Traffic Signal Advance Pre-emption Design within 200 Feet of Active Railroad Crossings

INDOT Division of Traffic Control Systems
Today’s Goals:

1. Give an overview of railroad preemption
   • How it works
   • Define terms
2. Show some potential problems
3. Look at TXDOT Preemption Worksheet
Preemption

What is traffic signal preemption?

• The transfer of normal operation of traffic signals to a special control mode.

   - NEMA TS-2
Why pre-empt traffic signals close to railroad crossings?

To clear any vehicles that may be in danger of being hit by the train before the train arrives at the crossing.
Any Failure Has the Potential for Tragic Consequences…
Preempt within 200’ but...

From Section 8C.09 of the 2011 Indiana MUTCD:

**Guidance:**

If a highway-rail grade crossing is equipped with a flashing-light signal system and is located within 200 feet of an intersection or midblock location controlled by a traffic control signal, the traffic control signal should be provided with preemption in accordance with Section 4D.27.

Coordination with the flashing-light signal system, queue detection, or other alternatives should be considered for traffic control signals located farther than 200 feet from the highway-rail grade crossing. Factors to be considered should include traffic volumes, highway vehicle mix, highway vehicle and train approach speeds, frequency of trains, and queue lengths.
When To Preempt

When you expect the queue to back up onto the railway crossing

– IMUTCD:
  • Within 200 feet of crossing (should be provided)
  • Over 200 ft- Queuing analysis or other methods (should be considered)

– ITE: perform a detailed queuing analysis including
  • Approach traffic volumes
  • Number of lanes
  • Nearby traffic signal timing
  • Motor vehicle characteristics
Preemption Sequence

- Prior to train arrival
  Call registered for Railroad; Entry into preemption
  - Controller lag time or programmed delay
  - Right-of-way transfer interval (RTT)
  - Track clearance interval (TCG)
- Train present on crossing
  Call remains
  - Preemption hold interval (dwell) or limited service
- Train departs crossing
  Exit from preemption
Highway Terms

• Right-of-Way Transfer Time (RTT)
• Track Clear Green (TCG)
• Preempt Hold
• Limited Service
• Exit Interval
ROW Transfer Time Interval (RTT)

• RTT is the time required to terminate any phase(s) that conflicts with the track clearing phase and arrive at TCG.

Includes:

  Controller lag time or programmed delay

  Must provide required clearance intervals under normal operation (MUTCD)

Policy decisions for truncating:

  – Minimum Green
  – Walk and Pedestrian clearance times (if present)
  – Shortening Red Revert (Amber back to Green)
Termination of current interval
(R/W Transfer Interval RTT)
Track Clear Green

- Duration must be long enough to clear the vehicles off the rail crossing

- Not a requirement to clear all vehicles between crossing and the intersection
- Design vehicle must be considered
Preemption Hold, Dwell, or Limited Service Options

- All RED Flash
- YELLOW / RED Flash
- Steady all RED
- Dwell in single phase state
- Limited service
Exit Interval

- Specific exit phases can be serviced first when returning to normal operation. (Last phase, return to coordination, anticipated need.)

- Controllers should be tested to check if a preemption call during an exit phase will be registered.
Requirements for Preemption

- Preemption Interconnect input (ON/OFF) – controlled by normally energized interconnect circuit, which drops when train is approaching the crossing
- Preemption sequence – Programmed in the signal controller with settings for a special, preemption control mode
- Timing of each sequence based on signal phasing, traffic queue characteristics and time required to clear the crossing
- Indiana MUTCD recommends backup power supply for traffic signals with railroad preemption
**Railroad Active Control**

Indicates the imminent arrival of a train.

