Division / Business Unit: Enterprise Services
Function: Signalling
Document Type: Guideline

STOPDIST Train Braking Distance Calculation Tool User Guide

ESI-05-12

Applicability

ARTC Network Wide

Publication Requirement

Internal / External

Primary Source

Document Status

Version #	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.0	19 June 2017	Signal Standards Engineer	Stakeholders	Manager Standards	A/General Manager Technical Standards 29/06/2017

Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
1.0	19 June 2017		First Issue

© Australian Rail Track Corporation Limited (ARTC)

Disclaimer

This document has been prepared by ARTC for internal use and may not be relied on by any other party without ARTC's prior written consent. Use of this document shall be subject to the terms of the relevant contract with ARTC.

ARTC and its employees shall have no liability to unauthorised users of the information for any loss, damage, cost or expense incurred or arising by reason of an unauthorised user using or relying upon the information in this document, whether caused by error, negligence, omission or misrepresentation in this document.

This document is uncontrolled when printed.

Authorised users of this document should visit ARTC's intranet or extranet (www.artc.com.au) to access the latest version of this document.

Table of Contents

1 Introduction

1.1 Purpose

This user guide describes how to use the STOPDIST calculation tool and how it is normally applied for calculating train braking distances.

1.2 Background

During the signalling design process, train braking distances for signal spacing are calculated using train brake tables. The majority of trains operating on the ARTC network are long and heavy hauled freight trains. Consequently, a train's mass is distributed over the entire length of the train which can be spread over a number of varying gradients. Providing consistent and accurate calculations for train braking distances can be quite complex.

By performing iterative style train braking calculations using the STOPDIST tool, improved consistency and accuracy will be provided.

1.3 Reference Documents

The following documents should be read in conjunction with this guide:

- ESD-05-03 Train Braking Application Design
- ESI0512T-01 STOPDIST ver 2.1

1.4 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
Brake Table	A table of predetermined braking distances for a particular type of train travelling at multiple speeds, on multiple gradients.
STOPDIST	The STOPDIST calculation tool calculates stopping distances for the different types of trains.

2 Description of STOPDIST

STOPDIST is an Excel program, which runs on a Windows based PC. It is important to ensure the most current approved version is being used for calculating train braking distances.

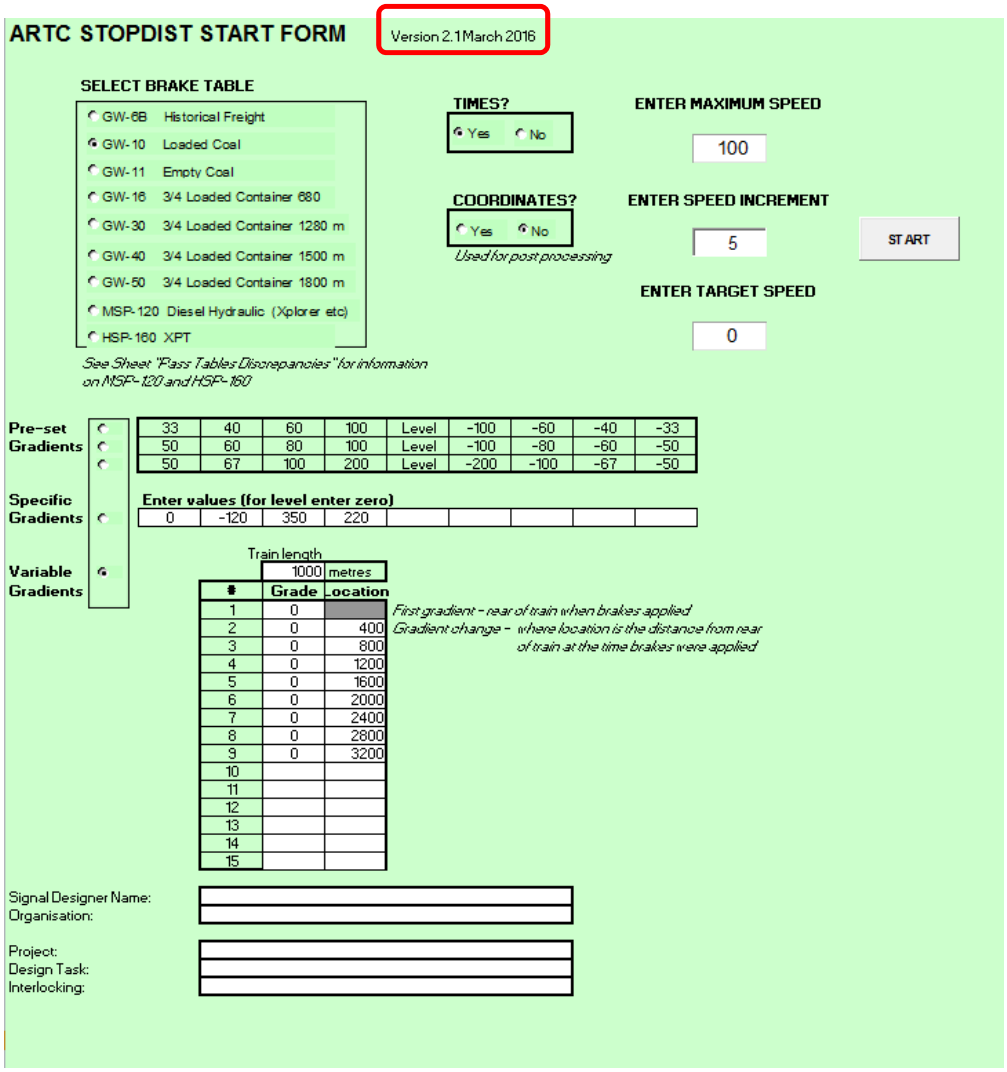
The STOPDIST tool shall be used for determining the actual train braking distances for all signalling design.

Refer to ARTC Engineering Extranet for the most current version.

2.1 Open STOPDIST

Open STOPDIST the same way as any regular excel file. The file should open on the “Start” worksheet, which is called the START FORM and is displayed as a green screen as below.

Note: it may be necessary to “Enable Macros” when opening the file.



The START FORM is the only worksheet in STOPDIST that data is entered to calculate the braking distance for determining signal spacing between each signal. All other worksheets are for information only.

Note: Before performing any calculations, check the version being used is the current version (highlighted red above).

2.2 START FORM Features

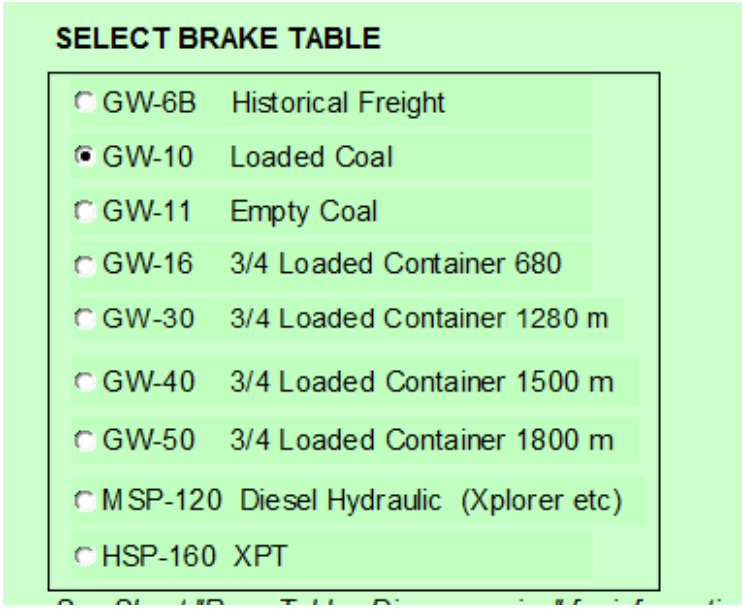
The active cells on START FORM are white cells. Values and text data can only be entered into active cells. Option buttons can be selected by clicking on them with the mouse.

2.2.1 Signal Designer and Associated Signal Details

For every braking distance calculation for each signal, the Signal Designer must complete the above table on the START FORM. The information required is self-explanatory, however the 'Design Task' details must include the associated signal numbers (*Entry and Stop signals*) the braking distance (signal spacing) is being calculated for.

The details entered in this table will automatically appear on a similar table on the Results Report worksheet.

