J. TRAFFIC SIGNALS

The traffic signal system shall consist of the signal controller, signal poles, signal heads, cable, conduit, vehicle detectors and any other appurtenances required to provide a complete, operable traffic signal system. Components of the system shall conform to the City of Lenexa's technical specifications and standard details.

Signal poles shall typically be located a minimum of 6 feet from the back of curb to the center of the pole. Mast arm lengths shall be designed with an extra two (2) feet in length in order to accommodate varying field conditions. The Designer shall add a note to the signal plan indicating that a short section of the mast arm may need to be cut off, as directed by the City, depending upon the final location of the pole.

Turning templates shall be shown on the signal plan for review during preliminary plan submittals.

When pedestrian signal heads are used, signal poles with push buttons should be placed at locations that are convenient to the pedestrian. However, the City does not require that poles be aligned with the crosswalk locations. Signal poles within two feet of a sidewalk or ADA ramp shall have top-of-footing elevations called out on the plans. All signal poles and controllers shall be shown on the intersection detail sheet(s).

When designing a traffic signal whether it's an existing signal or a new signal, the engineering consultant shall propose recommendations with regards to the signal phasing. Once these recommendations are discussed with the City, the City will make the final determination regarding the number and sequence of the phases. The City uses a standard phasing sequence which is shown below:

Phase 1 – southbound left
Phase 2 – northbound through
Phase 3 – westbound left
Phase 4 – eastbound through
Phase 5 – northbound left
Phase 6 – southbound through
Phase 7 – eastbound left
Phase 8 – westbound through

Traffic signal heads shall be placed in accordance with the *Manual on Uniform Traffic Control Devices* (MUTCD). In addition, the City has developed some guidelines in an effort to standardize the placement of signal heads:

- Typically, a standard three-section head (Signal Head A) should be centered over each EXITING lane for all through lanes of traffic.
- When a left-turn lane is provided without protected left-turn phasing, a separate signal head displaying the solid red arrow, solid yellow arrow and flashing yellow arrow indications should be centered over the left-turn lane for the permissive left-turn movement.
- When protected left-turn phasing is specified, the three-section head should typically be centered over the left-turn lane. Likewise, when dual left-turn movements are specified, a separate Signal Head B indication should be centered over each left-turn lane. In addition, a separate LEFT TURN SIGNAL sign (R10-10) shall accompany each Signal Head B indication.

- When protected/permissive left-turn phasing is specified, a four-section head with a flashing yellow arrow display should be centered over the left-turn lane.

All traffic signal and pedestrian indications shall be LED displays. Countdown displays shall be used for pedestrian indications. In addition, backplates shall be provided for all traffic signal heads that are mounted to the mast arm. Signal heads that are mounted to the signal pole should not be equipped with backplates.

Opticom emergency preemption equipment shall be shown on the signal plan and shall be designed for ALL directions of traffic at an intersection.

A Pan, Tilt, and Zoom (PTZ) camera shall be included as part of the design at each signalized intersection. The exact location of the PTZ camera shall be determined by the City.

A connection to the City's central control system either by wireless technology or by fiberoptic cable shall be part of the signal plan. Connection to this system may require the extension of the fiberoptic network.

All signalized intersections shall be fully actuated. Full actuation shall typically be achieved through the use of detector loops. In addition to loops, there are various vehicle detection technologies such as video detection camera systems, radar, microwave and induction loop systems. Use of these alternate detection technologies requires the special approval by the City. When advance vehicle detection is needed, as directed by the City, advance detection shall be achieved through the use of radar.

Standard loop dimensions for stop bar detection are 6 ft. x 50 ft. and shall be quadrapole loops (2-4-2 turns). In order to determine where to place a 6 ft. x 50 ft. stop bar detector loop, the City typically places the FRONT of the loop 15 to 20 feet from the nearest edge of the through lane of the intersecting road extended.

Service boxes shall typically be provided whenever conduit changes direction and adjacent to signal poles and controllers. Junction boxes should typically be used adjacent to detector loop locations for the splicing of loop wire to the lead-in cable. Type I junction boxes shall be used where one or two conduit runs enter/exit the box. Type II junction boxes shall be used where more than two conduit runs enter/exit the box. Service and junction boxes shall be installed at least 2 feet from the back of curb to the center of the box and no closer than 2 feet to any pole. The distance between service and/or junction boxes shall not exceed 500 feet to facilitate the pulling of cable. The installation of boxes in streets, driveways and handicap ramps is unacceptable. In addition, the City prefers that boxes not be installed in the sidewalk.

All conduit for traffic signal installations shall be either Schedule 40 polyvinyl chloride (PVC) conduit or Schedule 40 high density polyethylene (HDPE) conduit. Rigid metallic conduit shall NOT be used. Below is a summary of typical conduit sizes for signals.