- Flashing lights with or without gates, bells
- Required in order to allow for signal preemption
- Designed to be “fail-safe,” meaning that the devices will fail in the activated state - as if a train is approaching
Rail Elements

• Types of traffic control devices
• Types of train detection
• Types of preemption
• Warning time design elements
Active Rail Traffic Control Devices

- Flashing lights, Bells, Horns, Whistles
- 2 Quadrant Gates
- 4 Quadrant Gates
Types Of Train Detection

- Non-constant warning time
  - Warning time dependent on train speed
  - Warning time can be highly variable
- “Constant warning time” (CWT)
  - Predicts train arrival time at crossing
  - 5 - 10 seconds added to track circuit to measure train speed
  - Warning time less variable (if speed is constant)
Pre-Signals

- Prevent Queuing onto Tracks
- Separate Phasing/Overlaps
- Located on Near side of Tracks
- Separate Mast Arm or Span
- “Stop Here On Red” Signs
Pre-Signals

- Clear Storage Distances
  - 50 ft or less
  - Up to 75 ft w/ high truck volume
  - 50 to 120 ft with queue analysis
- Clear storage distances greater than 120’ - Use a queue cutter signal instead
Total Approach Time (TAT) - For Rail Design

- Total time between the train entering the track circuit and reaching the grade crossing
- Also determines the length of the track circuit
- Time required by railroad equipment to
  - Detect presence of train
  - Activate lights and bells
  - Lower the gates
  - Clear roadway vehicles out of crossing
Total Approach Time (For Rail Design)

\[
TAT = MT + CT + APT + ERT + BT
\]

Where:
- TAT = Total Approach Time
- MT = Minimum Time
- CT = Clearance Time
- APT = Advance Preemption Time
- ERT = Equipment Response Time
- BT = Buffer Time
RR Warning Time Design Elements

- **Equipment response time (ERT)**
  - Equipment response, motion sensing, and device activation time (5 - 10 Secs)
- **Minimum time (MT)**
  - Usually 20 Seconds
- **Clearance time (CT)**
  - Based on minimum track clearance distance
  - Other factors
- **Buffer time (BT)**
  - Added to account for any uncertainty in warning time
  (Consider 0 seconds for design purposes)
Minimum Time

Definition:
The least amount of time active warning devices shall operate prior to the arrival of a train at a railroad-highway grade crossing.

FRA regulation (49 CFR 234) requires railroad warning devices to provide at least 20 seconds of activation prior to the arrival of a train.
Minimum Warning Time (Need to know from the RR)

The least amount of time active warning devices shall operate prior to the arrival of a train at a crossing

Preempt to Controller

Train Arrives at Xing

<table>
<thead>
<tr>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning</td>
<td>Minimum Warning Time (MT=20 sec)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lights</td>
<td>Lights Flashing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gates</td>
<td>Gates Descending</td>
<td>Gates Down</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal</td>
<td>Track Green</td>
<td>Hold Dwell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queue</td>
<td>Queue Clear</td>
<td>Separation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RTT

Time
Minimum Warning Time (From the RR Perspective)

\[ \text{MWT} = \text{MT} + \text{CT} \]

– Where:
– \( \text{MWT} = \text{Minimum warning time} \)
– \( \text{MT} = \text{Minimum Time (usually 20 seconds)} \)
– \( \text{CT} = \text{Clearance time (time in excess of 20 seconds)} \)
Highway Design Values

- MPT - Minimum Preemption Time
- RTT - Right-of-Way Transfer Time
- Track Clear Green
- CT - Clearance time (Queue)
- ST - Separation Time
- APT - Advance Preemption Time

Preempt to Controller

APT

Train Arrives at Xing

Warning

Minimum Warning Time (MT = 20 sec)

Lights

Lights Flashing

Gates

Gates Descending

Gates Down

Signal

Track Green

Hold Dwell

Queue

Queue Clear

Separation

0  5  10  15  20

RTT

Time
Types of Preemption

• Simultaneous Preemption

• Advance Preemption
Simultaneous Preemption

- Preempt call received in the signal controller simultaneously with the initiation of active warning device
- MPT includes a minimum of 20 seconds (MT) plus Clearance and Separation Times for both signal controller and active warning device for normal train movement
Simultaneous Preemption

