

# **NCDOT Guidelines and Procedures for Traffic Signal–Railroad Grade Crossing Interconnection and Preemption Inspections**

## **I. Purpose & Objectives**

The purpose of the Traffic Signal-Railroad Grade Crossing Interconnect and Preemption Inspection is to ensure proper traffic signal operation in conjunction with the railroad crossing signals. In doing this, care should be taken in the testing of the operational characteristics of the equipment, determining the distance of the railroad crossing signal termination shunts (starters), determining maximum train speeds and traffic signal track clearance times. A careful comparison must be made of the calculated RR advance warning time and the time needed for the traffic signal to clear the track(s) of all potentially queued vehicles (Preemption Time Required). A complete system test must be performed by shunting the rails together in order to activate the crossing signals and traffic signal preemption. In cases of Advance Preemption operation, a train movement must be observed to determine if preemption system is working properly throughout.

All existing railroad preempt installations should be inspected a minimum of once every twelve months. All new installations shall be inspected BEFORE the traffic signal is turned on to normal operation. It is important to note that there are five primary objectives that you are to achieve:

- Identify railroad preemption phasing and timing required for traffic signal track clearance phase(s).
- Verify that the total railroad warning time is adequate to accommodate preemption time required by the signal plans.
- Verify safe operation of preemption sequence and ensure that vehicles can be cleared of crossing dynamic envelope as train approaches.
- Verify operation of both railroad and traffic signal control equipment.
- Ensure active communication is established between Railroad Company and NCDOT.

## **II. Preparing for the Inspection**

1. OBTAIN PROPER TRAINING –The Transportation Mobility and Safety Division offers training classes to prepare you for this inspection. It is imperative that the Division inspection coordinator and signal technician supervisor, or designated signal technician appointee, receives this training prior to starting any inspections.

