it may be adequate to limit the rumble strip removal to the shift tapers.

640-5.5 Inlets on Median Shoulders

When a lane of traffic is shifted onto the median shoulder of an Interstate or expressway, special consideration should be given to temporary grade adjustments at inlets and the impact of drainage on a given corridor. The drainage requirements shall be in accordance to **L&D Manual Volume 2, Section 1010**.

640-6 Work Zone Drop-Offs

A pavement edge drop-off occurs when there is a vertical difference in height between adjacent road surfaces. Treatments for pavement edge drop-offs in construction work zones are shown on [Traffic SCD MT-101.90](#). The drawing may be used as a designer's tool for determining the appropriate measures to specify in the plans for treatment or protection of drop-off conditions. The designer may also use it to develop designs or sequences of operations that would avoid or minimize drop-offs.

The treatments indicated on the **SCD** are intended for high-volume projects. For low-volume situations, a one-level drop in protection may be used, e.g., use drums instead of PB. For low-speed situations, protection may not be needed. In all situations, engineering judgment should be used to select the most appropriate treatment for each work zone. (See **Section 605-5.13** and [OMUTCD Section 6F.44](#) for additional information.)

Maintenance of traffic **Plan Notes** should address the treatment of any anticipated open trench areas. Whenever possible, it should be stipulated that trench excavating operations will not remove any more material than can be replaced by the end of each day's work. In areas where this is not possible, or where adverse conditions prevent it, overnight trench openings shall be temporarily backfilled. See **Plan Notes 642-14 and 642-15** in **Chapter 642** for additional information.

640-7 Ramp Closure

640-7.1 Volume Considerations

In urban areas, consideration may be given to closing some entrance ramps. This can reduce the volume of traffic using the highway and minimize the negative effect on mainline traffic capacity caused by the ramp traffic merging onto the highway. Such closures could significantly improve traffic flow on the freeway; however, detours must be provided on the surface street system to handle the diverted traffic volume.

640-7.2 Geometric Considerations

Geometric conditions on ramps often make it difficult to perform work on the ramp while maintaining traffic. Consideration should be given to temporarily closing ramps and providing detours in such cases.

640-8 Detours

When a detour has been designated for a project (*see Section 602-6*), provisions must be made for erecting adequate Detour signing along with other appropriate traffic control devices. The plans shall specify all necessary detour traffic control in accordance with the **OMUTCD** and the **TEM** (also see related typical applications in **Chapters 607 and 698**). The plans shall provide the appropriate traffic control information, for installation by **ODOT** or the contractor (as specified by the District). On local or other projects where detour traffic control cannot be provided by the maintaining agency, the plans shall provide for installation by the contractor.

Reassurance Detour signing in rural areas should be erected at intervals not to exceed 2 miles. In urban areas, Detour signing should be spaced no more than two blocks apart.

640-9 Construction Access Points

The traffic control plan shall address the need for construction access to the work zone. This is important for all work zones, but is a particularly critical issue on freeways, expressways, and multi-lane highways with original posted speed limits of 45 miles per hour or greater in order to provide a safe means of interaction between project-related vehicles and the traveling public by providing dedicated areas outside the traveled lanes for the deceleration and acceleration of project vehicles. The designer must address the question of how to get equipment and material into and out of the work zone safely. The following should be considered:

1. Type of work zones likely to create ingress/egress problems (e.g., median work spaces that will require vehicles to merge into and out of high-speed traffic, work activities that require frequent delivery of materials such as paving projects).
2. Temporary acceleration and deceleration lanes for work vehicles should be provided.
3. The location of the construction access point should provide good sight distance for oncoming traffic while avoiding locations such as just beyond sharp horizontal curves and crest vertical curves, on overhead structures, on upgrades, within one-quarter mile in advance of an exit ramp or beyond an entrance ramp, etc.
4. In extreme conditions, lane closures may need to be considered.
5. Openings in barrier walls on multi-lane highways with original posted speed limits under 45 miles per hour, and on two-lane facilities shall be planned to ensure the ends are properly protected, and the barrier wall should not create sight distance issues.
6. Special warning signs may be necessary.
7. The use of Portable Changeable Message Signs may be considered.

The number of construction access points shall be kept to a minimum with consideration given to relocating the construction access points during the project as necessary to accomplish construction activities.

Acceptable locations for openings in barrier walls on freeways, expressways and multi-lane highways with original speed limits of 45 miles per hour or greater shall be designed into the plans and laid out as directed in **Traffic SCD MT-103.10**. See **Section 641-33** for additional information on **MT-103.10**.

640-10 Private Driveway Access

Except as noted herein, where private drives exist within the work area, access to the drives shall be maintained. It may be necessary to adjust the work procedures to work around the drives as much as possible and to provide temporary access to the drives when normal access cannot be provided.

At urban residential locations, access to residential driveways may be denied for a few hours at a time after adequate advance notice of closure has been provided to the residents of the property involved.

640-11 Temporary Roads**640-11.1 General**

A temporary road is any crossover, runaround, ramp, roadway, etc., whose sole purpose is to temporarily maintain traffic during construction. After construction is complete, temporary roads are typically removed.

Temporary roads are required when the existing roadway is inadequate to properly accommodate both the work and the traffic. They may also be required in certain cases where bridge construction or reconstruction does not facilitate part-width construction or realignment to the extent that the existing facility can serve as the temporary road. The use of runarounds and temporary structures in such cases shall be evaluated by the designer for cost-effectiveness and public service.

640-11.2 Design Speed

The design speed used in designing temporary roads shall be that which is discussed in **Section 640-18.1**.

640-11.3 Geometrics

The geometric design of temporary roads should be commensurate with the chosen design speed. Pavement design criteria are provided under **C&MS 615**. Typical roadway plans for temporary roadway are provided in **L&D Manual Volume 3, Figures 1306-6s and 1306-7s**.

The horizontal alignment of temporary roads shall comply with the criteria discussed in **L&D Manual Volume 1, Sections 202.1 and 202.2**. Superelevation of temporary roads is discussed in **Subsection 640-11.4**. Spirals are not required.

Crest and sag vertical curves on temporary roads should comply with [L&D Manual Volume 1, Section 203.3](#) using minimum criteria. Maximum allowable grades are the values shown in **L&D Manual Volume 1, Figure 203-1** under hilly terrain for the appropriate design speed.

Stopping sight distances shall meet or exceed the minimum criteria discussed in **L&D Manual Volume 1, Section 201.1** and pavement cross slopes shall be as discussed in **L&D Manual Volume 1, Section 301.1.5**.

The designer shall also ensure that vertical clearances in conformance with **L&D Manual Volume 1, Section 302.1** (existing structures to remain) are provided.

Additional general information regarding geometric design is provided in **Section 640-2**.

640-11.4 Superelevation

Except as noted in **Section 640-12**, superelevation on temporary roads should conform to the requirements shown in **L&D Manual Volume 1, Figure 202-8** for design speeds greater than or equal to 50 miles per hour and **L&D Manual Volume 1, Figure 202-9** for design speeds less than 50 miles per hour.

640-11.5 Lane Width

Lane widths of temporary roads should conform to the requirements discussed in **Section 640-2**.

Where horizontal curve geometrics are less than adequate for the temporary road conditions ($D_c > 10$ degrees), curve widening should be provided as called for in **Table 697-4**.

640-11.6 Guardrail Offset and Sideslopes

C&MS 615.04, permits a minimum guardrail offset of 1.5 feet and a maximum side slope of 1.5:1. These dimensions are appropriate for absolute minimum design, but design above these values should be provided when feasible. For design speeds over 40 miles per hour, a minimum shoulder width and guardrail offset of 6 feet is desired and 4:1 side slopes are desired where right-of-way is available.

Barrier placement along temporary roads shall conform to the appropriate requirements of **L&D Manual Volume 1, Section 600**.

640-11.7 Pavement

C&MS 615.05, provides Class A and Class B pavement designs for temporary roads. These designs are intended to be specified on projects with large traffic volumes where the proposed project pavement design is stronger than either of these two designs. A temporary road pavement should not normally be stronger than the permanent pavement design of the project.

For a temporary road pavement design that is weaker than Class A or B, the design should be based on the anticipated total equivalent 18-kip single axle-load applications and determined from information contained in the **Pavement Design Manual** published by the **Office of Pavement Engineering**.

For temporary road pavement that is to be used for a short time (less than two months) by moderate traffic volumes (2000 ADT or less), **C&MS Item 410** Traffic Compacted Surface, stabilized with **C&MS Item 616**, may be provided.

640-12 Crossover Construction

640-12.1 General

For general information regarding crossover construction, see **OMUTCD Section 6G.16 and Section 606-16**. Further detail information on traffic control for crossovers is provided in the following Sections and in **OMUTCD Figures 6H-39 and 6H-40, TEM Sections 607-12 and 607-13, Figure 698-3** and **Traffic SCDs MT-95.70 and MT-95.71**.

All temporary crossover areas shall be illuminated as shown on **Traffic SCD MT-100.00**, and the transition areas for temporary crossovers shall be delineated in accordance with **Traffic SCD MT-99.30**.

All temporary crossovers shall be removed at the completion of the current proposed work unless retention for future use is recommended and justified by the **District**. Any crossover which is to remain for future use or left in place without use between construction seasons shall be camouflaged with an earth overlay so that the crossover area appears as part of the normal median.

640-12.2 Traffic Separation

The use of breaks in the traffic separation runs, to permit access, should not normally be allowed. For unusual circumstances where breaks are necessary, each end of the barrier shall be protected by a temporary impact attenuator. Such breaks for access shall not be created for construction access.

640-12.3 Considerations for Reversed Flow

When a traffic diversion requires that two-way operation be maintained on a roadway which normally carries one-directional traffic, as is the case in crossover construction, the designer shall provide temporary barrier protection from hazards that are in the clear zone of the reversed movement. The designer should evaluate the project to ensure the proper barriers, bridge terminal assemblies, and guardrail end treatments, and to specify the appropriate changes or additions to barrier protection (**see Traffic SCD MT-95.82**). It is not necessary to

change the lap in the existing guardrail.

640-12.4 Crossover Geometric Design

For guidance on traffic control for crossovers, see **Section 640-12.1** and **Traffic SCDs MT-95.70, MT-95.71, MT-95.72, and MT-95.73**. **Figures 698-4 through 698-7** provide geometric detail information for two-lane crossovers. **Figure 698-12** provides geometric detail information for one-lane crossovers. For single-lane crossovers, decrease all pavement widths by 12 feet, providing one 12-foot lane with 3 feet of paved shoulder and 2 feet of aggregate shoulder on each side. Superelevation for these curves shall be limited to 0.016 sloped toward the inside of the curves. Variations in design due to mainline curvature will be considered on a case-by-case basis.

The plans should detail temporary crossovers, including locations, horizontal alignment, typical sections, profiles, and pavement transitions to the existing pavement.

Crossover locations should be very carefully selected with traffic needs being the primary consideration. A tangent section on flat terrain is the most desirable location for constructing a crossover. The designer should field check possible crossover locations to select the optimum site and not necessarily choose the project limits as their location. Crossovers should also be located away from interchange, rest area or other ramp decision points.

Regarding lane width on single-lane crossovers, there has been some debate in the past as to the proper width of the single lane. It was determined that this lane should be 12 feet wide, with 3 feet of paved shoulder and 2 feet of aggregate shoulder on each side. This provides for the same typical section as does the two-lane crossover design provided in **Figures 698-4 through 698-7**, except that the pavement width is decreased by 12 feet. In the past, this drawing called for a 16-foot lane, as is typical of a permanent single-lane ramp, with a 1-foot shoulder on each side. However, a 12-foot lane width is adequate for a properly designed single-lane median crossover and will contribute to providing uniformity in temporary work zone geometrics among **ODOT** work zones.

640-12.5 Considerations for Crossover Drainage

When removing barrier for the installation of a crossover, impacts to the existing drainage as well as potential conflicts with existing inlets should be evaluated. Additional guidance for drainage requirements during MOT Phasing is provided in **L&D Manual Volume 2, Section 1010**. A temporary slotted drain may be installed if the drainage requirements cannot be met in accordance with **L&D Manual Volume 2, Section 1010**; refer to **Hydraulic SCD DM-1.3**.

640-13 Capacity

640-13.1 General

Capacity restrictions shall be evaluated for each project. The capacity criteria below have been developed to assist in identifying when traffic volumes may cause delays and/or backups during construction phases.

1. On two-lane highways where the ADT is greater than 6,000 (two-way) or where the peak hour traffic is greater than 600 vph (two-way).
2. On multi-lane non-freeway/non-expressways (more than two lanes, divided or undivided) where the directional ADT is greater than 14,000 per lane of traffic being maintained, or where the peak hour traffic is greater than 1,400 vph per lane of traffic being maintained.
3. On freeways and expressways, where lane closures do not meet the minimum criteria presented in the Permitted Lane Closure Schedule (PLCS), discussed in **Sections 601-2 and 630-4**. Development of the PLCS is based on a simplified capacity calculation based on the Highway Capacity Manual.

When the capacity criteria is exceeded, the Procedures set forth in **ODOT Policy 21-008(P)** shall be followed. Mitigation measures should also be considered in preparing Maintenance of Traffic Plans. These include re-sequencing construction to allow additional lanes to be used, use of shoulders as traffic lanes, temporary pavement, providing additional advance Warning Signs, use of alternate routes and corresponding signing, use of Portable Changeable Message signs or detours, Work Zone Intelligent Transportation Systems, and night work. If there is a need to deviate from the PLCS provided for a specific location, the Lane Closure Queue Analysis Tool, discussed in **Section 640-13.2**, shall be used.

640-13.2 Queue Length Predictions for Freeways and Expressways

Apart from exception approval from the **Maintenance of Traffic Exception Committee (MOTEC)**, queue lengths on freeways and expressways shall not exceed the maximum thresholds set forth in **ODOT Policy 21-008(P)** (see **Section 601-2**). An analysis of traffic patterns within freeway and expressway sections shall be performed in order to develop maintenance of traffic strategies which attempt to meet these queuing thresholds. The queuing thresholds set forth in the **Policy** are as follows:

<u>Queue Length</u>	<u>Maximum Duration</u>
≤ 0.75 miles	Allowable
> 0.75 miles	Not allowable

The Lane Closure Queue Analysis Tool, was developed by Cleveland State University and has been adopted by ODOT to calculate queue lengths in work attributed to the reduction in available lanes. A copy of this spreadsheet and the user manual are available for downloading from the [Office of Roadway Engineering website](#).

The tool's final output provides length of queue and delay by hour of day.

640-14 Considering Holidays and Special Events

The designer should, in conjunction with the **District Work Zone Traffic Manager**, investigate the use of lane closure restrictions on Interstates and other freeways during holiday and other significant events.

The plan shall require the contractor to have all existing lanes (a number of traffic lanes equal to the existing highway) open to traffic during specifically designated periods. These requirements are in addition to the requirements identified in the Permitted Lane Closure Schedules discussed in **Section 630-4** and the requirements identified in **ODOT Policy 21-008(P)** (see **Section 601-2**).

Lane closure restriction schedules for urban locations may differ from schedules for rural locations. Where rural location would be expected to carry high traffic volumes during holiday weekends, some urban routes, such as radial freeway segments leading to a central business district, may be found to carry less traffic during holiday weekends. An analysis of traffic patterns shall be made to determine whether or not it is appropriate to restrict lane closures for designated periods including holiday weekends.

The designated "lane closure restriction" periods shall be identified in the plan and may include, but are not limited to:

1. National holidays and holiday weekends:

New Year's,
Memorial Day,
Fourth of July,
Labor Day,
Thanksgiving, and
Christmas.

2. Weekends with greater than normal travel:

- Easter,
Mother's Day, and
Other weekends, or periods, when regional travel is significant.
3. Periods involving local events having attendance greater than 75,000 persons per day or event, or a lesser attendance for events producing mass arrivals or departures, such as football games.
 4. Periods when snow accumulation is probable. During these periods daily isolated lane closures may be used during non-peak hours, weather permitting.

A "holiday weekend," for traffic maintenance purposes, begins at noon on the last normal weekday preceding the weekend. Traditionally, the "holiday weekend" has been considered to end at noon on the first normal weekday following the holiday; however, the designer should review the traffic patterns at the specific location. Traffic data shows that at many locations, the traffic on the following weekday morning is not significantly different from a typical weekday morning. In such cases it is suggested that the holiday weekend be considered to end at 6:00 AM or earlier to allow the contractor a full day of normal operation. A day between the holiday and Saturday or Sunday is considered part of the weekend.

Section 630-4 contains information regarding Permitted Lane-Closure Schedule (PLCS) which are intended for use in the scheduling of part-time lane closures.

640-15 Project Length Restrictions

Although **ODOT** has no written policy limiting the length of lane closures, consideration should be given to potential effects on traffic flow, and the potential negative public reaction to closures of extensive length. These factors are of concern primarily where only a single lane remains open in each direction of travel. In rolling to hilly terrain where underpowered vehicles tend to slow traffic flow, the length of one-lane operations should be minimized. In flat terrain, the length of reduced-lane operations is less critical; however, the designer should give consideration to the type of activities to be performed, and what effect these activities might have on traffic movement. Access to accident sites by tow trucks and emergency vehicles on one-lane operations may become especially difficult if concrete barrier is present on both sides of the lane. Sections of open roadway between adjacent lane closures should meet the lengths suggested in **Section 640-4**.

The public reacts negatively to seeing lane closures in areas of no activity. To avoid such situations on projects of considerable length, it may be desirable to concentrate activity in one section of the project at a time, and to minimize the lengths of lane closures accordingly. On multi-year projects, concentrating work in a portion of the project each construction season may allow an added benefit of opening the entire highway during the inactive winter months.

The designer should not overlook the advantage of scheduling adjacent corridor improvements simultaneously, if this would minimize the time period for inconveniencing road users. For example, two adjacent projects, requiring only one season each to construct, could be constructed in the same construction season (rather than in consecutive seasons) to minimize the inconvenience to one season rather than two.

640-16 Work on Detour and Alternate Routes

Work along designated detours and alternate routes is strongly discouraged. These routes carry volumes which may be significantly increased over the volumes carried under normal conditions. The potential for traffic queue development would be greater than if the work were performed prior to implementation, or following elimination, of the detour or alternate route.

Work along a designated detour or alternate route can also create a negative public response. Under such conditions the road user would be directed around one construction project, only to be directed through another one. See **Section 640-17** regarding project coordination.

640-17 Coordination with Adjacent Projects

Coordination of signing between adjacent projects is recommended in order to minimize presenting misleading information to the road user. If proper location of advance signing for one project results in this signing being located within the limits of another construction project, then consideration should be given to treating the two projects as one project for the purpose of signing.

For more information about coordinating speed reductions and increased fines policies, see **Sections 600-2, 605-4.2, 640-18.2.5 and 640-18.3.**

640-18 Speeds in Work Zones**640-18.1 Design and Advisory Speeds**

The design speed for maintaining traffic through a construction zone should remain at the original posted legal speed limit, except as indicated in **Section 640-18.2.3**. If necessary, reductions in design speed should be accomplished gradually, in increments of 5 or 10 miles per hour. Sudden changes in design speed and the related geometrics should be avoided. With the October 2015 changes in **Section 640-18.2** more projects will need to be designed to the original posted speed limit, rather than a work zone speed limit. For point locations that cannot be designed to the original posted speed limit, advisory speed signing should be considered for use.

Advisory speed signing (W13-1P) should be provided in accordance with [OMUTCD Sections 2C.08 and 6F.52](#) and **TEM Chapter 641**.

Where design speed becomes an issue on ramps in relation to maintenance of traffic in work zones, a reduced ramp design speed limit can be used as provided in [L&D Manual Volume 1 Section 503.2 and Figure 503-1](#). Ramp design speeds used from this table shall be limited to those classified as Upper Range speeds.

640-18.2 Speed Limit Reductions**640-18.2.1 General**

Any portion of a work zone with an approved speed limit reduction is considered to be a Work Zone Speed Zone (WZSZ). As noted in **Section 1203-2.9**, the standard WZSZ process applies to work zones located on multi-lane highways with a pre-construction speed limit of ≥ 55 mph and with a work zone condition at least 0.5 mile in length that reduces the existing functionality of the travel lanes or shoulders (as defined in **Section 1203-2.9.1**) and has an expected work duration of at least three hours. If the work zone meets these minimum criteria, it should be analyzed to determine if it qualifies for a work zone speed limit reduction using the process established in **Chapter 1203** and **Table 1297-7**. Research completed by **Texas A&M Transportation Institute** titled "Evaluation of Ohio Work Zone Speed Zones Process" conducted for **ODOT** in July of 2014 indicates that motorists will only reduce their speed if they clearly perceive a need to do so.

Depending on the original posted speed limit, the type of temporary traffic control used (with or without positive protection), and whether or not workers are present, a warranted WZSZ will vary in the approved speed limit to be posted over time. In other words, all WZSZ are variable in nature and all WZSZs will frequently fluctuate between two approved reduced speed limits or between an approved reduced speed limit and the original posted speed limit. One of two signing strategies may be used to implement a WZSZ. The primary signing strategy uses Digital Speed Limit (DSL) Sign Assemblies. The secondary strategy uses traditional temporary flatsheet Speed Limit signs (R2-1). The designer must indicate the signing strategy selection by inclusion of the appropriate pay item (only one pay item to be included, not both).

640-18.2.2 Process

The overall process for Speed Zoning is addressed in **Chapter 1203**. **Section 1203-2.9**, **Figure 1298-1** and **Table 1297-7** address the specific process, guidelines and forms used for review and approval of a Work Zone Speed Zone (WZSZ) on high-speed multi-lane highways. **Section 1203-2.9.1** addresses general information about WZSZs.

Work zone speed limit revisions for construction projects should be completed during the design phase (**see Section 1203-2.9.2**). However, requests for WZSZs may also be initiated during the construction phase if the need for one was not determined during the design phase, or if new conditions have been identified that subsequently warrant their implementation (**see Section 1203-2.9.3**). WZSZs for operations/maintenance work are addressed in **Section 1203-2.9.4**.

640-18.2.3 Guidelines

Whenever an approved WZSZ is implemented, the design speed for the layout of the temporary traffic control devices (TTCD) shall remain at the original posted speed limit on initial approaches to the work zone. Within the work limits, the design speed should match whichever speed limit is in effect at the time and location. This means that the placement of the TTCDs shall either be adjusted each time the speed limit is changed or, if adjustment is unreasonable, the more conservative design speed parameters must be used. For example, the higher speed limit is used for the taper rates, buffers, clear zone, etc.; and the lower speed limit is used for the device spacing, etc.

The WZSZ shall be limited to only the portion of the project and the work that warranted the work zone speed limit reduction. **See Section 1203-2.9.1** for details.

When the work zone condition no longer reduces the existing functionality of the travel lanes or shoulders (as defined in **Section 1203-2.9.1**), the speed limit shall return to the original posted speed limit.

The two directions of a divided highway are considered separate highway sections (see **C&MS Item 614.02(B)**). Therefore, if the work on a multi-lane divided highway is limited to only one direction, a speed reduction in the direction of the work does not automatically constitute a speed reduction in the opposite direction. Each direction shall be analyzed independently.

When a work zone qualifies for a speed limit reduction, **Plan Note 642-24 (Section 642-24)** and **Traffic SCD MT-104.10 (Section 641-34)** shall be included in the plans. The **Plan Note** shall document the WZSZ Revision Number. If DSL Sign Assemblies will be used to implement the WZSZ, **Supplemental Specifications (SS) 808** and **908** shall also be included in the plans.

When the need for the WZSZ has ended, it shall be withdrawn in accordance with the procedures described in **Section 1203-4** (Withdrawal of Authorization).

640-18.2.4 Overall Signing Requirements

The WZSZ is not in effect and enforceable until all of the existing Speed Limit signs within 1 mile in advance of and inside the WZSZ are removed or covered, and the WZSZ Speed Limit signs are in place with the appropriate legends displayed. Legends reflecting a speed limit in accordance with **Table 1297-7** shall only be displayed when the work zone condition in place reduces the existing functionality of the travel lanes or shoulders. At all other times (when the work zone condition no longer reduces the existing functionality of the travel lanes or shoulders) the original posted speed limit shall be displayed.

The research indicates that to be effective the initial WZSZ Speed Limit signs should, generally, be located such that the driver can see the work and thus recognize the need to slow. Therefore, the first WZSZ Speed Limit sign(s) should be located in advance of the warranting work zone condition by approximately 500 feet on freeways and expressways, and approximately 250 feet on major conventional highways (**see Traffic SCD MT-104.10**).

The VARIABLE SPEED LIMIT AHEAD (W3-H5b) sign shall be used to warn of the upcoming WZSZ (**see Section 605-6.4**). It should be placed approximately 1,250 feet in advance of the first reduced speed limit sign (DSL Sign Assembly or temporary flatsheet Speed Limit sign) on freeways and expressways, approximately 500 feet on major conventional highways, and on each open entrance ramp within the WZSZ.

A temporary flatsheet Speed Limit sign (applicable R2-1, R2-H2a, etc.) indicating resumption of the original posted speed limit shall be erected 300 feet downstream from the point where there is no longer the work zone condition that warranted the speed limit reduction.

640-18.2.5 Adjacent Projects and Speed Zones

Whenever a reduced speed limit is to be used within a section that has more than one original posted speed, the areas should be evaluated as separate sections. If there is not enough room (lengthwise) to implement the separate WZSZs, consideration may be given to lowering consecutive work zone speed zones to the lower approved work zone speed limit.

Where adjacent projects exist, any WZSZs shall be coordinated. If the distance between the limits of the WZSZs on the separate adjacent projects is less than 1 mile, then the upstream work zone shall omit the temporary flatsheet Speed Limit sign indicating the resumption of the original posted speed limit at the end of the WZSZ.

640-18.2.6 Work Zone Speed Zones (WZSZs) Using Digital Speed Limit (DSL) Sign Assemblies

As noted in **Section 1203-2.9.1**, **Table 1297-7** is used to determine if a work zone qualifies for a standard WZSZ based on the presence of specific work zone conditions and factors.

See [Traffic SCD MT-104.10](#), **Plan Note 642-24**, **SS 808** and **908** for the requirements and proper use of Digital Speed Limit (DSL) Sign Assemblies. As noted in **Section 640-18.2.1**, DSL Sign Assemblies are the preferred method for implementing a WZSZ. If temporary flatsheet Speed Limit signs are used to accomplish a WZSZ (if no DSL Sign Assemblies are on the [Approved List](#) or are not available), see **Section 640-18.2.7**. For WZSZs using temporary flatsheet Speed Limit signs, the speed limit displayed will still need to be appropriately changed per **Table 1297-7** as the work zone conditions and factors change. The designer must indicate the signing strategy selection by inclusion of the appropriate pay item (only one pay item to be included, not both).

The DSL Sign Assemblies should be repeated every 1 mile. They should also be placed immediately after each open entrance ramp (or intersection) within the WZSZ but beyond the ramp lane merge taper if applicable.

WZSZs shall not be used for Moving/Mobile activities, as defined in **OMUTCD Part 6**.

All qualifying projects (construction or maintenance) using WZSZs with DSL Sign Assemblies shall use **Plan Note 642-24**, **SS 808**, **SS 908** and [Traffic SCD MT-104.10](#).

[Supplement 1108](#) and **SS 908** establish the criteria for inclusion on **ODOT's Approved List for DSL Sign Assemblies**. DSL Sign Assemblies furnished on **ODOT** projects shall be on **ODOT's** Approved List.

Detailed and accurate tracking information regarding the use of each DSL Sign Assembly is necessary to provide a historical record of what specific speed limits were in effect at which location and which date/time. This documentation is to be provided on **Form 1296-18**. (Note that the DSL Sign Assemblies are not able to electronically provide the necessary

information. This information will need to be populated by the user on the separate form as the speed limits changes occur in the field.)

Speed feedback signs are not regulatory devices and shall not be used within the project limits of a project with a WZSZ using DSL Sign Assemblies. Use of both devices may lead to driver confusion or may negatively impact the compliance of the regulatory DSL Sign Assemblies.

640-18.2.7 Work Zone Speed Zones (WZSZs) Using Temporary Flatsheet Speed Limit Signs

As noted previously, **Table 1297-7** is used to determine if a work zone qualifies for a standard WZSZ based on the presence of specific work zone conditions and factors.

See [Traffic SCD MT-104.10](#) and **Plan Note 642-24** for the requirements and proper use of temporary flatsheet Speed Limit signs to accomplish WZSZs. This signing strategy is available for use if no DSL Sign Assemblies are on the [Approved List](#) or are not available. For WZSZs using temporary flatsheet Speed Limit signs, the speed limit displayed will still need to be appropriately changed per **Table 1297-7** as the work zone conditions and factors change. The designer must indicate the signing strategy selected (DSL Sign Assemblies or temporary flatsheet speed limit signs) by inclusion of the appropriate pay item (only one pay item to be included, not both).

The temporary flatsheet Speed Limit signs (R2-1) shall be changed to display the appropriate warranted speed limit no earlier than 1 hour before workers arrive and no later than 1 hour after workers depart from a warranted work zone condition.

The temporary flatsheet Speed Limit signs shall be repeated every 1 mile for WZSZs for Freeways and Expressways and every 0.5 mile for WZSZs on Major Conventional roadways. The signs shall also be erected immediately after each open entrance ramp (or intersection) within the WZSZ but beyond the ramp lane merge taper if applicable.

WZSZs shall not be used for Moving/Mobile activities, as defined in [OMUTCD Part 6](#).

All qualifying projects (construction or maintenance) using WZSZs with temporary flatsheet Speed Limit signs shall use **Plan Note 642-24** and [Traffic SCD MT-104.10](#).

Detailed and accurate tracking information regarding the use of each temporary flatsheet Speed Limit sign is necessary to provide a historical record of what specific speed limits were in effect at which location and which date/time. This documentation is to be provided on **Form 1296-18**.

640-18.3 Work Zone Increased Penalty Signs (R11-H5a)

The Work Zone Increased Penalty sign can be used to address speeding concerns on projects independent of work zone speed zones. See **Section 605-4.2** for details on the use of these signs. When these signs are used on a project **Plan Note 642-27 (Section 642-27)** shall be included.

640-19 Law Enforcement Officers (LEOs)

640-19.1 Law Enforcement Officers (LEOs) for Assistance During Construction Operations

Law enforcement officers (LEOs) with patrol cars are effective for slowing traffic speed through work zones. Their use shall be specifically identified in the construction plans. Their primary purpose is to ensure the safe, efficient and orderly movement of traffic. They are not to be used for the convenience of the contractor at project cost.

In general, LEOs should be positioned in advance of and on the same side as the lane restriction (or at the point of road closure), and to manually control traffic movements through intersections in work zones.

For lane closures, the use of LEOs should be required during: initial set up periods, tear down periods, substantial shifts of a closure point or when new lane closure arrangements are initiated; and for operations without positive protection occurring within 10 feet of an open traveled land that meet all of the criteria listed within **Plan Note 642-55**. Use of LEOs is required during: the entire advance preparation and closure sequence where complete blockage of traffic is required; and during traffic signal installation when impacting the normal function of the signal or the flow of traffic, or when traffic needs to be directed through an energized traffic signal contrary to the signal display. LEOs should not be used where the [OMUTCD](#) intends that flaggers be used.

Use of LEOs by contractors other than the uses specified above shall not be permitted at project cost.

State Highway Patrol Officers may be specified on rural Interstate projects.

For additional information, see **Plan Note 642-55** in **Chapter 642**.

640-20 Temporary Traffic Control Devices

The design and application of standard traffic control devices for temporary traffic control zones are addressed in [OMUTCD Part 6](#), **TEM Chapters 605, 607, 641 and 642**, the [Traffic SCDs](#) and in [C&MS 614.04](#).

640-21 Removal of Logo (Specific Service) Signs and Tourist-Oriented Directional Signs (TODS)

The Ohio Business Logo Sign Program, also known as the Specific Service Sign Program, permits eligible businesses which provide fuel, food, lodging, camping or attraction services to road users to have their Logo Sign Panels placed on Specific Service Signs. Mainline Logo Sign Panels are placed in advance of eligible interchanges, and directional Logo Sign Panels are placed along the exit ramps. The Logo Sign Program is operated by a private company (**Program Manager**) under contract with **ODOT**. See **Section 207-2** for more information on the Logo Sign Program.

Information regarding removal, temporary re-erection, and permanent re-erection of Logo Signs and Tourist-Oriented Directional Signs due to construction and maintenance activities is addressed in **C&MS 614.07 and 630.09**.

640-22 Temporary Lighting

For guidance in the use of temporary lighting for crossovers, see [Traffic SCD MT-100.00](#) and **Plan Note 642-35 (Section 642-35 in Chapter 642)**. For floodlighting see **Plan Note 642-29 in Chapter 642. Part 11** of the **TEM** provides additional guidance for general lighting design principles.

See **Plan Note 642-39 in Chapter 642** for when temporary traffic signals are provided for closing one lane of a two-lane highway.

If a project requires illumination for special situations, the [Office of Roadway Engineering \(ORE\)](#) should be contacted for design guidance.

On contract work, the contractor is responsible for obtaining power for temporary lighting. Power shall not be obtained from an existing nearby highway lighting system.

640-23 Traffic Incident Management (TIM) During MOT

Ohio TIM is the state's traffic incident management program composed of several agencies, including ODOT, local and state law enforcement agencies, Fire, EMA, and towing and recovery services. These agencies work together to safely and efficiently clear traffic incidents on Ohio highways. More information regarding this program can be found at www.OhioTIM.com.

During MOT on certain projects, there is a need for enhanced coordination and planning between the contractor, the project engineer and the Department to effectively implement TIM. **Plan Note 642-45** shall be included on projects meeting the criteria indicated in the associated Designer Note in order to define the contractor's role in TIM during MOT.

See **Section 608-2** for Department duties and responsibilities regarding TIM During MOT on applicable projects. See **Construction Administration Manual of Procedures (MOP), 614 Maintaining Traffic** for ODOT Project Engineer specific duties and responsibilities regarding TIM During MOT on applicable projects.

640-24 Disincentives

640-24.1 Requirements/Guidelines

Disincentives may be assessed against the contractor for failure to complete his work on schedule. They may also be assessed for failing to reopen a closed lane within an allowable timeframe. The disincentives should be based upon costs incurred by the public as a result of the contractor's delay in completing the project. Various methodologies are available for analyzing the cost incurred by the public depending on the specific circumstances.

640-24.2 Lane(s) Closed on Mainline

To ensure consistency in the application and calculation of disincentives associated with lane restrictions on roadway segments within the Permitted Lane Closure Schedule (PLCS), all projects with work limits located on these highway segments shall utilize the "Lane(s) Closed on Mainline" tab in the Road User Cost Spreadsheet to determine the appropriate disincentive rate. This spreadsheet is located on the [Office of Construction Administration](http://www.odot.ms2soft.com) website at the bottom of the page under "CPM Scheduling". The disincentive rate shall be added to the plans via Proposal Note 127 – Lane Value Contract.

This method for calculating a disincentive rate assigns a value per minute to each lane based on AADT, percent trucks, the number of through lanes and utilizes an established User Cost for Passenger Cars and Commercial Vehicles.

To find the appropriate disincentive rate, provide the Construction Calendar Year, the AADT, the percent trucks and the lanes per direction in the corresponding cells. The AADT, percent trucks and lanes per direction can be found in a combination of the PLCS and the [odot.ms2soft.com](http://www.odot.ms2soft.com) website.

On occasion, there may be roadway segments not shown on the PLCS where the district has determined based on experience that the lane restrictions during certain hours result in excessive delay/queuing. If the district chooses to identify these areas in the construction plans, the disincentive shall be calculated in the same manner.

640-24.3 Detour

When all lanes are closed and a detour is required, use one of the two available "Detour" tabs in the Road User Cost Spreadsheet to determine the cost of the additional delay to the road user as a result of the closure and detour.

The average delay cost per day that is calculated by the detour tab in the Road User Cost Spreadsheet, or some lesser amount, may be used as the incentive/disincentive amounts in innovative contracting methods such as Incentive/Disincentive (PN 121) and A + B Bidding (PN 124, PN 125).

640-24.4 Other Considerations

Additional ways to motivate Contractors to provide quality transportation facilities while minimizing travel delays and maintaining a competitive bidding process are considered Innovative Contracting methods and include Lane Value (PN 127), Incentive/Disincentives (PN 121), and A + B Bidding (PN 125). Guidelines on use of these concepts is presented in the Compendium of Traffic Control Options in Section 630-2 and Tables 697-1a through 697-1f.

The Lane Value concept calls for the contractor to be charged for keeping a lane closed longer than called for in the plans.

The incentive/disincentive concept is typically applied to the completion of a phase of a project.

With A + B Bidding, the contractor bids on the cost of the project and on the time required to complete the project.

The Innovative Contracting Manual contains additional information on all of these methods. This manual is maintained by the Office of Construction Administration.

640-25 Pedestrian Considerations

Planning and design for maintaining pedestrian traffic should consider both the characteristics of that traffic and the type of construction activities. An analysis of trip origins, destinations and travel paths is useful for providing adequate temporary facilities. Also see [OMUTCD Chapter 6D](#) for additional information about accommodating pedestrians in temporary traffic control zones.

Pedestrian accommodations within work zones should be provided: where sidewalks existed prior to construction; where the work zone is located along a route to a school or park; where there is evidence of pedestrian usage (where well-worn paths exist, for example); or where existing land use generates pedestrian traffic.

In residential and commercial areas, adequate pedestrian access should be provided to properties abutting a work zone.

Use of increased pedestrian crossing times at signalized intersections (based on a walking speed of 3.5 feet per second) may be necessary, particularly in locations where the percentage of elderly pedestrians is expected to be significant. See **Section 603-2** for additional information on pedestrian issues that should be considered.

The following general principles should be followed when designing pedestrian facilities:

1. If a sidewalk or bridge that carries pedestrians is closed, provide a temporary walkway (concrete or asphalt) around the work area or direct the pedestrians to an alternate route. Do not force pedestrians to walk through the work area or into traveled lanes.
2. Passageways for pedestrians, especially elderly and disabled, should be well defined and safe for use by these groups. Ramps should be provided for access to streets.
3. All signs or devices should be set up so that they do not cause a hazard for pedestrians. All signs mounted near or over sidewalks should have a minimum 7 foot vertical clearance.
4. Minimum width of walkway shall be 5 feet. Wider walkways are required in areas of high pedestrian activity.
5. Pedestrian walkways shall be free of any obstructions or hazards (holes, debris, mud, etc.). It is especially important to cover or repair any holes and to have broken or damaged sidewalks repaired quickly.
6. Lighting should be provided for temporary walkways if the existing facility was lighted.

7. Fixed walkway and canopy-type pedestrian protection should be provided in the case of long-duration building projects involving construction, demolition and repair activities located close to the street.
8. The design of a temporary pedestrian structure shall be approved by the [Office of Structural Engineering](#). The following criteria shall be used:
 - a. Live Loading - 85 psf
Maximum Allowable Live Load Deflection - $1/800$ of the span with no allowable increase for temporary structure.
 - b. Minimum Width - 5 feet face to face of railing.
Railing - 5 feet high with chain link fence fabric.

[Traffic SCD MT-110.10](#) provides detail for maintaining or detouring pedestrian traffic. However, it is the responsibility of the designer to provide site-specific detail when necessary. For example, although **MT-110.10** (in Note 5B) calls for a maximum grade of 5 percent and a maximum cross slope of 2 percent for temporary walkways, there could be specific locations where the profile of the existing street and sidewalk are at 5 percent or greater. In such a case, the designer should specify in the plans the appropriate criteria to be applied at the specific site. It is suggested that under conditions where pedestrians are detoured into the curb lane, the elevation of the temporary walkway be raised to that of the sidewalk in order to eliminate the need for ramps between the sidewalk and the roadway elevations.

640-26 Advance Work Zone Information Signs

Advance work zone information signs may be required as part of the maintenance of traffic plan for major construction projects. Their need is usually determined by the **Corridor Traffic Management Team** during their review of the project. These signs are fixed message types and advise the road user of alternate routes, possible delays, etc. The signs are generally located at extreme distances from the work area.

To ensure uniformity in the design and application of these signs, the following guidelines will apply:

1. These signs shall be shown in the plans whether supplied by the contractor or by others. This choice shall be clearly indicated in the plans. The normal procedure is for the contractor to provide the signs.
2. The location of the signs shall be field checked by the designer to ensure that there are no conflicts with existing features or with other signs in the area. The designer will assure that signs are not blocked by being too close to other signs and that the motorist has sufficient time to read, understand and act on the information provided by all the signs.
3. The plans shall indicate the legend, level and size of the signs. The signs shall be considered Supplemental Guide Signs as described in the [OMUTCD Section 2E.35 and Tables 2E-2 and 2E-4](#). The signs shall be black on orange, including a black border. The layout shall conform to the [OMUTCD](#) and [SDMM Appendix C](#).
4. Where appropriate, advance work zone information signs shall make use of the same exit numbers, route numbers, directions and destinations as shown on the permanent Guide Signs.
5. In some instances, instead of providing separate installations, it may be desirable to modify existing overhead Guide Signs. These changes are accomplished by providing black-on-orange overlays to cover portions of the existing signs. Letter size on these overlays should be the same as on the existing signs. When lane arrows are to be covered, a blank overlay should be placed over each of the affected arrows. When a ramp is being closed, rather than using a blank overlay to cover the entire sign, the legend "EXIT CLOSED" (W20-H15) should be used on a diagonal overlay (lower left to upper right) on the sign. The size of lettering on overlays and the size of the overlay shall be indicated in the plans. The minimum letter size for the diagonal "EXIT CLOSED" (W20-H15) overlay shall be 12" C.
6. When regulatory information is provided, it shall be displayed separately as a standard black-on-white sign. Mixing of black-on-white regulatory information on a black-on-orange information

sign is prohibited.

7. If the road user is being detoured or if an alternate route is provided, the route should be signed with assemblies consisting of the appropriate black-on-orange (DETOUR or ALT) marker with a standard Route sign and arrow plate (see [OMUTCD Sections 2D.32 and 6F.59](#)). If more target value is desired, this trailblazer information may be shown on an orange panel, M2-H3 type (see [SDMM Chapter 4d](#)).
8. Route Sign assemblies shall be sized according to the type of road on which they are located in accordance with the [OMUTCD](#).
9. Supports for sign installations shall conform to all existing standards for permanent signs. These signs should not be attached to existing supports.
10. All advance work zone information sign installations located outside of the project work limits shall be paid for under appropriate [C&MS 630](#) items (signs, supports, concrete, breakaway connection, overlay, removal, etc.). This requirement does not apply to advance Warning Signs or to sign installations within the work limits.

640-27 Retiming of Existing Traffic Signals

Work Zones can affect the normal operation of signalized intersections. In these cases, the MOT plans shall provide updated signal timing to accommodate the new traffic volumes and patterns caused by the work zone at ALL of the signals impacted by the work zone, without regard to their proximity to the physical work.

