SECTION 8

Traffic Signals

8.0 TRAFFIC SIGNALS

8.1 General

Traffic signals may be required to increase intersection capacity or enhance the safety of vehicular traffic or pedestrians. The need for a traffic signal will be determined by the City Engineer based on the Institute of Transportation Engineers (ITE) traffic signal warrants.

These guidelines are not intended to be a substitute for sound engineering knowledge and experience. Traffic signal designs should be prepared under the direction the Design Engineer who has the appropriate experience.

8.2 Standardization

Some traffic signal details should be standardized throughout British Columbia to avoid potential confusion of the travelling public, both local and visiting. Items to be standardized include:

- Vertical mounted signal heads;
- left side secondary heads; and
- Order of signal indication.

8.3 Codes, Rules, Standards, and Permits

Traffic signal systems are to be designed in general conformance with the following:

8.3.1 Codes

- Canadian Electrical Code, most recent adopted edition, and bulletins issued by the BC Safety Authority.

8.3.2 Rules

- WorkSafeBC;
- Canadian Standards Association;
- Utility companies;
- Regulations issued by municipal, provincial, or federal authorities; and
- *BC Motor Vehicle Act* and Regulations.

8.3.3 Standards

- BC Ministry of Transportation Electrical and Traffic Engineering Manual;
- Institute of Transportation Engineers (ITE);
- AASHTO - Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals;
- CAN/CSA-S6-00 Canadian Highway Bridge Design Code;
- CAN3-CSA22.3 No. 7 Underground Systems;
- CAN3-CSA22.3 No. 1 Overhead Systems;

- National Electrical Manufacturers Association (NEMA) - Traffic Controller Assemblies - TS1 or TS2;
- Canadian Manual of Uniform Traffic Control Devices (MUTCD);
- Master Municipal Construction Document (MMCD) Specifications and Standard Detail Drawings, plus Supplementary Specifications and Drawings;
- The City of Kamloops Amendments to the MMCD; and
- British Columbia Pedestrian Crossing Control Manual.

8.3.4 Permits

- Electrical permits are required for any new electrical installations and as required by the provincial inspection authorities for maintenance work;
- Interconnection permits from Railroads, Ministry of Transportation, or other authorities; and
- Right-of way and utility permits for crossings of electrical transmission lines, railways, highways and regional, provincial and federally regulated pipelines.

8.4 Signal Head Types

Types and general locations of signal heads are as follows:

- Primary — Mounted over the centre of each through lane which a vehicle is to enter
- Secondary — Mounted to the left of the roadway which a vehicle is to enter
- Auxiliary — Mounted to the right of the primary head, or other location to enhance visibility
- Pedestrian — Mounted on the far side of the intersection in line with the painted crosswalk

8.5 Visibility

Signal visibility distance is defined as the distance in advance of the stop line from which a signal must be continuously visible for approach speeds varying between 40 and 80 km/h. For speeds exceeding 80 km/h, the minimum visibility distance must equal or exceed the minimum stopping sight distance. Visibility distance guidelines are shown on Table 8.5.1.

8.5.1 Signal Visibility Distance

85th Percentile Speed (km/h)	Minimum Visibility (m)	Desirable Visibility (m)	Add for % Downgrade (m)		Subtract for % Upgrade (m)	
			5%	10%	5%	10%
40	65	100	3	6	3	5
50	85	125	5	9	3	6
60	110	160	7	16	5	9
70	135	195	11	23	8	13
80	165	235	15	37	11	20

8.5.2 Cone of Vision

Visibility of a signal head is influenced by three factors:

- Vertical, horizontal, and longitudinal position of the signal head;
- Height of driver's eye; and
- Windshield area.

Lateral vision is considered to be excellent with 5° of either side of the centreline of the eye position (10° cone) and adequate within 20° (40° cone). Horizontal signal position should therefore be as follows:

- Primary heads within the 10° cone; and
- Secondary heads within the 40° cone.

Vertical vision is limited by the top of the windshield. Signal heads should be placed within a 15° vertical sight line. Overhead signals should be located a minimum of 15 m beyond the stop line.

