Intelligent Infrastructure

Track Circuit Monitoring

Briefing Notes – Updates and Changes

Version	Notes
2	• Addition of DC Track Circuit Initial Setting Guide
3	• Clarification of terminology to describe events, especially 'High Occupied Current' and 'Poor Shunt'. • Addition of 'TC Minimum Occupied Time' matrix as an aid for setting Clear-Occupied-Clear upper time limit. • Track flick: occupied – clear – occupied – typo corrected to show "track circuit goes clear briefly".
4	• Track circuit occupied current (OCC level) drop away current values revised to average values for BR Spec 938A, 939A, 966F2 and 966F9 relay types.
5	• New sections added providing guidance with DC TC event analysis and response.

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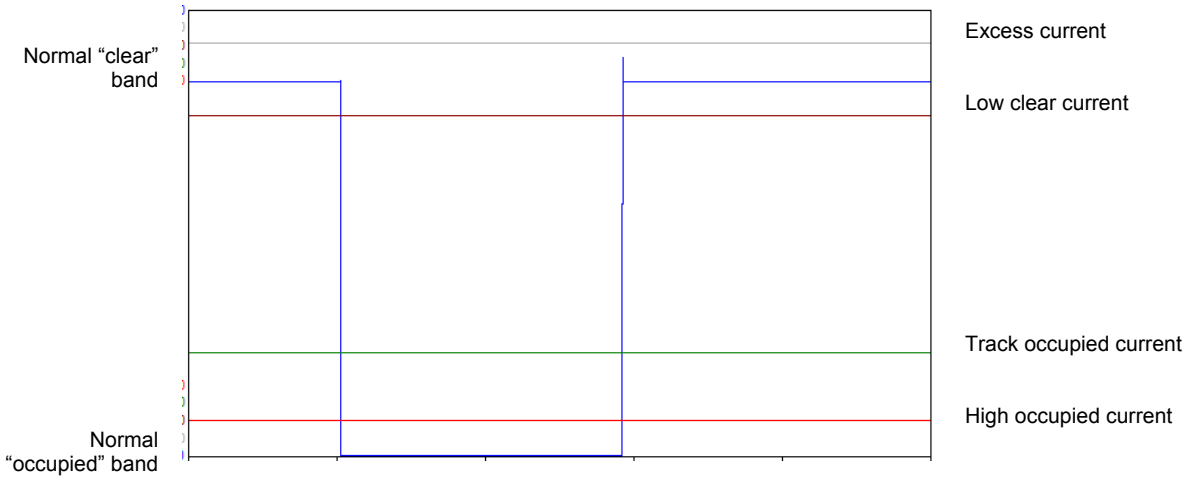
Track circuit monitoring

1. Principles



In normal operation, the current in a track circuit relay is expected to be in one of two states, at a "clear current" value or at or close to 0mA.

The "clear current" should sit somewhere between an "excess current" level, where there is a risk that the train shunt will not be low enough to reduce the current in the track circuit relay below the drop away value, and a "low clear current" value, where the current is getting close to dropping the relay without the presence of a train.

When occupied, the current should be somewhere between 0mA and the "High occupied current level"; the defined maximum acceptable level of current whilst the track circuit is occupied.

The track circuit current will go outside these bands during a transition between clear and occupied but this transition is expected to happen quickly (and therefore the time outside the "normal" bands will be minimal). It is also expected to happen in sequence, so the current will fall from the normal clear current to the normal occupied current and vice versa, rather than occupying the bands in any other order.

2. Track circuit events

Low clear current

A low clear current event is generated if the current falls below the "low clear current" threshold but remains above the track circuit occupied current (i.e. the fall in current is not due to a train) for a given time.

Typical failure modes causing a reduction of current in the circuit would be deteriorating rail insulation (pads and nylons), high resistance tail cables or connections or the failure of a block joint.

Unstable Clear Current

This event is generated if the track circuit current falls below the low clear current threshold for a short duration but then recovers into the normal operating band again.