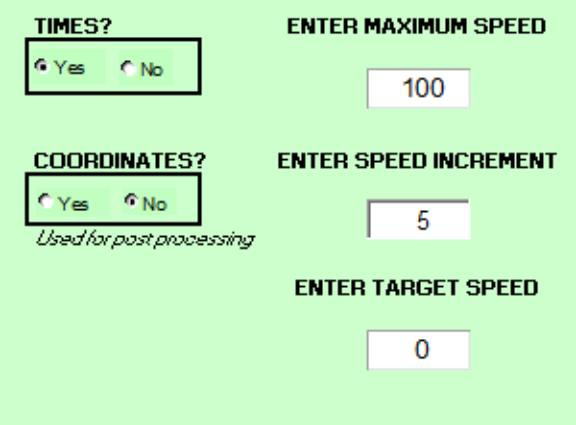
2.2.2 Select Brake Table



This table is used to select which train type is to be applied for the braking distance calculation. To select the train type, click on the appropriate option button, which will turn black when selected.

Where multiple train types are operating on a section of the network, the Signal Designer **must undertake the calculations for each type of train.**

2.2.3 Train Speed, Times and Coordinates Entries



To calculate the braking distance for each type of train the following must be entered:

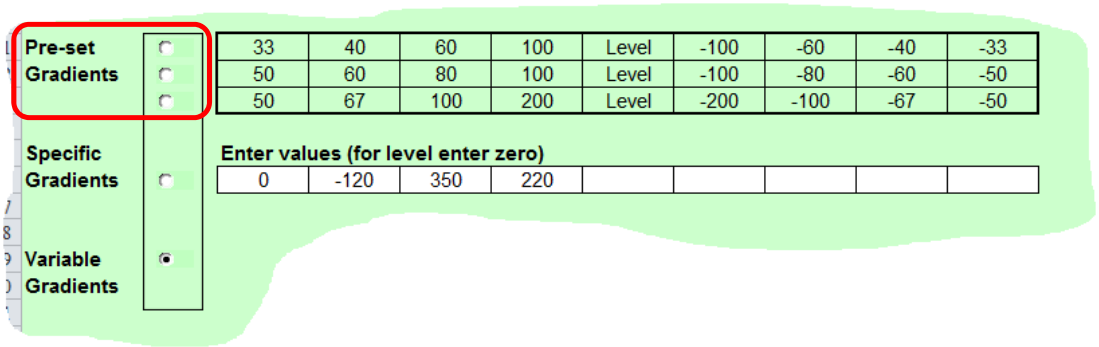
- maximum speed in Km/h, usually the line speed for that type of train at that location
- the speed increment (usually 5 or 10 Km/h)
- target speed 0 Km/h for stopping or target speed for passing over a turnout
- Times option button, select 'Yes' if times are required to be displayed in the results table for each speed increment
- Coordinates option button, select 'No' (this function is Not Used)

Note: the line speed may vary considerably between train types, eg HSP160 may be 160Km/h, GW40 may be 115Kph and GW10 may 60Km/h at the one signal location.

2.2.4 Track Gradients

The STOPDIST Tool has a general function to calculate Pre-set Gradients or Specific Gradients but these are not used for a specific signalling design.

The 'Variable Gradients' option button must be selected for all braking distance calculations and entries added to a separate table (refer 2.2.5).



To create general brake tables for a particular train type for specific constant gradients, the appropriate 'Pre-set Gradients' can be selected or for customised gradients, the 'Specific Gradients' can be selected and the specific gradient values added to the table.

2.2.5 Variable Track Gradients

Train length a) 1000 metres

#	Grade	Location
1	b) 0	
2	0	c) 400
3	0	800
4	0	1200
5	0	1600
6	0	2000
7	0	2400
8	0	2800
9	0	3200
10		
11		
12		
13		
14		
15		

First gradient - rear of train when brakes applied
Gradient change - where location is the distance from rear of train at the time brakes were applied

In all cases, the 'Variable Gradients' option button (refer 2.2.4) shall be used and values entered in this table.

With reference to Figure 1 below of a train and track gradient profile, the table entries are:

a) The length of the train is entered. (*Note: this provides a reference point for the changes in gradient. It does NOT change the braking rate, which is dependent on the train type selected*.)

b) The changes of grades are entered (#1= -80 grade at EOT, #2=+400 grade at 1st change of grade, #3= +50 grade at 2nd change of grade, etc…)

c) Location is the distance from **EOT** (End of Train) to start of each grade change (#2= 500m distance to start of +400, #3= 800m distance to start of +50, etc…)

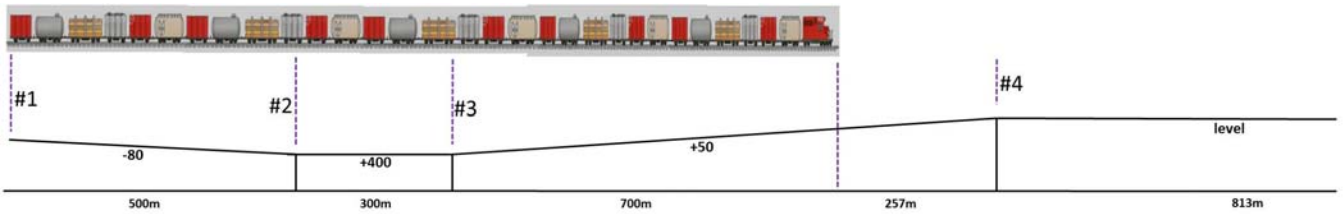
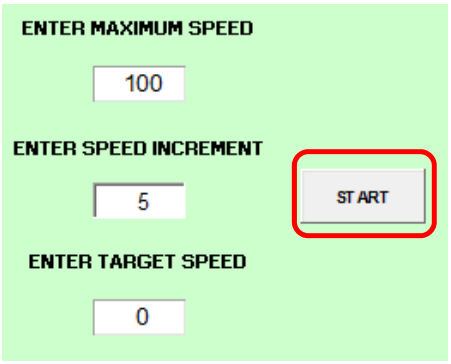


Figure 1

For a more detailed description of how to enter the values in the table, please refer to the worked example in Appendix A.

2.2.6 START Button



Once all the parameters have been entered as described in sections 2.2.1 to 2.2.5, the START button can be activated by clicking on it. The program will generate the braking distance results on the "Results" worksheet.

2.3 Results Report

By clicking on the "Results" worksheet tab, the Results Report page will be displayed. For example:

GW-10 **Loaded Coal**

STOPPING DISTANCE TABLE (time in seconds, distances in metres) **(Includes 15 % allowance)**
(distances only)

	GRADE (1 in X)									
	Variable									
Speed km/h	Time	Distance								
5	12	14								
10	16	37								
15	21	69								
20	25	107								
25	28	151								
30	32	200								
35	34	254								
40	37	313								
45	39	376								
50	41	444								
55	44	516								
60	47	593								
65	49	674								
70	51	760								
75	54	851								
80	56	946								
85	58	1048								
90	61	1157								
95	65	1274								
100	68	1402								

Calculated from STOPDIST program — ARTC STOPDIST Version 2.1
Air Brake Parameters used (speed km/h,decel m/s/s) (1,0.7) (45,0.5) (115,0.35) (0,0)
Rolling Resistance - Included
Brake delay - 0 seconds Air brake build up time - 55 seconds Date: 16/11/2016

Signal Designer Name:
Organisation:
Project:
Design Task:
Interlocking:

3 Calculating Braking Distance to Determine Signal Spacing

3.1 General

The Signal Designer must first determine which train types will operate on the part of the ARTC network to be signalled. For a description of this process, train types and where they run on the network, please refer to the Train Braking Application Design document, ESD-05-03 section 2.

3.2 Calculating Braking Distance (Signal Spacing)

The STOPDIST tool is used iteratively by the Designer to determine the braking distance between 2 signals. Usually the braking distance will be calculated back to an Entry signal from a fixed signal (Stop signal), which may be fixed due to it providing protection of a set of points, for example.

To determine the optimum signal spacing, the designer will perform a number of iterative braking distance calculations. *The final resultant braking distance value to be used as basis for signal spacing for the actual signal plan design must be within the range of the calculated braking distance <+20m >-0m.*

3.3 Printed Reports

The STOPDIST tool has ‘print areas’ set up for both the START Form report and the Results Report. This allows the signal designer to print both reports of each brake distance calculation for verification and recording purposes.

It is important the signal designer includes the designer details and associated signal details (refer section 2.2.1) before printing the reports.