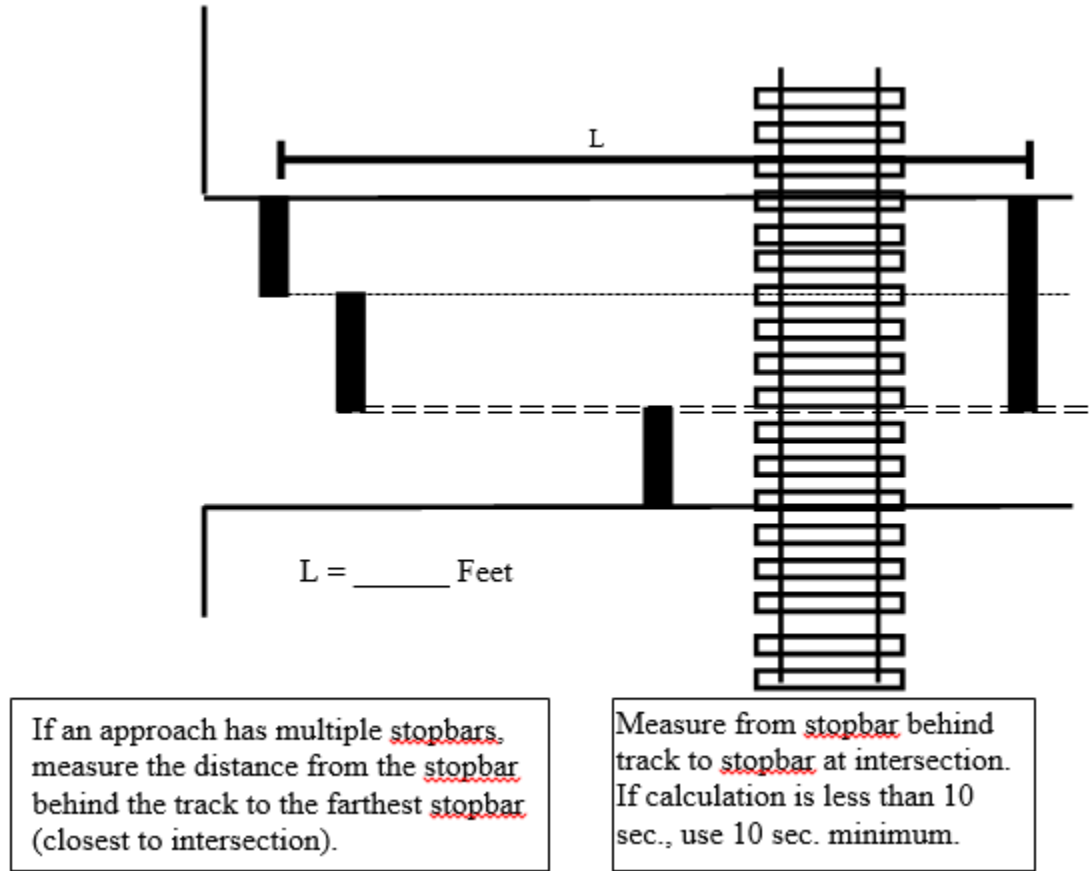
2. CONTACT AND SCHEDULE THE APPROPRIATE INSPECTION PERSONNEL – The following personnel shall be in attendance: The Division appointed Railroad Inspection coordinator, the Division Traffic Signal Technician Supervisor or designated signal technician appointee, and the railroad signal maintainer. Remember that critical information is needed from the crossing signal maintainer in order to perform the inspection. Railroad signal maintainers are required by the Federal Railroad Administration (FRA) to inspect their crossings every 30 days (monthly), so it may be easier if you coordinate the traffic signal preemption inspection when railroad signal maintainer will be on site to do his 30 day grade crossing inspection.
3. OBTAIN SIGNAL DESIGN AND ELECTRICAL DETAIL PLANS (IF AVAILABLE) – A fresh copy of the signal plans— including the electrical detail plans— are very valuable to have before you leave the office. It is always a good practice to be familiar with the particular signal design before you start the inspection. The office environment is a good place to “digest” how the particular signal operates.
4. OBTAIN INSPECTION FORM FROM LAST INSPECTION – Looking over the inspection record from the last inspection will alert you to problems that may still exist.
5. IDENTIFY THE TYPE OF TRAFFIC EQUIPMENT USED AT THE LOCATION TO BE INSPECTED – To properly inspect traffic signal control equipment you must do your homework. Knowledge of the type of equipment you are dealing with is essential to your ability to determine if the equipment is functioning properly. It is a good idea to know beforehand what type of equipment you will encounter in your inspections for the day. This will allow you to bring necessary controller manuals and intersection design plans to the site (for reference), as well as give you time in the office to identify any special wiring or programming features that may be present at that particular location. It is not expected that you become an expert on all traffic signal control equipment that NCDOT operates; however, there are certain basics that are essential for you to know to adequately perform an inspection, and be confident in your findings and recommendations.

### III. Completing the Inspection Form

The information below is detailed instructions that go along with the *Highway–Railroad Interconnection and Preemption Inspection Form*. **The numbered items below directly reference the same number/letter of questions shown on the inspection form.**

#### 1. Calculate track clearance green by current standard (Greenshield’s formula).

*This calculation is used to determine how much time is necessary to clear any vehicles potentially queued up on the railroad track.*



- *Measure the distance from the stopbar behind the track (if no stop bar is behind track, measure 15 feet beyond farthest rail from the intersection) to the intersection stop bar (closest to the intersection).*
- a)** *The stop bar to stop bar distance (L) is divided by 20 feet (which is used as a standard vehicle length); this total is multiplied by 2. The start-up delay should then be added (which is 4 seconds).*
  - b)** ***Simultaneous Preemption*** *is defined as a preemption event in which the traffic signal starts its preempt sequence at the **same time** that the railroad crossing signals activate (first flash). Consult with the railroad signal maintainer to determine if crossing utilizes simultaneous preemption.*
  - c)** ***Advance Preemption*** *is defined as a preemption event in which the traffic signal starts its preempt sequence **before** the activation of the RR crossing signals. Usually the amount of advance preemption is programmed as “DAX” time in the constant warning time control system (predictor). Consult with the railroad signal maintainer to determine if crossing utilizes advance preemption.*