This could be caused by an intermittent connection (loose track circuit pin, damaged tail cable, loose back nut).

Excess Current

If the value of current measured in the track circuit rises above the “excess current” threshold an alarm is generated.

Causes of this include work on the track circuit reducing the loss of current along the track circuit (renewal of pads and nylons), failure of an unstaggered block joint leading to current from an adjacent track affecting the relay.

High Occupied Current

A ‘high occupied current’ event will be generated if the current rises above the high occupied current level but not above the track occupied current for a given time.

Typical causes may be severe wheel or rail contamination or the failure of an unstaggered block joint, allowing current from an adjacent track circuit to flow through the relay.

Poor Shunt

This event is generated if the track circuit current rises above the high occupied threshold for a short duration but then falls back into the normal occupied band. The ‘poor shunt’ may be alternatively defined as an ‘unstable occupied’ event.

This may be caused by wheel or rail contamination briefly preventing the train from properly shunting the track circuit.

Track flick: clear – occupied – clear

In the event that the track circuit goes occupied briefly, a track flick – occupied event will be generated.

Track flick: occupied – clear – occupied

In the event that the track circuit goes clear briefly, a track flick – clear event will be generated.

3. Calibration

Track circuit current levels

The first task in calibrating an instance of track circuit monitoring is to set the levels at which the track circuit normally operates:

- *Track circuit occupied current (OCC level)*

This parameter is set according to the drop away current of the track relay. Select the value from the table below. The condition and length of the track have no bearing on this level.

Specification	Pin Code	Coil resistance	Drop away current
BR939A	105	20Ω	58mA
BR938A	101	4Ω	76mA
BR966F2	110	9Ω	88mA
BR966F9	104	60Ω	40mA

Alternatively, carry out a drop shunt test and set the *track circuit occupied current* to current value shown on the II trace between the end of the drop shunt test and the start of the pick-up test.

- *High OCC level*

In normal operation, the current through the track relay is 0mA when the track circuit is occupied. Set the High occupied current level a little way above the normal value seen when the track circuit is occupied to detect when a poor wheel shunt allows some current to flow in the relay. This level should be set no higher than 50% of the occupied level.

- *Excess current level (Excess Level)*

This level should be set so as to alarm if the current in the track circuit relay goes too high and there is a danger that the presence of a train on the track circuit will not divert sufficient current away from the relay to allow it to drop.

Set the level around 20% above the highest level of current measured when the track is clear.

- *Low clear current (Low clear level)*

Set this level around 10% lower than the lowest level of current measured when the track circuit is clear.

Setting this level too high will result in false alarms if the track circuit current falls during wet weather. Setting the level too low (too close to the track occupied current) means that alarms will not be generated until the track circuit is very close to failing right side – leaving you little time to react and fix it. Generally, the low clear current level should be set no lower than 50% above the nominal pick up value.

Setting the times

There are a number of time "deadbands" to be set. These allow the monitoring system to differentiate between events that are normal and those that, due to the time they last, are not.

- *Low current – clear deadband*

This is the time after which an event is generated if the track clear current is low.

Setting it too short risks false alarms due to the current value passing through this band as it is going from clear to occupied or vice versa.

The time should be set sufficiently long that it will filter out activity such as drop shunt testing, which will result in a reducing value of track relay current.

- *High current – occupied deadband*

This is the time after which an event is generated if the current when the track circuit is occupied rises above the High occupied current level.

Setting the time too short risks false alarms due to the current value passing through this band as it is going from occupied to clear or vice versa.

Setting the time too long risks missing a poor train shunt event. The time should be set sufficiently long that it will filter out activity such as drop shunt testing, which will result in a reducing value of track relay current.

- *Track circuit flick time: clear – occupied – clear; lower limit*

This value should generally be left at 0s but in some cases, track circuits have been observed to occupy briefly and then clear as the train rolls on to them. To ignore these cases, set the minimum time to longer than the length of these events.