Refer to MUTCD for additional detail.

8.5.3 High Vehicles

Drivers of vehicles following high vehicles must be able to see at least one signal head upon reaching the dilemma point. The dilemma point is defined as the location where a driver seeing the signal indication change from green to yellow must decide either to bring the vehicle to a safe stop or proceed through and clear the intersection prior to the start of the conflicting green. Factors to consider in assessing signal head visibility are road geometry, design speed, spacing between vehicles, and horizontal and vertical signal head locations.

8.5.4 Environmental

Signal heads need to stand out from the surroundings in order to prevent confusion due to distractions. Primary signal heads must have backboards. Backboards are optional for secondary and auxiliary heads. Backboards must be yellow with a reflective surface. A yellow reflective tape border on the backboard can increase signal visibility.

8.5.5 Flash Rates

The effectiveness of flashing signals is influenced by flash rates. Recommended rates are:

- Red and amber balls: 50 to 60 flashes/minute
- Arrows: 100 to 120 flashes/minute

The ON and OFF periods should be equal.

8.5.6 Size

Signal head sizes are to be as indicated in Table 8.5.8.

8.5.7 Visors

Visors are required on all signal heads. Cowl-type visors are standard, except in the following cases, where tunnel visors are required:

- Fully protected left turn signal heads; and
- At skewed intersections, where the signal heads may be viewed from other approaches.

8.5.8 Signal Head Sizes

Signal Head Type	Area Classification	Lens Size and Shape
Primary	All Areas	300 mm round
Secondary	Rural and Small Urban Areas	200 mm round green, yellow and red with 300 mm green arrow
	Large Urban Areas	300 mm round
Auxiliary	Rural and Small Urban Areas	200 mm round green, yellow and red with 300 mm green arrow
	Large Urban Areas	300 mm round
Pedestrian	All Areas	Combination walk/don't walk indication 425 mm x 467 mm

8.6 Light Sources

- All new and upgraded signal heads including pedestrian signals shall use LED lamps; and
- The Design Engineer must complete a BC Hydro signal load calculation.

8.7 Signal Head Placement

Signals should be mounted on poles, davits, mast arms, or gantries.

Mounting heights, as measured to the lowest portion of the signal head, are as follows:

- Primary signals mounted above roadways should be mounted at any height that meets visibility requirements and is between 5 m and 6 m above the roadway; and
- Secondary and auxiliary signals should be mounted at any height that meets visibility requirements and is between 2.5 m and 4.75 m above the roadway.

Each approach to an intersection requires a minimum of one primary and one secondary signal head. Requirements for additional signal heads are to be determined on the basis of visibility issues.

8.7.1 Primary Signal Head Placement

STRAIGHT THROUGH LANES		
Number of Lanes	**Number of Primary Heads**	**Placement of Primary Heads**
One	1	Centered over through lane
Two	2	Centered over each through lane
Three	3	Centered over each through lane
LEFT TURN LANES		
Left Turn Type	**Primary Head Type**	**Placement of Primary Heads**
Protected/Permissive	Flashing Green Arrow, Steady Yellow Arrow and Steady Green Ball	Centered over left-most through lane
Protected - Single Left Turn Lane	Steady Green Arrow	Centered on the left turn lane, either post mounted in median or overhead arm mounted
Protected - Dual Left Turn Lane	Steady Green Arrows	Centered over each left turn lane, either post mounted in median or overhead arm mounted

8.8 Pole Placement

Signal poles should be placed between 1.5 m and 3 m from the face of curb or edge of pavement, preferably behind the sidewalk. Pole arms should be oriented at 90° to the centreline of the road, except where the intersection is skewed. When laying out a skewed intersection, ensure the arms do not block the view of the signal heads.

Other considerations for pole placement are:

- Clear zone requirements as defined in the Roads Section of this manual.
- Ease of access for pedestrians;
- Arm reach to ensure signal head is over lane centres or lane markings as appropriate;
- Minimizing the number of poles required; and
- Limiting number of heads on a pole shaft to four.