**d)** *The **Right of Way Transfer Time** is the maximum amount of time needed to switch the traffic signal from normal operation to the beginning of the track clearance green interval. This time is used to “buffer” the Greenshield’s calculation when ADVANCE PREEMPTION is used to decrease the possibility of the track clearance phase ending before the entrance gate of the crossing signal is fully horizontal. Additionally, **Right of Way Transfer Time** along with the use of a dummy overlap – usually designated “**OVERLAP P**”– and sometimes even “**DUMMY PHASES**” are used to make sure that the relationship between the end of TRACK CLEAR GREEN and the entrance GATE DOWN (fully horizontal) position remain constant, no matter what phase or interval was being serviced prior to the arrival of the preempt call. This time is usually between 6-8 seconds, but can vary based on the individual crossing.*

*Enter the total amount of track Clear Green Time. Regardless of the distance measured between stopbars, this time is usually set to a minimum of 10 seconds, but is often much greater.*

**e)** *This item is a double check to make sure that the plans reflect the timing that was calculated in the field.*

## **2. Calculate the PREEMPTION TIME REQUIRED.**

*The PREEMPTION TIME REQUIRED is the maximum amount of time needed – following initiation of the preemption sequence – for the traffic signal to complete the timing of the right of way transfer time and track clearance phase intervals before the arrival of the train in the crossing. It is calculated by adding the following preemption timing parameters together:*

**DELAY before preemption** (SHOULD ALWAYS BE SET TO 0 SECONDS WITH RAILROAD PREEMPTION)

**MINIMUM WALK before preemption** (TIMES WITH MIN. GREEN BEFORE PREEMPTION, USUALLY 0 SEC.)

**PEDESTRIAN CLEAR before preemption** (SEE NOTE BELOW)

**MINIMUM GREEN before preemption** (SEE NOTE ON NEXT PAGE, USUALLY 1 SEC.)

**YELLOW CLEARANCE before preemption** (SEE NOTE ON NEXT PAGE)

**RED CLEARANCE before preemption** (SEE NOTE ON NEXT PAGE)

**TRACK CLEARANCE 1 GREEN**

**TRACK CLEARANCE 1 YELLOW CLEARANCE**

**TRACK CLEARANCE 1 RED CLEARANCE**

**TRACK CLEARANCE 2 GREEN** (IF APPLICABLE)

**TRACK CLEAR 2 YELLOW CLEAR** (IF APPLICABLE)

**TRACK CLEAR 2 RED CLEARANCE** (IF APPLICABLE)

***EQUALS: PREEMPTION TIME REQUIRED** for optimum operation.*

- ***PED CLEAR BEFORE PREEMPTION** should be timed concurrently with **YELLOW CLEAR BEFORE PREEMPT**. When possible, the **PED CLEAR BEFORE PREEMPT TIME** should be*

*programmed to be within 1 second of the YELLOW CLEAR BEFORE PREEMPT for consistent operation when actuated pedestrian movements are present at the intersection. If the PED CLEAR BEFORE PREEMPT is greater than the YELLOW CLEAR BEFORE PREEMPT, the remaining PED CLEAR is timed concurrently with the vehicle phase green actively timing when the preempt call is received and must be added into the time. For example, if the PED CLEAR BEFORE PREEMPT time is programmed for 5 seconds and the YELLOW CLEAR BEFORE PREEMPT is 4.5 second AND the PED CLEAR BEFORE PREEMPTION is timed concurrently with YELLOW CLEAR BEFORE PREEMPT, then .5 seconds ( $5-4.5=0.5$ ) of additional pedestrian clearance time should be added, not the full 5 seconds.*

*If the controller is not capable of timing PED CLEAR BEFORE PREEMPT concurrently with the YELLOW CLEAR BEFORE PREEMPT, the entire PED CLEAR interval will need to be added to the PREEMPTION TIME REQUIRED calculation.*