- *Track circuit flick time: clear – occupied – clear; upper limit*

If a track circuit is occupied for less than the time set in this value, a track flick event is generated. The value should be set to less than the time for which the shortest, fastest train will occupy the track circuit. Any occupation shorter than this will then be counted as a genuine fault. See Appendix A 'TC Minimum Occupation Time Matrix', for further guidance with setting this level.

- *Track circuit flick time: occupied – clear – occupied; lower limit*

This value should generally be left at 0s but in some cases, track circuits have been observed to occupy briefly and then clear as the train rolls on to them before going occupied properly. To ignore the brief clearance of the track circuit in these cases, set the minimum time to longer than the length of these events.

- *Track circuit flick time: occupied – clear - occupied; upper limit*

If a track circuit is clear for less than the time set in this value, a track flick event is generated. The value should be set to less than the minimum time between trains. Any clearance shorter than this will then be counted as a fault. In complex junction areas, this time may be quite short.

Setting the counters

Experience in monitoring track circuits has shown that they sometimes show odd behaviour that would be detected by the condition monitoring software above. In order to prevent these generating alerts and alarms and causing people to respond, there is a system of counters.

Each time an event (such as a track flick or a poor shunt) is detected, it increments a counter. When the counter reaches a particular value, an alert is generated and when further increments take it over a second threshold, an alarm is generated to the control centre.

The counter is reset at midnight to clear out the previous day's events.

For perfectly behaving track circuits, the alert and alarm thresholds can be low but they may need to be increased where the track circuit displays a background level of events every day. The default value for the alert (Hi) threshold is therefore 1, meaning that the first event of the day will generate an alert. Similarly, the default alarm (HiHi) threshold in most cases is 5 so that an odd event will not send an alarm to control but a repetitive event will be highlighted.

4. DC TC Event Analysis Guide

This section of the document is intended to provide guidance to II system analysts and in conjunction with section 5 – 'DC TC Event Response Matrix', help with decision making regarding action to be taken for the different types of track circuit events. It is not exhaustive and is subject to change and amendment to reflect ongoing developments with the II system and the knowledge and experience of its users.

General Considerations

Whilst analysing a TC event the analyst must keep an open mind to all underlying causes that may have generated the event. These include the following considerations:

1. Has the track circuit been correctly calibrated for the type of track relay installed and the typical characteristics of operation?

   It is good practice to add the relay pin code or type to the end of the 'local name' field in brackets e.g. *"TC:123 KEMPTON RD (PC 105)".*

2. Is the event a known characteristic of the TC concerned? I.e. the event has already been investigated and it has been concluded further action is not necessary.

3. The event has been caused by engineering works – e.g. movement of hand trolleys, or track circuit testing. Engineering work may cause multiple events / alarms and it is good practice for the Scheduled Maintenance tool to be used for pre-planned work to avoid these events generating alarms.

Events caused by known characteristics may be suppressed by making small adjustments to the calibration and or counter settings. However, any changes made to calibration / counter settings must be made with cognisance to the effect it may have on the sensitivity of the system to detect genuine issues that may affect TC reliability.

For further advice regarding calibration settings refer to TC Monitoring Guide Sections 3 and 4. Note that any changes to calibration settings must be approved by the SM&TE.

Conventionally, technicians use voltage measurements to assess track circuit health; assessment of current levels may not be as familiar. Therefore to assist technicians with site investigation work Ohms Law may be used to convert II current readings to voltage as follows:

V = I x R
(Where 'I' is the circuit current – milliamps and 'R' -the resistance of the relay coil Ω)

E.g. a track circuit current reading is recorded by II as 250 mA. The relay pin code is 105 with a coil resistance of 20 Ω.

