4.2.3.2 *Late Start*

The Late Start interval usually provides a delayed introduction of the green display for one or more signal groups in order to provide additional clearance time for particular traffic movements in the previous phase. Where the sequence of phase transitions does not require additional clearance time, the Late Start interval shall be skipped.

The Late Start interval shall be of fixed duration and shall have a separate timesetting for each phase. The range for Late Start timesettings shall be specified in the controller Personality data. The typical range is 0–15 s.

4.2.3.3 *Minimum Green*

The Minimum Green interval provides a safety minimum time for signal groups that start the green display in the phase.

The Minimum Green interval shall be of fixed duration and shall have a separate timesetting for each phase. The range for Minimum Green timesettings shall be specified in the controller Personality data. The typical range is 0–15 s.

The control program shall make provision to enforce a minimum time of 5 s for the Minimum Green interval, if so specified in the controller Personality data.

4.2.3.4 *Variable Initial Green*

The Variable Initial Green interval provides additional minimum green time when detectors in advance of the stop-line are used for controlling traffic movements in the phase. Each vehicle crossing the detectors while the controlling signal group is not displaying green provides an increment of time to the Variable Initial Green interval during the phase in which the controlling signal group next displays green.

The Variable Initial Green interval shall be of variable duration in accordance with the increment timesetting for the phase and the number of increment counts registered since the controlling signal group(s) last displayed green.

A separate increment timesetting shall be provided for each phase. The range for increment timesettings shall be specified in the controller Personality data. The typical range is 0–5 s.

A separate Maximum Initial Green timesetting shall be provided for each phase. The Maximum Initial Green timer shall commence timing at the start of the phase Minimum Green interval and shall limit the maximum duration of the Variable Initial Green interval, but shall not limit the duration of the Minimum Green interval. The range for Maximum Initial Green timesettings shall be specified in the controller Personality data. The typical range is 0–40 s.

4.2.3.5 *Rest Green*

The Rest Green interval shall be an untimed interval in which the controller shall rest when there is no demand for another phase.

4.2.3.6 *Extension Green*

The Extension Green interval shall be of variable duration in accordance with the controller operating mode. A separate Maximum Green timesetting shall be provided for each phase to limit the duration of the Extension Green interval when the controller is operating in the Isolated mode. The controller Personality data shall specify whether the Maximum Green timer shall commence timing at the start of the Minimum Green interval or the start of the Extension Green interval. The range for Maximum Green timesettings shall be specified in the controller Personality data. The typical range is 0–150 s.

Depending upon the controller operating mode, the Extension Green interval may be terminated subject to the traffic demand, as determined by the approach timers for the phase. Four separate sets of Gap, Headway and Waste timesettings shall be provided for each phase. The ranges for Gap, Headway and Waste timesettings shall be specified in the controller Personality data. The typical ranges are 0–10 s, 0–5 s and 0–50 s respectively for Gap, Headway and Waste timesettings. (See Clause 4.2.5)

4.2.3.7 *Early Cut-Off Green*

The Early Cut-Off Green interval provides clearance time with a green signal display to the traffic movement. Typically this is used where a movement has more than one stop-line or where there are widely separated signals controlling the same movement.

The Early Cut-Off Green interval shall be of fixed duration and shall have a separate timesetting for each phase. The range for Early Cut-Off Green timesettings shall be specified in the controller Personality data. The typical range is 0–20 s.

4.2.3.8 *Early Cut-Off Yellow*

The Early Cut-Off Yellow interval provides early termination of one or more movements in the phase while other movements continue to have right-of-way to provide clearance of a controlled zone.

The Early Cut-Off Yellow interval shall be of fixed duration and shall commence timing following the termination of the Extension Green interval. The Early Cut-Off Yellow interval shall time concurrently with the phase Early Cut-Off Green interval and may continue timing concurrently with the phase Yellow interval.

The Early Cut-Off Yellow interval shall use the Yellow timesetting for the corresponding phase. That is, separate timesettings are not required for the Early Cut-Off Yellow interval.

The control program shall not permit the duration of the Early Cut-Off Yellow interval to be less than 3 s.

4.2.3.9 *Yellow*

The Yellow interval shall be of fixed duration and shall have a separate timesetting for each phase. The range for Yellow timesettings shall be specified in the controller Personality data. The typical range is 3–6.4 s.