- Preempt call received in the **signal controller** *simultaneously* with the initiation of **active warning device**
- MPT includes a **minimum** of 20 seconds (MT) plus Clearance and Separation Times for both signal controller and active warning device for normal train movement

Fox River Grove
Simultaneous Preemption

Preemption Time / Warning Time Relationship:

\[ MPT = MWT \]

(Highway) (Railroad)
Maximum (Minimum) Preemption Time

Definition:
The maximum amount of time needed following the initiation of the preempt sequence for the highway traffic signals to complete the timing of the RTT, Queue Clearance, and Separation Time.

With Simultaneous Preemption,

\[ \text{MPT}=\text{MWT} \]

and

\[ \text{MPT}=\text{RTT}+\text{CT}+\text{ST} \]
Simultaneous Preemption with Restrictive Minimum Warning Times

- Adequate pedestrian clearance interval may not be provided
- No consideration of trucks or buses
- Design based on receiving a preempt call just after the onset of the phase conflicting with the track phase.
- Only considers the case where the RTT is the maximum possible

![Diagram showing pedestrian and rail phase timing](image)
Operational Considerations

• Preempt call could come in at any point in the cycle
• RTT is variable and could be as low as 0 seconds
Example: \textbf{RTT = 0 Seconds}

- Design process does not explicitly consider variability in RTT
- RTT variability may result in an increase in separation time (not necessarily bad)
What if queue clearance and separation time cannot be satisfied within a reasonable Minimum Warning Time?

Preempt to Controller

Train Arrives at Xing

Simultaneous Preemption Solution: Increase warning time

Warning

Minimum Warning Time (MT=20 sec)

Lights

Lights Flashing

Gates

Gates Descending

Gates Down

Signal

Min

Track Green

Hold Dwell

Queue

RTT

Queue Clear

Separation

Time

0 10 20 30 40
Increasing Minimum Warning Times

• Gates will be down much longer than 20 seconds (potential gate violations)

• The track clearance green should extend beyond train arrival at the crossing

  • Could result in inefficient operations due to a delay in transitioning to the Preemption Hold, Dwell state
Advance Preemption

– Additional time given to the traffic signals BEFORE railroad warning devices activate

• Advance Preemption Time (APT)

– A solution when MWT is not enough time for safe and adequate clearance of the crossing

– This APT is added to the elements defined earlier
Advance Preemption

Preemption Time / Warning Time Relationship:

\[ \text{MPT} = \text{MWT} + \text{APT} \]

(Highway) (Railroad)
Advance Preemption
Vehicle / Rail Considerations

• Pedestrians
• Alignment
• Design vehicles and volumes
  – Standard truck
  – School bus
  – Hazardous material carriers
• Types of trains
  – Low speed freight trains
  – High speed commuter/passenger trains
  – Light rail transit
Preemption Complications

- Geometrics
  - Vertical Alignment
  - Sight Distance
Preemption Complications

- Geometrics
  - Horizontal Alignment
  - Multiple Alignments
  - Coordinated Signals
  - Queuing
Equipment

Traffic Signal Controller

MMU

Power Source & Relays

Traffic Cabinet

Interconnect Wire

RR Cabinet

Relays in RR cabinet
So what if a wire is cut?

- Failsafe
  - Relay De-energizes
  - Signal Goes into Preempt

A False Preempt;
but No Problem! …..
……Right????
Trap #1- Failed Preempt Trap

- Signals Preempted
- Railroad Controls and Warning Devices Functional

- Worse than No Preemption
- No notification of a problem, because it appears normal
R/W Transfer Interval RTT (Broken Wire)

Track Clearing Signal Red - Appears like normal phase transition

Gates Not Active

Track side signal red
Track Clear Green (Broken Wire)

Track Clearing Signal Green

Gates Not Active

Track-Side Signal Red
Preemption Hold, Dwell
(Broken wire)

Track Clearing Signal Red

Sneakers across Pre Signal and tracks

Gates Not Active

Track-Side Signal Red
Preemption Hold, Dwell (Broken wire) Preempt Active Gates descending

Signal still Red-No acceptable Gaps

Lights and Gates Active

Track-Side Signal Red
Preemption Hold, Dwell
(Broken wire)
Gates Down
Train Approaching

Collision
Vehicles try to clear tracks
Gates down
Track-Side Signal Red
How do we avoid Failed Preempt Trap?