In this example voltage is: 0.250 x 20 = 5.0V

5. DC TC Event Response Matrix

Event	Description	Trace Analysis requirements	Analysis Findings	Severity	Most Likely Causes	Action
Poor Shunt (Unstable Occupied)	When a train occupies the TC the current value should at or close to zero. This event is generated should the circuit current fluctuate up and down, but below the level that may cause the TC to show clear.	Assess: Amplitude, Duration, Position of the event relative to the time duration of 'the period of occupation'.	1) Event close to the moment of occupation and / or clearing and , apart from this event, the current remains at or close to zero for the duration of the occupied period.	a) One Off or Occasional Occurrence	Possible issue related to IBJ condition. Or slow moving train and / or issue with wheel Set.	Monitor, for evidence of any pattern of events. Consider a check of IBJ. Investigate if rogue rolling stock could be identified as cause. STME to consider authorising adjustment to TC counter if cannot be resolved.
				b) Regular Occurrence	Issue near an end of the TC. Possible minor rail head contamination. Or issue related to IBJ condition, or stagger of joints, or bonding,	Determine the affected end of TC and arrange for examination with cognisance to likely causes. STME to consider authorising adjustment to TC counter if issue cannot be resolved.
			2) Not associated with moment of TC occupation or clearing event as above.	a) One period of occupation only	Suspect issue with train but confirm TC operates ok for other trains of same formation and type of rolling stock.	Action as Per TCM Autumn User Guide
				b) More than One period of occupation	Suspect Rail Head Contamination	Action as Per TCM Autumn User Guide
High Occupied	When a train occupies the TC the current value should at or close to zero. This event is generated should the circuit current remain above this level, but below the level that may cause the TC to shown clear.	Assess: Amplitude, Duration, Position of the event relative to the time duration of 'the period of occupation'.	1) Event close to the moment of occupation and / or clearing and , apart from this event, the current remains at or close to zero for the duration of the occupied period.	a) One Off or Occasional Occurrence	Possible issue near end of TC. Or slow moving train and / or issue with wheel Set.	Monitor, for evidence of any pattern of events. Consider a check of IBJ area. Investigate if rogue rolling stock could be identified as cause. STME to consider authorising adjustment to TC counter if cannot be resolved.
				b) Regular Occurrence	Issue near an end of the TC. Possible minor rail head contamination . Issue related to IBJ condition, or stagger of joints, or bonding,	Determine the affected end of TC and arrange for examination with cognisance to likely causes. STME to consider authorising adjustment to TC counter if issue cannot be resolved.
			2) Not associated with moment of TC occupation or clearing event as above.	a) One Off	Suspect issue with train but confirm TC operates ok for other trains of same formation and type of rolling stock.	Action as Per TCM Autumn User Guide
				b) More than One	Suspect Rail Head Contamination	Action as Per TCM Autumn User Guide