8.9 Left Turn Phasing

Left turns at signalized intersections are phased in three different manners as follows:

- A Permissive left turn has no signal indication other than a green ball, which permits a left turn when opposing traffic is clear;
- A Protected left turn presents a continuous green arrow indication while all opposing traffic is held by a red ball. A Protected left turn is always terminated with a yellow ball. A Protected left turn signal head requires the placement of a "left turn signal sign"; and
- A Protected/Permissive left turn presents a flashing green arrow followed by a green ball. During the flashing phase (advanced movement), opposing through traffic is held by a red ball. After the advance has timed out, left turn traffic is presented with a green ball permitting the movement when conflicting traffic is clear. The protected phase of this movement is always terminated with a non-flashing yellow arrow indication.

Protected left turns are typically used in the following circumstances:

- Permissive left turns are deemed hazardous due to gap judgment difficulty caused by high speed, geometrics or visibility;
- More than one left turn lane on the approach;
- Lack of sight distance to oncoming vehicle;
- High pedestrian volumes;
- High accident experience; and
- Left turn phase is in a lead-lag operation.

Protected/Permissive left turns are appropriate in cases where:

- Peak hour left turn traffic volumes justify the movement;
- Left turn delays are a concern; and
- Accident experience dictates.

Care should be taken when considering a left turn phase, as it could cause delays at the intersection by increasing the total cycle length.

8.10 Advanced Warning Flashers

- Advanced warning flashers should be used where sight distance to an intersection is less than optimal, or where design speed of the road is sufficiently high to justify warning motorists of signal status; and
- The Design Engineer shall refer to the Transportation Association of Canada's guidelines and use its appropriate formulas to calculate distance and timing parameters.

8.11 Signal Pre-Emption

8.11.1 Rail Crossings

Traffic signals in close proximity to rail crossings require interconnection with the rail crossing controls to ensure maximum driver safety. Refer to MUTDC and MOT standards, and the railway operator pre-emption requirements.

8.11.2 Emergency Vehicle

For all new signal installations, the City of Kamloops requires emergency vehicle pre-emption to override normal signal operation and provide continuous green signals for emergency vehicles such as fire department equipment, ambulances, and RCMP. Refer to City of Kamloops Traffic and Transportation Section requirements and specific pre-emption system details.

8.12 Audible Pedestrian Signals

Where required by the City Engineer, use audible pedestrian signals to assist visually impaired pedestrians.

The audible signal is interconnected with the Walk signal, and produces a "cuckoo" or "peep" sound, depending on the direction of crossing. The cuckoo sound is used for north-south crossings and the peep is used for east-west crossing. Where the streets are not oriented north-south and east-west, maintain consistency with adjacent signals.

8.13 Control Types

The principal types of signal control are pre-timed (fixed time) and traffic actuated. Traffic actuated controls are categorized as fully actuated, semi-actuated and volume density control. The type to be used will be determined by the City of Kamloops Traffic and Transportation Section.

Pre-timed controls assign the right-of-way at an intersection according to a pre-determined schedule. The time interval for each signal indication is fixed according to this schedule.

Fully Actuated controls require traffic detectors for all phases, with each phase timed according to preset parameters. Fully actuated controls allow for the maximum flexibility of signal control.

Semi actuated controls typically have detectors only on the minor street approaches. Semi actuated controls are effective in coordinated systems, and at intersections where the major street has relatively uniform flows and the minor street has low volumes with random peaks.

Volume Density control is a type of actuated control appropriate for major high speed roads with unpredictable fluctuations. This type of control, although rarely used in a municipal environment, has certain advantages, which may be appropriate under certain circumstances. Refer to local requirements.

8.14 Detection Methods

Traffic detection for signal actuation is typically accomplished through one of the following methods:

- Vehicle detector loops (induction); and
- Image sensor (video detector system).

The method to be used will be determined by the City of Kamloops Traffic and Transportation Section.

A vehicle detector loop is a coil of wire buried in the road surface. The coil detects the presence of a vehicle by the change in electrical induction. This change is sensed by the detector module in the traffic control cabinet. Detector loop locations and details are indicated in the City of Kamloops amendments to standard detail drawing SE 9.7.

The image sensor system is a video detection system using cameras and computer software to send signals to the traffic controller.