The control program shall not permit the duration of the Yellow interval to be less than 3 s. The control program shall check the timesetting used for timing the Yellow interval and shall substitute a value of 3 s if the timesetting is less than 3 s or greater than the maximum limit specified in the controller Personality data.

4.2.3.10 *All Red*

The All Red interval shall be of fixed duration and shall have a separate timesetting for each phase. The range for All Red timesettings shall be specified in the controller Personality data. The typical range is 0–15 s.

4.2.4 Phase demands

4.2.4.1 *General requirements*

A demand for a phase shall be placed by any of the following, in accordance with the controller Personality data:

(a) A vehicle detector actuation (see Clause 4.2.4.2).

(b) Expiry of the presence timer associated with a vehicle detector input (see Clause 4.2.4.3).

(c) A reversion demand (see Clause 4.2.4.4).

(d) A demand for a pedestrian movement (see Clause 4.2.4.5).

(e) An Arterial switch (front panel switch or HHT simulated switch) (see Clause 4.2.4.6).

(f) A logic flag defined by the controller Personality data (see Clause 4.2.4.7).

(g) An artificial demand set by the condition tables in the controller Personality data (see Clause 4.2.4.8).

(h) An external input (see Clause 4.2.4.9).

The controller Personality data shall specify the conditions under which any or all of the above shall place a demand for a phase.

The control program shall provide for phase demands to be specified as locked or non-locked. For the case of a locked demand, the phase demand remains active regardless of whether the stimulus remains active or not. For the case of a non-locked demand, the phase demand remains active only while the stimulus remains active.

The controller Personality data shall specify the conditions under which the demand for a phase is cancelled. Typically the demand for a phase is cancelled when the phase is introduced, or when a controlling signal group for a traffic movement displays green. A phase demand shall also be cancelled when the demand for a traffic movement is satisfied in another phase by a filter movement, such as vehicles permitted to filter by signal displays, or vehicles permitted to filter by a left turn on red control.

The control program shall allow the Personality data to specify the logic to be applied to the various sources of phase demands to allow efficient operation at the junction.

4.2.4.2 *Vehicle detector actuations*

The control program shall allow actuations from passage and presence detectors to place locked and non-locked demands for phases in accordance with the controller Personality data.

Detectors that have current alarms shall place phase demands in the same manner as detectors that have actuations.

4.2.4.3 *Vehicle detector presence timers*

The control program shall allow the presence timer associated with each vehicle detector input to place locked and non-locked demands for phases in accordance with the controller Personality data. The timed-out state of a presence timer shall be the active state for placing a phase demand. (See Clause 4.2.12.2.)

4.2.4.4 *Reversion demands*

The control program shall make provision for phase reversion demands to place locked and non-locked phase demands as specified in the controller Personality data. (See Clause 4.2.5.)

4.2.4.5 *Pedestrian movement demands*

The control program shall make provision for the demands for pedestrian movements to place locked and non-locked phase demands as specified in the controller Personality data.

4.2.4.6 *Arterial demands*

The control program shall make provision for the Arterial switches to place locked and non-locked phase demands as specified in the controller Personality data.

4.2.4.7 *Logic flags*

The control program shall make provision for the logic flags used in the Personality condition tables to place locked and non-locked phase demands as specified in the controller Personality data.

4.2.4.8 *Condition table demands*

The control program shall make provision for the Personality condition tables to override the phase demands, such that locked and non-locked phase demands may be set, or cleared, or ignored, or not-ignored. The control program shall thereby allow strategies to be implemented using the Personality condition tables to improve the efficiency of phase introduction at the junction.

4.2.4.9 *External inputs*

The control program shall make provision for special inputs to place phase demands as specified in the controller Personality data. Typically, special inputs are used for priority demands, such as from fire vehicles or trains.

4.2.5 Extending a phase

The control program shall provide eight sets of approach timers that shall be used to provide timing for vehicle actuated termination of the current phase. Each set of approach timers shall include a Gap timer, Headway timer and Waste timer. The controller Personality data shall specify which detectors and which signal groups control each set of approach timers in each phase. The Personality data shall also assign sets of approach timesettings for the phase to the approach timers.

