TRAIN BRAKING SIMULATION STUDY ATTACHMENTS 1–34

Supporting data, calculated TEDS simulation stopping distance comparison plots, relevant ECP stopping distance observations documented in a current FRA research report, NTSB back-of-the-envelope ECP calculations, exemplar TEDS simulation time history plots, and exemplar vehicle kinetic energy comparison plots are included in Attachments 1–34. Table 15 provides a description of the content included in each attachment and the starting page number.

Table 15: Summary of Attachments

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1	Locomotive Sizing (Estimated Tractive Effort and Dynamic Brake Effort)			A1.1
2	Sanitized Model of Brake Shoe Coefficient of Friction (for Type A and B Brake Shoes) Based on Empirical Data from AAR R-469, “Brake Shoe Performance Evaluation,” April 1981.			A2.1
3	Brake Signal Propagation Effects, Emergency Braking Percent Distance Required to Stop Relative to CONV 10% NBR Baseline			A3.1
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8			78 tank cars	A8.1
9			104 tank cars	A9.1
10			130 tank cars	A10.1
11			156 tank cars	A11.1
12		Locomotive Brakes Applied	52 tank cars	A12.1
13			78 tank cars	A13.1
14			104 tank cars	A14.1
15			130 tank cars	A15.1
16			156 tank cars	A16.1
17	Full Service Braking Plots; Calculated train stopping distance as a function of speed and grade; Benefit relative to CONV baseline	Locomotive Brakes Bailed Off	52 tank cars	A17.1
18			78 tank cars	A18.1
19			104 tank cars	A19.1
20			130 tank cars	A20.1
21			156 tank cars	A21.1
22		Locomotive Brakes Applied	52 tank cars	A22.1
23			78 tank cars	A23.1
24			104 tank cars	A24.1
25			130 tank cars	A25.1
26			156 tank cars	A26.1
27	CONV, DP, and ECP Increased NBR Benefit (Relative to Respective 10% NBR Baseline)			A27.1
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Attachment 1: Locomotive Sizing (Estimated Tractive Effort and Dynamic Brake Effort)

Estimated Number of TEDS 4400 HP Locomotives Required as a Function of Trailing Tons, Speed, and Grade (No Curves, Includes Air Resistance)

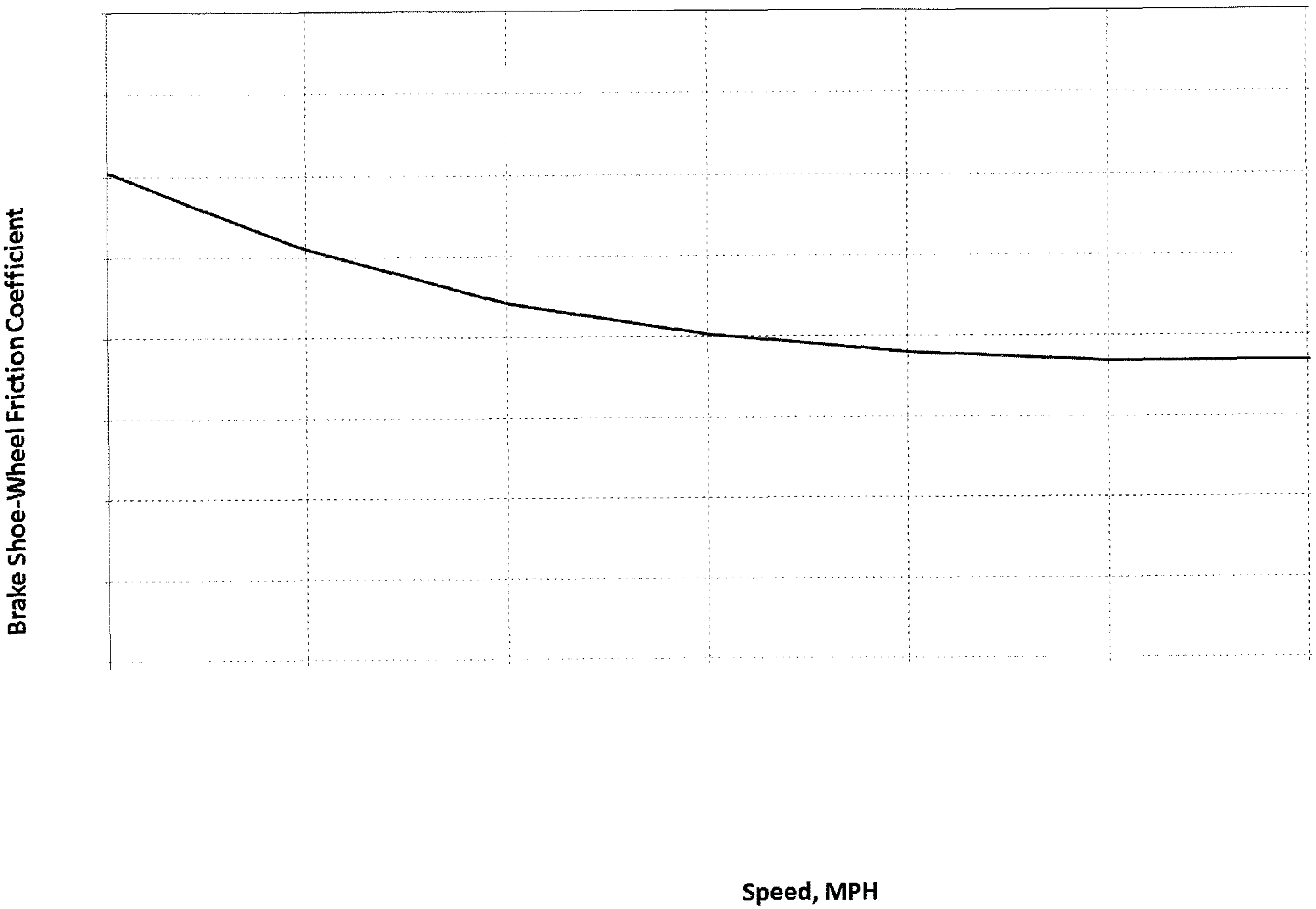
Speed mph	Loco. #	Tank #	Buffer #	Trailing tons	Grade -2.00 Dynamic	Grade -1.75 Dynamic	Grade -1.50 Dynamic	Grade -1.25 Dynamic	***Grade -1.00 Dynamic***	Grade -0.75 Dynamic	Grade -0.50 Dynamic	Grade -0.25 Dynamic	**Grade 0.00 Tractive**	Grade 0.25 Tractive	Grade 0.50 Tractive	Grade 0.75 Tractive	***Grade 1.00 Tractive***	Grade 1.25 Tractive	Grade 1.50 Tractive	Grade 1.75 Tractive	Grade 2.00 Tractive	***Grade 1 Rounded***	*Grade 2 Rounded*
10	5	52	2	7840	3.0	2.6	2.2	1.8	***1.4***	1.0	0.6	0.2	**0.1**	0.4	0.7	1.0	***1.2***	1.5	1.8	2.1	2.3	***2***	*3*
	5	78	2	11112	4.2	3.7	3.1	2.5	***2.0***	1.4	0.8	0.3	**0.2**	0.6	1.0	1.4	***1.8***	2.2	2.5	2.9	3.3	***2***	*4*
	5	104	2	14385	5.5	4.7	4.0	3.3	***2.5***	1.8	1.1	0.3	**0.3**	0.8	1.3	1.8	***2.3***	2.8	3.3	3.8	4.3	***3***	*5*
	5	130	2	17658	6.7	5.8	4.9	4.0	***3.1***	2.2	1.3	0.4	**0.3**	1.0	1.6	2.2	***2.8***	3.4	4.0	4.7	5.3	***3***	*6*
	5	156	2	20931	8.0	6.9	5.8	4.8	***3.7***	2.6	1.6	0.5	**0.4**	1.1	1.9	2.6	***3.3***	4.1	4.8	5.5	6.2	***4***	*7*
15	5	52	2	7840	3.0	2.6	2.2	1.8	***1.4***	1.0	0.6	0.2	**0.2**	0.6	1.1	1.5	***1.9***	2.3	2.7	3.1	3.5	***2***	*4*
	5	78	2	11112	4.2	3.6	3.1	2.5	***1.9***	1.4	0.8	0.2	**0.3**	0.9	1.5	2.1	***2.6***	3.2	3.8	4.4	4.9	***3***	*5*
	5	104	2	14385	5.4	4.7	4.0	3.2	***2.5***	1.8	1.0	0.3	**0.4**	1.2	1.9	2.7	***3.4***	4.2	4.9	5.7	6.4	***4***	*7*
	5	130	2	17658	6.7	5.8	4.9	4.0	***3.1***	2.2	1.3	0.4	**0.5**	1.5	2.4	3.3	***4.2***	5.1	6.0	6.9	7.9	***5***	*8*
	5	156	2	20931	7.9	6.8	5.8	4.7	***3.6***	2.6	1.5	0.4	**0.6**	1.7	2.8	3.9	***5.0***	6.1	7.2	8.2	9.3	***5***	*10*
20	5	52	2	7840	2.9	2.5	2.1	1.7	***1.3***	0.9	0.5	0.1	**0.4**	0.9	1.4	2.0	***2.5***	3.0	3.6	4.1	4.6	***3***	*5*
	5	78	2	11112	4.2	3.6	3.0	2.5	***1.9***	1.3	0.8	0.2	**0.5**	1.3	2.0	2.8	***3.5***	4.3	5.0	5.8	6.6	***4***	*7*
	5	104	2	14385	5.4	4.7	3.9	3.2	***2.5***	1.7	1.0	0.3	**0.6**	1.6	2.6	3.6	***4.6***	5.6	6.5	7.5	8.5	***5***	*9*
	5	130	2	17658	6.6	5.7	4.8	3.9	***3.0***	2.1	1.2	0.3	**0.8**	2.0	3.2	4.4	***5.6***	6.8	8.0	9.2	10.4	***6***	*11*
	5	156	2	20931	7.8	6.8	5.7	4.6	***3.6***	2.5	1.4	0.4	**0.9**	2.4	3.8	5.2	***6.6***	8.1	9.5	10.9	12.4	***7***	*13*
25	5	52	2	7840	3.7	3.2	2.7	2.2	***1.7***	1.2	0.7	0.1	**0.5**	1.1	1.8	2.5	***3.1***	3.8	4.4	5.1	5.8	***4***	*6*
	5	78	2	11112	5.3	4.5	3.8	3.1	***2.4***	1.6	0.9	0.2	**0.7**	1.6	2.5	3.5	***4.4***	5.4	6.3	7.2	8.2	***5***	*9*
	5	104	2	14385	6.8	5.9	4.9	4.0	***3.1***	2.1	1.2	0.3	**0.9**	2.1	3.3	4.5	***5.7***	6.9	8.1	9.4	10.6	***6***	*11*
	5	130	2	17658	8.4	7.2	6.1	4.9	***3.8***	2.6	1.5	0.3	**1.1**	2.6	4.0	5.5	***7.0***	8.5	10.0	11.5	13.0	***8***	*13*
	5	156	2	20931	9.9	8.5	7.2	5.8	***4.5***	3.1	1.7	0.4	**1.3**	3.0	4.8	6.6	***8.3***	10.1	11.9	13.6	15.4	***9***	*16*
30	5	52	2	7840	4.3	3.7	3.1	2.5	***1.9***	1.3	0.7	0.1	**0.6**	1.4	2.2	3.0	***3.8***	4.5	5.3	6.1	6.9	***4***	*7*
	5	78	2	11112	6.2	5.3	4.5	3.6	***2.7***	1.9	1.0	0.2	**0.9**	2.0	3.1	4.2	***5.3***	6.4	7.5	8.7	9.8	***6***	*10*
	5	104	2	14385	8.0	6.9	5.8	4.7	***3.6***	2.5	1.3	0.2	**1.1**	2.6	4.0	5.4	***6.9***	8.3	9.8	11.2	12.6	***7***	*13*
	5	130	2	17658	9.8	8.4	7.1	5.7	***4.4***	3.0	1.7	0.3	**1.4**	3.1	4.9	6.7	***8.4***	10.2	12.0	13.7	15.5	***9***	*16*
	5	156	2	20931	11.6	10.0	8.4	6.8	***5.2***	3.6	2.0	0.3	**1.6**	3.7	5.8	7.9	***10.0***	12.1	14.2	16.3	18.4	***11***	*19*
35	5	52	2	7840	5.0	4.3	3.6	2.9	***2.2***	1.5	0.8	0.1	**0.8**	1.7	2.6	3.5	***4.5***	5.4	6.3	7.2	8.1	***5***	*9*
	5	78	2	11112	7.1	6.1	5.1	4.1	***3.1***	2.1	1.1	0.1	**1.1**	2.4	3.7	5.0	***6.3***	7.6	8.9	10.2	11.5	***7***	*12*
	5	104	2	14385	9.2	7.9	6.6	5.3	***4.0***	2.8	1.5	0.2	**1.4**	3.1	4.8	6.5	***8.2***	9.8	11.5	13.2	14.9	***9***	*15*
	5	130	2	17658	11.3	9.7	8.1	6.5	***5.0***	3.4	1.8	0.2	**1.8**	3.8	5.9	7.9	***10.0***	12.1	14.1	16.2	18.2	***11***	*19*
	5	156	2	20931	13.4	11.5	9.6	7.7	***5.9***	4.0	2.1	0.3	**2.1**	4.5	7.0	9.4	***11.9***	14.3	16.7	19.2	21.6	***12***	*22*

Estimated Number of TEDS 4400 HP Locomotives Required as a Function of Trailing Tons, Speed, and Grade (No Curves, Includes Air Resistance)

Speed mph	Loco. #	Tank #	Buffer #	Trailing tons	Grade -2.00 Dynamic	Grade -1.75 Dynamic	Grade -1.50 Dynamic	Grade -1.25 Dynamic	Grade -1.00 Dynamic	Grade -0.75 Dynamic	Grade -0.50 Dynamic	Grade -0.25 Dynamic	Grade 0.00 Tractive	Grade 0.25 Tractive	Grade 0.50 Tractive	Grade 0.75 Tractive	Grade 1.00 Tractive	Grade 1.25 Tractive	Grade 1.50 Tractive	Grade 1.75 Tractive	Grade 2.00 Tractive	Grade 1 Rounded	Grade 2 Rounded
40	5	52	2	7840	5.8	5.0	4.2	3.3	2.5	1.7	0.9	0.0	1.0	2.0	3.1	4.1	5.2	6.2	7.3	8.3	9.4	6	10
	5	78	2	11112	8.3	7.1	5.9	4.8	3.6	2.4	1.2	0.1	1.4	2.9	4.4	5.8	7.3	8.8	10.3	11.8	13.2	8	14
	5	104	2	14385	10.7	9.2	7.7	6.2	4.6	3.1	1.6	0.1	1.8	3.7	5.6	7.5	9.5	11.4	13.3	15.2	17.1	10	18
	5	130	2	17658	13.1	11.3	9.4	7.6	5.7	3.8	2.0	0.1	2.2	4.5	6.9	9.3	11.6	14.0	16.3	18.7	21.0	12	22
	5	156	2	20931	15.6	13.4	11.2	9.0	6.8	4.6	2.4	0.2	2.6	5.4	8.2	11.0	13.8	16.5	19.3	22.1	24.9	14	25
45	5	52	2	7840	6.4	5.4	4.5	3.6	2.7	1.8	0.9	0.0	1.2	2.4	3.6	4.7	5.9	7.1	8.3	9.4	10.6	6	11
	5	78	2	11112	9.0	7.7	6.4	5.1	3.8	2.6	1.3	0.0	1.7	3.4	5.0	6.7	8.4	10.0	11.7	13.4	15.0	9	16
	5	104	2	14385	11.7	10.0	8.3	6.7	5.0	3.3	1.6	0.0	2.2	4.3	6.5	8.7	10.8	13.0	15.1	17.3	19.5	11	20
	5	130	2	17658	14.4	12.3	10.2	8.2	6.1	4.1	2.0	0.0	2.7	5.3	8.0	10.6	13.3	15.9	18.6	21.2	23.9	14	24
	5	156	2	20931	17.0	14.6	12.1	9.7	7.3	4.8	2.4	0.0	3.2	6.3	9.4	12.6	15.7	18.9	22.0	25.1	28.3	16	29
50	5	52	2	7840	6.9	5.9	4.9	3.9	2.9	1.9	0.9	0.2	1.5	2.8	4.1	5.4	6.7	8.0	9.3	10.6	11.9	7	12
	5	78	2	11112	9.8	8.4	7.0	5.5	4.1	2.7	1.3	0.2	2.1	3.9	5.8	7.6	9.5	11.3	13.2	15.0	16.9	10	17
	5	104	2	14385	12.7	10.9	9.0	7.2	5.3	3.5	1.7	0.2	2.6	5.0	7.4	9.8	12.2	14.6	17.0	19.4	21.8	13	22
	5	130	2	17658	15.6	13.4	11.1	8.8	6.6	4.3	2.0	0.3	3.2	6.2	9.1	12.1	15.0	17.9	20.9	23.8	26.8	15	27
	5	156	2	20931	18.5	15.9	13.2	10.5	7.8	5.1	2.4	0.3	3.8	7.3	10.8	14.3	17.8	21.3	24.7	28.2	31.7	18	32
55	5	52	2	7840	7.4	6.3	5.2	4.1	3.0	1.9	0.9	0.3	1.8	3.2	4.7	6.1	7.5	9.0	10.4	11.9	13.3	8	14
	5	78	2	11112	10.5	9.0	7.4	5.9	4.3	2.8	1.2	0.4	2.5	4.5	6.6	8.6	10.7	12.7	14.8	16.8	18.9	11	19
	5	104	2	14385	13.6	11.6	9.6	7.6	5.6	3.6	1.6	0.5	3.2	5.8	8.5	11.1	13.8	16.4	19.1	21.7	24.4	14	25
	5	130	2	17658	16.7	14.3	11.8	9.4	6.9	4.5	2.0	0.6	3.9	7.1	10.4	13.6	16.9	20.1	23.4	26.6	29.9	17	30
	5	156	2	20931	19.8	16.9	14.0	11.1	8.2	5.3	2.4	0.7	4.6	8.4	12.3	16.1	20.0	23.8	27.7	31.6	35.4	20	36
60	5	52	2	7840	8.1	6.9	5.6	4.4	3.2	2.0	0.8	0.5	2.1	3.7	5.3	6.9	8.4	10.0	11.6	13.2	14.8	9	15
	5	78	2	11112	11.5	9.8	8.0	6.3	4.6	2.9	1.2	0.7	2.9	5.2	7.4	9.7	11.9	14.2	16.4	18.7	20.9	12	21
	5	104	2	14385	14.9	12.7	10.4	8.2	6.0	3.8	1.6	0.8	3.7	6.6	9.6	12.5	15.4	18.3	21.2	24.1	27.0	16	28
	5	130	2	17658	18.3	15.5	12.8	10.1	7.4	4.7	2.0	1.0	4.6	8.1	11.7	15.3	18.9	22.4	26.0	29.6	33.1	19	34
	5	156	2	20931	21.7	18.4	15.2	12.0	8.8	5.6	2.3	1.1	5.4	9.6	13.9	18.1	22.3	26.6	30.8	35.0	39.3	23	40
65	5	52	2	7840	8.6	7.3	6.0	4.7	3.4	2.1	0.8	0.7	2.5	4.2	5.9	7.6	9.4	11.1	12.8	14.6	16.3	10	17
	5	78	2	11112	12.2	10.4	8.5	6.7	4.8	3.0	1.1	1.0	3.4	5.9	8.3	10.8	13.2	15.7	18.1	20.6	23.0	14	24
	5	104	2	14385	15.9	13.5	11.1	8.7	6.3	3.9	1.5	1.2	4.4	7.6	10.7	13.9	17.1	20.2	23.4	26.6	29.8	18	30
	5	130	2	17658	19.5	16.6	13.6	10.7	7.7	4.8	1.8	1.5	5.3	9.2	13.1	17.0	20.9	24.8	28.7	32.6	36.5	21	37
	5	156	2	20931	23.1	19.7	16.2	12.7	9.2	5.7	2.2	1.7	6.3	10.9	15.5	20.2	24.8	29.4	34.0	38.6	43.2	25	44
70	5	52	2	7840	9.4	7.9	6.5	5.0	3.6	2.1	0.7	1.0	2.9	4.7	6.6	8.5	10.4	12.2	14.1	16.0	17.9	11	18
	5	78	2	11112	13.4	11.3	9.3	7.2	5.1	3.1	1.0	1.3	4.0	6.6	9.3	12.0	14.6	17.3	19.9	22.6	25.2	15	26
	5	104	2	14385	17.4	14.7	12.0	9.4	6.7	4.0	1.4	1.7	5.1	8.5	12.0	15.4	18.8	22.3	25.7	29.2	32.6	19	33
	5	130	2	17658	21.3	18.1	14.8	11.5	8.3	5.0	1.7	2.0	6.2	10.4	14.7	18.9	23.1	27.3	31.5	35.7	40.0	24	40
	5	156	2	20931	25.3	21.4	17.6	13.7	9.8	5.9	2.1	2.3	7.3	12.3	17.3	22.3	27.3	32.3	37.3	42.3	47.3	28	48

Attachment 2: Brake Shoe Coefficient of Friction

TEDS Composition Brake Shoe-Wheel Friction Coefficient



Attachment 3: Brake Signal Propagation Effects, Emergency Braking

Table A3.1: Brake Signal Propagation Effect, Speed = 20 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	-1	-3	-3	-4	-4	-6	-6	-6	-6
ECP 10% NBR	-2	-4	-4	-5	-6	-8	-8	-8	-8
Short Consist									
DP 10% NBR	---	0	-3	-5	-6	-9	-9	-8	-9
ECP 10% NBR	---	-3	-6	-8	-9	-13	-12	-12	-12
Nominal Consist									
DP 10% NBR	---	---	-3	-5	-7	-10	-10	-10	---
ECP 10% NBR	---	---	-8	-10	-12	-16	-16	-16	---
Long Consist									
DP 10% NBR	---	---	---	-6	-9	-12	-11	-12	---
ECP 10% NBR	---	---	---	-13	-16	-20	-18	-20	---
Longer Consist									
DP 10% NBR	---	---	---	-5	-10	-12	-14	---	---
ECP 10% NBR	---	---	---	-13	-19	-22	-23	---	---

Table A3.2: Brake Signal Propagation Effect, Speed = 30 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-3	-3	-4	-5	-5	-5	-5
ECP 10% NBR	---	---	-4	-5	-5	-6	-6	-6	-6
Short Consist									
DP 10% NBR	---	---	---	-4	-5	-7	-7	-6	---
ECP 10% NBR	---	---	---	-7	-8	-10	-10	-10	---
Nominal Consist									
DP 10% NBR	---	---	---	-5	-6	-8	-8	---	---
ECP 10% NBR	---	---	---	-9	-10	-13	-12	---	---
Long Consist									
DP 10% NBR	---	---	---	-7	-8	-9	-8	---	---
ECP 10% NBR	---	---	---	-13	-13	-15	-15	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-10	-10	---	---	---
ECP 10% NBR	---	---	---	---	-17	-18	---	---	---

Table A3.3: Brake Signal Propagation Effect, Speed = 40 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-3	-3	-3	-4	-4	-4	---
ECP 10% NBR	---	---	-4	-4	-4	-5	-5	-5	---
Short Consist									
DP 10% NBR	---	---	---	-4	-4	-5	-5	---	---
ECP 10% NBR	---	---	---	-6	-7	-8	-8	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-5	-6	---	---	---
ECP 10% NBR	---	---	---	---	-9	-10	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-6	-8	---	---	---
ECP 10% NBR	---	---	---	---	-11	-13	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-8	-8	---	---	---
ECP 10% NBR	---	---	---	---	-14	-15	---	---	---

Table A3.4: Brake Signal Propagation Effect, Speed = 50 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	---	-3	-3	-3	-3	---	---
ECP 10% NBR	---	---	---	-3	-4	-4	-4	---	---
Short Consist									
DP 10% NBR	---	---	---	-3	-4	-4	-4	---	---
ECP 10% NBR	---	---	---	-5	-6	-7	-7	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-5	-5	---	---	---
ECP 10% NBR	---	---	---	---	-8	-9	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-6	-6	---	---	---
ECP 10% NBR	---	---	---	---	-10	-11	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-7	-7	---	---	---
ECP 10% NBR	---	---	---	---	-12	-13	---	---	---

Table A3.5: Brake Signal Propagation Effect, Speed = 20 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	-4	-5	-6	-6	-6	-6	-6	-6	-7
ECP 10% NBR	-5	-6	-7	-7	-8	-8	-8	-9	-9
Short Consist									
DP 10% NBR	---	-6	-7	-8	-9	-9	-9	-9	-11
ECP 10% NBR	---	-9	-11	-12	-13	-12	-13	-13	-14
Nominal Consist									
DP 10% NBR	---	---	-7	-9	-11	-11	-12	-13	---
ECP 10% NBR	---	---	-13	-15	-17	-17	-17	-18	---
Long Consist									
DP 10% NBR	---	---	---	-9	-12	-13	-14	-16	---
ECP 10% NBR	---	---	---	-17	-20	-21	-22	-23	---
Longer Consist									
DP 10% NBR	---	---	---	-9	-13	-14	-17	---	---
ECP 10% NBR	---	---	---	-19	-22	-24	-26	---	---

Table A3.6: Brake Signal Propagation Effect, Speed = 30 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-4	-4	-5	-4	-5	-5	-5
ECP 10% NBR	---	---	-5	-6	-6	-6	-6	-7	-7
Short Consist									
DP 10% NBR	---	---	---	-6	-6	-6	-6	-7	---
ECP 10% NBR	---	---	---	-9	-9	-10	-10	-10	---
Nominal Consist									
DP 10% NBR	---	---	---	-7	-8	-8	-8	---	---
ECP 10% NBR	---	---	---	-12	-13	-13	-13	---	---
Long Consist									
DP 10% NBR	---	---	---	-9	-9	-10	-11	---	---
ECP 10% NBR	---	---	---	-15	-16	-16	-16	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-11	-11	---	---	---
ECP 10% NBR	---	---	---	---	-19	-19	---	---	---

Table A3.7: Brake Signal Propagation Effect, Speed = 40 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-3	-3	-4	-4	-4	-4	---
ECP 10% NBR	---	---	-4	-5	-5	-5	-5	-5	---
Short Consist									
DP 10% NBR	---	---	---	-5	-5	-5	-5	---	---
ECP 10% NBR	---	---	---	-7	-8	-8	-8	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-6	-6	---	---	---
ECP 10% NBR	---	---	---	---	-10	-10	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-8	-8	---	---	---
ECP 10% NBR	---	---	---	---	-13	-13	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-9	-9	---	---	---
ECP 10% NBR	---	---	---	---	-15	-15	---	---	---

Table A3.8: Brake Signal Propagation Effect, Speed = 50 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	---	-3	-3	-3	-3	-3	---
ECP 10% NBR	---	---	---	-4	-4	-4	-4	-4	---
Short Consist									
DP 10% NBR	---	---	---	-4	-4	-4	-4	---	---
ECP 10% NBR	---	---	---	-6	-6	-6	-6	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-5	-5	---	---	---
ECP 10% NBR	---	---	---	---	-9	-9	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-6	-6	---	---	---
ECP 10% NBR	---	---	---	---	-11	-11	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-7	-8	---	---	---
ECP 10% NBR	---	---	---	---	-13	-13	---	---	---

Attachment 4: Brake Signal Propagation Effects, Full Service Braking

Table A4.1: Brake Signal Propagation Effect, Speed = 20 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	-7	-9	-11	-13	-15	-16	-16	-16	-16
ECP 10% NBR	-43	-46	-49	-52	-55	-50	-50	-50	-50
Short Consist									
DP 10% NBR	---	-6	-8	-11	-13	-16	-16	-16	-16
ECP 10% NBR	---	-47	-52	-55	-58	-56	-56	-56	-56
Nominal Consist									
DP 10% NBR	---	---	-8	-11	-15	-19	-19	-19	---
ECP 10% NBR	---	---	-53	-57	-61	-60	-60	-60	---
Long Consist									
DP 10% NBR	---	---	---	-18	-25	-33	-33	-33	---
ECP 10% NBR	---	---	---	-62	-67	-69	-69	-69	---
Longer Consist									
DP 10% NBR	---	---	---	-19	-28	-36	-36	---	---
ECP 10% NBR	---	---	---	-64	-70	-72	-72	---	---

Table A4.2: Brake Signal Propagation Effect, Speed = 30 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-11	-12	-13	-14	-14	-14	-14
ECP 10% NBR	---	---	-44	-47	-49	-42	-43	-44	-44
Short Consist									
DP 10% NBR	---	---	---	-11	-13	-15	-15	-15	---
ECP 10% NBR	---	---	---	-49	-52	-49	-49	-50	---
Nominal Consist									
DP 10% NBR	---	---	---	-13	-15	-18	-18	---	---
ECP 10% NBR	---	---	---	-52	-55	-53	-54	---	---
Long Consist									
DP 10% NBR	---	---	---	-22	-28	-33	-32	---	---
ECP 10% NBR	---	---	---	-58	-63	-64	-64	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-30	-36	---	---	---
ECP 10% NBR	---	---	---	---	-66	-68	---	---	---

Table A4.3: Brake Signal Propagation Effect, Speed = 40 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-10	-11	-11	-12	-12	-12	---
ECP 10% NBR	---	---	-40	-42	-43	-36	-37	-38	---
Short Consist									
DP 10% NBR	---	---	---	-11	-12	-13	-13	---	---
ECP 10% NBR	---	---	---	-45	-47	-43	-44	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-15	-17	---	---	---
ECP 10% NBR	---	---	---	---	-50	-48	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-28	-33	---	---	---
ECP 10% NBR	---	---	---	---	-59	-60	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-31	-36	---	---	---
ECP 10% NBR	---	---	---	---	-62	-64	---	---	---

Table A4.4: Brake Signal Propagation Effect, Speed = 50 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	---	-10	-10	-10	-11	---	---
ECP 10% NBR	---	---	---	-38	-39	-31	-33	---	---
Short Consist									
DP 10% NBR	---	---	---	-10	-11	-12	-12	---	---
ECP 10% NBR	---	---	---	-41	-42	-38	-39	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-14	-16	---	---	---
ECP 10% NBR	---	---	---	---	-45	-43	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-28	-32	---	---	---
ECP 10% NBR	---	---	---	---	-56	-56	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-32	-36	---	---	---
ECP 10% NBR	---	---	---	---	-59	-61	---	---	---

Table A4.5: Brake Signal Propagation Effect, Speed = 20 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	-8	-10	-12	-14	-16	-16	-17	-17	-16
ECP 10% NBR	-37	-40	-43	-46	-49	-49	-47	-45	-42
Short Consist									
DP 10% NBR	---	-7	-10	-13	-16	-17	-19	-20	-22
ECP 10% NBR	---	-43	-47	-51	-55	-55	-55	-54	-52
Nominal Consist									
DP 10% NBR	---	---	-9	-13	-17	-20	-23	-27	---
ECP 10% NBR	---	---	-50	-54	-59	-60	-60	-60	---
Long Consist									
DP 10% NBR	---	---	---	-17	-24	-30	-36	-44	---
ECP 10% NBR	---	---	---	-58	-64	-67	-69	-71	---
Longer Consist									
DP 10% NBR	---	---	---	-22	-31	-39	-46	---	---
ECP 10% NBR	---	---	---	-62	-69	-73	-75	---	---

Table A4.6: Brake Signal Propagation Effect, Speed = 30 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-11	-12	-13	-13	-13	-13	-10
ECP 10% NBR	---	---	-37	-39	-40	-40	-38	-35	-30
Short Consist									
DP 10% NBR	---	---	---	-13	-15	-16	-16	-17	---
ECP 10% NBR	---	---	---	-45	-47	-47	-45	-43	---
Nominal Consist									
DP 10% NBR	---	---	---	-14	-18	-20	-22	---	---
ECP 10% NBR	---	---	---	-49	-52	-52	-52	---	---
Long Consist									
DP 10% NBR	---	---	---	-20	-26	-31	-36	---	---
ECP 10% NBR	---	---	---	-54	-59	-61	-63	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-33	-39	---	---	---
ECP 10% NBR	---	---	---	---	-65	-68	---	---	---

Table A4.7: Brake Signal Propagation Effect, Speed = 40 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	-10	-11	-11	-11	-11	-10	---
ECP 10% NBR	---	---	-32	-33	-34	-33	-30	-27	---
Short Consist									
DP 10% NBR	---	---	---	-12	-13	-14	-14	---	---
ECP 10% NBR	---	---	---	-39	-41	-40	-38	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-17	-18	---	---	---
ECP 10% NBR	---	---	---	---	-46	-46	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-26	-30	---	---	---
ECP 10% NBR	---	---	---	---	-55	-56	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-33	-39	---	---	---
ECP 10% NBR	---	---	---	---	-61	-64	---	---	---

Table A4.8: Brake Signal Propagation Effect, Speed = 50 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
DP 10% NBR	---	---	---	-9	-10	-10	-9	-8	---
ECP 10% NBR	---	---	---	-29	-29	-28	-25	-21	---
Short Consist									
DP 10% NBR	---	---	---	-11	-12	-12	-12	---	---
ECP 10% NBR	---	---	---	-35	-36	-35	-33	---	---
Nominal Consist									
DP 10% NBR	---	---	---	---	-16	-17	---	---	---
ECP 10% NBR	---	---	---	---	-42	-41	---	---	---
Long Consist									
DP 10% NBR	---	---	---	---	-26	-29	---	---	---
ECP 10% NBR	---	---	---	---	-51	-52	---	---	---
Longer Consist									
DP 10% NBR	---	---	---	---	-33	-37	---	---	---
ECP 10% NBR	---	---	---	---	-58	-60	---	---	---

Attachment 5: Combined ECP Brake Signal Propagation and NBR Effects, Emergency Braking

Table A5.1: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 20 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	-2	-4	-4	-5	-6	-8	-8	-8	-8
ECP 12.8% NBR	-8	-10	-12	-14	-15	-22	-22	-22	-22
ECP 14% NBR	-11	-13	-15	-17	-19	-26	-27	-27	-27
Short Consist									
ECP 10% NBR	---	-3	-6	-8	-9	-13	-12	-12	-12
ECP 12.8% NBR	---	-11	-14	-17	-19	-26	-26	-26	-26
ECP 14% NBR	---	-13	-17	-20	-23	-30	-30	-30	-30
Nominal Consist									
ECP 10% NBR	---	---	-8	-10	-12	-16	-16	-16	---
ECP 12.8% NBR	---	---	-16	-20	-23	-29	-29	-29	---
ECP 14% NBR	---	---	-19	-23	-26	-32	-33	-33	---
Long Consist									
ECP 10% NBR	---	---	---	-13	-16	-20	-18	-20	---
ECP 12.8% NBR	---	---	---	-22	-26	-32	-31	-32	---
ECP 14% NBR	---	---	---	-25	-29	-35	-35	-36	---
Longer Consist									
ECP 10% NBR	---	---	---	-13	-19	-22	-23	---	---
ECP 12.8% NBR	---	---	---	-23	-29	-34	-35	---	---
ECP 14% NBR	---	---	---	-26	-32	-38	-38	---	---

Table A5.2: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 30 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-4	-5	-5	-6	-6	-6	-6
ECP 12.8% NBR	---	---	-13	-14	-16	-22	-21	-21	-20
ECP 14% NBR	---	---	-16	-18	-19	-27	-26	-25	-25
Short Consist									
ECP 10% NBR	---	---	---	-7	-8	-10	-10	-10	---
ECP 12.8% NBR	---	---	---	-18	-20	-25	-24	-24	---
ECP 14% NBR	---	---	---	-21	-24	-29	-29	-28	---
Nominal Consist									
ECP 10% NBR	---	---	---	-9	-10	-13	-12	---	---
ECP 12.8% NBR	---	---	---	-20	-23	-27	-27	---	---
ECP 14% NBR	---	---	---	-24	-27	-32	-31	---	---
Long Consist									
ECP 10% NBR	---	---	---	-13	-13	-15	-15	---	---
ECP 12.8% NBR	---	---	---	-24	-26	-29	-28	---	---
ECP 14% NBR	---	---	---	-27	-29	-34	-33	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-17	-18	---	---	---
ECP 12.8% NBR	---	---	---	---	-29	-31	---	---	---
ECP 14% NBR	---	---	---	---	-33	-36	---	---	---

Table A5.3: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 40 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-4	-4	-4	-5	-5	-5	---
ECP 12.8% NBR	---	---	-13	-15	-16	-22	-21	-20	---
ECP 14% NBR	---	---	-17	-18	-20	-27	-26	-25	---
Short Consist									
ECP 10% NBR	---	---	---	-6	-7	-8	-8	---	---
ECP 12.8% NBR	---	---	---	-18	-19	-24	-23	---	---
ECP 14% NBR	---	---	---	-22	-24	-29	-28	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-9	-10	---	---	---
ECP 12.8% NBR	---	---	---	---	-22	-26	---	---	---
ECP 14% NBR	---	---	---	---	-26	-31	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-11	-13	---	---	---
ECP 12.8% NBR	---	---	---	---	-25	-28	---	---	---
ECP 14% NBR	---	---	---	---	-29	-33	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-14	-15	---	---	---
ECP 12.8% NBR	---	---	---	---	-27	-30	---	---	---
ECP 14% NBR	---	---	---	---	-32	-34	---	---	---

Table A5.4: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 50 mph, Emergency Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	---	-3	-4	-4	-4	---	---
ECP 12.8% NBR	---	---	---	-15	-16	-22	-21	---	---
ECP 14% NBR	---	---	---	-19	-20	-27	-26	---	---
Short Consist									
ECP 10% NBR	---	---	---	-5	-6	-7	-7	---	---
ECP 12.8% NBR	---	---	---	-18	-19	-24	-23	---	---
ECP 14% NBR	---	---	---	-22	-24	-29	-28	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-8	-9	---	---	---
ECP 12.8% NBR	---	---	---	---	-22	-25	---	---	---
ECP 14% NBR	---	---	---	---	-26	-30	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-10	-11	---	---	---
ECP 12.8% NBR	---	---	---	---	-24	-27	---	---	---
ECP 14% NBR	---	---	---	---	-28	-32	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-12	-13	---	---	---
ECP 12.8% NBR	---	---	---	---	-26	-28	---	---	---
ECP 14% NBR	---	---	---	---	-30	-33	---	---	---

Table A5.5: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 20 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	-5	-6	-7	-7	-8	-8	-8	-9	-9
ECP 12.8% NBR	-13	-16	-17	-19	-21	-24	-26	-29	-33
ECP 14% NBR	-16	-19	-21	-23	-26	-28	-31	-35	-39
Short Consist									
ECP 10% NBR	---	-9	-11	-12	-13	-12	-13	-13	-14
ECP 12.8% NBR	---	-18	-21	-23	-25	-27	-29	-32	-36
ECP 14% NBR	---	-21	-24	-27	-29	-31	-34	-37	-41
Nominal Consist									
ECP 10% NBR	---	---	-13	-15	-17	-17	-17	-18	---
ECP 12.8% NBR	---	---	-23	-26	-29	-30	-32	-35	---
ECP 14% NBR	---	---	-26	-29	-33	-34	-37	-40	---
Long Consist									
ECP 10% NBR	---	---	---	-17	-20	-21	-22	-23	---
ECP 12.8% NBR	---	---	---	-28	-31	-33	-36	-38	---
ECP 14% NBR	---	---	---	-31	-35	-37	-40	-42	---
Longer Consist									
ECP 10% NBR	---	---	---	-19	-22	-24	-26	---	---
ECP 12.8% NBR	---	---	---	-29	-34	-36	-39	---	---
ECP 14% NBR	---	---	---	-32	-37	-40	-43	---	---

Table A5.6: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 30 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-5	-6	-6	-6	-6	-7	-7
ECP 12.8% NBR	---	---	-17	-19	-22	-24	-26	-30	-35
ECP 14% NBR	---	---	-21	-24	-26	-29	-32	-36	-42
Short Consist									
ECP 10% NBR	---	---	---	-9	-9	-10	-10	-10	---
ECP 12.8% NBR	---	---	---	-22	-24	-26	-29	-32	---
ECP 14% NBR	---	---	---	-26	-29	-31	-34	-38	---
Nominal Consist									
ECP 10% NBR	---	---	---	-12	-13	-13	-13	---	---
ECP 12.8% NBR	---	---	---	-25	-27	-29	-31	---	---
ECP 14% NBR	---	---	---	-29	-31	-33	-36	---	---
Long Consist									
ECP 10% NBR	---	---	---	-15	-16	-16	-16	---	---
ECP 12.8% NBR	---	---	---	-27	-29	-31	-33	---	---
ECP 14% NBR	---	---	---	-31	-34	-36	-38	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-19	-19	---	---	---
ECP 12.8% NBR	---	---	---	---	-32	-33	---	---	---
ECP 14% NBR	---	---	---	---	-36	-38	---	---	---

Table A5.7: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 40 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-4	-5	-5	-5	-5	-5	---
ECP 12.8% NBR	---	---	-17	-19	-22	-24	-27	-31	---
ECP 14% NBR	---	---	-22	-24	-27	-30	-33	-37	---
Short Consist									
ECP 10% NBR	---	---	---	-7	-8	-8	-8	---	---
ECP 12.8% NBR	---	---	---	-22	-24	-26	-28	---	---
ECP 14% NBR	---	---	---	-26	-29	-31	-34	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-10	-10	---	---	---
ECP 12.8% NBR	---	---	---	---	-26	-28	---	---	---
ECP 14% NBR	---	---	---	---	-31	-33	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-13	-13	---	---	---
ECP 12.8% NBR	---	---	---	---	-28	-30	---	---	---
ECP 14% NBR	---	---	---	---	-33	-35	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-15	-15	---	---	---
ECP 12.8% NBR	---	---	---	---	-30	-31	---	---	---
ECP 14% NBR	---	---	---	---	-34	-36	---	---	---

Table A5.8: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 50 mph, Emergency Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	---	-4	-4	-4	-4	-4	---
ECP 12.8% NBR	---	---	---	-19	-22	-24	-27	-31	---
ECP 14% NBR	---	---	---	-24	-27	-30	-33	-38	---
Short Consist									
ECP 10% NBR	---	---	---	-6	-6	-6	-6	---	---
ECP 12.8% NBR	---	---	---	-21	-23	-26	-28	---	---
ECP 14% NBR	---	---	---	-26	-29	-31	-34	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-9	-9	---	---	---
ECP 12.8% NBR	---	---	---	---	-25	-27	---	---	---
ECP 14% NBR	---	---	---	---	-30	-33	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-11	-11	---	---	---
ECP 12.8% NBR	---	---	---	---	-27	-29	---	---	---
ECP 14% NBR	---	---	---	---	-32	-34	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-13	-13	---	---	---
ECP 12.8% NBR	---	---	---	---	-28	-30	---	---	---
ECP 14% NBR	---	---	---	---	-33	-36	---	---	---

Attachment 6: Combined ECP Brake Signal Propagation and NBR Effects, Full Service Braking

Table A6.1: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 20 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	-43	-46	-49	-52	-55	-50	-50	-50	-50
ECP 12.8% NBR	-47	-50	-53	-57	-60	-58	-59	-59	-59
ECP 14% NBR	-48	-52	-55	-58	-62	-61	-61	-61	-61
Short Consist									
ECP 10% NBR	---	-47	-52	-55	-58	-56	-56	-56	-56
ECP 12.8% NBR	---	-52	-56	-60	-63	-63	-63	-64	-64
ECP 14% NBR	---	-53	-58	-61	-65	-66	-66	-66	-66
Nominal Consist									
ECP 10% NBR	---	---	-53	-57	-61	-60	-60	-60	---
ECP 12.8% NBR	---	---	-58	-62	-66	-67	-67	-67	---
ECP 14% NBR	---	---	-59	-63	-68	-69	-69	-69	---
Long Consist									
ECP 10% NBR	---	---	---	-62	-67	-69	-69	-69	---
ECP 12.8% NBR	---	---	---	-66	-72	-74	-74	-74	---
ECP 14% NBR	---	---	---	-68	-73	-76	-76	-76	---
Longer Consist									
ECP 10% NBR	---	---	---	-64	-70	-72	-72	---	---
ECP 12.8% NBR	---	---	---	-68	-74	-77	-77	---	---
ECP 14% NBR	---	---	---	-69	-75	-78	-78	---	---

Table A6.2: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 30 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-44	-47	-49	-42	-43	-44	-44
ECP 12.8% NBR	---	---	-50	-52	-55	-52	-53	-53	-53
ECP 14% NBR	---	---	-51	-54	-57	-56	-56	-56	-56
Short Consist									
ECP 10% NBR	---	---	---	-49	-52	-49	-49	-50	---
ECP 12.8% NBR	---	---	---	-55	-58	-58	-58	-58	---
ECP 14% NBR	---	---	---	-57	-60	-61	-61	-61	---
Nominal Consist									
ECP 10% NBR	---	---	---	-52	-55	-53	-54	---	---
ECP 12.8% NBR	---	---	---	-58	-61	-62	-61	---	---
ECP 14% NBR	---	---	---	-60	-63	-64	-64	---	---
Long Consist									
ECP 10% NBR	---	---	---	-58	-63	-64	-64	---	---
ECP 12.8% NBR	---	---	---	-64	-68	-70	-70	---	---
ECP 14% NBR	---	---	---	-66	-70	-72	-72	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-66	-68	---	---	---
ECP 12.8% NBR	---	---	---	---	-71	-73	---	---	---
ECP 14% NBR	---	---	---	---	-73	-75	---	---	---

Table A6.3: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 40 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-40	-42	-43	-36	-37	-38	---
ECP 12.8% NBR	---	---	-46	-48	-50	-48	-48	-48	---
ECP 14% NBR	---	---	-48	-50	-53	-51	-52	-52	---
Short Consist									
ECP 10% NBR	---	---	---	-45	-47	-43	-44	---	---
ECP 12.8% NBR	---	---	---	-51	-54	-53	-54	---	---
ECP 14% NBR	---	---	---	-54	-57	-56	-57	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-50	-48	---	---	---
ECP 12.8% NBR	---	---	---	---	-57	-57	---	---	---
ECP 14% NBR	---	---	---	---	-59	-60	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-59	-60	---	---	---
ECP 12.8% NBR	---	---	---	---	-65	-67	---	---	---
ECP 14% NBR	---	---	---	---	-68	-69	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-62	-64	---	---	---
ECP 12.8% NBR	---	---	---	---	-68	-70	---	---	---
ECP 14% NBR	---	---	---	---	-70	-72	---	---	---

Table A6.4: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 50 mph, Full Service Braking, No Bailoff
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	---	-38	-39	-31	-33	---	---
ECP 12.8% NBR	---	---	---	-45	-47	-44	-45	---	---
ECP 14% NBR	---	---	---	-47	-50	-48	-48	---	---
Short Consist									
ECP 10% NBR	---	---	---	-41	-42	-38	-39	---	---
ECP 12.8% NBR	---	---	---	-48	-51	-50	-50	---	---
ECP 14% NBR	---	---	---	-51	-53	-53	-53	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-45	-43	---	---	---
ECP 12.8% NBR	---	---	---	---	-54	-54	---	---	---
ECP 14% NBR	---	---	---	---	-56	-57	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-56	-56	---	---	---
ECP 12.8% NBR	---	---	---	---	-63	-64	---	---	---
ECP 14% NBR	---	---	---	---	-65	-67	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-59	-61	---	---	---
ECP 12.8% NBR	---	---	---	---	-66	-68	---	---	---
ECP 14% NBR	---	---	---	---	-68	-70	---	---	---

Table A6.5: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 20 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	-37	-40	-43	-46	-49	-49	-47	-45	-42
ECP 12.8% NBR	-42	-46	-50	-54	-57	-58	-59	-60	-61
ECP 14% NBR	-45	-49	-52	-56	-60	-61	-62	-63	-66
Short Consist									
ECP 10% NBR	---	-43	-47	-51	-55	-55	-55	-54	-52
ECP 12.8% NBR	---	-49	-54	-58	-62	-63	-64	-65	-67
ECP 14% NBR	---	-51	-56	-60	-64	-66	-67	-68	-70
Nominal Consist									
ECP 10% NBR	---	---	-50	-54	-59	-60	-60	-60	---
ECP 12.8% NBR	---	---	-56	-60	-65	-67	-68	-70	---
ECP 14% NBR	---	---	-58	-62	-67	-69	-71	-72	---
Long Consist									
ECP 10% NBR	---	---	---	-58	-64	-67	-69	-71	---
ECP 12.8% NBR	---	---	---	-64	-70	-73	-75	-78	---
ECP 14% NBR	---	---	---	-66	-71	-74	-77	-80	---
Longer Consist									
ECP 10% NBR	---	---	---	-62	-69	-73	-75	---	---
ECP 12.8% NBR	---	---	---	-68	-74	-78	-80	---	---
ECP 14% NBR	---	---	---	-69	-76	-79	-82	---	---

Table A6.6: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 30 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-37	-39	-40	-40	-38	-35	-30
ECP 12.8% NBR	---	---	-45	-48	-51	-52	-53	-54	-57
ECP 14% NBR	---	---	-48	-51	-54	-56	-57	-59	-62
Short Consist									
ECP 10% NBR	---	---	---	-45	-47	-47	-45	-43	---
ECP 12.8% NBR	---	---	---	-53	-56	-58	-58	-59	---
ECP 14% NBR	---	---	---	-56	-59	-61	-62	-64	---
Nominal Consist									
ECP 10% NBR	---	---	---	-49	-52	-52	-52	---	---
ECP 12.8% NBR	---	---	---	-56	-60	-62	-63	---	---
ECP 14% NBR	---	---	---	-59	-63	-65	-66	---	---
Long Consist									
ECP 10% NBR	---	---	---	-54	-59	-61	-63	---	---
ECP 12.8% NBR	---	---	---	-61	-66	-69	-71	---	---
ECP 14% NBR	---	---	---	-63	-68	-71	-74	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-65	-68	---	---	---
ECP 12.8% NBR	---	---	---	---	-71	-74	---	---	---
ECP 14% NBR	---	---	---	---	-73	-76	---	---	---

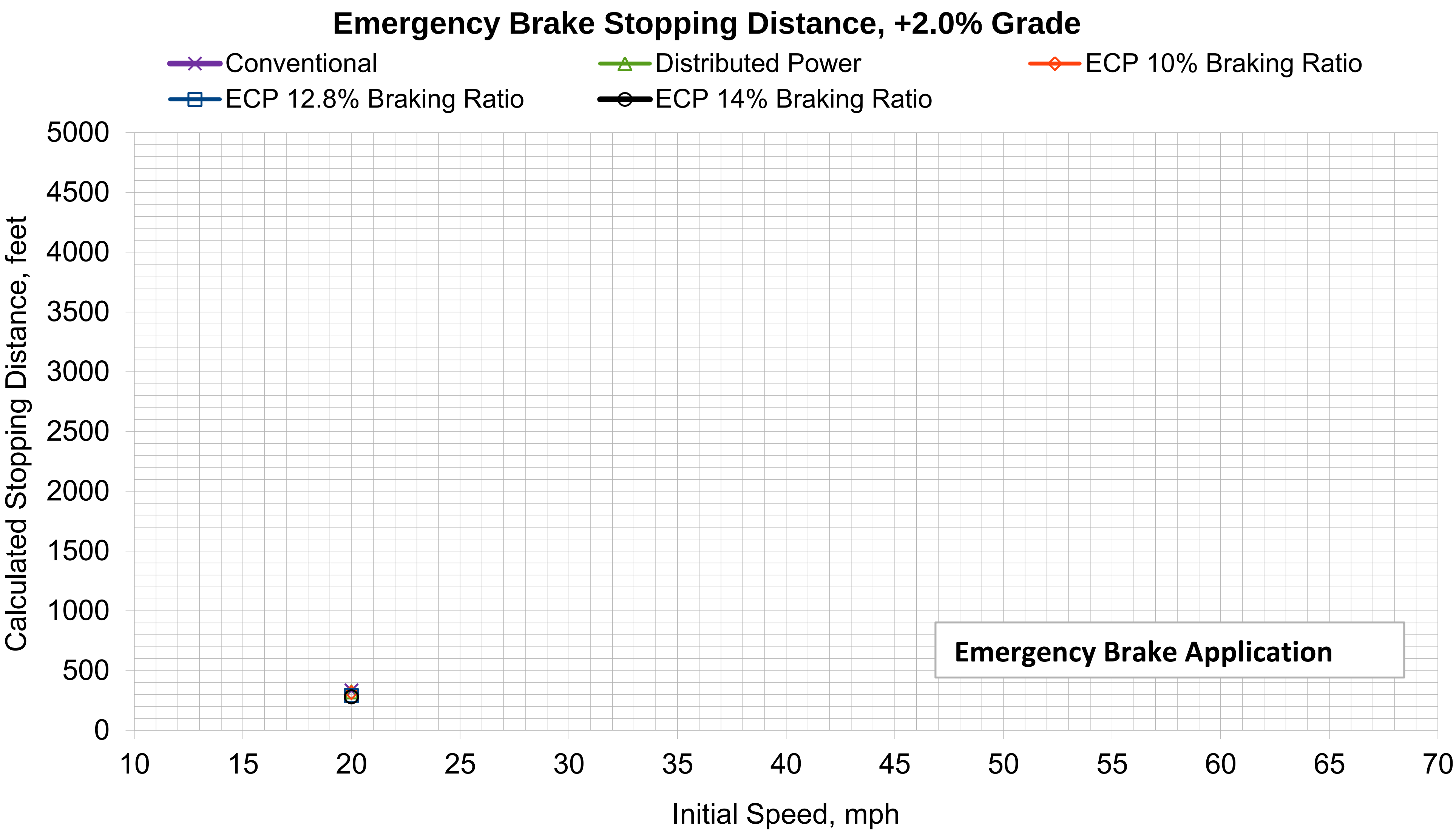
Table A6.7: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 40 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	-32	-33	-34	-33	-30	-27	---
ECP 12.8% NBR	---	---	-41	-44	-46	-47	-48	-50	---
ECP 14% NBR	---	---	-44	-47	-50	-52	-53	-55	---
Short Consist									
ECP 10% NBR	---	---	---	-39	-41	-40	-38	---	---
ECP 12.8% NBR	---	---	---	-49	-52	-53	-54	---	---
ECP 14% NBR	---	---	---	-52	-55	-57	-58	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-46	-46	---	---	---
ECP 12.8% NBR	---	---	---	---	-56	-58	---	---	---
ECP 14% NBR	---	---	---	---	-59	-61	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-55	-56	---	---	---
ECP 12.8% NBR	---	---	---	---	-63	-65	---	---	---
ECP 14% NBR	---	---	---	---	-65	-68	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-61	-64	---	---	---
ECP 12.8% NBR	---	---	---	---	-68	-71	---	---	---
ECP 14% NBR	---	---	---	---	-70	-73	---	---	---

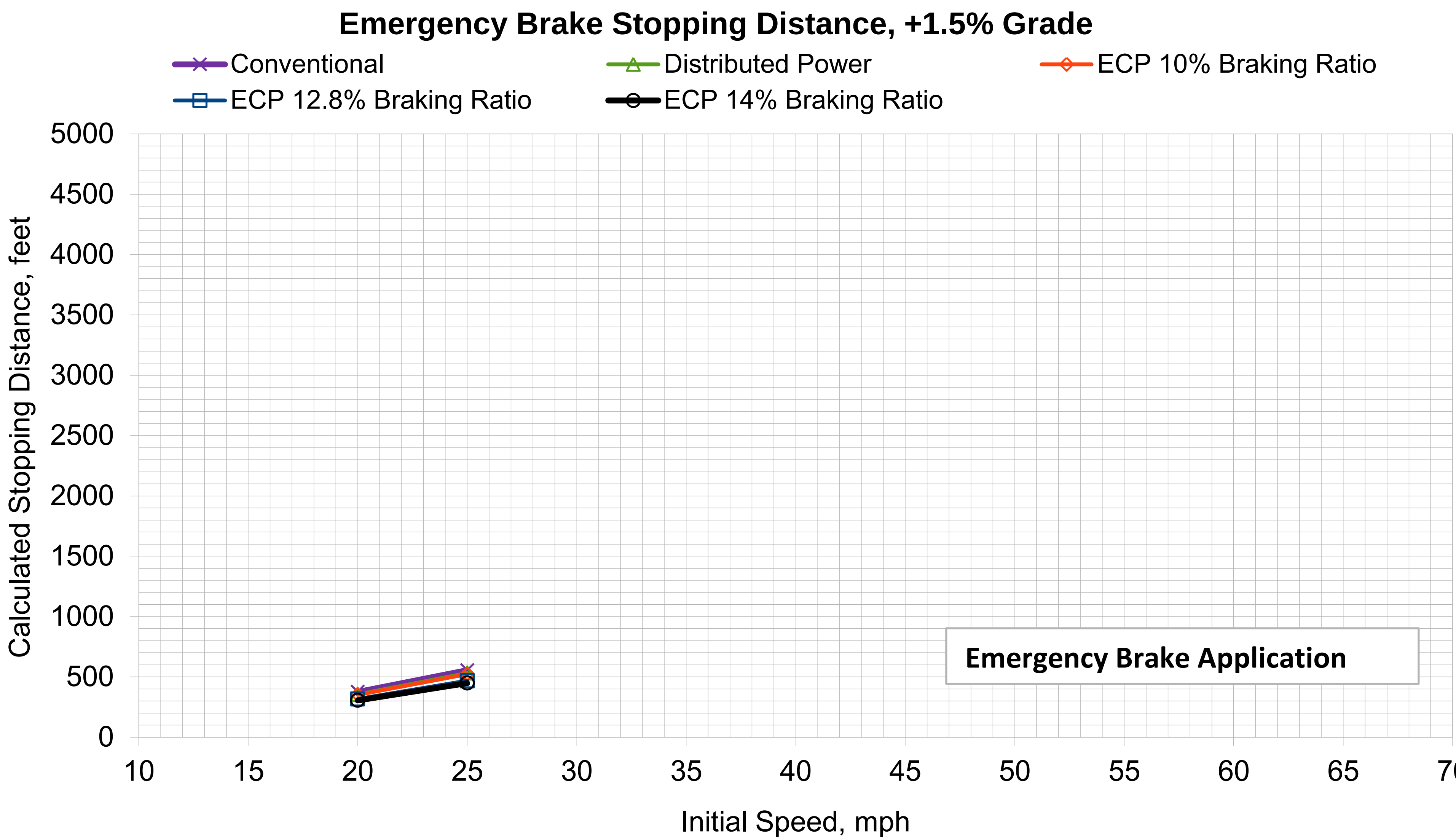
Table A6.8: Combined ECP Brake Signal Propagation and Net Braking Ratio Effect
Speed = 50 mph, Full Service Braking, Bailed Off
Percent Distance Required to Stop Relative to CONV Baseline

	Track Grade, Percent								
	+2.0	**+1.5**	**+1.0**	**+0.5**	**0.0**	**-0.5**	**-1.0**	**-1.5**	**-2.0**
Shorter Consist									
ECP 10% NBR	---	---	---	-29	-29	-28	-25	-21	---
ECP 12.8% NBR	---	---	---	-40	-43	-44	-45	-46	---
ECP 14% NBR	---	---	---	-44	-47	-49	-50	-53	---
Short Consist									
ECP 10% NBR	---	---	---	-35	-36	-35	-33	---	---
ECP 12.8% NBR	---	---	---	-45	-48	-49	-50	---	---
ECP 14% NBR	---	---	---	-49	-52	-53	-55	---	---
Nominal Consist									
ECP 10% NBR	---	---	---	---	-42	-41	---	---	---
ECP 12.8% NBR	---	---	---	---	-53	-54	---	---	---
ECP 14% NBR	---	---	---	---	-56	-58	---	---	---
Long Consist									
ECP 10% NBR	---	---	---	---	-51	-52	---	---	---
ECP 12.8% NBR	---	---	---	---	-60	-62	---	---	---
ECP 14% NBR	---	---	---	---	-63	-65	---	---	---
Longer Consist									
ECP 10% NBR	---	---	---	---	-58	-60	---	---	---
ECP 12.8% NBR	---	---	---	---	-66	-68	---	---	---
ECP 14% NBR	---	---	---	---	-68	-71	---	---	---

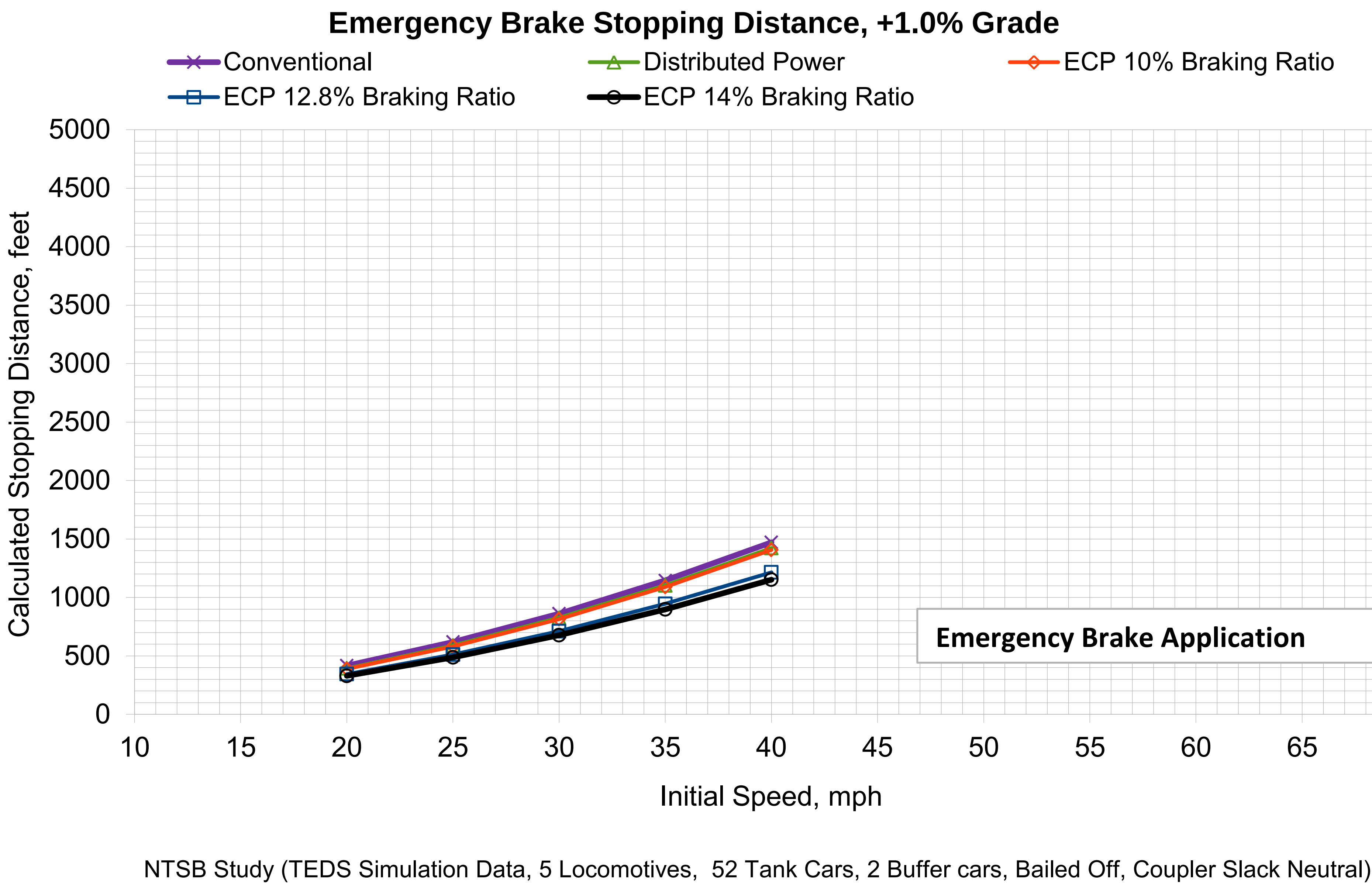
Attachment 7: Emergency Braking, Bailed Off, 52 Tank Cars

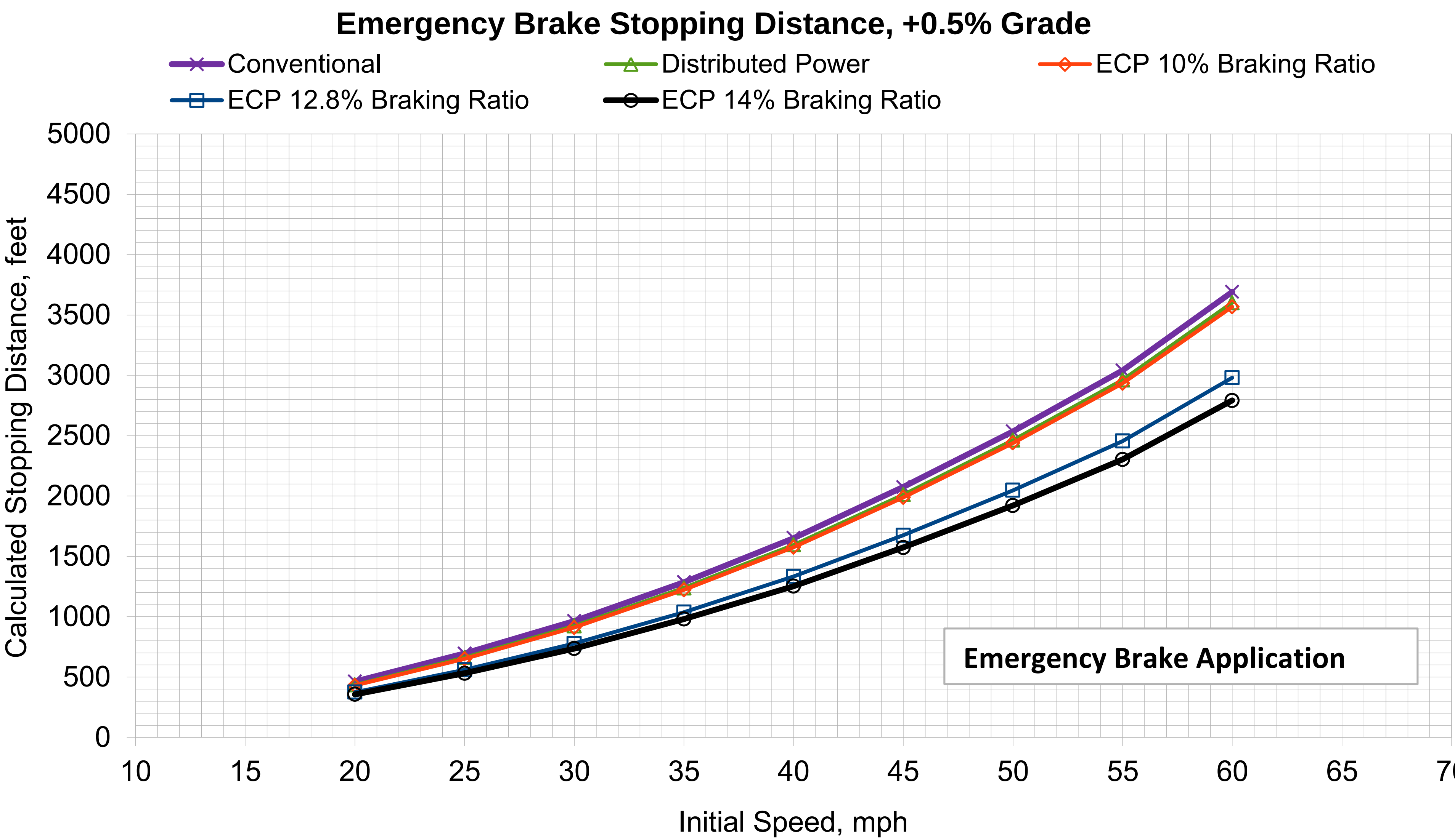


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

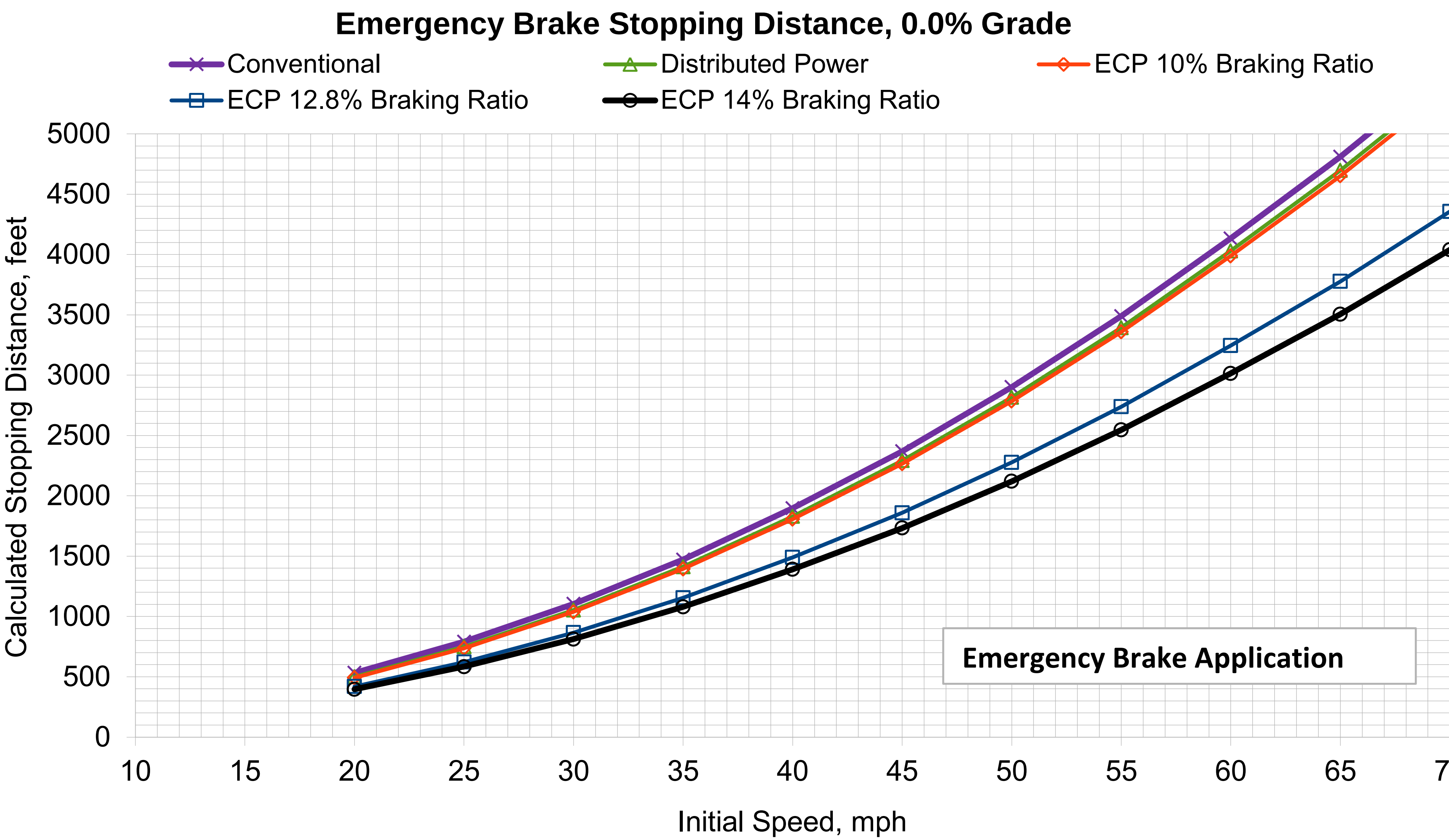


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

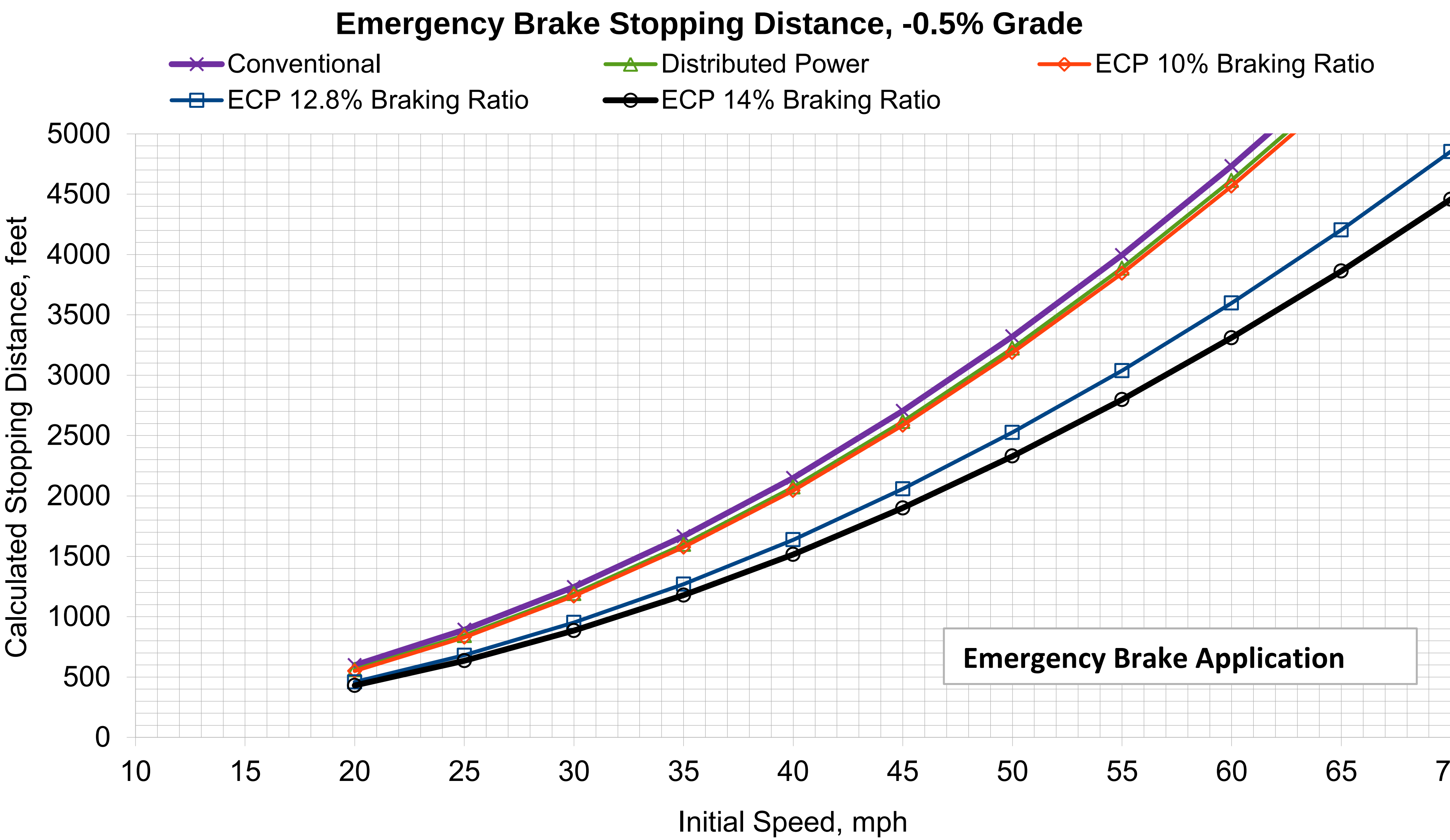

Emergency Brake Stopping Distance, +1.0% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



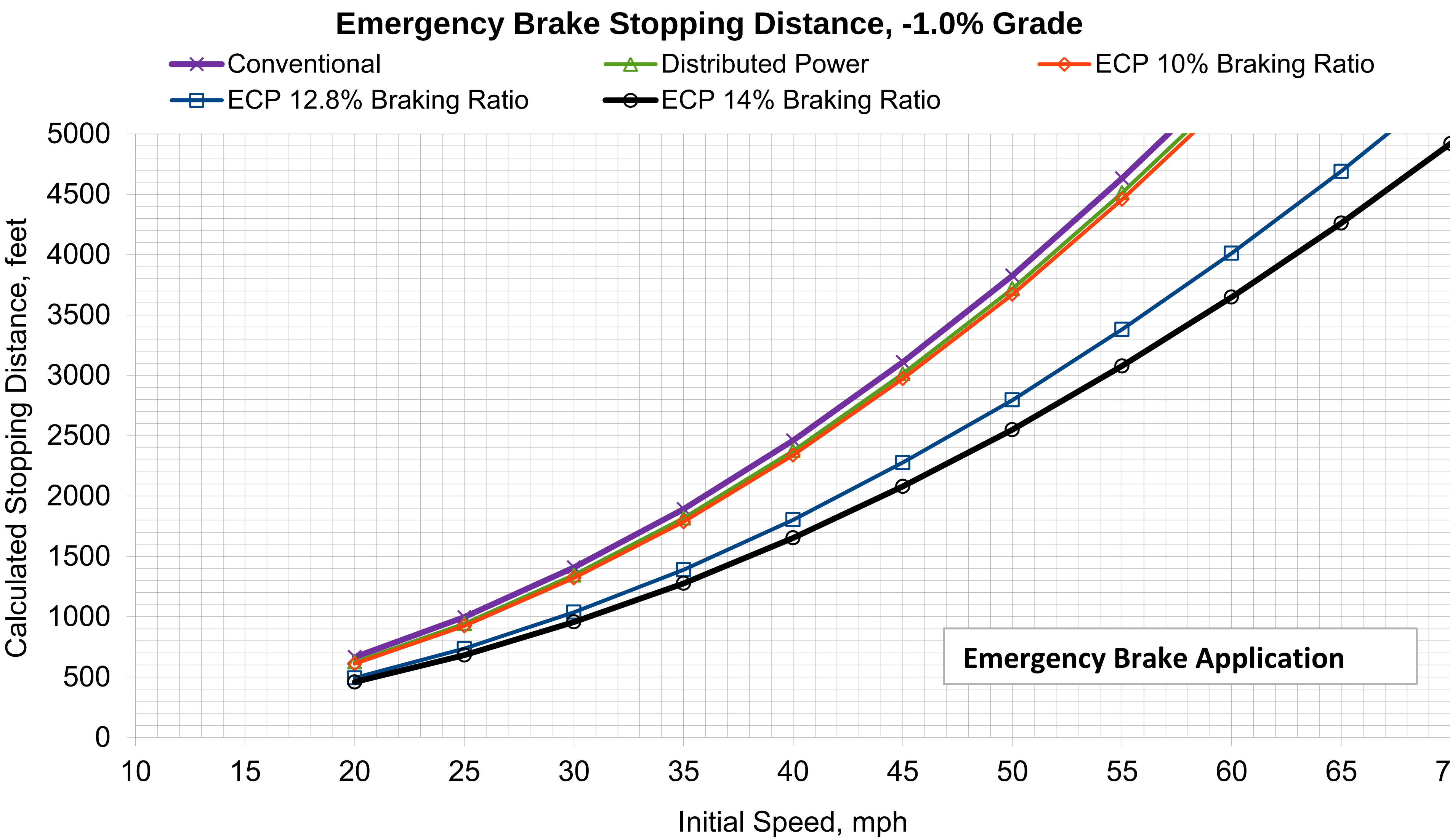
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



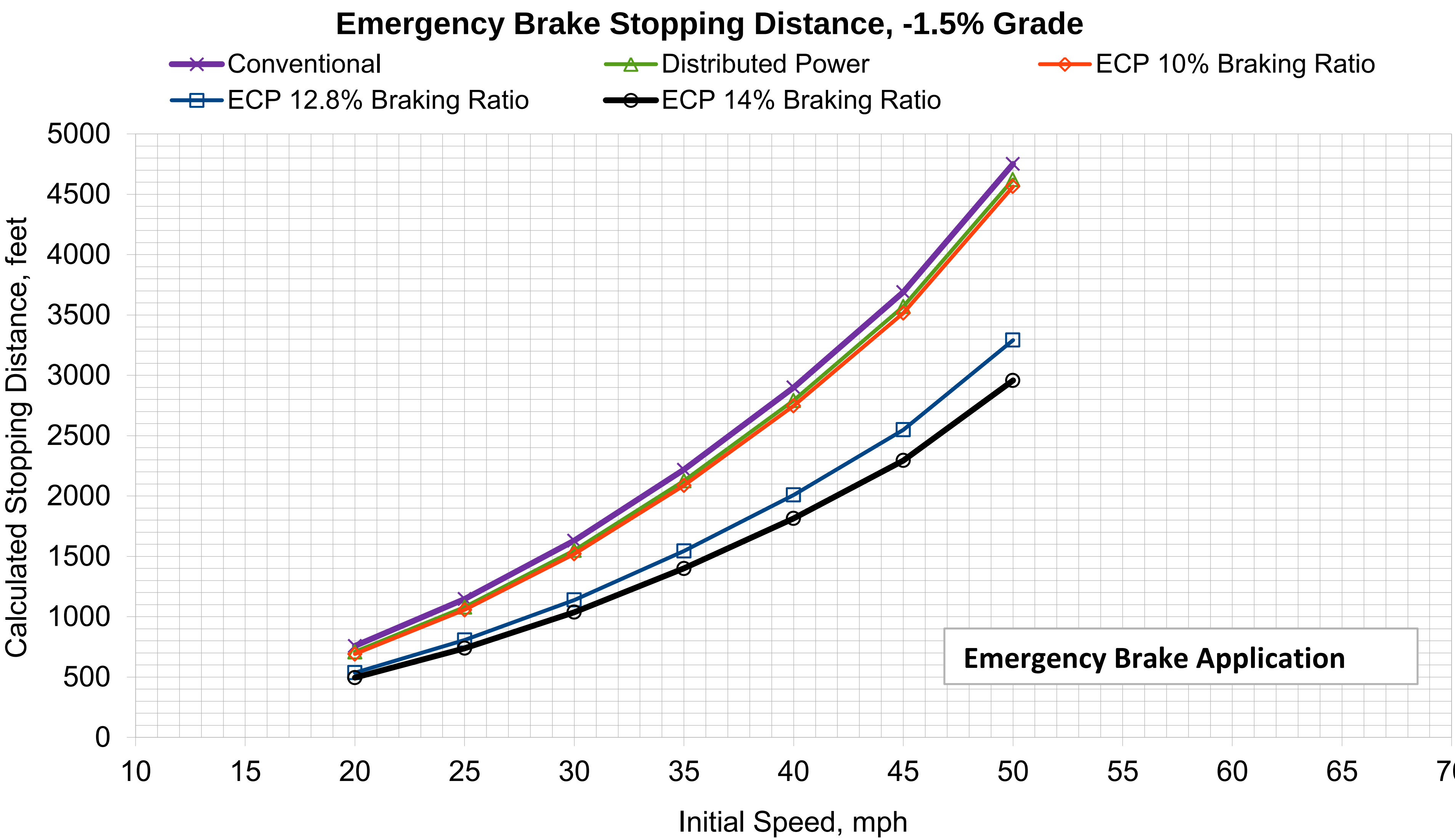
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



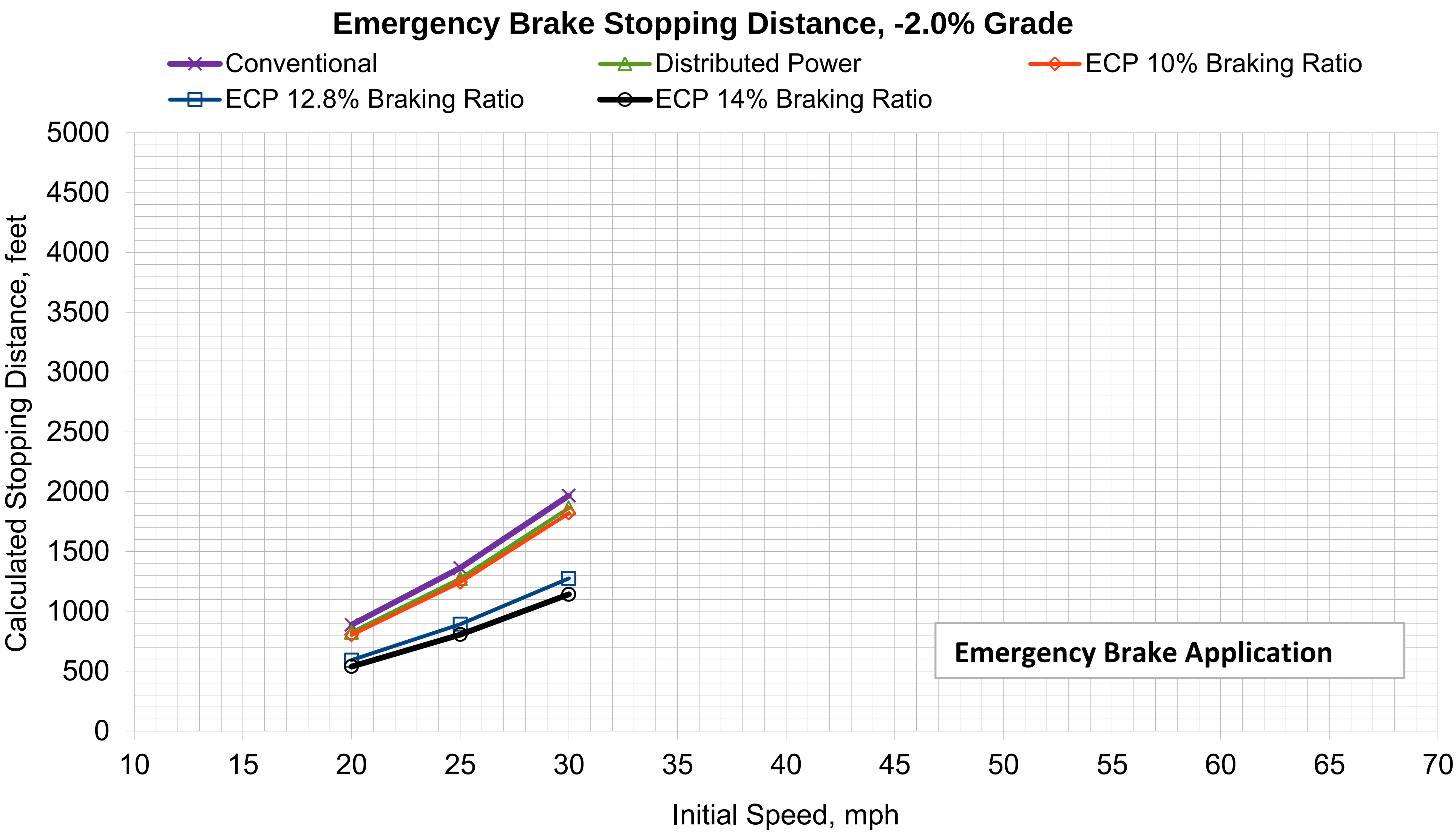
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



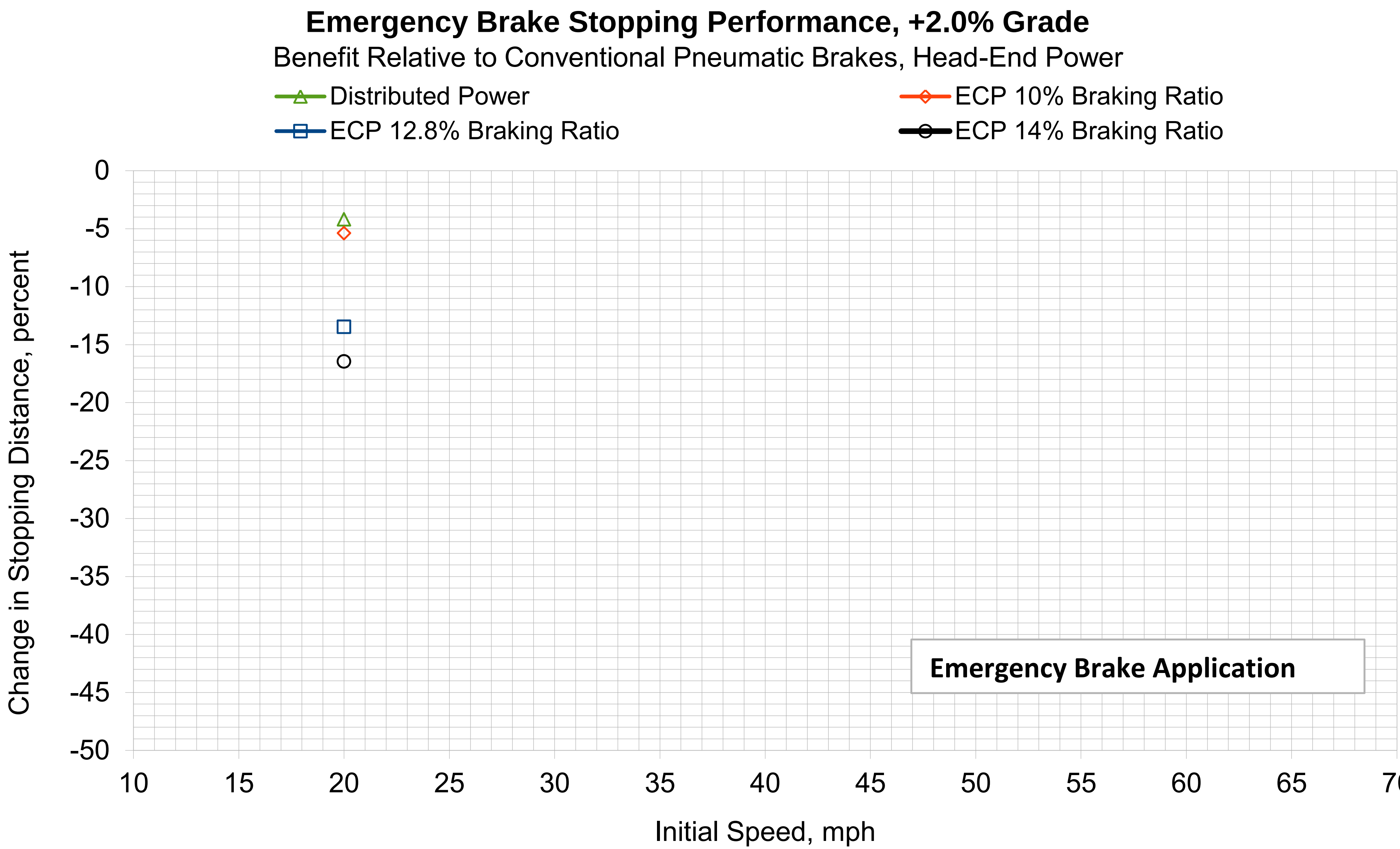
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



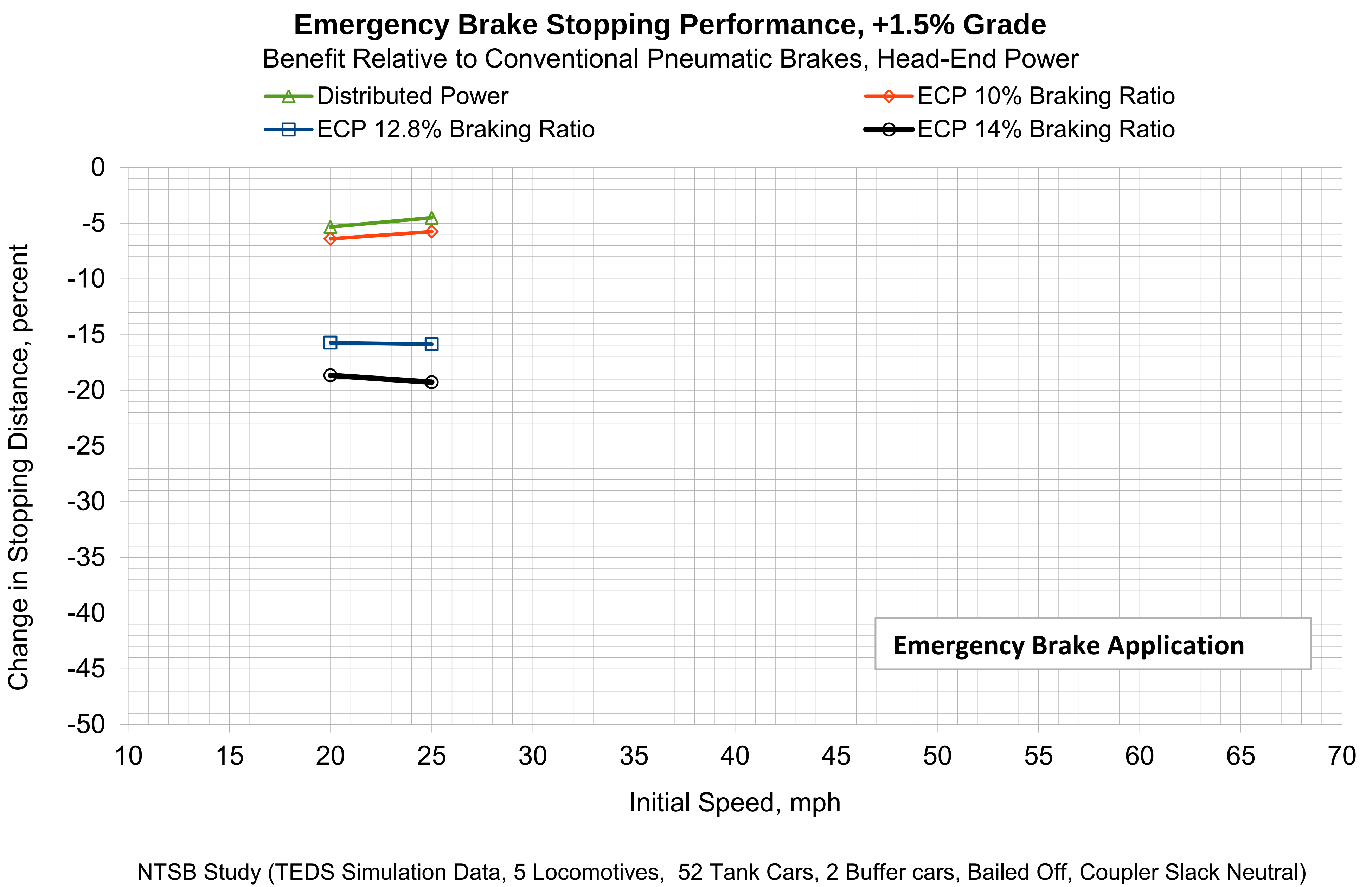
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



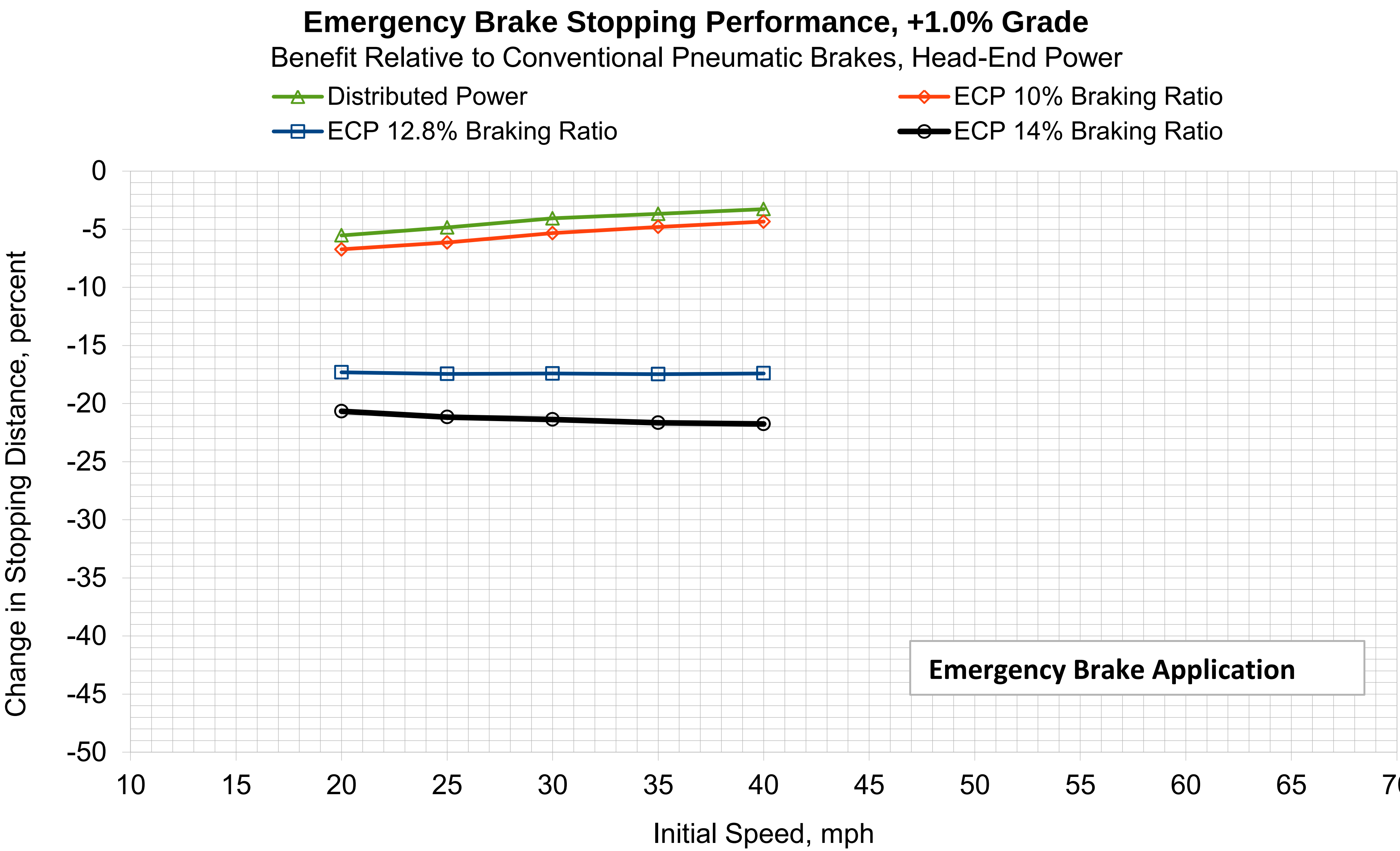
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



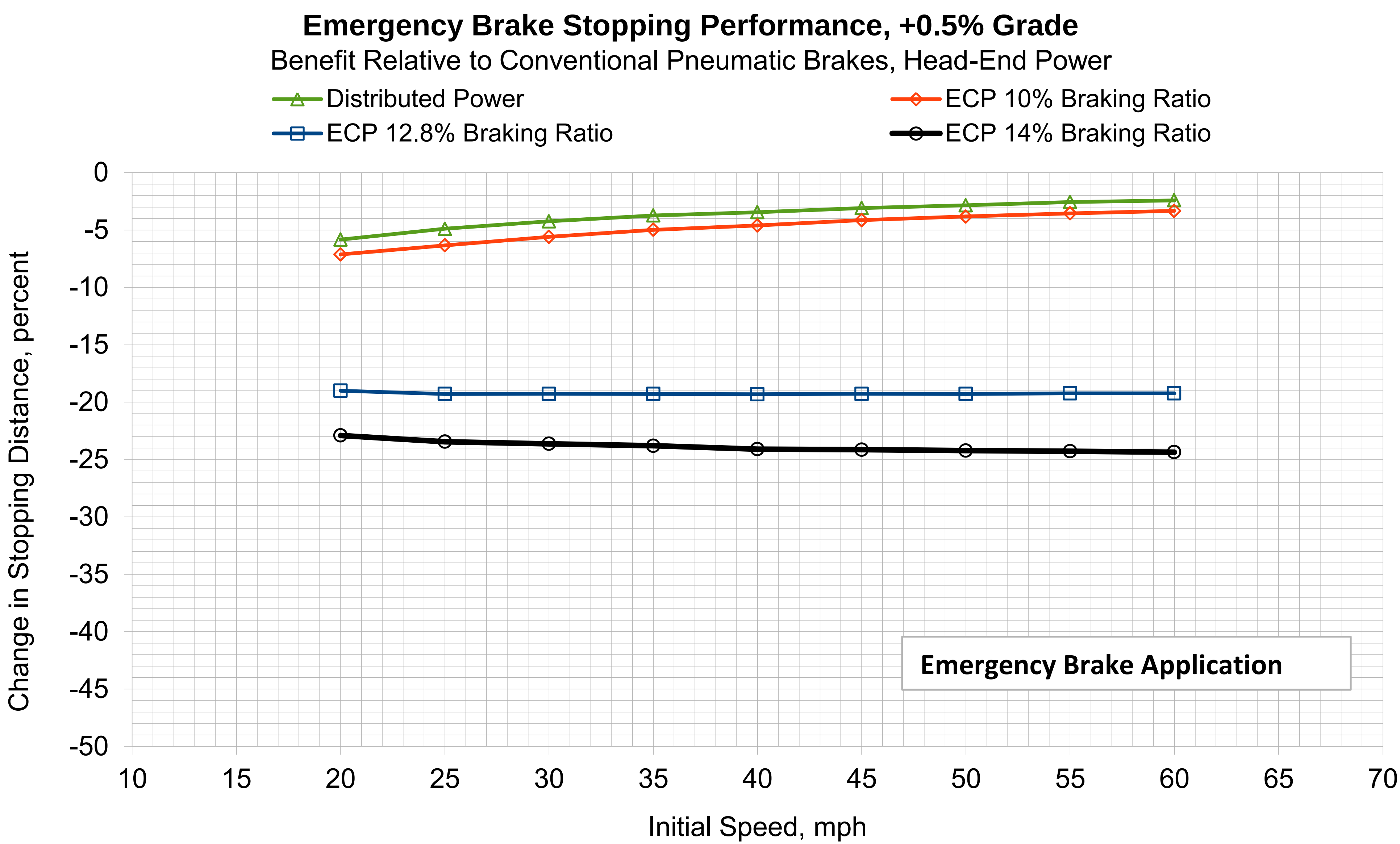
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



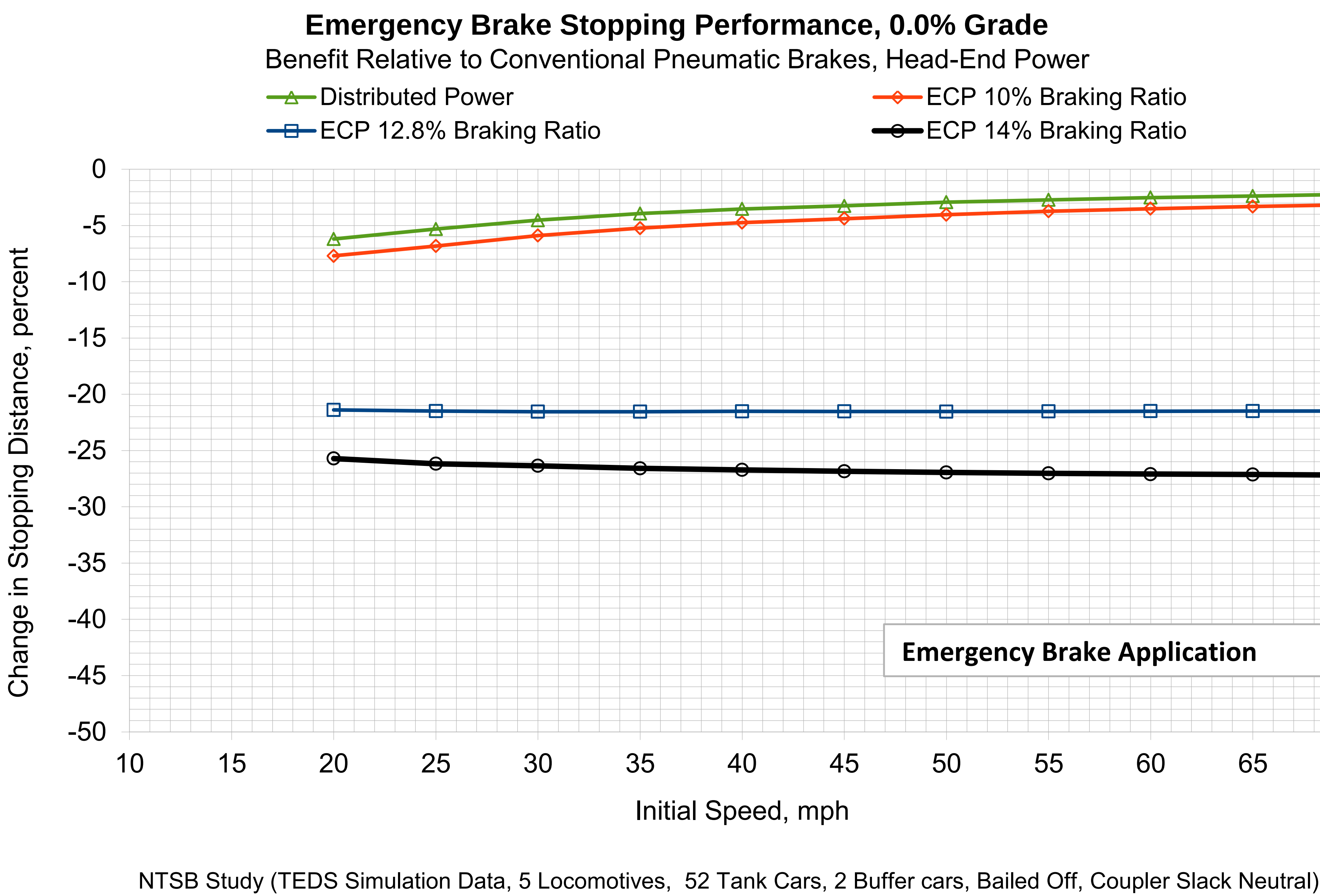
Emergency Brake Stopping Performance, +1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Change in Stopping Distance, percent
Emergency Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

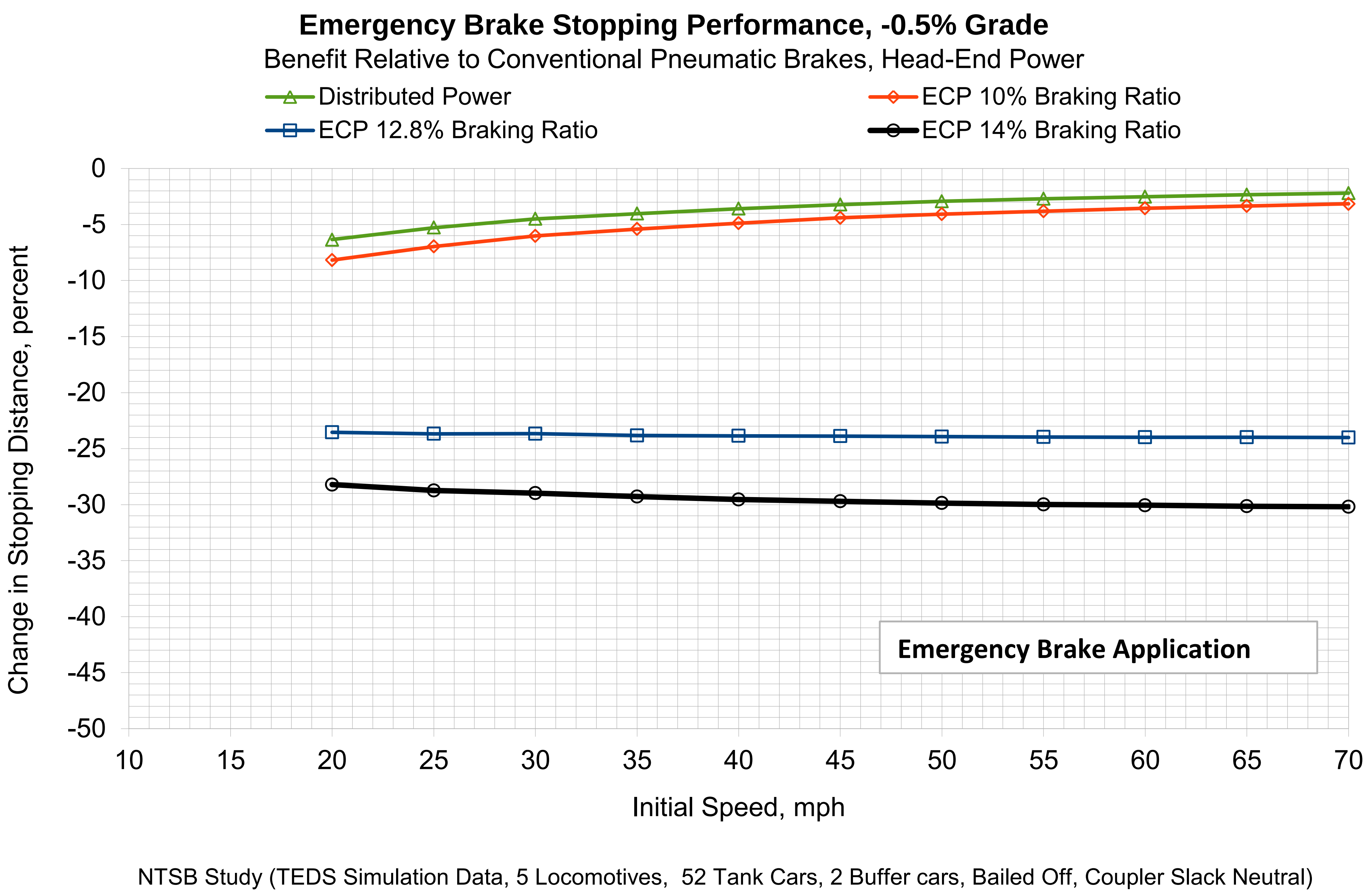


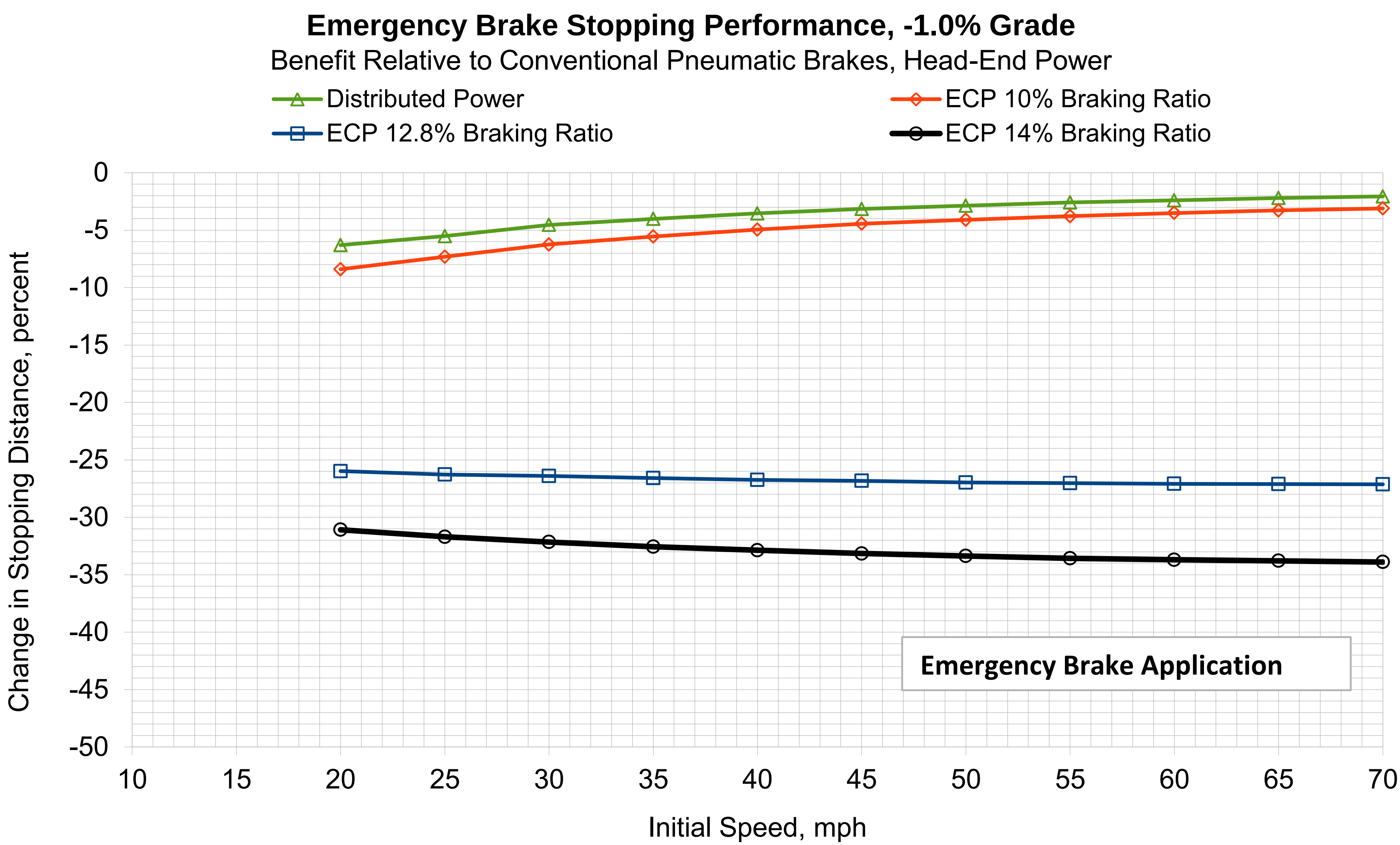
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