The following are typical situations that will require the MOT plans to provide signal timing:

1. On arterial streets or ramps where the number of lanes or lane use has been altered by the work zone;
2. Significant volume or traffic pattern changes caused by the work zone (e.g., closure of a ramp or street);
3. Along routes which are designated as detour or alternate routes;
4. Where temporary signals are used.

It is the intent of this requirement for the project plans to provide signal timing to accommodate the traffic impacts caused by work zones for each construction phase. Where the affected signals are part of a coordinated signal system, the MOT plans shall provide revised coordination timing plans (i.e., not just local timing parameters). In the case of a coordinated signal system, all of the signals in a system shall be provided updated coordination timing without regard to their proximity to the physical work zone. The number of coordinated timing plans shall match the number of plans being used prior to the start of the construction project.

For isolated (i.e., non-coordinated) traffic signals that are impacted, as described above, new local timing plans shall be provided for each construction phase.

640-28 Freeway/Expressway Termination ("Permanent")

Occasionally there may be a need for "permanent" termination of a freeway/expressway. Such termination will be located at an interchange, forcing all traffic to exit at that point. This is not a work zone. Such a condition differs from that which is discussed in **Section 641-19** in that this termination point would be somewhat "permanent." Construction of a section of new roadway may have been built and open to traffic while the adjacent section of roadway is not yet built and may not be built for several years, if at all.

If it is expected that the construction of a section of new highway will create such a condition upon completion, it will be the responsibility of the designer to address this condition in the permanent traffic control plans for the project.

The designer may use [Traffic SCD MT-99.50](#) as a guide to develop the permanent traffic control plan at such location. Taper rates for lane closures and shifts shall be as shown in **MT-99.50**. Advance signing shall be by use of extrusheet Guide Signs as shown in **MT-99.50**. However, the arrow boards and portable changeable message signs shown in **MT-99.50** will not be appropriate for use in this or any other permanent traffic control condition.

Use of drums in permanent situations is not appropriate. A section of pavement which is to be permanently closed shall be separated from the open traveled lanes by use of PB. The PB shall be located parallel to and offset approximately 4 feet from, the edge line along the shifting taper. Upstream from the shifting taper, the PB shall be continued at the same taper rate as the shifting taper.

Where the PB is located parallel to and within 5 feet of the traveled lane, object markers shall be provided on the PB at 50-foot spacing.

Any pavement between the edge line and the PB shall be marked with transverse lines at 100 foot spacing. It is recommended that raised pavement markers be provided along the edge line where the PB does not run parallel to the edge line.

The designer should keep in mind that, as this is not a work zone, orange is not generally an appropriate color for any traffic control devices under such conditions. For example, barricades, under such conditions, shall contain red and white diagonal stripes rather than orange and white.

640-29 Work Zone Intelligent Transportation Systems

640-29.1 Work Zone Queue Detection Warning System

A Work Zone Queue Detection Warning System (WZQDWS) may be used on projects to detect queues through the project area. The systems utilize non-intrusive traffic sensors in order to detect slow moving traffic and warn upstream drivers via Portable Changeable Message Signs (PCMS). WZQDWS are recommended for use in locations where there is potential for queuing and are required for some locations with an approved MOT Exception.

There are two classes of WZQDWS. Class I devices are more sophisticated devices meant to be used in long term work zones. The Class II systems are meant for short duration projects and for use in operations such as nightly lane closures.

A WZQDWS plan must be prepared as part of the design process and shall include a detail showing the proposed locations of all WZQDWS devices. Note any changes that could be necessary due to stage changes or other factors relating to the project.

For a lane closure application, it is recommended to use a sensor at the beginning of the taper, a sensor at 0.5 miles from the taper, a sensor at 1 mile from the taper, and then sensors spaced at 1 mile from there. For all other applications 0.5 miles, 1 mile, or a combination or 0.5 miles and 1 mile sensor spacing is recommended depending on the expected queueing. For all applications, there should be at a minimum one PCMS for every four sensors.

All projects using WZQDWS shall use **Plan Note 642-57** and [Supplemental Specifications 896 and 996](#).

640-29.2 Work Zone Egress Warning System

A Work Zone Egress Warning System (WZEWS) should be used on any project that has construction egress points as detailed in Maintenance of Traffic Standard Construction Drawing (SCD) MT-103.10. The systems utilize non-intrusive traffic sensors in order to detect construction vehicles as they drive into Opening B of SCD MT-103.10 and warn upstream drivers via a WZEWS Sign Trailer.

All projects using WZEWS shall use **Plan Note 642-59** and [Supplemental Specifications 829 and 929](#).

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lane, and delineation. It is important for the designer to anticipate the general need for construction access and identify within the plans acceptable locations that facilitate the ability to utilize construction access points per [Traffic SCD MT-103.10](#). The location of the access points needs to be considered when developing project staging since the pavement within the access area typically cannot be replaced while actively being used as a construction access point. The number of construction access points shall be kept to a minimum; however, they may be relocated during the project as necessary to accomplish construction activities.

641-34 Work Zone Speed Zones for High-Speed (≥55 MPH) Multi-Lane Highways (MT-104.10)

The process for review and approval of Work Zone Speed Zones is addressed in **Section 1203-2.9**. Based on criteria discussed in **Sections 1203-2.9 and 640-18**, some construction projects may warrant a Work Zone Speed Zone (WZSZ). [Traffic SCD MT-104.10](#) and **Plan Note 642-24** shall be used on qualifying projects that are approved to use a WZSZ. WZSZs using DSL Sign Assemblies also require the use of [Supplemental Specifications 808 and 908](#).

641-35 Emergency Pull-Offs (PIS 2010350)

Emergency pull-off considerations are addressed in **Section 640-5.3**. When emergency pull-offs are used on projects, PIS 2010350 shall be included in the plans.

It is important for the designer to anticipate the general need for emergency pull-offs and identify within the plans acceptable locations that facilitate the ability to utilize emergency pull-offs per PIS 2010350. The location of the emergency pull-offs needs to be considered when developing project staging since the pavement cannot be replaced while actively being used as an emergency pull-off. The number and spacing of emergency pull offs shall be in accordance to PIS 2010350; however, they may be relocated during the project as necessary to accomplish construction activities.

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required mitigation measures.

In the event that more than one MOT Exception was approved for a particular project, include each one as a separate item in the list in the second paragraph along with the respective MOT Exception approval dates. In addition modify the last sentence of the fourth paragraph to list the references for each individual approved MOT Exception.

The minimum number of calendar days the maintenance of traffic meeting is to be held prior to the implementation should be as determined by the **District**. If the minimum number of days specific to the project cannot be determined, the default minimum number of days shall be 30.

For additional information see **Sections 601-2, 601-3, 630-4 and 640-13**.

642-33 Extra Advance Warning Signs (Note A)

An Extra Advance Warning Sign Group consists of two W20-1 (ROAD WORK AHEAD) signs, two W20-5 (RIGHT /LEFT LANE CLOSED AHEAD) signs with W16-3a Distance plates, and two W3-H7 (WATCH FOR STOPPED TRAFFIC) signs and required warning lights.

The Contractor shall provide, erect, maintain and remove Extra Advance Warning Sign Groups as shown on Traffic SCD MT-95.50 at the following distances in advance of the lane tapers with the appropriate W16-3a distance plates:

- 1) Lane Taper No. _____, Station _____, Phases _____ & _____; provide sign groups at _____ miles _____ miles and _____ miles.
- 2) Lane Taper No. _____, Station _____, Phases _____ & _____; provide sign groups at _____ miles, _____ miles, _____ miles, and _____ miles.

(Optional paragraph - The Contractor shall have an additional Extra Advance Warning Sign Group (6 signs and 2 distance plates) available for use when directed by the Engineer. The distance plates for this group shall be able to be modified in the field to show appropriate whole miles to the lane taper.)

Payment for providing, erecting, maintaining and removing Extra Advance Warning Sign Groups shall be included in the lump sum bid for Item 614, Maintaining Traffic.

Designer Note: As noted in **Section 641-5.2**, this note should be used to require extra Advance Warning Sign Groups if the queue resulting from a lane closure on a multi-lane divided highway is expected to extend beyond the normal ROAD WORK AHEAD sign (W20-1). See **Section 641-5.2** for further information.

642-34 Extra Advance Warning Signs (Note B)

An Advance Warning Sign Group consists of two W20-1 (ROAD WORK AHEAD) signs, two W20-5 (RIGHT/LEFT LANE CLOSED AHEAD) signs with W16-3a Distance plates, and two W3-H7 (WATCH FOR STOPPED TRAFFIC) signs and required flashing lights.

The Contractor shall provide, erect, maintain and remove an Extra Advance Warning Sign Group as shown on Traffic SCD MT-95.50. The W16-3 Distance plates shall read "____ MILES". The Right (Left) Lane Closed Ahead signs shall be located _____ miles from the beginning of the lane taper. Spacing of the other signs shall be as shown on Traffic SCD MT-95.40.

The Contractor shall provide, erect, maintain and remove an additional Extra Advance Warning Sign Group to provide additional warning for the anticipated traffic increase during the following national holidays: (appropriate holidays to be filled in as defined by policy and the specific needs of the project). These signs shall be erected no later than 1:00 p.m. the third day preceding the holiday or holiday weekend and not removed before 9:00 a.m. the third day subsequent to the holiday or holiday weekend. The signs shall be removed during the periods

between holidays. The W16-3a Distance plates shall read "_____ MILES" with the W20-5 signs located _____ miles from the beginning of the lane taper. Spacing of the other signs shall be as shown on Traffic SCD MT 95.30 or 95.40.

(Optional paragraph - The contractor shall have a third Extra Advance Warning Sign Group (6 signs and 2 distance plates) available for use when directed by the Engineer. The distance plates for this group shall read "_____ MILES.")

Payment for providing, erecting, maintaining and removing Extra Advance Warning Sign Groups shall be included in the lump sum bid for Item 614, Maintaining Traffic.

Designer Note: As noted in **Section 641-5.2**, this note should be used to require extra Advance Warning Sign Groups in situations involving work that will extend over a holiday or any other anticipated period of unusually high traffic demand, if the queue resulting from a lane closure on a multi-lane divided highway is expected to extend beyond the normal ROAD WORK AHEAD sign. See **Section 641-5.2** for further information.

642-35 Item 614, Work Zone Crossover Lighting System

This work shall consist of furnishing, erecting, operating, maintaining and removing a work zone lighting system for a single crossover, or overlapping a pair of crossovers. The system shall be as shown on Traffic SCD MT-100.00. The Contractor shall arrange for and pay for power. All materials and construction shall comply with applicable portions of 625 and 725 except: The Performance test of 625.19F, and certified drawing requirement of 625.06, are waived and used materials in good condition are acceptable.

Poles which are not protected by guardrail or portable barrier shall be located outside the clear zone, and should be located at least 30 feet (preferably 40 feet) from the edge of pavement when possible. Additional pole lines, cables and appurtenances necessary to furnish power to the lighting system shall be included in this item. Service poles shall be positioned with the same constraints as the lighting poles as a minimum.

Payment will be made at the unit price per each for Item 614, Work Zone Crossover Lighting System throughout all phases of work when the crossover roadways are used.

Designer Note: As noted in **Section 641-11.5**, this note should be included in the plan when a work zone crossover lighting system is provided.

642-36 Multi-Plan, Time-of-Day Operation of Work Zone Signal

The work zone signal control required for this project and shown on sheets _____ and Traffic SCDs MT-96.11, 96.20, and 96.26 shall be capable of providing multiple timing patterns chosen on a time-of-day basis.

Traffic control equipment shall be capable of time-of-day/day-of-week programming; with a minimum of three-dial, three offsets and three splits, or a minimum of fifteen separate timing plans.

Approach	Timing Plan (Seconds)		
	A	B	C
Northbound Green	31.0	41.0	16.0
Northbound Yellow	3.5	3.5	3.5
Northbound All Red (Internal Clearance)	18.0	18.0	18.0
Southbound Green	30.0	20.0	15.0
Southbound Yellow	3.5	3.5	3.5
Southbound All Red (Internal Clearance)	19.0	19.0	19.0
Total Cycle Length	105.0	105.0	75.0

Provide timing appropriate for the signal location under consideration.

Time of Day	SUN	MON	TUE	WED	THUR	FRI	SAT
Midnight - 7:00 a.m.	C	C	C	C	C	C	C
7:00 a.m. - 9:00 a.m.	C	A	A	A	A	A	C
9:00 a.m. - 4:00 p.m.	A	C	C	C	C	C	A
4:00 p.m. - 6:00 p.m.	C	B	B	B	B	B	A
6:00 p.m. - Midnight	C	C	C	C	C	C	C

Payment is incidental to the lump sum bid for Item 614, Maintaining Traffic.

Designer Note: This note should be included in the plan when a signalized one-lane, two-way closing is used. The values and Time of Day schedule above are strictly for example purposes only.

642-37 Fully-Actuated Operation of Work Zone Traffic Signal

The work zone signal control required for this project and shown on sheets _____ and Traffic SCDs MT- 96.11, 96.20 and 96.26 shall be fully traffic-actuated and operate in a manner similar to that described in Section 733.02 of the Construction and Material Specifications.

The initial controller timing shall be as follows:

	Phase			
	1 (All Red) Dummy Phase	2 Mainline (direction)	3 (All Red) Dummy Phase	4 Mainline (direction)
Min. Green		10		10
Extension		4		4
Max. Green		30		30
Yellow		3.5		3.5
All Red	X		X	
Recall	On	Off	Off	Off

Provide timing appropriate for the signal location under consideration. Typical flow rates are displayed in **Table 697-2** in the ODOT Traffic Engineering Manual (TEM).

The Contractor shall also design, furnish, install and maintain a traffic detector on each traffic approach which will reliably detect all legal traffic approaching (but not leaving) the signal as it passes or waits in the designated detector zone shown in the plans. Detector designs which do not provide reliable detection, free from false calls, shall be immediately replaced by the Contractor.

Designer Note: This note should be included in the plan when a signalized one-lane, two-way closing is used. The chart is intended to show the timing for the signal location under consideration. Phases shown in the chart match those shown in **SCD MT-96.20**. Add more phases as needed to accommodate side streets, driveways, etc. Usually, the desired internal clearance time for phase 1 is the same as the desired internal clearance time for phase 3. The direction should be indicated for the mainline green. The values above are strictly for example purposes only.

642-38 Overhead-Mounted Work Zone Signals

Signals shall be overhead mounted in accordance with the details shown on Traffic SCD MT- (July 16, 2021)

96.20.

Designer Note: This note shall be provided if there is a reason to prohibit side-mounted signal heads. See OMUTCD Table 4D-1 for minimum number of overhead mounted primary through signal faces for approaches with posted speed limits of 45 mph or higher. Exclusively side-mounted signal heads may only be used on facilities with posted speed limits of 40 mph or lower.

642-39 Lighting

Lighting shall be provided at each end of the lane closure for the closing of one lane of a two-lane highway.

Lighting shall be by conventional methods, with luminaire arms attached to the signal supports. Area illumination shall be provided by using an 8000-lumen LED, 150 watt minimum high pressure sodium luminaires or 250 watt minimum mercury luminaires. The minimum height of the luminaire shall be 27 ft from the ground surface.

Payment for lighting shall include delivery, erection, maintenance and removal as called for in the plans. Payment shall be per Each.

Designer Note: This note may be included in the plans if the designer finds that there is a special need for the lighting at the project location. Examples of need for such lighting might be the existence of an intersection at the point of the lane closure, or poor geometrics or poor sight distance at the point of the lane closure.

Item 614	Work Zone Lighting System	Each
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642-40 Maintenance of Canoe Traffic

Canoe traffic shall be maintained throughout construction of the project either through existing river channel or through portage trail approved by the Engineer.

Adequate signing both upstream and downstream shall be installed and maintained by the Contractor. The following type signs are considered to be minimum treatment:

1. Approximately one-quarter mile upstream, advanced warning type signs on both banks;
2. Approximately 300 feet upstream, signs specifying actions required of canoeist on both banks;
3. Approximately one-quarter mile downstream, advance warning type signs on both banks; and
4. Approximately 300 feet downstream, signs specifying actions required of canoeist of both banks.

The above signing shall be mounted in such a way as to be a minimum of 4 feet above the water level, unobstructed by tree branches, and properly angled for maximum visibility from the main clear channel. The method of supporting the signs shall be approved by the engineer prior to installation. Upon completion of the project, the signs and support systems shall be completely removed from the river channel. The Contractor shall notify local canoe liveries using this portion of the river at least 10 days prior to any changes affecting canoe traffic. Portage trails if used shall be constructed and maintained by the Contractor with the least possible disturbance to the surrounding area. The trail shall be adequately marked in both directions. The Contractor shall be responsible for obtaining the right-of-way for the portage trails if required.

In the event pipes are used to divert or carry river water, both the inlet and outlet ends shall be adequately protected by grates or fence so that people or canoes are not drawn through or held by them.

796 FORMS INDEX**796-1 Agreement for School Signs with Beacons**

As noted in **Section 702-6**, **Form 796-1** is a sample that can be used in establishing an agreement for the maintenance of school signs with beacons.

796-2 Letter Confirming Operation of School Signs with Beacons

As noted in **Section 702-6**, **Form 796-2** is a sample letter that can be used to have a school confirm annually the school schedule and timings for operation of school signs with beacons.

796-3 Letter Confirming School Bus Stop Ahead / SCHOOL BUS TURN AHEAD Signs

As noted in **Section 702-7**, **Form 796-3** is a sample letter that can be used to have a school annually confirm the need for School Bus Stop Ahead / SCHOOL BUS TURN AHEAD signs.

796-4 School Zone Extension Request Form

As noted in **Section 705-2**, **Form 796-4** is used when submitting a request to extend the boundaries of a School Zone beyond the traditional boundary limits.

796-5 School Zone Extension Withdrawal Form

As noted in **Section 705-3**, **Form 796-5** is used for withdrawal of an established School Zone Extension.

Form 796-1. Agreement for School Signs with Beacons

ODOT Agreement # _____
Consent Ordinance # _____

Agreement for School Signs with Beacons

THIS AGREEMENT is made and entered into by and between the STATE OF OHIO, DEPARTMENT OF TRANSPORTATION (hereinafter referred to as "ODOT"), the _____ School District (hereinafter referred to as the "SCHOOL") and collectively referred to as the Parties.

WHEREAS, the SCHOOL has requested School Sign(s) with Beacons, specifically [describe sign(s) requested – speed limit/school entrance...] (hereinafter referred to as "SIGNS") be installed on [insert name of State Highway and location]; and

WHEREAS, ODOT has agreed to install the requested SIGNS conditioned upon the Parties fulfilling their respective responsibilities as it pertains to the installation, operation and maintenance of said SIGNS and appurtenances.

NOW THEREFORE, in consideration of the mutual covenants herein, the Parties agree to the following:

A. Responsibilities of the Parties

1. ODOT shall bear the cost and develop the plans for the installation of the SIGNS, and furnish, install, maintain and repair all SIGNS and appurtenances located within the highway right-of-way.

2. The SCHOOL shall bear the cost and furnish, install, maintain and repair all SIGN appurtenances located on the SCHOOL's property.

3. [Select one and delete the other options including the Note]

The SCHOOL shall furnish the electric energy required for the operation of the SIGNS and appurtenances.

or

ODOT shall furnish the electrical energy required for the operation of the SIGNS and appurtenances.

or

[if solar powered] The SCHOOL shall be responsible for the replacement of all solar panels and appurtenances for the operation of the SIGNS.

4. The SCHOOL shall determine appropriate times of operation of the SIGNS in accordance with the Ohio Revised Code and shall obtain concurrence from ODOT.

5. [Select one and delete the other options including the Note]

The SCHOOL shall program and operate the timers controlling the SIGNS in accordance with the times of operation determined by the SCHOOL and agreed upon by ODOT, and in accordance with the Ohio Revised Code and the Ohio Manual of Uniform Traffic Control Devices. [Note: For use with manually operated signs.]

or

The SCHOOL shall program and operate the timer in accordance with the times of operation determined by the SCHOOL and agreed upon by ODOT, and in accordance with the Ohio Revised Code and the Ohio Manual of Uniform Traffic Control Devices. [Note: For use with timers located in the school building.]

or

The STATE shall program and operate the timer in accordance with the times of operation determined by the SCHOOL and agreed upon by ODOT, and in accordance with the Ohio Revised Code and the Ohio Manual of Uniform Traffic Control Devices. [Note: For use with timers located on the highway right-of-way.]

or

The SCHOOL shall purchase, maintain, repair and replace all remote internet-based communication controllers and shall program and operate the timers controlling the SIGNS in accordance with the times of operation determined by the SCHOOL and agreed upon by ODOT, and in accordance with the Ohio Revised Code and the Ohio Manual of Uniform Traffic Control Devices. [Note: For use with internet-/web-based remote communication control of the beacons.]

6. ODOT will remove the SIGNS and appurtenances located within the highway right-of-way whenever it is determined by ODOT that the SIGNS are no longer justified, and this Agreement shall thereupon terminate.

B. General Provisions

1. This Agreement shall be binding upon and inure to the benefit of the Parties hereto, their respective successors and/or assigns.
2. Any modifications to this Agreement shall be agreed to by all Parties in writing.
3. Any Party may terminate this Agreement upon ninety (90) day written notice to the other Party.
3. The ODOT District Deputy Director shall have authority to ensure the compliance with the provisions of this Agreement.
4. Each Party shall be responsible for all loss, liability, and damages to persons or property caused by its own actions or failure to act.
5. Any person executing this Agreement in a representative capacity hereby warrants that he/she has been duly authorized to do so.
6. Any Party hereto may deliver a copy of its counterpart signature page to this Agreement via fax or email. Each Party shall be entitled to rely upon a facsimile or electronic signature of any other Party delivered in such a manner as if such signature were an original.

The Parties hereto have caused this agreement to be executed by their duly authorized officers or agents.

_____ **School District**

by _____ Date: _____

Printed Name and Title: _____

THE OHIO DEPARTMENT OF TRANSPORTATION

by _____ Date: _____
Jack Marchbanks, Director

Form 796-2. Letter Confirming Operation of School Signs with Beacons

(DATE)

(ADDRESS)

RE: (2013-2014) School Clock Schedule

Dear Superintendent,

Would you please send us a copy of your **(2012-2013) school year calendar** for the school signs with beacons that ODOT signal electricians maintain on U.S. or State Routes in your school district. **Please complete and return the enclosed Daily School Clock Schedule Form by (date),** indicating when you wish to have the school flashers operate, including recess times.

We will input this information into the programmable time clocks that control the school flashers at each of the school locations. Your cooperation in this matter will allow us to have each location programmed and ready when school begins next fall. Please forward the information to me at the above address.

If you should have any questions concerning this request, please contact me at the above listed telephone number, (extension).

Respectfully,

Enclosure

c: file

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1101 DISTRICT SYSTEM LIGHTING PLAN (DSLPP)

Each **District** should develop and maintain a **District System Lighting Plan (DSLPP)**. This is typically a GIS thematic map that uses a systematic approach to show both the **District's** existing and future highway lighting. The **DSLPP** is a Planning tool and shall be maintained even as ODOT develops Collector-Based Asset Management databases. It is intended to provide for a uniform system and to improve maintenance efficiency with regard to factors such as partial, complete, conventional, high-mast and composite/hybrid designs. It allows the **District** to set priorities for the allocation of available funding for roadway lighting projects, and should be used as a guide in making Light B Don't Light decisions.

The **DSLPP** is composed of county maps merged into a district-wide map. The twelve **DSLPPs** make up a **Statewide System Lighting Plan (SSLPP)**. Through the use of the **DSLPP** and **SSLPP** a consistent systematic treatment can be insured. Each **DSLPP** database should be updated a maximum of every five years.

GIS requires a database made up of the existing physical inventory records. Suggested data and codes that should be used in the **DSLPP** are shown in **Tables 1197-1 and 1197-2**, respectively.

There are a number of decisions to be made to create the **DSLPP**. These decisions will involve not only the examination of each of the various intersections, interchanges and roadways in the highway system, with regard to the engineering merits of lighting that particular location, but they will also involve insuring equality of treatment of similar locations, prioritizing the planned changes, and forecasting the availability of resources.

1102 JURISDICTIONAL BOUNDARIES

Care should be exercised in defining the limits of highway lighting and individual circuits in regards to jurisdictional boundaries. Existing ownership and maintenance of various roadways and other facilities should be considered. Layout and extent of circuits will determine maintenance and power usage charge responsibilities.

These issues should be addressed through appropriate planning and design of the lighting system, and appropriate prearranged agreements with local jurisdictions.

Where new lighting systems cross existing jurisdictional boundaries to serve a complete area, additional circuits and control centers should be utilized to cleanly separate the units between maintenance areas. This will simplify billing practices. Generally, each jurisdiction should have its own Power Service.

Where new jurisdictional boundaries cross existing lighting systems, consideration should be given to assigning (by written agreements) maintenance responsibilities to one entity.

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1103 WARRANTS and GUIDELINES**1103-1 General**

Lighting warrants are based on the need for highway lighting and the benefits derived from lighting. In justifying lighting, many factors should be considered, including traffic volume, speed, nighttime road use, night accident rate, road geometrics, general night visibility, economic benefits and future increase in capacity or changes in road use.

1103-2 Warrants for Highway Lighting

Warrants for freeway and interchange lighting are shown in **Table 1197-3**. These are ODOT-specific warrants derived and modified by ODOT from the 1984 **AASHTO** publication titled **An Informational Guide for Roadway Lighting**. The ability to satisfy these warranting criteria does not, in itself, necessitate that lighting be installed. Warranting criteria determine location eligibility for lighting; however, there are numerous other factors which must be considered.

For each of the levels of highway lighting shown in **Table 1197-3** only one of the Cases need be achieved to meet warrants. However, consideration should be given to whether a location meets only one or all warranting conditions.

1103-3 Accident History

Several factors may contribute to an increase in night accidents, such as:

1. Lack of adequate visual information.
2. Glare from background lighting and headlights.
3. Problems with vehicle lighting.
4. Driver fatigue.
5. Increased use of alcohol and other drugs.
6. Declining visual capability, especially with older drivers.

There is little research on the impact that lighting has on reducing accidents. However, lighting can provide an increase in highway safety by impacting the above mentioned factors.

1103-4 Land Use

The area surrounding a proposed lighting facility must be taken into account when considering the different types and intensities of light needed for a lighting plan. **American National Standard Practice for Roadway Lighting (RP-8)** sponsored by the **Illuminating Engineering Society (IES)** defines three general categories for land use: commercial, intermediate and residential:

1. Commercial - Commercial areas tend to create a heavy area of background lighting. High-mast or low-mast towers are well suited to these type of areas. Towers will blend in more with the surrounding area and yet still light the roadway to the needed level.

In **Table 1197-4**, "commercial" refers to that portion of a municipality in a business development where ordinarily there are large numbers of pedestrians and a heavy demand for parking space during periods of peak traffic, or a sustained high pedestrian volume and a continuously heavy demand for off-street parking space during business hours. This definition applies to densely developed business areas outside of, as well as those that are within, the central part of a municipality.

2. Intermediate - These areas have a blend of commercial or residential types of land use. Multi-family residential rental property owners are much like industrial and commercial property owners in that lighting, while at lower levels, is still needed for security. Therefore, they are usually not bothered by any light trespass from adjacent highway lighting units.

Low-mast towers or conventional poles tend to work best in these areas. High-mast towers will work, but the designer must consider the impact they will cause to the residential area. Common complaints are heavy light trespass on non-roadway areas and perceived glare from the visible part of the light bulb or fixture (the part not under a metal shroud).

In **Table 1197-4**, “intermediate” refers to that portion of a municipality which is outside of a downtown area, but generally within the zone of influence of a business or industrial development, often characterized by a moderately heavy nighttime pedestrian traffic and somewhat lower parking turnover than is found in a commercial area. This definition includes densely developed apartment areas, hospitals, public libraries and neighborhood recreational centers.

3. Residential - Owners of single family residential property are more sensitive to light trespass from adjacent highway lighting units, especially if the owner occupies the property. The needs of the traveling public must be balanced with the concerns of the surrounding residents. Low-mast towers and conventional lighting offer the best solution for this type of area. Low-mast towers in conjunction with one or two luminaires will generally light the area within the highway right-of-way and have very little light trespass. They also do not tend to cause the classic light tunnel effect produced when using conventional lighting.

At times, these residents are also concerned with the aesthetics of highway lighting units that stand above the surrounding area or have drop glass refractors. If high-mast lighting is proposed, it is recommended that a public meeting be held to generate local input.

In **Table 1197-4**, “residential” refers to a residential development, or a mixture of residential and commercial establishments, characterized by few pedestrians and a low parking demand or turnover at night. This definition includes areas with single family homes, townhouses, and/or small apartments. Regional parks, cemeteries and vacant lands are also included.

1103-5 Background Lighting

Background lighting has several effects on a lighting system that should be noted.

When the surrounding light is minimal, the transition from lighted sections to unlighted sections should be gradual. Sudden changes in lighting can cause a visual blind spot. The driver's eyes must be given sufficient time to adjust to the new lighting level.

In commercial areas where the surrounding light is more prevalent, lighting should be increased to more closely match the existing commercial lighting. This will help overcome the light trespass from the surrounding area.

1103-6 Special Locations

1103-6.1 General

There are a number of locations other than freeways and interchanges for which lighting may be considered. Specific warrants are not available for these other locations. Primary concerns are typically related to safety issues. Quite often illumination levels for these locations will differ from standard freeway and interchange lighting.

1103-6.2 Intersections

Lighting may be provided at intersections to enhance safety and to improve visibility of the intersection and approaches.

All ODOT-maintained intersections with marked crosswalks shall include intersection lighting.

Intersections with a high percentage of night accidents but no pedestrian facilities shall be considered for lighting.

Intersections with sight distance limitations, unusual or complicated geometrics, channelization, skewed approaches, high volumes, unusual traffic patterns, turning roadways, protected turning lanes or driver recognition problems may benefit from illumination.

Lighting units may be combined with signal and sign supports wherever feasible to minimize clutter and obstacles within the intersection and approaches. When lighting is utilized at channelized intersections and at intersections on turning roadways, units should be placed to illuminate protected turning lanes, at radius points and at approaches to divided areas and traffic islands.

1103-6.3 Pedestrian Walkways

Walkway lighting may be considered for security and aesthetic reasons. Walkway lighting may also include landscape or decorative lighting. Lighting of walkways may significantly increase use during the hours of darkness. Lower voltages (120 volts AC or 48 volts DC), vandal-proofing and safety issues should be taken into consideration. For example, control centers should be securely padlocked, wiring and anchor bolts enclosed and sharp edges and corners should be eliminated.

1103-6.4 Weigh Stations

Lighting and levels of lighting provided at weigh stations should take into account the full range of activities and needs of the various agencies utilizing these facilities for enforcement. Besides weighing, various degrees of inspection may be conducted. Temporary storage of detained cargo may also require lighting for security reasons.

Exit and entrance ramps at these facilities should be provided with at least partial interchange lighting (as defined in **Section 1105-5**). The weigh lane from intersection to intersection over the scale and the inspection and parking area behind the scale house should be lighted with the intensity and uniformity normally provided for continuous freeway lighting, with additional low-mounted floods provided for the reading of vehicle markings, observation of vehicle undercarriages and position on the scales from the operator's position within the scale house.

1103-6.5 Park and Ride Facilities

Park and ride lots present two lighting requirements. The first is for the mixing of vehicular and pedestrian movements. The other is for security if the lot remains open late (after the evening peak and before the morning peak). Lighting for these facilities should be divided into three areas: drive intersections with adjacent highways, the drives themselves and the parking areas.

1103-6.6 Bicycle Facilities

Bike paths are facilities which are independent of the roadway. They may double as pedestrian or recreational corridors. For these facilities, lighting is more of a security measure and decisions are made based on the amount of night use to be permitted or encouraged.

A bicycle lane is a dedicated lane provided contiguous to the lanes for motor vehicles, as part of a roadway. In this case, the visibility of the bicyclist and lane becomes more important. Lighting should be considered both: 1) to assist the motorist to detect and allow for the bicyclist;

and 2) to assist the bicyclist in detecting and avoiding debris in the bike lane, and in compensating for or avoiding pavement irregularities.

1103-6.7 School Zones / Crossings

School Zone lighting may be considered where a significant pedestrian volume exists. Accident prevention should be considered if a significant volume of turning or stopping vehicles are in potential conflict with pedestrian movements.

Appropriate School Zone signing should be in place before lighting is installed. See **Part 7** for further information about School Zones.

1103-6.8 Sign Lighting

See **Chapter 212** for further information on sign lighting.

1103-6.9 Underpasses and Tunnels

1103-6.9.1 Underpasses

Underpasses should be evaluated to determine if existing underpass illumination is adequate or needs to be supplemented. Artificial illumination is normally not needed for underpasses that are less than 75 feet in length. However, both skewed underpasses and parallel underpasses less than 40 feet apart may need underpass lighting regardless of their length. Each underpass should be evaluated on its own merits.

The evaluation of lighting intensity and uniformity for the underpass and adjacent highway should be made under both daytime and nighttime conditions. When the length of the structure limits the amount of light from natural daylight or adjacent luminaires located outside the structure, the need for lighting units should be evaluated. Factors to consider include lighting design criteria (**see Chapter 1140**), the extent, if any, that shadows are produced, and the extent, if any, that lighting intensity and uniformity are compromised. The limited adaptability of older drivers to changes in illumination should also be a factor in determining the need for lighting.

Determination of the need for lighting units for new construction should be made on the basis of design criteria as well as direct comparisons with existing underpasses, to assure consistency of underpass lighting treatment within an area.

Additional guidance is available in the latest version of **ANSI/IES Recommended Practice for Tunnel Lighting (RP-22)**, the **AASHTO Roadway Lighting Design Guide (GL-6)**, and the **NFPA Standard for Road Tunnels, Bridges, and Other Limited Access Highways (NFPA 502)**.

1103.6.9.2 Tunnels

All ODOT design projects should require use of the **TEM** and **RP-22** for tunnel lighting design. This requirement should be in the project **Scope of Services**. Lighting design assistance for underpasses and tunnels is available from the Office of Roadway Engineering.

The definition of a “tunnel” can vary, depending upon the particular engineering application and standards documents referenced. For highway lighting, ODOT defines a tunnel using definitions very similar to the definition in Chapter 5 of the **AASHTO Roadway Lighting Design Guide (GL-6)**.

Tunnel: A structure of any type that surrounds a vehicular roadway and is longer than an underpass (e.g., greater than 75 feet), and requires supplementary daytime lighting.

1130 PLANNING / PROGRAMMING**1130-1 General**

The following sections are provided to assist planners and designers in developing standard uniform lighting systems. These sections discuss various aspects of lighting that should be taken into account when planning new, or rehabilitating existing, lighting systems. The following are guidelines and are not meant to override a planner's engineering judgment.

1130-2 Programming of Projects

Before a lighting project is programmed, whether alone or in conjunction with a roadway project, a preliminary study should be completed. A preliminary study should include the following: Verifying that the project meets lighting warrants where available and is in conformance with the **DSLP (Chapters 1101 and 1103)**; verifying what types of funding will be used (**Section 1130-3**); deciding what type of lighting is to be used (**Chapter 1120**); verifying who will maintain the system (**Chapter 1102**); and deciding what type of power supply is to be used (**Section 1120-6**). For temporary lighting see **Part 6**.

1130-3 Funding Considerations**1130-3.1 General**

The programming should specify all funding types used on the project. Federal funding for highway lighting is governed by **FHWA** policy. In general, highway lighting is eligible for Federal participation when warrants and criteria satisfy **AASHTO** and **ANSI** requirements (*see Chapter 1106*) and the project is on a Federal-aid highway system. There may also be occasional special programs involving Federal aid which require approval from offices other than the **Ohio Division Office of FHWA**. Under such circumstances, it is essential that requests for participation be initiated at the programming stage. **State** participation in lighting projects shall be as specified in **Section 1130-4**.

1130-3.2 New Installation

If the proposed lighting system is in more than one funding jurisdiction, all agencies must agree in writing on their portion to be paid. For example, if an interchange that is to be lighted is within the boundaries of two incorporated areas, the funding would typically follow the corporation boundaries. If only a small portion of an interchange is in an incorporated area, an attempt should be made in the design of the lighting to avoid placing any material or equipment within this area.

1130-3.3 Upgrade/Retro-fit

If the existing lighting system is in more than one maintenance jurisdiction, all agencies must agree in writing on their portion to be paid. Any changes in corporation limits from the original installation should be reflected in the funding split of the project and in the new maintenance agreement. It should also be remembered that lighting circuits do not necessarily stop at the project limits and therefore the project's lighting needs may be greater than expected if only the area inside the project limits is considered.

1130-3.4 Maintenance

If the existing lighting system is in more than one maintenance jurisdiction, each jurisdiction should have independent circuits that do not trespass into other jurisdictions. Each jurisdiction should have a separate control center. The maintenance agreements should be initiated in the planning stages.

1130-4 State Participation

ODOT participation in highway lighting projects shall be as follows:

1. On limited-access highways and freeways, **ODOT** will participate in the cost of all lighting system items that are necessary to complete the lighting system. **ODOT** participation will be limited to the cost of a system to provide an average initial intensity in the range of 1.0 to 1.2 foot candles. If a system to provide higher intensities is provided at the insistence of any political subdivision, the added cost of construction and maintenance resulting therefrom shall be borne by that political subdivision.
2. Existing lighting systems on crossroads and streets which cross limited-access highways and freeways without interchange facilities will be rearranged and/or replaced with similar styles and types of systems and equipment to provide a light intensity equal to that provided by the existing system. However, if the rearrangement of the existing road or street creates a need for a greater intensity for the safety of the traveling public, or requires changes in types and styles of system and equipment, modifications to the extent necessary to meet such need and requirements may be included subject to approval by the **Assistant Deputy Director of the Development Design Administration**.
3. On major improvements of existing highways within municipal corporations, existing lighting systems will be rearranged or replaced, if necessary, to restore light intensities to those previously existing, and in any event, to provide not less than the minimum average maintained intensity as recommended by **AASHTO** for expressways and highways, and for urban streets.
4. **ODOT** participation in the eligible costs of such construction, rearrangement, and replacement will be the same as **ODOT** participation in the other construction costs of the project.
5. **ODOT** will not participate in the cost of extensions and betterments to existing publicly-owned lighting systems included in the **ODOT** construction contract at the request of a municipality or other political subdivision.

1130-5 FAA Requirements

The programmer shall verify the location of the project in relation to all airports or heliports. If the project is within a 20,000 feet radius of a public-use or military airport or heliport, the programmer shall perform an Airway/Highway Clearance Analysis to determine if **FAA** notification is required (**see L&D Manual Volume 3, Section 1404.1**).

1130-6 Light Fixtures

Where a municipality desires to maintain aesthetic consistency for existing street lighting systems by using distinctive unit designs or by painting light poles, specific justification for such designs shall be submitted for **ODOT** approval before funds are authorized. In general, such justification must demonstrate that the municipality is not requesting funding for designs which exceed the official, published **City** standard, and that the distinctive design is used consistently through a reasonably large or historical area within the **City**.

1130-7 Maintenance Concerns

Prior to the programming of the lighting project, the programmer should verify that the **City** or **Village** will be able to maintain the lighting. Typically small **Cities** and **Villages** have lighting provided for and maintained by the local power company. Prior to the programming of a project to replace the existing utility-maintained lighting with **City** or **Village**-maintained lighting, **ODOT** should verify that the **City** or **Village** is capable of maintaining the proposed lighting or that they are willing to contract out the

1140 DESIGN INFORMATION**1140-1 General**

Chapter 140 provides general background regarding design information for **ODOT** projects, including the three-stage review process typically used for traffic control plans. Additional information about lighting design has been provided in this Part.

This Chapter provides the designer with information to satisfy the requirements of **ODOT** relative to highway lighting construction plans. It is not intended to substitute for nationally-accepted criteria and standards nor to relieve the designer of the responsibility for using personal skills and ingenuity in developing the best possible plan for a specific project. Rather, it is intended to supplement more formal design references and knowledge by explaining policies, criteria, design considerations and plan procedures which experience has indicated are pertinent to the state highway system.

The **Lighting Design Reference Packet** is available to assist designers with lighting design and plan preparation.

1140-2 General Theory

To properly understand the effects of roadway lighting, one must have a basic understanding of the theory of lighting and the design of roadway lighting. The following sections will outline some basic theory and design principles followed by plan preparation elements. Those wishing to gain a fuller understanding of lighting theory should consult the **Illuminating Engineering Society (IES) of North America's American National Standard Practice for Roadway Lighting ANSI/IES RP-8**.

1140-3 Lighting Theory**1140-3.1 General**

The act of seeing involves three separate elements: the eye, the visual task and light. Light emitted by a source strikes an object, the object reflects some of the light toward the eye, and the object is seen. Except when light sources themselves are being observed, seeing is by reflected light. Light which enters the eye directly from the source is of no value in the effort to see an object; in fact, it will actually impair vision.

At the low levels of illumination involved in highway lighting, objects are often seen by silhouette rather than by light reflected from the object itself. In this case, the primary concern is surrounding or background brightness, rather than illumination or brightness of the object. For maximum effectiveness, discernment by silhouette depends upon the degree of brightness difference, or contrast between the object and its background.

In highway lighting, as contrasted with interior lighting, the objects to be perceived are relatively large, and visual acuity, or the ability to distinguish fine detail is not involved as a general rule. The most important objective is to create or enhance the brightness contrast between an object and its background, or the roadway surface itself. In all highway lighting, objects are made visible by a combination of two or more methods of discernment. For example, on a well-lighted highway:

1. Distant objects are seen by direct silhouette.
2. Projections above the pavement (the upper portions of pedestrians and vehicles) usually are seen by reverse silhouette.
3. Traffic signs and very close objects are seen by surface detail.
4. Many objects produce glint or highlights on irregular or specular surfaces.

The same light that produces visibility on the highway also produces a negative result known as glare. Glare is any brightness in the field of view that causes discomfort, annoyance, eye fatigue or interference with vision. It may best be described as negative light or light out of place. Glare is a function of intrinsic brilliancy, candlepower toward the eye, distance, contrast, and angular displacement with the line of sight.

Roadway luminaires are classified by the way they transmit and distribute light. The use of various types of reflectors and refractors permits the lighting designer to produce an efficient and aesthetic design. Luminaire classifications are defined in terms of vertical light distribution, lateral light distribution, and the control of distribution above maximum candlepower, known as cutoff. Vertical and lateral light distributions apply primarily to the shape of the roadway area to be illuminated. Both of these distributions can be important when determining the amount of light trespass from a source. **Figure 1198-1** illustrates five basic lateral distributions of highway lighting fixtures.

The control of the distribution above the maximum candlepower, known as the cutoff, is important for determining the amount of glare emitted by a fixture. A non-cutoff roadway fixture typically has a dropped lens (a refractor). This allows the light to be more easily distributed from the fixture and permits the illumination design to be less precise; however, it produces more undesirable glare. A full cut-off fixture typically has the dropped refractor replaced with a flat glass, while the reflecting elements inside the fixture have been redesigned to provide control of the light output. This provides much better glare control; however, the illumination design must be much more precise to maintain lighting uniformity. **Figure 1198-2** illustrates the effect of non-cutoff and full cut-off luminaires.