A set of approach timers shall not be enabled for timing until the controlling signal group is displaying green. If a set of approach timers is controlled by more than one signal group then at least one of the controlling signal groups shall be displaying green to enable timing for the set of approach timers.

The control program shall set all Gap timers to the timed-out state at the commencement of each phase. When a set of approach timers is enabled, each actuation on a controlling detector shall reset the Gap timer. During the Extension Green interval, each actuation on a controlling detector shall also reset the Headway timer. The Waste timer shall only be permitted to time in the Extension Green Interval while the Headway timer is in the timed-out state. Waste timing shall be suspended each time the Headway timer is reset and shall resume when the Headway timer is again timed-out. The Waste timer shall thus accumulate wasted time for a traffic movement due to the traffic flow being below saturation flow (refer to Figure 4.2).

A set of approach timers is effectively expired when either the Gap timer or the Waste timer is in the timed-out state. Depending on the operating mode for the controller, the Extension Green interval may be permitted to terminate when all eight sets of approach timers are expired.

In the event that all demands for other phases are cancelled, then the controller shall not be permitted to terminate the Extension Green interval, and shall restart the Maximum Green timer and the Waste timers to their initial values.

The control program shall make provision for the Personality data to specify the setting of a reversion demand for a phase in which the Extension Green interval is terminated by the Maximum Green timer or by a coordination command pulse, with one or more Gap timers unexpired.

The controller shall provide the following status flags relating to the termination of the current phase:

(a) Termination inhibit flag.

(b) Request-for-termination flag.

The terminate inhibit flag shall be set when any of the following conditions exist:

(i) The phase interval is not Variable Initial Green, Rest Green or Extension Green.

(ii) A signal group minimum is still timing.

(iii) A pedestrian movement interlock is preventing phase termination.

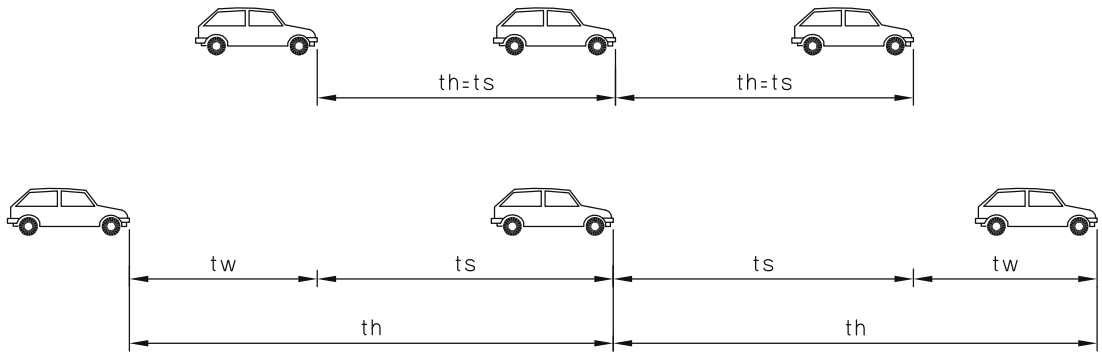
(iv) A condition table interlock is preventing phase termination.

The request-for-termination flag shall be set when all of the following conditions exist:

(A) The phase interval is Rest Green or Extension Green.

(B) The terminate inhibit flag is not set.

(C) None of the approach timers is extending the phase.



th=headway time

ts=headway time at saturated flow (or desired flow rate)

tw=wasted time per vehicle for flow rate less than saturated flow

FIGURE 4.2 HEADWAY AND WASTE TIMING

4.2.6 Pedestrian movements

4.2.6.1 *General requirements*

The control program shall provide control for eight pedestrian movements. Each pedestrian movement shall provide seven consecutive intervals, as depicted in Figure 4.3. The intervals are as follows:

(a) Don't Walk (see Clause 4.2.6.2).

(b) Delay1 (see Clause 4.2.6.3).

(c) Delay2 (see Clause 4.2.6.4).

(d) Walk1 (see Clause 4.2.6.5).

(e) Walk2 (see Clause 4.2.6.6).

(f) Clearance1 (see Clause 4.2.6.7).

(g) Clearance2 (see Clause 4.2.6.8).