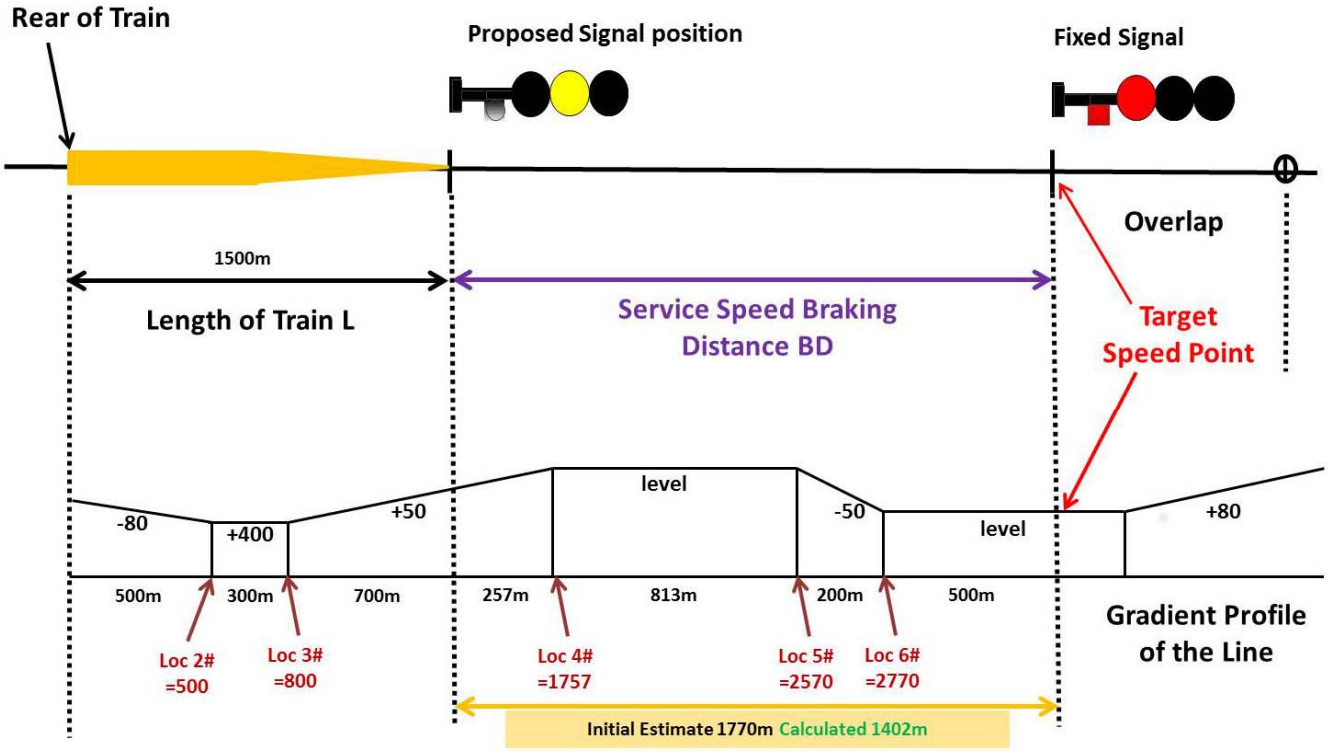
4 Appendix A – Worked Example

The following is an example of a 1500m train operating on track with a variable gradient profile with a line speed of 100Kph. There are 4 iterations of braking distance calculations to determine the optimum signal spacing between the fixed signal and the proposed signal.

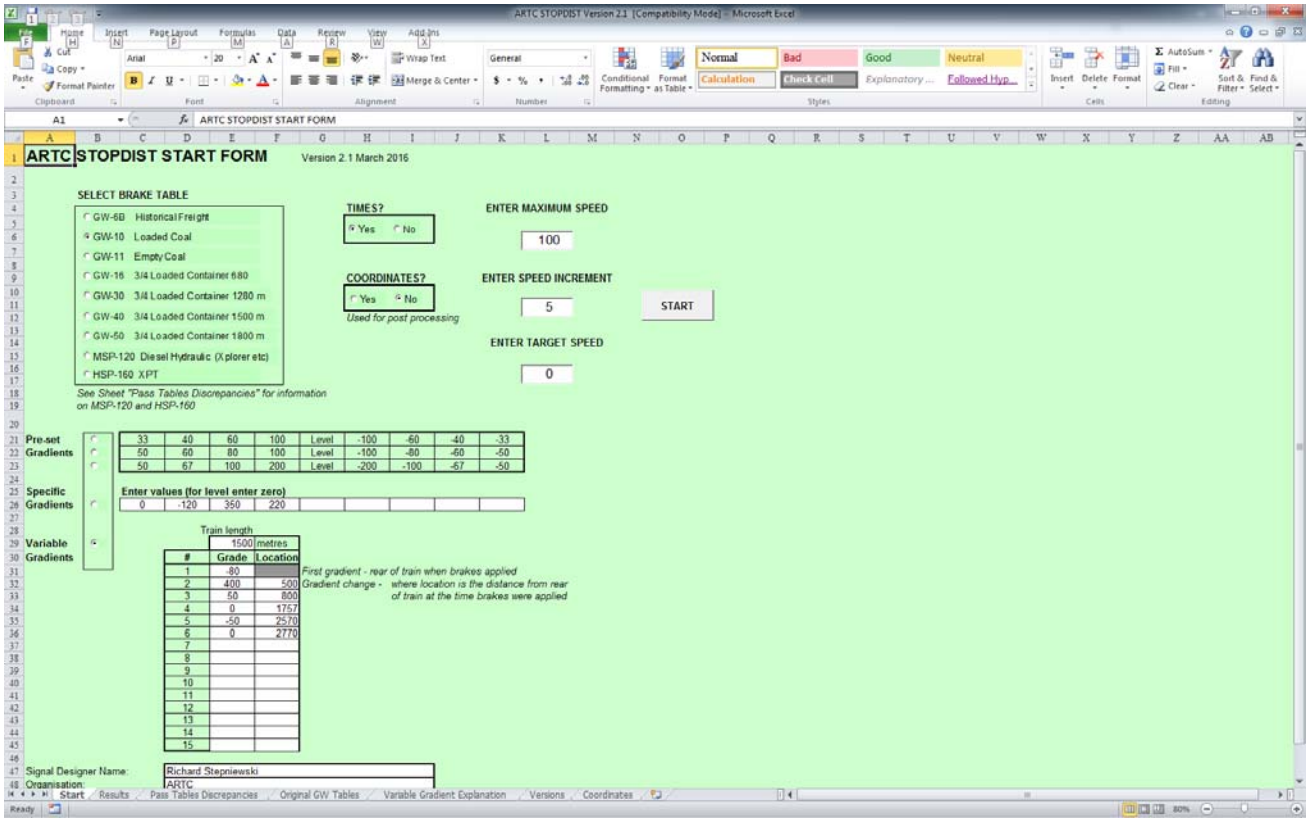
The fourth iteration provides a result of the calculated braking distance +7m, which falls in the range of +20m/-0m.

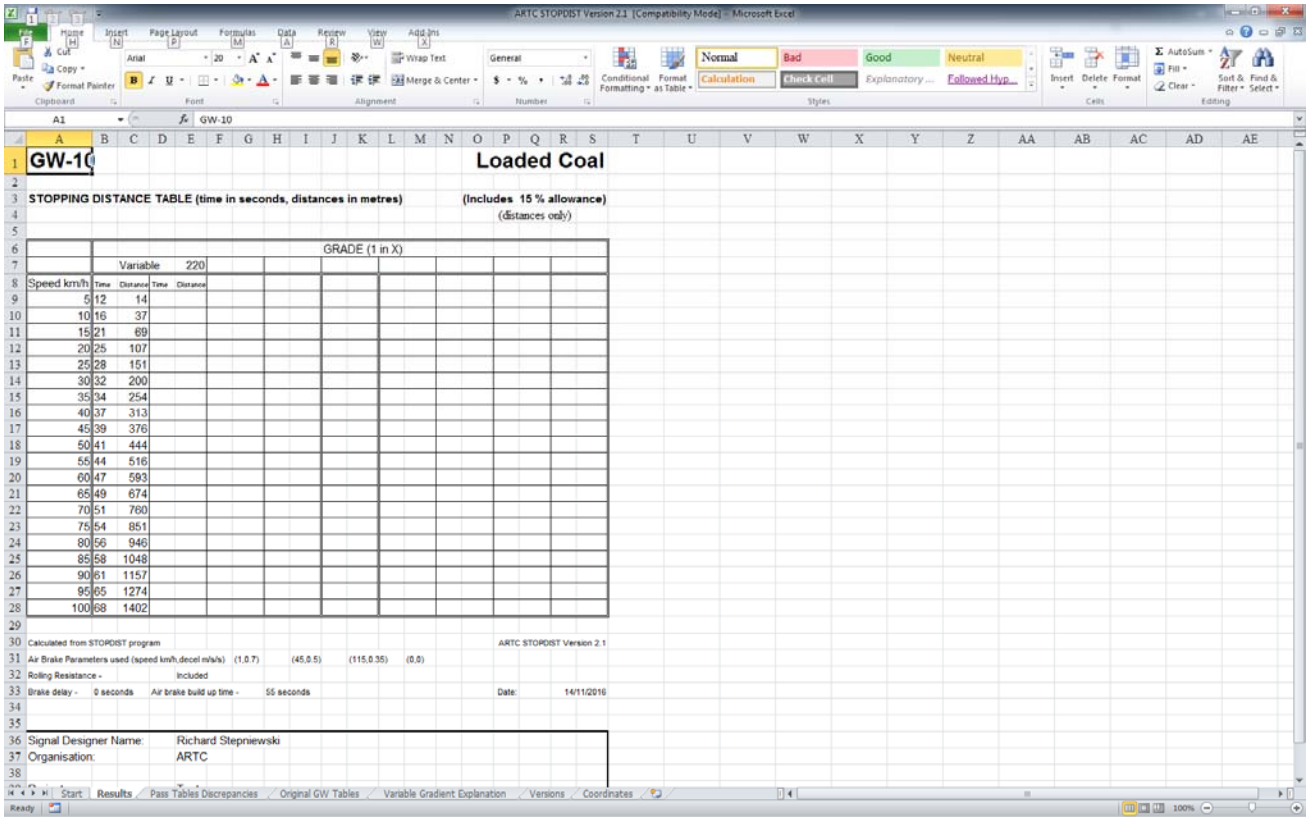
The 4 iterations are listed below in sequence:

4.1 Iteration 1

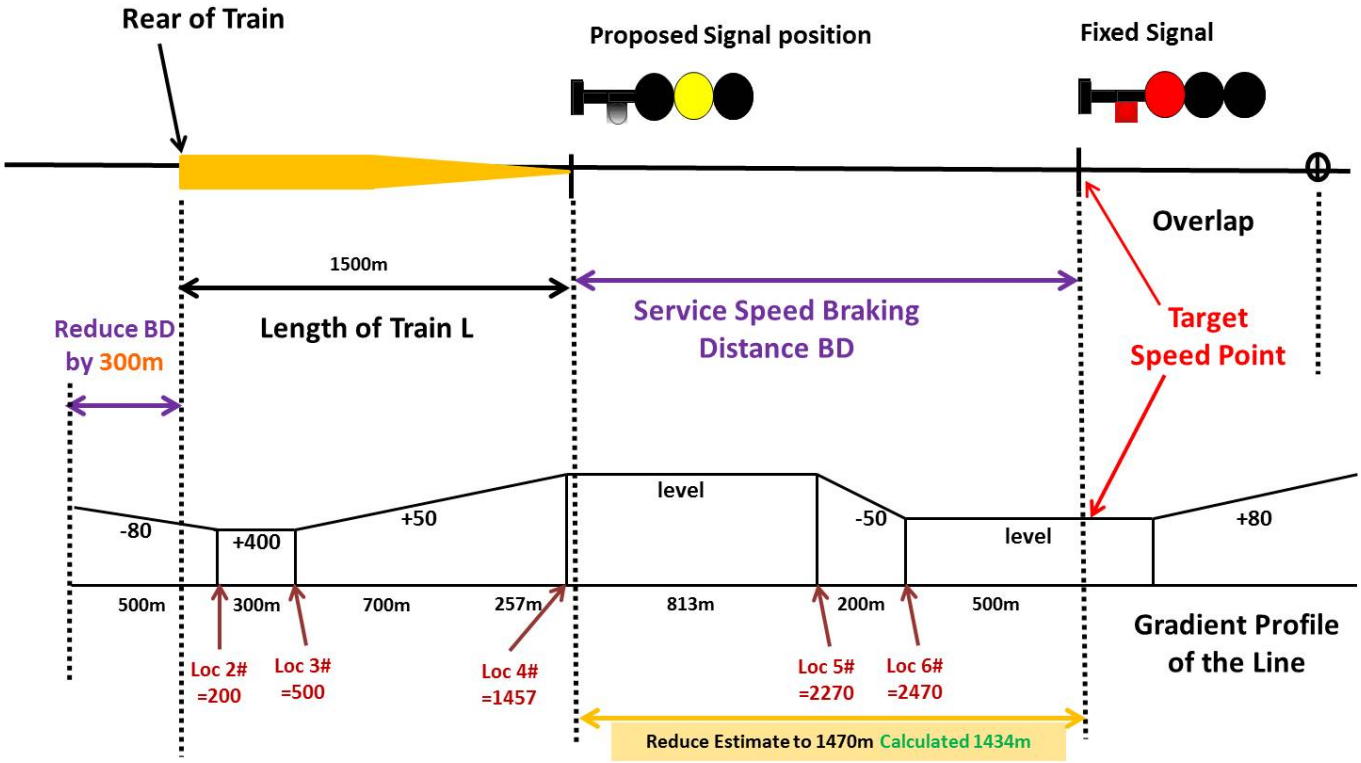


Initial Calculation BD is excessive by +368m NOT within acceptable range of +20m/-0m

