WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

REVISED

	)	DOCKET NO. TR-151861-P
BNSF Rwy. Co.	)	PETITION TO CONSTRUCT OR RECONSTRUCT A HIGHWAY-RAIL GRADE CROSSING AND INSTALL AN INTER-TIE BETWEEN A HIGHWAY SIGNAL AND A RAILROAD CROSSING SIGNAL SYSTEM
Petitioner,	)	
vs.	)	
City of Auburn, WA	)	
Respondent	)	
....	)	USDOT CROSSING NO.: 085655A

Prior to submitting a Petition to **Construct** a highway-rail grade crossing and install an inter-tie between a Highway Signal and a Railroad Crossing Signal System to the Washington Utilities and Transportation Commission (UTC), State Environmental Protection Act (SEPA) requirements must be met. Washington Administrative Code (WAC) 197-11-865 (2) requires:

> **All actions of the utilities and transportation commission under statutes administered as of December 12, 1975, are exempted, except the following:**
>
> **(2) Authorization of the openings or closing of any highway/railroad grade crossing, or the direction of physical connection of the line of one railroad with that of another;**

Please attach sufficient documentation to demonstrate that the SEPA requirement has been fulfilled. For additional information on SEPA requirements contact the Department of Ecology.

The Petitioner asks the Washington Utilities and Transportation Commission to approve construction or reconstruction of a highway-rail grade crossing and inter-tie the highway signal with the railroad crossing signal system.

☐ **Construction** X **Reconstruction**

Section 1 – Petitioner's Information

BNSF Rwy. Co.

Petitioner

Signature

2454 Occidental Ave. S.

Street Address

Seattle, WA 98134

City, State and Zip Code

Mailing Address, if different than the street address

Richard Wagner

Contact Person Name

206-625-6152, Richard.Wagner@bnsf.com

Contact Phone Number and E-mail Address

Section 2 – Respondent's Information

City of Auburn, WA

Respondent

25 W. Main St.

Street Address

Auburn, WA 98001

City, State and Zip Code

Mailing Address, if different than the street address

Pablo Para

Contact Person Name

253-876-1958,ppara@auburnwa.gov

Contact Phone Number and E-mail Address

Section 3 – Proposed or Existing Crossing Location

1. Existing highway/roadway W Main St
2. Existing railroad BNSF Railway
3. Location of proposed crossing:
   Located in the____ 1/4 of the ____1/4 of Sec. 13, Twp. 21N , Range 4E W.M.
4. GPS location, if known 47deg 18'27"N, 122deg 13'57"W
5. Railroad mile post (nearest tenth) 21.41X
6. City Auburn County King

Section 4 – Proposed or Existing Crossing Information

1. Railroad company BNSF Railway
2. Type of railroad at crossing x Common Carrier ☐ Logging ☐ Industrial ☐ Passenger ☐ Excursion
3. Type of tracks at crossing x Main Line ☐ Siding or Spur
4. Number of tracks at crossing 2
5. Average daily train traffic, freight 24
   Authorized freight train speed 60 Operated freight train speed 60
6. Average daily train traffic, passenger 23
   Authorized passenger train speed 79 Operated passenger train speed 79
7. Will the proposed crossing eliminate the need for one or more existing crossings?
   Yes ____ No X
8. If so, state the distance and direction from the proposed crossing.

9. Does the petitioner propose to close any existing crossings?
Yes ____ No _X_

Section 5 – Temporary Crossing

1. Is the crossing proposed to be temporary? Yes ____ No _X_

2. If so, describe the purpose of the crossing and the estimated time it will be needed

____

____

____

3. Will the petitioner remove the crossing at completion of the activity requiring the temporary crossing? Yes ____ No ____

Approximate date of removal ______________________________

Section 6 – Current Highway Traffic Information

1. Name of roadway/highway W. Main St

2. Roadway classification City Street

3. Road authority City of Auburn

4. Average annual daily traffic (AADT) 5100

5. Number of lanes 2

6. Roadway speed 25

7. Is the crossing part of an established truck route? Yes ____ No _X_

8. If so, trucks are what percent of total daily traffic? 3

9. Is the crossing part of an established school bus route? Yes _X_ No ____

10. If so, how many school buses travel over the crossing each day? 16

11. Describe any changes to the information in 1 through 7, above, expected within ten years:

____

Section 7 – Alternatives to the Proposal

1. Does a safer location for a crossing exist within a reasonable distance of the proposed location?
   Yes ____ No ____

2. If a safer location exists, explain why the crossing should not be located at that site.

   ____

   ____

   ____

   ____

3. Are there any hillsides, embankments, buildings, trees, railroad loading platforms or other barriers in the vicinity which may obstruct a motorist's view of the crossing?
   Yes ____ No ____

4. If a barrier exists, describe:
   - ♦ Whether petitioner can relocate the crossing to avoid the obstruction and if not, why not.
   - ♦ How the barrier can be removed.
   - ♦ How the petitioner or another party can mitigate the hazard caused by the barrier.

   ____

   ____

   ____

   ____

5. Is it feasible to construct an over-crossing or under-crossing at the proposed location as an alternative to an at-grade crossing?
   Yes ____ No ____

6. If an over-crossing or under-crossing is not feasible, explain why.

   ____

   ____

   ____

   ____

7. Does the railway line, at any point in the vicinity of the proposed crossing, pass over a fill area or trestle or through a cut where it is feasible to construct an over-crossing or an under-crossing, even though it may be necessary to relocate a portion of the roadway to reach that point?
   Yes ____ No ____

8. If such a location exists, state:
   - ♦ The distance and direction from the proposed crossing.
   - ♦ The approximate cost of construction.
   - ♦ Any reasons that exist to prevent locating the crossing at this site.

____

____

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9. Is there an existing public or private crossing in the vicinity of the proposed crossing?
   Yes ____ No ____

10. If a crossing exists, state:
   - ♦ The distance and direction from the proposed crossing.
   - ♦ Whether it is feasible to divert traffic from the proposed to the existing crossing.

____

____

____

____

____

Section 8 – Sight Distance

1. Complete the following table, describing the sight distance for motorists when approaching the tracks from either direction.

a. Approaching the crossing from ___West___, the current approach provides an unobstructed view as follows:
(North, South, East, West)

Direction of sight (left or right)	Number of feet from proposed crossing	Provides an unobstructed view for how many feet
Right	300	33
Right	200	36
Right	100	45
Right	50	110
Right	25	Unobstructed
Left	300	75
Left	200	85
Left	100	120
Left	50	1330
Left	25	Unobstructed

b. Approaching the crossing from ___East___, the current approach provides an unobstructed view as follows:
(Opposite direction-North, South, East, West)

Direction of sight (left or right)	Number of feet from proposed crossing	Provides an unobstructed view for how many feet
Right	300	0
Right	200	33
Right	100	515
Right	50	1055
Right	25	155
Left	300	80
Left	200	90
Left	100	105
Left	50	145
Left	25	670

2. Will the new crossing provide a level approach measuring 25 feet from the center of the railway on both approaches to the crossing?

Yes ____ No _X_

3. If not, state in feet the length of level grade from the center of the railway on both approaches to the crossing. ___10ft to the west, Unchanged to the East___

4. Will the new crossing provide an approach grade of not more than five percent prior to the level grade?

Yes _X_ No ____

5. If not, state the percentage of grade prior to the level grade and explain why the grade exceeds five percent.

___

___

___

___

Section 9 – Illustration of Proposed Crossing Configuration

Attach a detailed diagram, drawing, map or other illustration showing the following:

- ♦ The vicinity of the proposed crossing.
- ♦ Layout of the railway and highway 500 feet adjacent to the crossing in all directions.
- ♦ Percent of grade.
- ♦ Obstructions of view as described in Section 7 or identified in Section 8.
- ♦ Traffic control layout showing the location of the existing and proposed signage.

Section 10 – Sidewalks

1. Provide the following information:
   a. Provide a description of the type of sidewalks proposed.
   b. Describe who will maintain the sidewalks.
   c. Attach a proposed diagram or design of the crossing including the sidewalks.

___

Existing sidewalks will be replaced in kind.

___

___

___

___

___

___

___

Section 11 – Proposed Warning Signals or Devices

1. Explain in detail the number and type of automatic signals or other warning devices planned at the proposed crossing, including a cost estimate for each. If requesting pre-emption include the type of train detection circuitry, sequencing and advanced preemption time, justification for the changes and its effects on current warning devices and warning times for drivers.

Existing crossing protection will be relocated to the West to accommodate the new track. Will remove existing cantilever signals. Install shoulder mount crossing gates and signals. Will add a pedestrian crossing gate in the southeast quadrant of the intersection and shoulder mount flashing lights in the northwest quadrant. Relocation of existing crossing protection and addition of pedestrian crossing gate and shoulder mount signal will be done at BNSF expense. Existing simultaneous pre-emption will be replaced with advanced pre-emption. City of Auburn is responsible for any traffic signal upgrades required due to BNSF's advanced pre-emptions upgrades.

2. Provide an estimate for maintaining the signals for 12 months. ______________________

3. Is the petitioner prepared to pay to the respondent railroad company its share of installing the warning devices as provided by law?

Yes ____ No ____

Section 12 – Traffic Signal Preemption

Complete the attached Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings.

1. Specify simultaneous or advance preemption requested.

   Advanced

If advance preemption, what is the preemption time.

   31 seconds

Section 13 – Additional Information

Provide any additional information supporting the proposal, including information such as the public benefits that would be derived from constructing a new crossing as proposed or modifying an existing crossing. Provide project specific information.

BNSF is constructing the third main line in this area to expedite train movement through the City of Auburn. The addition of the third main line will allow commuter trains to access the passenger platforms, just south of W. Main St, while other trains will be able to continue to move down the third track.

Section 14 – Waiver of Hearing by Respondent

Waiver of Hearing

The undersigned represents the Respondent in the petition to construct or reconstruct a highway-railroad grade crossing and inter-tie the highway signal with the railroad crossing signal system.

USDOT Crossing No.: 085655A

We have investigated the conditions at the proposed or existing crossing site. We are satisfied the conditions are the same as described by the Petitioner in this docket. We agree that a crossing be installed or reconstructed and the highway signals inter-tied with the railroad crossing signal system and consent to a decision by the commission without a hearing.

Dated at Auburn, Washington, on the 10th day of August, 2016.

Nancy Backus

Printed name of Respondent

Nancy Backus

Signature of Respondent's Representative

Mayor

Title

City of Auburn

Name of Company

253-931-3041,nbackus@auburnwa.gov

Phone number and e-mail address

25 W. Main St.

Auburn, WA 98001

Mailing address

GUIDE FOR DETERMINING TIME REQUIREMENTS FOR TRAFFIC SIGNAL PREEMPTION AT HIGHWAY-RAIL GRADE CROSSINGS

City: Auburn

County: King

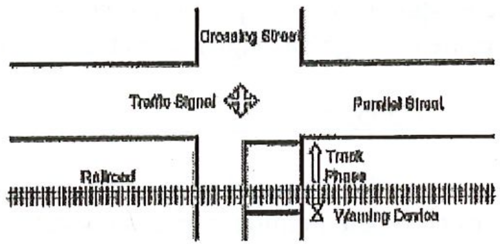
District:

Date: 08/25/15

Completed by: Scott Nutter

District Approval:

Show North Arrow



Parallel Street Name: C Street NW

Crossing Street Name: West Main Street

Railroad: BNSF

Crossing DOT#: 066665A

Railroad Contact: Richard Wagner

Phone: (206) 625-6152

SECTION 1: RIGHT-OF-WAY TRANSFER TIME CALCULATION

Preempt verification and response time

Remarks: Econolite

1. Preempt delay time (seconds) .... 1. [ ]
2. Controller response time to preempt (seconds) .... 2. [ ]

Controller type: ASC III

3. Preempt verification and response time (seconds): add lines 1 and 2 .... 3. [0.0]

Worst-case conflicting vehicle time

Remarks

4. Worst-case conflicting vehicle phase number .... 4. [4]
5. Minimum green time during right-of-way transfer (seconds) .... 5. [5.00]
6. Other green time during right-of-way transfer (seconds) .... 6. [ ]
7. Yellow change time (seconds) .... 7. [4.00]
8. Red clearance time (seconds) .... 8. [1.00]
9. Worst-case conflicting vehicle time (seconds): add lines 5 through 8 .... 9. [10.0]

Worst-case conflicting pedestrian time

Remarks

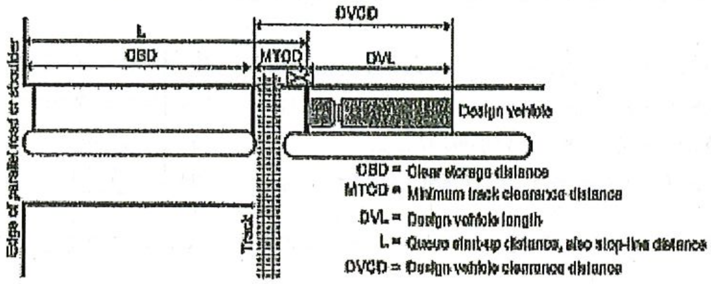
10. Worst-case conflicting pedestrian phase number .... 10. [8]
11. Minimum walk time during right-of-way transfer (seconds) .... 11. [0.0]
12. Pedestrian clearance time during right-of-way transfer (seconds) .... 12. [18.0]
13. Vehicle yellow change time, if not included on line 12 (seconds) .... 13. [4.0]
14. Vehicle red clearance time, if not included on line 12 (seconds) .... 14. [1.0]
15. Worst-case conflicting pedestrian time (seconds): add lines 11 through 14 .... 15. [23.0]

Worst-case conflicting vehicle or pedestrian time

16. Worst-case conflicting vehicle or pedestrian time (seconds): maximum of lines 9 and 15 .... 16. [23.0]
17. Right-of-way transfer time (seconds): add lines 3 and 16 .... 17. [23.0]

SECTION 2: QUEUE CLEARANCE TIME CALCULATION

Form 2304
(03/00)
Page 2 of 3



			Remarks
18.	Clear storage distance (CSD, feet)	120	Accounts for Future third rail -20 ft
19.	Minimum track clearance distance (MTCD, feet)	58	
20.	Design vehicle length (DVL, feet)	55	Design vehicle type: Truck restrictions in pl
21.	Queue start-up distance, L (feet): add lines 18 and 19	178	
22.	Time required for design vehicle to start moving (seconds): calculate as 2+(L÷20)	10.9	
23.	Design vehicle clearance distance, DVCD (feet): add lines 19 and 20	113	
24.	Time for design vehicle to accelerate through the DVCD (seconds)	14.7	Read from Figure 2 in Instructions.
25.	Queue clearance time (seconds): add lines 22 and 24	25.6	

SECTION 3: MAXIMUM PREEMPTION TIME CALCULATION

			Remarks
26.	Right-of-way transfer time (seconds): line 17	23.0	
27.	Queue clearance time (seconds): line 25	25.6	
28.	Desired minimum separation time (seconds)	4.0	
29.	Maximum preemption time (seconds): add lines 26 through 28	52.6	

SECTION 4: SUFFICIENT WARNING TIME CHECK

			Remarks
30.	Required minimum time, MT (seconds): per regulations	20.0	
31.	Clearance time, CT (seconds): get from railroad	2.0	
32.	Minimum warning time, MWT (seconds): add lines	22.0	Excludes buffer time (BT)
33.	Advance preemption time, APT, if provided (seconds): get from railroad		
34.	Warning time provided by the railroad (seconds): add lines 32 and 33	22.0	
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	31	

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, 5, 6, 7, 8, 11, 12, 13 and 14.