- ***THE MINIMUM GREEN BEFORE PREEMPTION*** time setting is very important to the proper operation of the preemption sequence, as this parameter essentially determines the responsiveness of the controller to the input calling for entry into preemption. The *MINIMUM GREEN BEFORE PREEMPTION* setting will override the normal phase setting for *MINIMUM GREEN*, except for the value 0 sec. (on most traffic controllers). For example, any other value (greater than 0 sec.) will override normal controller minimum green time settings upon entry into preemption; a 0-sec. setting will default the time to the normal phase minimum green time. This can be very dangerous! Most existing track circuits cannot support a normal phase minimum green time before preemption. To get the most rapid response time, a 1-sec. setting should be entered. Even if the signal plans show 0 SEC. *MINIMUM GREEN BEFORE PREEMPTION*, the value entered should be 1 second. There are some signal plans with values greater than 1 second shown for the minimum green before preempt; however, the RR track circuits may have been designed to account for this time (refer to your advance RR warning time provided by track circuit calculation). If no *MINIMUM GREEN BEFORE PREEMPTION* is shown, or if a value of 0 sec. is shown on the signal plans, the programmed value should be set to 1 second.
- *In most cases, especially where ADVANCED PREEMPTION is used, values are shown on the signal plan for YELLOW CLEAR BEFORE PREEMPT and RED CLEAR BEFORE PREEMPT. These values should be used for the calculation of Preemption Time Required. For plans where 0.0\* are shown indicating a default to the normal phasing time, such as some SIMULTANEOUS PREEMPTION locations, the highest YELLOW CLEAR and RED CLEAR times shown for normal operation should be used. If one of these times corresponds to the Track Clearance Phase, use the next highest time since that phase will not clear prior to entering preemption.*

**3. Observe Operation of the signal (including control equipment in the cabinet and field equipment) for proper programming & operation. Is equipment operating properly and does the operation coincide with the signal plans?**

*Verify that the controller is running the normal phasing operation properly before attempting to check the preempt sequence. Controller programming (i.e. timing, sequence, overlaps, preemption, etc.) settings should be verified using signal plans & electrical details. Please note that the controller should never be programmed for late night flash. Make sure controller is timing all intervals properly. Ensure detectors are picking up and dropping out vehicle calls (detectors may be programmed for extend and/or delay). Controller should be resetting the gap timer for each detector actuation received for the phase currently timing. Ensure all signal head displays are visible.*

*After verifying normal operation, the preemption sequence may be verified (without activating the crossing signals) by PRESSING THE RR PREEMPT TEST SWITCH located in the controller/cabinet. It is recommended that the preempt call be applied during the timing of a minimum green interval to verify that the preemption will override minimum green and immediately proceed to the track clearance phase(s).*

**a) Are signs shown on signal plan installed properly?**

*Signs should be in place as shown on the signal plans (including Blank-out signs). The presence of a DO NOT STOP ON TRACK sign is recommended for installations where the potential exists for vehicles to queue up on the tracks. Other signs to look for are NO TURN ON RED; STOP HERE ON RED; and ONCOMING TRAFFIC HAS/MAY HAVE EXTENDED GREEN.*

**4. If intersection has MULTIPLE PREEMPTS in use, verify that the RAILROAD PREEMPT is set as the HIGHEST PRIORITY.**

*Some locations have multiple preemptions (i.e. railroad and emergency vehicle preemption). If multiple preemptions are activated simultaneously (or if one preempt is called while the controller is serving another preempt), railroad preemption shall be set for a higher priority to ensure that it will override any other preempt that may be active.*

**5. If crossing has multiple through line tracks — perform SECOND TRAIN SEQUENCE test (preempt re–service).**

*Some crossings have two or more tracks that vehicular traffic must cross. When multiple tracks are present, the possibility exists that back-to-back preemption events can occur. This procedure checks to make sure the controller will re–time the track clearance phase(s), should the preempt call be dropped by the first train (leaving the crossing), and then reapplied one or two seconds later by a second train (approaching the crossing).*