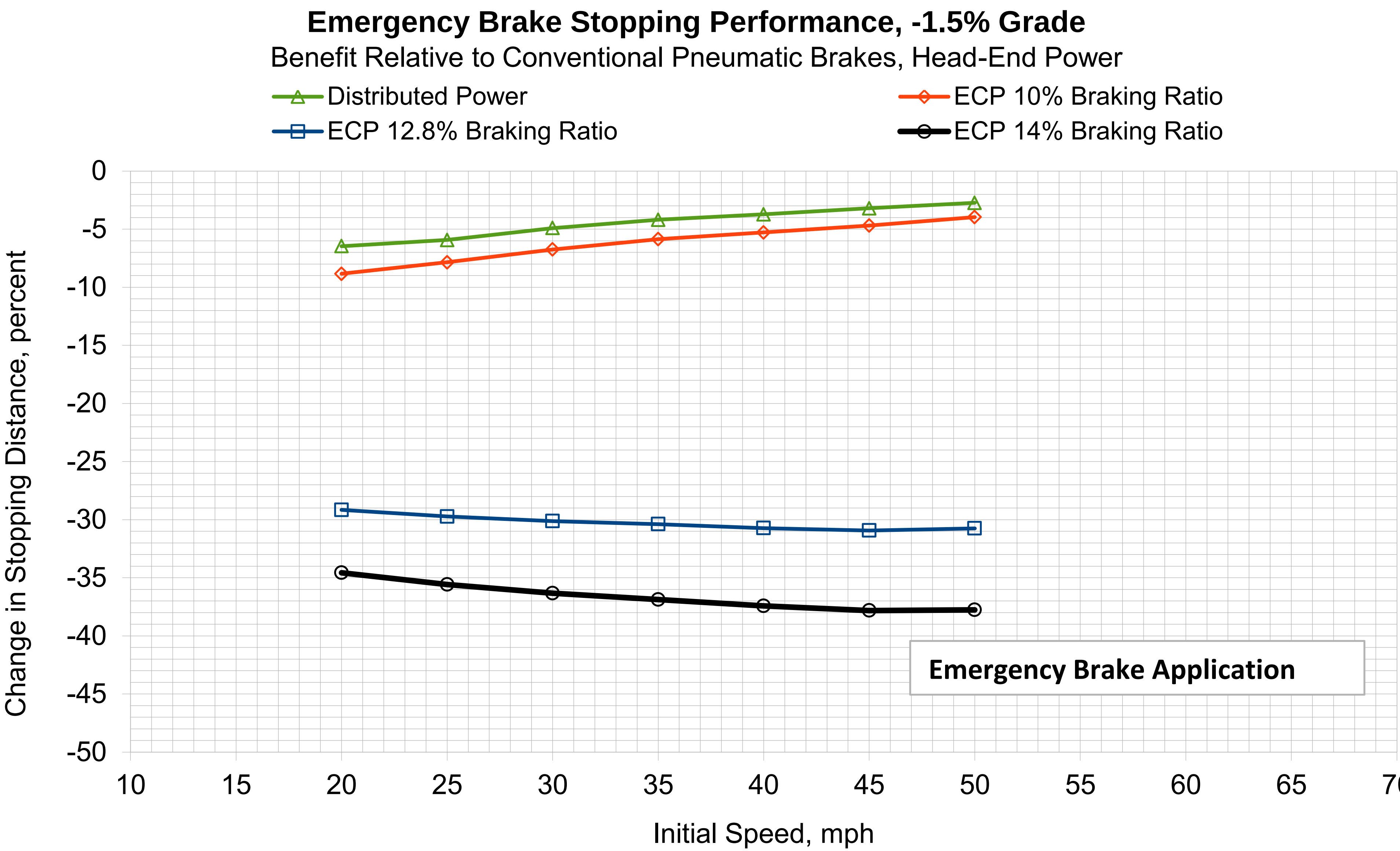
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Emergency Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

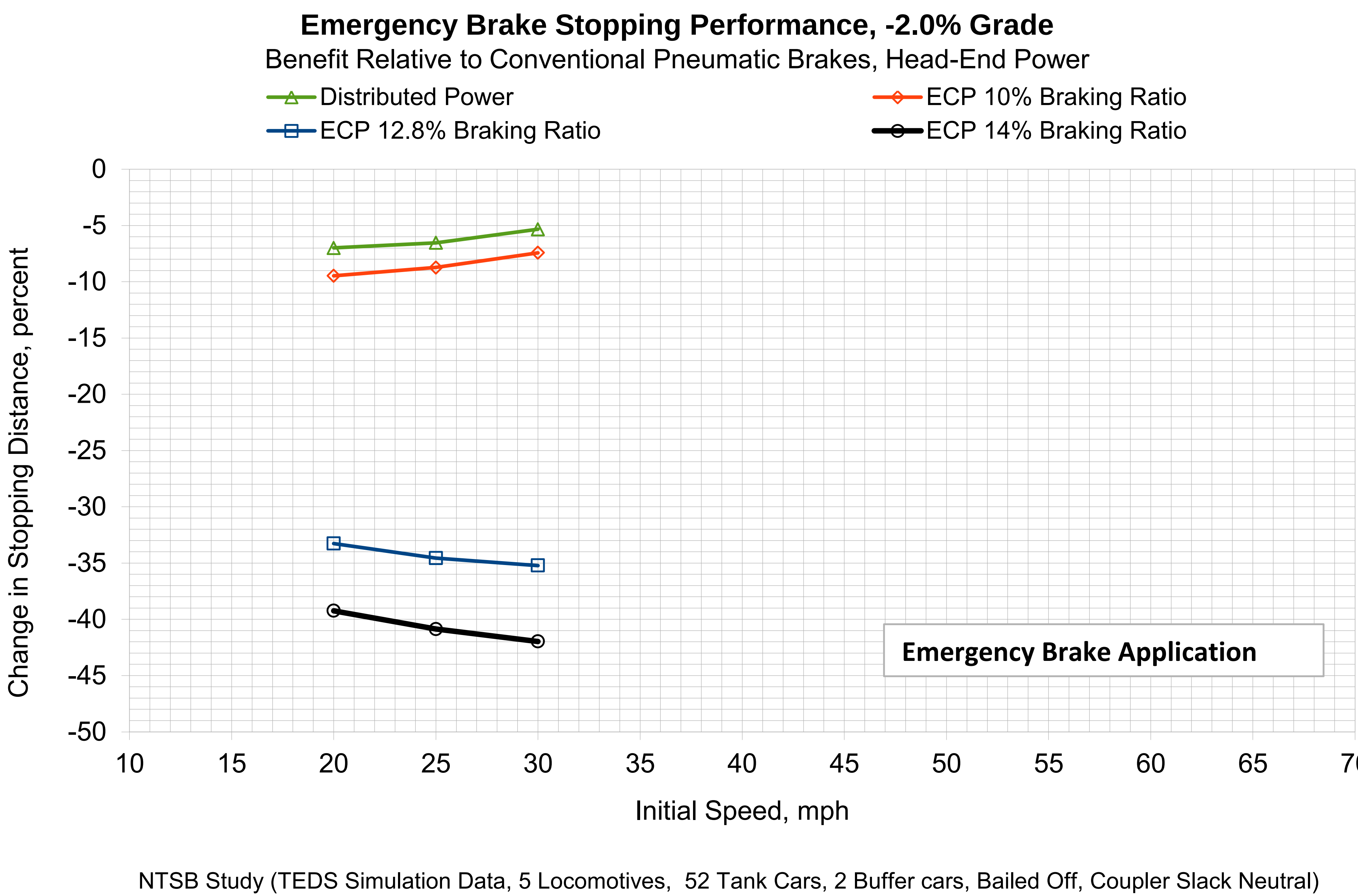

Emergency Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



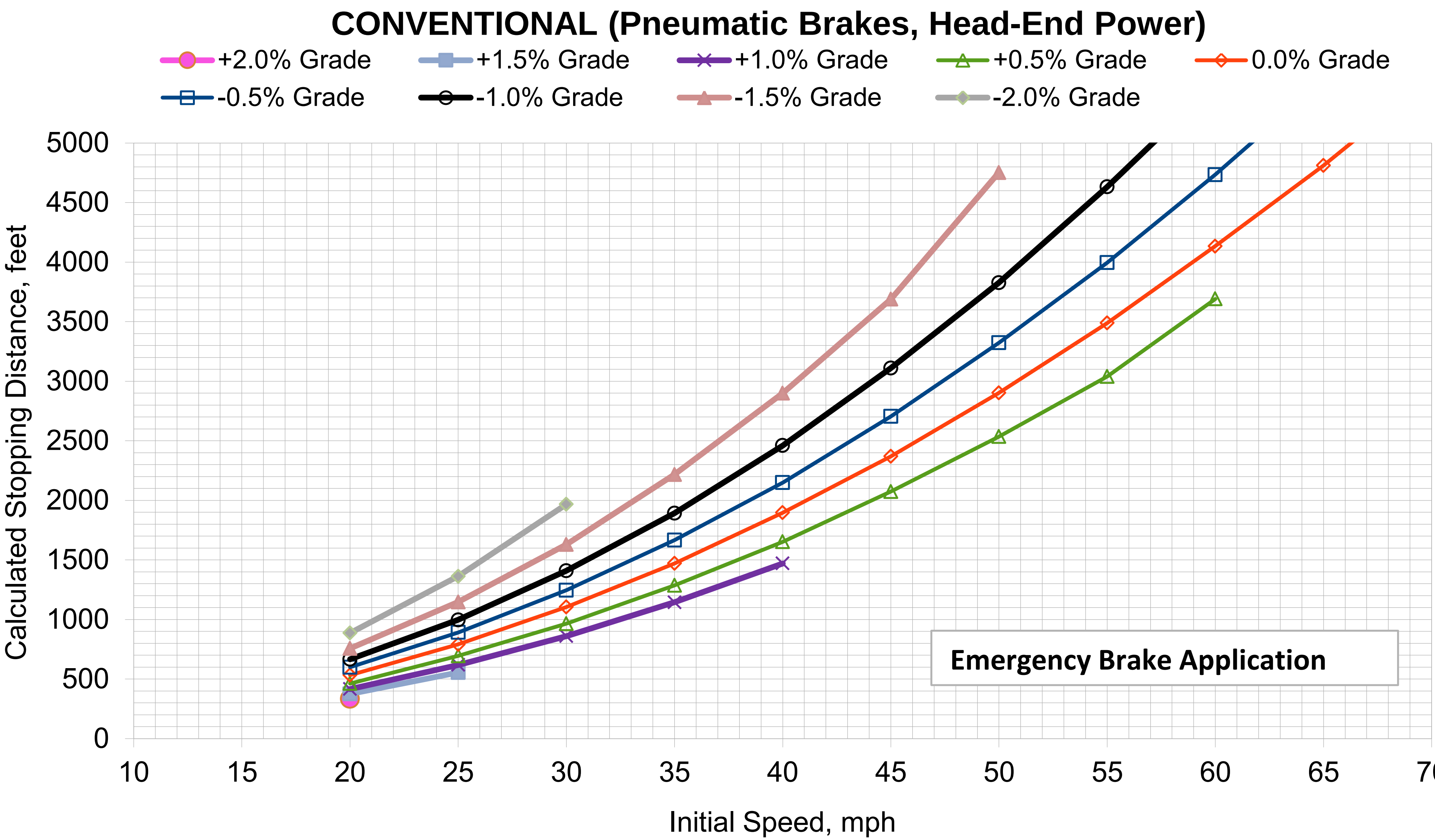
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



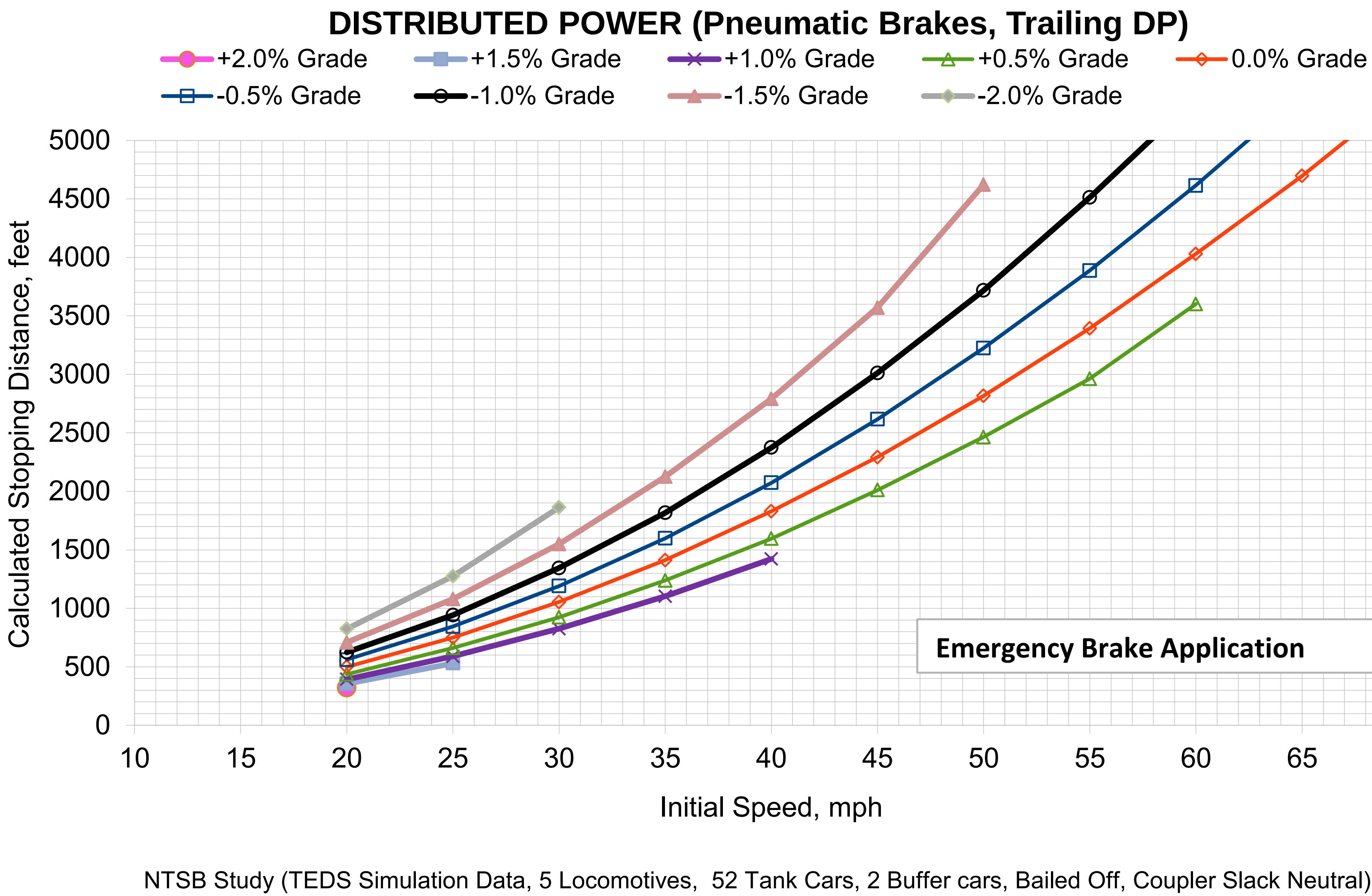
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

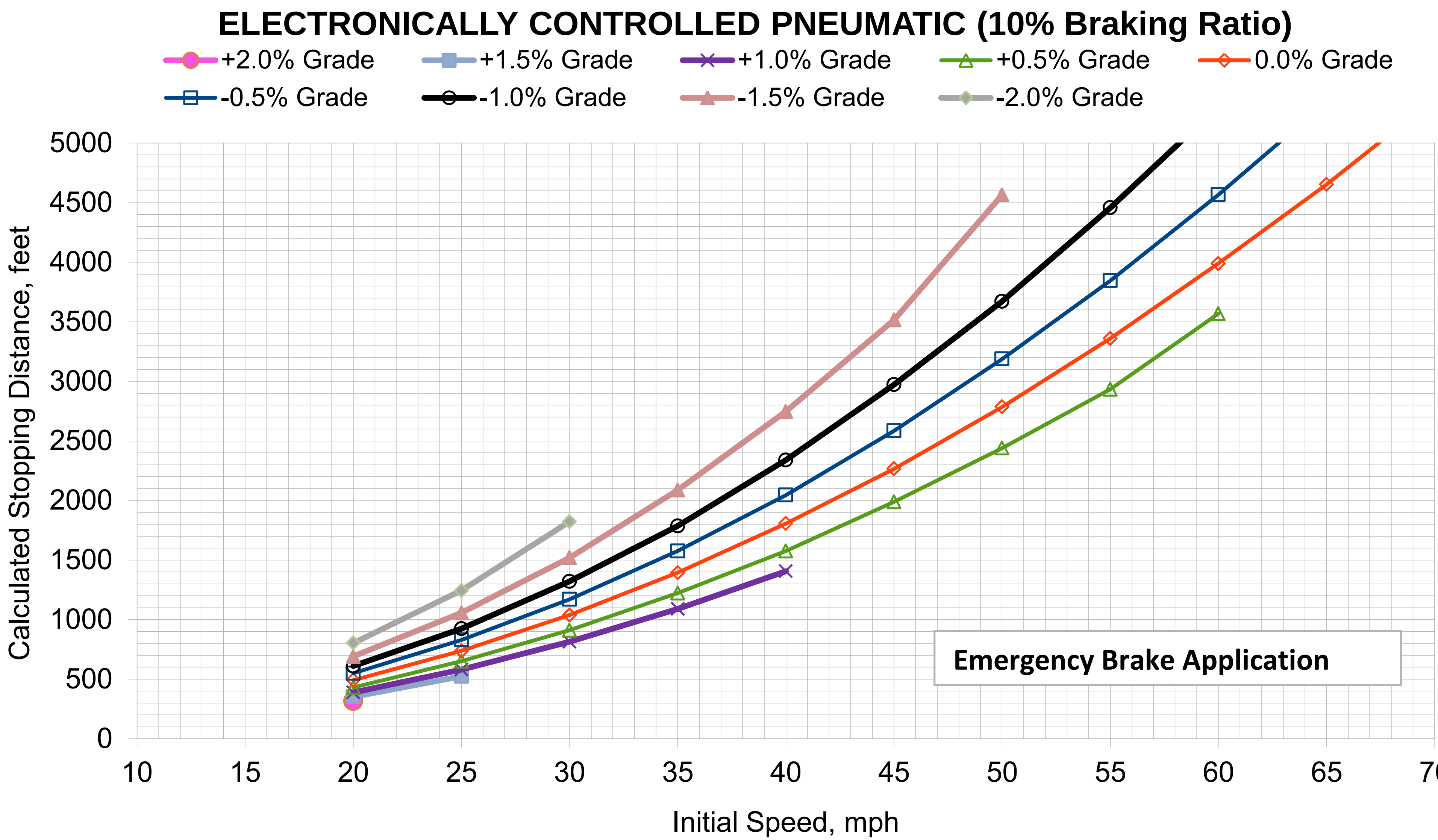


Emergency Brake Stopping Performance, -2.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

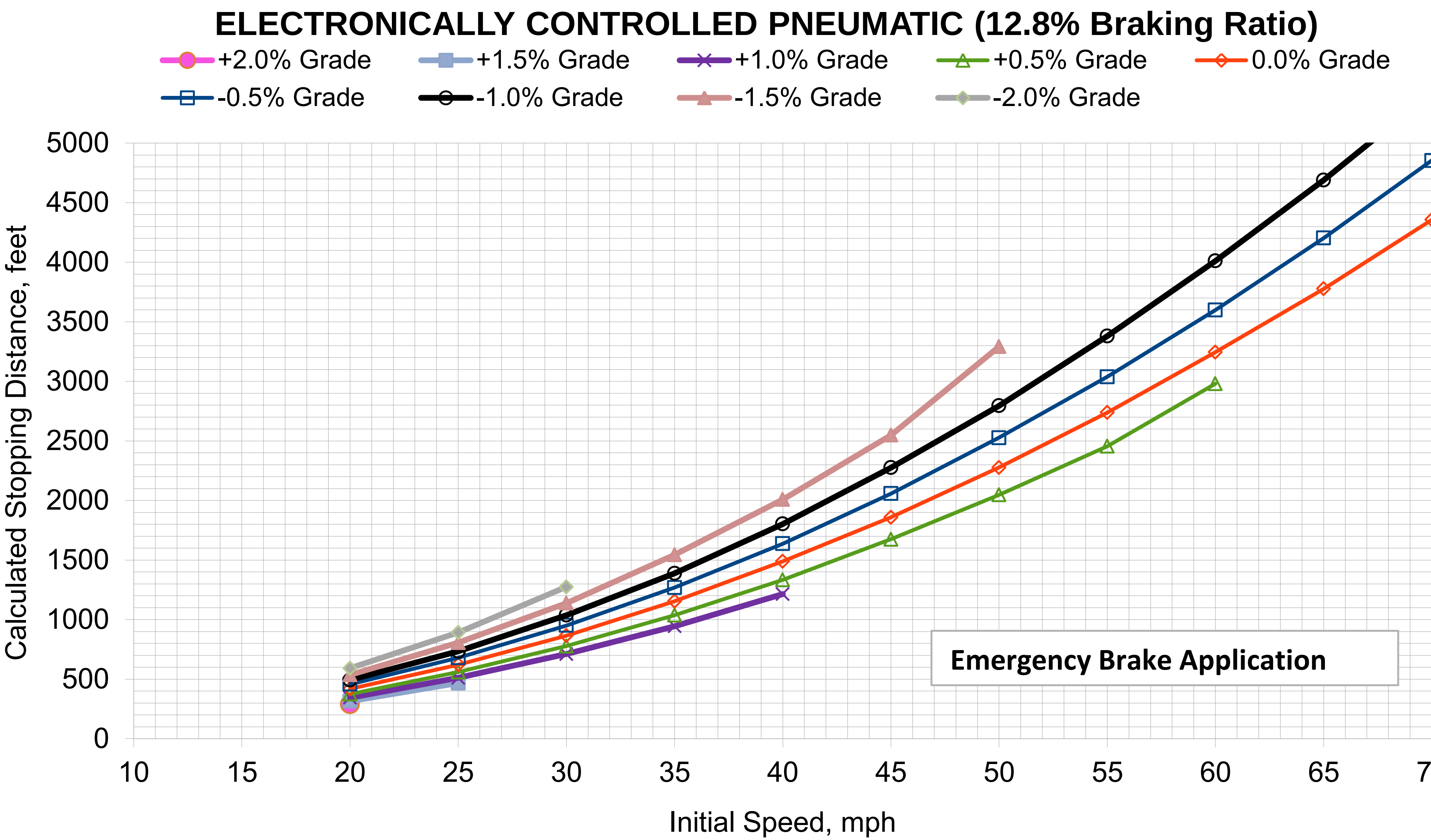


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

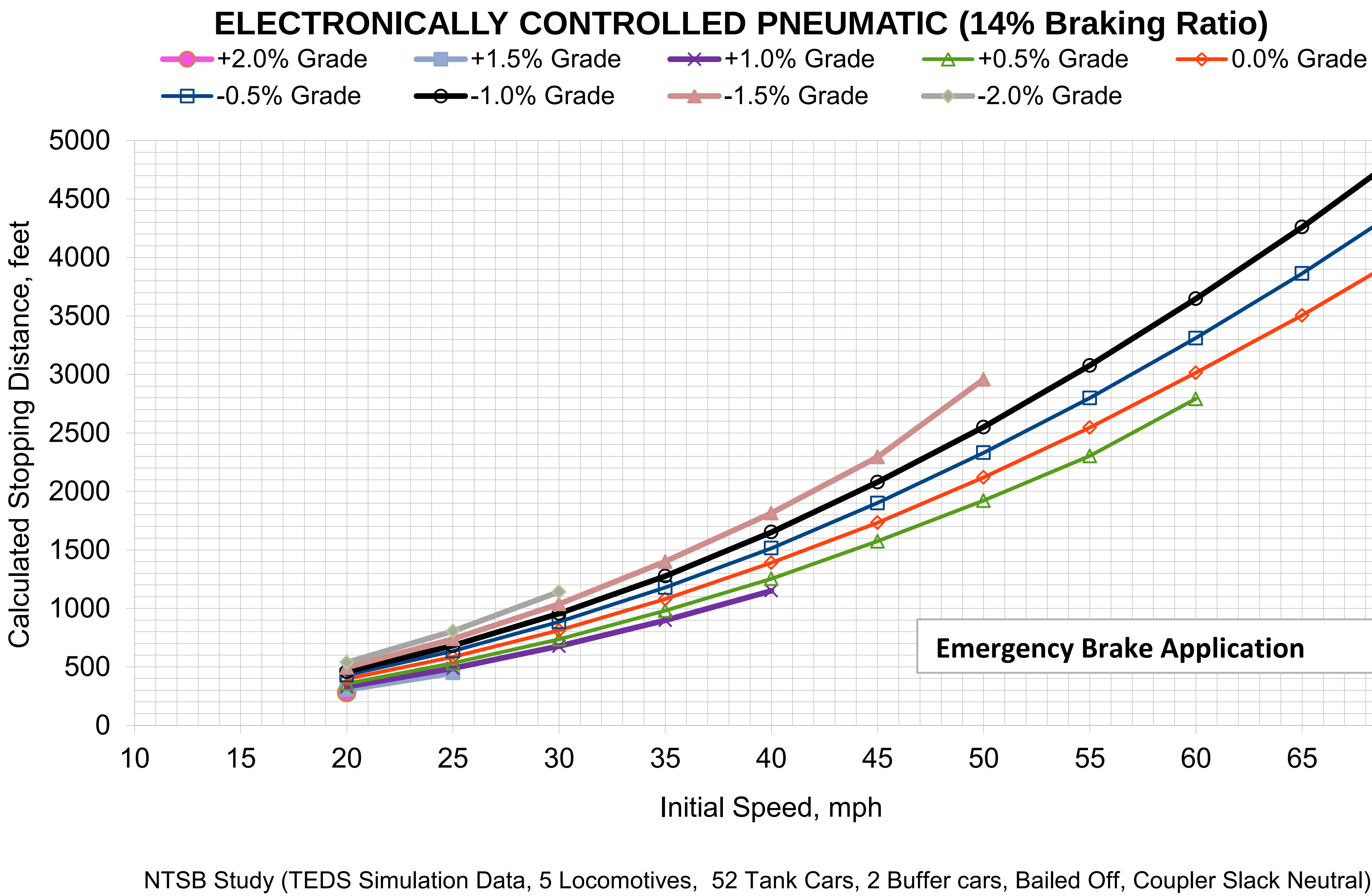

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

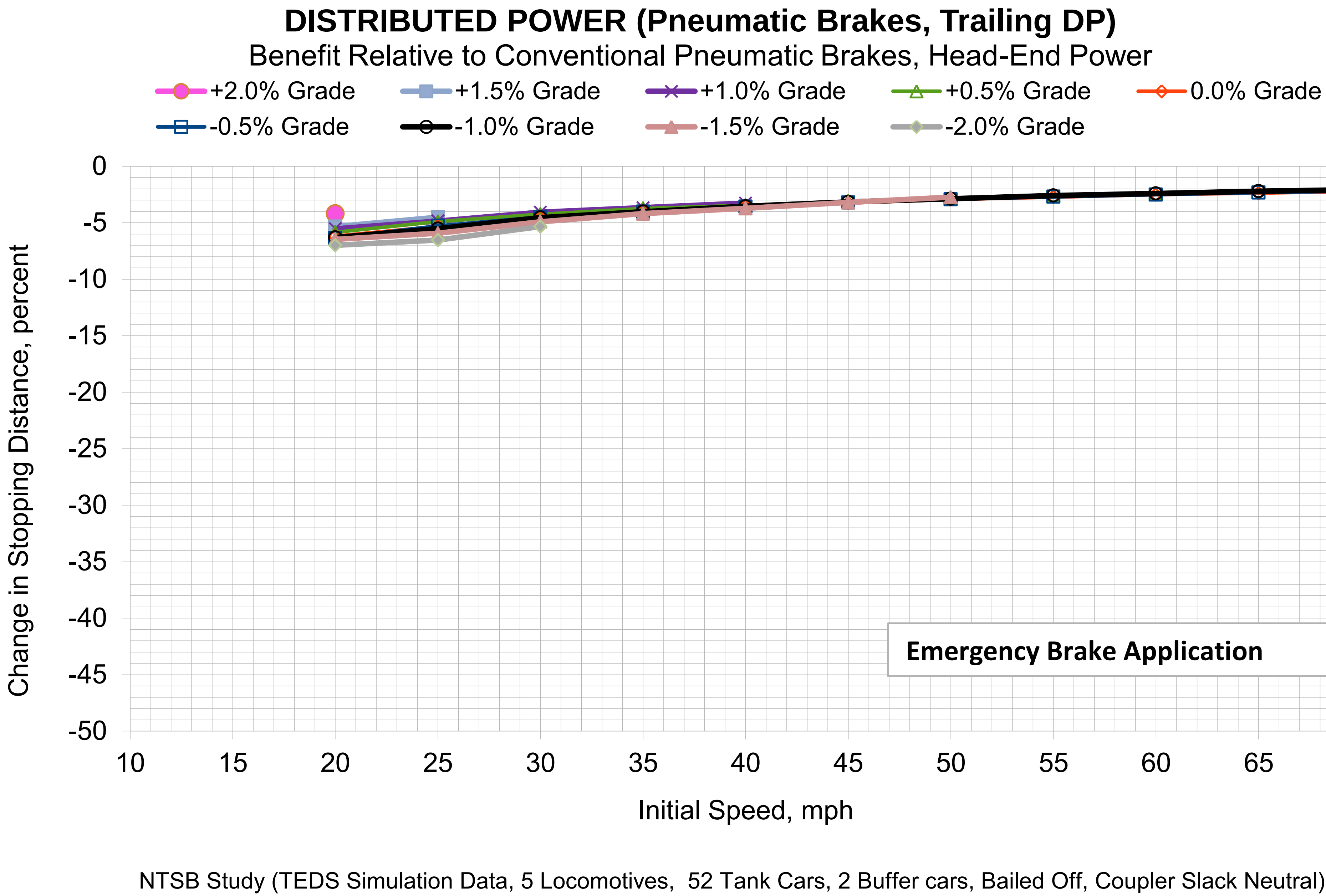


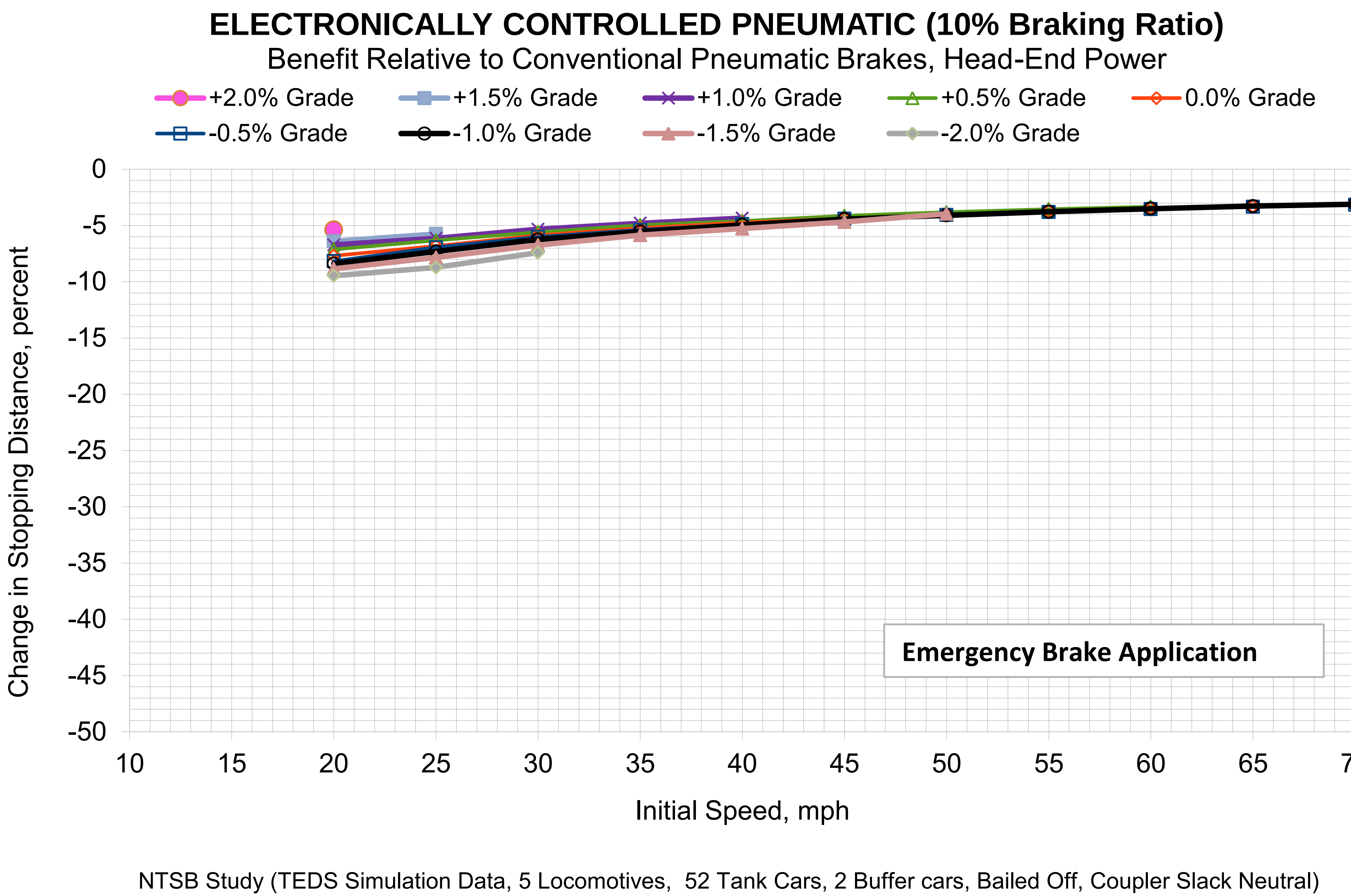
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



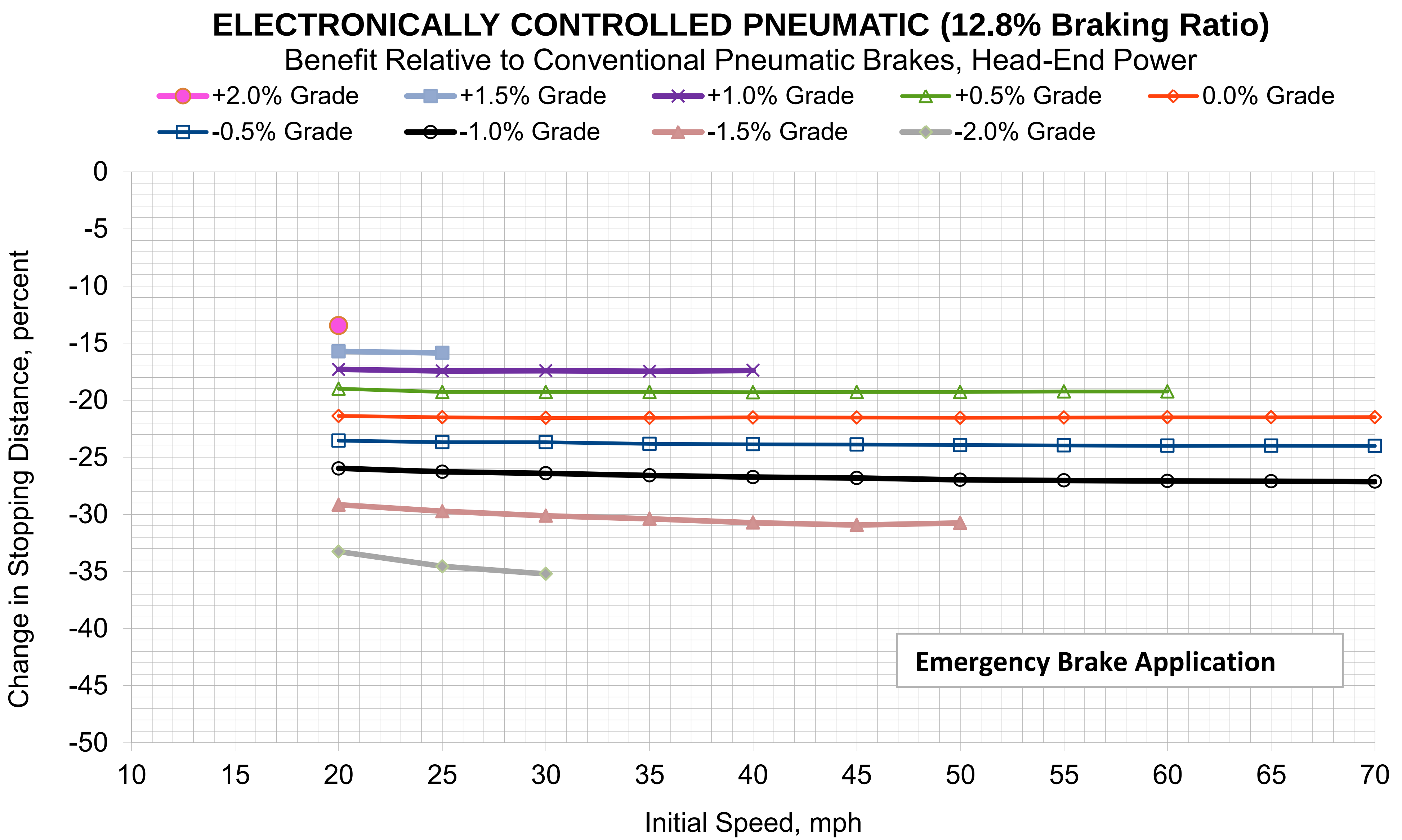
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

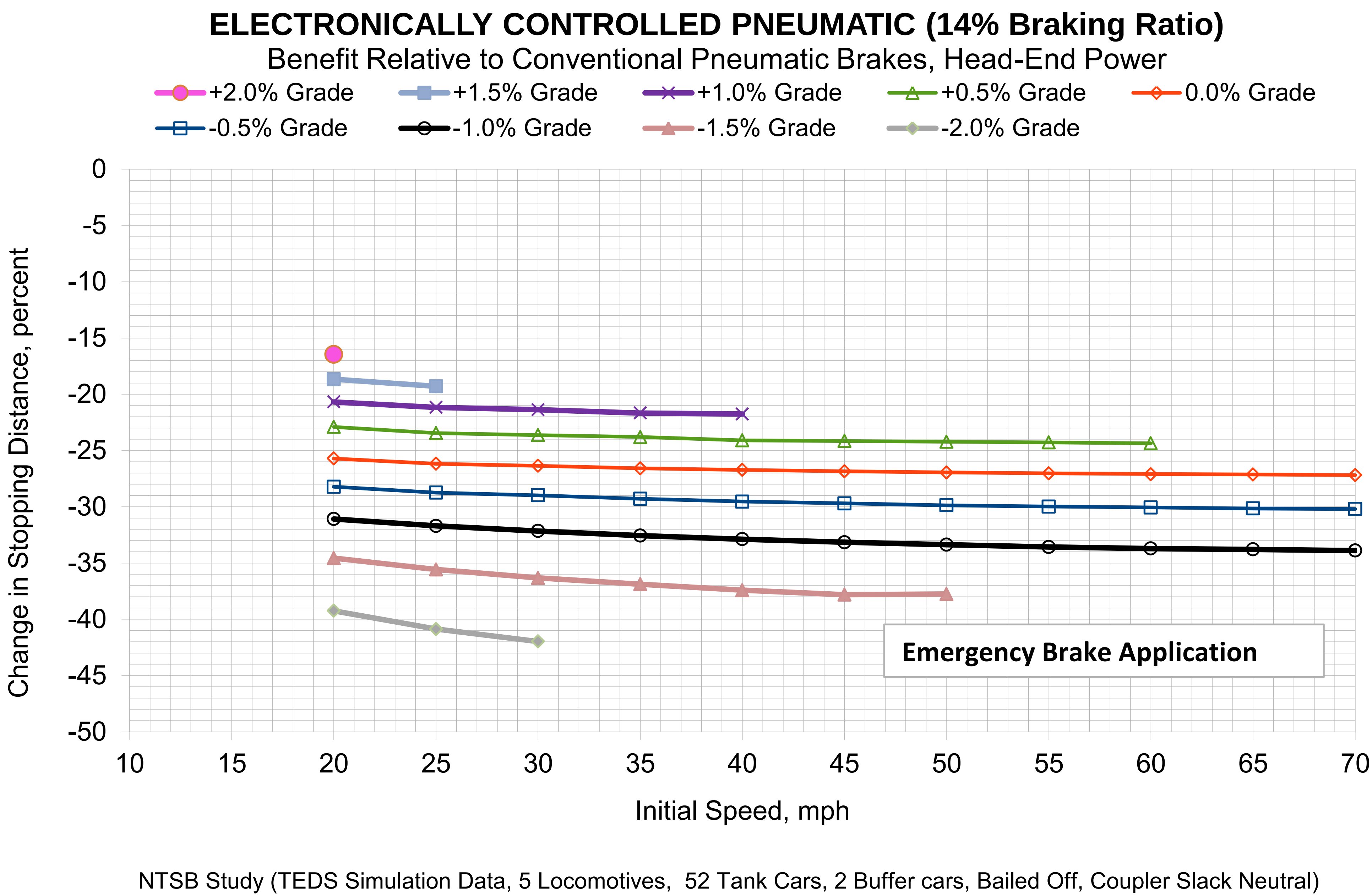

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



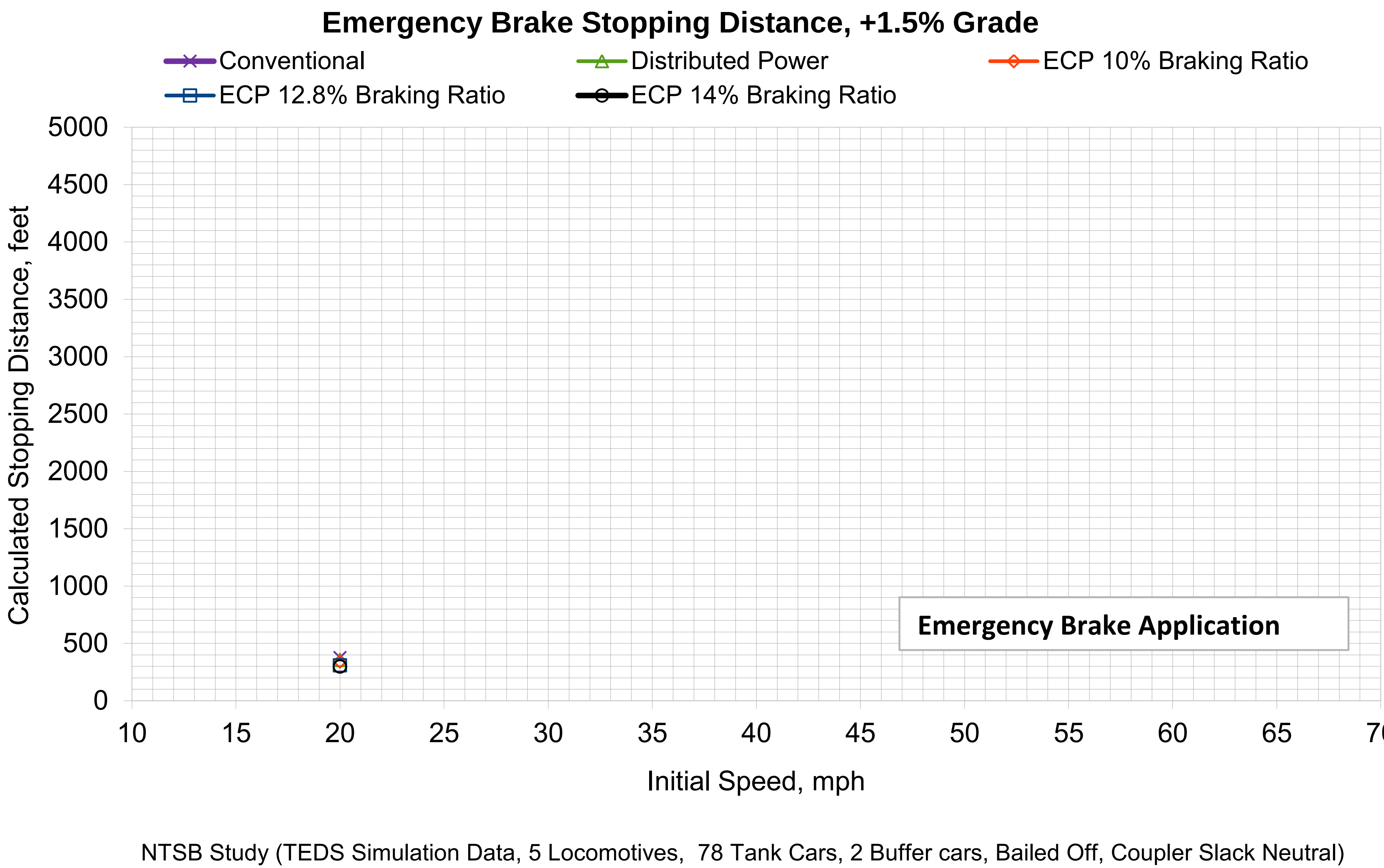
ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



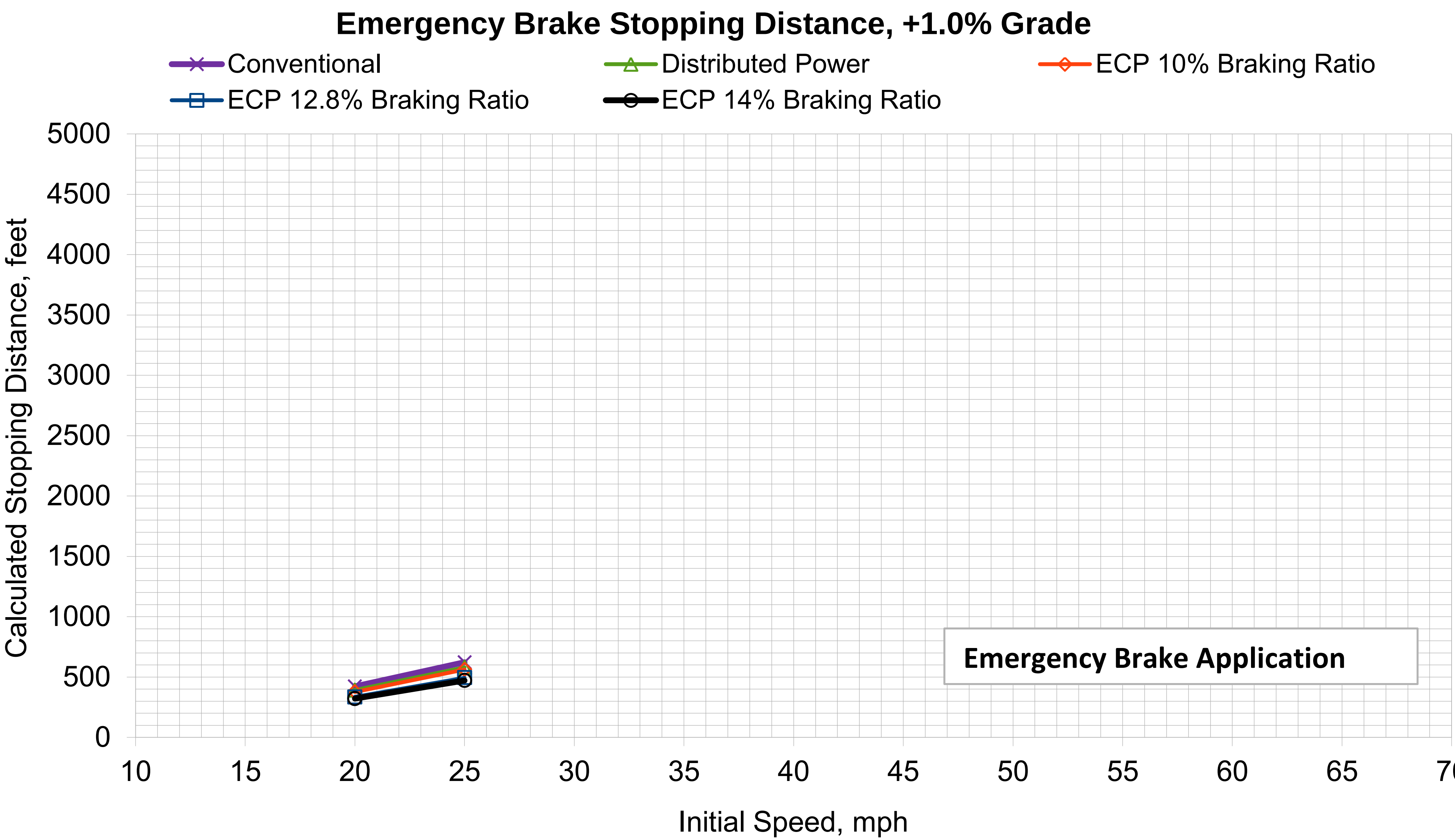
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

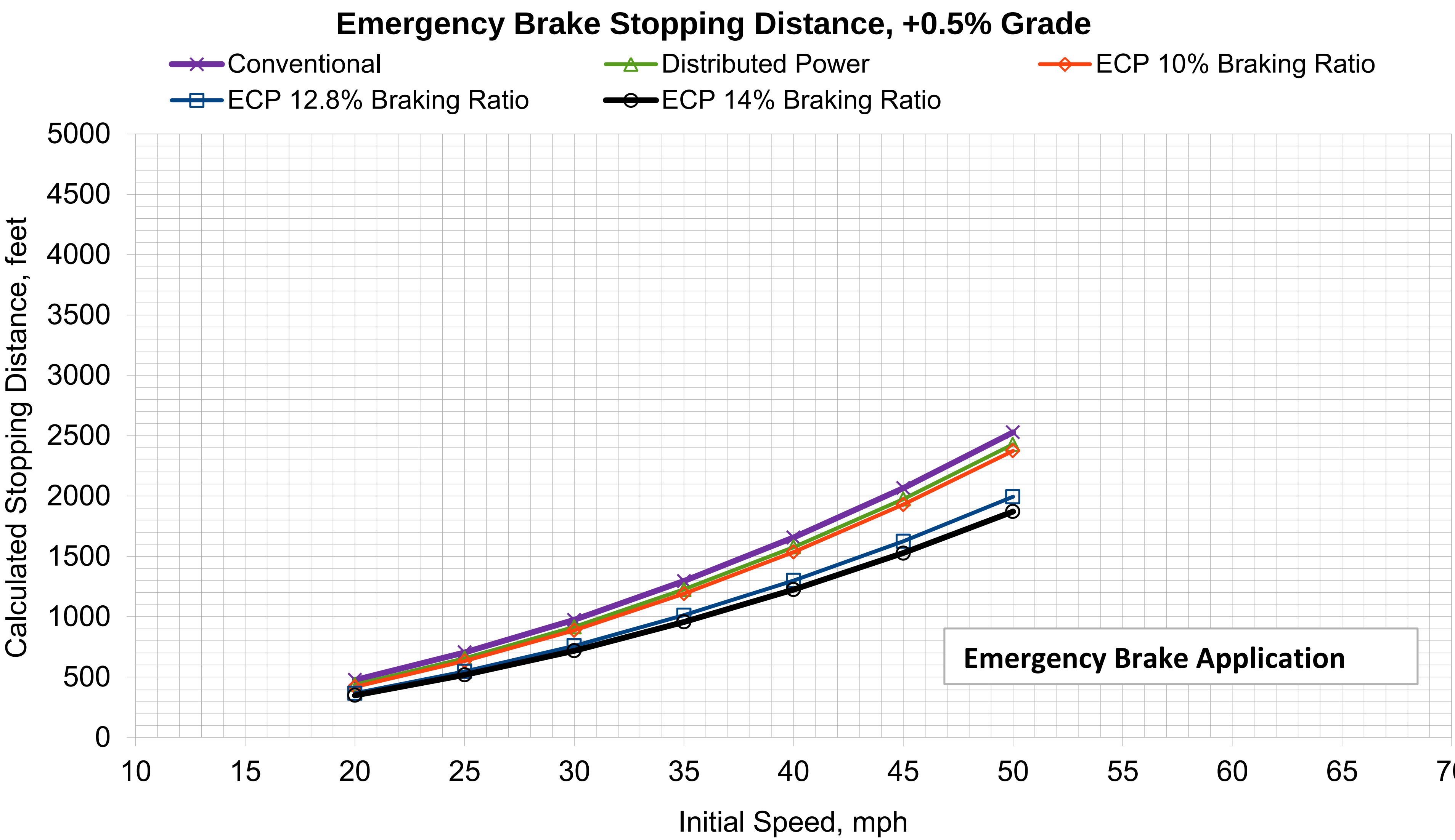
Attachment 8: Emergency Braking, Bailed Off, 78 Tank Cars



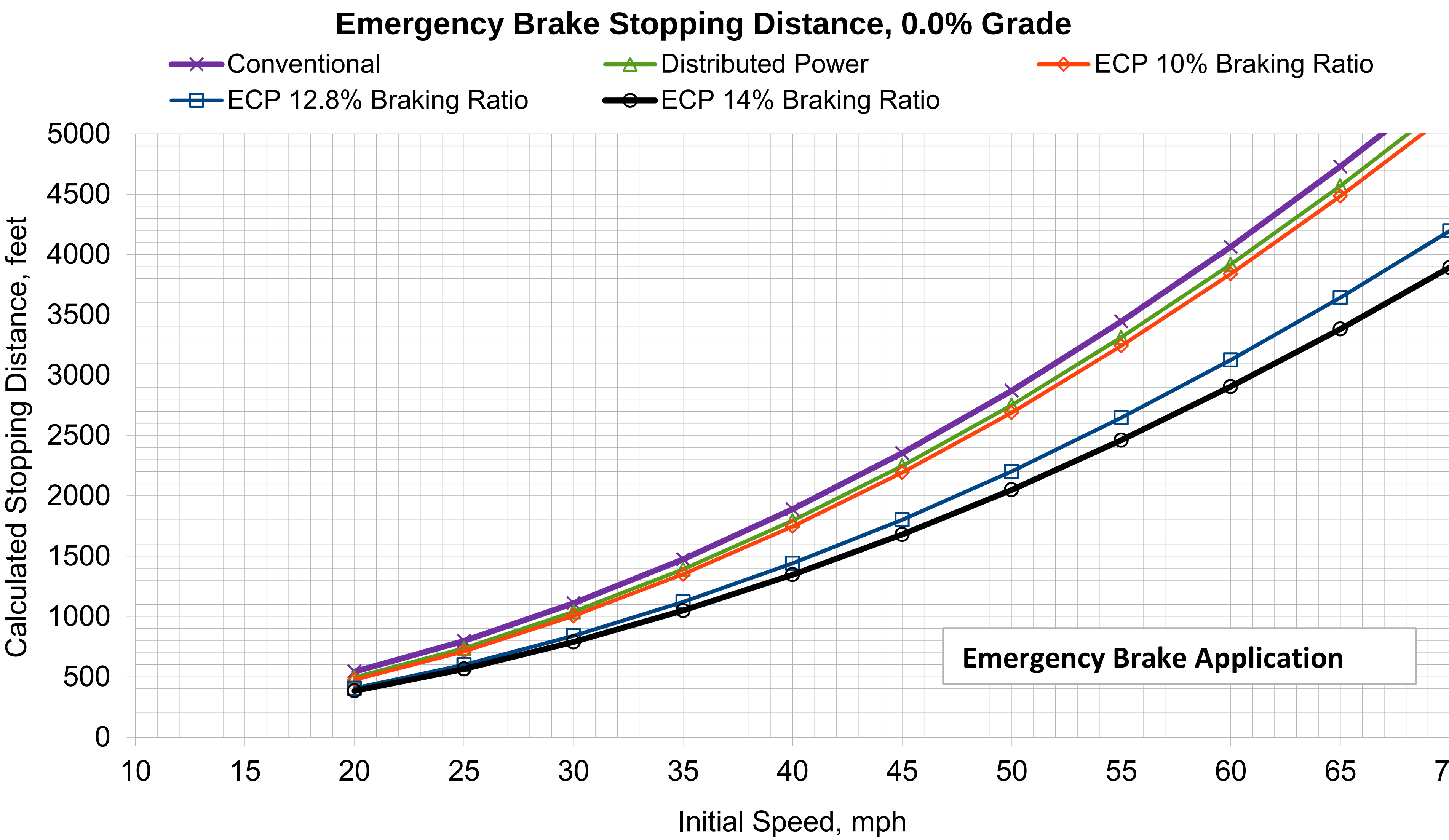
Emergency Brake Stopping Distance, +1.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Emergency Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



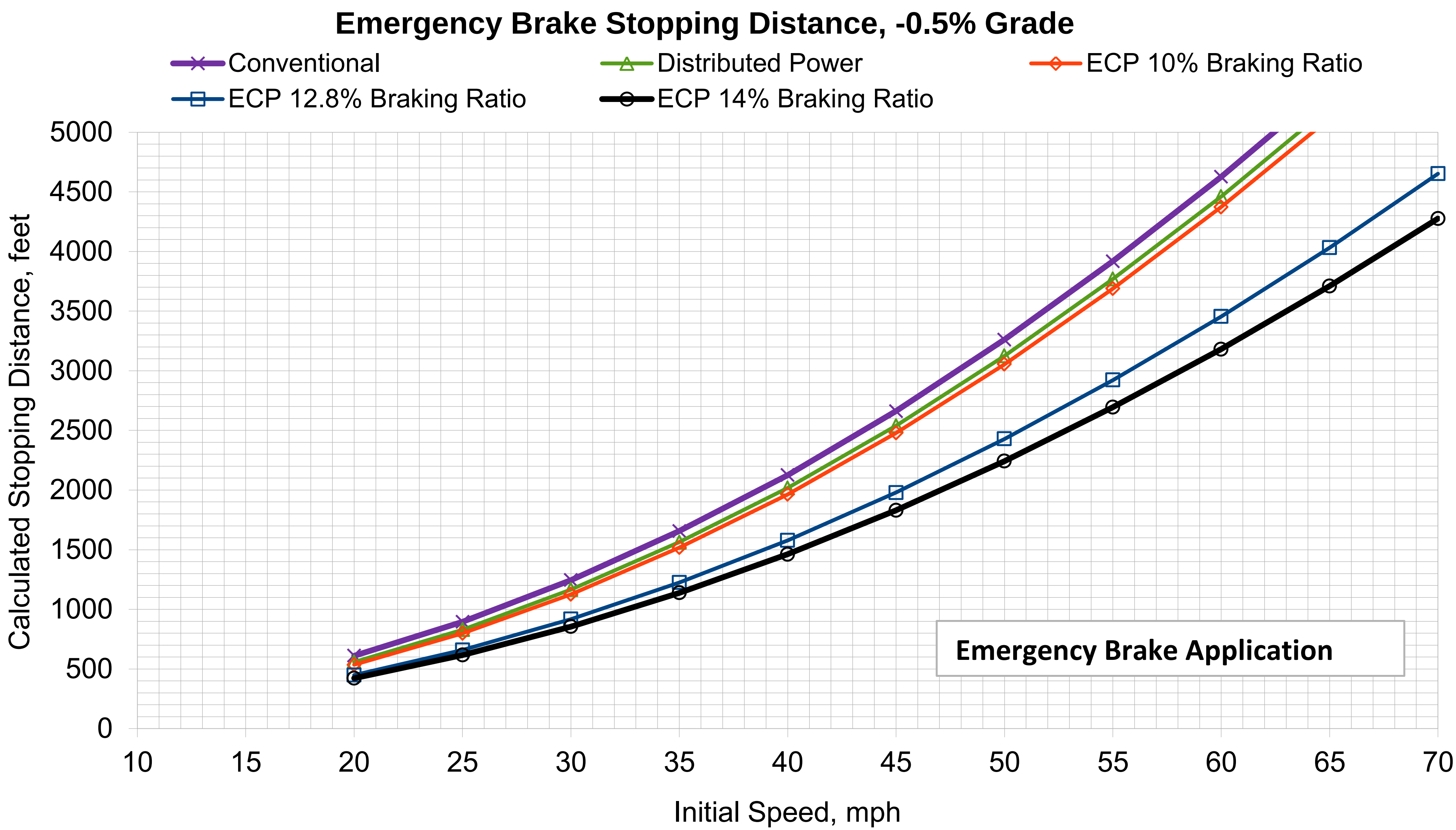
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



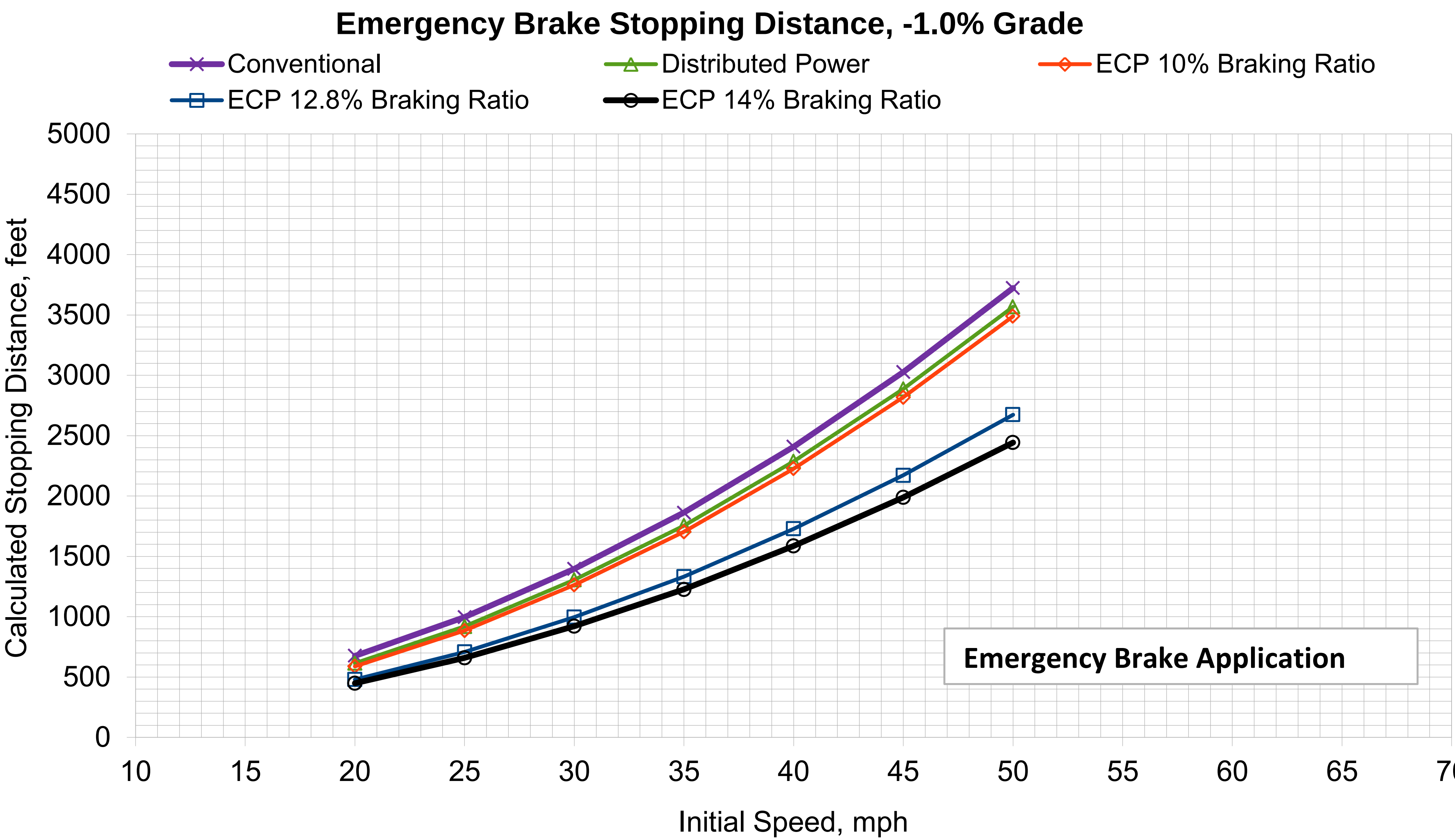
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



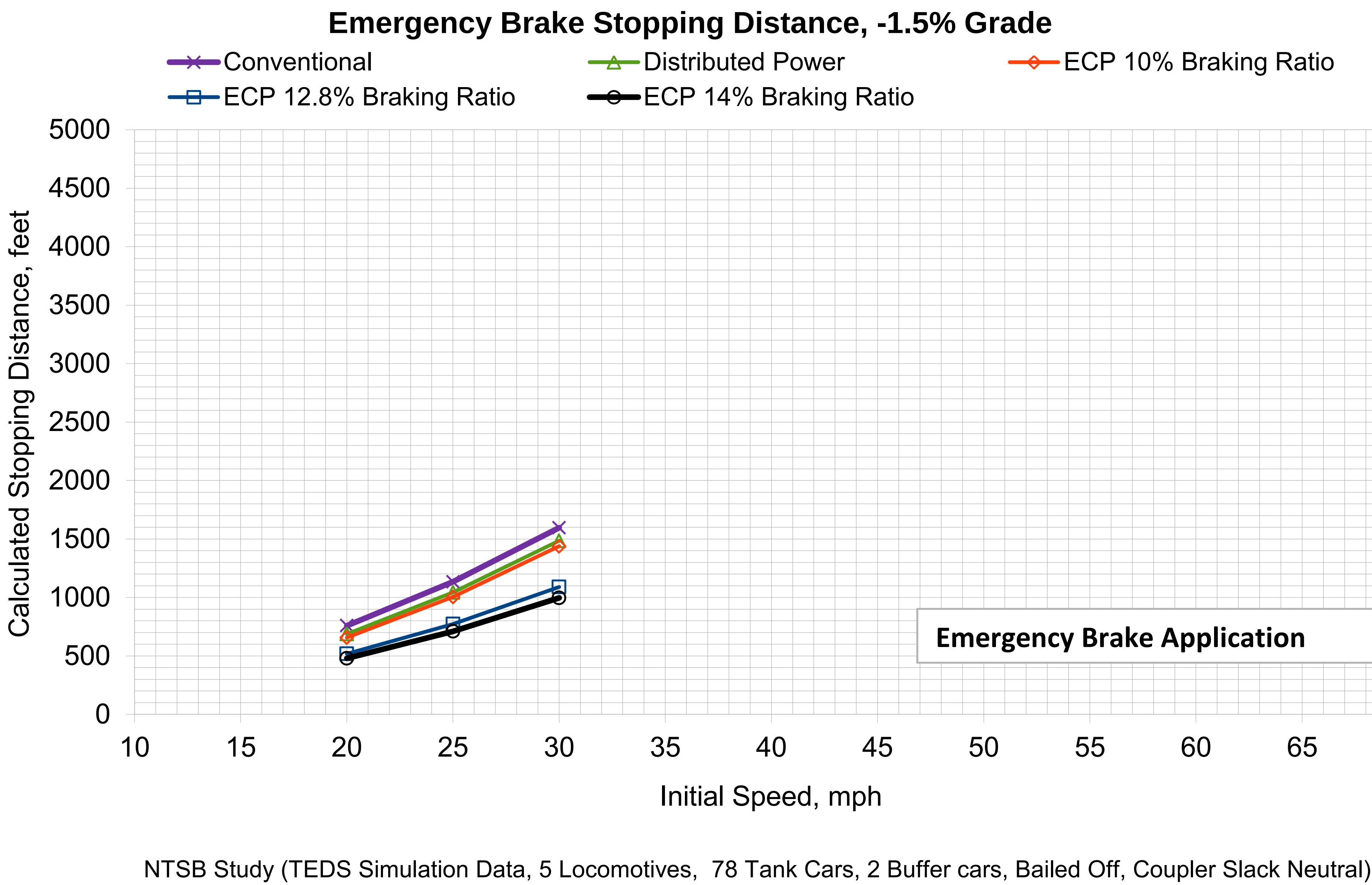
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

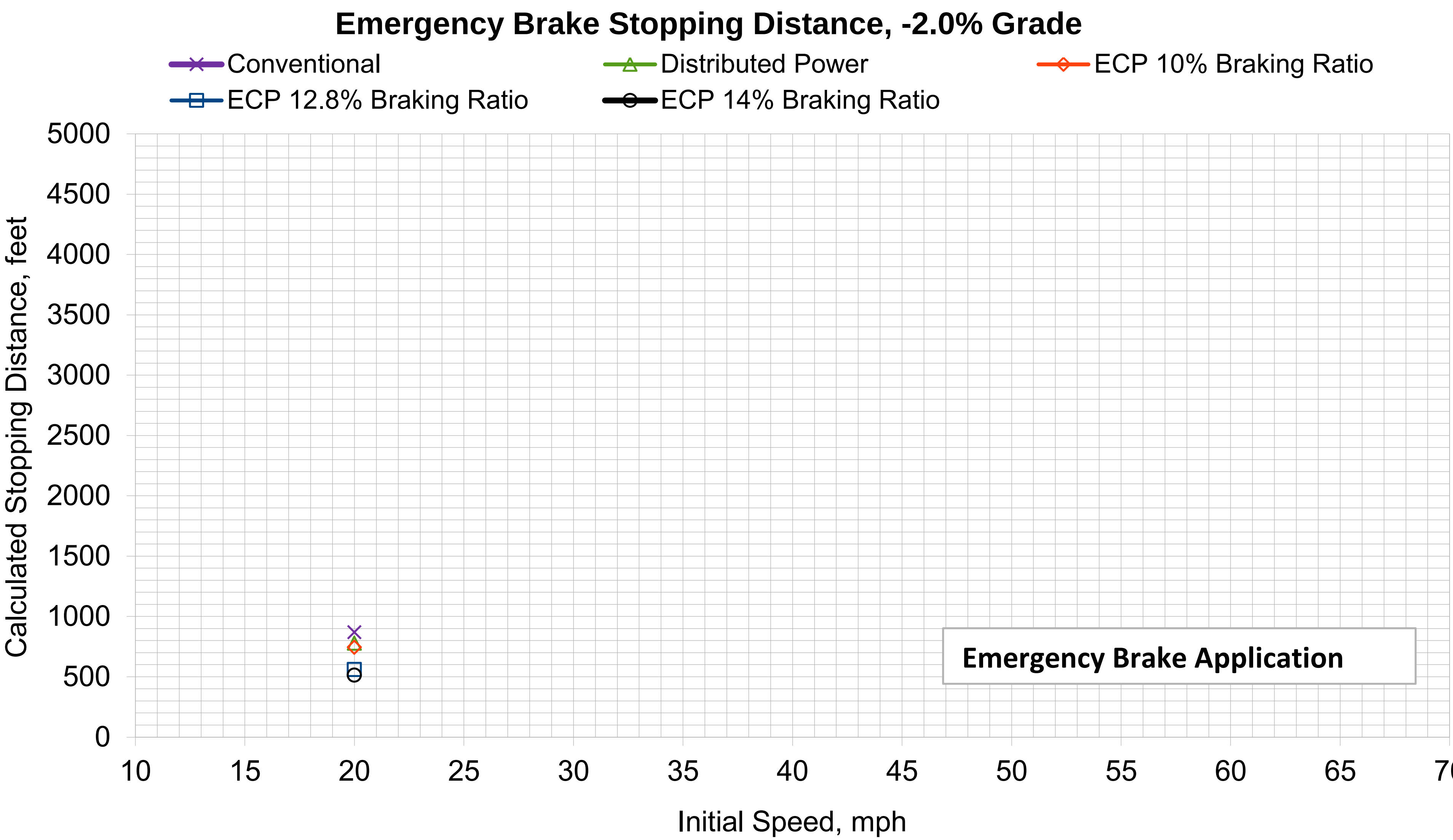


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

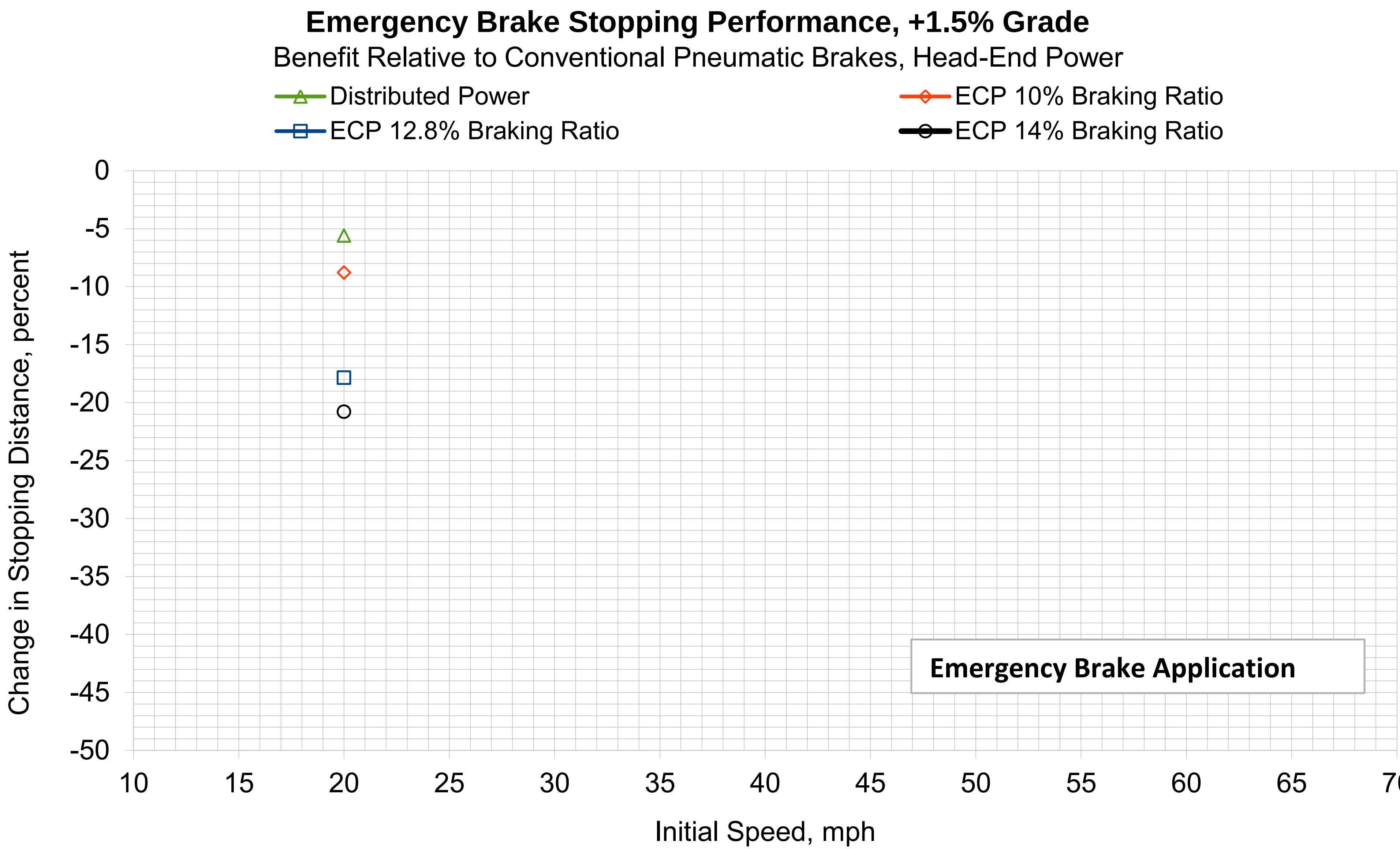


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

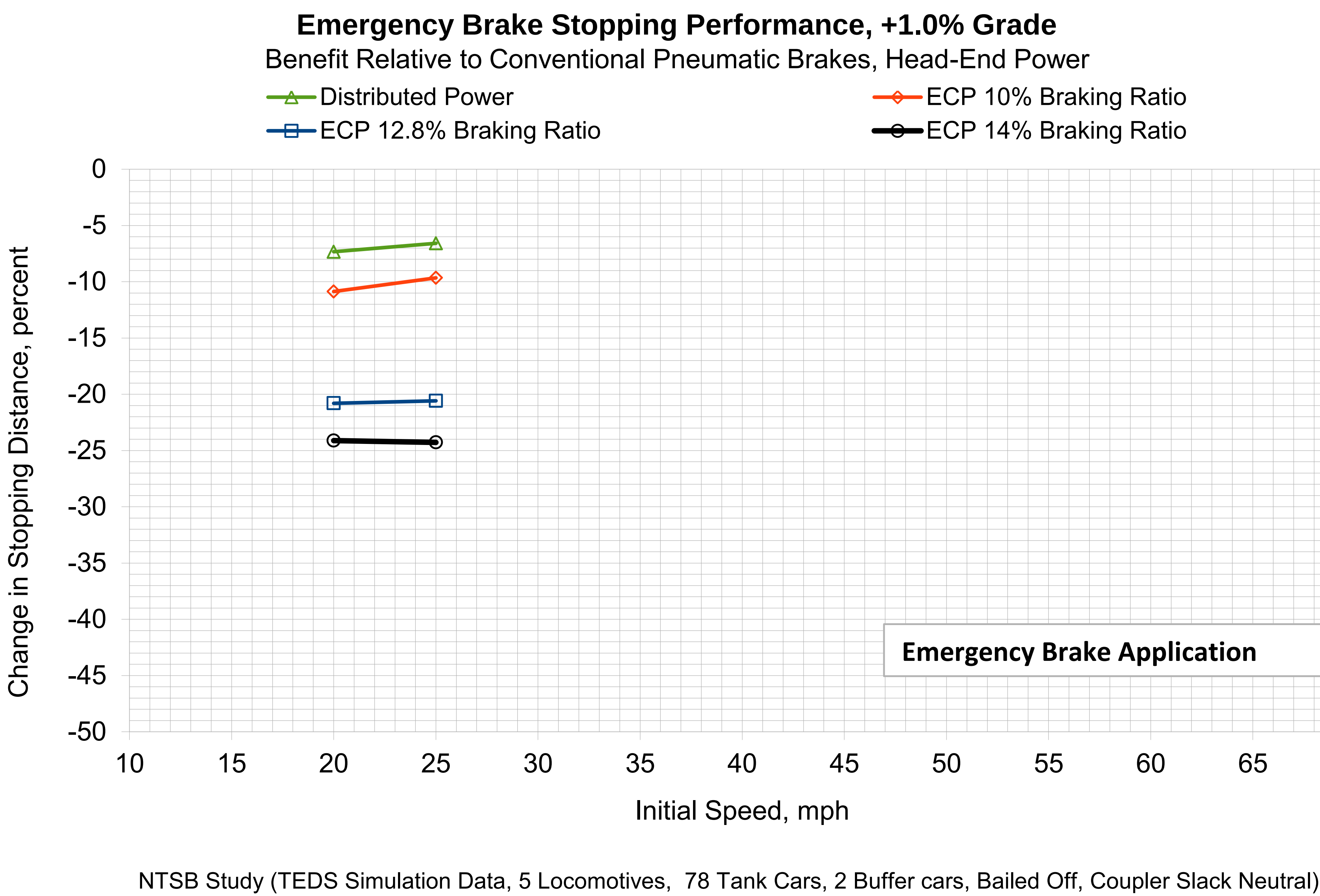

Emergency Brake Stopping Distance, -1.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Initial Speed, mph
10
15
20
25
30
35
40
45
50
55
60
65
70
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

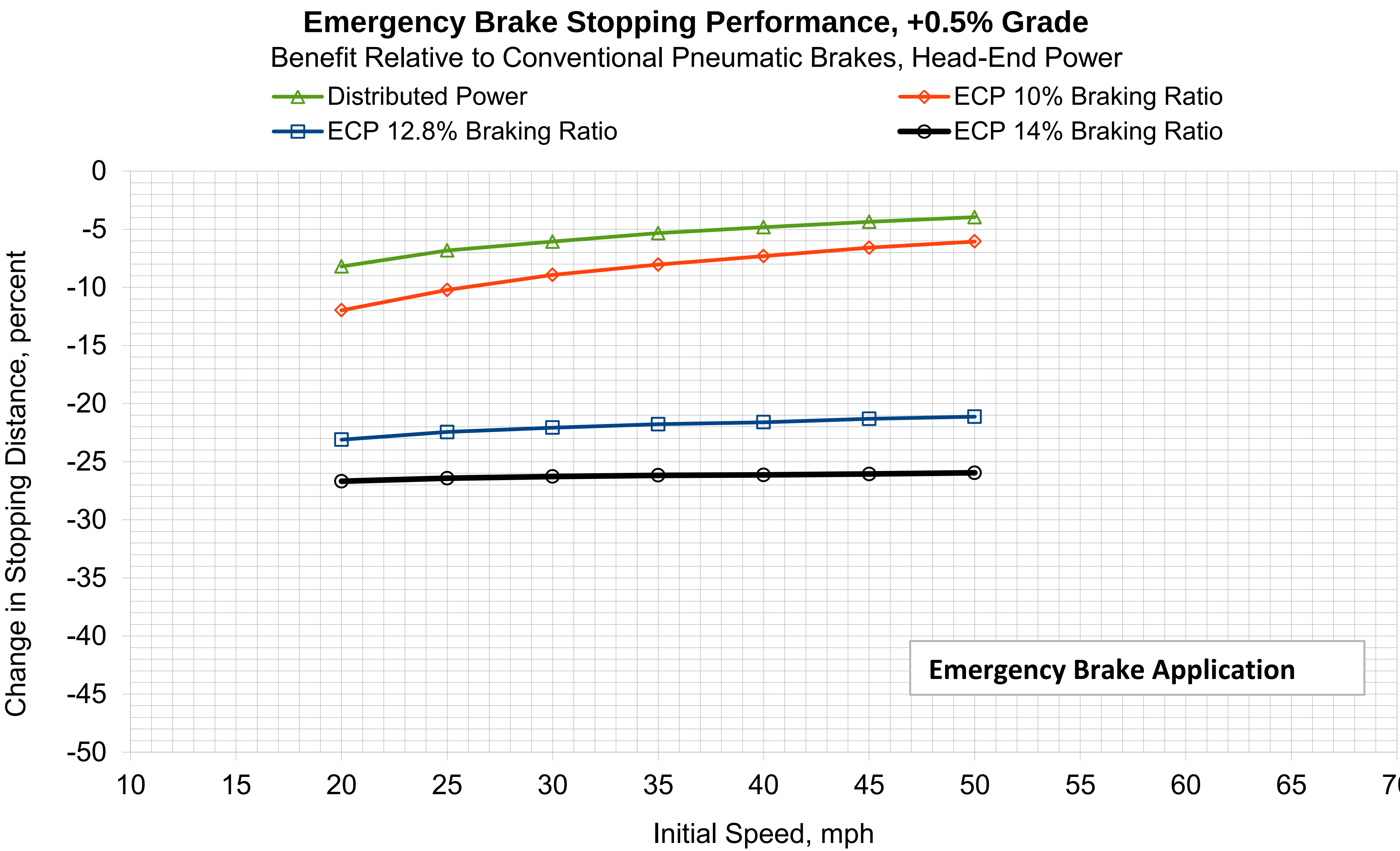


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

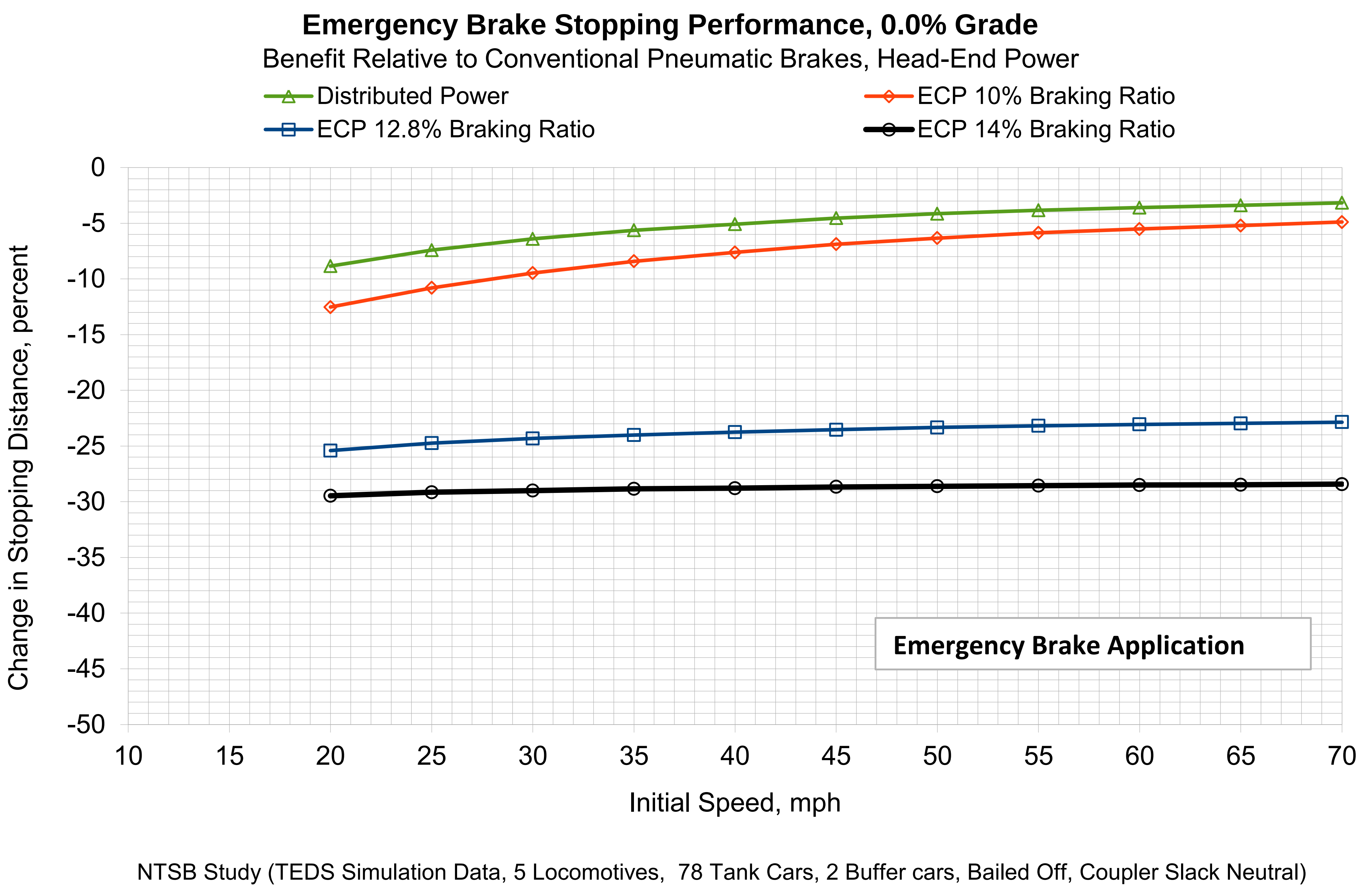


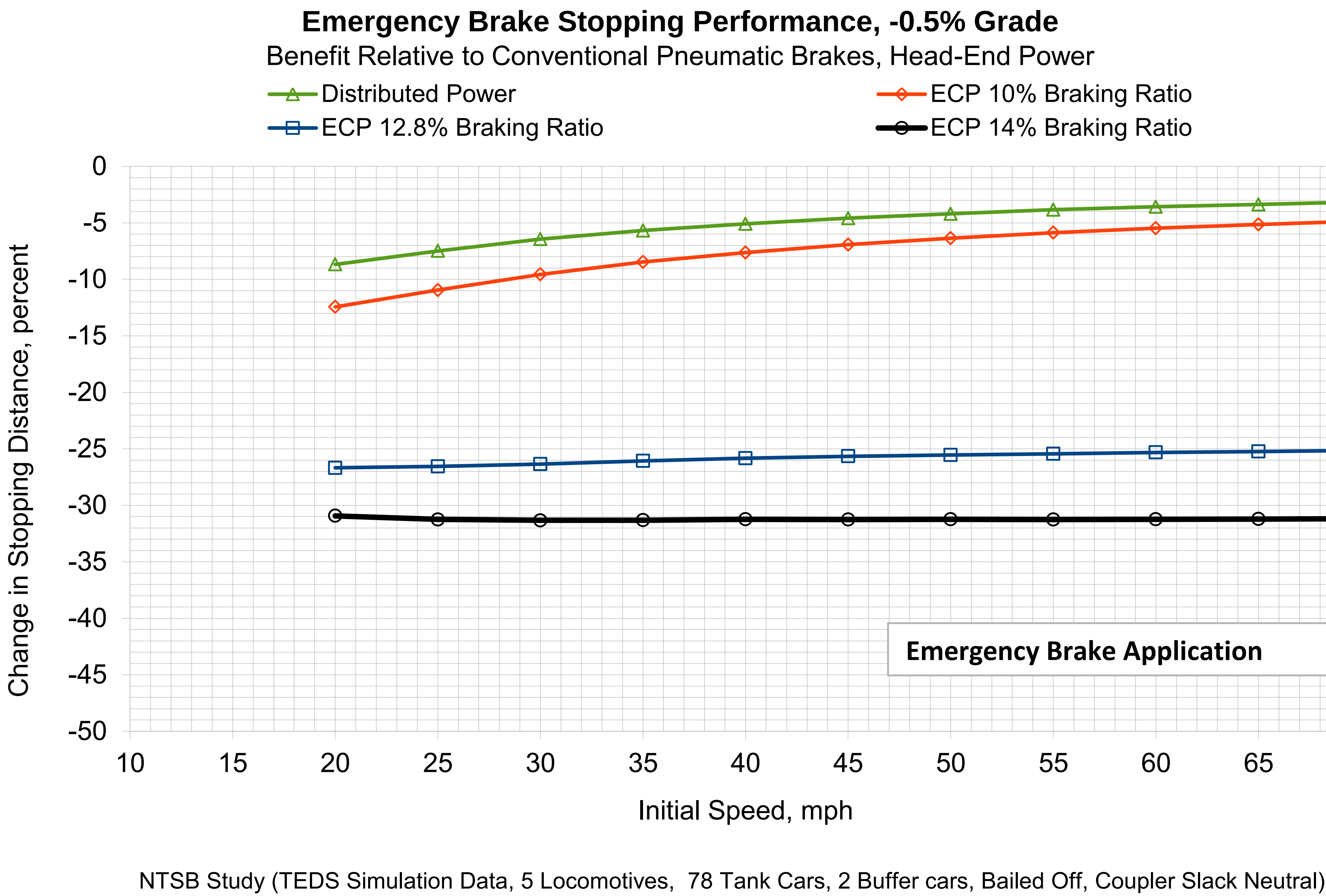
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Emergency Brake Stopping Performance, +1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Change in Stopping Distance, percent
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

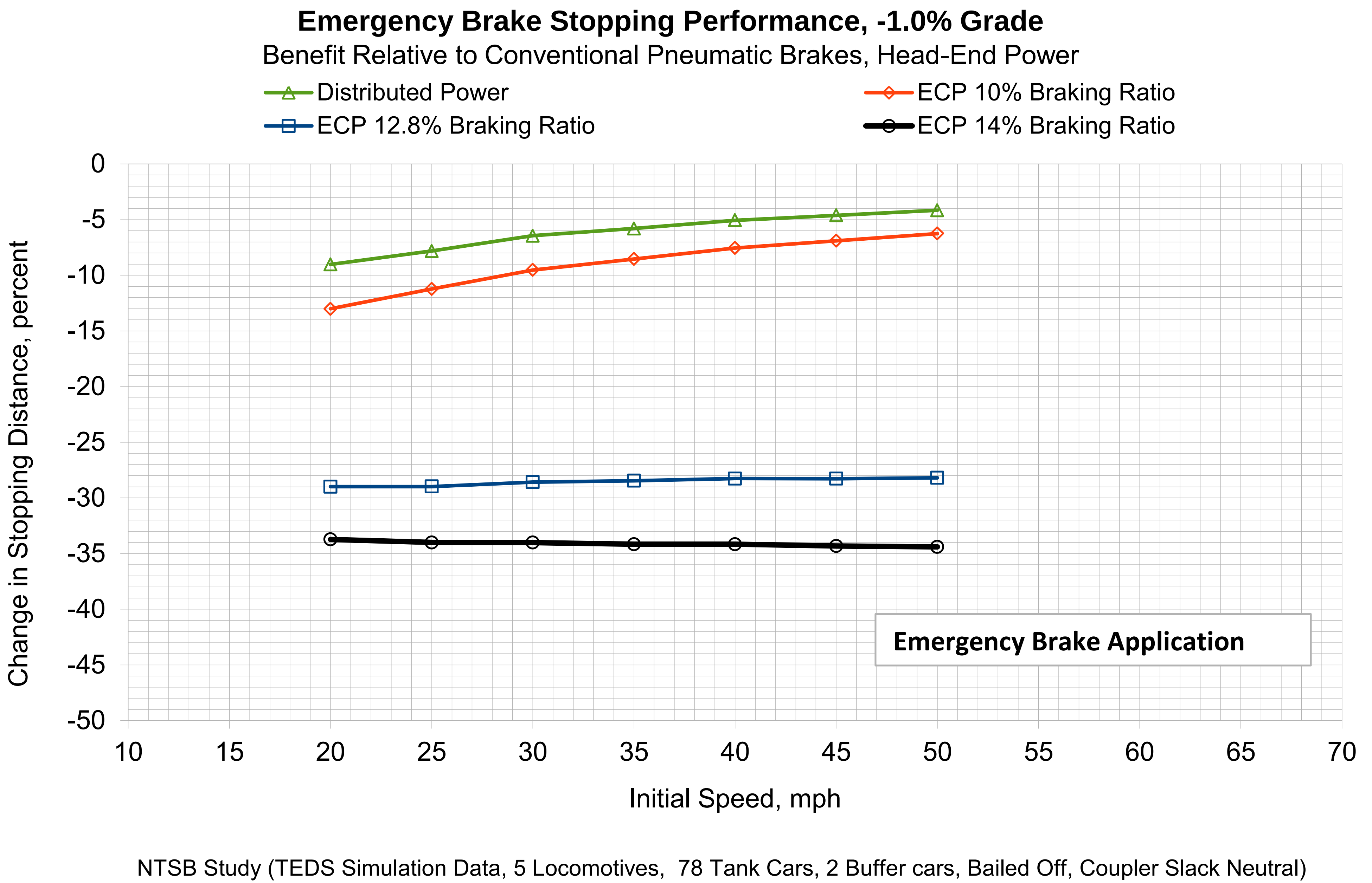


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

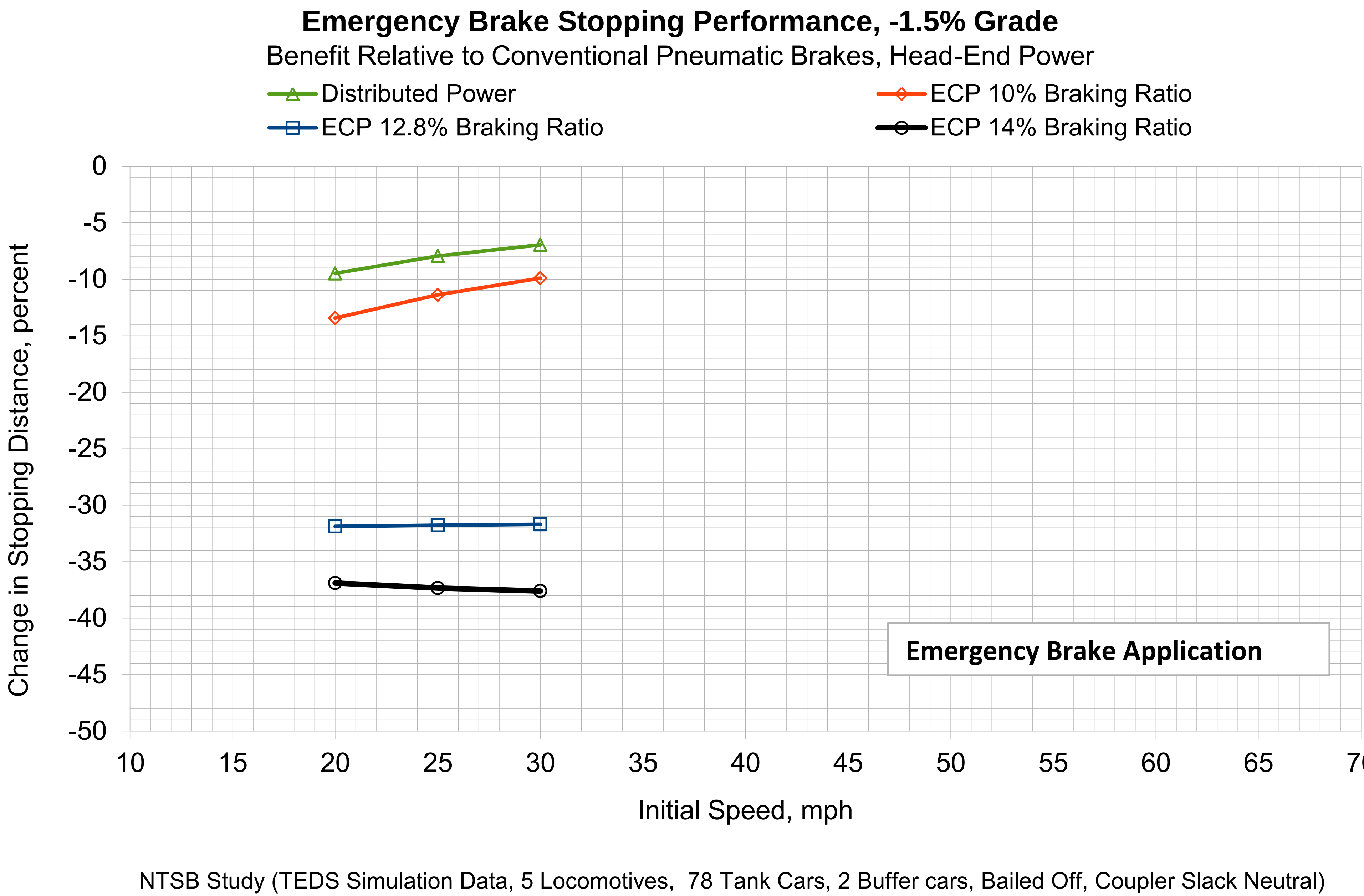

Emergency Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

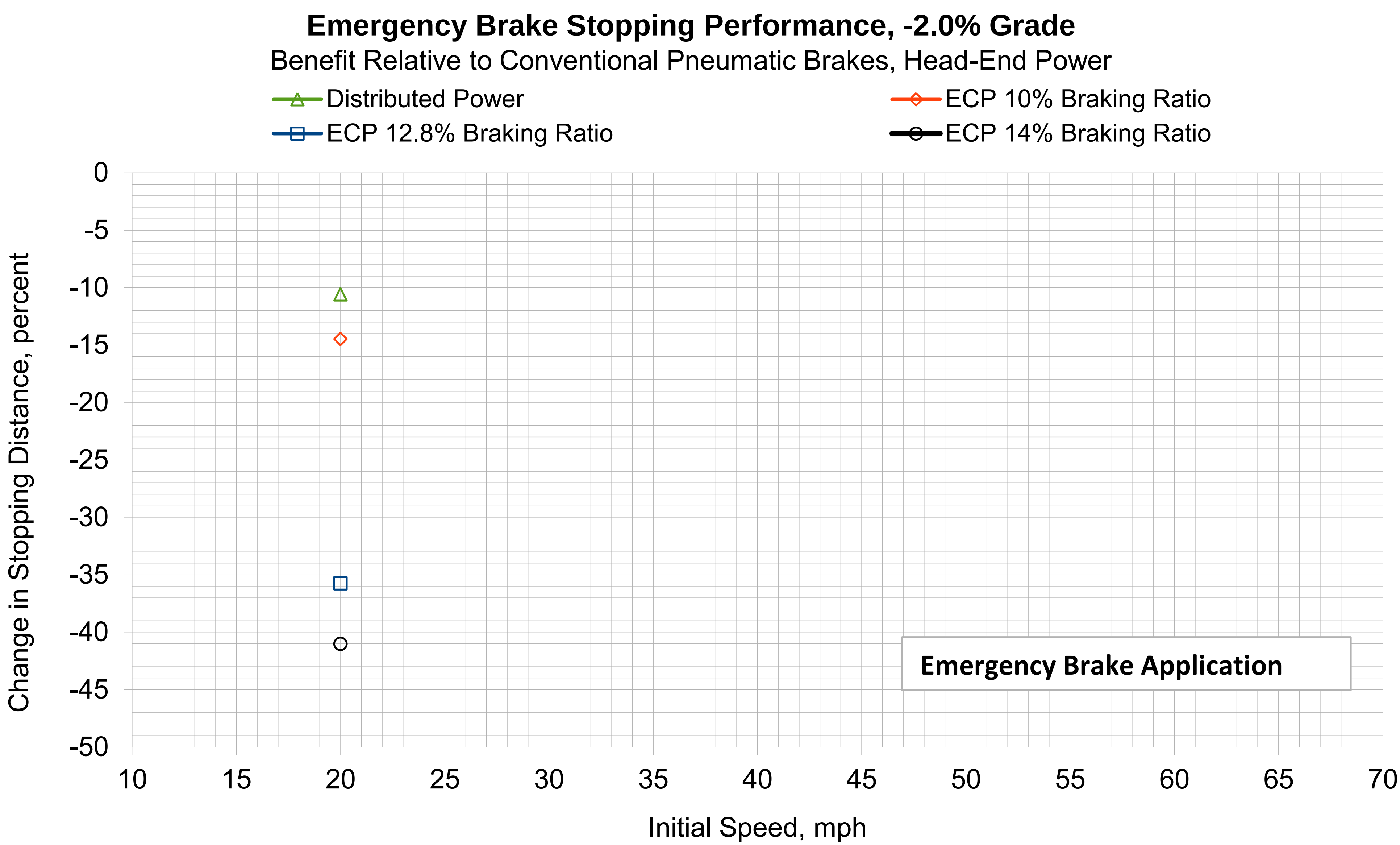


Emergency Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

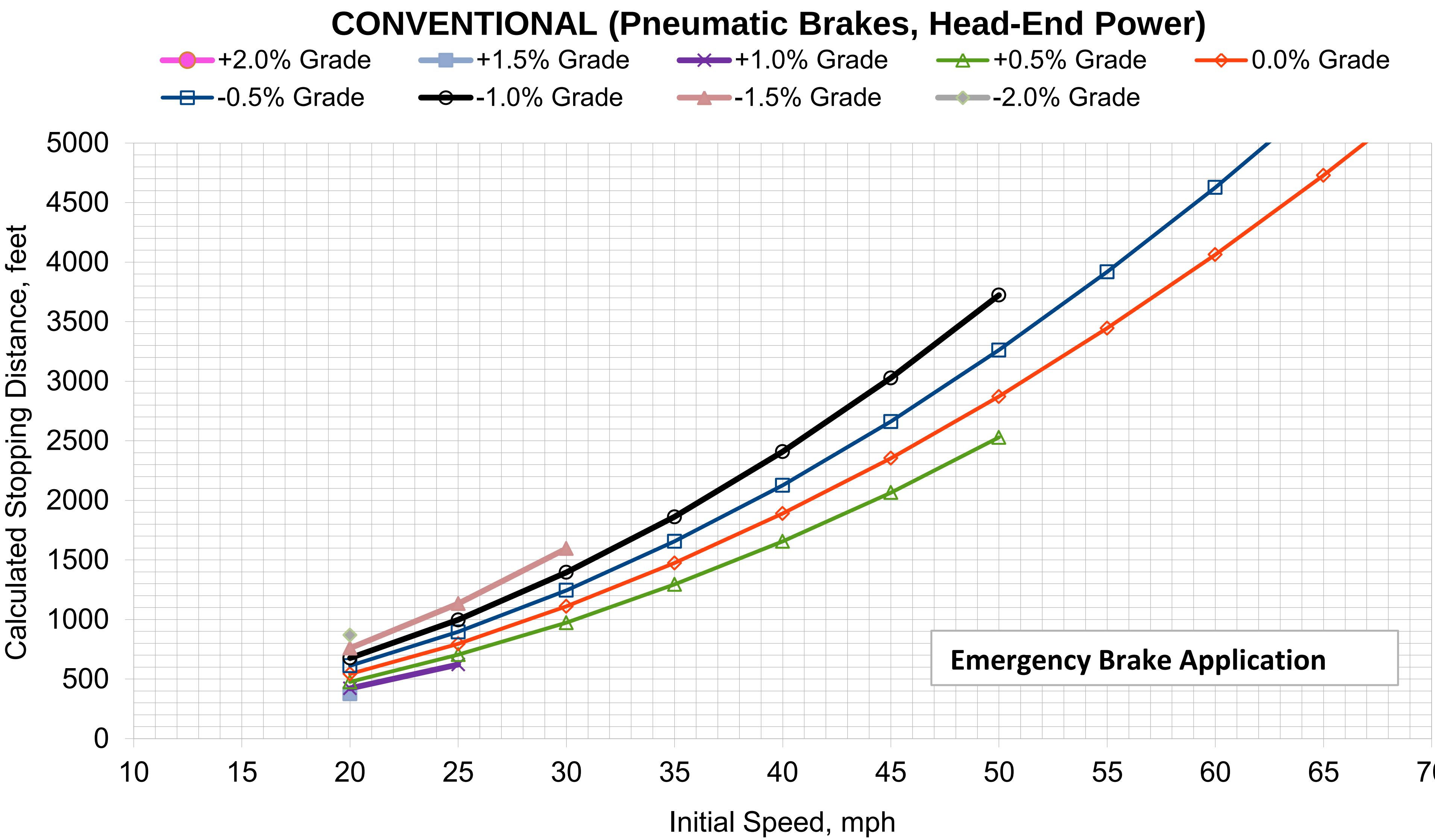


Emergency Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

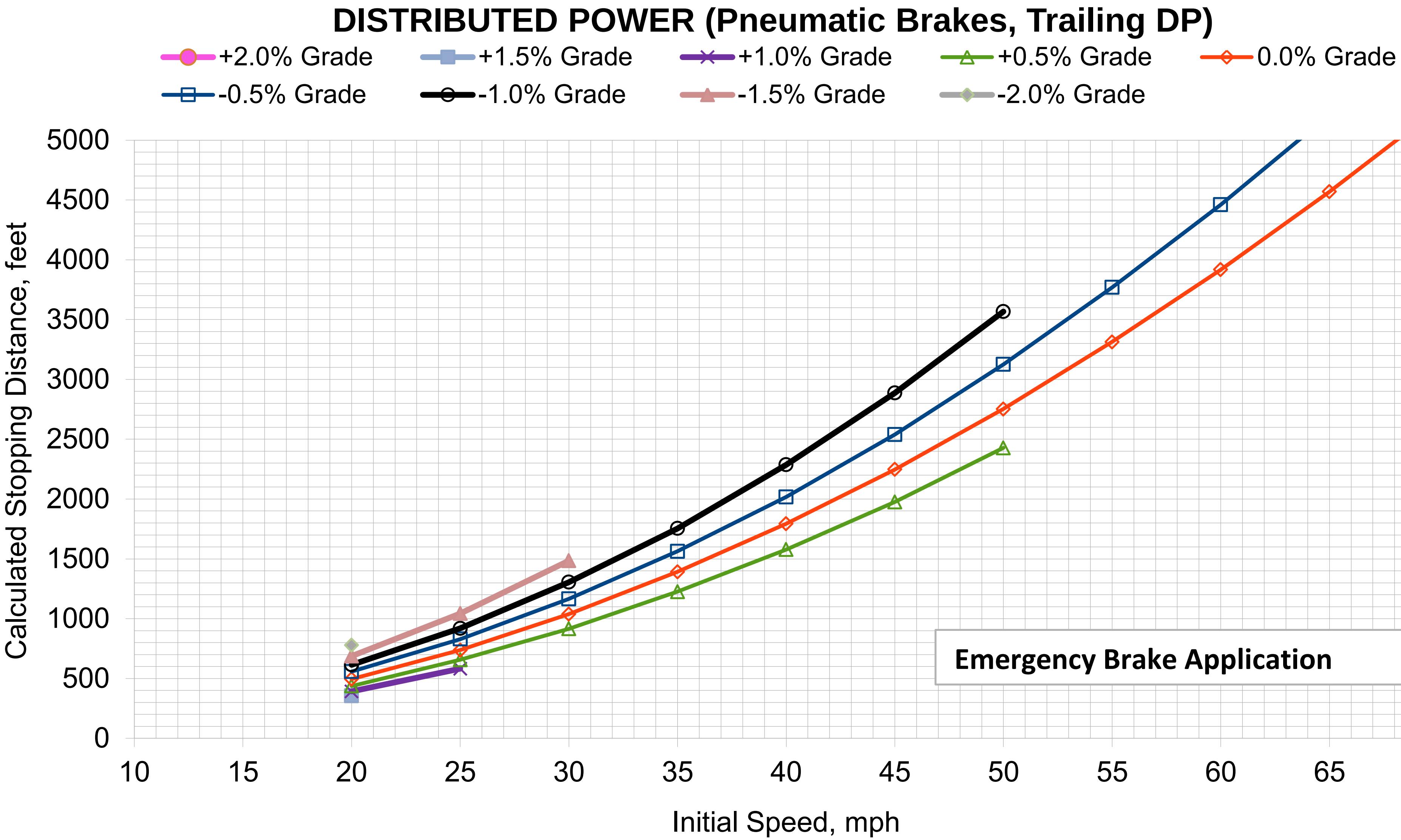

Emergency Brake Stopping Performance, -1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



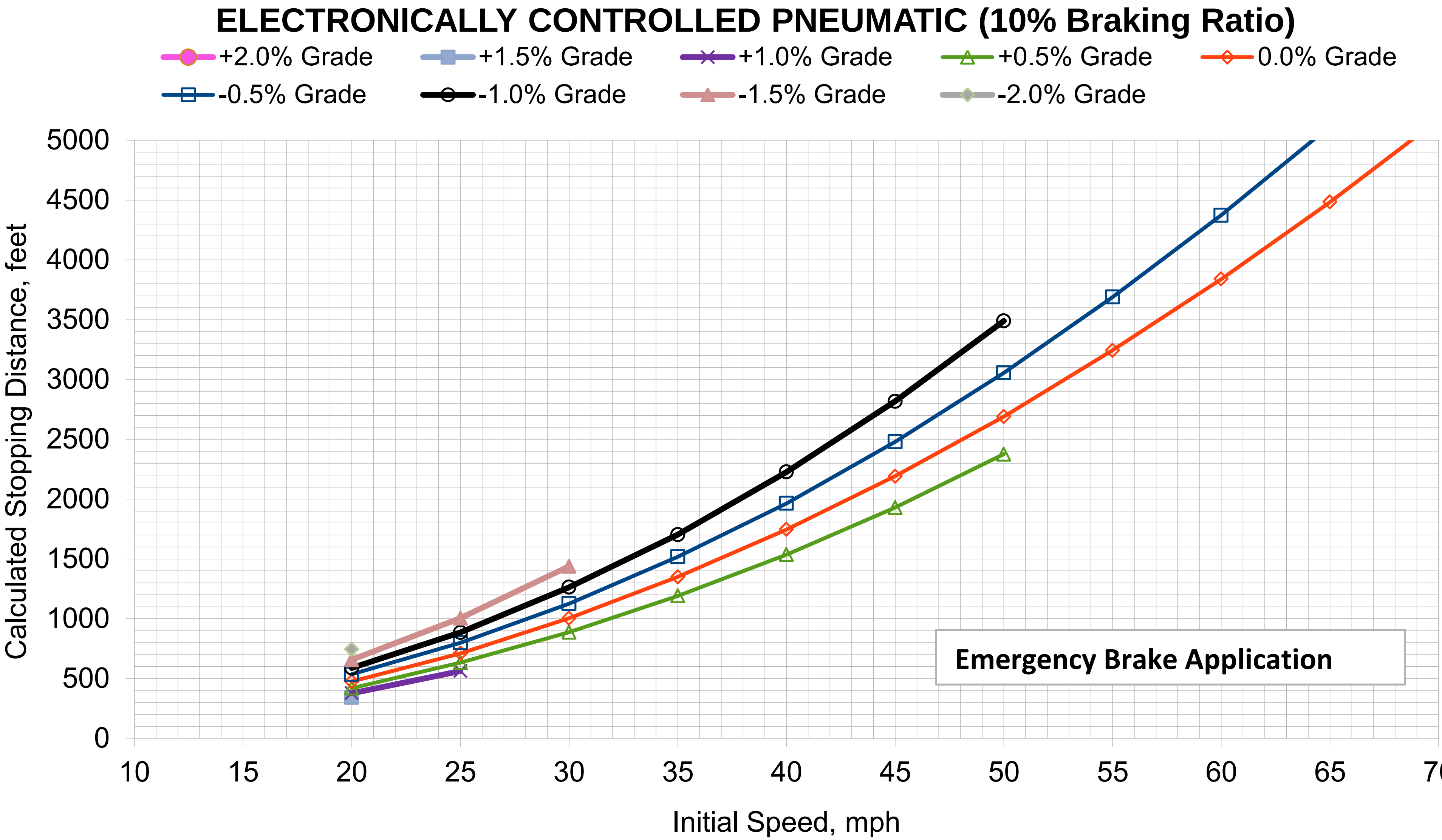
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