Remarks: ______________________________

SECTION 5: TRACK CLEARANCE GREEN TIME CALCULATION (OPTIONAL)

Preempt Trap Check

36. Advance preemption time (APT) provided (seconds): .... 36. 31.0 Line 33 only valid if line 35 is zero.

37. Multiplier for maximum APT due to train handling .... 37. 1.60 See instructions for details.

38. Maximum APT (seconds): multiply line 36 and 37 .... 38. 49.6 Remarks

39. Minimum duration for the track clearance green interval (seconds) .... 39. 15.0 For zero advance preemption time

40. Gates down after start of preemption (seconds): add lines 38 and 39 .... 40. 64.6

41. Preempt verification and response time (seconds): line 3 .... 41. 0.0 Remarks

42. Best-case conflicting vehicle or pedestrian time (seconds): usually 0........ 42. 0.0

43. Minimum right-of-way transfer time (seconds): add lines 41 and 42 .... 43. 0.0

44. Minimum track clearance green time (seconds): subtract line 43 from line 40 .... 44. 64.6

Clearing of Clear Storage Distance

45. Time required for design vehicle to start moving (seconds), line 22 .... 45. 10.9

46. Design vehicle clearance distance (DVCD, feet), line 23 ...... 46. 113 Remarks

47. Portion of CSD to clear during track clearance phase (feet) ... 47. 120 CSD* in Figure 3 in instructions.

48. Design vehicle relocation distance (DVRD, feet): add lines 46 and 47 ...... 48. 233

49. Time required for design vehicle to accelerate through DVRD (seconds) .... 49. 15.0 Read from Figure 2 in instructions.

50. Time to clear portion of clear storage distance (seconds): add lines 45 and 49 .... 50. 25.9

51. Track clearance green interval (seconds): maximum of lines 44 and 50, round up to nearest full second 51. 65

SECTION 6: VEHICLE-GATE INTERACTION CHECK (OPTIONAL)

52. Right-of-way transfer time (seconds): line 17 .... 52. 23.0

53. Time required for design vehicle to start moving (seconds), line 22 .... 53. 10.9

54. Time required for design vehicle to accelerate through DVL (on line 20, seconds) ...... 54. 10.0 Read from Table 3 in instructions.

55. Time required for design vehicle to clear descending gate (seconds): add lines 52 though 54 ..... 55. 43.9 Remarks

56. Duration of flashing lights before gate descent start (seconds): get from railroad .... 56. 12.0 Remarks

57. Full gate descent time (seconds): get from railroad .... 57.

58. Proportion of non-interaction gate descent time .... 58. 0.56 Read from Figure 5 in instructions.

59. Non-interaction gate descent time (seconds): multiply lines 57 and 58 .... 59. 0.0

60. Time available for design vehicle to clear descending gate (seconds): add lines 56 and 59 .... 60. 12.0

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 .... 61. 32

WASHINGTON UTC UTILITIES AND TRANSPORTATION COMMISSION

INSTRUCTIONS

GUIDE FOR DETERMINING TIME REQUIREMENTS FOR TRAFFIC SIGNAL PREEMPTION AT HIGHWAY-RAIL GRADE CROSSINGS

USING THESE INSTRUCTIONS: *These instructions are designed to assist applicants in completing the* Guide For Determining Time Requirements For Traffic Signal Preemption At Highway-Rail Grade Crossings. *This assists in determining if additional time (advance preemption) is required for the traffic signal to move stationary vehicles out of the crossing before the arrival of the train. If you have any questions about completing the form, please contact Kathy Hunter, commission staff at (360)664-1257 or by e-mail at khunter@utc.wa.gov.*

SITE DESCRIPTIVE INFORMATION:
Enter the location for the highway-rail grade crossing including the (nearest) **City** and the **County** in which the crossing is located. Next, enter the **Date** the analysis was performed, your (the analyst's) name next to **Completed by.**

To complete the reference schematic for this site, place a **North Arrow** in the provided circle to correctly orient the crossing and roadway. Record the name of the **Parallel Street** and the **Crossing Street** in the spaces provided and remember to include any street sign or local name for the streets as well as any state or interstate highway designation. You may wish to note other details on the intersection and crossing diagram as well, including the number of lanes or turn bays on the intersection approach crossing the tracks and any adjacent land use.

Enter the **Railroad** name, **Railroad Contact** person's name and **Phone** number for the responsible railroad company and its equipment maintenance and operations contractor (if any). Finally, record the unique 7-character **Crossing USDOT#** (6 numeric plus one alphanumeric characters) for the crossing.

Note that this guide for determining warning time requirements for traffic signal preemption requires you to input many controller unit timing and phasing values. To preserve the accuracy of these values, record all values to the next highest tenth of a second (i.e., record 5.42 seconds as 5.5 seconds).

SECTION 1: RIGHT-OF-WAY TRANSFER TIME CALCULATION

Preempt Verification and Response Time

Line 1. The **preempt delay time** is the amount of time, in seconds, that the traffic signal controller is programmed to wait from the initial receipt of a preempt call until the call is "verified" and considered a viable request for transfer into preemption mode. Preempt delay time is a value entered into the controller unit for purposes of preempt call validation, and may not be available on all manufacturer's controllers.

Line 2. Unlike preempt delay time (Line 1) which is a value entered into the controller, **controller response time to preempt** is the time that elapses while the controller unit electronically registers the preempt call (i.e., it is the controller's equipment response time for the preempt call). The controller manufacturer should be consulted to find the correct value (in seconds) for use here. For future reference, you may wish to record the controller type in the **Remarks** section to the right of the controller response time to preempt value. However, note that the manufacturer's given response time may be unique for a controller unit's model and software generation; other models and/or software generations may have different response times.

Line 3. The sum of Line 1 and Line 2 is the **preempt verification and response time**, in seconds. It represents the number of seconds between the receipt at the controller unit of a preempt call issued by the railroad's grade crossing warning equipment and the time the controller software actually begins to respond to the preempt call (i.e., by transitioning into preemption mode).

Worst-Case Conflicting Vehicle Time
Line 4. Worst-case conflicting vehicle phase number is the number of the controller unit phase which

conflicts with the phase(s) used to clear the tracks—the track clearance phase(s)—that has the longest sum of minimum green (if provided), other (additional) green time (if provided), yellow change interval, and red clearance interval durations that may need to be serviced during the transition into preemption. Note that all of these time elements are for vehicular phases only; pedestrian phase times will be assessed in the next part of the analysis. The worst-case vehicle phase can be any phase that conflicts with the track clearance phase(s); it is not restricted to only the phases serving traffic parallel to the tracks.

Line 5. Minimum green time during right-of-way transfer is the number of seconds that the worst-case vehicle phase (see Line 4 discussion) must display a green indication before the controller unit will terminate the phase through its yellow change and red clearance intervals and transition to the track clearance green interval. The minimum green time during right-of-way transfer may be set to zero to allow as rapid a transition as possible to the track clearance green interval. However, local policies will govern the amount of minimum green time provided during the transition into preemption.

Line 6. If any additional green time is preserved beyond the preempt minimum green time for the worst-case vehicle phase (line 4), it should be entered here as **Other green time during right-of-way transfer.** Given the time-critical nature of the transition to the track clearance green interval during preempted operation, this value is usually zero except in unusual circumstances. One situation where other green time may be present is when a trailing green overlap is used on the worst-case vehicle phase, and the controller unit is set up to time out the trailing green overlap on entry into preemption.

Line 7. Yellow change time is the required yellow change interval time for the worst-case vehicle phase (line 4) given prevailing operating conditions. Yellow change time for the phase under preemption is usually the same value, in seconds, programmed for the phase under normal operating circumstances.

Line 8. Red clearance time is the required red clearance interval for the worst-case vehicle phase (line 4) given prevailing operating conditions. Red clearance time for the phase under preemption is usually the same value, in seconds, programmed for the phase under normal operating circumstances.

Line 9. Worst-case conflicting vehicle time is the sum of lines 5 through 8. It will be compared with the worst-case conflicting pedestrian time to determine whether vehicle or pedestrian phase times are the most critical in their impact on warning time requirements during the transition to the track clearance green interval.

Worst-case Conflicting Pedestrian Time

Line 10. Worst-case pedestrian phase number is the pedestrian phase number (referenced as the vehicle phase number that the pedestrian phase is associated with) that has the longest sum of walk time, pedestrian clearance (i.e., flashing don't walk) times, and associated vehicle clearance times that have to be provided during the transition into preemption. The worst-case pedestrian phase is not restricted to pedestrian phases running concurrently with vehicle phases that serve traffic parallel to the tracks. The vehicle phase associated with the worst-case pedestrian phase may even be one of the track clearance phases if the pedestrian phase is not serviced concurrently with the associated track clearance phase.

Line 11. Minimum walk time during right-of-way transfer (seconds) is the minimum pedestrian walk time for the worst-case pedestrian phase (line 10).

Line 12. Pedestrian clearance time during right-of-way transfer (seconds) is the clearance (i.e., flashing don't walk) time for the worst-case pedestrian phase.

Line 13. Enter a **Yellow change time** if the pedestrian clearance interval does not time simultaneously with the yellow change interval of the vehicular phase associated with your worst-case pedestrian phase; enter zero if does. Local policies will determine if this is allowed. Simultaneous timing of the pedestrian clearance interval and the yellow change interval (i.e. a zero value on line 13) allows for the most rapid transition to the track clearance green interval. If a non-zero value is entered, make sure to enter the yellow change time of the vehicular phase associated with your worst-case pedestrian phase. This value may not be the same value you enter on Line 7, since the worst-case pedestrian phase may not be the same as the worst-case vehicular phase.

Line 14. Enter a **Red clearance time** if the pedestrian clearance interval does not time simultaneously with the red clearance interval of the vehicular phase associated with your worst-case pedestrian phase; enter zero if does. Local policies will determine if this is allowed. Also, note than not all traffic signal controllers allow simultaneous timing of the pedestrian clearance interval and the red clearance interval. Simultaneous timing of the pedestrian clearance interval and the red clearance interval (i.e. a zero value on line 14) allows for the most rapid transition to the track clearance green interval. If a non-zero value is entered, make sure to enter the red clearance time of the vehicular phase associated with your worst-case pedestrian phase. This value may not be the same value you enter on Line 8, since the worst-case pedestrian phase may not be the same as the worst-case vehicular phase.

Line 15. Add lines 11 through 14 to calculate the **Worst -case conflicting pedestrian time.** This value will be compared to the worst-case conflicting vehicle time to determine whether vehicle or pedestrian phase times are the most critical in their impact on warning time requirements during the transition to the track clearance green interval.

Worst-case Conflicting Vehicle or Pedestrian Time

Line 16. Record the **Worst-case conflicting vehicle or pedestrian time** (in seconds) by comparing lines 9 and 15 and writing the larger of the two as the entry for line 16.

Line 17. Calculate the **Right-of-way transfer time** by adding lines 3 and 16. The right-of-way transfer time is the maximum amount of time needed for the worst case condition, prior to display of the track clearance green interval.

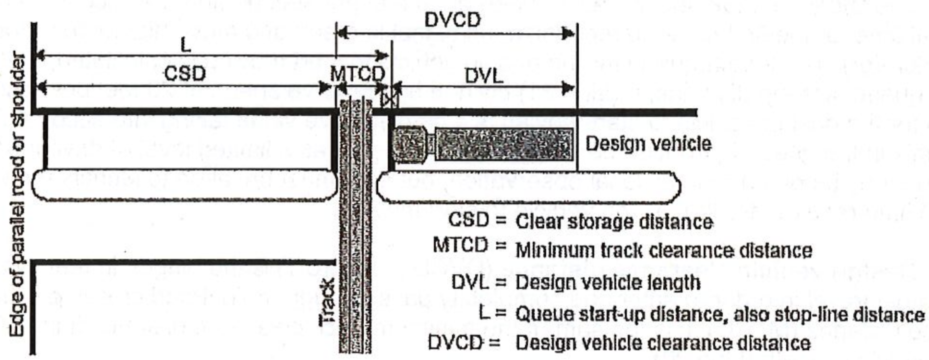


Figure 1 Queue clearance distances.

SECTION 2: QUEUE CLEARANCE TIME CALCULATION

Line 18. Record the **Clear storage distance** (CSD in Figure 1), in feet, as the shortest distance along the crossing street between the edge of the grade crossing nearest the signalized intersection—identified by a line parallel to the rail 6 feet (2 m) from the rail nearest to the intersection—and the edge of the street or shoulder of street that parallels the tracks. If the normal stopping point on the crossing street is significant different from the edge or shoulder of parallel street, measure the distance to the normal stopping point. For angled (i.e., non-perpendicular) railroad crossings, always measure the distance along the inside (centerline) edge of the leftmost lane or the distance along the outside (shoulder) edge of the rightmost lane, as appropriate, to determine the shortest clear storage distance and record that value.

Line 19. Minimum track clearance distance (MTCD in Figure 1), in feet, is the length along the highway at one or more railroad tracks, measured from the railroad crossing stop line, warning device, or 12 feet (4 m) perpendicular to the track centerline—whichever is further away from the tracks, to 6 feet (2 m) beyond the tracks measured perpendicular to the far rail. For angled (i.e., non-perpendicular) railroad crossings, always measure the distance along the inside (centerline) edge of the leftmost lane or the distance along the outside (shoulder) edge of the rightmost lane, as appropriate, to determine the longest minimum track clearance distance and record that value.

Line 20. Design vehicle length (DVL in Figure 1), in feet, is the length of the design vehicle, the longest vehicle permitted by road authority statute on the subject roadway. In the **Remarks** section to the right of the data entry box for Line 20, note the design vehicle type for ease of reference. Some design vehicles from the *AASHTO Green Book (A Policy on Geometric Design of Highways and Streets)* are given in Table 1.

Table 1. AASHTO Design vehicle lengths and heights.

Design Vehicle Type	Symbol	Length (ft)
Passenger Car	P	19
Single Unit Truck	SU	30
Large School Bus	S-BUS 40	40
Intermediate Semi-Trailer	WB-50	55

Line 21. Queue start-up distance (L in Figure 1), in feet, is the maximum length over which a queue of vehicles stopped for a red signal indication at an intersection downstream of the crossing must get in motion so that the design vehicle can move out of the railroad crossing prior to the train's arrival. Queue start-up distance is the sum of the clear storage distance (Line 18) and minimum track clearance distance (Line 19).

Line 22. Time required for the design vehicle to start moving (seconds) is the time elapsed between the start of the track clearance green interval and the time the design vehicle, which is located at the edge of the railroad crossing on the opposite side from the signalized intersection, begins to move. This elapsed time is based on a "shock wave" speed of 20 feet per second and a 2 second start-up time (the additional time for the first driver to recognize the signal is green and move his/her foot from the brake to the accelerator). The time required for the design vehicle to start moving is calculated, in seconds, as 2 plus the queue start-up distance, L (Line 21) divided by the wave speed of 20 feet per second. The time required for the design vehicle to start moving is a conservative value taking into account the worst-case vehicle mix in the queue in front of the design vehicle as well as a limited level of drive inattentiveness. This value may be overridden by local observation, but care must be taken to identify the worst-case (longest) time required for the design vehicle to start moving.

