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Project Bulletin

The Preempt Trap: How to Make Sure You Do Not Have One

The Preempt Trap

The preempt trap is a potentially hazardous condition that can occur under advance preemption and is worsened by variation in warning time. The preempt trap occurs when the track clearance phase—designed to move stationary vehicles off the tracks before the train arrives at the crossing—ends before the gates and the warning devices are activated by the grade crossing predictor. Because the warning lights have not been activated and the gates are still vertical, vehicles can continue to cross the tracks and possibly stop on the tracks. However, the track clearance phase has already expired and there will be no further opportunity to clear! The effect is that vehicles may be trapped between the intersection stop line and the moving train or, even worse, trapped on the tracks in the path of the oncoming train.

The preempt trap usually occurs if the traffic signal is already in the phase that crosses the track when the controller receives a preempt call. In this case, the right-of-way transfer time—the amount of time needed to display the track clearance green after the activation of the preemption sequence—is zero. The track clearance phase starts timing immediately, and terminates at the earliest possible time after the activation of the preemption sequence. If the warning lights and gates are not active when track clearance phase terminates, the preempt trap occurs, as illustrated in Figure 1. The preempt trap is worsened by any variation in warning time that would result in a longer advance preemption time, the time between the activation of the preemption sequence in the controller and the activation of the railroad warning devices.

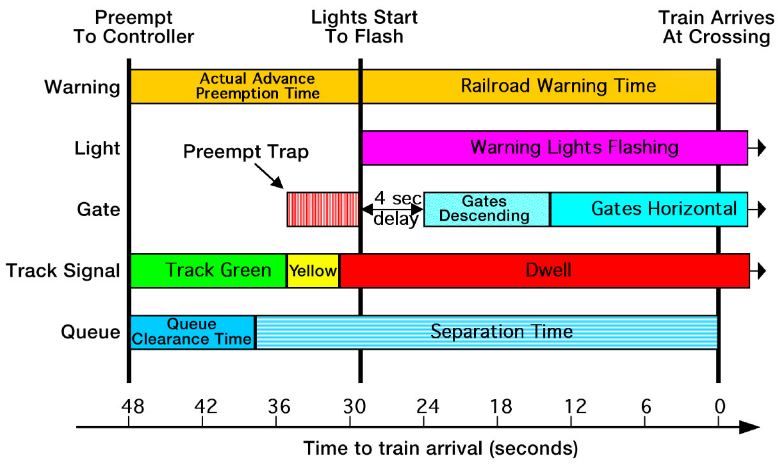

Figure 1. The preempt trap

Variation in train arrival times caused by train handling, a term used by the railroads to describe the speeding up and slowing down of trains as they approach a crossing, exasperates the preempt trap problem. Our observations of 107 trains at a single grade crossing in College Station, Texas, showed that about 85 percent of the trains had arrival times of 44 seconds or more at a crossing designed to have a minimum of 35 seconds of warning time. The problem is that once the train triggers a preempt call in the controller, the call cannot be delayed, sped up, or recalled. Therefore, any change in train speed cannot be accommodated after the preempt call has gone to the controller. If the train speeds up after the call has been placed, the train will arrive at the crossing sooner than expected, which means the traffic signal will not have completed its preemption sequence. If the train slows down, however, the train will arrive at the crossing later than expected, which means that the traffic signal may have completed its preemption sequencing before the gates come down. The combination of these two situations, the traffic signal already in the track clearance phase and the longer-than-expected train arrival times, can effectively negate any of the benefits of preemption.

How Do I Know If My Crossings Have the Preempt Trap?

First, the preempt trap occurs only at grade crossings that use advance preemption. Grade crossings that have simultaneous preemption (i.e., those crossings where the warning lights start to flash at the same time the signal controller receives the preempt notification) do not experience this preempt trap.

Second, the preempt trap is more likely to occur at those grade crossings where the track clearance time is relatively short in relation to the advance preemption time. If the track clearance time is less than the minimum advance preemption time, the preempt trap will occur even without any warning time variation. If there is variation in warning times, the probability of the preempt trap occurring will increase.

Rule of Thumb:

The track clearance green duration should be equal to the expected advance preemption time plus 15 seconds.

"Quick Fix" to the Preempt Trap

One "quick fix" to the preempt trap is to increase the track clearance green programmed into the traffic signal controller. Any increase in the track clearance green will reduce the probability of the preempt trap. The track clearance green should be displayed at least until the gates start to descend and, ideally, until the gates block the path of approaching vehicles.

As a general rule of thumb, the track clearance green should be equal to the expected advance preemption time plus 15 seconds. This rule of thumb is based on the federal grade-crossing requirement that the gates should be horizontal for at least the last 5 seconds of the minimum 20 second warning time.

It should be noted that this strategy *does not guarantee* that the gates will be down when the track clearance green terminates. Because of variations in train speeds, it is still possible that the advance preemption time can exceed the track clearance green time when the right-of-way transfer time is zero.