The **Illuminating Engineering Society (IES)** is the recognized authority for the setting of various illumination recommendations, including those for roadway lighting. These standards, as listed in **ANSI/IES, RP-8**, have been well researched and established as the minimum requirements for the safety of roadways. Several studies have been undertaken in recent years involving test targets placed on roadways. The **IES** standards have been confirmed during these studies as the minimum requirements for proper illumination with respect to stopping sight distances. To give some idea of the scale of illuminance required for various roadways refer to **Table 1197-4**.

1140-3.2 Illuminance

1140-3.2.1 General

Illuminance (or illumination level) is defined as the amount of light being transmitted upon a certain area. The English unit for illuminance is the footcandle, which is equal to one lumen per square foot. Illuminance is governed by the inverse square law. The illuminance of an area or object diminishes as the square of the distance.

The remaining information in this section is included for reference only; it refers to practices used for HPS luminaires. Lighting design with modern LED luminaires does not use the coefficient of utilization.

Highway lighting is generally designed as the illuminance of the area in question. It is based on the premise that, by providing a given level of illumination and a uniformity of distribution, satisfactory visibility can be achieved. The basic calculation for roadway illuminance is as follows:

$$E_{ave} = \frac{(L \times CU \times LLF)}{S \times W}$$

Where:

E_{ave} = average illuminance of the area in horizontal footcandles

L = luminous flux of the source in lumens

CU = coefficient of utilization of the luminaire (obtained from a photometric data chart supplied by the manufacturer and dependent on the width of the road and the mounting height)

LLF = light loss factor (the amount of light that will be lost over time due to dirt accumulation on the luminaire and lamp depreciation - typically 0.7 to 0.8)

S = spacing of the streetlight poles

W = width of the pavement to be illuminated

For example, a roadway with a pavement width of 33 feet and a light pole spacing of 164 feet utilizing a luminaire which has an output of 25,000 lumens, a coefficient of utilization of 45 percent, and a light loss factor of 70 percent will have an average illuminance of:

$$I = \frac{(25000 \times 0.45 \times 0.7)}{164 \times 33} = 1.46 \text{ footcandles}$$

1140-3.2.2 Point-by-Point Analysis

Point-by-point calculations are used to determine the illuminance at a specific location from a "point" source of light. This assumes the source behaves as a point source; consequently, this method cannot be used for linear and area sources. This computational process utilizes a candlepower distribution curve. The inverse square law is used to determine from the values on the distribution curve the levels of illumination at various points on the interchange or area to be lighted.

The illumination in horizontal footcandles at a grid point resulting from one high-mast assembly can be computed by using the formula:

$$E_h = \frac{cp \cos \theta}{d^2}$$

Where:

E_h = illumination at the point in horizontal footcandles

cp = candlepower at angle θ

θ = the angle from the vertical axis through the system to the point in question

d = the distance from the light source to the point in questions in feet

The total illumination at each of the grid points is the sum of the contributions of illumination from the high-mast assemblies within an effective range of the point in question.

Because of the time involved with hand calculations in the point-by-point method, and due to the number of trials which may be required, the point-by-point method is usually accomplished by computer. Generally, computer programs are built around the point-by-point method. Manufacturers have these type programs available and will normally provide design layouts.

1140-3.3 Luminance

1140-3.3.1 General

Luminance is the brightness of an object that has been illuminated by a source. The luminance of an object depends on its material characteristics and reflectance. For example, under the same illuminance conditions a dark object will look less bright than a light object. Since luminance refers to the amount of light reflected back by an object, this object in effect acts as a new source. There is a direct relationship between the luminance of a viewed object and the resulting illuminance of the image on the retina of the eye. The unit of luminance is the candela per meter squared (cd/m^2).

Highway lighting may also be designed by calculating the luminance of the roadway surface. This involves determining the reflective properties of the pavement, which can vary dramatically depending if the surface is concrete or asphalt. Although considered superior to the illuminance method, the luminance method is complex and because it involves reflective properties of the pavement, is subject to change over time due to aging of the pavement as well as change associated with weather.

Although Luminance-Based Design is not a current ODOT requirement, it is likely to be in the future, when ODOT adopts RP-8-2018. Therefore, ODOT encourages the following approach to lighting design that indicates when luminance-based and illuminance-based design shall be used.

1. STRAIGHT ($r > 2000'$) roadways with uniform luminaire geometry; use luminance-based design, and use the maximum L_v ratio criterion, because it is the likely limiting criterion. Uniformity is defined as pole spacing along the roadway that is within $\pm 15\%$ of the average spacing.
2. STRAIGHT ($r > 2000'$) roadways with non-uniform luminaire geometry; use luminance-based design, but designers may ignore the maximum L_v ratio criterion. Optionally, designers may use illuminance-based design if it makes for a “cleaner” presentation of results (e.g., straight ramp segments adjacent to curved segments of interchanges). Results are likely to be uniformity-limited.
3. CURVED ($r < 2000'$) roadways; use illuminance-based design. Results are likely to be uniformity-limited.

1140-3.3.2 Small Target Visibility (STV)

The visibility of an object is that property which makes it discernable from its surroundings and depends on a combination of the following factors: (1) the difference in luminance between the object and its immediate background (contrast); (2) the angular size of the object at the eye of the observer; (3) the luminance adaptation level to which the eye is exposed; and (4) the duration of the observation. The object that is used for STV is a 7 x 7 inch target. The observer is located on a line parallel to the centerline of the roadway at a distance of 273 feet. Using the four measurements stated above and a series of equations, the visibility level (VL) of the target can be calculated. Visibility models must also incorporate age-related changes in visual processing efficiency that have notable effects on target visibility.

ODOT does not use the Small Target Visibility method for design.

1140-3.4 Headlamps

If we drive in an “empty” road situation (i.e., just one car on the roadway), a proper level of STV is all that is required. High beam headlights produce a very low level of pavement luminance at 200 to 300 feet ahead, yet we can drive quite safely with them as long as we are the only car on the road. The same light that produces visibility on the highway, also produces a negative result known as glare.

In the driving task the most commonly experienced glare is probably that from approaching headlamps on an unlighted highway. The effect is one of shock; the eye has been adapted to relatively low brightness and suddenly is confronted with an extremely bright source, often close to the normal line of sight. The effect may be sufficiently severe to contract the iris, which further reduces the ability to see. The same headlamp fails to glare when encountered in the daytime, although its candlepower is the same day and night. The glare effect is due to excessive brightness contrast, because of the dark surroundings at night.

When the roadway is not “empty,” a reasonably high level of pavement luminance is essential to reduce the adverse effect of glare from the headlights of oncoming vehicles. An adequate level of visibility can be achieved with fixed lighting, which also provides much higher level of pavement luminance than do headlights alone.

1140-3.5 Middle Third

The preferred location for overhead sign supports is in the middle third of the design spacing for the lighting units. When the desired location criteria for a sign support does not result in its

falling within the preferred area, the following minimum separation between overhead sign installations and lighting units should be maintained:

Mounting Height for Lighting Unit Feet	Minimum Separation Feet
32.5	40
40	60
50	90

If the lighting unit or the sign support locations cannot be adjusted to maintain the above minimum separation, the lighting unit may be placed immediately in advance of the sign support when a 40 or 50-foot mounting height is used for lighting. However, such a position cannot be used effectively for a 32.5-foot mounting height, and consideration should be given to raising such mounting heights for several units in the general vicinity of the sign support.

1140-3.6 Illumination Criteria

1140-3.6.1 General

In designing a new highway lighting system, the quantity and quality of illumination must first be established.

1140-3.6.2 Average Illumination

The quantity of illumination is that average illumination level which has been established through experience in the lighting profession that represent economic and practical restraints. The quantity of light is referred to as the "average maintained horizontal illumination" and is a function of the classification of the roadway and the area which is served by the lighting system. Breaking this term into its parts, the first term, "average," refers to the method of measuring the illumination level, and means that this is a mean value of all points within the area being lighted. The second term, "maintained," refers to the illumination value at some point in time after the system is installed. Maintained illumination takes into account reductions in luminous output due to factors such as LED lumen depreciation (LLD factor) and luminaire dirt depreciation (LDD factor). The net Light Loss Factor (LLF) is provided for designers in the ODOT Approved List for each luminaire, and is usually between 0.85 and 0.89. Thus, a lighting system begins within an initial illumination level and depreciates to some level less than this. For this reason, the initial design level of illumination is higher than the maintained value. The final term, "horizontal," refers to the surface on which the illumination is measured, in this case, a horizontal plane, such as the roadway surface.

Average maintained illumination levels currently recommended by the IES for various areas and facilities are shown in **Table 1197-4**.

1140-3.6.3 Uniformity

The illumination concept of lighting design defines an average quantity of illumination over the pavement surface. This average quantity of illumination can, however, be accomplished by either producing a generally uniform level of illumination over the area or by producing relatively high and low areas of illumination. The latter is not desirable. As a driver passes through areas of relatively high and low illumination levels, his eyes must adapt.

The uniformity of illumination is considered a qualitative means of defining highway lighting. The term used to quantitatively describe uniformity is the uniformity ratio. As the name implies, it is a ratio of various illumination values. Current practice makes use of the Average Level-to-Minimum Point method (average-to-minimum ratio) of calculating uniformity, in which the average illumination is divided by the lowest illumination point

encountered within the traveled portion of the roadway. For example, a street with an average illumination level of 2.0 footcandles and a minimum point of 0.5 footcandle would have an average/ minimum uniformity ratio of 4:1.

The Maximum-to-Minimum Point method uses the maximum and minimum values within the traveled portion of the roadway. It is felt that the use of a maximum/minimum uniformity ratio more accurately portrays the degree of uniformity, because it takes into account the full effects of the differences of illumination on the lighted roadway.

1140-3.7 Critical Location

Roadways have many areas where the problems of vision and maneuvering of vehicles are complex and require lighting units at critical locations. These locations are in addition to what are commonly called key unit locations at intersections, acceleration and deceleration lanes, underpasses, overpasses, pedestrian bridges and on structures. Key and critical unit locations must be identified for each project prior to developing a traditional (non-high mast) layout where light poles are relatively close to the traveled way. These locations are the basis for the ultimate design with additional units filling in the gaps. See **Sections 1140-4.4 and 1140-4.6** for specific information.

1140-4 Luminaires and Sources

1140-4.1 General

The design of a highway lighting system involves consideration of visibility, economics, aesthetics, safety and environmental conditions, as well as appropriate material and equipment. The first major step in the design process involves the selection of tentative luminaires and light sources and the selection of one or more tentative lighting system geometric arrangements (conventional or high mast), including mounting heights and lateral luminaire positions, that may provide an acceptable design based on the required uniformity criteria (i.e., average maintained footcandles, ave/min uniformity ratio and max/min uniformity ratio).

As noted in **Section 1120-8**, ODOT has specifications and Approved Lists related to various types of luminaires.

1140-4.2 Luminaire Placement

1140-4.2.1 General

On freeways or expressways, through lanes normally should be lighted with luminaires having IES Type III medium distribution as discussed in the [American National Standard Practice for Roadway Lighting \(RP-8\)](#), published by ANSI. The Type II distribution should generally be used where the pavement width is less than 1.25 times the mounting height. For wider pavements, the Type III distribution should be used.

ODOT-maintained lighting systems shall use solid-state (LED) luminaires.

1140-4.2.2 High-Mast Lighting

High-mast lighting, or light towers, have frequent applications, especially in interchange areas and along major freeways. In **Ohio**, lighting units are considered to be high masted, or towers, when the height of the luminaires is 70 feet or more above the supporting foundation. Towers shall be placed according to Clear Zone setbacks per L&D Table 600-1, including all Slope and Curvature factors. Designers SHALL NOT limit setback to the 30-foot maximum clear zone asterisk statement in the Table. Setbacks in excess of 30 feet are much safer and shall be used whenever the site permits. The more obvious advantages of towers over conventional lighting units are as follows:

1. Because of their increased height and number of luminaires (up to six luminaires per tower), illumination distribution is improved to the extent that a single tower will usually

replace from four to eight conventional lighting units. While the increased height of luminaires in itself does not necessarily guarantee lower disability glare, careful system design with towers can result in reducing glare and increasing comfort as the installation is approached and driven through. In general, greater uniformity of illumination can be achieved by a well-designed tower system.

2. Towers can be significantly safer than conventional lighting units from the viewpoints of the road user and the maintenance forces. Towers shall be located as far as practicable from traveled pavement, the opportunities for impact by errant vehicles are greatly reduced. Maintenance vehicles, equipment and personnel are remote from traffic lanes during servicing operations, which may eliminate the need for temporary traffic control devices and allow for complete concentration on maintenance activities, without fear of interference or distraction from moving vehicles. Since **ODOT** specifications require that towers be equipped with luminaire lowering devices, the most common maintenance operations are performed at ground level.
3. Daytime aesthetics are improved because of the fewer numbers of poles and their greater distance from the roadway.

[C&MS Item 725.21](#) discusses detailed requirements for light towers, and the designer should be familiar with that specification when evaluating proposals relative to tower lighting.

1140-4.2.3 Solid-State (LED) Luminaires

For an LED lighting system, the designer shall strive to find two interchangeable solid-state (LED) luminaires. If this is not possible, it may be necessary to request a proprietary bid. **Section 120-4** describes the for approval of patented or proprietary materials. A Proprietary Bid Request for Solid-State (LED) Luminaires shall be made in writing to the [Office of Roadway Engineering's Traffic Control Engineer](#), with a copy to the **District**. If the proprietary bid is not granted, and two interchangeable solid-state (LED) luminaires cannot be found, then two separate lighting designs (one for each luminaire) shall be submitted by the designer, each constituting an Alternate Bid. These shall be called Roadway Lighting Design A and B and shall apply project-wide. All LED luminaire Plan Notes should include the phrase "or approved equal" unless a proprietary approval has been obtained.

1140-4.3 Conventional

1140-4.3.1 General

ODOT projects scoped for lighting will generally specify whether conventional or high-mast units are to be used in the design. Currently, conventional units refer to a "cobra head" roadway fixture mounted on round tapered poles at a mounting height of nominally 30 to 50 feet. The units are widely used, readily available and economically attractive.

1140-4.3.2 Mounting Height and Wattage of HPS Luminaires (Historical Reference)

Although High-Pressure Sodium (HPS) luminaires are obsolete, for historical reference the standard mounting height and luminaire rating combinations used by **ODOT** can be found in **Table 1197-5**.

The designer should always check with the maintaining agency for mounting height and luminaire rating preferences due to replacement stock standardization.

The designer should also note that the mounting height and the support height (as defined in the HL Series of the [Traffic Standard Construction Drawings \(SCDs\)](#)) may differ, depending on the pole base type required, and affects the Item Description/Light Pole Design Number, used in the construction plan Lighting General Summary.

1140-4.3.3 Spacing

In designing a lighting system, maximizing spacing of luminaires consistent with good illumination design should be emphasized. From the standpoint of economy and safety, the minimum number of luminaires and supports should be used while satisfying the illumination quantity and quality criteria. Spacing of lighting units will be influenced by mounting heights, lamp sizes, luminaire arrangements, uniformity ratios, veiling luminance, illumination levels (footcandles), and special roadway features such as variable pavement widths, sign supports, bridges and other structures, intersection, ramps and utility locations.

In general, luminaires should be located along the right in the direction of travel.

On undivided highways and streets, the use of one-sided arrangements should be limited to pavement having overall widths of less than 1.25 times the mounting height.

1140-4.3.4 Pole Location

1140-4.3.4.1 Lateral Placement

See [L&D Manual Volume 1, Section 600](#) for minimum lateral placement requirements. Setbacks are measured from the edge of traveled way. Where guardrail is not provided, the normal offset distance of the pole from the edge of traveled way may be the same as if guardrail were provided if frangible bases are used in accordance with the latest [AASHTO](#) safety requirements.

For improved safety, where the typical section of the roadway will allow a greater setback, poles shall be located farther from the pavement edge, consistent with available bracket arm lengths and frangible base capacities. Modern LED luminaires allow setbacks of 30 feet or more to be used on the same pole spacing as traditional HPS supports placed much closer to the roadway; therefore designers shall use 30' setbacks while still including breakaway transformer bases.

1140-4.3.4.2 Bracket Arm Length

Currently, conventional light poles are available with extended bracket arm lengths of 18, 20, 25 and 30 feet. These are in addition to the standard lengths of 4, 6, 8, 10, 12 and 15 feet. Poles with increased arm lengths should not be used intermittently except in unusual circumstances, such as may occur in a flare guardrail area in which the guardrail is not readily adjustable to accommodate the lighting units.

For historical reference, typical bracket arm lengths for given pole offsets from the edge of traveled way can be found in **Table 1197-6** for HPS luminaires. LED luminaires will usually achieve similar illumination with greater setbacks and shorter arms.

The following maximum combinations of bracket arm length and pole height are useful rule-of-thumb values for light poles mounted on aluminum transformer bases. Other combinations are possible but their feasibility must be verified by the designer with at least two manufacturers before including in the Plans.

- 40' MH / 22' arm
- 45' MH / 18' arm
- 50' MH / 15' arm

1140-4.3.5 High Mast

ODOT projects scoped for high-mast lighting generally utilize 400 watt high pressure sodium fixtures mounted on 70-foot or higher poles. Fixtures may be symmetric (**IES** Type V), asymmetric (**IES** Type II or III), or asymmetric "long and narrow" (**IES** Type I). Each high-mast pole supports two to six luminaires in a symmetrical arrangement. See [C&MS 725.21](#) for additional information on luminaires for light towers.

1140-4.3.6 Low Mast

An **ODOT** project utilizing a low-mast lighting system is made up of 50-foot poles supporting single 400 watt high pressure sodium fixtures. The fixture is generally symmetric (Type V) and is supported by a Style III or “shepherd’s crook” pole ([see Traffic SCD HL-10.11](#)) which is barrier-mounted between opposing lanes of traffic. This method is ideal for lighting sections of freeway with three to five lanes of traffic in each direction without the daytime “visual clutter” of twin-arm conventional units or the nighttime light trespass to areas adjacent to the roadway resulting from high-mast units.

1140-4.3.7 Decorative

Occasionally, a project will require the use of decorative poles and fixtures in order to maintain or establish the aesthetics of an area, such as replacement of a bridge in an area already utilizing fluted post-top units, or lighting the pedestrian/picnic areas of a rest area or Welcome Center.

Since most projects requiring decorative poles will be in an urban (i.e., curbed) area, the minimum offset to maintain 2 feet minimum lateral clearance from curb face will apply, with consideration given to overhead and underground utilities. Decorative post-top pole placement in the pedestrian/picnic area of a rest area varies with the individual layout, but an offset of 5 feet from the edge of the sidewalk is often used.

1140-4.4 Partial Lighting

1140-4.4.1 Interchange - General Information

Partial lighting is the process of lighting only the parts of the interchange that are considered most critical to the night driver. Partial interchange lighting implies that later stages of more fully developed lighting are not anticipated during the expected life of the initial system. Partial interchange lighting will generally apply in rural areas, and occasionally in suburban areas, to the lighting of interchanges on otherwise unlighted freeways for which ADT traffic satisfies warrants under Case PIL-1 or Case PIL-2 ([see Table 1197-3](#)). Lighting provided under this concept will generally be limited to diverging lanes, merging lanes and ramp intersections as described in the following section.

The following information is intended to provide guidance in determining the number and locations of lighting units for partial interchange lighting. The procedures outlined are generally applicable under the conditions stated; however, it does not necessarily follow that lighting at a given level will automatically be approved simply because conditions satisfy the warrants.

The typical luminaire arrangement for partial interchange lighting as shown in **Figure 1198-3** should be used in the following situations.

1. All diverging roadways, including exit ramps, ramp divergences, directional roadways, etc., should be lighted, particularly in the gore point areas. Normally, four units will suffice for partial lighting; however, when the taper is shorter than the normal unit spacing, the unit at the beginning of the taper may be omitted.
2. All converging roadways, including ramp acceleration lanes, ramp convergences, directional roadways and C-D roads, should be lighted. Normally, three units will suffice for partial lighting; however, the number of units may be adjusted in proportion to the taper length when it varies substantially from the standard 1200-foot ramp entrance length.
3. Combined accel-decel lanes (weaving lanes) should be lighted as combinations of the above two treatments. The seven units normally used may be adjusted to a fewer number depending on the length of the lane.
4. All ramp intersections with crossroads and all crossroad intersections within the

general interchange area should be lighted in accordance with typical arrangements shown in **Figure 1198-3**.

5. At RCUT installations, the default treatment shall be intersection lighting at each U-Turn end and intersection lighting at the central interchange, with no continuous lighting in-between.

In general, key unit locations for ramps are controlled by their speed change lanes and/or their intersections with side roads. However, overpasses and underpasses are not uncommon on ramps, and it will be necessary to adjust unit spacing in such cases to accommodate the various structure related items (**see Section 1140-4.6**). On partially lighted interchanges, the ramp proper is usually left unlighted for the initial installation; however, where loop ramps are involved, and the loop is entered from roads with high operating speeds, full loop ramp lighting may be provided.

Key unit locations for acceleration lanes or merging pavements should be at the point of the convergence of the right edge of mainline traveled pavement and the left edge of the subordinate traveled pavement (oriented in the direction of travel).

At deceleration lanes or diverging pavements, the key unit location should be approximately 40 feet in advance of the transverse joint which ends the gore area traveled pavement.

Key unit locations for combined accel-decel lanes and for relatively short auxiliary lanes should be treated at each end in accordance with the above, and reference should be made above for lighting the mainline pavement from the right of the added lane.

When calculating lighting unit spacing along tapers or variable width pavement, the pavement width at the key location (as located in the above discussion) should be used to determine the spacing for the succeeding, or second, location. The spacing from the second to the third unit should be determined from the pavement width at the second unit position. The spacing from the third to the fourth unit should be determined from the pavement width at the third position, and so on, until the pavement width and the spacing become uniform.

The following procedures should be followed in establishing key unit locations and subsequent spacing for partial interchange lighting.

1. Normally, the key unit location at the entrance nose for a ramp or merging lane will be installed in the future (**see Figure 1198-3**). The unit spacing to the second unit (or first unit to be installed initially) should be computed on the basis of the pavement width at the entrance nose. The spacing calculations should then be continued, as discussed previously in this section, proceeding toward the end of the acceleration taper, and alternating the initial and future units until the desired unit locations for the initial installations have been satisfied. If the entrance nose occurs on or immediately adjacent to a bridge, the nose unit should be installed initially, and the alternating of future and initial units as shown in **Figure 1198-3** should be reversed (i.e., units labeled "F" should be installed initially, and vice versa).
2. For exit ramps or diverging lanes, the key unit should be installed initially at a point 40 feet in advance of the gore point as shown in **Figure 1198-4**. From this key unit location, spacing calculations should be continued toward the beginning of the exit taper, using the pavement width at the key location to determine the spacing to the second (future/full) location. Using the pavement width at that location as a basis for spacing to the next unit (future/full) location, the process should be repeated as necessary as previously discussed for tapered areas. The unit within the tapered area nearest the beginning of the taper should be installed initially, as shown in **Figure 1198-4**. Reference should also be made to **Figure 1198-4** for location of the first mainline unit beyond the exit gore and for spacing along the ramp proper.
3. Lighting units at ramp intersections should be installed with the initial lighting project

(see Section 1140-4.6.2).

4. Unit locations for future/full lighting on interchange separation structures or other major structures within the interchange area should be determined as discussed in **Section 1140-4.6**, and grounding, conduit, pilasters, etc., for these units should be provided with the initial bridge construction to facilitate the future addition of bridge lighting.

1140-4.4.2 Diamond Interchanges

An illustration of partial lighting applications to a basic diamond interchange is shown in **Figure 1198-5**.

1140-4.4.3 Partial Cloverleaf and Cloverleaf Interchanges

For the intersections to work safely they should be designed properly with channelization to discourage/prohibit wrong movements, adequate signing to reaffirm the design, and lighting to give the driver the ability to see the geometry of the intersection.

At partial cloverleaf interchanges, in addition to the merge-diverge areas and the intersections with the highway, critical points include the loop ramps.

Full cloverleaf interchanges generally do not involve partial lighting since most of the interchange is composed of critical areas.

1140-4.4.4 Intersection

Partial lighting will alert the driver to an approaching intersection. In general, all lighting units for intersections may be considered key units. Severely skewed intersections, or those having more than four approaches, will require special consideration to assure that the apron areas and traffic control devices are discernable at night and that appropriate lateral clearances are available in the interest of safety. Unit locations for the more common intersection types are shown in **Figure 1198-7**.

Using a single light source at an intersection is generally undesirable because it may create a "brightness barrier." This "brightness barrier" is the same problem we experience when we attempt to see beyond the headlights of an oncoming vehicle. Multiple light sources at an intersection increase the lighted area and reduce the need to see beyond until the driver is inside the lighted area looking out.

1140-4.4.5 Combination Supports

The designer should always check with the maintaining agency of the traffic signals prior to combining signal/light poles. This is especially important if the lighting system is 480 volts. However, modern LED luminaires utilizing 120V circuits can illuminate an intersection using a single 15A branch circuit, which may originate from its own external disconnect switch (preferred) or from a circuit breaker mounted within the traffic signal cabinet, if present. Many agencies do not desire signal maintenance crews working with live high voltage lighting cables in the signal poles, pull boxes and conduits. In this event, the designer should attempt to maintain at least 10 feet separation between signal and lighting supports for aesthetic reasons, if possible. If combination signal/light poles are to be used, the signal and lighting designer(s) should carefully locate the supports so as to satisfy traffic and lighting needs, such as pedestrian push button and signal indication locations, vehicular signal locations, mast arm length, luminaire location and bracket arm length.

1140-4.5 Full Lighting

1140-4.5.1 Interchange

On simpler interchanges, it is assumed that the driver will be able to visualize the layout of the interchange by viewing the critical points. When interchanges become more

complicated such that the driver will need to be able to see the ramps, turning roadways, and the various elements of the interchange to get the visual picture, it may be necessary to light the entire interchange. This is known simply as complete or full interchange lighting. Full interchange lighting is generally associated with freeways and expressways where the mainline is lighted; however, it can be used in rural or suburban locations where there is a need to light the interchange, but not necessarily a need to light the mainline. In such instances, the need usually arises from the complex nature of the interchange.

With conventional lighting, luminaires are located at regular spacings along the ramps and turning roadways of the interchange. High-mast lighting is often used, especially at large or complex interchanges for the economic, safety and aesthetic reasons mentioned in **Section 1140-4.2**. High-mast unit locations vary with every interchange due to the geometrics; however, along the on and off-ramps, they are generally located on the outside (driver's right side) of the ramp. At interchange intersection areas, the high-mast units are usually best located inside the interchange.

When providing a more modern interchange configuration such as the Diverging Diamond or the Single Point Urban Interchange (SPUI), it generally utilizes full interchange lighting due to the extremely wide intersection area with the crossing arterial and the unfamiliar geometrics involved. High-mast units are ideal for this application.

1140-4.5.2 Street

Instead of partial lighting along a street (i.e., intersection lighting, as discussed in **Section 1140-4.4.4**), continuous or full street lighting may be required for a project. First, the pole arrangement and spacing must be determined based on the street width and illumination level, as discussed in **Section 1140-4.3.3**. The "one-side," "staggered" and "opposite" arrangements (**Figure 1198-8**) are used when it is impossible or inadvisable to use a median-mounted configuration. The choice among the three options depends mainly on the width of the facility to be lighted. The "one-side" arrangement is for narrow, one-way streets; two-way, two or three-lane streets; and other situations where the street is no wider than one to one and a half times the mounting height of the luminaire. The "staggered" arrangement is for streets of medium width (one and a half to two times the mounting heights). The "opposite" arrangement is used for streets which are extremely wide and where medians are too wide to effectively accommodate median lighting. In this latter case, the arrangement is actually two independent "one-side" arrangements.

Once the arrangement and spacing have been determined, the critical or key units at the intersections are chosen as shown in **Section 1140-4.4.4**. Finally, the pole locations between intersections are determined based on the arrangement and calculated spacing, with minor spacing adjustments as needed.

1140-4.6 Specific Cases

1140-4.6.1 Exit and Entrance Gores

See **Section 1140-4.4.1** for information about lighting exit and entrance gore areas.

1140-4.6.2 Intersections

In general, all lighting units for intersections may be considered key units. In the interest of reducing costs and the number of support poles in intersection areas, light poles, traffic signal, or overhead sign supports, are often combined when practical. This practice is encouraged to minimize the clutter effect of numerous supports which could hamper sight distance and increase the opportunity for vehicle impact with obstacles. Severely skewed intersections, or those having more than four approaches, will require special consideration to assure that the apron areas and traffic control devices are discernible at night and that appropriate lateral clearances are available in the interest of safety.

Also see **Section 1140-4.4.4** for information about highway lighting at intersections.

1140-4.6.3 Bridges Over Highways

Light poles on overpasses should be located as near to piers as possible to reduce pole vibration, and midway between construction joints where feasible. If abnormal pole vibration is anticipated, consideration should be given to the use of special pole mountings such as pier cap extensions or other structural modifications; or special padding material may be desirable between the pole base and pilaster support to dampen the effect of vibration.

Designers shall consider the maintenance of luminaires over the traveled roadway, and the potential for a large globe or other part to be accidentally dropped onto moving traffic below. Therefore, ODOT recommends arm-type supports over post-top supports on bridges.

Lighting units should not be installed within approach slab areas, nor within 10 feet of approach slabs. When the length of the bridge and approach slabs, plus the 20 feet for approach slab clearance, results in a length less than the design spacing for the lighting, the lighting units should be located uniformly at each end of the structure. If a staggered arrangement is being used, the units should be located at the far end of the structure on the right in the direction of travel.

When the length of the bridge and approach slabs, plus the 20 feet for approach slab clearance, results in a length greater than the design spacing, the first lighting unit associated with the structure must be located at least 10 feet in advance of the beginning of the approach slab. Subsequent units should follow design spacing across the bridge. See **Figure 1198-9** for overpass key unit locations.

1140-4.6.4 Pedestrian Bridges

Generally, all pedestrian bridges should be lighted. Since approaches to pedestrian bridges are not always accessible to maintenance vehicles, and since pedestrian bridge lighting is highly susceptible to vandalism, special consideration should be given to the location and protection of this type of lighting design.

1140-4.6.5 Overhead Signs

See **Section 1140-3.5** for information about lighting overhead signs.

1140-4.6.6 Street Trees

Since many projects involve modifying the typical section of an urban or suburban roadway and include the replacement or addition of street lighting and street trees, coordination in the placement of the light poles and street trees is essential. The location and spacing of the light poles is of primary concern. Street trees can then be placed between pole locations with adequate spacing from lighting units to allow for the illumination of the pavement. Consideration should be given to mounting height, bracket arm length and type of tree, as well as the tree trimming maintenance issue.

1140-4.6.7 Underpasses

Underpass luminaires may be required beneath any structure whose transverse width (between outer edges of parapets) is 75 feet or more. For underpass lighting design purposes, twin structures having less than 40 feet between adjacent parapets should be considered as a single structure. When the separation between twin structures is between 40 and 60 feet, consideration should be given to the use of post-mounted underpass units located between the two structures at a mounting height of approximately 20 feet.

Occasionally, skewed structures less than 75 feet in width will require underpass units, especially where the omission of such units would result in a serious compromise of the uniformity criteria. Underpass lighting may be required when a structure prevents adjacent

roadway units from providing lighting on the roadway beneath the underpass to the average intensity and uniformity of that provided for the roadway outside of the underpass. Each underpass must be evaluated on its own merits. However, installations employing luminaire mounting heights of 50 feet or less with underpasses whose length (structure width) is less than 1.5 times the luminaire mounting height and which are located in the middle third of the space between the roadway luminaires will not normally require underpass lighting units.

Adjacent underpasses may be located in such proximity that the roadway beneath the underpass structures must have supplemental lighting during daylight hours. In these cases, guidance will be found in the [IES's Recommended Practice 22 \(RP-22\)](#). This possibility should be considered when the length of the underpass exceeds 80 feet.

When underpass luminaires are not required, and the conventional unit mounting height exceeds the vertical clearance of the structure, lighting units should be provided in advance of and/or beyond the outer edge of the parapet of the overpassing structure at a distance conforming with the following conditions:

Mounting Height Feet	Distance from Light Unit to Parapet Feet
32.5	40
40	60
50	90

When a staggered arrangement is used, luminaires should be located to the right in the direction of travel at the exit end of the underpass.

When the above separation distance cannot be provided, the designer should check the need for glare shields to protect the overpassing traffic.

When underpass luminaires are used, their effect should be considered relative to adjacent conventional units, and distances between the overpassing structure parapets and the nearest conventional units should be established accordingly.

When the overpassing structure clearance is greater than the mounting height, conventional highway light poles may be used under the structure, or the units may be mounted on piers or abutments. Under such circumstances, the above distances need not apply. See **Figure 1198-10** for underpass key unit locations.

1140-4.6.8 Tunnels

Planners and designers should review **Section 1103-6.9, Underpasses and Tunnels**, for definitions, warrants, and other information related to tunnels. The goal of tunnel lighting is to provide for good driver visibility and a safe environment within a tunnel, day and night. The many factors that contribute to or detract from visibility need to be identified and their specific importance determined for each tunnel. The factors include:

1. Characteristics of the roadway approaches.
2. Characteristics of the tunnel roadway, walls and ceiling.
3. Characteristics of the area surrounding the tunnel portal.
4. Atmospheric and environmental conditions.
5. Characteristics of vehicular traffic operations.
6. Orientation of the tunnel with respect to sun and sky.

Since the need for design of tunnel lighting is relatively rare in **Ohio**, the designer should

reference the [ANSI/IES Tunnel Lighting \(RP-22\)](#) publication for an in-depth discussion on how these factors relate to each other. The publication contains information that will assist in determining lighting needs, providing solutions and evaluating resulting visibility within vehicular roadway tunnels.

1140-4.6.8.1 Tunnel Lighting Design Guidance

Tunnel lighting design is done using luminance criteria (units of cd/m^2) instead of the illuminance criteria (units of fc) typically used by ODOT for lighting design on open roadways. Designers should be aware that luminance-based tunnel design usually requires special software (e.g., AGI32™) not commonly used for open-roadway lighting design.

The following list includes specific design guidance for tunnel lighting design on ODOT projects. Contact the **Office of Roadway Engineering** for additional guidance.

- A. An early step in tunnel lighting design is to obtain the required threshold luminance level (L_{th}). **RP-22** gives several methods for this in Part 6.4.
 - a. For short tunnels, the use of **RP-22** Part 6.4.1, which determines preliminary design L_{seq} and L_{th} values, will often be acceptable to ODOT as a final design value as well.
 - b. For long tunnels, the more involved **RP-22** Part 6.4.2 method of determining L_{seq} should be used. Essentially, the designer first calculates an equivalent veiling luminance (L_{seq}) for the general area seen by the driver approaching the tunnel under worst-case (bright sun) conditions. Next, L_{th} is obtained by multiplying L_{seq} by a ratio. The ratio value is determined by a subjective criterion known as the Safety Rating Number (SRN). Note that ODOT recommends the use of $SRN = 5$.
- B. Long tunnels are rare in Ohio. However, if the tunnel is long, then following the threshold lighting zone will be one or more additional lighting zones of gradually decreasing design luminance values. **RP-22** Part 6.4.3 presents two methods for calculating the transition zone luminance values, either of which are acceptable to ODOT, but the Step-Down Method is preferred.
- C. Choose the nighttime luminance levels per **RP-22** Part 6.4.5.
- D. Some tunnels require switching steps that vary the internal luminance in response to the external luminance changes created by the weather and changes in the position of the sun. The following guidelines apply to ODOT projects:
 - a. Provide a PLC conforming to ODOT Supplemental Spec 818 for the control system.
 - b. Provide a control system enclosure conforming to ODOT Supplemental Spec 820. Locate the enclosure in an area that will not be in direct sunlight or provide a shelter, because the enclosure is passively cooled (unless active cooling is approved by ODOT). Provide all conduit entries with O-ring sealed hubs.
 - c. Obtain entrance portal measurements with one or more luminance meters compatible with the PLC inputs. An analog output is preferred, and this signal should be filtered and appropriately time-averaged at the PLC.
 - d. Dim tunnel luminaires using a 0-10VDC dimming signal obtained from the PLC. Buffer the signal as necessary. Provide a separate control signal for each zone.
- E. Provide communications conforming to Supplemental Specification 809 for monitoring the tunnel conditions. The set of tunnel condition parameters that require remote monitoring will vary from project to project. Contact the **Office of Traffic Operations**, ITS Section, for additional guidance.
 - a. The preferred method of monitoring tunnels that do not have fire alarm control panels is by CCTV. Unless the tunnel is short enough for the CCTV camera to see completely through, provide a CCTV camera at each entrance and exit portal.

- b. For tunnels equipped with fire alarm control panels, coordinate with the District and any other authority having jurisdiction (**AHJ**) to determine communication requirements for the project. See also **NFPA 502**, Part 4.5.
- F. If used, provide conduit bodies made of cast steel or malleable iron, with wedge-type malleable iron cover (not sheet steel), both triple-coated (electroplated or hot-dip zinc base coat, chromate intermediate coat, and epoxy finish coat), neoprene seal material, and all stainless steel hardware.
- G. Provide metal conduit per **NFPA 502** Part 12.3.1. If stainless steel conduit is not specified, provide Rigid Metallic Conduit per ODOT CMS 725.04. Exposed PVC conduit is not permitted in tunnels, per **NFPA 502** Part 12.3.2.
- H. Assure all electrical devices used in exposed areas are UL-Listed for Wet Locations.
- I. Assure that all electrical and electronic devices in exposed locations operate over the following environmental conditions, within their respective enclosures:
 - a. Temperature: -30°F to +165°F.
 - b. Humidity: 0-100% RH.
- J. Assure all circuit breakers are labeled for 100% load continuous use.
- K. Do not locate luminaires or junction boxes directly under roof joints because the joints sometimes leak.
- L. Provide LED tunnel lighting, emergency lighting and auxiliary lighting conforming to Supplemental Specification 813.
- M. Assure that the lowest point of each conduit run is equipped with a conduit drain with a stainless steel screen, except drains located in areas subject to wash-down, which shall be rated NEMA 4X or IP66. Long horizontal conduit runs shall be equipped with such drains at a spacing not to exceed 50 feet and located on a short stub below the run.
- N. Assure that each electrical pull box or manhole located above the tunnel level is equipped with a drain conduit routed to a suitable protected outlet location not subject to damage by mowers and other sources. Provide a varmint screen at the conduit drain outlet. Locate the outlet at least 1.5 feet above the bottom of a ditch, wall, slope or swale, or route to a suitable roadway drainage conduit. For conduit drain outlets in ditches, slopes or swales, install a 12-inch square flat-panel marker sign on two U-channel posts that straddle the conduit at the outlet, to help locate and protect it. The sign message shall be "CONDUIT DRAIN" in 2-inch green letters on a white field using 730.18 Type F sign sheeting, with a 1-inch green stripe across the top, and facing the roadway. Mount the bottom of the sign panel at least 5 feet above grade.

1140-4.6.8.2 Tunnel Fire Protection Design Guidance

Tunnels shall conform to **NFPA 502, Road Tunnels, Bridges, and Other Limited-Access Highways**, including all documents referenced therein. **NFPA 502** provides fire protection and life safety requirements for tunnels. If a fire alarm system is required by **NFPA 502** or other project documents, then designers should pay particular attention to **NFPA 72**, National Fire Alarm and Signaling Code, and **NFPA 70 (NEC)** Article 760, Fire Alarm Systems.

Because tunnel fire-protection system and tunnel lighting design tasks are interrelated, this section of the Traffic Engineering Manual lists a number of fire-protection design guidelines below.

- A. The fire alarm control panel enclosure will be separate from the tunnel lighting control system enclosure.
 - a. Do not locate the enclosure in direct sunlight or mount directly to a wall.
 - b. Provide all conduit entries to the enclosure with O-ring sealed hubs.
 - c. Equip the enclosure with a vent-drain placed in the lowest point of the enclosure.
 - d. Do not mount enclosures containing electrical or electronic components, switches, shunts, or similar devices susceptible to internal condensation directly onto concrete walls. Instead, the designer should specify suitable

- concrete anchors and standoffs to leave at least one inch of air space between the enclosure and the wall. Provide stainless steel standoff hardware.
- e. Do not expose any touch-panel or monitor screens directly to the weather; provide a transparent, snap-latch, weather-tight UV-resistant access door.
 - f. Provide external labels of 630.02 Reflective Sheeting, Type F, silk-screened, with red letters on white background.
- B. If used, provide conduit bodies made of cast steel or malleable iron, with wedge-type malleable iron cover (not sheet steel), both triple-coated (electroplated or hot-dip zinc base coat, chromate intermediate coat, and epoxy finish coat), neoprene seal material, and all stainless steel hardware.
 - C. If stainless steel conduit is not specified, provide Rigid Metallic Conduit per ODOT CMS 725.04.
 - D. Provide stainless steel clamps and hardware for all conduit wall and ceiling attachments.
 - E. Unless specified otherwise, use linear heat detector cable for automatic detection.
 - a. Provide stainless steel hanger hardware for linear detectors. Route all linear detector cable direction changes as gradual sweeps conforming to the manufacturer's bend specifications.
 - b. Provide stainless steel junction boxes conforming to Supplemental Specification 820 for all linear detector circuits. Do not locate any junction boxes over traveled lanes.
 - c. Provide all locking enclosures (including test shunts) with a stainless steel latching hardware and marine brass lock core with weatherproof tab.
 - d. Provide O-ring sealed hubs for all conduit entries into junction boxes.
 - F. Provide LED alarm indicators for each manual fire alarm box. Provide stainless steel wall supports at each end of any conduit used to mount indicators directly to the manual fire alarm box.
 - G. Traffic control and ITS construction items (beacons, signs, dynamic message signs, etc.), used to control traffic approaching the tunnel portal and direct approaches, shall meet all applicable sections of the ODOT CMS, in particular Parts 625, 630, 631, 632, 633, Supplemental Specification 809, and other Supplemental Specifications as required.
 - H. Water supply construction items shall meet the requirements of the Authority Having Jurisdiction (AHJ) and ODOT CMS Part 638.
 - I. Designers shall pay particular attention to NFPA 502 Chapter 12, Electrical Systems during all stages of electrical system design.

1140-4.6.9 Median Mounted

When median-mounted lighting is used, the system will require supplemental units along the outside of the roadway when the effective width of the directional pavement is excessive. For example, if the directional pavement exceeds 48 feet, and a 40-foot mounting height is used, supplemental units will be needed; or if the directional pavement exceeds 60 feet and a 50-foot mounting height is used, supplemental units should be added.

High-mast units can also be very effective along freeways when median mounted, either in a grass median with proper lateral clearance or barrier mounted.