Event	Description	Trace Analysis requirements	Analysis Findings	Severity	Most Likely Causes	Action
Occupied-Clear-Occupied Flick	The TC current should remain at or close to zero for the period of train occupation. This event is generated should a shorter clear current period occur than is likely to be a train and thus may be the 'TC showing clear when occupied' . (Time threshold settable in II system)	Assess: Amplitude, Duration, Frequency of Occurrence and time relative to periods of TC 'occupation' .	1) Event close to the moment of occupation and / or clearing and , apart from this event, the current remains at or close to zero for the duration of the occupied period.	a) One Off or Occasional Occurrence	Possible issue near end of TC. Or slow moving train and / or issue with wheel Set.	Monitor, for evidence of any pattern of events. Consider a check of IBJ. area. Investigate if rogue rolling stock could be identified as cause. STME to consider authorising adjustment to TC counter if cannot be resolved.
				b) Regular Occurrence	Issue near an end of the TC. Possible minor rail head contamination . Issue related to IBJ condition, or stagger of joints, or bonding,	Determine the affected end of TC and arrange for examination with cognisance to likely causes. STME to consider authorising adjustment to TC counter if issue cannot be resolved.
			2) Not associated with moment of TC occupation or clearing event as above.	a) Single occurrence of clear period between apparent genuine occupations	May be genuine train occupation with clear period less than calibration level Occ-Clear-Occ upper limit.	Check permissible time between trains and where appropriate adjust upper time limit. If upper limit not an issue follow b or c below.
				b) One occupation period with one of more flicks	Suspect issue with train but confirm TC operates ok for other trains of same formation and type of rolling stock.	Action as Per TCM Autumn User Guide
				c) More than one occupation period with one or more flicks	Suspect Rail Head Contamination	Action as Per TCM Autumn User Guide
Clear-Occupied-Clear Flick	The TC current should remain at a clear level between trains. This event is generated should a period of occupation occur that is shorter than is likely to be a train and may be the 'TC showing occupied when clear'. (Time threshold settable in II system)	Assess: Amplitude, Duration, Frequency of Occurrence and time relative to TC 'occupation' or 'clear' periods	1) Blips either immediately prior to TC occupation or after TC clears	One or more blips (Blips < 0.5s may not be visible to the signalling system)	Possible issue with IBJ or Rail End area loose connections / terminals / cable joints / crushed cable. Affected by vibration.	Carry out impact discussion and arrange for technicians to carry out appropriate checks. Reference SMTH U005 for guidance
			2) Blips not to immediately prior to TC occupation or after TC clears	a) One or more short duration blips during 'clear' period (Blips < 0.5s may not be visible to the signalling system)	May be loose / HR connections or intermittent short circuit in any part of TC.	Carry out impact discussion and arrange for technicians to carry out appropriate checks. Reference SMTH U005 for guidance
				b) Longer duration blips >0.5 and less than upper time limit setting.	Check not train occupation - i.e. short TC	Confirm TC length with reference to TC Monitoring guide and Minimum Occupied Time Matrix. Adjust calibration upper time limit as appropriate.
					Confirmed not train occupation. May be loose / HR connections or intermittent short circuit in any part of TC.	Carry out impact discussion and arrange for technicians to carry out appropriate checks. Reference SMTH U005 for guidance

Event	Description	Trace Analysis requirements	Analysis Findings	Severity	Most Likely Causes	Action
Unstable Clear	The TC clear current value should be stable. This event is generated should the circuit current fluctuate down and up but not falling below the level where the TC may become occupied.	Assess: Amplitude, Duration, Frequency of Occurrence and time relative to TC 'occupation' or 'clear' periods	1) Blips either immediately prior to TC occupation or after TC clears	One or more blips.	Possible issue with IBJ or Rail End area loose connections / terminals / cable joints / crushed cable. Affected by vibration.	Carry out impact discussion and arrange for technicians to carry out appropriate checks. Reference SMTH U005 for guidance
			2) Blips not immediately prior to TC occupation or after TC clears	One or more blips during 'clear' period.	May be loose / HR connections or intermittent partial short circuit in any part of TC.	Carry out impact discussion and arrange for technicians to carry out appropriate checks. Reference SMTH U005 for guidance
Low Clear	The clear circuit current should be a healthy value above the level where there is a risk of the TC becoming occupied. This event is generated should the TC current value fall below the desired current level for a period of time, but not below the level where the TC may become occupied. (Time threshold and current level is settable in II)	Assess: Rate of Deterioration, Duration, Frequency of Occurrence and time relative to TC 'occupation' or 'clear' periods	1) Gradual reduction of clear current value over time span typically of hours	a) Current remains in 'low clear' band	Weather / Ballast Conditions. Get advice as to TC condition. Location / asset history.	Discuss with Section Manager. If no previous history arrange for investigation. If known issue, confirm plan for remedial action and consider short term change to low clear calibration level as appropriate.
				b) Current has returned to 'normal clear' level	Check asset history for condition issues	Discuss with Section Manager. If known issue confirm plan for remedial action and consider short term change to low clear calibration level.
			2) Rapid or step change reduction of clear current	a) Current remains low or intermittently goes low.	May be loose / HR connections or intermittent partial short circuit in any part of TC.	Carry out impact discussion and arrange for technicians to carry out appropriate checks. Reference SMTH U005 for guidance
				b) Current has returned to 'normal clear' level	Check asset history for condition issues	Discuss with Section Manager. If known issue confirm plan for remedial action and consider short term change to low clear calibration level.
Excess Current	The TC clear current value is higher than would be expected.	Trend circuit current over time	1) Gradual rise of clear current value over time	a) Current remains high	Ballast conditions may have improved	Discuss with Section Manager if current level is acceptable. Take remedial action to reduce circuit current or adjust calibration levels as appropriate.
				b) Current has returned to 'normal clear' level	Check asset history for condition issues	Discuss with Section Manager. If known issue confirm plan for remedial action or change to calibration level as appropriate.
			2) Quick or step change increase in clear current	a) Current remains high	TC equipment may have been renewed or adjusted or defect causing partial high resistance or short circuit has cleared.	Discuss with Section Manager if current level is acceptable. Take remedial action to reduce circuit current or adjust calibration levels as appropriate.
				b) Current has returned to 'normal clear' level	Check asset history for condition issues	Discuss with Section Manager. If known issue confirm plan for remedial action or change to calibration level as appropriate.