- Signal conduit that extends from signal poles to adjacent service boxes should typically be 3-inch conduit.
- Signal conduit that extends from the signal controller to the adjacent service box shall consist of two 4-inch conduits.

- Signal conduit that extends from service box to service box should be either 3-inch or 4-inch conduit, depending upon the number and size of conductors.
- Signal conduit for advance detector conduit runs should typically be 1.5-inch conduit.
- Conduit for signal interconnect/fiberoptic cable should typically be 2-inch conduit.

Please note, the conduit sizes above are typical applications. The Designer shall verify that the signal conduit is properly sized so that no more than 40 percent of the conduit cross-sectional area is filled. Additionally, street lighting cable is permitted in signal conduit runs and boxes. However, fiberoptic cable for the main trunk line is not permitted in signal conduit runs. This fiberoptic cable shall be contained in its own conduit runs.

The Designer shall coordinate and verify the location of the proposed secondary service point with the appropriate utility company to ensure availability of service. For projects within KCP&L's service area, the Designer shall include the conduit AND the service/power cable from the secondary service point to the meter on the controller in the plans as the Contractor is now required by KCP&L to install the cable and the conduit. A 2-inch conduit shall be used when KCP&L is providing the power; a 3-inch conduit shall be used when Westar is providing the service.

The controller cabinet shall be a Model 332D and shall include an 8-inch riser. A Model 332 or 336 may be used only if approved by the City's Transportation Manager. The actuated controller shall be a Rack Mount ATC Cobalt-C controller manufactured by Safetran and shall include the current firmware that is compatible with Operation Green Light (OGL). Controllers should typically be located adjacent to and behind the sidewalk or at least 10 feet from the back of curb to the center of the controller where no sidewalk exists. In locations where no curb exists, the controller should typically be placed more than 10 feet from the edge of pavement to the center of the controller if possible. When the location of the controller has been finalized and power has been verified with the utility company, the City will provide the Designer with an address and an identification number for the proposed controller. The address and identification number shall be placed in the lower right corner of the traffic signal plan sheet above the titleblock.

All signalized intersections shall include a battery back-up system.

The City has standardized the number of conductors required for the various types of traffic signal equipment. Cable for vehicle signal heads should consist of 7-conductor cable while cable for pedestrian and pushbutton detectors should consist of 5-conductor cable. Typically, the City uses 1-7c per phase for the vehicle signal heads regardless of how many heads are on the mast arm or the signal pole. When pedestrian heads and pushbutton detectors are used, 1-5c cable should extend from the controller to the signal pole for each pedestrian head and an additional 1-5c should extend from the controller to the signal pole for each push button. Detector lead-in cable should consist of 4-conductor cable while detector loop wire should consist of single conductor PVC/nylon with tube jacket. Street lighting distribution cable should consist of 3-1c No. 4 AWG while pole and bracket cable shall be No. 14 AWG 3-conductor stranded copper conforming to IMSA Specification 19-1. In addition, all street lighting cable for luminaires on signal poles should be spliced inside the signal pole, not the service box adjacent to the pole. Trunk fiberoptic cable shall consist of a 144-count fiber single-mode fiber assembly. The

connection to the traffic signal controller shall be with an 8-count Gator Patch spliced into the main trunk fiber.

The City has developed some typical signal timings and some guidelines that should be used when developing timings for a proposed traffic signal. They are as follows:

- Maximum Green – to be determined by the City
- Minimum Green – 6 seconds for through and left-turn phases
- Walk – 7 seconds for through movements (no Walk time is given for left-turn phases)
- Flashing Don't Walk (FDW) – distance is measured from the face of curb to the edge of the edge line extended and then divided by 3.5 feet/second
- Total FDW and Walk – the sum of the FDW and Walk time shall be greater or equal to the distance measured from the pushbutton to the edge of the edge line extended on the far side of the crosswalk divided by 3.0 feet/second. If not, any additional time needed shall be added to the Walk time.
- Passage – 1 second for through and left-turning phases
- Yellow – to be determined using the methodology found in the ITE Journal article, *Application of the ITE Change and Clearance Interval Formulas in North Carolina,* from the January 2008 issue. See below.
- Red – to be determined using the methodology found in the ITE Journal article, *Application of the ITE Change and Clearance Interval Formulas in North Carolina*, from the January 2008 issue. See below.