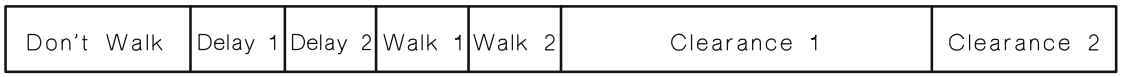


FIGURE 4.3 PEDESTRIAN MOVEMENT INTERVALS

4.2.6.2 *Don't Walk*

The Don't Walk interval shall be an untimed interval in which the pedestrian movement rests when there is no demand for the pedestrian movement.

The condition table entries in the controller Personality data shall initiate the transition from the Don't Walk interval to either the Delay1 interval or the Walk1 interval.

4.2.6.3 *Delay1*

The Delay1 interval provides a minimum delay before the introduction of the Walk signal for the pedestrian movement, if required. Upon completion of timing for the Delay1 interval, the pedestrian movement shall change automatically to the Delay2 interval.

The Delay1 interval shall be of fixed duration and shall have a separate timesetting for each pedestrian movement. The range for Delay1 timesettings shall be specified in the controller Personality data. The typical range is 0–20 s.

4.2.6.4 *Delay2*

The Delay2 interval is an untimed interval in which the pedestrian movement rests following completion of timing for the Delay1 interval. The condition table entries in the controller Personality shall initiate the transition from the Delay2 interval to the Walk1 interval.

4.2.6.5 *Walk1*

The Walk1 interval provides a minimum time for the display of the Walk signal for the pedestrian movement. Upon completion of timing for the Walk1 interval, the pedestrian movement shall change automatically to the Walk2 interval.

The Walk1 interval shall be of fixed duration and shall have a separate timesetting for each pedestrian movement. The range for Walk1 timesettings shall be specified in the controller Personality data. The typical range is 0–15 s.

4.2.6.6 *Walk2*

The Walk2 interval is an untimed interval in which the pedestrian movement rests following completion of timing for the Walk1 interval. The Walk2 interval allows the Walk signal to be displayed for a longer time if required. The transition from the Walk2 interval to the Clearance1 interval shall be initiated either by a command pulse from a coordination master or by condition table entries in the controller Personality data.

4.2.6.7 *Clearance1*

The flashing Don't Walk signal for the pedestrian movement is displayed during both the Clearance1 and Clearance2 intervals. If the pedestrian movement is not permitted to overlap to the following phase, then the current phase shall be held in the Extension Green interval and/or the Early Cut-Off Green interval until completion of timing for the Clearance1 interval. Upon completion of timing for the Clearance1 interval, the pedestrian movement shall change automatically to the Clearance2 interval.

The Clearance1 interval shall be of fixed duration and shall have a separate timesetting for each pedestrian movement. The range for Clearance1 timesettings shall be specified in the controller Personality data. The typical range is 0–40 s.

4.2.6.8 *Clearance2*

The Clearance2 interval provides a fixed time for the display of the flashing Don't Walk signal for the second of the two clearance intervals for the pedestrian movement. The Clearance2 interval can time simultaneously with the clearance intervals for the current phase (i.e. the Early Cut-Off Green, Yellow and All Red intervals). Upon completion of timing for the Clearance2 interval the pedestrian movement shall change automatically to the Don't Walk interval.

The Clearance2 interval shall be of fixed duration and shall have a separate timesetting for each pedestrian movement. The range for Clearance2 timesettings shall be specified in the controller Personality data. The typical range is 0–10 s.

4.2.7 Pedestrian demands

Pedestrian pushbutton actuations shall place a demand for the corresponding pedestrian movement when the pedestrian signal for the movement is not displaying the Walk signal.

A demand for a pedestrian movement shall also place a demand for one or more phases in which the pedestrian movement is permitted to display the Walk signal.

The demand for a pedestrian movement shall be cancelled when the Walk signal is displayed for the pedestrian movement.

4.2.8 Safety interlocks

The current phase shall be prevented from terminating (i.e. held in the Extension Green interval), until a demand is present for another phase.

The current phase shall be held in the Extension Green interval, and/or the Early Cut-Off Green interval, until the safety requirements have been satisfied. That is, the phase shall be held until all terminating pedestrian movements have completed timing the Clearance1 interval and until all vehicle signal groups have completed timing the Minimum Green display.

Additionally, the current phase shall be held in the All Red interval until all terminating pedestrian movements have completed timing the Clearance2 interval.