6. DC Track Circuit Initial Calibration Setting Guide

Intelligent Infrastructure DC Track Circuit Initial Calibration Setting Guide

This guide advises how to initially set the calibration levels for a DC track circuit. Typically 7 days of data is required to allow for accurate setting of levels and limits, during this period of time maintenance mode should be set to avoid false alarms. Each type of relay has different operating characteristics and requires different settings. Initial setting values for each type of common plug in relay are given in the table below. Following site commissioning, set up TC in Windows Viewer with the following steps:

1. Check in the 'Logger Offsets' tab that the TC asset is mapped correctly.
2. In the 'Attributes' tab, enter the values for the type of track relay as per the table below.
3. In the 'Details' tab check that data is being received for train shunts; a valid current value and track circuit occupation count is displayed.
4. Allow at least 24 hours then review the alarm 'Count since Midnight'. Where a count is registered this will require investigation and consideration of adjustment to levels and limits.
5. Continue to review daily and Go-Live when confirmed that values are ok.

Over time some of the values shall require to be adjusted as the performance of the track circuit over a range of conditions is understood. Further guidance on II TC monitoring and calibration levels and limits may be found in the II "TC Monitoring Guide". Additionally, further advice can be obtained from II Project Engineers.

Specification	BR939A	BR966F2	BR938A	BR966F9	Notes
Pin Code	**105**	**110**	**101**	**104**	For other types of DC track relay, 'Drop Away' and 'Pick Up' values may be obtained from details on the relay label. The drop away value may also be determined by following the guidance given in the II TC monitoring guide.
Coil Resistance	**20 Ω**	**9 Ω**	**4 Ω**	**60 Ω**	
Nominal Pick Up Volts	**2.0v**	**1.4v**	**0.5v**	**4.0v**	
Nominal Pick Up Current	**100mA**	**156mA**	**125mA**	**67mA**	
Occupied Level / Drop Away Current	**58mA**	**88mA**	**76mA**	**40mA**	'Occupied Level' set to specified drop away current for type of relay.
High Occupied Current Level	**29mA**	**44mA**	**38mA**	**20mA**	Set no higher than 50% of minimum drop away value.
Low Clear Current Level	**150mA**	**230mA**	**190mA**	**100mA**	Initial setting 150% of nominal pick up value. When data available raise to 10% below lowest clear current i.e. wet conditions. (Clear currents <150% should be regarded as too low and cause investigated)
Excess Current Level	**Set 20% higher than clear current level**				Currents greater then 4.5 times the nominal pick value should be investigated.
Occupied-Clear-Occupied Lower Limit	**0 Seconds**				Cause of short duration flicks requires to be understood before setting value >0. Value should be set no higher than 0.3 seconds.
Occupied-Clear-Occupied Upper Limit	**20 Seconds**				Will require reducing if time between trains less than 20 seconds.
Clear-Occupied-Clear Lower Limit	**0 Seconds**				Cause of short duration flicks requires to be understood before setting value >0.
Clear-Occupied-Clear Upper Limit	**5 Seconds**				Should be set to less than the time for which the shortest, fastest train will occupy the track circuit. Usually, requires to be reduced for short track circuits.
Low Current-Clear Time	**2 Seconds**				Time allowed for TC current to be in the low clear band before alarm is raised. May require to be adjusted to suit specific TC characteristics.
High Current-Occupied Time	**2 Seconds**				Time allowed for occupied track current to be in high occupied band before alarm is raised. May require to be adjusted to suit specific TC characteristics.