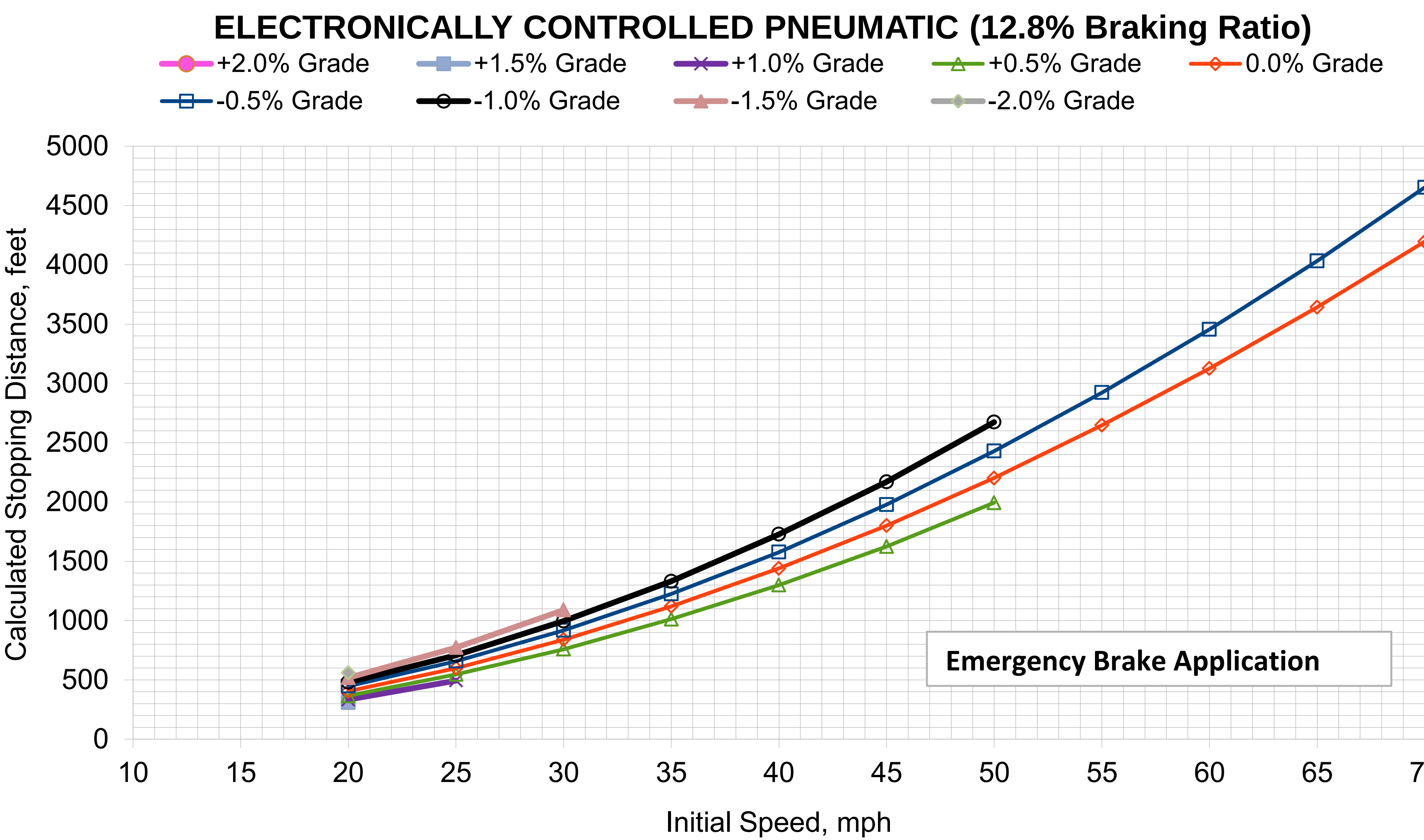
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



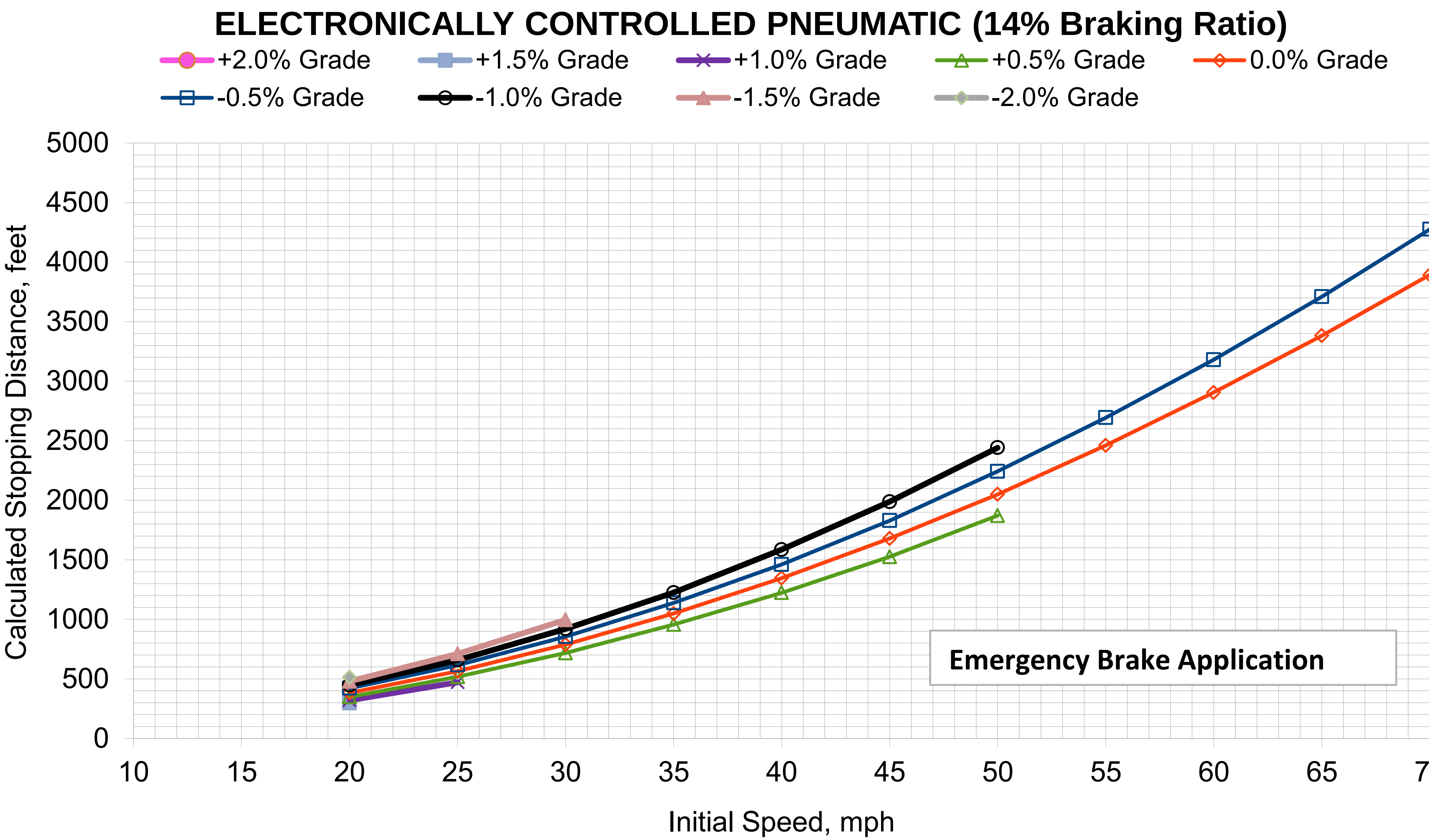
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



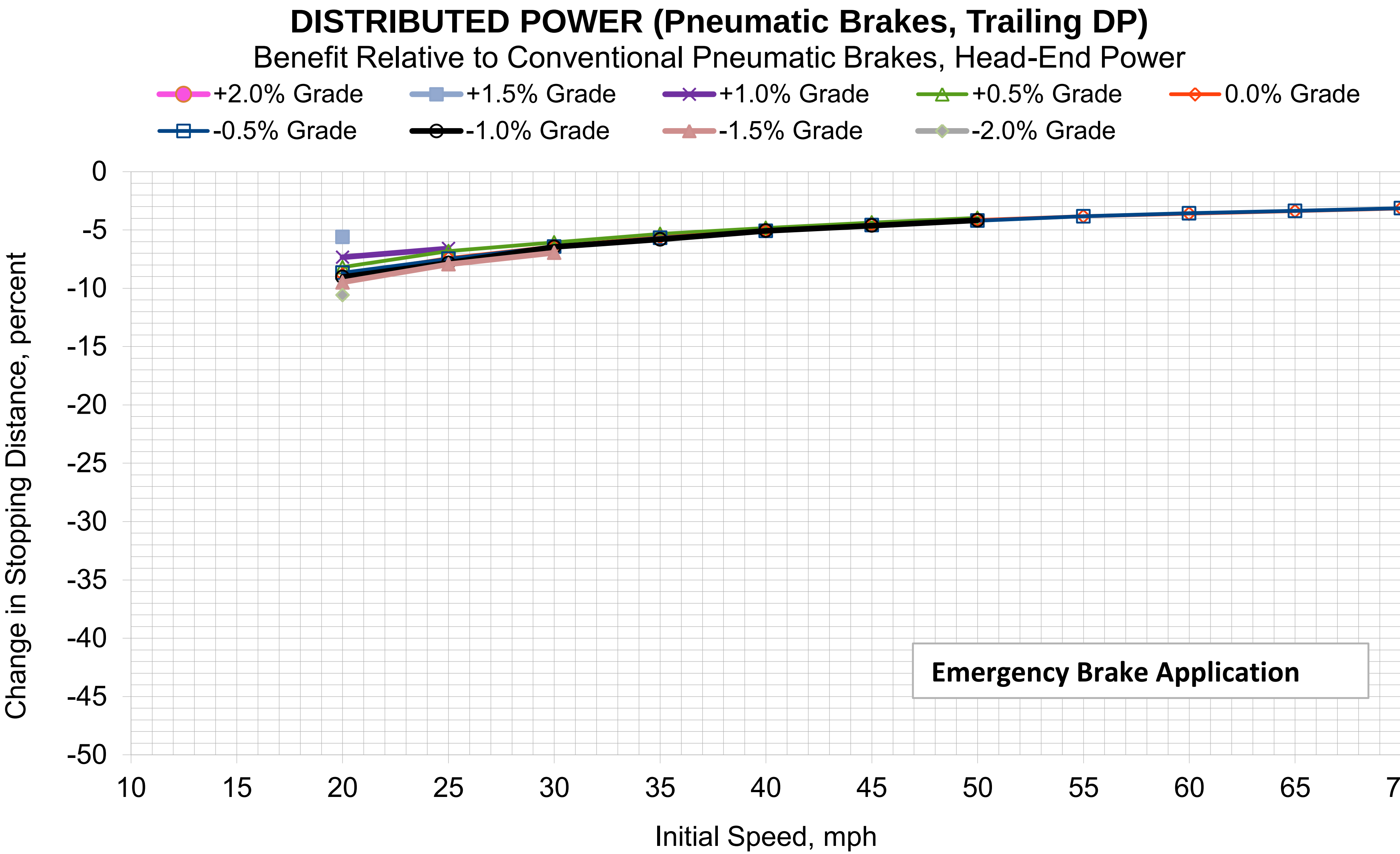
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



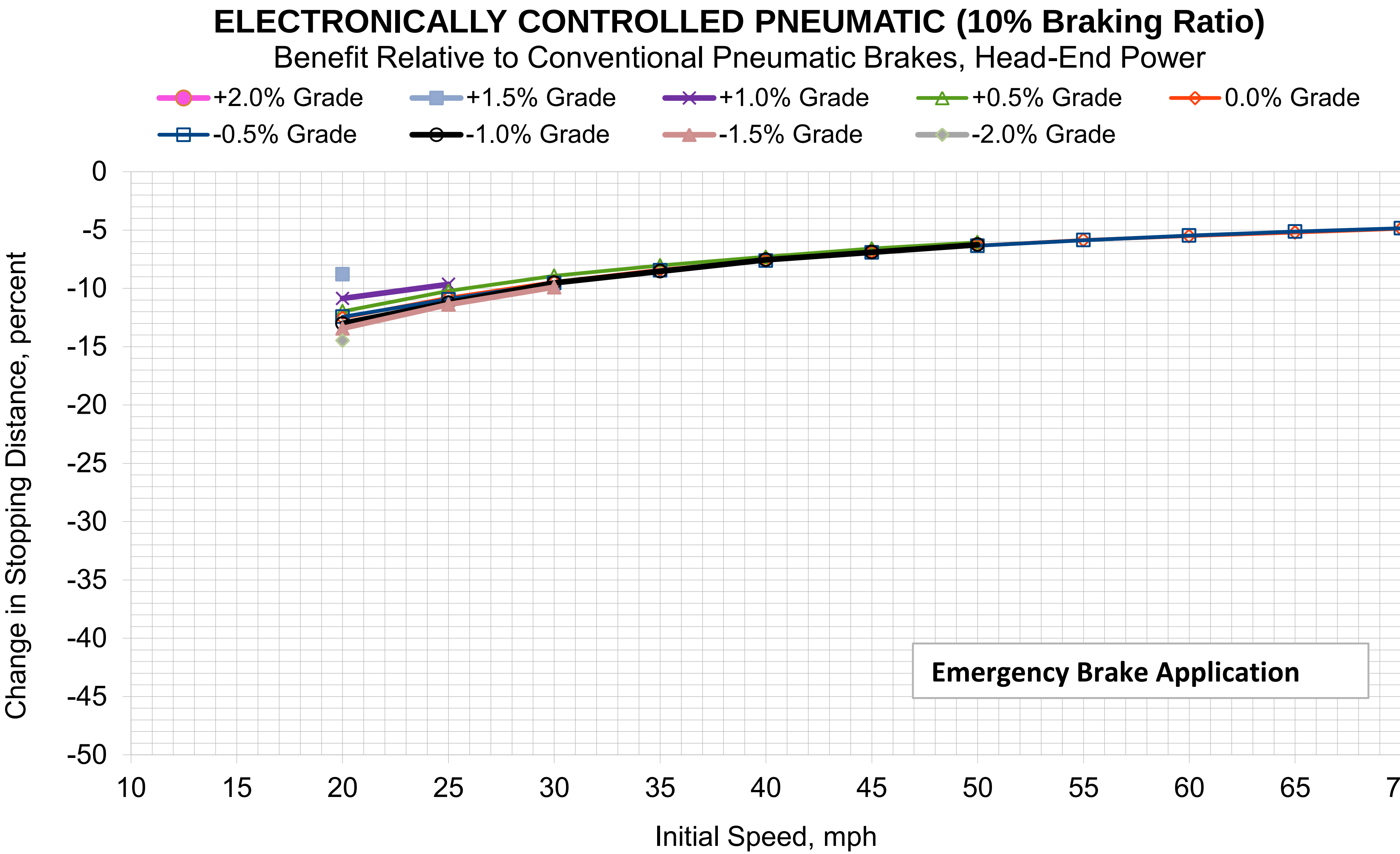
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



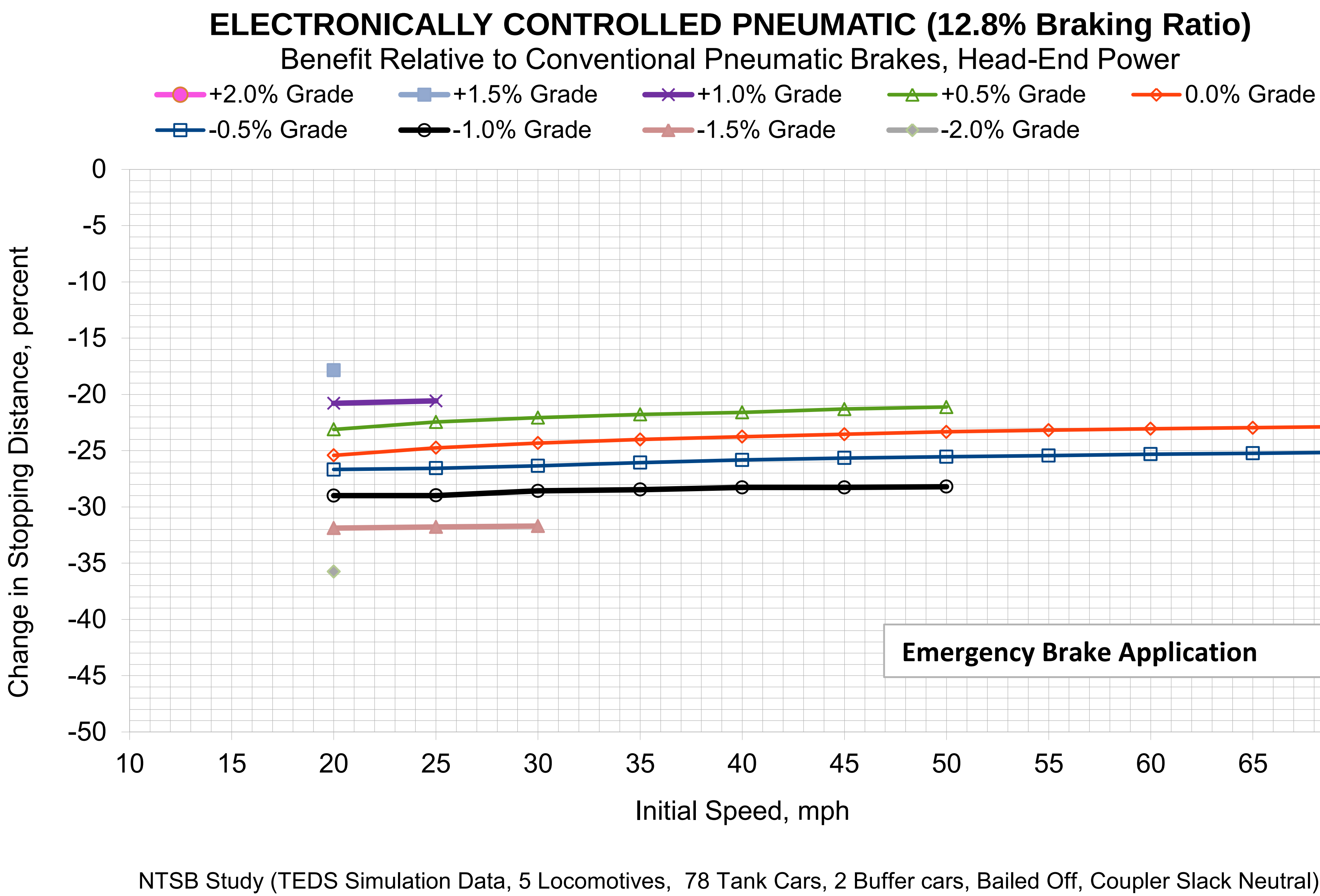
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

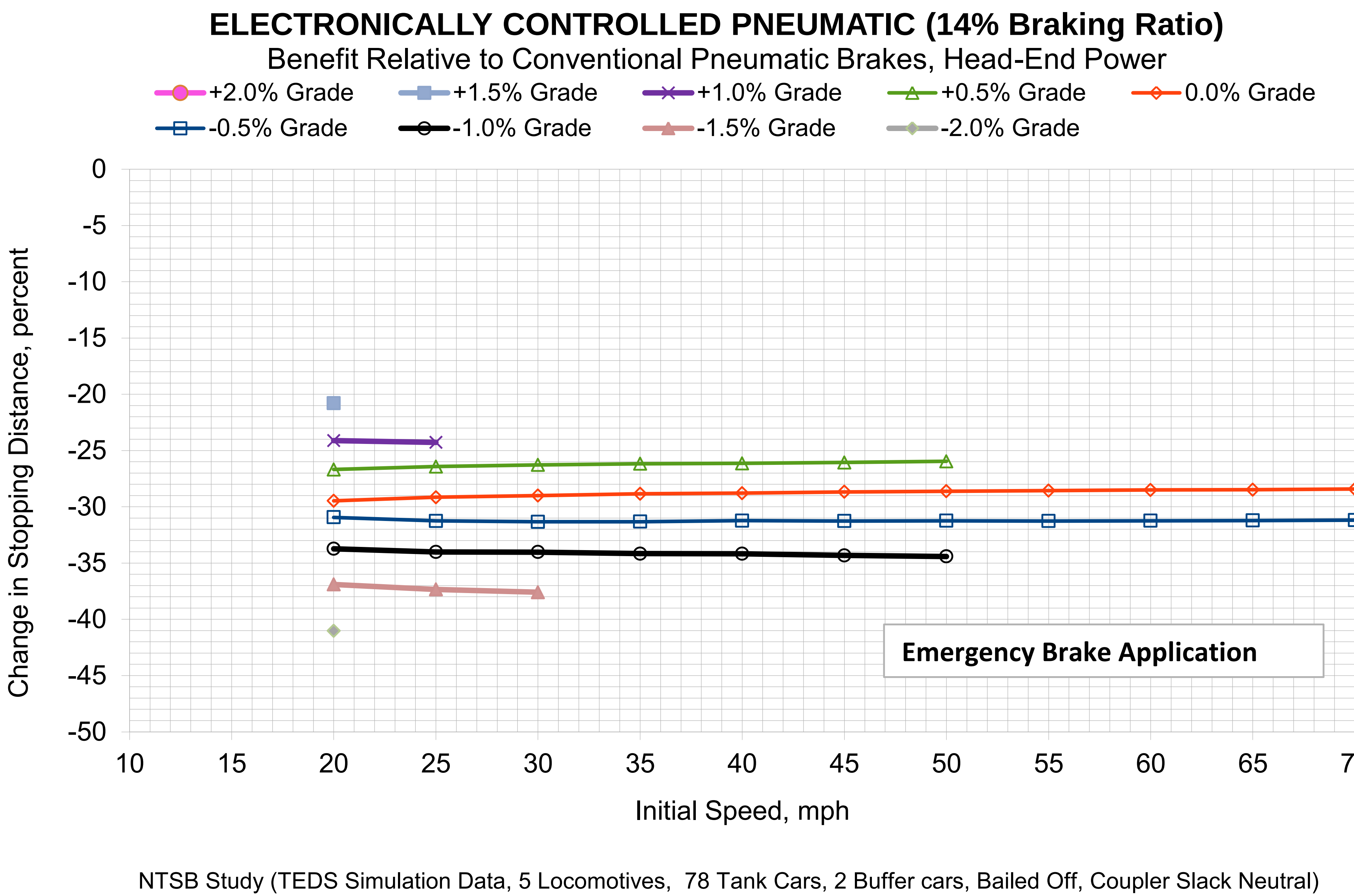


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

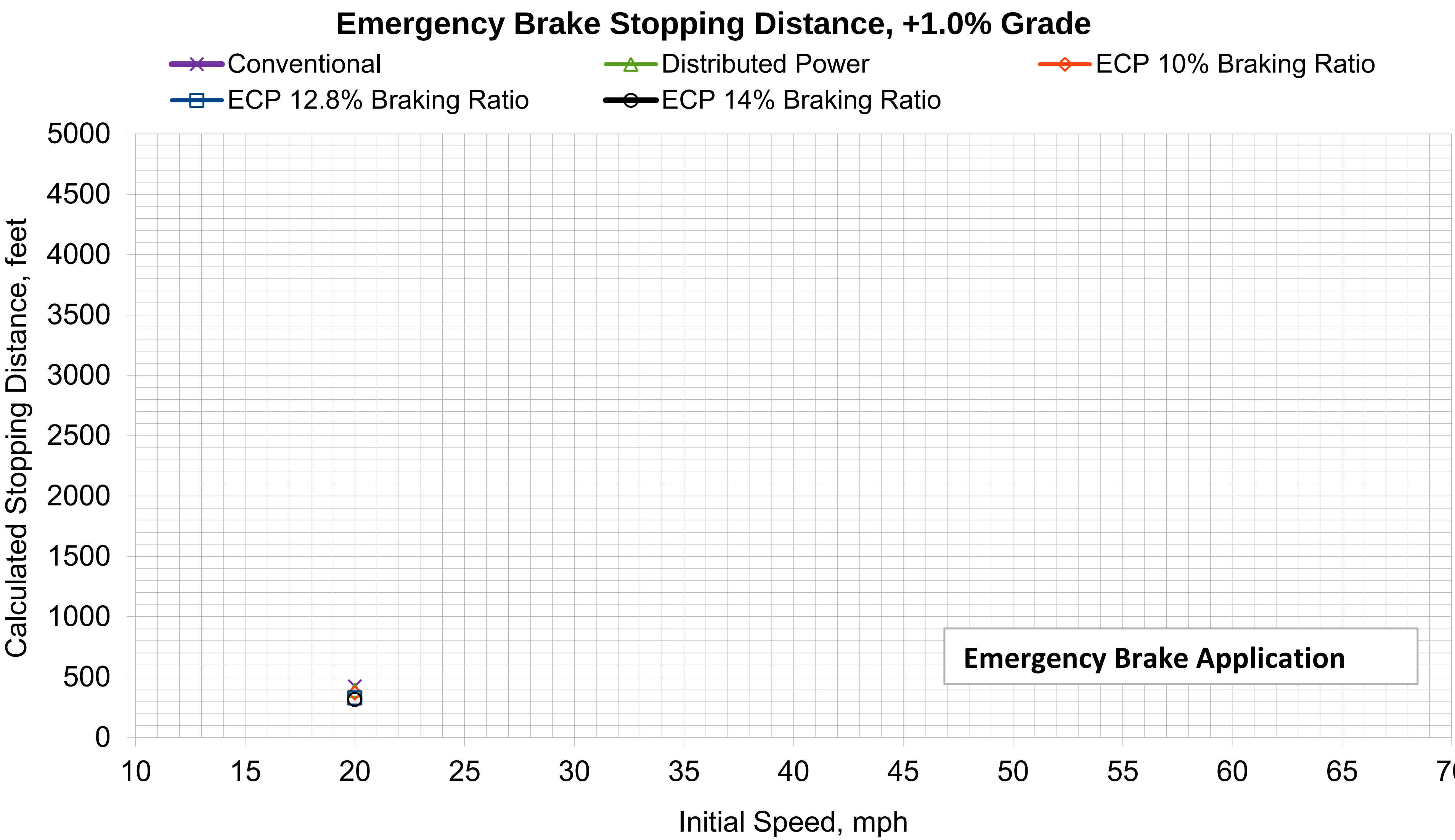


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

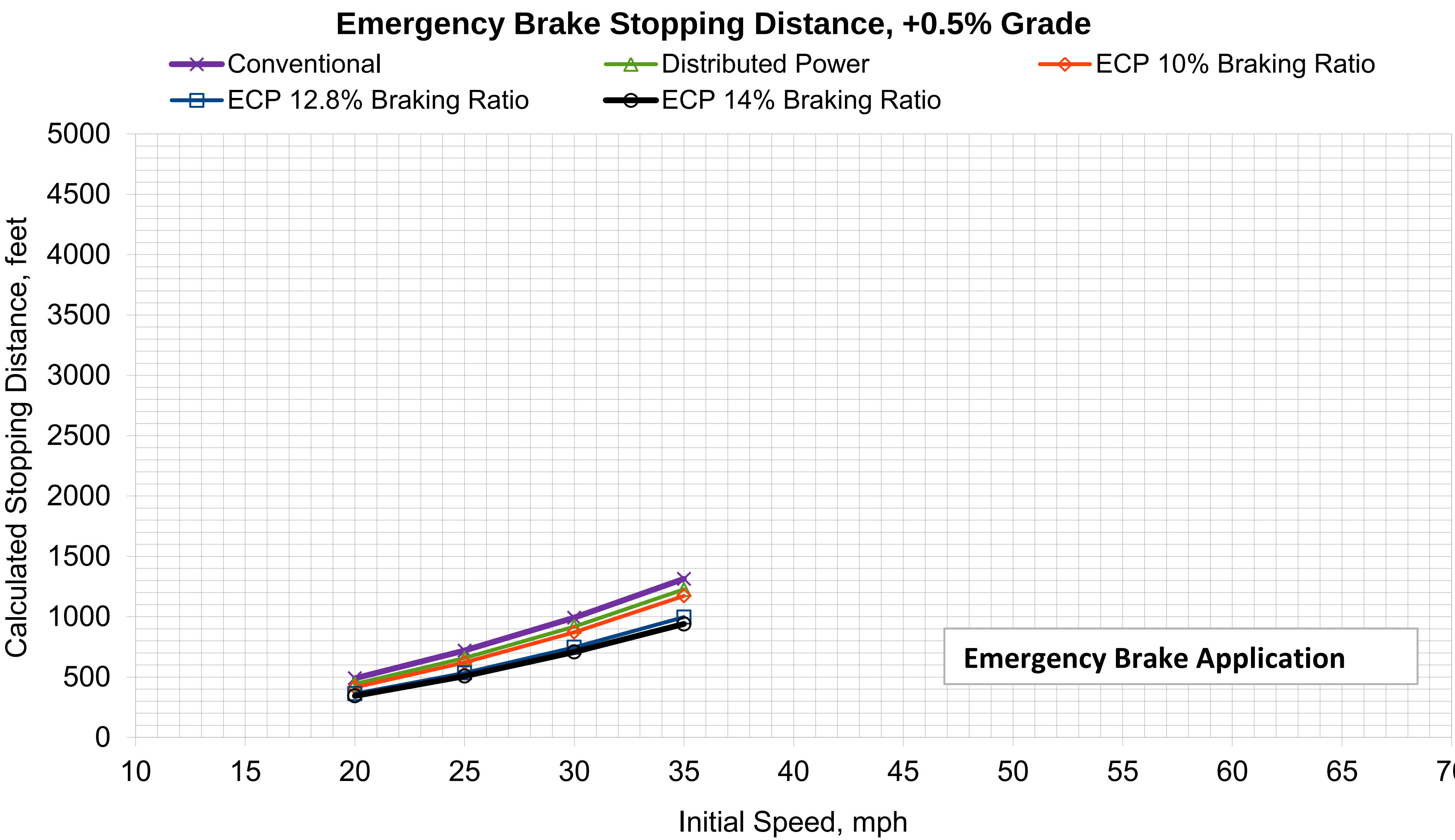

ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Emergency Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Emergency Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

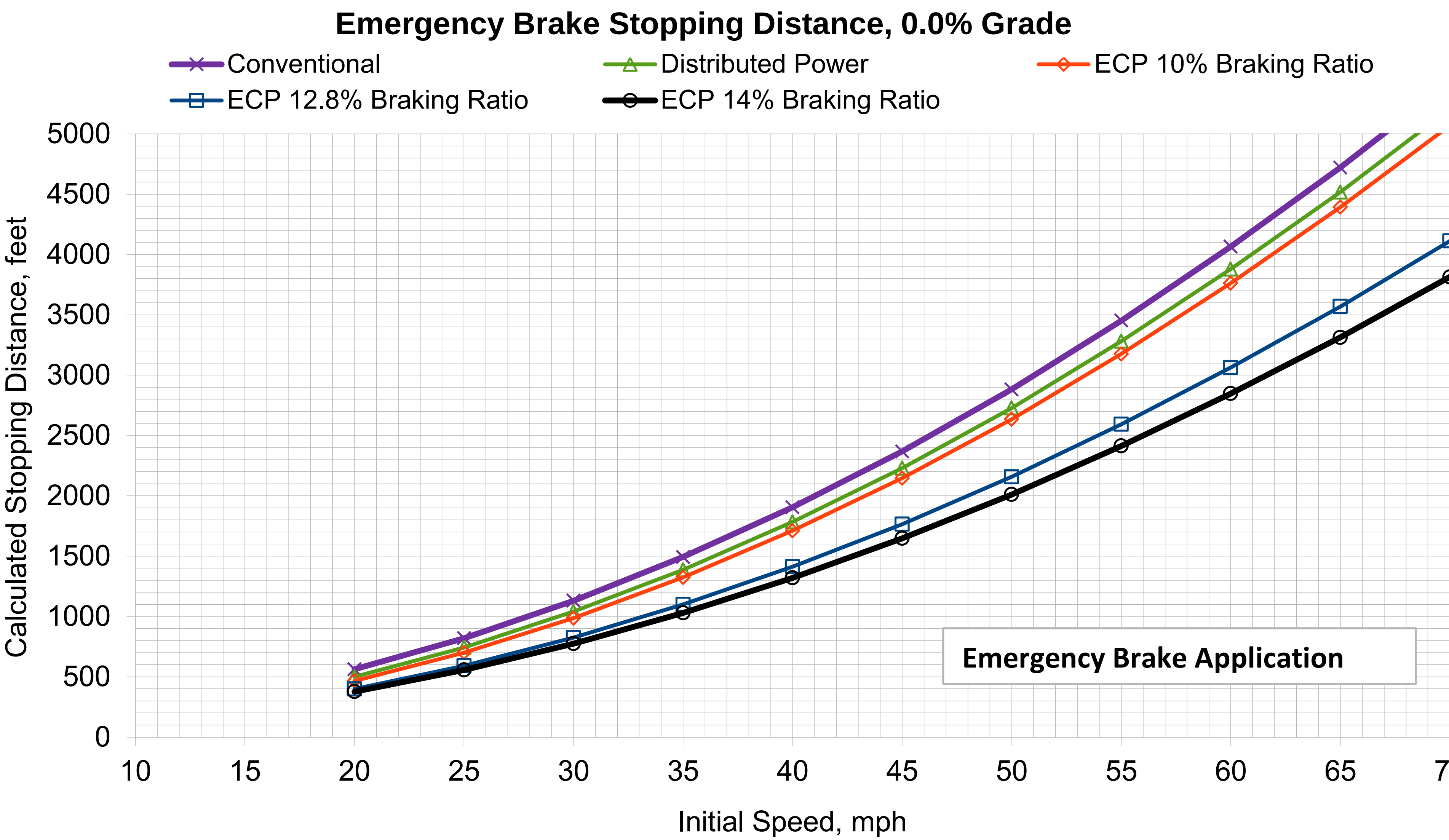
Attachment 9: Emergency Braking, Bailed Off, 104 Tank Cars



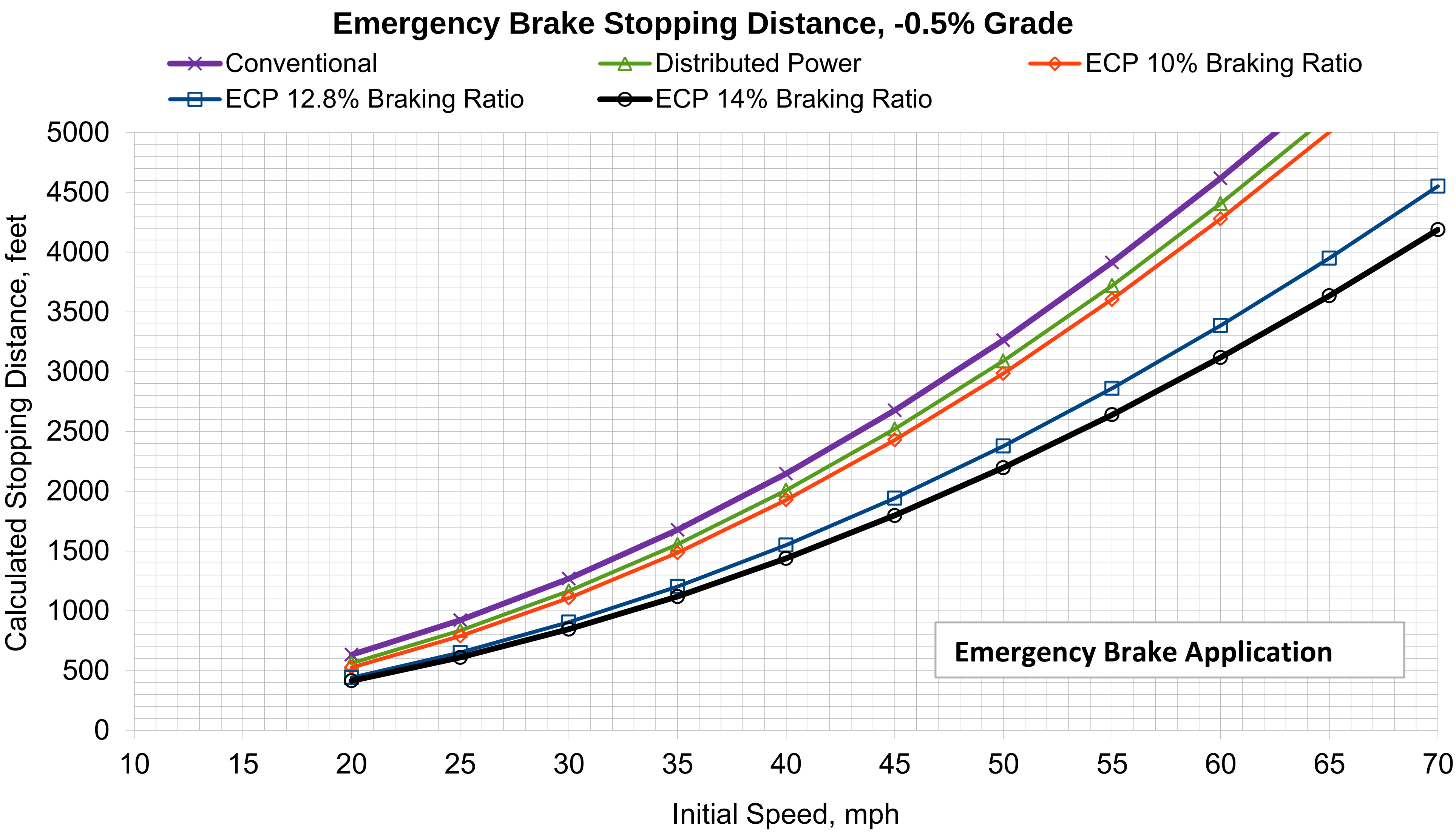
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



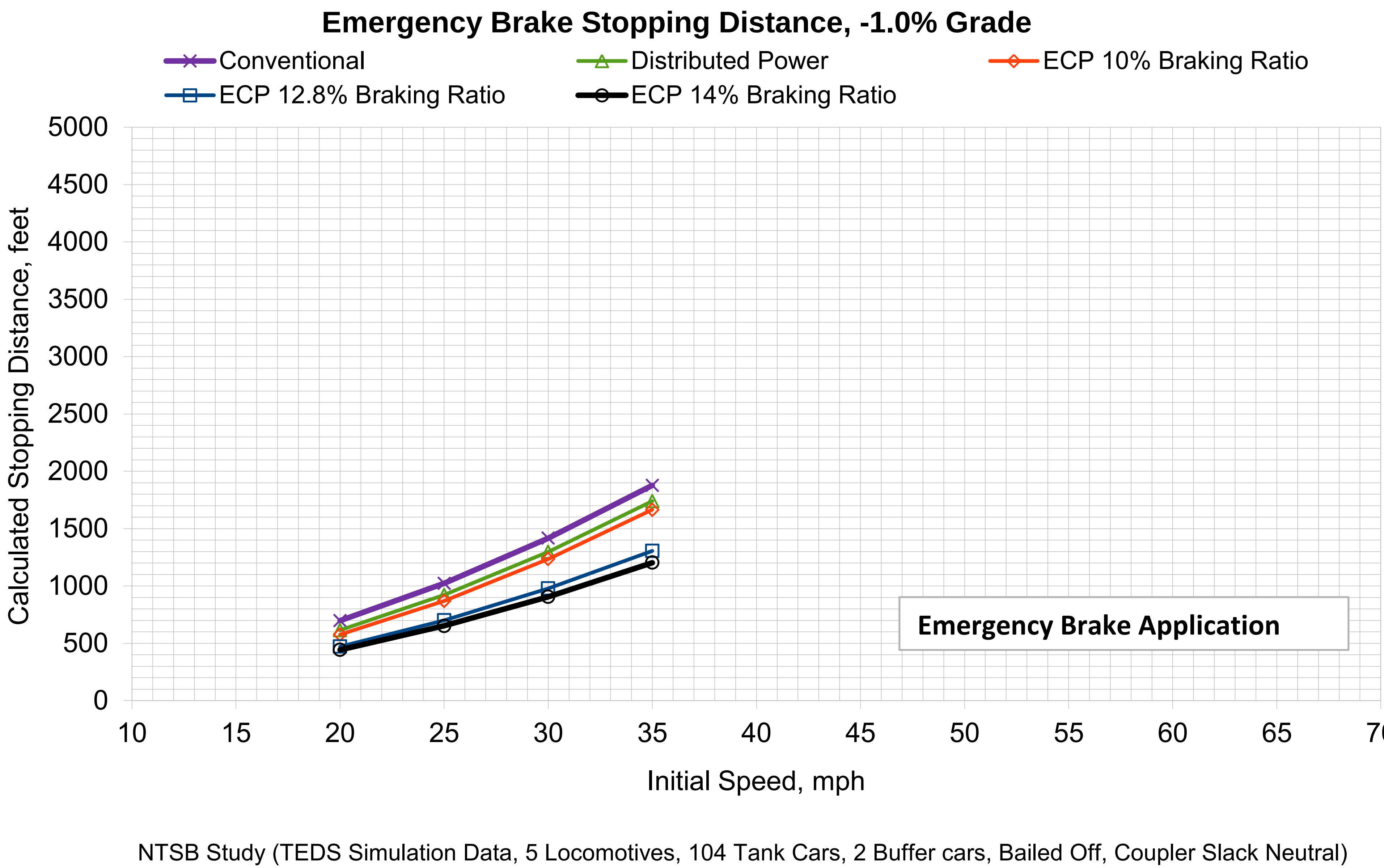
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



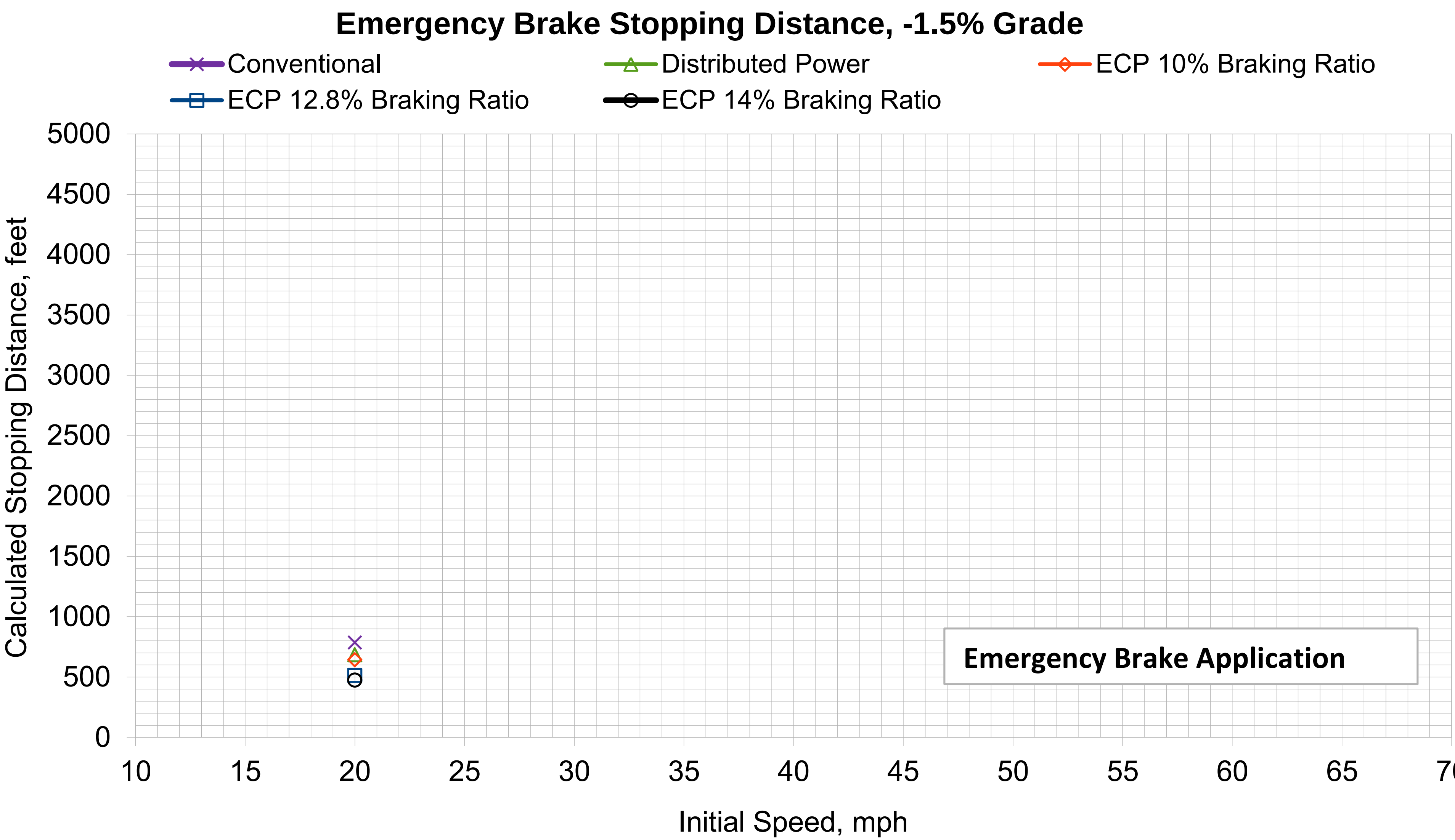
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



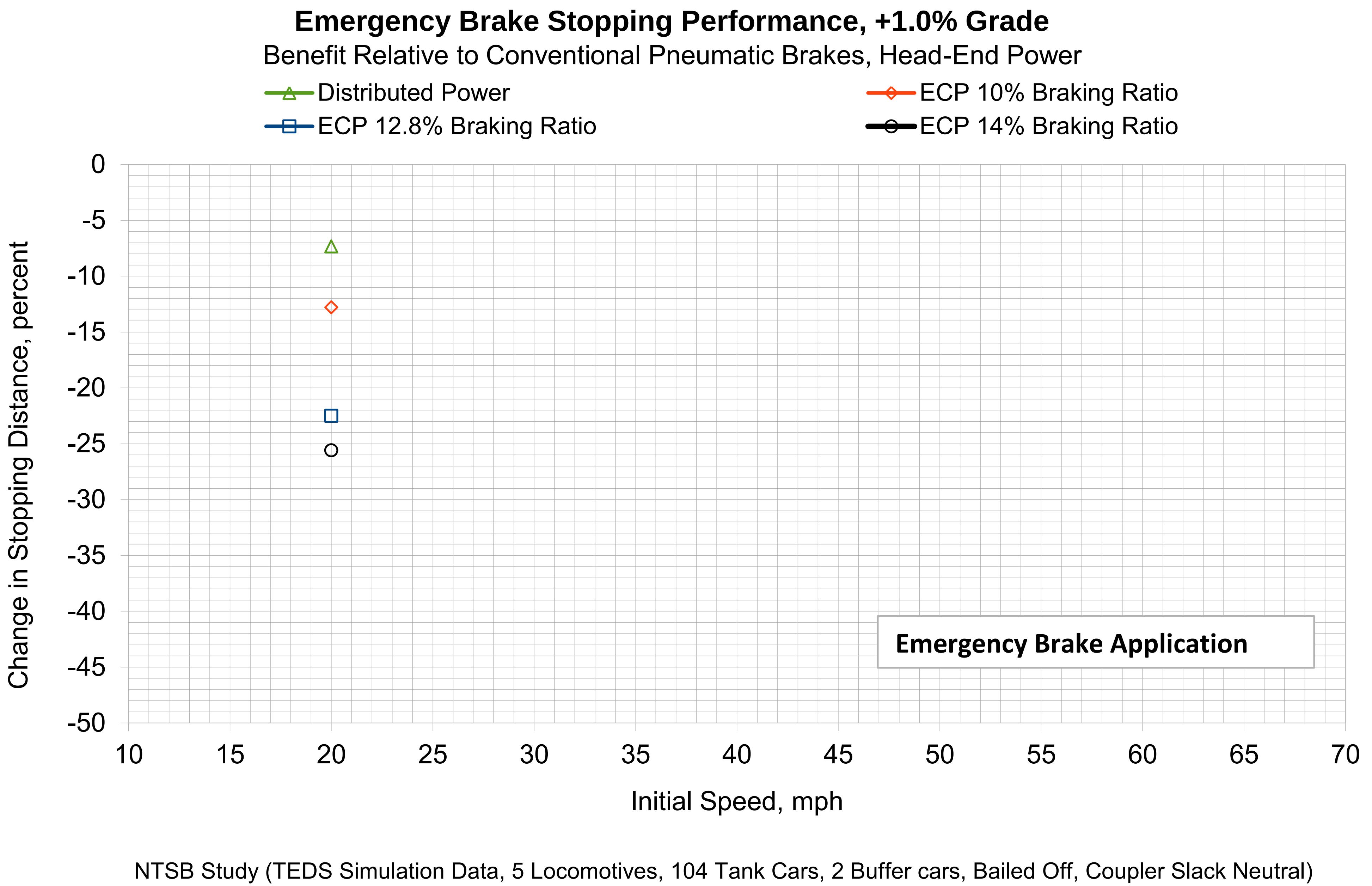
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

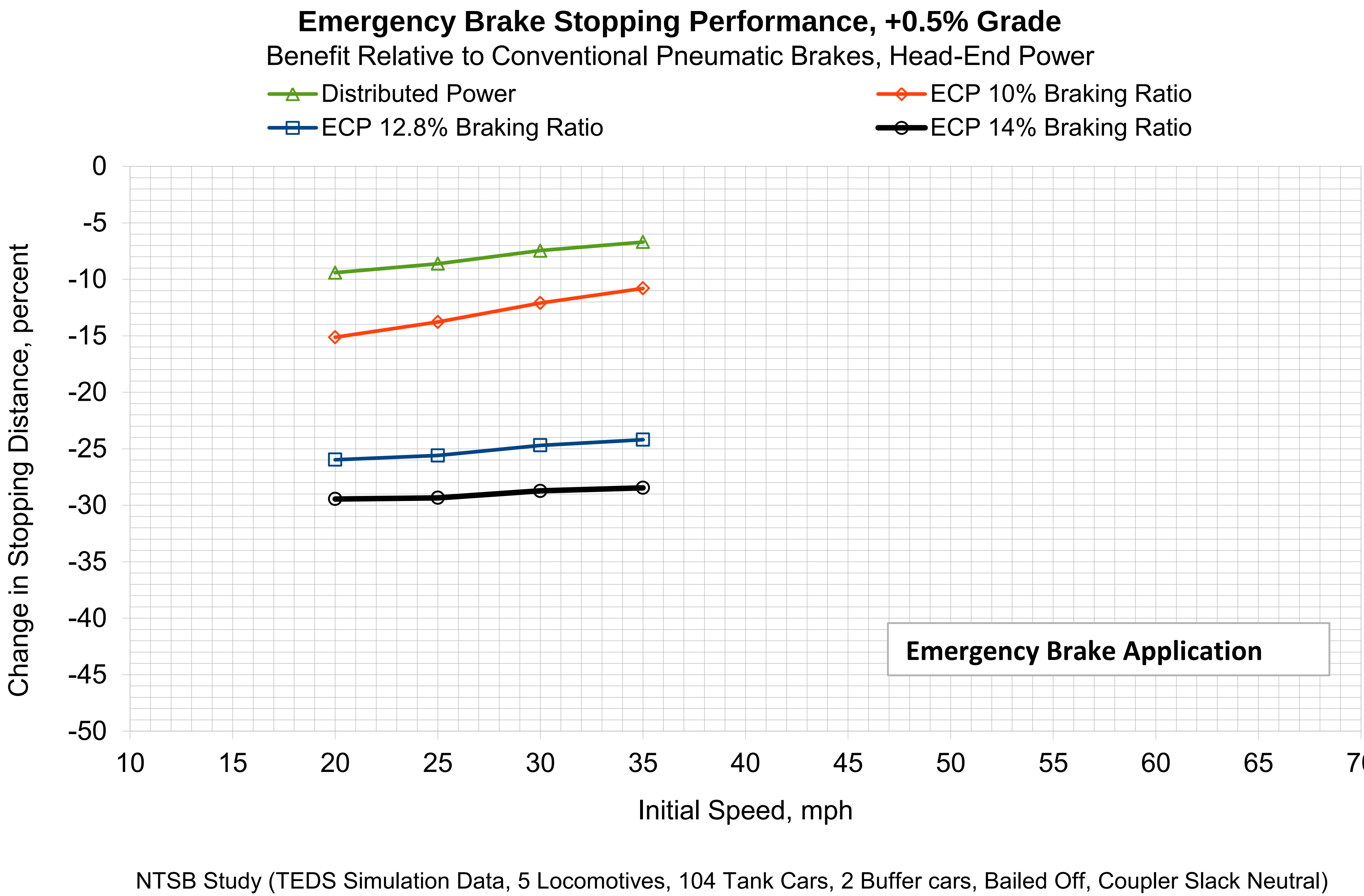


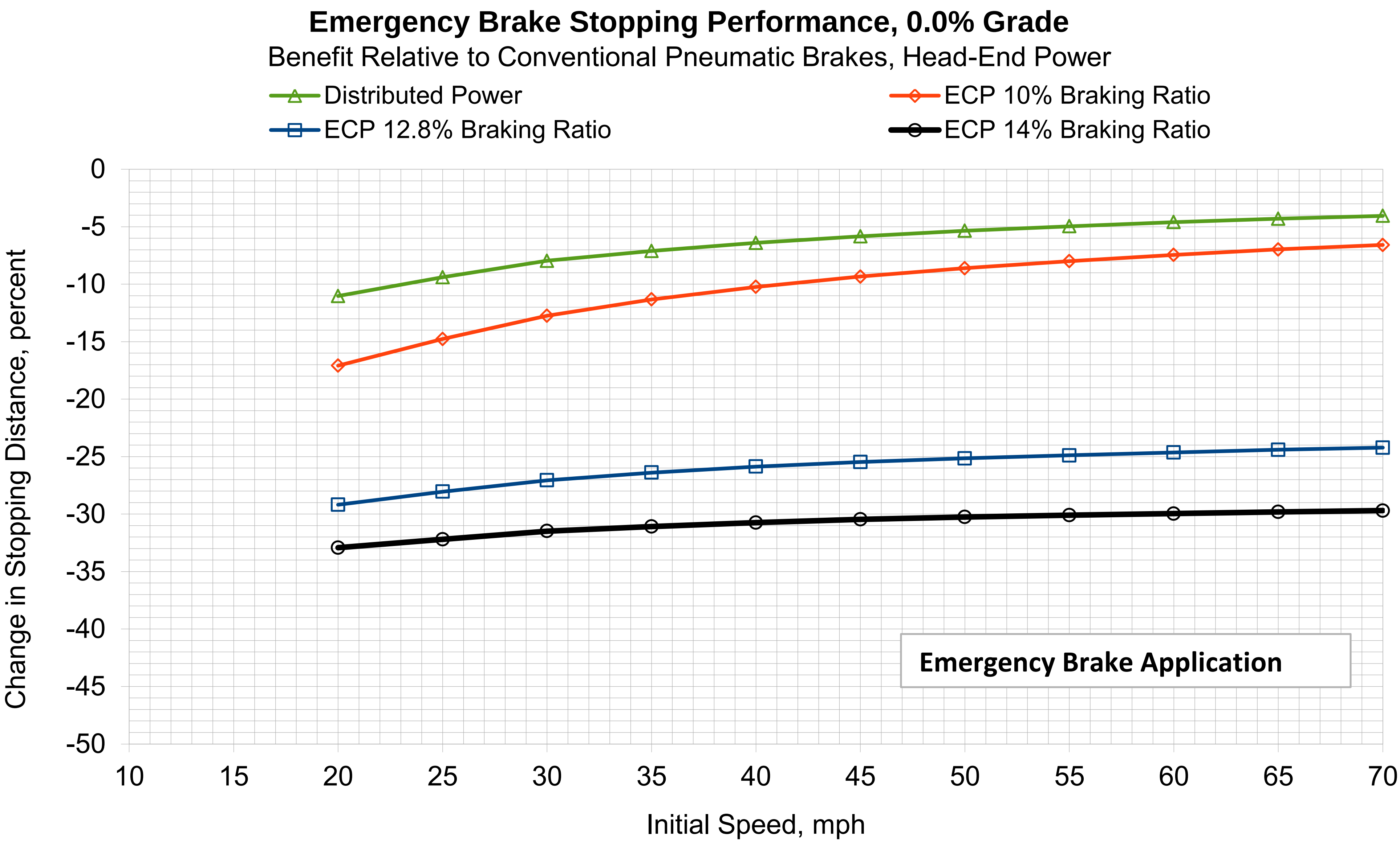
Emergency Brake Stopping Distance, -1.0% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



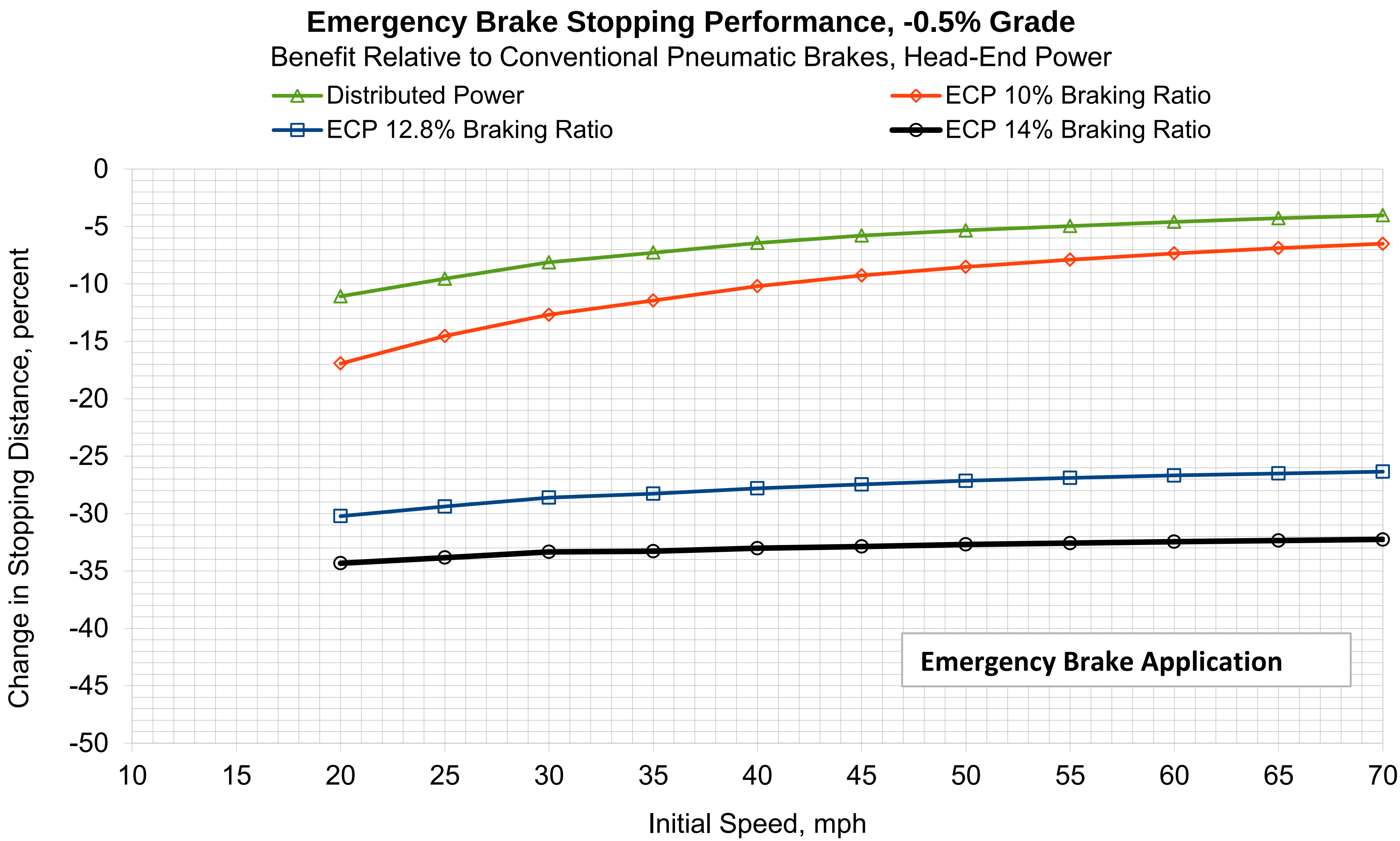
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Emergency Brake Stopping Performance, +1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

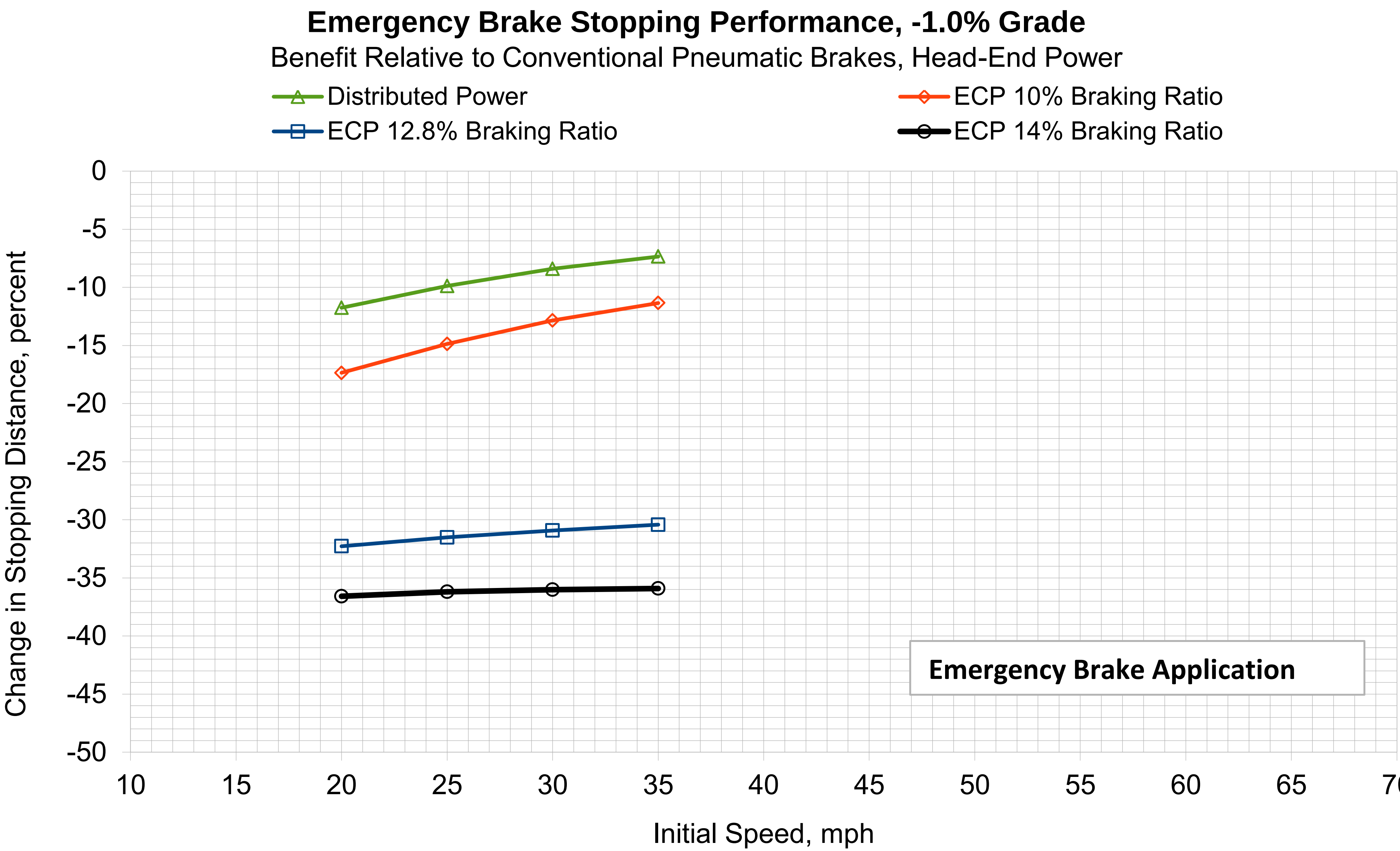

Emergency Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



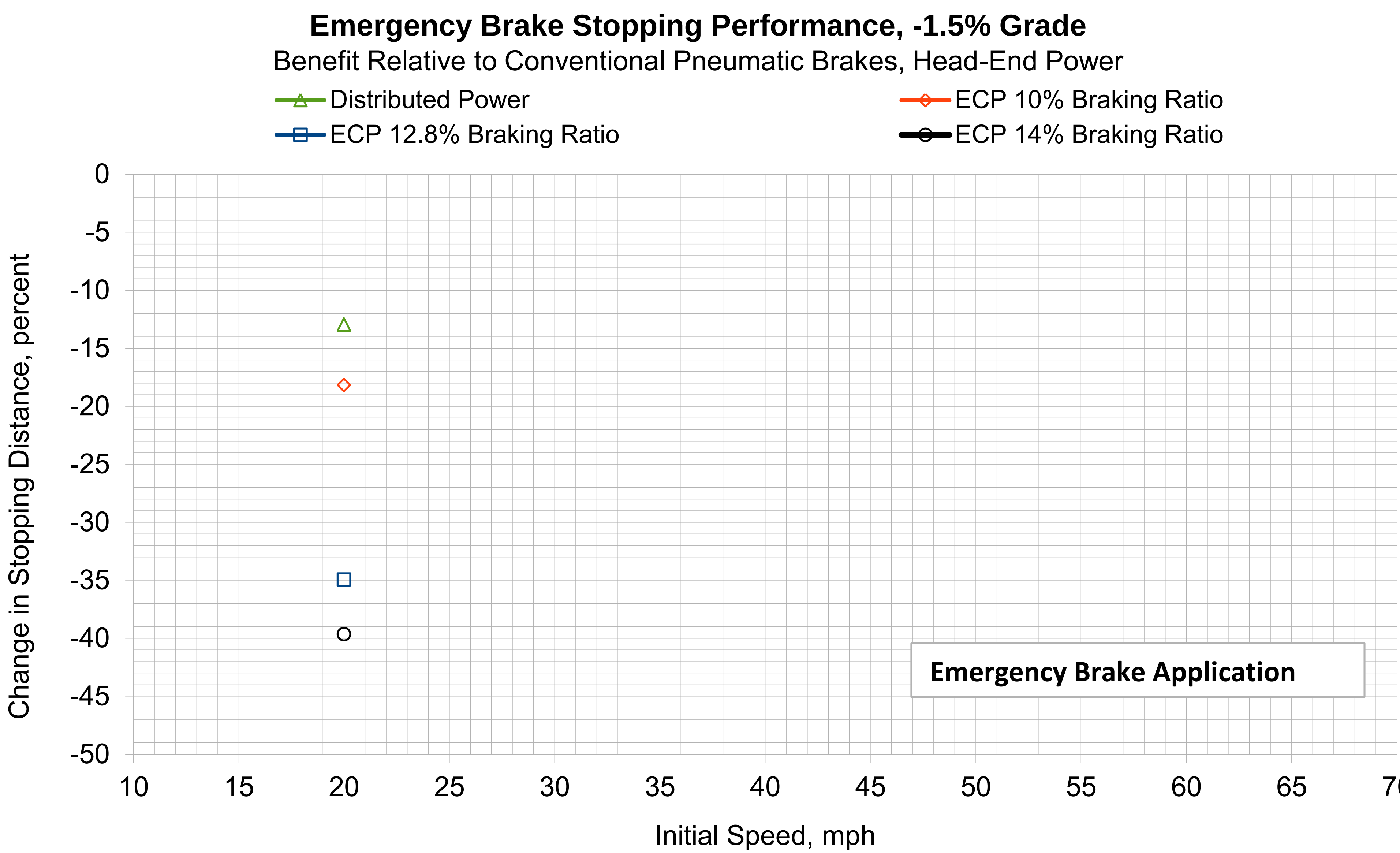
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



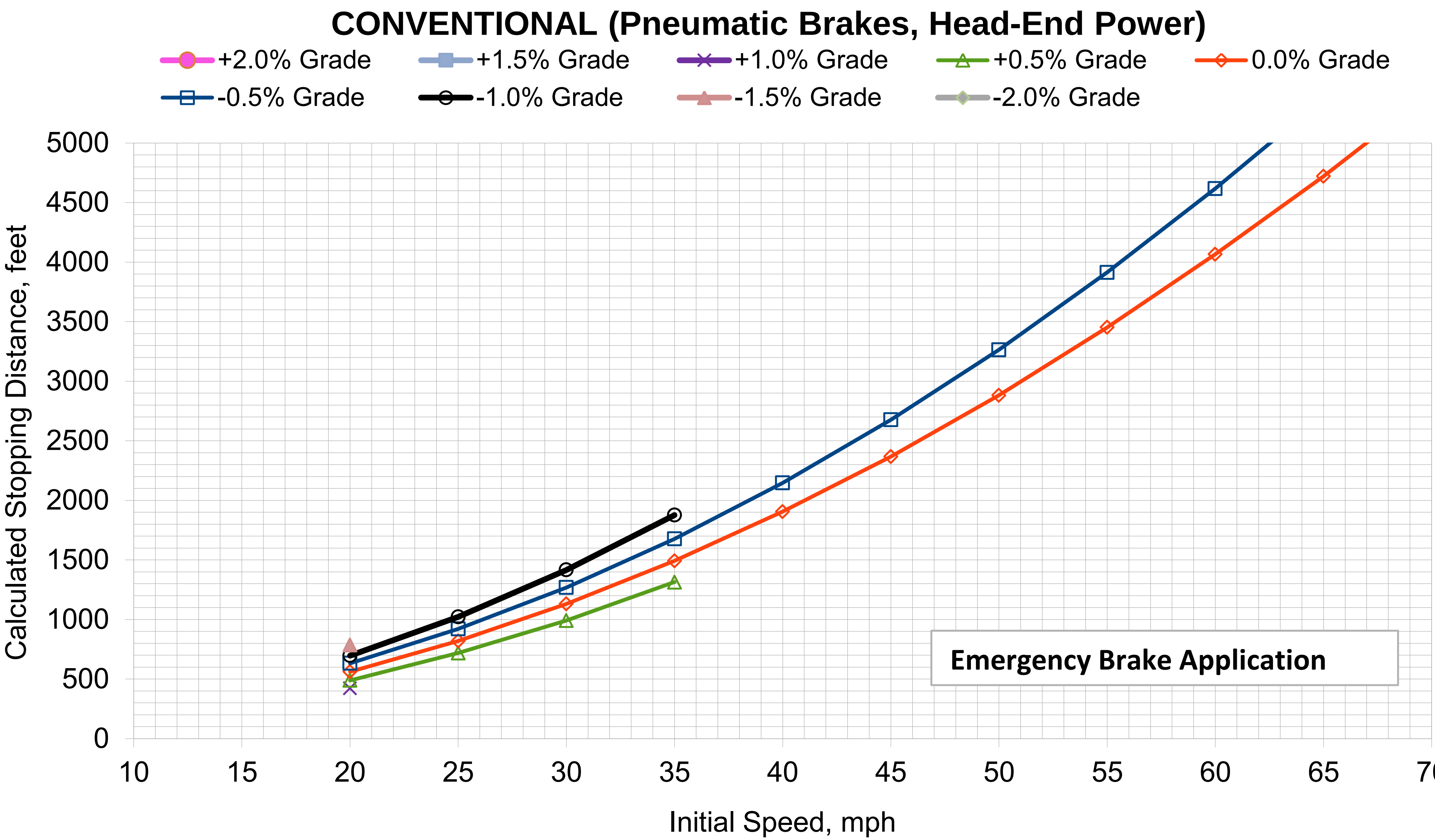
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



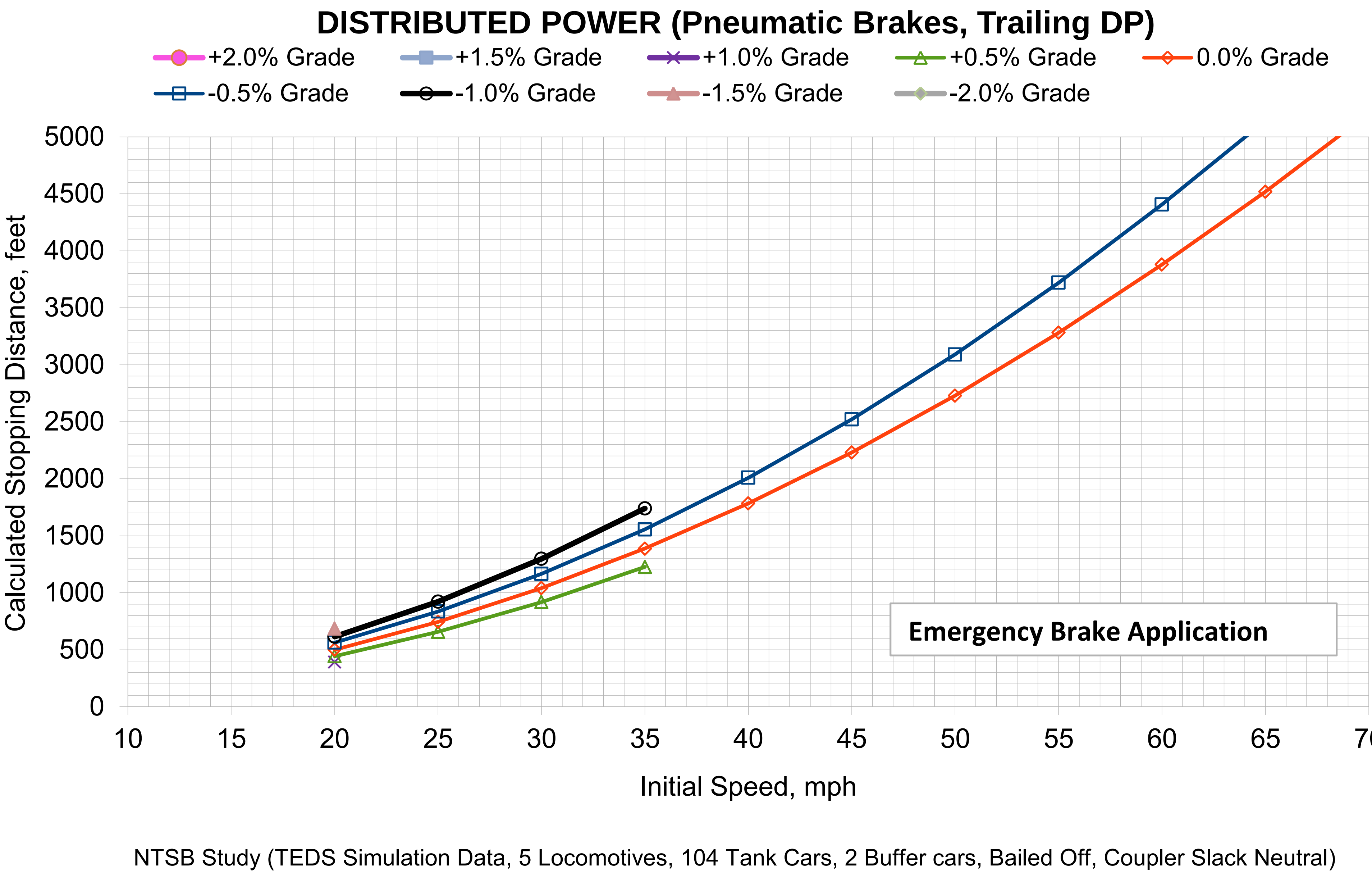
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

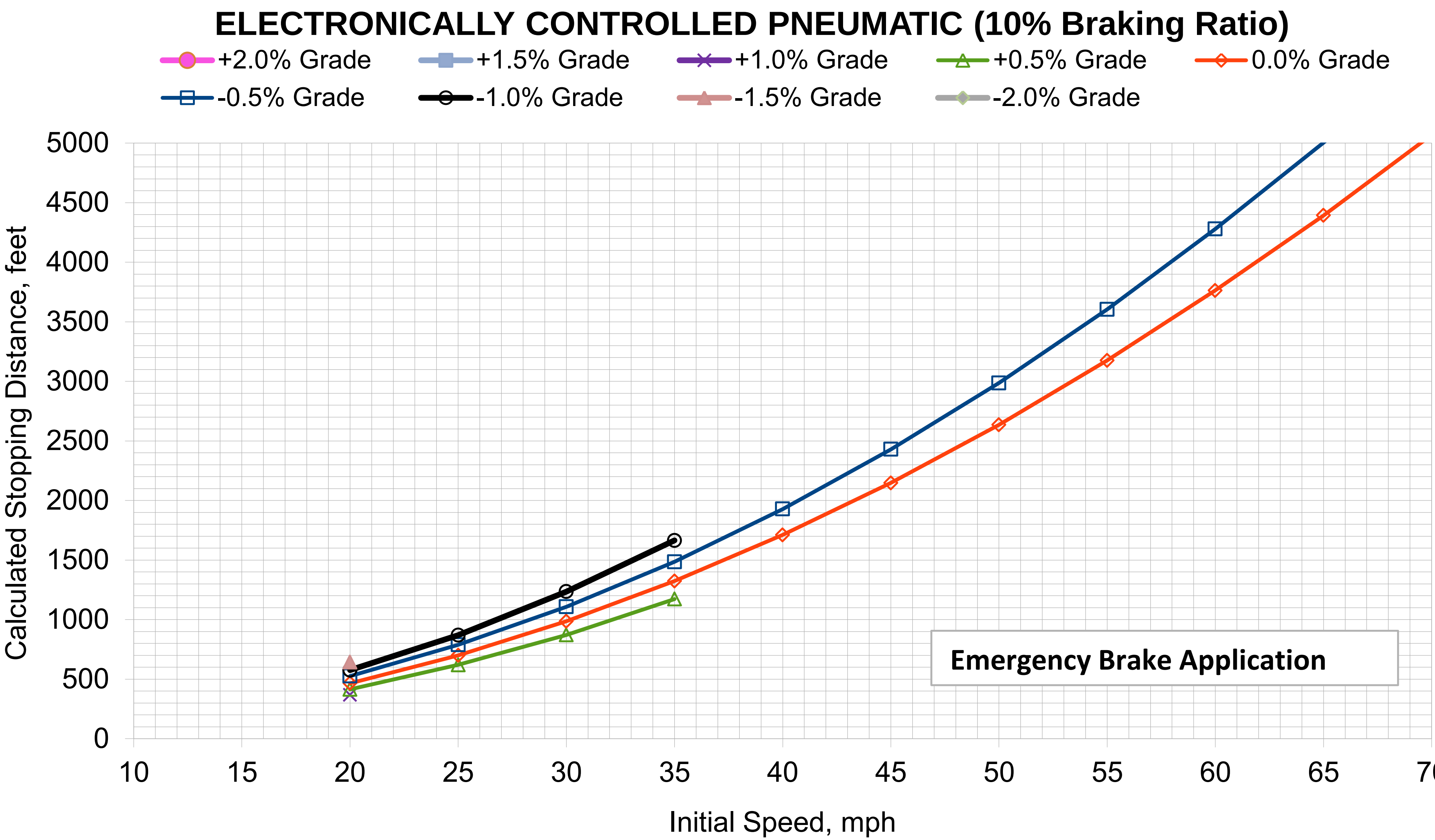


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

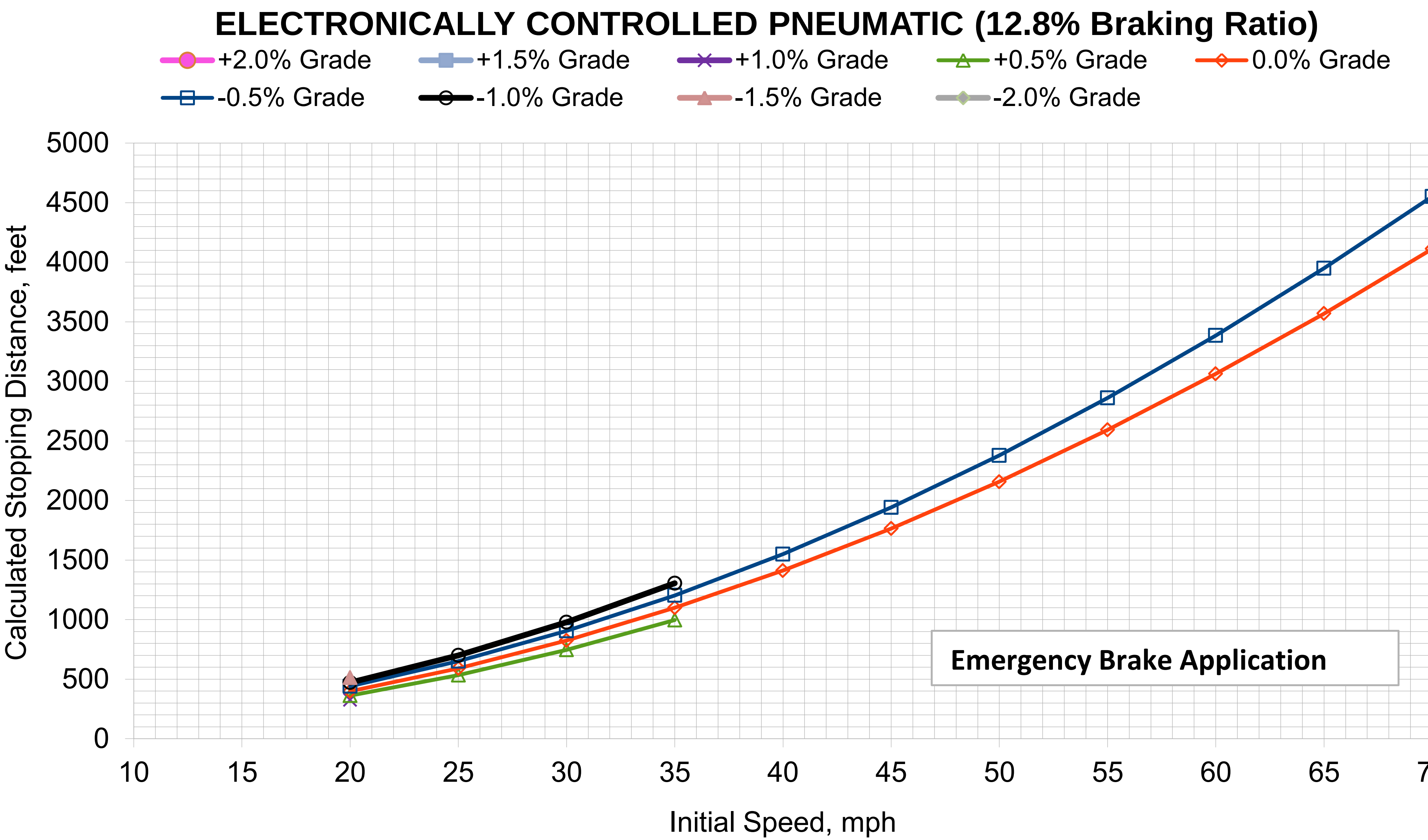


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

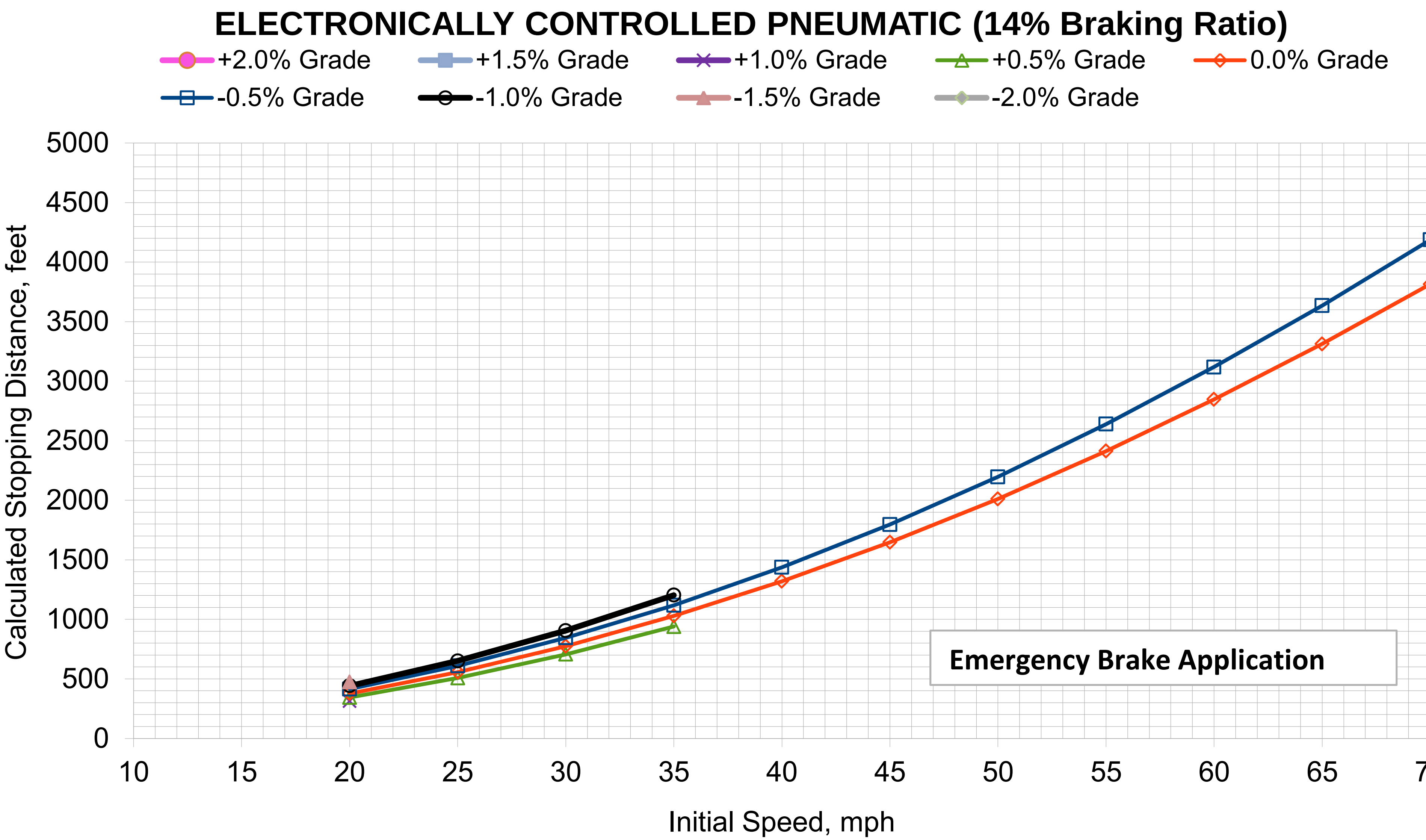

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



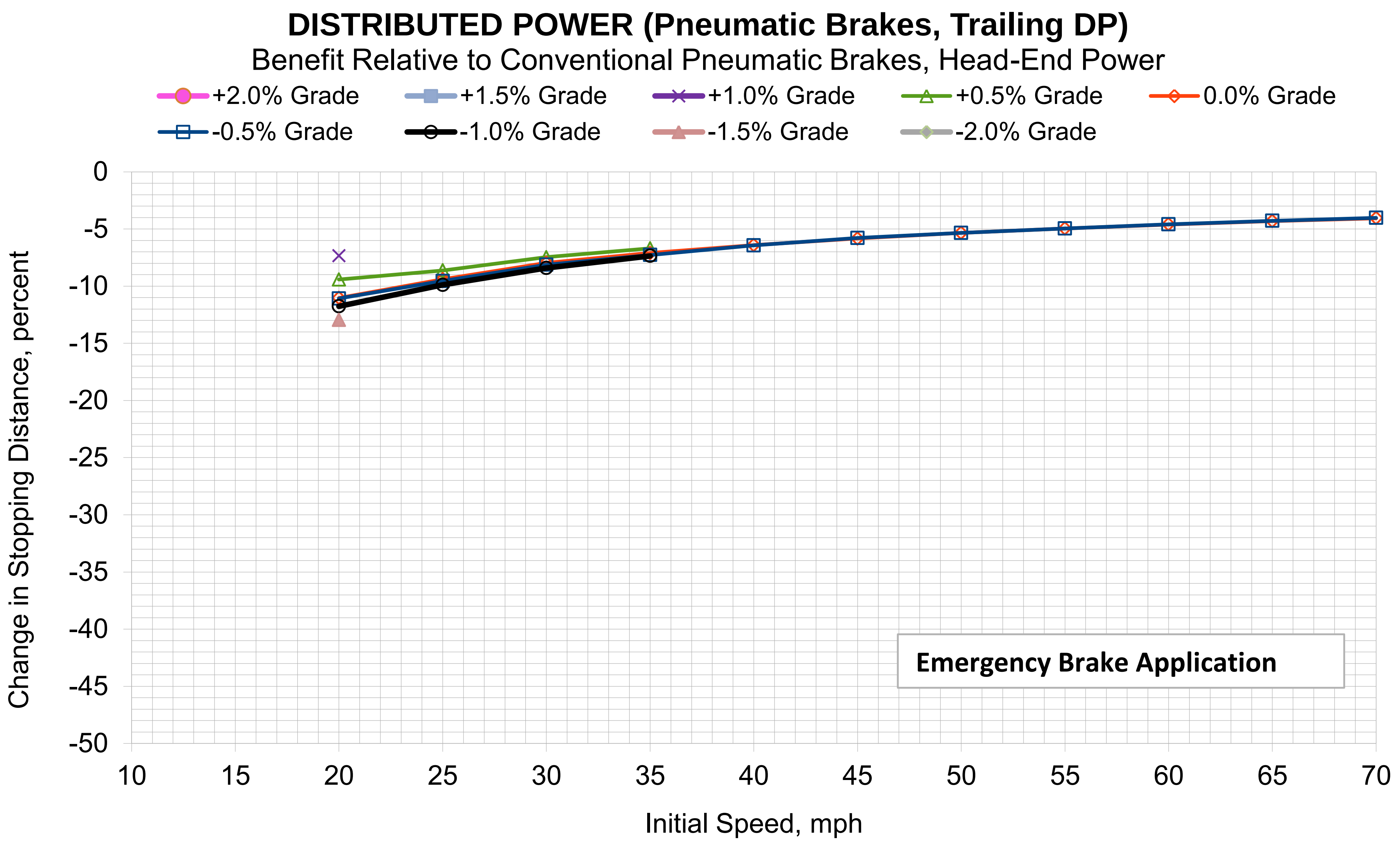
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



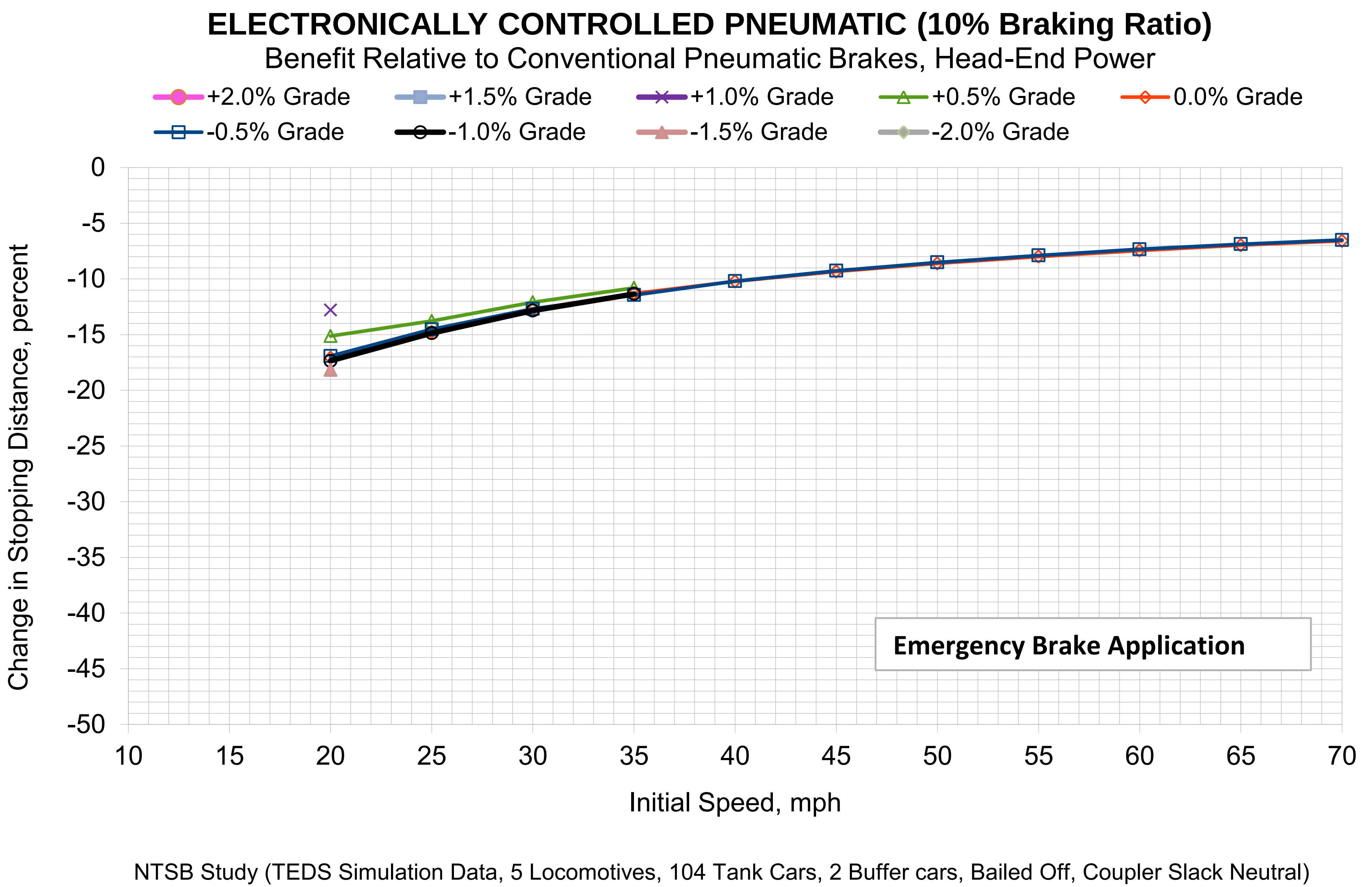
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



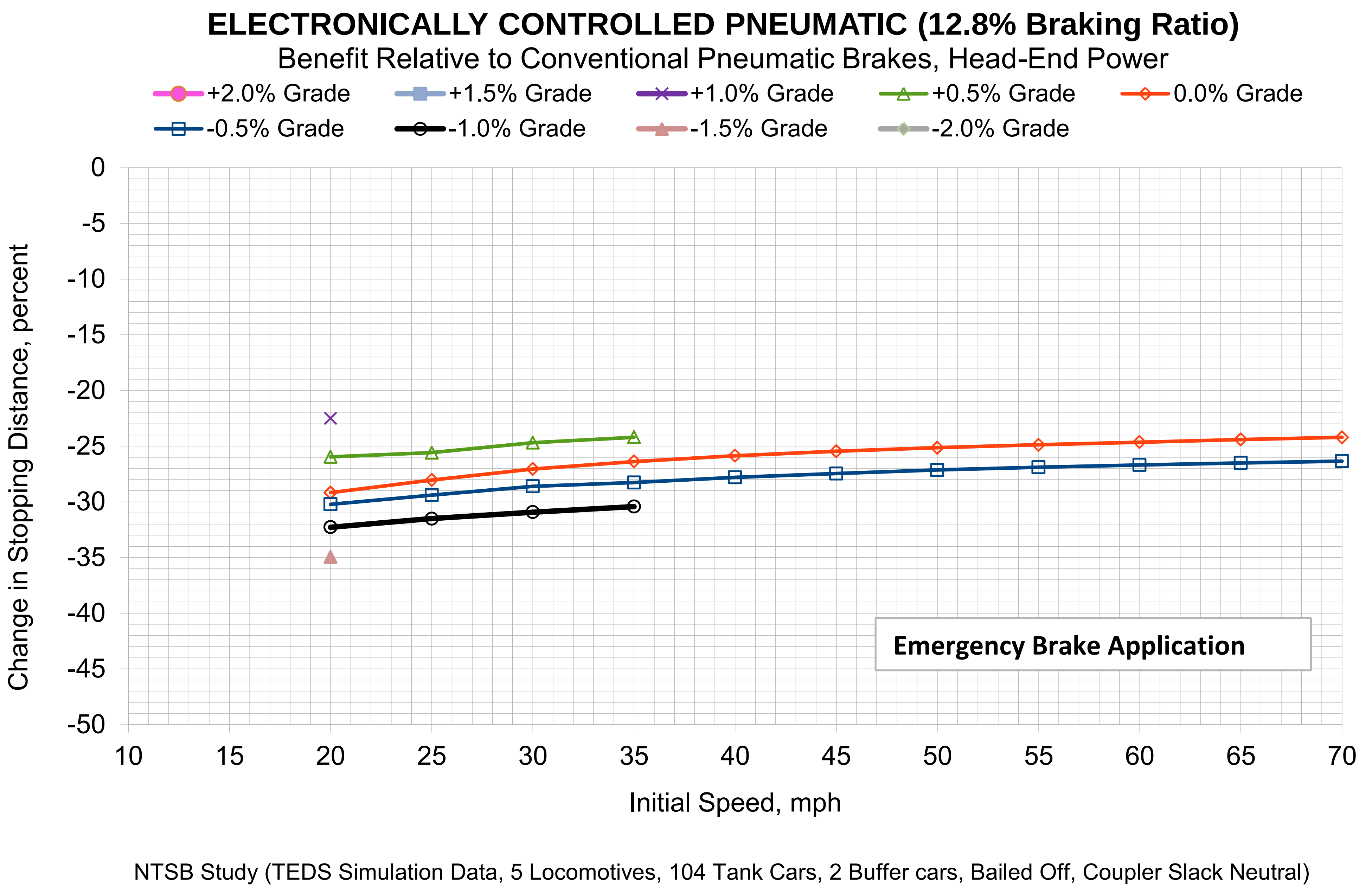
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

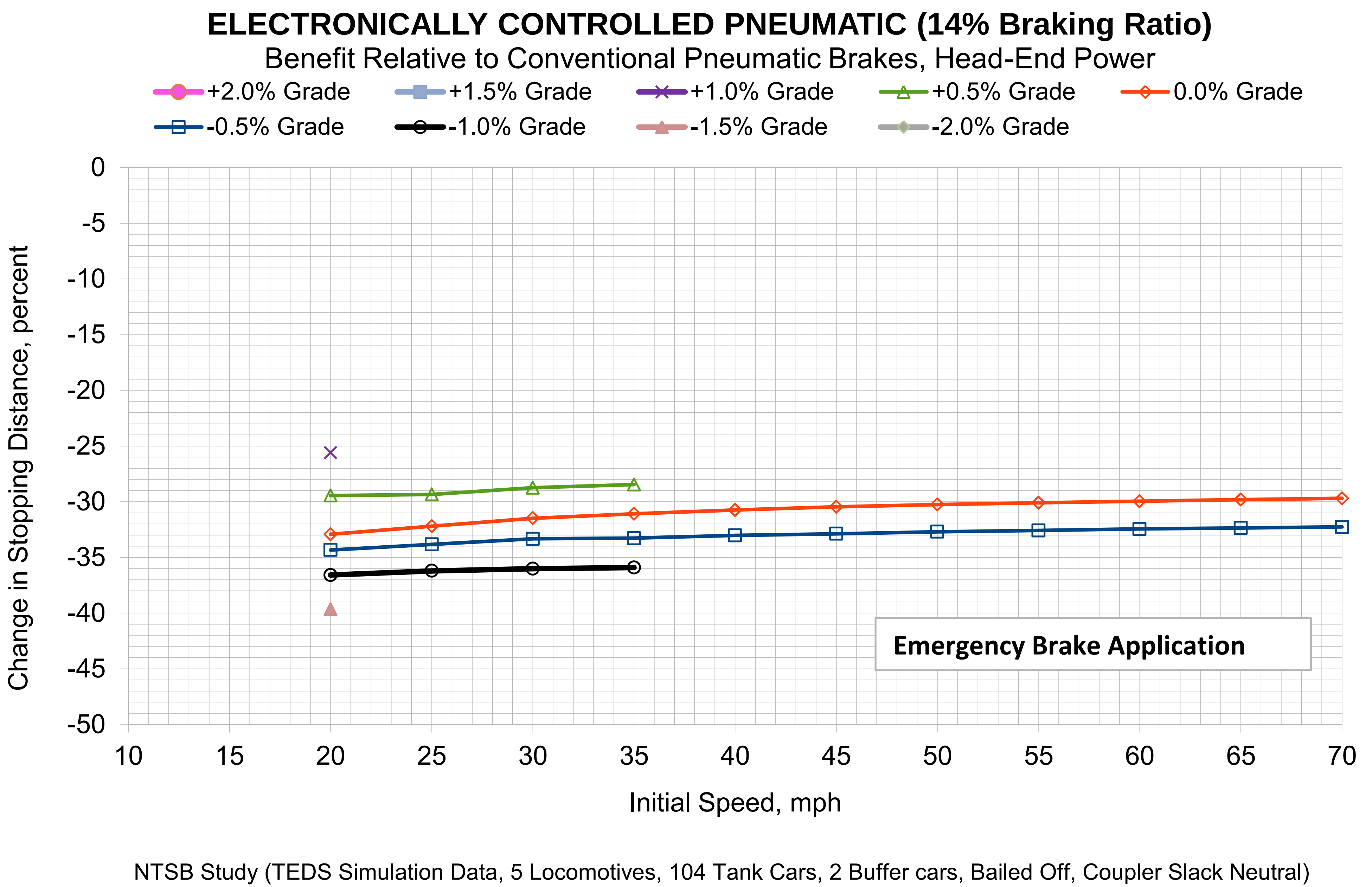


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

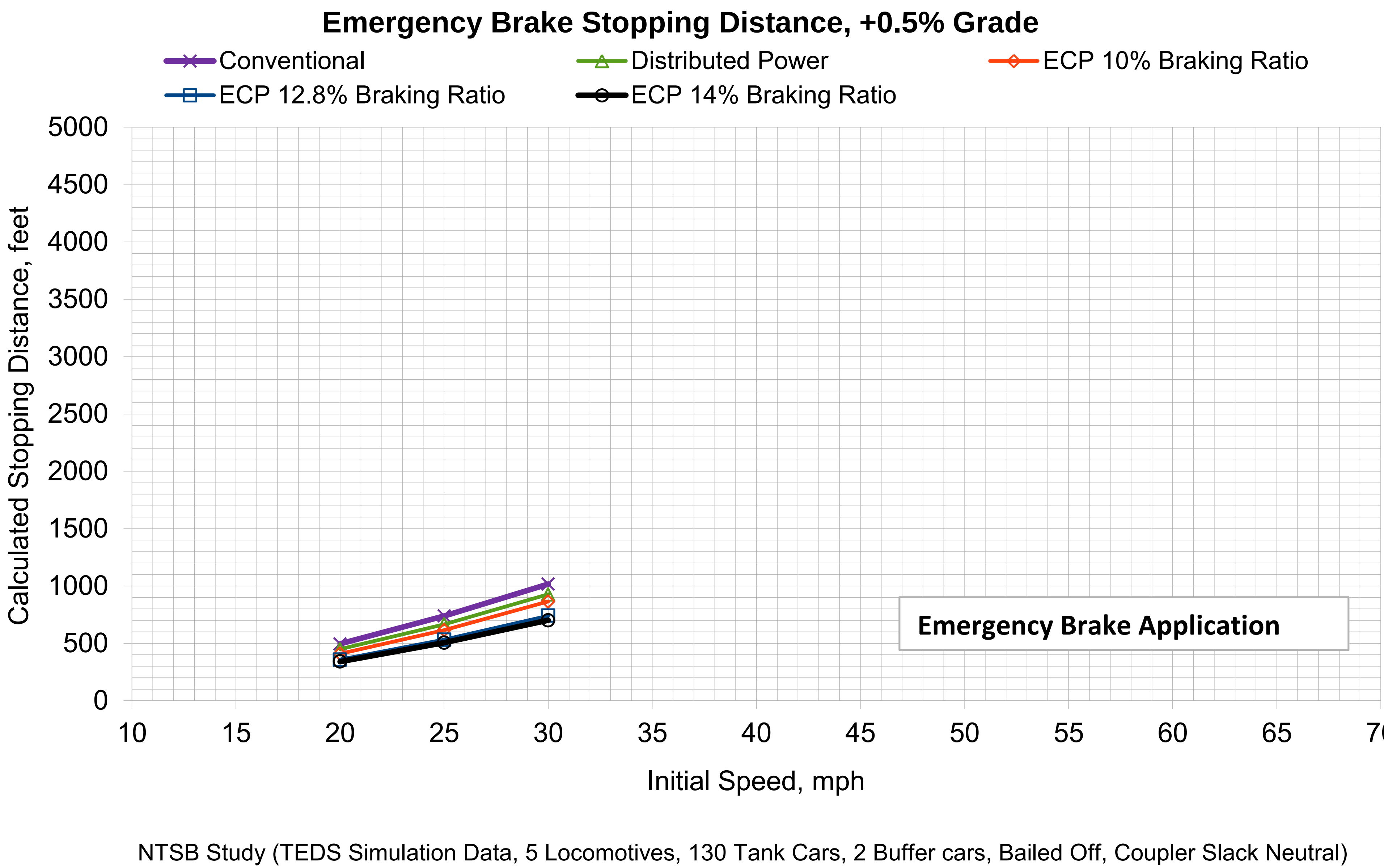


ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

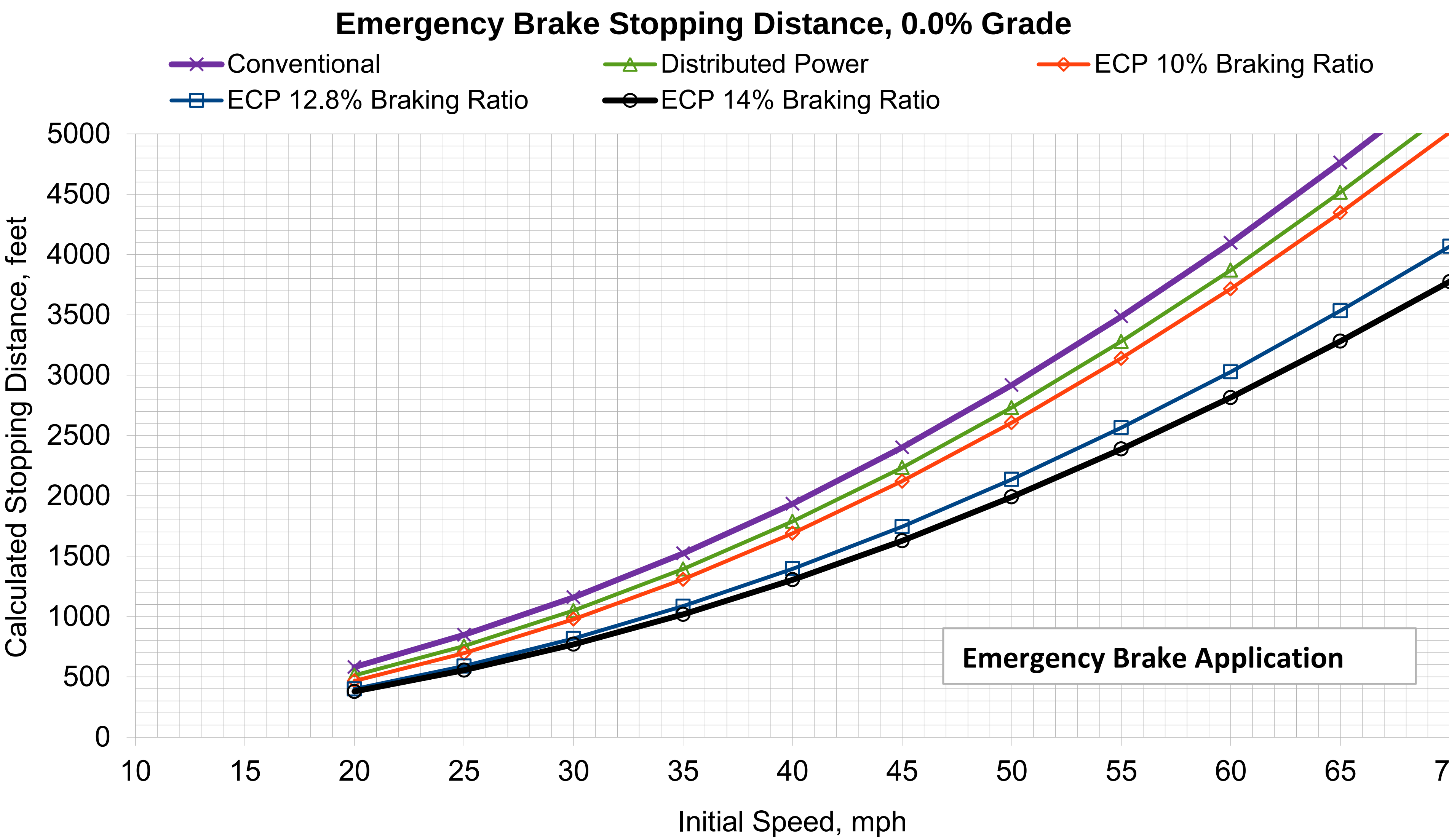

ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

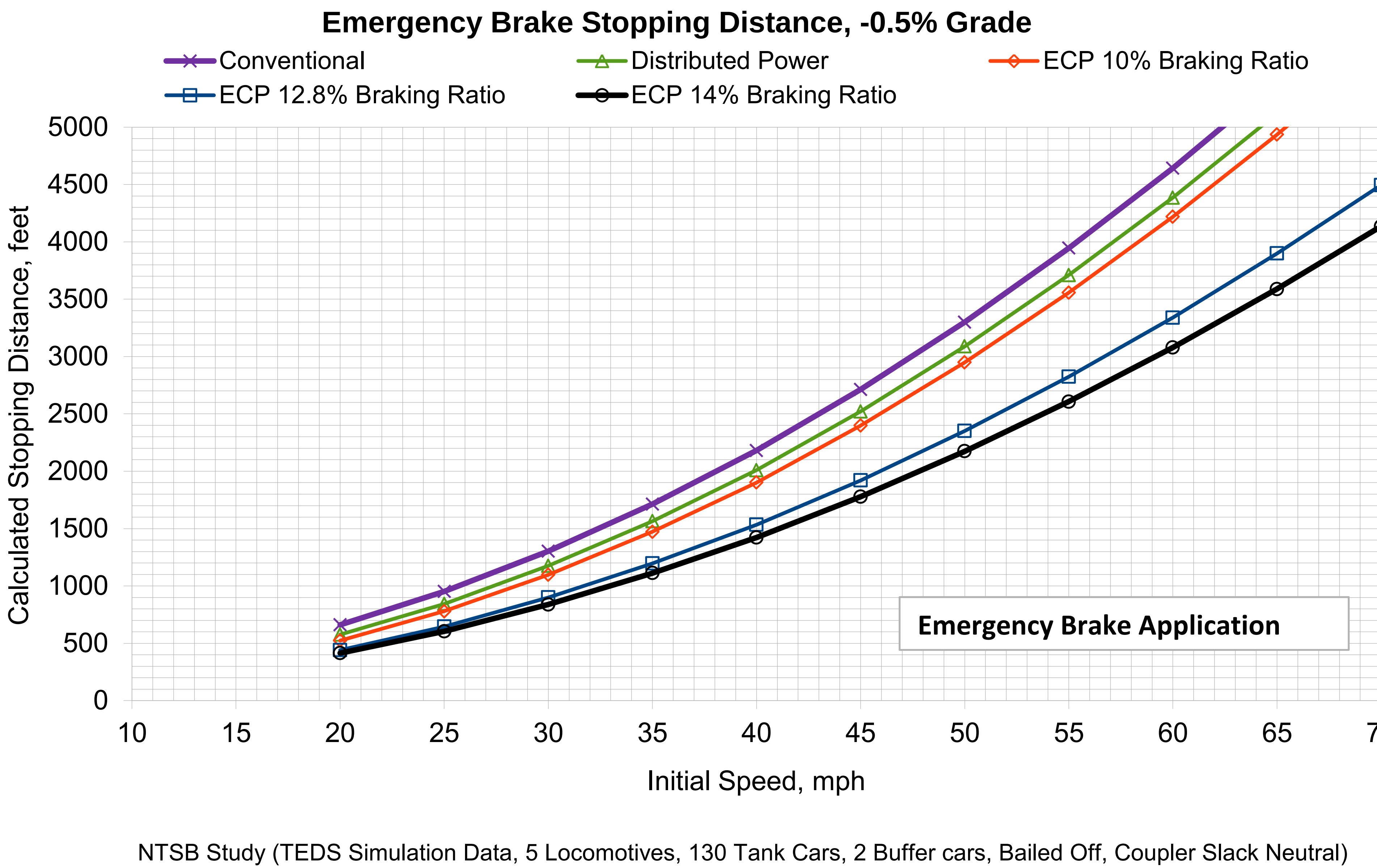
Attachment 10: Emergency Braking, Bailed Off, 130 Tank Cars