1140-4.6.10 Roundabouts

All roundabouts shall be lighted. Roundabout lighting shall be designed according to **IES DG-19-08, Design Guide for Roundabout Lighting**, published by the **Illuminating Engineering Society**. In general, ODOT-maintained roundabouts shall have lighting design limits extending beyond the approach tapers, as shown in **IES DG-19-08 Figure 3**.

Typical installations shall have a minimum of eight pole locations: four illuminating the circulatory roadway and pedestrian areas and four illuminating the approach tapers. Design lighting levels and uniformity shall comply with **IES DG-19-08 Table 1**, which is based on functional class of the intersecting roadways and pedestrian demand. This Table is reproduced below.

Illumination for Roundabouts				
Functional Classification	Maintained Average Horizontal Illuminance in Lux/ftc on the Pavement Based on Pedestrian Area Classification			E _{avg} / E _{min}
	High	Medium	Low	
Major/Major	34.0/3.4	26.0/2.6	18.0/1.8	3:1
Major/Collector	29.0/2.9	22.0/2.2	15.0/1.5	3:1
Major/Local	26.0/2.6	20.0/2.0	13.0/1.3	3:1
Collector/Collector	24.0/2.4	18.0/1.8	12.0/1.2	4:1
Collector/Local	21.0/2.1	16.0/1.6	10.0/1.0	4:1
Local/Local	18.0/1.8	14.0/1.4	8.0/0.8	6:1

1140-4.7 Placement Adjustments

Once all pole locations have been determined for a given design area, individual poles may require slight adjustment longitudinally or laterally to avoid interference with utilities, minor structures (e.g., catch basins, headwalls), drive aprons and ditches. In urban areas where building faces are often at the back of the sidewalks, attention should also be given to doorways to buildings, overhead canopies and signs, basements and utility vaults under sidewalk areas, and heated sidewalks. Such adjustments should normally not exceed a 5 to 6-foot shift per location.

1140-5 Circuit Design

1140-5.1 General

Proposed circuitry, including service pole locations, is a basic requirement of any lighting system. The following sections reflect general **ODOT** standard materials and methods; however, the lighting designer should always check with the specific **District** (or local maintaining agency) for confirmation of standards or preferred alternate materials and/or methods.

1140-5.2 Voltage

1140-5.2.1 General

See **1120-6** and **1141-3.10** for information about power service and branch circuit voltages.

1140-5.2.2 Voltage Drop

After formal approval of proposed service pole locations has been obtained from the power supplying agency and the proposed lighting layout has been approved by **ODOT** for detailed design, voltage drop calculations should be completed and included in the Stage 3 review submittal. The calculations should indicate the voltage at each lighting unit, at each lighted sign installation, at each "wye" in each circuit, and at the end of each circuit.

The allowable voltage drop in each circuit is 5 percent. Reference should be made to **Figure 1198-12** for a sample voltage drop calculation for a 480-volt, two-wire grounded neutral system (current **ODOT** systems use three-wire grounded neutral but the voltage drop calculation method is unchanged.)

1140-5.3 Control Center**1140-5.3.1 General**

The Control Center and Power Service items are related but are not synonymous. The Power Service item includes the Control Center. Several standard construction methods are available for power service and control centers, as shown in the Power Service standard drawing. The designer shall contact the individual **District** (or maintaining agency) to determine if a meter is required.

1140-5.3.2 Load

As part of the construction plan preparation, the designer should include a Control Center Data chart (**Figure 1198-11**) with all the required information. Details of the enclosures and how they are wired and mounted are shown in the [Traffic SCD HL Series](#).

Designers should limit lighting branch circuit loads to 30A or less, if possible, to allow wires to be terminated and bent into position in the support base volume. Up to six (6) branch circuits can emanate from a typical HL-60.31 Lighting Control Center. Designers should strive to use no larger than #2 AWG in branch circuits. See **1140-5.4.2**.

1140-5.3.3 Location

Service facilities should be located outside interchange areas, but within right-of-way limits. Where safety criteria applies, the supporting poles should be located more than 30 feet from the edge of the traveled pavement. Special care should be taken in the location of service facilities to assure reasonable accessibility by maintenance personnel and equipment during wet weather. Areas such as at the toe of a steep slope below the access roadway and deeply swale areas should be avoided, especially if they are subject to temporary flooding or drifting snow. Cross section data and right-of-way information shall be examined for each service pole and control center location to facilitate evaluation of its suitability relative to adjacent terrain. Each location shall also be formally cleared with the power supplying agency, and copies of all correspondence relative to electrical service shall be furnished to the **District** reviewing the lighting plan. During the initial contact with the power supplying agency, special offset requirements for service poles should be discussed, the supplying agency's system power requirements should be determined, and policies with respect to secondary lightning arrestor locations, grounding, metering, etc., should be clearly understood. Where local governmental agencies require that service pole areas be enclosed by fence, the designer should determine if grounding of the enclosure fence is required.

1140-5.4 Cable**1140-5.4.1 General**

All new or completely replaced lighting systems maintained by **ODOT** shall be three-wire systems utilizing distribution cable rated at 2400 volts. On projects that are within existing lighting systems, the new distribution cable should match the existing distribution cable.

1140-5.4.2 Cable Size

The preferred size of circuit cable is No. 4 **AWG**. If necessary to avoid an excessive voltage drop, larger cable may be used between the control center and the first lighting unit within a given circuit. If this procedure still results in a voltage drop exceeding 5 percent, the circuit cable size should be increased to No. 2 **AWG**, or larger in rare instances. Most modern LED-based lighting installations use No. 6 or No. 4 **AWG**. Uniformity in circuit cable size and type of connector kit is highly desirable in a given project area. Reference should be made to **Section 1140-5.2.2** for documentation requirements for circuitry voltage drop calculations.

Pole and bracket cable, used and itemized separately with conventional units, should be No. 10 **AWG** and extends from the connector kits in the pole base to the lighting fixture.

1140-5.4.3 Cable Type

There are two types of circuit cable, distribution cable and duct cable. Distribution cable is single conductor wire with polyethylene insulation, while duct cable is a factory preassembled cable in a coilable, high-density polyethylene pipe-type duct (typically 1.5-inch diameter) with the specified number and size of insulated conductors.

1140-5.4.4 Cable Applications

Duct cable is often used within an interchange area since it is easily installed, cost efficient, and there is generally a reduced risk of it being disturbed since the interchange is within limited access right-of-way. Duct cable is generally not used along a highway where sign post installation, utility work, plantings and new curb/driveway cuts are apt to damage the cable.

Distribution cable is installed in conduit (**Section 1140-5.5**) along highways, under streets and ramps, and through bridges and concrete barrier.

1140-5.5 Conduit

1140-5.5.1 Conduit Type

Buried conduits should generally be rigid ferrous metal without encasement, including those which are specified for embedment in structure concrete; however, under the following conditions, buried conduits should be concrete encased:

1. Between primary service sources and distribution transformers.
2. Circuit interconnections on embankment slopes adjacent to separation structures.
3. On any slope steeper than 3:1.

1140-5.5.2 Conduit Size

The a list of conduit sizes appropriate for the usage indicated can be found in **Table 1197-7**; however, the nominal size may be increased where necessary to provide adequate space for the circuitry proposed.

1140-5.5.3 Conduit Fill

The required conduit size is determined by the number and sizes of cable to be contained in the conduit. The conduit should not be filled to more than 40 percent. The fill areas are determined by adding the cross-sectional areas of all cables to be contained in the conduit and compared to the 40 percent fill area of the conduit.

1140-5.6 Splice Types

1140-5.6.1 Connections Unfused Permanent

Connections unfused permanent are used in pull boxes to splice circuit wires together in the following situations:

1. Where a circuit branches.
2. Where a circuit enters the pull box adjacent to a lighted sign installation.
3. Where a circuit must change from duct cable to distribution cable (e.g., on either end of a structure and at the base of the service pole).

Although the connections are water resistant, connections in pull boxes should be kept to

a minimum due to the inherent moisture problems which result.

1140-5.6.2 Connections Non-Permanent

Connections of several types, are described in [C&MS 725](#). The most routinely used connections are the fused and unfused pull-apart types, used to connect circuit cable with the pole and bracket cable in a conventional or post-top light pole base.

1140-5.6.3 Summary of Connection Applications

1. Connection, Fused Pull Apart - used for hot wires when pull-apart or breakaway action is needed, as in light pole bases that might get knocked over by vehicles.
2. Connection, Unfused Pull Apart - used for neutral wires, similar to above but since the neutral provides no substantial voltage, no integral fuse is needed.
3. Connection, Unfused Bolted (not pull-apart) - used for hot and neutral connections when breakaway action is not needed, such as median junction boxes or structure junction boxes.
4. Connection, Unfused Permanent - typically used in pull/junction boxes for splitting one lighting circuit into two or more circuits (i.e., a "split" in the branch circuit) or for splicing long runs of wire. Can also be used for the Equipment Grounding Conductor in branch circuits, especially when the grounding conductor is insulated. See NEC 250.64 and 250.118, which requires crimp connectors to be "irreversible" when used for grounding conductors. (725.15E used the phrase "one time use" for "irreversible".)

1140-5.7 Pull Box

1140-5.7.1 General

The **ODOT** standard pull box is detailed on [Traffic SCD HL-30.11](#). The 18-inch diameter pull box is intended for one circuit or for a maximum of three connections; and the 24-inch diameter pull box is intended for two or three circuits, or for a maximum of six connections. If more than three circuits are involved, consideration should be given to the use of two boxes or a box of special design. Pull boxes, when used, are generally located within the alignment of the normal longitudinal trench.

City standard pull boxes may be used where consistent with the practices and policies of the maintaining agency.

In general, the use of pull boxes is discouraged because experience has indicated that inherent moisture problems results in more disadvantages than advantages. If flow lines within approximately 20 feet of a pull box location will permit drainage, a positive drainage system using 4-inch shallow underdrains, should be installed.

1140-5.7.2 Pull Box Types

The **ODOT** standard pull box is concrete ([C&MS 725.08](#)); however, plastic ([C&MS 725.07](#)) may be used in urban lawn areas where there is no chance of vehicles driving over the box. Steel pull boxes, although used in highway and interchange areas in the past due to their low cost, are no longer used because of the lids being difficult to secure in place. The pull box then fills with water and debris and/or becomes a safety issue with mowing equipment and maintenance personnel.

1140-5.7.3 Placement

Acceptable locations for pull boxes are as follows:

1. At the base of a pole used to mount a control center or disconnect switch, if located lower than the roadway proper.
2. At each end of a structure which carries electrical utility lines across the structure (approximately 10 feet beyond the ends of the parapet).

3. At the conduit riser for underground lighting circuits.
4. For connection of illuminated signs or underpass lighting to a lighting circuit.
5. At any split or tap in a lighting circuit that cannot be provided in the transformer base of a light pole.
6. At a minimum, at one end of a conduit jacked under pavement.

In urban areas, the designer should avoid placing pull boxes within curb ramps, curb ramp landing areas, or too close to intersection radii where large turning vehicles will disturb the pull box or cover.

1140-5.8 Junction Box

Junction boxes, as detailed in [Traffic SCDs HL-20.13 and HL-20.14](#), are intended for use in concrete barrier and on structures, respectively. The designer should check with the **District** before using them. There is some concern that unless structure junction boxes are required for cable pulling purposes due to an excessively long conduit run (in excess of 300 to 400 feet), junction box lids end up missing because of screws becoming loose, and screws lost or not replaced during maintenance operations. The box becomes an easy access point for water, rodents and debris.

1140-5.9 Trenching

1140-5.9.1 General

The normal longitudinal trench alignment for distribution cable or duct-cable installations will be parallel to the controlling pavement edge or base line and in a direct line from pole to pole, as detailed on [Traffic SCD HL-20.11](#).

1140-5.9.2 Trench in Paved Areas – Jacking and Boring

When circuits require crossing under existing ramp, mainline or arterial pavement open to traffic, steel conduit (3-inch minimum diameter) is often jacked or bored under the pavement to minimize disruption to traffic and the pavement itself. Push pits must be dug behind guardrail or beyond the back of the paved berm, as shown on [Traffic SCD HL-30.22](#). Concrete pull boxes are usually installed at the ends of the jacked conduit for cable splicing purposes.

1140-5.9.3 Trench in Paved Areas - Open Cut

The alternative to jacking conduit under pavement is laying conduit in an open cut trench. This method is used when conditions are such that finding areas for push pits is difficult because of numerous utilities, right-of-way constraints, walls, sidewalks, etc., or if construction phasing is such that traffic can be satisfactorily maintained when trenching. In paved areas either a T trench or "narrow slit type" trench is used as shown in [Traffic SCD HL-30.22](#). The cost of open cut trench (including conduit and replacement backfill and pavement) is generally one-third more than jacking the same size conduit.

1140-6 Foundations

1140-6.1 Foundation Types

1140-6.1.1 Conventional

1140-6.1.1.1 General

The standard conventional light poles is a transformer base type. All poles located within 30 feet of the edge of traveled pavement shall include a cast aluminum transformer base meeting current [AASHTO](#) safety requirements for frangibility, with

the following exceptions:

1. Poles located along streets or roadways with design speeds less than 40 miles per hour and with adjacent pedestrian traffic shall be mounted on steel transformer bases.
2. High-mast (tower) poles, and light poles mounted on concrete barrier medians or certain walls and structures, shall be anchor base types.
3. Light poles located on bridges shall have steel transformer bases.

1140-6.1.1.2 Drilled Shaft

The Office of Roadway Engineering has several foundation design aids available on its web page.

Since roadways are normally constructed on stable subgrades, foundations for conventional light poles may be designed for the following minimum depths unless unstable soil conditions are suspected:

Light Unit Mounting Height Feet	Min. Foundation Depth Feet
Less than 40	6
40 - 44	8
45 - 55	10

1140-6.1.1.3 Median Mounted

Conventional light poles mounted on concrete barrier median shall be anchor base poles. The poles shall have drilled shaft foundations as shown above except that the depth shown shall be the depth extending below the base of the median barrier. The **SCDs** show additional details.

[Traffic SCD HL-10.15](#) is available for use on projects where the height of an existing concrete median barrier is being increased by at least 8 bolt diameters. It allows for the extension of existing anchor bolts using a coupling nut. This drawing does not constitute a general foundation and/or anchor bolt repair method; such methods shall be developed on a project-specific basis by a qualified structural engineer.

1140-6.1.1.4 Pilasters

Conventional light poles mounted on a bridge shall have steel anchor bases and are mounted on a projection beyond the normal outside face of parapet, or pilaster. Poles on pilasters should be located as near to piers as possible to reduce pole vibration. Where fencing separates the lighting pilaster from the bridge proper, a suitable handhold should be provided in the fencing to allow access to the pole handhole.

1140-6.1.2 High Mast

1140-6.1.2.1 General

Since light towers should be located more than 30 feet from the traveled roadway, it is unlikely that the compaction for the roadway would have the same influence as for conventional light pole sites. Consequently, the design of foundations for towers will require a procedure involving soil classification at the site. Where soils profiles and/or reasonably accurate soils data are available from existing highway plans or other reliable sources, the soil classification and related foundation design process may proceed without the need for individual soil borings at each proposed site. However, designers are expected to exercise prudent engineering judgment in the event there is

reason to suspect that existing soils information is not reliable for the tower site or if the information available indicates that the allowable lateral soil resistance is not compatible with design guide tables and charts. In such cases, individual soils borings should be obtained for each tower site which is suspect, and specific designs should be prepared for each tower foundation.

Reference should be made to the suggested procedure for light tower foundation design in **Section 1140-8**. This procedure is applicable to projects where reasonably reliable soils data is available.

1140-6.1.2.2 Maintenance Platforms and Grade Flattening

Maintenance platforms and grade flattening have been found to be traps for debris. The steepened slopes above and below the flattened area or the diversion of water along the wall of the platform are sources of slope erosion. These areas also require the manual trimming of vegetation since chemical control only leaves bare ground which is even more susceptible to erosion. These negative aspects and the resulting increased maintenance are more detrimental than the nicety of the flat area about the base of the high-mast lighting unit. Therefore, the use of these features is no longer recommended.

1140-6.1.2.3 Median Mounted

Light towers mounted on, or more correctly, incorporated into, concrete barrier median are treated similar to overhead sign supports. Their foundation size (usually 36-inch diameter) requires a widening of the median barrier by use of 40-foot transitions as shown in the [Roadway SCDs](#). When considering median-mounted tower lighting, the designer must consider the shoulder width on either side of the median. An adequate width shoulder must be available for the maintenance vehicle and the lowering of the luminaire mounting ring.

1140-6.1.3 Low Mast

1140-6.1.3.1 General

Generally, low-mast lighting (defined as a single high-mast luminaire or as a dual-high mast luminaire (2-foot offset) mounted on a pole with a 50-foot nominal mounting height) requires a 2-foot diameter by 10 feet deep foundation in non-sloping areas. Deeper foundations should be considered in steeper sloping areas or areas of poor soils.

1140-6.1.3.2 Median Mounted

Low-mast units are frequently mounted on concrete barrier median separating two-lane groups of traffic each having three or four lanes plus shoulders. The anchor base units utilize a rectangular pole base plate mounted on top of 50-inch barrier. The foundation extends 10 feet minimum below the base of the barrier as detailed in [Traffic SCD HL-20.13](#).

1140-6.1.4 Decorative

Decorative poles should be looked at on an individual basis when determining foundations. Often, the standard 6, 8 or 10-foot depths can be used for poles 50 feet in height or less with possible modifications of the formed top 6 inches to accommodate larger decorative bases or sidewalk paver areas. Foundations for decorative units over 50 feet in height should be determined by a soils engineer furnished with soils information, pole heights and luminaire weights, quantities and effective projected areas.

1140-6.2 Locations

1140-6.2.1 Conventional

Along uncurbed sections of roadway, the normal location of conventional light poles is 6.5 feet behind the face of guardrail. Where guardrail is not provided, the normal offset distance of the pole from the edge of pavement should be the same as if guardrail were provided, and frangible bases should be used in accordance with the latest [AASHTO](#) safety requirements.

In curbed areas, the normal location of conventional light poles is 2.5 feet behind face of curb (2 feet minimum clear), but no closer than adjacent utility poles near the curb.

For improved safety, where the typical section of the roadway will allow a greater setback than normal, poles may be located farther from the pavement edge, consistent with available bracket arm lengths.

1140-6.2.2 High Mast**1140-6.2.2.1 General**

High-mast units must have 30 feet minimum clearance from the edge of pavement/traveled way (i.e., painted edge line) on freeways and expressways in the absence of guardrail. A 40-foot clearance is preferred if maintenance access is not compromised. The designer should be aware of culverts, ditches, fences, right-of-way/limited access limits, and underground and overhead utilities when selecting high-mast pole locations. Guardrail should not be installed solely to “protect” a high-mast unit unless absolutely necessary as the guardrail itself becomes an object for road users to strike. If guardrail or concrete barrier will be required to protect bridge columns or overhead cantilever or truss signs, the guardrail may be extended no more than 75 feet to include a high-mast pole.

1140-6.2.2.2 Maintenance Platforms

The use of maintenance platforms is discussed in **Section 1140-6.1.2.2**. When used, the clearance from the edge of pavement to the nearest edge of the platform wall must conform to the minimum offsets in the [ODOT L&D Manual Volume 1](#).

1140-6.2.3 Low Mast

Unless mounted on concrete barrier median, low-mast units may be mounted on breakaway transformer bases or anchor bases, in which case, offsets must comply with those described for conventional poles (**Section 1140-6.2.1**) or high-mast poles (**Section 1140-6.2.2**) as appropriate.

1140-6.2.4 Decorative

Since most projects requiring decorative poles will be in an urban (i.e., curbed) area, the minimum offset to maintain 2 feet minimum lateral clearance from curb face will apply, with consideration given to overhead and underground utilities. Decorative post-top pole placement in the pedestrian/picnic area of a rest area varies with the individual layout, but an offset of 5 feet from the edge of the sidewalk is often used.

1140-7 Grounding**1140-7.1 Towers**

Two ground rods are required (and separately itemized in the plan) for each high-mast pole. The second ground rod is associated with the lightning protection system required with each tower.

1140-7.2 Conventional

1140-7.2.1 General

All conventional, decorative and low-mast poles require one ground rod. This includes poles mounted on concrete barrier median. Details for pole grounding are shown on [Traffic SCDs HL-20.11 and HL-20.13](#) (median mounted).

1140-7.2.2 Pilasters

Poles mounted on bridge pilasters are grounded via grounding bushings in the steel conduit to interconnect structure conduit system with structure grounding system. [Traffic SCDs HL-20.14 and HL-50.21](#) provide details.

1140-7.3 Bridges

A structure grounding system (described in [C&MS 625.16](#) and detailed in [Traffic SCD HL-50.21](#)) shall be paid with each bridge as part of the lighting plan quantities. Although the structure grounding system pay item is composed of several ground rods, cable, etc., the callout location on the lighting plan for the pay item is at the centerline station of a fixed pier.

1140-7.4 Fences

Where overhead power lines cross a fenced roadway right-of-way, or where overhead transmission lines rated 110 KV or higher are parallel to roadway fences and the transmission line easement is contiguous to the roadway right-of-way, the roadway fences shall be grounded as shown and described on [Traffic SCD HL-50.11](#).

1140-8 Suggested Procedure for Light Tower Foundation Design

The following information is intended to be used in determining caisson lengths for tower foundations without the need for an extensive soil investigation at each tower location.

Regardless of the type of foundation used, information on soil classifications and soil strengths which resist the lateral movement must be established for the foundation design and also to determine the lateral soil pressure. In most cases the subsurface investigations and soil borings made for the Project Soils Profile and bridges will be sufficient to determine the soils classification and strength. However, the determination of soil parameters should be made by a soils engineer. If the soil strength and classification are relatively uniform on a given project site, one value for lateral soil pressure can be used, and the need for extensive soil investigations at each tower location can be avoided. Recommended lateral soil pressure values are shown on **Table 1197-9**.

In addition to the lateral soil pressure, load reactions on the tower, horizontal shear, uplift and overturning moments shall all be taken under consideration when designing foundations. The foundations shall be designed for loads equal to, or greater than, the maximum loads of the tower design, with considerations given to economics and construction feasibility.

Design calculations to determine load reactions and horizontal shear on light towers shall comply with applicable [AASHTO](#) requirements as set forth in the latest issue of **Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals**, except that the design wind load shall be based on wind speed of 90 miles per hour, with a maximum load of six luminaires, each weighing 75 pounds (35 kilograms), with a maximum actual projected area of 3.5 square feet and mounted in one horizontal plane.

When the values for allowable lateral soil pressure, total lateral force, and total moment about the resisting surface of the tower have been determined, the required embedded depth can be found using the Foundation Embedment Nomograph in **Table 1197-10**, which is based on E. Czerniak's recommendations for lateral soil pressure of various soil strengths and classifications. This nomograph satisfies foundation criteria currently used for **Ohio** designs and is valid for caisson type foundations where the embedded depth does not exceed ten times the foundation diameter.

Values for lateral force and overturning moment must be adjusted to a value per foot of caisson width prior to using the nomograph. The normal tower foundation diameter shall be 36 inches unless the tower anchor base plate and bolt circle requires a diameter of 42 inches.

Since the foundation embedment obtained from the nomograph is the depth below the resisting surface of the earth and not from the ground line, the total required foundation length can be obtained by increasing the graph value by 1 or 2 feet (0.3 or 0.6 meter) . For design purposes, the foundation length determined from the graph should be increased to the next longer length that is a multiple of five (English units only).

The foregoing design procedure provides a suitable design method for determining the required caisson length as functions of soil classification, shear force and overturning moment. The soils likely to be encountered have been categorized into six values of allowable lateral soil pressures. Where existing soils information will permit identification for strength and classification, it will not be necessary to use refined design procedures involving extensive soil exploration.

Another acceptable method of design is the Broms method. The Office of Roadway Engineering makes an Excel spreadsheet available on its webpage to assist with the application and documentation of the method. Using only three basic soil parameters 1) undrained shear strength, 2) friction angle, and 3) effective unit weight, design foundation depths may be obtained for cohesive or cohesionless soils. For the many Ohio soils that do not clearly fall into the categories of purely cohesive or cohesionless, it is recommended that the designer use each case, which have separate calculation sheets; the cohesionless calculation will represent drained condition and the cohesive calculation will represent undrained condition. The designer applies a factor of safety representative of the site and loading uncertainties, with a minimum value of 1.5 for very well-known conditions. When conditions are less well known, a factor of safety of 3-4 should be used.

Table 1197-11 presents recommended tower foundation depths calculated for structures with round tapered shafts designed in accordance with the [1975 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals](#) for a 90 miles per hour wind zone when supporting the following load:

- ▶ Six cylindrical luminaires with projected area of 3.5 square feet ($C_D = 0.5$) and weighing 75 pounds each.
- ▶ One cylindrical head from assembly with projected area of 5.3 square feet ($C_D=1.0$) and 340 pounds top latched lowering device.

4. The end of each acceleration lane.
5. Bridge structures and retaining walls, including pier and abutment locations, and length of approach slabs. Include **ODOT** structure number when appropriate.
6. Drainage culverts and flow lines.
7. Existing and proposed overhead and underground utilities. Show width and/or boundaries of the utility right-of-way or easement and fence grounding points where overhead electrical lines are involved.
8. Type, wattage or lumen rating, and ownership of existing lighting in the project area, and planned disposition.
9. Maintenance jurisdiction boundaries.
10. Funding participation boundaries.
11. Future lighting unit locations needed to portray the coordination between adjacent improvements.
12. A north arrow, located on the upper right corner of the sheet.
13. A legend, or reference to the plan layout sheet showing the legend. The legend shall indicate by appropriate symbol the various nodes (e.g., light poles, light towers, pull boxes, junction boxes, power services, etc.) and links (e.g., conduits with distribution cable, unitized cable in duct assemblies, etc.) to be installed.
14. The location of each light pole foundation, conduit crossover, pull box, control center, tower, etc., by centerline or baseline station and offset distance from the controlling pavement edge. Include the maintenance platform type, if any.
15. Existing and proposed rights-of-way (R/W).
16. Guardrails and barriers.
17. Illuminated signs. Show an appropriate symbol, the sign installation number, the centerline station and the total wattage of the installation.
18. Combination supports. Clearly indicate the nature of the combined support (e.g., Sign & Luminaire, Signal & Luminaire) and show all applicable data for electrical service and the separate bid items necessary to provide the lighting components. Add a cross-reference to the Traffic Control Plan sheet showing the support details.
19. Begin Project and End Project, along with work limits for the mainline and for each crossroad.
20. Match lines. Avoid the use of match lines along the centerline of any illuminated roadway.
21. Station equations. Show the station equations along lines of survey, between centerline of route and baselines of roadways, crossings between routes and intersections of roadways.
22. If landscaping is part of the project, proposed trees in areas adjacent to the proposed light poles should be shown.

1141-3.7 Special Details

Special detail sheets should show only those details which are not covered in the [SCDs](#), the [C&MS](#) or the [Supplemental Specifications](#). In cases where modification of a standard detail is necessary, variations from the standard should be clearly identified. Clearly indicate the location(s) to which the detail applies especially if it does not apply to all locations within the project. The designer should carefully review the latest edition of the [Traffic SCD HL series](#) to determine if a particular detail has been covered before creating of a special detail drawing.

1141-3.7.1 Required Special Details for Underpass Lighting

If the lighting plan includes underpass lighting, the following should be included for each

lighted underpass: a detail (elevation) view indicating the location of each luminaire; the disconnect for the underpass lighting; and the routing of all conduits comprising the service to underpass lighting from the pull box or junction box that is the point of connection of the main lighting circuit.

1141-3.8 Circuit Maps

When the lighting installation is large and circuits continue across several sheets, a map of each circuit in abbreviated detail should be included. The Control Center Data Chart (**Figure 1198-11**) should be included on the map of the first circuit (numbered "1" or "A") radiating from the service point. The maps of all other circuits radiating from that service point should contain a cross reference to the sheet on which the data table for that particular service appears. If circuit maps are not being prepared for an installation, then the Control Center Data chart should be located on the plan view sheet showing the location of the service.

1141-3.9 Tower Cross Sections

To support the pole height selected for each tower, the designer shall provide pavement elevation(s) for the roadway(s) lighted by each tower and finished grade at the base of the tower in tabular form on supplemental worksheets and no cross sections will be drawn.

In some cases, this will be illustrated by a cross section drawn from the edge of pavement out through the location of the tower, or if the tower lights multiple roadways, a cross section will be drawn from each roadway out through the tower location.

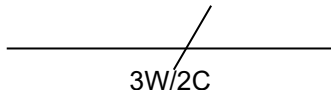
1141-3.10 Wiring and Circuit Designations

In plan preparation, it is very important to describe existing and proposed circuits correctly. Wiring for lighting circuits requires the following information in order to be completely described:

1. Number of wires;
2. Number of Conductors;
3. Nominal voltage (typically, L-N and L-L shown);
4. The phrase "with ground" as required; and
5. Wire size (guage) as required.

Note that the Ground wire (grounding conductor) of a system is not counted as a *conductor* (because it does not carry load current), but it is counted as a *wire*. The Neutral wire is the grounded conductor.

Thus, when drafting plans, the clearest way to mark circuits is by specifying both the number of conductors and number of wires, as in the example below:



Some example wiring and circuit designations are shown below. The designation in parentheses is the terminology per **NEC-2011 Art. 250.26**, which applies to circuits that use a grounded conductor; it is also helpful in describing the circuit.

1. 2-wire, 2-conductor, 240/480V
 — L1 (240V) —
 — L2 (240V) —
2. 2-wire, 2-conductor, 480V (a single-phase, 2-wire system, common on very old ODOT lighting installations)
 — L1 (480V) —
 — N —

- b. The repair material is not concrete in kind, but patch material per 256.07. Coarse aggregate should be added, as needed, to extend the patch material if the repair volume and gaps are large enough.

Payment for this item will be made at the bid price, for each foundation repaired, regardless of the number of anchor bolts contained in the foundation.

1142-5 Luminaire, High Mast, As Per Plan (This Plan Note is obsolete but is retained for historical reference.)

The luminaire arrays and associated illumination test areas specified in C&MS 725.11 are hereby waived. Instead, the luminaires for high-mast lighting shall meet the following requirements:

Luminaires for high-mast lighting units with symmetric distribution shall be Holophane "HMST" with photometric distribution 36383, General Electric "HM" with photometric distribution 6312, or Cooper "HMX" with photometric distribution HMX4SDW, or equal as approved by the Engineer.

Luminaires for high-mast lighting units with asymmetric distribution shall be Holophane "HMST" with photometric distribution 46973, General Electric "HM" with photometric distribution 7349, or Cooper "HMC" with photometric distribution HMC4S3D, or equal as approved by the Engineer.

Luminaires for high-mast lighting units with long narrow distribution shall be Holophane "HMST" with photometric distribution 36801, General Electric "HM" with photometric distribution 8946, or Cooper "HMC" with photometric distribution HMC4S1DL, or equal as approved by the Engineer.

In addition, other luminaires will be considered if the designed intensity and uniformity are provided using the designed pole locations and the designed number and type of fixtures per pole.

1142-6 Luminaire, Low Mast, As Per Plan (This Plan Note is obsolete but is retained for historical reference.)

The luminaires shall be as specified for high-mast luminaires in C&MS 725.11 except that the luminaire arrays and associated illumination test areas are hereby waived. In addition, the luminaires for low-mast lighting shall meet the following requirements:

Luminaires for low-mast lighting units with symmetric distribution shall be Holophane "HMST" with photometric distribution 36383, General Electric "HM" with photometric distribution 6312, or Cooper "HMX" with photometric distribution HMX40SXXDW, or equal as approved by the Engineer.

Luminaires for low-mast lighting units with asymmetric distribution shall be Holophane "HMST" with photometric distribution 46973, General Electric "HM" with photometric distribution 7349, or Cooper "HMC" with photometric distribution HMC4S3D, or equal as approved by the Engineer.

Luminaires for low-mast lighting units with long narrow distribution shall be Holophane "HMST" with photometric distribution 36801, General Electric "HM" with photometric distribution 8946, or Cooper "HMC" with photometric distribution HMC4S1DL, or equal as approved by the Engineer.

In addition, other luminaires will be considered if the designed intensity and uniformity are provided using the designed pole locations and the designed number and type of fixtures per pole.

1142-7 625, Luminaire, Conventional, As Per Plan (This Plan Note is obsolete but is retained for historical reference.)

In addition to the requirements of ODOT'S Construction and Material Specifications, luminaires for conventional lighting units shall be as follows:

Luminaires for conventional lighting units with an IES II-M-SC distribution and 200 Watt high pressure sodium lamps shall be American Electric "Series 126" with photometric distribution AE3849I (adjust lumen value for 200w HPS), Cooper "OVX" with photometric distribution OVX25SXX2DF (adjust lumen value for 200w HPS), General Electric "M-400" with photometric distribution 1014 (adjust lumen value for 200w HPS), or equal as approved by the Engineer.

Payment will be made at the unit bid price for each C&MS Item 625, "Luminaire, Conventional, As Per Plan (add supplemental description)" for each luminaire which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-8 625, Luminaire, Post-top, As Per Plan (This Plan Note is obsolete but is retained for historical reference.)

In addition to the requirements of ODOT's **Construction and Material Specifications**, luminaires for post-top lighting units used in green spaces of rest areas shall be as follows:

Luminaires shall be American Electric "Contempo Series 245/246" with photometric distribution P5236, Cooper "USA Style King" with photometric distribution USA1S55, General Electric "PM16/PM17" with photometric distribution 6928, or equal approved by the Engineer.

Luminaire refractors may be of glass, polycarbonate, or acrylic.

Payment will be made at the unit price bid under C&MS Item 625, "Luminaire, Post-Top, As Per Plan (add supplemental description)" for each luminaire which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-9 625, Luminaire, Underpass, As Per Plan (This Plan Note is obsolete but is retained for historical reference.)

In addition to the requirements of ODOT's Construction and Material Specifications, luminaires for underpass lighting shall be as follows:

Luminaires for underpass lighting units shall be American Electric "Sidelight series 582" with photometric distribution AE2081I, Cooper "Wall Light" with photometric distribution WPK15SXX, General Electric "Versaflood II Wallighter" with photometric distribution 8578, Holophane "Wallpack II" Test with photometric distribution 33263, or equal as approved by the Engineer.

Luminaires for underpass lighting unit which are wall mounted shall be furnished with an integral fuse holder and 10-ampere fuses.

Payment will be made at the unit price bid under C&MS Item 625, "Luminaire, Underpass, AsPer Plan (add supplemental description)" for each luminaire which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-10 625, Luminaire, Installation Only, As Per Plan (This Plan Note is obsolete but is retained for historical reference.)

This item of work shall consist of installing an existing luminaire removed from a previous location on the project or supplied to the project site by others.

The luminaire shall be cleaned, repairs to ensure that it is in good serviceable condition made, adjustments to the optical components to ensure that the specified distribution is being produced made, and a new lamp installed if the light source is a lamp.

Payment will be made at the unit price bid under Item 625, "Luminaire, Installation Only, As Per Plan" for each luminaire installed and shall be full compensation for all material, labor, equipment and incidentals necessary to complete this item in a workmanlike manner.

1142-11 Lamps (This Plan Note is obsolete but is retained for historical reference.)

High pressure sodium lamps shall be General Electric "Lucalox," Osram Sylvania "Lumalux," Philips "Ceramalux," or equal approved by the Engineer.

1142-12 625, Light Pole, Installation Only, As Per Plan

This item of work shall consist of installing an existing light pole removed from a previous location on the project or supplied to the project site by others.

The light pole shall be cleaned and repairs needed for the pole to be in good serviceable condition made. The existing pole number decal shall be removed if it is in poor condition or the pole number has changed. A pole number decal shall be supplied and applied if the existing decal is removed or missing.

When required, new anchor bolts shall be furnished as part of this item.

Payment will be made at the unit price bid under Item 625, "Light Pole, Installation Only, As Per Plan" for each pole installed and shall be full compensation for all material, labor, equipment and incidentals necessary to complete this item in a workmanlike manner.

1142-13 625, Light Tower, Installation Only, As Per Plan

This item of work shall consist of installing an existing light tower removed from a previous location on the project site or supplied to the project by others.

When required, additional luminaire bracket arms shall be added to the existing luminaire brackets relocated along with the necessary adjustments and additions to the luminaire wiring to enable the luminaires to be mounted symmetrically around the luminaire mounting ring.

Where the tower will be installed on a new foundation, new anchor bolts shall be furnished.

The tower and lowering mechanism shall be cleaned and lubricated.

Any repairs and adjustments necessary to return the tower and mechanism to good operating condition shall be made.

The existing light tower identification decal shall be removed, and a new decal for the new identification number furnished and installed.

Payment shall be made at the unit price bid under C&MS Item 625, "Light Tower, Installation Only, As Per Plan" for each tower re-erected which shall include all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-14 Light Pole Anchor Bolts On Structures

When a light pole is mounted on a pilaster on a bridge parapet or on a retaining wall, the required anchor bolts may differ in length and/or shape from those required when the pole is mounted on a cast-in-place drilled shaft foundation. The cost differential for furnishing such bolts is included herein.

In addition, there is no foundation construction item in which to include the setting of the anchor bolts. Thus, the setting of the anchor bolts into the pilaster is also part of this work.

Payment will be made at each such pole location at the unit price bid for each C&MS Item 625, "Light Pole Anchor Bolts On Structure" and shall be full compensation for furnishing and placing the set of anchor bolts required.

1142-15 Reserved for Future Information

This Section is reserved for future information.

1142-16 Conduit Expansion and Deflection

Expansion fittings shall be OZ Type AX, Crouse Hinds Type XJG, or equal approved by the Engineer. Each expansion fitting shall provide either 4 or 8 inches total movement as specified by the plan details and shall have an external copper bonding jumper, unless specified otherwise by the plan details.

Deflection couplings shall be OZ Type DX, Crouse Hinds Type XD, or equal approved by the Engineer. Each deflection coupling shall have an external copper bonding jumper, unless

specified otherwise by the plan details. Minimum deflection capability: 25°.

Expansion and deflection fittings fully or partially embedded in concrete, soil, or similar material shall be completely wrapped in a neoprene sleeve or sheet of 1/2-inch minimum thickness.

Secure neoprene wrap with tie-wraps prior to embedment of the fitting.

1142-17 625, Power Service, As Per Plan

In addition to the requirements of the Specifications, the following is added.

The power supplying agency for this project is:

Power Company _____

Address _____

Phone # _____

Contact Name _____

The Engineer shall ensure that each power service electrical energy account is in the name of and that the billing address is to the maintaining agency noted in the plans. This shall be done not only for each new power service established by this project but also for each existing power service, since there may be a reassignment of the responsibility for an existing service as a result of the work performed by this project.

Payment will be made at the unit bid price for each C&MS Item 625, "Power Service, As Per Plan" which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-18 Special, Power Service Fence

This item of work shall consist of installing a new chain link fence, with gate, around a power service. The fence and gate shall be installed as specified in C&MS 607 and in the plan. The fence shall be 8 feet in height, and one gate of 4 feet in width shall be included, except as specified herein unless detailed otherwise in the plan.

Where the power service is adjacent to the right-of-way fence and there is reasonable access to the power service from outside the highway right-of-way, the fence around the power service shall utilize the right-of-way fence line as a portion of the fence line of the enclosed area. The right-of-way portion of the fence shall include a second access gate.

The gate hasp of each gate shall be secured by a steel rod, with one end drilled for the maintaining agency padlock and the opposite end drilled for the power company padlock.

Payment will be made at the unit price bid under Item Special, "Power Service Fence" for each area fenced which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-19 High Voltage Test Waived

The high voltage test shall not be performed on the circuits constructed by this project, since the test could damage the portion of the completed circuit which has been in service prior to this project.

1142-20 Padlocks and Keys

Padlocks furnished shall be either brass or bronze, equal to Master No. 4BKA or Wilson Bohannon 660A, and shall be keyed in accordance with C&MS 631.06. Payment shall be included in the bid for the item(s) being locked.

1142-21 Special, Maintain Existing Lighting

Existing roadways which are to remain open to traffic during construction of this project and which are lighted shall have the lighting maintained as described herein.

Before any work is started in the immediate vicinity of the existing lighting circuits, representatives of ODOT, the Maintaining Agency and the Contractor shall make a visual inspection of the existing roadway lighting circuits to be maintained. During this inspection, a written record of the condition of existing lighting shall be made by ODOT'S representative. This written report shall note individual luminaires which are not in working order, individual poles which are not standing, and individual circuits which are not in working order. The completed report shall be signed by the representatives of ODOT, the Maintaining Agency and the Contractor.

If, as a result of this inspection, it is determined that the condition of the existing system is below that required for the safety of the traveling public, then the Maintaining Agency shall make the repairs necessary to return the system to an acceptable condition. Following these repairs, the system shall again be inspected and a report shall be made and signed as outlined herein.

When the existing system is in an acceptable condition, it shall be turned over to the Contractor who shall then be required to maintain the existing lighting to the condition outlined in this report with the exception of knockdowns due to traffic accidents.

Replacement of knocked down units shall be done only when the Engineer has determined that the replacement of the knocked down unit is necessary and shall be paid separately on a unit basis.

Betterments shall be covered in items of work pertaining to the construction of permanent improvement.

When the sequence of construction activities requires, or should the Contractor desire, the removal of the existing lighting before the new lighting is operational, the Contractor shall be responsible for providing temporary lighting of this portion of the roadway.

Prior to installing such lighting, the Contractor shall prepare and submit four sets of the temporary lighting plan to the Engineer for review and approval.

This plan shall show locations of poles, lengths of bracket arms, styles of luminaires, mounting heights, wiring methods and other pertinent information. The temporary lighting shall provide an average initial intensity of 1.2 footcandles with an average to minimum uniformity not to exceed 3:1. Mounting height of temporary luminaires shall not be less than 30 feet, and the minimum overhead conductor clearance shall be 20 feet. Temporary overhead construction shall not be less than Grade "B" for strength requirements as defined by the National Electric Safety Code. Wood poles with overhead wiring may be used. However, temporary lighting shall meet Federal and State safety criteria. If breakaway poles are used to meet these criteria, then underground wiring shall be used. Reconditioned or used materials may be furnished for temporary lighting.

All materials necessary to complete the temporary lighting shall be furnished and installed by the Contractor. When no longer needed, the temporary lighting installation shall be removed and properly disposed of by the Contractor.

The Maintaining Agency will pay for electrical energy consumed by existing power services and by proposed permanent power services after acceptance of the lighting work. The Contractor will pay for electrical energy, installation, removal and maintenance of any temporary power services.

The lump sum price bid for Item Special "Maintain Existing Lighting" shall include payment for all labor, equipment, materials and incidentals necessary to maintain the existing lighting as specified herein.

The unit price bid for Item Special "Replacement of Existing Lighting Unit" shall be full payment for the replacement of an existing lighting unit which has been knocked down after the aforementioned inspection and shall include all labor, equipment, materials and incidentals necessary to provide a replacement for such unit.

1142-22 625 Lighting, Misc.: FAA Type L-864 Obstruction Lighting, LED

This item consists of installation and testing of FAA L-864-compliant obstruction lighting for marking of structures over 150 feet. Location and wiring shall be as shown in the Bridge Plans.