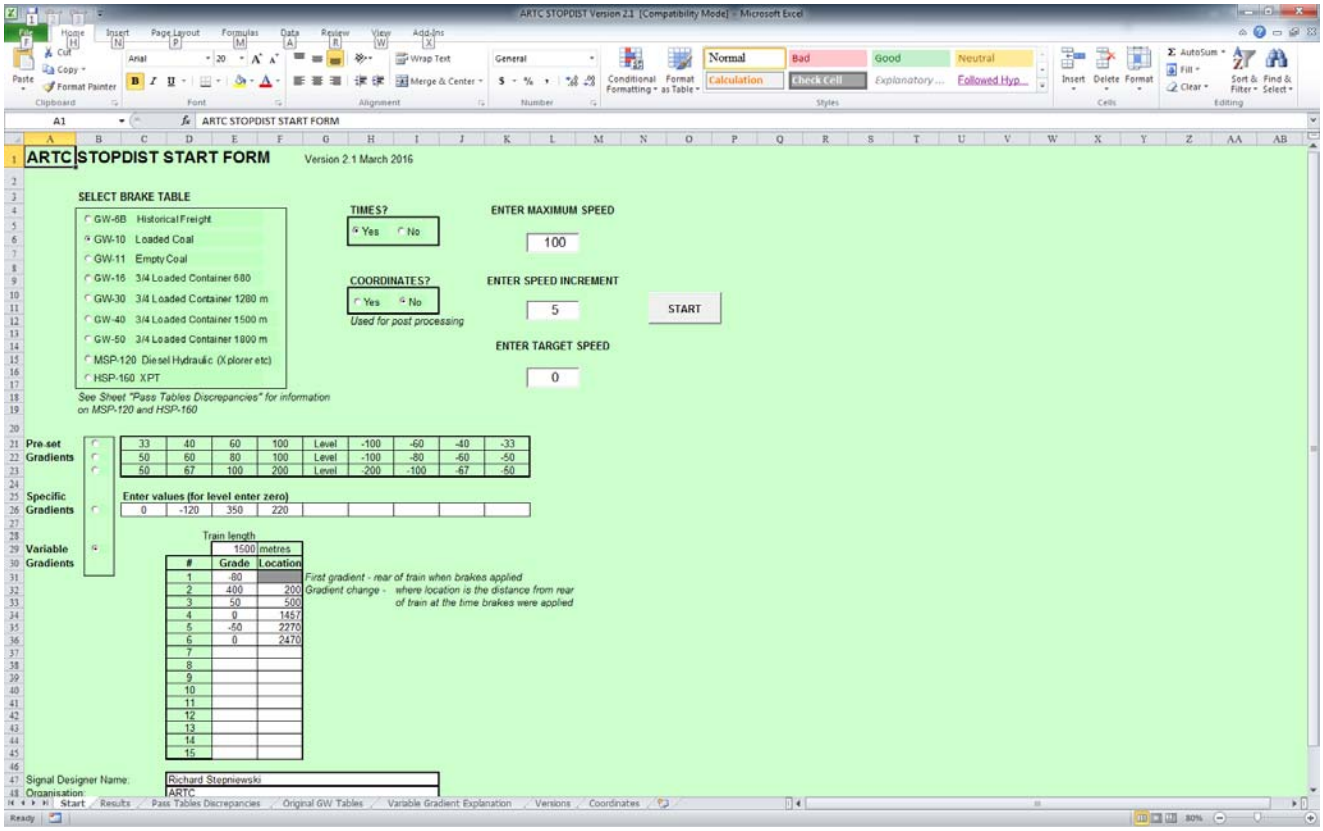

ARTC STOPDIST START FORM
Version 2.1 March 2016
SELECT BRAKE TABLE
GW-60 Historical Freight
GW-10 Loaded Coal
GW-11 Empty Coal
GW-16 3/4 Loaded Container 680
GW-30 3/4 Loaded Container 1280 m
GW-40 3/4 Loaded Container 1500 m
GW-50 3/4 Loaded Container 1800 m
MSP-120 Diesel Hydraulic (Xplorer etc)
HSP-160 XPT
See Sheet "Pass Tables Discrepancies" for information on MSP-120 and HSP-160
TIMES?
Yes No
COORDINATES?
Yes No
Used for post processing
ENTER MAXIMUM SPEED
100
ENTER SPEED INCREMENT
5
START
ENTER TARGET SPEED
0
Pre-set Gradients
33 40 60 100 Level -100 -60 -40 -33
50 60 80 100 Level -100 -80 -60 -50
50 67 100 200 Level -200 -100 -67 -50
Specific Gradients
Enter values (for level enter zero)
0 -120 350 220
Variable Gradients
Train length
1500 metres
Grade Location
1 -80
2 400 500
3 50 800
4 0 1757
5 -50 2570
6 0 2770
First gradient - rear of train when brakes applied
Gradient change - where location is the distance from rear of train at the time brakes were applied
Signal Designer Name: Richard Stepniewski
Organisation: ARTC
Start Results Pass Tables Discrepancies Original GW Tables Variable Gradient Explanation Versions Coordinates

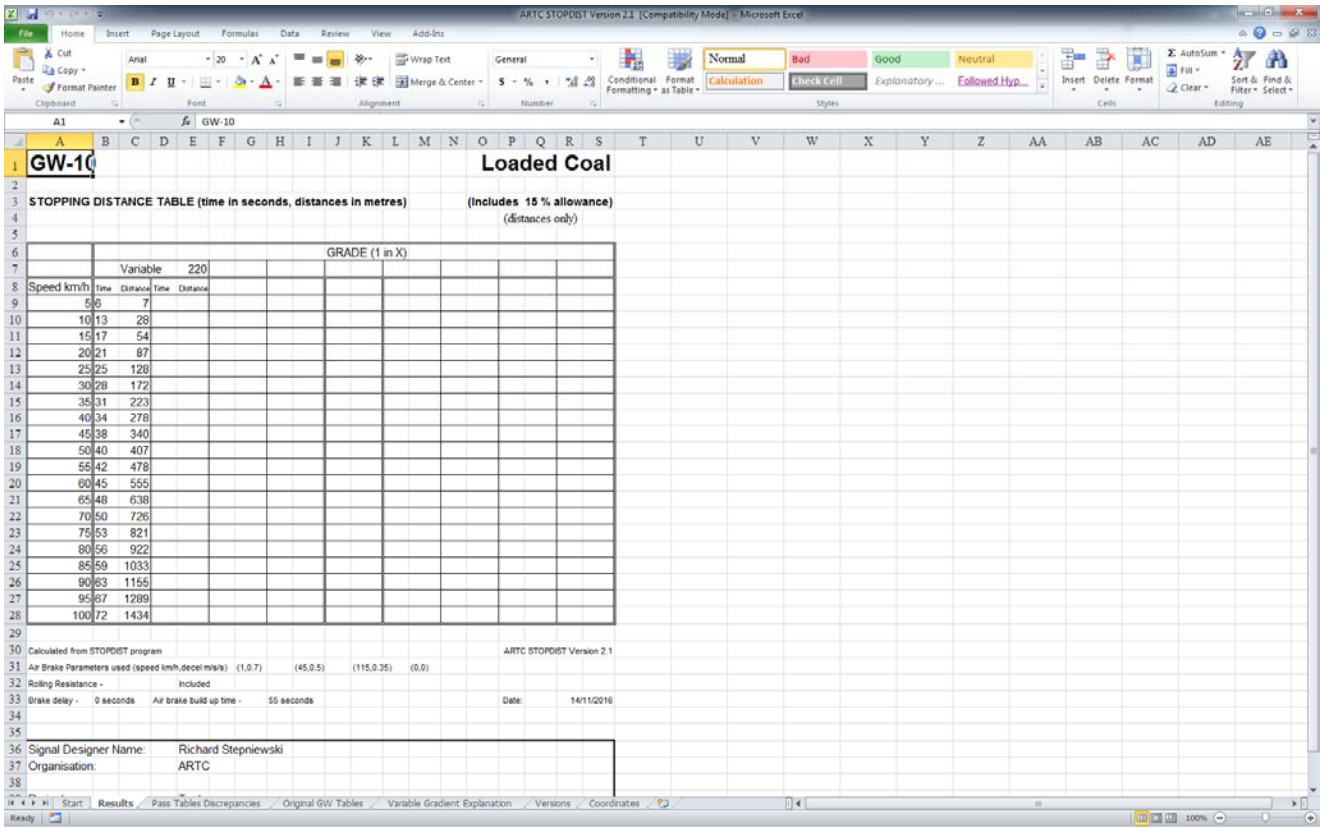

GW-10
Loaded Coal
STOPPING DISTANCE TABLE (time in seconds, distances in metres)
(Includes 15 % allowance)
(distances only)
GRADE (1 in X)
Variable 220
Speed km/h Time Distance Time Distance
5 12 14
10 16 37
15 21 69
20 25 107
25 28 151
30 32 200
35 34 254
40 37 313
45 39 376
50 41 444
55 44 516
60 47 593
65 49 674
70 51 760
75 54 851
80 56 946
85 58 1048
90 61 1157
95 65 1274
100 68 1402
Calculated from STOPDIST program
ARTC STOPDIST Version 2.1
Air Brake Parameters used (speed km/h,decel m/s/s) (1,0.7) (45,0.5) (115,0.35) (0,0)
Rolling Resistance - Included
Brake delay - 0 seconds Air brake build up time - 55 seconds
Date: 14/11/2016
Signal Designer Name: Richard Stepniewski
Organisation: ARTC
Start Results Pass Tables Discrepancies Original GW Tables Variable Gradient Explanation Versions Coordinates