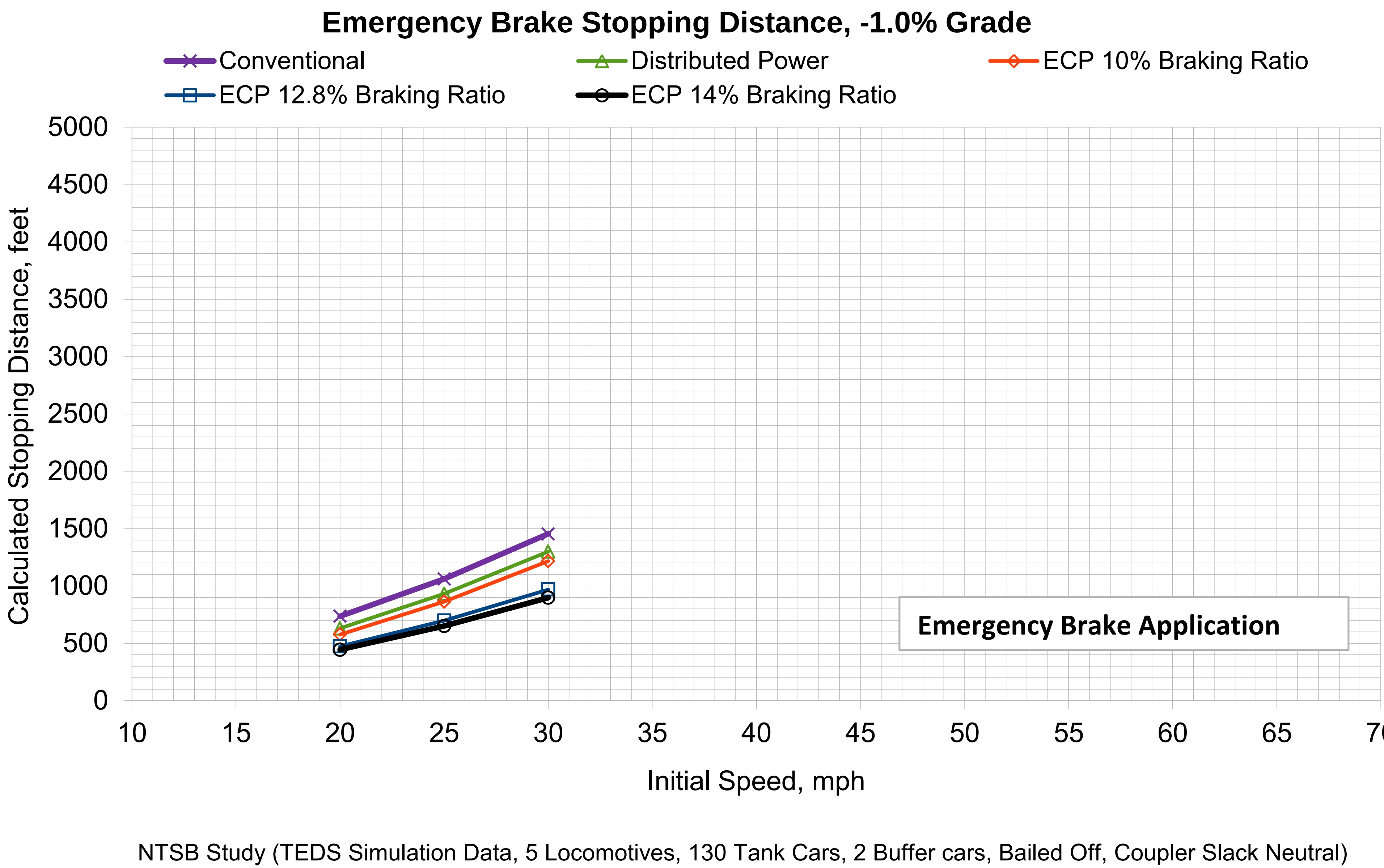


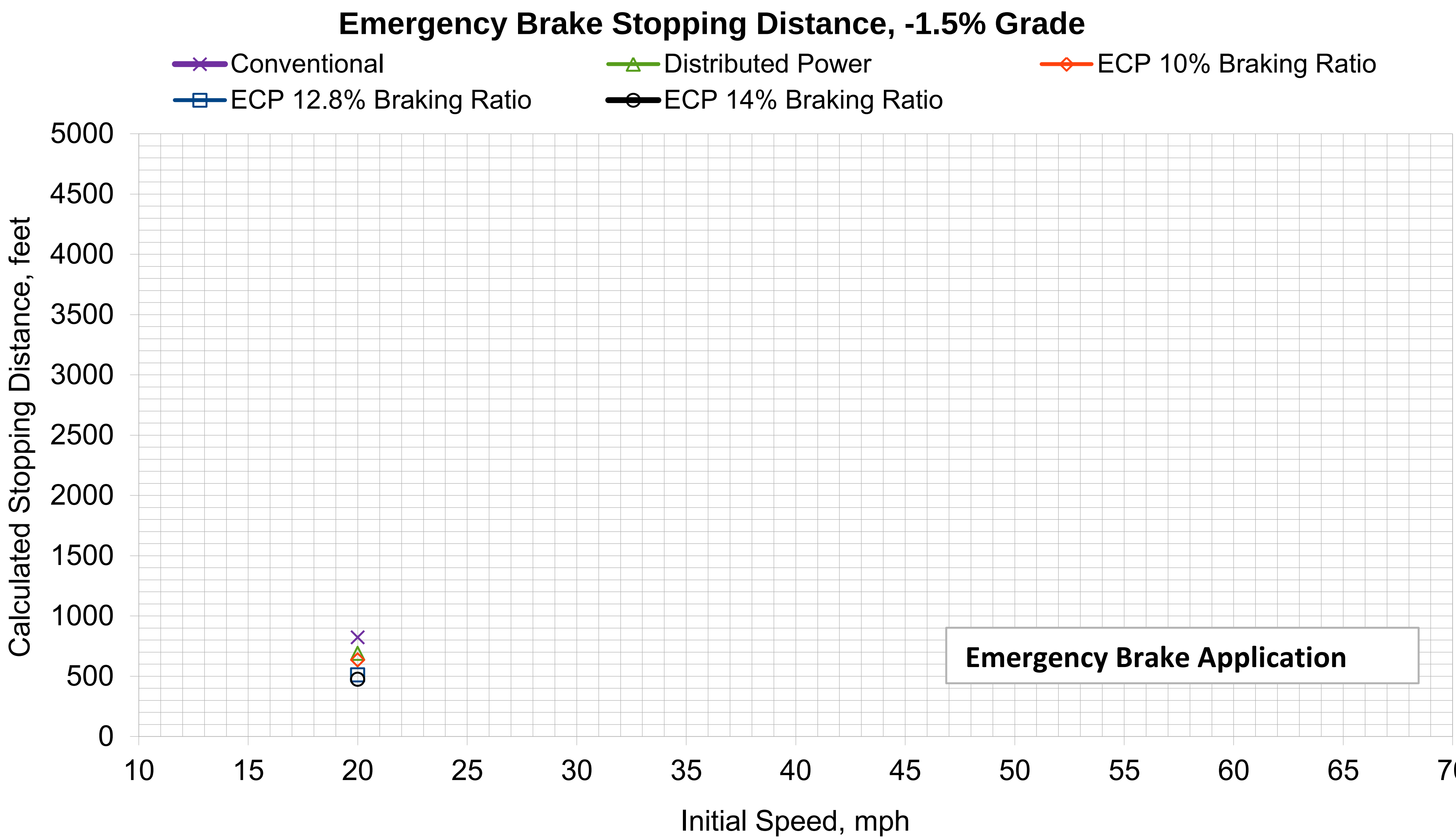
Emergency Brake Stopping Distance, +0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



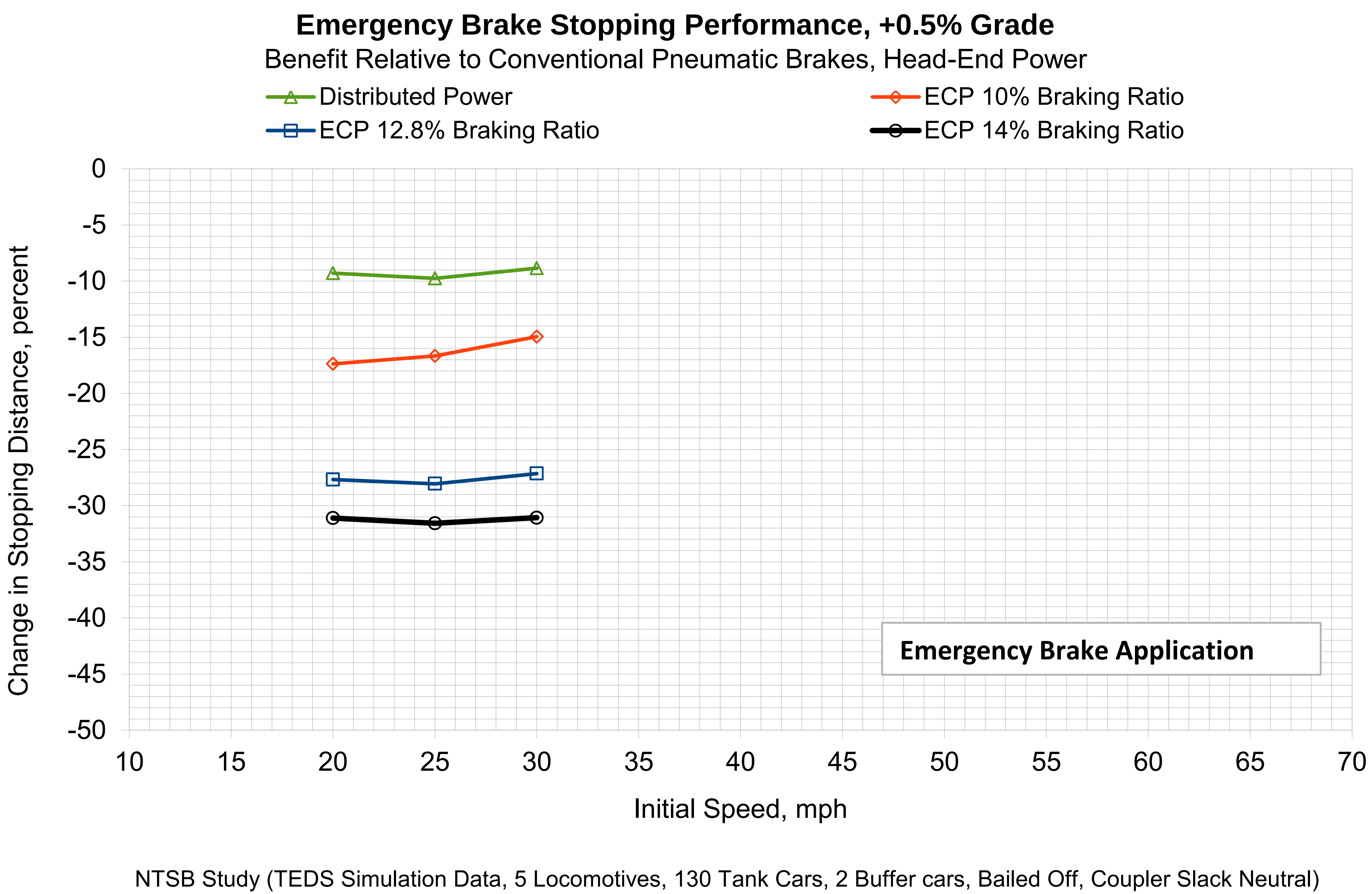
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Emergency Brake Stopping Distance, -0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

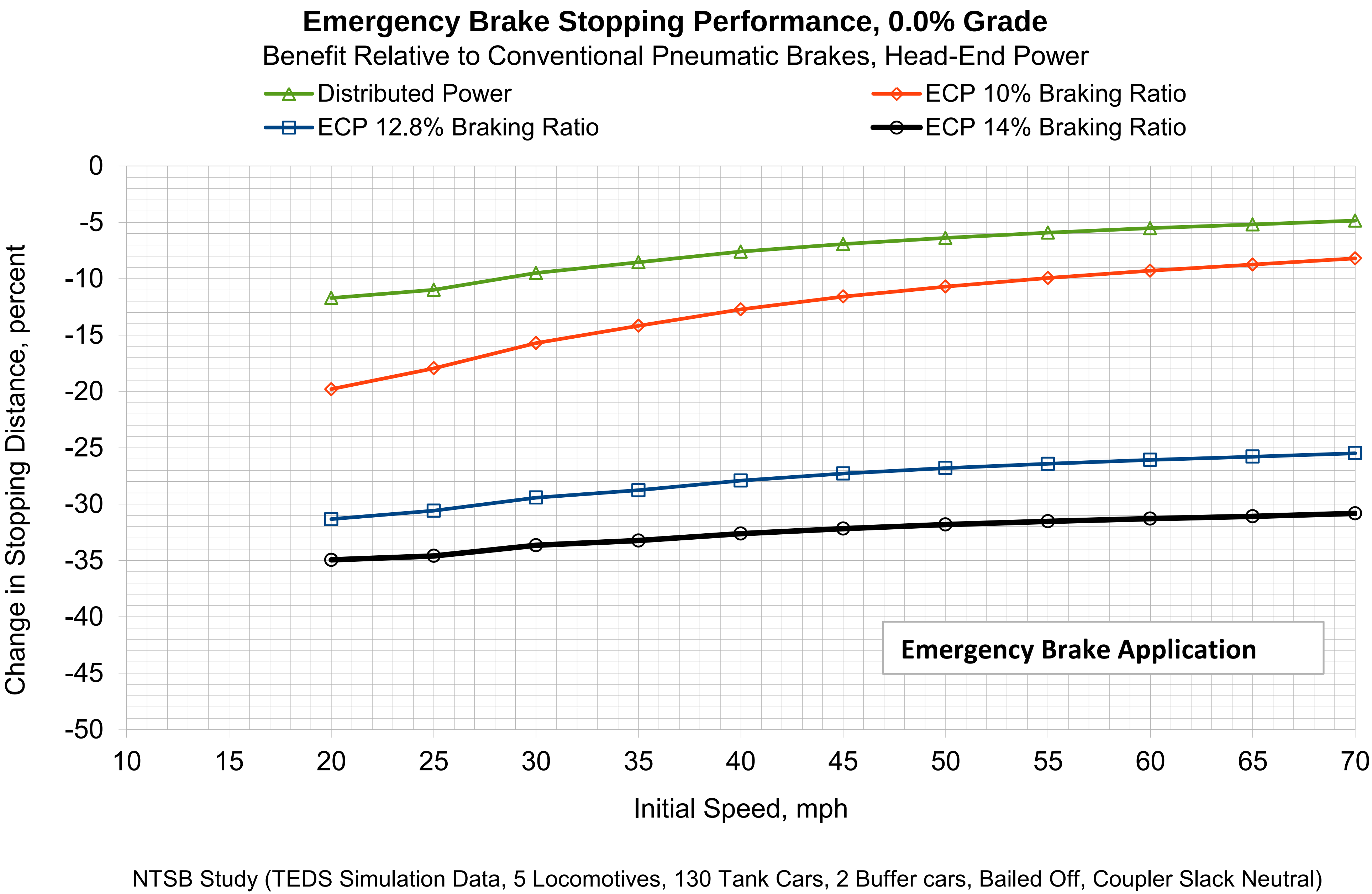

Emergency Brake Stopping Distance, -1.0% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

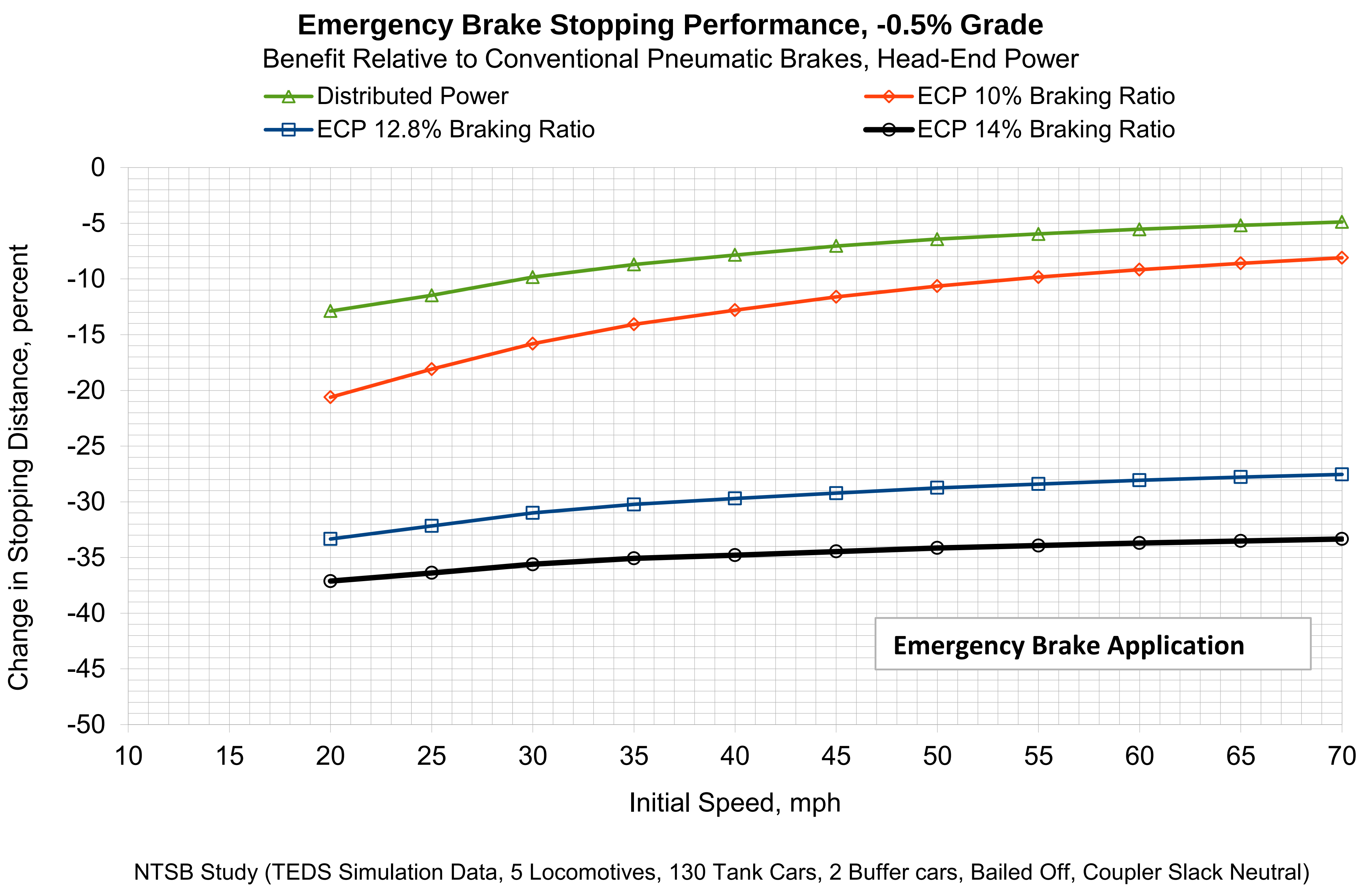


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

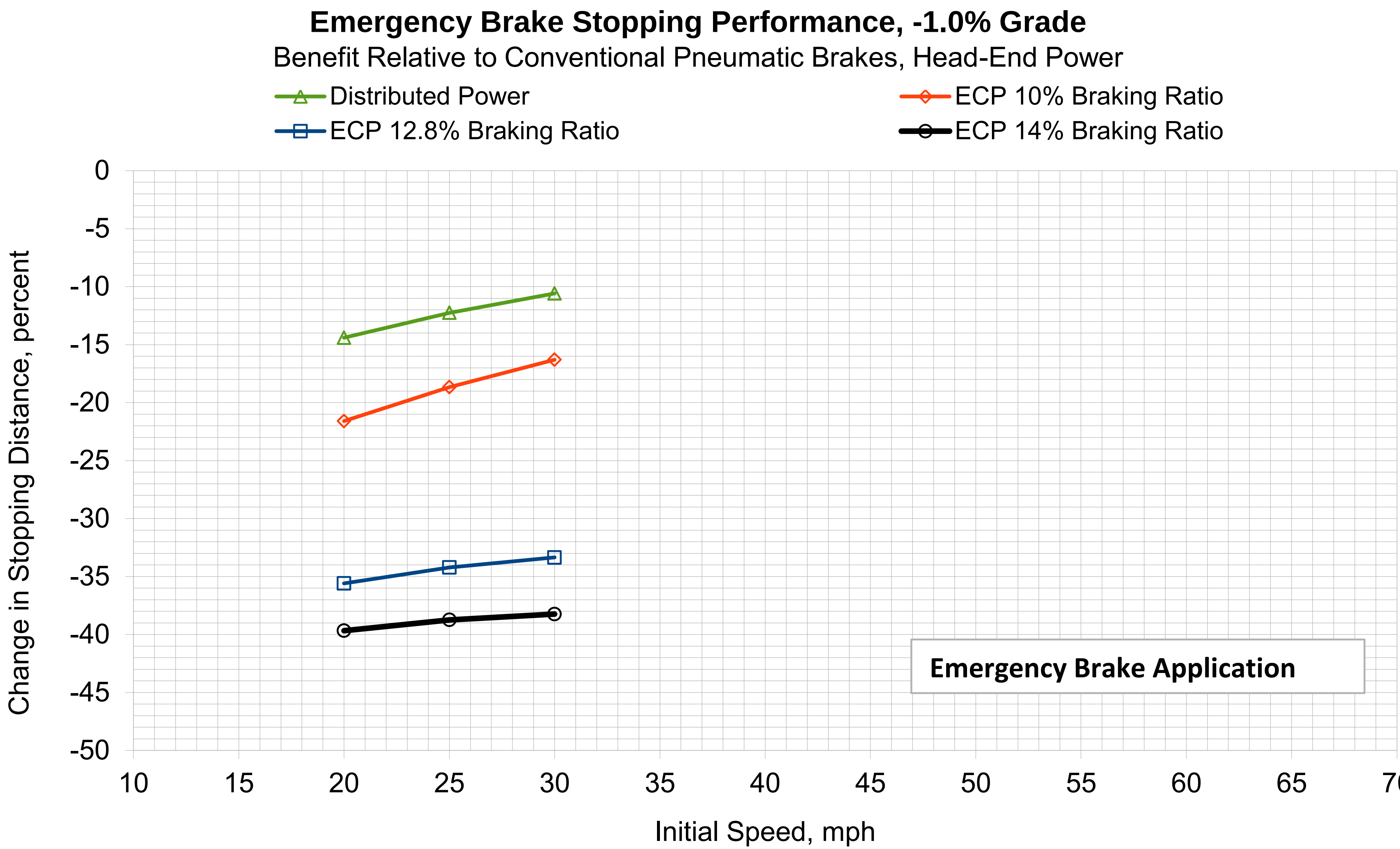


Emergency Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

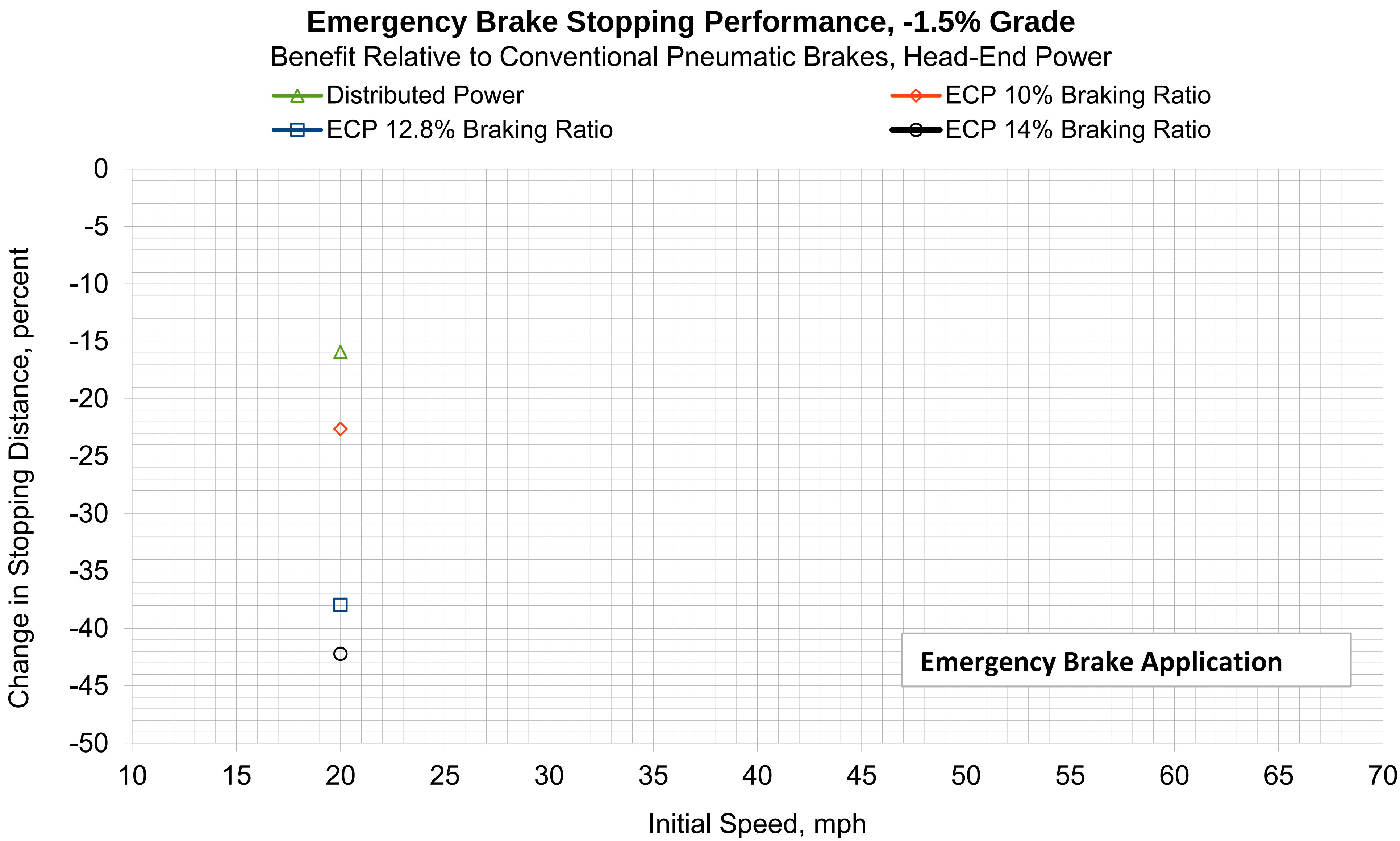

Emergency Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Emergency Brake Application
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



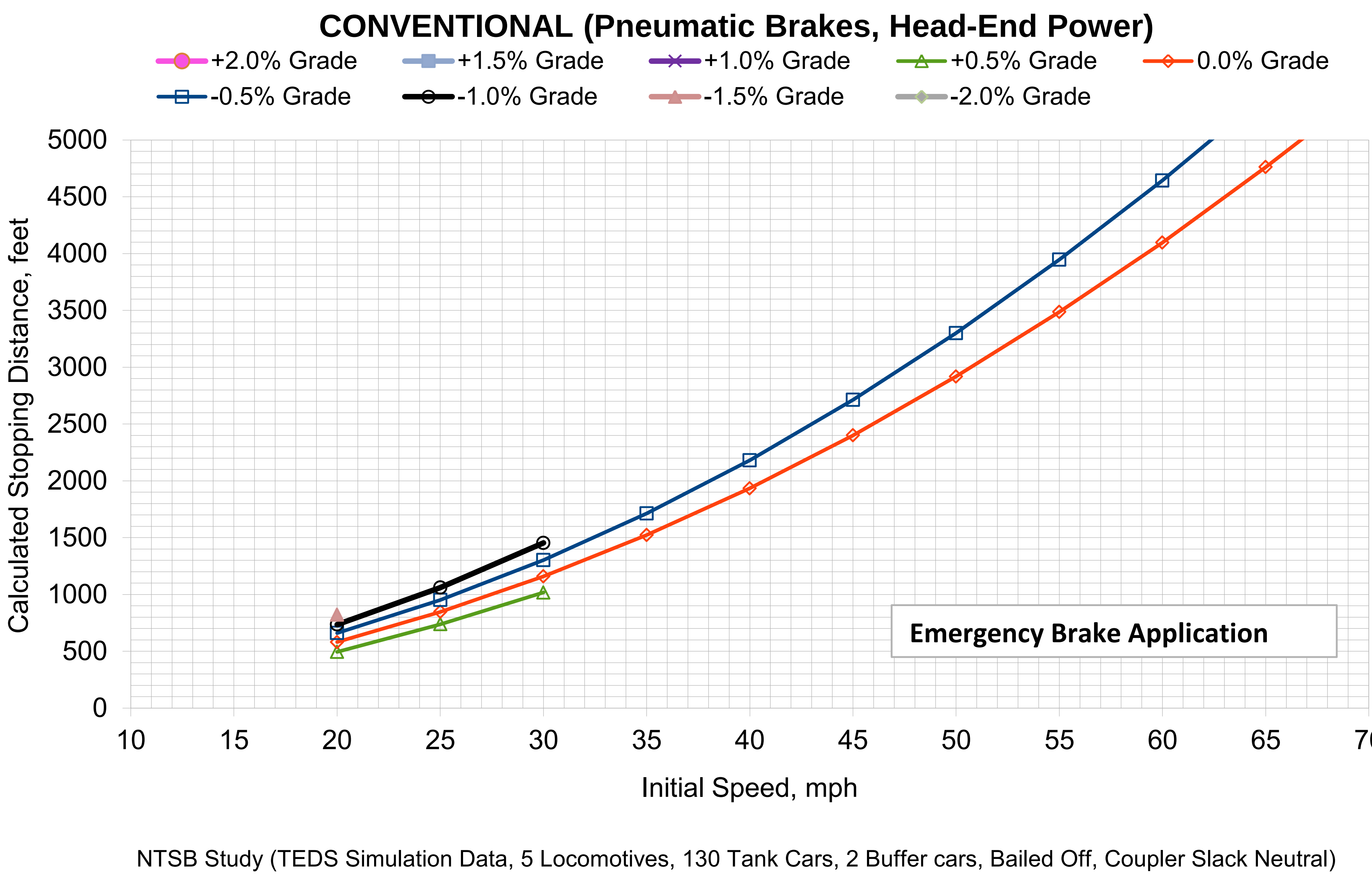
Emergency Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Change in Stopping Distance, percent
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



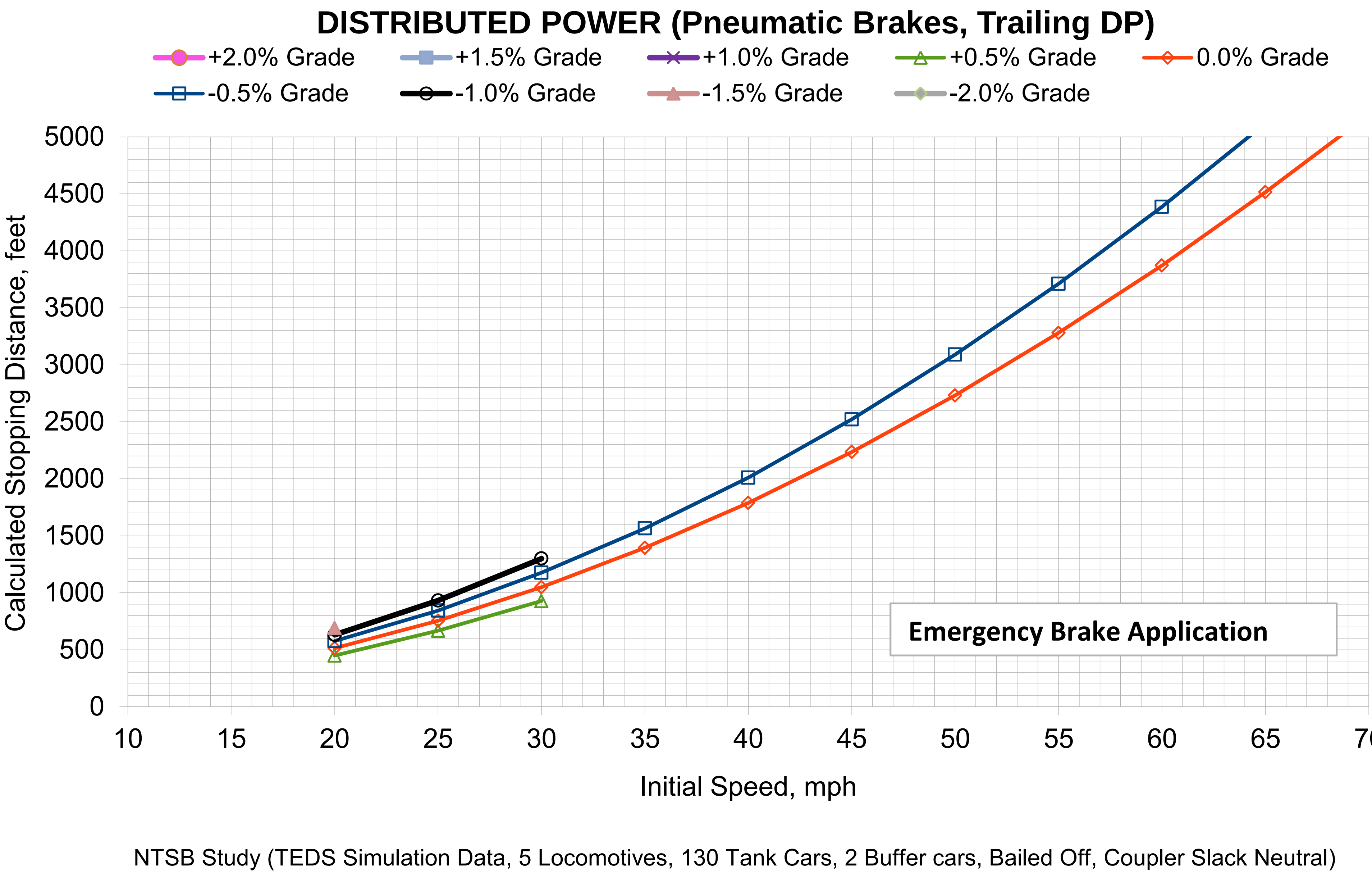
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

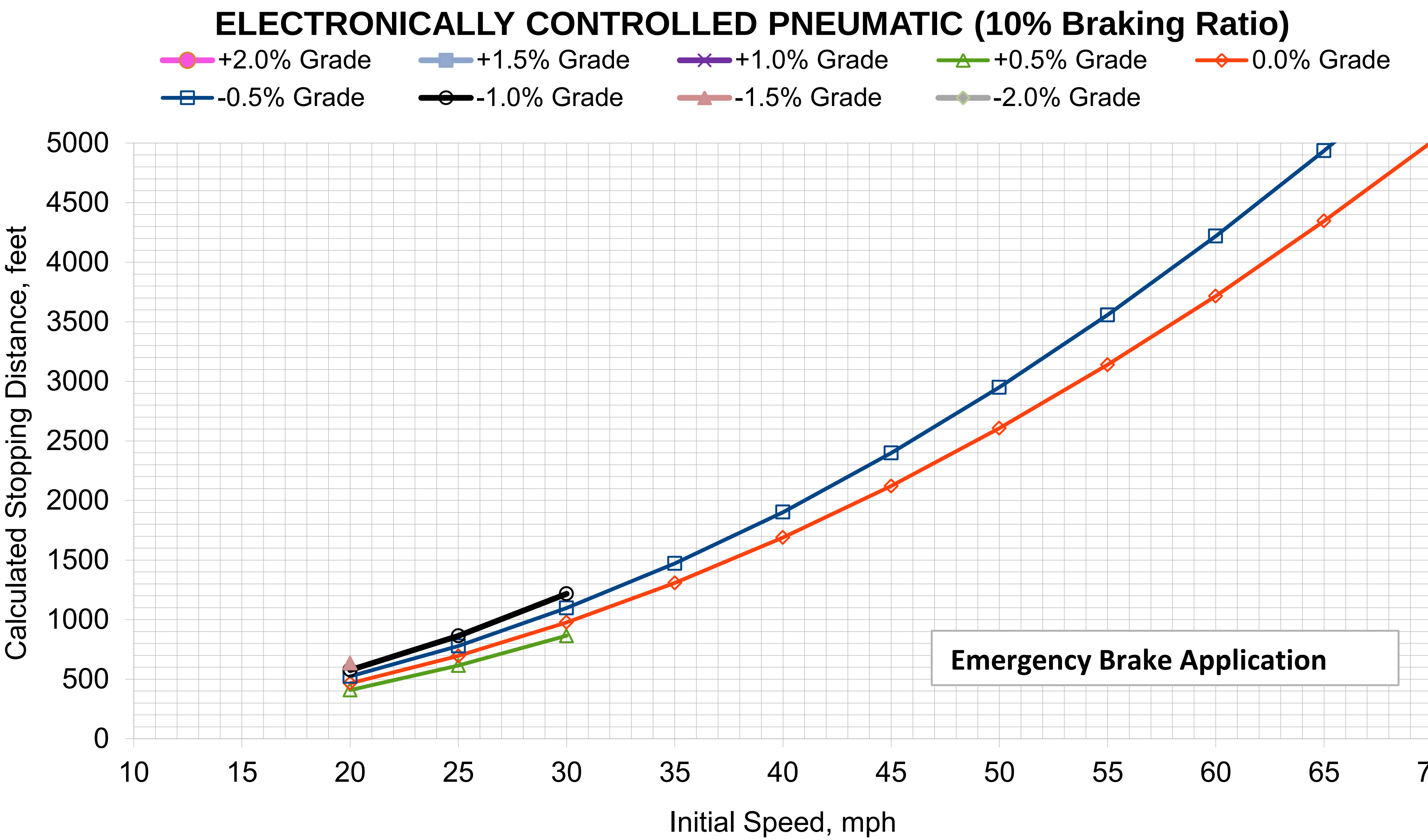


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

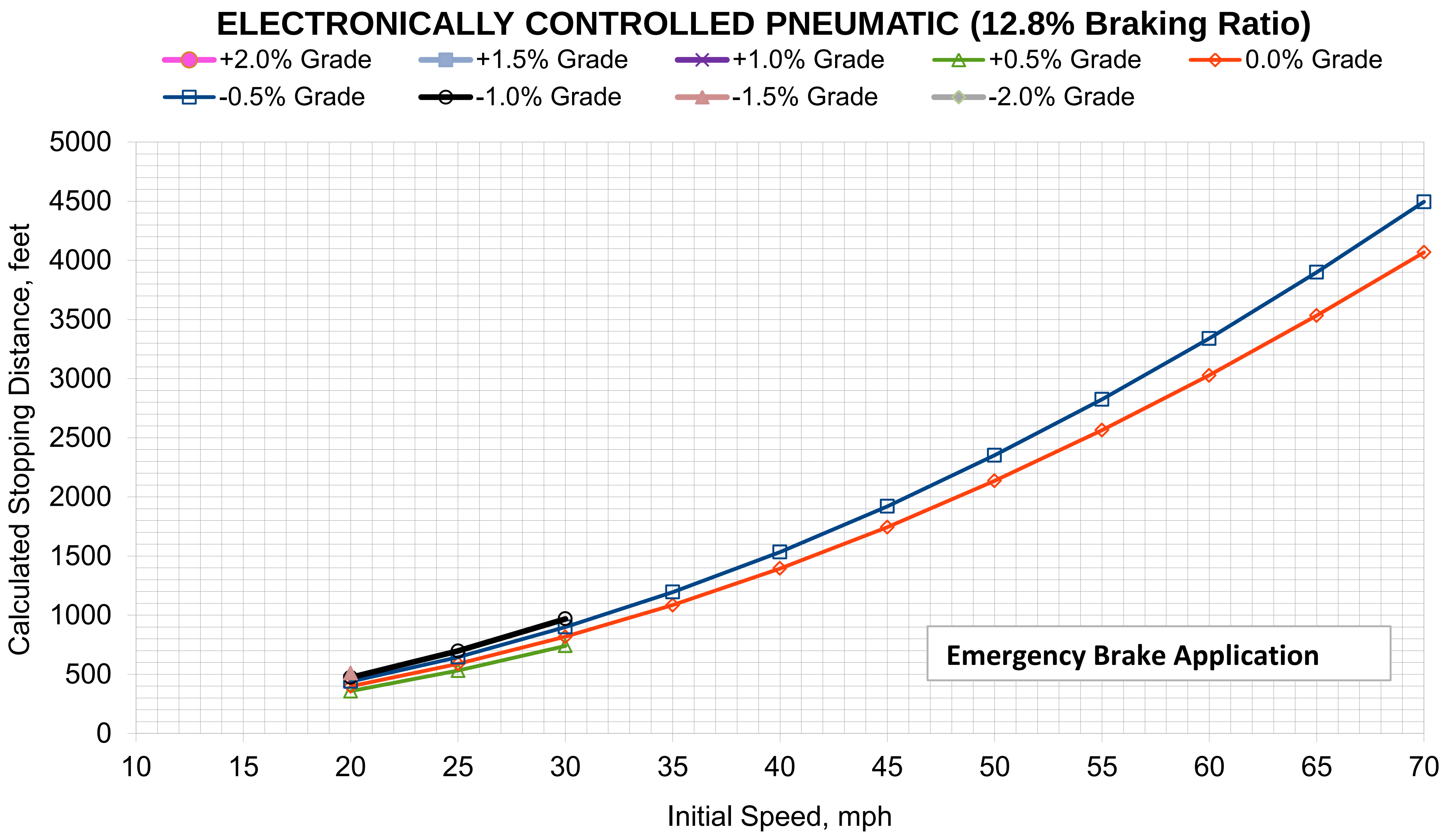


CONVENTIONAL (Pneumatic Brakes, Head-End Power)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

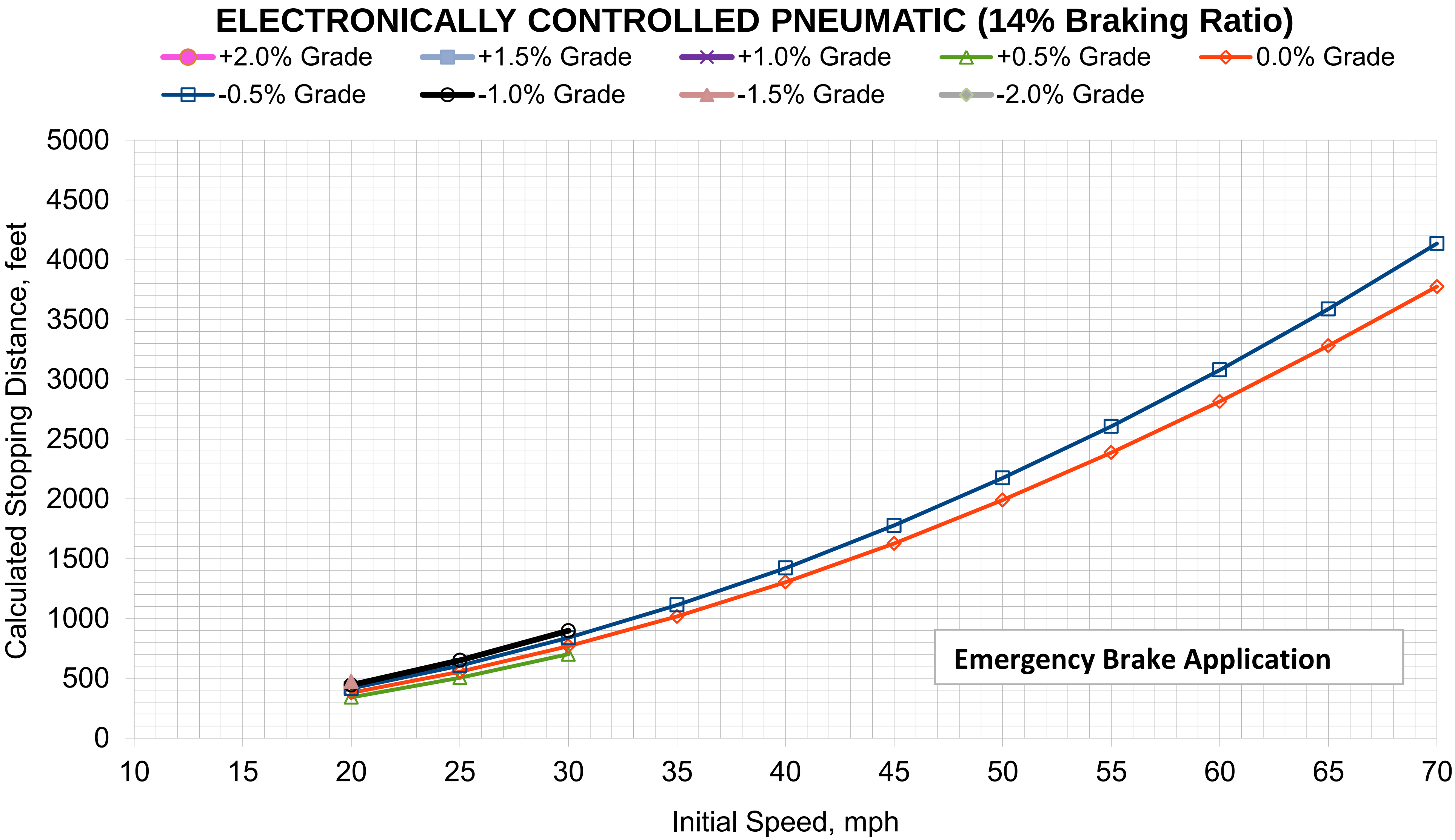

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



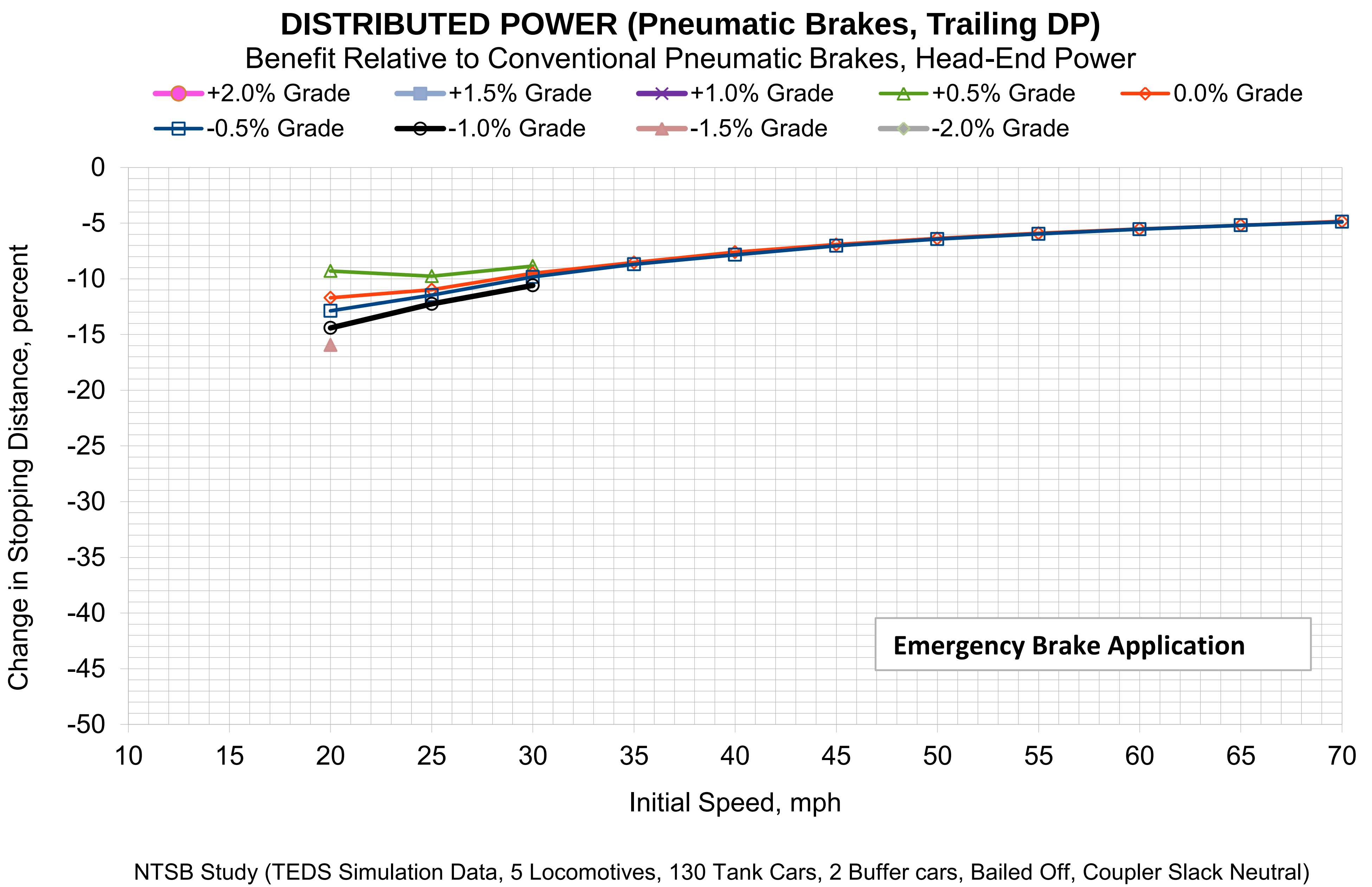
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

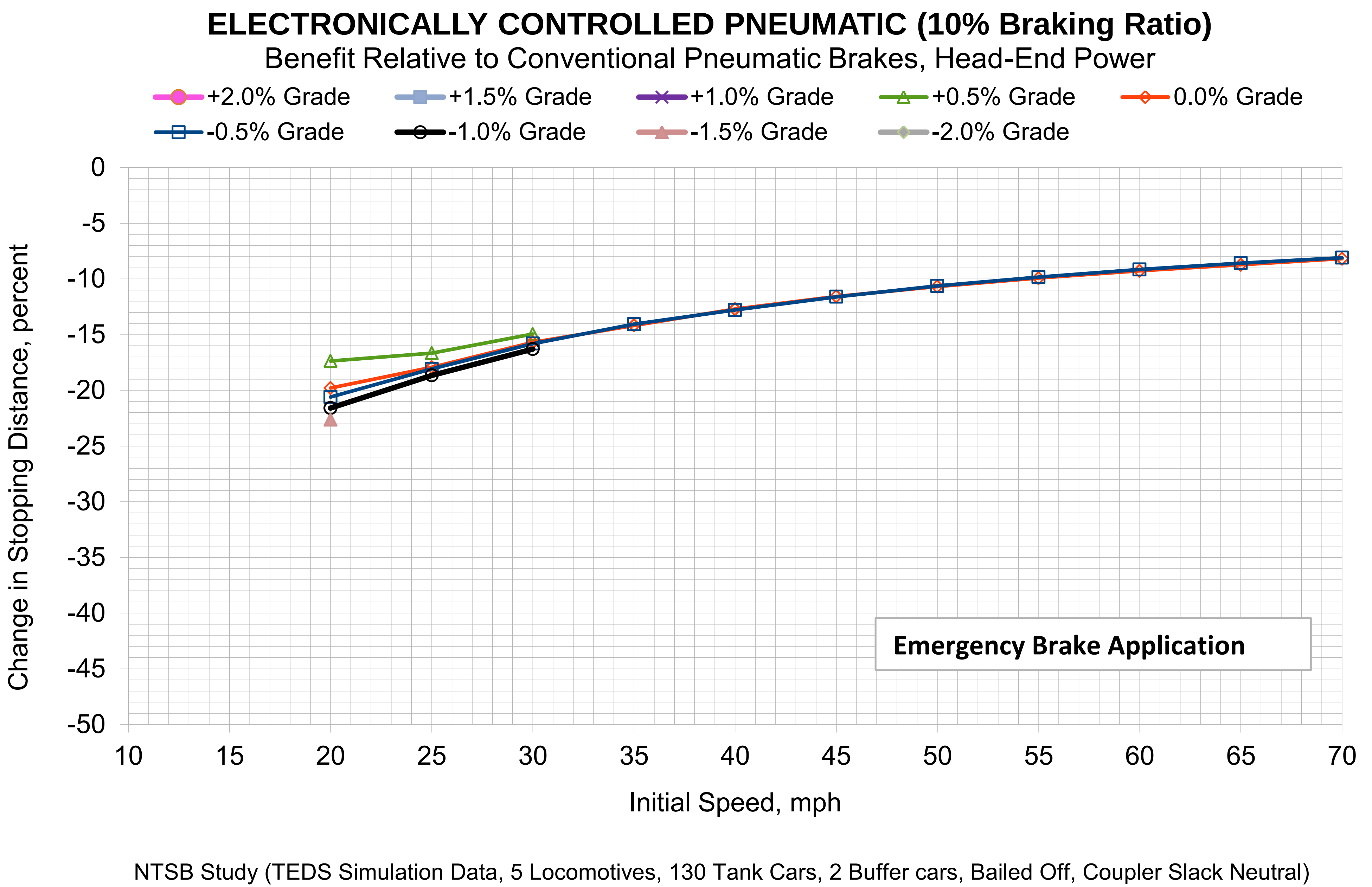


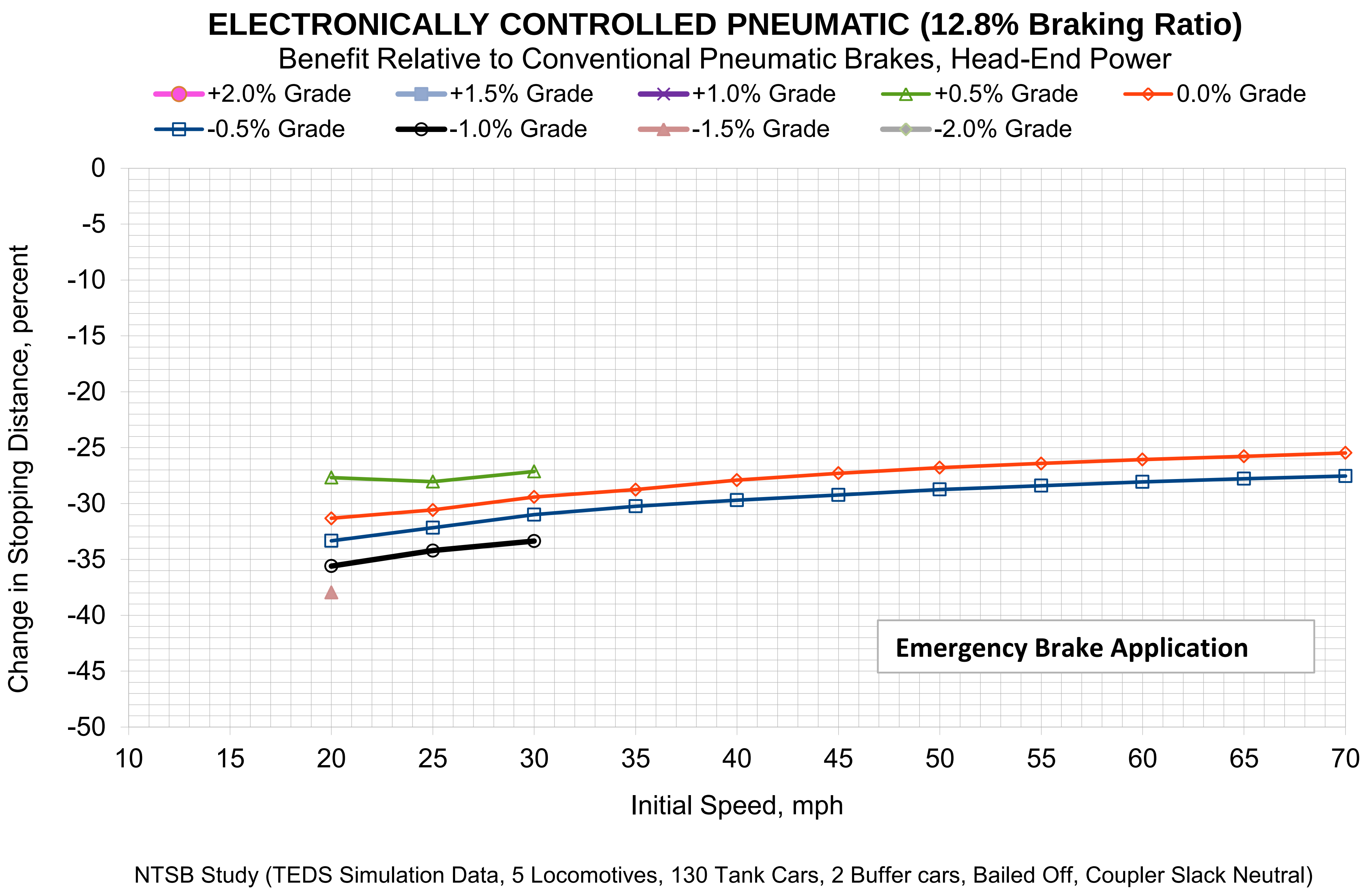
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

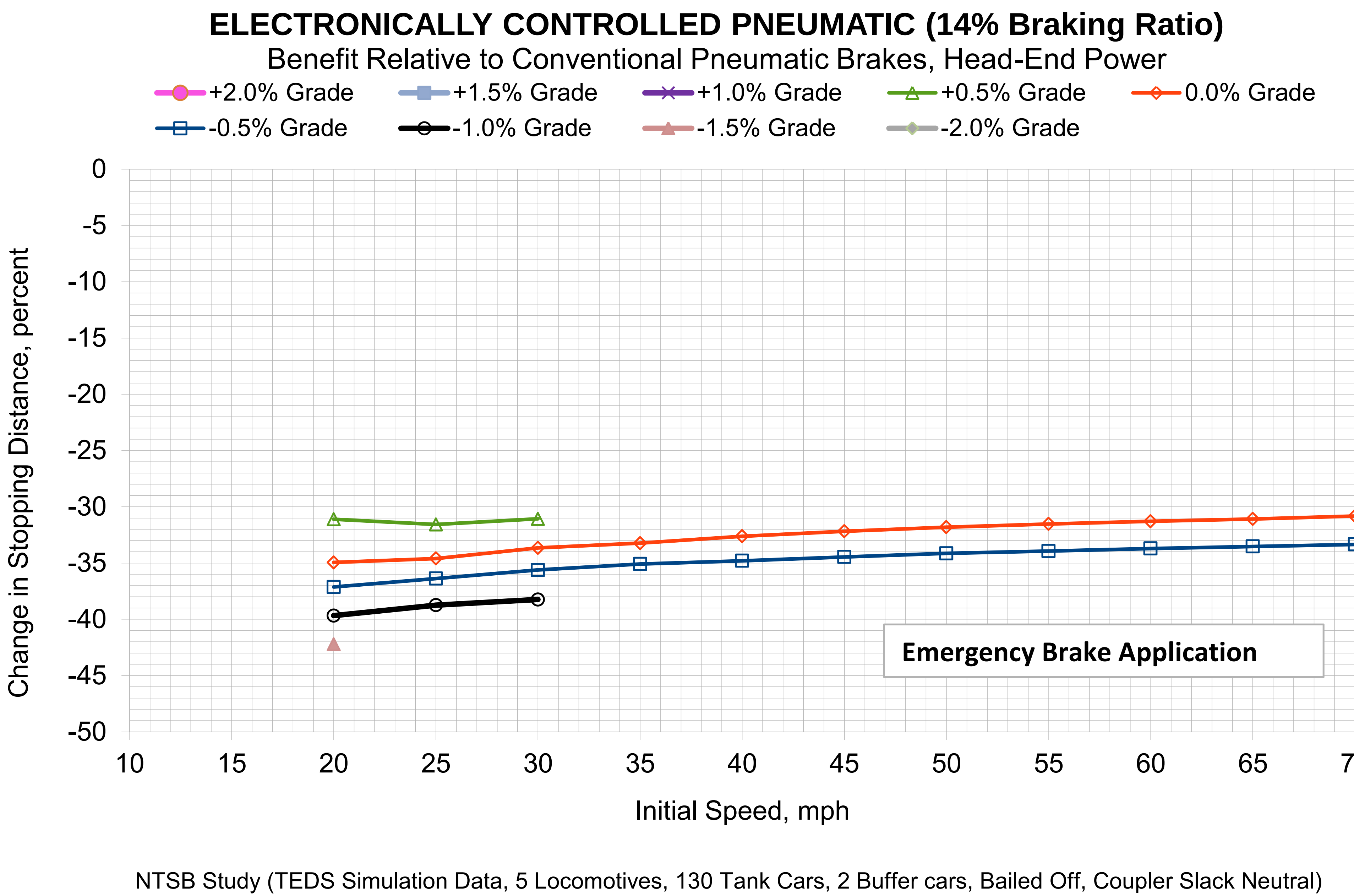


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

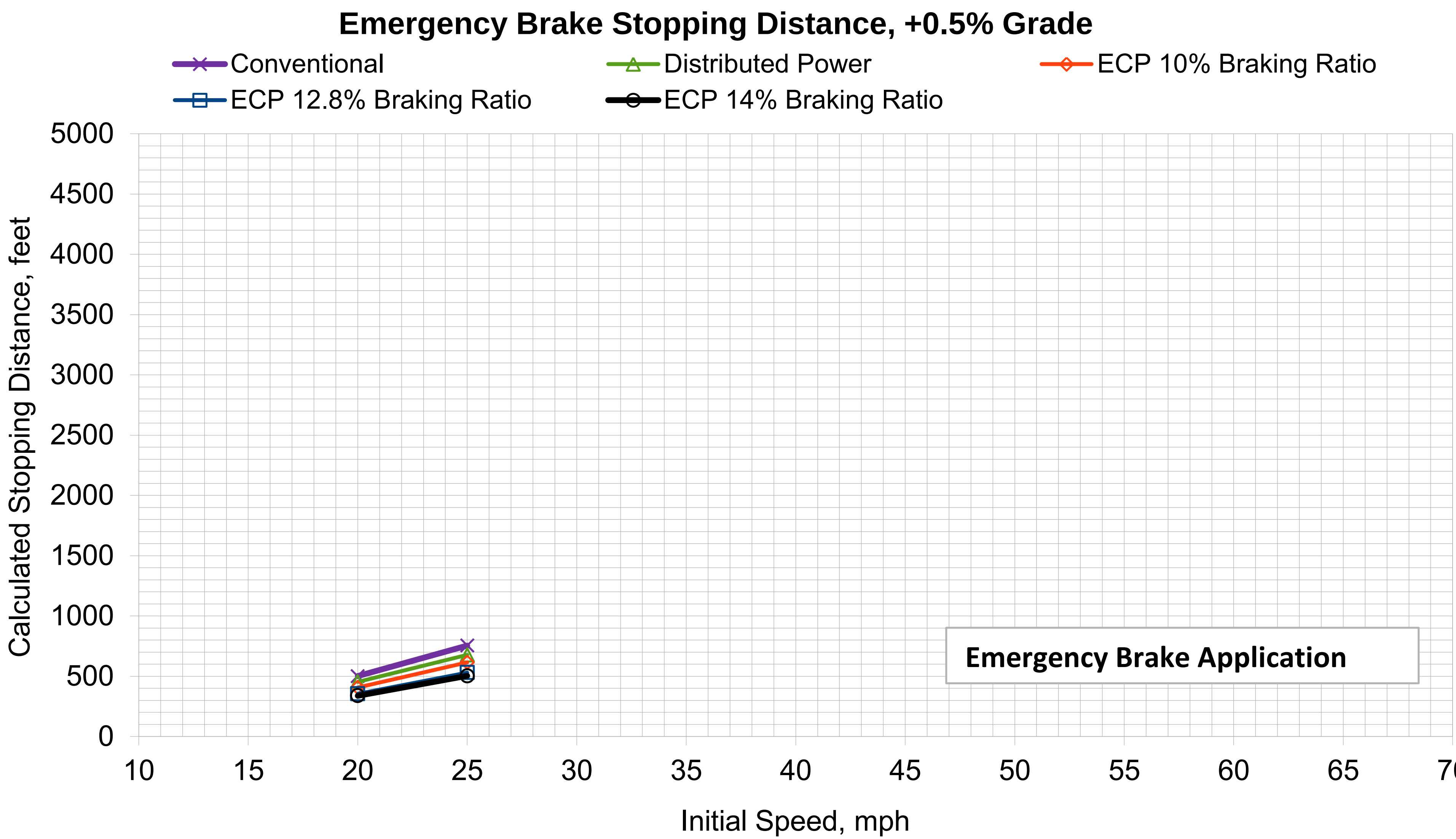

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

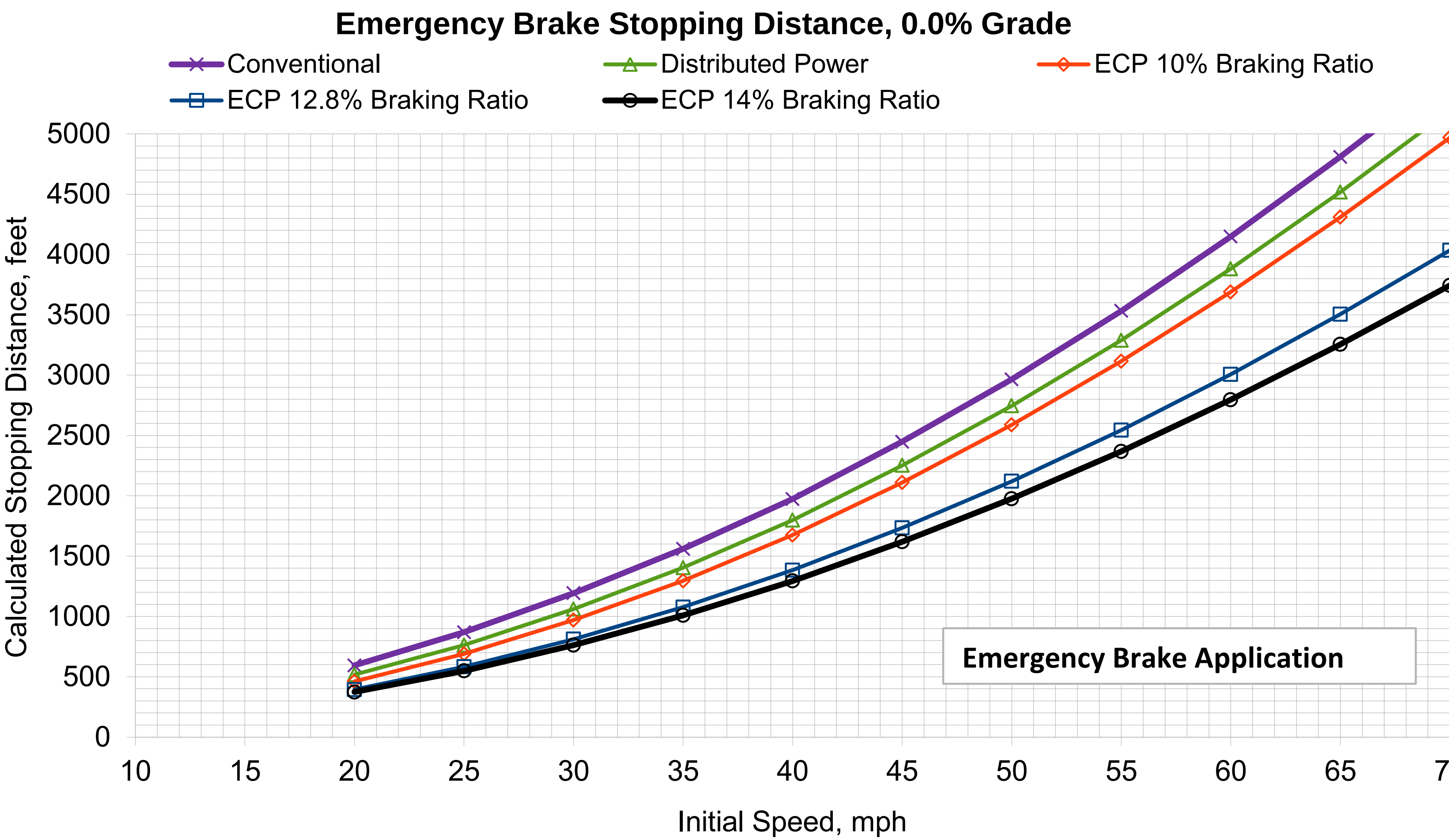

ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

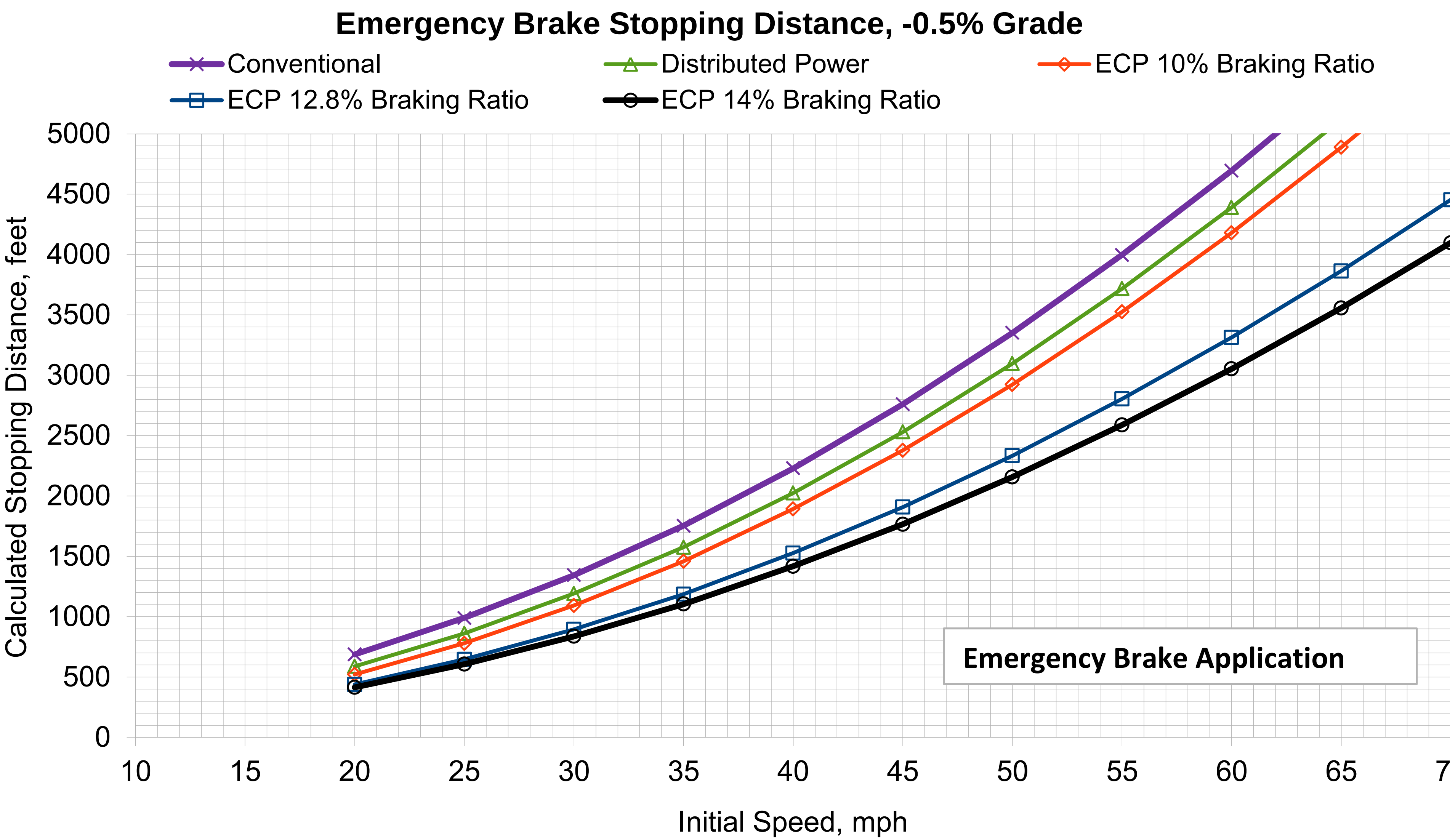
Attachment 11: Emergency Braking, Bailed Off, 156 Tank Cars



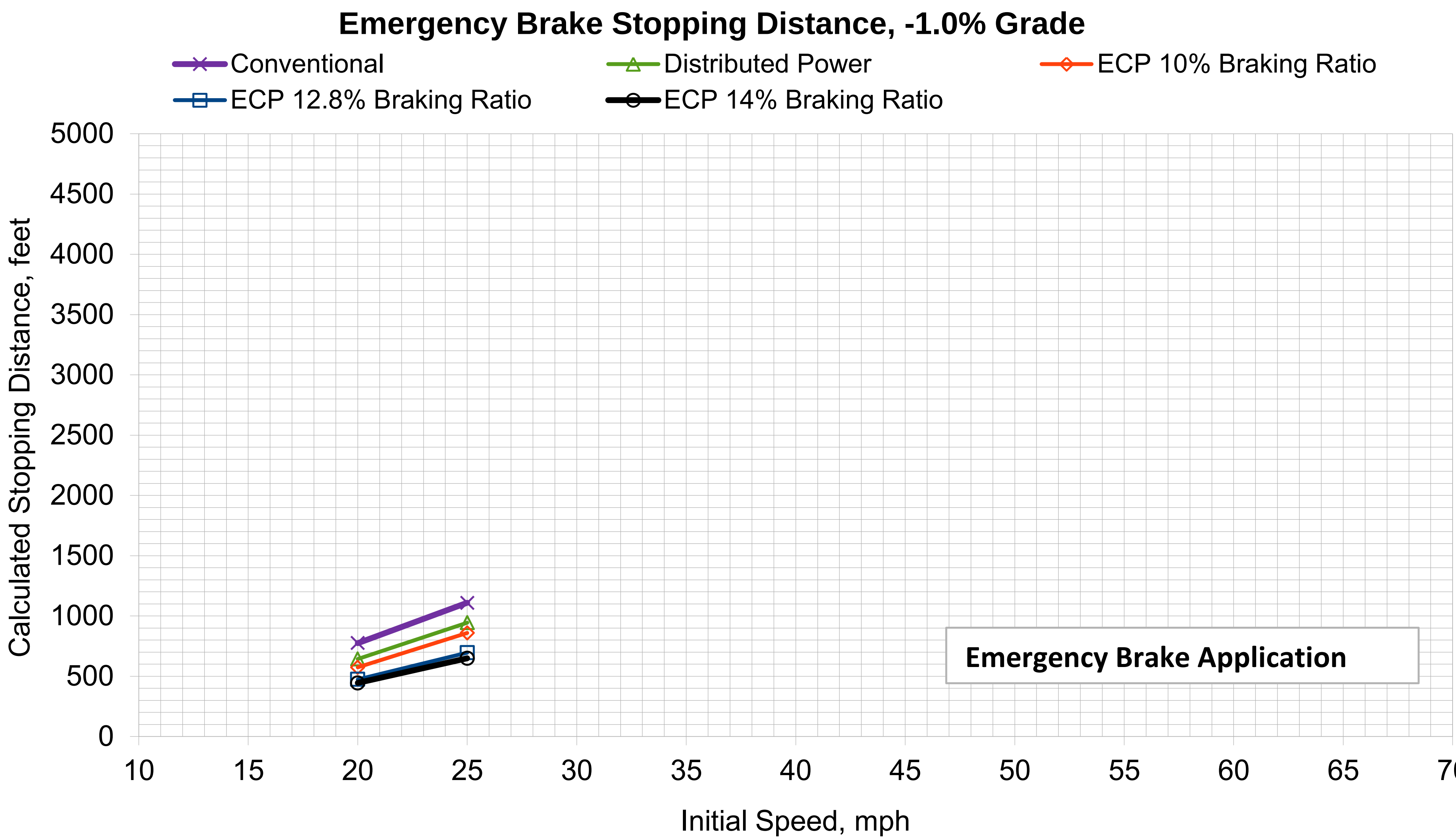
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



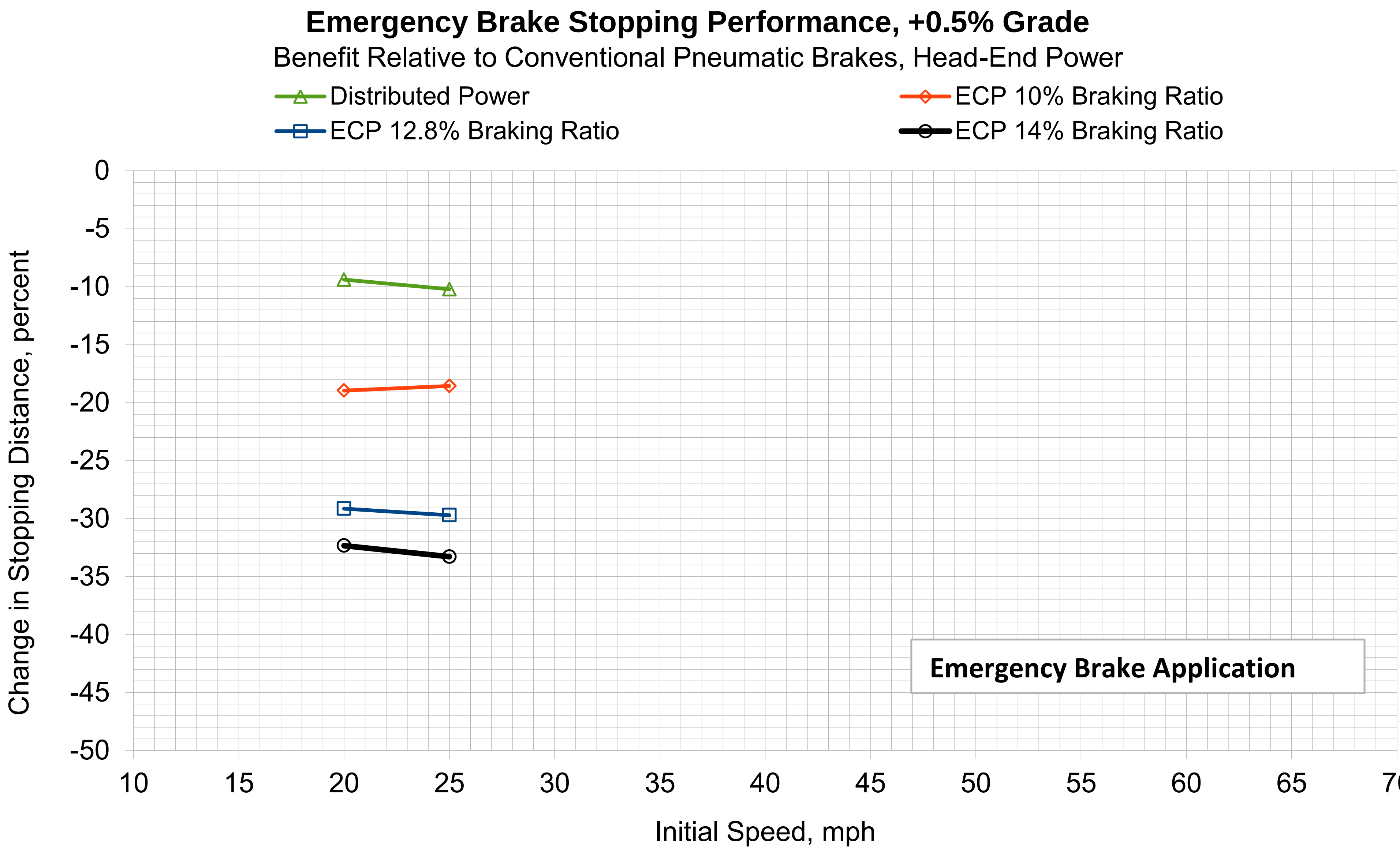
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



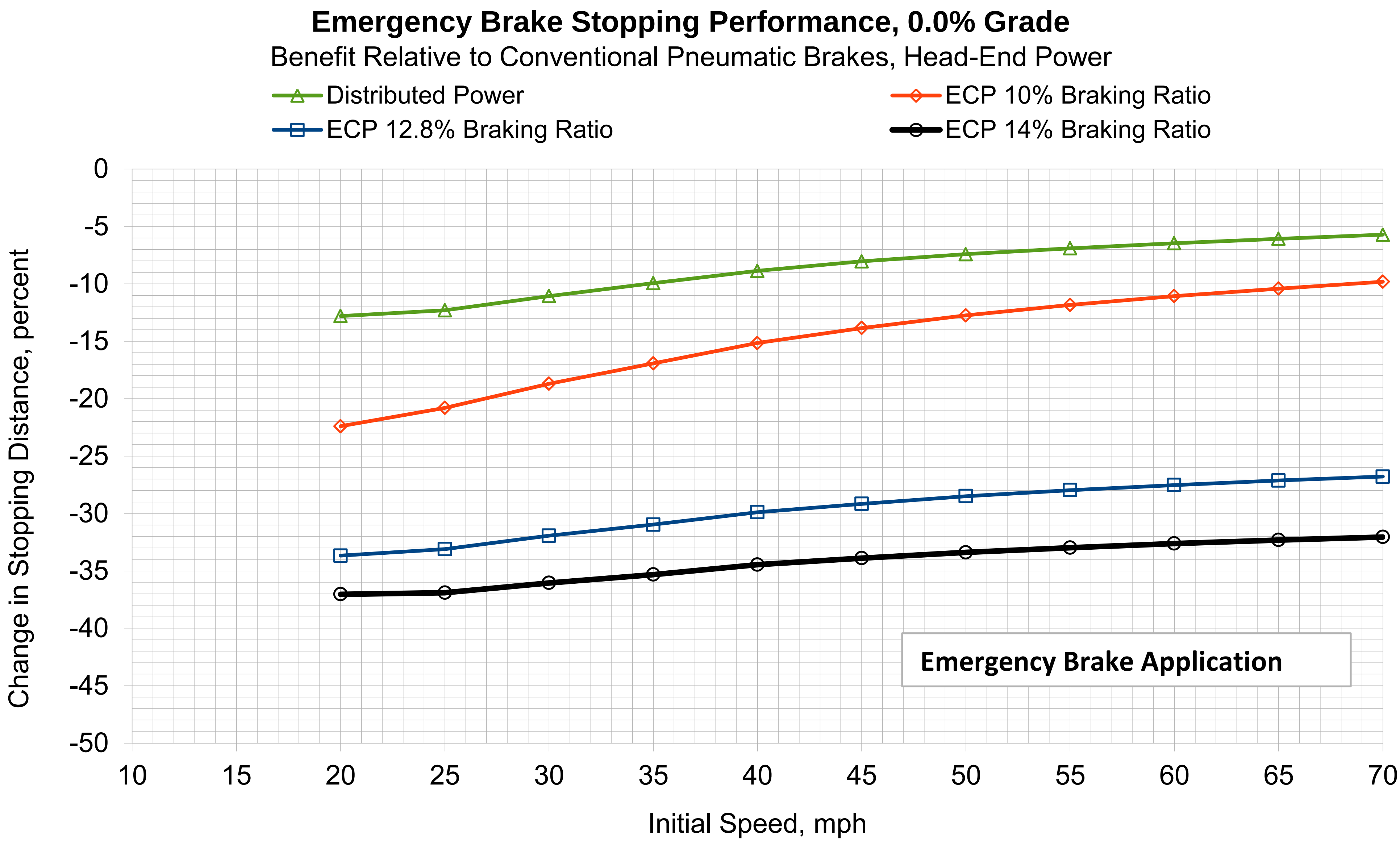
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



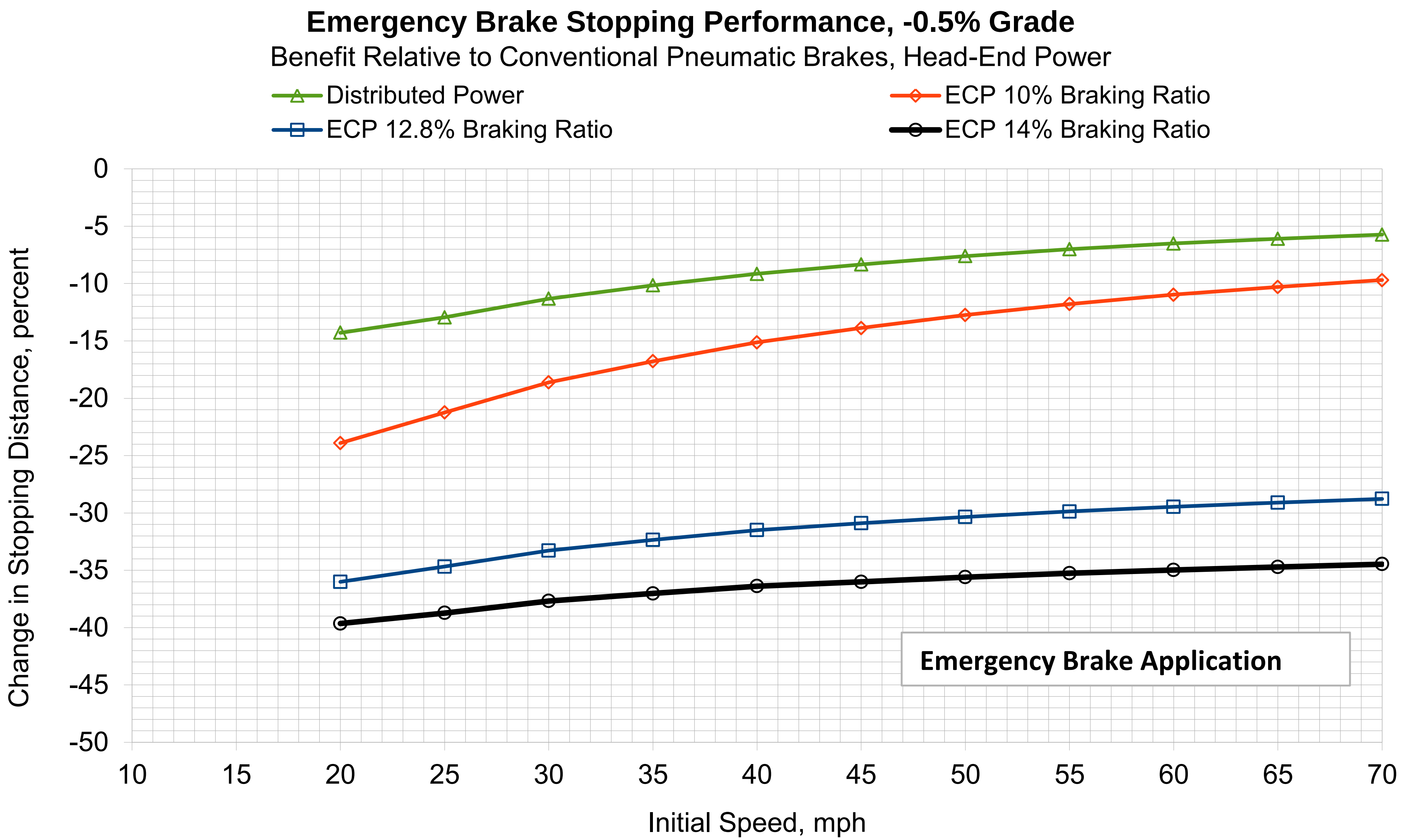
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



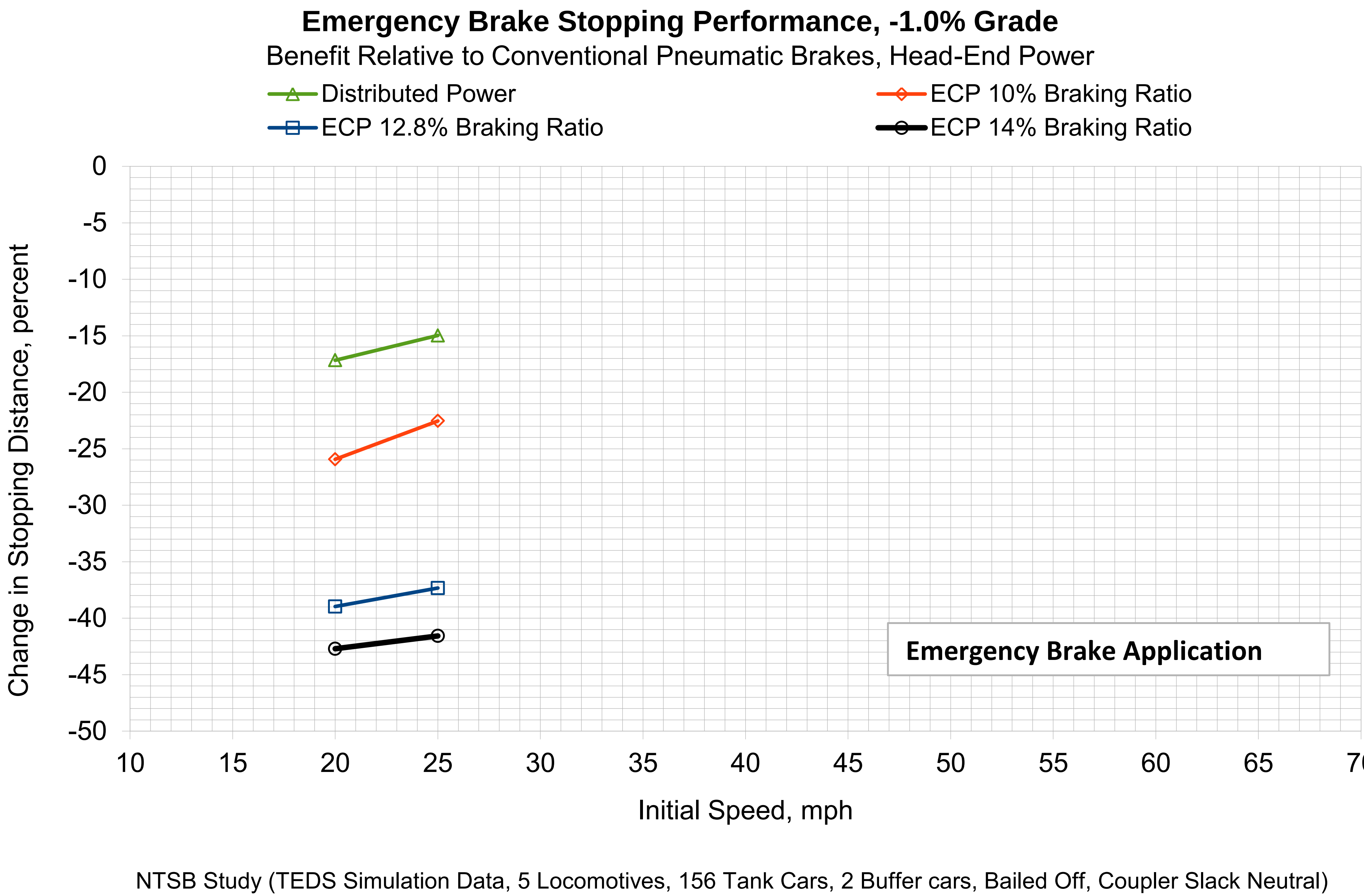
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



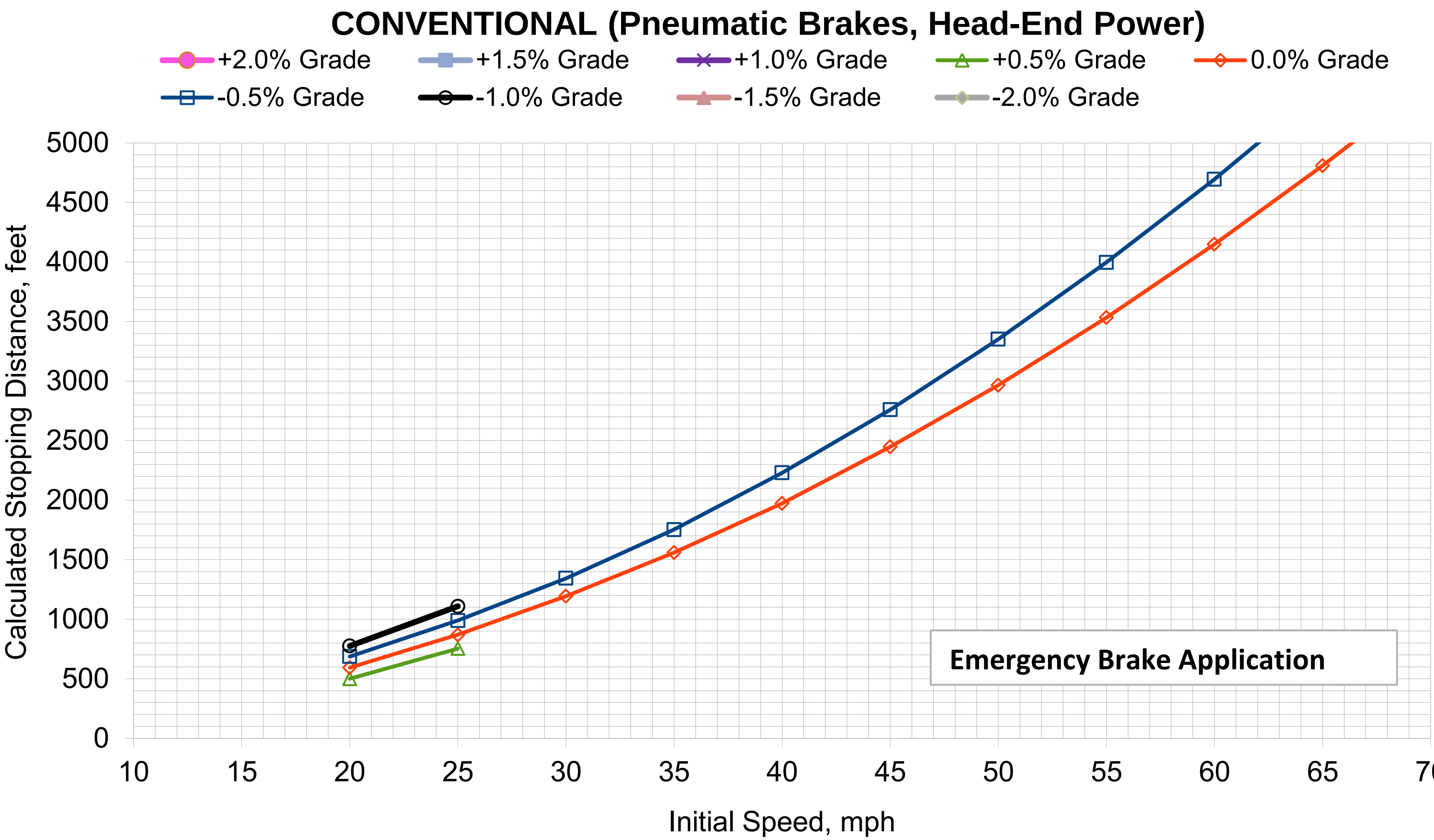
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



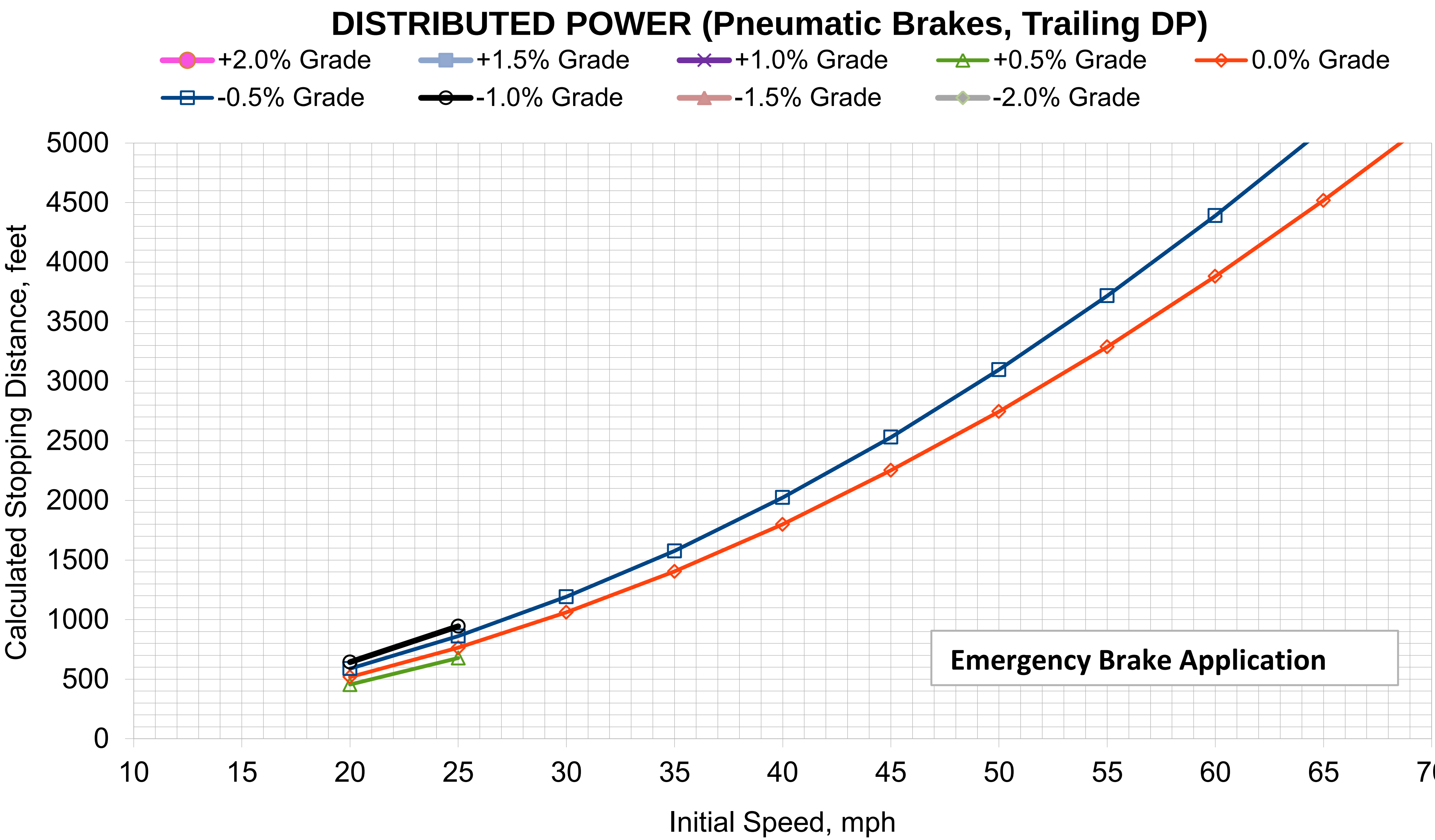
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



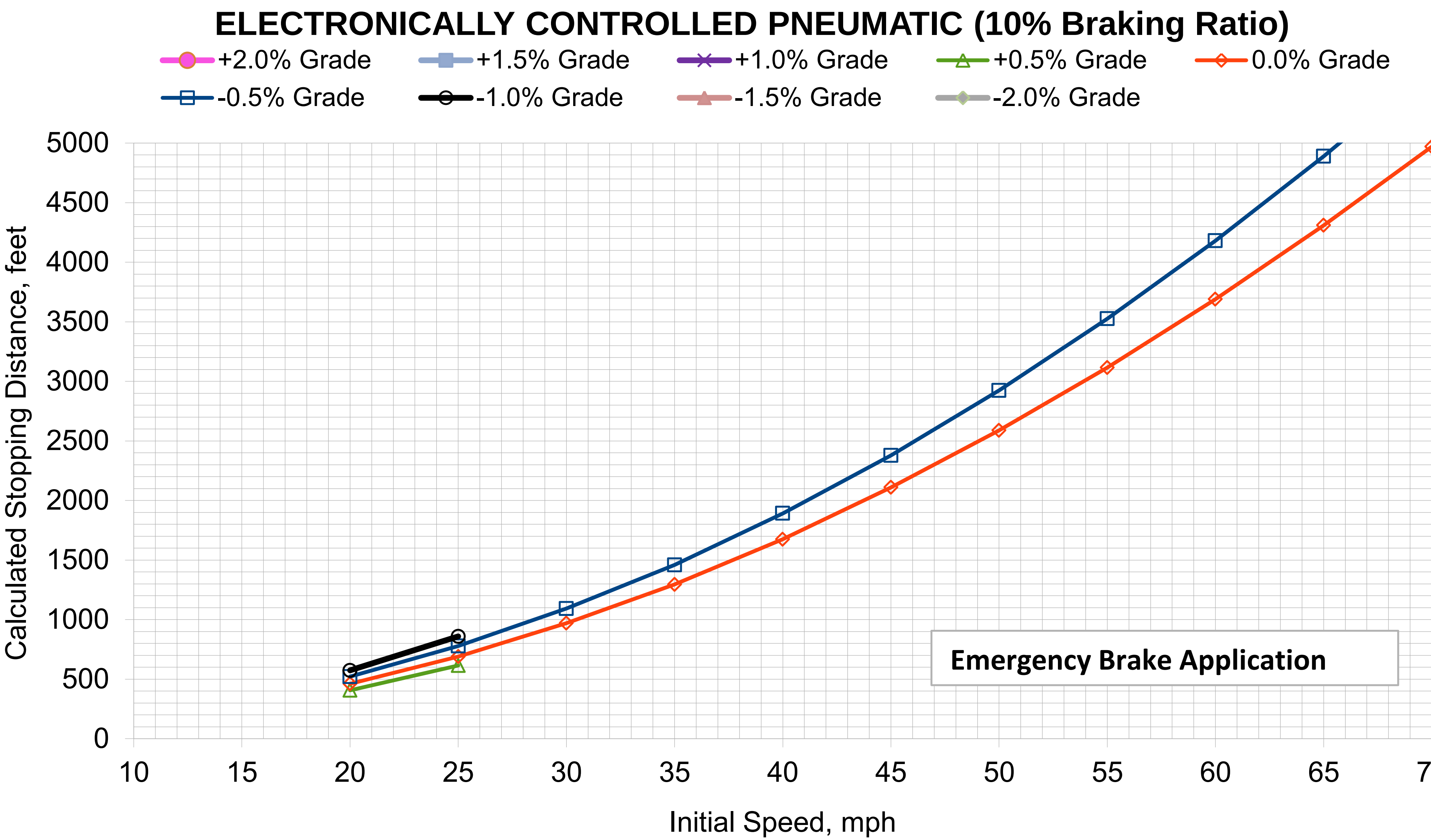
Emergency Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



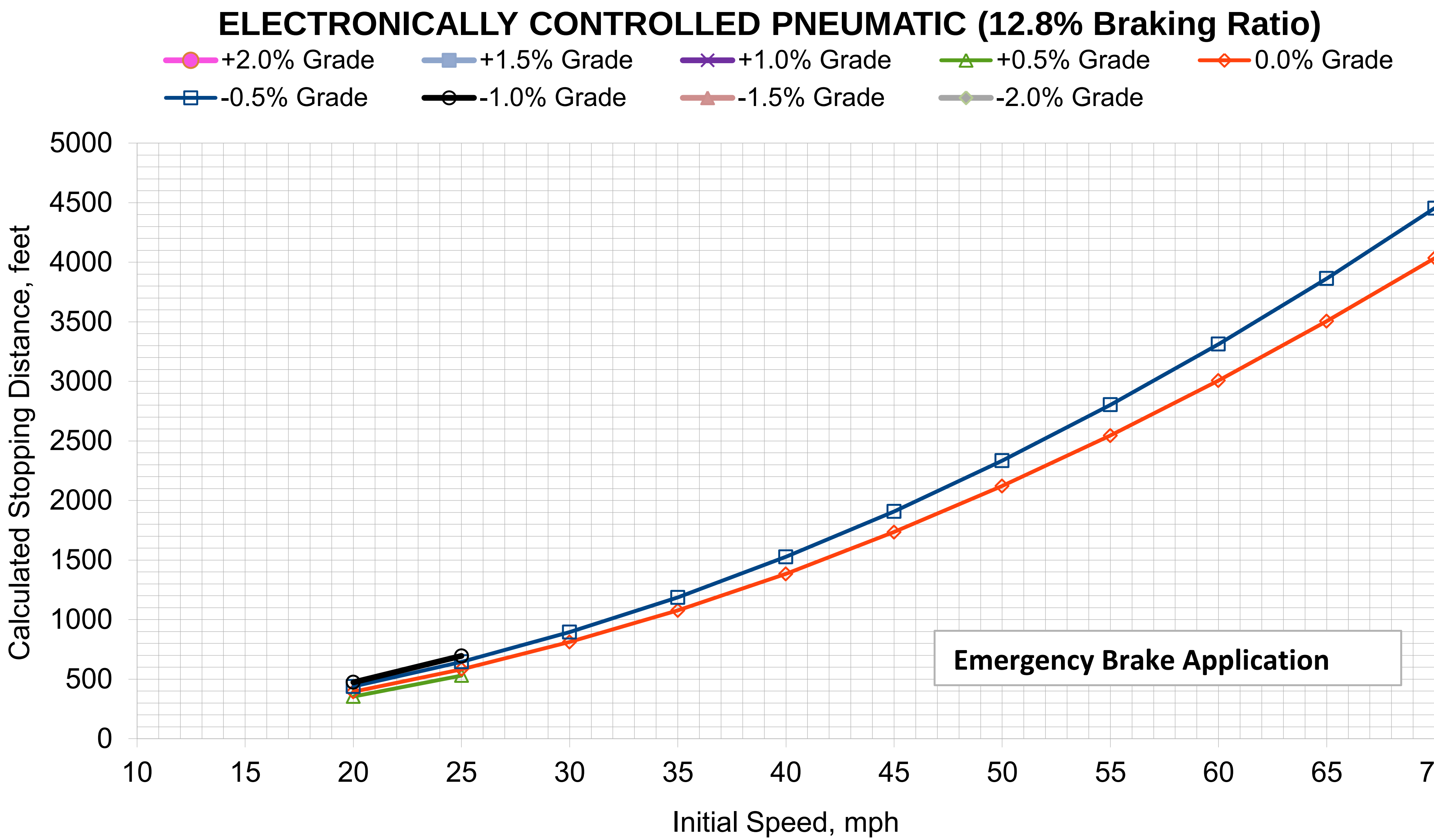
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



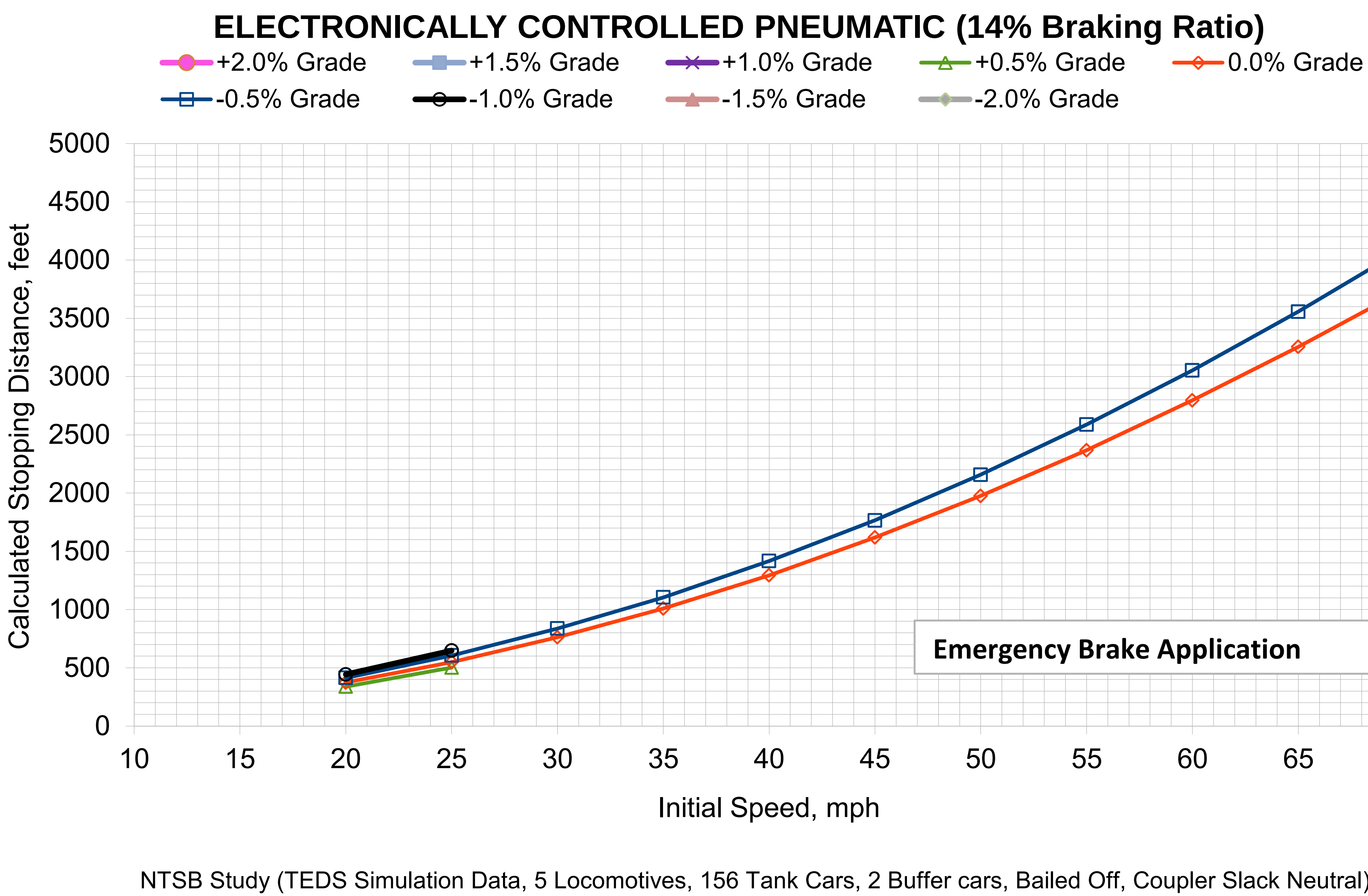
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