Each obstruction lamp shall utilize Light Emitting Diodes (LEDs). The obstruction lamp shall have a written minimum 5-year manufacturer warranty. The lamp shall be ETL verified to FAA Advisory Circular AC150/5345-43F, Type L-864 and shall be one of the following or approved equal:

1. Specialty Tower Lighting Model RB-LED
2. International Tower Lighting Model IFH-1710
3. Point Lighting Model PFB-37001
4. Pharos Marine Automatic Power Model FA-250LED L-864.

Each obstruction lamp shall have its own controller, housed in its own metal enclosure accessible by maintenance personnel standing at floor level. The controller shall operate at 120VAC, 60Hz and have its own dedicated circuit breaker in a nearby panelboard as detailed in the Bridge Plans. The controller shall produce the appropriate FAA-required flashing rate, and the obstruction lamp shall operate continuously twenty-four (24) hours per day, with no intervening photocell control. The controller shall provide at least one unused alarm status output in the form of a dry-contact or solid-state relay closure that responds to defective or inoperative obstruction lamp conditions. At least one relay with complete contacts (Normally Open, Normally Closed, and Common) shall be provided. Alarm relay contact ratings shall be at least 500 mA resistive at 120VAC/30VDC. The controller shall provide at least one visible alarm status indicator for lamp failure indication. This indicator shall be in the form of a panel-mounted red dome-type LED visible from the outside of the enclosure.

The controller enclosure shall utilize a vertically hinged, swing-open door, and be rated NEMA 3R, minimum. Enclosure shall include at least one commercial grade NEMA 5-15 receptacle to accommodate wireless communication equipment to be installed later by ODOT for alarm status monitoring. An integral shelf shall be provided for this equipment inside the enclosure, and shall provide an open, accessible space for equipment measuring at least twelve (12) inches wide, eight (8) inches deep, and six (6) inches in height.

The Contractor shall fully test the system and arrange for acceptance inspection of the Obstruction Lighting installation by ODOT District signal maintenance personnel after the system is operational. During acceptance inspection, the Contractor shall demonstrate the proper operation of all lamps and alarms. Contractor shall provide written manufacturer warranty and all operating manuals for obstruction lighting controller and lamp to ODOT District signal maintenance personnel at the time of inspection.

The Department shall measure LED FAA Type L-864 Obstruction Lighting by each individual obstruction light, complete and installed including any control devices and all wiring and conduits.

Designer Note: Although obstruction lighting is thought of as an incidental bridge item, this note appears in the **TEM** as a 625 Item because bridge lighting maintenance typically falls to **District** signal and lighting electricians. **FAA** regulations require daily visual monitoring of obstruction lighting by the operator (**ODOT**) if they are not equipped with automatic monitoring. Very fast notification and response times are required for repair of malfunctioning obstruction lights. The use of LED lighting significantly reduces **ODOT's** maintenance operations and provides much better reliability by eliminating the frequent outages and routine lamp changes associated with obstruction lights using older incandescent lamp technology. The use of cellular modems for automatic monitoring is recommended and is coordinated through the **Office of Traffic Operations**.

1142-23 625 Lighting, Misc.: Bridge-Mounted Marine Navigation Lighting, LED

This item consists of installation and testing of IALA/AISM-compliant, U.S. Coast Guard approved marine navigation lighting for marking of structures over navigable waters. Location and wiring shall be as shown in the Bridge Plans.

Each marine navigation lamp shall utilize Light Emitting Diodes (LEDs). The marine navigation lamp shall have a written minimum 5-year manufacturer warranty. The lamp shall meet the

color, brightness (range), sectoring, and divergence requirements as shown in the Plans and approved by the applicable Coast Guard District. The lamp shall be manufactured by one of the following manufacturers or an approved equal:

1. Tideland Signal Corporation, Houston, TX
2. B&B Roadway, Russellville, AL
3. Pharos Marine Automatic Power, Houston TX

Each marine navigation lamp shall have its own controller/power supply, housed in its own metal enclosure accessible by maintenance personnel, as shown on the Bridge Plans. The controller shall operate at 120VAC, 60Hz and have its own dedicated circuit breaker in a nearby panelboard as detailed in the Bridge Plans. The marine navigation lamp shall operate continuously twenty-four (24) hours per day, with no intervening photocell control. The controller shall provide alarm status output in the form of a blue LED confirmation light visible to ODOT maintenance personnel from deck level to indicate defective or inoperative marine navigation lamp conditions.

The Contractor shall fully test the system and arrange for acceptance inspection of the Marine navigation Lighting installation by ODOT District signal maintenance personnel after the system is operational. During acceptance inspection, the Contractor shall demonstrate the proper operation of all lamps and alarms. Contractor shall provide written manufacturer warranty and all operating manuals for marine navigation lighting controller and lamp to ODOT District signal maintenance personnel at the time of inspection.

The Department shall measure Bridge-Mounted Marine Navigation Lighting by each individual marine navigation light, complete and installed including any control devices and all wiring and conduits.

Designer Note: Although marine navigation lighting is thought of as an incidental bridge item, this note appears in the **TEM** as a 625 Item because bridge lighting maintenance typically falls to **District** signal and lighting electricians. The use of LED lighting significantly reduces **ODOT's** maintenance operations and provides much better reliability by eliminating the frequent outages and routine lamp changes associated with marine navigation lights using older incandescent lamp technology.

1142-24 625 Decorative Post-Top Luminaire, Solid-State (LED), Lantern Style, 3000K, Black Finish.

This item consists of supplying and installing decorative post-top LED luminaires for street and/or sidewalk illumination.

A lantern style luminaire consists of a four discrete flat sloping sides, per HL-10.11, with or without glass or polymer panels, and a rounded or pointed top and a small cupola. Provide a luminaire with a B-U-G up-lighting rating of U2 or less.

The luminaire is intended for external on/off control and shall not include a photocell socket.

Assure the luminaire has a nominal power of 65-85 watts and a nominal color temperature of 3000K.

Provide a luminaire with factory-applied black finish.

Supply one of the following luminaires, or an approved equal:

1. AEL Valient
2. Eaton UTLD
3. GE Salem

Designer Note: Use this text as a plan note template for streetscape and other decorative lighting applications. The goal of the note is to assist designers by listing several models of similar luminaires when no specific requirements are set forth in the project scope. Also, the note provides for a reasonable expenditure of public funds, serving as the Base Bid for which Alternate Bid Items may be included in the Plans. The note describes functional decorative

LED luminaires in the most popular style category, without excessive decorative trim. The luminaires listed in this note are similar in aesthetic and photometric properties, provide adequate horizontal illuminance (per IES RP-8) for a representative decorative lighting scenario, and meet material and workmanship requirements similar to those of ODOT SS 813. The “generic” lighting installation used to establish this note consists of luminaires on 17-foot mounting heights (16-foot pole) on each side of a two-lane (12') roadway with on-street parallel parking, 2-foot setback from curb, a 10-foot sidewalk, major street classification, and medium pedestrian conflict classification, yielding a longitudinal pole spacing of at least 120 feet. Lighting installations with different geometry than the “generic” installation should be designed using the same luminaires, perhaps with different distributions, mounting heights and lumen outputs, as guided by the Project Scope of Services and the specific conditions of the site. The design veiling luminance ratio shall be per RP-8. Because this note only lists a few representative models, it must always include the “or approved equal” clause so that competing models that meet the specifications may be used. The poles used to support the luminaires are not specified in this note, but should be finished black per SS 916. Colored finishes other than black shall be Alternate Bid items. The designer must assure at least three luminaires are specified in the Plans, and shall provide illumination design documentation for each.

1142-25 625, Decorative Post-Top Luminaire, Solid-State (LED), Acorn Style, Refractive Glass, 3000K, Black Finish

This item consists of supplying and installing a decorative post-top LED luminaire for roadway and/or sidewalk illumination on posts of 16 feet nominal height.

HL-10.11 shows an acorn-style post-top luminaire schematically. This item consists of a base fitter, glass (not acrylic) globe and a rounded top with no decorative features such as finial, crown, band or ribs. Provide a luminaire with a B-U-G up-lighting rating of U4 or less.

Provide a luminaire compatible with the lighting branch circuit shown in the Plans. Assure the luminaire post-fitter has a hinged or captive door. Assure the luminaire can mount a photocell or wireless control that uses a NEMA standard photocell receptacle.

Provide a luminaire with 3G vibration rating. Protect each luminaire using a Surge Protective Device (SPD) conforming to ODOT Supplemental Spec 913.

Assure the luminaire has a nominal color temperature (CCT) of 3000K.

Provide a luminaire with factory-applied black finish meeting Supplemental Specification 916.

Supply one of the following luminaires, or an approved equal:

1. Holophane Granville LED 2, _____ lumens, photometric distribution: _____
2. Sternberg G73LED Hometown Series, _____ lumens, photometric distribution: _____
3. King Luminaire K445, _____ lumens, photometric distribution: _____

Designer Note: Use this text as a plan note template for streetscape and other decorative lighting applications. The goal of the note is to assist designers by listing several models of similar luminaires when no specific requirements are set forth in the project scope. Also, the note provides for a reasonable expenditure of public funds, serving as the Base Bid for which Alternate Bid Items may be included in the Plans. The note describes functional decorative LED luminaires in the most popular style category, without excessive trim. This generic luminaire item is intended for external on/off control and should not include a photocell socket or control.

Designers should note the up-lighting and CCT restrictions intended to limit light pollution. There are options available for the refractive glass luminaires to limit up-lighting.

The luminaires listed in this note are similar in aesthetic and photometric properties, provide adequate horizontal illuminance (per IES RP-8) for a representative decorative lighting scenario, and meet material and workmanship requirements similar to those of ODOT SS 813. The “generic” lighting installation used to establish this note consists of luminaires on 16-foot mounting heights, staggered, on each side of a two-lane (12') roadway with on-street parallel parking 8 feet wide, 2-foot setback from curb, a 8-foot sidewalk, major street classification, and

Protect each luminaire using a Surge Protective Device (SPD) conforming to ODOT Supplemental Spec 913.

Assure the luminaire has a nominal color temperature (CCT) of 3000K.

Provide a luminaire with factory-applied black finish meeting Supplemental Specification 916.

The luminaire shall be one of the following, or an approved equal.

1. Holophane Esplanade LED2 #ESL2-Pxxx-30K-Ax-BK-SG-x-P
2. King Coronet #K804-P4SA-xxx-xxx-(SSL)-xxx-KPL21-3K-BK
3. Sternberg Libertyville #A-1914LED-xL-30-Tx-MDxxx-SG-HSHN-BKT

Designer Note: Use this text as a plan note template for streetscape and other decorative lighting applications. The goal of the note is to assist designers by listing several models of similar luminaires when no specific requirements are set forth in the project scope. Also, the note provides for a reasonable expenditure of public funds, serving as the Base Bid for which Alternate Bid Items may be included in the Plans. The note describes functional decorative LED luminaires in the most popular style category, without excessive trim. This generic luminaire item is intended for external on/off control and should not include a photocell socket or control.

Designers should note the up-lighting and CCT restrictions intended to limit light pollution.

There are options available for the refractive glass luminaires to limit up-lighting.

The luminaires listed in this note are similar in aesthetic and photometric properties, provide adequate horizontal illuminance (per IES RP-8) for a representative decorative lighting scenario, and meet material and workmanship requirements similar to those of ODOT SS 813. Because this note only lists a few representative models, it must always include the "or approved equal" clause so that competing models that meet the specifications may be eligible. The poles used to support the luminaires are not specified in this note but should follow HL-10.11 and be unfinished or finished black per SS 916. Colored finishes other than black shall be Alternate Bid items. The designer must specify at least three luminaires in the Plans and shall provide illumination design documentation for each luminaire specified, with a specific emphasis on the Veiling Luminance Ratio. For lighting low-speed roadways (35mph or less) it is acceptable to exceed the RP-8 maximum Veiling Luminance Ratio value of 0.3, up to a value of 0.8. Installations on roadways with posted or 85th-percentile speeds exceeding 35mph shall conform fully with RP-8 veiling luminance specifications.

1143 SPECIFICATIONS

ODOT specifications for the furnishing and installation of highway lighting equipment are contained in **C&MS 625** and **C&MS 725**. There are also ODOT Supplemental Specifications related to highway lighting. These are not listed here, so designers and others should frequently check the ODOT web page for updates, which typically occur twice per year.

1150 CONSTRUCTION**1150-1 Introduction****1150-1.1 General**

The following information does not alter or supersede the contract documents. It is provided as a guide for the **ODOT** personnel assigned to a project to help them with their work.

Electrical construction work must adhere to the contract documents which commonly include proposal notes, project plans, standard drawings, and the **Construction and Material Specifications**. In addition there may be building or electrical codes or change orders that must be followed.

1150-1.2 Contractor Prequalification

Only contractors prequalified by the **ODOT Office of Contracts** for Work Type 43 Highway Lighting shall be allowed to do the highway lighting items of work on the project.

1150-1.3 Respect for Contractor

Contractors are prequalified for specialized work types. They bring expertise to the project and an independent perspective from the project management team. As the contractor reviews plans and specifications, he wants to ensure that he can install material that will ultimately operate as the designer intended. The contractor relies on the engineer to guide the project, to approve materials and work, and to ensure that he will be paid for work completed. It is important to remember that even when the roles of the project team and the contractor conflict successful completion of the project relies on all those involved and the maintenance of good working relationships.

1150-1.4 Protection of Utility Lines

The contractor is to notify all utilities before construction work begins. Names and addresses of these utilities are given in the project plans. It is also the contractor's responsibility to contact the **Ohio Utility Protection Services** (1-800-362-2764) to have utility locations marked in all areas where digging is involved.

1150-1.5 Plan Discrepancy, Design Ambiguity, Consultation with Designer

When there is a question regarding the intent of the plan, the engineer should:

1. Define the discrepancy or ambiguity.
2. Determine if more than the highway lighting is affected.
3. Identify the standard drawings and specifications pertinent to the situation.
4. Determine potential solutions.
5. If the issue involves the location of the luminaires or light poles, the mounting height of the luminaires above the pavement, the luminaire to be used or the lamp to be used; the engineer should consult **ODOT's** design office and the designer to ensure that the performance goals for the lighting system will still be met by the solution under consideration.
6. Consider the maintenance of the installation if the solution is implemented. Will parts not normally stocked by the maintaining agency be required, or will tools and equipment not normally at the disposal of the maintenance crews be required, or will special training of the workers be required?
7. Evaluate potential solutions for safety. Consider measures needed to keep errant vehicles from striking the item, the danger to those who must maintain the installation, the danger to traffic from the maintenance activities.
8. Determine if applicable codes and regulations will be met. Commonly involved will be the

National Electric Code, The National Electric Safety Code and utility company requirements. There may also be **State** and local building codes.

1150-2 Materials**1150-2.1 General**

Highway lighting items are found in **Section 625** of the **ODOT Construction and Material Specifications (C&MS)** with detailed descriptions of materials in **Chapter 725 (C&MS)**.

In general, all material furnished shall be new and of first quality (unless otherwise noted in the plans) and shall be identified either by a permanently attached name plate or by an indelible marking.

Before installation, all material shall be checked to determine that it is indeed the material that has been specified, that the appropriate material process has been completed and that all paperwork is in hand.

Four procedures are commonly used to ensure that the correct materials are installed.

1. Qualified Product List (QPL) and/or Approved List
2. **ODOT** Plant Sampling and Testing Plan (TE 24 Certification)
3. Certified Drawings or Certified Catalog Cuts
4. Project Inspection of Material

1150-2.2 Qualified Products List, Approved List

Lighting material which may be on a Qualified Product List:

1. Pull Box
2. Junction Box
3. Conduit
4. Wire and Cable
5. Ground Rod
6. Photocell

The **Office of Materials Management** maintains the Qualified Product Lists. The engineer can verify that the material is on a Qualified Product List (QPL) through **ODOT's Construction Management System (C&MS)**. After verifying that the material being supplied is that specified by the contract and on such a list, the project may accept the material.

Approved List

1. Solid-State (LED) Luminaires
2. Programmable Logic Controller

1150-2.3 TE-24 Material Certification

Lighting material for which TE 24 Certification may be obtained:

1. Pull Box
2. Junction Box
3. Anchor Bolt

The **ODOT** Plant Sampling and Testing Plan (TE-24 system) is administered by the **Office of Materials Management**. This system was designed to allow certain material to be sampled, tested, approved and stocked for future use on **ODOT** projects. The material is inspected at the manufacturing or distribution site. Each approved lot of material is assigned a certification number and documented on Form TE-24. Material from the approved lot may then be transferred directly to an **ODOT** project or it can be transferred to other warehouses, such as a contractor's storage facility, then transferred to a project at a later date.

1150-2.4 Certified Drawings

Lighting material requiring certified drawings (shop drawing or catalog cuts):

1. Luminaires
2. Luminaire Supports (Towers, Lowering Devices, Poles, Bracket Arms)
3. Power Service Equipment
4. Portable Power Units
5. Temporary Lighting Systems

The contractor shall submit two copies of the certified drawings prior to the installation of the material. The submittal ensures that the **State** has a good record of the material installed in case there are any questions about the material meeting criteria, or should additional or replacement units be required.

Each submittal shall identify the project and the bid reference number under which the item is being provided. Certified drawings shall be clearly marked by circling or underlining to indicate the exact item and options being supplied. If a given item is to be supplied under multiple bid item reference numbers, separate and complete documentation packages shall be submitted for each bid item reference number. If multiple items are to be supplied under a single bid reference number, all the items to be supplied under said reference number shall be submitted as a package. The contractor's cover letter for each package is to certify in writing that each manufactured item in the package conforms to all contract requirements for that item.

The submittal of certified drawings does not relieve the contractor from furnishing additional information concerning the material as deemed necessary by the **State**.

1150-2.5 Project Inspection of Material

The following materials are normally manufactured to standards that meet **ODOT** criteria and therefore do not have a **QPL**, do not normally have a **TE-24** and certified drawings are not normally required:

1. Exothermic Welds
2. Insulating Varnish
3. Split Bolt Connector
4. Expansion Fittings
5. Connector Kits
6. Splice Kits
7. Copper Crimps and Compression Connectors
8. Light Pole Decals
9. Circuit Identification Tags
10. Cable Grips
11. Wood Service Poles
12. Fuses for Control Center and Connector Kits
13. Photoelectric Cell and Bracket
14. Secondary Lightning Arrestor
15. Guy Anchors and Anchor Rods
16. Weather Heads
17. Watertight Hubs
18. Remote Ballast Enclosures and Mounting Brackets

Project inspection of material is used to verify that the material at hand is that listed on a **QPL**, or described on a **TE-24**, or for which certified drawings have been received, and that the material complies with the requirements of the contract documents. For material not on a **QPL** which does not have a **TE-24**, and for which certified drawings are not required, the project inspection of material is limited to comparing the material at hand with the requirements of the contract documents.

1150-3 Luminaires

1150-3.1 General

Verify that the luminaire installed at each location is one of the luminaires listed in the plan for that location. Verify that the distribution and lumen output are as specified in the plans. Instructions packed with the luminaire will explain the distributions that the luminaire is capable

of producing and how to set any adjustments in the luminaire to provide each distribution. Verify that luminaire is compatible with the circuit voltage.

1150-3.2 Conventional Luminaire

The conventional luminaire used by **ODOT** is also known in the trade as an “Ovate” or “Cobra Head” fixture. It may be equipped with a flat or a dropped style refractor as specified.

Verify that the luminaire is properly leveled according to the instructions packed with the luminaire.

1150-3.3 Side-Mount Roadway Luminaire

This luminaire reminds one of a floodlight. It is normally only used for temporary installations during construction, such as at crossovers.

Verify that the “tilt” has been set as specified in the plan according to instructions packed with the luminaire. Verify that the luminaire is oriented “normal” to the line of survey for the roadway being lighted unless the plans stipulate otherwise.

1150-3.4 High-Mast Luminaire

These luminaires are mounted on tall structures equipped with devices to bring the luminaires to ground level for servicing.

Verify that the luminaire is not “twisted” with regard to its bracket arm. There are three distributions commonly used. If the luminaire has a rotatable refractor, verify that it has been aligned properly. Normally, the arrow on the luminaire shall be pointed in the direction of traffic flow on the adjacent roadway.

1150-3.5 Low-Mast Luminaire

Low-mast luminaires are the same luminaire as a high-mast luminaire but installed as a fixed unit on a pole of more traditional height.

Verify that the luminaire is not “twisted” with regard to its bracket arm. There are three distributions commonly used. If the luminaire has a rotatable refractor, verify that it has been aligned properly.

1150-3.6 Underpass Luminaire

Underpass luminaires are used to light roadways beneath bridge decks. Commonly they are wall mounted on a pier cap or abutment. Rarely they may be ceiling mounted on the underside of the deck or to a panel attached to the deck supporting beams or pendant mounted on suspension pipes attached to the structure. Occasionally, they will be post-top mounted on short poles.

Verify that the luminaire has been attached to the structure at the location and in the manner specified.

1150-4 Lamps (Obsolete. Retained for historical reference only.)

Verify that the lamp is one of the brands listed in the plan. Verify that the lamp type and wattage is compatible with the luminaire and its ballast. Unless specified otherwise for a particular installation, the lamps are to have clear envelopes. Do not substitute lamps with “frosted” envelopes. Verify that the installation date has been properly marked on the base of the lamp. Instructions packaged with the lamp explain how to use the dating provision built into the base.

1150-5 Supports**1150-5.1 General**

The inspection of the supports (poles, arms, towers, lowering devices, brackets, etc.) consists of two phases: inspection of the components and inspection of the completed assembly. While these may be done together, it is better if the components are inspected upon arrival at the project since there is then more time to obtain replacements or correct faults.

1150-5.2 Inspection of Support Components

Three areas are examined in this phase: welding, galvanizing and compliance with certified drawings.

1150-5.2.1 Inspection of Welds

Examine each weld to verify the following:

1. Each of the welds called for by the certified drawings is present and there is no weld present that is not shown on said drawings.
2. There is no misalignment of the parent material being joined by the weld.
3. There has been no warping of the parent material by the weld.
4. Each weld is of the type, size and continuity shown on the certified drawings.
5. Each weld is of full cross section without excessive concavity or convexity.
6. There is no over filling or cratering at either the beginning or the end of the weld.
7. There is no undercutting (a shallow groove melted into the base metal adjacent to a weld and left unfilled by weld metal) along any weld.
8. There is no porosity (pitting or pinholes) in any weld.
9. There is no crack or discontinuity in either the base metal or weld material along any weld.

1150-5.2.2 Inspection of Galvanizing

Examine the galvanizing to verify the following:

1. There are no spots where the galvanizing is missing or loose and can be flaked off with a penknife.
2. There is no ash that has been picked up from the top of the bath, which usually appears as coarse lumps.
3. There are no pimples from entrapped bath scum particles.
4. There are no blisters from hydrogen gas absorbed during pickling being released and rupturing the surface of the galvanizing.
5. There are no flux inclusions from flux picked up from the top of the bath during dipping and burned on during immersion.
6. There are no lumps or runs of excess zinc from delayed run off of molten metal trapped near surface discontinuities such as joints, seams or holes as the part was lifted from the bath.
7. There are no rust stains from impurities from the pickling process weeping at seams and folds.
8. There is no general overall roughness from over pickling or of excess zinc bath temperature and/or immersion time.
9. There are no patches of dull gray coating from slow cooling of the heavier cross sections of the part after immersion.
10. The galvanizing has a uniform appearance.

Excessive galvanizing faults and gross imperfections or overall poor workmanship may be cause for rejection of the support. Minor scratches in galvanized surfaces may be accepted.

1150-5.2.3 Compliance with Shop Drawings

Shop drawings shall include the AASHTO criteria and loads for which the support was designed.

Supports are frequently shipped to the job site and stored prior to assembly and erection as components which give opportunity for the components to get mixed up, leading to improper assemblies since the basic design often does not prevent errors. Therefore, prior to beginning the assembly of a given support, it is necessary to check the major dimensions of the various components against the certified drawing for the support to verify that this has not occurred.

On poles, verify the length, base diameter, top diameter and wall thickness of each pole or section of the pole for poles shipped in multiple sections that are field assembled. Verify the length, width and thickness of the base plate along with the bolt circle diameter, bolt hole size and number of anchor bolt holes provided.

On bracket arms for conventional supports, verify the arm length and arm rise.

On lowering devices, verify the diameter of the luminaire mounting ring and number of luminaire arms on the ring. Also, verify the length of the power cord along with the wire size and number of conductors in the cord. Verify the diameter and length of each piece of hoisting cable.

1150-5.3 Assembly of Supports

Support components stored in the field should be kept off the ground to prevent finish blemishes where the components lay in contact with a damp surface, earth or water. Support components and assembled supports should be loaded, transported, unloaded, stored and erected in a manner avoiding damage to the factory applied surface finishes.

On multi-piece poles, verify that the sections to be assembled are the correct pieces for the pole at hand. Before tightening each telescopic joint between the sections, verify that the sections are properly oriented and that the male section has been marked to indicate when full insertion has been achieved. Verify that the process used for tightening the joint between sections is approved by the pole manufacturer and that the pole is not bent during the tightening process.

On each steel light pole used with an aluminum transformer base, verify that both the bottom of the pole base plate and the top of the transformer base were given a coat of zinc rich paint prior to assembly.

On each light pole, verify that the cable grip in the light pole is properly installed as shown in **Traffic SCD HL-10.12** to prevent damage to the pole and bracket cable.

On each light tower, verify that the luminaire ring has the correct number of mounting arms and that each arm is attached such that when the tower is erected the arms will be in the positions relative to the roadway as shown on **Traffic SCD HL-10.31**. If the lowering device is equipped with top latches, verify that when the luminaire mounting ring is fully raised and latched, the latch indicator on each latch will be in the "extended" or "visible" position. Verify that all moving parts on the head frame assembly and hoist mechanism have been lubricated in accordance with the manufacturer's instructions.

Verify that all parts are in place and that all fasteners have been properly installed according to the manufacturer's instructions.

Verify that each handhole door or cover closes with no excessive gaps.

Verify that a light amount of anti-seize or grease lubricant has been worked into the threads of each fastener holding each removable cover in place.

1150-5.4 Erection of Supports

Prior to erection, verify that nuts can be easily turned by hand onto the threads of each anchor bolt.

When leveling nuts are to be used, verify that the leveling nuts are level before beginning the lift to set the support.

Each support should be lifted and set by crane with the hoist line attached at a point as far above the center of gravity of the support as possible, with a tethering cable from the lifting point to the base of the pole. The lifting point on poles made up of sections slip fitted together should be above the uppermost joint. Hoisting should be smooth and continuous without abrupt jerks. Light tension should be maintained in the hoist lines until an anchor nut has been threaded onto each anchor bolt far enough that the bolt is projecting through the nut by a full thread.

Verify that each support with a transformer base has been plumbed using leveling shims approved by the base manufacturer, installed between the base and the foundation according to the base manufacturer's instructions and limitations, and that the anchor nut on each anchor bolt has been properly tightened.

Verify that each support with an anchor base installed directly on a foundation without leveling nuts has been plumbed using leveling shims approved by the pole manufacturer installed between the base and the foundation according to the pole manufacturer's instructions and limitations, and that the anchor nut on each anchor bolt has been properly tightened.

Verify that each support with leveling nuts is plumbed by adjusting the leveling nuts, and that both the anchor nut and the leveling nut on each anchor bolt have been properly tightened.

Verify that a light tower has been plumbed early in the morning when there is minimum heat effect from the sun.

Verify that each support has been plumbed when there is no appreciable wind.

Verify that the space between the top of the foundation and the base of the support has NOT been grouted.

When a high-mast support (light tower) is equipped with a lowering device that has top latches, verify that the ring engages all latches simultaneously. This is often referred to as "leveling" the ring. It should be done following the manufacturer's directions. Generally, the procedure is to place a block on each hoisting cable that is attached to the ring a few inches above the ring in such a manner that the block will slide along the cable when the block contacts the portion of the mechanism at the top of the tower. The ring is then raised until all blocks have made contact, but not fully raised. The ring is then lowered and the distance between each block and the ring measured. Hoisting cables are then adjusted to make the measurements equal. The process is repeated until no further adjustments are required. The blocks are removed and the lowering device operated several times through its full cycle watching all latches for proper operation.

Verify that support identification decals have the proper legend and that the decals are located approximately 7 feet above the base of the pole facing oncoming traffic.

1150-6 Foundations

1150-6.1 General

Foundation inspection normally consists of three parts: location, excavation and concrete placement.

1150-6.2 Foundation Location

After the location of each foundation has been staked, verify that the location is that specified in the plan and that **Ohio Utility Protection Service** and all utilities in the area have been allowed at least 48 hours to mark their utility locations relative to the proposed foundation. Then verify that the location appears logical. Be alert for the following:

1. Installing the lighting item at the staked location will require removal of vegetation that shields adjacent property owners from the highway.
2. Installing the lighting item at the staked location will locate the item at the top of the back slope, in a cut cross section or at the bottom of the fill in a filled cross section where

guardrail is to be used to keep errant vehicles from going down the slope.

3. Installing the lighting item at the staked location will place the item under an overhead utility line or over an underground utility line.
4. Installing the lighting item at the staked location will require a graded access drive for the construction that has not been addressed in the plan.

The designer should be consulted prior to relocating any support more than 10 feet or if two or more adjacent supports need to be relocated.

1150-6.3 Excavation

Foundations are to be placed only in undisturbed soil or compacted embankment.

If a minor cave-in should occur, the contractor may, with the approval of the engineer, continue excavating using sleeving or casing. When bedrock is encountered, the engineer may reduce the specified foundation depth.

If construction crews must leave the job site with a hole unfilled, it shall be covered and marked with cones, barrels or warning tape.

1150-6.4 Placement of Concrete

Verify that the top of the foundation will be at the proper elevation.

Tops of foundations shall be finished smooth and level to enable proper plumbing of the light pole.

Verify that the anchor bolts are of the correct size and number, and that each bolt is securely held in the correct position. The use of an anchor bolt setting template is encouraged. Verify that each anchor bolt will project the proper distance from the foundation.

Verify that conduit ells are present and that each ell is of the correct size and material, and that each is properly oriented.

Verify that all reinforcing bars are present and that each is of the correct size and shape.

Verify that all items to be cast into the foundation, along with any forming aids, are secured in such a manner that they will not move out of position during the placement of concrete.

Verify that water encountered in the foundation excavation is pumped out before concrete placement. If this is not feasible, verify that the concrete is placed by the tremi-tube method.

Verify that the concrete is of the proper design, has been properly mixed, has the correct slump, and is properly handled during placement. Verify that the concrete is vibrated to eliminate voids.

Verify that the top of the foundation is properly finished and that the concrete is properly cured.

1150-7 Pull Boxes

Verify that each pull box is of the size and material specified.

Verify that each pull box is at the planned location unless the planned location puts the box in a low spot with respect to the surrounding surface. In such cases, notify the engineer so that the engineer, in consultation with the designer if necessary, may attempt to move the box to a location where it will be less likely to hold water.

Verify that a light amount of anti-seize or grease lubricant has been work into the threads of each fastener holding the cover in place.

1150-8 Junction Boxes

Verify that each junction box is of the correct size and material, and securely fastened in the correct location. Verify that a light amount of anti-seize or grease lubricant has been work into the threads of each fastener holding the cover in place.

1150-9 Conduit

Verify that each conduit run is of the correct size and material.

Verify that each cut end on each piece of conduit is reamed to remove rough edges.

Verify that all field cut threads on galvanized conduit have been coated with zinc-rich paint.

Verify that each expansion or deflection fitting has a bonding strap for ground continuity when used with metal conduit.

Verify that each conduit run has been properly fastened in place.

Verify that the contractor shall check each run of conduit by rodding (pushing a mandrel through the empty conduit) or pulling a cleaning puck through the conduit.

Verify that each run of new conduit with cables contains a flat woven polyester pulling tape, rated for 600 pound minimum, in the conduit.

Verify that each run of conduit being left empty for future use contains an HDPE insulated copper tracer wire, 12 AWG minimum, in the conduit.

Verify that each end of each conduit run is terminated either in a box connector that contains an integral bushing or with a separate bushing to protect cable pulled into the conduit.

1150-10 Trench

Verify that the trench did not deviate more than 6 inches from the line designate unless such deviation has been approved by the engineer.

Verify that the sidewalls and bottom of the trench do not have any protruding sharp rocks.

When duct cable is installed in the trench, verify that the backfill material within 2 inches of the duct cable does not contain pieces larger than one-half inch.

Verify that the backfill is placed in compacted layers not to exceeding 4 inches in thickness.

1150-11 Power Service

Power service includes all equipment from the connection point to the utility company to the beginning point of the individual lighting circuits.

Verify that the power service location will be readily accessible both to maintenance personnel and to utility company personnel. There should be a safe parking area for service vehicles since the site will be visited regularly. The location should not be prone to standing or flowing water during rain events or to drifting snow. If the location appears unreasonable, involve the designer and the utility company as soon as possible, since moving a power service often means redesigning the lighting circuits.

Verify that the contractor has been in touch with the utility company and become aware of any utility company requirements which may differ from the requirements of the Contract Documents.

Verify that the photocell is facing the north sky, unless otherwise stipulated by the plan, and that no artificial lighting source is disrupting its proper operation.

Verify that the conduits are neatly routed and fasten securely in place.

Verify that enclosures are securely mounted.

Verify that enclosure covers are in place and that fasteners for the covers have had anti-seize or grease worked into the threads.

Verify that moving parts of the switch gear have been lubricated and operate smoothly.

Verify that no debris has been left in enclosures and that the wiring in each enclosure is neat, orderly and tied into place where appropriate.

1150-12 Grounding**1150-12.1 General**

The conducting portions of those items containing electrical conductors are to be connected to each other and to earth electrodes to lessen the chance of injury and damage from unwanted electrical currents. Connecting the various conducting portions together to form the continuous path for the flow of stray electrical currents, often referred to as bonding, in **ODOT'S** projects is generally an incidental to the construction. Installation of the earth electrodes and the connection of the conducting portions to those electrodes is often referred to as grounding and in **ODOT'S** projects payment is somewhat related to the electrodes installed.

1150-12.2 Ground Rods

Verify that the ground rods specified have been installed. When additional rods have been added to lower the resistance, verify that the installation of each rod was approved prior to its installation.

Verify that the connection between the ground rod and the grounding cable is an exothermic weld. When additional rods have been added to reduce the resistance, verify that the additional connections are exothermic welds.

The normal ground rod item is for one rod driven into earth and the lead between the rod and the first connection and the associated connections. The earth resistance is then checked. When said resistance exceeds the specified limit, an additional rod is to be driven and connected to the first. The earth resistance of the pair is then checked. The process is repeated until the resistance of the group is lower than the specified limit. Payment is then made at the per rod price for each rod installed.

ODOT has reserved the right to approve the use of each additional rod before it is installed and may decline to install additional rods; thereby stopping the process at any point. When **ODOT** stops the installation of additional rods, it may decide to take another course of action to lower the earth resistance. If no additional action is taken, then by default the earth resistance becomes acceptable as it stands.

1150-12.3 Exothermic Welds

An exothermic weld often has a rougher surface texture on the weld metal than one may be used to seeing, but the weld is not to have other signs of a poor quality weld such as porosity, cratering, cracking or undercutting.

1150-12.4 Structure Grounding (Standard Construction Drawing HL-50.22)

Verify that each grounding electrode is acceptable before structure construction makes modification of the electrode or the installation of additional electrodes along side impractical. Remember that if some of the electrodes are driven rods, that such rods are incidental to the structure grounding system, not separate items. However, if due to high resistance, additional rods are driven, those rods are not incidental to the structure grounding system.

Verify that the necessary bonding jumpers are in place and functioning correctly before structure construction makes the installation of additional jumpers impractical.

Structures present special needs. Not only is it not practical to have a separate ground rod for each light pole or similar item mounted upon the structure, but also there are elements of the structure itself that need grounding. Thus the normal practice is to use bonding jumpers to connect all exposed metal items together and thence to the several electrodes frequently utilizing the main conducting portions of the structure as the main grounding buss. This means that electrodes are often under footers and bonding jumpers are frequently embedded in the structure. If something is left out or does not function as intended and it is not discovered until the final stages of construction, the grounding can become expensive, unsightly and less than desired. Unfortunately, structure designers all too often include little in the way of specific details for the structure grounding. Therefore, it is imperative to be constantly thinking ahead to fully understand where each electrode and jumper is to be located and to verify that it is in place

and functioning correctly at each stage.

1150-12.5 Bonding Along Circuits

Verify that all of the conducting items containing the conductors of each circuit are bonded to form a continuous path back to the source of the circuit.

At light poles, verify that metal conduits entering the base of the pole are bonded to the pole.

At pull boxes, verify that the metal conduits entering the pull box are bonded together and that the metal lid and lid frame are bonded to the metal conduits.

At junction boxes, verify that the metal conduits entering the junction box are bonded to the box.

At the expansion and deflection joints in conduits of conducting materials, verify that a bonding strap has been install across the joint.

When non-conducting conduit or duct is used, verify that a grounding conductor has been installed to provide for the continuous grounding path when necessary.

1150-13 Wiring and Cabling

1150-13.1 General

Field wiring of highway lighting circuits is broken into three types, pole and bracket cable, distribution cable and duct cable.

1150-13.2 Pole and Bracket Cable

Pole and bracket cable is the insulated single conductor used in a light pole (but not in a light tower) to connect from the distribution cable, up the pole and out the bracket arm to the light fixture (in a tower the electrical wiring from the base of the tower to the luminaires is a component of the lowering device).

Verify that each run of cable is of the size and type specified. The wire size and insulation are to be indelibly marked on the insulating jacket at frequent intervals along the length of the cable.

Verify that each run of cable is installed in a continuous piece without inline splices between the terminations shown on the plan.

Verify that the insulating jacket was not nicked nor portions shaved away as the cable was pulled into place.

Verify that the cable was not stretched as it was pulled into place. If the cable can be pulled back and forth by hand enough to move both ends, stretching probably did not occur.

Verify that a cable support was installed at the upper end of the vertical run of cable up the pole.

Verify that there is enough length on each end of the run for the cable to be routed properly to its termination and still remain slack.

1150-13.3 Distribution Cable

Distribution cable is the insulated single conductor used to construct lighting circuits from the control equipment of the power service to the disconnect kits of a light pole, the terminal block of a light tower, or the disconnect switch for underpass or sign lighting.

Verify that each run of distribution cable is of the size and type specified. The wire size and insulation are to be indelibly marked on the insulating jacket at frequent intervals along the length of the cable.

Verify that each run of cable is installed in a continuous piece without inline splices between the terminations shown on the plan.

Verify that the insulating jacket was not nicked nor portions shaved away as the cable was

pulled into place.

Verify that the cable was not stretched as it was pulled into place. If the cable can be pulled back and forth by hand enough to move both ends, stretching probably did not occur. Unfortunately, for the larger wire sizes and the longer runs commonly encountered in highway lighting circuits, the cable cannot be pulled by hand. Thus, the most common indication of stretching is when the length of pulling lead exiting the raceway is greater than the length of cable entering the raceway or the pulling forces are greater than normally encountered; both of which are not easily detected by other than experienced installers.

Verify that there is enough length on each end of the run for the cable to be routed properly to its termination and still remain slack.

All cables shall be labeled in accessible enclosures (pull boxes, hand holes, transformer base, device housing, etc.). A minimum of 5 feet of extra cable shall be provided for each conductor at all terminal points.

1150-13.4 Duct Cable

Duct cable consists of insulated conductors, of the type used for distribution cable, installed into a duct and shipped as an assembly to the project. It is used in place of conduit and distribution cable to speed the installation of underground circuits.

Verify that the temperature of the duct cable was above 32 degrees Fahrenheit throughout the installation process.

It is permissible to install duct cable when the outdoor air temperature is actually below those temperatures, but the Contractor must obtain authorization from the engineer. The contractor shall submit in writing his method of heating the duct cable and maintaining the duct cable at a uniform temperature throughout the installation process. To assure that the duct cable is heated uniformly, the heating process shall keep the temperature of the duct cable above 32 degrees Fahrenheit a minimum of 24 hours prior to installation. Under conditions such as the preceding where the temperature of the duct cable can be expected to vary widely during the installation process, the expansion and contraction of the duct cable must be taken into consideration. Typically, the duct cable length will decrease (or increase) 1 foot per 1000 feet for each 10 degree Fahrenheit decrease (or increase) in temperature.

Verify that the duct of the installed duct cable extends out of any conduit sleeve through which it passes enough to allow for the expansion and contraction in the duct due to seasonal changes in temperature. Typically a projection of 2 to 3 inches is appropriate at the usual installation temperatures for the lengths of run typical in **ODOT'S** installations.

As received on the reel from the manufacturer, it will appear that the cables inside the duct and the duct are equal in length but in reality the cables are shorter than the duct. In order to reel the assembly onto the shipping spool both the cables and the duct were anchored to the spool. As the duct cable assembly is unrolled from the shipping spool, the cables will be drawn into the duct resulting in empty duct at the start of the run. For the assemblies typically used in **ODOT's** projects, leaving 25 feet of duct for each 1,000 feet of run to be installed at the start of the run, in addition to that required as slack for connections at the start of the run, will compensate for this. At the end of the run, only the slack amount for connections is required.

Verify that the insulating jacket of each cable within the duct has not been damaged when the duct was stripped to allow the connections to be made. Often the length of duct to be stripped is such that no protection can be slid over the cables and into the end of the duct which means that the cables within are saved from damage only by the skill of the person stripping the duct.

When a duct cable assembly has been passed through a conduit sleeve, verify that the duct has been sealed to each end of the sleeve by means of a molded boot or wrapped sealing pad.

Verify that the seal installed between the cable and the duct is installed in the same location and in the same manner as outlined under the installation of distribution cable into conduits.

Verify that there is enough length on each end of the run for each cable to be routed properly to its termination and still remain slack.

1150-13.5 Conductor Identification

At each access point (pole base, pull box, junction box, switch gear enclosure, etc.) each conductor of each run of the field wiring (pole and bracket cable, distribution cable, duct cable) of each circuit is to be identified by applying a tag to the conductor indelibly marked to indicate the circuit and the use of that conductor within the circuit.

1150-14 Connections**1150-14.1 General**

This covers the connection of the field installed wire and cable to other such wire and cable and to the various items of equipment.

1150 14.2 Sizing Conductor to Device Terminal

When the circuit conductor is of a larger size than the device terminals can accommodate, verify that the connection has been made by splicing a short piece of smaller wire onto the end of the large wire and then connecting the smaller wire to the device terminal. The smaller wire is normally identical to the larger wire in all aspects except for size. The smaller wire must be large enough to carry the current that the circuit protection will allow. It is not acceptable to cut back some of the strands of a conductor, so that the remaining stranded will fit into the terminal.

1150-14.3 Compression Connections

Verify that the die in the compression tool was for the connector applied and that the connector is sized to match the wire to which it was applied and that the tool used was of a type that did not release the connector from the die once compression started until full compression was achieved.