– Detect Failure (Supervised Circuit)
– Add Special Preemption Sequence for Failed Condition to Ensure Safe Operations
– Make Failed Preempt Higher Priority
– Automatically Notify of Failure Immediately
3 Wire Supervised Circuit: How is it different?

- 3 Conductor wire instead of 2
- Extra Relay in Traffic Cabinet
- 2 levels of RR Preempt instead of 1
- MMU fail safe prevents bypass
- Alarms set to notify on Preempt 1
3 Wire Supervised Circuit

- Preempt 2 - Normal Operation
- Preempt 1 - Failed Sequence
  » Entry into Preempt
  » Notify
  » Termination of current interval (RTT)
  » Track clearing Intervals (TCG)
  » Preempt Hold - Red Flash

» Repair
» Exit
How Does it Work?

Traffic Cabinet

RR Cabinet

Interconnect Wire
Interconnect Wire Between Signal & Railroad Cabinets

3 conductors
Traffic Cabinet is DC source and load
Interconnect Wire

- Black- DC + Source from Traffic Cabinet
Interconnect Wire

- Black- DC Source from Traffic Cabinet
- Blue- DC+ Return 1 from RR Relay
Interconnect Wire

- Black - DC + Source from Traffic Cabinet
- Blue - DC + Return 1 from RR Relay
- Red - DC + Return 2 from RR Relay
Interconnect Wire

• Fused at source:
Interconnect Wire

- Fused at source
- 2 out of 3 wires must be live at all times (1 Source and 1 Return)
Interconnect Wire

• Fused at source:
• 2 out of 3 wires must be live at all times (1 Source and 1 Return)
• Any cut on any live line almost certainly blows fuse
Interconnect Wire

- Fused at source:
- 2 out of 3 wires must be live at all times (1 Source and 1 Return)
- Any cut on any live line almost certainly blows fuse
- 2 of 3 live lines is impossible upon preemption w/ any cut
Normal Operation
R/W Transfer Interval RTT (Supervised Broken Wire)

Track Clearing Signal Red - Appears like normal phase transition

Gates Not Active

Track-Side Signal Red
Track Clear
(Supervised broken Wire)
Preemption Hold, Dwell Flash
(Supervised broken wire)
Trap #2- Advance Preempt Trap

- Occurs with Advance Preemption
- Preempt May Occur When Signal is already in Track Clear Green (TCG) Phase or When RTT is less than maximum
- TCG expires prior to warning lights starting to flash
- Vehicles Begin to Queue onto Tracks
- Track clear has expired and now dwells in Preemption Hold

  Potentially with vehicles on the tracks

- No better than having no preemption at all…
 Advance Preemption Trap

Advance preemption

Causing the Preempt Trap

Already in Track Green
RTT=0

Track Green expires before Warning Lights flash causing vehicles to arrive on yellow/red and form a queue on the track
Potential Solutions for Advance Preempt Trap:

- Truncate pedestrian clearance to reduce Max RTT
- Request two preempt inputs to the signal controller for each train arrival and
- Incorporate “gate down” signal from railroad warning device into preemption sequence (extend track clearance phase until gates are down)
- Use a special phase for track clearance to control Minimum RTT
- Make Track Clear Green time greater than the APT
Trap #3- Second Train Trap (Advance Preemption)