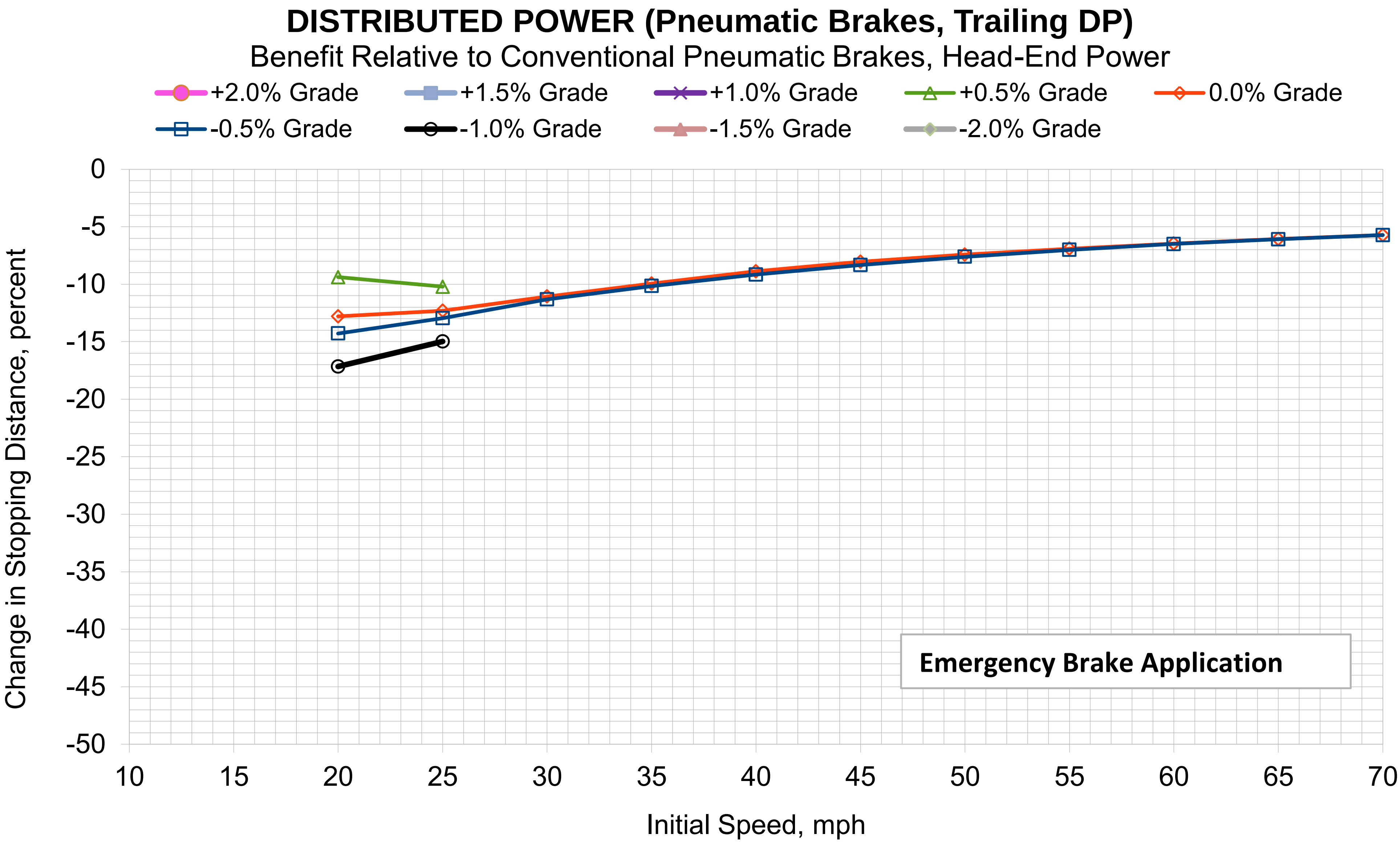


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

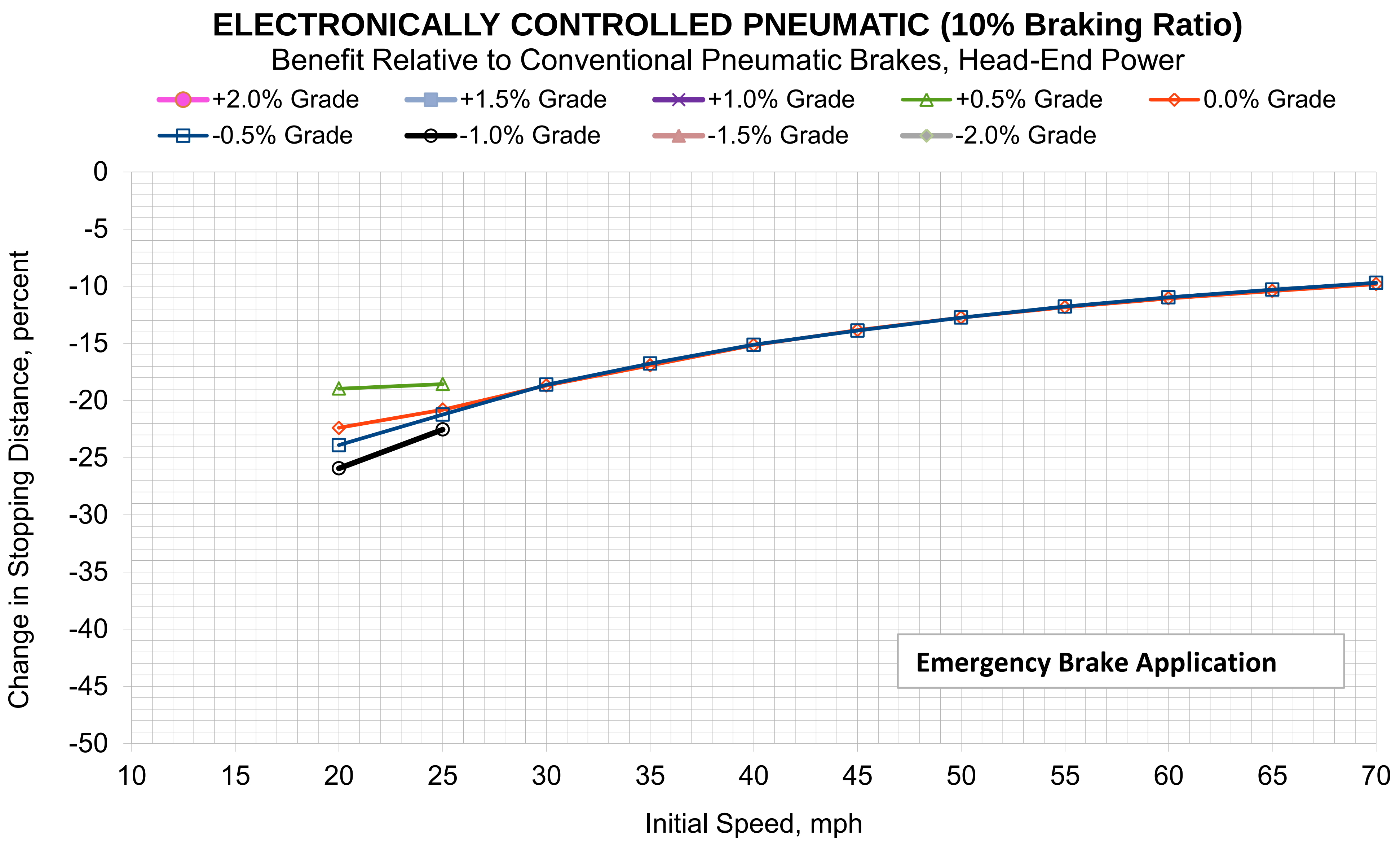


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

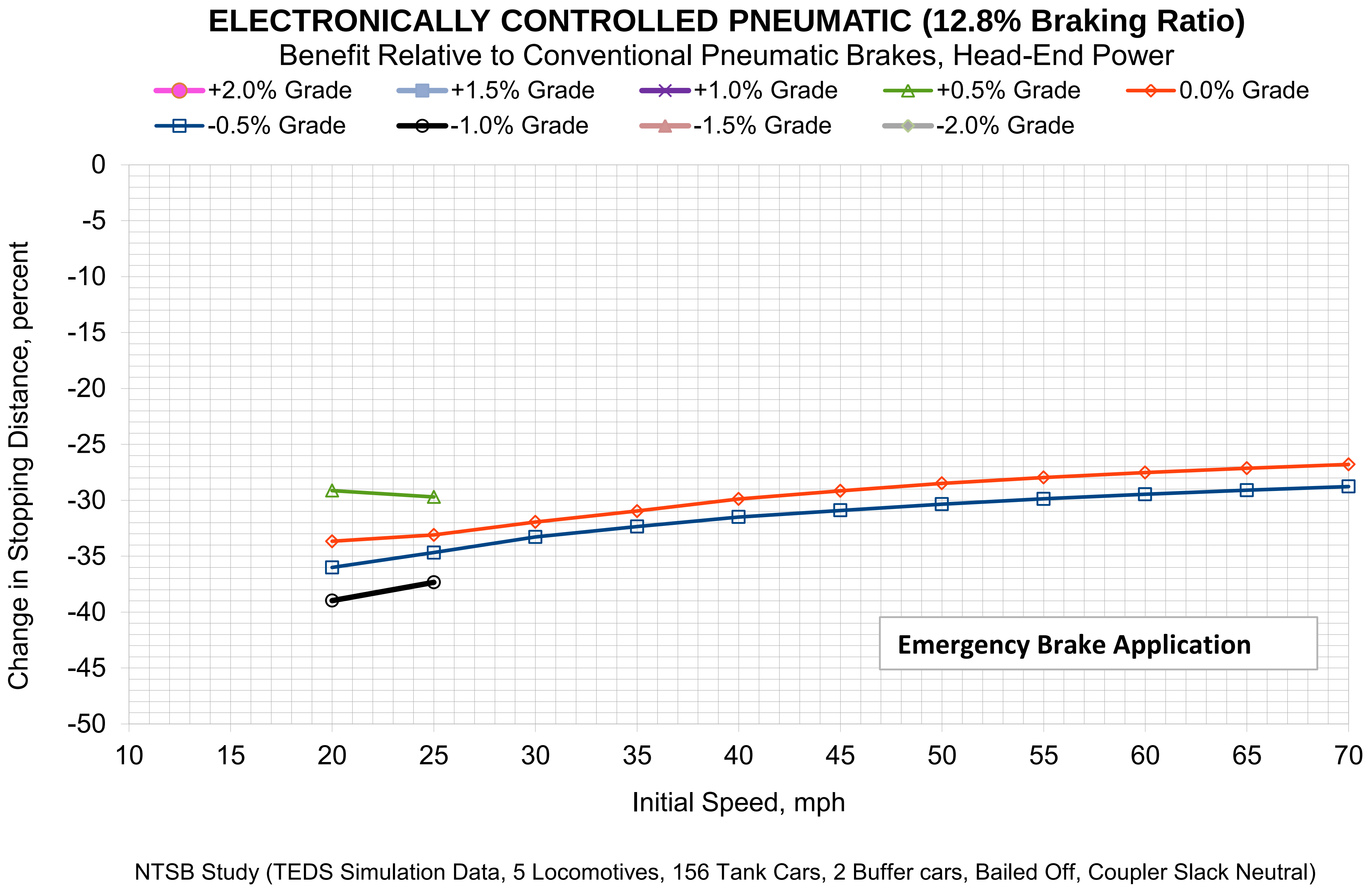

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

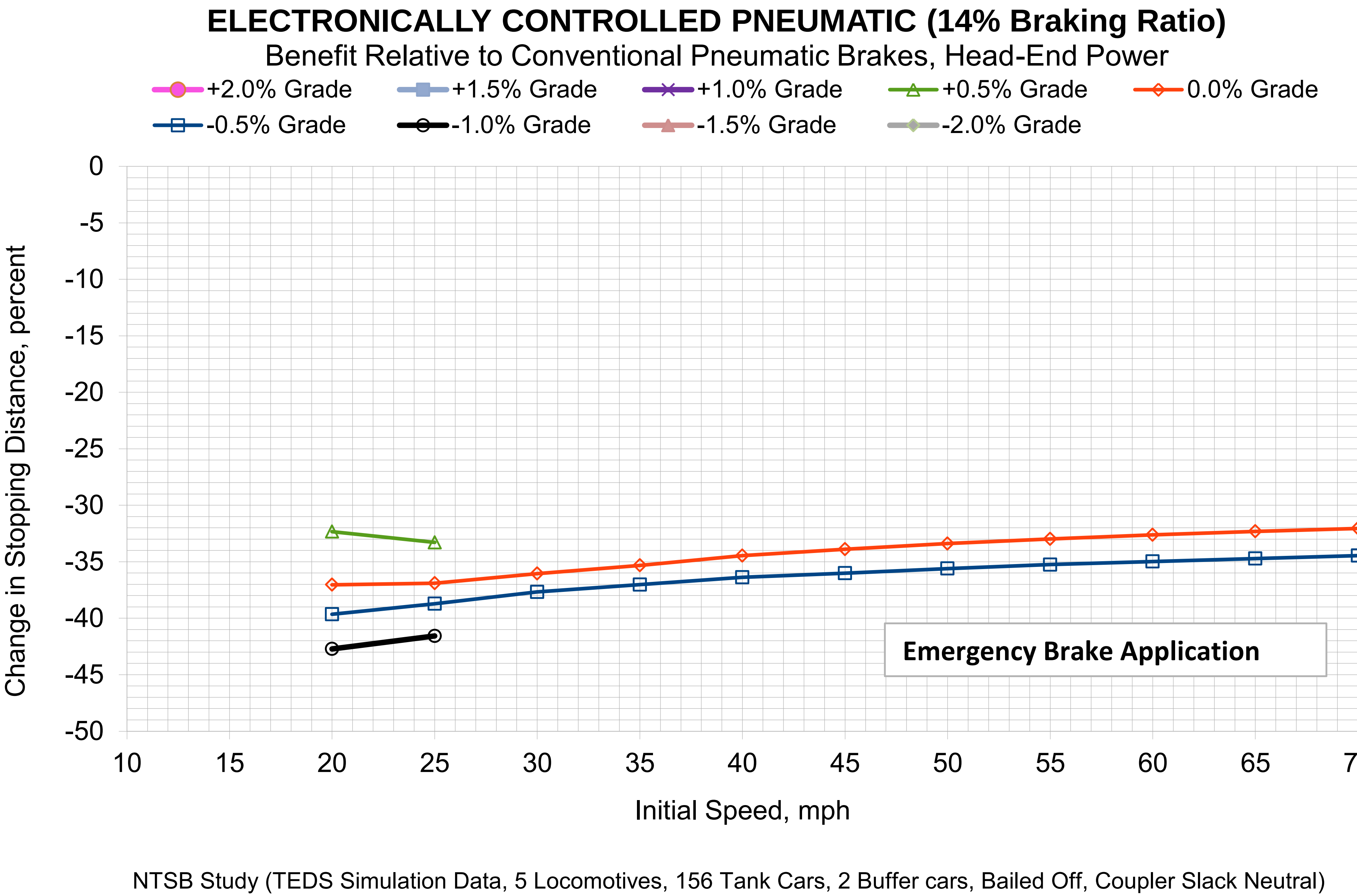


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



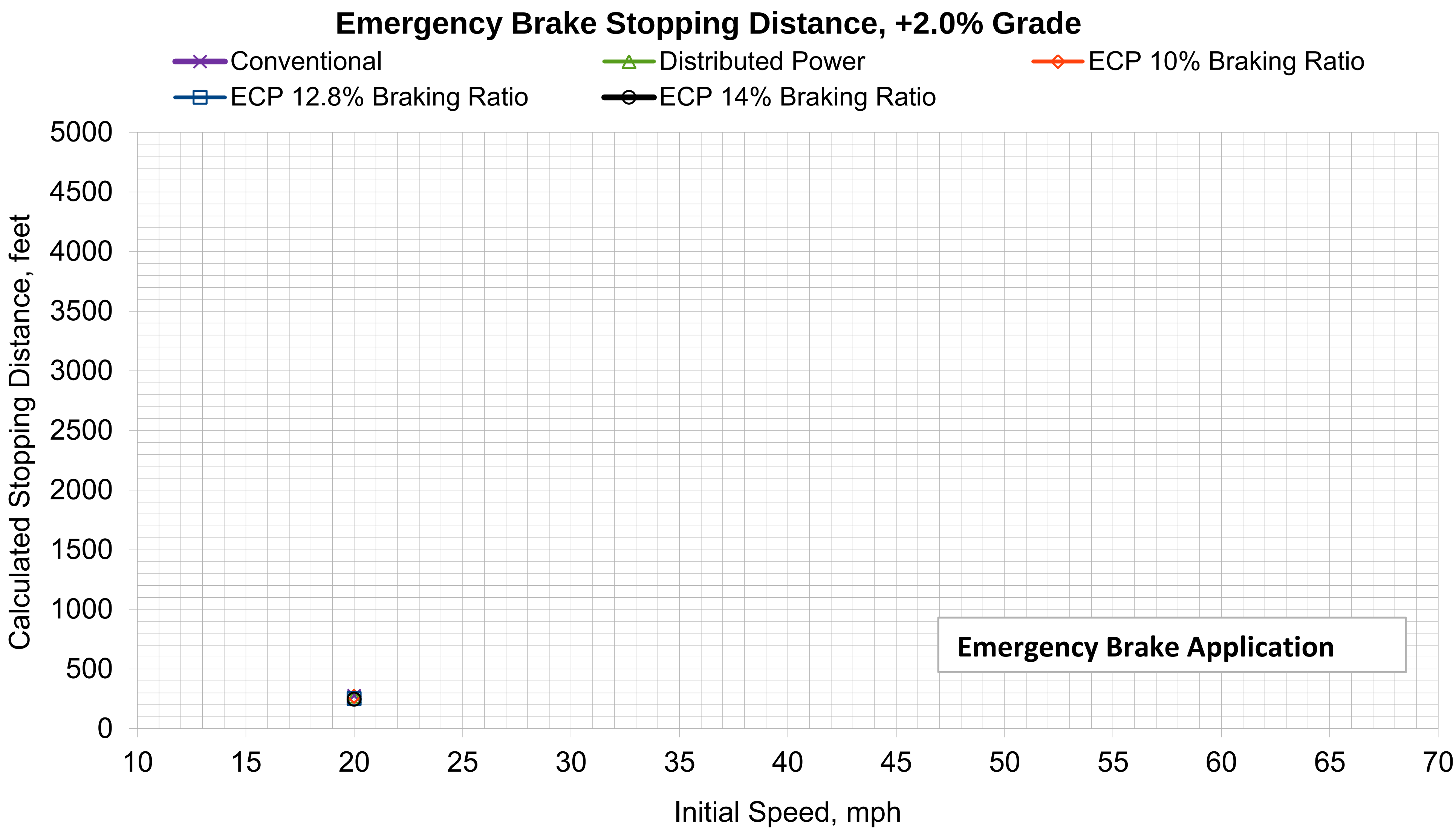
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

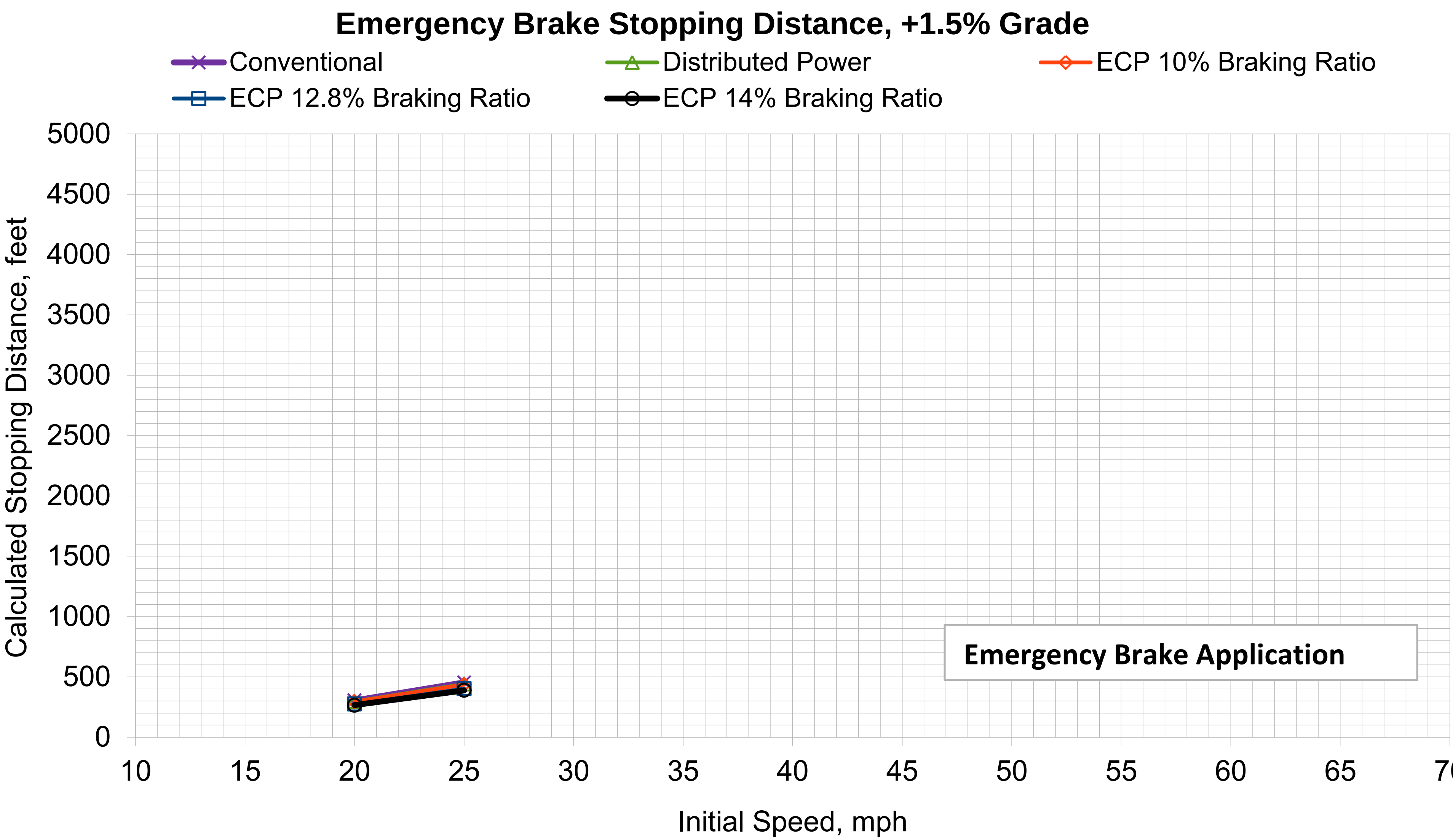


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

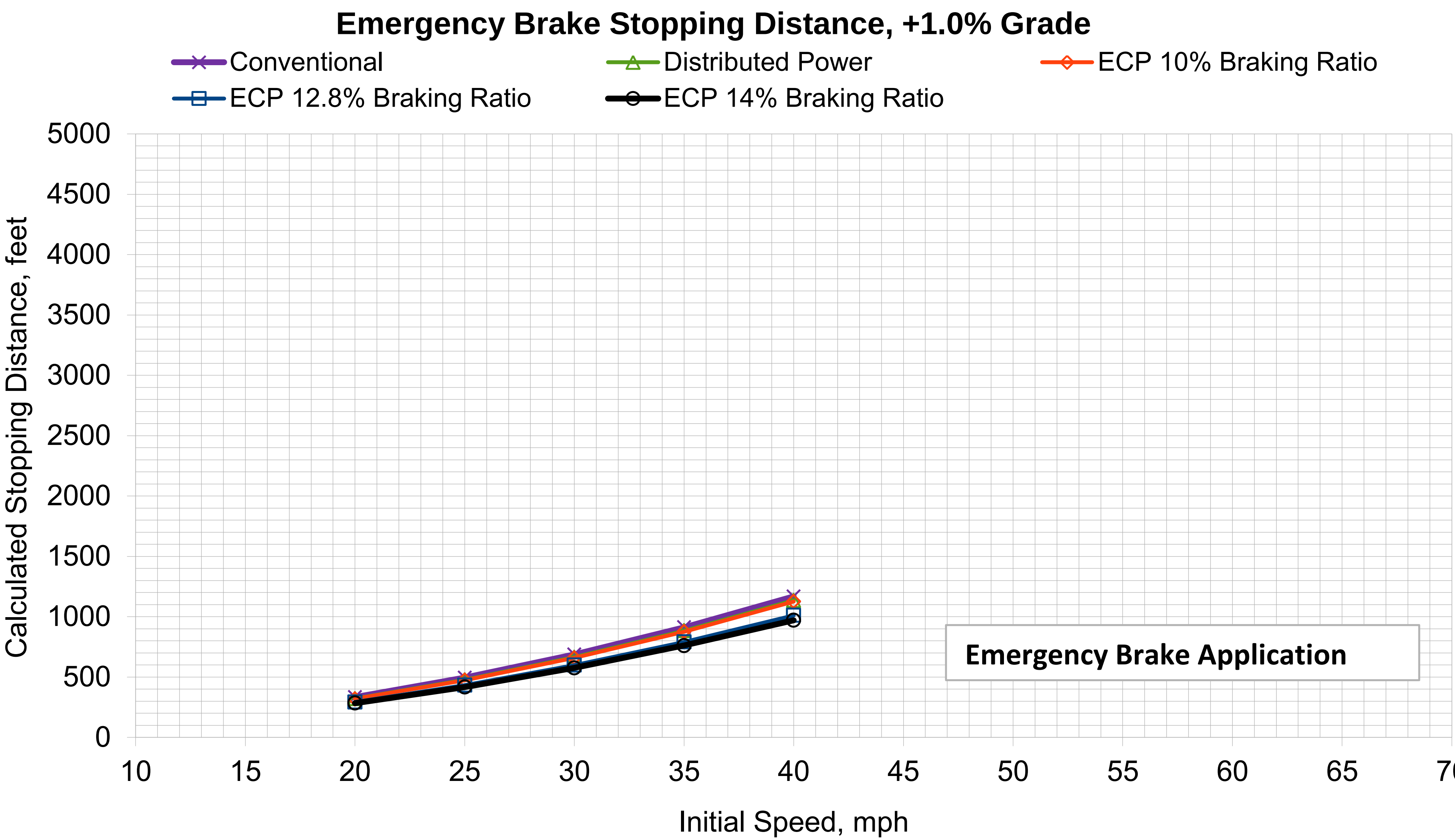
Attachment 12: Emergency Braking, No Bailoff, 52 Tank Cars



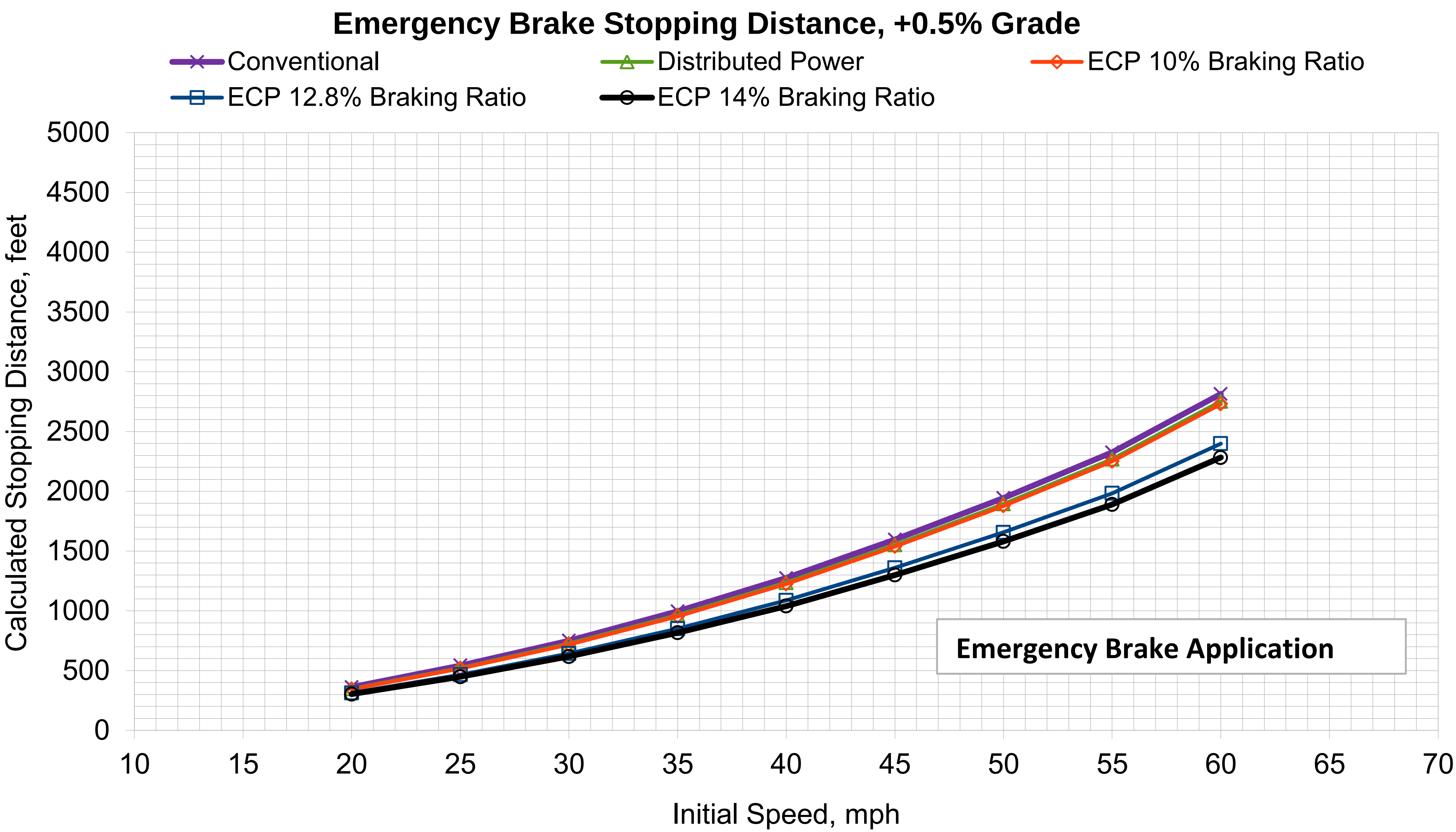
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



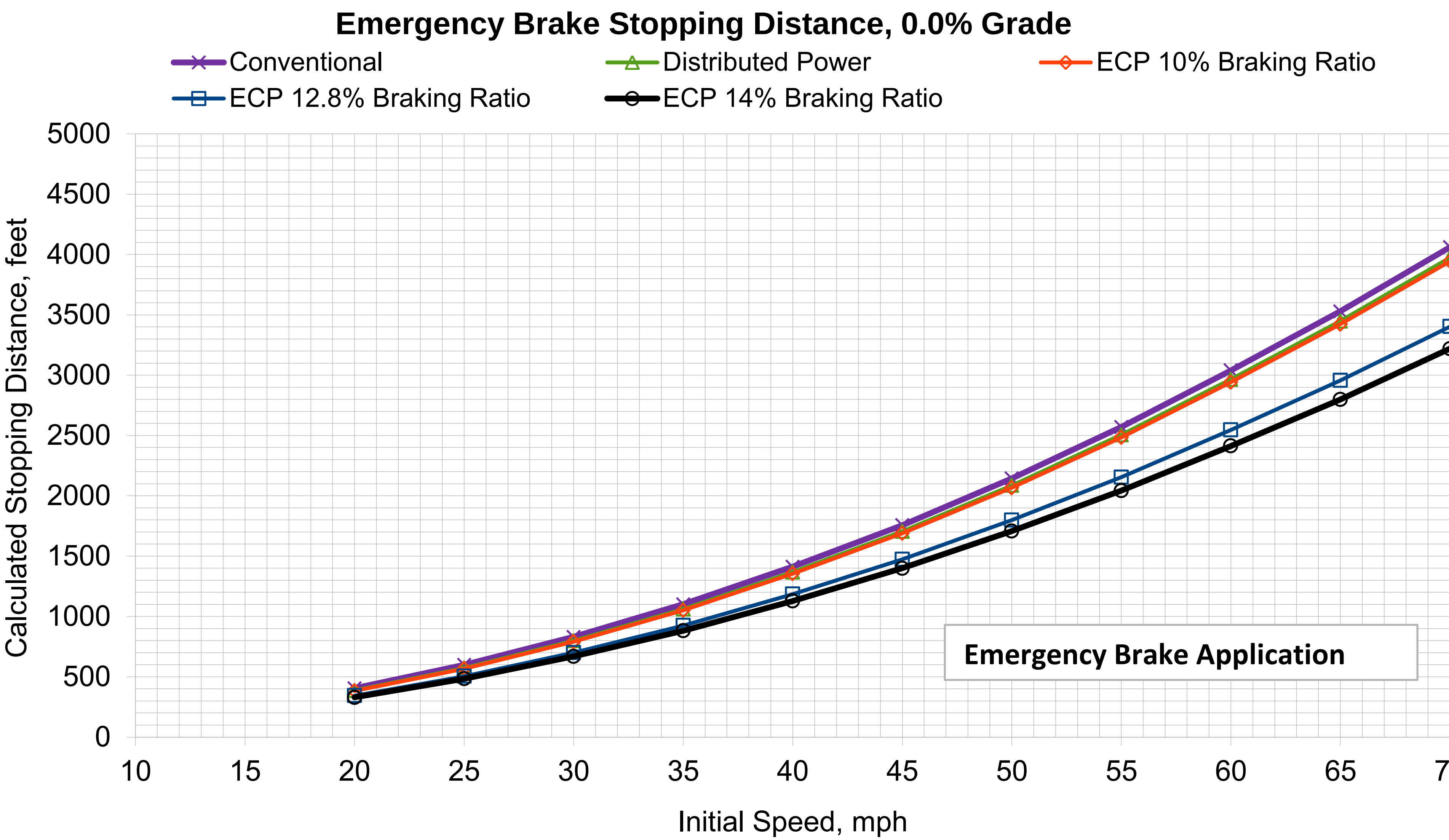
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



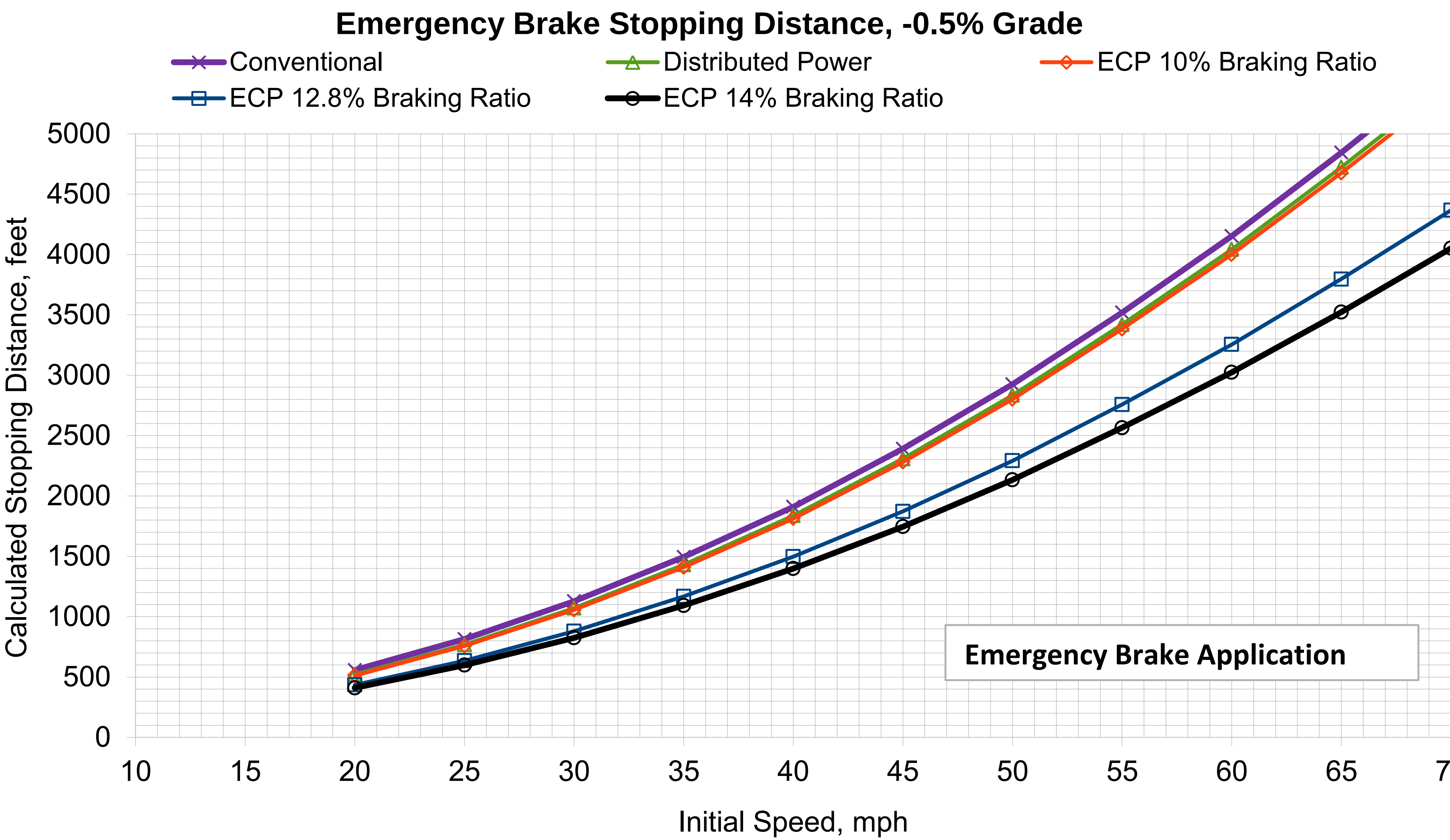
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



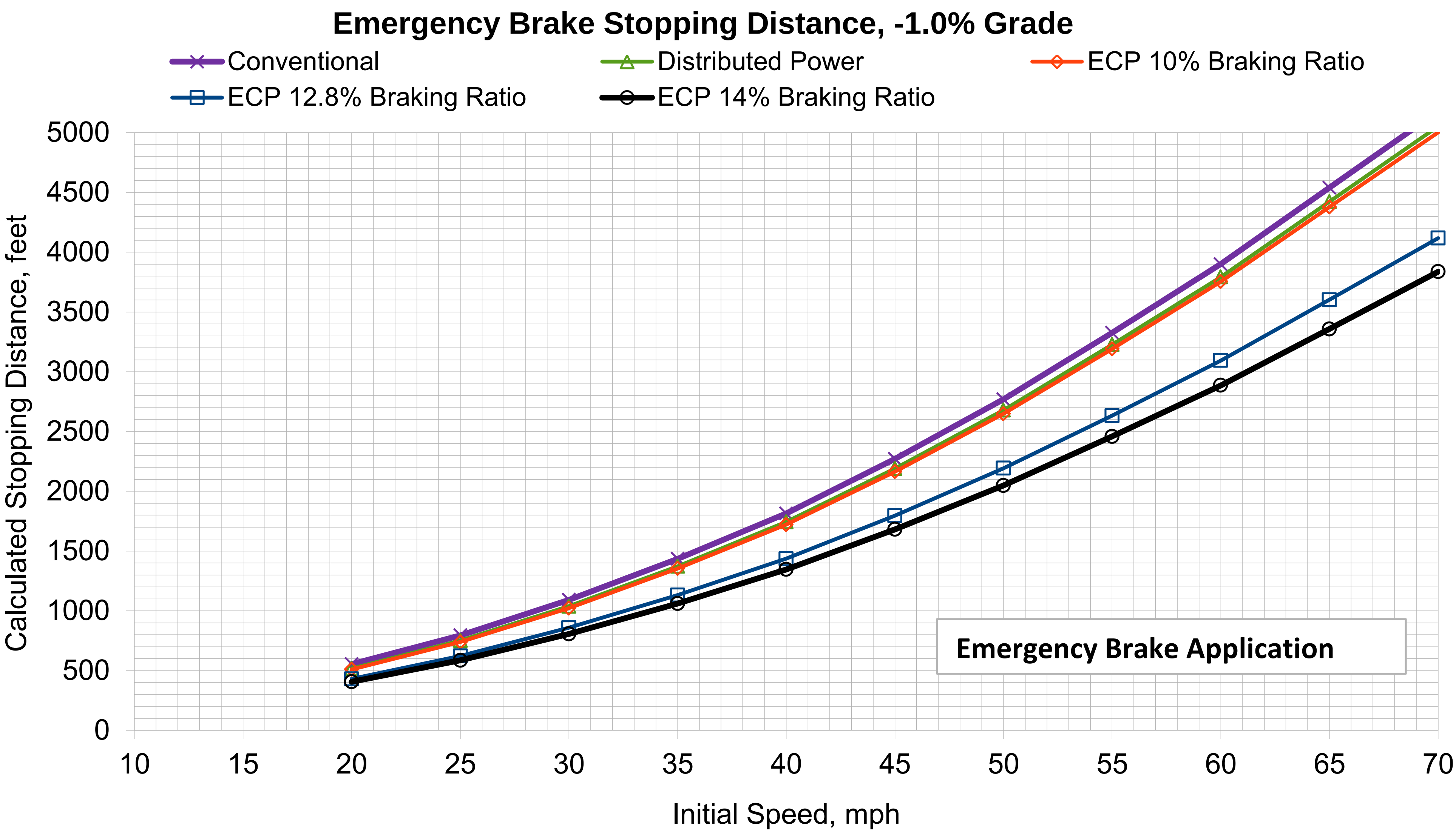
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



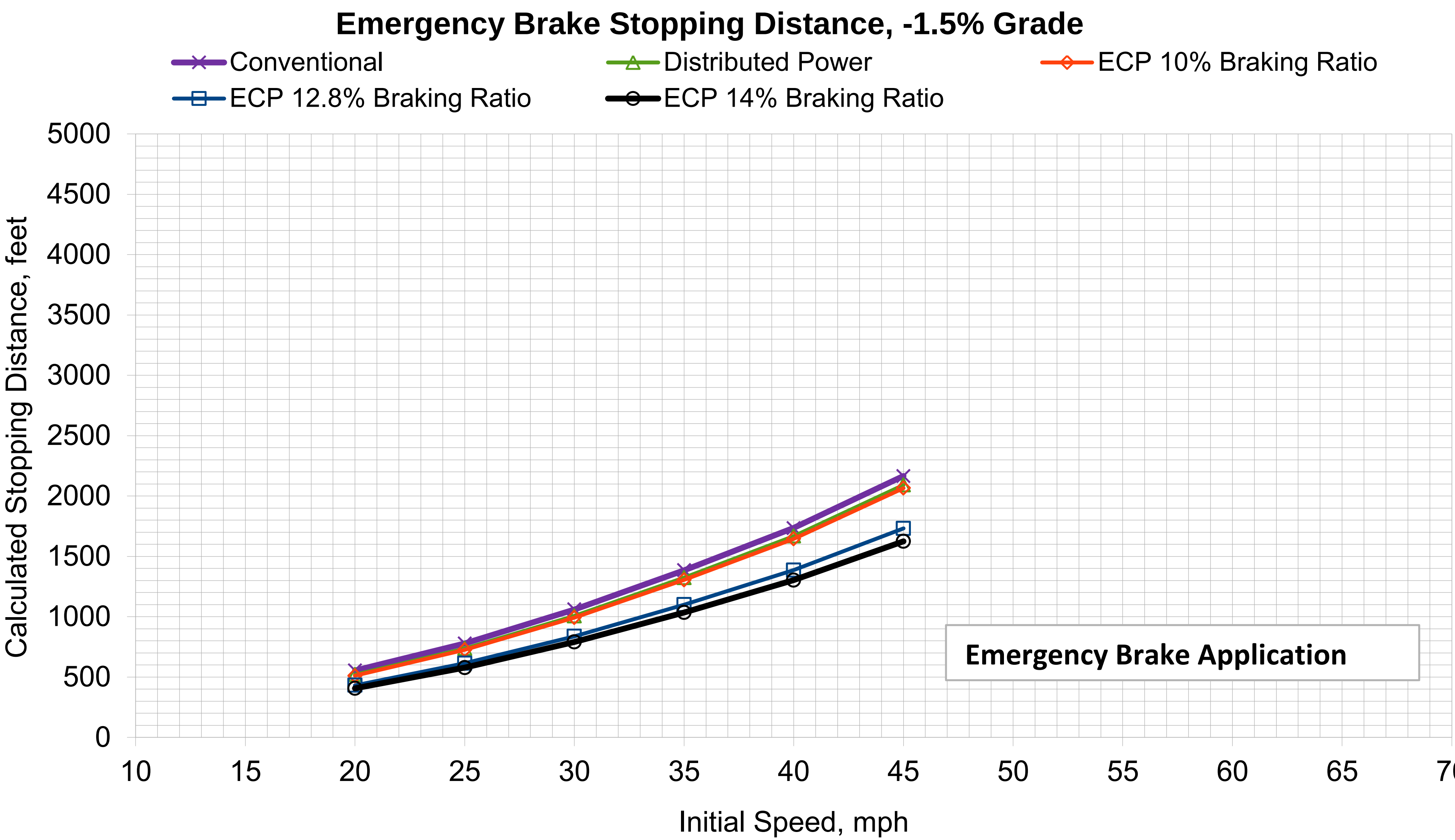
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



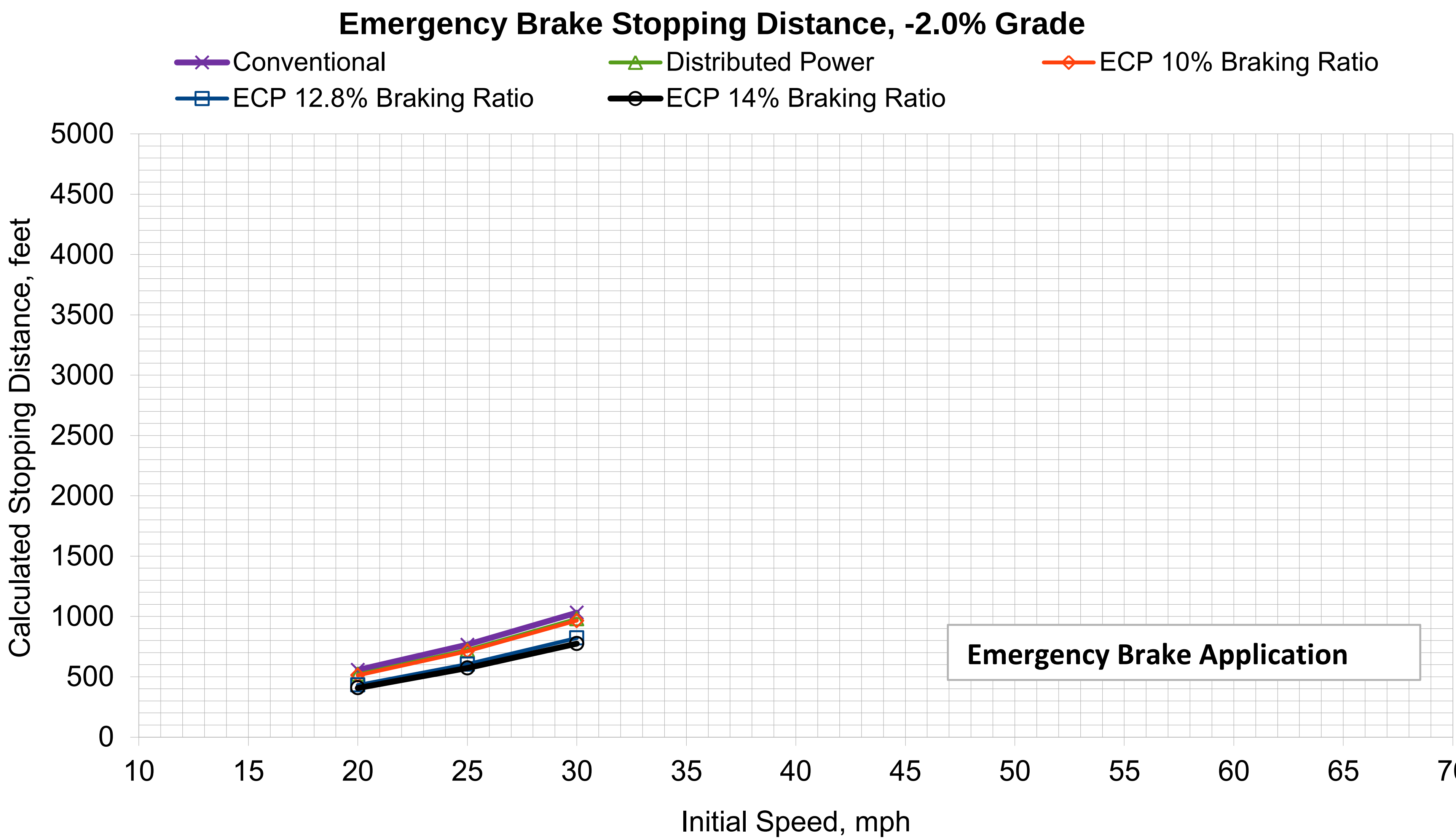
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



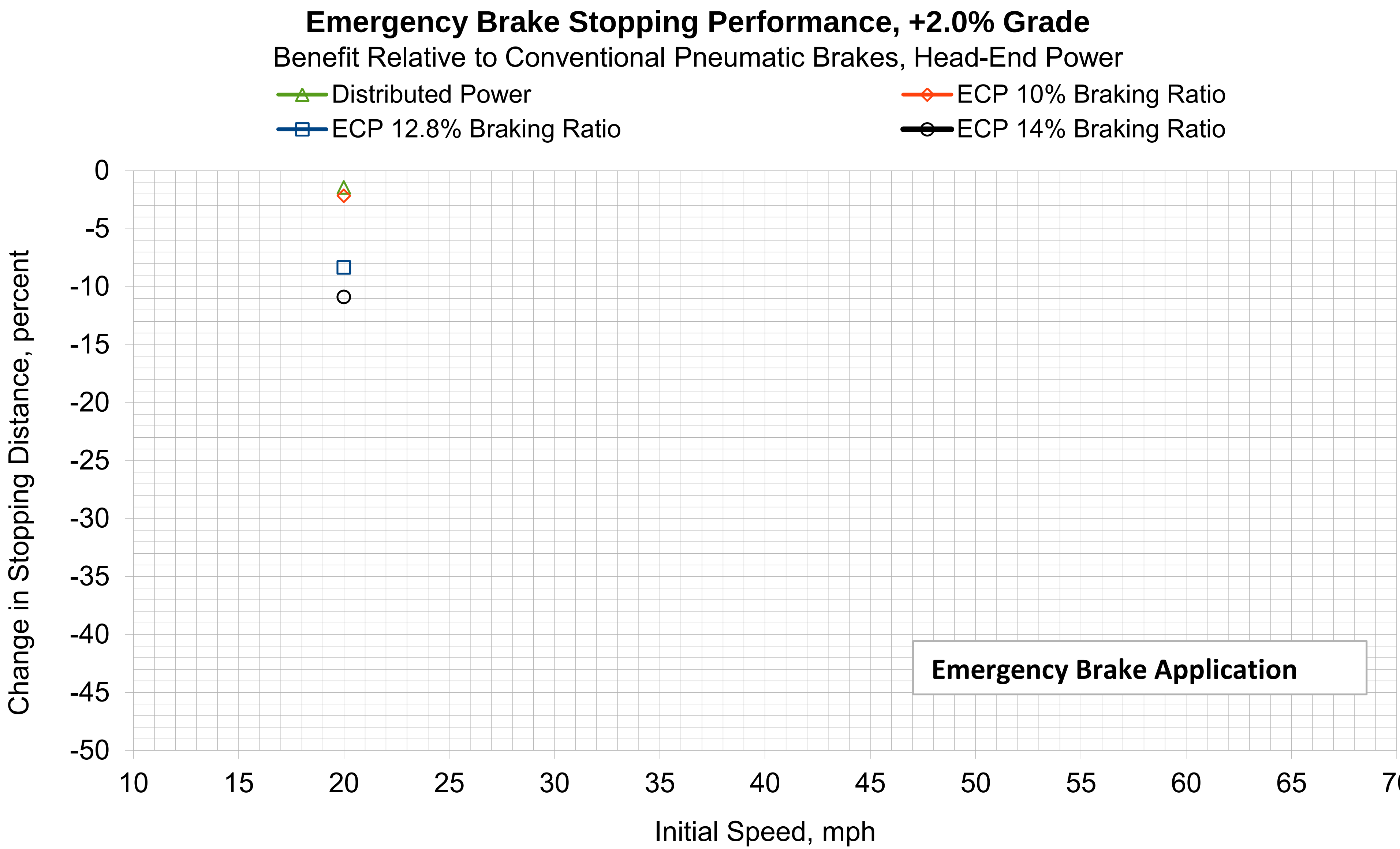
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



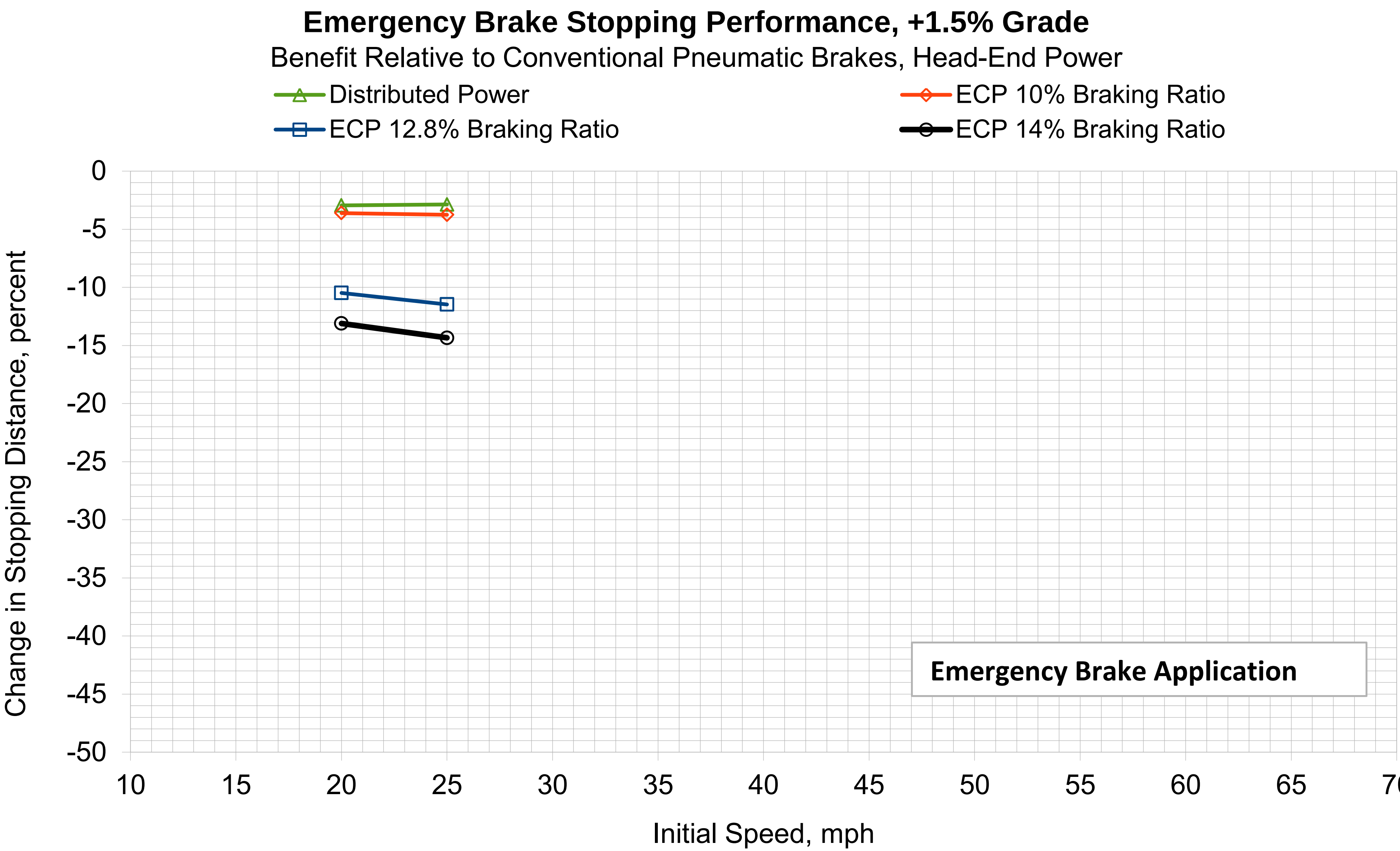
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



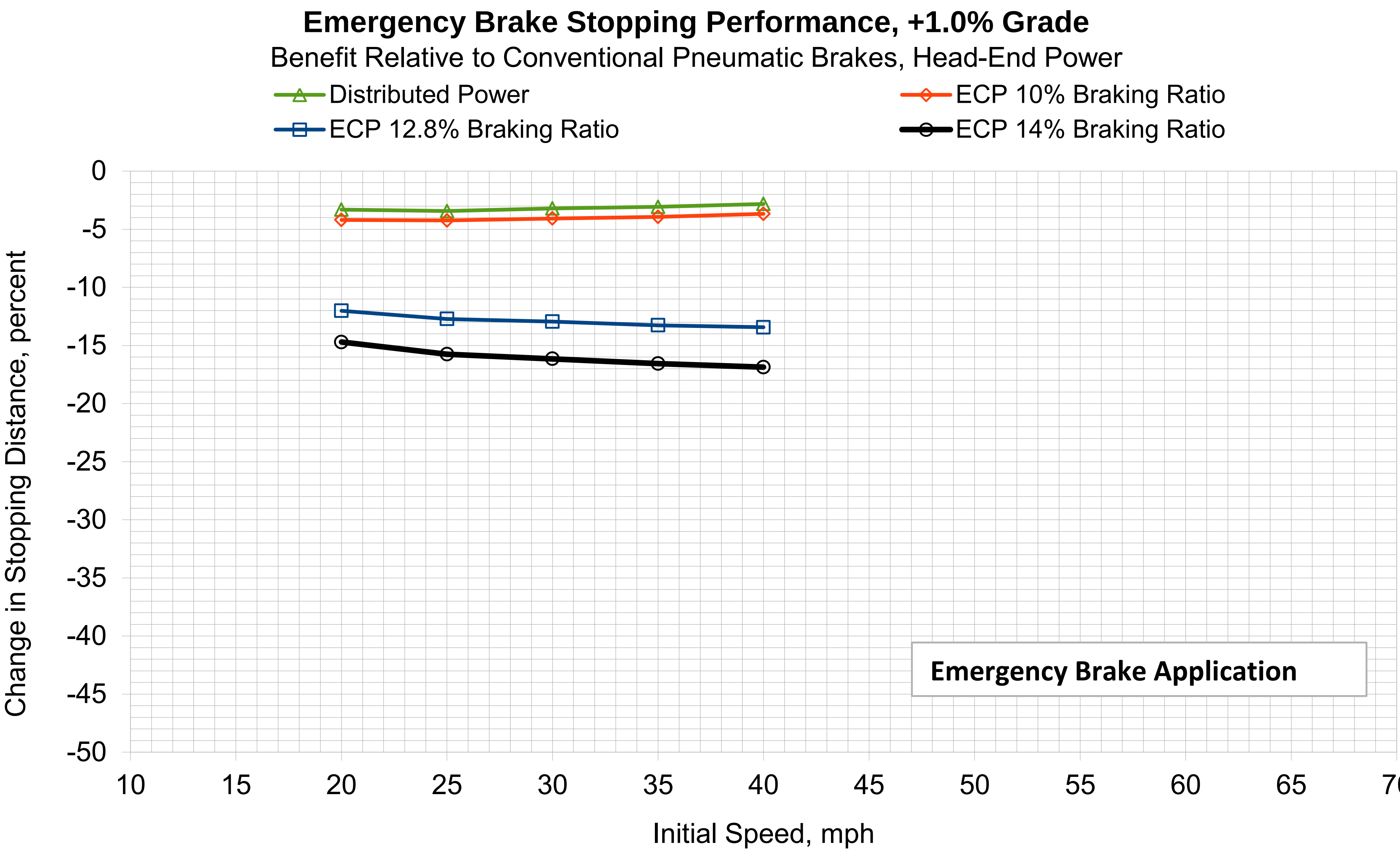
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



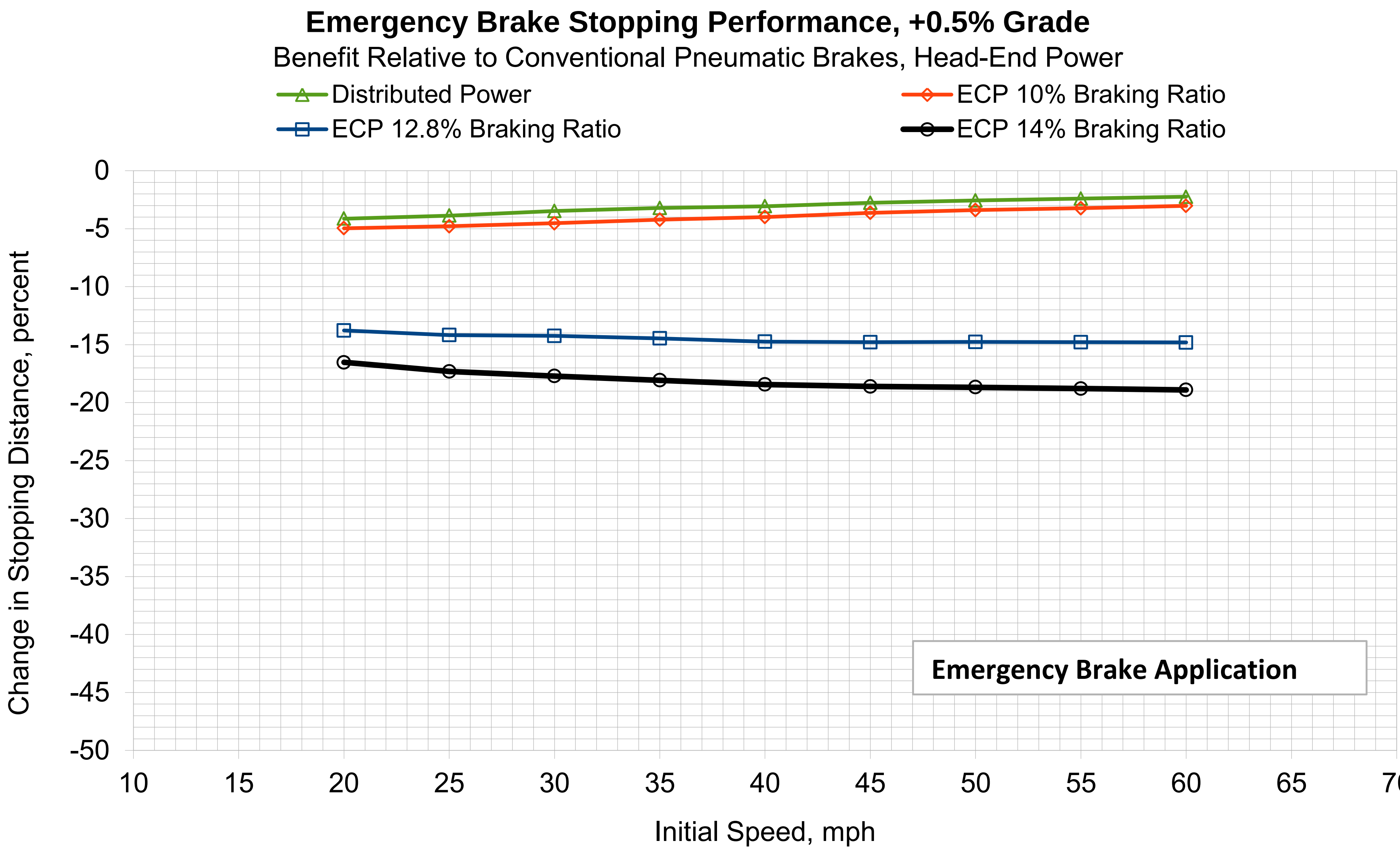
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



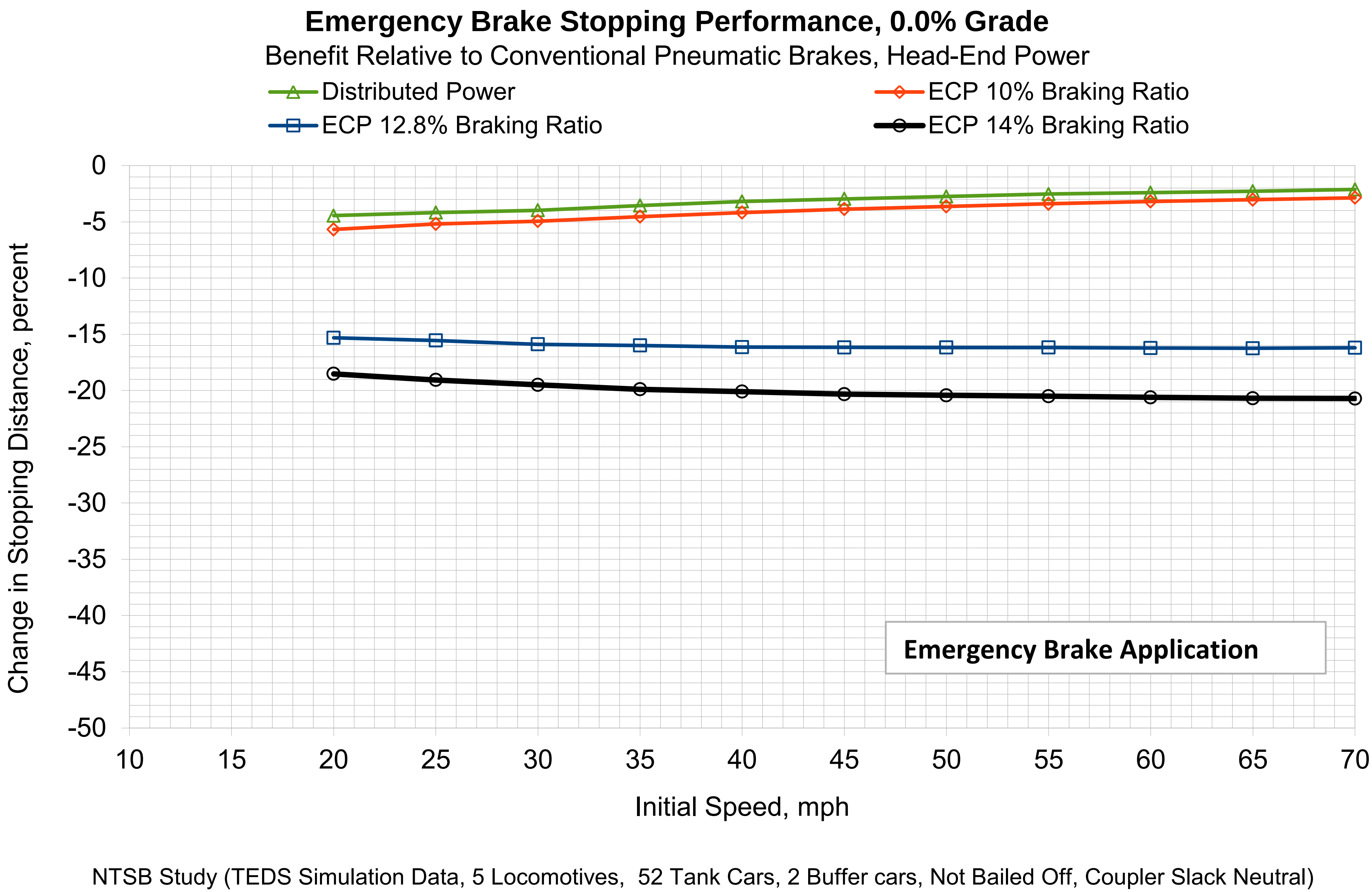
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

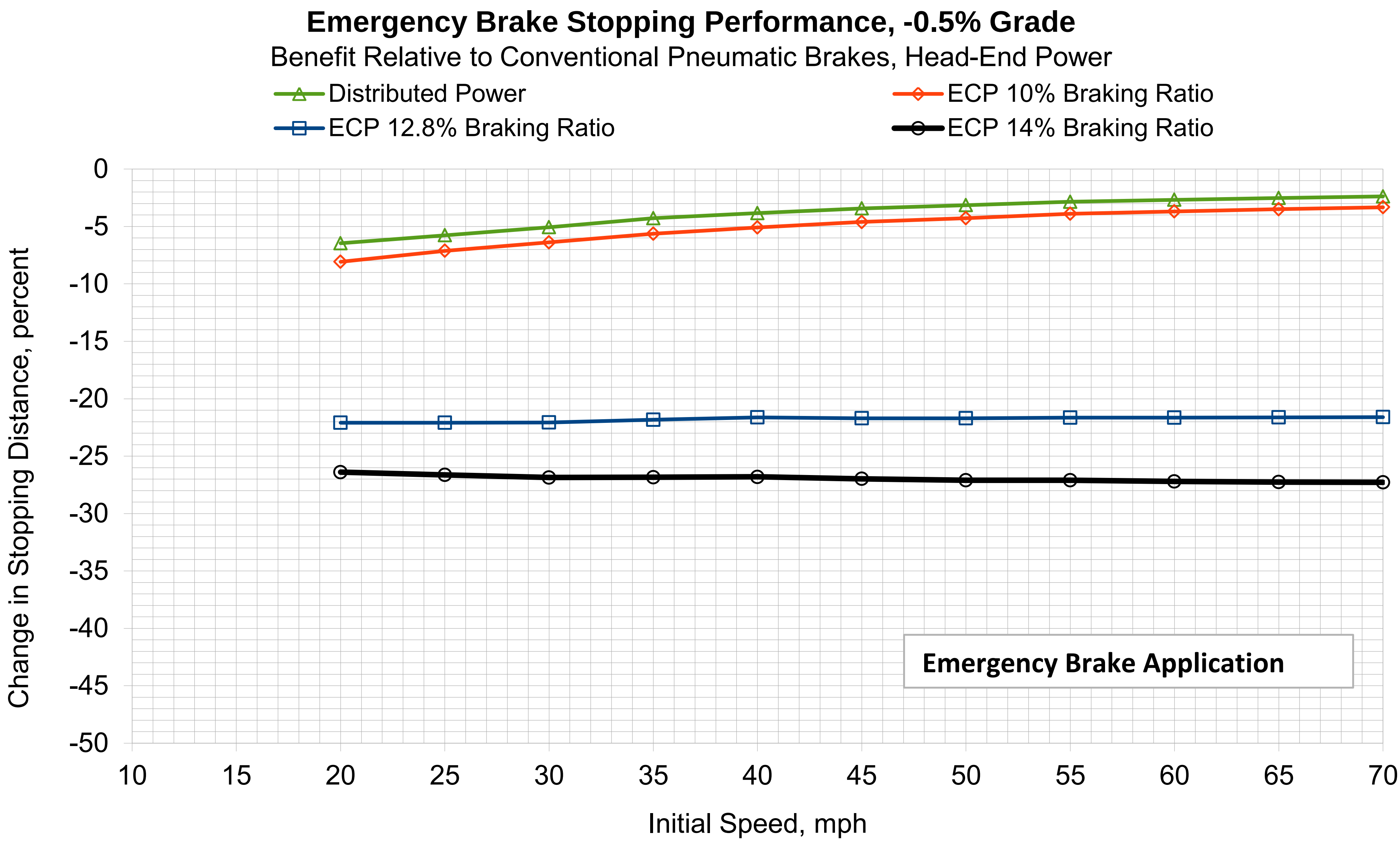


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

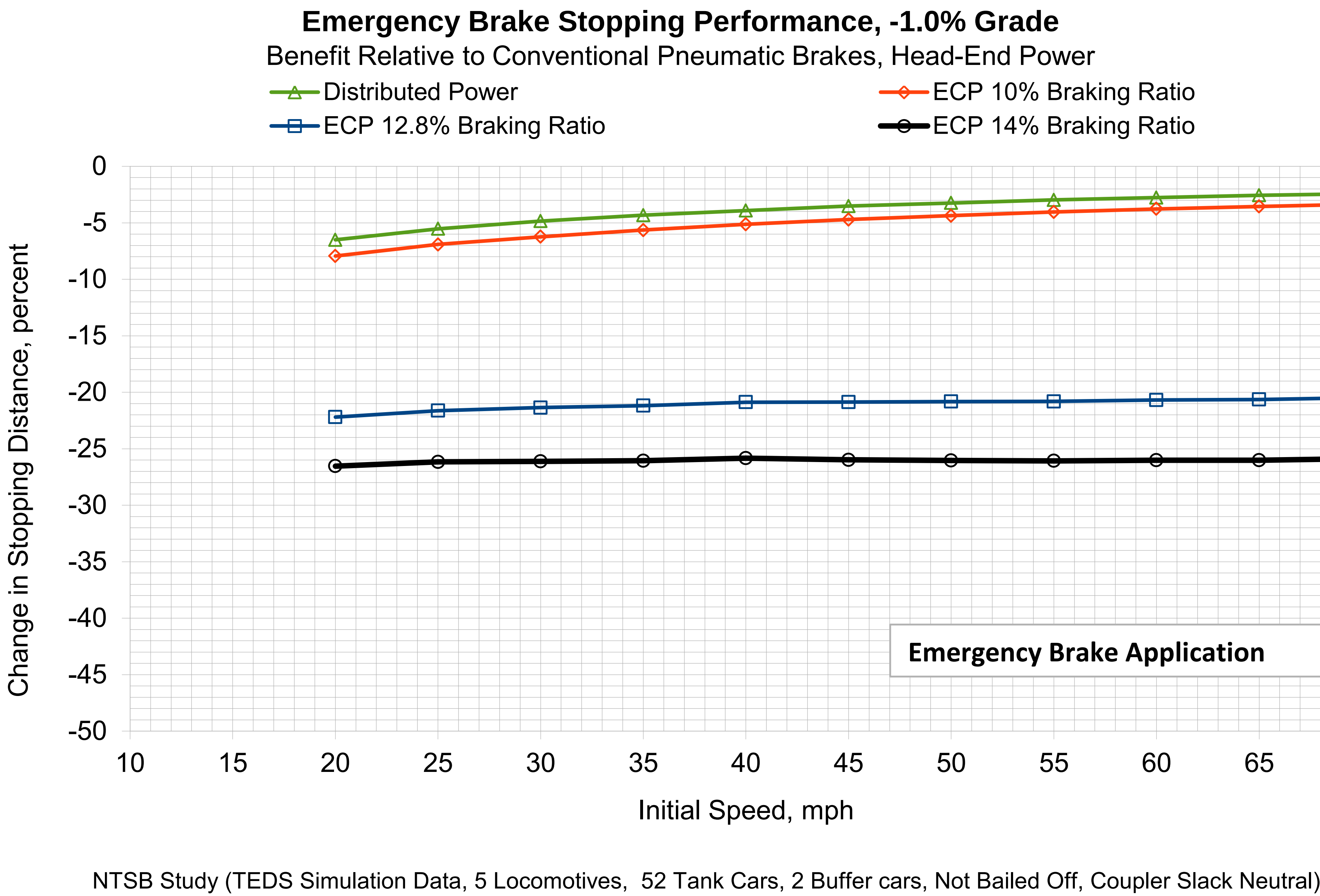


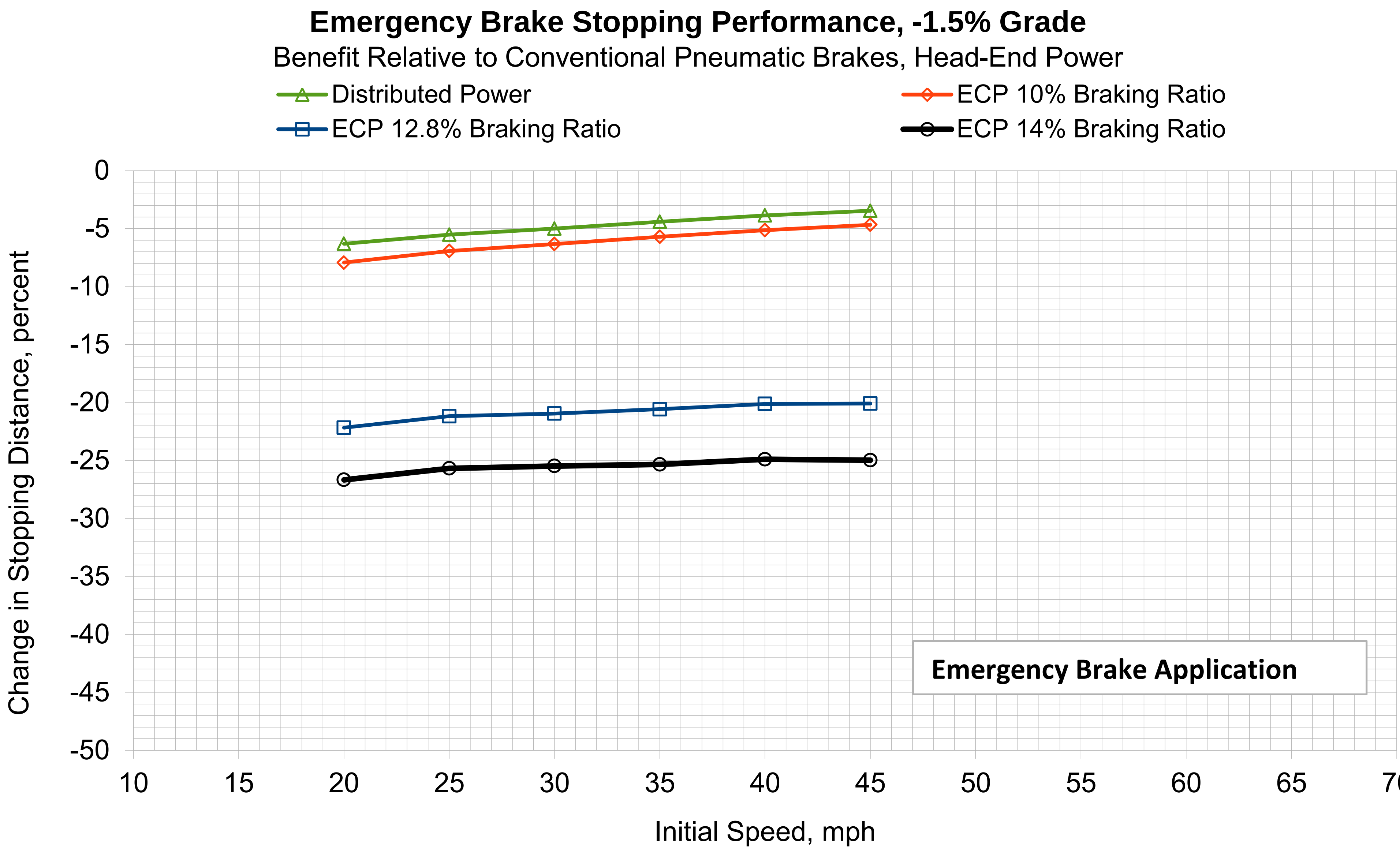
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


Emergency Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

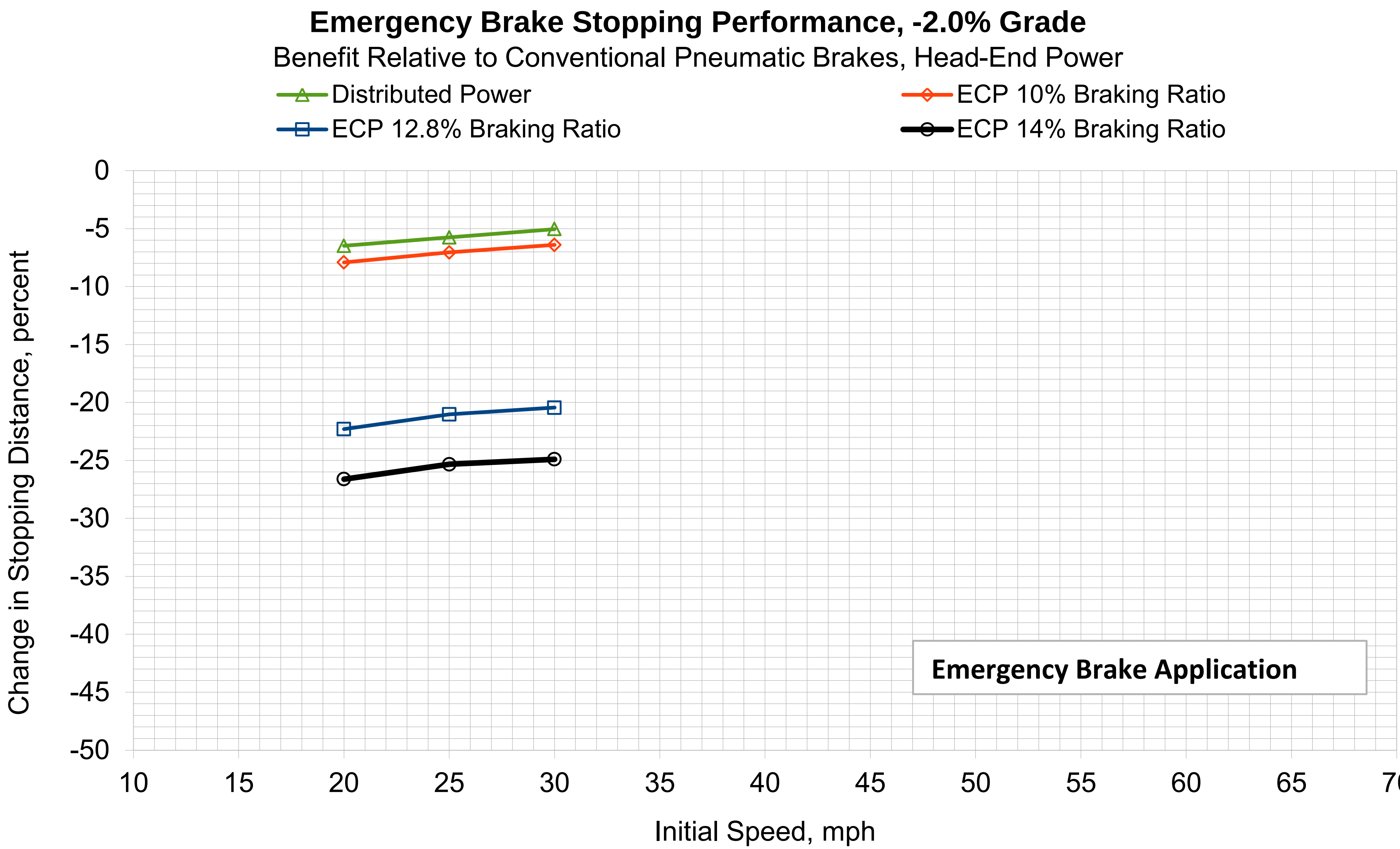


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

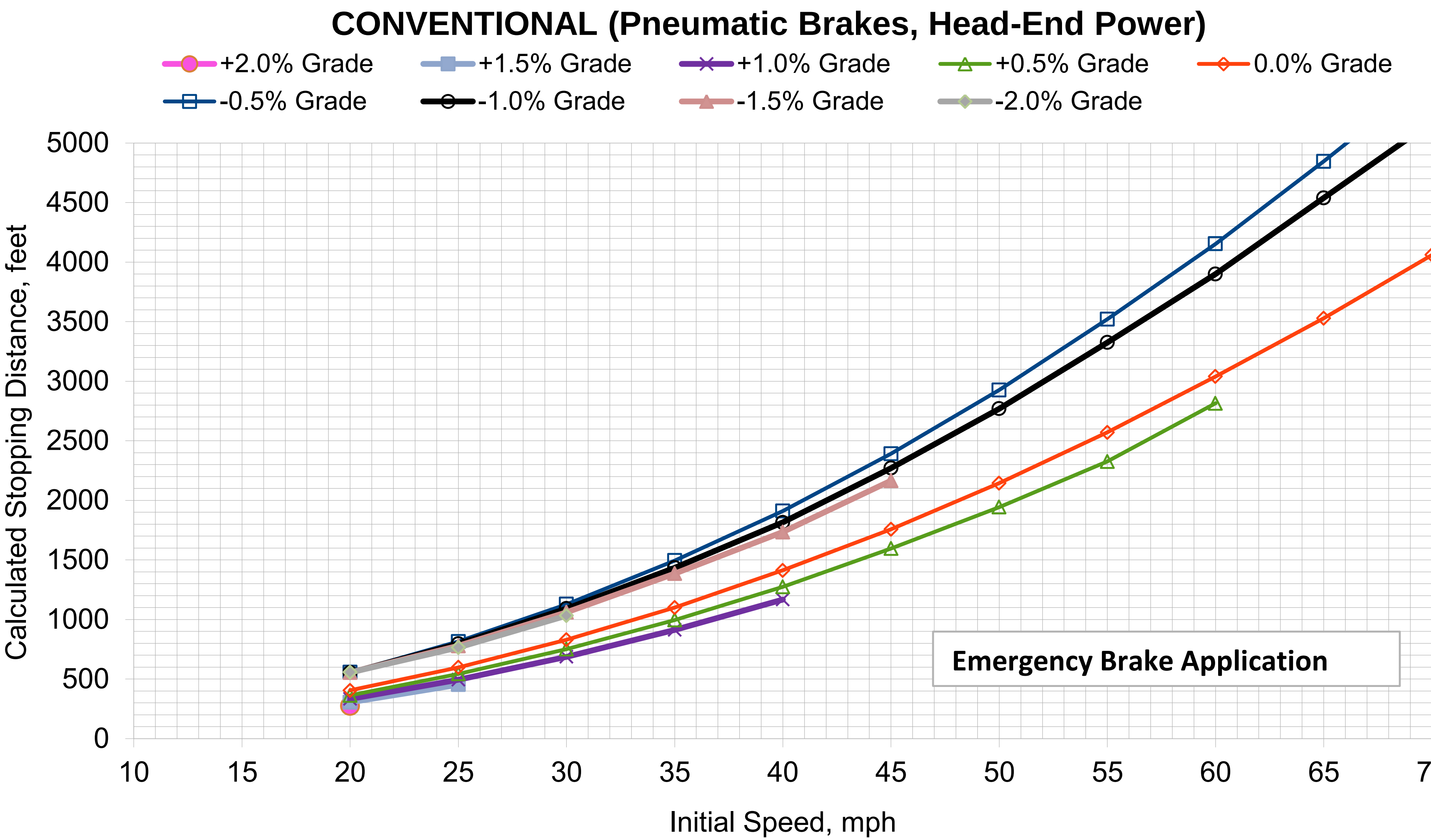

Emergency Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



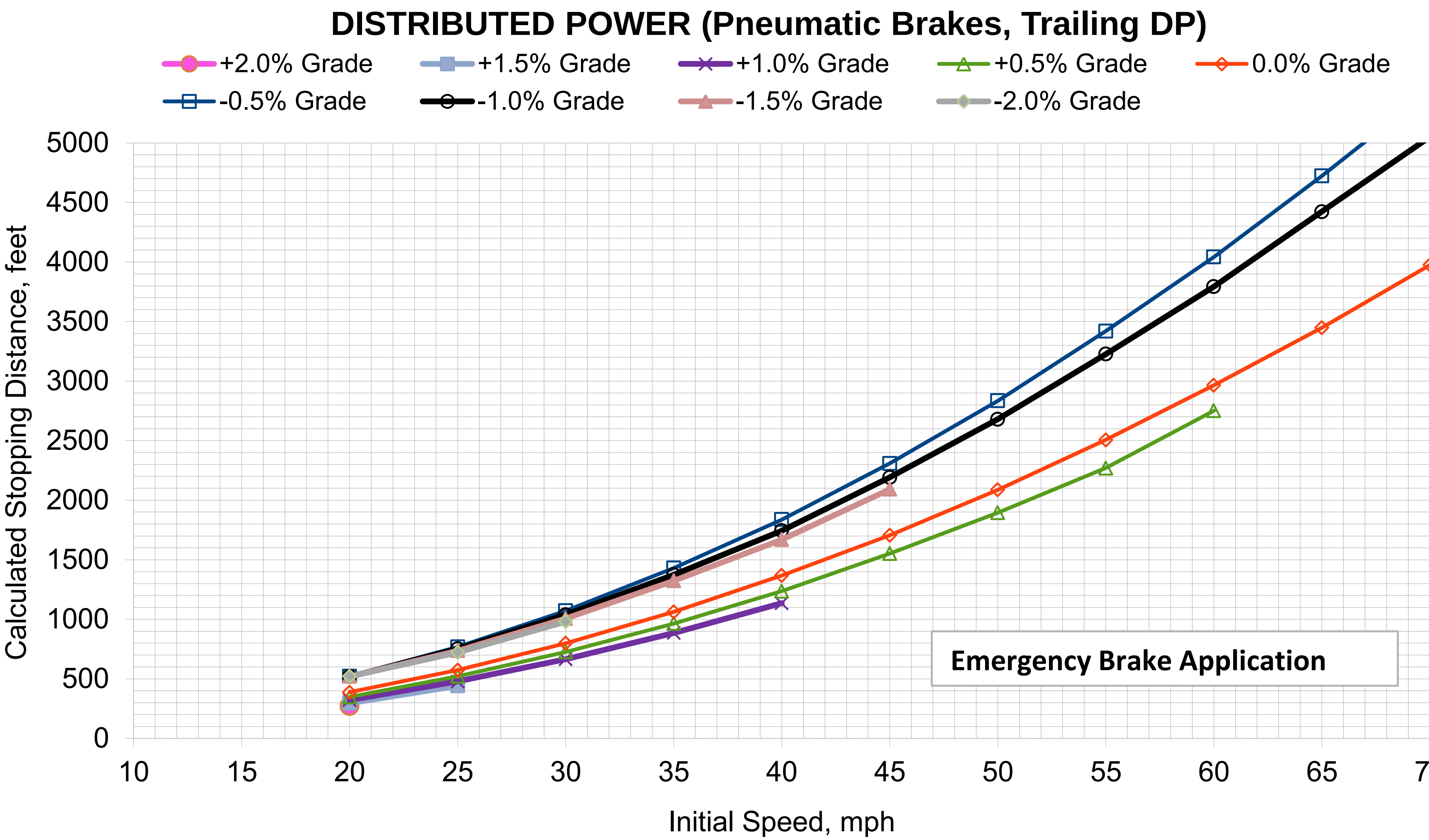
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



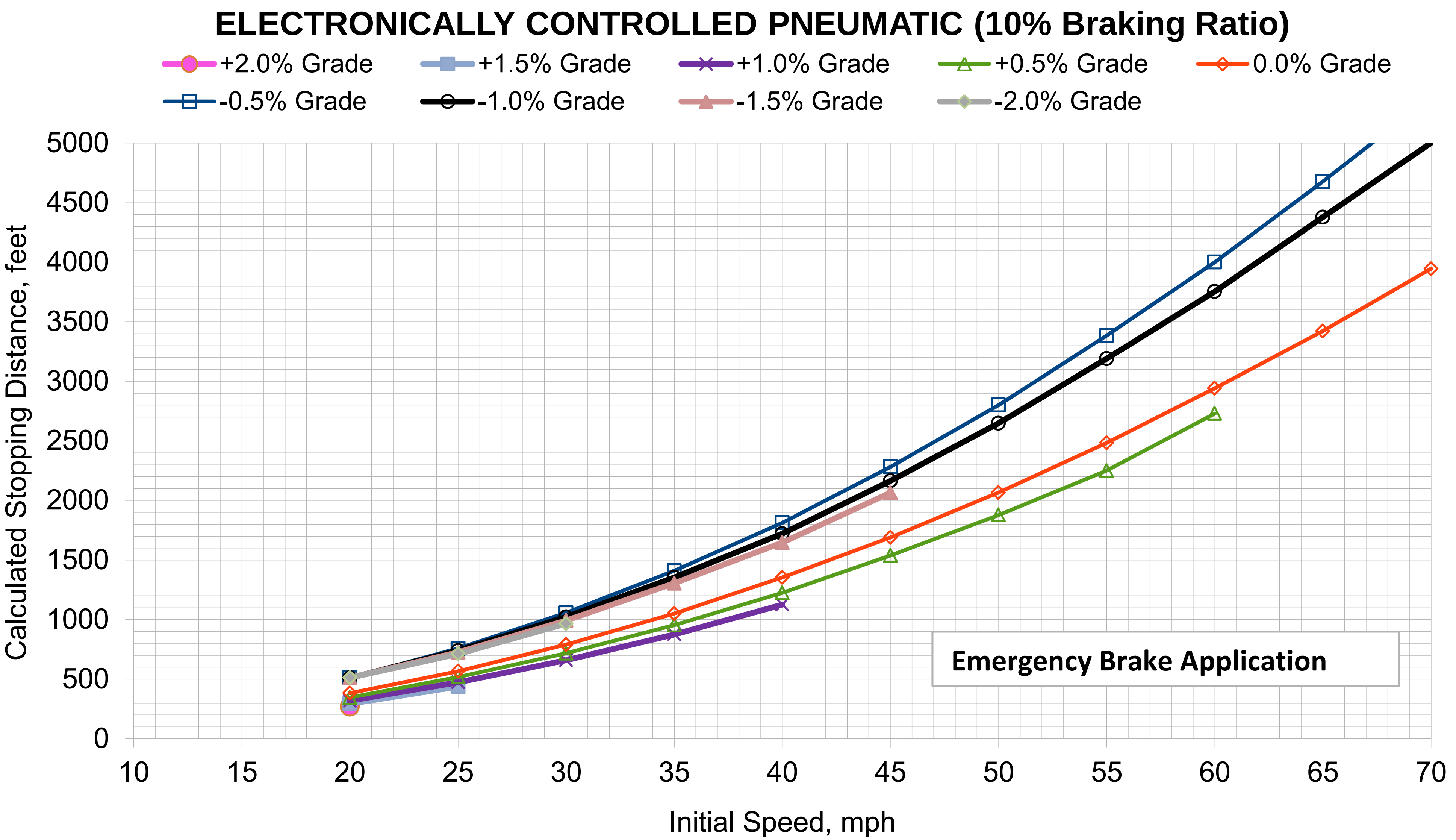
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



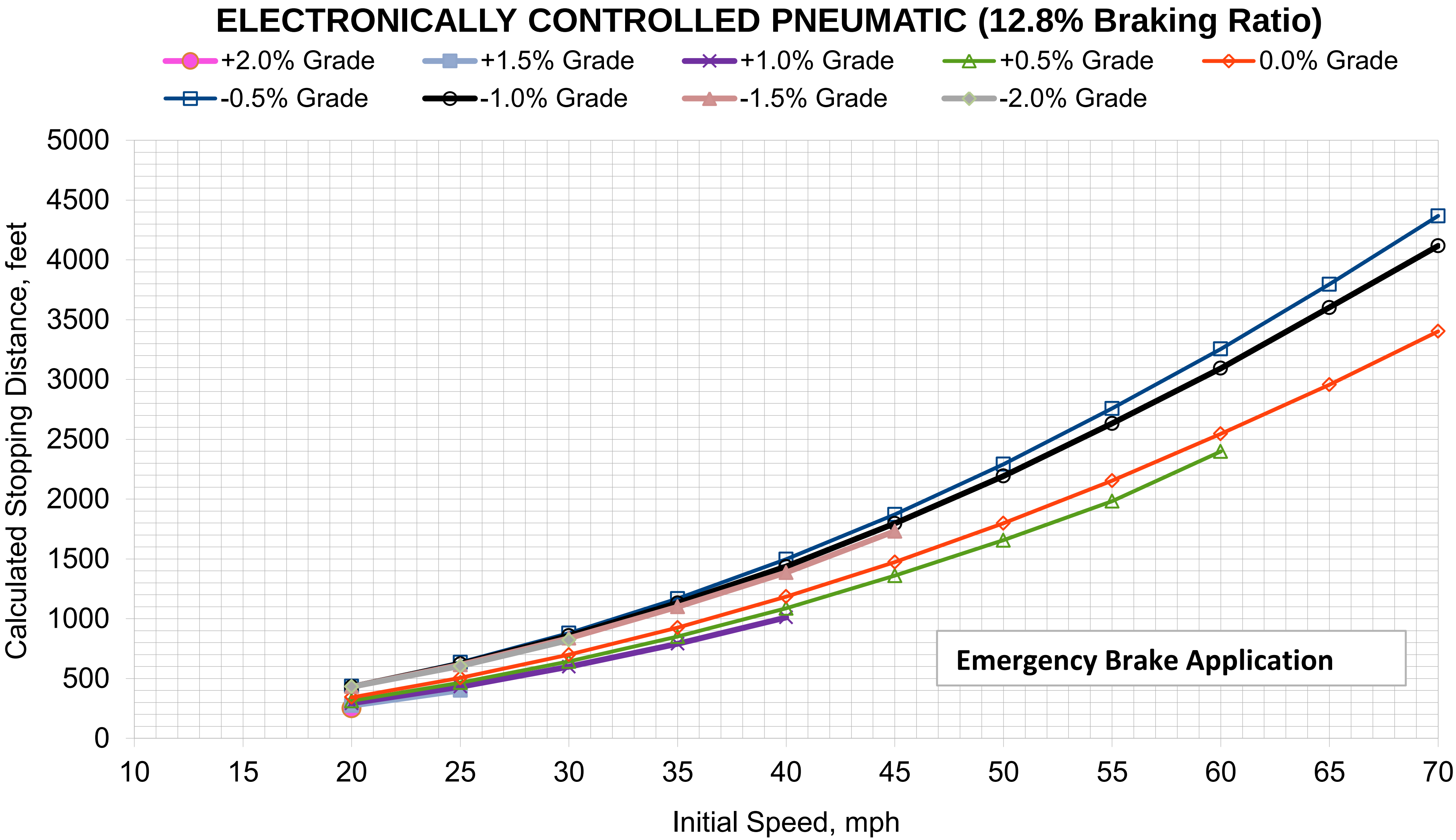
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



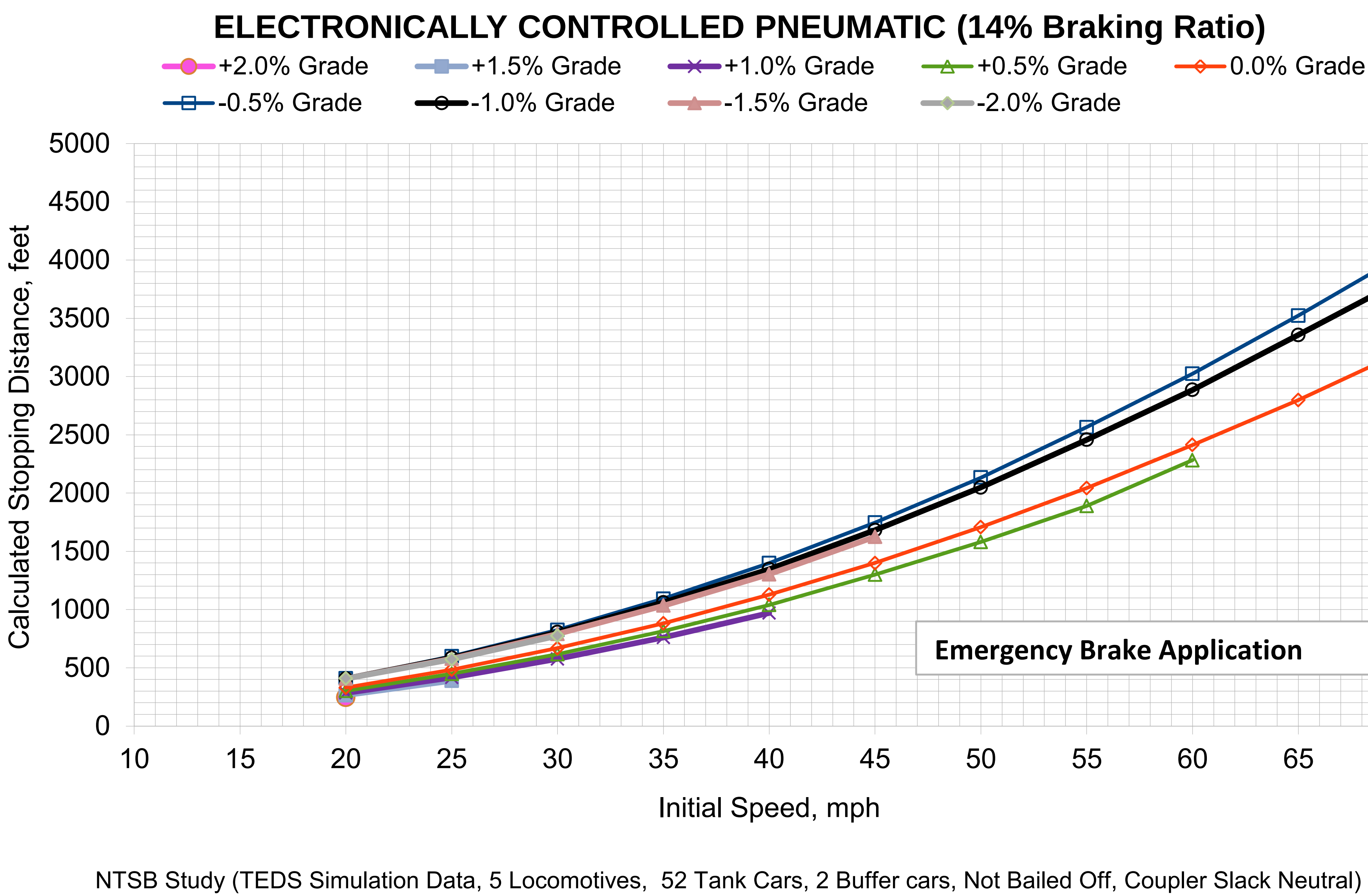
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

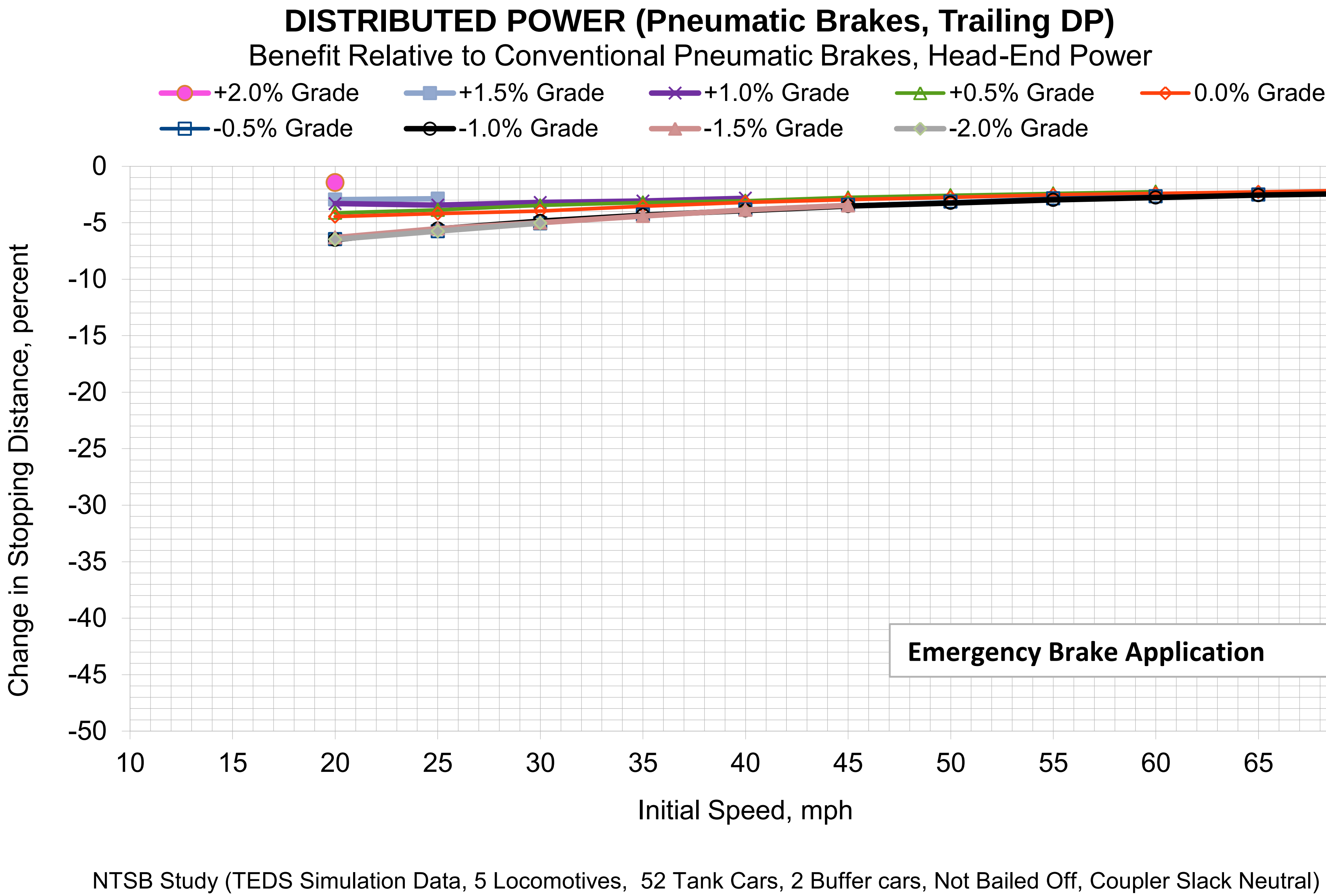


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

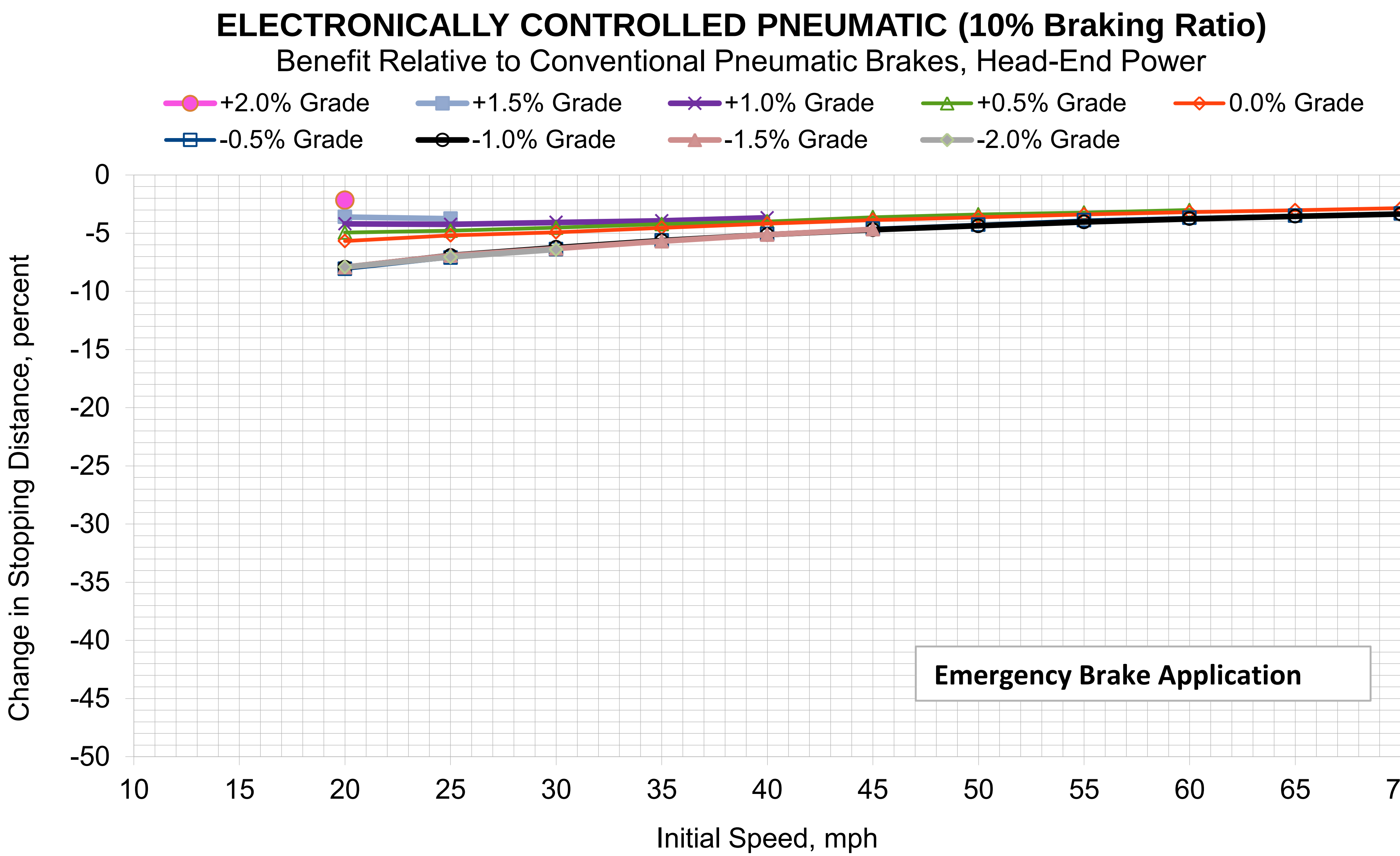


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

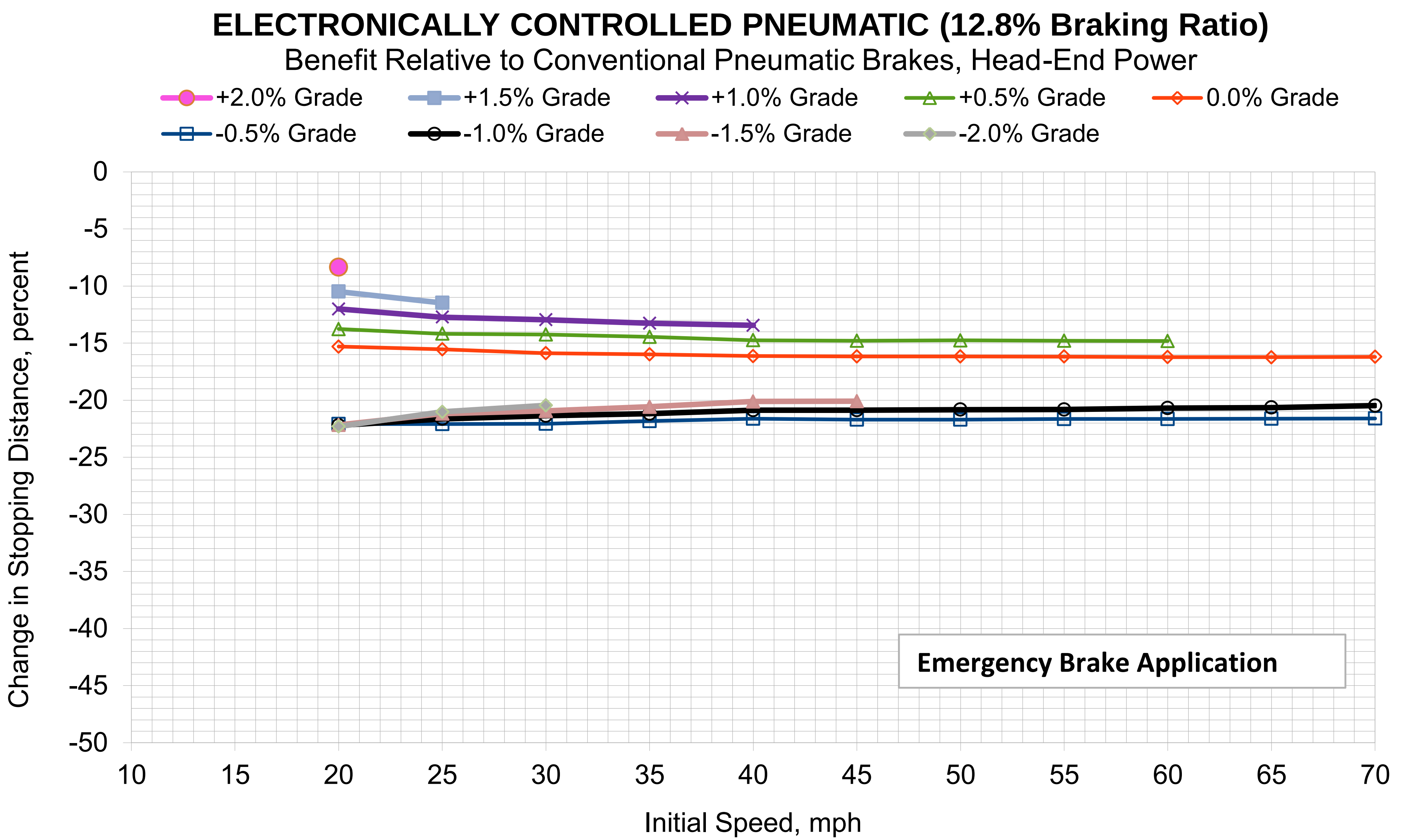

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



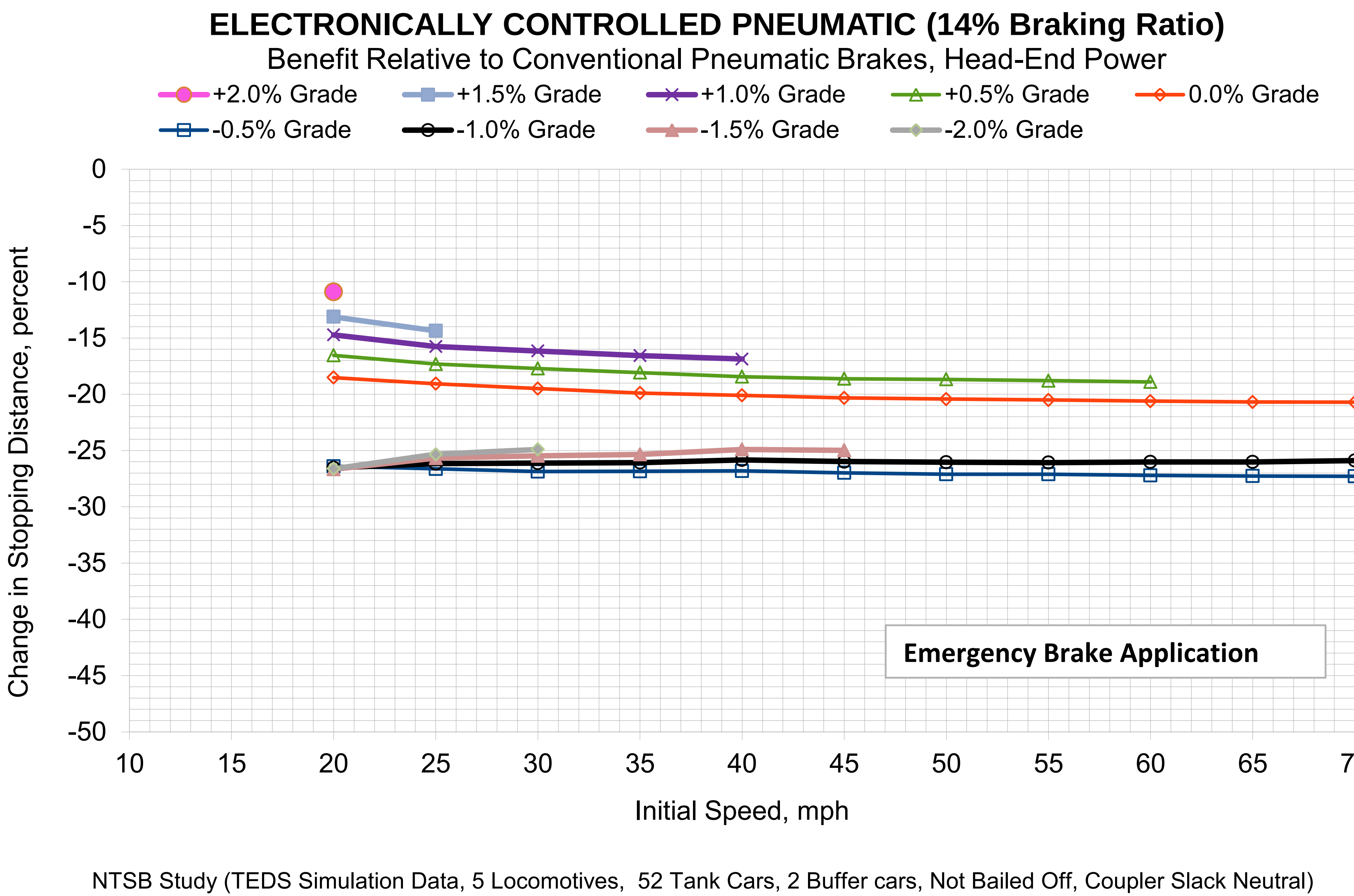
DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