1150-14.4 Pull-Apart and Bolted Connections

Verify that the internal connector is properly applied to the conductors.

Verify that the insulating cover was cut to proper step for a snug fit over the insulation on each entry to the housing.

Verify that the internal parts are all present in good condition and are fully seated into the housing.

Verify that the male half of the housing is a snug fit and fully inserted into the female half of the housing.

Verify that a thin coating of the kit manufacturer's approved non-conducting grease has been used at the joint between the two halves of the housing, between the housing and each cable entering the housing, and on other internal parts as shown in the manufacturer's instructions, to allow the parts to slide smoothly into place and help seal out water.

Verify that there are no sharp bends in each cable where the cable enters the housing sufficient to cause the housing to pull away from the insulating jacket on the cable.

When the kit is to contain a fuse, verify that the fuse is of the proper ampacity.

Where the kit contains bolted connections, verify that the connections were properly tightened before the housing was closed.

Verify that there is sufficient slack in the cables being connected to permit bringing the connector kit outside of the pole, transformer base or junction box in which it is housed for servicing.

1150-14.5 Unfused Permanent Connections

Verify that the internal connection is via a proper crimp compression connector.

Verify that the mold surrounding the connection is completely filled with resin.

Verify that the connection is positioned within the mold such that the resin properly surrounds the connection.

Verify that there are no voids in the resin.

Verify that no fillers have been used.

Verify that the resin has properly set.

1150-15 Test Procedures

1150-15.1 General

There are a number of tests normally utilized to ascertain that the lighting installation has been well constructed and is in good operational order. For a particular test to have meaning, it must be properly conducted and the results properly interpreted.

Verify that the equipment used to conduct the test is in working order and calibration.

1150-15.2 Grounding Electrodes

Verify that each specific grounding electrode meets the requirements of the earth resistance test.

The first key to conducting a successful test of a grounding electrode is to understand what constitutes the electrode. A single driven rod is an electrode. When that rod fails the earth resistance test and another rod is added, the electrode then becomes both rods together. However, in the case of a light tower where two rods are typically specified, the initial electrode is the two rods together rather than each rod separately. In structure grounding, the cluster of driven piles at the end of a pier footer should be considered as a single electrode with the cluster at the other end of that same footer considered as a separate electrode. A continuous grid of mesh, bars or cables laid beneath a footer is one electrode, but separate grids under different portions of the same footer are separate electrodes. Wires buried in a radial pattern from a single pole constitute an electrode.

The second key to successful ground resistance is to understand the limitations of the various test instruments and procedures. The chosen procedure must be appropriate for both the electrode under test and the conditions in which the electrode is installed, and the instrument must be capable of producing valid results for the situation at hand.

1150-15.3 Circuit Continuity

The key to the proper checking of circuit continuity is to remember the objective and to test one conductor at a time. The objective is to see that the conductor is connected to the desired device point and that the conductor has not been connected to any other devices. The difficulty is that the devices are scattered over a large area thus requiring the other conductors of the same circuit to be used as returns for the test signal. For the test to be of use often means that testing must start at one node in the circuit and test all connections along an isolated link from that node. Additional nodes and links are then added one at a time and the continuity of the conductors rechecked until the entire circuit has been verified.

1150-15.4 Cable Insulation

This test is designed to verify that the insulation of each conductor in the circuit and permanent and bolted connections in that conductor are in good conditions by impressing a much higher than normal voltage on the conductor using the change in leakage current over time. Care must be used not to impress the test voltage on devices normally connected by the circuit since the devices would probably be damaged. Since the other conductors in the circuit must often be used as the return path, it is necessary to use care to ensure that the other conductors are not damaged while serving as signal returns and careful interpretation of the results to determine whether the leakage is from a conductor failing the test or from a failure in the return path.

1150-15.5 Lowering Device Operation

This test is simply repeated operation of the lowering device on a light tower to verify that it operates smoothly and correctly throughout its full range cycle of motions.

1150-15.6 System Performance

The test uses the concept “Infant Mortality” to determine if the equipment is likely to operate satisfactorily throughout the projected life of the installation. The concept is the equipment is most likely to fail from manufacturing defects and installation in the first few hours of use and that once these hours are past it is likely to run the rest of its life with only normal maintenance. In conducting the test, it is important to recognize the significance of each component malfunction encountered and to properly interpret whether the malfunction indicates a need to extend the test period.

1150-16 Provide Information to Maintaining Agency

Ensure that each maintaining agency receives the documents pertinent to the maintenance and operation of the lighting units for which it is responsible. Typically included are:

1. A copy of the plan marked to show any changes made during the construction.
2. A copy of each certified drawing.
3. A copy of each instruction or parts manual supplied by each manufacturer.

1150-17 Documentation Requirements

1. Luminaires
 - a. Each luminaire has the distribution, lumen output and aiming stipulated in the Contract Documents.
 - b. Each luminaire has been “leveled”.
2. Supports
 - a. Each support is the one stipulated for that location by the Contract Documents.
 - b. Each support is comprised of the correct components according to the certified shop drawings.
3. Pull boxes
 - a. Each pull box is the size and type stipulated for that location by the Contract Documents.
 - b. Each pull box supplied under plant sampling and testing program, that it has a TE 24.
 - c. Each drain is documented on form CAP 1.
4. Conduit
 - a. The conduit is the size stipulated for that location by the Contract Documents.
 - b. The conduit is of the material stipulated for that location by the Contract Documents.
 - c. The measurement of the length installed.
5. Trench
 - a. The location and depth is as stipulated by the Contract Documents.
 - b. There are no sharp rocks in backfill adjacent to duct.
 - c. The backfill is placed in 4-inch lifts and mechanically tamped.
 - d. The measure length installed.
6. Grounding electrodes
 - a. Each electrode is installed as stipulated for that location by the Contract Documents.
 - b. Each grounding conductor is connected to ground rod with exothermic weld.
 - c. Each document ground resistance.
7. Wire and Cable.
 - a. Wire size and insulation is as stipulated for that location by the Contract Documents.
 - b. Measurement of the length installed.

1160 MAINTENANCE / OPERATIONS**1160-1 General**

It is not enough to simply install highway lighting and leave it exposed to the ravages of the elements. The public expects **ODOT** to protect the dollars invested in the lighting by making sure that the lighting is operable so that it can be used by those traveling the highway when natural light is inadequate. This chapter addresses **ODOT'S** lighting maintenance policies and practices.

The **District Highway Management Administrator** through the **Roadway Services Manager** is responsible for ensuring that highway lighting units that **ODOT** is responsible for within the **District** are in proper operating order. The physical work required to fulfill this responsibility may be contracted out to other governmental entities, utility companies and private contracting companies, or performed by **ODOT** forces.

1160-2 Lighting Maintenance Practice Process

A contact point shall be established by each **District** for receiving notification from law enforcement personnel, emergency response and maintenance units, other governmental entities, utility companies, and the traveling public of damage to, and malfunction of, highway lighting. Periodic inspection of lighting installations shall also be made.

The information obtained from these notifications and inspections shall be used to document the damage or failures, and the date of discovery. Based on the nature of the damage or failure, the **District Roadway Services Manager** will ensure that the appropriate responses are made, the incident tracked until repairs have been completed, and the date of completion of repairs documented.

Each **District** shall also see that preventive maintenance is performed to forestall failures, to facilitate repairs during responses to damage and failure, and to provide proper general housekeeping of the installations.

The use of "hot sticks" is not allowed.

1160-3 Determination of Responsibility**1160-3.1 ODOT and Local Jurisdictions**

To avoid conflicts during design and construction, planners should included the lighting responsibility in the project scope, since the designer must split the electrical service and circuits between the various agencies. Unless transferred to another entity by a properly executed and approved agreement, the responsibility for the maintenance of, and energy for, the operation of each highway lighting unit is as shown in **Table 1197-12**.

The responsible party may through an approved agreement or contract arrange for another party to provide materials and equipment, and to perform the actual work. However, agreements and contracts to provide materials and to perform the actual work shall not transfer the responsibility.

1160-3.2 ODOT and the Power Companies**1. Overhead Power Feed via a Weatherhead**

- a. ODOT is responsible for the circuit from the weatherhead into the control center and subsequent lighting circuits.
- b. If the circuit is damaged between the weatherhead and the control center, or within the control center itself, **ODOT** must contact the power company to shut off the power feed so **ODOT** forces can make necessary repairs. Once repairs are complete, the power company shall be contacted to turn the power service back on.
- c. If the circuit is damaged down from the control center, the power shall be shut off at the control center by **ODOT** forces, and perform lock-out, tag-out procedures, and proceed repairing the circuits.

- d. No work shall be performed on live circuits.

2. Underground Power Feed

- a. ODOT is responsible for the circuit from and including the control center.
- b. If the control center is damaged, the power company shall be contacted to shut off the power prior to any repair work being done.
- c. If the circuit is damaged down from the control center, the power shall be shut off at the control center by **ODOT** forces, and perform lock-out, tag-out procedures, and proceed repairing the circuits.
- d. No work shall be performed on live circuits.

1160-4 Emergency Maintenance

Downed or damaged supports that could pose a danger to the traveling public shall be removed as soon as practical, either off the right-of-way or outside the clear zone as defined by the **L&D Manual Volume 1, Chapter 600**.

Exposed live wires shall be secured as soon as possible after discovery.

1160-5 Reactive Maintenance

The maintenance operations are expected to keep the number of working luminaires at a satisfactory level.

To be considered as working, a luminaire must not only be lighted but must be properly aimed. A satisfactory level is when the total number of working luminaires meets or exceeds 90 percent of the total number of luminaires for which the **District** is responsible.

1160-6 Periodic Inspection

Each **District** should periodically inspect all highway lighting units and sign lighting luminaires for which it is responsible. This shall include the units maintained using **District** forces, as well as those maintained for the **District** by other entities such as contractors, power companies or cities.

1160-7 Required Preventive Maintenance

Exposed Equipment - Each cover on a support, junction box, pull box, or piece of power service switch gear shall be secured in the closed position. Any such cover which is missing shall be replaced. Fence gates shall be secured in the closed position.

1160-8 Recommended Preventive Maintenance

Re-lamping – Any sodium vapor (highway lighting) lamps should not remain in service longer than four years, as measured by the date code marked on the lamp at the time of installation.

Housekeeping - The following preventative maintenance measures are recommended while performing spot maintenance work and should be performed annually on those pieces of equipment that did not receive the measures during the previous twelve months as part of spot maintenance.

1. Whenever a moving part, latch or lock is accessed it should be lubricated, if in need. For lubrication of electrical switchgear parts, such as those found in power service disconnects and lighting control centers, the Office of Roadway Engineering (ORE) recommends use of CRC HV Switchgear Lubricant, Part # 02060. Make sure electrical equipment is de-energized before using aerosol lubricant sprays. For lubrication of enclosure door gaskets, ORE recommends 3M Silicone Lubricant spray (UPC 021200-85822). For lubrication of padlocks and key-lock mechanisms, ORE recommends an extra-fine dry powdered (not dry-film) graphite such as Superior Graphite Tube-O-Lube.
2. Whenever a threaded cover fastener is accessed, an appropriate anti-seizing agent should be applied or redistributed.
3. Damaged or missing fasteners should be repaired or replaced.
4. Debris should be removed from in and around the base of each light pole and vegetation cut back. Debris and vegetation cuttings should be properly disposed and not left piled at the site.

5. For frangible poles, adjustments to grade should be made to ensure that the pole foundation is flush with grade on the up slope side, and that the top of the foundation is not below grade.
6. For non-frangible poles, adjustments to the grade should be made to ensure that the top of foundation is above grade.
7. Debris should be removed from in and around each power service (and power service enclosure fence, if used) and vegetation cut back. Debris and vegetation cuttings should be properly disposed and not left piled at the site. Debris should be removed from in and around each pull box and the grade adjusted whenever the pull box is opened. Debris and vegetation cuttings should be properly disposed and not left piled at the site.
8. Eroded and sunken areas adjacent to foundations pull boxes and control sites, or over cable trenches, should be filled, seeded and covered with erosion resistant material to slow the flow of runoff and promote vegetative growth.

1160-9 Replacement Luminaires

A replacement luminaire should be of such similar photometric distribution that the intensity and uniformity of the lighting system is not unduly compromised from the installed design. In addition, the weight and effective area of the replacement luminaire shall not exceed the capacity of the support. Where the support is equipped with a mechanical device for lowering the luminaires, the luminaires shall be replaced in the quantity needed to keep the mechanism in balance if necessary.

Replacement supports shall maintain the luminaire mounting height and overhang or underhang.

1160-10 Failure Analysis

The **District** should use historical inspection reports to discover locations experiencing repeated knock downs, pull box locations with repeated cover or box damage, or other patterns of damage that may suggest mitigating actions.

1160-11 Repairing Broken Conduit and Duct Cable

1160-11.1 General

The following procedures should be followed when performing repairs on an existing electrical system.

All damaged cables shall be replaced, except when the distance between terminal points is determined to be excessive in length. In this case pulling of new cables is not recommended because the cable insulation may be damaged. The repair should be accomplished by strategically installing a new pull box to minimize the length of cable to be replaced. Cable splice kits, as specified in **C&MS 725.15**, will be stored in the pull box.

No direct buried splices are allowed. No splices are allowed inside the duct since that violates the National Electric Code.

1160-11.2 Repair Damaged Duct Cable

Duct cable repair shall be accomplished by splicing the duct at the break point in one of the following methods:

Repair with Compression Fittings.

After the duct break is exposed, the damaged cable shall be removed. The duct is prepared for splicing by cutting the duct square to remove the rough edges off each end of the duct. Use either a hacksaw or plastic pipe cutter. Burrs shall be removed from the cut ends and the duct cleaned of dust, dirt, etc. Two compression fittings (such as E-lock or Duraline's Comfit) and a short length of duct are needed to complete the repair. One compression fitting is placed on each cut end and the length of duct is fit between the two fittings. Test fittings to make sure the duct fit is tight. Pull in new wire and complete cable connections.

Repair with PVC Coupling.

PVC couplings use a standard piece of Schedule 40 PVC conduit to replace the missing

section of duct cable. After the duct break is exposed, the damaged cable shall be removed. The duct is prepared for splicing by cutting the duct square to remove the rough edges off each end of the duct. Heat shrink tubing should be placed over the PVC before the duct cable is inserted in the PVC coupling. The PVC coupling shall be sufficiently long to replace the missing section of duct. Heat shrink tubing shall extend at least 6 inches on each side of each seam. Heat shrink tubing should be heated with a heat gun or hair dryer. Applying heat with an open flame will damage the tubing and shall not be permitted.

PVC cement will not adhere to duct cable and should not be used.

1160-11.3 Repair PVC Conduit

PVC conduit shall be repaired using PVC couplings and PVC cement in the procedures normally followed during initial installation.

1160-11.4 Repair Rigid Conduit

Rigid conduit shall be repaired using rigid conduit and threadless couplings.

1160-12 Troubleshooting Lamps

1160-12.1 General

Defective HPS luminaires shall be replaced with equivalent LED luminaires. Before attempting any troubleshooting, the electrician should verify the circuit operation and path. Lock out/tag out procedures and other safety procedures for 480 volt systems should be followed and documented. The following sections outline possible causes and corrective action for various problems.

1160-12.2 HPS Lamp Will Not Start

Possible Causes

Lamp loose in socket.

Incorrect lamp.

Incorrect or loose wiring.

End of ballast life.

Photoelectric control inoperative.

Supply voltage to fixture or ballast output voltage is low.

HPS starter circuit failure.

Corrective Maintenance

Screw lamp firmly into socket until good contact is made. **STOP!** Excess torque may cause lamp to shatter at neck.

Check and compare data on ballast or fixture name plate with lamp electrical characteristics.

With power off, check wiring against wiring diagram; check for loose connectors and loose terminal screws; check for broken insulation. Check circuit continuity with ohm meter.

Check for charred spots and/or swollen capacitors.

With power **ON**, cover photocell. Wait the few minutes generally required for an operative photocell to apply power to the fixture. Replace if inoperative.

Check supply voltage and ballast output voltage.

Check lamp on Discharge Lamp Checker or try known good lamp. Replace starter.

1160-12.3 Short HPS Lamp Life

Possible Causes

Incorrect lamp.

Shorted ballast.

Corrective Maintenance

Check and compare data on ballast or fixture nameplate with lamp electrical characteristics.

Check electrically for a shorted ballast.

Over wattage operations.

Check ballast or fixture rating for lamp type and wattage. Check operation for correct voltage and current at socket terminals.

1160-12.4 Flickering**Possible Causes**

Supply voltage to fixture is low.

Incorrect ballast.

High operating voltage.

Low ballast output voltage.

Variable voltage.

Bad lamp.

Loose wiring.

Corrective Maintenance

Check both supply and ballast output voltage with lamp operating.

Check and compare data on ballast or fixture nameplate with lamp electrical characteristics.

Check lamp voltage at socket terminals while operating.

Check ballast output and supply volts without lamp in circuit.

Use recording voltmeter to check degree and duration of voltage variation. Check to determine other electrical loads on lamp circuit. Remove lighting circuit from lines with large electrical loads.

Replace lamp.

Check wire connections.

1160-12.5 Blown Fuses**Possible Causes**

High momentary line current at turn "ON."

Overloaded circuit.

Shorted wires.

Old or worn fuses.

Lightning induced peak.

Corrective Maintenance

Check ballast literature for recommended rating of circuit protective devices. Circuit protective devices should have time delay elements when used with reactor or auto-transformer ballasts.

Check total load on circuit; lamps and ballasts plus other connected equipment.

Locate shorted wires and repair.

Replace with new and correct fuses.

Replace fuse. Check for other damage.

1160-12.6 HPS Lamp Light Output Low**Possible Causes**

Lamps near end of life.

Supply voltage to fixture is low.

Incorrect ballast

Low ballast voltage.

Dirt accumulation.

No refractor.

Corrective Maintenance

Replace lamp.

Check both supply and ballast output voltage with lamp operating.

Check and compare data on ballast or fixture name plate with lamp electrical characteristics.

Check ballast output and supply volts without lamp in circuit.

Clean luminaires and lamps.

Install refractor.

1160-12.7 HPS Lamp Starts Slowly**Possible Causes****Corrective Maintenance**

Supply voltage to fixture is low.	Check both supply and ballast output voltage with lamp operating.
Low ballast output voltage.	Check both ballast output and supply volts without lamp in circuit.
Lamp is defective causing a hard start.	Replace lamp IF other system components are OK .

1160-12.8 Blackened HPS Arc Tube

<u>Possible Causes</u>	<u>Corrective Maintenance</u>
Incorrect ballast.	Check and compare data on ballast or fixture name plate with lamp electrical characteristics.
Lamp life used up.	Replace lamp.
Low voltage at socket.	Check ballast for voltage.

1160-12.9 Abnormal HPS Lamp Color Difference

<u>Possible Causes</u>	<u>Corrective Maintenance</u>
Low supply voltage.	Check supply voltage and ballast output voltages with lamp operating.
Low ballast output.	Check ballast output and supply volts without lamp in circuit.
Variation in light distribution.	Check luminaire. To test, interchange lamps between suspected and normally performing luminaires. Check refractor and glass lens.
Dirt accumulation.	Clean luminaires and lamps.
Illumination color differences.	Variations in environmental color-walls, tunnels, bridges, etc., can cause illumination-color illusions.

1160-12.10 Whole Circuit Off

<u>Possible Causes</u>	<u>Corrective Maintenance</u>
Control Center problems.	Check supply voltage and output voltage. Check fuses. Check contactor.

1160-13 Pole Replacement/Foundation Repair**1160-13.1 General**

Before new poles and transformer bases are installed on existing foundations they shall be checked for the following:

1. Anchor bolt threads shall not show signs of excessive rusting that could later deteriorate to a point where they could become a safety hazard should they fail.
2. Foundation concrete does not indicate excessive deterioration whereby it is impossible for the transformer base to be properly installed and leveled.
3. Check to determine if the foundation has shifted or tilted to the extent that the pole cannot be properly plumbed.
4. Top of foundation shall not protrude above ground level on the upslope side.
5. All painted light poles shall be checked for excessive rusting. If it is determined that they are unsafe, they should be replaced with either new or used galvanized steel or aluminum poles.
6. Pull boxes extending more than 1 inch above the existing grade should be reset, flush with the existing grade level.

When a light pole falls down, the pole and foundation should be inspected and the best method for repairing the installation determined. If a material deficiency in the pole or foundation was

fully or partially responsible for the failure, the materials should be examined closely for defects, corrosion and vandalism. The probable cause of the failure should be noted.

When a pole falls, the simplex weld for the bracket arm should be inspected by looking down the inside of the top of the pole to see if the impact has cracked the weld. If the weld is cracked, the pole should not be reinstalled.

1160-13.2 Anchor Bolts Sheared

Standard light pole foundations can be repaired by jack hammering out the concrete to 1 foot below grade, using threaded couplings and threaded bolt extensions on the anchor bolts, recapping the foundation (with the threaded coupling encased in concrete), and erecting a new pole/base.

It is also possible to extend the anchor bolts with a special cadweld instead of threaded couplings. The bolt extension could be welded on and the weld embedded in the new concrete. Welded extensions would be necessary if the remaining anchor bolt did not have enough thread to receive the threaded coupling. This may also be necessary if repairing a tower foundation. In the case of welding on bolts, the concrete foundation would likely need to be removed to a depth greater than 1 foot below grade.

1160-13.3 Anchor Bolt Bent

When a bolt is bent by the impact of a knockdown, it can be repaired by straightening the bolt using physical force (sledgehammer) or by heating it. Consider the location of the bolt (tension or compression side) and the amount of bending necessary when assessing if a repair is possible. If the concrete around the anchor bolt has been cracked by the impact, consider replacing the foundation.

1160-13.4 Cracked Concrete in Foundation

Most cracked foundations should be replaced with new foundations. A repair would involve removing the concrete at least 1 foot below grade and recapping the foundation.

1160-13.5 Anchor Bolt Adapter Plates

When a foundation has a unique anchor bolt configuration which is not matched by any other current pole manufacturer, the foundation can be used for a new pole by manufacturing a specialized anchor bolt adapter plate. The adapter plate would mount on the existing bolts and provide a new bolt circle (typically 15-inch bolt circle) for mounting a new pole.

1160-14 Bracket Arm Repairs

When a bracket arm falls down, the pole and arm should be inspected to determine the best method for repairing the installation. If a material deficiency in the pole or arm was fully or partially responsible for the failure, the materials should be examined closely for defects, corrosion and vandalism. The probable cause of the failure should be noted.

Replacement bracket arms should closely match the style, length and rise of the bracket arm being repaired.

Before installing a replacement arm on an existing simplex hanger, the simplex weld should be inspected by looking down the inside of the top of the pole to see if the weld is cracked. If the weld is cracked, the arm should not be installed on that hanger. Bracket-type or banding-type attachments should be used instead.

If the arm fell because the simplex bolt sheared off, but the hanger and weld are in good condition, the bolt hole can often be redrilled and a new bolt installed.

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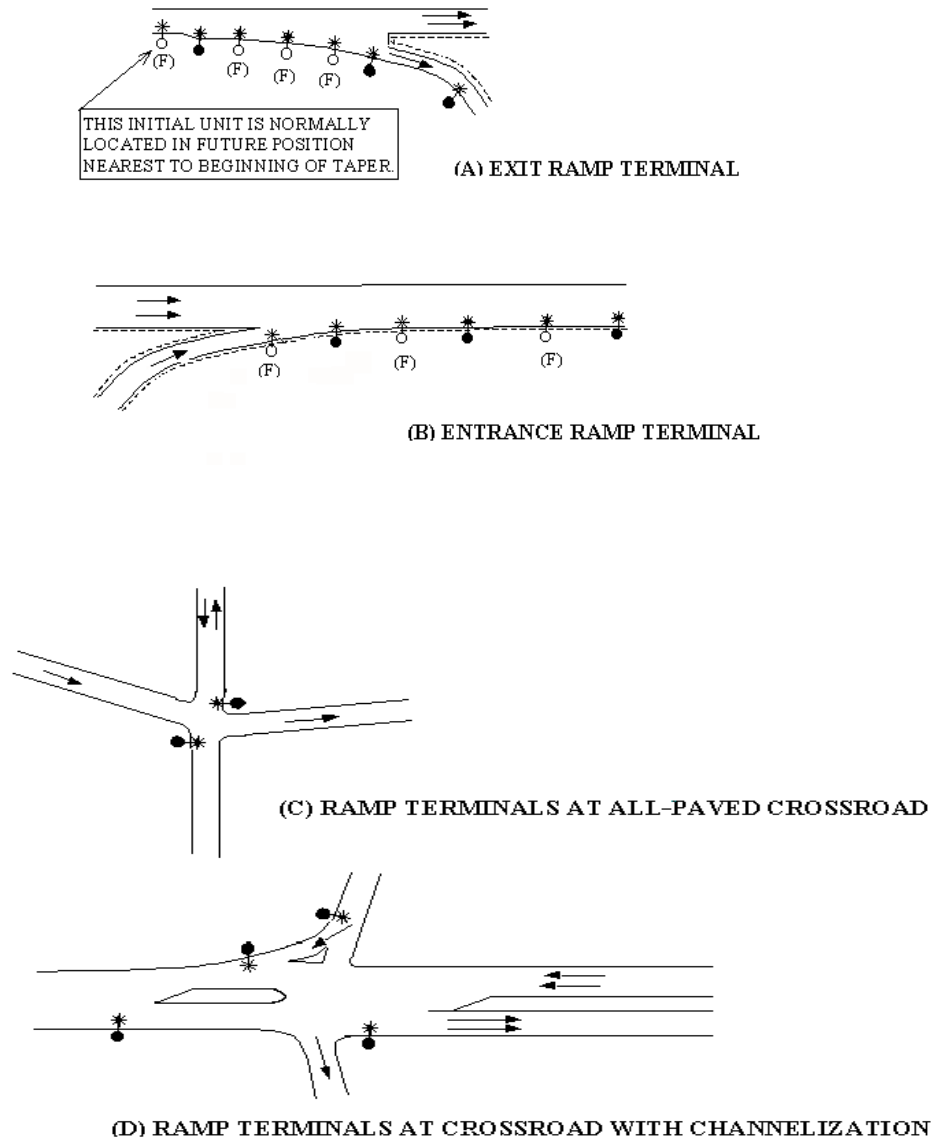
Table 1197-1. Suggested Data for the District System Lighting Plan

Luminaires	Pole or Tower	Control Center	Circuits	Maintenance Costs
Voltage	Tower or Pole Number	Energy Account Number	Number	Energy Units Consumed
No. of Units	Height	Power Company	AWG	Lamp Life Cycle
Manufacturer	Foundation Diameter & Depth	Capacity Current & Future	Two or Three-wire	Direct Labor
Wattage (HPS) Lumen Output (LED)	Manufacturer	Service Type		
Ballast (HPS only)	Lowering Device Type	Supply Voltage		
Shields	Bracket Arm Length	Voltage Drop & Circuit		
IES Distribution	Pole Base Type	Amperage		
IES Photometric #	Installation Year	Meter Type & Number		
Re-lamp Date	Control center	Latitude & Longitude		
	Circuit number	Owner or Maintaining Agency		
	Latitude & Longitude	Control Center ID Number		

Table 1197-2. Codes for Use in the District System Lighting Plan

Code	Description
B - Blue	Isolated intersections which are not part of an interchange.
G - Green	Interchanges which have partial interchange lighting.
O - Orange	Interchanges which have full interchange lighting.
P - Pink	Roadways which are not within an interchange area, but which are between interchanges or intersections which have continuous lighting.
F - Future	Unlighted locations to be lighted.
U - Upgrade	Lighted locations to received more comprehensive lighting (e.g., partial interchange to full interchange).
D - Downgrad	Lighted locations to be downgraded to less comprehensive lighting (e.g., full interchange to partial interchange).
R - Remove	Lighted locations to become unlighted.

Figure 1198-3. Typical Luminaire Placement Partial Interchange Lighting (PIL)



Notes:

1. For additional details of sketch (A), see **Figure 1198-4**.
2. (F) denotes additional unit, when future/full lighting is provided.
3. Unit spacing varies with pavement width.
4. Number of units depends upon the length of the speed-change lane.
5. For intersections with marked crosswalks, see also **Figure 1198-7**.

Figure 1198-7. Intersection Lighting Examples

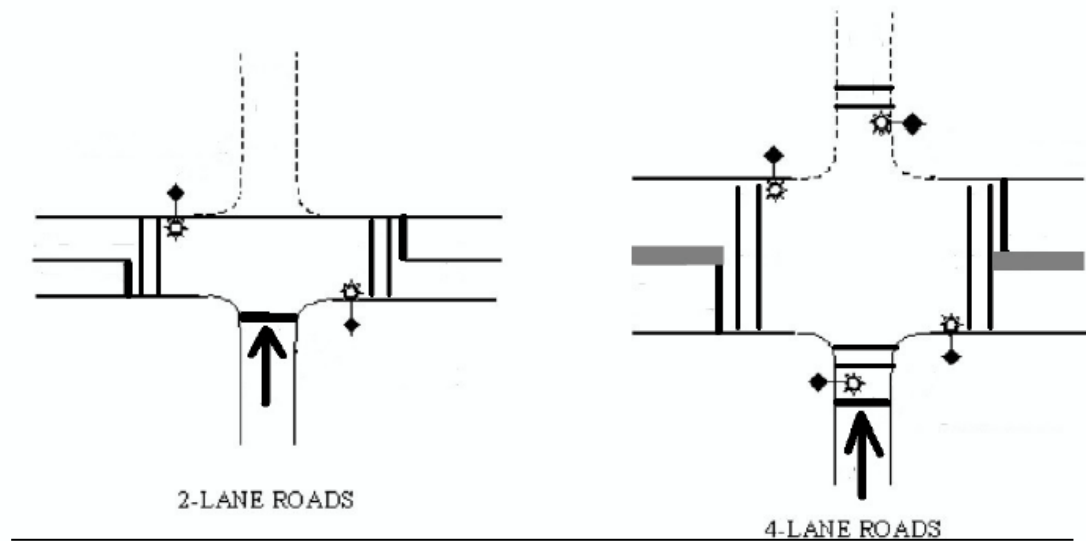
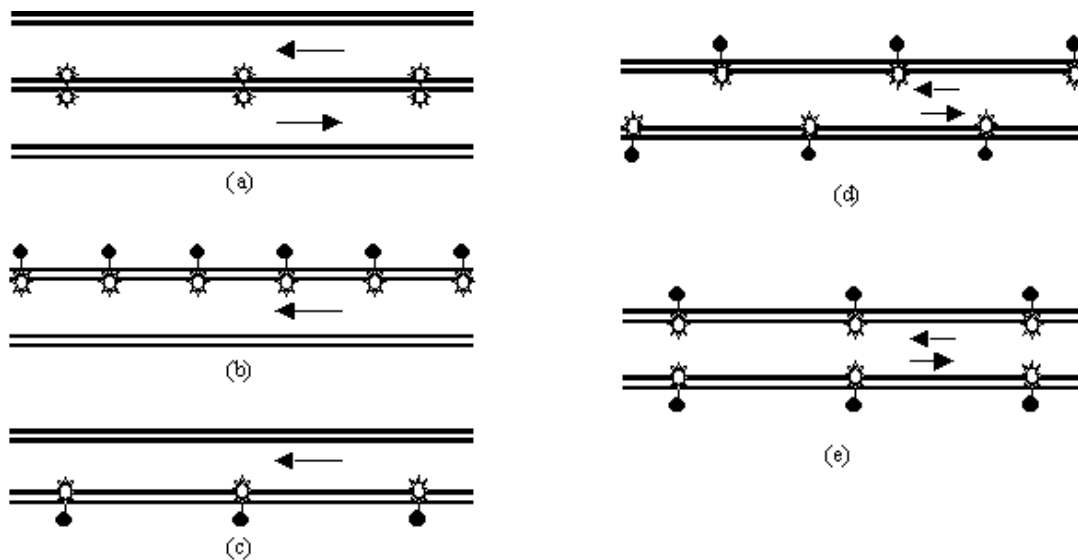
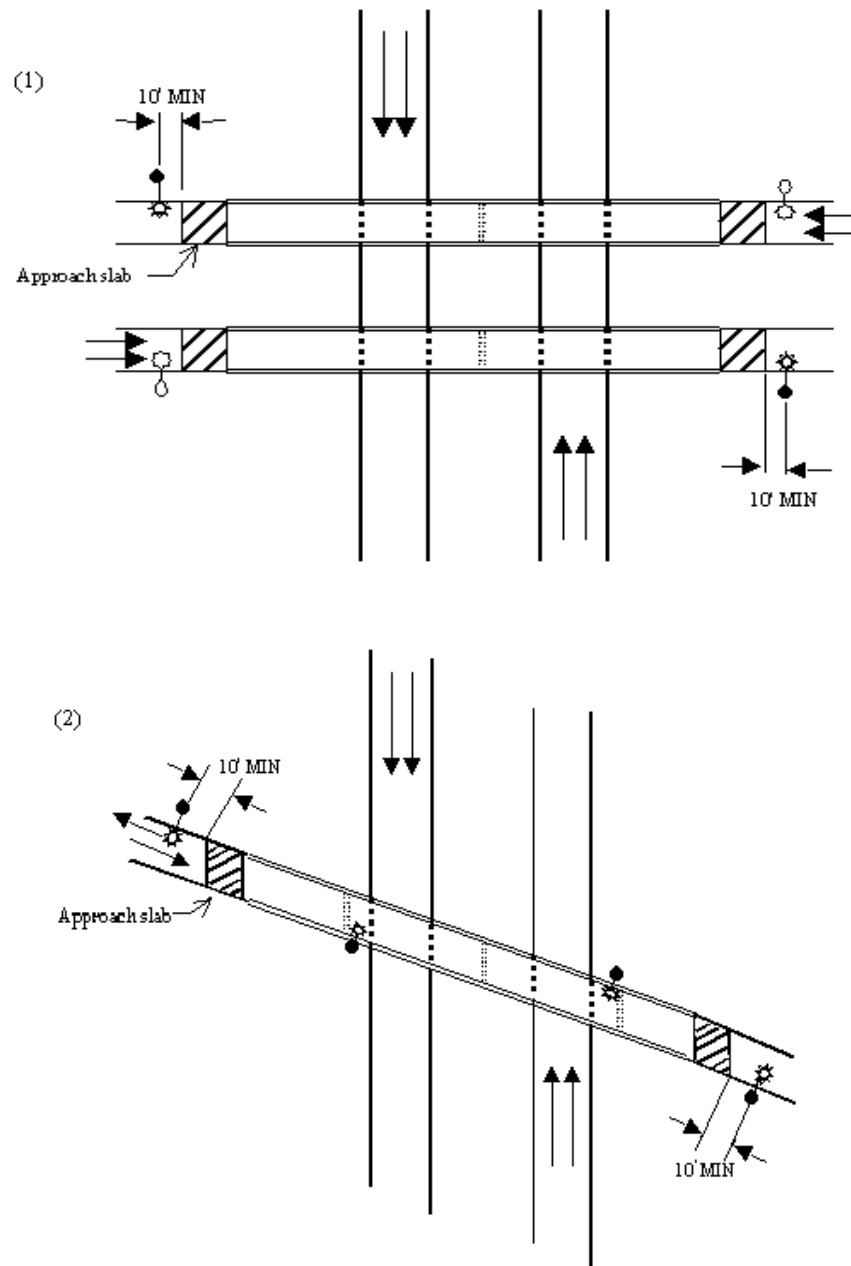


Figure 1198-8. Luminaire Mounting Arrangements



Luminaire mounting arrangements: (a) Median; (b) Right-side; (c) Left-side; (d) Staggered; and (e) Opposite.

Figure 1198-9. Overpass Key Unit Locations



**Figure 1198-12a. Voltage Drop Study –
Cable Sizing Calculation Notes**

Note: This illustrative procedure uses HPS luminaires, but it is valid for LED luminaires as well, except that LED luminaires have no ballast loss.

1. Voltage drop on circuit not to exceed 5% nominal circuit voltage in steady state since equipment can generally tolerate a voltage variance of 10%.

Because of the small wire sizes involved and the high power factor of the lighting load, the reactance is considered to be negligible in this computation. (AIEE publication No. 952 dated October, 1956)

2. Operating current for typical luminaires in **ODOT** HPS Highway Lighting Systems:
Line Amperes Operating = (Lamp watt + Ballast watts)/Line voltage
Ballast watts may be as much as 30% lamp watts for tertiary winding ballast.

Lamp Wattage	Line Amps. Operating		
	480 Volts	240 Volts	120 Volts
100	0.27	0.54	1.1
150	0.41	0.81	1.6
200	0.54	1.1	2.2
250	0.68	1.4	2.7
310	0.84	1.7	3.4
400	1.1	2.2	4.3
1000	2.7	5.4	11

3. Obtain wire resistance from published data (engineering handbooks, manufacturers' data sheets, etc. The following values are taken from **NEC** (2011) Chapter 9, Table 9:

Wire Size	Ohms per 1000 feet
14	3.1
12	2.0
10	1.2
8	0.78
6	0.49
4	0.31
2	0.19
1/0	0.12
2/0	0.10
4/0	0.079

4. Voltage drop in a Lighting Circuit Section = Amperes in and beyond the Section x [(Length of the Section in feet x 2 wires)/1000] x Resistance wire per 1000.

Include in length of a section an allowance for connection at each end and slack. Frequently this is done by allowing 5-10 feet at each end and rounding up section lengths in increments of 5 feet.

5. To simplify calculations (*see Figure 1198-12c*): Lighting unit lead and voltage drop is computed only to the base of the support; underpass lighting load and voltage drop is computed only to the disconnect switch; and the sign lighting load and voltage drop are computed only to point of connection to the lighting circuit.

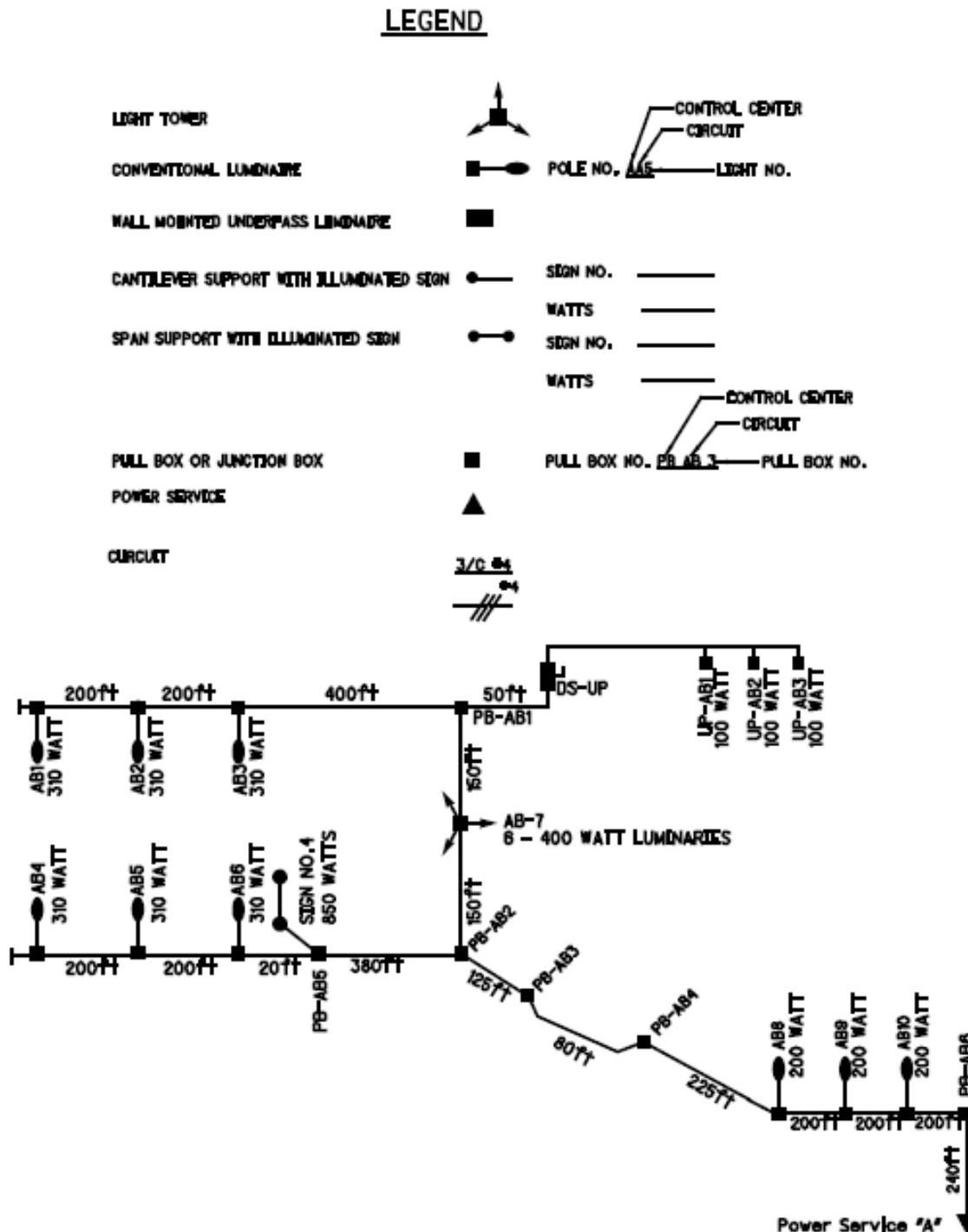
Figure 1198-12b. Voltage Drop Study –
Sample Circuit Layout

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Part 12 – ZONES AND TRAFFIC ENGINEERING STUDIES**1200 GENERAL**

This Part of the **TEM** addresses **ODOT** standards, policies, guidelines and procedures for Traffic Control Zones (*see Chapter 1201*) and traffic engineering studies (*see Chapter 1210*).

1201 TRAFFIC CONTROL ZONES

Traffic Control Zones include School Zones, Speed Zones, Parking Control Zones, Pedestrian Safety Zones, Loading Zones, No-Passing Zones and Temporary Traffic Control Zones (Work Zones).

ORC Section 4511.21 addresses Speed Zones and School Zones, and Section 4511.22 addresses Slow and Minimum Speeds. For additional information: see **Chapter 1202** of this Manual regarding School Zones and School Zone Extensions; Chapter **1203** regarding Speed Zones; and **Chapter 1204** regarding Parking Control Zones at locations not covered by existing law (**ORC Sections 4511.66, 4511.68, 4511.681 and 4511.69**). **Chapter 1205** addresses other zones.

No-Passing Zones and Temporary Traffic Control Zones are addressed in **OMUTCD Parts 3 and 6**, respectively, and additional information may be found in **TEM Parts 3 and Part 6**.

1202 SCHOOL ZONES

OMUTCD Section 7B.09 addresses School Zones and School Zone Extensions. **Chapter 705** of this Manual describes the procedures for requesting and withdrawing School Zone Extensions. The related forms are shown in **Part 7** of this Manual. Full-size copies of the forms are also available for downloading from the Forms page on the **Office of Traffic Operations (OTO)** website.