Potential Solutions to the Preempt Trap

The only way to guarantee that the gates will be down when the track clearance green terminates is to *treat the causes* of the problem: the variability in the advance preemption time together with the variability in the right-of-way transfer time.[1] If there were no variability in either of these times, the end of the track clearance green could easily be timed to coincide with gate descent. There are a number

of potential methods for eliminating this variability when advance preemption is used:

- *Actuate the End of the Track Clearance Green* — Under this solution, the traffic signal controller will change to the track clearance phase as usual but will remain in the track clearance phase until the "gate down" confirmation is received, or until a user-definable maximum time has expired. Unfortunately, existing TxDOT traffic signal controllers do not support an actuated track clearance green. Implementation of such a feature would require changes to the current TxDOT controller firmware and possibly cabinet interface specifications.

- *Use Two Preempts* — This approach uses two preempts, a lower priority preempt activated at the start of the preemption sequence and a higher priority preempt activated by the "gates down" confirmation signal. The first, lower priority preempt would go through the right-of-way-transfer sequence without a track clearance interval and then dwell in the phase crossing the tracks. When the gates are down, the second, higher priority preempt will override the lower priority preempt. Since the signal will already be dwelling in the track clearance phase, no right-of-way transfer would be required and track clearance can immediately start.

  Another two-preempt approach is to activate the second, higher priority preempt at the same time the warning lights are activated, just like a simultaneous preempt. The first, lower priority preempt would still proceed through the right-of-way-transfer sequence without a track clearance phase and dwell in the phase crossing the tracks. The second, higher priority preempt would then start the track clearance phase at the same time the warning lights start flashing, or very soon thereafter, in the case where the first preemption did not reach the dwell stage, since it overrides the lower priority preempt. The track clearance phase would be long enough to terminate only once the gates are down and the traffic is cleared out between the crossing and the intersection.

- *Use "Not-To-Exceed" Timing Circuit* — In its 2000 Signal Manual, the American Railway Engineering and Maintenance-of-Way Association (AREMA) recommends the following[2]:

  Where advance preemption is utilized, a timing circuit should be employed to maintain the maximum time interval between the initiation of the advance preemption and operation of the warning system for a train move where speed is decreasing.

  This not-to-exceed timer will be able to control the maximum

[1] In the current TxDOT preemption design procedures, the variability in the right-of-way transfer time is not taken into account. Only the maximum value of the right-of-way transfer time is considered, since it controls the required preemption warning time. It should be recognized that the right-of-way transfer time can vary between zero and the maximum value normally used in design.
[2] Communications & Signals Manual of Recommended Practices - 2000 Edition. American Railway Engineering and Maintenance-of-Way Association, Landover, Maryland, July 2000.

advance preemption time but will not be able to prevent shorter advance preemption times. However, only longer than expected advance preemption times worsen the preempt trap. Therefore, this railroad timing solution can be very successful in preventing long advance preemption times, thereby helping to eliminate the preempt trap.

Although the not-to-exceed timer can control advance preemption time variation, it should be kept in mind that variation in advance preemption time is not the only cause for the preempt trap. Variation in the right-of-way transfer time also contributes and therefore should be controlled as well.

- *Use a separate, non-actuated phase during preemption* — In this strategy, the track clearance phase is not defined as a regular phase but as a separate, non-actuated phase that is only activated during preemption. This special track clearance phase is overlapped with the regular phase(s) that crosses the tracks. Any preemption will call the special track clearance phase but, due to the overlap, drivers will not be able to distinguish between the special track clearance phase and the regular phase(s) crossing the tracks. Using the special track clearance phase will ensure that there will always be a vehicle clearance interval, even if the track phase is active at the start of the preemption sequence. In the case where the track phase is active at the onset of preemption, the overlap will ensure display of a green signal during the phase change from the regular track phase to the special track clearance phase.

Recommended Changes to TxDOT Procedures

When developing traffic signal preemption timings for grade crossings, TxDOT should be aware that *warning times of the trains can be variable*. This variation is larger when train speeds are low and switching maneuvers are common. Warning time variability can affect safety and may lead to the condition known as the preempt trap, where the track clearance phase ends before the gates are down, so that vehicles can cross over and stop on the tracks without another opportunity to clear out.

The following is recommended as an outcome of this research:

1. TxDOT should be aware that warning times are variable, even where they are generated by "constant warning time devices." These variable warning times can lead to undesirable and potentially hazardous operations at some grade crossings, especially those that require advance preemption.

2. TxDOT should alert its field personnel of the potential preempt trap and the conditions under which it can occur.

3. TxDOT should modify its signal timing preemption procedure to explicitly consider both the minimum and maximum right-of-way transfer times to check for the preempt trap. At a minimum, TxDOT should ensure that the track clearance green duration is equal to the expected advance preemption time plus 15 seconds.

4. TxDOT should consider a change to its traffic signal controller specifications that would permit the actuation of the end of the track clearance green and/or the use of two preempts when advance preemption is required at highway-rail grade crossings.

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