4.2 Iteration 2

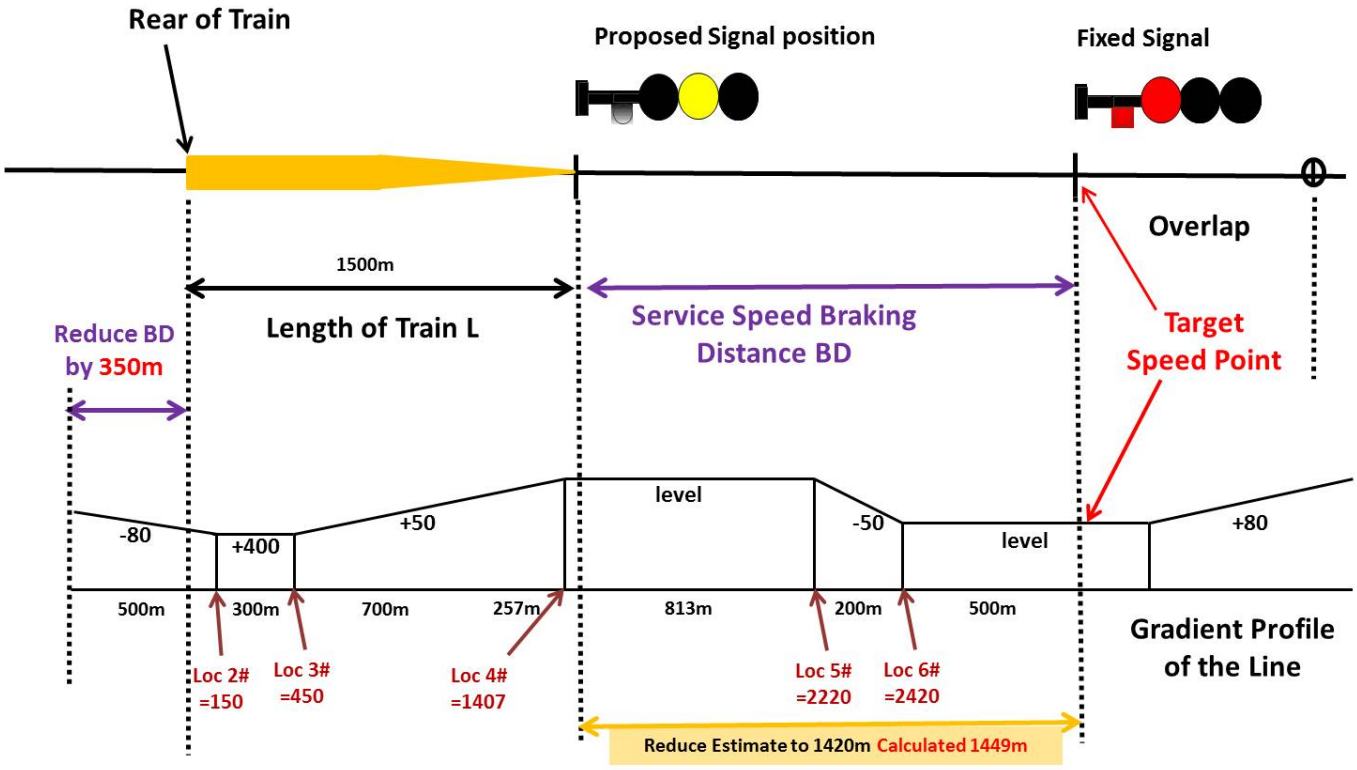


2nd Calculation BD is excessive by +36m NOT within acceptable range of +20m/-0m

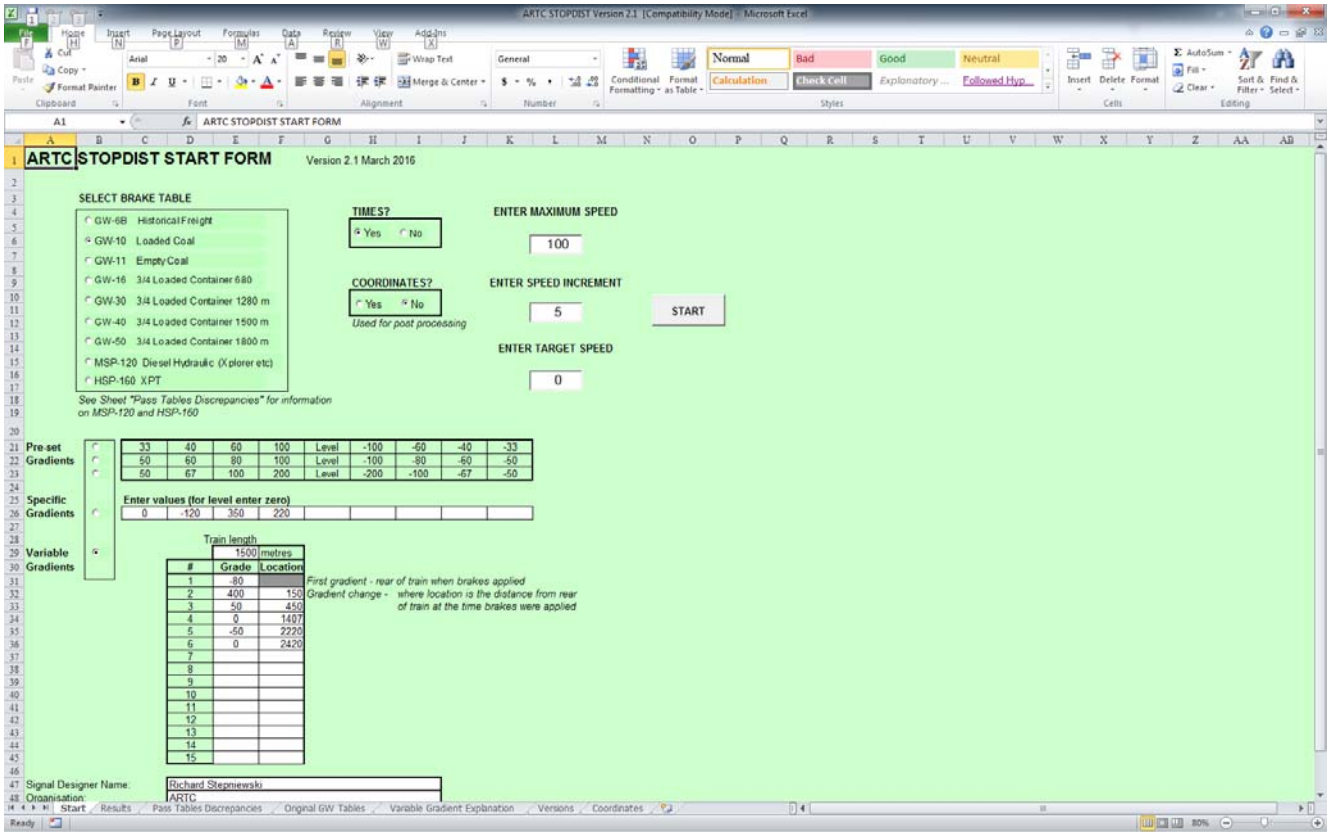

ARTC STOPDIST START FORM
Version 2.1 March 2016
SELECT BRAKE TABLE
GW-6B Historical Freight
GW-10 Loaded Coal
GW-11 Empty Coal
GW-16 3/4 Loaded Container 680
GW-30 3/4 Loaded Container 1280 m
GW-40 3/4 Loaded Container 1500 m
GW-50 3/4 Loaded Container 1800 m
MSP-120 Diesel Hydraulic (Xplorer etc)
HSP-160 XPT
See Sheet "Pass Tables Discrepancies" for information on MSP-120 and HSP-160
TIMES?
Yes No
COORDINATES?
Yes No
Used for post processing
ENTER MAXIMUM SPEED
100
ENTER SPEED INCREMENT
5
ENTER TARGET SPEED
0
START
Pre-set Gradients
33 40 60 100 Level -100 -60 -40 -33
50 60 80 100 Level -100 -80 -60 -50
50 67 100 200 Level -200 -100 -67 -50
Specific Gradients
Enter values (for level enter zero)
0 -120 350 220
Variable Gradients
Train length 1500 metres
Grade Location
1 -80
2 400 200
3 50 500
4 0 1457
5 -50 2270
6 0 2470
First gradient - rear of train when brakes applied
Gradient change - where location is the distance from rear of train at the time brakes were applied
Signal Designer Name: Richard Stepniewski
Organisation: ARTC


GW-10
Loaded Coal
STOPPING DISTANCE TABLE (time in seconds, distances in metres)
(Includes 15 % allowance)
(distances only)
GRADE (1 in X)
Variable 220
Speed km/h Time Distance Time Distance
5 6 7
10 13 28
15 17 54
20 21 87
25 25 128
30 28 172
35 31 223
40 34 278
45 38 340
50 40 407
55 42 478
60 45 555
65 48 638
70 50 726
75 53 821
80 56 922
85 59 1033
90 63 1155
95 67 1289
100 72 1434
Calculated from STOPDIST program
ARTC STOPDIST Version 2.1
Air Brake Parameters used (speed km/h,decel m/s/s) (1,0.7) (45,0.5) (115,0.35) (0,0)
Rolling Resistance - Included
Brake delay - 0 seconds Air brake build up time - 55 seconds
Date: 14/11/2016
Signal Designer Name: Richard Stepniewski
Organisation: ARTC

4.3 Iteration 3



3rd Calculation BD is short by -29m NOT within acceptable range of +20m/-0m



ARTC STOPDIST START FORM

ARTC STOPDIST START FORM Version 2.1 March 2016

SELECT BRAKE TABLE

- GW-68 Historical Freight
- GW-10 Loaded Coal
- GW-11 Empty Coal
- GW-16 3/4 Loaded Container 680
- GW-30 3/4 Loaded Container 1280 m
- GW-40 3/4 Loaded Container 1500 m
- GW-50 3/4 Loaded Container 1800 m
- MSP-120 Diesel Hydraulic (Xplorer etc)
- HSP-160 XPT

See Sheet "Pass Tables Discrepancies" for information on MSP-120 and HSP-160

TIMES? Yes / No

COORDINATES? Yes / No

Used for post processing

ENTER MAXIMUM SPEED: 100

ENTER SPEED INCREMENT: 5

START

ENTER TARGET SPEED: 0

Pre-set Gradients	33	40	60	100	Level	-100	-60	-40	-33
	50	60	80	100	Level	-100	-80	-60	-50
	50	67	100	200	Level	-200	-100	-67	-50

Specific Gradients — Enter values (for level enter zero)