1. First train clears crossing

2. Gates rise
   • Upon seeing gates rise, motorist begin to cross tracks

3. Signal remains preempted for second train
   • Preempt Hold (Track Red)

4. Vehicles Trapped on Crossing

5. Second Train Arrives

Solution: Signal controller must recognize second preempt call and restart preemption- RTT, TCG
Trap #4- Yellow Trap (Non-symmetrical phasing)

1. Occurs with pre-signals with trailing overlaps.
2. Controller ends phases for pre-signal and the opposing approach at the same time; the signals for the same direction as the pre-signals change 3-4 seconds later.
3. Vehicle making left turn assumes opposing traffic’s phase is ending as well, but it’s actually green for 3-4 seconds longer.
4. Vehicle makes left turn into opposing traffic.

Solution: Run phase for approach opposite the track crossing on a trailing overlap using dummy phases (never displayed) so the signal heads at the intersection end together.
Trap #4 - Yellow Trap (Non-symmetrical phasing)
Texas Railroad Preemption Worksheet

- Is Advance Preempt Time necessary, and if so, how much?
- What’s the minimum Track Clear Green (with APT)?
- Calculate Max Preemption Time
- Check Sufficient Warning Time
- Track Clearance Green Calculation
- Check Vehicle-Gate Interaction
## Section 1: Right-of-Way Transfer Time Calculation

1. Preempt verification and response time:
   - Preempt delay time (seconds) ____________
   - Controller response time to preempt (seconds) ____________
   - Preempt verification and response time (seconds): add lines 1 and 2 ____________

2. Worst-case conflicting vehicle time:
   - Worst-case conflicting vehicle phase number ____________
   - Minimum green time for conflicting vehicle (seconds) ____________
   - Other green time for conflicting vehicle (seconds) ____________
   - Yellow change time (seconds) ____________
   - Red clearance time (seconds) ____________
   - Worst-case conflicting vehicle time (seconds): add lines 5 through 8 ____________

3. Worst-case conflicting pedestrian time:
   - Worst-case conflicting pedestrian phase number ____________
   - Minimum walk time during right-of-way transfer (seconds) ____________
   - Pedestrian clearance time during right-of-way transfer (seconds) ____________
   - Vehicle yellow change time, if not included on line 12 (seconds) ____________
   - Vehicle red clearance time, if not included on line 12 (seconds) ____________
   - Worst-case conflicting pedestrian time (seconds): add lines 11 through 14 ____________

4. Right-of-way transfer time (seconds): add lines 3 and 17 ____________
Section 2: Queue Clearance Time Calculation

SECTION 2: QUEUE CLEARANCE TIME CALCULATION

18. Clear storage distance (CSD, feet) ........................................... 18.
20. Design vehicle length (DVL, feet) ......................................... 20.

Remarks

21. Queue start-up distance, L (feet): add lines 18 and 19 ..................... 21. 0

Remarks

22. Time required for design vehicle to start moving (seconds): calculate as 2+L/20 ... 22. 0.0

23. Design vehicle clearance distance, DVCD (feet): add lines 19 and 20 .... 23. 0

24. Time for design vehicle to accelerate through the DVCD (seconds) ...... 24. Read from Figure 2 in Instructions.

25. Queue clearance time (seconds): add lines 22 and 24 .................... 25. 0.0

SECTION 3: MAXIMUM PREEMPTION TIME CALCULATION

26. Right-of-way transfer time (seconds): line 17 .......................... 26. 0.0
27. Queue clearance time (seconds): line 25 ................................ 27. 0.0
28. Desired minimum separation time (seconds) ............................. 28. 4.0

29. Maximum preemption time (seconds): add lines 26 through 28 ....... 29. 4.0

SECTION 4: SUFFICIENT WARNING TIME CHECK

30. Required minimum time, MT (seconds): per regulations ............... 30. 20.0
31. Clearance time, CT (seconds): get from railroad ....................... 31. 