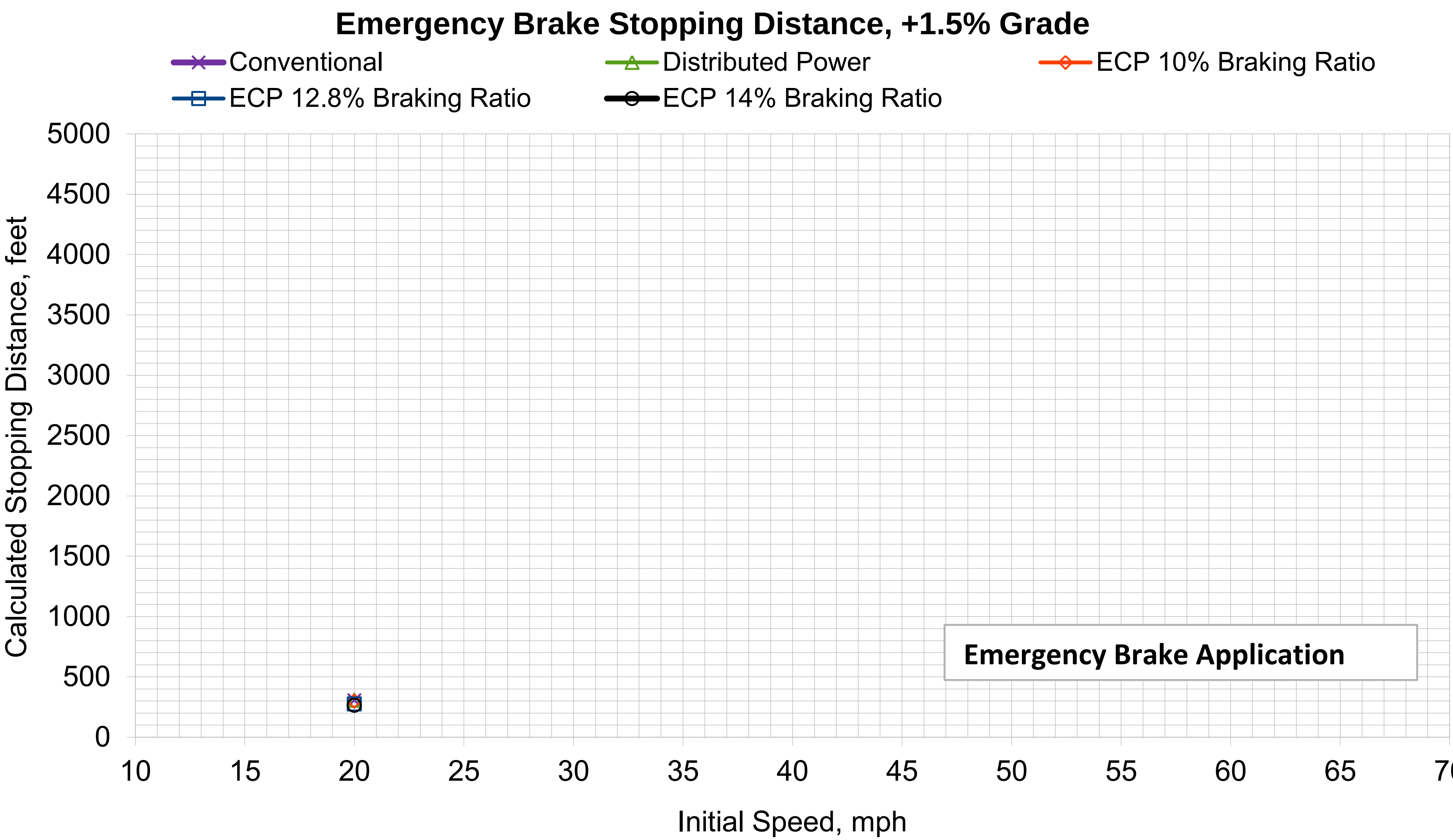
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



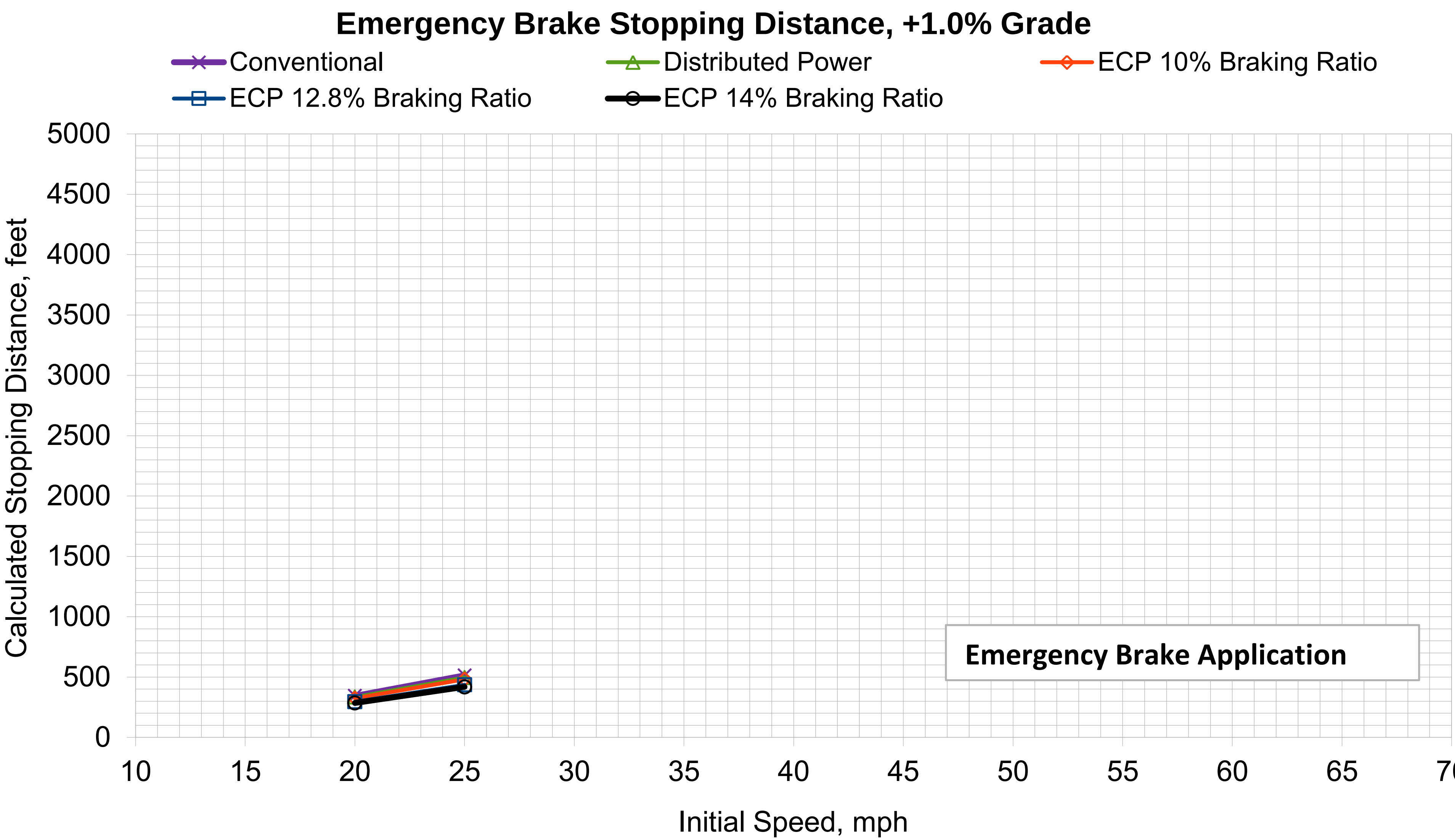
ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

A12.28

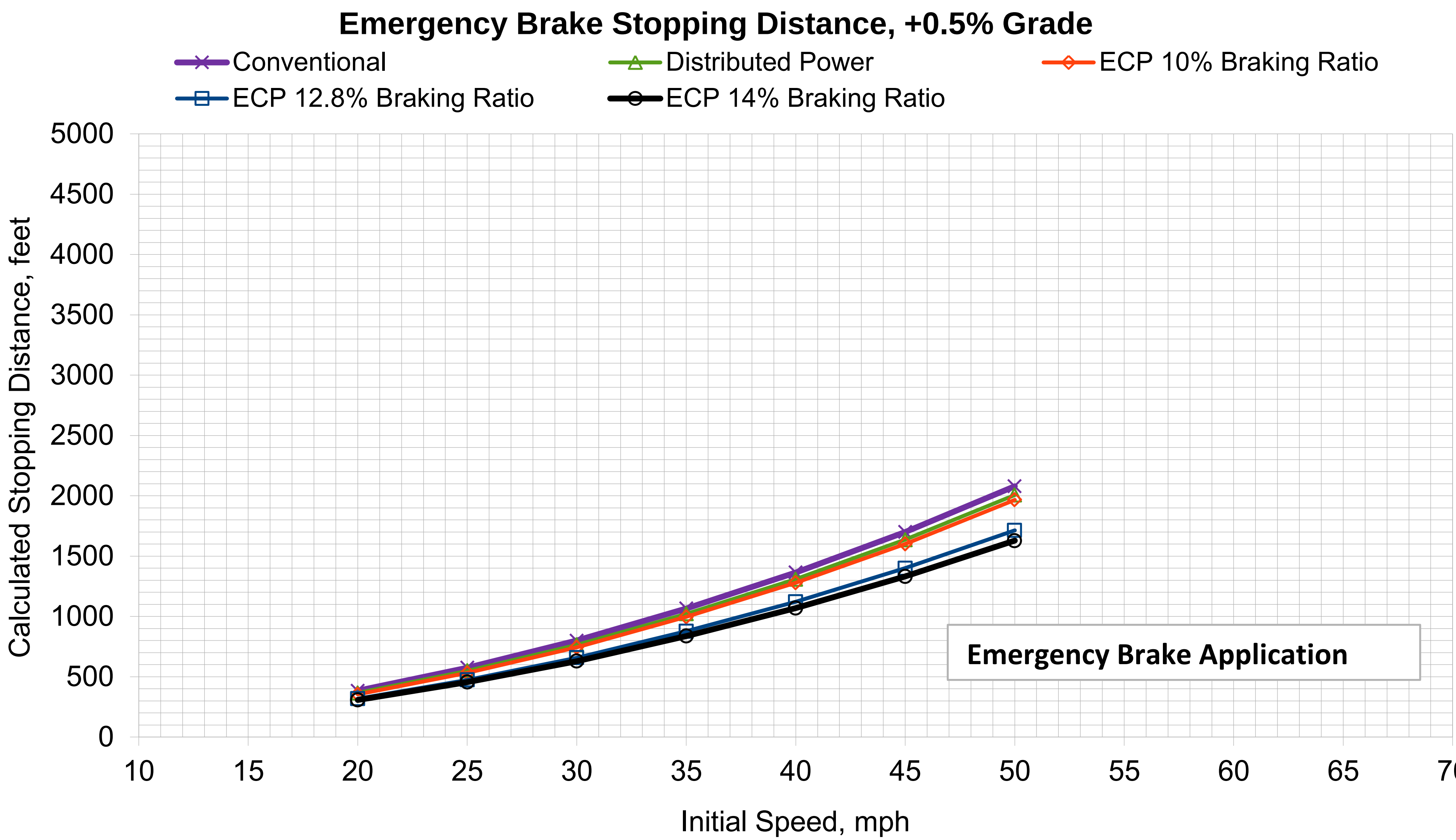
Attachment 13: Emergency Braking, No Bailoff, 78 Tank Cars



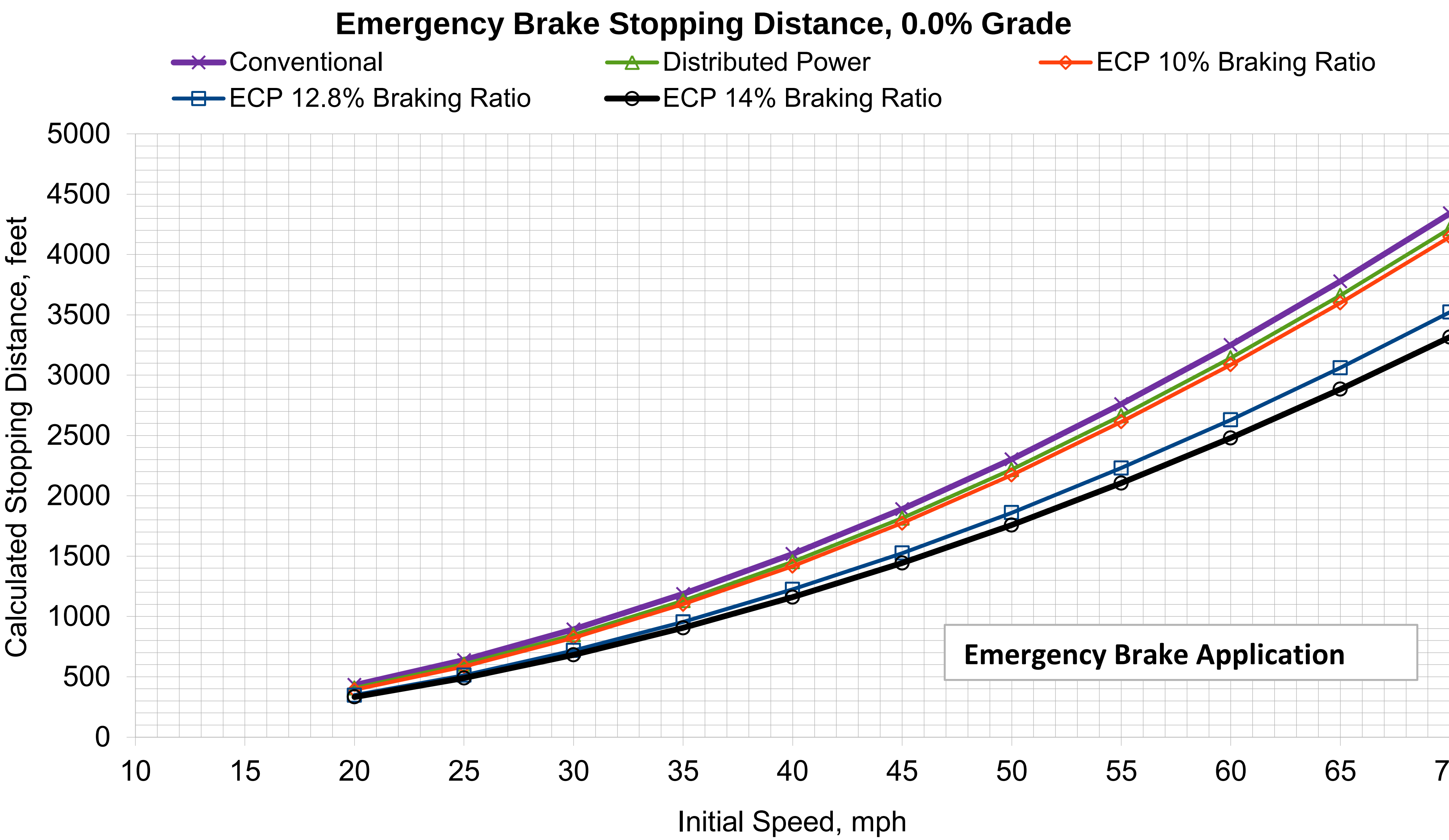
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



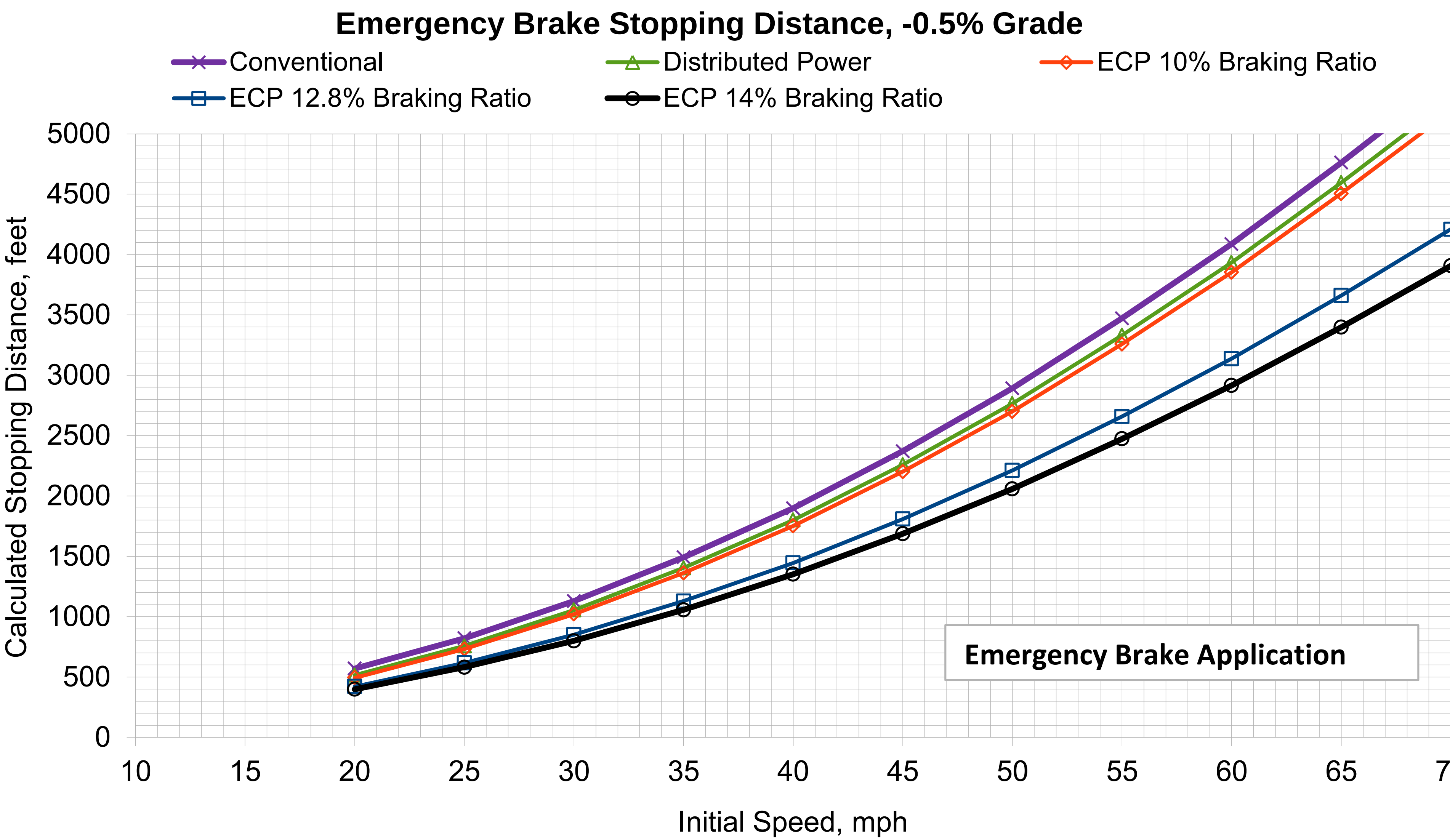
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



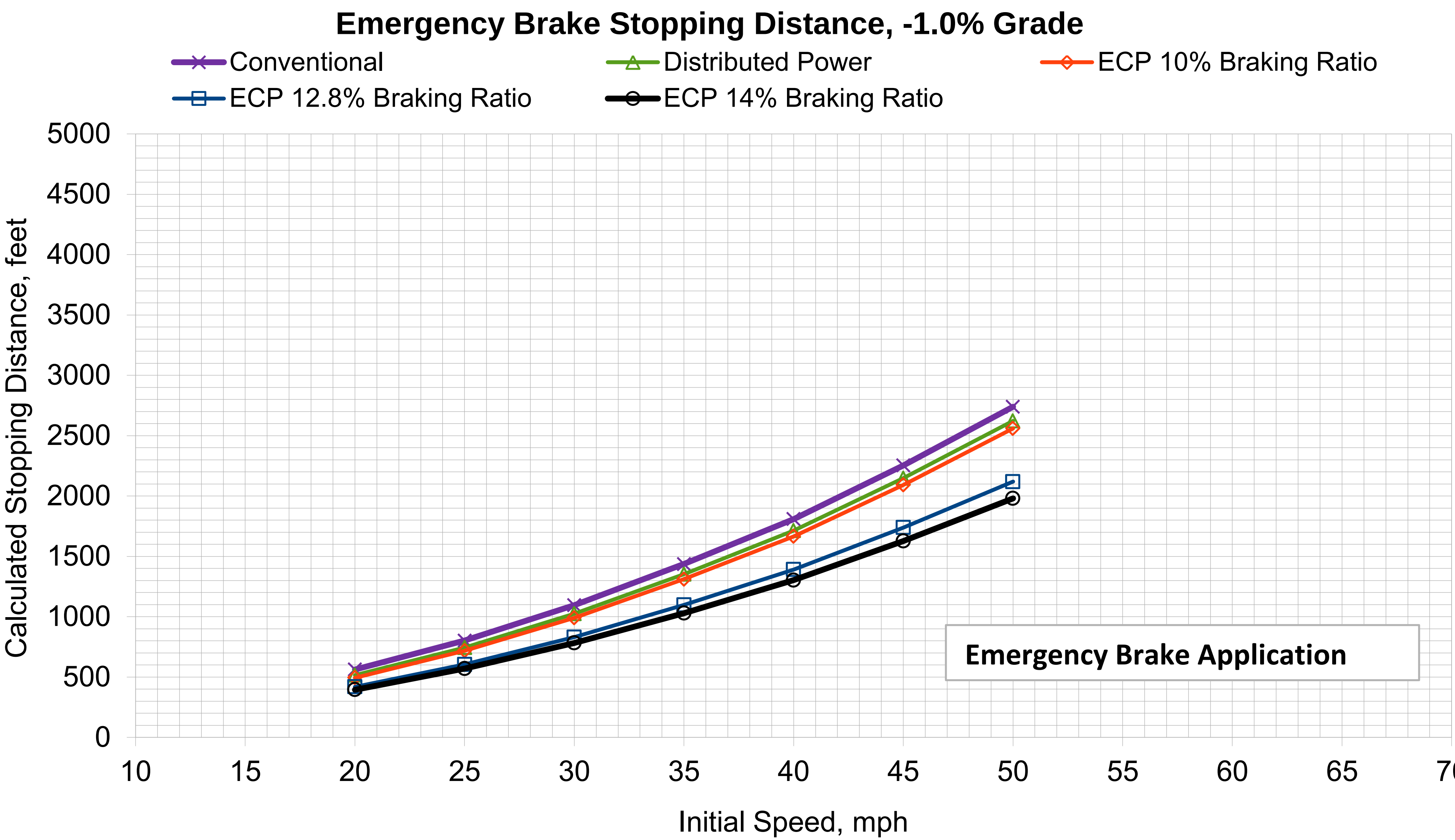
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



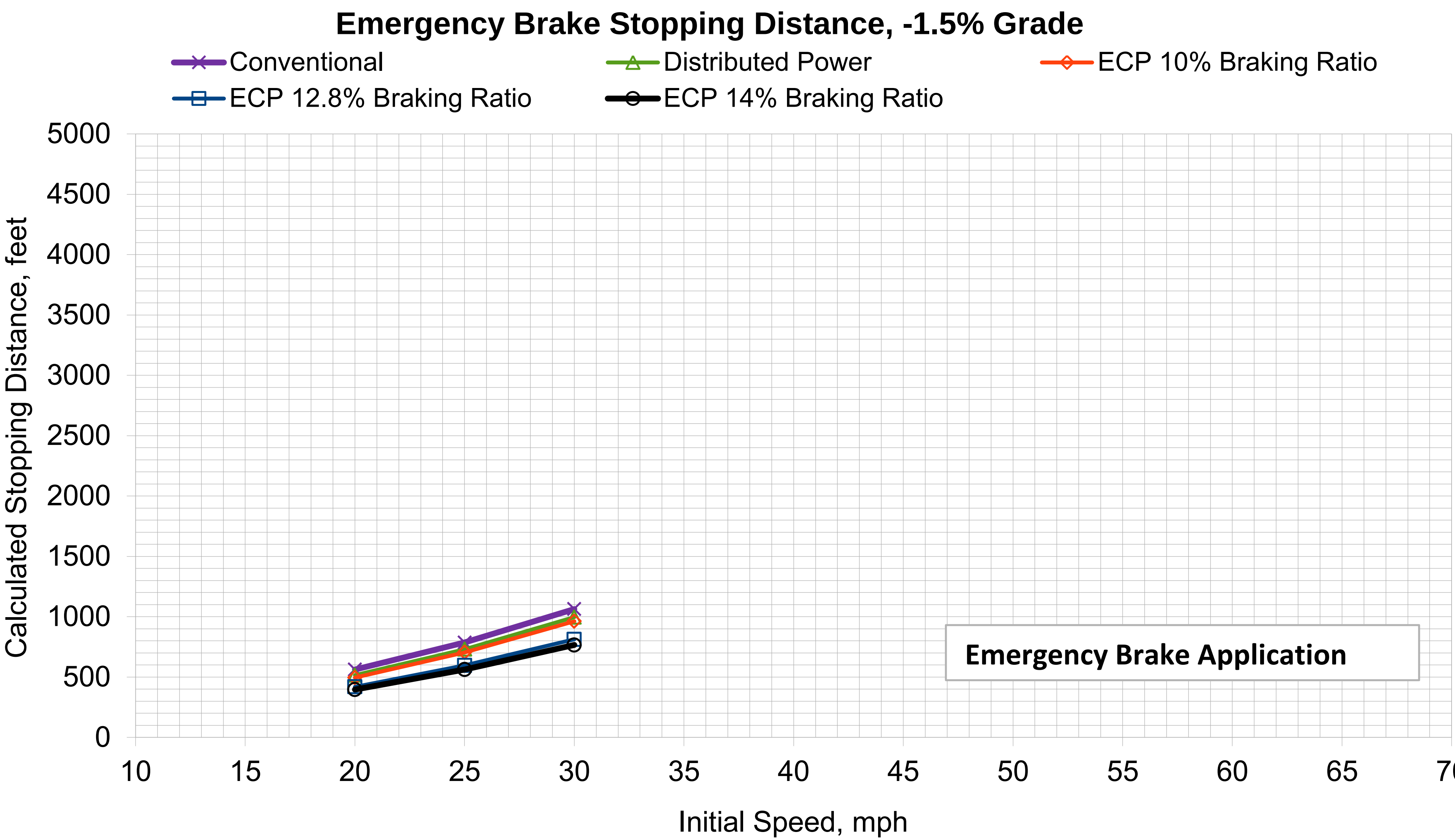
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



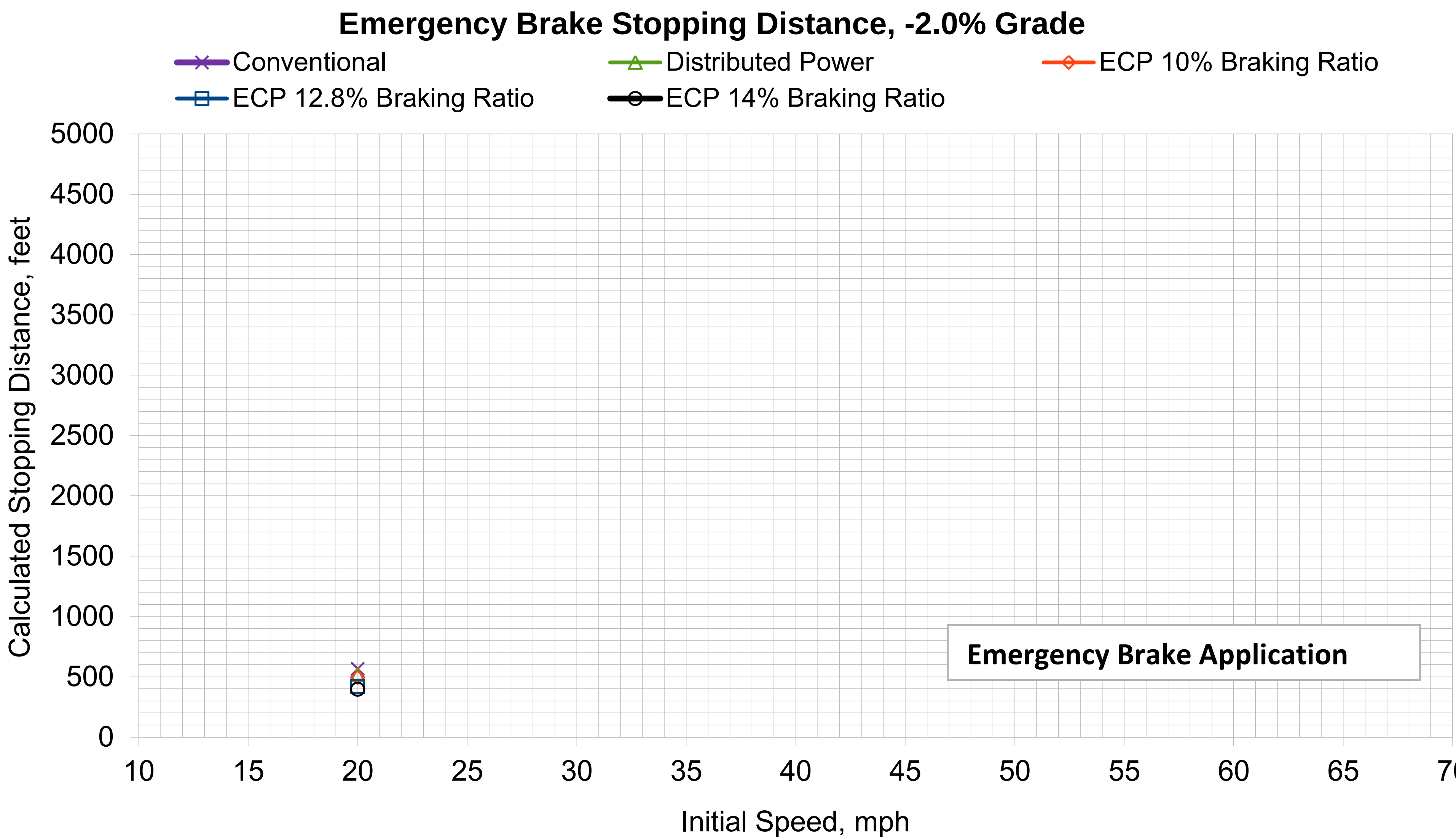
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



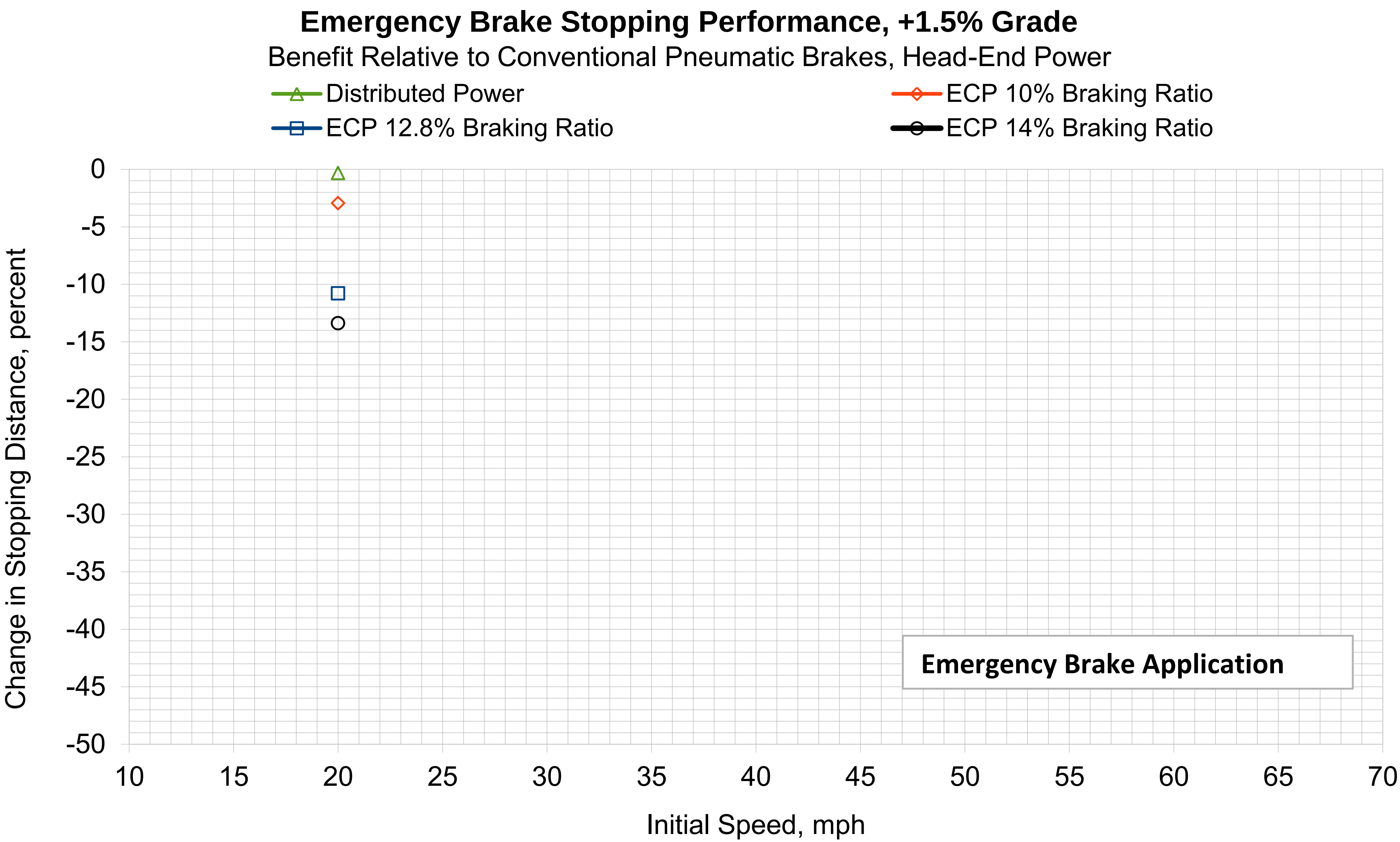
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



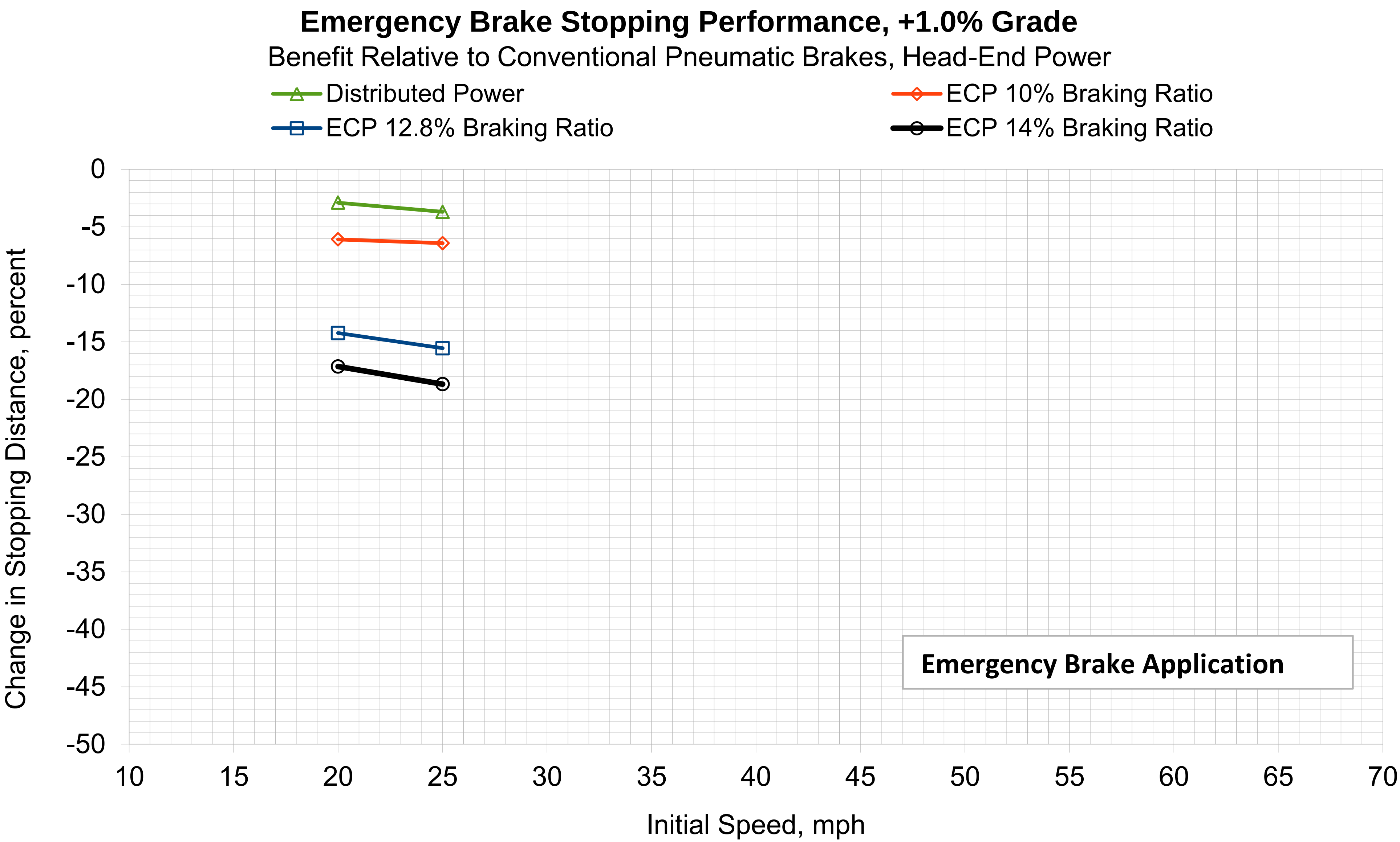
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



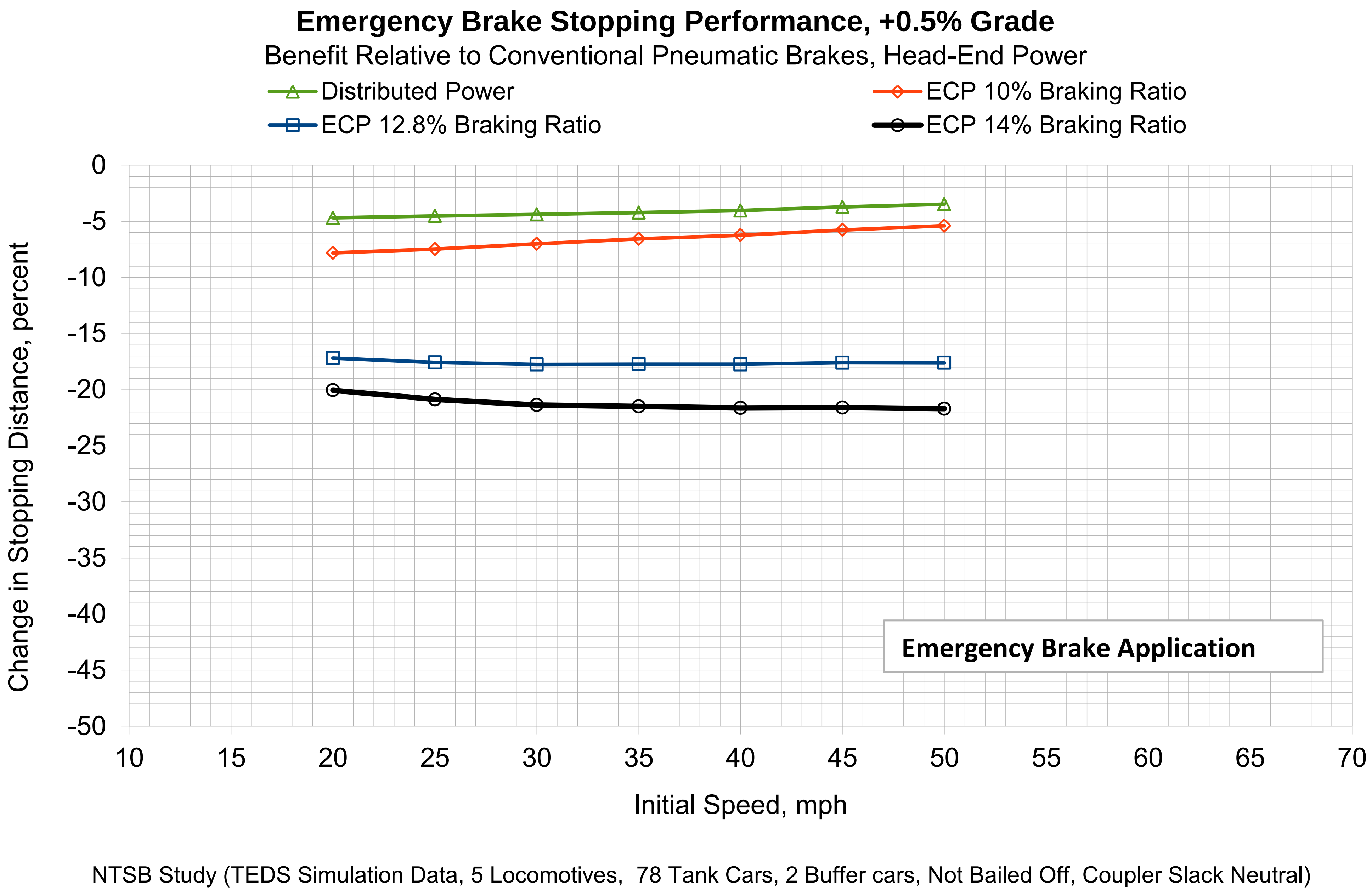
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

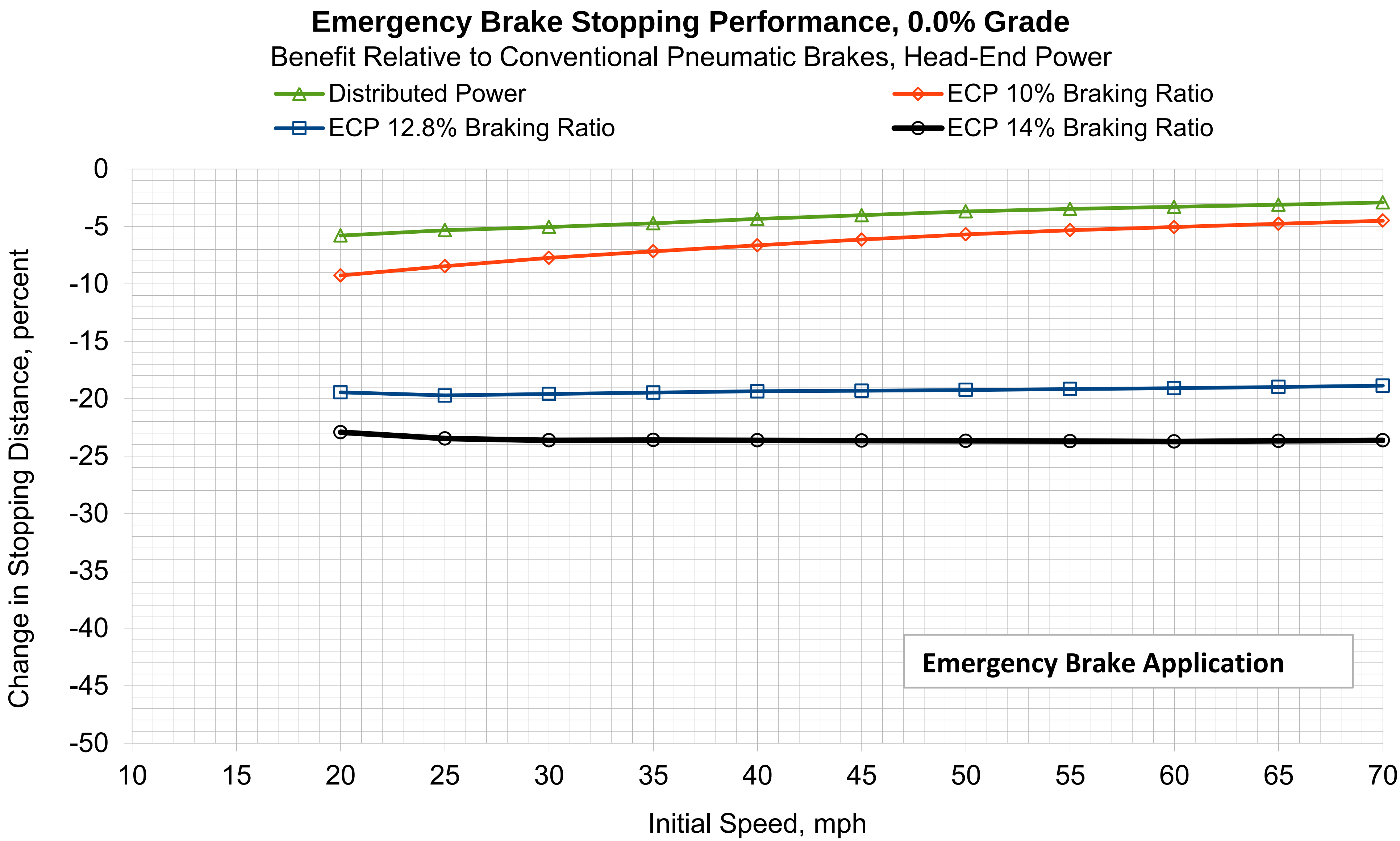


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

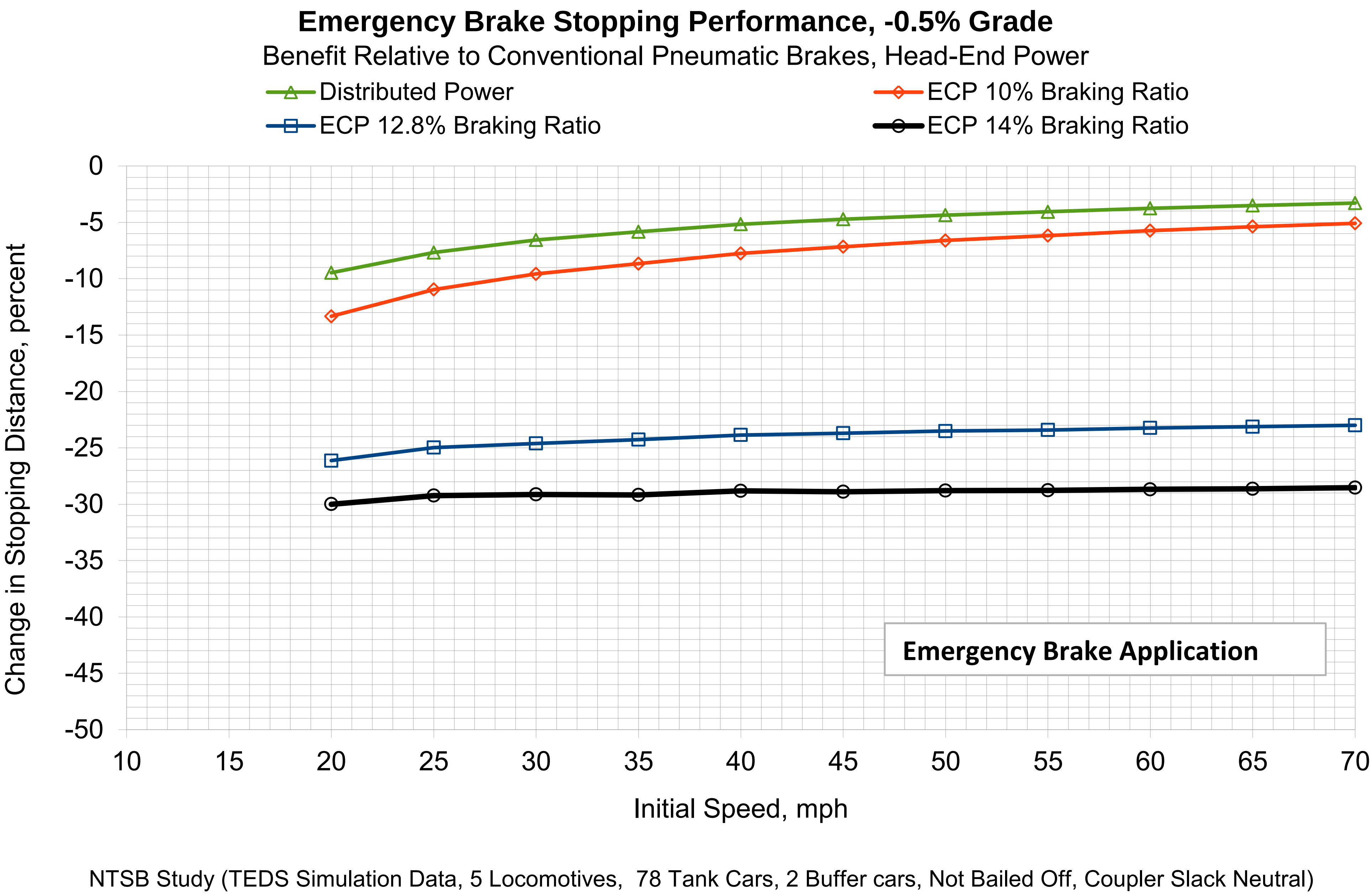


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


Emergency Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

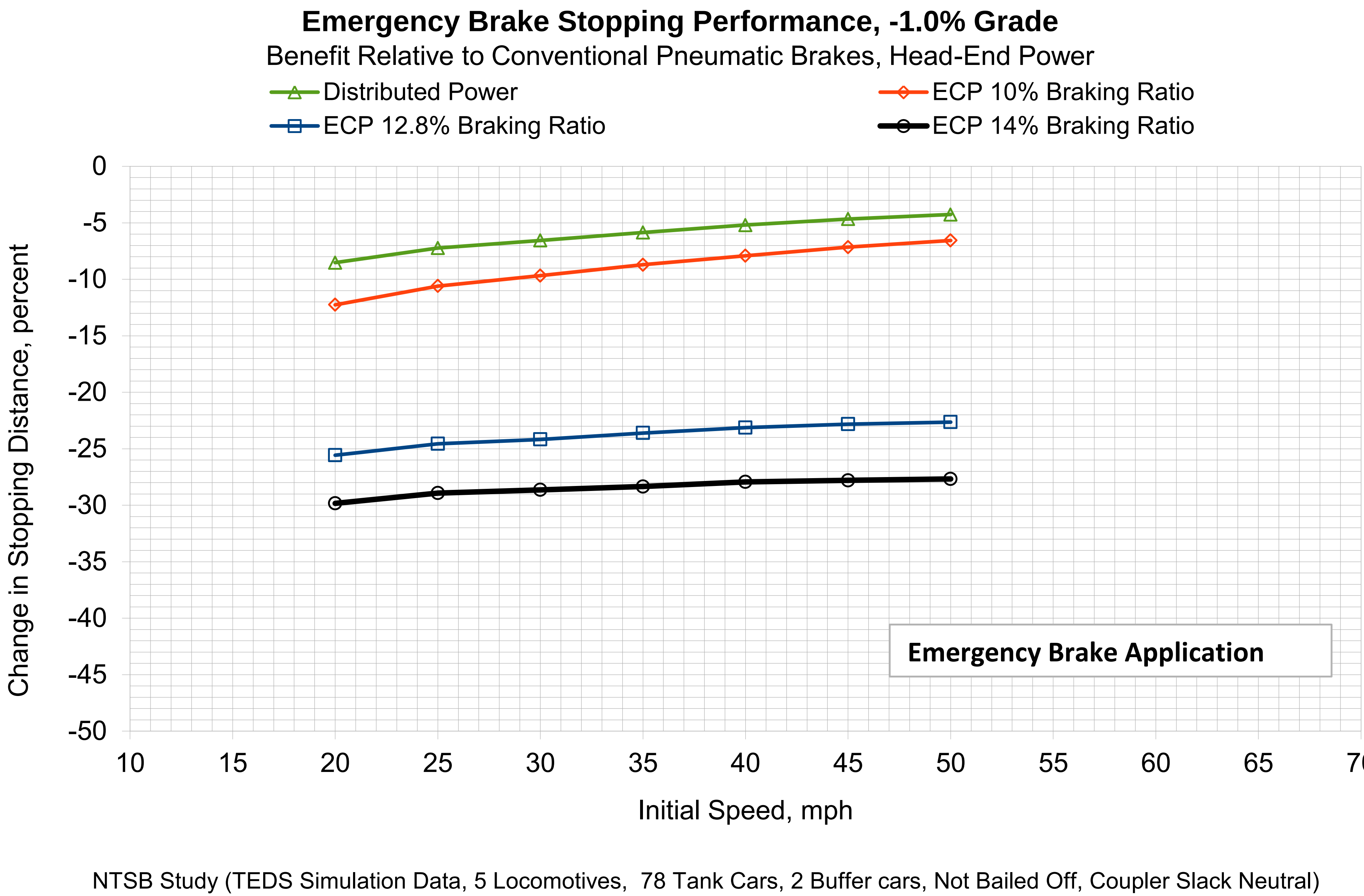


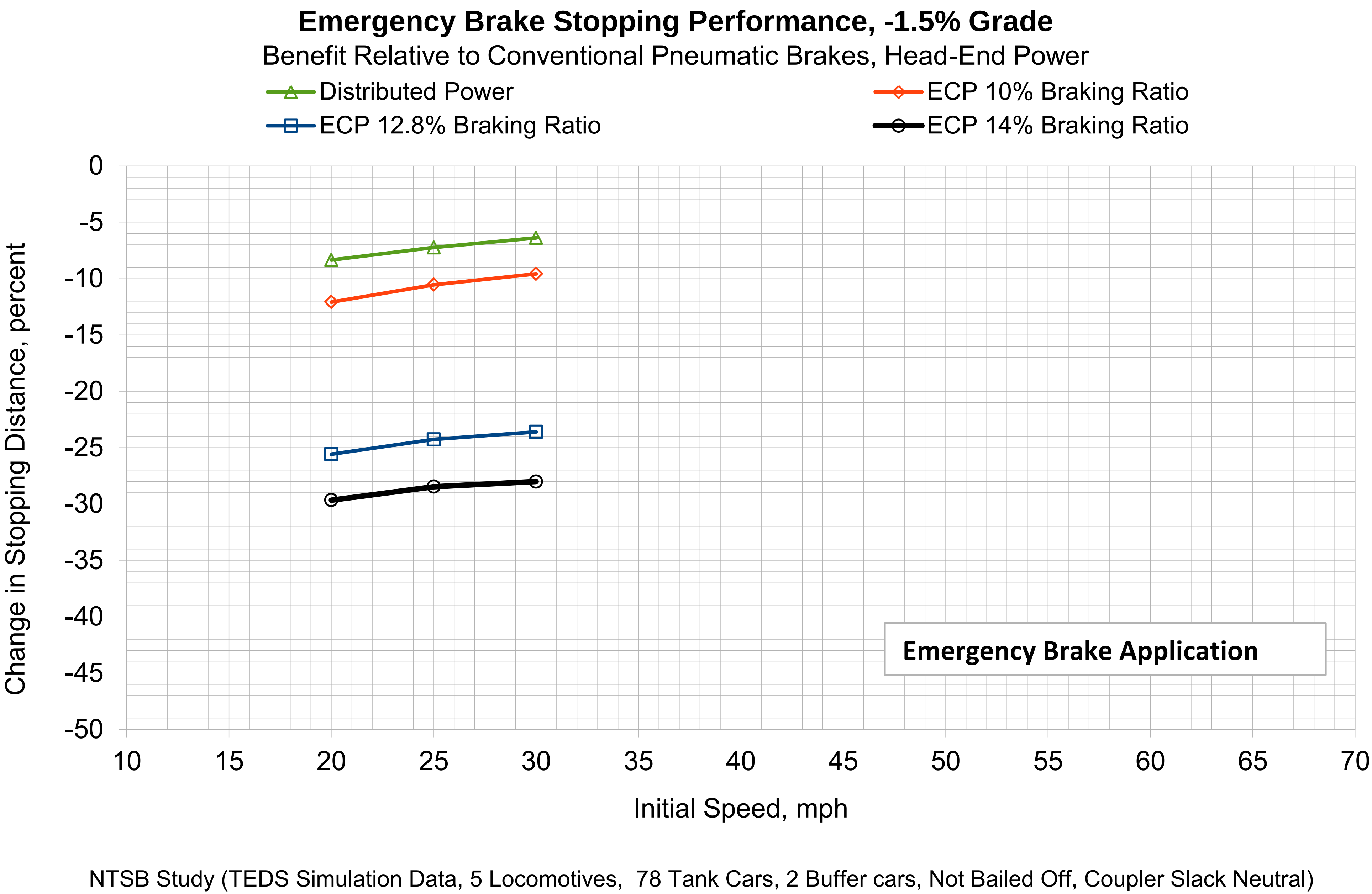
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

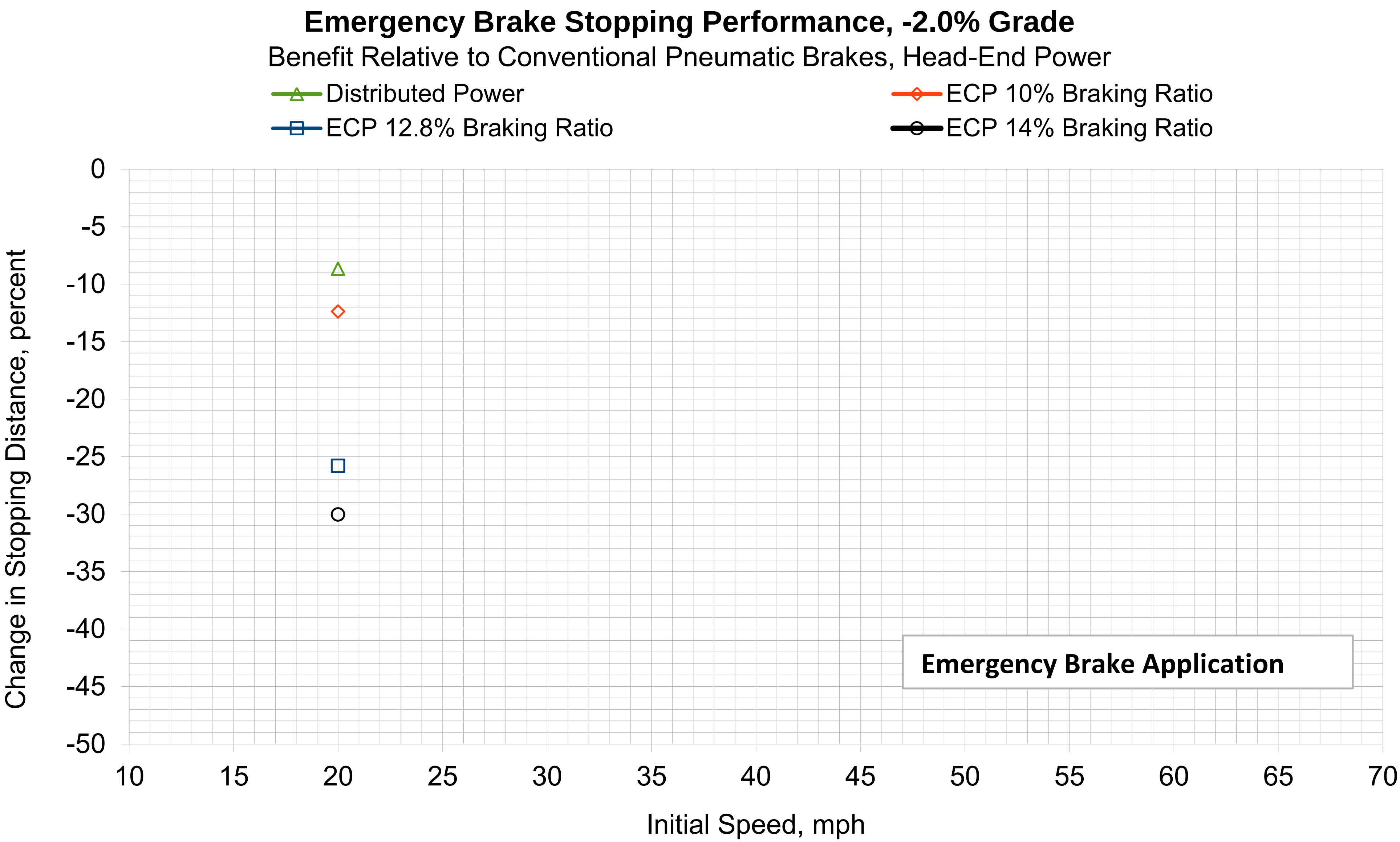


Emergency Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Change in Stopping Distance, percent
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

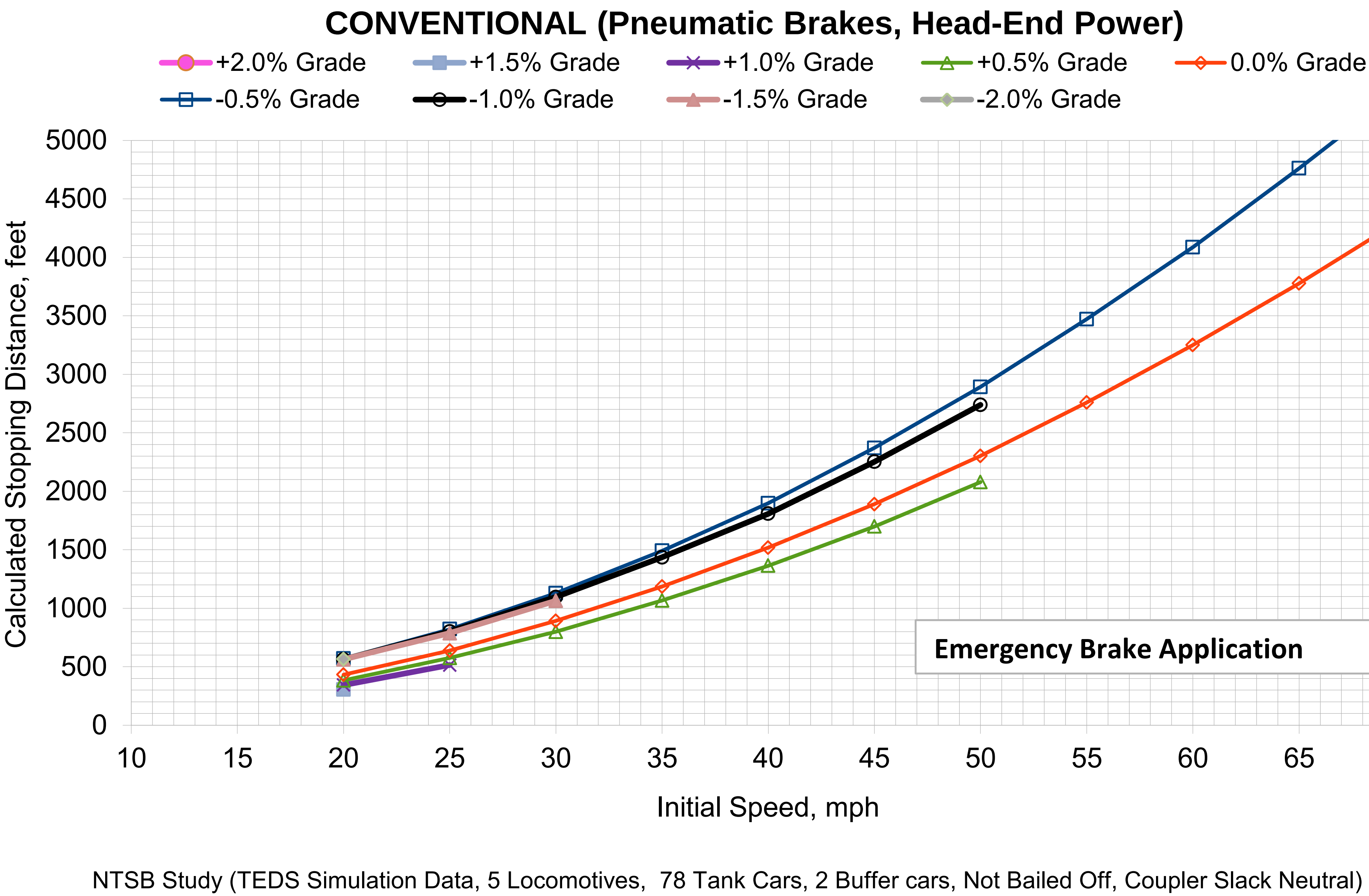
A13.14

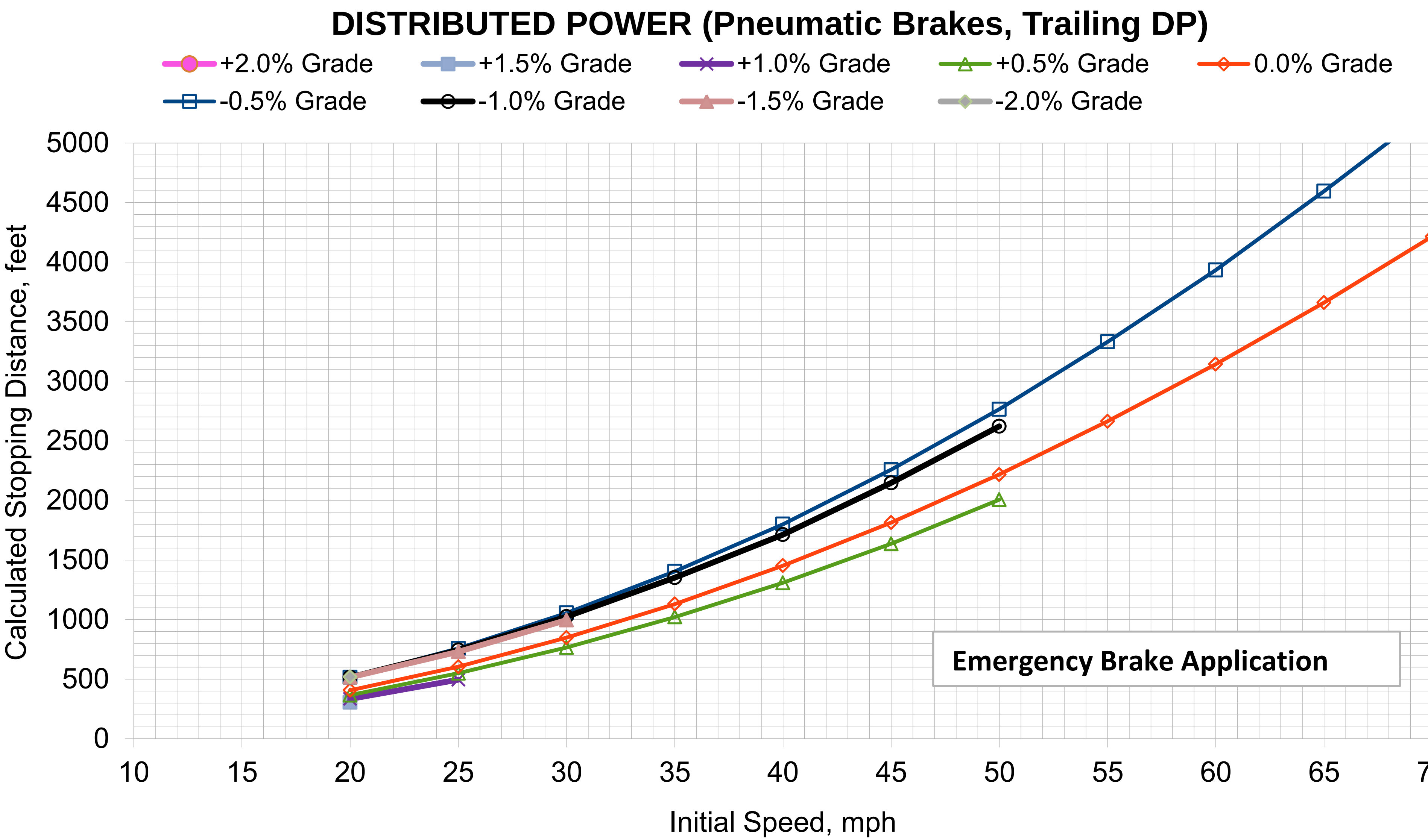

Emergency Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Emergency Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


Emergency Brake Stopping Performance, -1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

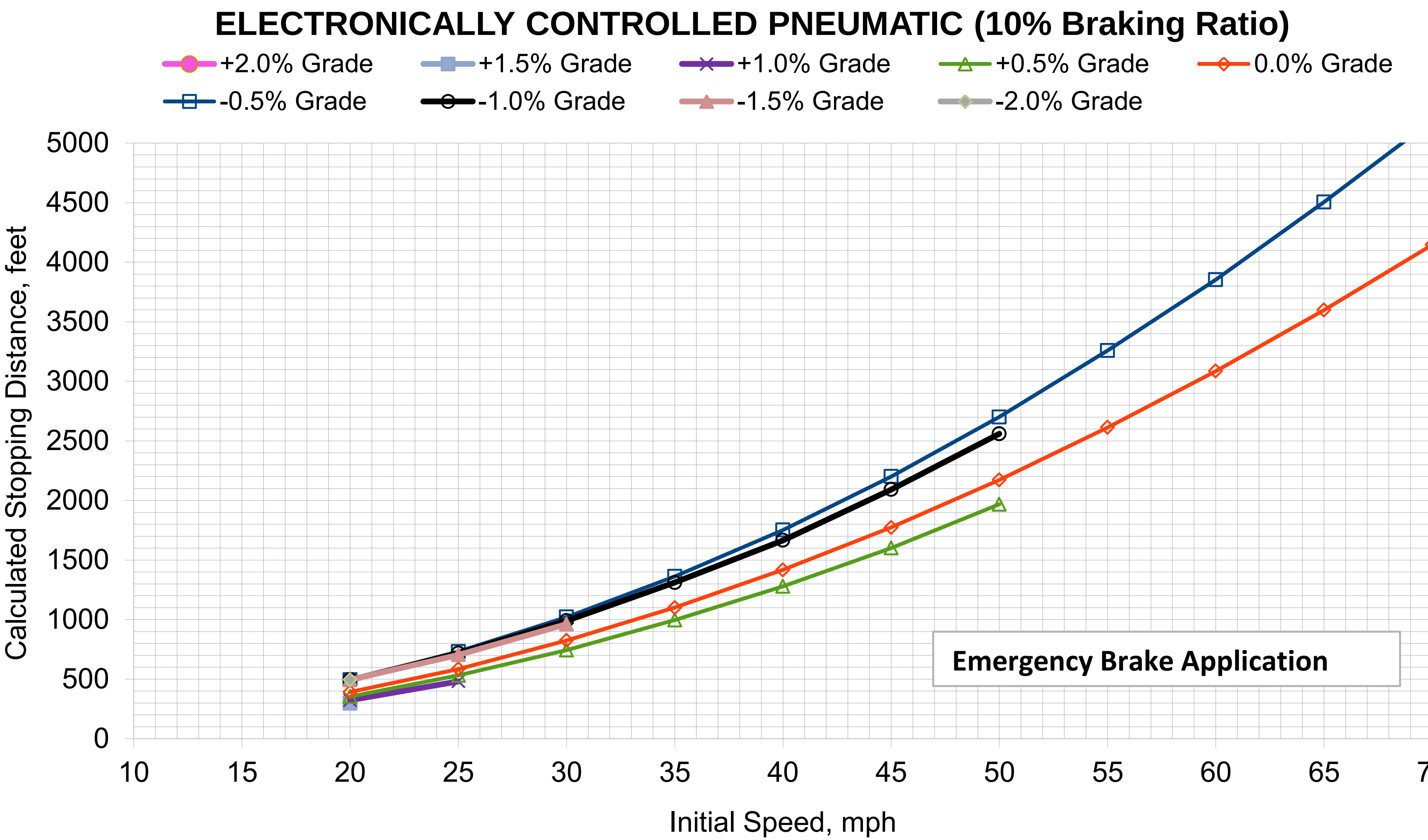


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


CONVENTIONAL (Pneumatic Brakes, Head-End Power)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
Initial Speed, mph
Emergency Brake Application
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

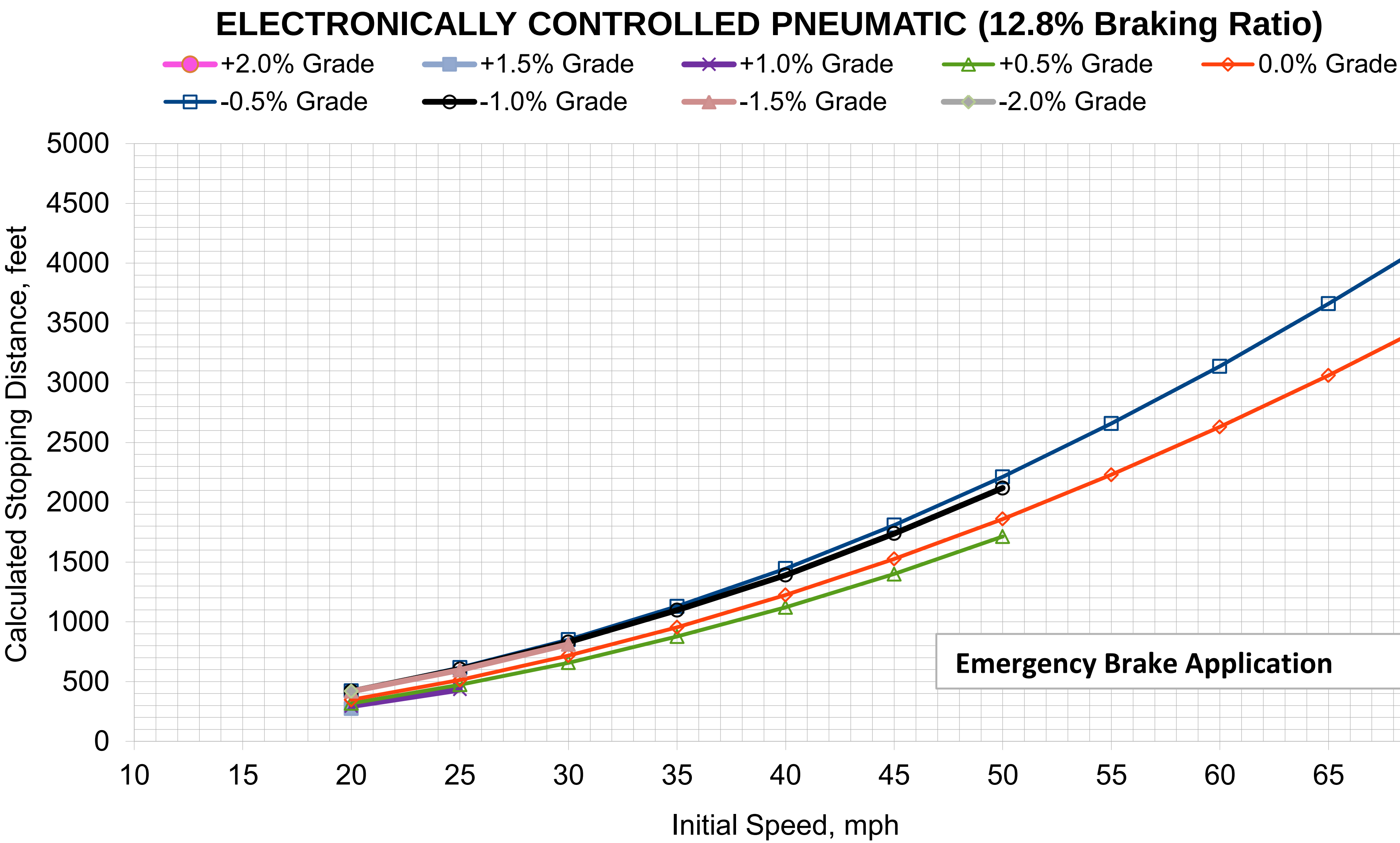


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

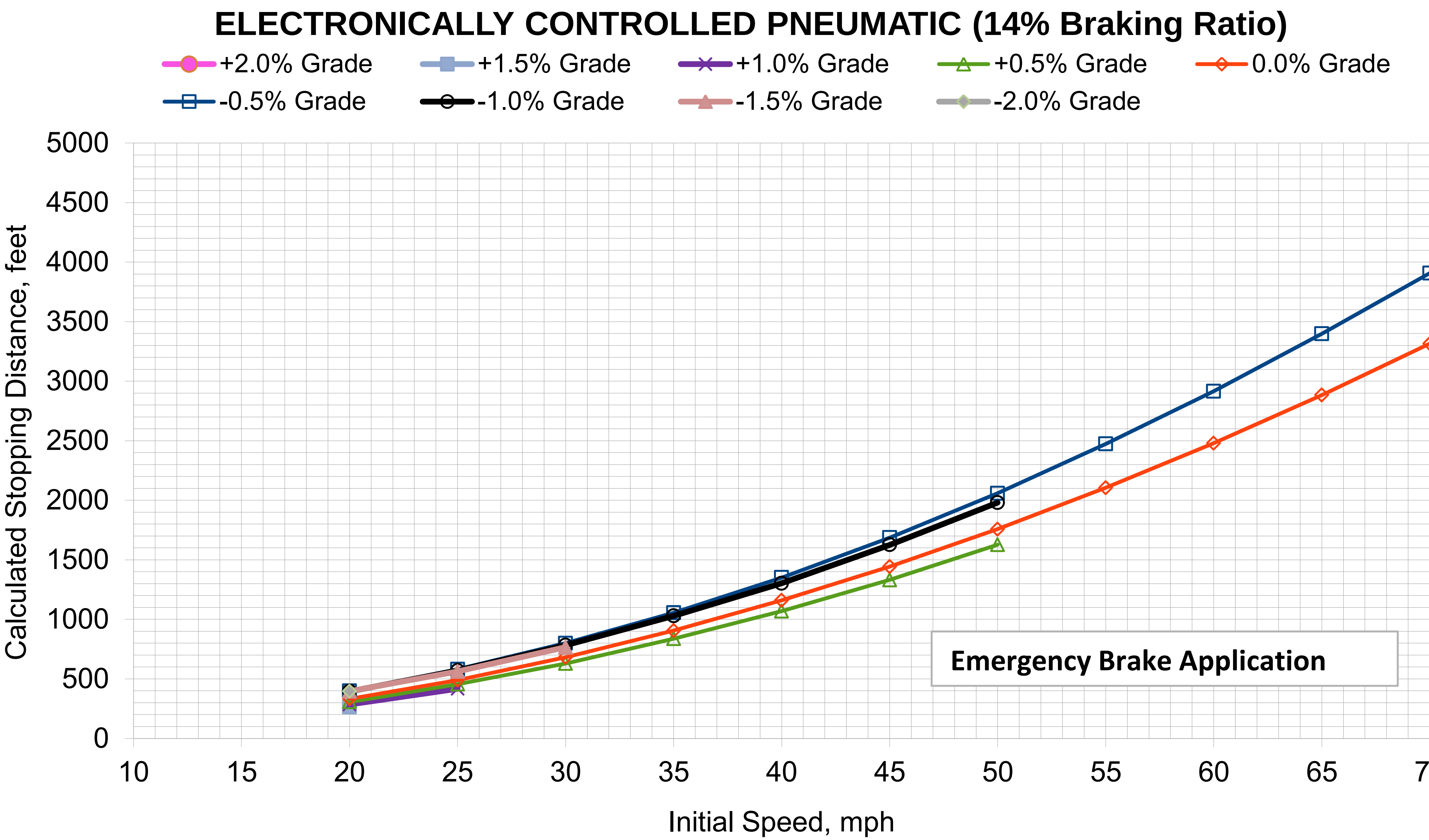


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

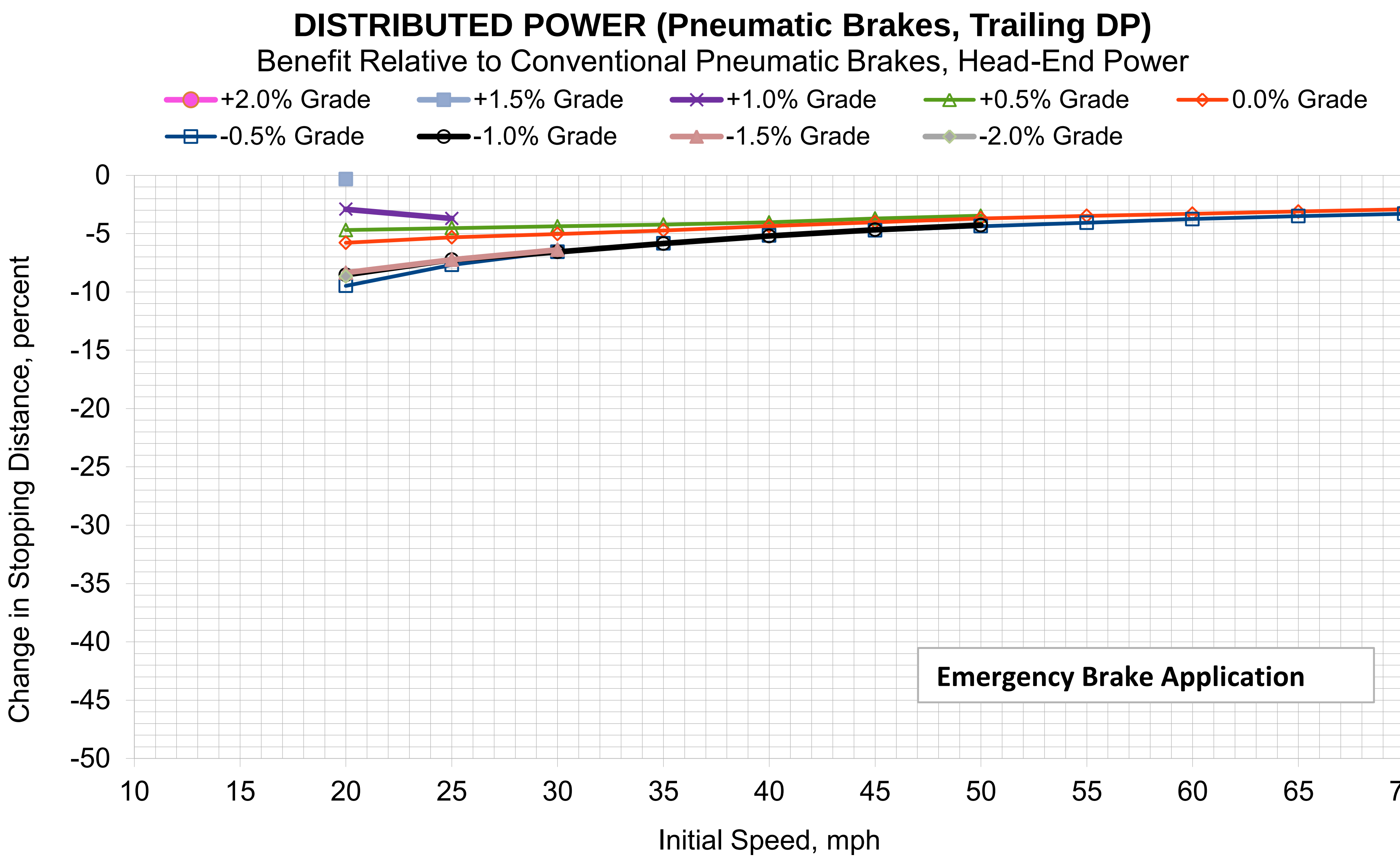
A13.20



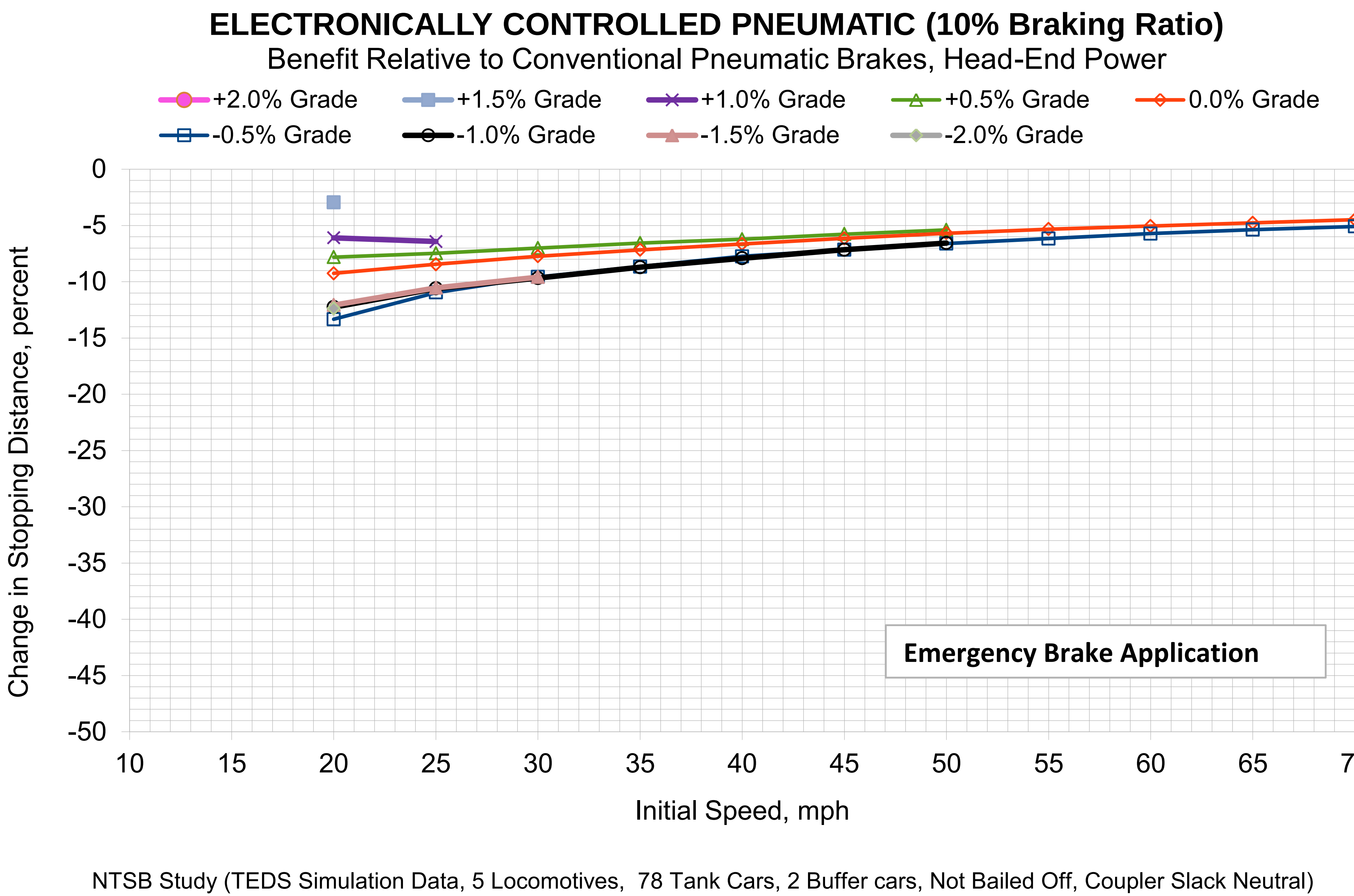
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

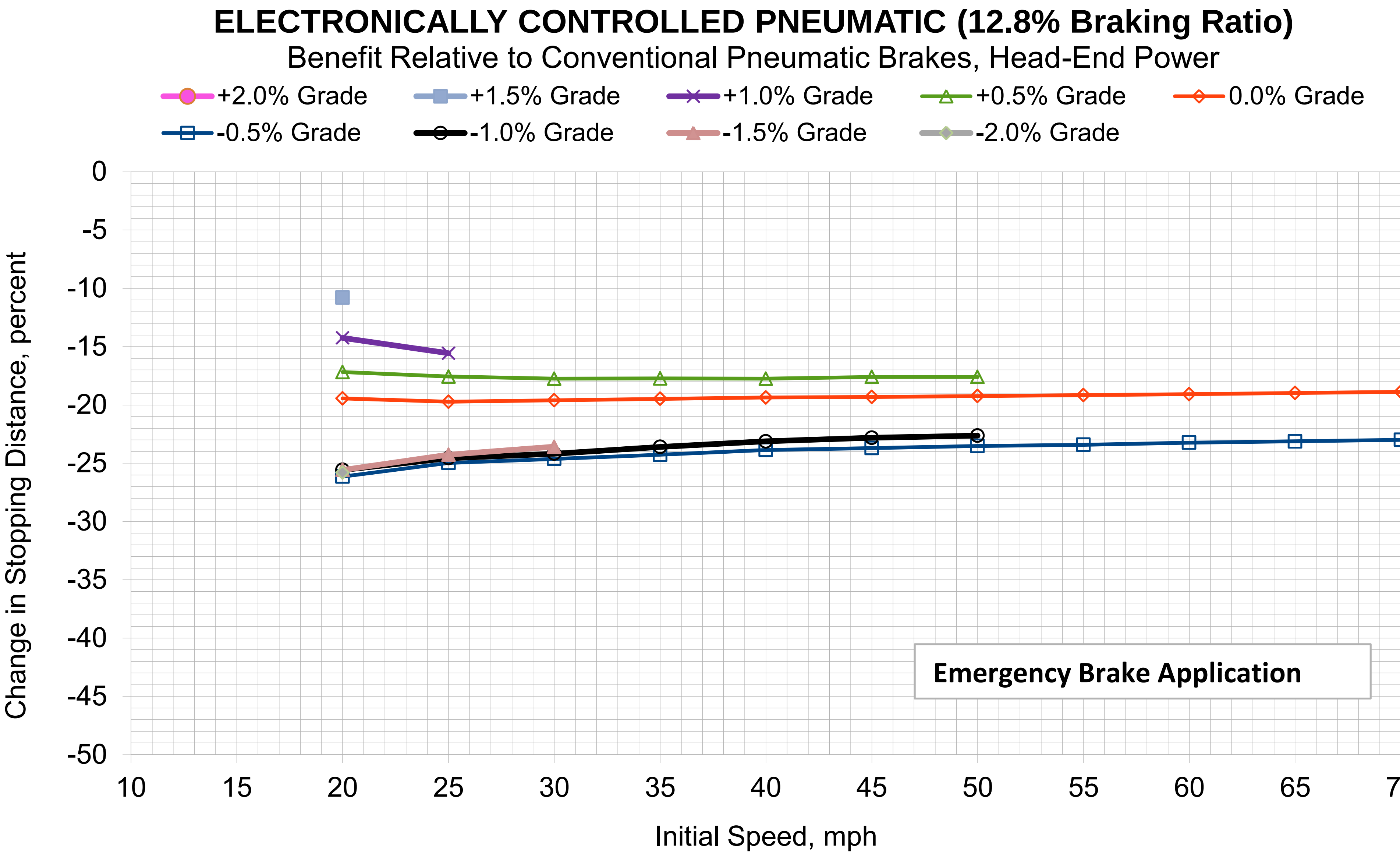


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

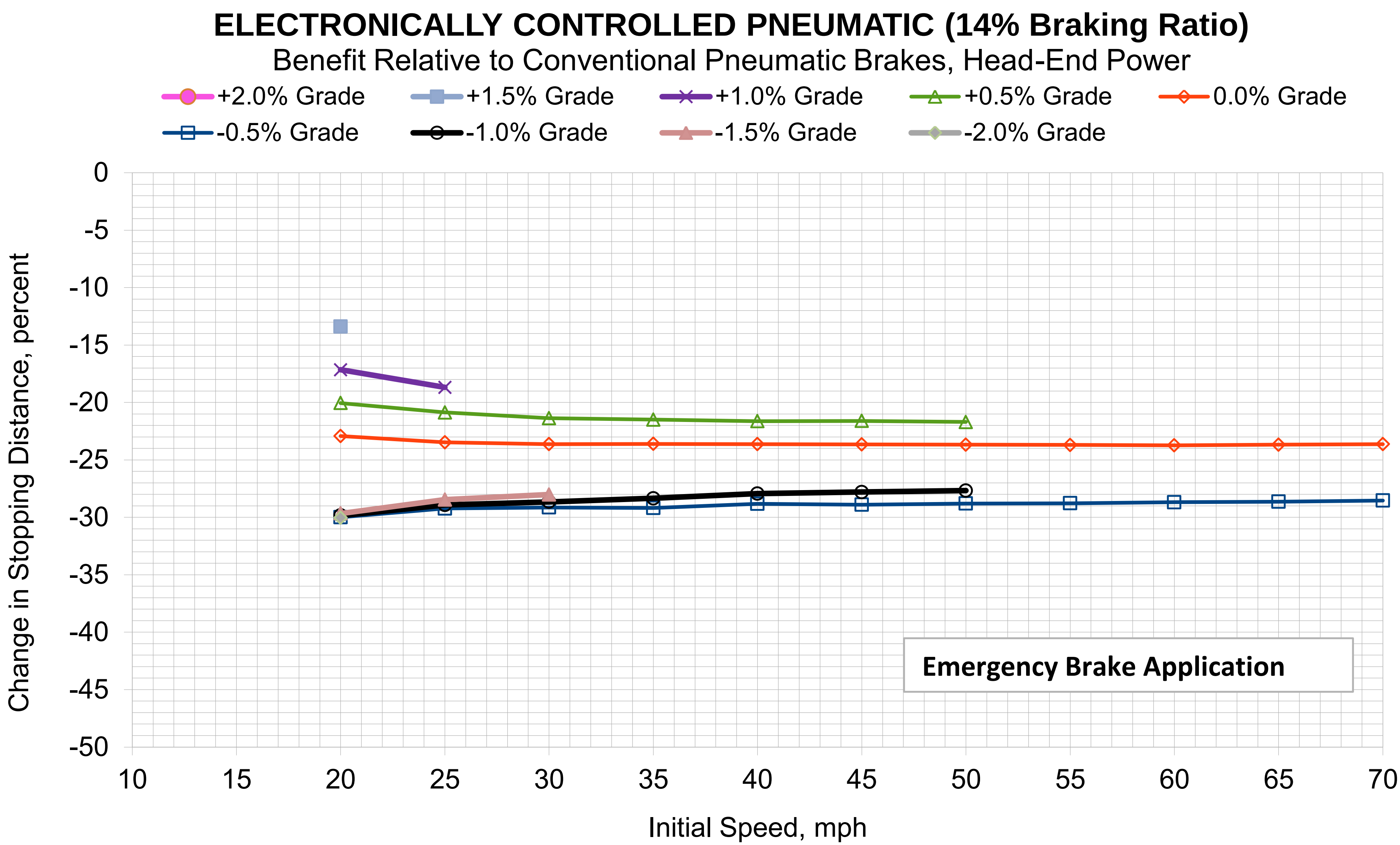


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

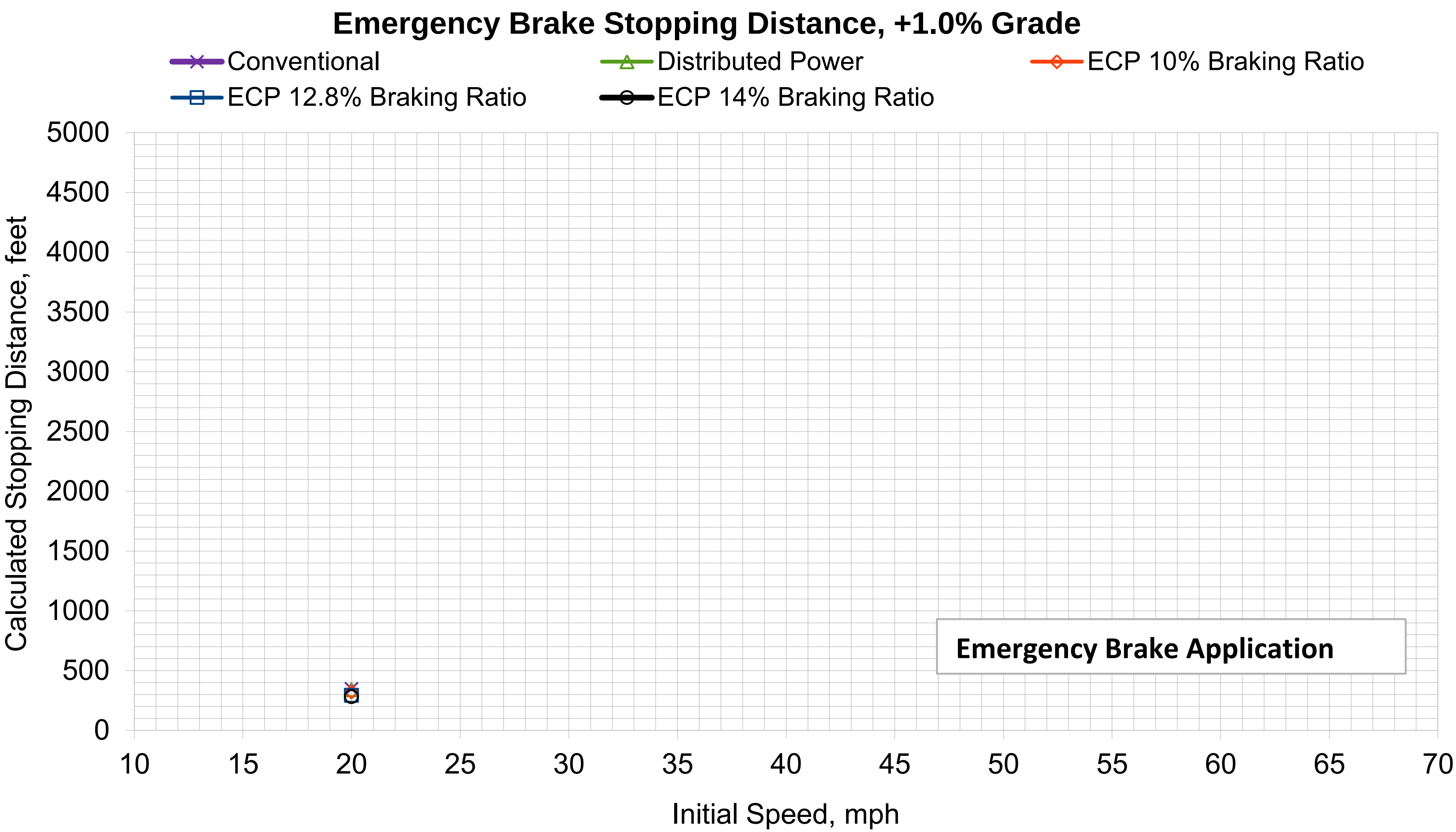


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

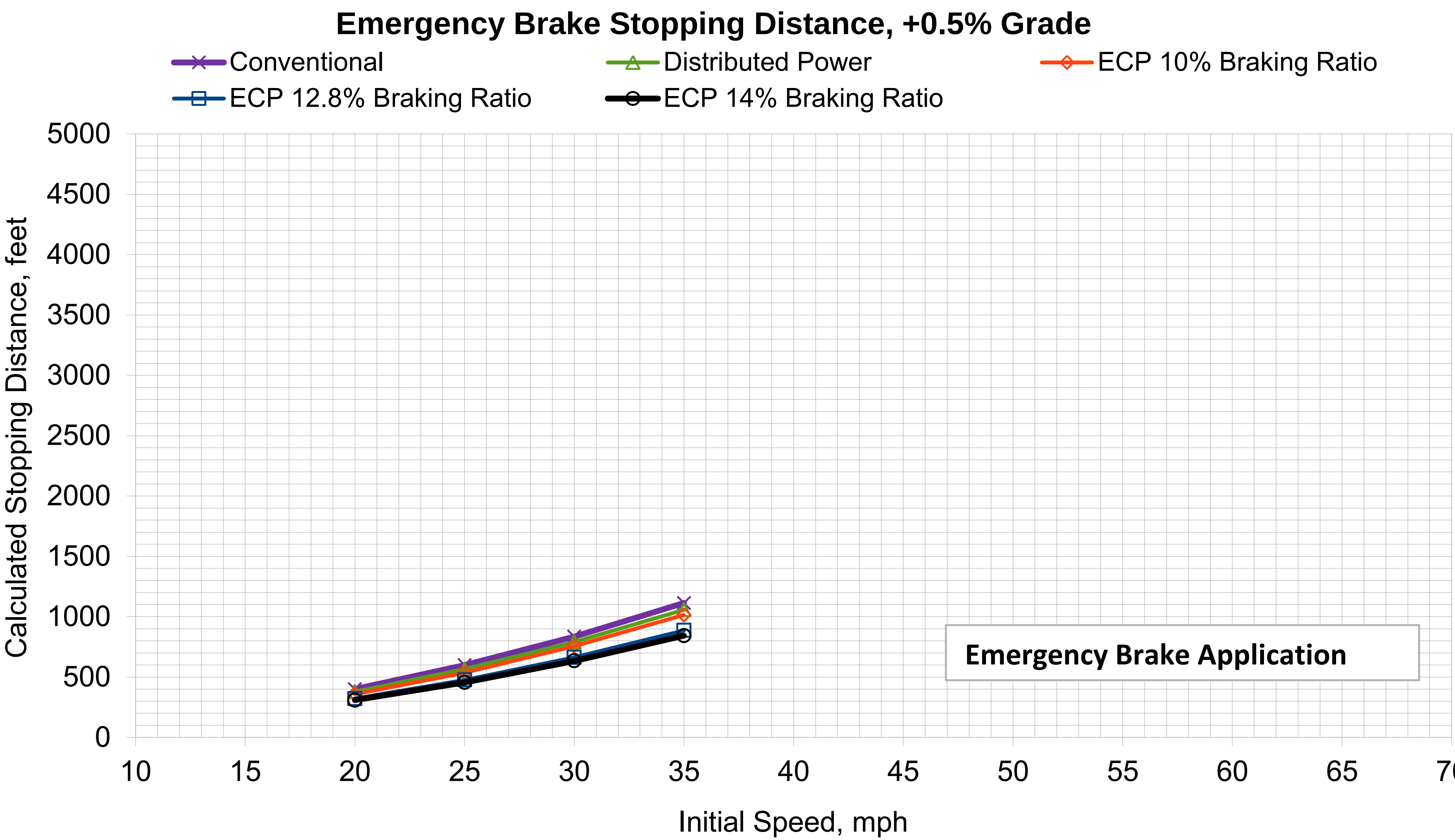


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

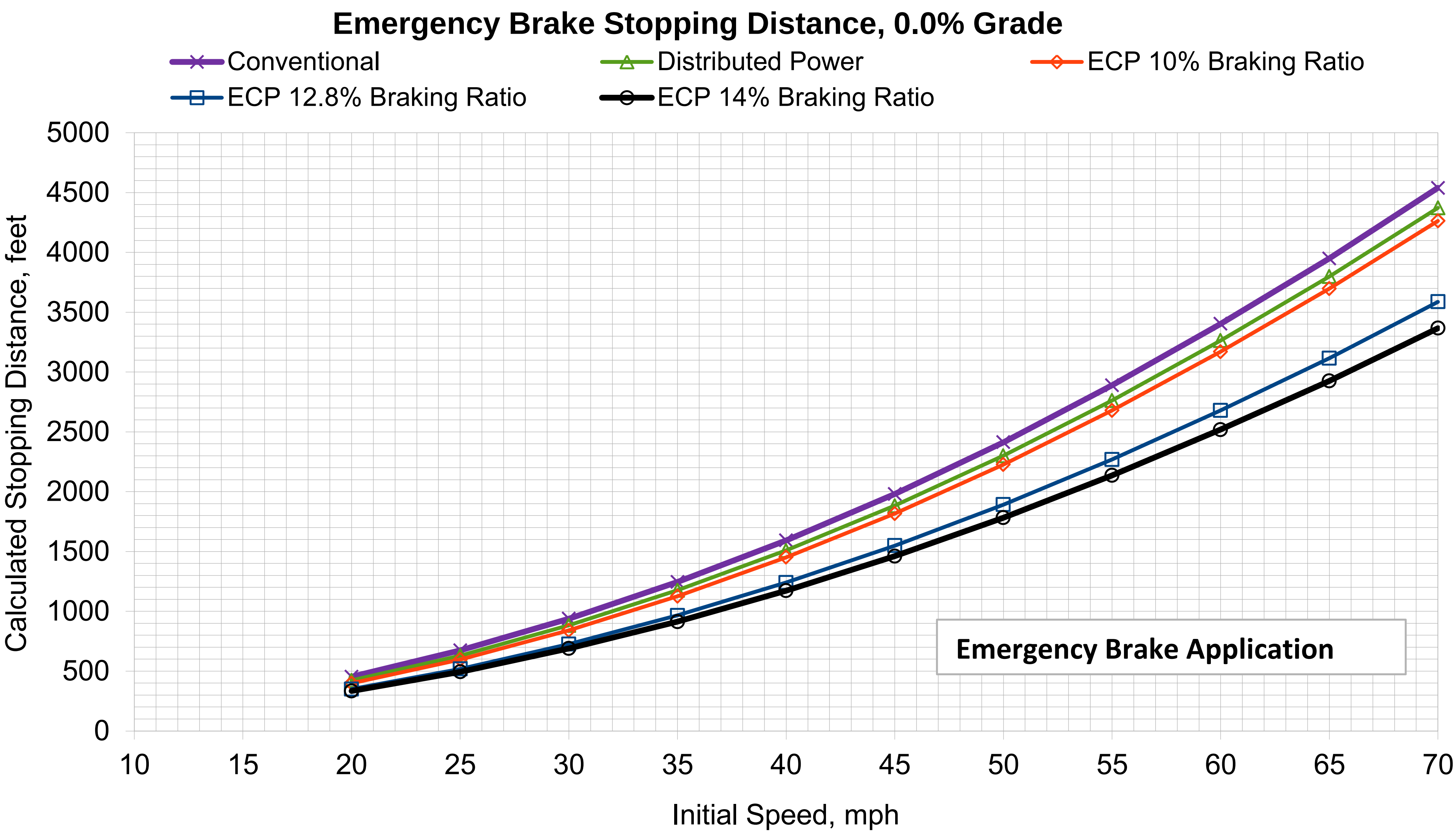
Attachment 14: Emergency Braking, No Bailoff, 104 Tank Cars



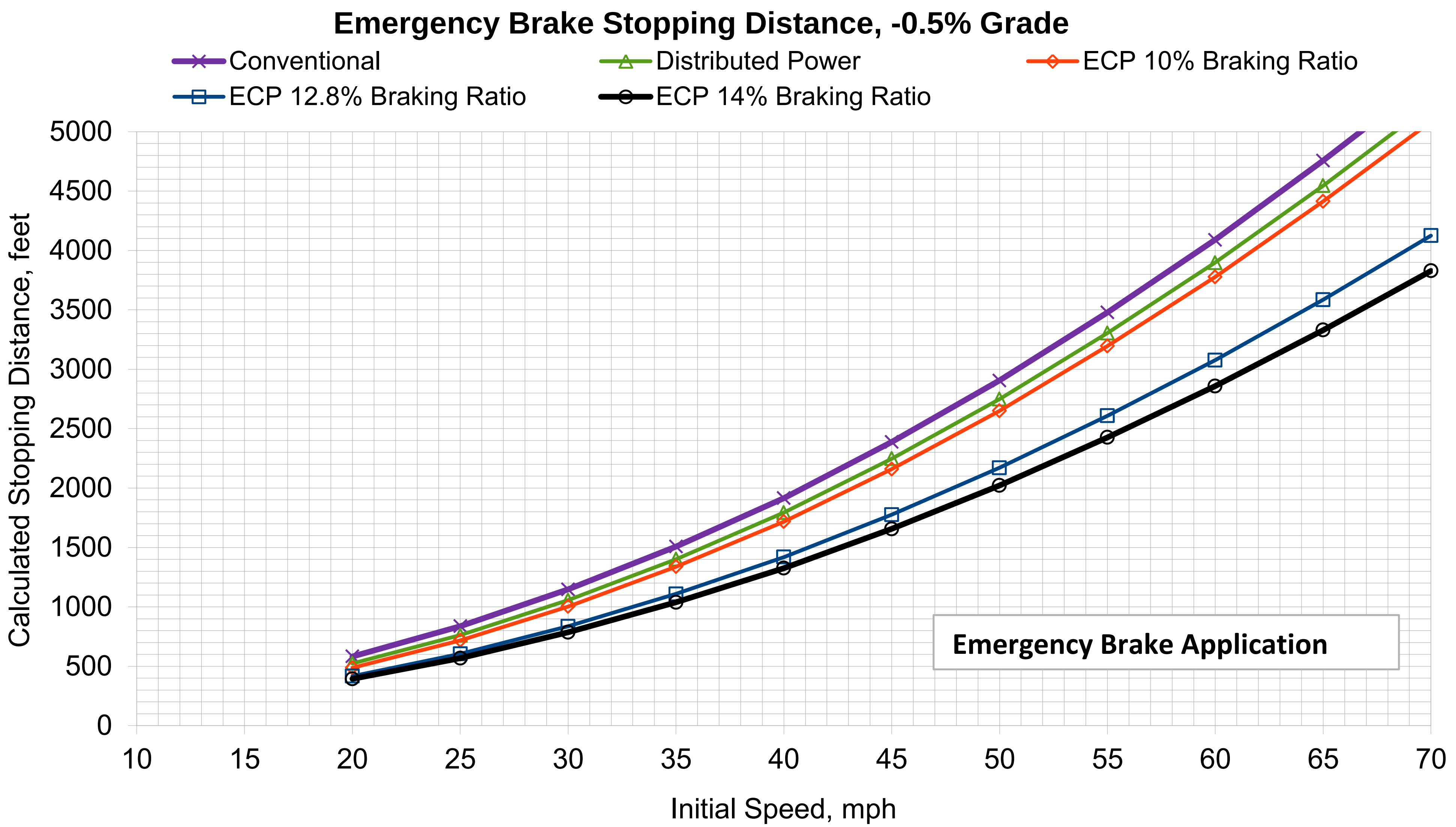
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