The safety interlocks shall be effective for all modes of controller operation.

4.2.9 Vehicle signal groups

The display colours for vehicle signal groups shall be controlled by the entries in the controller Personality data.

Typically the display colours for a vehicle signal group are computed according to the current phase and the current phase interval. That is, a vehicle signal group is typically required to display the green signal during the Late Start through Early Cut-Off Green intervals of the associated phase, the yellow signal during the Yellow interval of the associated phase, and the red signal at all other times.

A vehicle group may be specified to display the red signal during the Late Start interval of the associated phase to provide delayed introduction of the green signal.

A vehicle group may be specified to terminate the green signal at the commencement of the Early Cut-Off Green interval of the associated phase. In such a case the vehicle group shall display the yellow signal for the duration of the Early Cut-Off Yellow interval of the associated phase and display the red signal thereafter.

The controller Personality data shall permit the green signal for a vehicle group to overlap between two or more compatible phases.

The controller Personality data shall permit a blank display for an arrow signal group to allow a filter turning movement when an adjacent signal group is displaying the green signal.

The controller Personality data shall also allow the display colours for a vehicle signal group to be controlled independently of the current phase and phase intervals.

The control program shall update the vehicle signal group display outputs at 100 ms intervals.

4.2.10 Pedestrian signal groups

The signal display for each pedestrian movement shall be controlled by the intervals for the pedestrian movement.

A pedestrian signal group shall display red (Don't Walk) for the Don't Walk, Delay1 and Delay2 intervals of the corresponding pedestrian movement.

A pedestrian signal group shall display green (Walk) for the Walk1 and Walk2 intervals of the corresponding pedestrian movement.

A pedestrian signal group shall display flashing Don't Walk for the Clearance1 and Clearance2 intervals of the corresponding pedestrian movement.

The control program shall update the pedestrian signal group display outputs at 100 ms intervals.

4.2.11 Controller operating modes

4.2.11.1 *General requirements*

The controller shall provide the following modes of operation:

(a) Isolated mode (see Clause 4.2.11.2).

(b) Flexilink-Isolated mode (see Clause 4.2.11.3).

(c) Flexilink mode (see Clause 4.2.11.4).

(d) Masterlink mode (SCATS only) (see Clause 4.2.11.5).

(e) Pre-emption mode (see Clause 4.2.11.6).

(f) Fault mode (see Clause 4.2.11.7).

(g) Site Diagnostic mode (see Clause 4.2.11.8).

NOTE: This Standard does not specify the requirements for a manual mode of operation.

4.2.11.2 *Isolated mode*

The controller shall operate in the Isolated mode when it is specified to operate in this mode and also when it is unable to operate in any of the coordinated modes of operation (i.e. Masterlink or Flexilink).

In the Isolated mode of operation the duration of the current phase shall be determined by the prevailing traffic demand sensed by the vehicle detectors for the traffic movements associated with the current phase.

With under-saturated traffic flows the current phase may terminate due to expiry of all approaches associated with the phase. With saturated traffic flows, or in the absence of vehicle detectors, the phase duration shall be determined by the phase Maximum Green timesetting.

The phases shall appear in cyclic order as specified in the controller Personality data. Phases that are not demanded shall be skipped in the sequence.

4.2.11.3 *Flexilink-Isolated mode*

The Flexilink-Isolated mode shall be the same as the Isolated mode of operation, with the following exceptions:

(a) The control program shall place an automatic demand for the pivot phase.

(b) The plan data shall specify the status of Special Facility control signals.

That is, the Flexilink-Isolated mode of operation does not provide coordinated operation, does not require a cycle time, and does not require phase splits in the plan data.

The pivot phase shall be specified in the controller Personality data as the first phase in the phase sequence.

4.2.11.4 *Flexilink mode*

The Flexilink mode shall provide coordinated operation of the signal displays by means of a cycle generator that is synchronized to the controller clock. The control program shall generate control pulses at the cycle generator steps specified in the plan data for the currently selected Flexilink plan.

The pivot phase is the coordination phase in the Flexilink mode of operation. The software shall place an automatic demand for the pivot phase in the Flexilink mode of operation.

The stored Flexilink schedule data shall specify the current plan for Flexilink operation according to the day of week and the time of day. The control program shall routinely search the Flexilink schedule data to establish the current Flexilink plan.