Excludes buffer time (BT)

32. Minimum warning time, MWI (seconds): add lines .................... 32. 20.0
33. Advance preemption time, AFT, if provided (seconds): get from railroad ... 33.

34. Warning time provided by the railroad (seconds): add lines 32 and 33 .... 34. 20.0

35. Additional warning time required from railroad (seconds): subtract line 34 from line 29, round up to nearest full second, enter 0 if less than 0 .......................... 35. 0

If the additional warning time required (line 35) is greater than zero, additional warning time has to be requested from the railroad. Alternatively, the maximum preemption time (line 29) may be decreased after performing an engineering study to investigate the possibility of reducing the values on lines 1, 6, 7, 8, 11, 12, 13 and 14.

Remarks: 

__________________________

__________________________
Queue Clearance Distances

CSD = Clear storage distance
MTCD = Minimum track clearance distance
DVL = Design vehicle length
L = Queue start-up distance, also stop-line distance
DVCD = Design vehicle clearance distance

Figure 1 Queue clearance distances.
Effects of skew on Track Clearance Distances

EXHIBIT 4: TRACK CLEARANCE DISTANCE

OBTUSE ANGLE

ACUTE ANGLE

RIGHT ANGLE
Vehicle Acceleration Time Through DVCD

Figure 2 Acceleration time over a fixed distance on a level surface.

Note
Multiply acceleration time for SU, S-BUS 40, and WB-50 vehicles with factor from Table 2 to account for acceleration taking place on an uphill grade.
SECTION 2: QUEUE CLEARANCE TIME CALCULATION

Queue Clearance Time

21. Queue start-up distance, L (feet): add lines 18 and 19
   \[ L = \text{Queue start-up distance, also stop-line distance} \]

22. Time required for design vehicle to start moving (seconds): calculate as \( 2 + (L - 20) \)
   \[ T = 2 + (L - 20) \]

23. Design vehicle clearance distance, DVCD (feet): add lines 19 and 20
   \[ DVCD = \text{Design vehicle clearance distance} \]

24. Time for design vehicle to accelerate through the DVCD (seconds)
   \[ T_{\text{accel}} = \text{Read from Figure 2 in Instructions} \]

25. Queue clearance time (seconds): add lines 22 and 24
   \[ T_{\text{queue}} = T + T_{\text{accel}} \]

SECTION 3: MAXIMUM PREEMPTION TIME CALCULATION

26. Right-of-way transfer time (seconds): line 17
   \[ T_{\text{transfer}} = 0.0 \]

27. Queue clearance time (seconds): line 25
   \[ T_{\text{queue}} = 0.0 \]

28. Desired minimum separation time (seconds)
   \[ T_{\text{sep}} = 4.0 \]

29. Maximum preemption time (seconds): add lines 26 through 28
   \[ T_{\text{preempt}} = T_{\text{transfer}} + T_{\text{queue}} + T_{\text{sep}} \]

SECTION 4: SUFFICIENT WARNING TIME CHECK

30. Required minimum time, MT (seconds): per regulations
   \[ MT = 20.0 \]

31. Clearance time, CT (seconds): get from railroad
   \[ CT = 20.0 \]

32. Minimum warning time, MW (seconds): add lines 30 and 31
   \[ MW = MT + CT \]

33. Advance preemption time, APT, if provided (seconds): get from railroad
   \[ APT = 20.0 \]

34. Warning time provided by the railroad (seconds): add lines 32 and 33
   \[ T_{\text{warn}} = MW + APT \]

35. Additional warning time required from railroad (seconds): subtract line 34 from line 29, round up to nearest full second, enter 0 if less than 0
   \[ T_{\text{add}} = \text{If the additional warning time required (line 35) is greater than zero, additional warning time has to be requested from the railroad. Alternatively, the maximum preemption time (line 29) may be decreased after performing an engineering study to investigate the possibility of reducing the values on lines 1, 6, 7, 8, 11, 12, 13 and 14.} \]
### Section 5: Track Clear Green Time Calculation