Line 23. Design vehicle clearance distance (DVCD in Figure 1) is the length, in feet, which the design vehicle must travel in order to enter and completely pass through the railroad crossing's minimum track clearance distance (MTCD). It is the sum of the minimum track clearance distance (Line 19) and the design vehicle's length (Line 20).

Line 24. The **Time for design vehicle to accelerate through the design vehicle clearance distance (DVCD)** is the amount of time required for the design vehicle to accelerate from a stop and travel the complete design vehicle clearance distance. This time value, in seconds, can be found through local observation or by using by Figure 2. If local observation is used, take care to identify the worst-case (longest) time required for the design vehicle to accelerate through the DVCD. If Figure 2 is used to estimate the time for the design vehicle to accelerate through the DVCD, locate the DVCD from Line 23 on the horizontal axis of Figure 2 and then draw a line straight up until that line intersects the acceleration time performance curve for your design vehicle. Then, draw a horizontal line from this point to the left until it intersects the vertical axis, and record the appropriate acceleration time. Round up to the next higher tenth of a second. For example, with a DVCD of 80 feet and a WB-50 semi-trailer design vehicle on a level surface, the time required for the design vehicle to accelerate through the DVCD will be 12.2 seconds.

If your design vehicle is a WB-50 semi-trailer, large school bus (S-BUS 40), or single unit (SU) vehicle, you may need to apply a correction factor to estimate the effect of grade on the acceleration of the vehicle. Determine the average grade over a distance equal to the design vehicle clearance distance

(DVCD), centered around the minimum track clearance distance (MTCD). If the grade is 1% uphill (+1%) or greater, multiply the acceleration time obtained from Figure 2 with the factor obtained from Table 2 and round up to the next higher tenth of a second to get an estimate of the acceleration time on the grade. For example, with a DVCD of 80 feet and a WB-50 semi-trailer design vehicle on a 4% uphill, the (interpolated) factor from Table 2 is 1.30. Therefore, the estimated time required for the design vehicle to accelerate through the DVCD will be 12.2 x 1.30 = 15.86 seconds, or 15.9 seconds rounded up to the next higher tenth of a second.

If you selected a design vehicle different from those listed in Figure 2 and Table 2, you may still be able to use Figure 2 and Table 2 if you can match your design vehicle to the weight, weight-to-power ratio, and power application characteristics of the design vehicles in Figure 2 and Table 2. The WB-50 curve and grade factors are based on an 80,000 lb vehicle with a weight-to-power ratio of 400 lb/hp accelerating at 85% of its maximum power on level grades and at 100% of its maximum power on uphill grades, and may therefore be representative of any heavy tractor-trailer combination with the same characteristics. The school bus curve and grade factors are based on a 27,000 lb vehicle with a weight-to-power ratio of 180 lb/hp accelerating at 70% of its maximum power on level grades and at 85% of its maximum power on uphill grades. The SU curve and grade factors are based on a 34,000 lb vehicle with a weight-to-power ratio of 200 lb/hp accelerating at 75% of its maximum power on level grades and at 90% of its maximum power on uphill grades.

Table 2. Factors to account for slower acceleration on uphill grades. Multiply the appropriate factor (depending on the design vehicle, grade, and acceleration distance) with the acceleration time in Figure 2 to obtain the estimated acceleration time on the grade.

Acceleration Distance (ft)	Design Vehicle and Percentage Uphill Grade													
	Single Unit Truck (SU)				Large School Bus (S-BUS 40)					Intermediate Tractor-Trailer (WB-50)				
	0-2%	4%	6%	8%	0-1%	2%	4%	6%	8%	0%	2%	4%	6%	8%
25	1.00	1.06	1.13	1.19	1.00	1.01	1.10	1.19	1.28	1.00	1.09	1.27	1.42	1.55
50	1.00	1.09	1.17	1.25	1.00	1.01	1.12	1.21	1.30	1.00	1.10	1.28	1.44	1.58
75	1.00	1.10	1.19	1.29	1.00	1.02	1.13	1.23	1.33	1.00	1.11	1.30	1.47	1.61
100	1.00	1.11	1.21	1.32	1.00	1.02	1.14	1.25	1.35	1.00	1.11	1.31	1.48	1.64
125	1.00	1.12	1.23	1.34	1.00	1.03	1.15	1.26	1.37	1.00	1.12	1.32	1.50	1.66
150	1.00	1.12	1.24	1.37	1.00	1.03	1.16	1.28	1.40	1.00	1.12	1.33	1.52	1.68
175	1.00	1.13	1.25	1.38	1.00	1.03	1.17	1.29	1.42	1.00	1.12	1.34	1.53	1.70
200	1.00	1.13	1.26	1.40	1.00	1.04	1.17	1.30	1.43	1.00	1.13	1.35	1.54	1.72
225	1.00	1.14	1.27	1.42	1.00	1.04	1.18	1.32	1.45	1.00	1.13	1.35	1.56	1.74
250	1.00	1.14	1.28	1.43	1.00	1.04	1.19	1.33	1.47	1.00	1.13	1.36	1.57	1.76
275	1.00	1.14	1.29	1.44	1.00	1.05	1.20	1.34	1.49	1.00	1.14	1.37	1.58	1.77
300	1.00	1.14	1.30	1.46	1.00	1.05	1.20	1.35	1.50	1.00	1.14	1.37	1.59	1.79
325	1.00	1.15	1.30	1.47	1.00	1.05	1.21	1.36	1.52	1.00	1.14	1.38	1.60	1.81
350	1.00	1.15	1.31	1.48	1.00	1.05	1.22	1.37	1.54	1.00	1.15	1.39	1.61	1.82
375	1.00	1.15	1.31	1.49	1.00	1.06	1.22	1.38	1.55	1.00	1.15	1.39	1.62	1.84
400	1.00	1.15	1.32	1.50	1.00	1.06	1.23	1.40	1.57	1.00	1.15	1.40	1.63	1.85

For design vehicle clearance distances greater than 400 feet, use Equation 1 to estimate the time for the design vehicle to accelerate through the design vehicle clearance distance or any other distance:

$$T = e^{\left[a - b\sqrt{c + \frac{2}{b}\ln\left(\frac{d}{X}\right)}\right]} \qquad (1)$$

where

T = time to accelerate through distance X, in seconds;
X = distance over which acceleration takes place, in feet;
ln = natural logarithm function;
e = 2.17828, the base of natural logarithms; and
a, b, c, *and* d = calibration parameters from Table 3.

Note: To interpolate between grades, do not interpolate the parameters in Table 3. The correct way to interpolate is to calculate the acceleration time *T* using Equation 1 for the two nearest grades and then interpolate between the two acceleration times.

Line 25. Queue clearance time is the total amount of time required (after the signal has turned green for the approach crossing the tracks) to begin moving a queue of vehicles through the queue start-up distance (L, Line 21) and then move the design vehicle from a stopped position at the far side of the crossing completely through the minimum track clearance distance (MTCD, Line 19). This value is the sum of the time required for design vehicle to start moving (Line 22) and the time for design vehicle to accelerate through the design vehicle clearance distance (Line 24).

Table 3. Parameters to estimate vehicle acceleration times over distances greater than 400 feet using Equation 1.

Design Vehicle	Grade	*a*	*b*	*c*	*d*
Through Passenger Car	Level	7.75	3.252	5.679	2.153
Left Turning Passenger Car	Level	10.29	5.832	3.114	5.090
Single Unit Truck (SU)	Level to 2%	8.16	3.624	5.070	2.018
	4%	10.39	4.865	4.560	1.739
	6%	9.52	4.542	4.393	1.700
	8%	9.38	4.597	4.165	1.668
Large School Bus (S-BUS 40)	Level to 1%	10.02	4.108	5.95	0.885
	2%	11.51	5.254	4.801	1.300
	4%	10.79	5.042	4.577	1.266
	6%	10.61	5.101	4.329	1.253
	8%	11.84	6.198	3.652	1.554
Intermediate Semi-Trailer (WB-50)	Level	17.75	7.984	4.940	0.481
	2%	10.26	4.026	6.500	0.249
	4%	9.39	3.635	6.670	0.193
	6%	9.38	3.732	6.310	0.188
	8%	10.31	4.515	5.219	0.265

SECTION 3: MAXIMUM PREEMPTION TIME CALCULATION

Line 26. Right-of-way transfer time, in seconds, recorded on Line 17. The right-of-way transfer time is the maximum amount of time needed for the worst case condition, prior to display of the track clearance green interval.

Line 27. Queue clearance time, in seconds, recorded on Line 25. Queue clearance time starts simultaneously with the track clearance green interval (i.e. after right-of-way transfer), and is the time required for the design vehicle stopped just inside the minimum track clearance distance to start up and move completely out of the minimum track clearance distance.

Line 28. Desired minimum separation time is a time "buffer" between the departure of the last vehicle (the design vehicle) from the railroad crossing (as defined by the minimum track clearance distance) and the arrival of the train. Separation time is added for safety reasons and to avoid driver discomfort. If no separation time is provided, a vehicle could potentially leave the crossing at exactly the same time the train arrives, which would certainly lead to severe driver discomfort and potential unsafe behavior. The recommended value of four (4) seconds is a based on the minimum recommended value found in the Institute of Transportation Engineer's *ITE Journal* (in an article by Marshall and Berg in February 1997).

Line 29. Maximum preemption time is the total amount of time required after the preempt is initiated by the railroad warning equipment to complete right-of-way transfer to the track clearance green interval, initiate the track clearance phase(s), move the design vehicle out of the crossing's minimum track clearance distance, and provide a separation time "buffer" before the train arrives at the crossing. It is the sum of the right-of-way transfer time (Line 26), the queue clearance time (Line 27), and the desired minimum separation time (Line 28).

SECTION 4: SUFFICIENT WARNING TIME CHECK

Line 30. Minimum time (seconds) is the least amount of time active warning devices shall operate prior to the arrival of a train at a highway-rail grade crossing.

Line 31. Clearance time (seconds), typically known as CT, is the additional time that may be provided by the railroad to account for longer crossing time at wide (i.e., multi-track crossings) or skewed-angle crossings. You must obtain the clearance time from the railroad responsible for the railroad crossing. In cases where the minimum track clearance distance (Line 19) exceeds 35 feet, the railroads' *AREMA Manual* requires clearance time of one second be provided for each additional 10 feet, or portions thereof, over 35 feet. Additional clearance time may also be provided to account for site-specific needs. Examples of extra clearance time include cases where additional time is provided for simultaneous preemption (where the preemption notification is sent to the signal controller unit simultaneously with the activation of the railroad crossing's active warning devices), instead of providing advance preemption time.

Line 32. Minimum warning time (seconds) is the sum of the minimum time (Line 30) and the clearance time (Line 31). This value is the actual minimum time that active warning devices can be expected to operate at the crossing prior to the arrival of the train under normal, through-train conditions. The term "through-train" refers to the case where trains do not stop or start moving while near or at the crossing. Note that the minimum warning time, does not include buffer time (BT). Buffer time is added by the railroad to ensure that the minimum warning time is always provided despite inherent variations in warning times; however, it is not consistently provided and cannot be relied upon by the traffic engineer for signal preemption and/or warning time calculations.

Line 33. Advance preemption time (seconds), if provided, is the period of time that the notification of an approaching train is forwarded to the highway traffic signal controller unit or assembly prior to activating the railroad active warning devices. Only enter advance preemption time if you can verify from the railroad that advance preemption time is already being provided for your site. If you are determining whether or not you need advance preemption time, enter zero for the advance preemption time in Line 33.

Line 34. Warning time provided by the railroad is the sum of the minimum warning time (Line 32) and the advance preemption time (Line 33), in seconds. This value should be verified with the railroad, and should not include buffer time (BT).

Line 35. Additional warning time required from railroad is the additional time needed (if any), in seconds, that is required to provide safe preemption in the worst case (the maximum preemption time on Line 29), given the warning time provided by the railroad (Line 34). The additional warning time required is calculated by subtracting the warning time provided by the railroad (Line 34) from the maximum preemption time (Line 29). If the result of the subtraction is equal to or less than zero, it means that sufficient warning time is available, and you should enter zero (0) on Line 35. However, keep in mind that highly negative (-10 or less) subtraction results may indicate the potential for operational problems due to insufficient track clearance green time. Section 5 of the worksheet contains a methodology for calculating sufficient track clearance green time.

If the additional warning time is greater than zero (0), it means that the warning time provided by the railroad is insufficient, and additional warning time has to be requested from the railroad to ensure safe operation. The railroad can provide additional warning time either by providing additional clearance time (CT) (Line 30), or by providing or increasing advance preemption time (Line 33).

As an alternative, it may be possible to reduce the maximum preemption time (Line 29). To reduce the maximum preemption time, you can reduce either the preempt delay time (Line 1), if this is possible; reduce preempt minimum green time (Line 5) or other green time (Line 6), as long as you do not violate local policies for signal timing; or, reduce yellow change time (Line 7) or red clearance time (Line 8) as long as adequate and appropriate yellow change and red clearance intervals are provided.

If pedestrian rather than vehicular phasing controls warning time requirements for preemption, it may be possible to reduce the minimum walk time (Line 11) and/or pedestrian clearance time (Line 12) as long as you do not violate local policies for signal timing. You can also let the pedestrian clearance time (flashing don't walk) time simultaneous with vehicular yellow change and red clearance and so reduce the values on Line 13 (yellow change time) and Line 14 (red clearance time) to zero (0). If local policies do not currently allow simultaneous clearance for pedestrian and vehicular phasing, you may want to consider allowing this type of operation to reduce your worst-case conflicting pedestrian time. Once you have made all of the possible adjustments to the warning time, recompute the totals in Lines 3, 9, 15, 16, 17, 26, 29, and 35. If Line 35 remains greater than zero, then you will have to request additional warning time from the railroad, as described above, to ensure safe preemption of the adjacent signalized intersection.

SECTION 5: TRACK CLEARANCE GREEN TIME CALCULATION (OPTIONAL)

Note: This section is optional and is used to calculate the duration of the track clearance green interval. If this worksheet is only used to determine if additional warning time has to be requested from the railroad, this section need not be completed. The objective of the section is to calculate the duration of the track clearance green interval to ensure safe and efficient operations at the crossing and adjacent traffic signal.

The Preempt Trap Check section (lines 36 to 44) focuses on safety by calculating the minimum duration of the track clearance green interval to ensure that the track clearance green does not terminate before the gates block access to the crossing. If the gates do not block access to the crossing before the expiration of the track clearance green, it is possible that vehicles can continue to cross the tracks and possibly stop on the tracks. However, the track clearance green interval has already expired and there will be no further opportunity to clear. This potentially hazardous condition is called the "preempt trap".

The Clearing of Clear Storage Distance section (lines 45 to 50) focuses on efficiency by calculating duration of the track clearance green interval that is needed to clear the clear storage distance (CSD in Figure 1), or a specific portion thereof.

Preempt Trap Check

Line 36. Advance preemption time provided is the duration (in seconds) the preempt sequence is active in the highway traffic signal controller before the activation of the railroad active warning devices. If Line 35 is zero (i.e. no additional warning time is required from the railroad), the value on Line 33 can be used. In other cases, use the actual value of the advance preemption time (APT) provided by the railroad. If no APT is provided, enter zero on Line 36.