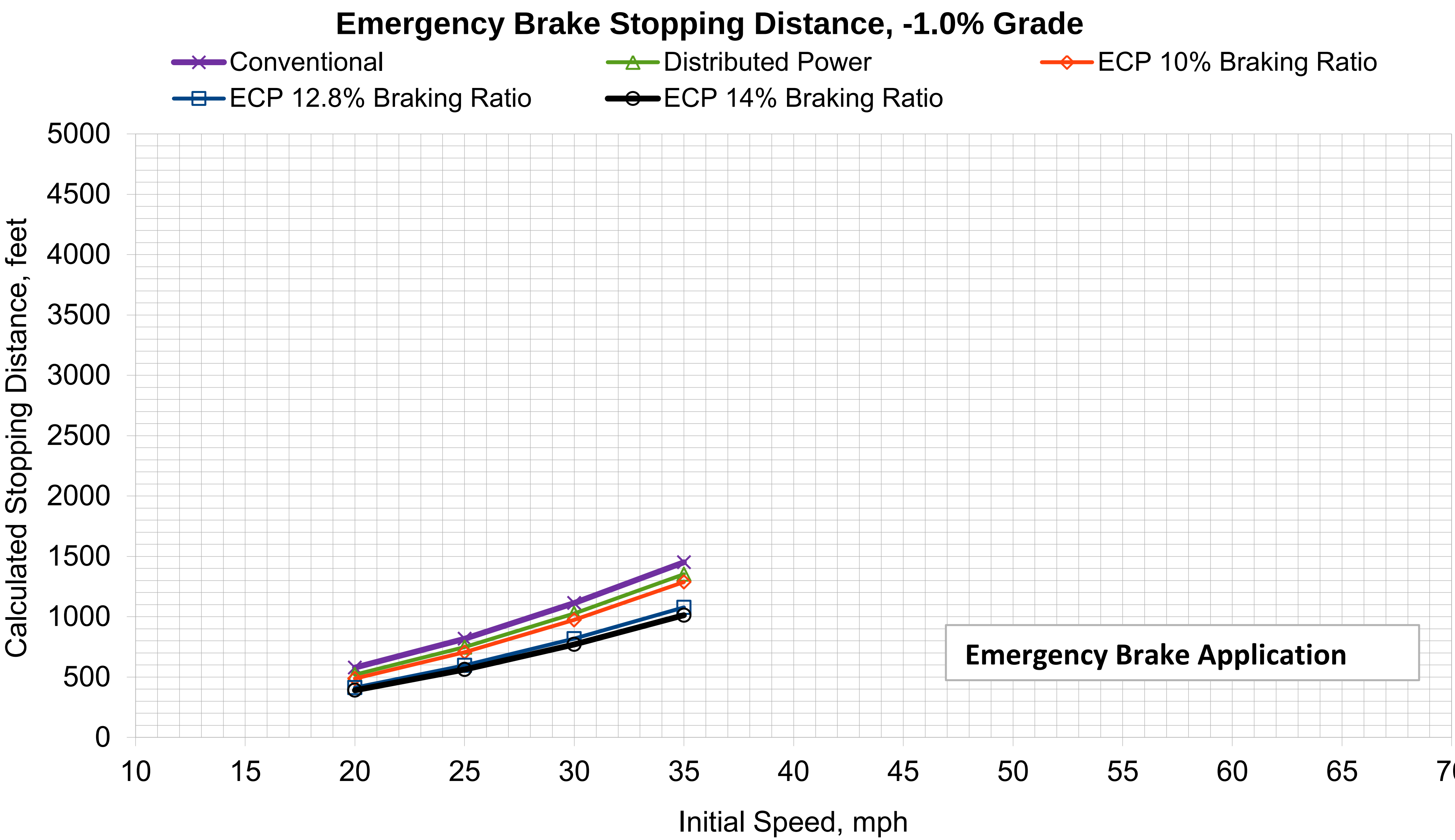
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



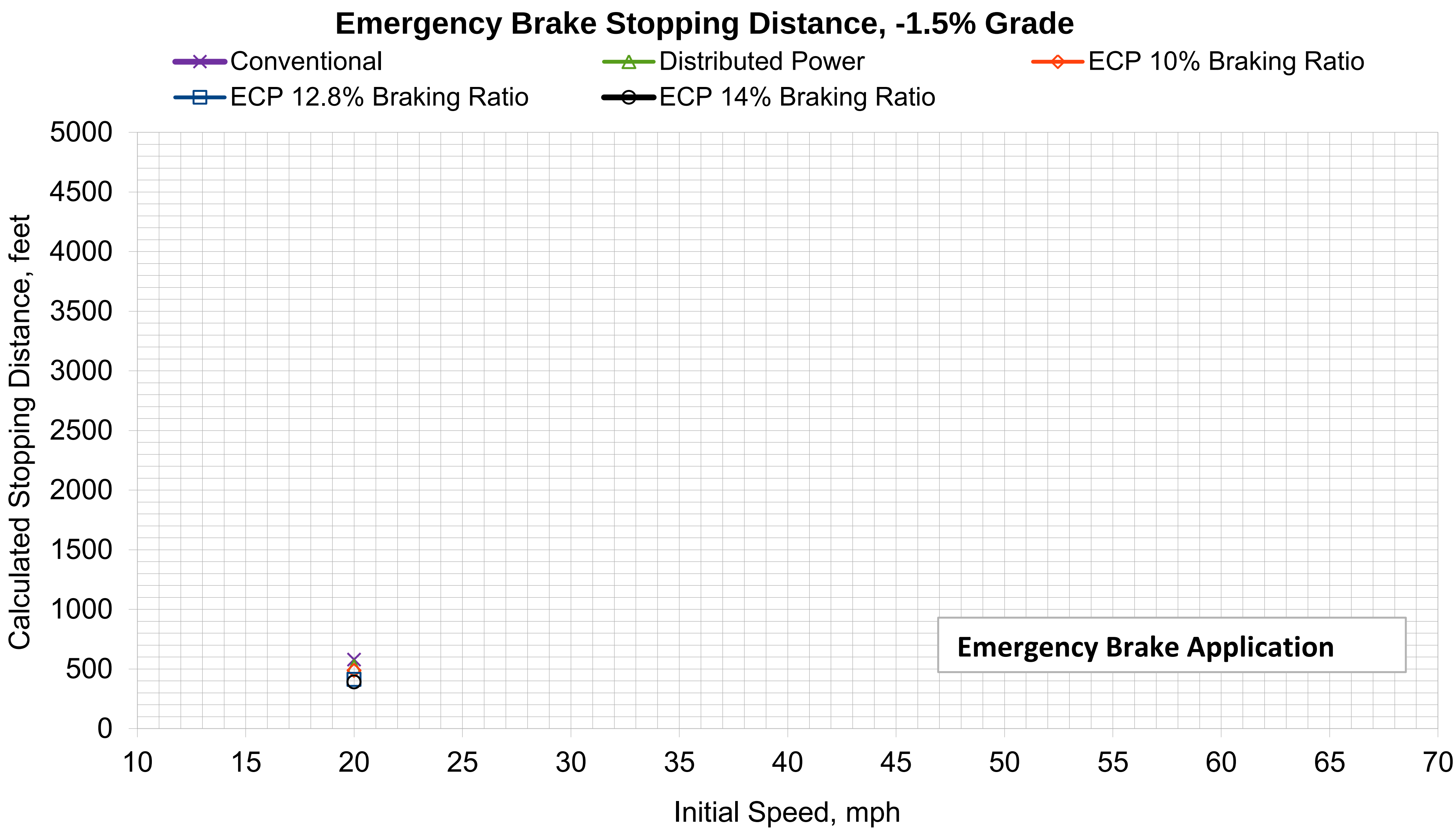
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



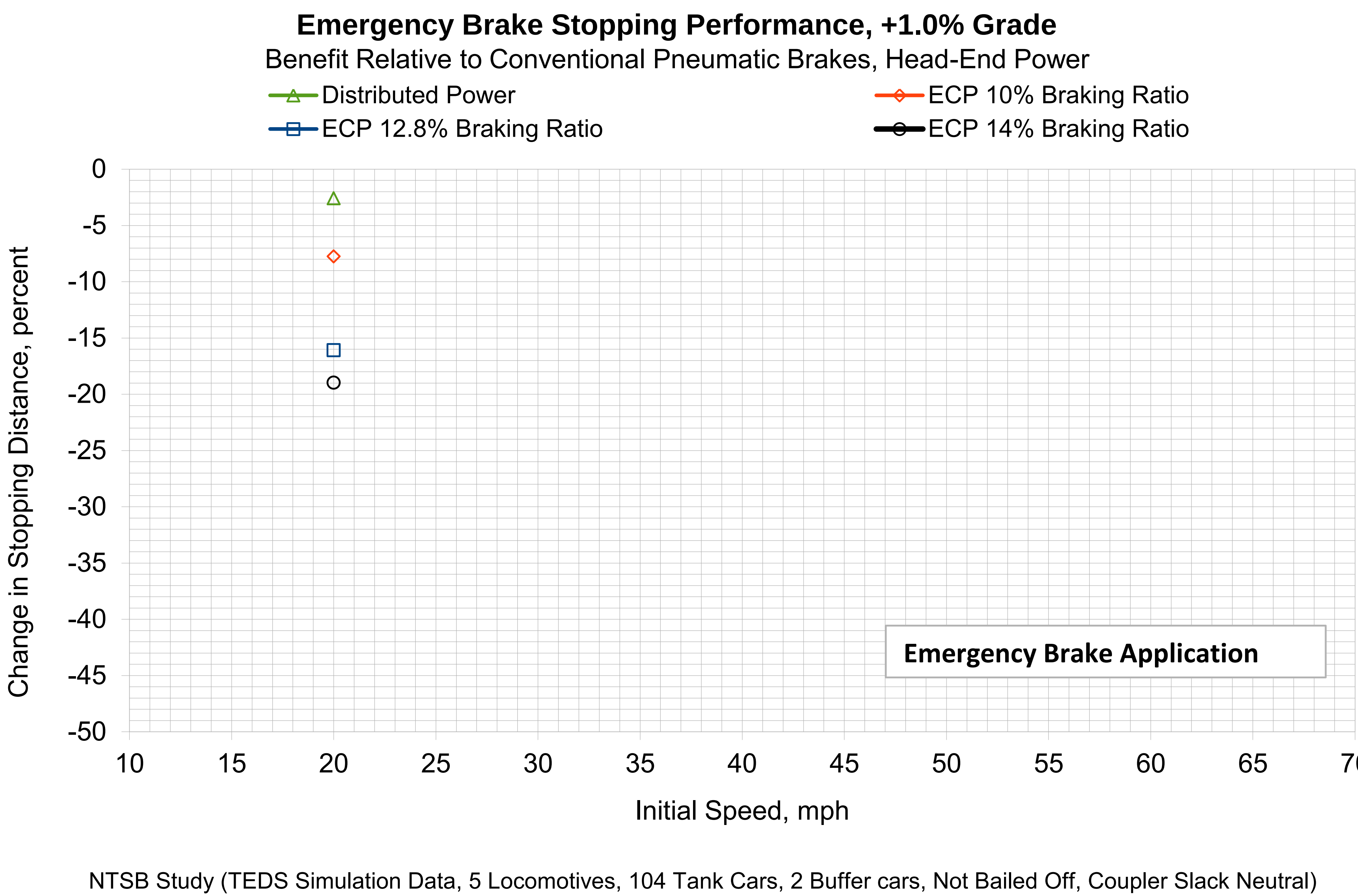
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

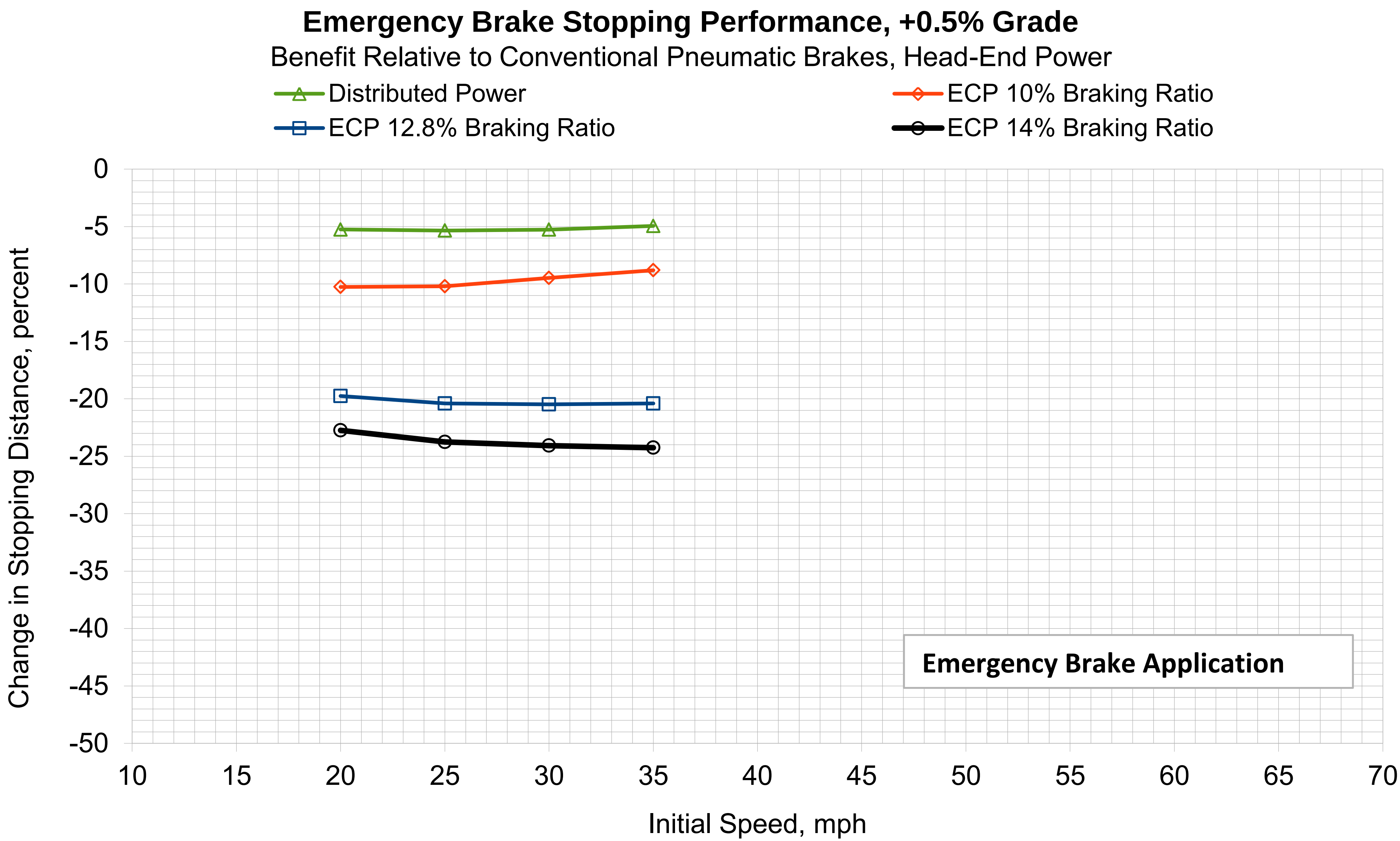


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

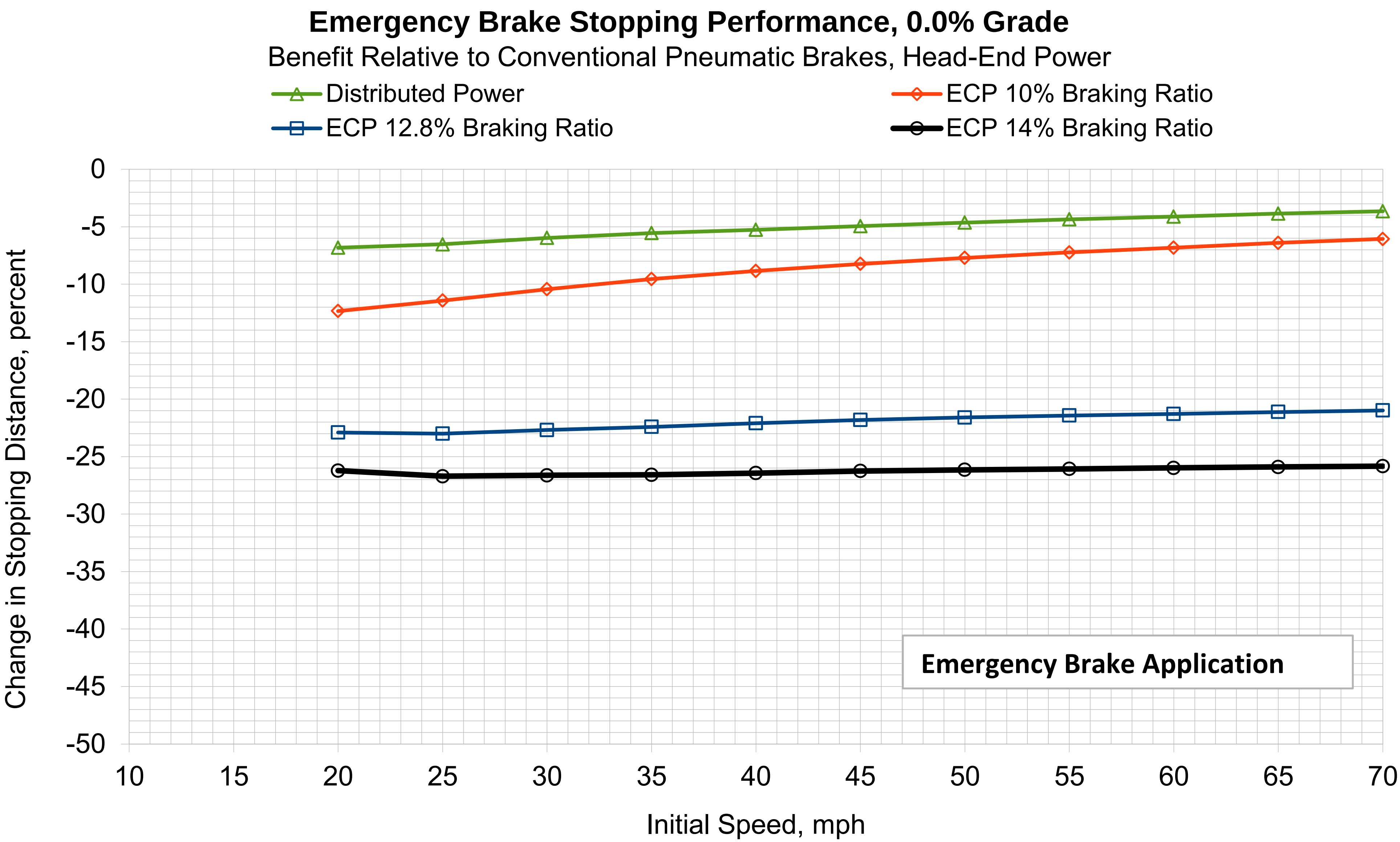


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

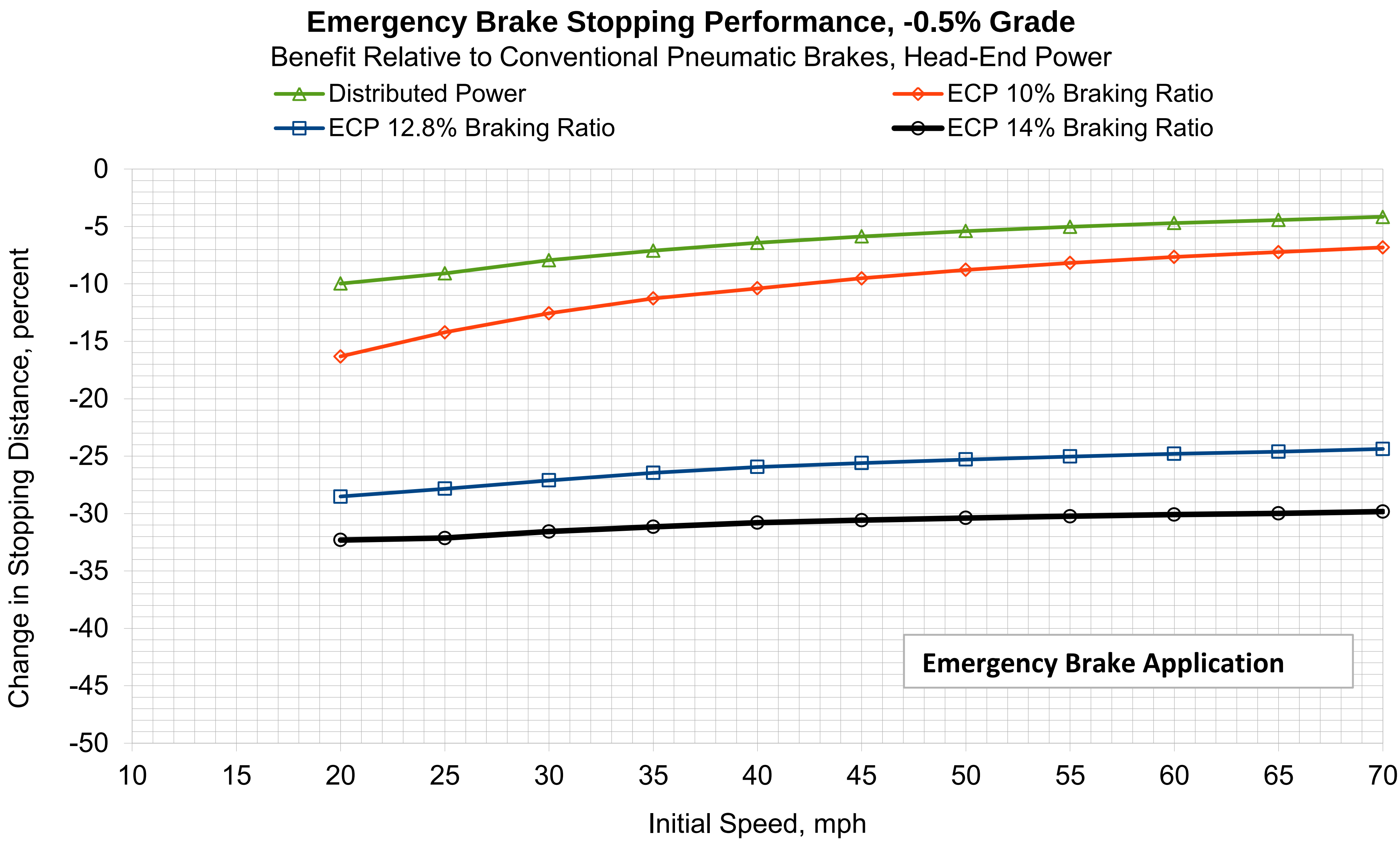

Emergency Brake Stopping Performance, +1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



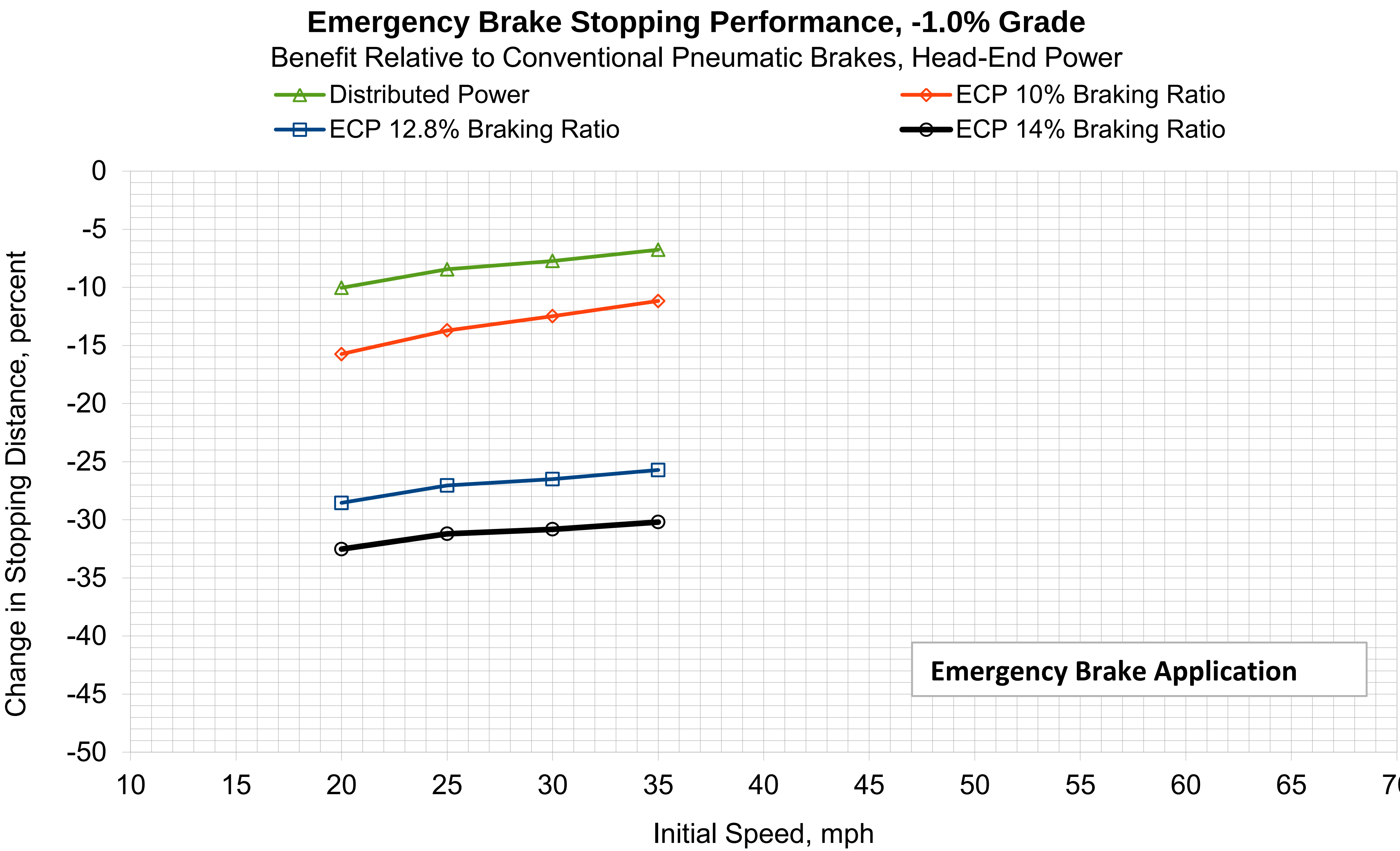
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



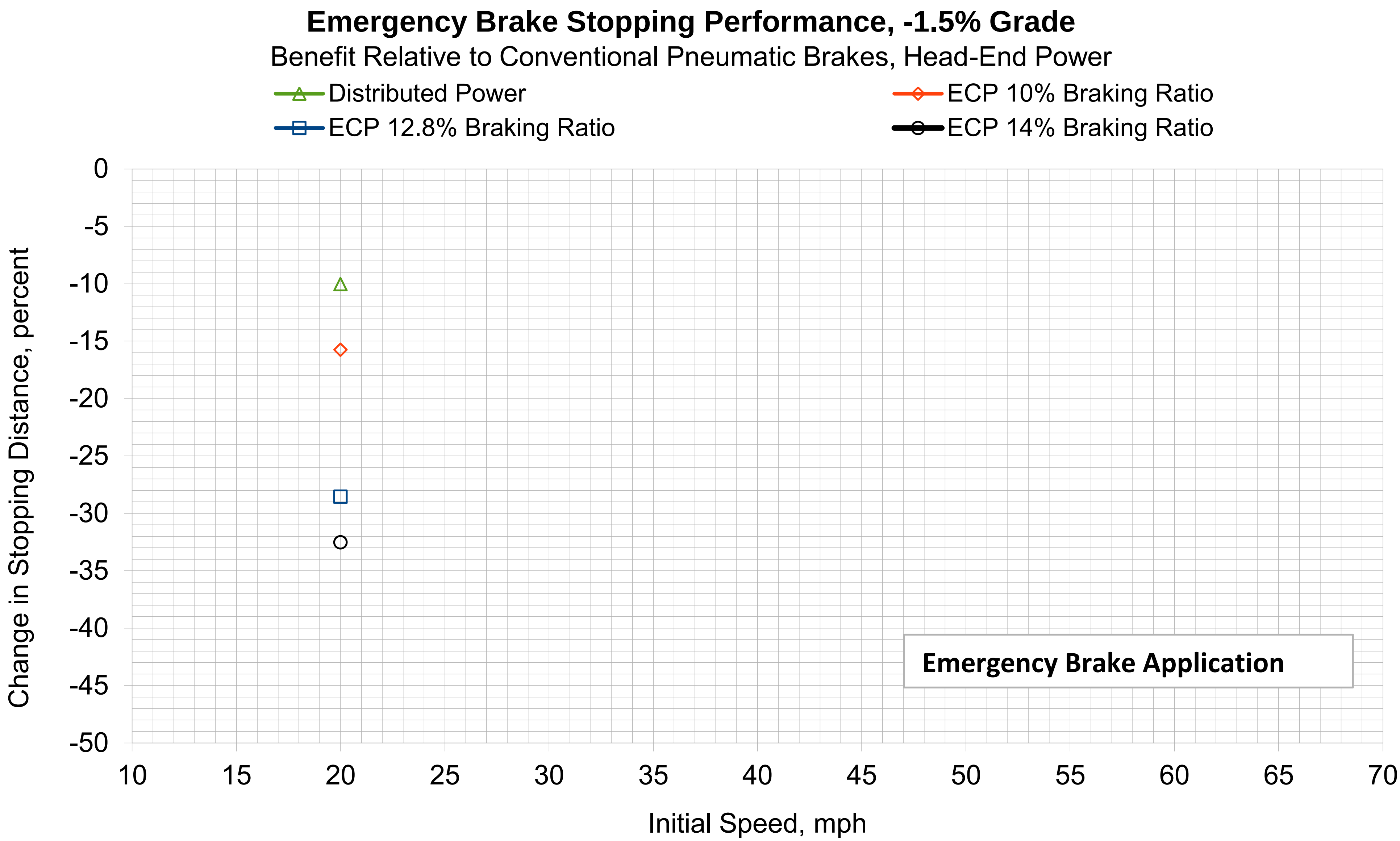
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



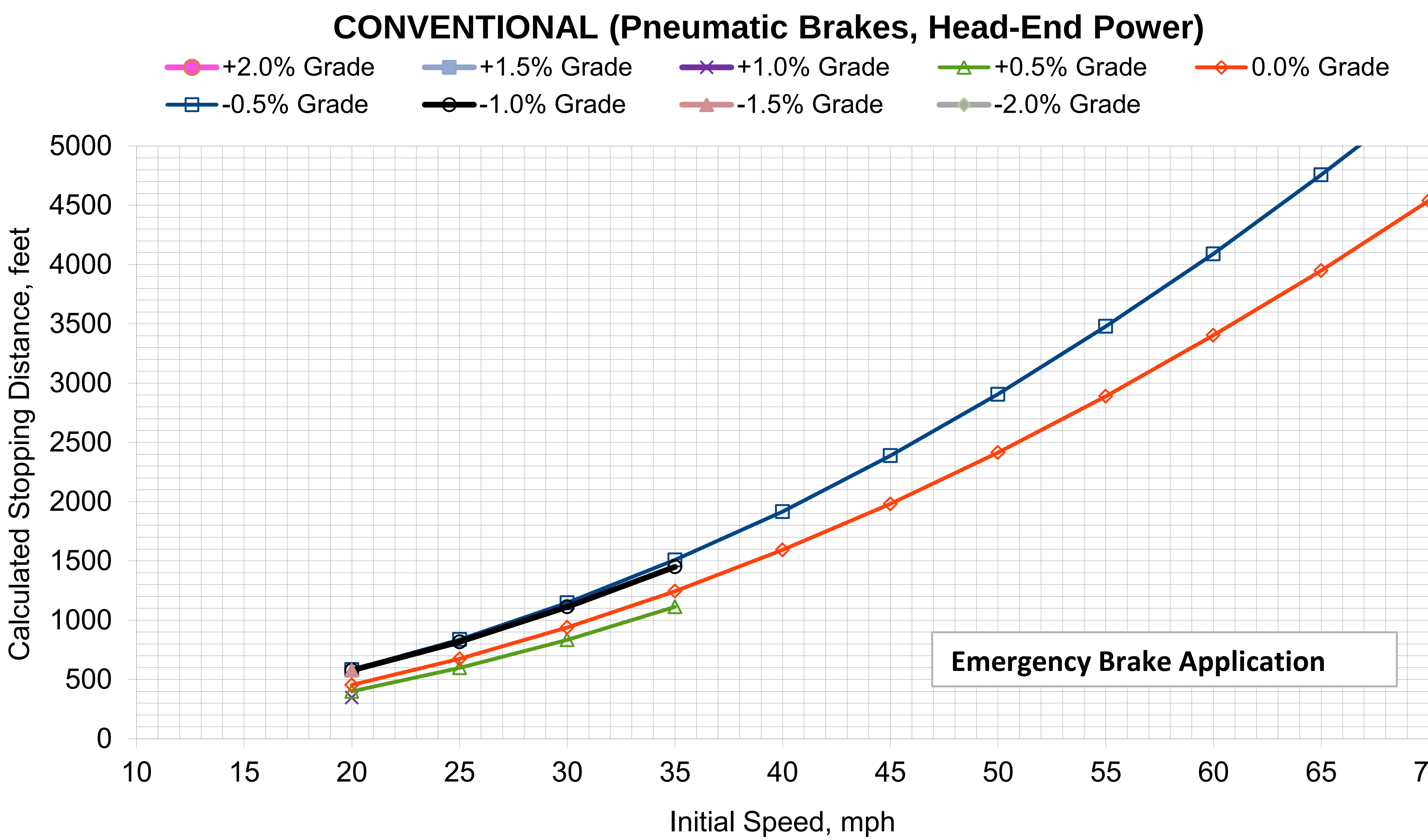
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



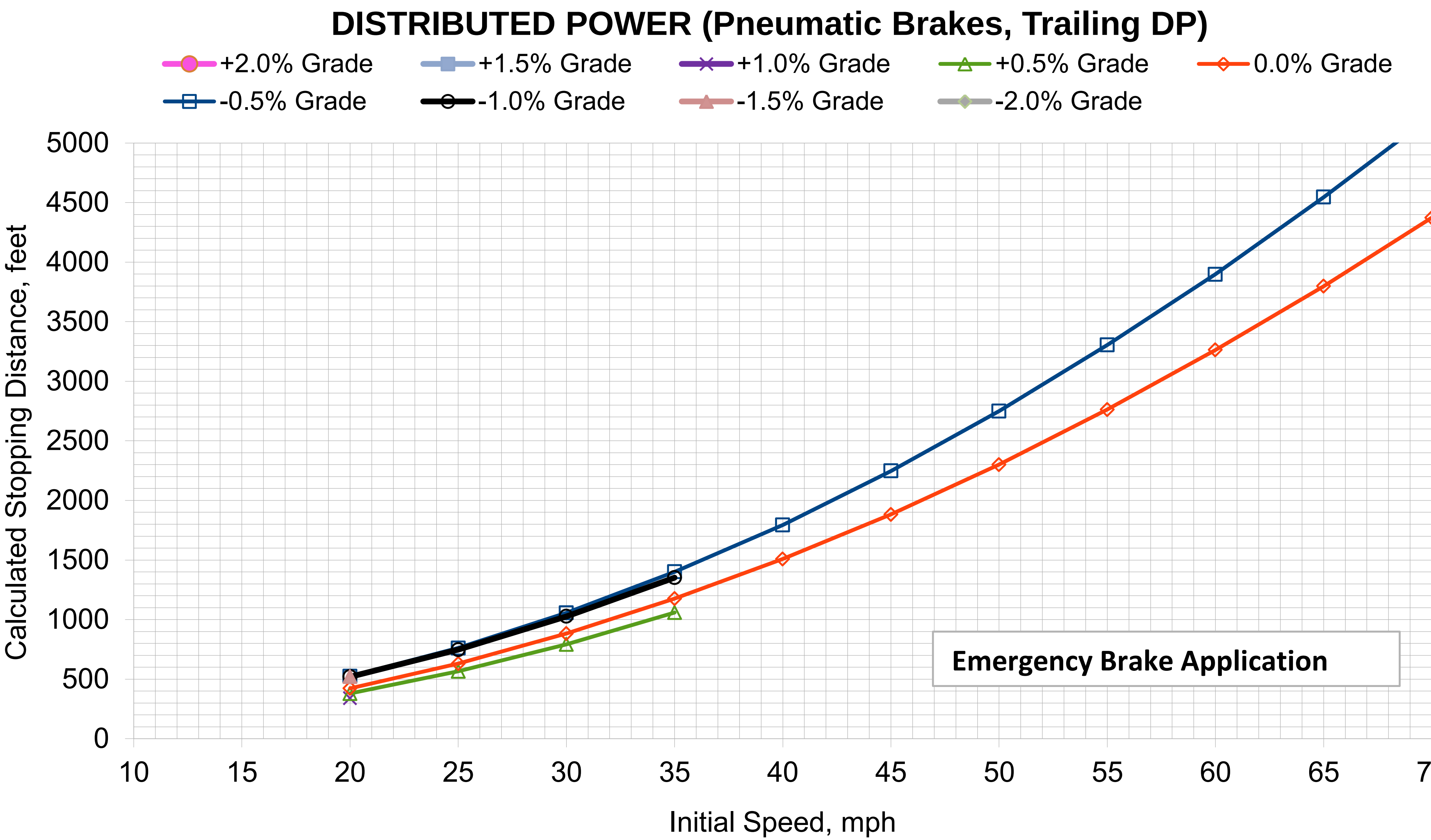
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



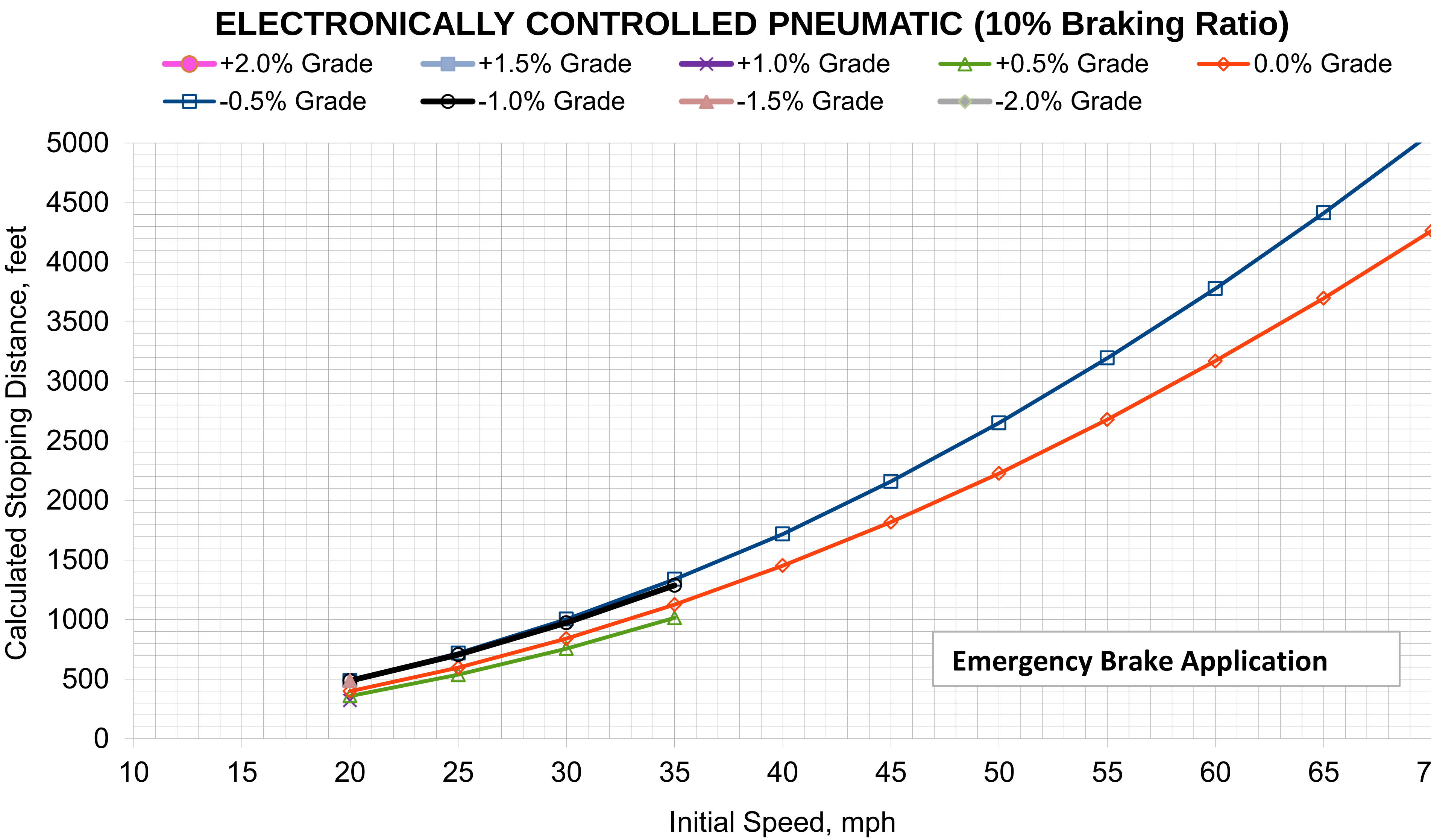
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



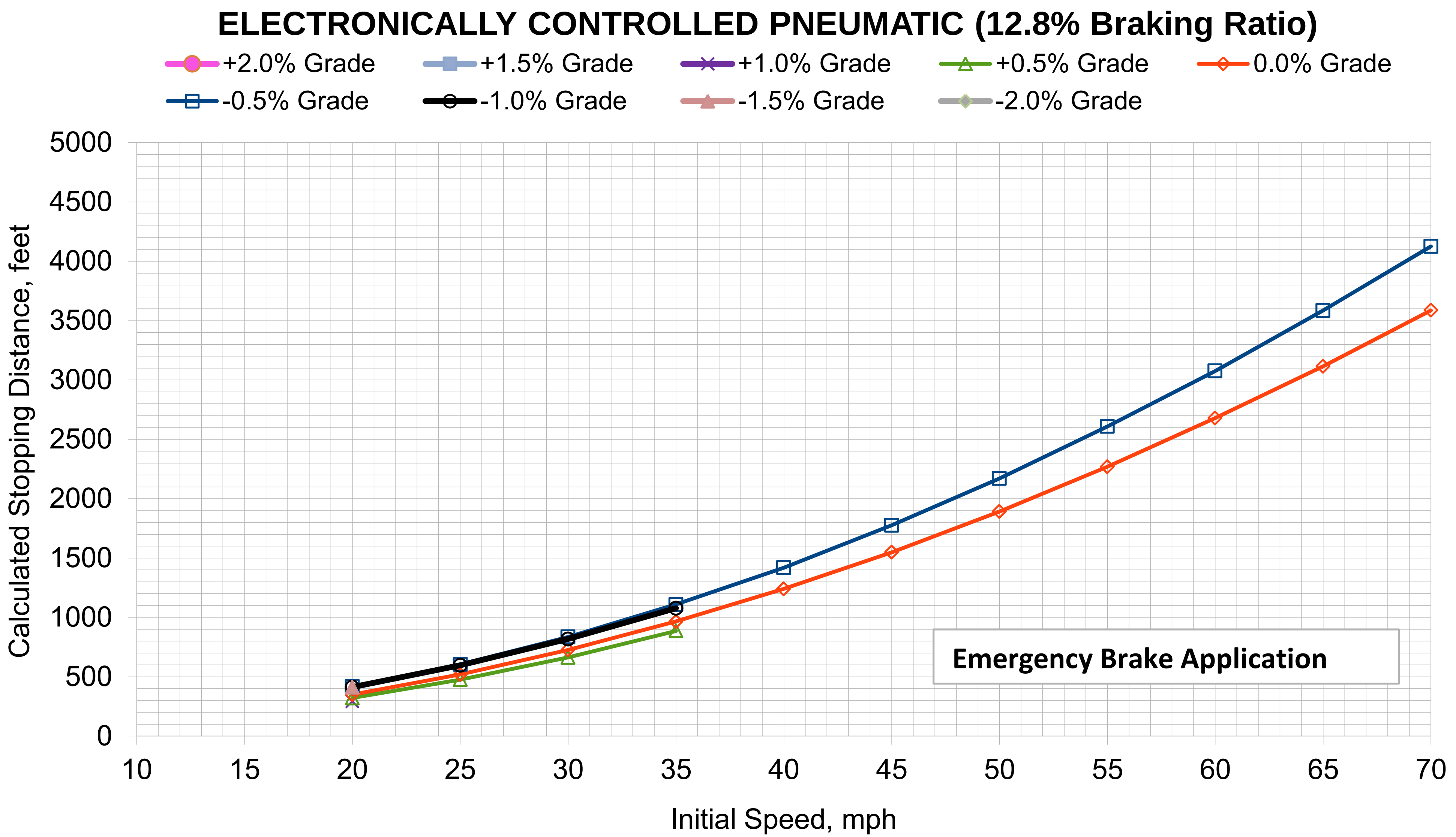
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



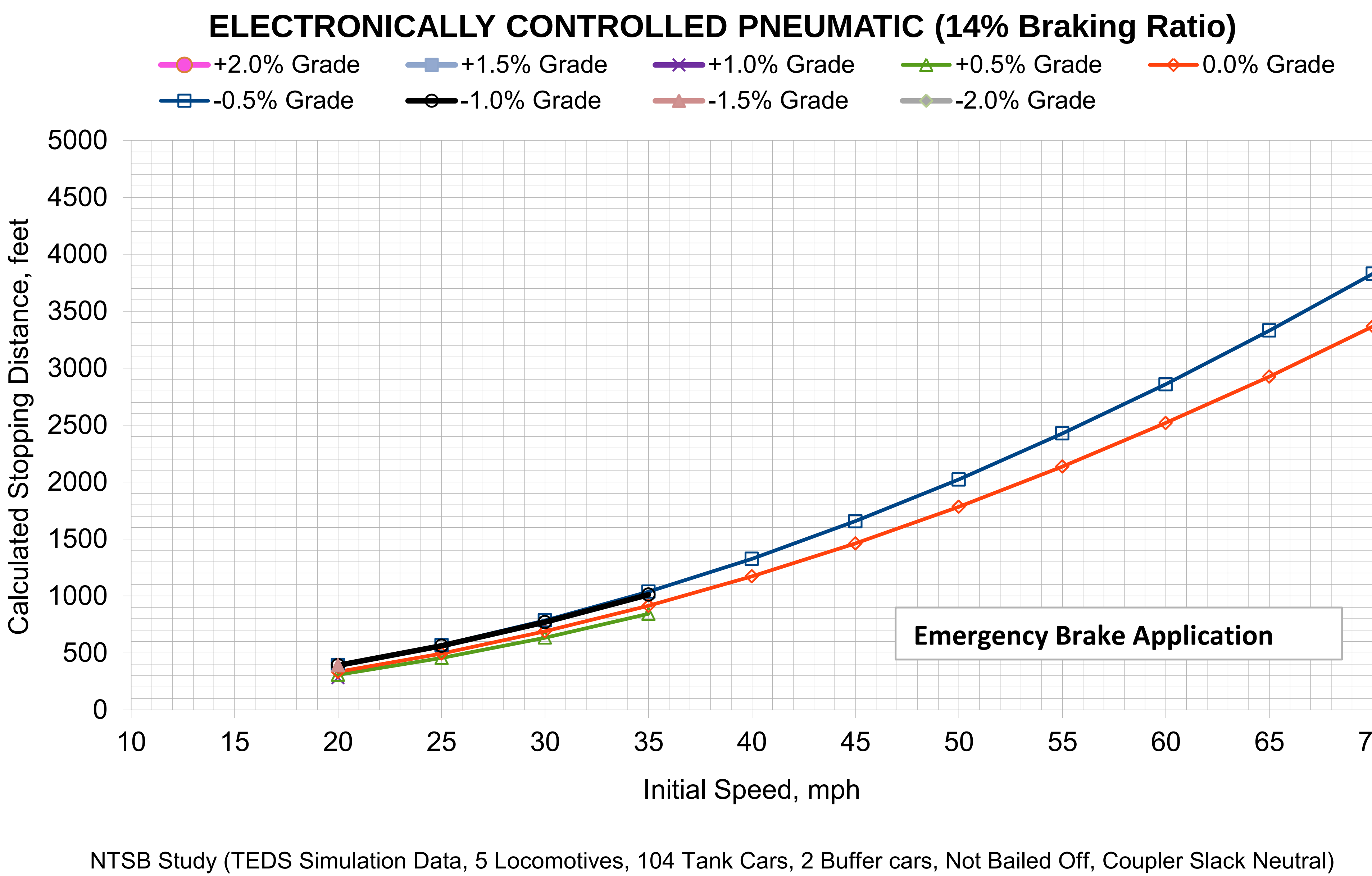
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

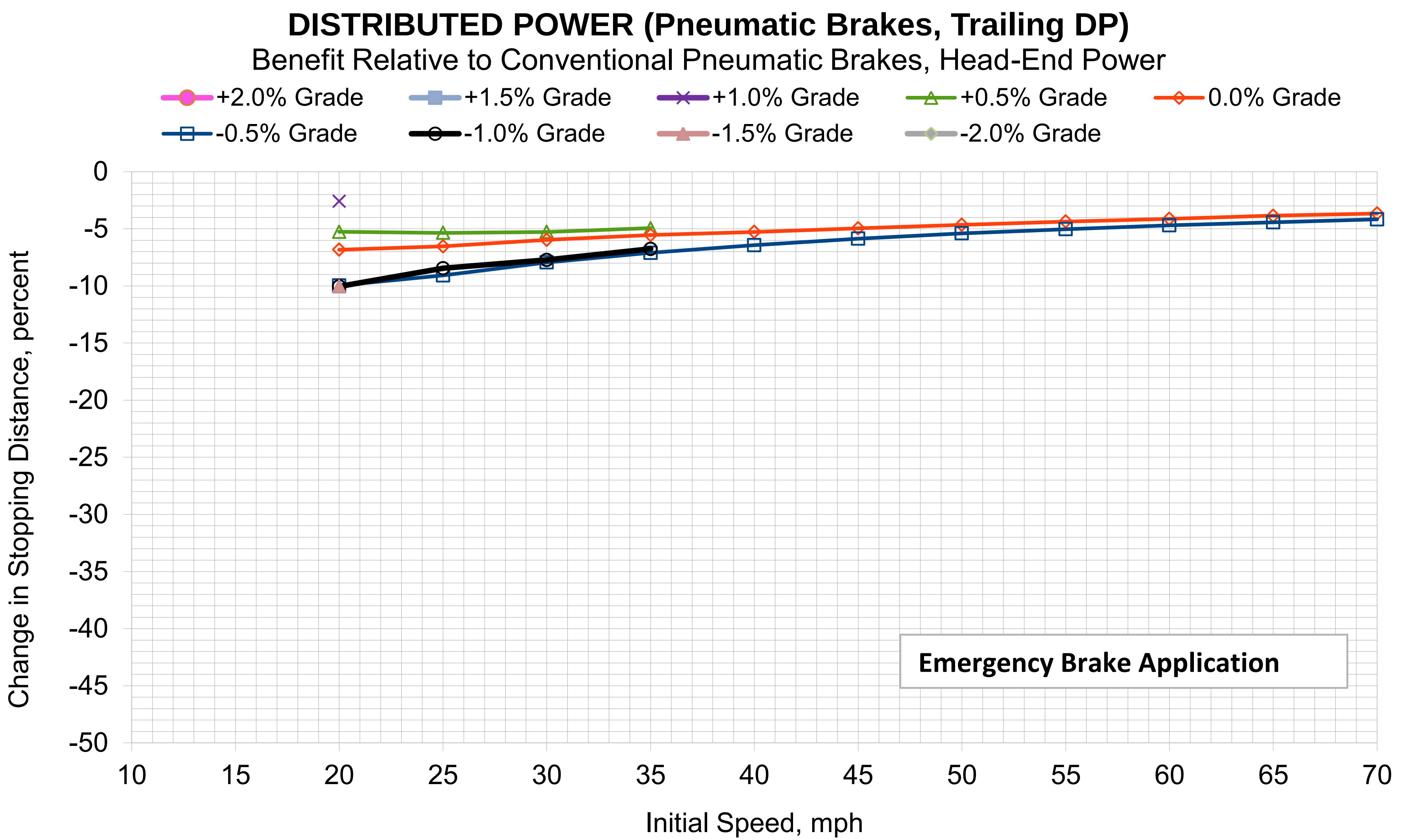


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

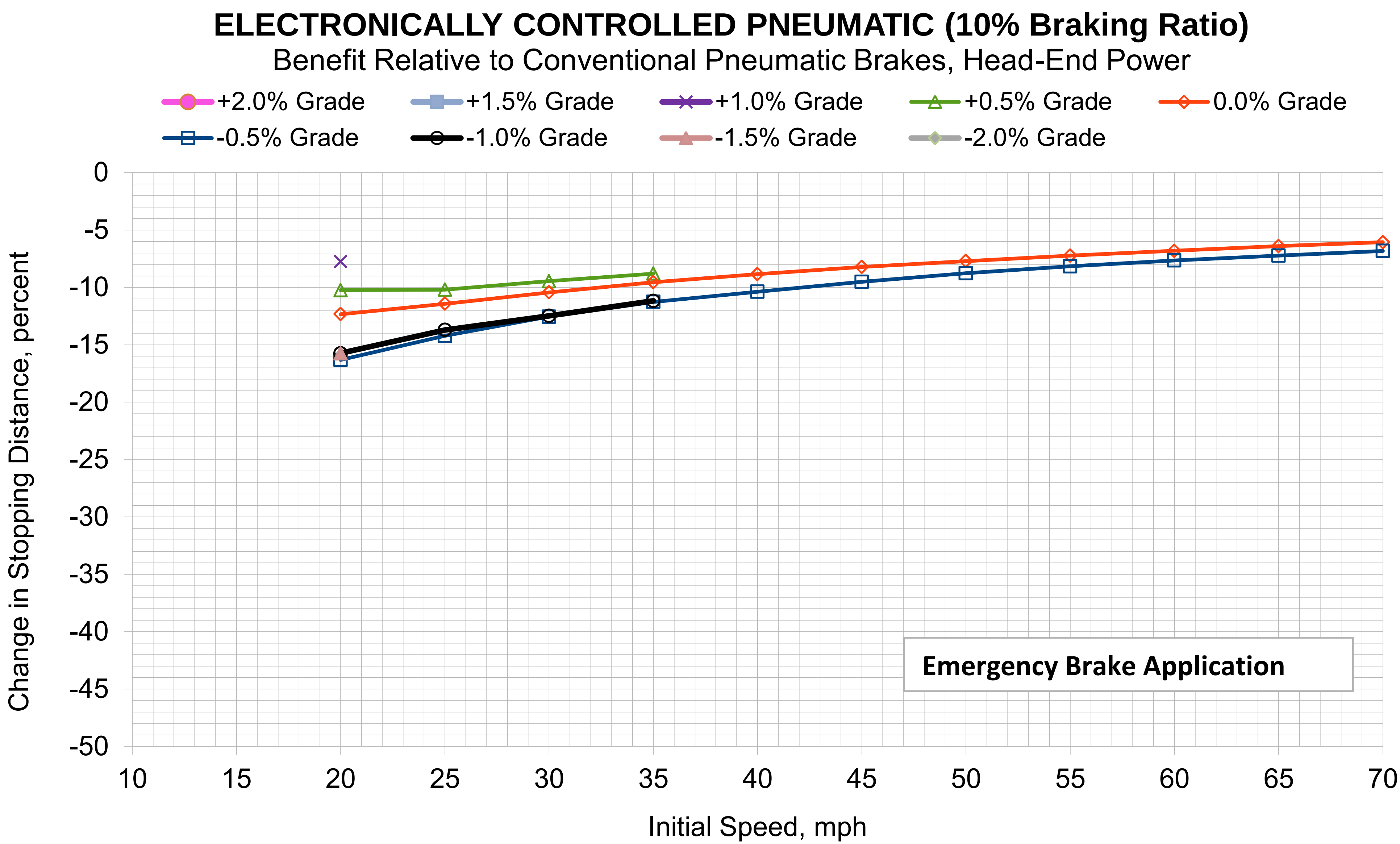


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

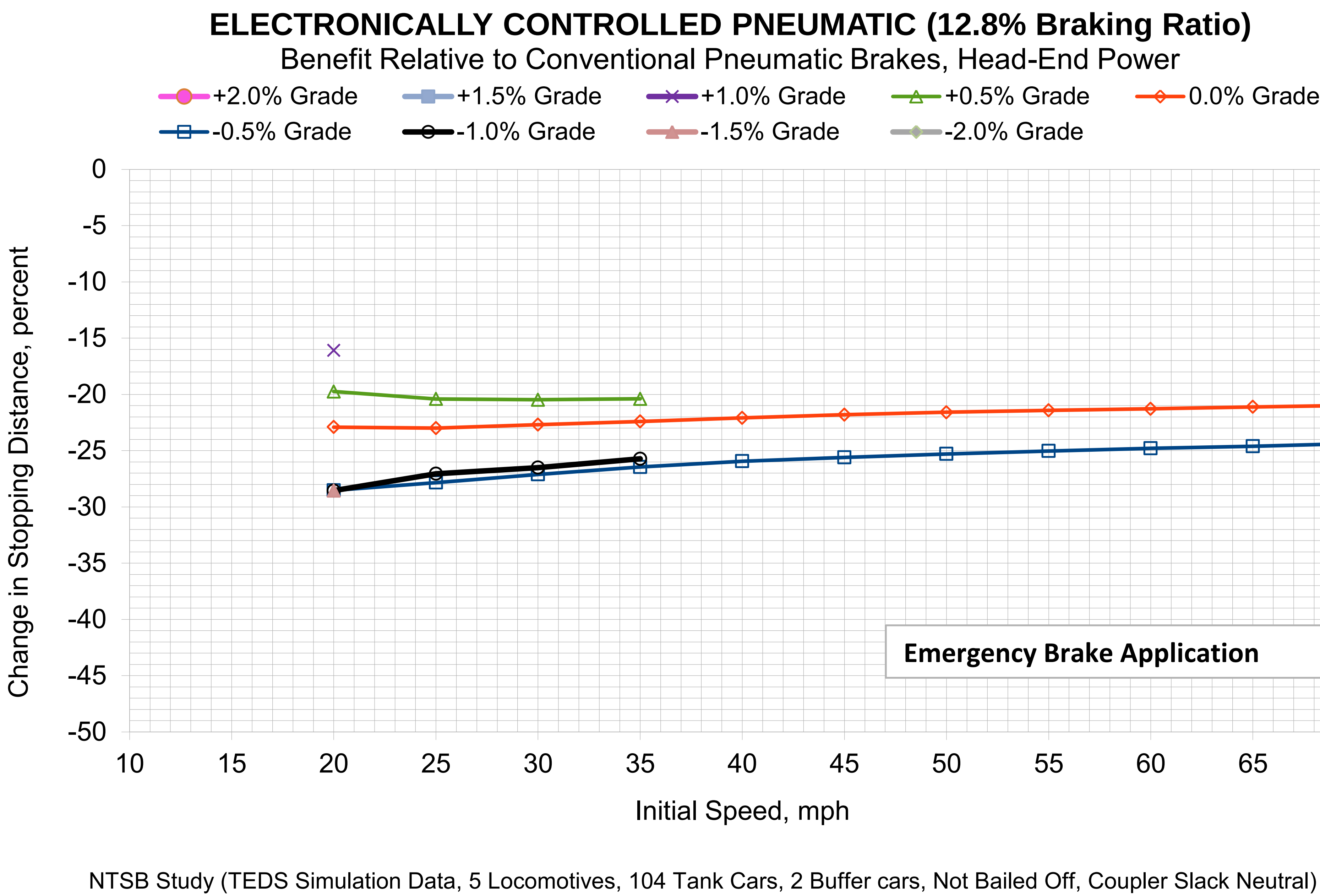

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

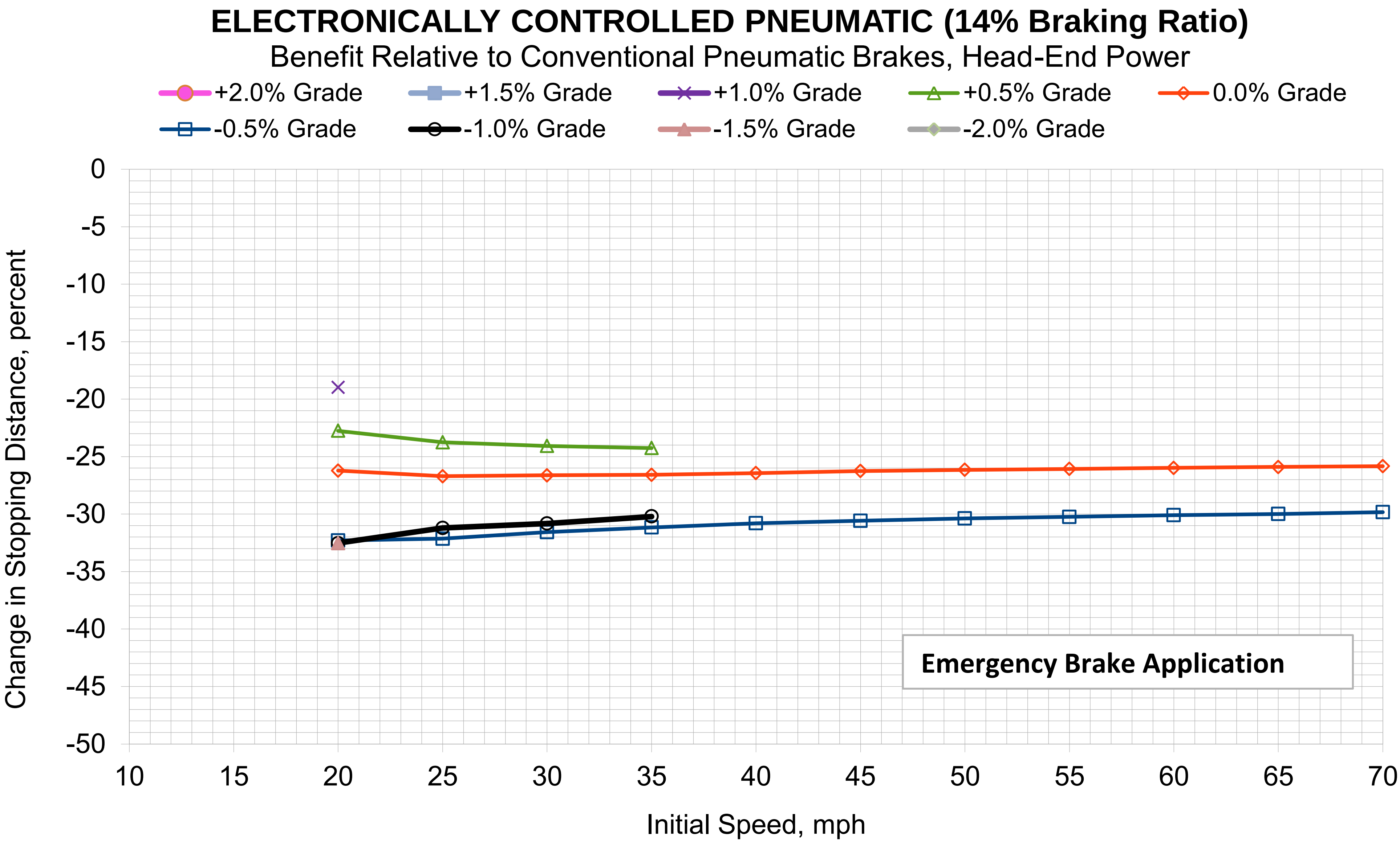


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



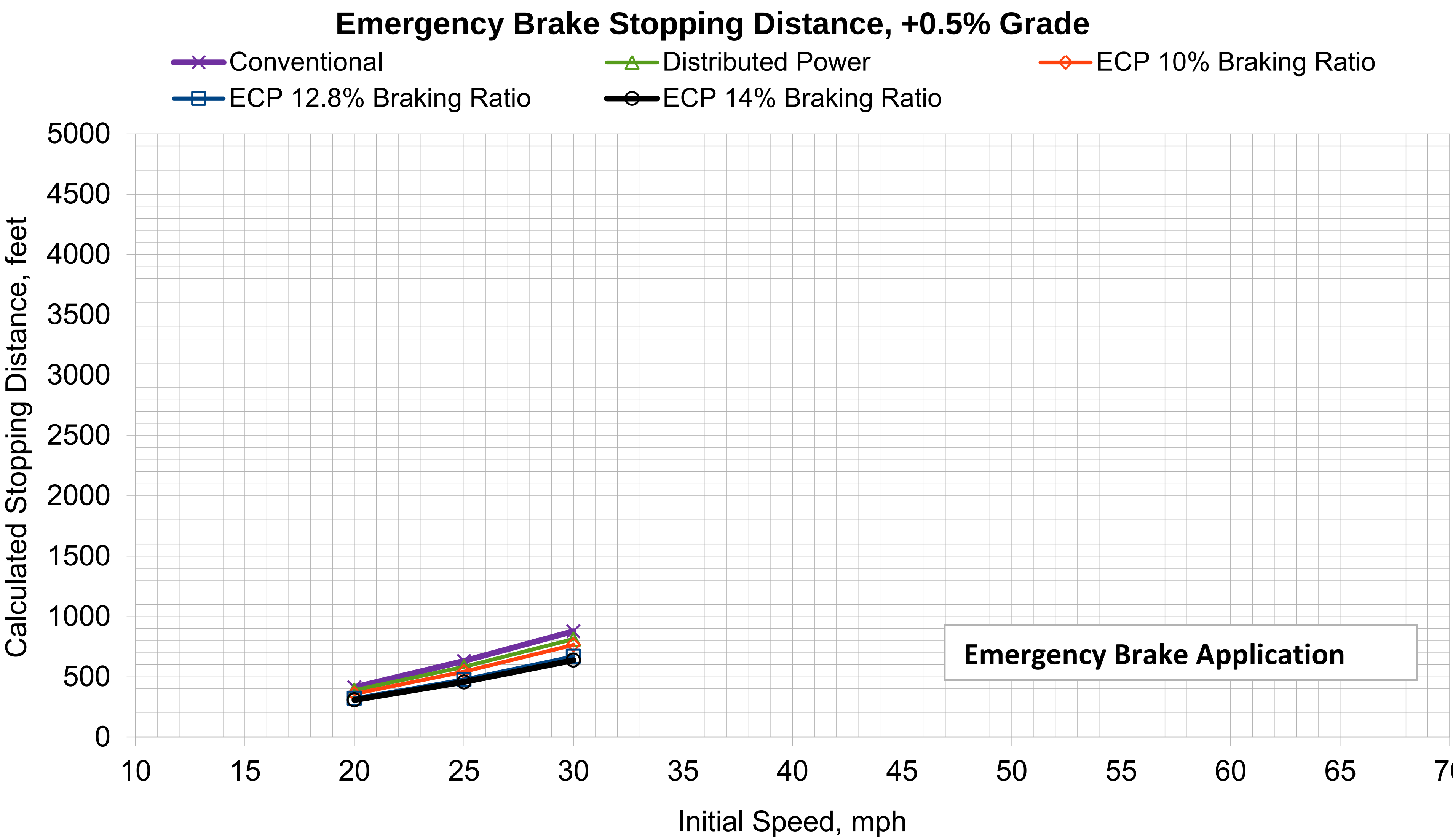
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

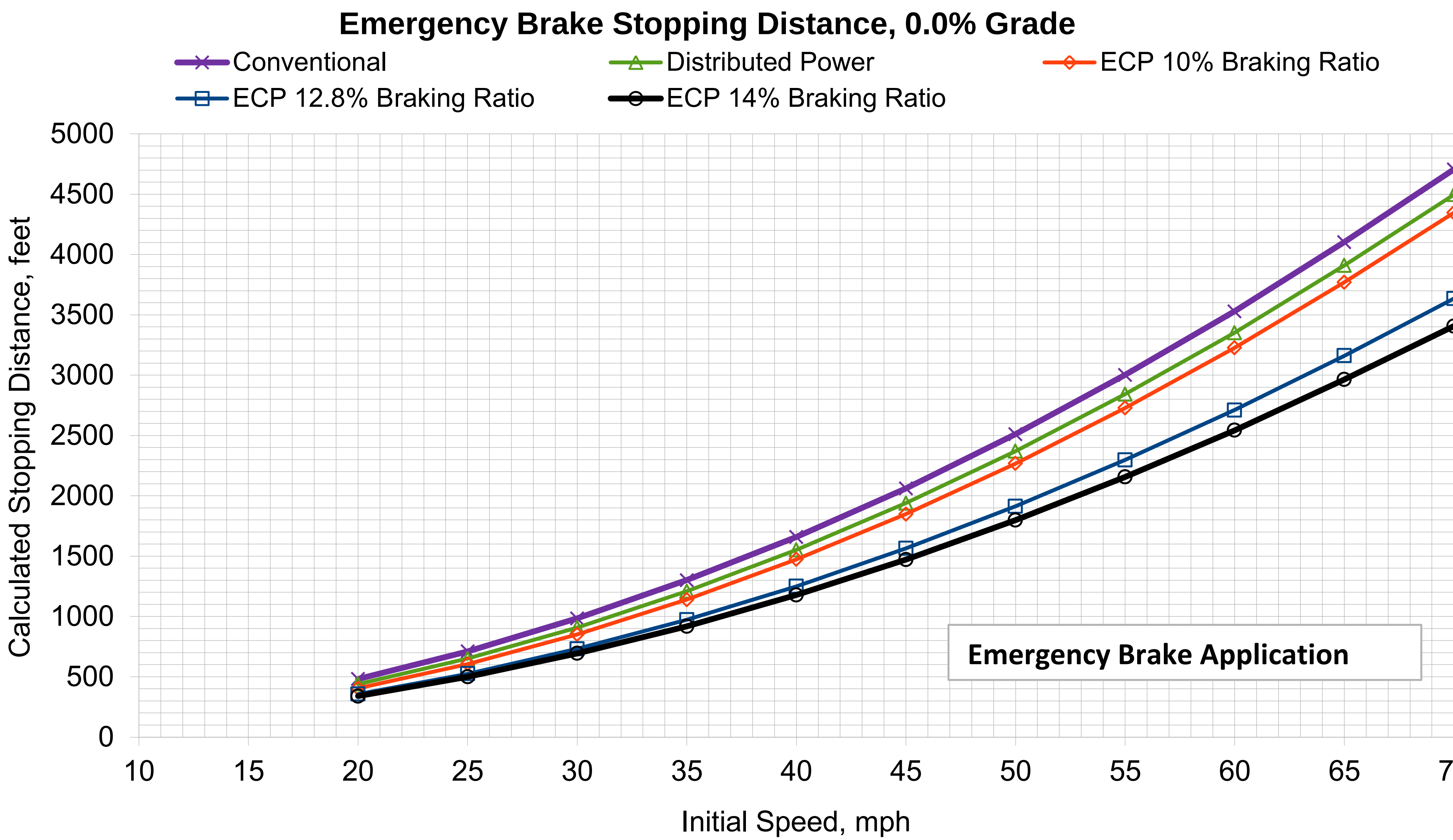


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

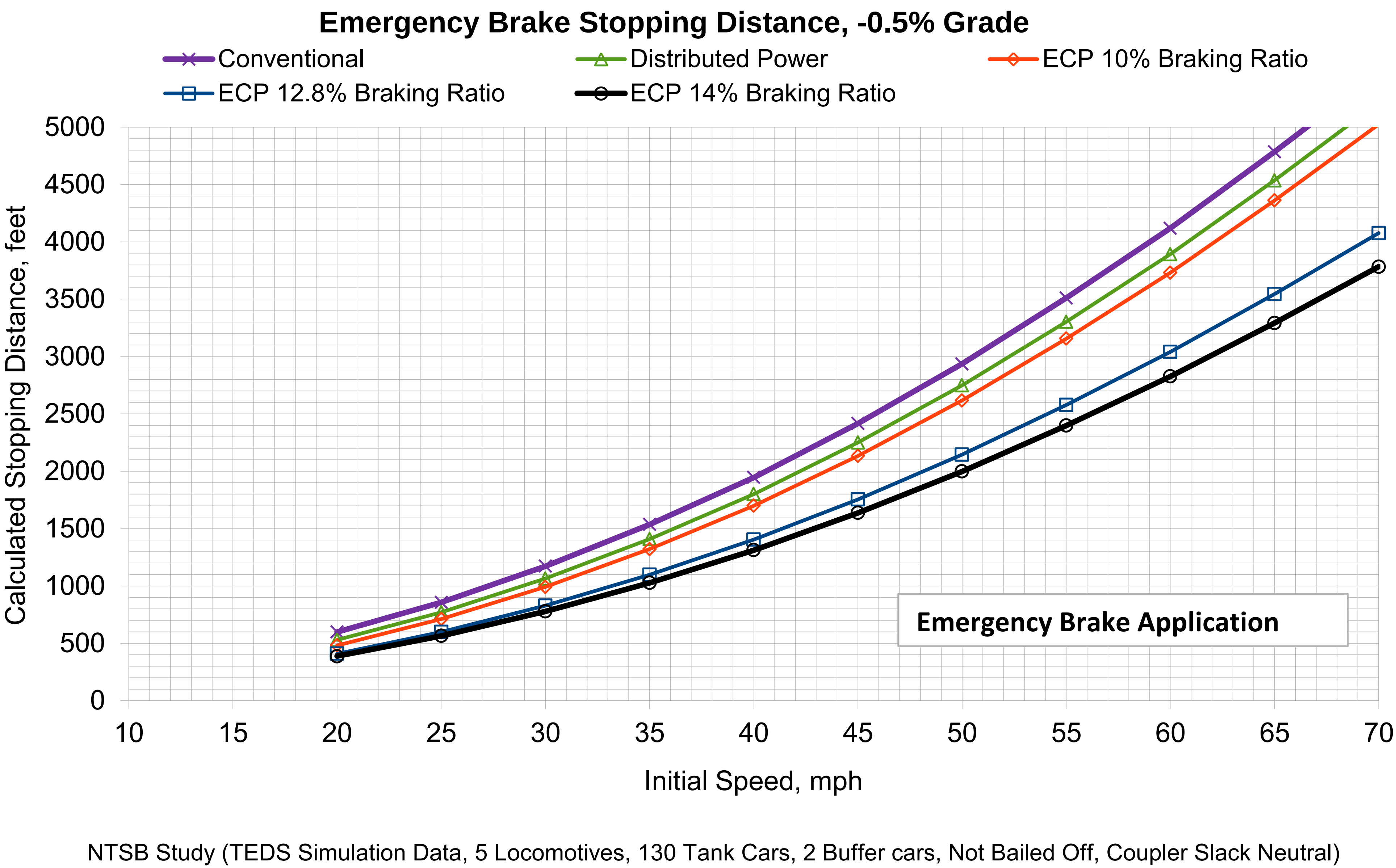
Attachment 15: Emergency Braking, No Bailoff, 130 Tank Cars



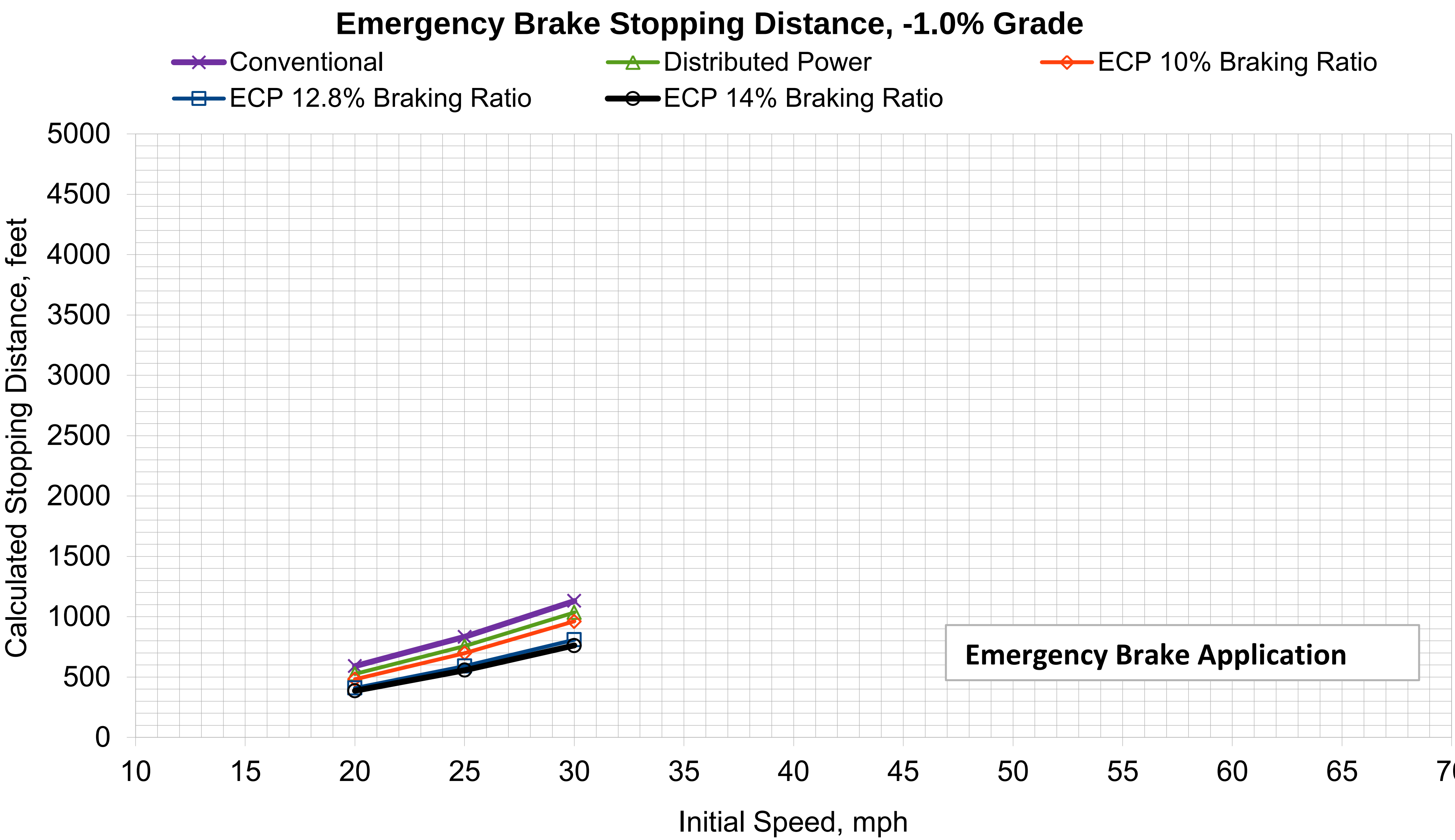
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



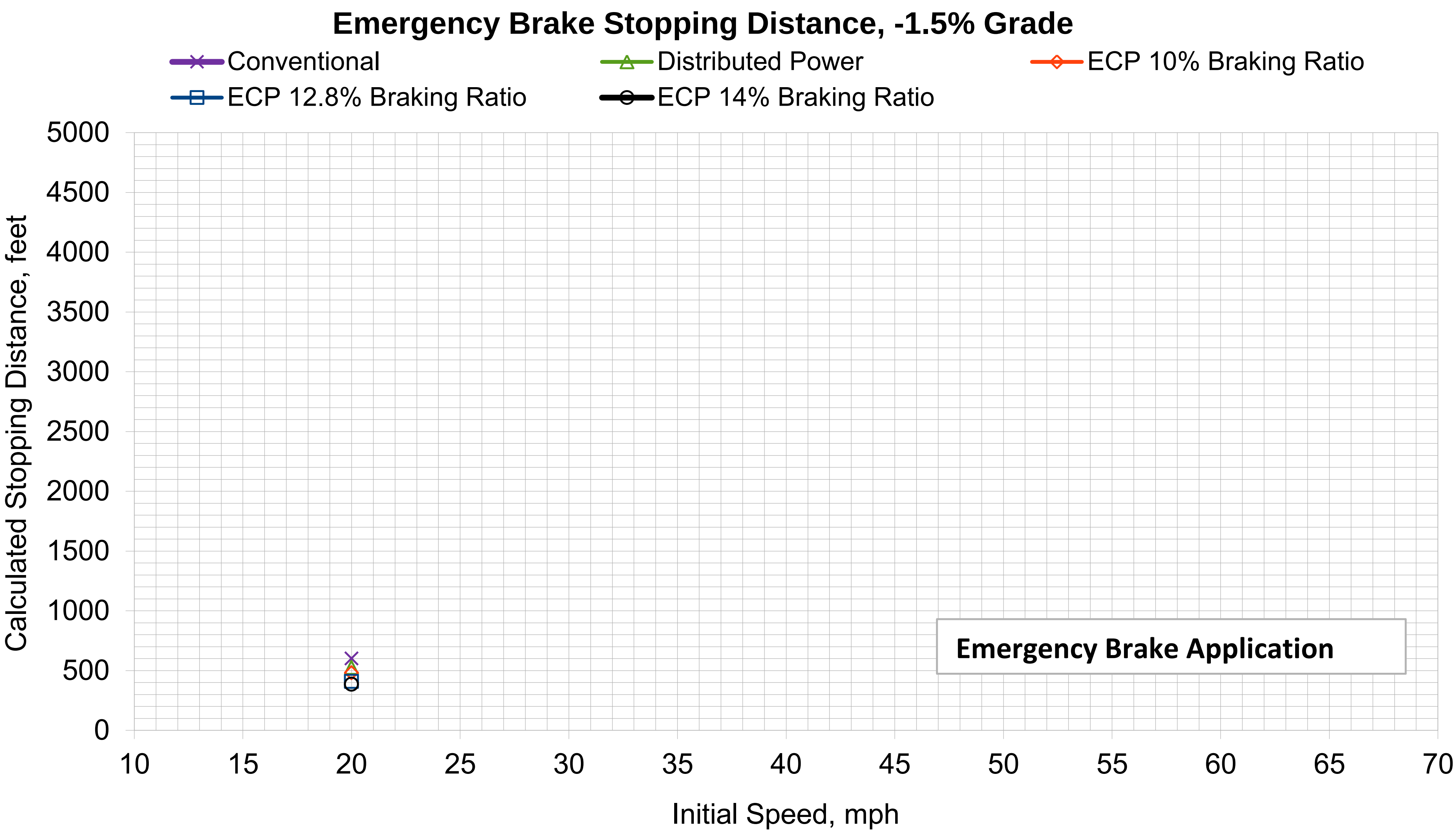
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



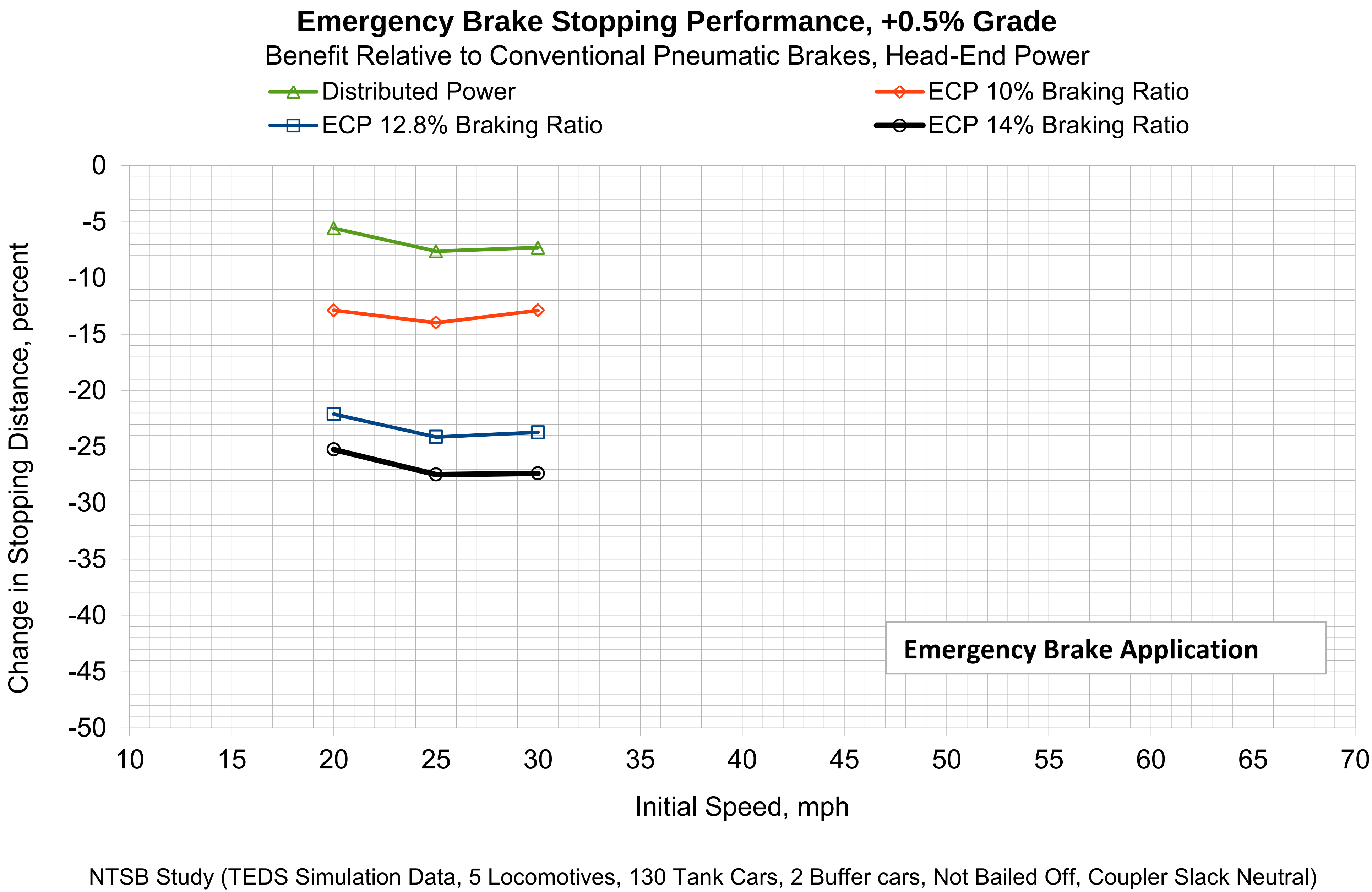
Emergency Brake Stopping Distance, -0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

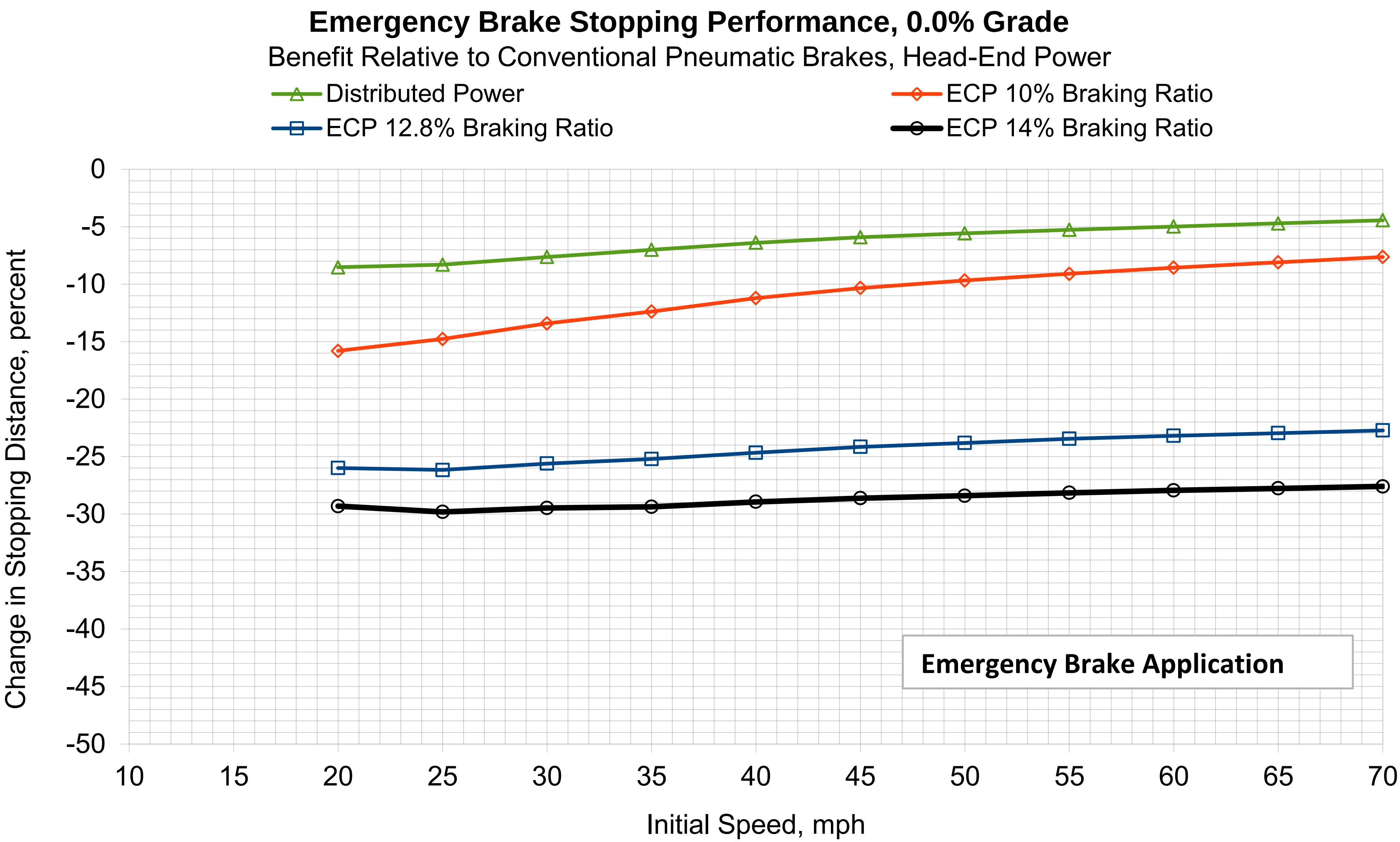


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

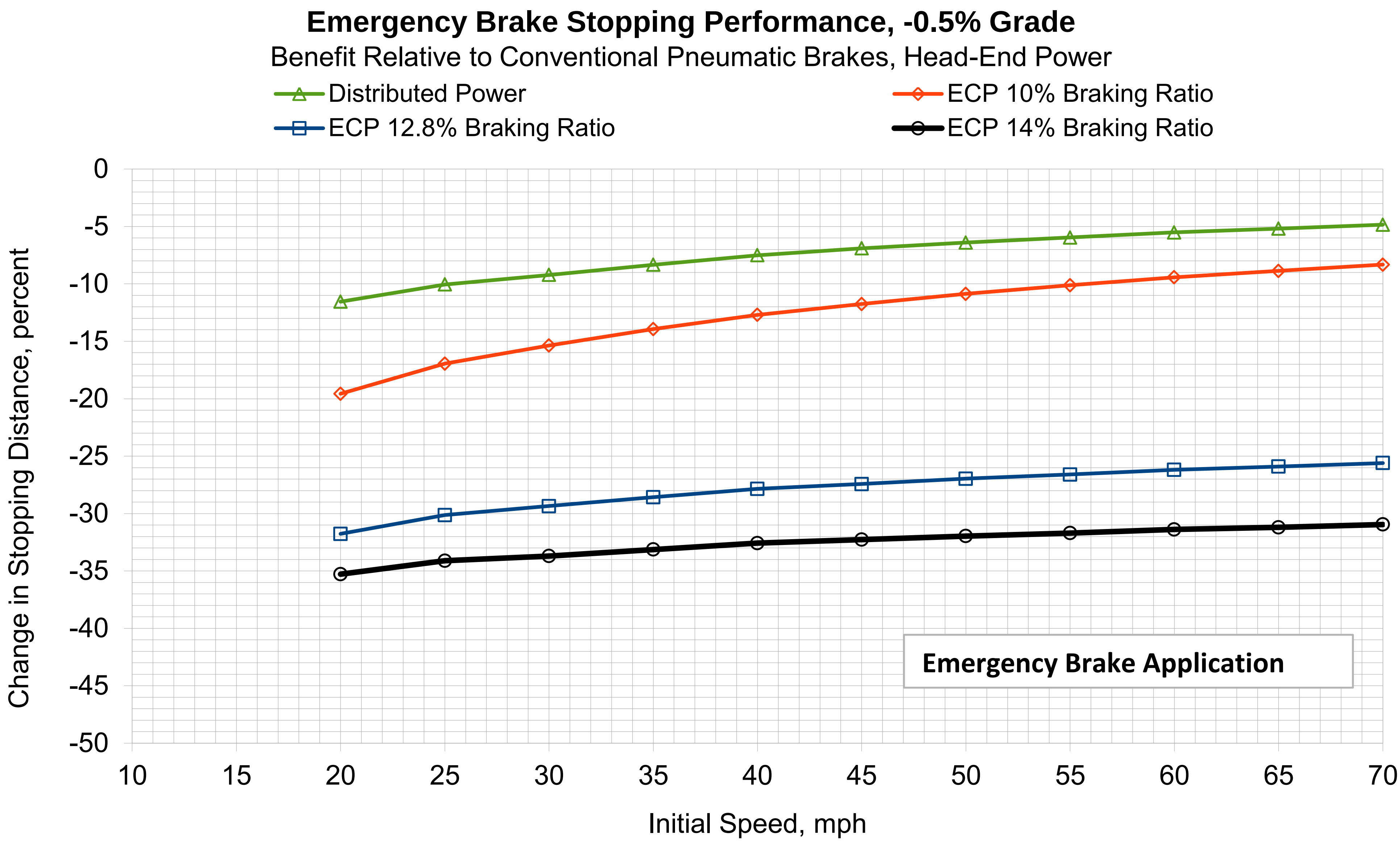


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

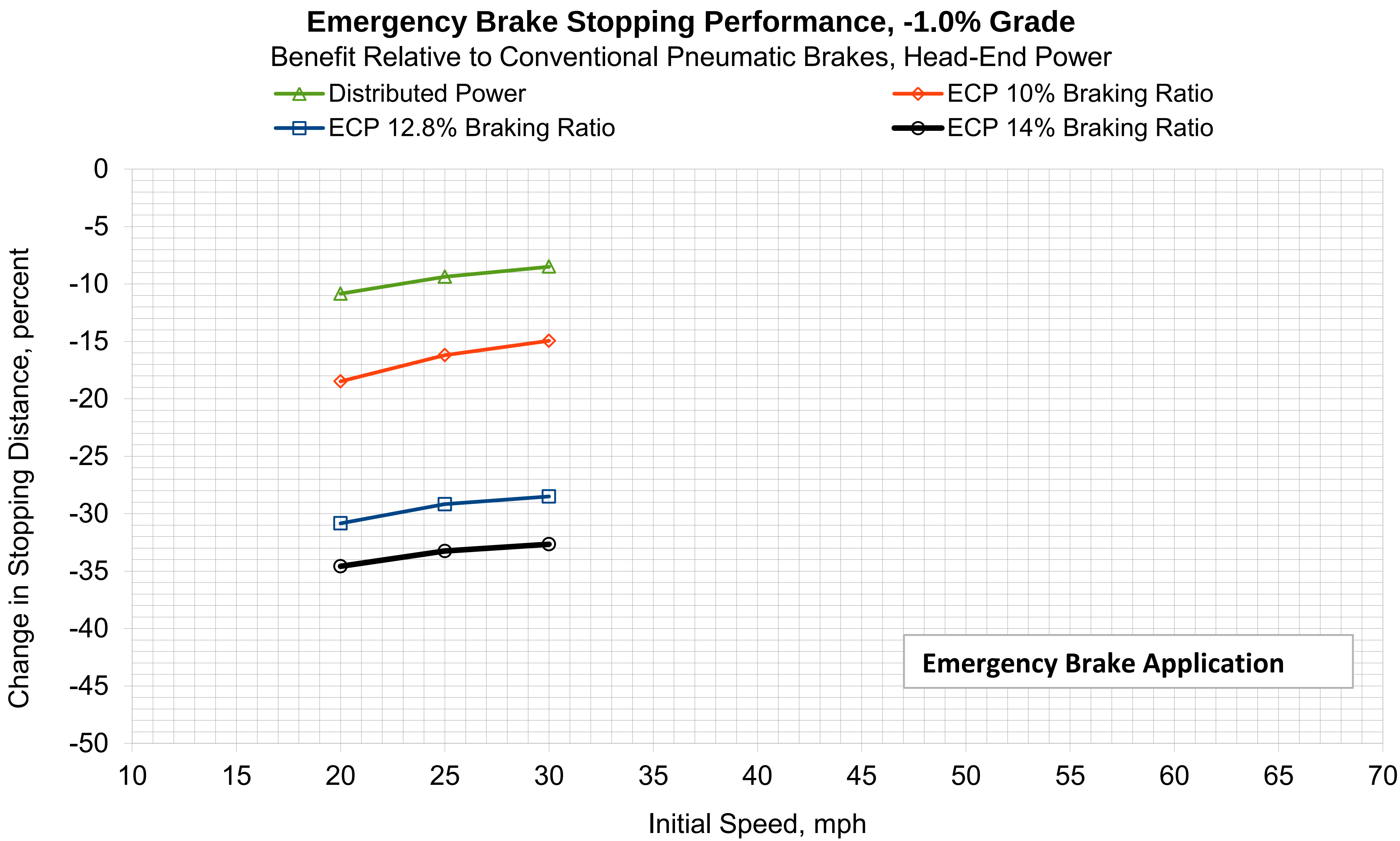

Emergency Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



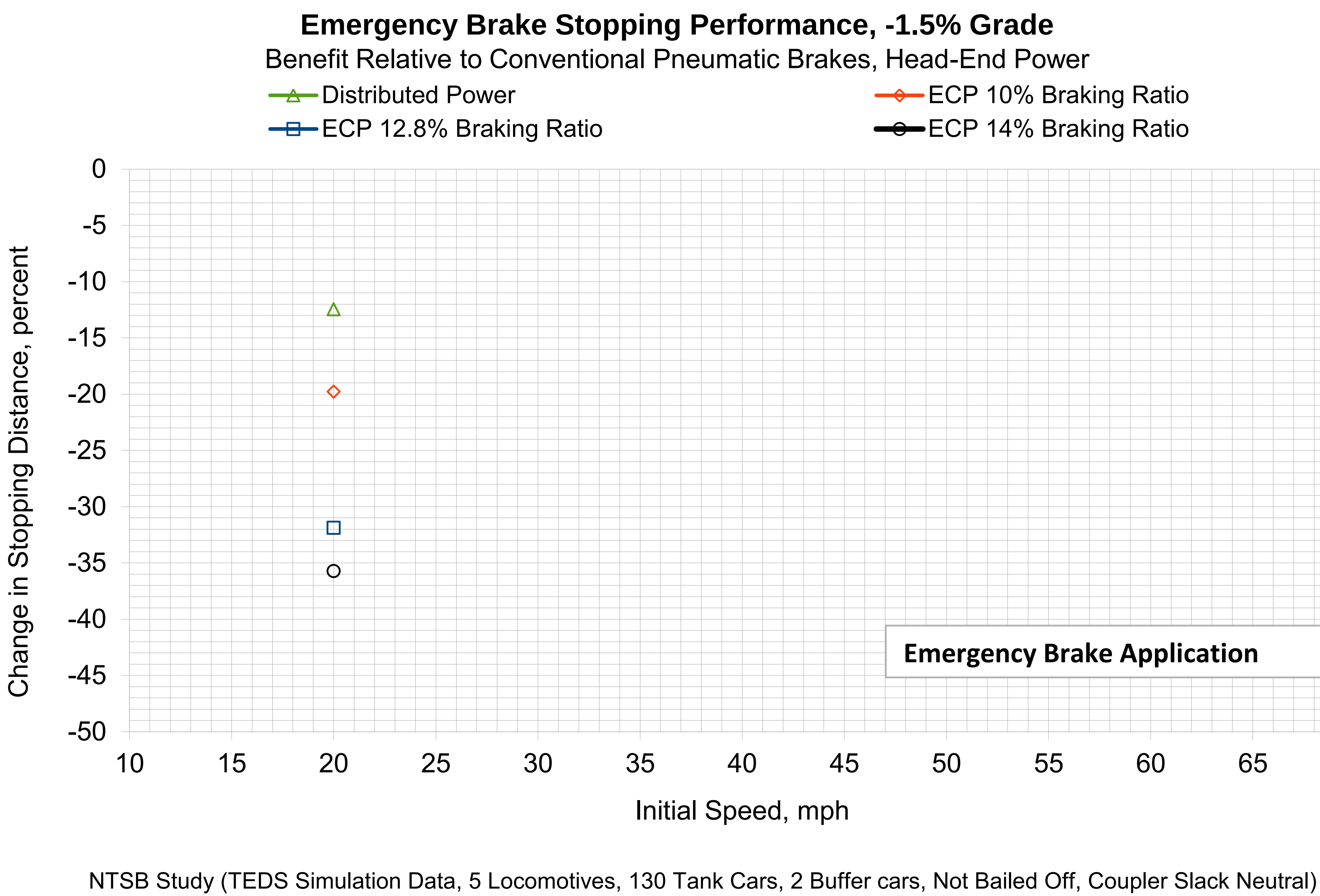
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

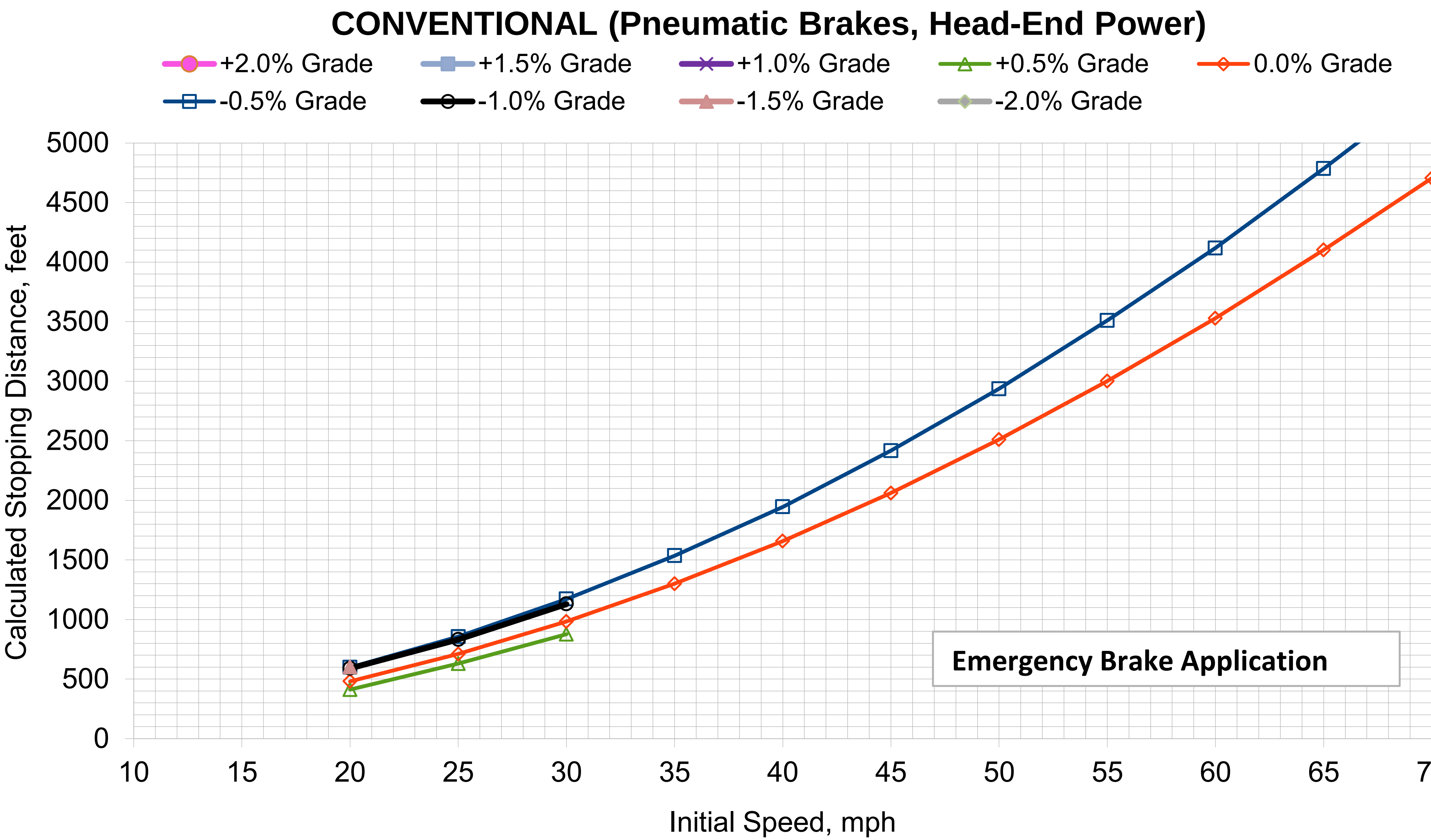


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

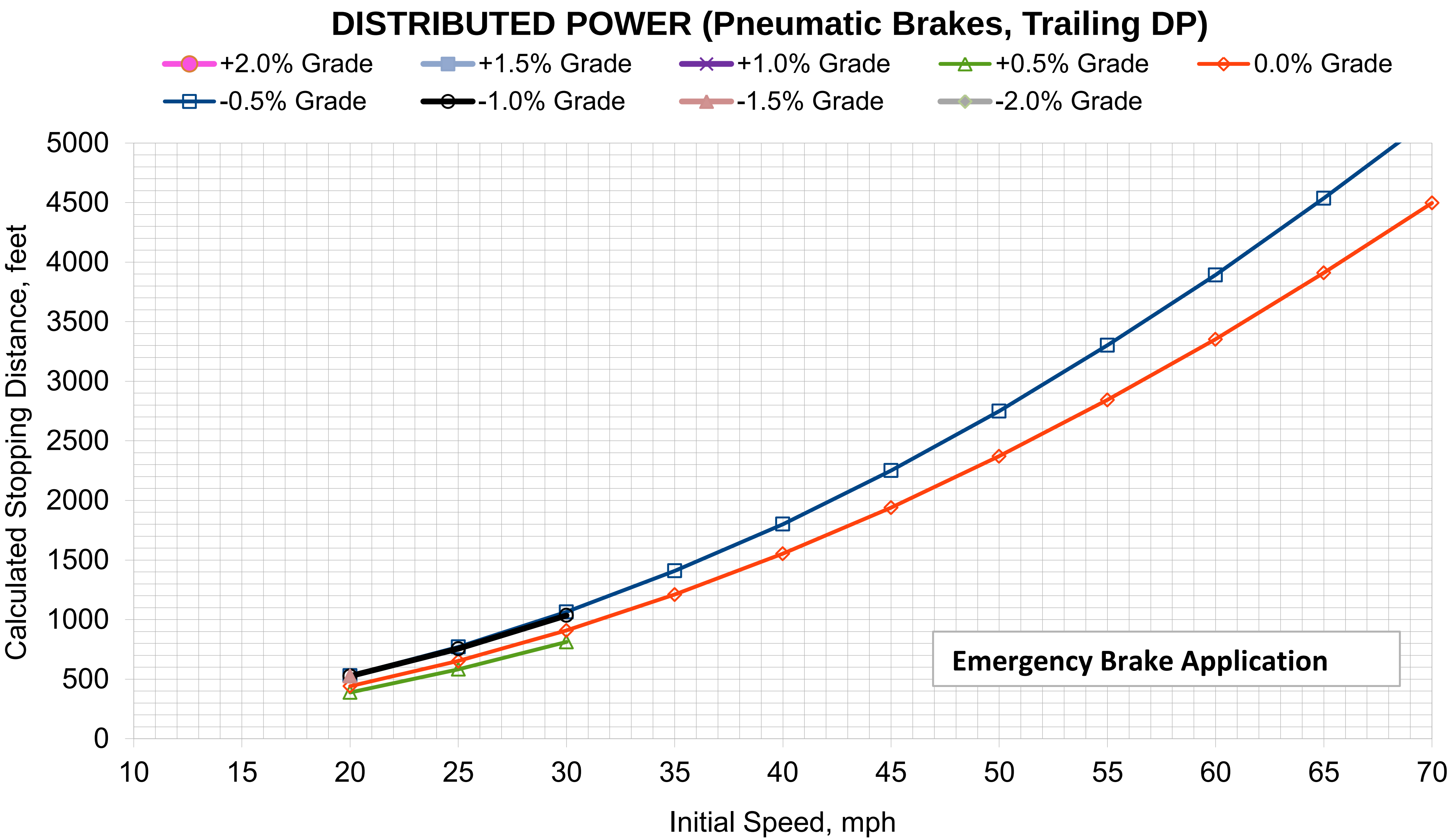


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

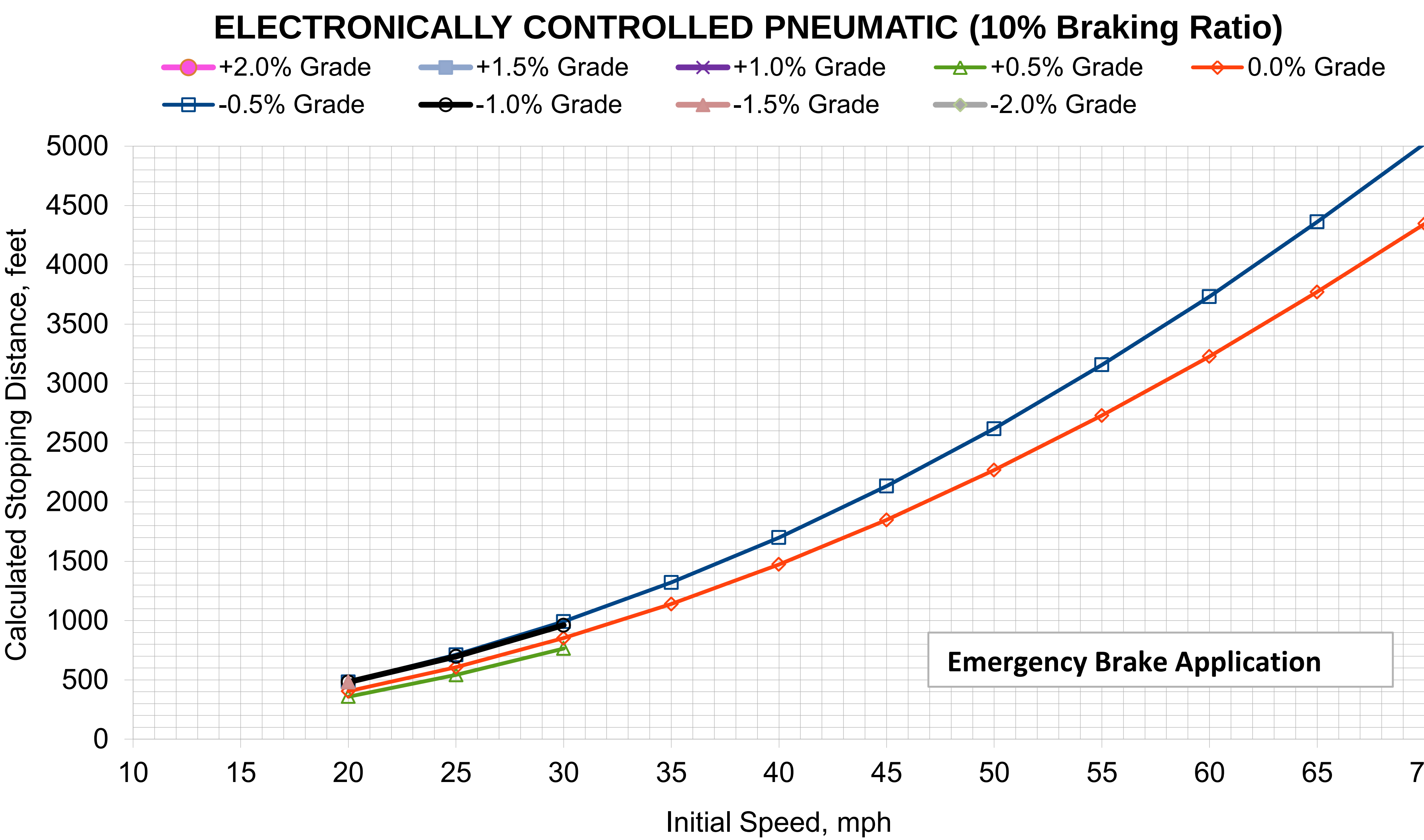

Emergency Brake Stopping Performance, -1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Emergency Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