Appendix A – TC Minimum Occupied Time Matrix

		Line Speed MPH																							
		125	**120**	**115**	**110**	**105**	**100**	**95**	**90**	**85**	**80**	**75**	**70**	**65**	**60**	**55**	**50**	**45**	**40**	**35**	**30**	**25**	**20**	**15**	**10**
Effective Length (metres) = TC Length + Train Length	**300**	5.3	5.5	5.8	6.1	6.3	6.7	7.0	7.4	7.8	8.3	8.9	9.5	10.3	11.1	12.2	13.4	14.9	16.7	19.1	22.3	26.8	33.5	44.7	67.1
	290	5.1	5.4	5.6	5.8	6.1	6.4	6.8	7.2	7.6	8.1	8.6	9.2	9.9	10.8	11.7	12.9	14.4	16.2	18.5	21.6	25.9	32.4	43.2	64.8
	280	5.0	5.2	5.4	5.6	5.9	6.2	6.5	6.9	7.3	7.8	8.3	8.9	9.6	10.4	11.3	12.5	13.9	15.6	17.8	20.8	25.0	31.3	41.7	62.6
	270	4.8	5.0	5.2	5.4	5.7	6.0	6.3	6.7	7.1	7.5	8.0	8.6	9.2	10.0	10.9	12.0	13.4	15.1	17.2	20.1	24.1	30.2	40.2	60.4
	260	4.6	4.8	5.0	5.2	5.5	5.8	6.1	6.4	6.8	7.2	7.7	8.3	8.9	9.6	10.5	11.6	12.9	14.5	16.6	19.3	23.2	29.0	38.7	58.1
	250	4.4	4.6	4.8	5.0	5.3	5.5	5.8	6.2	6.5	6.9	7.4	7.9	8.6	9.3	10.1	11.1	12.4	13.9	15.9	18.6	22.3	27.9	37.2	55.9
	240	4.2	4.4	4.6	4.8	5.1	5.3	5.6	5.9	6.3	6.7	7.1	7.6	8.2	8.9	9.7	10.7	11.9	13.4	15.3	17.8	21.4	26.8	35.7	53.6
	230	4.1	4.2	4.4	4.6	4.9	5.1	5.4	5.7	6.0	6.4	6.8	7.3	7.9	8.5	9.3	10.2	11.4	12.8	14.7	17.1	20.5	25.7	34.3	51.4
	220	3.9	4.1	4.2	4.4	4.6	4.9	5.1	5.4	5.7	6.1	6.5	7.0	7.5	8.2	8.9	9.8	10.9	12.3	14.0	16.4	19.6	24.6	32.8	49.2
	210	3.7	3.9	4.0	4.2	4.4	4.6	4.9	5.2	5.5	5.8	6.2	6.7	7.2	7.8	8.5	9.3	10.4	11.7	13.4	15.6	18.7	23.4	31.3	46.9
	200	3.5	3.7	3.8	4.0	4.2	4.4	4.7	4.9	5.2	5.5	5.9	6.3	6.8	7.4	8.1	8.9	9.9	11.1	12.7	14.9	17.8	22.3	29.8	44.7
	190	3.4	3.5	3.6	3.8	4.0	4.2	4.4	4.7	5.0	5.3	5.6	6.0	6.5	7.0	7.7	8.5	9.4	10.6	12.1	14.1	17.0	21.2	28.3	42.5
	180	3.2	3.3	3.5	3.6	3.8	4.0	4.2	4.4	4.7	5.0	5.3	5.7	6.1	6.7	7.3	8.0	8.9	10.0	11.5	13.4	16.1	20.1	26.8	40.2
	170	3.0	3.1	3.3	3.4	3.6	3.8	4.0	4.2	4.4	4.7	5.0	5.4	5.8	6.3	6.9	7.6	8.4	9.5	10.8	12.6	15.2	19.0	25.3	38.0