Line 37. Multiplier for maximum APT due to train handling is a value that relates the maximum duration of the advance preemption time (APT) to the minimum value guaranteed by the railroad. Although the railroad guarantees a minimum duration for the APT, it is probable that in most cases the actual duration of the APT will be longer than the guaranteed duration. This variability in APT occurs due to "train handling", which a term that describes the acceleration and deceleration of trains on their approach to the crossing. If a train accelerates or decelerates while approaching to the crossing, the railroad warning system cannot estimate the arrival time of the train at the crossing accurately, resulting in variation in the actual duration of APT provided. This variation needs to be taken into account to ensure safe operation.

To make sure that the preempt trap does not occur we need to determine the maximum value of the APT so that a sufficiently long track clearance green interval can be provided to ensure that the gates block access to the crossing before the track clearance green ends. The maximum APT can be estimated by multiplying the advance preemption time provided (and guaranteed) by the railroad (Line 36) with the multiplier for maximum APT due to train handling. This value is only significant if the value for APT on Line 36 is non-zero. If APT is zero, continue to line 38.

In the case where APT is provided, the difference between the minimum and maximum values of APT is termed excess APT. Excess APT usually occurs when the train decelerates on the approach to the crossing, or where train handling affects the accuracy of the estimated time of train arrival at the crossing so that the preempt sequence is activated earlier than expected. The amount of excess APT is increased by the following conditions:

- Increased variation in train speeds, since more trains will be speeding up and slowing down;
- Lower train speeds, since a fixed deceleration rate has a greater effect on travel time at low speeds than at higher speeds; and
- Longer warning times, because more time is available for the train to decelerate on the approach to the crossing.

The multiplier for maximum APT can be determined from field measurements as the largest advance preemption time observed (or the 95th percentile, if enough observations are available) divided by the value on Line 36. If no field observations are available, the multiplier for maximum APT can be estimated as 1.60 if warning time variability is high or 1.25 if warning time variability is low. High warning time variability can typically be expected in the vicinity of switching yards, branch lines, or anywhere low-speed switching maneuvers takes place. According to Section 16.30.10 of the *AREMA Signal Manual* the railroad can provide a "timer for constant time between APT and CWT." The effect of such a "not to exceed" timer is to eliminate excess APT, and if provided, the multiplier on Line 37 can be set to 1.0.

Line 38. Maximum APT is largest value (in seconds) of the advance preemption time that can typically be expected, which corresponds to the earliest possible time the preemption sequence in the traffic signal controller will be activated before the activation of the railroad grade crossing warning system (flashing lights and gates). It is the calculated by multiplying the APT provided by the railroad (Line 36) with the multiplier for maximum APT due to train handling (Line 37).

Line 39. Minimum duration for the track clearance green is the minimum duration (in seconds) of the track clearance green interval to ensure that the gates block access to the crossing before the track clearance green expires in the case where no advance preemption time is provided. It is necessary to block access to the crossing before the track clearance green expires to ensure that vehicles do not enter the crossing after the expiration of the track clearance green and so be subject to the preempt trap (described in the introduction to Section 5). The 15 seconds minimum duration for the track clearance green interval is calculated from federal regulations and requirements.

Line 40. Gates down after start of preemption is the maximum duration (in seconds) from when the preempt is activated in the highway traffic signal controller until the gates reach a horizontal position. Calculate this value by adding the maximum advance preemption time on Line 38 to the minimum duration for the track clearance green interval on Line 39.

Line 41. Preempt verification and response time, recorded on Line 3, is the number of seconds between the receipt at the controller unit of a preempt call issued by the railroad's grade crossing warning equipment and the time the controller software actually begins to respond to the preempt call.

Line 42. Best-case conflicting vehicle or pedestrian time (in seconds) is the minimum time from when the preempt starts to time in the controller (i.e. after verification and response) until the track clearance green interval can start timing. In most cases, this value is zero, since the controller may already be in the track clearance phase(s) when the preempt starts timing, and therefore the track clearance green interval can start timing immediately. The best-case conflicting vehicle or pedestrian time may be greater than zero if the track clearance green interval contains phases that are not in normal operation (and conflicts with the normal phases), or where another phase or interval always has to terminate before the track clearance green interval can start timing.

Line 43. Minimum right-of-way transfer time is the minimum amount of time needed for the best case condition, prior to display of the track clearance green interval. Calculate the minimum right -of-way transfer time by adding lines 41 and 42.

Line 44. Calculate the **Minimum track clearance green time** by subtracting Line 43 from Line 40. This yields the minimum time that the track clearance green interval has to be active to avoid the preempt trap.

Clearing of Clear Storage Distance

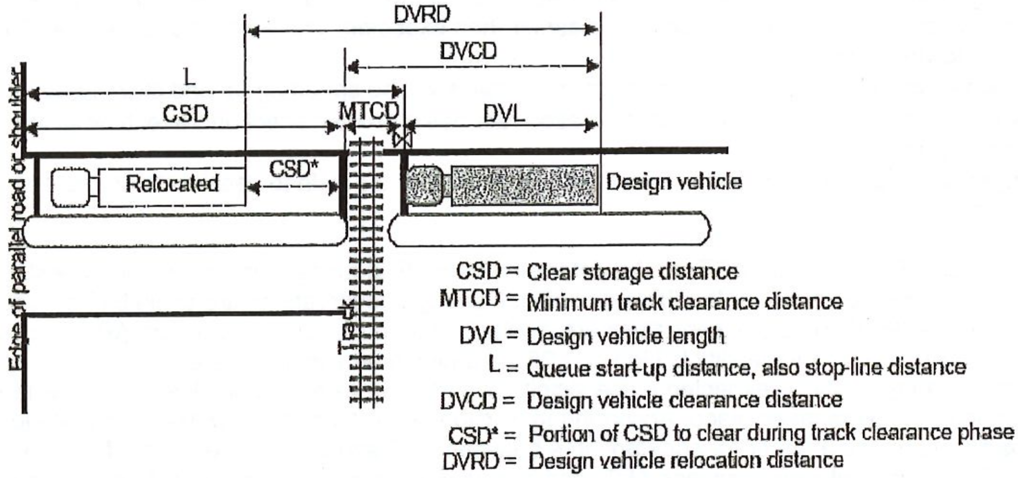


Figure 3 Relocation distances during the track clearance green interval.

Line 45. Time required for design vehicle to start moving, recorded on Line 22, is the number of seconds that elapses between the start of the track clearance green interval and the time the design vehicle, which is located at the edge of the railroad crossing on the opposite side from the signalized intersection, begins to move.

Line 46. Design vehicle clearance distance (DVCD in Figure 3) is the length, in feet, which the design vehicle must travel in order to enter and completely pass through the railroad crossing's minimum track clearance distance (MTCD). This is the same value as recorded on Line 23.

Line 47. Portion of CSD to clear during track clearance, (CSD* in Figure 3) is the portion of the clear storage distance (CSD), in feet, that must be cleared of vehicles before the track clearance green interval ends. For intersections with a CSD greater than approximately 150 feet it is desirable—but not necessary—to clear the full CSD during the track clearance green interval. In other words, it is desirable to set Line 47 to the full value of CSD (Line 18). If the full CSD is not cleared, however, vehicles will be stopped in the CSD during the preempt dwell period, and if not serviced during the preempt dwell period, will be subject to unnecessary delays which may result in unsafe behavior. For CSD values less than 150 feet the full CSD is typically cleared to avoid the driver task of crossing the tracks followed immediately by the decision to stop or go when presented by a yellow signal as the track clearance green interval terminates.

Line 48. Design vehicle relocation distance (DVRD in Figure 3) is the distance, in feet, that the design vehicle must accelerate through during the track clearance green interval. It is the sum of the design vehicle clearance distance (Line 46) and the portion of CSD to clear during the track clearance green interval (Line 47).

Line 49. The **Time required for design vehicle to accelerate through DVRD** is the amount of time required for the design vehicle to accelerate from a stop and travel the complete design vehicle relocation distance (DVRD). This time value, in seconds, can be found by locating your design vehicle relocation distance from Line 48 on the horizontal axis of Figure 2 and then drawing a line straight up until that line intersects the acceleration time performance curve for your design vehicle. For a WB-50 semi-trailer, large school bus (S -BUS 40), or single unit (SU) vehicle, multiply the acceleration time with a correction factor obtained from Table 2 to estimate the effect of grade on the acceleration of the vehicle. Use the average grade over the design vehicle relocation distance. For design vehicle relocation distances greater than 400 feet, use Equation 1 with the appropriate parameters listed in Table 3.

Line 50. Time to clear portion of clear storage distance, in seconds, is the total amount of time required (after the signal has turned green for the approach crossing the tracks) to begin moving a queue of vehicles through the queue start-up distance (L in Figure 3) and then move the design vehicle from a stopped position at the far side of the crossing completely through the portion of clear storage distance that must be cleared (CSD* in Figure 3). This value is the sum of the time required for design vehicle to start moving (Line 45) and the time for the design vehicle to accelerate through the design vehicle relocation distance, DVRD (Line 49).

Line 51. The **Track clearance green interval** is the time required, in seconds, for the track clearance green interval to avoid the occurrence of the preempt trap and to provide enough time for the design vehicle to clear the portion of the clear storage distance specified on Line 47. The track clearance green interval time is the maximum of the minimum track clearance green time (Line 44) and the time required to clear a portion of clear storage distance (Line 50).

SECTION 6: VEHICLE-GATE INTERACTION CHECK (OPTIONAL)

Note: This section is optional and is used to calculate the required advance preemption time to avoid the automatic gates descending on a stationary or slow moving design vehicle as it moves through the minimum track clearance distance (MT CD). If this worksheet is only used to determine if additional warning time has to be requested from the railroad to ensure that vehicles have enough time to clear the crossing before the arrival of the train, this section need not be completed.

Line 52. Right-of-way transfer time, in seconds, recorded on Line 17, is the maximum amount of time needed for the worst case condition, prior to display of the track clearance green interval.

Line 53. Time required for design vehicle to start moving, recorded on Line 22, is the time (in seconds) elapsed between the start of the track clearance green interval and the time the design vehicle, which is located at the edge of the railroad crossing on the opposite side from the signalized intersection, begins to move.

Line 54. Time required for design vehicle to accelerate through the design vehicle length, DVL, is the time required for the design vehicle to accelerate through its own length. The design vehicle length is recorded on Line 20. This time value, in seconds, can be read from Figure 2 and Table 2 or looked up in Table 4 for standard design vehicles. For a WB-50 semi-trailer, large school bus, or single unit (SU) truck use the average grade over the design vehicle length at the far side of the crossing.

Line 55. Time required for design vehicle to clear the descending gates, in seconds, is the sum of the right -of-way transfer time on Line 52, the time required for design vehicle to start moving on Line 53, and the time required for design vehicle to accelerate through the design vehicle length on Line 54.

Line 56. Duration of flashing lights before gate descent start, in seconds, is the time the railroad warning lights flash before the gates start to descend. This value typically ranges from 3 to 5 seconds and must be obtained from the railroad. The value obtained from the railroad may be verified using field observation.

Table 4. Time required for the design vehicle to accelerate through the design vehicle length.

Design Vehicle	Design Vehicle Length (feet)	Grade	Acceleration Time (seconds)
Through Passenger Car	19	Level	2.6
Left Turning Passenger Car	19	Level	2.7
Single Unit Truck (SU)	30	Level to 2%	3.8
		4%	4.0
		6%	4.3
		8%	4.6
Large School Bus (S-BUS 40)	40	Level to 1%	5.5
		2%	5.5
		4%	6.1
		6%	6.6
		8%	7.0
Intermediate Semi-Trailer (WB-50)	55	Level	10.0
		2%	11.0
		4%	12.8
		6%	14.4
		8%	15.8

Line 55. Time required for design vehicle to clear the descending gates, in seconds, is the sum of the right -of-way transfer time on Line 52, the time required for design vehicle to start moving on Line 53, and the time required for design vehicle to accelerate through the design vehicle length on Line 54.

Line 56. Duration of flashing lights before gate descent start, in seconds, is the time the railroad warning lights flash before the gates start to descend. This value typically ranges from 3 to 5 seconds and must be obtained from the railroad. The value obtained from the railroad may be verified using field observation.

Line 57. Full gate descent time, in seconds, is the time it takes for the gates to descend to a horizontal position after they start their descent. This value must be obtained from the railroad and may be verified using field observation. In the case where multiple gates descend at different speeds, use the descent time of the gate that reaches the horizontal position first.

Line 58. The **Proportion of non-interaction gate descent time** is the decimal proportion of the full gate descent time on Line 57 during which the gate will not interact with (i.e. not hit) the design vehicle if it is located under the gate. This value depends on the design vehicle height, h, and the distance from the center of the gate mechanism to the nearest side of the design vehicle, d, as shown in Figure 4. Figure 5 can be used to determine the proportion of non-interaction gate descent time. Select the distance from the center of the gate mechanism to the nearest side of the design vehicle, d, on the vertical axis of Figure 5, draw a horizontal line until you reach the curve that represents the design vehicle, and then draw a vertical line down to the horizontal axis and read off the value of the proportion of non-interaction gate descent time.

Line 59. Non-interaction gate descent time is time (in seconds) during gate descent that the gate will not interact with (i.e. not hit) the design vehicle if it is located under the gate. In other words, it is the time that expires after the gate starts to descend until it hits the design vehicle if it is located under the gate. This value is calculated by multiplying the full gate descent time on Line 57 with the proportion of non-interaction gate descent time on Line 58.

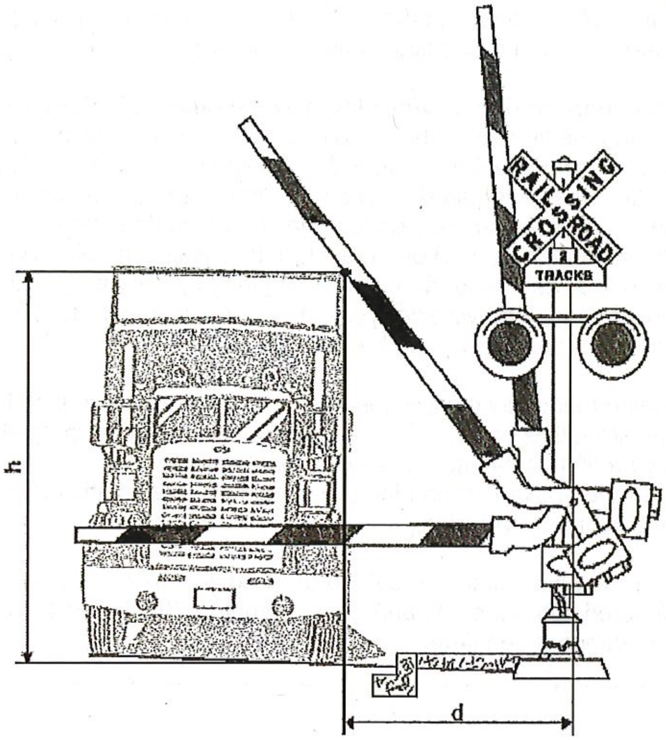


Figure 4 Gate interaction with the design vehicle.