YELLOW CLEARANCE INTERVAL

$$Y = t + \frac{v}{2a + 64.4g} = 1.5 + \frac{v}{2(11.2) + 64.4g} = 1.5 + \frac{v}{22.4 + 64.4g}$$

- t Perception reaction time = 1.5 s (changed from 1.0 s to 1.5 s based on ITE Journal article)
- v Speed in fps (mph x 1.47 = fps)
- a Deceleration rate = 11.2 ft/s^2 (changed from 10 ft/s^2 to 11.2 ft/s^2 based on ITE Journal article)
- g Grade in percent divided by 100

GRADE: Measure grade as the average from the stop bar to the following distances at each speed:

TABLE 8. Distance Grade is Measured

Speed	Distance
≤ 30 mph	100 ft
35 mph	150 ft
40 mph	200 ft
45 mph	250 ft
≥ 50 mph	300 ft

If the grade of the approach is:

TABLE 9. Determination of Grade

+7% or more	use +8%
+5% to +7%	use +6%
+3% to +5%	use +4%
-3% to +3%	use 0%
-5% to -3%	use -4%
-7% to -5%	use -6%
-7% or less	use -8%

Additional remarks:

- The minimum value for yellow should be 3.0 seconds.
- Positive grade should be factored into the yellow clearance calculation.
- The speed used for left-turn movements should be 20 mph.
- For protected/permissive phasing, use the same yellow time for both approaches (i.e. opposing approaches). When determining the yellow clearance value, use the worst case / greatest value for opposing approaches.

For grades of -3% to +3%, the following yellow times have already been calculated:

TABLE 10. Typical Yellow Times

Speed	Yellow Time
25 mph	3.1 sec
30 mph	3.5 sec
35 mph	3.8 sec
40 mph	4.1 sec
45 mph	4.5 sec

RED CLEARANCE INTERVAL

$$R = \frac{w}{v}$$

If the all-red clearance is greater than 3.0 seconds, use:

$$R = \frac{1}{2}\left(\frac{w}{v} - 3\right) + 3$$

w Width of intersection (see Figure 3 from ITE Journal article below)
v Speed in fps (mph x 1.47 = fps)

NOTE: Length of vehicle (20 ft) has been deleted from the red clearance formula based on the ITE Journal article referenced above. Additional remarks are as follows:

- The minimum value for the all-red clearance should be 1.0 second.
- The speed used for left-turn movements should be 20 mph.
- To measure the width of an intersection for both through and left-turning movements, see Figure 6 below.
- For protected/permissive phasing, use the same all red time for both approaches (i.e. opposing approaches). When determining the all red clearance value, use the worst case / greatest value for opposing approaches.