8.15 Signal Timing Plans

Must refer to the City of Kamloops Safer Cities Traffic Signal Timing Standards.

8.16 Signal Coordination

Road capacity and/or driver convenience can be improved on some traffic corridors by implementing a system to coordinate or synchronize traffic signal operation. A detailed traffic study is required to determine the potential effectiveness of a coordination system.

Coordination systems operate by coordinating the timing plans for each traffic signal controller with the timing plans of the adjacent controllers using the controller clocks. Timing "offsets" between intersections are based on distance and design speed. Signal controller clocks can be synchronized using radio signals, telephone connections, or hard-wire interconnections between intersections. The most effective coordination systems include a master controller which is in communication with all of the intersection controllers. This allows for continuous clock synchronization and remote adjustment of system parameters.

Signal coordination plan will be developed using the most recent version of "Synchro" a traffic signal software tool.

8.17 Pedestrian Controlled Signals

There are two styles of pedestrian controlled signals, a Full Signal with a green-yellow-red indication, and a Special Crosswalk Signal. The requirement for a pedestrian signal, and the type of signal to be installed will be established by the City of Kamloops and should be supported by Warrants as indicated in the BC Pedestrian Crossing Control Manual (MOT).

Pedestrian signals serve pedestrian traffic only, and are generally placed in areas of high pedestrian traffic or in school zones. Pedestrian signals should be located at intersections.

A full pedestrian signal has heads placed on the main road only. Cross street traffic is controlled by signage. When not activated, the signal presents a flashing green indication to drivers. When the signal is activated by a pedestrian, the flashing green indication becomes a steady green ball, followed by a yellow ball and then red. Pedestrian heads provide the Walk/Don't Walk indications to the pedestrian.

A Special Crosswalk Signal consists of pedestrian controlled signage and lighting designed to draw driver attention to the crosswalk. The special crosswalk has illuminated overhead pedestrian crossing signs, with yellow flashing lights, and crosswalk luminaires. Additional enhancements are required as per the City of Kamloops Traffic and Transportation Section.

8.18 Pole Loading

Traffic signal poles are to be designed to accommodate the weight of the arms and the items mounted on the poles, as well as wind and ice loading, arm length, anchor bolt size and concrete base size.

The BC Ministry of Transportation has made available a load calculator spreadsheet, based on the Ministry's standard equipment. Design Engineers are encouraged to obtain a copy of the spreadsheet from MOT for use in calculations, but should note that the calculations are applicable only to MOT standard poles, arms, and bases. It is the Design Engineer's responsibility to ensure that the pole/base combinations used are appropriate for local conditions.

8.19 Controller Cabinets

Controller cabinets are available in various sizes and styles depending on equipment requirements. MMCD standards include details of cabinet and base sizes and installation methods.

Cabinets should be located entirely within the road dedication, including maintenance pad and door swing. Location should be behind the sidewalk, with access door on the side away from the sidewalk and the signals visible from the access.

Cabinets should be heavy gauge, all welded aluminum with powder coat exterior finish, with colour as directed by the City of Kamloops Traffic and Transportation Section. All cabinets must come with an uninterruptible power supply (UPS).

- Selection of cabinet, UPS, and controller requires City of Kamloops Traffic and Transportation Section approval.

8.20 Controllers

Traffic signal controllers should be NEMA TS2. The choice of manufacturer is to be approved by the City of Kamloops Traffic and Transportation Section with due consideration for the models already in use, availability of spare parts and experience of maintenance personnel.

8.21 Calculations

As a minimum, the calculations required for each project include:

- Lighting calculations for the intersection. (Intersection is defined as the area bounded by the outer crosswalk markings);
- Pole Loading;
- Service Panel Loading;
- Cone of Vision Calculations;
- Traffic Signal Load Calculations; and
- Advance Warning Flasher Calculation.