0	-120	350	220					

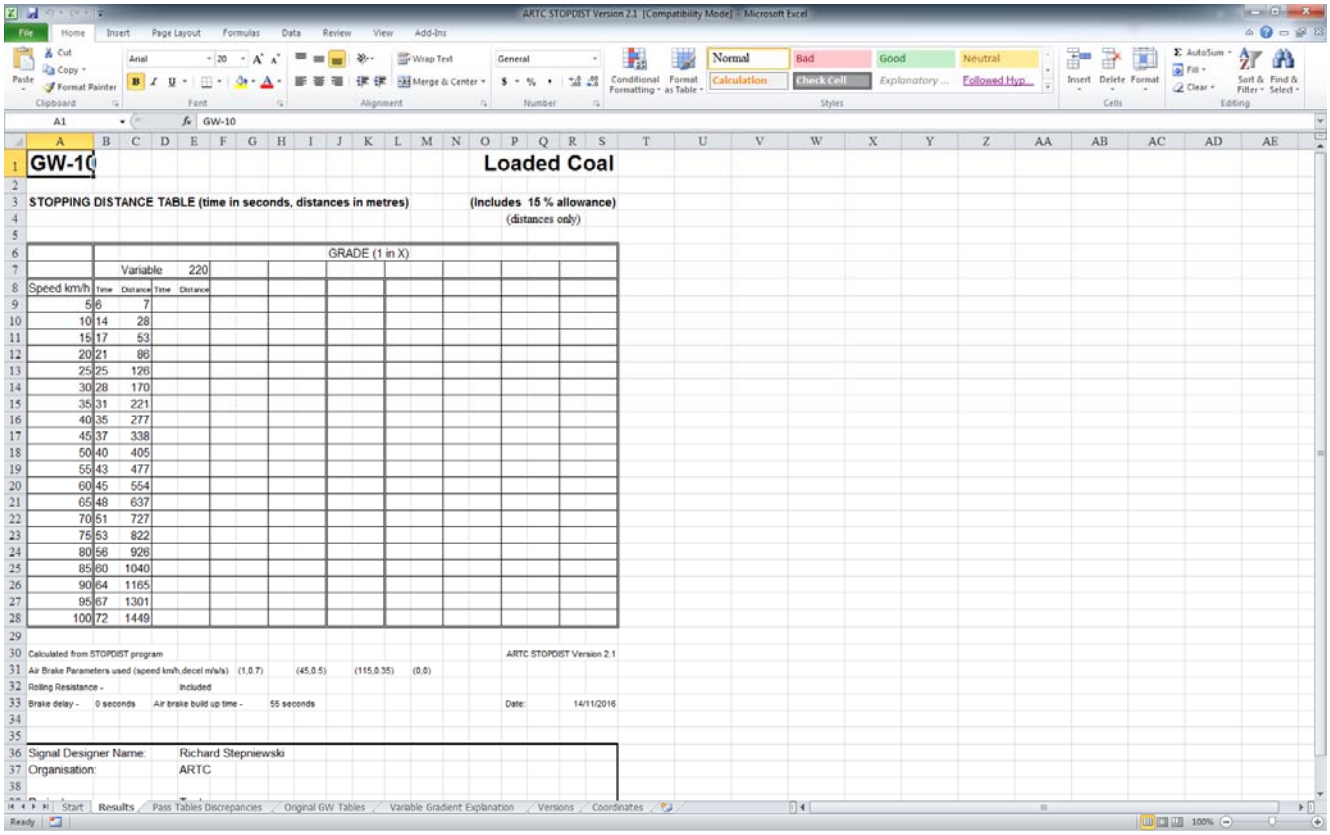
Variable Gradients

Train length: 1500 metres

#	Grade	Location
1	-80	
2	400	150
3	50	450
4	0	1407
5	-50	2220
6	0	2420
7		
8		
9		
10		
11		
12		
13		
14		
15		

First gradient - rear of train when brakes applied
Gradient change - where location is the distance from rear of train at the time brakes were applied

Signal Designer Name: Richard Stepniewski
Organisation: ARTC



GW-10 Loaded Coal

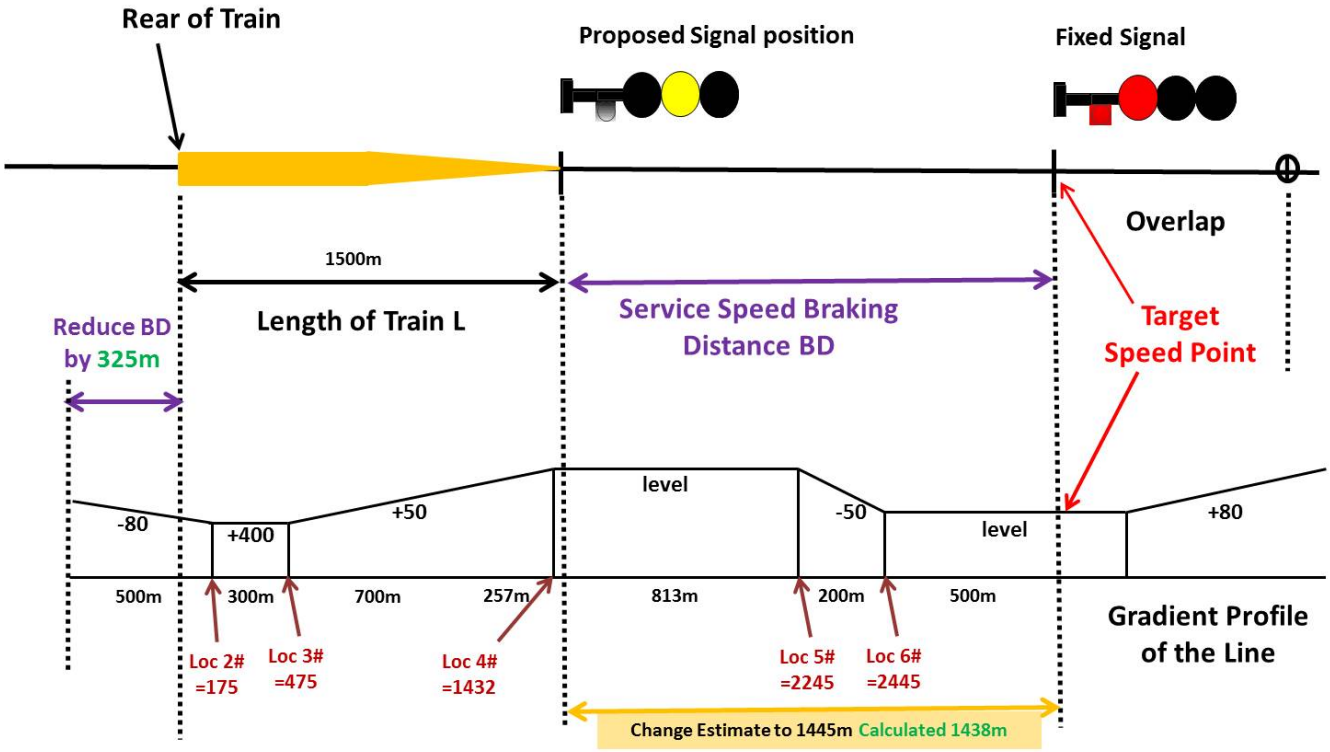
STOPPING DISTANCE TABLE (time in seconds, distances in metres) (Includes 15 % allowance) (distances only)

	GRADE (1 in X)			
	Variable		220	
Speed km/h	Time	Distance	Time	Distance
5	6	7		
10	14	28		
15	17	53		
20	21	86		
25	25	126		
30	28	170		
35	31	221		
40	35	277		
45	37	338		
50	40	405		
55	43	477		
60	45	554		
65	48	637		
70	51	727		
75	53	822		
80	56	926		
85	60	1040		
90	64	1165		
95	67	1301		
100	72	1449		