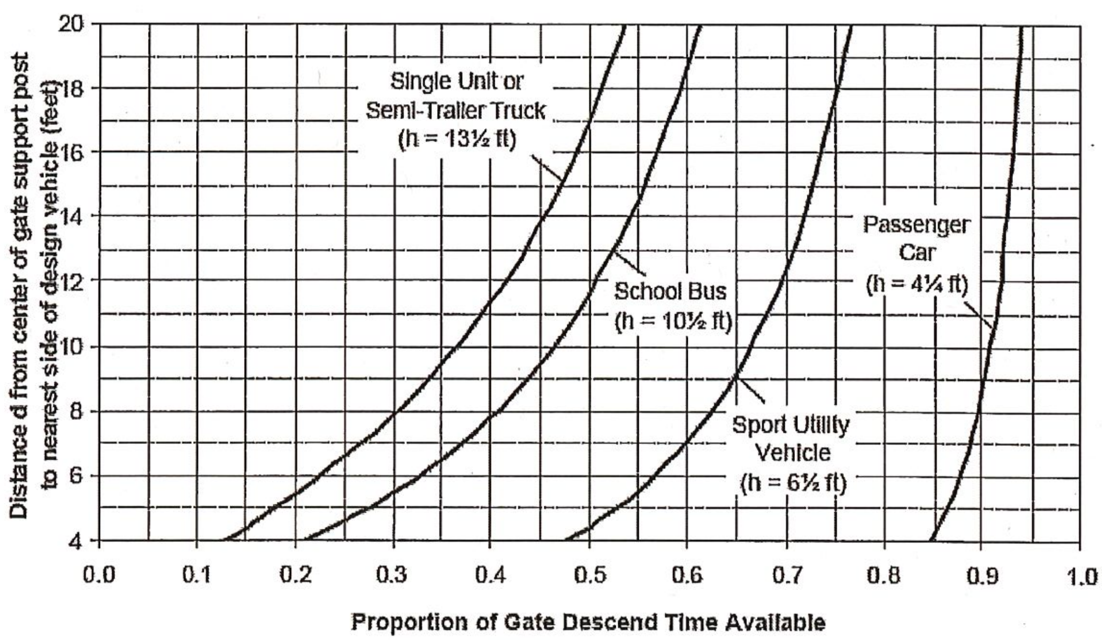


Figure 5 Proportion of gate descent time available as a function of the design vehicle height and the distance from the center of the gate mechanism to the nearest side of the design vehicle.

Line 60. Time available for design vehicle to clear descending gate, in seconds, is the time, after the railroad warning lights start to flash, that is available for the design vehicle to clear the descending gate before the gate hits the vehicle. It is the sum of the duration of the flashing lights before gate descent start (Line 56) and the non-interaction gate descent time (Line 59).

Line 61. Advance preemption time required to avoid design vehicle-gate interaction, in seconds, is calculated by subtracting the time available for the design vehicle to clear descending gate (Line 60) from the time required for the design vehicle to clear descending gate (Line 55). The result is the amount of advance preemption time that is required to avoid the gates descending on a stationary or slow-moving design vehicle. If the result of the subtraction is equal to or less than zero, it means that sufficient time is available, and you should enter zero (0) on Line 61. If the result is greater than the amount of advance preemption time provided by the railroad, as given on Line 36, there is a possibility that the gates could descend on a stationary or slow-moving design vehicle. To avoid this situation, additional advance preemption time should be requested from the railroad.

It should be kept in mind that on its own, gates descending on a vehicle is not a critical safety failure, because enough time still exists to clear the crossing before the arrival of the train, if the advance preemption time on Line 36 is provided. Therefore, local policies may vary on whether additional advance preemption time (over and above that on Line 36) should be requested solely for the purpose of prohibiting gates descending on vehicles.

If additional advance preemption time is provided to avoid design vehicle-gate interaction, Line 33 of this Worksheet has to updated, and Lines 34 and 35 recomputed. Section 5 also needs to be recomputed to calculate the track clearance green time.

BNSF RAILWAY

Version 11/10/2009

Has Form been revised for this request?

☐ YES, Revision Date:

☒ NO

HIGHWAY-RAIL GRADE CROSSING TRAFFIC SIGNAL PREEMPTION REQUEST FORM

The Road Authority traffic controller circuitry requires railroad preemption contacts to initiate the preemption sequence. Per BNSF standard, we will provide normally closed "dry" preemption relay contacts to interconnect the railroad active warning system to the Road Authority traffic signal controller assembly. These contacts are rated at 4 amps. With no trains in the area, these contacts remain closed. The Road Authority Traffic Department will be responsible for installing the interconnection cable between the traffic signal controller and the crossing warning signal control housing. If exit gates are utilized, the Road Authority Traffic Department will be responsible for installing and maintaining the "In pavement" vehicle detection loops from the street to the cable junction box.

To estimate and or design the crossing warning system, BNSF needs to know certain timing parameters.

Definitions:

"Advance Preemption" – The system will be designed to open the preemption contacts for a predetermined amount of time (Advance Preemption Time) prior to activation of the warning devices (flashing lights).

"Simultaneous Preemption" – The system will be designed to open the preemption contact at the same time the warning devices (flashing lights) are activated. Additional warning time may be requested.

"Gate Down Logic" – Per BNSF standard, we will provide normally open "dry" gate down relay contacts to interconnect the crossing warning system to the Road Authority traffic signal controller assembly. These contacts are rated at 4 amps. The system will be designed to close the gate down contacts upon the gates arrival in the down position. This logic is normally utilized to hold track clearance green until the gates are down since the time from preemption to gate down will vary depending upon the traffic signal cycle.

"Minimum Warning Time" – Per the MUTCD and FRA regulations, BNSF must provide at least 20 seconds of warning time for through trains (typically main track applications). However, per BNSF standards for constant warning time train detection equipment, the system will be designed to provide a "nominal" warning time of 30 seconds to ensure MUTCD/FRA minimums are met and to compensate for accelerating trains and ballast conditions.

"Minimum Track Clearance Distance" – For standard two-quadrant railroad warning devices, the minimum track clearance distance is the length along a highway at one or more railroad tracks, measured either from the railroad stop line, warning device or 12 ft. perpendicular to the far rail, along the centerline or edge line of the highway, as appropriate, to obtain the longer distance. For locations with exit gate warning devices, the minimum track clearance distance is the length along a highway at one or more railroad tracks, measured either from the railroad stop line or entrance warning device to the point clear of the exit gate. Note that in cases where the exit gate arm is parallel to the track(s) and/or not perpendicular to the roadway, clearance will be either along the centerline or edge line of the highway, as appropriate, to obtain the longer distance.

When (entrance) gates are used they are typically designed to start their decent within 3 to 5 seconds of the warning lights flashing, descend in an additional 10 to 15 seconds, and reach horizontal at least 5 seconds prior to train arrival per FRA regulations.

The length of the railroad's control circuit approach distance is directly related to the amount of requested "Advanced Preemption Time" (APT). Typically, the longer the APT requirement is, the longer the approach distance, and thus the more control equipment that will be required.

With the above items in mind, please provide the following information to help us process your request:

Date: 12/14/2015 Request by (name/title): Pablo Para, Transportation Manager
Crossing Street Name: W Main Street DOT #: 085655A
Parallel Street Name: C Street NW District: _____
City: Auburn County: King State: Washington
Traffic Engineer: Pablo Para Phone: 2538761958 E-mail: ppara@auburnwa.gov

1) Is this request for Simultaneous Preemption? ☐ YES ☒ NO
If "Yes" what is your requested Additional Warning Time? (If Additional Warning Time is required) _____ Seconds.

2) Is this request for Advanced Preemption? ☒ YES ☐ NO
If "Yes" what is your requested Advanced Preemption Time? 31 Seconds.

3) Will this location utilize exit gates? ☐ YES ☒ NO

The following questions should be completed if this location utilizes exit gates:

The exit gate arm(s) shall operate in one of the following modes of operation known as the EGOM (exit gate operating mode):

a. Dynamic EGOM – A mode of operation where exit gate operation is based on presence of vehicles within minimum track clearance distance (MTCD).

1) The exit gate arm(s) shall be designed to start downward motion after the vehicle detection system indicates no vehicles are located within the MTCD and any (optional) exit gate clearance time has completed timing. Note that the entrance gate arm(s) and the exit gate arm(s) may start downward motion almost simultaneously if no vehicles are located within the MTCD.

b. Timed EGOM – A mode of operation where exit gate operation is based on a predetermined time interval. This mode may be used if the vehicle detection system (Dynamic EGOM) is unhealthy.

1) The exit gate arm(s) shall be designed to start downward motion a predetermined number of seconds after the entrance gate arm(s) start downward motion. Note that the entrance gate arms(s) may or may not be fully horizontal at the time the exit gate arm(s) start downward motion. This timed value is known as the exit gate clearance time (EGCT).

1) The BNSF standard is to use Dynamic EGOM and revert to Timed EGOM if the vehicle detection system is unhealthy.
Is this operation acceptable? ☐ YES ☐ NO

2) When operating in "Dynamic" exit gate operating mode, how much exit gate clearance time (optional) do you request?
_____ seconds.

3) When operating in "Timed" exit gate operating mode how much exit gate clearance time do you request?
_____ seconds.

Comments: The city requests the following additional interconnection circuit: gate down circuit

[signature] 12/16/2015

Pablo Para

Please contact the BNSF Signal Engineering office at (913) 577- 5570 with any questions or possible changes to the above requirements.

Review of Interconnected Highway-Rail Grade Crossing

Prepared by CTC, Inc., for BNSF Railway

January 7, 2016

WA, Auburn
W Main St @ C St
DOT # 085655A, MP 21.25X
Seattle Subdivision
Line Segment 51

Review of Interconnected Highway-Rail Grade Crossing

WA, Auburn
West Main Street @ C Street
BNSF Railway
DOT# 085655A, MP 21.25X
Seattle Subdivision, Line Segment 51

Prepared by:

I hereby certify that this Report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Washington. This report represents an electronic version of the original hard copy report, sealed, signed and dated by Nicole L. Jackson, PE, PTOE. The content of the electronically transmitted report can be confirmed by referring to the original hard copy which will be kept on file with CTC, Inc.

1/8/16

Nicole L. Jackson, PE, PTOE
Washington License No. 51424

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Fort Worth, TX 76116
817-866-8210
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1.0 General Information

Advance Preemption Time[1] (APT) is being requested for the BNSF Railway (Railroad) Highway-Rail Grade Crossing (DOT# 085655A) on the Seattle Subdivision, Line Segment 51 located in Auburn, Washington near the intersection of West Main Street and C Street.

CTC, Inc. (CTC) has reviewed the above referenced highway-rail grade crossing at the request of the Railroad, which includes an analysis of the design, calculations and other documents submitted by the Agency and the Railroad. The review has been summarized in this report, which includes proposed preemption time requirements and recommendations for other improvements which may be required by the MUTCD and/or general industry practices.

In accordance with the 2009 MUTCD Chapter 8C, Section 8C.09

The Railroad acknowledges that its actions are limited to those permitted under the MUTCD and/or applicable regulatory agency and that the decision to implement any of the recommendations contained in this report rests solely with the Agency.

2.0 References

CTC utilized the following supporting documents and recommended operational practices in evaluating the preemption operation and design:

- AREMA (2014). *Manual for Communications and Signals (C&S Manual)*. Landover, MD: American Railway Engineering and Maintenance-of-Way Association (AREMA).
- FHWA (2009). *Manual on Uniform Traffic Control Devices (MUTCD)*. Federal Highway Administration (FHWA).
- FHWA (June 2008). *Traffic Signal Timing Manual, Publication No HOP-08-024, Section 5.3 - Minimum Green to Satisfy Driver Expectancy*. Federal Highway Administration (FHWA).
- FHWA (2007). *Railroad-Highway Grade Crossing Handbook - Revised Second Edition*. Federal Highway Administration (FHWA).
- FRA (July 25, 2012). *Technical Bulletin S-12-0, Guidance Regarding the Appropriate Processes for the Inspection of Highway-Rail Grade Crossing Warning System Pre-emption Interconnections with Highway Traffic Signals*. Federal Railroad Administration (FRA).
- FRA (October 1, 2010). *Federal Register Volume 75, Issue 190 - Safety Advisory 2010-02, Signal Recording Devices for Highway-Rail Grade Crossing Active Warning*

[1] **Advance Preemption Time (APT)** - The period of time that is the difference between the required maximum highway traffic signal preemption time and the activation of the railroad or light rail transit warning devices. (MUTCD, Chapter 1A, Section 1A.13)

Systems that are Interconnected with Highway Traffic Signal Systems. Federal Railroad Administration (FRA).

- ITE (2006). *Preemption of Traffic Signals Near Railroad Crossings, An ITE Recommended Practice*. Washington, DC: Institute of Transportation Engineers (ITE).
- NTSB (2003). *Collision Between Metrolink Train 210 and Ford Crew Cab, Stake Bed Truck at Highway-Rail Grade Corrsing in Burbank, California, on January 6, 2003, Highway Accident Report NTSB/HAR-03/04*. Washington, DC: National Transportation Safety Board (NTSB).
- TRB (2003). *National Cooperative Highway Research Program (NCHRP), Report 493, Evaluation of Traffic Signal Displays for Protected/Permissive Left-Turn Control.* Transportation Research Board TRB).
- TRB (1999). *National Cooperative Highway Research Program (NCHRP), Synthesis 271, Traffic Signal Operations near Highway-Rail Grade Crossings. Chepater 3, Highway Traffic Signals near Highway-Rail Grade Crossings.* Transportation Research Board (TRB).
- TTI (March 2002). *Report 1752-9, The Preempt Trap: How to Make Sure You Do Not Have One*. Texas A&M Transportation Institute (TTI).
- TXDOT (March 2009). *Form 2304 Instructions, Instructions for the Guide for Determining Time Requirements for Traffic Signal Preemption at Highway Grade Crossings*. Texas Department of Transportation (TXDOT).
- TXDOT (March 2009). *Form 2304, Guide for Determining Time Requirements for Traffic Signal Preemption at Highway Grade Crossings*. Texas Department of Transportation (TXDOT).
- WSDOT (December 2011). Washington Modifications to the Federal Manual on Uniform Traffic Control Devices. Washington Department of Transportation (WSDOT).

Unless otherwise noted, the analysis of the proposed traffic signal railroad preemption was based on the following document submitted by the Agency:

- Preemption Calculation Form dated August 25, 2015

  CTC Inc

3.0 Contact Information

Agency:

Scott Nutter
Traffic Operations
City of Auburn
25 West Main Street
Auburn, WA 98001
253-804-5068
snutter@auburnwa.gov

Railroad:

Rick Wagner
Manager of Public Projects
BNSF Railway
2454 Occidental Avenue South, Suite 2D
Seattle, WA 98134
206-625-6152
richard.wagner@bnsf.com

4.0 Preemption Design Elements

The Agency must consider several elements when proposing a railroad preemption design. The design should incorporate such elements as, but not limited to, current roadway conditions, traffic signal controller functional capabilities, future site improvements, as well as, other mitigating conditions. The design elements used in this review are outlined below:

- The Railroad operates on two main line tracks through the crossing.
- There is one lane over the tracks approaching the intersection with C Street.
- Flashing-light signals with automatic gates are provided at the crossing.
- Overhead railroad flashing-light signals are provided for eastbound and westbound West Main Street.