8.22 Submission of Design Details

Calculations and design details should be submitted to the City of Kamloops Traffic and Transportation Section, as follows:

- Completed design checklist (Figure 8.1);
- Signal Timing Plan (Figure 8.2);
- Design drawings to include summary table and circuit loading schedule showing the following information:
  - Roadway classification;
  - Lighting level (lux or cd/m^2);
  - Uniformity ratio (Avg/Min);
  - Luminaire and lamp details;
  - Power supply phases;
  - Lighting load in VA;
  - Traffic Controller loads;
  - Additional loads;
  - Main and branch breaker sizes;
  - Signal phasing diagram;
  - Detector or sensor table; and
  - Conductor colour coding/cable connection table.

8.23 Electrical Issues

Wiring issues include the following:

- Minimum number of conduits:
  - 3-53 RPVC conduits on all road crossings;
  - 1-53 RPVC extra conduit on two legs at right angle to the controller;
  - Apply 40% conduit fill rule;
  - Bundle signal phase conductors
  - Colour coding of power wiring (red, black, blue, white, green) as per CEC. Taping of power wiring for identification is not acceptable;
  - Separation of power, detector, and communication wiring between the controller and the pole hand hole;
  - Splicing of signal phase wiring only in junction boxes; and
  - No splicing of radio antenna, detector loop wiring or pre-emption cables.
  - Image sensor cables may be spliced in pole handhole.

Figure 8.1 - Signal Design Checklist

Signal Design Checklist (100% Submission)			
Project Title:			
Project No.:			
		Drawing Series	
No.	Item	✓ Yes	✓ No
1	Traffic signal phasing/sequence confirmed with local authority.		
2	Electrical service locations confirmed with utility company.		
3	Telephone service locations confirmed with utility company.		
4	Overhead utility lines checked for conflicts with Luminaire, Signal, or Sign Poles.		
5	Signal and Sign pole capacities checked.		
6	Illumination levels meet applicable standards.		
7	Roadworks, Structures, Signing, and Landscaping design drawings cross checked with Electrical Design drawings for general compliance.		
8	Materials List checked and finalized. Estimate Completed.		
9	Road Design Section comments addressed.		
10	Electrical Section comments addressed.		
11	Signing Section comments addressed.		
12	Electrical Maintenance comments addressed.		
13	Independent Design and Drafting Quality Review carried out.		
Review Completed By:			
Name:			
Title:			
Company:			
Date:			

Figure 8.2 - Signal Timing Plan

Page 1 of 2	**Signal Timing Plan**							
Date Issued				Location				
Controller Type		Drawing				Project		
Phase Setting	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	ON	**ON**	**OFF**	**ON**	**ON**	**ON**	**OFF**	**ON**
Street:								
Function:								
Overlap Info:								
Minimum Green:								
Passage:								
Yellow:								
Red:								
Max Green:								
Walk:								
Ped. Clear:								
Pedestrian Recall:								
Walk:								
Recall:								
Memory:								
Coordination on Phase:								
Full Operation Phase:								
Intersection Flash:								
Adv. Warning (CH1/CH2):								
Adv. Warning:								
Delay Detection Timing:				COMMENTS:				
Emergency Pre-Emption:								
Delay Time:								
Pre-Emption Time:								
Controller Sequence:								
Min. Flash:								
Initialization:								

Page 2 of 2	**Signal Timing Plan**							
Date Issued			Location					
Controller Type		Drawing		Project				
Coordination Information								
Phase	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 Split (1/2/3/4) %								
Cycle 2 Split (1/2/3/4) %								
Cycle 3 Split (1/2/3/4) %								
Cycle 4 Split (1/2/3/4) %								
Cycle 5 Split (1/2/3/4) %								
Cycle 6 Split (1/2/3/4) %								
Cycle 7 Split (1/2/3/4) %								
Cycle 8 Split (1/2/3/4) %								

Cycle	**Cycle 1**	**Cycle 2**	**Cycle 3**	**Cycle 4**	**Cycle 5**	**Cycle 6**	**Cycle 7**	**Cycle 8**
Length								
Offset 1								
Offset 2								
Offset 3								
Offset 4								
Offset 5								
Time Clock Settings								

Time of Day	**Day of Week**	**Cycle (1-8)**	**Split (1-4)**	**Offset (1-5)**	**Additional Time Clock Information**			
Check								