	160	2.8	2.9	3.1	3.2	3.4	3.5	3.7	3.9	4.2	4.4	4.7	5.1	5.5	5.9	6.5	7.1	7.9	8.9	10.2	11.9	14.3	17.8	23.8	35.7
	150	2.6	2.7	2.9	3.0	3.1	3.3	3.5	3.7	3.9	4.1	4.4	4.7	5.1	5.5	6.1	6.7	7.4	8.3	9.5	11.1	13.4	16.7	22.3	33.5
	140	2.5	2.6	2.7	2.8	2.9	3.1	3.2	3.4	3.6	3.9	4.1	4.4	4.8	5.2	5.6	6.2	6.9	7.8	8.9	10.4	12.5	15.6	20.8	31.3
	130	2.3	2.4	2.5	2.6	2.7	2.9	3.0	3.2	3.4	3.6	3.8	4.1	4.4	4.8	5.2	5.8	6.4	7.2	8.3	9.6	11.6	14.5	19.3	29.0
	120	2.1	2.2	2.3	2.4	2.5	2.6	2.8	2.9	3.1	3.3	3.5	3.8	4.1	4.4	4.8	5.3	5.9	6.7	7.6	8.9	10.7	13.4	17.8	26.8
	110	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.7	2.8	3.0	3.2	3.5	3.7	4.1	4.4	4.9	5.4	6.1	7.0	8.2	9.8	12.3	16.4	24.6
	100	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.6	2.7	2.9	3.1	3.4	3.7	4.0	4.4	4.9	5.5	6.3	7.4	8.9	11.1	14.9	22.3
	90	1.6	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.5	2.6	2.8	3.0	3.3	3.6	4.0	4.4	5.0	5.7	6.7	8.0	10.0	13.4	20.1
	80	1.4	1.4	1.5	1.6	1.7	1.7	1.8	1.9	2.1	2.2	2.3	2.5	2.7	2.9	3.2	3.5	3.9	4.4	5.1	5.9	7.1	8.9	11.9	17.8
	70	1.2	1.3	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4	2.6	2.8	3.1	3.4	3.9	4.4	5.2	6.2	7.8	10.4	15.6
	60	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.9	2.0	2.2	2.4	2.6	2.9	3.3	3.8	4.4	5.3	6.7	8.9	13.4
	50	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.7	1.8	2.0	2.2	2.4	2.7	3.1	3.7	4.4	5.5	7.4	11.1
	40						0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.7	1.9	2.2	2.5	2.9	3.5	4.4	5.9	8.9

Notes: Effective Length (metres) = TC Length + Minimum Train Length. Where exact train length is not known allow 20 metres per vehicle. E.g. Two car DMU (40 metres long) travelling over a TC section 80 metres long at a line speed of 60 mph = 'Minimum Occupied Time' of 4.4 Seconds. It is advisable to set the 'Clear-Occupied-Clear' Upper Limit 0.5 secs lower than 'Minimum Occupied Time'; E.g. 3.9 secs. For shortest occupied times set the upper limit no lower than 0.5 secs.