Aerial of subject crossing:

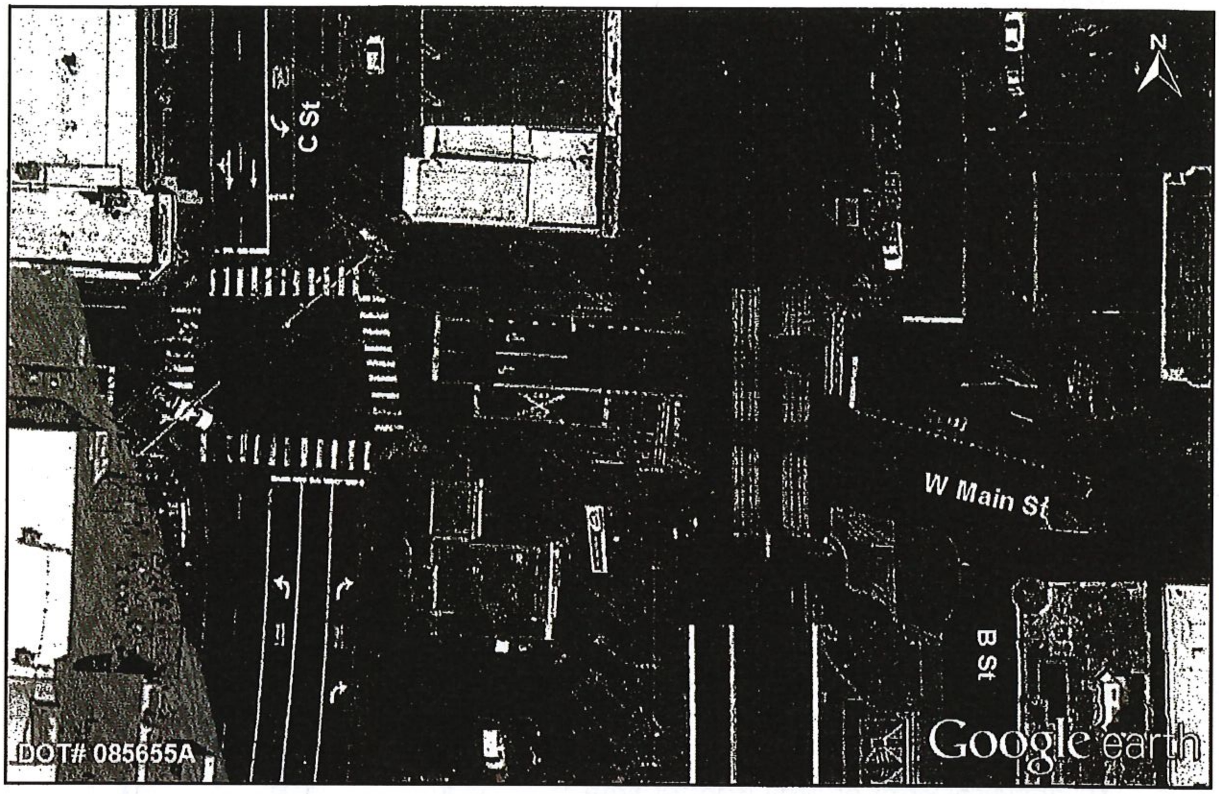


Figure 1 - DOT# 085655A; W Main St @ C St

The preemption calculation design values used in the determination of the amount of APT being requested are outlined below:

- The design vehicle overall length provided on the preemption calculation form is a 55-ft. tractor-trailer.
- The Clear Storage Distance[2] (CSD) of 120 feet was provided on the preemption calculation form.
- The Minimum Track Clearance Distance[3] (MTCD) of 58 feet was provided on the preemption calculation form.

[2] **Clear Storage Distance** - The distance available for vehicle storage measured between 6 feet from the rail nearest the intersection to the intersection stop line or the normal stopping point on the highway. (MUTCD, Chapter 1A, Section 1A.13)

[3] **Minimum Track Clearance Distance** – For standard two-quadrant warning devices, the minimum track clearance distance is the length along a highway at one or more railroad or light rail transit tracks, measured from the highway stop line, warning device, or 12 feet perpendicular to the track center line, to 6 feet beyond the furthest track(s) measured perpendicular to the far rail, along the center line or edge line of the highway, as appropriate, to obtain the longer distance. (MUTCD, Chapter 1A, Section 1A.13)

- The roadway grade approaching, over and departing the MTCD does not exceed 1½ %.

The measurements provided on the preemption calculation form were reviewed in Google Earth, but were not field verified by CTC.

The traffic signal controller is an Econolite ASC3.

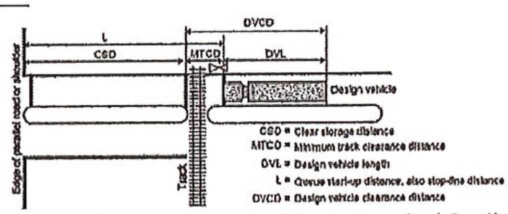
The traffic signal controller firmware is Econolite.

The proposed Right-of-Way Transfer Time[4] provided on the preemption form:

	Proposed Values (Seconds)
Controller Preemption Delay Time[5]	0.0
Controller Preemption Response Time[6]	0.0
Minimum Green before Track Clearance	5
Walk before Track Clearance	0
Pedestrian Change before Track Clearance*	18
Yellow Change before Track Clearance	4.0
Red Clearance before Track Clearance	1.0
Additional Right-of-Way Transfer Time	0.0
Maximum Right-of-Way Transfer Time	**23.0**

Table 1 - Right-of-Way Transfer Time

** Pedestrian Intervals time concurrently with minimum green time.*



[4] **Right-of-Way Transfer Time** – The maximum amount of time needed for the worst case condition, prior to the display of the track clearance green interval. This includes any railroad or light rail transit or highway traffic signal control equipment time to react to a preemption call, and any traffic control signal green, pedestrian walk and clearance, yellow change, and red clearance intervals for conflicting traffic. (MUTCD, Chapter 1A, Section 1A.13)

[5] **Controller Preemption Delay Time** – The traffic signal controller programmed time between receipt of the preemption call and initialization of the preemption sequence.

[6] **Controller Preemption Response Time** – Time provided by the traffic signal controller application designer to account for controller reaction time of individual components prior to initiating activation of the preemption sequence.

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5.0 Proposed Railroad Preemption Values

As a result of the design and preemption calculation review, the following outlines the proposed APT requested by the Agency:

The APT requested by the Agency is 31 seconds (Line 35 of the Preemption Calculation Form).

For more details regarding the preemption values, see the preemption calculation form in appendix B.

6.0 Recommendations for the Agency

As a result of the plan review, CTC proposes the following recommendations for Agency consideration to improve the operation of the preemption system. The Agency is the authority regarding the design and operation of the preemption system in accordance with the MUTCD Chapter 8C, Section 8C.09.

Note: Should the Agency decide to pursue the following recommendations, the Agency should be aware that multiple solutions exist for any recommendation. The Agency should perform due diligence to determine the solution(s) or product(s) that best meet site-specific conditions for the highway-rail grade crossing.

2009 MUTCD Chapter 8C, Section 8C.09 Paragraph 6

"The highway agency or authority with jurisdiction and the regulatory agency with statutory authority, if applicable, should jointly determine the preemption operation and the timing of traffic control signals interconnected with highway-rail grade crossings adjacent to signalized highway intersections."

The Railroad is available to assist the Agency with any of the proposed recommendations.

<u>Recommendations:</u>

- **Review traffic signal controller hardware and firmware capabilities for railroad preemption.** The traffic signal controller is an integral part of the operation of the preemption system and understanding the traffic signal controller functionality during railroad preemption is critical to the safety of the preemption operation. Many conditions such as, but not limited to, coordinated operation, train restart or second train events, emergency vehicle preemption, transit priority, or manual control will alter the operation of the traffic signal controller when those conditions are in effect.

CTC Inc

The Agency must thoroughly inspect and test the functionality of the traffic signal controller and firmware to ensure the recommended railroad preemption features can be provided. Periodic updates or revisions to the controller unit firmware or hardware may negatively affect the operation and/or programming parameters of the traffic signal controller. Any change in the firmware or hardware should be followed by a performance test in order to assure that the traffic signal controller is functioning in accordance with the design plans.

- **Review traffic signal controller capabilities for train restart or second train event.** Due to the potential of a train stopping and restarting within the approach of the crossing and the potential for a second train event, the traffic signal controller may not be able to transition back to the track clearance interval to provide a sufficient amount of time to clear the design vehicle from the MTCD. Modifications or additional logic may be needed for the traffic signal controller to provide the transition to the track clearance interval during the event.

- **Ensure that the actual right-of-way transfer time during railroad preemption does not exceed the design value of 23 seconds (see the preemption calculation form in appendix B).** If the right-of-way transfer time is programmed to exceed this value, then additional APT would need to be requested by the Agency.

- **Review the preemption operation of the traffic signal controller and make the appropriate modifications to ensure adequate Track Clearance Green Time[A] is provided to clear the design vehicle from the MTCD.** The track clearance green time is the period of time programmed into the traffic signal controller that the green indication is displayed to vehicles stopped within the CSD and MTCD. The track clearance green indication affords these vehicles an opportunity to start and move clear of the track provided there is adequate railroad warning time. It is critical that the track clearance green not end until after the flashing-lights have started their operation and the automatic gate arms have reached the horizontal position. The recommended practice to ensure that the traffic signal sequence does not terminate the track clearance interval early is to implement a gate down circuit.

  - **A gate down circuit is not specified in the documents provided.** If the Agency elects not to implement the gate down circuit, then the Agency must request a not-to-exceed advance preemption timer be implemented in the railroad warning system in order to limit APT which exceeds the specified APT. Additional APT can result from variability in train speed. The Agency must also determine the traffic signal preemption time variability and increase the track clearance green time appropriately.

    CTC does not take exception to the track clearance green time of 65 seconds noted on line 51 of the preemption calculation form, provided a not-to-exceed advance preemption timer has been implemented in the railroad warning system.

➢ **Improve the interconnection circuits between the traffic signal controller and the railroad warning system and ensure the interconnection cable has an adequate number of conductors for the circuits requested.** The interconnection between the traffic signal controller and the railroad warning system requires careful consideration as to the types of circuits to be utilized. In older installations, the majority of interconnection circuits used a single pair of wires to initiate the preemption sequence in the controller unit. However, experience and extensive research on railroad preemption operation has revealed that additional interconnection circuits are necessary in order to assure that the highway-rail grade crossing and highway-highway intersection are operating together as one system. Dependent on the location, the number of circuits that would be utilized in the preemption system generally vary from two to five. Some complex systems could require more than five circuits. Intersection geometry, phasing, pedestrian considerations, type of controller unit, train volumes, train speeds and passenger station stops are all factors which must be considered in order to determine which circuits are necessary.

The following list identifies the most commonly used interconnection circuits:

- <u>Advance Preemption Circuit</u>[B] - This circuit begins the preemption sequence when the railroad warning system first notifies the traffic signal controller of the approaching train.

- <u>Supervised Circuit</u>[C] - This circuit provides a means to verify the integrity of the interconnection cable between the traffic signal controller and the railroad warning system. The purpose is to provide notification to the traffic signal controller in the event there is a failure (open or short) in the cable or associated circuitry.

- <u>Crossing Active Circuit</u>[D] - This circuit will notify the traffic signal controller of an approaching train at the point the active warning devices (railroad flashing-lights) begin their operation. This circuit is commonly referred to as an "XR" or "XC" circuit by the railroad. It is also the circuit typically used for "Simultaneous Preemption." By using the crossing active circuit, the traffic signal controller can be notified when the railroad flashing-lights and automatic gates begin operation, and adjustments to the preemption sequence can be implemented as programmed.

- <u>Gate Down Circuit</u>[E] - This circuit will notify the traffic signal controller when the automatic gate arms controlling access to the railroad tracks are lowered to within approximately five (5) degrees of horizontal. This circuit prevents the traffic signal controller from terminating the track clearance green prior to the railroad warning devices becoming active and the lowering of the automatic gates.

- Traffic Signal Health Circuit[E] - Where there is an advance preemption circuit, the traffic signal health circuit may be used to notify the railroad warning system if the traffic signal has an operational failure where the traffic signals are flashing or dark. When the traffic signal health circuit has de-energized, the railroad warning system devices may be activated early. The amount of additional time the railroad warning devices will be active can be extended up to the APT provided by the train detection equipment. By activating the systems early, the automatic gates will be lowered, preventing additional traffic from queuing onto the tracks and affording a longer period of time for stopped vehicles to start up and move clear of the tracks.

Note: The Agency must notify the Railroad which circuits are being requested at each location.
Another item to be addressed as a part of the interconnection determination is the electrical arrangement of the circuits. There are three possible interconnection options:

1. Single Break[G] with Supervision – This option provides a means to open a single energy source conductor through the railroad circuitry. In order to provide a means to verify the integrity of the interconnection cable between the traffic signal controller and the railroad warning system, an additional conductor is provided that closes upon approach of a train. This is known as a supervised circuit.

2. Double Break[H] – This option provides a means to open both the positive and negative or line and neutral energy source leads through the railroad circuitry. By opening both conductors of the circuit, a level of reliability equal to single break with supervision is achieved.

3. Double Break with Supervision - This option makes use of #1 and #2 where both conductors are opened through the railroad circuitry and a supervision circuit is included. By opening both conductors of the circuit and providing a supervision circuit, a higher level of reliability is achieved.

There are several railroad preemption interface methods[I] that have been used successfully to implement the above circuits. Examples can be found in appendix A.

➢ **Implement a Maximum Preemption Timer[J].** The purpose of this timer is to allow the traffic signal to transition to an all-red flash mode in the event the railroad warning system "fails-safe" for an extended period of time.

➢ **Ensure yellow trap (lagging yellow left turn condition) is eliminated during the transition to the track clearance interval.** The existing left turn movement opposing the track clearance phase operates in a protected/permissive mode. This can create a yellow trap condition that displays a circular yellow indication for the left turn

CTC Inc

movement opposing the track clearance phase during the transfer to the track clearance interval. *(Refer to NCHRP Report 493, page 16, Heading: Lead-Lag Phasing With PPLT Control)*.

The following methods may be implemented at this location to resolve this condition:

- Protected only mode left turn operation for the approach opposing the track clearance direction.
- Controller programming to provide a transition through an all-red signal display to eliminate the lagging yellow. It should be noted that not all controllers are capable of providing this operation.
- Split phase sequence for the movement where the lagging yellow occurs.
- Implementation of Flashing Yellow Arrow Operation to eliminate the lagging yellow and retain the protected/permissive mode left turn operation.

➢ **Install a back-up power supply for the traffic signal equipment.** When local power outages occur, a dark traffic signal loses its ability to provide a track clearance interval. Railroad warning devices are required to be equipped with a back-up power supply to provide continuous operation for a number of hours. With the advent of LED technology, back-up power for traffic signals is now a realistic option. A back-up power supply maintains the operation of the traffic signal and its ability to display a track clearance interval. The MUTCD recommends the use of back-up power for interconnected signals in Chapter 4D, Section 4D.27.

➢ **Install "DO NOT STOP ON TRACKS" signs (R8-8).** Vehicles may extend over the tracks based on the existing preemption system operation and the installation of these signs provides additional emphasis to alert road users not to stop on the tracks.

➢ **Implement a Preemption Operation and Maintenance Program[K].** In accordance with the FRA Safety Advisory 2010-02 and FRA Technical Bulletin S-12-01, a comprehensive joint inspection program should be established between the Agency and the Railroad to provide, at a minimum, an annual operational test of the preemption system. Operational tests should also be conducted when traffic signal controller changes are made, including firmware updates.