“Special Elementary Schools” (e.g., Amish), are eligible for school zone signing provided they meet the requirements in **Ohio Revised Code 4511.21(B)(1)(c)** and **4511.21(B)(1)(e), (i-v)**.

1203 SPEED ZONES**1203-1 General**

A Speed Zone is a section of street or highway where, on the basis of an “engineering study”, the prima facie speed limit set forth in **ORC 4511.21 (B)(1)(a) to (D)** is determined to be greater or less than is reasonable or safe and the **Director** and/or appropriate local authorities have declared a reasonable and safe prima facie speed limit and erected signs in accordance with **ORC 4511.21**. This “study” or “investigation” is typically referred to as a Speed Zone Study. The processes for requesting and authorizing Speed Zones, and some “short form” alternative studies and forms, are described in **Section 1203-2**. Details related to conducting a full “traditional” Speed Zone Study are addressed in **Section 1203-3**. It should be noted that Warning Signs and Advisory Speed signs in accordance with the **OMUTCD** should be considered before speed zoning based solely on roadway characteristics.

As noted in **OMUTCD Section 2B.13**, **ORC Section 4511.21** establishes speed limits for all streets and highways within the **State**. It also provides that the **Director** may alter speed limits, and that local authorities may request that the **Director** determine and declare a reasonable and safe speed limit on certain highways under their jurisdiction.

When circumstances that were part of the justification for an altered speed limit change, it may be

necessary to “withdraw” the authorization for the Speed Zone, e.g., a Corporation Line moves, or the roadway features are modified. **Section 1203-4** describes the withdrawal process.

Under **ORC Division 4511.21 (K)**, a **Board of Township Trustees** may, by resolution and based on “an engineering study,” declare a prima-facie speed limit on unimproved highways and also on highways under their jurisdiction which are within residential and commercial subdivisions (**see Section 1203-2.3**).

In altering speed limits, the minimum length of a new zone not contiguous to an existing Speed Zone should be greater than or equal to 0.5 miles; however, a new zone contiguous to an existing warranted zone may be shorter.

Occasionally, to promote safe and efficient operations on the highway system, it may be determined that the speed limit should temporarily be reduced due to a construction work zone (**see TEM Section 1203-2.9** and **ORC Section 4511.98**).

Additional regulations on speed limits can be found in **ORC Sections 4511.211** (Speed limit on private residential road or driveway), **4511.23** (Speed regulations on bridges) and **4511.24** (Emergency vehicles exempt from speed regulations).

1203-2 Procedures for Requesting and Authorizing Speed Zones

1203-2.1 General

Requests for Speed Zones needing the approval of the **Director of Transportation** are submitted to the **District Speed Zoning Coordinator (DSZC)** for review and approval using one of the forms and procedures described in this Section.

All the forms described herein and shown in **Chapter 1296** are also available from the Forms webpage on the **OTO** website. For certain situations, “short form” alternative studies have been developed: for rural roads with a width of 16 feet or less or an ADT of 400 or less, see **Section 1203-2.6**; for unimproved County Roads and residential or commercial subdivision streets see **Section 1203-2.7**; for freeways and high-speed multi-lane divided highways see **Section 1203-2.8**.

The procedure and forms for speed zones in temporary traffic control zones (work zone speed zones) are addressed in **Section 1203-2.9**.

A quick reference guide is provided below as to what situation each of the forms addresses:

Form No.	Section No.	Form Title
1296-1	1203-2.6	Speed Zone Request for Narrow & Low-Volume Rural Roads
1296-2	1203-3.3	Speed Zone Warrant Sheet (for situations not covered by the alternative forms)
1296-14	1203-2.8	Freeway & Expressway Speed Zone Evaluation Sheet
1296-15	1203-2.7	Speed Zone Request for Unimproved Highways & Residential and Commercial Subdivision Streets
1296-17	1203-2.9	Work Zone Speed Zone (WZSZ) Evaluation Sheet for High-Speed (≥ 55 mph) Multi-Lane Highways

1203-2.2 State Highways with ODOT’s Jurisdiction – General Procedure

All proposals for alterations of speed limits on **State** highways within ODOT’s jurisdiction shall be documented with the appropriate Speed Zone Study as outlined in **Section 1203-3** or using an appropriate alternative process or form described in **Section 1203-2**. For temporary traffic control situations (WZSZs), see **Subsection 1203-2.9**.

Once a determination has been made to alter a speed limit, the **District** should forward the proposed speed limit reduction to the appropriate **Ohio State Highway Patrol (OSHP) District Office** for review and comment. **Form 1296-19** is a sample form that can be used to help expedite this review. The information at the top of the form would be completed by the **District** as appropriate for the specific zoning proposal, so that the form just has to be signed and returned to the **District** after **OSHP** review.

Following resolution of the **OSHP** comments, if any, the **District** shall prepare a description of the Speed Zone for the **Director's** approval using **Form 1296-6** (Speed Limit Revision).

The revised speed limit is not in effect until the appropriate signs have been erected. Therefore, erection of the new Speed Limit signs, and their removal if/when the zone is withdrawn, must be documented to verify when the Speed Zone is in effect. See **Section 1203-5** for further details on the documentation process.

1203-2.3 Highways within Local Jurisdictions – General Procedure

As noted in **Section 1203-1**, a **Board of Township Trustees** may, by resolution and based on “an engineering study,” declare a prima-facie speed limit on unimproved highways and also on highways under their jurisdiction which are within residential and commercial subdivisions. The terms unimproved highway, and residential and commercial subdivision are defined in [ORC Division 4511.21\(K\)](#). It is recommended that the **Townships** document the reasons for these Speed Zones and when the Speed Limit signs are erected. **Form 1296-15** is an example of a form that can be used for such documentation.

Except as provided in **ORC 4511.21(K)** for Township Roads, all requests for reduced speed limits on local roads (i.e., roads under the jurisdiction of a local authority other than **ODOT**) shall be submitted to the **District** using one of the forms described herein. The request shall be accompanied by the appropriate resolution or ordinance from the local authorities. The appropriate Speed Zone Study, as outlined in **Section 1203-3**, shall be included with all such requests unless the request qualifies for one of the abbreviated processes or forms described in **Section 1203-2**. All requests shall be acknowledged, and the local authorities shall be notified whether additional data will be necessary to substantiate their request.

For temporary traffic control situations (WZSZs), see **Subsection 1203-2.9**.

Based on the information received and a field review conducted by **ODOT** personnel (if appropriate), the **District** shall determine a reasonable and safe speed limit. If this determination is substantially different from that which was requested, the local authorities may be asked to further substantiate their original request, and a new determination may be made.

Following resolution of any comments, the **District** shall prepare a description of the Speed Zone for the **Director's** approval using **Form 1296-6** (Speed Limit Revision).

The **District** shall notify the local authorities of **ODOT's** final action on the proposed Speed Zone.

The revised speed limit is not in effect until the appropriate signs have been erected. Therefore, erection of the new Speed Limit signs, and their removal if/when the zone is withdrawn, must be documented to verify when the Speed Zone is in effect. See **Section 1203-5** for further details on the documentation process.

1203-2.4 Split Jurisdictions

[ORC Division 4511.21\(M\)\(1\)](#) addresses situations where the boundary of two local authorities rests on the centerline of a highway and both authorities have jurisdiction over the highway. Aside from **Division 4511.21(M)(1)** and the speed zoning process, there is currently no provision to address the inconsistency and confusion caused when responsibility for a section of highway

is split between different jurisdictions. The speed limit may differ depending on which side of the roadway you are traveling. This can be confusing to motorists. When this occurs on State highways within ODOT's jurisdiction, using the speed zoning process, the **District** should work with the local jurisdiction(s) to try to address the differences. This may involve:

1. Raising the lower speed limit to match the higher statutory speed.
2. Lowering the higher speed limit to match the lower statutory speed.
3. Determining an altered speed limit in between the existing speed limits that both jurisdictions can agree is appropriate.
4. Leaving the statutory speed limit on each highway section.

Although this process will usually involve the **District** reviewing a speed zoning request submitted by the local jurisdiction, the **District** should periodically review sections where this split jurisdiction situation occurs on State highways to consider making a change in the speed limit on the **ODOT** portion of the highway under ODOT's jurisdiction. The **District** may also initiate discussions with the local jurisdiction about jointly determining an appropriate altered speed limit for the section of highway.

If a local jurisdiction is going to submit a speed zoning request for a roadway section that involves split jurisdictions, the jurisdiction initiating the request shall first contact the adjacent jurisdiction(s) to see if a compromise request can be developed. The speed zone request submitted to the **District** shall include copies of the related Resolutions (or Ordinances) from all jurisdictions involved.

1203-2.5 Speed Zone Tracking Application

When the Speed Zone Study has been properly prepared the review process should take no more than 90 days from the date the **District** received the request to the date the **District** notifies the local jurisdiction of **ODOT's** final determination on the proposed Speed Zone. The **District** will notify the local jurisdiction upon receipt of the Speed Zone Study. The local jurisdiction will also receive a progress report from **ODOT** after 45 days. If the initial request is incomplete or if the **District** later in the review process requires additional information, this 90-day period begins again when the **District** receives the information.

A software application was implemented in January 2008 to track the status of Speed Zoning requests from local authorities as they are processed by **ODOT**. Each **District** enters the required data as requests are received and updates the records as each request is processed. As the 90-day deadline approaches for each request, email reminder notices are sent to key **District** personnel.

1203-2.6 Narrow and Low-Volume Rural Roads (*Form 1296-1*)

For roadways with a width of 16 feet or less or an ADT of 400 or less, **Form 1296-1** may be used to request a reduced speed limit. The data required for a Speed Zone Study for roads in these categories has been reduced and the form has been streamlined. A Speed Check is not required. The form was developed as a Microsoft Excel program; however, it may also be completed by hand.

The first sheet of the short form for Narrow and Low-Volume Roads is basically for data input. In the Excel file, when the mouse cursor hovers over the characteristics designations A1, B1, etc. a text description of that category pops up. There are also links to graphic examples of the characteristics categories and crash data samples. The second sheet in the file is a more traditional version of the warrant form: it includes the formulas and makes the calculations, based on the data entered on the first sheet. The third sheet provides a graphic illustration of the roadway characteristics information.

Table 1297-6 provides additional information about the Roadway Characteristics categories used with this form, and **Figures 1298-3 through 1298-5** provide aerial view illustrations to help describe these categories.

If the Excel software isn't available, sheet 1 or 2 may be copied, completed by hand and submitted.

Test Run data is recorded when reviewing the speed zoning request and the information is shown on the form because the average test run speed is beneficial in supporting the spot speed data as reflecting free-flow conditions. Also, it is beneficial in comparing or matching the fit of the spot speed data to the full length of the section under study. Test runs conducted by ODOT should be heavily relied upon to determine the appropriate speed limit for the studied section of roadway.

A Comments section has been provided on the form in case there is additional information the requesting agency wants to bring to the reviewer's attention (**see Section 1203-3.5**).

1203-2.7 Unimproved Highways and Residential and Commercial Subdivision Streets (Form 1296-15)

As noted in **Sections 1203-1 and 1203-2.3**, the **Ohio Revised Code** allows **Townships** (based on "an engineering study") to alter by Resolution the speed limit on unimproved highways and residential and commercial subdivision streets to less than 55 miles per hour, but not less than 25 miles per hour. **ODOT** has established an abbreviated speed zoning request form to allow the **Counties** to do the same, by submitting a copy of **Form 1296-15** to the **ODOT District** with a Resolution from the **Board of County Commissioners**. The definitions for "unimproved highway," "residential subdivision" and "commercial subdivision" shall be as shown in [ORC Division 4511.21\(K\)](#), except that they will apply in this case to County Routes. For County roads, this speed limit change will be established and documented through a Speed Limit Revision form.

The Comments portion of the form can be used to document information from the study made to support the speed reduction.

As noted in **Section 1203-2.3**, it is recommended that **Townships** document the reasons for the Speed Zones they establish on unimproved highways and residential and commercial subdivision streets, and when the Speed Limit signs are erected. **Form 1296-15** is an example of a form that can be used for such documentation.

1203-2.8 Freeways and High-Speed Multi-Lane Divided Routes

Since the basic Speed Zone Warrant Sheet (**Form 1296-2**) is not set up to address situations involving speed limits over 60 miles per hour, other methods have been developed for reviewing situations involving freeway and other high-speed multi-lane divided highways when they arise.

For freeways and rural expressways, **Form 1296-14** may be used to submit requests for changes in the speed limit. The ADT/lane is intended to be vehicles per continuous lane.

Generally, 65 miles per hour is considered appropriate for expressways with no driveways. For controlled access non-expressways with no driveways, 60 miles per hour is generally considered a more appropriate speed limit; and 55 miles per hour is considered more appropriate when there is no access control and driveways are present. However, these guidelines are not intended to be rigid. It is recognized that there may be cases where exceptions are appropriate. For example, a single drive added in a several mile section of an expressway would not be considered sufficient by itself to warrant lowering the speed limit to 60 miles per hour. Also, for a non-expressway section with no driveways between two expressway sections, it may be appropriate to consider a 65 miles per hour speed limit. As with

other speed zoning situations, there may be a need to go 5 miles per hour one way or the other to address other considerations, such as those noted in **Section 1203-3.5**

1203-2.9 Speed Zones in Temporary Traffic Control Zones (Work Zone Speed Zones)

1203-2.9.1 General

Research has shown that motorists will only reduce their speed if they clearly perceive a need to do so. However, a speed limit reduction may be desirable in temporary traffic control zones that involve work on or near the traveled way, particularly on high-speed multi-lane highways. The Work Zone Speed Zone (WZSZ) process described herein applies to any work zone located on a multi-lane highway with a pre-construction speed limit of ≥ 55 mph and with a work zone condition at least 0.5 mile in length that reduces the existing functionality of the travel lanes or shoulders and has an expected work duration of at least three hours.

For purposes of the WZSZ process: the conditions that would “reduce existing functionality” of the travel lanes or shoulders are lane closures, lane shifts, crossovers, contraflow and/or shoulder closures; and the length of the work zone condition is measured from the beginning of the taper for the subject work zone condition impacting the travel lanes and/or shoulder to the end of the downstream taper, where drivers are returned to typical alignment.

The three-hour duration requirement is used to balance the additional exposure created by installing and removing WZSZ signing with the time needed to complete the construction or maintenance work.

Speed zones in construction work zones should be reviewed and approved as early as possible in the planning process. **Sections 1203-2.9.2 through 1203-2.9.4** address details of the process as applied to construction projects in the design phase and during construction, as well as Operations/Maintenance projects. **Sections 1203-2.9.6 and 1203-2.9.7** provide additional information used to navigate and complete the process.

At this time, Work Zone Speed Zones (WZSZs) on other streets and highways will be considered on a case-by-case basis, and must be submitted individually to the **District Work Zone Traffic Manager (DWZTM) and District Speed Zoning Coordinator (DSZC)** using one of the other applicable processes described in **Section 1203-3**. Before the **District** may approve such request, concurrence shall be obtained from the **Office of Roadway Engineering (ORE)**. If approved, the WZSZ must still be established and documented through a Speed Limit Revision Form, implemented in the field and tracked using principles consistent with the WZSZs on high-speed (≥ 55 mph) multi-lane highways, and withdrawn when completed.

A WZSZ is not in effect and enforceable unless all of the existing speed limit signs within 1 mile in advance of and inside the WZSZ are removed or covered and the WZSZ Speed Limit signs are in place with the appropriate legends displayed. Legends reflecting a speed limit in accordance with **Table 1297-7** shall only be displayed when the work zone condition in place reduces the existing functionality of the travel lanes or shoulders. At all other times (when the work zone condition no longer reduces the existing functionality of the travel lanes or shoulders) the original posted speed limit shall be displayed.

For further details about information that needs to be addressed regarding WZSZs, see **Sections 605-3.4, 605-6.4, 640-18, 641-34 and 642-24**.

When the need for the WZSZ has ended, the WZSZ signage shall be removed and the original (pre-construction) speed limit signage restored. The related Work Zone Speed Limit Revision shall be withdrawn (**see Section 1203-4**).

See **Section 1203-5** for further information about documentation of WZSZs. This includes the required documentation of when and where the signs are erected, what speed limit is displayed, and when they are removed.

1203-2.9.2 WZSZs on High-Speed (≥ 55 mph) Multi-Lane Highways for Construction Projects – During Design (Figure 1298-1a)

In addition to the provisions of **Section 1203-2.9.1**, details of the WZSZ process for construction projects during design, including design build projects, are described in **Figure 1298-1a, Work Zone Speed Zoning Process for Construction Projects – Design Phase**.

As noted above, Speed Zones in construction work zones should be reviewed and approved as early as possible.

1203-2.9.3 WZSZs on High-Speed (≥ 55 mph) Multi-Lane Highways for Construction Projects – During Construction (Figure 1298-1b)

In addition to the provisions of **Section 1203-2.9.1**, details of the WZSZ process for construction projects during construction, are described in **Figure 1298-1b, Work Zone Speed Zoning Process for Construction Projects – During Construction**.

1203-2.9.4 WZSZs on High-Speed (≥ 55 mph) Multi-Lane Highways for Operations/Maintenance Work (Figure 1298-1c)

In addition to the provisions of **Section 1203-2.9.1**, details of the WZSZ process for operations and maintenance work on high-speed (≥ 55 mph) multi-lane highways are described in **Figure 1298-1c, Work Zone Speed Zoning Process for Operations/Maintenance Work**.

1203-2.9.5 Reserved for Future Information

The new WZSZ process eliminated the need for the **Work Zone Speed Zone Justification Report (Form 1296-16)**. Therefore, the form and related text has been deleted. This Section is reserved for future use.

1203-2.9.6 Warranted Work Zone Speed Limits for Work Zones on High-Speed (≥ 55 mph) Multi-Lane Highways (Table 1297-7)

Table 1297-7 is used to determine the warranted speed limit value(s) during qualifying work zone conditions (defined below and in **Section 1203-2.9.1**) for multi-lane highways with a pre-construction speed limit of 55 mph or higher. All WZSZs are variable in nature, with the warranted work zone speed limit fluctuating with the conditions and factors in place at the time.

The table provides the warranted speed limit for each of the specific conditions given. Only one warranted speed limit applies at any one time; speed limit reductions are not cumulative. As conditions in the work zone change, the work zone speed limit shall adjust accordingly per **Table 1297-7**. WZSZ shall not be used for Moving/Mobile activities, as defined by the **OMUTCD**.

The following are definitions and additional information for use with **Table 1297-7**:

Work Zone Condition – A qualifying work zone condition is one that is at least 0.5 mile in length (as defined in **Section 1203-2.9.1**), with an expected work duration of at least three hours, and reduces the existing functionality of the travel lanes or shoulders. As noted in **Section 1203-2.9.1**, the conditions that would “reduce existing functionality” of the travel lanes or shoulder are lane closure, lane shift, crossover, contraflow and/or shoulder closure.

Original Posted Speed Limit – The original, pre-construction, speed limit prior to any WZSZ. When determining a warranted work zone speed limit for a new or revised work zone condition in which there is a pre-existing work zone speed limit in place, always use the original (pre-construction) speed limit. Do not base a new work zone speed limit upon a prior work zone speed limit. Speed limit reductions are not cumulative.

Positive Protection - Positive protection is generally regarded as portable barrier or other rigid barrier in use along the work area within the subject qualifying work zone condition. A work zone Without Positive Protection is generally regarded as using drums, cones, shadow vehicle, etc., along the work area within the subject qualifying work zone condition. For work zones that are utilizing a combination of Temporary Traffic Control Devices (TTCDs), the designation of “with” or “without” positive protection should be based upon the type of devices used for the qualifying work zone condition being considered. If there is a combination of TTCD within the qualifying work zone condition being considered, engineering judgement should be used in determining the designation with consideration being given more towards the area in which workers will be located.

Worker Presence – Workers are considered as being present when on-site, working within the subject qualifying work zone condition.

The following are two examples demonstrating how to determine warranted work zone speed limit values from **Table 1297-7**:

Example 1

An Interstate with an original, pre-construction, posted speed limit of 70 mph will have a lane shift of 10-feet (>0.5 mile in length) in place 24/7 for several weeks using portable barrier. The work zone speed limit while the lane shift is in place when workers are present is 60 mph (65 when workers are not present, but the lane shift remains in place). For one night there will also be a lane closure (> 0.5 mile in length) for six hours using drums; and the closed lane will be restored (reopened) before the end of the work shift, while the lane shift remains in place. The work zone speed limit during the lane closure is 55 mph and would only be applicable for the length of the lane closure. Once the closed lane was restored, the work zone speed limit in that area would go back to 60 mph while workers and the lane shift were still present.

Example 2

An Interstate with an original, pre-construction, posted speed limit of 65 mph will have a nighttime lane closure (>0.5 mile in length) in place for seven hours using drums, and the closure will be repeated nightly for three days. When workers are not present, all lane and shoulder functionality is restored. The work zone speed limit during times when the lane closure is in place and workers are present would be 50 mph. When workers are not present (and the condition impacting the existing functionality of the lane and shoulder is not present) the work zone speed limit would be the original, pre-construction, speed limit of 65 mph.

See **Section 1203-2.9.7** for information regarding an optional form for assistance in working with **Table 1297-7**.

1203-2.9.7 WZSZ Evaluation Sheet for High-Speed (≥55 mph) Multi-Lane Highways (Form 1296-17)

Form 1296-17 is an optional form available to assist in navigating the information in **Table 1297-7**. The form is used in the same way as **Table 1297-7**, to determine the warranted work zone speed limit values during qualifying work zone conditions on multi-lane highways with original (pre-construction) speed limits of 55 mph or higher. See **Section 1203-2.9.6** for definitions and additional information that applies to the use of **Form 1296-17**.

1203-2.10 Variable Speed Limits

ORC Section 4511.21(H)(3) allows the **Director** to establish a Variable Speed Limit that is different from the established speed limit for weather conditions, traffic incidents and congestion that occur on all or portions of I-670, I-275 and I-90 (at the intersection with I-71 and continuing to the Ohio-Pennsylvania border).

1203-3 Speed Zone Studies

1203-3.1 General

Generally, a Speed Zone Study used to support a request for alteration of a speed limit should include **Forms 1296-2** (Speed Zone Warrant Sheet), and **Form 1296-5** (Speed Check Form) and a scaled area map, sketch, or aerial view to identify the location of the proposed zone. Alternative study procedures have been developed to address certain situations involving narrow or low-volume rural roads, unimproved County Roads, residential and commercial **County** subdivision streets, freeways, rural expressways, and temporary traffic control zones on high-speed (≥ 55 mph) multi-lane highways. These are addressed in **Sections 1203-2.6, 1203-2.7, 1203-2.8 and 1203-2.9**, respectively.

If conditions are not relatively consistent throughout the section under study, consideration should be given to splitting the study area into shorter sections. Turning lanes, or other special lanes, are not normally used in this calculation.

FHWA's USLIMITS2 is a web-based tool used to conduct speed studies for setting appropriate speed limits. Except for the abbreviated speed zone request procedure under **Section 1203-2.9**, use of USLIMITS2 is required for all speed zone studies as a way to check and compare the results obtained via the speed zoning process described herein. USLIMITS2 provides an objective second opinion that will increase confidence in setting reasonable, safe and consistent speed limits. Information regarding this tool can be found at the following website:

<https://safety.fhwa.dot.gov/uslimits/>

1203-3.2 Field Review

A field review of the roadway section shall be made noting various physical conditions along and adjacent to the highway and identifying where crashes have occurred. The Speed Study Data Sheet (**Form 1296-3**) or a similar document may be useful in consolidating this information. (**Form 1296-4** provides a completed sample of this form, using symbols from **Table 1297-1**.) If any information is collected virtually (e.g. land-use characteristics), any imagery used should be recent enough to ensure the characteristics have not changed since the images were captured. The field review should consider:

1. Roadway width, width of lanes, width of berm, setbacks of the buildings, distances to any fixed objects within 10 feet of the pavement edge, and type and condition of the pavement surface should also be shown.
2. On **ODOT**-maintained routes, SLM log points shall be used. A 1 inch = 0.1-mile scale should be used along the centerline of the roadway. Lateral dimensions need not be scaled.
3. The review should consider features 500 feet beyond each end of the proposed zone.
4. Pavement marking or restricted sight distances less than 600 feet, signals and flashers, and Warning and Regulatory Signs.
5. Significant presence of vulnerable road users or significant land use or characteristics supporting the presence of vulnerable road users.
6. The number of crashes, types of crashes, and severity of crashes that occurred in the last three years.

7. Test run(s) should be made; however, these will also be conducted by the **District** personnel reviewing requests submitted to **ODOT**.
 - a. Test run(s) should be made by driving as fast as it is comfortably safe.
 - b. Test run(s) should be made in such a way that other traffic will not delay the test car.
 - c. The speed should be recorded at a range of 0.10 to 0.25-mile interval or more.
 - d. The average speed of the run(s) should be determined in each direction.

1203-3.3 Speed Check (Form 1296-5)

Except when using one of the abbreviated study procedures described in **Sections 1203-2.6 through 1203-2.9**, or a summary sheet resulting from a mechanical speed check device and its associated software, a speed check using **Form 1296-5** (Speed Check Form) or a similar form, shall be included in the study.

1. Speed checks may be taken with any device that will indicate vehicle speed with an accuracy of ± 10 percent.
2. Record speeds of 100 vehicles for each direction of travel (observation need not exceed one hour even if less than 100 vehicles are recorded traveling in each direction).
3. Speed checks should be taken at the 1/3 points (total of four checks) for zones 0.25-1.00 mile in length, and at 0.5-0.75-mile intervals for zones over 1 mile in length.

1203-3.4 Speed Zone Warrant Sheet (Form 1296-2)

1203-3.4.1 General

Form 1296-2 shall be used in analyzing speed reduction requests that do not fall into the categories discussed in **Sections 1203-2.6 through 1203-2.9** for the abbreviated Speed Zone request procedures. The data collected from the field review of the location and the information discussed in **Subsection 1203-3.4.2** are used to complete **Form 1296-2**. As mentioned in **Section 1203-3.1**, the data collected will also be used to complete a new USLIMITS2 project to assist in determining the appropriate speed limit.

The current form was developed as a **Microsoft Excel** file; however, it may also be completed by hand.

The first sheet of **Form 1296-2** is basically for data input. In the Excel file, when the mouse cursor hovers over the Roadway Characteristics designations A1, B1, etc. a text description of that category pops up. There are also links to graphic examples of the characteristics categories and crash data samples. The second sheet in the file is a more traditional version of the warrant form: it includes the formulas and makes the calculations, based on the data entered on the first sheet. The third sheet provides a graphic illustration of the roadway characteristics information; and the last sheet provides a sample crash diagram for the roadway section showing which types of crashes should be included when performing a speed study.

The Roadway Characteristics information used with this form are the same as those used in **Form 1296-1** for narrow and low-volume roads. **Table 1297-6** provides additional information about the Roadway Characteristics categories used with this form, and **Figures 1298-3 through 1298-5** provide aerial view illustrations to help describe these categories.

If the Excel software is not available, sheet 1 (Full Study Warrant Form) may be printed, completed by hand, and submitted.

A Comments section has been provided on the form in case there is additional information the requesting agency wants to bring to the reviewer's attention (**see Subsection 1203-3.5**).

1203-3.4.2 Information Used in Completing Form 1296-2

The following data is used in completing the Warrant Sheet:

1. **Highway Development** consists of evaluating the extent of building development and classification of intersections. These components are described in **Table 1297-2**. Intersections at the end of the study area should not be counted.

The building development and intersection classification calculations are added and then the total is divided by the length (in miles) of the zone.
2. **Roadway Features** consists of evaluating the roadway conditions including lane width, shoulders, crashes, and vulnerable road users.
 - a. It is recognized that some conditions may not be consistent throughout the entire roadway section under study. A judgment will need to be made to determine the most prominent condition, or consideration should be made to separate the segment into multiple smaller segments. **Crashes-** intersection crashes not on the approach to the section under study should not be included in the evaluation; and crashes at horizontal curves should be considered only after all appropriate Warning and Advisory Speed signs are in place.
 - i. Caution needs to be exercised in applying the crash experience if there is an over representation of crashes caused by situations essentially independent of the permanent speed limit. Therefore, in determining a permanent speed limit, crashes caused by animals, impaired drivers, vehicle defects, construction and environmental conditions, such as snow and ice, should not be included in the crash experience.
 - ii. It is desirable to consider a review of crashes over a three-year period; Copies of the crash reports, or a list documenting the location and type of each crash, shall be submitted with the request.
 - b. **Vulnerable Road Users** include presence of, or land use supporting the presence of, pedestrians, bicyclists, Amish buggies, etc. Other factors for vulnerable road users include:
 - i. Presence of bicycle lanes or sharrows
 - ii. Presence of sidewalks, shared use paths, or other pedestrian facilities
 - iii. Presence of high frequency transit stops
 - iv. High utilization of on-street parking
 - v. Frequent Amish buggy utilization
 - vi. Land use density supporting vulnerable road users to cross the street (restaurants, healthcare, gas stations, etc.)
 - c. Urban roadways can be identified by their physical characteristics, higher quantity of road users, higher quantity of intersections and higher density development. Other features of an urban roadway:
 - i. Curbs
 - ii. On-street parking
 - iii. Presence of sidewalks and crosswalks
 - iv. Street lighting
 - v. Heavy residential or commercial development

In urban areas with a high presence of vulnerable road users, or land use to support a high presence of vulnerable road users, the 50th percentile speed is used in place of the 85th percentile speed.

3. **50th and 85th-Percentile Speed** can be determined by taking spot speed observations during weekday off-peak periods. Spot speed checks should be taken to reflect only free-flowing vehicles. A vehicle is considered free flow if there is a minimum of five seconds gap (headway) from the other vehicle ahead of it, and it is not accelerating or decelerating for other reasons. If it is not possible to observe free-flow conditions, then the 85th-percentile speed of all vehicles should be increased 5 to 10 miles per hour to approximate the free-flow 85th-percentile speed. If the 85th-percentile speed of several speed checks varies considerably and is in more than one range in the warrant analysis, average the speed or select the most representative speed.

Another option for determining 50th and 85th-percentile speeds involves the use of probe-based data. Traffic information is collected from **ODOT**-maintained roads, then data analytics is used to determine the 50th and 85th-percentile speed. The **Office of Traffic Operations (OTO)** has created detailed instructions for downloading the data and calculating the 50th and 85th-percentile speeds using an **OTO** developed program. This information is available from the "Regulations" web page on the **OTO** website.

The calculated speed will be derived from the 50th percentile speed in lieu of the 85th percentile speed if there is a high presence of vulnerable road users and urban features are present.

4. **Pace** is the ten mile per hour range of speeds containing the greatest number of observed speeds. If the paces of several speed checks vary considerably and are in more than one range in the warrant analysis, average the pace or select the most representative pace.
5. **Roadway Characteristics** consists of evaluating available horizontal and vertical sight distance provided by the roadway alignment and the lateral sight distance limited by features or objects within the clear zone. Refer to Table 1297-6 for definitions of each roadway characteristic.
6. **Test Run** data is recorded by the **District** when reviewing the speed zoning request and the information is shown on the form because the average test run speed is beneficial in supporting the spot speed data as reflecting free-flow conditions. Also, it is beneficial in comparing or matching the fit of the spot speed data to the full length of the section under study.

1203-3.5 Additional Information/Considerations

There may be a need to consider adjusting the speed limit more than normal rounding to the nearest five miles per hour of the calculated speed as reflected in the speed study. Each Speed Zone Study form includes a provision for noting "Comments/Additional Information." This space has been provided for the requestor to note any additional information that might be of interest to the reviewer in considering the request. Items to consider or additional information to provide when recommending a speed limit different than the calculated value may include:

1. A study area near or adjacent to an incorporated area or other warranted speed reduction(s).
2. Maintaining uniformity of speed limits within a contiguous section of highway.
3. Truck volumes along with the lane width should be considered, i.e., Volumes:

< 5%	Low impact/consideration
5% to 10%	Moderate impact/consideration
> 10%	High impact/consideration

An effective width of 20 feet is considered adequate only for low-volume roads where meeting and passing are infrequent and the truck volumes are low.

4. Land along the study area is generally fully developed based on local zoning and/or local subdivision regulations.

5. Other conditions:
 - a. A large number of driveways with limited visibility.
 - b. The results of the test runs are not representative of the 85th-percentile or calculated speed.
 - c. Abnormal traffic volume flows.
 - d. The use of the road as related to access vs. mobility (e.g., functional classification).
 - e. An unincorporated area that looks to the driver the same as an incorporated area.
 - f. Large number of items that affect the assured clear stopping distance of the driver.
 - g. Proximity to a school.
 - h. Extreme geometric or other rare or unique work zone feature(s) that cannot otherwise be modified or mitigated and are not otherwise taken into consideration elsewhere in the process (for Work Zone Speed Zones that are on facilities other than high-speed, ≥55 mph, multi-lane highways).
6. Photographs may also be helpful in describing features of particular concern.

1203-3.6 Approved Speed Limit

The DSZC will consider the calculated speed from Form 1296-2 and USLIMITS2. Test runs conducted by ODOT will confirm the appropriate speed limit for the studied section of roadway. The approved speed limit shall not be less than the 50th percentile speed rounded to the closest 5 mph interval.

1203-4 Withdrawal of Authorization

The withdrawal of the authorization for a Speed Zone requires a traffic engineering study/investigation and, insofar as is applicable, shall be accomplished in the same manner in which it was established. **Form 1296-7a** (Withdrawal of Issued Speed Zone Authorization) is used to document the withdrawal of any Speed Zone approved by ODOT. **Form 1296-7b** is used for withdrawal of work zone speed zones established in accordance with **Table 1297-7**, described in **Section 1203-2.9**.

When an unimproved highway is improved, any Speed Zones established for it based on it being “unimproved” shall be withdrawn, basically using the same process by which the zone was established. **Form 1296-15** can be used, with the explanation noted in the Comments section. If a road is improved so that it no longer qualifies as a “narrow road” for speed zoning purposes, any Speed Zones established on it as a “narrow road” shall be withdrawn. The fact that the speed limit had been lowered previously because it was a narrow road, can be noted in the Comments portion of the Speed Zone request form if a speed reduction is requested for the improved highway. This would also apply if the ADT on a road increases to where it would no longer be classified as a low-volume road.

See **Section 1203-5** for additional information on documentation of the withdrawal of an authorized Speed Zone.

1203-5 Documentation and Records Management

1203-5.1 General

Table 1297-4 shows the range of Revision Numbers to be used by each **District** for Speed Zones. These numbers shall be used on forms where indicated. For speed zones in temporary traffic control zones, the prefix “WZ” shall be used with the number.

For further information on the documentation of Speed Zones within temporary traffic control zones (work zone speed zones) see **Section 1203-5.2**.

Following approval of a regular, “permanent” speed zone on **ODOT**-maintained highways, the **District** shall erect the appropriate Speed Limit signs, record the dates of sign erection on **Form 1296-6a**, and notify the **OSHP** and other law enforcement agencies as appropriate.

Following approval of a regular, “permanent” speed zone for a local jurisdiction, the **District** shall send the local authority the Speed Limit Revision authorization (**Form 1296-6a**). After erecting the related Speed Limit signs, the local authorities shall complete the bottom portion of the form, certifying that the signs were erected and when, and return the form to the **District**. Upon receipt of the completed **Form 1296-6a**, the **District** shall notify **OSHP** and other law enforcement agencies as appropriate.

As noted in **Section 1203-4**, withdrawal of an authorized Speed Zone basically follows the same process used to authorize it originally. The **District** uses **Form 1296-7a** to approve withdrawal of a Speed Zone, and the jurisdiction involved then uses the bottom portion of the form to certify that the related Speed Limit signs have been removed and when. The **District** shall notify **OSHP** and other law enforcement agencies as appropriate.

1203-5.2 Documentation for Work Zone Speed Zones (WZSZs)

Approval of a WZSZ for a temporary traffic control zone in accordance with **Table 1297-7** is documented on **Form 1296-6b, Work Zone Speed Limit Revision Form**. The **OSHP** and other law enforcement agencies shall be notified by the **District** (or local agency) as appropriate.

As noted in **Subsection 1203-2.9**, the WZSZ is not in effect and enforceable unless all of the existing Speed Limit signs within 1 mile in advance of and inside the WZSZ are removed or covered and the WZSZ speed limit signs are in place with the appropriate legends displayed. Legends reflecting a speed limit in accordance with **Table 1297-7** shall only be displayed when the work zone condition in place reduces the existing functionality of the travel lanes or shoulders. Therefore, records must be kept to document when WZSZs are in effect. This requires documentation of when the related work zone speed limit signs are actually erected and removed, or activated, digitally changed and deactivated.

Form 1296-18, Work Zone Speed Zone (WZSZ) Tracking Report was developed to document all WZSZs, whether using DSL Sign Assemblies or temporary flatsheet Speed Limit signs. On **ODOT** projects, this form shall be completed, signed and submitted to the project engineer (if applicable), **District Work Zone Traffic Manager (DWZTM)** and **District Speed Zoning Coordinator (DSZC)** weekly for all WZSZs.

All WZSZ documentation for **ODOT** construction projects is retained in the **District** Construction Project files (or **District Highway Management** files) and Speed Zoning files.

When the need for the WZSZ in accordance with **Table 1297-7** has ended, a withdrawal of the authorization shall be processed, using **Form 1296-7b**. The **OSHP** and other law enforcement agencies shall be notified as appropriate.

1203-5.3 Records Management and Retention

The **District** shall retain paper or electronic copies of the documentation used in establishing and tracking Speed Zones in their permanent files. Paper or electronic copies of the official document authorizing the issuance or withdrawal, as well as any paper or electronic copies of local requests or resolutions, shall also be retained permanently in **District** files.

When a corporation limit, or other feature, that was used as a terminus for an authorized Speed Zone moves, the existing Speed Zone should be withdrawn (**Section 1203-4**) and a new one established. However, if a road used as a reference point is renumbered or the name changes, it is not necessary to withdraw and reestablish the Zone. The changes may be noted in the documentation for the Zone. A typing error may also just be noted in the documentation.

If a road/route name changes but the road/route number does not, a new study and Speed Zone request (and withdrawal of the existing one) should not be needed if there is no change in the speed zone. However, the name change should be documented on or with the existing Revision form.

If a route is removed, but the road remains a State Route (for example, in an overlap situation), the Speed Zone does not have to be withdrawn and reestablished unless the speed limit should change.

Basically, an altered speed limit remains in effect until it is withdrawn. For example, inside a **City**, when a route has been removed from a street (as in the case of a bypass), the speed limit on the street reverts back to the statutory speed limit only after withdrawal of the Speed Zone.

Information from the speed zone report shall be uploaded by the **District** to the Traffic Regulations Database Management System (TRDMS), a statewide inventory and historical record that the **Office of Traffic Operations (OTO)** shall maintain. This Regulations inventory is available from the **OTO** website (see Misc. Applications, Documents, Projects and Programs/Regulations).

1204 PARKING CONTROL ZONES

1204-1 General

As noted in **OMUTCD Section 2B.46**, **ORC Section 4511.68** establishes certain parking prohibitions and **ORC Section 4511.69** notes additional provisions related to parking locations and provisions. In addition, **Section 4511.66** addresses the prohibition of parking upon the paved or main traveled part of the highway, and **4511.681** addresses the prohibition of parking on private property.

Special legal authority is required to establish parking controls at any type of location not covered under existing laws. For rural state highways, these Parking Control Zones must be authorized by the **Director**. In municipalities, such authority is granted by an Ordinance passed by the **Council** or by other local legal authority. The adoption of a Resolution by **County Commissioners** or **Township Trustees** provides similar authority in rural jurisdictions.

Any regulation established other than those specified in **ORC Sections 4511.66, 4511.68 and 4511.99 A through C** shall be indicated by the use of signs.

1204-2 Procedure for Authorizing Parking Control Zones

As noted in **Section 1204-1**, **ODOT** has no responsibility for Parking Control Zones on local roads or private property.

Requests for Parking Control Zones on **ODOT**-maintained highways are submitted through the **District** office. As noted in **Section 1204-3**, an engineering study is conducted to determine if a Parking Control Zone is appropriate.

Once a determination has been made to establish a Parking Control Zone, the **District** shall forward the parking control proposal to the appropriate **OSHP District Office** for review and comment. **Form 1296-19** is a sample form that can be used to help expedite this review. The information at the top of the form would be completed by the **District** as appropriate for the specific zoning proposal, so that the form just has to be signed and returned to the **District** after **OSHP** review.

Following resolution of the **OSHP** comments, if any, the **District** shall prepare a description of the Parking Control Zone for the **Director's** approval using **Form 1296-9** (Establishment of No-Parking Restrictions).

Following approval, the **District** shall erect the appropriate Parking Control signs, record the dates on **Form 1296-9**, and notify the **OSHP** and other law enforcement agencies as appropriate.

1204-3 Engineering Study

Chapter 1204 (Parking Control Zones) should be reviewed prior to submitting the study. The engineering study used to support a request for a Parking Control Zone shall include a field survey conducted to acquire necessary data to complete **Form 1296-8** (Field Report on Parking Practices). It should also include a sketch of the location and/or photographs to document the physical conditions noted in the survey report.

1204-4 Withdrawal of Authorization

The withdrawal of the authorization for a Parking Control Zone requires an engineering study and, insofar as is applicable, shall be accomplished in the same manner in which it was established. **Form 1296-10** (Withdrawal of Issued No-Parking Restrictions) is used to document the withdrawal.

1204-5 Documentation and Records Management

Table 1297-4 establishes Revision Numbers to be used by each **District** for Parking Control Zones. These numbers shall be used on **Forms 1296-9 and 1296-10**.

The **District** shall retain paper or electronic copies of the reports used in establishing the Parking Control Zone in their permanent files. Paper or electronic copies of the official document authorizing the regulation shall also be retained permanently in **District** files.

When a corporation limit, or other feature, that was used as a terminus for an authorized Parking Control Zone moves, the existing Parking Control Zone should be withdrawn (**Section 1204-4**) and a new one established. However, if a road used as a reference point is renumbered or the name changes, it is not necessary to withdraw and reestablish the Zone. The changes may be noted in the documentation for the Zone. A typing error may also just be noted in the documentation. Other documentation and records management concerns are addressed in **Section 1203-5**.

Information from the Parking Control Zone reports shall be uploaded by the **District** to the Traffic Regulations Database Management System (TRDMS), a statewide inventory and historical record maintained by the **Office of Traffic Operations (OTO)**. This Regulations inventory is available from the **OTO** website (see Misc. Applications, Documents, Projects and Programs/Regulations).

1205 OTHER ZONES

As noted in **Chapter 1201**, Traffic Control Zones also include Pedestrian Safety Zones, Loading Zones, No-Passing Zones and Temporary Traffic Control Zones (Work Zones). No-Passing Zones are addressed in **OMUTCD Part 3**. Temporary Traffic Control Zones are addressed in **OMUTCD Part 6** and **TEM Part 6**.