***TO PERFORM THIS TEST*** activate the RR preemption; allow the controller to time a few seconds of the track clearance green interval, not exhausting the time. After these few seconds, remove the preempt call for one or two seconds and then reapply the call. The controller should immediately start to retime the track clearance phase(s) green interval at the beginning of the preset time. If the controller does not retime the track clearance phase(s), either special programming may need to be added to the controller or the controller may not be appropriate to control a multi-track preemption location. In some special cases, a controller lacking second train sequence operation may be used in conjunction with special internally illuminated blank-out sign sequences. If a special blank-out sign sequence is needed, contact the NCDOT – Mobility and Safety Division for information.

**a) Does preempt call release immediately when gates begin to rise?**

*When the crossing signals are activated, please note that the point in which the preempt call is released by the crossing equipment — this is very important to the proper operation of PREEMPT RE–SERVICE. When the possibility of a second trains exists, the preempt call should be released as soon as the gates begin to rise, NOT when they reach the fully vertical position*

**6. Identify the general type of railroad signal equipment with its particular reaction time. Circle type: PREDICTOR — MOTION — AC/DC — AFO**

*Consult with the Railroad signal maintainer to determine the type of control equipment used to operate the crossing signals. The most common reaction times for the different types are listed below:*

- *Predictor (Safetran GCP 3000/4000 & Harmon HXP/SCX): 4 SECONDS*
- *Motion Detector (PMD 1 & 2): 3 SECONDS*
- *Motion Detector (PMD 3R): 2 SECONDS*
- *Audio Frequency Overlay (AFO): 5 SECONDS*
- *AC/DC: 0 SECONDS*

**7. Obtain the TRACK CIRCUIT APPROACH LENGTHS for each direction from the railroad signal maintainer / inspector as shown on their PLAN OF RECORD or inspection documentation in the railroad signal cabinet:**

*Each railroad cabinet (bungalow) should contain a set of plans for the highway–grade crossing signals. Record the approach lengths as shown on the Railroad plans. NCDOT personnel should not walk the railroad tracks to verify the track circuit approach lengths. This practice is discouraged and should be performed only in very limited situations. In situations where it may be necessary for NCDOT personnel to walk along the railroad tracks, it should be done only with permission and under the watchful supervision of the railroad maintainer or other railroad personnel.*

**Indicate to what point approach length is measured from starter/shunt, as each railroad may reference differently (circle):**

**ISLAND      EDGE OF CROSSING SURFACE      EDGELINE OF TRAVEL      CENTER OF CROSSING**

*Each railroad may measure their crossing approach length separately. All measurements begin at the shunt, but the approach may be measured to the beginning of the island circuit, the edge of the crossing surface, the edgeline of vehicle travel, or the center of the crossing/island circuit. For consistency, NCDOT prefers to measure to the edge of the crossing surface, which is considered the first point of impact at a crossing. While not critical, measuring to a different point could affect the calculated railroad warning time available.*

**8. Obtain MAXIMUM TRAIN SPEED for the crossing from the railroad signal maintainer / inspector (using *Timetable Speed or Railroad Permanent Speed Restriction*).**

*Ask the Railroad signal maintainer for the train speed limit as listed in the most recent timetable book. Use this speed, or a permanent restriction otherwise set by the railroad. Some cities or towns may have a speed ordinance for the railroad, but the railroad is not required to obey it. Also, do not factor in “temporary slow order” conditions when determining speed. In some cases, the speed limit may be higher on one approach than the other (due to yard limits, curve restrictions, etc.). If the train speed has changed from the previous inspection, please notify the NCDOT Rail Division.*

**9. Calculate amount of RR WARNING TIME provided by track circuitry as calculated using the formula below (use space provided at bottom of page to aid in calculation):**

$$\frac{\text{(Shortest Approach Length)}}{(1.47) \text{ (Train Speed in MPH)}} \text{ (Minus) Equipment Reaction Time} = \text{RR Warning Time}$$

minus  =  Seconds [Carry to item 14c]  
(1.47)