The Agency should develop a notification plan to contact the Railroad in the event the traffic control signal fails to operate as intended. The Agency should also develop a traffic management plan for special events or construction to help prevent motorists from stopping on the tracks as a result of the downstream traffic queues.

➢ **Install a warning label as recommended by the U.S. Department of Transportation Highway-Rail Grade Crossing Technical Working Group (USDOT TWG) in the traffic**

signal cabinet to alert traffic signal technicians to the presence of the interconnection with the railroad control equipment.

- **Work with the Railroad to determine if additional railroad flashing-light signals are needed to face southbound B Street Northwest, which is located approximately 35 feet east of the crossing.**

7.0 Conclusion

This report recommends preemption operational improvements that the Agency should consider as a result of CTC's design review. The Agency should contact the Railroad to review recommendations contained in this report and to resolve issues. If desired, the Agency may contact the Railroad to assist with implementing any recommendations, answer questions or participate in a diagnostic team inspection to review outstanding items and progress changes that may be needed.

APPENDIX A – End Notes

[A] Track Clearance Green Time:

The track clearance green time is the period of time programmed into the traffic signal controller that the green indication is displayed to vehicles stopped within the MTCD and the CSD. It is determined by calculating the time required for a design vehicle of maximum length to start up and move clear of the MTCD prior to the arrival of the train under normal conditions. The rule-of-thumb to determine the amount of track clearance green time is to use the greater of either the queue clearance time (time required for the design vehicle to start up and clear the MTCD) or a value 15 seconds greater than the APT (track clearance green time = APT+15) provided the railroad has a not-to-exceed advance preemption timer in their circuitry. Since the railroad warning devices activate following the APT and the automatic gate arm reaches the horizontal position approximately 15 seconds after activation of the warning devices, this rule-of-thumb estimates the track clearance green time needed to keep the track clearance interval green until the automatic gates are horizontal for a best case right-of-way transfer time condition (usually 0 seconds). If the railroad does not have a not-to-exceed advance preemption timer in their circuitry, a thorough analysis of train operations must be conducted in order to determine the effect of train deceleration on the preemption operation. It should be noted that this method may lead to inefficient traffic signal operations as it will hold the track clearance interval in green after the automatic gate is down when the actual right-of-way transfer time is not best case. Also, this rule-of-thumb should be considered an interim measure due to the fact that it does not take into account variability in actual APT versus design APT caused by accelerating or decelerating trains. Where APT is implemented, a gate down circuit is the preferred and best method for determining when to terminate the track clearance interval, but may require additional interconnect capabilities.

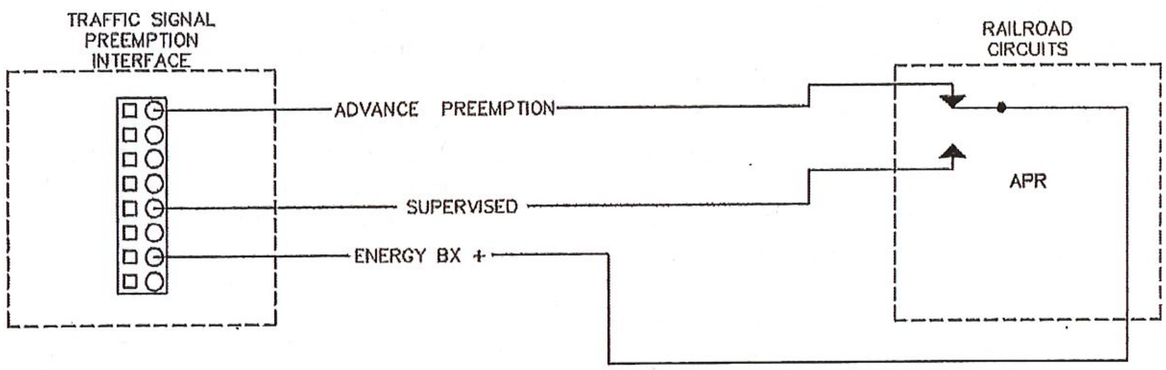
[B] Advance Preemption Circuit:

The advance preemption circuit will notify the traffic signal controller of an approaching train prior to the activation and operation of the railroad active warning devices. The period of time between this notification and the instant when the grade crossing warning devices are activated is known as APT. APT is used by the traffic signal controller to terminate any active non-track clearance movements and to change to a programmed track clearance interval.

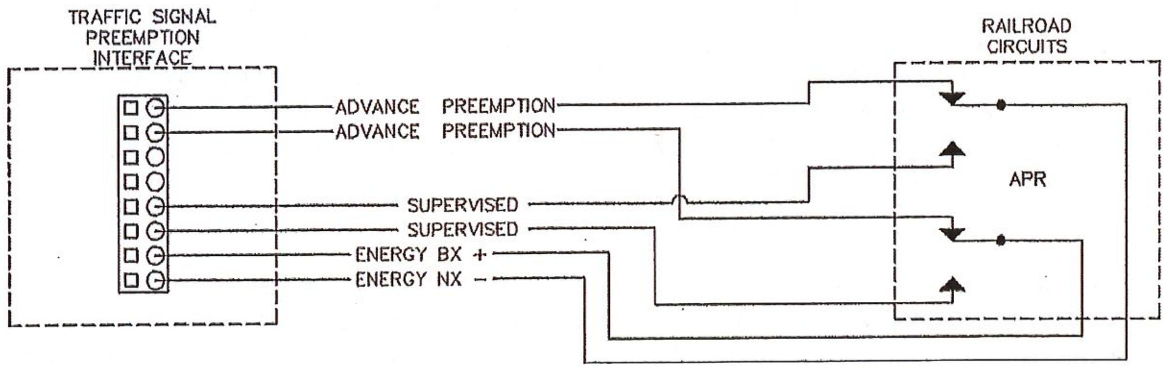
[C] Supervised Circuit:

The supervised circuit is an additional circuit that works in conjunction with either the advance preemption circuit or the crossing active circuit ("XR" or "XC" circuit). The supervised circuit closes when the advance preemption circuit or crossing active circuit ("XR" or "XC" circuit) opens, providing a means to verify the integrity of the interconnection cable between the traffic signal controller and the railroad warning system. The purpose of this circuit is to provide notification to the traffic signal controller in the event there is a failure (open or short) in the cable or associated circuitry. Potential failure can occur for a variety of reasons. Examples include: 1) a utility inadvertently digs up the cable and severs the wire; 2) shorting the wires or cable or; 3) if the interconnect cable connection is loose in one or both cabinets. With a supervised circuit, the traffic signal will be notified of the cable failure and respond as programmed. One possible response includes first clearing the tracks and then displaying all-way flashing red signals, in order to quickly gain attention of the Agency that a problem exists. This response allows all traffic movements at the intersection to continue. Once the Agency is notified of the all-red flashing signals, repairs must be made in order to return the traffic signal to normal operation, since the supervised circuit will not allow the traffic signal to operate with failed preemption interconnect cable. Below are examples of a supervised circuit applied to a single-break advance preemption circuit and to a double-break advance preemption circuit:

Supervised Advance Preemption Circuit Single-Break



Supervised Advance Preemption Circuit Double-Break



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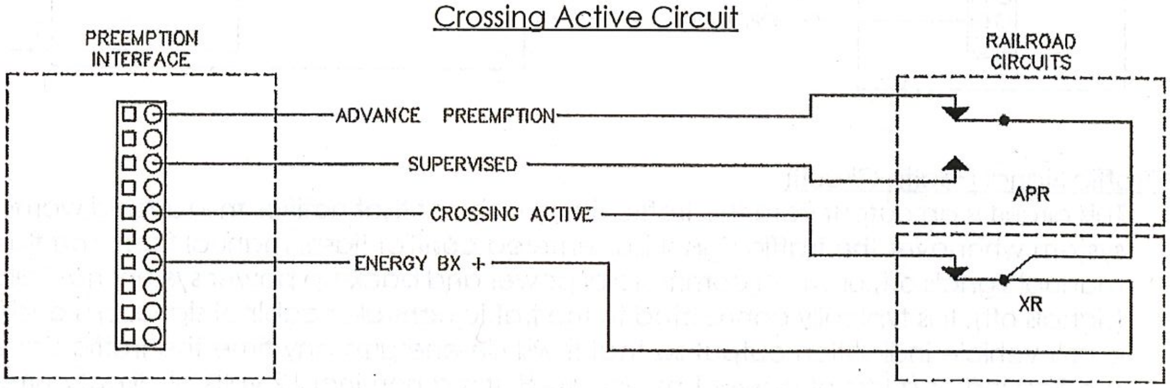
D Crossing Active Circuit:

This circuit, commonly referred to as "XR" or "XC", can be utilized to check the minimum APT provided by the railroad in varying conditions, such as when a train approaches and stops short of the crossing. Once the train remains stopped for approximately 20 seconds, the crossing warning system will usually de-activate, the preemption request will be cancelled, and the automatic gates will rise. When the train begins to move toward the crossing after this time period, the result can be reduced or no APT. In this case, the operation of the train over the crossing will be governed by operating rules of the railroad. These rules generally require the train crew to assure the crossing is clear prior to entering the roadway. When the APT is shortened or eliminated, the traffic signal sequence should advance to the track clearance green interval as quickly as possible. Therefore, the traffic signal controller may be required to abbreviate or eliminate the minimum green time and/or pedestrian change intervals from its normal sequence. By using the crossing active circuit, the traffic signal controller can be notified when the railroad flashing-lights and automatic gates begin operation and adjustments to the preemption sequence can be implemented as programmed.

Crossing Active Circuit



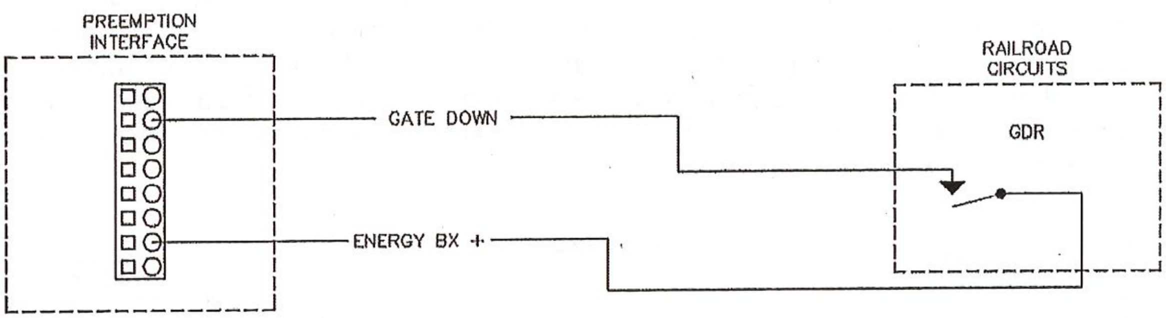
E Gate Down Circuit:

A gate down circuit will notify the traffic signal controller when the automatic gate arms controlling access over the railroad tracks approaching the intersection are lowered to within approximately five (5) degrees of horizontal. This circuit prevents the traffic signal controller from terminating the track clearance green interval before the railroad warning devices become active and the automatic gates are lowered.

It is critical that the track clearance green interval not end until after the flashing-lights have started their operation and the automatic gate arms warning vehicles approaching the intersection have reached the horizontal position. A preemption anomaly occurs if, due to time variability in the preemption sequence, the track clearance green ends before the automatic gate arms are not yet lowered. This may allow vehicles to continue to cross and queue onto the railroad tracks in the path of the approaching train, also known as a preempt trap, found in TTI Report 1752-9.

Although a gate down circuit should be implemented to improve safety, it also improves traffic operations by minimizing the excessive track clearance green time displayed. If there is not a gate down circuit present, the track clearance green time must be increased to account for right-of-way transfer time variability, train speed variability, track circuit design and other variable conditions. This timing correction may result in excessive track clearance green times that extend long after the automatic gates have already reached their horizontal position. For many traffic signal controller units, the implementation of gate down circuitry is straightforward and inexpensive.

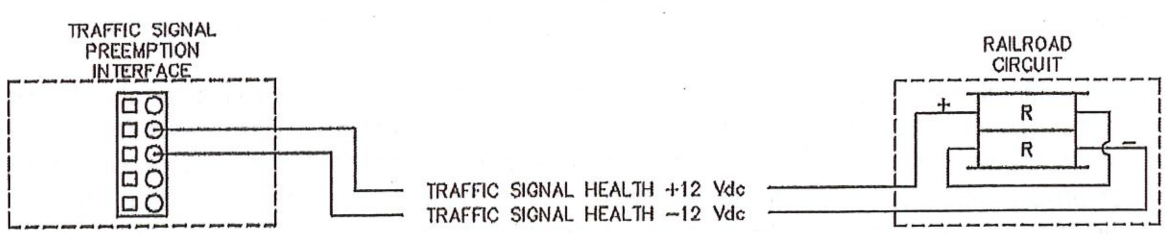
Gate Down Circuit



F Traffic Signal Health Circuit:

This circuit is an output from the traffic signal cabinet that notifies the railroad warning system whenever the traffic signal has entered conflict flash, manual flash, soft flash, manual signals off, or when commercial power and back-up power system has failed (signals off). It is typically connected to the traffic controller cabinet signal bus and/or a red vehicle indication output so that it will de-energize any time the traffic signals are flashing or a loss of power has occurred. It is a nominal 12 volts of direct current (V dc), which is output whenever the traffic signal is not in flash operation and power is on. If the traffic signal is in flash operation or the power is off, the output becomes 0 V dc. The output should be fused for 500 mA @ 12 V dc.