#### Preempt Trap Check

<table>
<thead>
<tr>
<th>Preempt Trap Check</th>
<th>Line 35 only valid if line 36 is zero.</th>
</tr>
</thead>
<tbody>
<tr>
<td>36. Advance preemption time (APT) provided (seconds):</td>
<td>36.</td>
</tr>
<tr>
<td>37. Multiplier for maximum APT due to train handling</td>
<td></td>
</tr>
<tr>
<td>38. Maximum APT (seconds): multiply line 36 and 37</td>
<td>38. 0.0</td>
</tr>
<tr>
<td>39. Minimum duration for the track clearance green interval (seconds)</td>
<td>39. 15.0</td>
</tr>
<tr>
<td>40. Gates down after start of preemption (seconds): add lines 38 and 39</td>
<td>40.</td>
</tr>
<tr>
<td>41. Preempt verification and response time (seconds): line 3</td>
<td>41. 0.0</td>
</tr>
<tr>
<td>42. Best-case conflicting vehicle or pedestrian time (seconds): usually 0</td>
<td>42.</td>
</tr>
<tr>
<td>43. Minimum right-of-way transfer time (seconds): add lines 41 and 42</td>
<td>43. 0.0</td>
</tr>
<tr>
<td>44. Minimum track clearance green time (seconds): subtract line 43 from line 40</td>
<td>44.</td>
</tr>
</tbody>
</table>

#### Clearing of Clear Storage Distance

<table>
<thead>
<tr>
<th>Clearing of Clear Storage Distance</th>
<th>CSD* in Figure 3 in Instructions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>45. Time required for design vehicle to start moving (seconds): line 22</td>
<td>45. 0.0</td>
</tr>
<tr>
<td>46. Design vehicle clearance distance (DVCD, feet), line 23</td>
<td>46. 0.0</td>
</tr>
<tr>
<td>47. Portion of CSD to clear during track clearance phase (feet)</td>
<td>47. CSD* in Figure 3 in Instructions.</td>
</tr>
<tr>
<td>48. Design vehicle relocation distance (DVRD, feet): add lines 46 and 47</td>
<td>48. 0.0</td>
</tr>
<tr>
<td>49. Time required for design vehicle to accelerate through DVRD (seconds)</td>
<td>49. Read from Figure 2 in Instructions.</td>
</tr>
<tr>
<td>50. Time to clear portion of clear storage distance (seconds): add lines 45 and 49</td>
<td>50. 0.0</td>
</tr>
<tr>
<td>51. Track clearance green interval (seconds): maximum of lines 44 and 50, round up to nearest full second</td>
<td>51. 15</td>
</tr>
</tbody>
</table>

#### Minimum Track Clear Green

<table>
<thead>
<tr>
<th>Vehicle-Gate Interaction Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>55. Time required for design vehicle to clear descending gate (seconds): add lines 52 though 54</td>
</tr>
<tr>
<td>56. Duration of flashing lights before gate descent start (seconds): get from railroad</td>
</tr>
<tr>
<td>57. Full gate descent time (seconds): get from railroad</td>
</tr>
<tr>
<td>58. Proportion of non-interaction gate descent time</td>
</tr>
<tr>
<td>59. Non-interaction gate descent time (seconds): multiply lines 57 and 58</td>
</tr>
<tr>
<td>60. Time available for design vehicle to clear descending gate (seconds): add lines 56 and 59</td>
</tr>
<tr>
<td>61. Advance preemption time (APT) required to avoid design vehicle-gate interaction (seconds): subtract line 60 from line 55, round up to nearest full second, enter 0 if less than 0</td>
</tr>
</tbody>
</table>
APT to Avoid Gate Interaction

Figure 4 Gate Interaction with the design vehicle.