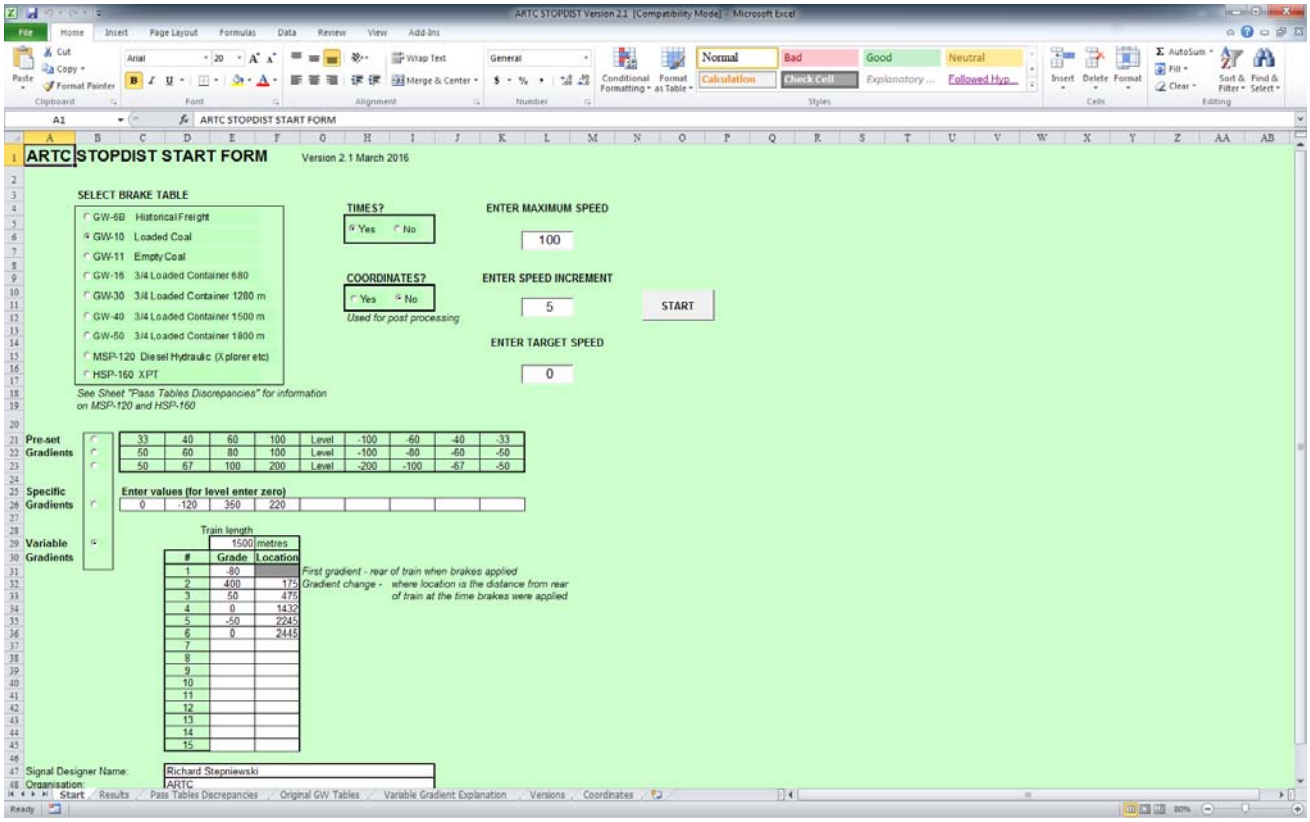
Calculated from STOPDIST program — ARTC STOPDIST Version 2.1
Air Brake Parameters used (speed km/h,decel m/s/s) (1,0.7) (45,0.5) (115,0.35) (0,0)
Rolling Resistance - Included
Brake delay - 0 seconds — Air brake build up time - 55 seconds — Date: 14/11/2016

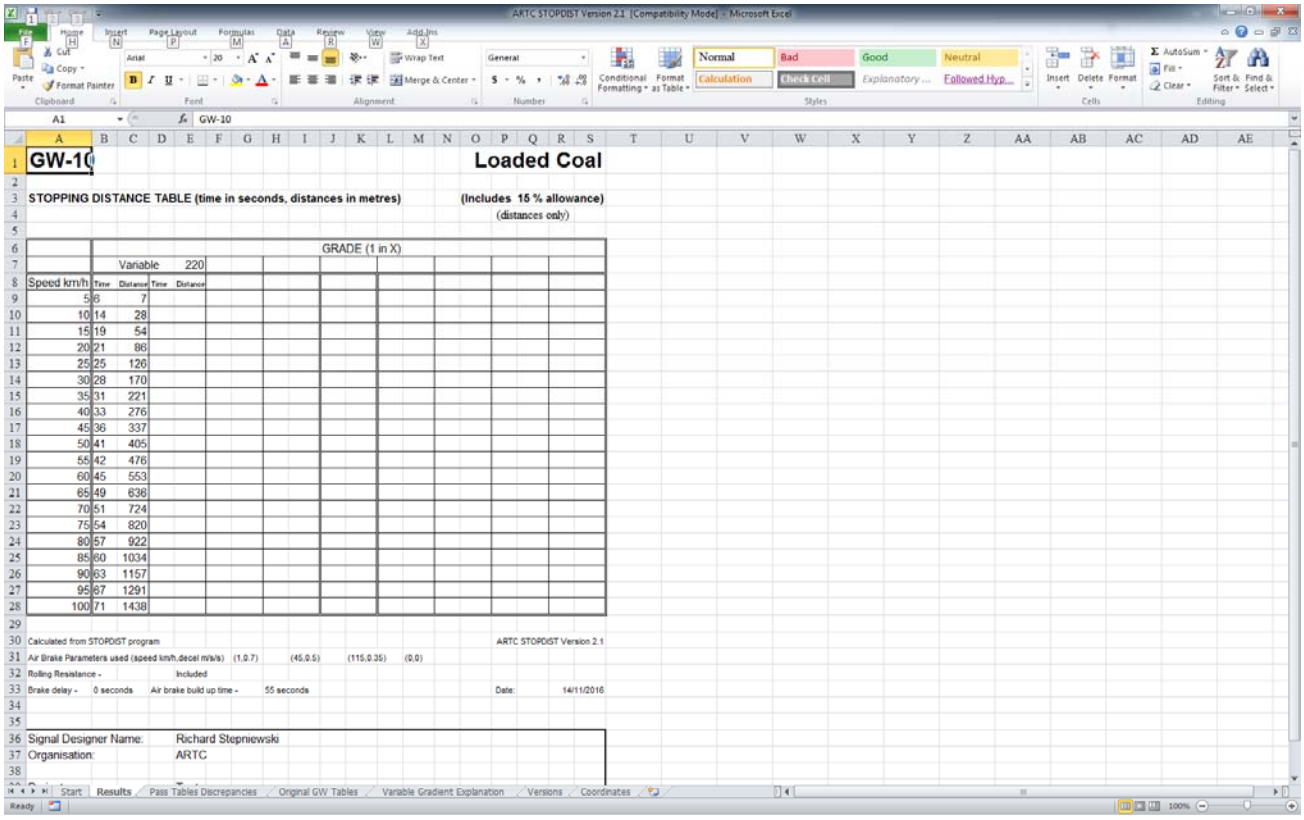
Signal Designer Name: Richard Stepniewski
Organisation: ARTC

4.4 Iteration 4



4th Calculation BD is 7m within acceptable range of +20m/-0m


ARTC STOPDIST START FORM
Version 2.1 March 2016
SELECT BRAKE TABLE
GW-6D Historical Freight
GW-10 Loaded Coal
GW-11 Empty Coal
GW-16 3/4 Loaded Container 680
GW-30 3/4 Loaded Container 1280 m
GW-40 3/4 Loaded Container 1500 m
GW-50 3/4 Loaded Container 1800 m
MSP-120 Diesel Hydraulic (Xplorer etc)
HSP-160 XPT
See Sheet "Pass Tables Discrepancies" for information on MSP-120 and HSP-160
TIMES?
Yes No
COORDINATES?
Yes No
Used for post processing
ENTER MAXIMUM SPEED
100
ENTER SPEED INCREMENT
5
ENTER TARGET SPEED
0
START
Pre-set Gradients
33 40 60 100 Level -100 -60 -40 -33
50 60 80 100 Level -100 -80 -60 -50
50 67 100 200 Level -200 -100 -67 -50
Specific Gradients
Enter values (for level enter zero)
0 -120 350 220
Variable Gradients
Train length
1500 metres
Grade Location
1 -80
2 400 175
3 50 475
4 0 1432
5 -50 2245
6 0 2445
First gradient - rear of train when brakes applied
Gradient change - where location is the distance from rear of train at the time brakes were applied
Signal Designer Name: Richard Stepniewski
Organisation: ARTC


GW-10
Loaded Coal
STOPPING DISTANCE TABLE (time in seconds, distances in metres)
(Includes 15 % allowance)
(distances only)
GRADE (1 in X)
Variable 220
Speed km/h Time Distance Time Distance
5 8 7
10 14 28
15 19 54
20 21 86
25 25 126
30 28 170
35 31 221
40 33 276
45 36 337
50 41 405
55 42 476
60 45 553
65 49 636
70 51 724
75 54 820
80 57 922
85 60 1034
90 63 1157
95 67 1291
100 71 1438
Calculated from STOPDIST program
ARTC STOPDIST Version 2.1
Air Brake Parameters used (speed km/h,decel m/s/s) (1,0.7) (45,0.5) (115,0.35) (0,0)
Rolling Resistance - Included
Brake delay - 0 seconds Air brake build up time - 55 seconds
Date: 14/11/2016
Signal Designer Name: Richard Stepniewski
Organisation: ARTC