*To obtain the maximum amount of RR warning time supported by the track circuitry, calculate by multiplying train speed (in MPH) by 1.47 (to convert MPH to feet/second), and then divide this speed into the distance for the shortest approach you measured, then subtract the appropriate reaction time for the RR equipment (listed under item 6).*



**10. Is crossing equipped with ADVANCE PREEMPTION?**

*Note: If ADVANCE PREEMPTION is used, a train movement must be observed. Care must be taken to answer items 11, 11a, and 11b) below. If SIMULTANEOUS PREEMPTION is used, a train movement observation is not required; however, if train movement occurs during inspection, enter actual observed warning time (taken with stopwatch) in item 11.*

*As mentioned earlier, some crossings have a feature known as ADVANCE PREEMPTION. When advance preemption is used, the traffic signal preemption begins prior to the crossing signals being activated and the motoring public may not yet be aware that a train is approaching. It is important to note that when ADVANCE PREEMPTION is used, it is possible for the time difference between initiation of traffic signal preemption and activation of the railroad crossing signals to be increased by a decelerating train approaching the crossing. IT IS IMPERATIVE THAT THE TIME DIFFERENCE DOES NOT INCREASE TO THE POINT WHERE THE TRAFFIC SIGNAL TRACK CLEARANCE GREEN INTERVAL ENDS (I.E. TRAFFIC SIGNAL TURNS RED) BEFORE THE CROSSING SIGNALS ACTIVATE. In order to check ADVANCE PREEMPTION, a train movement MUST be observed through the crossing. More on this in item 11.*

*If the crossing signal uses SIMULTANEOUS PREEMPTION (i.e. traffic signal preemption starts at the same time as the crossing activates) a train movement is not required to be observed and item 11 may be skipped. However, item 12 should be completed. It is always preferable to observe a train movement through a crossing whenever possible.*

**11. Observed total warning time of ACTUAL TRAIN MOVEMENT.**

*When timing the warning time of an actual train movement, the stop-watch should be started as soon as the traffic signal controller/cabinet receives the preempt call and stopped when the train reaches the edge of the travel lane.*

**a) Does controller/cabinet RESPOND TO PREEMPT call properly?**

*When the controller/cabinet receives the preempt call, the controller should immediately force out of normal operation and initiate the transfer of right of way to the track clearance phase(s). Blank-out signs should also illuminate immediately upon the receipt of the preempt call. After track clearance intervals expire the controller should run only the phases that are shown in the phasing diagram as dwell phases (phases that are compatible with the train movement). When preemption is terminated, the controller should proceed to the designated preempt exit phase(s).*

**b) During train movement, does signal remain in TRACK CLEARANCE GREEN until entrance gate is fully horizontal?**

*This check is essential in determining if the advance preemption is working correctly, as it ensures that the start of traffic signal preemption and the activation*

*of the crossing are in synch. While the train is approaching, you should NOTICE THE OPERATION OF THE ENTRANCE GATE — when the gate descends to fully horizontal, the traffic signal should still be timing the track clearance green interval. If the traffic signal is red before the entrance gate descends to horizontal, alert the Railroad signal maintainer and contact the NCDOT Rail Division.*

- 12. If no train movement is expected, activate crossing with a shunt placed across the rails in the island circuit (this item may be omitted if train movement is observed).**

**Observe traffic signal preemption & crossing operation.**

*This test verifies that the complete preempt system is working properly when no actual train is available to activate the crossing signals. Instruct the RR maintainer to put the shunt within the island circuit, which will ensure that the crossing stays activated for as long as needed to verify traffic signal preemption and crossing operation. The shunt should remain in place until traffic signal is “dwelling” in preemption. When the shunt is installed, the activation of the crossing and the traffic signal preempt will be SIMULTANEOUS, even if the crossing is programmed for ADVANCE PREEMPTION. When the controller/cabinet receives the preempt call, the controller should immediately force out of normal operation and initiate the transfer of right of way to the track clearance phase(s). Blank-out signs should also illuminate immediately upon the receipt of the preempt call. After track clearance intervals expire the controller should run only the phases that are shown in the phasing diagram as dwell phases (phases that are compatible with the train movement). When the shunt is removed and the crossing begins its de-activation (gates rising, etc.), the preempt call should drop and controller should proceed to its designated preempt exit phase(s).*