![Diagram of gate interaction with a design vehicle](image-url)
### SECTION 5: TRACK CLEARANCE GREEN TIME CALCULATION (OPTIONAL)

**Preempt Trap Check**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Advance preemption time (APT) provided (seconds):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Multiplier for maximum APT due to train handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Maximum APT (seconds): multiply line 36 and 37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Minimum duration for the track clearance green interval (seconds)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Gates down after start of preemption (seconds): add lines 38 and 39</td>
<td></td>
<td>15.0</td>
</tr>
<tr>
<td>41</td>
<td>Preempt verification and response time (seconds): line 3</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>42</td>
<td>Best-case conflicting vehicle or pedestrian time (seconds): usually 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Minimum right-of-way transfer time (seconds): add lines 41 and 42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Minimum track clearance green time (seconds): subtract line 43 from line 40</td>
<td></td>
<td>15.0</td>
</tr>
</tbody>
</table>

**Clearing of Clear Storage Distance**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>Time required for design vehicle to start moving (seconds), line 22</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>46</td>
<td>Design vehicle clearance distance (DVC, feet), line 23</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>47</td>
<td>Portion of CSD to clear during track clearance phase (feet)</td>
<td>CSD* in Figure 3 in Instructions</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Design vehicle relocation distance (DVRD, feet): add lines 46 and 47</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>49</td>
<td>Time required for design vehicle to accelerate through DVRD (seconds)</td>
<td>Read from Figure 2 in Instructions</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Time to clear portion of clear storage distance (seconds): add lines 45 and 49</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**Track clearance green interval (seconds): maximum of lines 44 and 50, round up to nearest full second**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>Track clearance green interval (seconds): maximum of lines 44 and 50, round up to nearest full second</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

### SECTION 6: VEHICLE-GATE INTERACTION CHECK (OPTIONAL)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>Right-of-way transfer time (seconds): line 17</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>53</td>
<td>Time required for design vehicle to start moving (seconds), line 22</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>54</td>
<td>Time required for design vehicle to accelerate through DVL (on line 20, seconds)</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>55</td>
<td>Time required for design vehicle to clear descending gate (seconds): add lines 52 though 54</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>56</td>
<td>Duration of flashing lights before gate descent start (seconds): get from railroad</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>57</td>
<td>Full gate descent time (seconds): get from railroad</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>58</td>
<td>Proportion of non-interaction gate descent time</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>59</td>
<td>Non-interaction gate descent time (seconds): multiply lines 57 and 58</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>Time available for design vehicle to clear descending gate (seconds): add lines 56 and 59</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>61</td>
<td>Advance preemption time (APT) required to avoid design vehicle-gate interaction (seconds): subtract line 60 from line 55, round up to nearest full second, enter 0 if less than 0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
TXDOT Railroad Preemption Forms

http://www.txdot.gov/txdot_library/forms/rail.htm

Form 2304 & 2304-I (Instructions)
Signal Controllers

• Different controllers can vary in the implementation of preemption
• Variation in the terminology
• May not have some capabilities
• Controllers should be tested to check if a preemption call during an exit phase will be registered
Communication

• Traffic engineers and railroad personnel should communicate all changes to crossing operation
  – Signal timing changes
  – Signal phasing changes
  – Proposed roadway geometry changes
  – Proposed railroad geometry changes
  – Changes to the train detection equipment
  – Consistent terminology
Sources

• **NCHRP Synthesis 271** - Traffic Signal Operations Near Highway-Rail Grade Crossings
• Preemption of Traffic Signals Near Railroad Crossings: An ITE Recommended Practice
• **Indiana MUTCD-2011** - Chapters 4D and 8C
• **Guide for Traffic Signal Preemption Near RR Grade Crossings** - FHWA/TX-01/1439-9
• TTI Highway Rail Preemption Workshop
• Illinois DOT
• INDOT Design Manual
Contact Information

Gregory J. Richards, P.E.
Senior Engineer, Signal Systems
INDOT Division of Traffic Control Systems

grichards@indot.in.gov
Phone: 317-899-8629