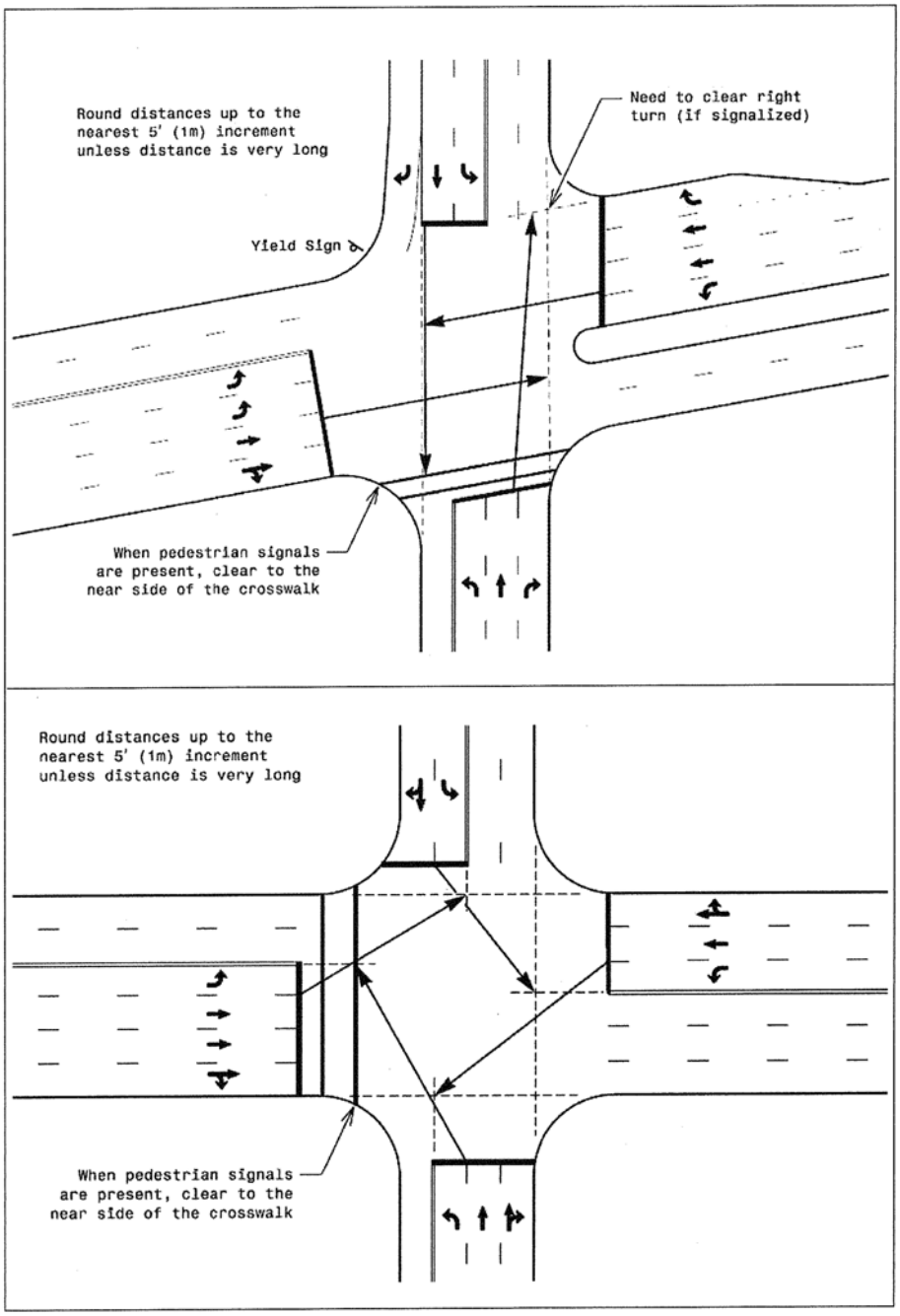

FIGURE 5. Measurement for Red Clearance Interval

In Table 1 – Phase Functions, information should be entered into the following function categories:

- Vehicle Recall – typically the main street through phases
- Permit – all phases in use
- Pedestrian Phases – all phases in use
- Lead Phases – typically left-turn phases
- Start-up Green – typically the main street through phases

In the Emergency Flash table, the indications for all applicable signal phases shall be RED while the indication for pedestrian phases shall be DARK.

In the Detector Input File Layout, the detector loops for the through phases on the main street should typically be arranged in such a way that enables the City to count traffic. This is done by arranging the advance detector loops in the Extend and Count slots of the appropriate detector channel and inserting the stop bar loops in the Extend or Call slots.

In Table 4 – Detector Map, the City typically adds a 10-second delay for loops in exclusive right-turn lanes that are not on recall. The City also adds a 3-second delay for loops in left-turn lanes that could be called when a left-turning vehicle on the adjacent approach crosses the loop.

With regards to the Signal Output File Layout, the City prefers right-turn overlaps to be programmed instead of hard-wired. The one exception to this rule is when a left turn has permissive phasing (i.e. permissive or protected/permissive phasing). In this situation, the opposing right turn shall be hard-wired instead of programmed in order to avoid a potential conflict between a yellow indication for the permissive left and a green arrow for the opposing right turn. Programming a right-turn overlap is done by connecting the yellow and green arrows in the E_d Signal Head to field terminals 105, 111, 114 and/or 120.

Overhead street name signs shall be either aluminum street name signs or LED-illuminated street name signs. Overhead aluminum street name signs shall be mounted to the mast arms using Astro-Brackets. There shall be a minimum of two brackets per sign placed no more than 3 feet apart with a maximum of 1 foot from the edge of the sign. Typically, the overhead street name signs should be placed between the signal pole and the first vehicle signal head. LED-illuminated street name signs should be mounted within 1 foot to 1-1/2 feet of the signal pole and shall be mounted to the mast arm according to manufacturer's recommendations. The City does not allow LED illuminated street name signs to hang and swing below the mast arms.

LED illuminated street name signs shall be installed at signalized intersections along all major arterial streets and/or truck routes. The LED signs shall be mounted to the mast arms located over the major street at these signalized locations. However, the street name signs mounted to the mast arms over the minor street at these intersections shall consist of the standard aluminum signs.

In addition to LED illuminated street name signs, advance street name signs/NEXT SIGNAL signs shall also be installed at signalized intersections along all major arterial streets and/or truck routes. The advance street name signs shall be standard aluminum signs and shall be placed 400-600 feet from the intersection. If the greenspace between the back of curb and the edge of the sidewalk is not wide enough to accommodate the advance street name sign and if there is minimal right-of-way behind the sidewalk to place the sign, the advance street name sign shall then straddle the sidewalk. The sign posts shall be located at least one foot (1') from the edge of the sidewalk to the sign posts. Additionally, the bottom of the sign shall be a minimum of 8 feet from the top of the sidewalk to the bottom or the sign.

Street lights attached to traffic signal poles shall be energized through and connected to the street lighting system. Additionally, the photocell on the traffic signal service enclosure is to be used only for illuminated street name signs. The street lights on the signal poles are to be controlled from the photocell in the street lighting control center.