1210 TRAFFIC ENGINEERING STUDIES

As noted in **Section 130-2**, **OMUTCD Section 1A.09** states that the decision to use a particular device at a particular location should be made on the basis of either an engineering study or the application of engineering judgment. An engineering study is also required in various sections of the **Ohio Revised Code (ORC)**. Definitions of the terms “engineering study” and “engineering judgment” are provided in **OMUTCD Section 1A.13**.

The scope of the study will depend on the specifics of a particular situation. The **ITE Manual of Transportation Engineering Studies (see Section 193-9)** is useful in providing guidance on preparing, conducting and analyzing different types of traffic studies. Additional information about specific types of studies (e.g., Safety Studies, Speed Studies, Ball Banking Studies and the Systematic Signal Timing & Phasing Program) is provided in this Part of the **TEM**.

Engineering studies related to Speed Zones and Parking Zones are discussed in **Chapters 1203 and 1204**, respectively. Safety Study guidelines are addressed in **Chapters 1211 and 1212**, and various other traffic engineering studies, including ball banking of curves, delay studies, the Systematic Signal Timing and Phasing Program and Road Safety Audits, are addressed in **Chapter 1213**.

1213 OTHER TRAFFIC ENGINEERING STUDIES**1213-1 General**

This Chapter includes information about various other traffic engineering studies.

1213-2 Determining Curve Advisory Speeds**1213-2.1 General**

OMUTCD Section 2C.08 addresses Advisory Speed (W13-1P) plaques, when to use them (see **OMUTCD Table 2C-5**) and methods for determining the speed to be displayed. The most common method used to determine the speed shown on an Advisory Speed plaque is a Ball Bank Indicator (BBI)

1213-2.2 Ball Bank Indicator

The ball bank indicator (BBI) should be mounted in a passenger car and carefully calibrated per the manufacturer's specifications. Several test runs are made in determining the speed to use. For each test run, the driver should:

1. Appraise the curve under observation to determine the approximate safe speed that may be maintained throughout the curve.
2. Conduct the first test at a speed 10 miles per hour below the appraised speed.
3. Make each succeeding test at a speed 5 miles per hour greater than the last one.
4. Attain the trial run speed on each test at a distance of at least one-quarter mile from the beginning of the curve.
5. Maintain a course throughout the curve precisely in the center of the lane and at uniform speed.

Form 1296-11 is a sample form for use in recording the results of this curve study and determining the recommended advisory speed. A full-size copy of the Curve Study Sheet is available from the **Office of Traffic Operations'** website.

1213-2.3 Calculation Method to Determine Curve Advisory Speed

The advisory speed indications for horizontal curves may also be calculated by inserting the curve data into the following equation relating superelevation, pavement friction, radius of curvature and vehicle speed:

$$V_{mph} = \sqrt{(e + f)15R}$$

Where V = speed of vehicle in miles per hour
 e = superelevation in feet per foot of horizontal width
 f = transverse coefficient of friction
 R = radius of curvature in feet.

The recommended values of transverse coefficient of friction are as follows:

Operating Speed	Transverse Coefficient of Friction
30 mph	0.16
40 mph	0.15
50 mph	0.14
60 mph	0.13

1213-3 Delay Studies

This Section is reserved to address information available regarding delay studies. In the interim, contact **ORE** for such information if needed.

1213-4 Systematic Signal Timing & Phasing Program (SSTPP)**1213-4.1 General**

The Systematic Signal Timing & Phasing Program (SSTPP) is funded by the **ODOT** Safety Program. Its purpose is to systematically update the timing and phasing of signal systems at approved candidate intersections and/or corridors. Requests can be submitted to the **Safety Program Manager** through the local **District** office. Applicants can contact the local **District Safety Coordinator**.

1213-4.2 Benefits

Safety Benefits - The following safety benefits can be realized by updated signal timing. The **Texas Transportation Institute (TTI)** cites the following crash reduction factors associated with improved signal timing and phasing:

- Properly timed addition of all red clearance interval = 25 % crash reduction factor
- Properly timed yellow clearance interval = 4-31 % crash reduction factor (all crashes)
- Adding protected/permitted left turn phase at existing signal = 40-60 % crash reduction factor (left-turn crashes)

Congestion Benefits - In addition to the safety benefits of good signal timing, a more obvious benefit is an improvement of mobility throughout the signalized corridor.

Ohio's Major New Program will go a long way to addressing congestion on **Ohio's** freeways. The Systematic Signal Timing & Phasing Program (SSTPP) is a complimentary program addressing congestion on surface street facilities. Numerous signal timing case studies have shown a reduction in stops of 10 to 20 percent, with a similar reduction in delays. As a result of reduced congestion, comparable decreases in fuel consumption and emissions are also realized. Case studies have shown that properly timed traffic signals reduce fuel consumption 10 to 15 percent when compared to poorly timed traffic signals. Most obvious to drivers is a significant decrease in travel times.

The tables shown in **Figure 1298-2** show examples of the benefits of improved signal timing and phasing that were realized through projects initiated in the **ODOT** Safety Program:

1213-4.3 Eligibility

The following intersections/corridors would be eligible for the SSTPP funding:

1. Intersections or corridors identified by **ODOT** as being high crash and relevant planned countermeasures will not be constructed within one year.
2. Intersections or corridors identified as being congested by **ODOT's** Congestion Model (**Office of Statewide Planning and Research**) and relevant planned countermeasures will not be constructed within one year.
3. Intersections or corridors identified by an **MPO** as being high crash or congested. See *Subsection 1213-4.4* for documentation requirements.
4. Intersections or corridors identified by a local government as being high crash or congested. See *Subsection 1213-4.4* for documentation requirements.

1296 FORMS INDEX

1296-1 Speed Zone Request for Narrow and Low-Volume Rural Roads

Form 1296-1 is used to document highway development, roadway features and roadway characteristics when submitting a Speed Zone request for a road with an ADT of 400 or less or a width of 16 feet or less. This form is described in detail in **Section 1203-2.6**.

1296-2 Speed Zone Warrant Sheet

Form 1296-2 is used for a full-scale Speed Zone Warrant analysis. The procedure for using this form is described in **Section 1203-3.4**.

1296-3 Sample Speed Study Data Sheet

Form 1296-3 may be used to record data used in the Speed Zone Warrant Analysis (**see Section 1203-3.2**). See **Table 1297-2** for determination of Intersection Class and Building Type.

1296-4 Completed Sample Speed Study Data Sheet

Form 1296-4 is a sample of a completed version of **Form 1296-3**.

1296-5 Speed Check Form

Form 1296-5 is used to record speed information to determine the 50th and 85th-percentile and pace speeds (**see Section 1203-3.3**).

1296-6a Speed Limit Revision

Form 1296-6a is used to establish a revised speed limit (**see Section 1203-2**). Note that the established limit becomes effective when appropriate signs giving notice thereof are erected. Location From and To on **Form 1296-6a** shall be in SLM to be compatible for use with the Traffic Regulation Data Management System (TRDMS).

1296-6b Work Zone Speed Limit Revision for High-Speed (≥ 55 mph) Multi-Lane Highways

Form 1296-6b is used to establish a Work Zone Speed Zone (**see Section 1203-2.9**) in accordance with **Table 1297-7**. Note that the established work zone speed limit(s) do not become effective until all of the existing speed limit signs within 1 mile in advance of and inside the WZSZ are removed or covered and the WZSZ speed limit signs are in place with the appropriate legends displayed. Legends reflecting a speed limit in accordance with **Table 1297-7** shall only be displayed when the work zone condition in place reduces the existing functionality of the travel lanes or shoulders. At all other times (when the work zone condition no longer reduces the existing functionality of the travel lanes or shoulders) the original posted speed limit shall be displayed. Location From and To on **Form 1296-6b** shall be in SLM to be compatible for use with the Traffic Regulation Data Management System (TRDMS).

1296-7a Withdrawal of Issued Speed Limit Revision

Form 1296-7a is used to withdraw a revised speed limit (**see Section 1203-4**). Location From and To on **Form 1296-7a** shall be in SLM to be compatible for use with the Traffic Regulation Data Management System (TRDMS).

1296-7b Withdrawal of Issued Work Zone Speed Limit Revision for High-Speed (≥ 55 mph) Multi-Lane Highways

Form 1296-7b is used to withdraw a Work Zone Speed Zone (*see Section 1203-4*) in accordance with **Table 1297-7**. Location From and To on **Form 1296-7b** shall be in SLM to be compatible for use with the Traffic Regulation Data Management System (TRDMS).

1296-8 Field Report on Parking Practices

Form 1296-8 is used to request a No-Parking Zone. The procedure for using this form is described in **Section 1204**.

1296-9 Establishment of No-Parking Restrictions

Form 1296-9 is used to establish a No-Parking Restriction (*see Section 1204-2*). Note that the restriction becomes effective when appropriate signs giving notice thereof are erected.

1296-10 Withdrawal of Issued No-Parking Restrictions

Form 1296-10 is used to withdraw an established No-Parking Restriction (*see Section 1204-4*).

1296-11 Curve Study Sheet

Form 1296-11 is used in the Ball Banking Study described in **Section 1213-2** to determine the recommended maximum speed to use on the Advisory Speed plate.

1296-12 Reserved – Deleted the Existing Form

1296-13 Reserved – Deleted the Existing Form

1296-14 Freeway and Rural Expressway Speed Zone Evaluation Sheet

Form 1296-14 is used to document a request for a change in the speed limit on a freeway or rural expressway (*see Section 1203-2.8*).

1296-15 Speed Zone Request for Unimproved Highways and Residential and Commercial Subdivision Streets

Form 1296-15 is used to document a request for a reduction of the speed limit on unimproved **County** highways and residential and commercial subdivision streets (*see Section 1203-2.7*). The form may also be used by **Townships** to document Speed Zones they establish based on **ORC Division 4511.21(K)**.

1296-16 Reserved – Deleted the Existing Form

1296-17 WZSZ Evaluation Sheet for High-Speed (≥ 55 mph) Multi-Lane Highways

The **WZSZ Evaluation Sheet for High-Speed (≥55 mph) Multi-Lane Highways** is an optional form that may be used to determine the warranted work zone speed limit values during qualifying work zone conditions on multi-lane highways with pre-construction speed limits of 55 mph or higher (as defined by **Section 1203.2.9.1**). Information in this form is based upon **Table 1297-7**. The procedure for using this form is described in **Section 1203-2.9**.

1296-18 Work Zone Speed Zone (WZSZ) Tracking Report

Form 1296-18 is used to document and log the date, time, location and other detailed information regarding implementation of all WZSZs.

1296-19 Sample OSHP Concurrence Sheet

Form 1296-19 is a sample of a form used to submit Speed Zone and Parking Control Zone requests to the **Ohio State Highway Patrol (OSHP)** for concurrence (*see Sections 1203-2 and 1204-2*).

Form 1296-1. Speed Zone Request for Narrow and Low-Volume Rural Roads (Sheet 1 of 4)

Ohio Department of Transportation SPEED ZONE EVALUATION SHEET <i>For Highways with an ADT of 400 or less; or Roadway Width of 16' or less</i>			
TEM FORM 1296-1			
COMPLETE ALL GREEN SHADED AREAS			
ROUTE NAME:		ROUTE NUMBER:	
BEGIN STUDY AT:		COUNTY:	
BEGIN LOGPOINT:		TOWNSHIP / MUNICIPALITY:	
END STUDY AT:		JURISDICTION:	
END LOGPOINT:		EXISTING SPEED LIMIT (MPH):	
LENGTH (MILE):		AVERAGE DAILY TRAFFIC (ADT):	
REFER TO THE TRAFFIC ENGINEERING MANUAL SECTION 1203 FOR ADDITIONAL GUIDANCE			
No. of Houses or Farms		Must have direct access to the roadway being studied.	
No. of Businesses			
No. of Intersections		Do not include intersections at the beginning or end of the section	
Road Width (Round down to nearest foot)		General width of traveled way throughout the section.	
Shoulder Width (Round down to nearest foot)		General shoulder width throughout the section.	
Presence of Vulnerable Road Users		Pedestrians / Bicyclists / Amish Buggies / etc..	
Roadway Characteristics		CATEGORIES:	<div style="display: flex; justify-content: space-around; font-size: 0.8em;"> C B3 B2 B1 A3 A2 A1 </div>
To View Calculation Sheet or Examples of Roadway Characteristics and Crashes to Include, use Buttons Below.			
<div style="border: 1px solid black; padding: 2px; background-color: #007bff; color: white; display: inline-block;">CALCULATION SHEET</div>		<div style="border: 1px solid black; padding: 2px; background-color: #007bff; color: white; display: inline-block;">ROADWAY CHARACTERISTICS</div>	
<div style="border: 1px solid black; padding: 2px; background-color: #007bff; color: white; display: inline-block;">CRASHES TO INCLUDE</div>			
CALCULATED SPEED:		MPH	
REQUESTED SPEED:		MPH	
ADDITIONAL CONSIDERATIONS AND COMMENTS			
STUDY BY: 		DATE: 	
INCLUDE THE RELATED RESOLUTION(S) WHEN SUBMITTING THIS FORM			
BELOW FOR ODOT USE ONLY			
CHECKED BY:		TEST RUN:	
		MPH	APPROVED SPEED: MPH

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Form 1296-1. Speed Zone Request for Narrow and Low-Volume Rural Roads (Sheet 2 of 4)

OHIO DEPARTMENT OF TRANSPORTATION									
SPEED CALCULATION SHEET									
TEM FORM 1296-1									
LOCATION									
Road Name:				Begin Study At:				Existing Speed Limit:	
Road Number:				Begin Log Point:				Average Daily Traffic:	
County:				End Study At:					
Township / Municipality:				End Log Point:					
Jurisdiction:				Length:					
HIGHWAY DEVELOPMENT									
(A) BUILDINGS				(B) INTERSECTIONS					
Houses or Farms		X 1 =		Intersections		X 3 =			
Business		X 2 =							
TOTAL TYPE (A)				TOTAL CLASS (B)					
TOTAL HIGHWAY DEVELOPMENT: (A) <input type="text"/> + (B) <input type="text"/> = <input type="text"/>									
Length <input type="text"/> miles									
ROADWAY FEATURES									
CRITERIA		FACTORS							
		7	8	9	10	11	12	13	TOTAL
Road Width (feet)		≤ 16'	17'	18'	19'	20' - 21'	22' - 23'	≥ 24'	
Shoulder Width (feet)		≤ 1'	1	2'	3'	4'	5'	≥ 6'	
Vulnerable Road Users		Not High = 0 / High = -2							
TOTAL ROADWAY FEATURES: <input type="text"/>									
SPEED CALCULATION									
CRITERIA		FACTORS							
		25	30	35	40	45	50	55	TOTAL
Highway Development		> 60	> 50 - 60	> 40 - 50	> 30 - 40	> 20 - 30	> 10 - 20	≤ 10	
Roadway Features		≤ 12	13 - 14	15 - 16	17 - 18	19 - 20	21 - 22	≥ 23	
Roadway Characteristics		C	B3	B2	B1	A3	A2	A1	
TOTAL SPEED FACTORS: <input type="text"/>									
CALCULATED SPEED = <input type="text"/> $\frac{\text{Total Speed Factors}}{\text{No. of Speed Criteria}}$ = <input type="text"/> MPH									
REQUESTED SPEED LIMIT = <input type="text"/> MPH									
ADDITIONAL INFORMATION AND COMMENTS									
STUDY BY: <input type="text"/> DATE: <input type="text"/>									
BELOW FOR ODOT USE ONLY									
CHECKED BY: <input type="text"/>		TEST RUN SPEED: <input type="text"/> MPH		APPROVED SPEED: <input type="text"/> MPH					

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Form 1296-2. Speed Zone Warrant Sheet
(Sheet 1 of 4)

Ohio Department of Transportation SPEED ZONE EVALUATION SHEET <i>For Highways with less than 50% of all crossroads grade separated</i>													
TEM FORM 1296-2													
COMPLETE ALL GREEN SHADED AREAS													
ROUTE NAME:					ROUTE NUMBER:								
BEGIN STUDY AT:					COUNTY:								
BEGIN LOGPOINT:					TOWNSHIP / MUNICIPALITY:								
END STUDY AT:					JURISDICTION:								
END LOGPOINT:					EXISTING SPEED LIMIT (MPH):								
LENGTH (MILE):					AVERAGE DAILY TRAFFIC (ADT):								
REFER TO SECTION 1203 OF THE TRAFFIC ENGINEERING MANUAL FOR ADDITIONAL GUIDANCE													
No. of Houses or Farms				Must have direct access to the roadway being studied.									
No. of Small Businesses, Apts./Condos													
No. of Medium Businesses, Apts./Condos													
No. of Major Businesses, Apts./Condos													
No. of Minor Street Intersections				Subdivision, Residential, or Other streets serving the residents of that street.									
No. of Major Street Intersections				Streets which serve both the residents and commuters of the area.									
No. of Signalized/Roundabout Intersections				Do not include intersections at the beginning or end of the section.									
No. of Interchange Ramps				Do not include Loop ramps at the beginning or end of the section.									
Lane Width (Round down to nearest foot)				General width of through lanes throughout the section.									
Shoulder Width (Round down to nearest foot)				General shoulder width throughout the section.									
No. of Property Damage Only Crashes				Latest three years of data									
No. of Injury Crashes				Weighted value is 2x that of a Property Damage Only Crash									
No. of Fatal Crashes				Weighted value is 4x that of a Property Damage Only Crash									
Presence of Vulnerable Road Users				Pedestrians / Bicyclists / Amish Buggies / etc..									
Urban Features				Sidewalks / Crosswalks / Curb & Gutter / On-Street Parking / Street Lighting / etc..									
50 th Percentile Speed				Average of all speed samples that were taken.									
85 th Percentile Speed				Average of all speed samples that were taken.									
10-mph Pace Speed				to				Average of all speed samples that were taken.					
Roadway Characteristics				CATEGORIES:		C	B3	B2	B1	A3	A2	A1	DIV
To View Calculation Sheet or Examples of Roadway Characteristics and Crashes to Include, use Buttons Below.													
CALCULATION SHEET				ROADWAY CHARACTERISTICS				CRASHES TO INCLUDE					
CALCULATED SPEED: MPH				USLIMITS2 SPEED: MPH				REQUESTED SPEED: MPH					
ADDITIONAL CONSIDERATIONS AND COMMENTS													
STUDY BY: 				DATE: 									
INCLUDE THE RELATED RESOLUTION(S) WHEN SUBMITTING THIS FORM													
BELOW FOR ODOT USE ONLY													
CHECKED BY: 				TEST RUN: MPH				APPROVED SPEED: MPH					

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Form 1296-2. Speed Zone Warrant Sheet (Sheet 2 of 4)

OHIO DEPARTMENT OF TRANSPORTATION											
SPEED CALCULATION SHEET											
TEM FORM 1296-2											
LOCATION											
Road Name:				Begin Study At:				Existing Speed Limit:			
Road Number:				Begin Log Point:				Average Daily Traffic:			
County:				End Study At:				Urban Features:			
Township / Municipality:				End Log Point:							
Jurisdiction:				Length:							
HIGHWAY DEVELOPMENT											
(A) BUILDINGS				(B) INTERSECTIONS							
Houses or Farms		X 1 =		Minor Street Intersections		X 2 =					
Small Business		X 2 =		Major Street Intersections		X 3 =					
Medium Business		X 3 =		Signalized/Roundabout Intersections		X 4 =					
Major Business		X 4 =		Interchange Ramps		X 5 =					
TOTAL TYPE (A)				TOTAL CLASS (B)							
TOTAL HIGHWAY DEVELOPMENT: (A) <input type="text"/> + (B) <input type="text"/> = <input type="text"/> Length <input type="text"/> miles											
ROADWAY FEATURES											
CRITERIA		FACTORS									
		7	8	9	10	11	12	13	TOTAL		
Lane Width (feet)		≤ 8'		9'		10'		11'	≥ 12'		
Shoulder Width (feet)		< 1'	1'	2'	3'	4'	5'	≥ 6'			
Crash Rate (Crashes/MVM)		> 6.2	> 5.1 - 6.2	> 4.0 - 5.1	> 3.4 - 4.0	> 2.8 - 3.4	> 2.2 - 2.8	≤ 2.2			
Presence of Vulnerable Road Users		Not High = 0 / High = 4									
Crashes Type By Severity:		No. of PDO:	No. of Injury:	No. of Fatal:	TOTAL ROADWAY FEATURES:						
Weighted Crash Values:		PDO x 1	Injury x 2	Fatal x 4							
CRASH RATE (Crashes/MVM):		<input type="text"/> Weighted Crashes X <input type="text"/> 1,000,000 <input type="text"/> ADT X <input type="text"/> 365 X <input type="text"/> 3 Years X <input type="text"/> Miles = <input type="text"/>									
SPEED CALCULATION											
CRITERIA		FACTORS									
		25	30	35	40	45	50	55	60	65	TOTAL
Highway Development		> 70	> 60 - 70	> 50 - 60	> 40 - 50	> 30 - 40	> 20 - 30	> 10 - 20	> 5 - 10	≤ 5	
Roadway Features		≤ 25	26 - 27	28 - 29	30 - 31	32 - 33	34 - 35	36 - 37	38	39	
*Speed (50th % or 85th %)		≤ 27	28 - 32	33 - 37	38 - 42	43 - 47	48 - 52	53 - 57	58 - 62	≥ 63	
10 mph Pace		≤ 14 - 27	19 - 32	24 - 37	29 - 42	34 - 47	39 - 52	44 - 57	49 - 62	≥ 54 - 67	
Roadway Characteristics		C	B3	B2	B1	A3	A2	A1	DIV		
* Use 50th percentile speed when both <i>Urban Features</i> and High Presence of <i>Vulnerable Road Users</i> are identified.											
TOTAL SPEED FACTORS:											
CALCULATED SPEED* = <input type="text"/> Total Speed Factors 5 No. of Speed Criteria = <input type="text"/> MPH <small>* Calculated speed will not be less than the 50th percentile speed rounded to the closest 5 mph increment.</small> USLIMITS2 SPEED = <input type="text"/> MPH REQUESTED SPEED = <input type="text"/> MPH											
ADDITIONAL INFORMATION AND COMMENTS											
STUDY BY: <input type="text"/> DATE: <input type="text"/>											
BELOW FOR ODOT USE ONLY											
CHECKED BY: <input type="text"/> TEST RUN SPEED: <input type="text"/> MPH APPROVED SPEED: <input type="text"/> MPH											

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1297 TABLES INDEX**1297-1 Symbols For Use with the Speed Study Data Sheet**

Table 1297-1 depicts the symbols mentioned in **Section 1203-3.2** that are used to represent physical features along the highway when completing the Speed Study Data Sheet (**Form 1296-3**).

1297-2 Speed Zone Warrant Analysis - Highway Development

Table 1297-2 defines components used in Highway Development portion of **Form 1296-2** for the Speed Zone Warrant Analysis (**see Section 1203-3.4**).

1297-3 Reserved for Future Information**1297-4 Speed and Parking Zone Revision Number Assignments**

Table 1297-4 assigns numbers to be used by **Districts** when submitting/reviewing a Speed or Parking Zone request (**see Sections 1203-5 and 1204-5**).

1297-5 Reserved for Future Information

"2000 – 2005 Average: Ohio Interstate Crash Data" has been deleted, but this number/space has been reserved for future information.

1297-6 Speed Zone Warrant Analysis – Roadway Characteristics

Table 1297-6 provides descriptions of the roadway characteristics categories used in **Form 1296-1** (**see Section 1203-2.6**).

1297-7 Warranted Work Zone Speed Limits for Work Zones on High-Speed (≥55 mph) Multi-Lane Highways

Table 1297-7 is used to determine the warranted speed limit value(s) during qualifying work zone conditions on multi-lane highways with pre-construction speed limits of 55 mph or higher (**see Section 1203-2.9**). The procedure for using this table is described in **Section 1203-2.9 and Figures 1298-1a through 1298-1c**. Definitions of terms used in this table are available in **Section 1203-2.9.6**.

Intentionally blank.

Table 1297-1. Symbols for Use with the Speed Study Data Sheet















Symbol	Feature
	Residence
	Business
	School
	Church (or other house of worship)
	Intersection
	Driveway
	Traffic Sign
	Painted Lane and Center Line
	No Passing Line
	Railroad
	Bridge Underpass
	Sidewalk
	Guardrail
	Signal or Flasher

Table 1297-2. Speed Zone Warrant Analysis - Highway Development

Building Development	
1	Houses or Farms
2	Small Businesses, Apartments, Condominiums
3	Medium Businesses, Apartments, Condominiums
4	Major Businesses, Apartments, Condominiums
Intersection Classification	
1	Minor Street Intersections – Subdivision, Residential, or Other streets serving the residents of that street.
2	Major Street Intersections – Streets which serve both the residents and commuters of the area.
3	Signalized / Roundabout Intersections – Do not include intersections at the beginning or end of the section.
4	Interchange Ramps – Do not include loop ramps at the beginning or end of the section.

Table 1297-3. Reserved for Future Information

Table 1297-4. Speed and Parking Zone Revision Number Assignments

Districts	Speed Zones	Parking Zones
District 1	10000 - 14999	10000 - 14999
District 2	15000 - 19999	15000 - 19999
District 3	20000 - 24999	20000 - 24999
District 4	25000 - 29999	25000 - 29999
District 5	30000 - 34999	30000 - 34999
District 6	35000 - 39999	35000 - 39999
District 7	40000 - 44999	40000 - 44999
District 8	45000 - 49999	45000 - 49999
District 9	50000 - 54999	50000 - 54999
District 10	55000 - 59999	55000 - 59999
District 11	60000 - 64999	60000 - 64999
District 12	65000 - 69999	65000 - 69999

Table 1297-5. Reserved for Future Information

"2000 – 2005 Average: Ohio Interstate Crash Data" has been deleted but the number/space has been reserved for future information.

Table 1297-6. Speed Zone Warrant Analysis – Roadway Characteristics
(also see Figures 1298-3, 1298-4 and 1298-5)

Alphabetic Value	Description
A1	Relatively straight, level road that generally provides adequate horizontal and vertical sight distance but may have a random curve and/or hillcrest that affect travel speeds in only a short section of the study area. Basically, free of roadside obstructions and features that limit lateral sight distance.
A2	Relatively straight, level road that generally provides adequate horizontal and vertical sight distance but may have a random curve and/or hillcrest that affect travel speeds in only a short section of the study area. Occasional roadside obstructions and features limit lateral sight distance.
A3	Relatively straight, level road that generally provides adequate horizontal and vertical sight distance but may have a random curve and/or hillcrest that affect travel speeds in only a short section of the study area. Frequent roadside obstructions and features limit lateral sight distances through most of the study area.
B1	Gentle curves and/or straightaways with level to moderate grades, interspersed with sharp curves and/or hillcrests that affect travel speeds and limit horizontal and/or vertical sight distance in much of the study area. Basically, free of roadside obstructions and features that limit lateral sight distance.
B2	Gentle curves and/or straightaways with level to moderate grades, interspersed with sharp curves and/or hillcrests that affect travel speeds and limit horizontal and/or vertical sight distance in the majority of the study area. Occasional roadside obstructions and features limit lateral sight distance.
B3	Gentle curves and/or straightaways with level to moderate grades, interspersed with sharp curves and/or hillcrests that affect travel speeds and limit horizontal and/or vertical sight distance in the majority of the study area. Frequent roadside obstructions and features limit lateral sight distance through most of the study area.
C	Constant, tightly spaced, sharp curves and/or hillcrests that affect travel speeds and/or severely restrict horizontal and/or vertical sight distance in nearly all of the study area. The sharp alignment dictates travel speeds to such an extent that roadside obstructions and features limiting lateral sight distance need not be a factor.
DIV	Four-lane divided highway as defined in ORC 4511.35.

Note: As an aid in selecting the most appropriate Road Characteristics, it is suggested that the alignment first be identified as most resembling the first sentence of “A,” “B” or “C” in the above descriptions. If the alignment is determined to be an “A” or a “B,” it should then be determined which description of the amount and proximity of roadside obstructions (1, 2 or 3) most closely resembles the conditions along the road being studied. If the alignment is determined to be “C,” a description of roadside obstructions is not required.

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- c. For installations where there is need for a temporary CCTV to be setup, such as at a work zone, the **809E60020, CCTV IP-Camera System, Portable** shall be utilized.
2. The appropriate CCTV pole height shall be chosen.
 - a. The standard installation requires the use of 70-foot concrete poles, utilizing pay item **809E61000, CCTV Concrete Pole with Lowering Unit, 70 FT.**
 - b. The use of 50 feet poles is not allowed unless directed by **OTO**. During the review process, **OTO** will review the plans and if necessary, may advise the designer to utilize item **809E61010, CCTV Concrete Pole with Lowering Unit, 50 FT** in some locations.
3. The appropriate ITS cabinet type shall be chosen.
 - a. The standard installation requires the use of ground-mounted cabinets, utilizing pay item **809E65000, ITS Cabinet – Ground Mounted.**
 - b. The use of ITS Cabinet – Pole Mounted is not allowed unless directed by **OTO**.
4. Appropriate grounding and power services shall be designed. Power services shall be designed with distribution cables based on appropriate voltage drop calculations; a max. wire size of No. 1/0 AWG and a minimum of 6 AWG shall be used. Voltage drop on circuit not to exceed 5% nominal circuit voltage in steady state since equipment can generally tolerate a voltage variance of 10%. All 60 Amp disconnects shall be fused at 30 Amps. See Standard Construction Drawings ITS-15.10 and ITS-15.11.
 - a. For instances where one power service is providing power to multiple cabinets, item **809E65020, ITS Cabinet – Power Distribution Cabinet** shall be utilized. This cabinet houses a load center with separate breakers for each cabinet and is also capable of housing smaller wall mount power transformers.

Also see **Plan Note 1342-2 (TEM Section 1342-2)**.

1303-4 Communication

ITS communication systems are critical to successful operation. **ODOT** has determined that the most effective (high-level) system requirement for ITS communications is to build upon the core **ODOT** network with robust security standards/protocols for devices connecting in from the field. Therefore, field device communications shall use Ethernet and other devices compatible with equipment routinely used by **ODOT**. The ITS network shall be separate from the **ODOT** network although there will be connectivity between the two systems. **ODOT** network interoperability is coordinated with **OTO** ITS Field Operations and the Network Operations Center of the [**ODOT Division of Information Technology \(DoIT\)**](#).

Fiber optic cable is the medium of choice although many “last-mile” and point-to-point applications require wireless or other forms of wire-line communications (e.g. Leased Telecom Lines, Wireless Radios, Cellular). Communications redundancy in the field is desired and shall be designed accordingly. Redundancy in some areas will be limited until additional funding is available or new techniques are developed. **TMC** operational redundancy shall be provided via backup Buckeye Traffic Servers.

To facilitate standardized communication protocols, NTCIP-compliant devices will be used when possible. Field device communication represents a significant cost in the design, deployment and operation of an FMS. **ODOT** systems will use a hybrid of Ethernet-based fiber optic and wireless communications to maximize bandwidth for the least cost to support the field infrastructure. Connectivity is desired for remote operations and “pushing” video and data to a number of external users/agencies. The central software system shall be designed to provide flexibility in the provision of access by others outside the **TMC** and the FMS/**ODOT** networks. An internet connection to the FMS network will be the most effective means of providing access to the system.

When designing plans that include fiber optic cable as a communication method, figures shall be included to show how the fiber optic cable is to be terminated / spliced at each location. These

figures include one figure per field cabinet (*e.g., Figure 1398-2: Node Cabinet Assembly*), one figure per splice enclosure (*e.g., Figure 1398-3: Underground Splice Enclosure*), and one figure showing a high-level splicing scheme for the entire project (*e.g., Figure 1398-4: Fiber Backbone Splice Chart*), and a high-level device communication plan for the entire project (*e.g., Figure 1398-5: ITS Device Communication Diagram*). For ODOT projects with fiber interconnect, coordinate the termination diagrams with OTO ITS Field Operations, and high-level diagrams can be provided.

When designing projects for current or future ITS deployments, the designer shall incorporate infrastructure containing conduit and fiber optic cable. While it may not always be possible or feasible to install fiber optic cable with projects, all effort should be made to include conduit infrastructure so that fiber optic cable can be installed with minimal effort in the future. The following parameters shall be followed when installing communications infrastructure.

1. All median wall construction shall include two 4-inch multi-cell Schedule 40 conduits. Median wall pull boxes shall be installed at a maximum of 1000 feet apart and on each side of bridge structures. Refer to **Plan Note 1342-11 (TEM Section 1342-11)** for median junction box notes. Contact the [Office of Traffic Operations](#) for Typical Plan Drawings to be included in the plans.
2. Lateral crossings out of medians (barriers and grass) shall be installed at a maximum of every 4500 feet and at all interchanges for future and existing device communications, as well as slack storage locations. The lateral crossing shall include two 4-inch multi-cell Schedule 80 conduits. A 32-inch pull box shall be installed in the shoulder of each lateral crossing. Contact the [Office of Traffic Operations](#) for Typical Plan Drawings to be included in the plans.
3. Within metropolitan areas, conduit infrastructure buried in earth shall contain two 4-inch multi-cell conduits, and 32-inch pull boxes with maximum spacing of 500 to 750 feet ([see Traffic SCDs ITS-14.10 and 14.11](#)).
4. For multi-cell conduit refer to **Plan Notes 1342-7 and 1342-8 (TEM Sections 1342-7 & 1342-8)**.
5. For fiber optic installations in long haul installations, such as on interstates between metropolitan areas, a combination of air-blown fiber and micro-duct pathway shall be utilized. Refer to **ODOT Supplemental Specification 804/904** for details regarding this method.
6. For fiber optic installations on signalized corridors, where there is not ample right-of-way to install fiber optic cable traditionally, as specified in 3. above, air-blown/pushable fiber optic cable shall be installed by saw cutting the pavement and installing a micro-duct pathway.
7. All newly installed buried conduit shall contain tracer wire. 20 feet of slack in each direction should be left in each pull box. This will allow for tracer wire to be run inside of communication cable markers to be installed when communication cable is installed. For tracer wire specifications, refer to **Plan Note 1342-9 (TEM Section 1342-9)** to be included in plans.
8. Communication cable markers shall be used whenever communication cable is installed. Refer to **Plan Note 1342-10 (TEM Section 1342-10)** for specification to be included in plans.
9. Device locations shall be designed so that maintenance personnel do not have to cross ditches or streams, as these areas fill up with water during parts of the year and present a hindrance to ITS maintenance operations.
10. Any conduit installed within 6 feet of guardrail shall be concrete-encased.

The following list outlines additional requirements:

1. For fiber optic design, the general rule of thumb is that any fiber cable having 48 strands or less should be routed through the cabinets and all splicing shall be performed in the cabinets. No splicing on this cable shall be performed in splice enclosures.

1342-8 Item 625E25740: Conduit, Multicell, 4", 725.20B, HDPE
Item 625E25740: Conduit, Multicell, 4", 725.20B, HDPE, Jacked or Drilled

Description

This conduit is intended for the use in underground or encased situations requiring more than one single conduit. This includes the main conduit raceway along the freeway, connection from pull boxes to the road side cabinets and for runs of conduit for multiple purposes, e.g., at ramp meter installations, for loop lead-in cable, signals cable for ramp meter displays, signal cable for ramp meter signing flashers & illumination and power. The contractor shall plug all unused cells with conduit caps to assure air and water integrity of each individual innerduct.

Materials

The traffic surveillance raceway shall consist of a factory-assembled system of (4) innerducts assembled within a protective outer duct high density polyethylene or approved equivalent. The innerducts shall be a minimum 1.10 inch inside diameter. The outer duct shall be nominal 4 inch inside diameter and a maximum outside diameter of 4.8 inch.

The HDPE conduit shall be coilable on reels.

Where innerduct(s) within a multi-cell duct are to remain empty, one 1/4" nylon rope shall be installed in each of the open innerducts, the rope will remain to be used for a future cable installation. Also, each innerduct shall be plugged to maintain the air and water integrity. In addition, the outer duct shall be capped to maintain the air and water integrity of the entire system.

Installation

Installation will be in 30" deep trench, drilled or plowed to a minimum of 30" deep, encased inside concrete barrier wall or as noted on the plans.

The HDPE conduit shall be installed in continuous lengths without joints or couplings between pull boxes or junction boxes.

When entering a pull box, conduit shall be brought in 3 inches minimum and a maximum of 6 inches from the edge of the pull box and knockout.

Method of measurement

The conduit will be measured by the amount of conduit in feet furnished and installed, measured from center-to center of pull boxes, foundation, etc., and will include all fitting and appurtenances, joints, bends, grounds, and concrete encasement where specified.

Basis of payment

The payment for these items will be made for the accepted liner foot quantities at the contract bid price.

1342-9 Tracer Wire

The Contractor shall furnish and install this item according to ODOT Supplemental Specifications 804/904.

1342-10 Communication Cable Marker

The Contractor shall furnish and install this item according to ODOT Supplemental Specifications 804/904.

1342-11 DMS & DDMS Support Structures

The Contractor shall furnish and install this item according to ODOT Supplemental Specification 809, as well as any Standard Construction Drawings noted on the plans.

The Contractor shall furnish shop drawings to the Project Engineer for approval. The drawings shall be stamped by a Professional Engineer from the manufacturer. The item shall not be released for construction until approved by the Office of Traffic Operations.

Designer Note: See **Table 1397-5** and **Table 1397-6** for additional information.

1342-12 Item 625E29931 Median Junction Box, As Per Plan

The Contractor shall supply the median barrier junction pull boxes that meet the following specifications:

Shall be of type polymer-concrete

Size: 17 inches (height) x 30 inches (length)

Minimum wall thickness: 0.5 inch

Minimum lid thickness: 2 inches

ANSI tier 22 rating with a minimum design load of 22,000 pounds

Lid shall be marked "Traffic."

The median junction box shall be secured in the median barrier wall using dowels. (non-shrink grout may be used when necessary).

1342-13 Utilities

Designer Note: Include ODOT, Office of Technical Services, Traffic Monitoring section as a utility owner anytime there is pavement milling or any excavation work within the vicinity of our permanent count stations, also known as ATR's and WIM's. Please utilize Utility Note G102A1; below is our contact info:

Traffic Monitoring Section ODOT, 1980 West Broad Street, Columbus, Ohio 43223

Ed Newmeyer (District 2, 3, 12) 614-204-0914

Daren Dalton (District 5, 6, 9, 10) 614-204-0291 or 614-275-1382

Dan Diddle (District 4, 11) 614-560-9541

Bryan Stanifer (District 1, 7, 8) 614-204-0971

Sandra Mapel (Field Operations) 614-644-0391

1342-14 Protection of Traffic Monitoring Equipment

Prior to beginning any pavement activities or any excavation activities between [insert station or log points] and [insert station or log point] the contractor, the project engineer, and a representative from the owner will coordinate a time for the owner/maintaining agency to disconnect the equipment. Following the disconnection by the owner, the contractor will be allowed to perform their pavement activities, including pavement removal. The remove loops and sensors become the property of the contractor.

(Add the following portion for projects that also include excavation activities)

During the meeting, the owner/maintaining agency will identify equipment locations. Do not disturb pull boxes, controllers, cabinets, poles and conduits. Any damage will be the responsibility of the contraction and repairs must be accepted by the owner.

Designer Note: For use on resurfacing, minor rehabilitation, and bridge projects within 300 feet of a permanent traffic count station.

Table 1397-1. Exempt, Low-Risk and High-Risk ITS Projects
 (Also see *TEM Section 1301-1.2.*)

Exempt	<ul style="list-style-type: none"> • Changes and/or upgrades to an existing traffic signal system, including signal timing revisions, additional phases (vehicle or pedestrian) or detector installation. • Routine maintenance and operation of an existing ITS system. • Expansion of an existing traffic signal, ITS or freeway management system (FMS) that does not change or add to the original needs and requirements of the system. This type of project does not change any existing hardware, software or interfaces. It simply adds equipment (DMS, DDMS, CCTV, RWIS, etc.), software, locations or intersections to an existing system. The new equipment and software must be compatible with the existing. • Installation of an isolated traffic signal. This is a single traffic signal, not connected to any type of external signal control, nor likely to be connected in the future due to its isolation. • Installation of traffic signals which are part of a Time-Based Coordinated system. • Installation of traffic signals which are part of a hardwired or wireless interconnected system that is locally controlled, i.e. where the timing patterns are controlled by the local controller and not by centrally controlled software. • Installation of cameras that are not functionally integrated into other types of systems; for example, cameras solely for the purpose of traffic data collection or surveillance cameras.
Low-Risk	<ul style="list-style-type: none"> • Closed loop arterial traffic signal system. • Centrally controlled arterial traffic signal system. • Highway Rail/Traffic Signal pre-emption. • Traffic signal system with Emergency Vehicle Pre-emption. • Traffic signal system with Transit Priority. • Ramp Meter system.
High-Risk	<ul style="list-style-type: none"> • Adaptive Traffic Signal Control system. • New freeway management systems (FMS). • Traffic signal systems that requires integration with other systems, e.g. FMS or RWIS. • Ramp meter systems that require integration with adjacent traffic signal system(s). • Regional traffic signal system (as opposed to an arterial traffic signal system) that as the potential to affect geographic areas outside of the maintaining agency. • Regional transit systems. • Any Low-Risk project that provides additional functionality than what is covered in the approved Functional Requirements document for that project category. • Any project that requires new or unproven hardware, software or interfaces. • Any project for which functional requirements and operations & management procedures have not been documented. • Any project not considered Exempt or Low-Risk under the Programmatic Agreement.

Table 1397-2. ITS User Services

To find detailed information relating to each of the User Services below, visit <http://www.iteris.com/itsarch/> and select "User Services" from the navigation bar at the top of the screen.

<u>Travel and Traffic Management</u>	
1.1	<u>Pre-trip Travel Information</u>
1.2	<u>En-route Driver Information</u>
1.3	<u>Route Guidance</u>
1.4	<u>Ride Matching And Reservation</u>
1.5	<u>Traveler Services Information</u>
1.6	<u>Traffic Control</u>
1.7	<u>Incident Management</u>
1.8	<u>Travel Demand Management</u>
1.9	<u>Emissions Testing And Mitigation</u>
1.10	<u>Highway Rail Intersection</u>

<u>Public Transportation Management</u>	
2.1	<u>Public Transportation Management</u>
2.2	<u>En-route Transit Information</u>
2.3	<u>Personalized Public Transit</u>
2.4	<u>Public Travel Security</u>

<u>Electronic Payment</u>	
3.1	<u>Electronic Payment Services</u>

<u>Commercial Vehicle Operations</u>	
4.1	<u>Commercial Vehicle Electronic Clearance</u>
4.2	<u>Automated Roadside Safety Inspection</u>
4.3	<u>On-board Safety And Security Monitoring</u>
4.4	<u>Commercial Vehicle Administrative Processes</u>
4.5	<u>Hazardous Material Security And Incident Response</u>
4.6	<u>Freight Mobility</u>

<u>Emergency Management</u>	
5.1	<u>Emergency Notification And Personal Security</u>
5.2	<u>Emergency Vehicle Management</u>
5.3	<u>Disaster Response And Evacuation</u>