For the case of a controller operating in a SCATS system, the Flexilink schedule data shall comprise 20 schedules, each with four entries: day code, hour for plan change, minute for plan change, and the plan number. The day code shall specify the particular days of week, (Sunday through Saturday) for the plan change. A zero entry for the day code shall terminate the searching of the schedule data at that schedule. In the event that more than one schedule specifies the same plan change time, then the schedule with the higher schedule number (i.e. the schedule encountered last in the search) shall take precedence.

For the case of a controller operating in a Streams system, the Flexilink schedule data shall comprise 12 schedules per day for each of the seven days of the week. Each schedule shall comprise three entries: hour for plan change, minute for plan change, and the plan number. A schedule with a value of 24 for the hour and zero entries for the minute and plan number shall terminate the searching of the schedule data at that schedule. In the event that more than one schedule specifies the same plan change time, then the schedule with the higher schedule number (i.e. the schedule encountered last in the search) shall take precedence. The control program shall allow the Streams master to disable searching of the schedule data and specify the plan number directly as an override.

The currently selected Flexilink plan data shall specify the cycle time, phase splits and the offset for coordinated operation. The cycle time shall have a value in the range 0–180 cycle steps. The phase splits shall have values in the range zero to one less than the cycle time. The offset shall have a value in the range 0–250 cycle steps. The controller Personality data shall specify the duration of a cycle step as either 1 or 2 s.

At the cycle step corresponding to a phase pulse, the controller shall terminate the current phase (subject to safety requirements) and change to the phase corresponding to the pulse.

The phase pulses shall be specified to occur in cyclic order as specified in the controller Personality data. Phases that are not demanded shall be skipped in the sequence. The Personality data shall specify the action to occur when a phase pulse occurs for a phase that does not have a current demand. The controller may remain in the current phase (false green operation) and the time for the unused phase allocated to the current phase. Alternatively, the Personality data may specify that the controller changes to the next demanded phase in the sequence.

The controller Personality data may permit a phase to terminate upon expiry of all approaches for the phase. The maximum time for a phase shall be determined by the data in the current plan. Any remaining unused time in the cycle shall be allocated to the coordination phase (i.e. the pivot phase).

The plan data shall permit a phase to be excluded from the cycle, regardless of any demand for the phase, by specifying a phase split of 1 cycle step. The plan data shall permit one or more phases to be excluded from the cycle in this manner.

The control program shall provide an algorithm for implementing transition plans when required at plan changes in order to prevent the controller from losing synchronization with the plan data.

The currently selected Flexilink plan data shall specify the status of Special Facility control signals. Typically the Special Facility signals are used for selection of alternative movements for one or more phases, and for control of signs or other devices.

The controller shall revert from Flexilink mode to the Flexilink-Isolated mode when the controller loses synchronization with the plan data for any reason.

For the case of a controller operating in a SCATS system, the controller shall provide storage for 11 plans (plans 0–10) and storage in RAM for a transition plan (plan 12).

For the case of a controller operating in a Streams system, the controller shall provide storage for 12 plans (i.e. plans 1–12) and storage in RAM for a transition plan (plan 13). Plan 0 shall be reserved to invoke the Flexilink-Isolated mode of operation. Plan 14 shall invoke flashing fallback operation of the signal displays and plan 15 shall invoke all signal displays off. Plans 0, 14 and 15 shall not have any data storage. Additionally, the offset entry in stored plan data shall specify special modes of operation as follows:

251 All signal displays off.

252 Signals Flash mode.

253 Flexilink-Isolated (traffic actuated termination enabled).

254 Coordinated, Flexilink mode with zero offset and traffic actuated termination enabled.

255 Coordinated, Flexilink mode with zero offset, automatic phase demands, and traffic actuated termination disabled.

To provide coordination, the clocks in all of the controllers in a Flexilink system shall be synchronized. The cycle times in each of the controllers shall also be the same or a multiple of the common cycle time.

4.2.11.5 *Masterlink mode (SCATS only)*

The Masterlink mode shall provide coordinated operation in accordance with the command messages received from the SCATS master.

The controller shall report the current phase and phase interval, the current phase demands, pedestrian movements displaying the Walk signal, and other relevant data to the SCATS master to allow the master to control the operation for optimum coordination of traffic flows.