Traffic Signal Health Circuit



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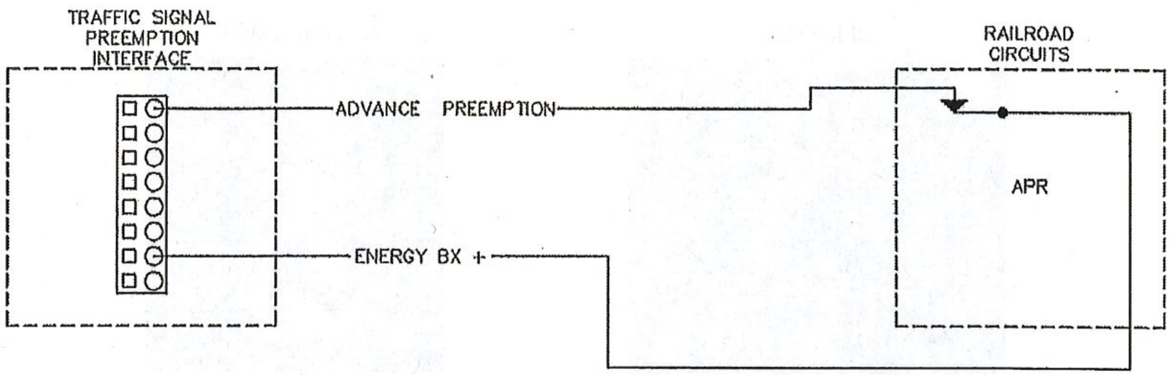
G Single-Break Interconnect Circuit:

A single-break interconnect circuit is a preemption interconnection circuit design technique where only one energy source lead is opened or closed through a control circuit or relay. It is not considered to be the most reliable method to activate or de-activate a circuit in a separate control case or cabinet by the railroad signal industry. This circuit design technique can be applied to all interconnection circuits. Below is an example of a single-break advance preemption circuit:

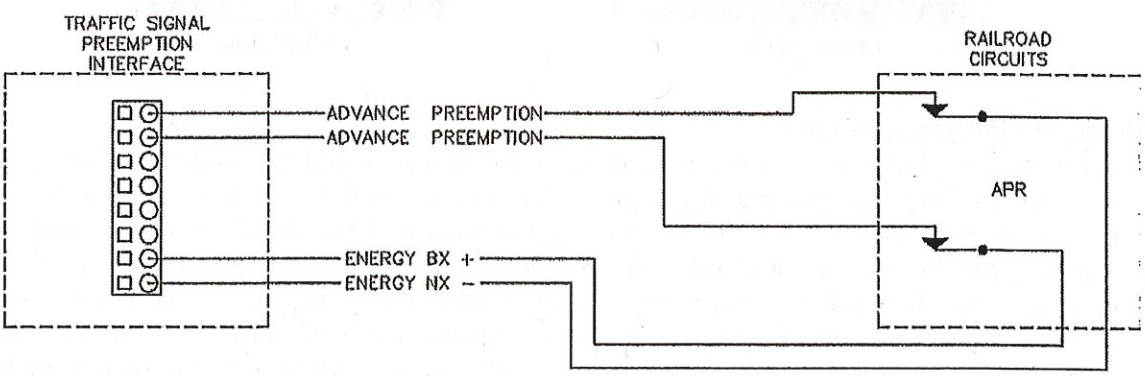
Advance Preemption Single-Break Circuit



H Double-Break Interconnect Circuit:

A double-break interconnect circuit is a preemption interconnection circuit design technique where both the positive and negative or line and neutral energy source leads are open or closed through a control circuit or relay. It is considered to be the most reliable method to activate or de-activate a circuit in a separate control case or cabinet by the railroad signal industry. This circuit design technique can be applied to all interconnection circuits. Below is an example of a double-break advance preemption circuit:

Advance Preemption Double-Break Circuit



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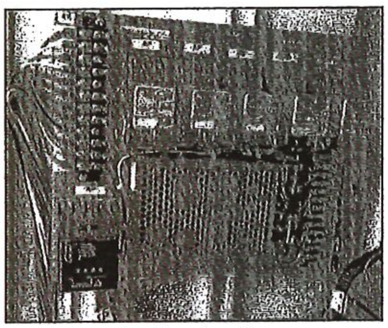
I Railroad Preemption Interface Methods:

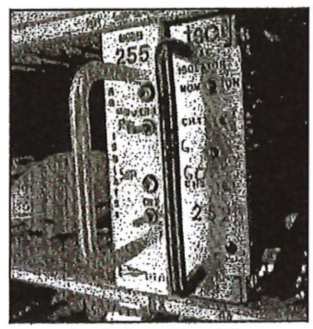
Where railroad preemption is required, various interconnection circuits can be used between the railroad warning system and the traffic signal controller for railroad preemption. In order for the interconnect circuits to interface with the traffic signal controller and railroad warning system, additional equipment is required in the traffic signal cabinet. As a general rule, traffic signal equipment manufacturers and distributors have the ability to provide the various interconnection circuits required for a specific application. Below are pictures of various methods used by agencies for implementation of interconnection circuits.

Ohio DOT



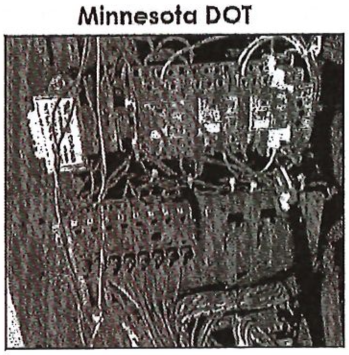
Relay Logic

Wyoming DOT



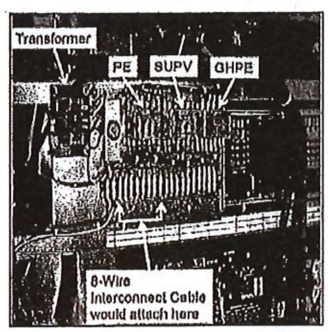
Isolator Card &
Traffic Controller Logic

Minnesota DOT



Relay Logic

Missouri DOT



Relay Logic

J Maximum Preemption Timer:

A maximum preemption timer is a timer in the traffic signal controller that limits the amount of time the preemption can be in effect. Implementation of a maximum preemption timer does require additional interconnection circuits from the railroad. The purpose of this timer is to allow the traffic signal to exit the preemption sequence in the event the railroad warning system "fails-safe". Because railroad warning systems are safety critical systems, they are designed in such a manner as to fail in a "safe" state in the event of a non-catastrophic fault. What this means is that the warning devices will operate to indicate that it is not safe to proceed even when no

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train is present. This is a "safe" failure mode. However, when a fail-safe condition occurs, the traffic control signal will remain in preemption if a maximum preemption timer has not been provided. Because of the limited sequence operation during the dwell interval, non-allowable movements are inhibited. Road users may become frustrated and attempt to make moves against a red traffic signal indication. The maximum preemption timer will cause the traffic signal to transition to all-red flash after a predetermined period of time until the preemption circuit returns to its normal state, at which time normal operation of the traffic signal resumes.

Note: Although it is the decision of the Agency as to the value programmed for the maximum preemption time, the Agency should take caution to ensure that the time is not set to a value that is too short. If the time set is too short, the timer could expire and place the traffic signal into all-red flash while a train is occupying the crossing. Therefore, the maximum preemption time should be set to a value two times greater than the longest train move, which may include switching moves.

Not all traffic signal manufactures have the ability to program a maximum preemption timer in the controller unit that will cause the traffic signal to transition to all-red flash after a predetermined period of time and/or exceed a maximum allowed value of 255 seconds. In those cases, an external timing relay may be used to implement the maximum preemption time operation.

K Implement a Preemption Operation and Maintenance Program:

In accordance with the FRA Safety Advisory 2010-02, a joint program should be established between the Agency and the Railroad to provide for an annual (minimum) operational test of the preemption system.

- The program should provide for a joint inspection with a representative from the Agency and the Railroad.
- The program should require a live operational test of the system under the maximum right-of-way transfer time condition.
- The program should include review of data recorder logs, where available, to verify proper operation of the system.
- The program should determine that no operational changes have been made to the grade crossing, warning system, roadway, traffic control signal or other facility that modifies the operation of the system as it is presently functioning.

Develop a plan to notify the Railroad in the event the traffic control signal fails to operate as intended.

The plan should include the following elements:

- If the traffic control signal enters flashing mode, notify the Railroad and provide law enforcement or flaggers to allow for the safe movement of roadway users over the grade crossing.

- If the traffic control signal loses power or all of the signals are dark, notify the Railroad and provide law enforcement or flaggers to allow for the safe movement of roadway users over the grade crossing.
- Notify the Railroad once the system has been restored to normal operation.

If a traffic signal technician is required to perform a joint test of the preemption system, notify the Railroad.

Implement procedures to provide flagging or other suitable temporary traffic control plan in the event a lane closure or traffic density caused by a high traffic volume event that has been planned downstream from the grade crossing causes roadway users to queue onto the crossing. (See MUTCD Section 8A.08 for additional information.)

Notify the Railroad any time changes are made to the roadway, the traffic control signal, or preemption operation, in accordance with MUTCD, Section 8A.02 Paragraph 6.

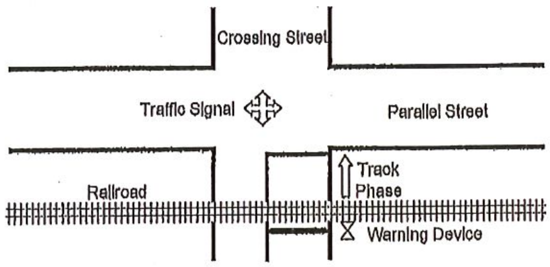
APPENDIX B – Preemption Calculation Form

GUIDE FOR DETERMINING TIME REQUIREMENTS FOR TRAFFIC SIGNAL PREEMPTION AT HIGHWAY RAIL GRADE CROSSINGS

City: Auburn
County: King
District:

Date: 08/25/15
Completed by: Scott Nutter
District Approval:

Show North Arrow



Parallel Street Name: C Street NW
Crossing Street Name: West Main Street

Railroad: BNSF
Crossing DOT#: 085655A

Railroad Contact: Richard Wagner
Phone: (206) 625-6152

SECTION 1: RIGHT-OF-WAY TRANSFER TIME CALCULATION

Preempt verification and response time

			Remarks
1. Preempt delay time (seconds)	1.		Econolite
2. Controller response time to preempt (seconds)	2.		Controller type: ASC III
3. Preempt verification and response time (seconds): add lines 1 and 2	3.	0.0	

Worst-case conflicting vehicle time

			Remarks
4. Worst-case conflicting vehicle phase number	4.	4	
5. Minimum green time during right-of-way transfer (seconds)	5.	5.00	
6. Other green time during right-of-way transfer (seconds)	6.		
7. Yellow change time (seconds)	7.	4.00	
8. Red clearance time (seconds)	8.	1.00	
9. Worst-case conflicting vehicle time (seconds): add lines 5 through 8	9.	10.0	

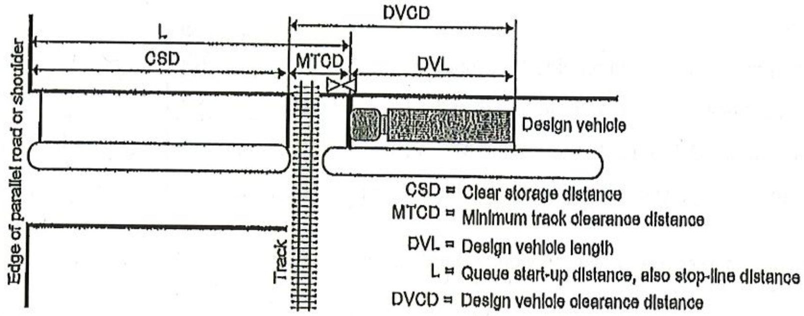
Worst-case conflicting pedestrian time

			Remarks
10. Worst-case conflicting pedestrian phase number	10.	8	
11. Minimum walk time during right-of-way transfer (seconds)	11.	0.0	
12. Pedestrian clearance time during right-of-way transfer (seconds)	12.	18.0	
13. Vehicle yellow change time, if not included on line 12 (seconds)	13.	4.0	
14. Vehicle red clearance time, if not included on line 12 (seconds)	14.	1.0	
15. Worst-case conflicting pedestrian time (seconds): add lines 11 through 14	15.	23.0	

Worst-case conflicting vehicle or pedestrian time

16. Worst-case conflicting vehicle or pedestrian time (seconds): maximum of lines 9 and 15	16.	23.0
17. **Right-of-way transfer time (seconds): add lines 3 and 16**	17.	23.0

SECTION 2: QUEUE CLEARANCE TIME CALCULATION



		Remarks
18. Clear storage distance (CSD, feet) ....18.	120	Accounts for Future third rail -20 ft
19. Minimum track clearance distance (MTCD, feet) ....19.	58	
20. Design vehicle length (DVL, feet) ....20.	55	Design vehicle type: Truck restrictions in pl

21. Queue start-up distance, L (feet): add lines 18 and 19 .... 21. **178**

22. Time required for design vehicle to start moving (seconds): calculate as 2+(L÷20) ......22. **10.9** Remarks: ____

23. Design vehicle clearance distance, DVCD (feet): add lines 19 and 20 ....23. **113**

24. Time for design vehicle to accelerate through the DVCD (seconds) .... 24. **14.7** Read from Figure 2 in Instructions.

25. Queue clearance time (seconds): add lines 22 and 24 .... 25. **25.6**

SECTION 3: MAXIMUM PREEMPTION TIME CALCULATION

		Remarks
26. Right-of-way transfer time (seconds): line 17 .... 26.	23.0	
27. Queue clearance time (seconds): line 25 .... 27.	25.6	
28. Desired minimum separation time (seconds) .... 28.	4.0	

29. Maximum preemption time (seconds): add lines 26 through 28 .... 29. **52.6**

SECTION 4: SUFFICIENT WARNING TIME CHECK

			Remarks
30. Required minimum time, MT (seconds): per regulations ....30.	20.0		
31. Clearance time, CT (seconds): get from railroad ....31.	2.0		
32. Minimum warning time, MWT (seconds): add lines ....32.		22.0	Excludes buffer time (BT)
33. Advance preemption time, APT, if provided (seconds): get from railroad ..... 33.			

34. Warning time provided by the railroad (seconds): add lines 32 and 33 ....34. **22.0**

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. **31**

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, 5, 6, 7, 8, 11, 12, 13 and 14.

Remarks: ____

SECTION 5: TRACK CLEARANCE GREEN TIME CALCULATION (OPTIONAL)

Preempt Trap Check

36. Advance preemption time (APT) provided (seconds): .... 36. 31.0 — Line 33 only valid if line 35 is zero.
37. Multiplier for maximum APT due to train handling .... 37. 1.60 — See instructions for details.
38. Maximum APT (seconds): multiply line 36 and 37 .... 38. 49.6
39. Minimum duration for the track clearance green interval (seconds) 39. 15.0

Remarks
For zero advance preemption time

40. Gates down after start of preemption (seconds): add lines 38 and 39 .... 40. 64.6

41. Preempt verification and response time (seconds): line 3 .... 41. 0.0
42. Best-case conflicting vehicle or pedestrian time (seconds): usually 0........ 42. 0.0

Remarks

43. Minimum right-of-way transfer time (seconds): add lines 41 and 42 .... 43. 0.0

44. Minimum track clearance green time (seconds): subtract line 43 from line 40 .... 44. 64.6

Clearing of Clear Storage Distance

45. Time required for design vehicle to start moving (seconds), line 22 .... 45. 10.9

46. Design vehicle clearance distance (DVCD, feet), line 23 ...... 46. 113
47. Portion of CSD to clear during track clearance phase (feet) ... 47. 120

Remarks
CSD* in Figure 3 in Instructions.

48. Design vehicle relocation distance (DVRD, feet): add lines 46 and 47 ...... 48. 233

49. Time required for design vehicle to accelerate through DVRD (seconds) .... 49. 15.0 — Read from Figure 2 in Instructions.

50. Time to clear portion of clear storage distance (seconds): add lines 45 and 49 .... 50. 25.9

51. **Track clearance green interval (seconds): maximum of lines 44 and 50, round up to nearest full second** 51. 65

SECTION 6: VEHICLE-GATE INTERACTION CHECK (OPTIONAL)

52. Right-of-way transfer time (seconds): line 17 .... 52. 23.0
53. Time required for design vehicle to start moving (seconds), line 22 .... 53. 10.9
54. Time required for design vehicle to accelerate through DVL (on line 20, seconds) ...... 54. 10.0 — Read from Table 3 in Instructions.

55. Time required for design vehicle to clear descending gate (seconds): add lines 52 though 54 ..... 55. 43.9

Remarks

56. Duration of flashing lights before gate descent start (seconds): get from railroad 56. 12.0

Remarks

57. Full gate descent time (seconds): get from railroad .... 57.
58. Proportion of non-interaction gate descent time .... 58. 0.58 — Read from Figure 5 in Instructions.

59. Non-interaction gate descent time (seconds): multiply lines 57 and 58 .... 59. 0.0

60. Time available for design vehicle to clear descending gate (seconds): add lines 56 and 59 .... 60. 12.0

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** 61. 32