*This test should be performed even on ADVANCE PREEMPTION locations when a train movement is not expected on the day of the inspection; however, a train movement will have to be observed on another day to complete the inspection.*

- 13. If Railroad crossing signal equipment is designed for CONSTANT WARNING TIME (i.e. predictor) and/or is equipped with ADVANCE PREEMPTION obtain the following values from the railroad signal maintainer/inspector:**

- a) How much RR WARNING TIME is programmed in the unit?**

*If the railroad control is a predictor, this is the warning time is programmed in the unit. This is the ACTUAL AMOUNT OF TIME that the crossing should be active prior to the arrival of the train, starting from the first flash of the warning lights. Be*

*aware that this time could be less than the time calculated for the measured approaches, but not greater. If the crossing is not using ADVANCE PREEMPTION, this time should be greater than or equal to the PREEMPTION TIME REQUIRED determined in item 2 of the inspection form.*

**b) If railroad provides ADVANCE PREEMPTION, how many seconds of additional DAX TIME is programmed (dax time minus warning time)?**

*If ADVANCE PREEMPTION is used, there will be DAX TIME programmed in the predictor. The DAX TIME will be the total amount of time that will elapse between the RECEIPT OF THE PREEMPT CALL and the ARRIVAL OF THE TRAIN at the crossing. The value of the DAX TIME minus the RR warning time [determined above in 13a)] equals the amount of ADVANCE PREEMPTION time that the system is programmed to operate. For example, if the DAX TIME is set for 45 seconds and the RR warning time is set for 36 seconds, then the ADVANCE PREEMPTION time is 9 seconds. Therefore, the traffic signal will be preempted 9 seconds prior to the activation of the crossing signals (first flash).*

**14. Compare PREEMPTION TIME REQUIRED with RR WARNING TIME:**

*This item is the where all the calculated values are compared to determine if entire system is set properly. Conclusion answers are prompted following this item.*

**a) PREEMPTION TIME REQUIRED (from item 2)**

*Enter the total calculated in item 2.*

**b) Total RR WARNING TIME programmed on railroad predictor (if used). Total from item 13a) + 13b).**

*Enter the sum of 13a) and 13b).*

**c) Total Warning Time avail. from TRACK CIRCUITRY (From Item 9).**

*Enter calculated value from item 9.*

**Conclusion**

**• Is 14c) GREATER THAN OR EQUAL TO 14b)?**

*The track circuit approach calculations should be greater than or equal to the total amount of RR WARNING time.*

**• Is 14a) LESS THAN OR EQUAL TO 14b) and 14c)?**

*The PREEMPTION TIME REQUIRED should be less than or equal to THE TOTAL AMOUNT OF RR WARNING TIME and THE TRACK CIRCUIT APPROACH warning time calculation.*

***If the answer to either of the above questions is NO, contact the Signal Design Section (Regional Signal Engineer) immediately at (919) 814-5000.***

*If the answer to one of the comparison questions is NO, the Signal Design Section’s Regional Signal Engineer will determine if special timing considerations can be applied to render the operation of the preemption system acceptable. Be sure to document telephone conversations of this nature on the inspection form.*

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Send a copy of this **INSPECTION FORM** with **ATTACHED COMMENTS** (if necessary) and any marked-up plans to:

Mail: NCDOT – Rail Division  
Engineering Coordination and Safety Branch  
ATTN: Inventory & Data Analysis Manager  
1556 Mail Service Center  
Raleigh, NC 27699-1556

Office/Delivery: 862 Capital Boulevard  
Raleigh, NC 27603