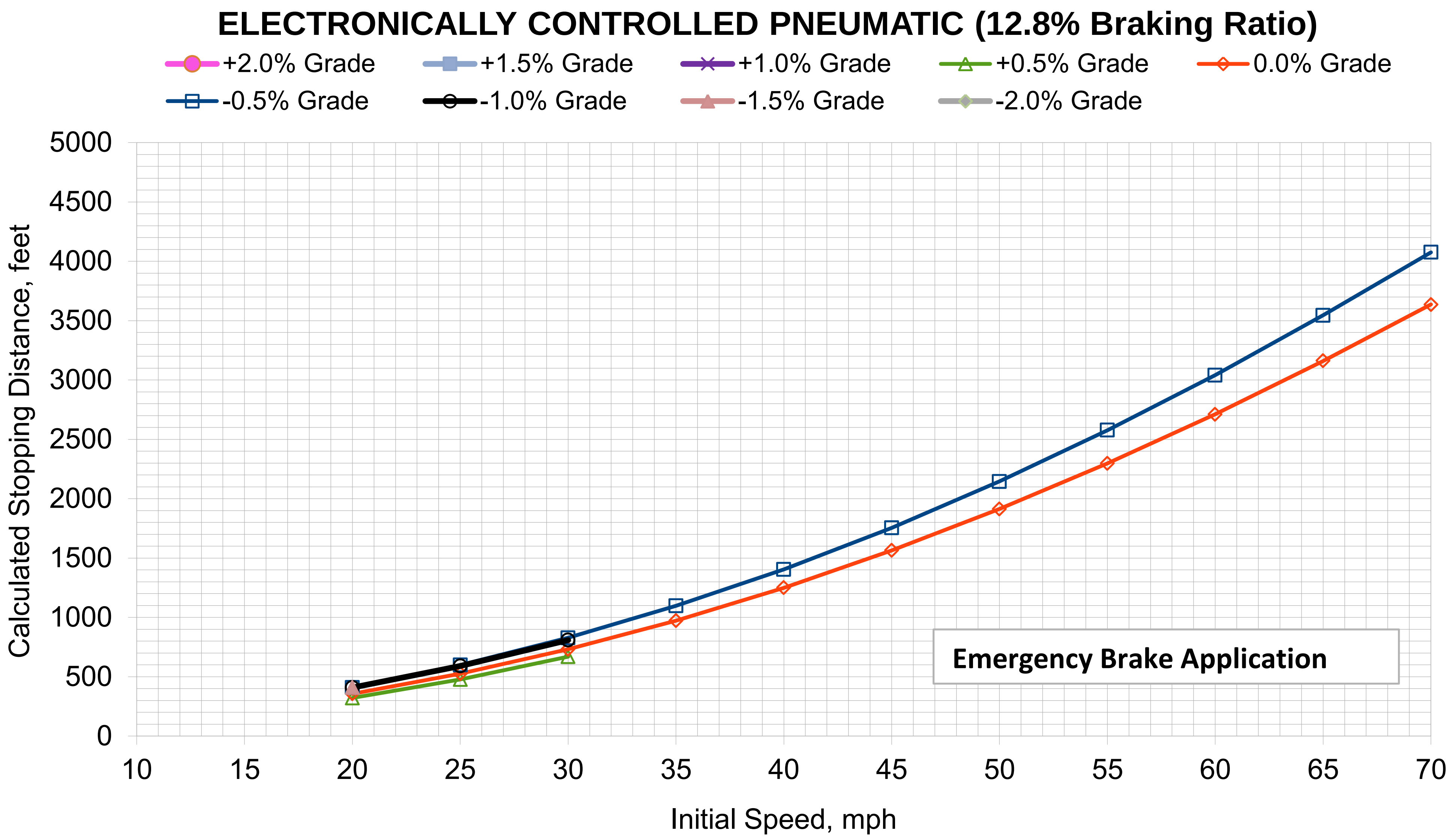
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

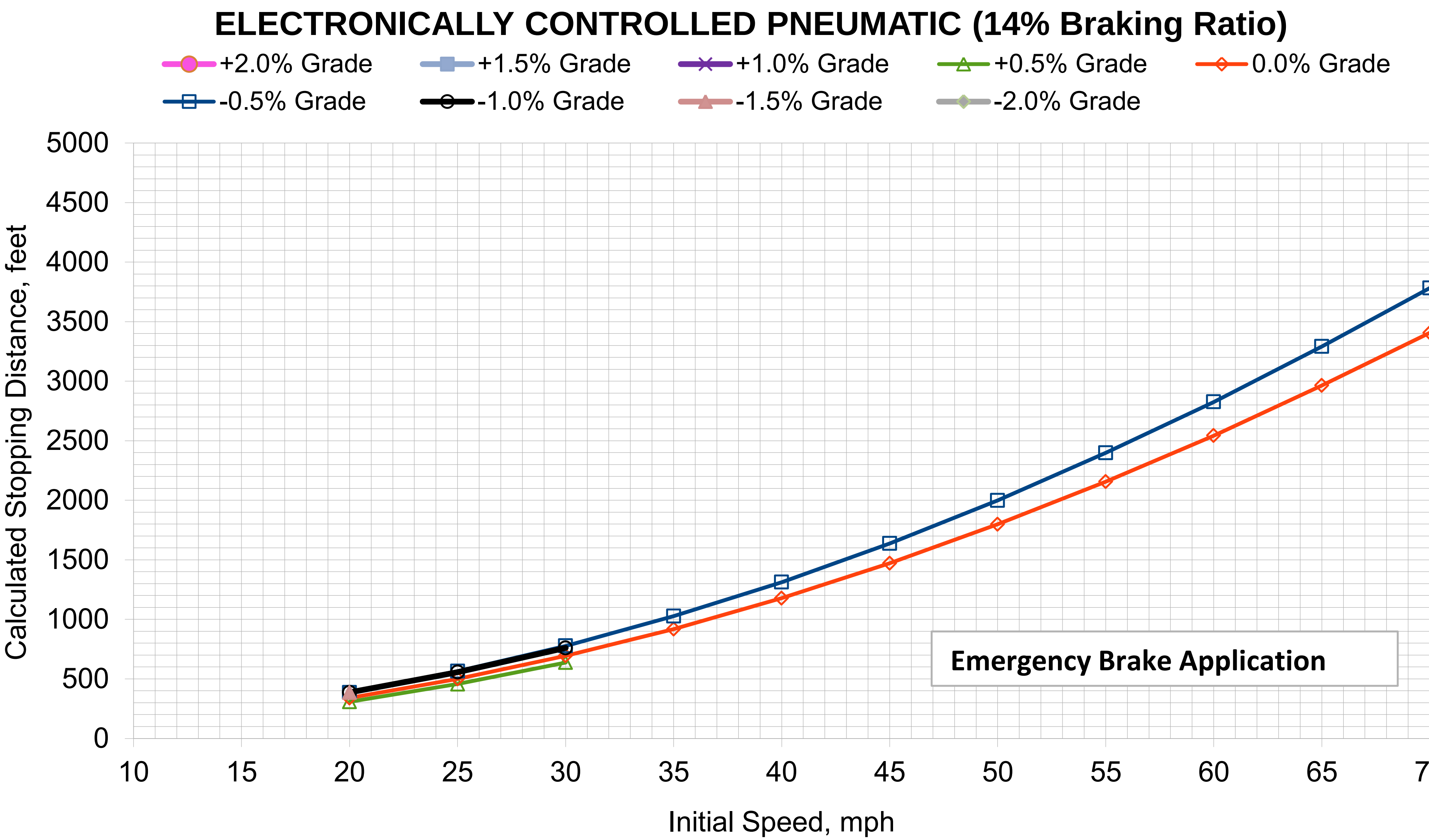


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



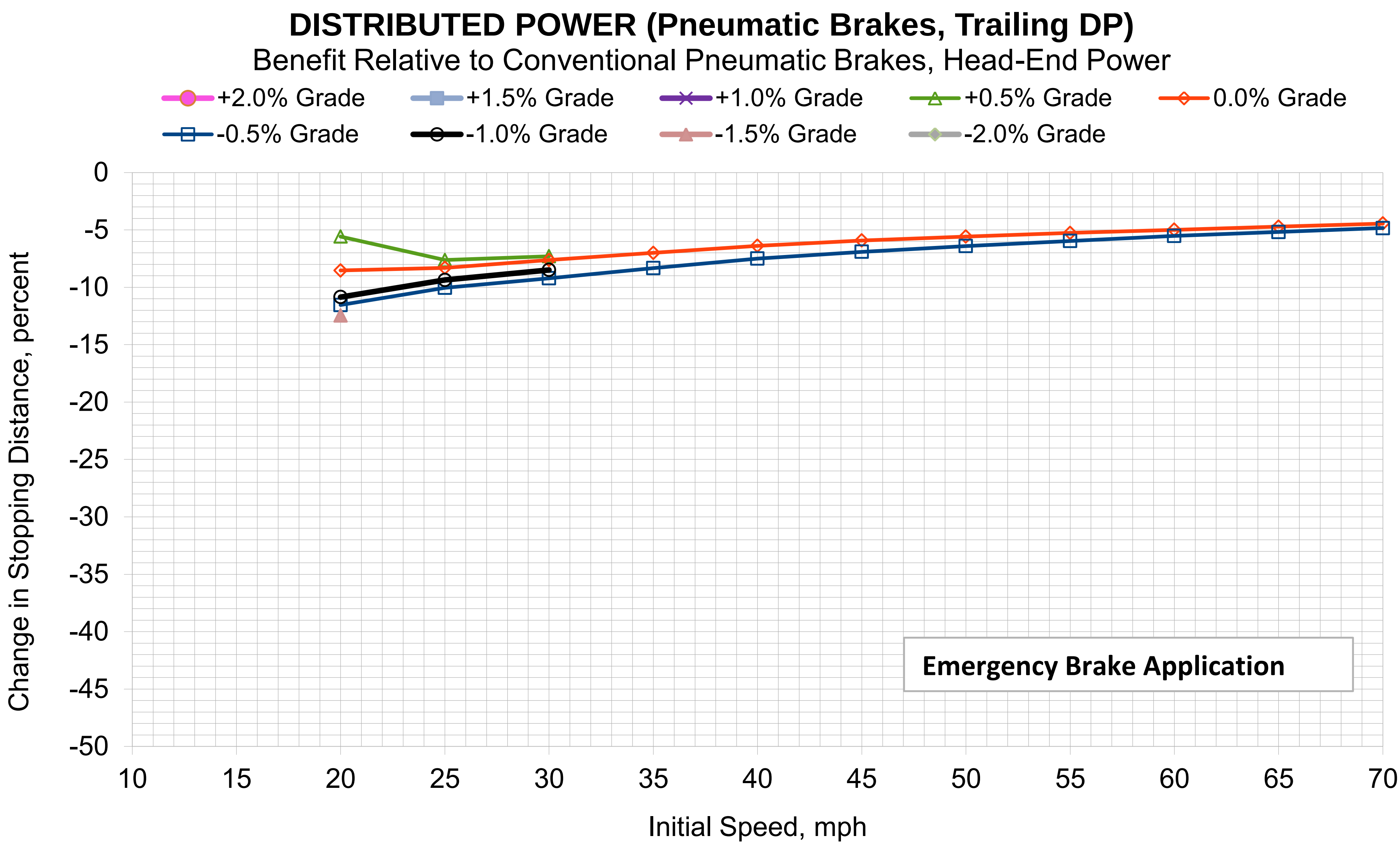
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

A15.15

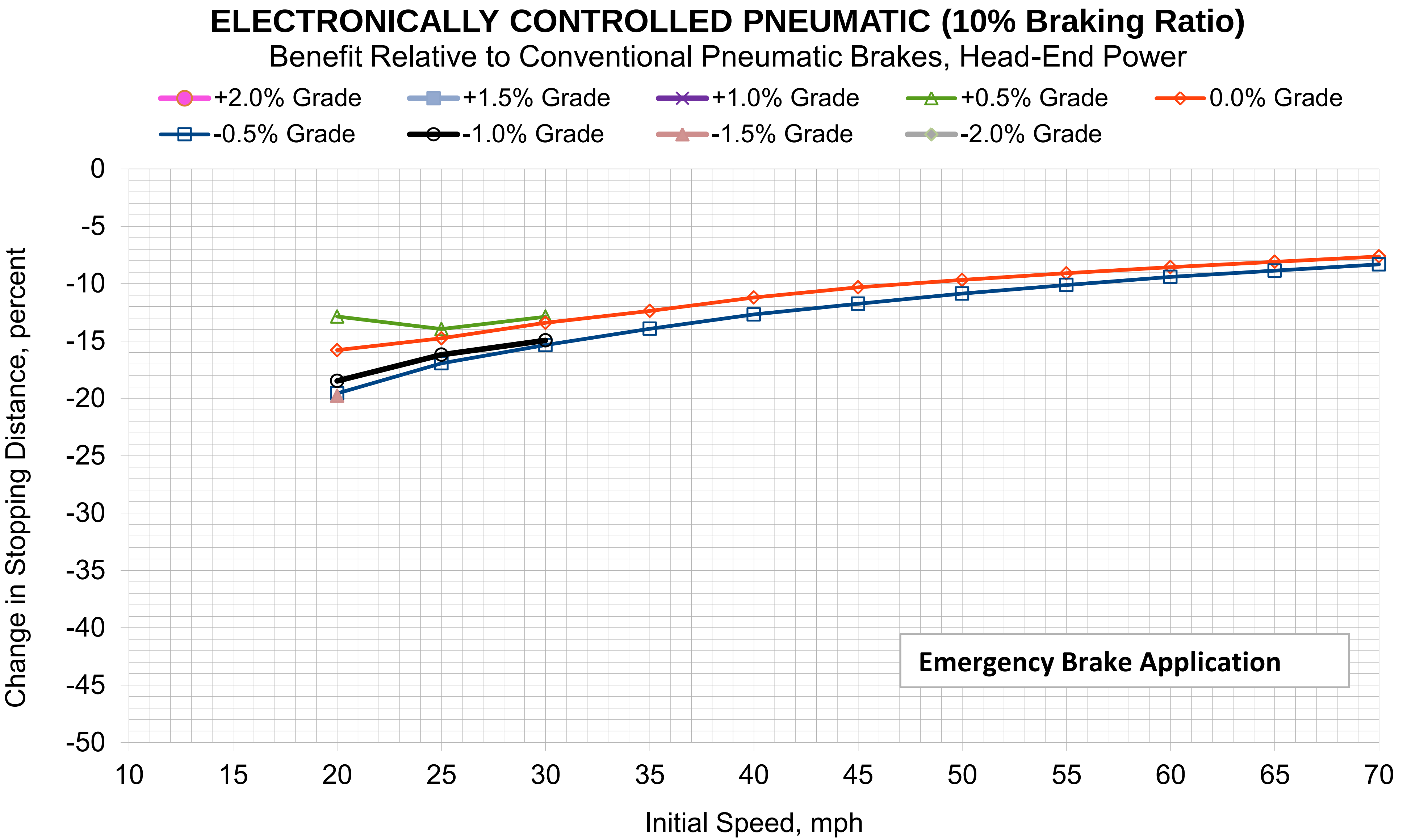


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

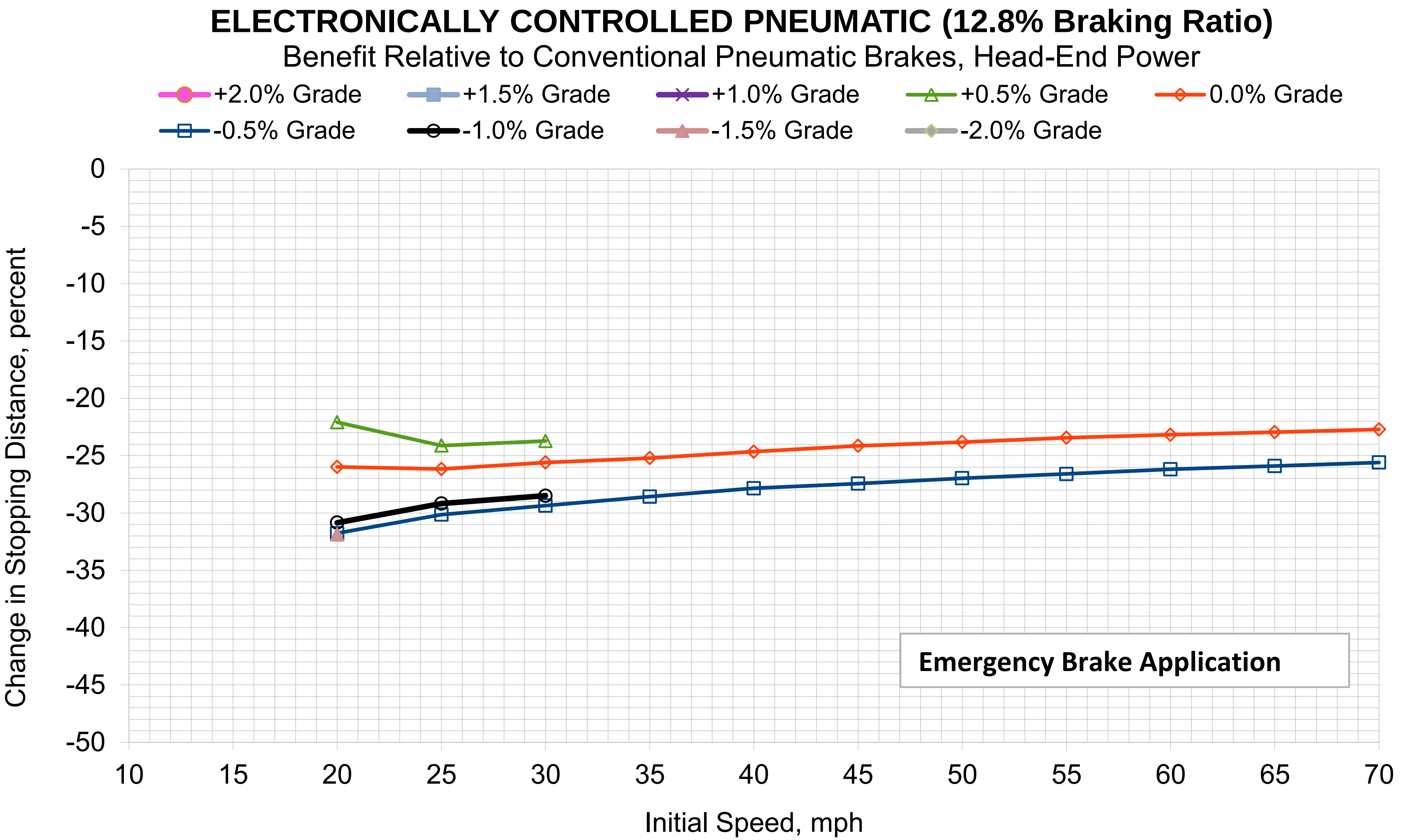
A15.16



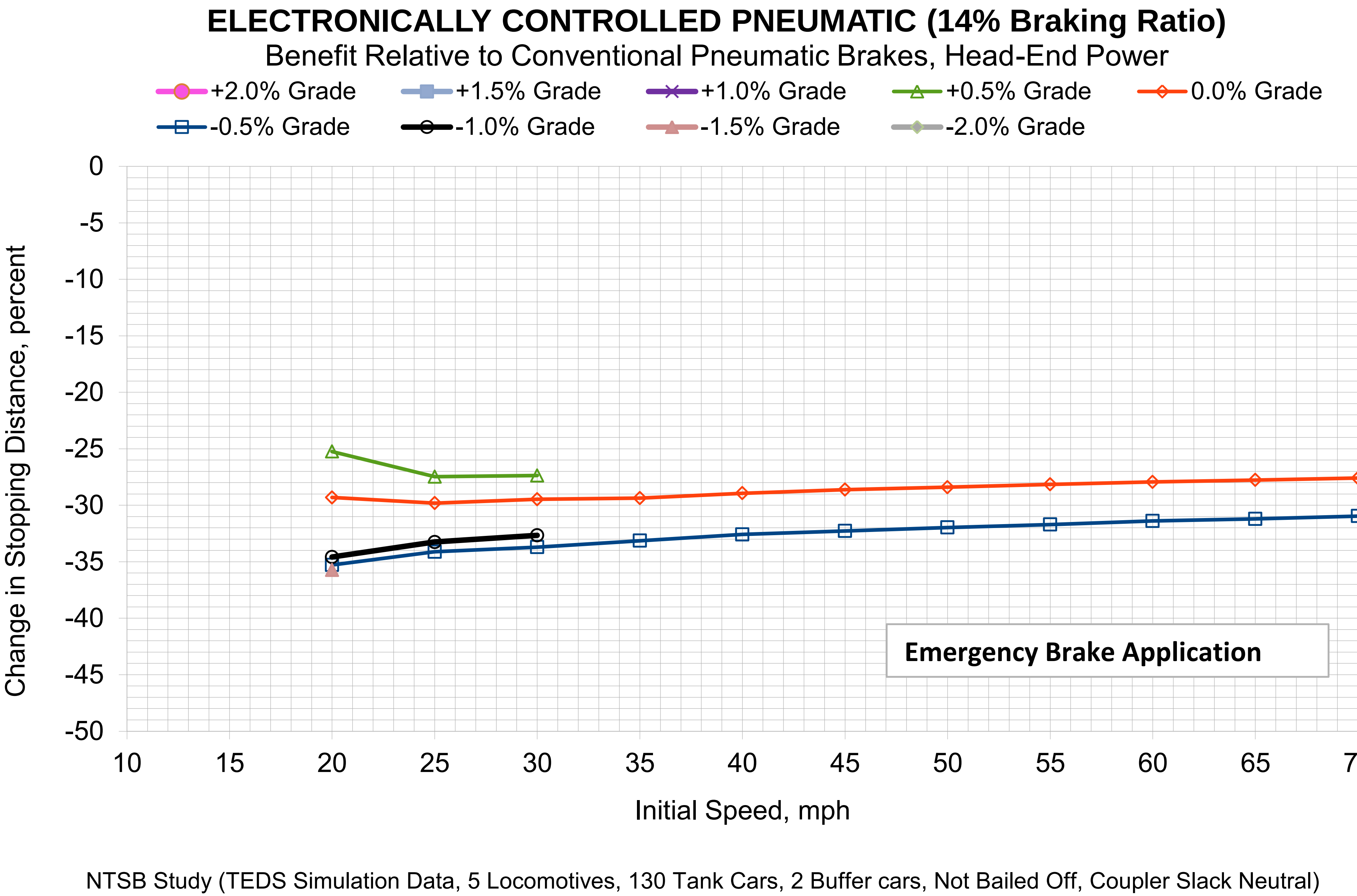
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

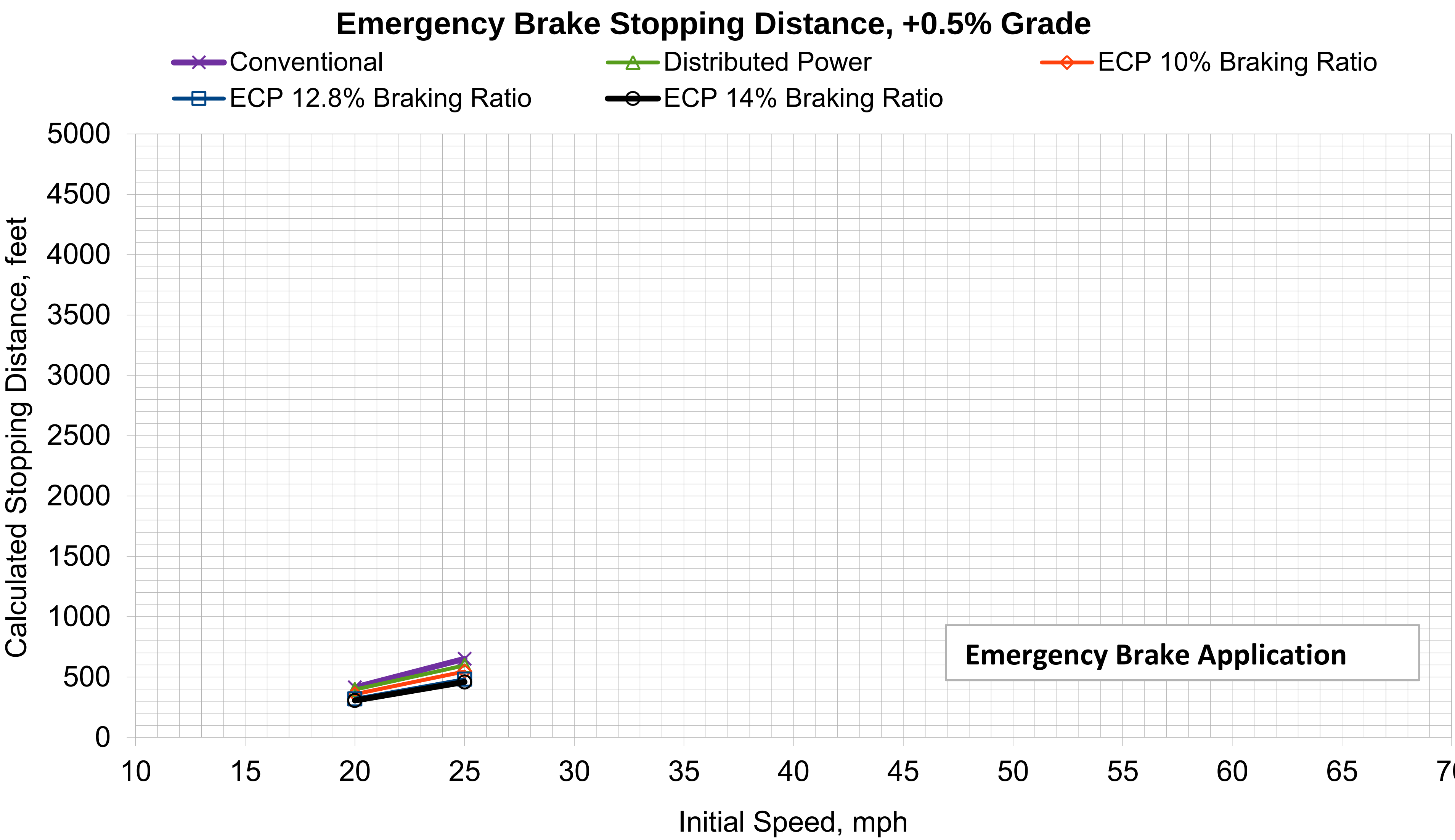


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

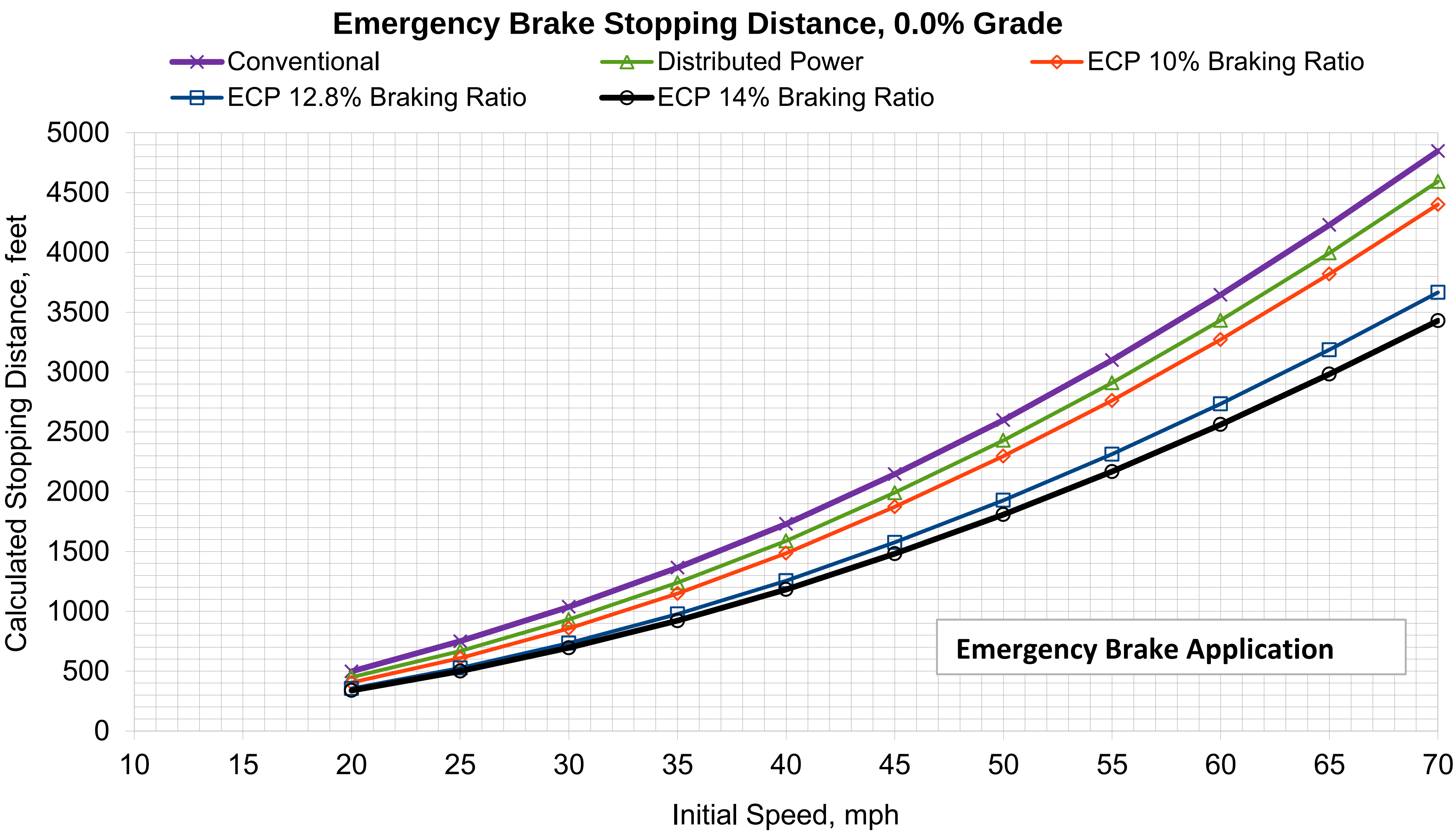

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

A15.20

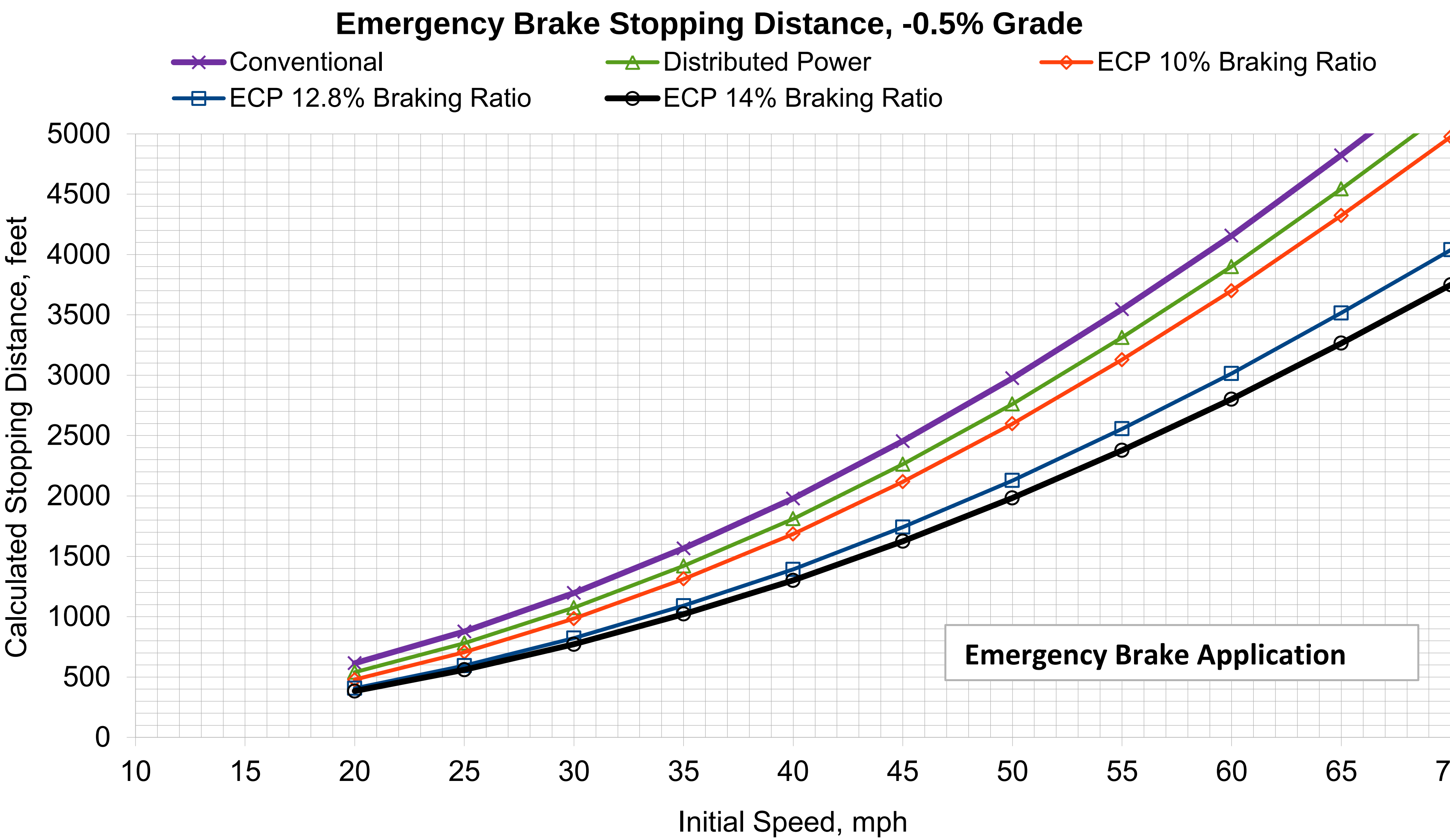
Attachment 16: Emergency Braking, No Bailoff, 156 Tank Cars



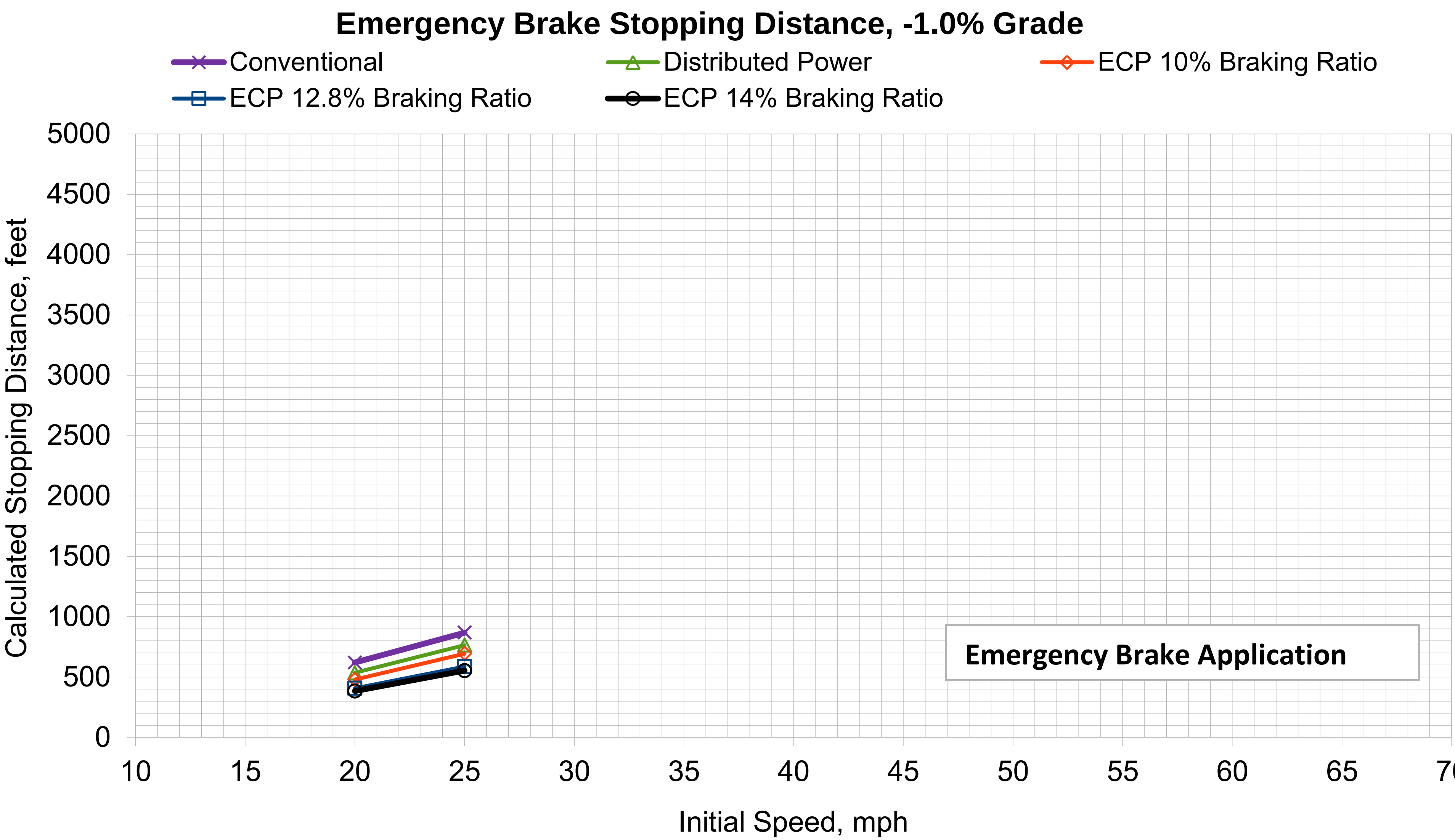
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



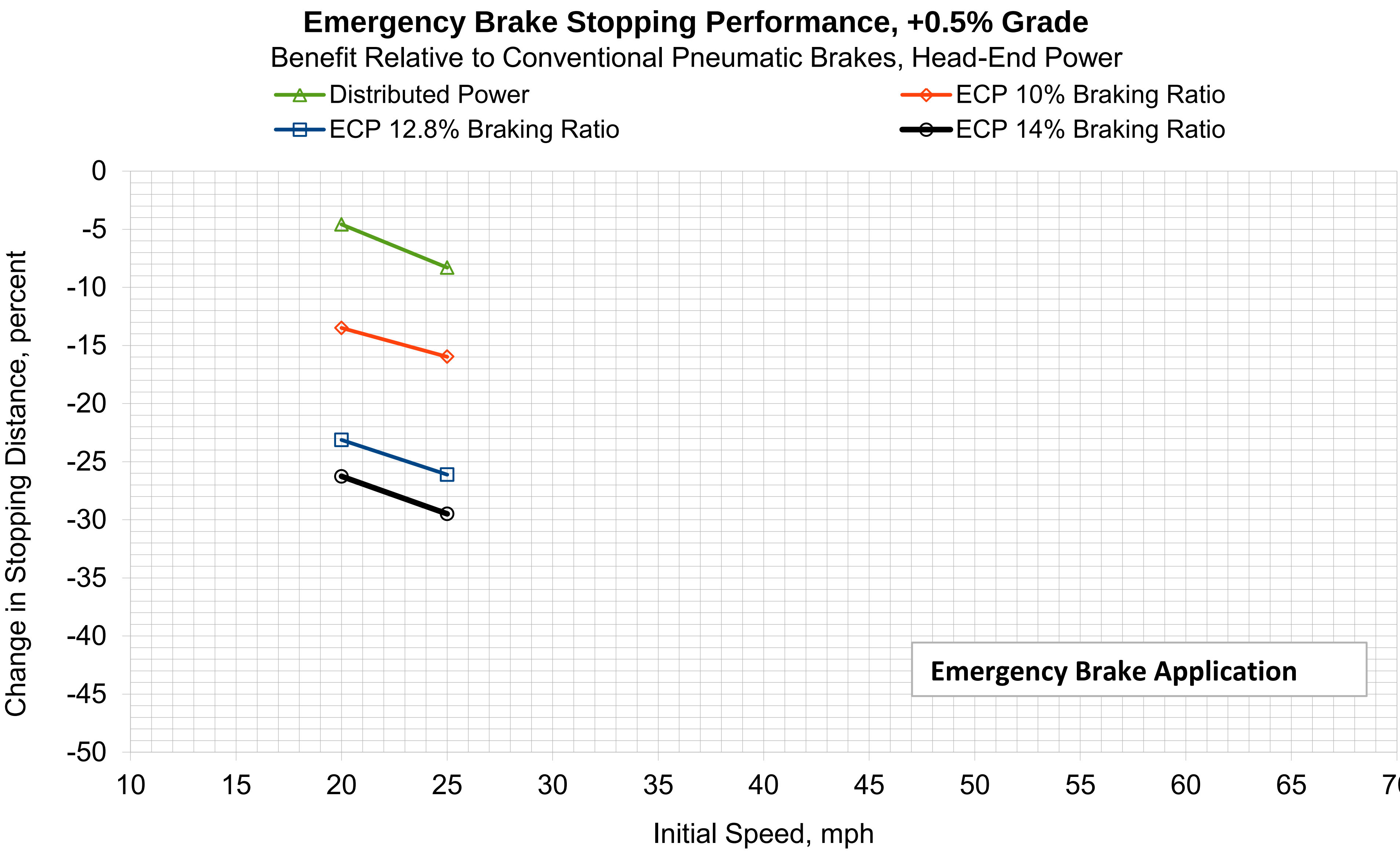
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



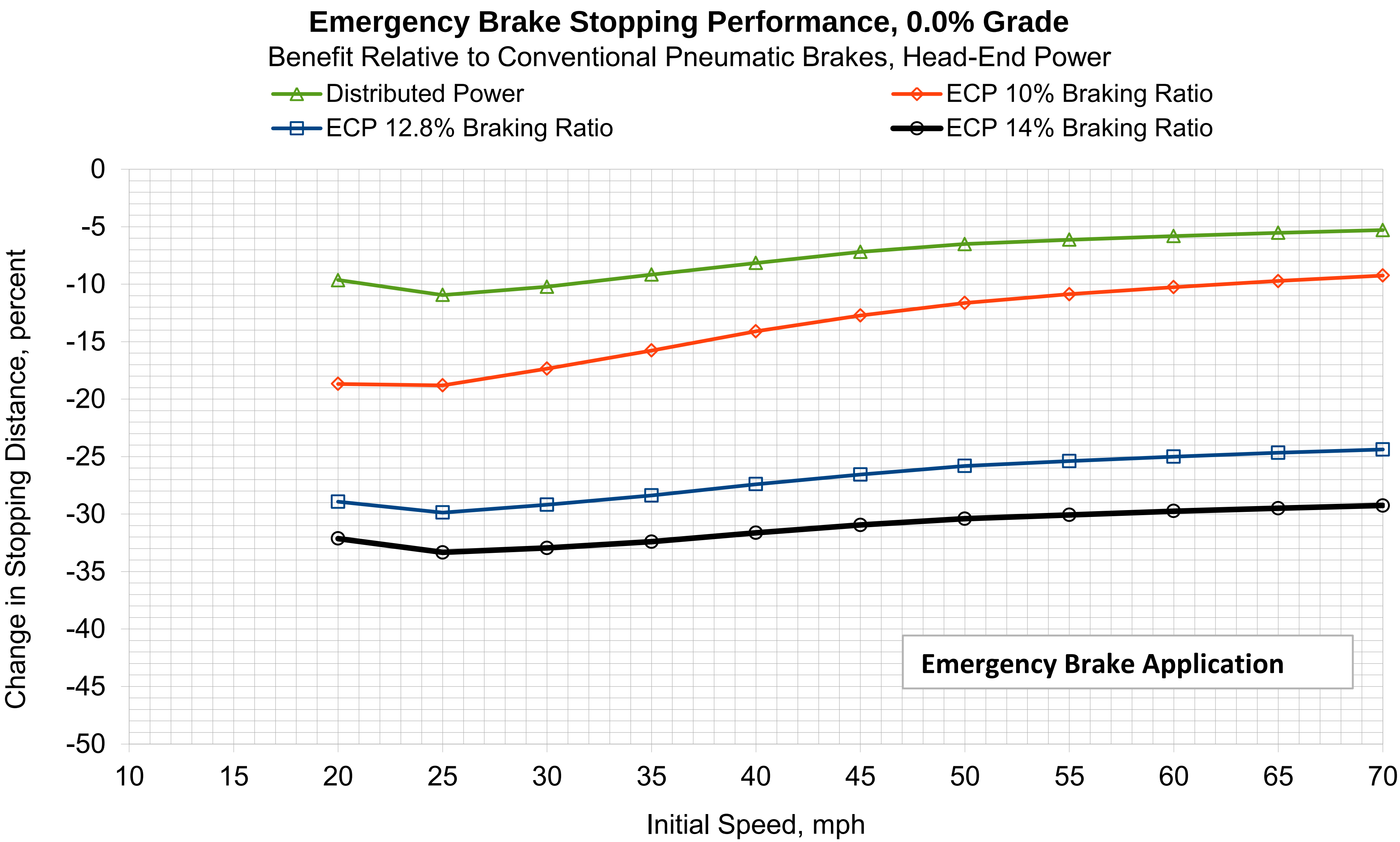
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



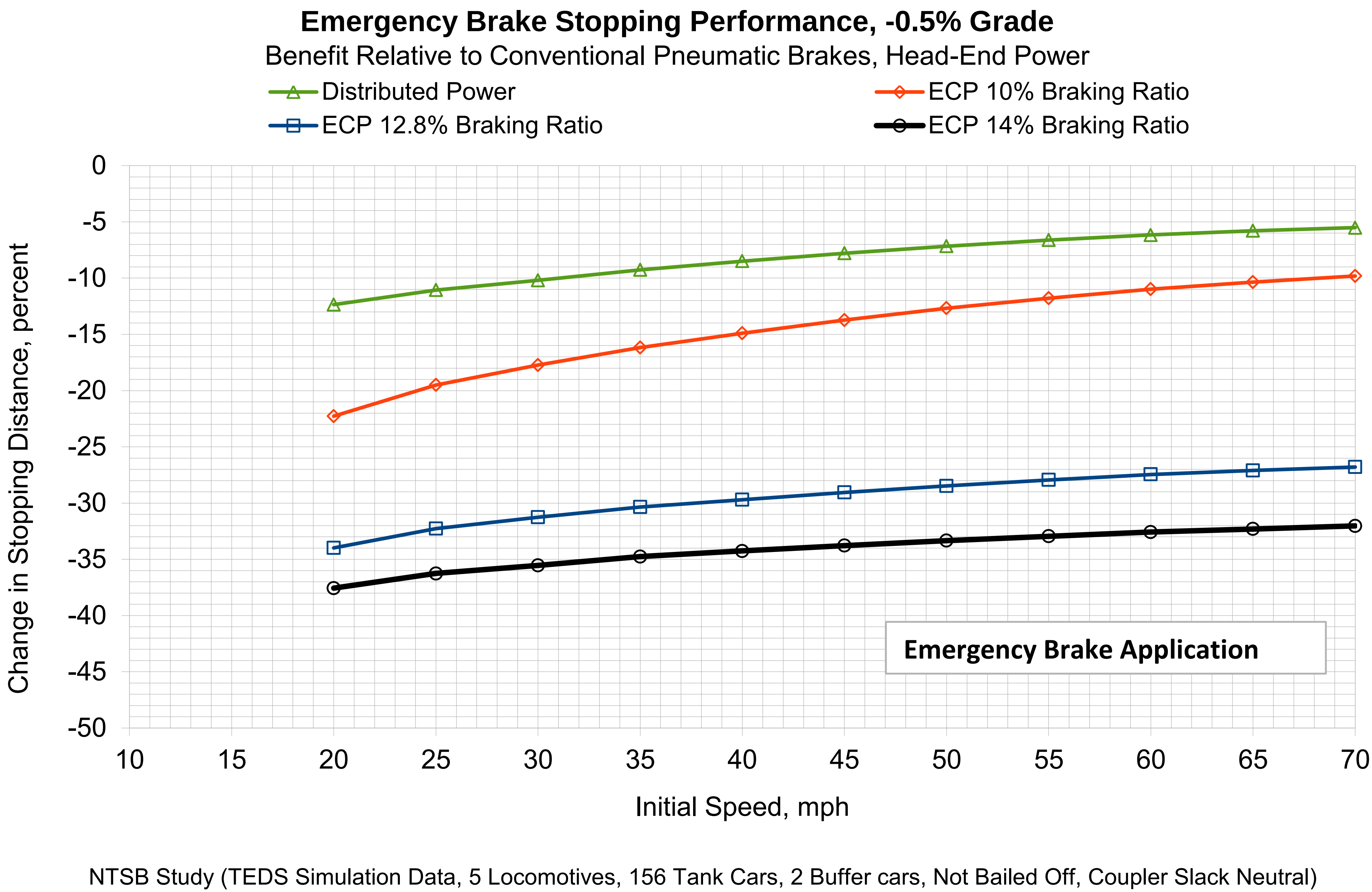
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



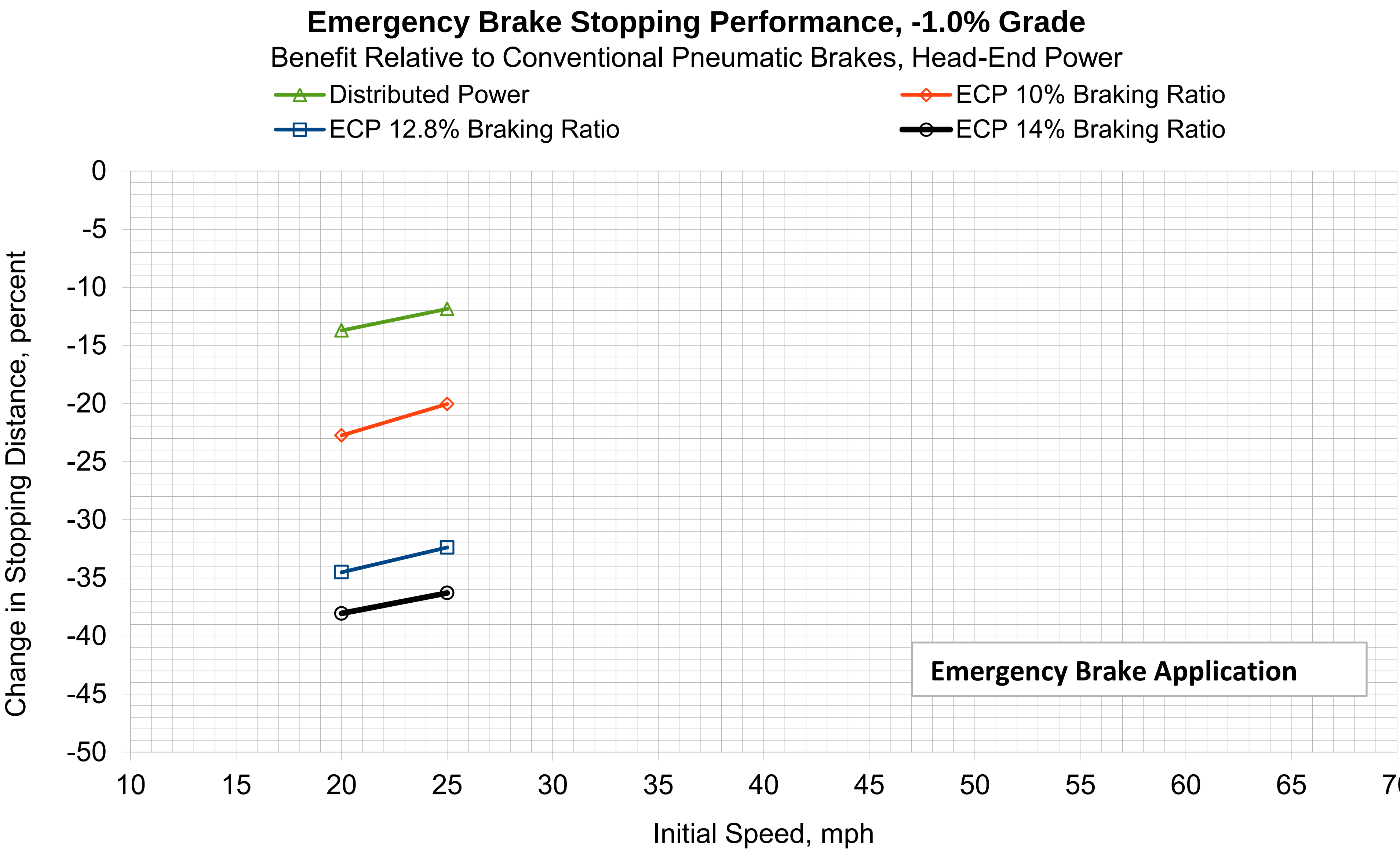
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



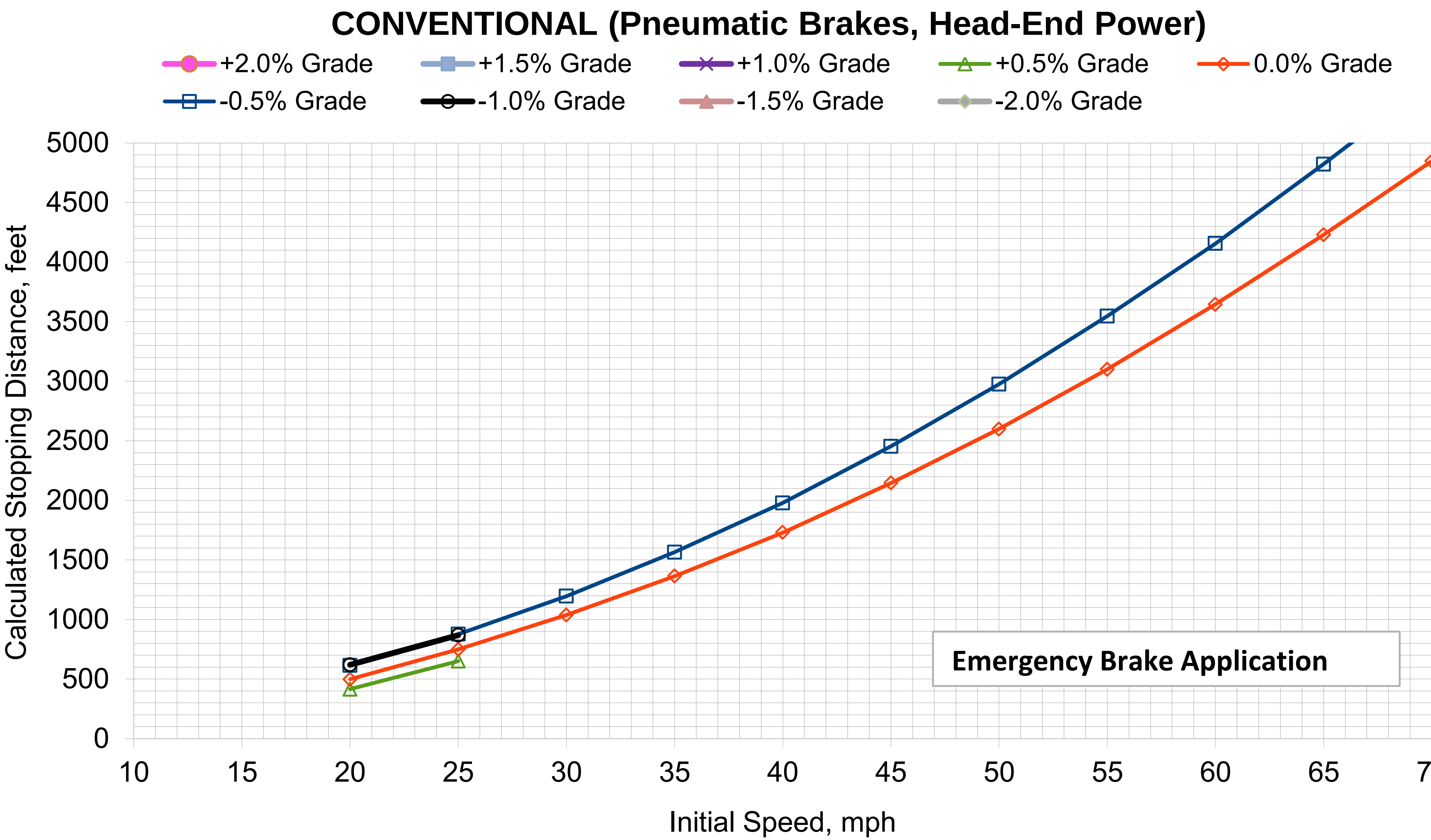
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



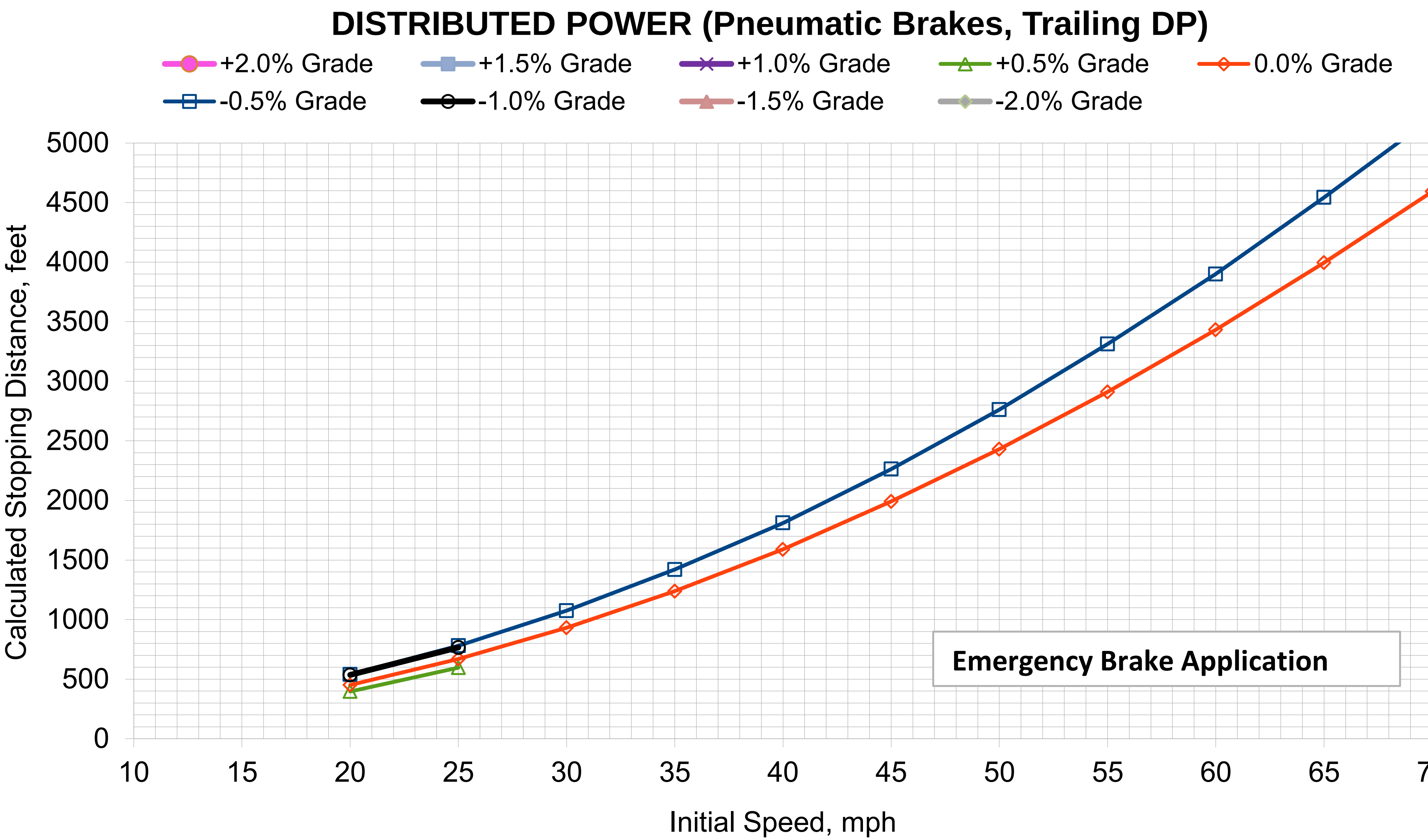
Emergency Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



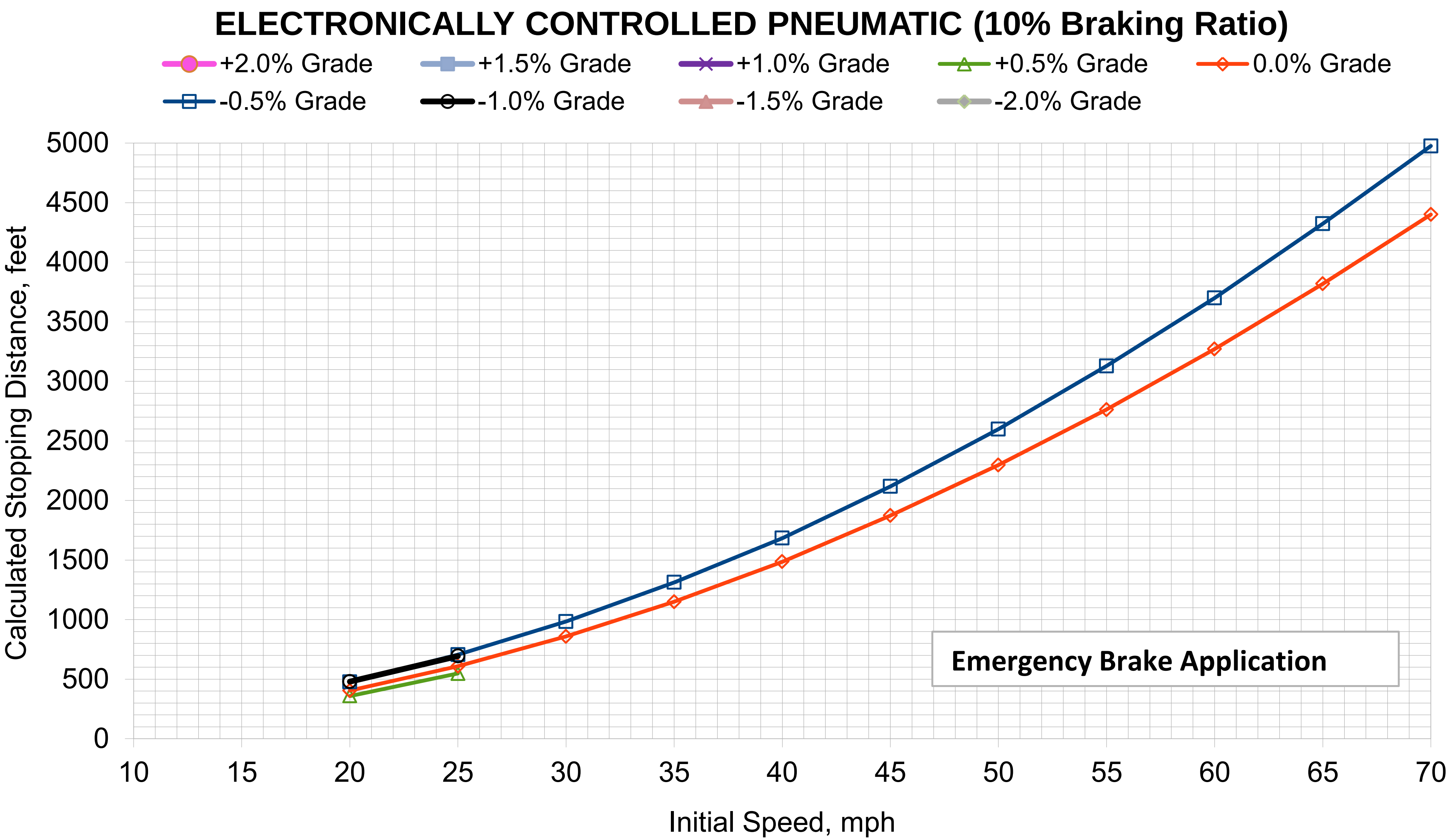
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



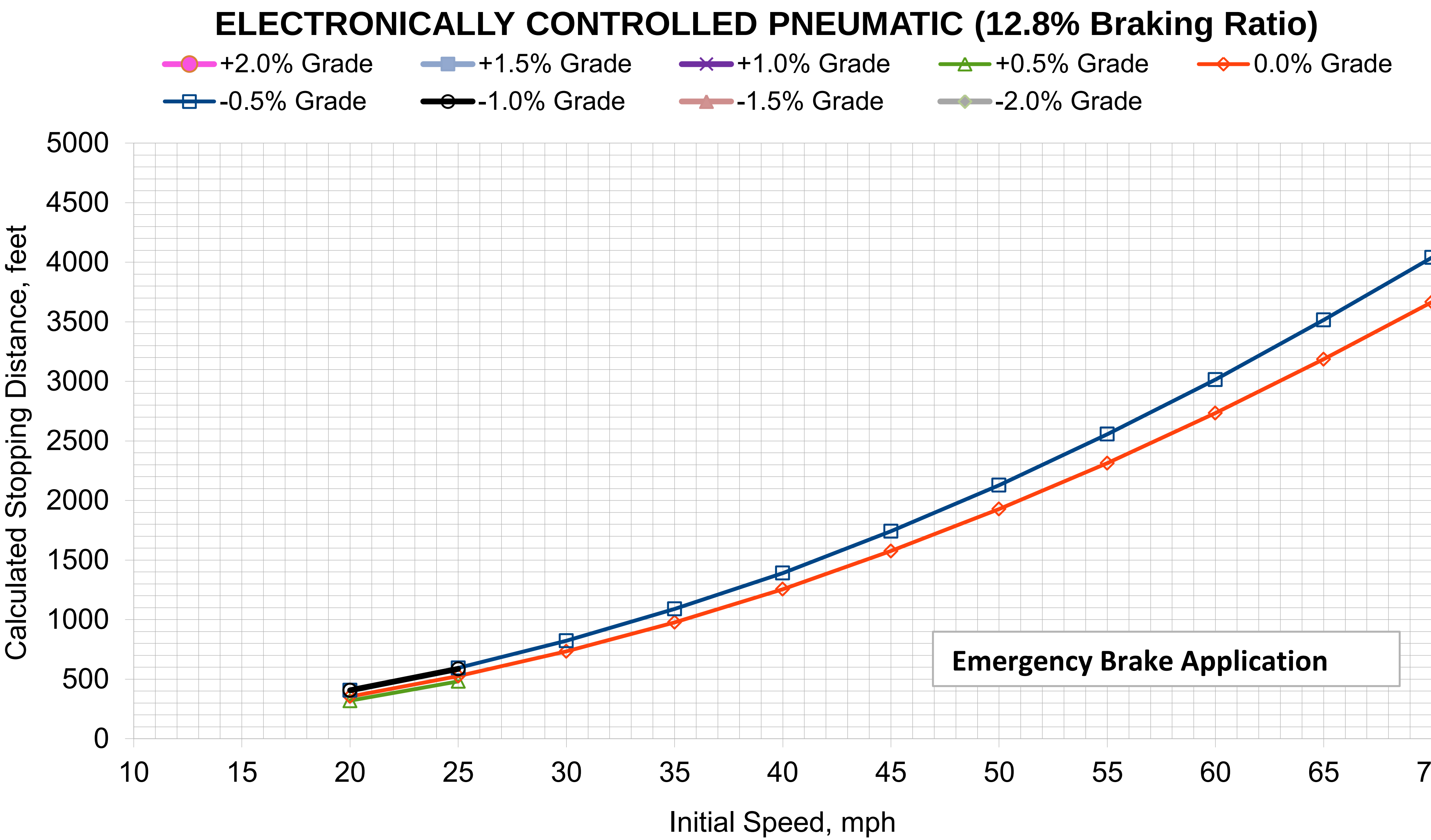
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



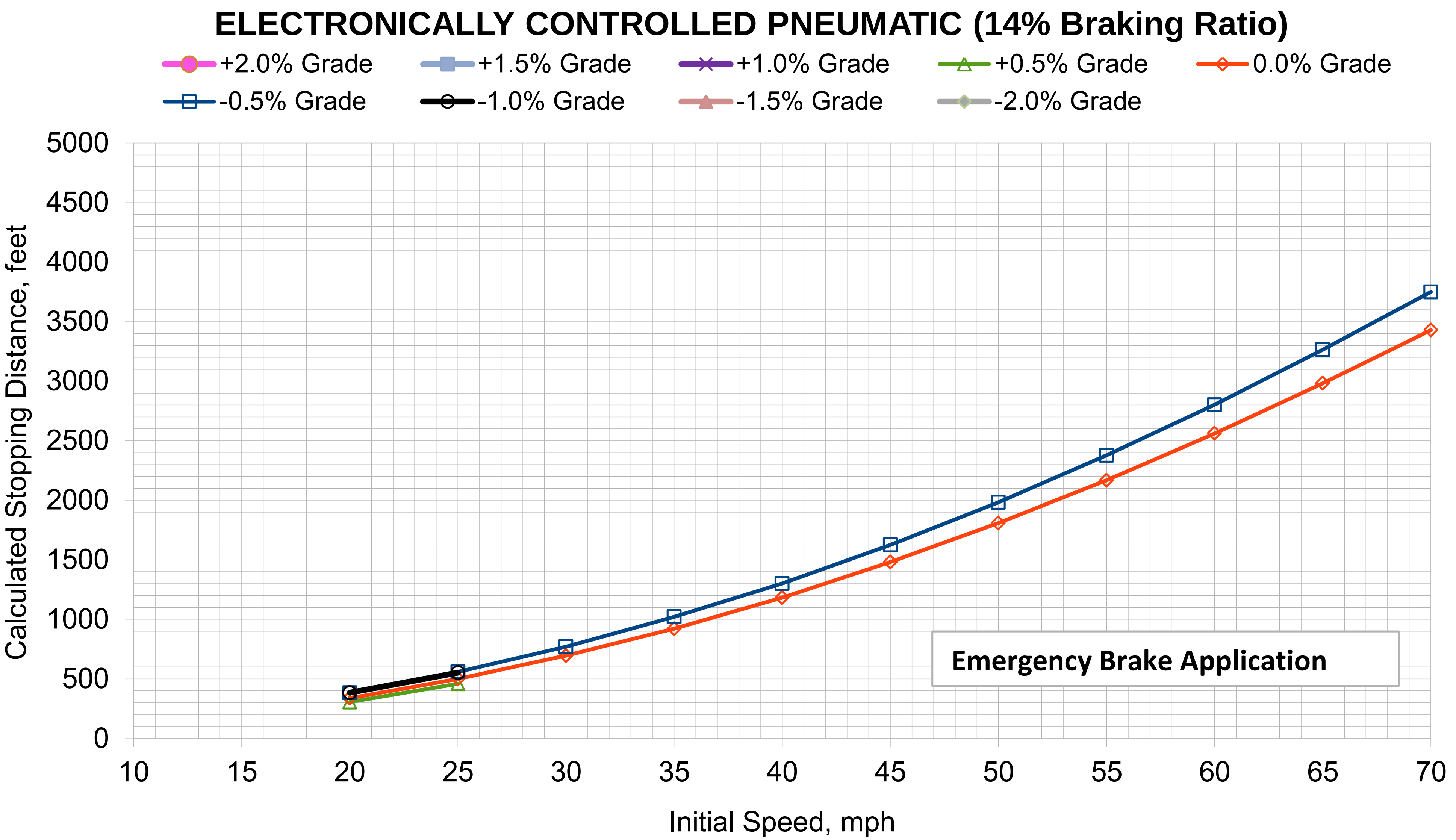
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



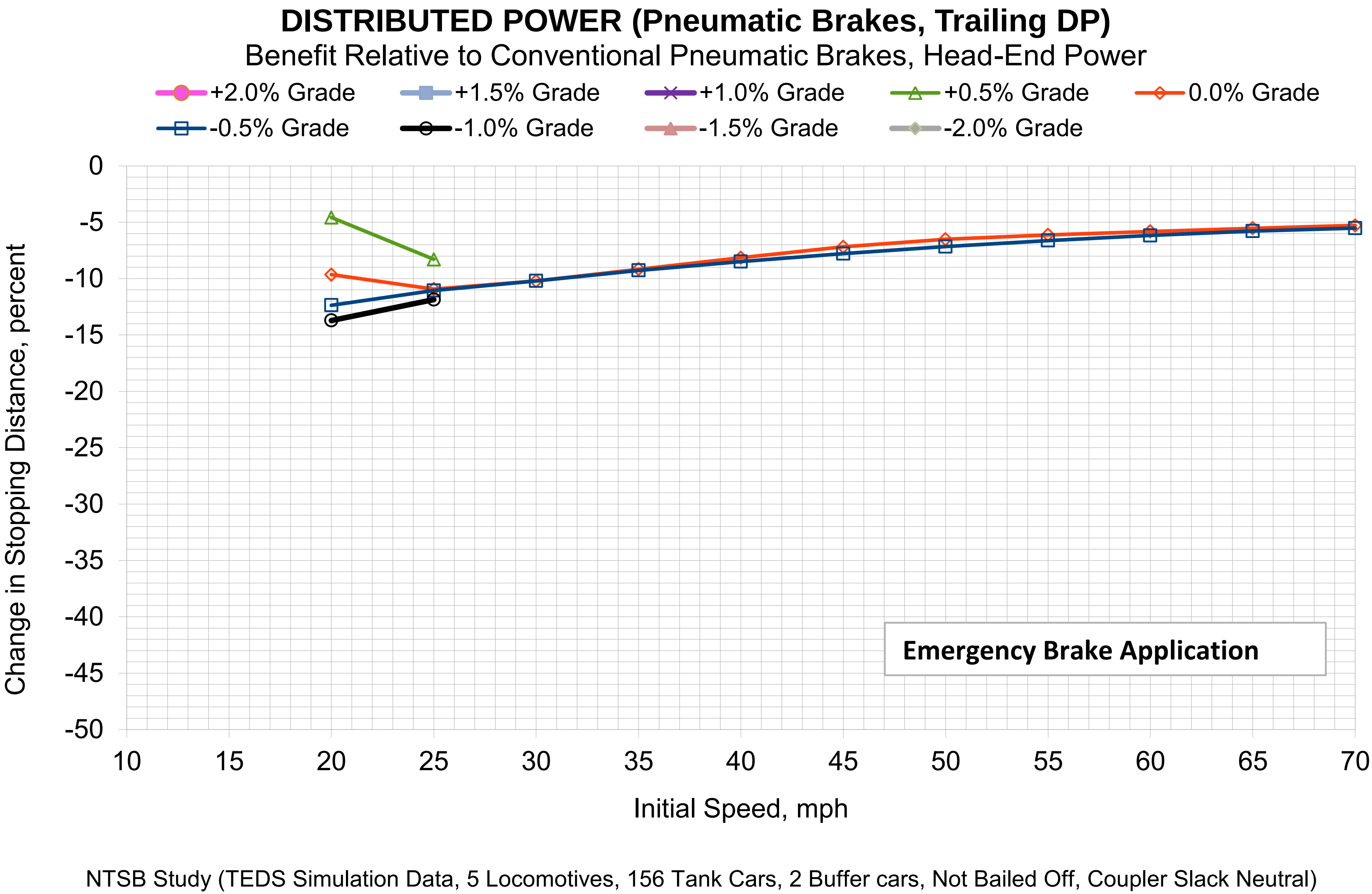
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

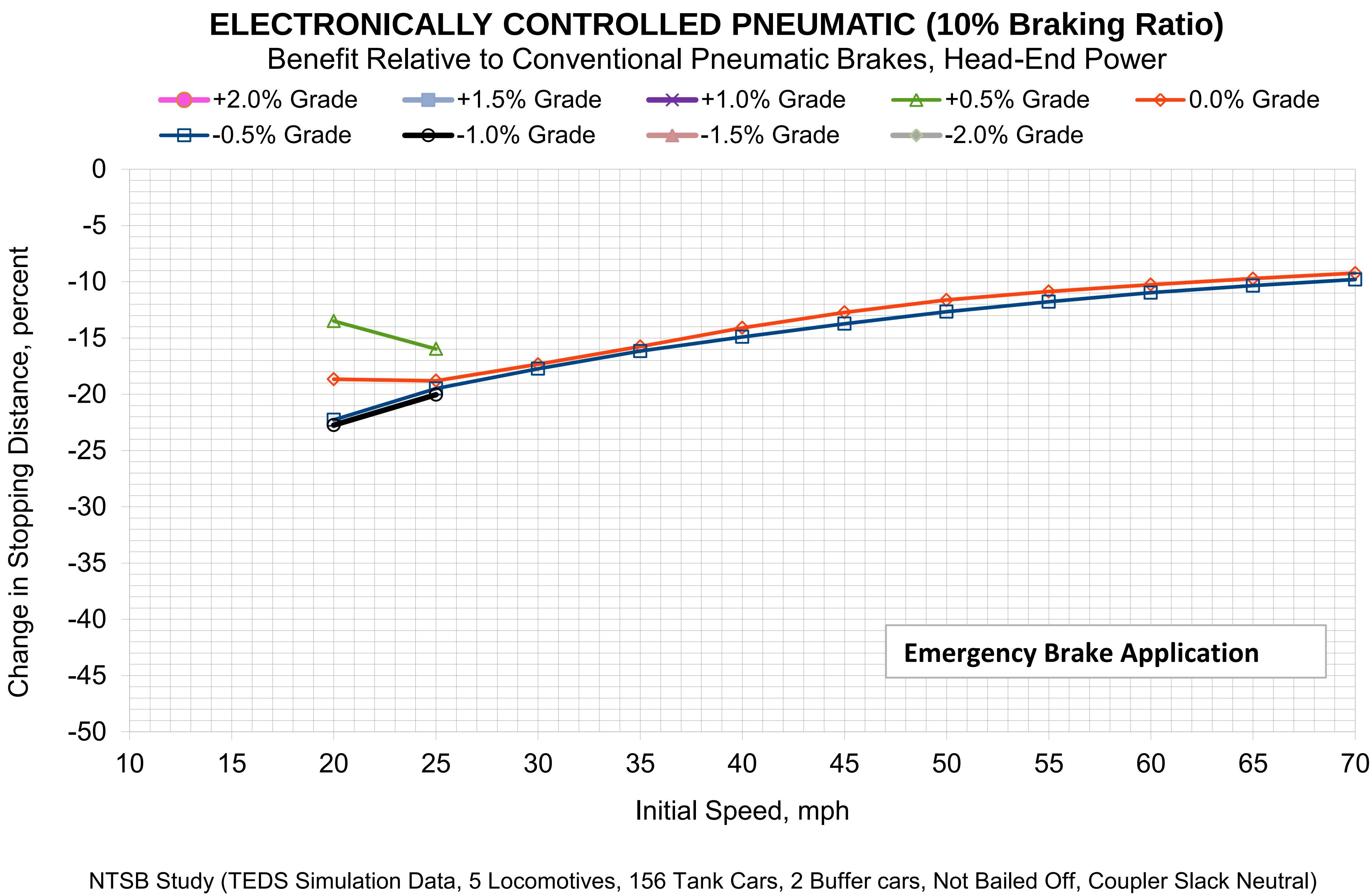


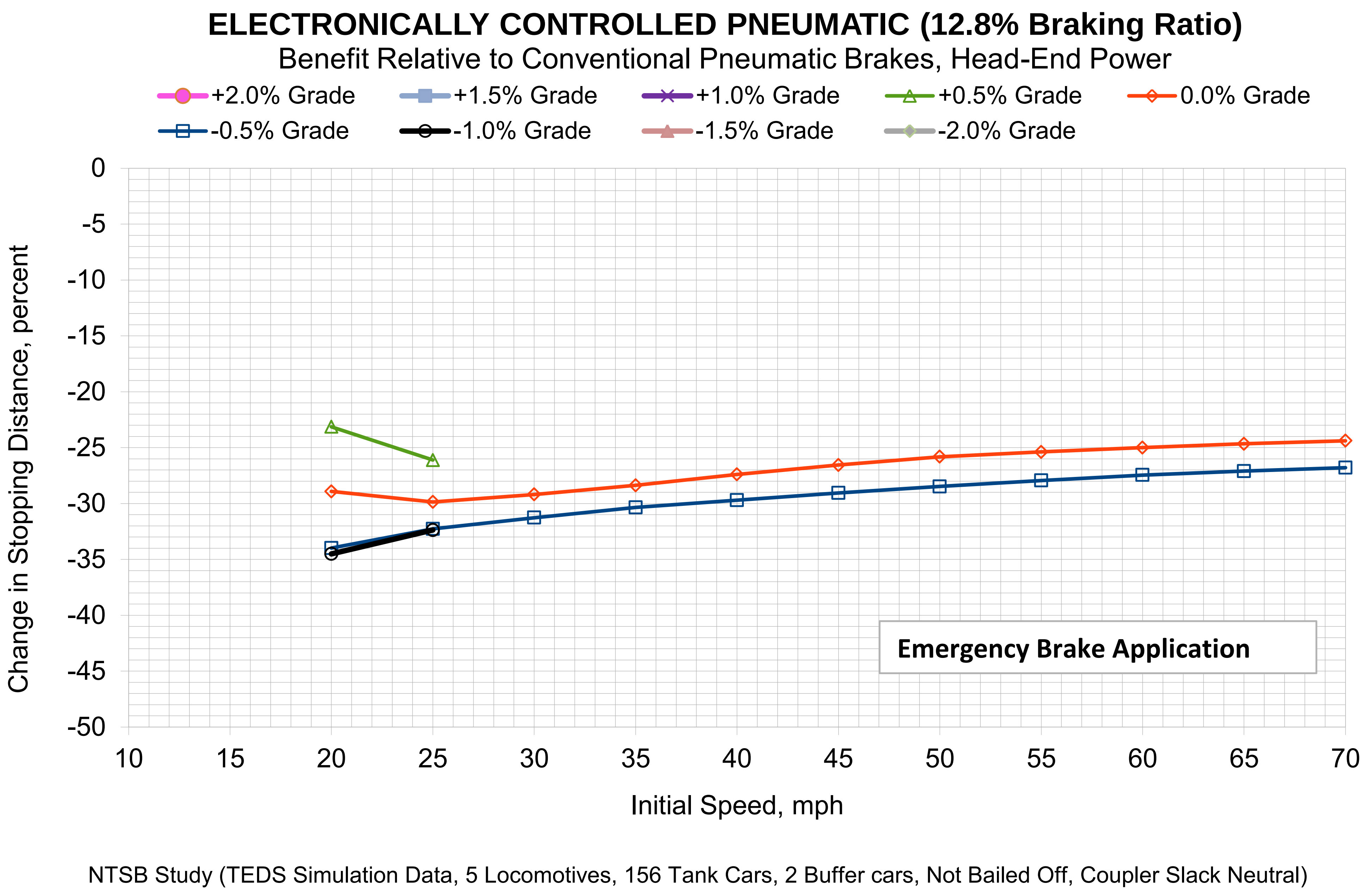
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



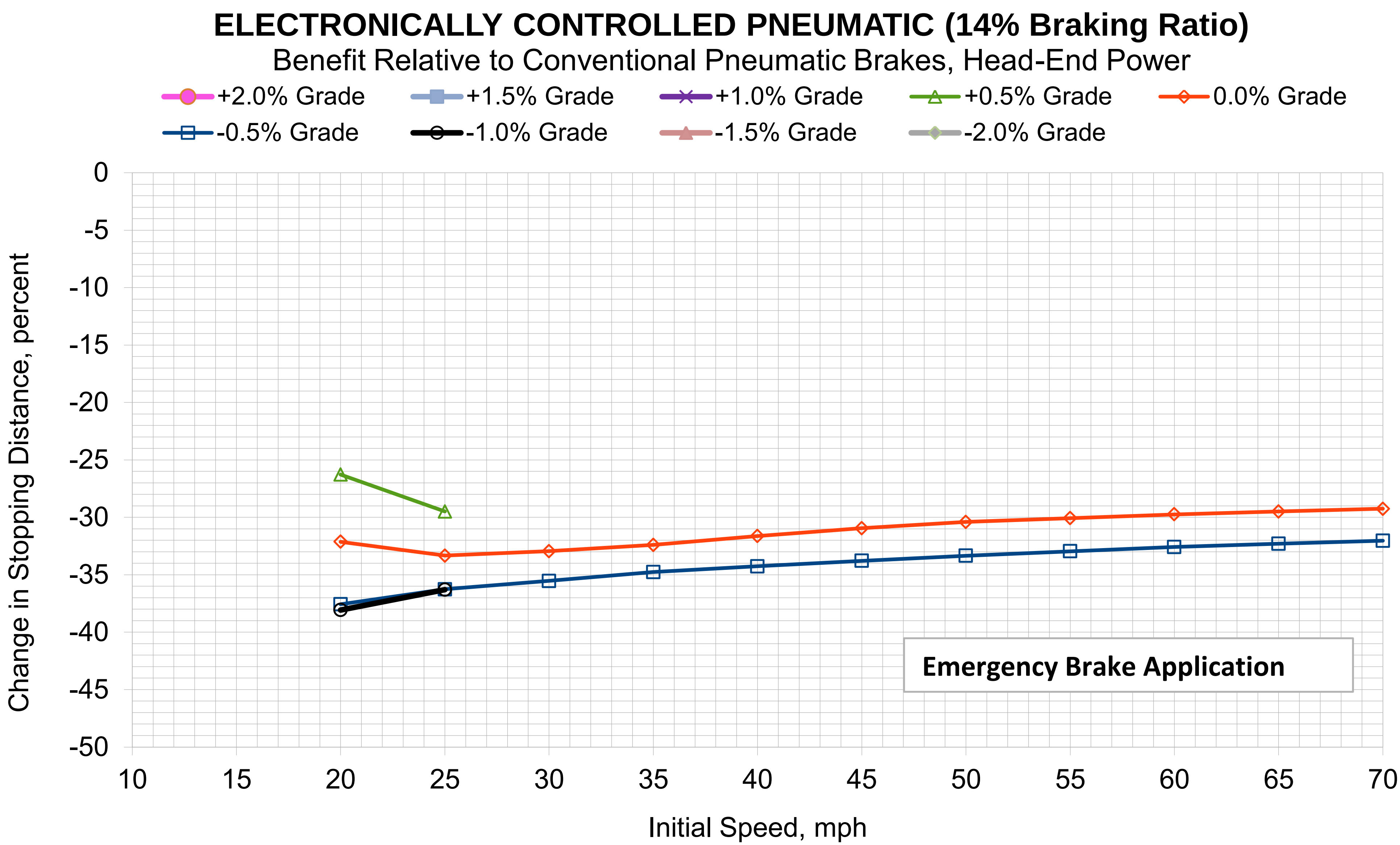
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

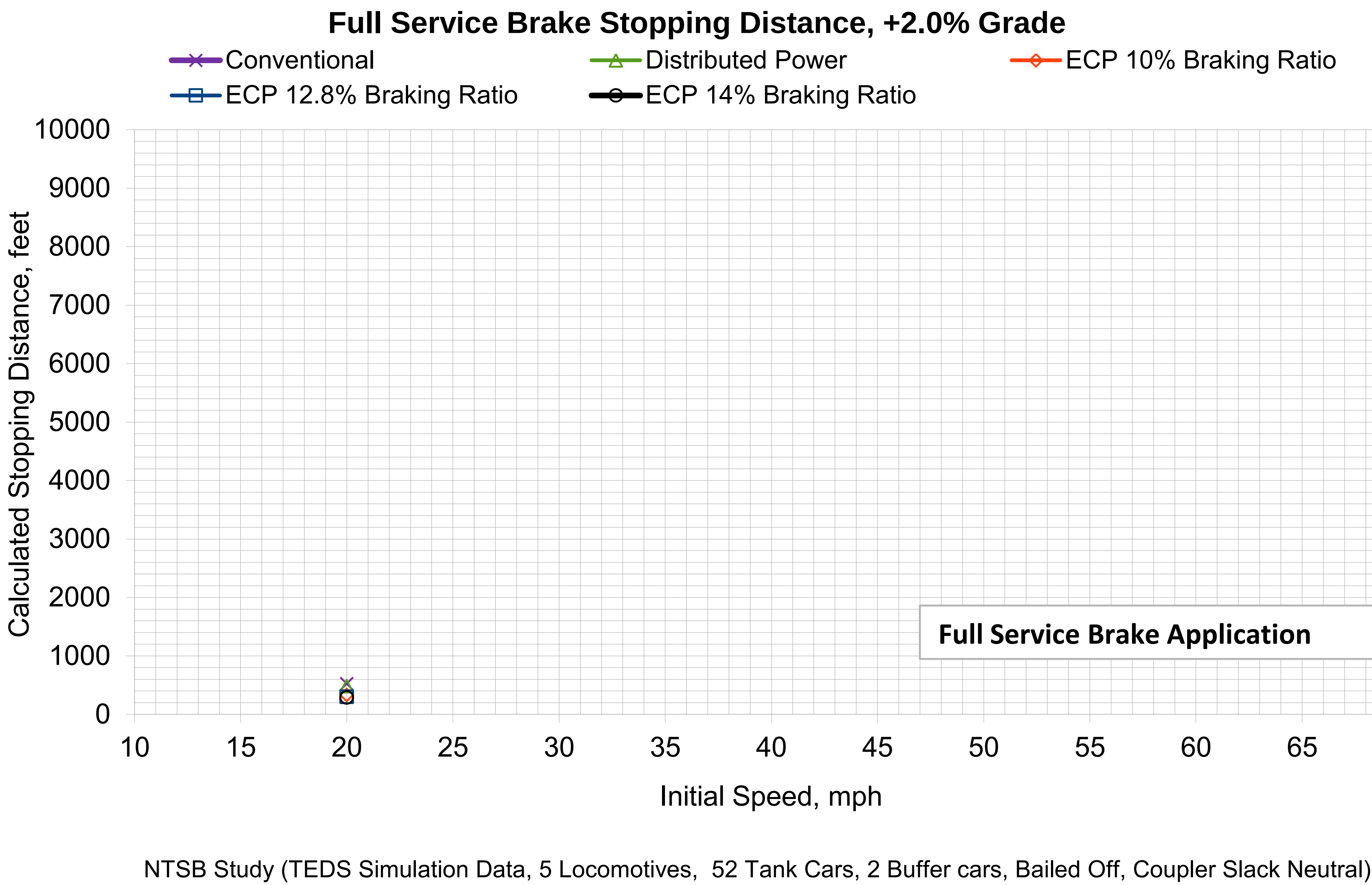


ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

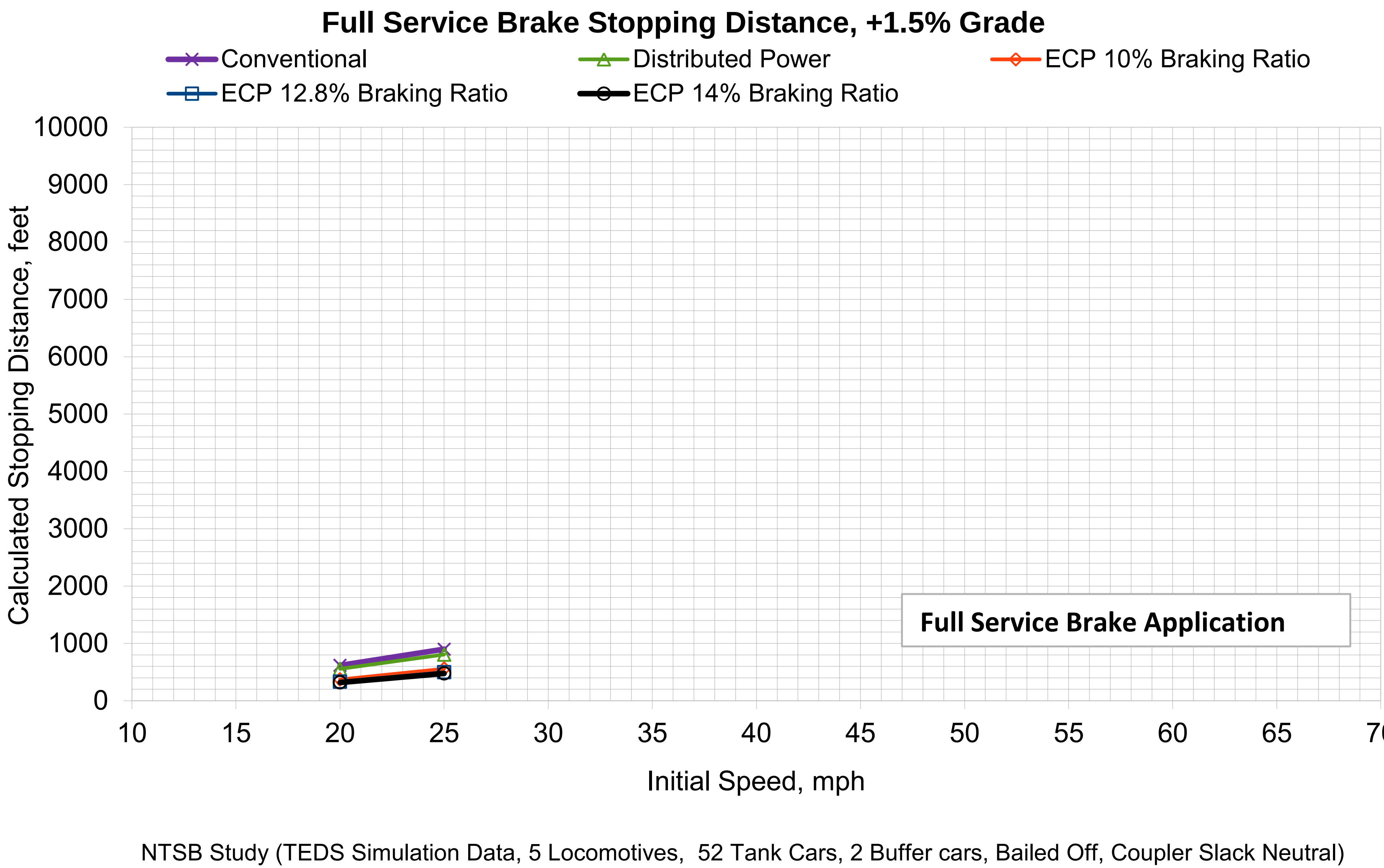


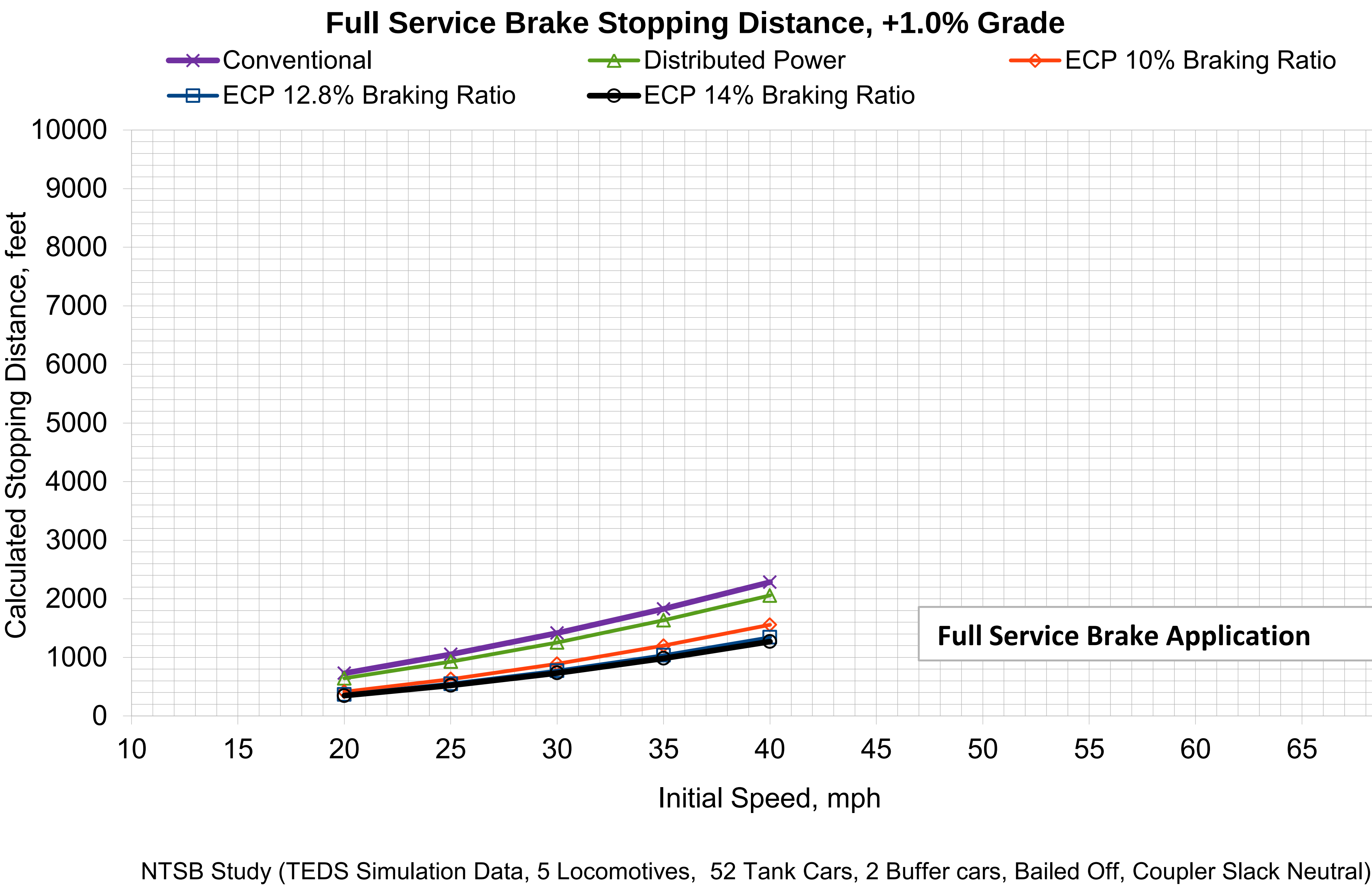
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

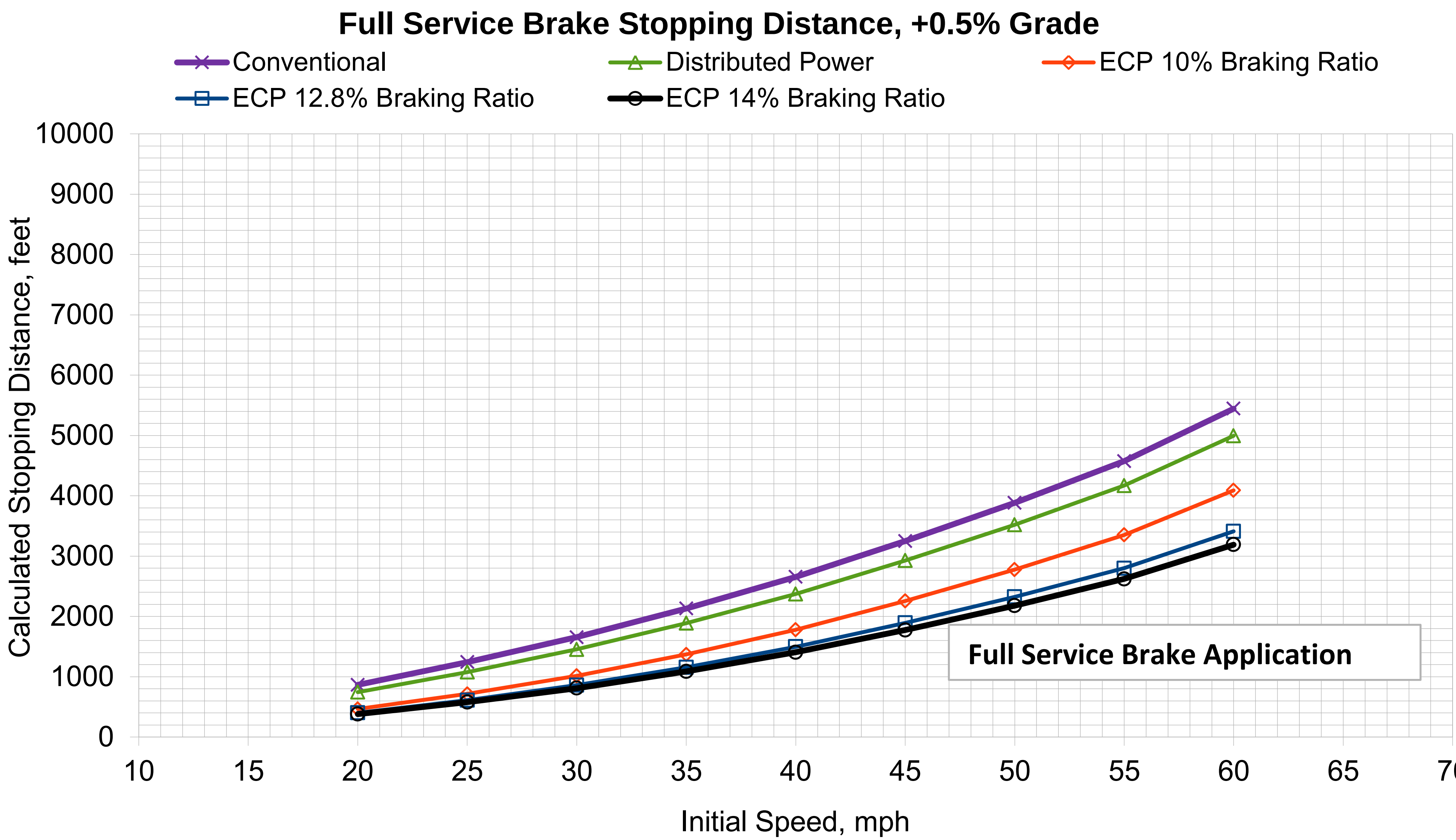
Attachment 17: Full Service Braking, Bailed Off, 52 Tank Cars



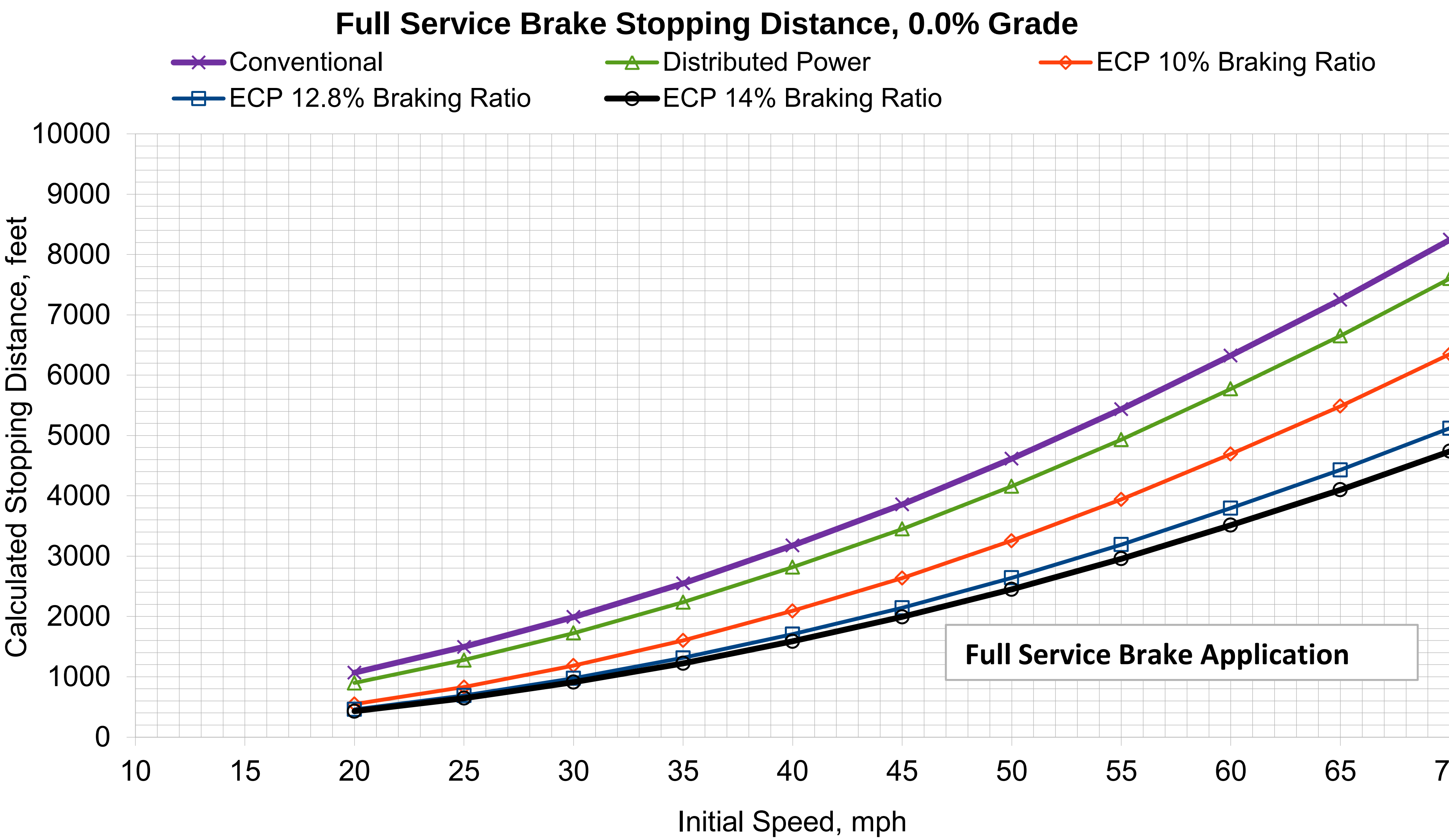
Full Service Brake Stopping Distance, +2.0% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Full Service Brake Stopping Distance, +1.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

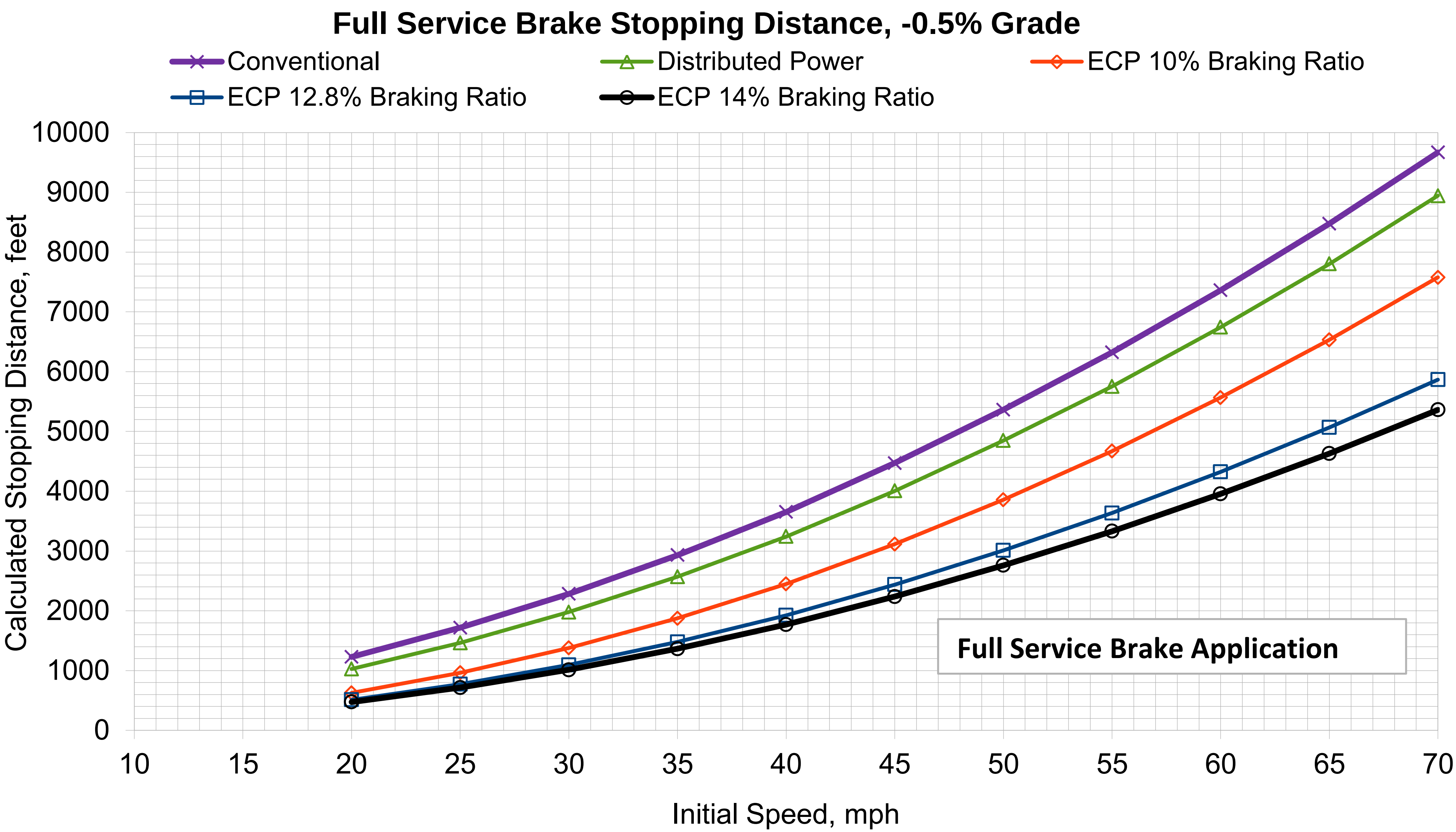

Full Service Brake Stopping Distance, +1.0% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



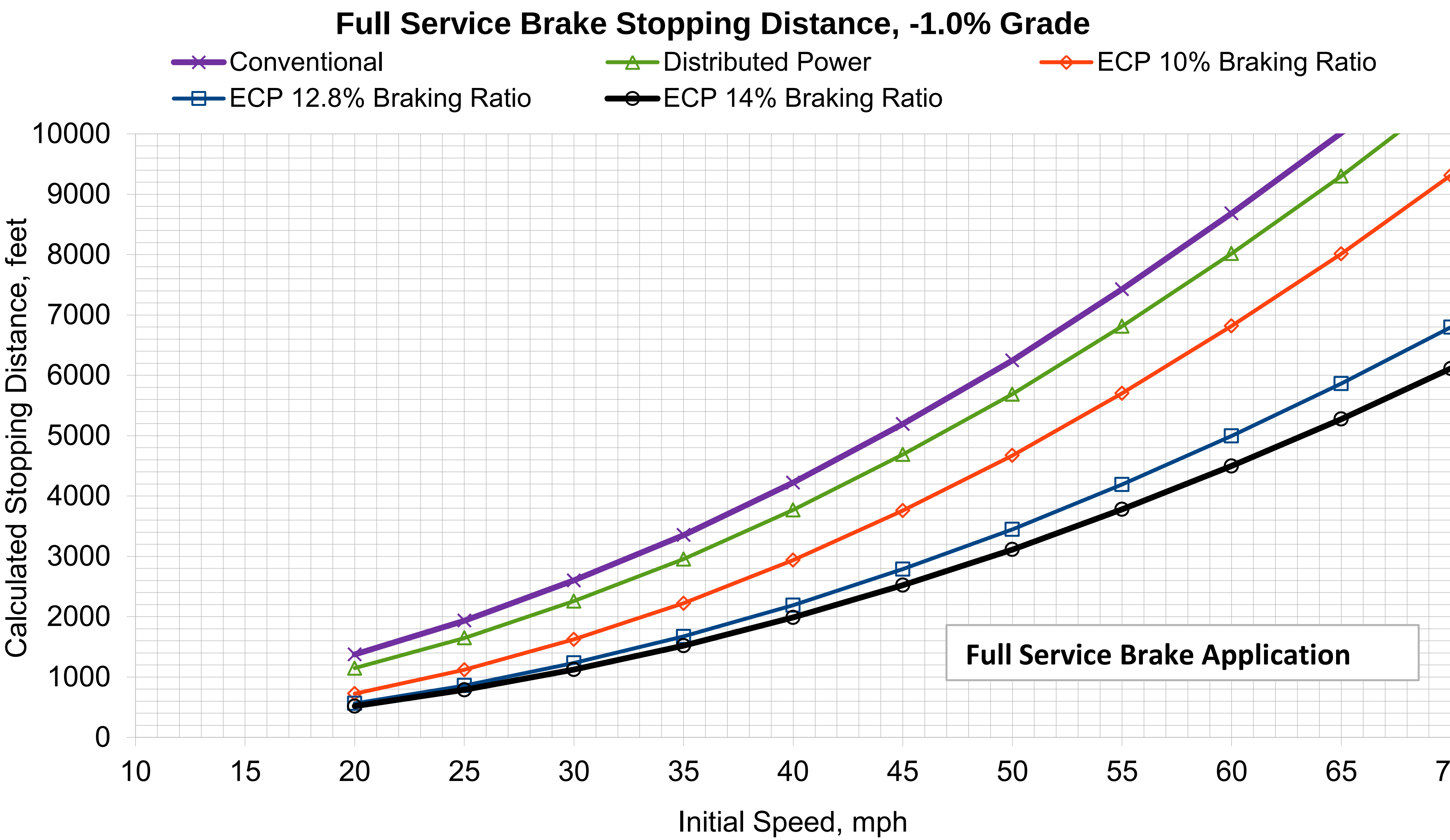
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



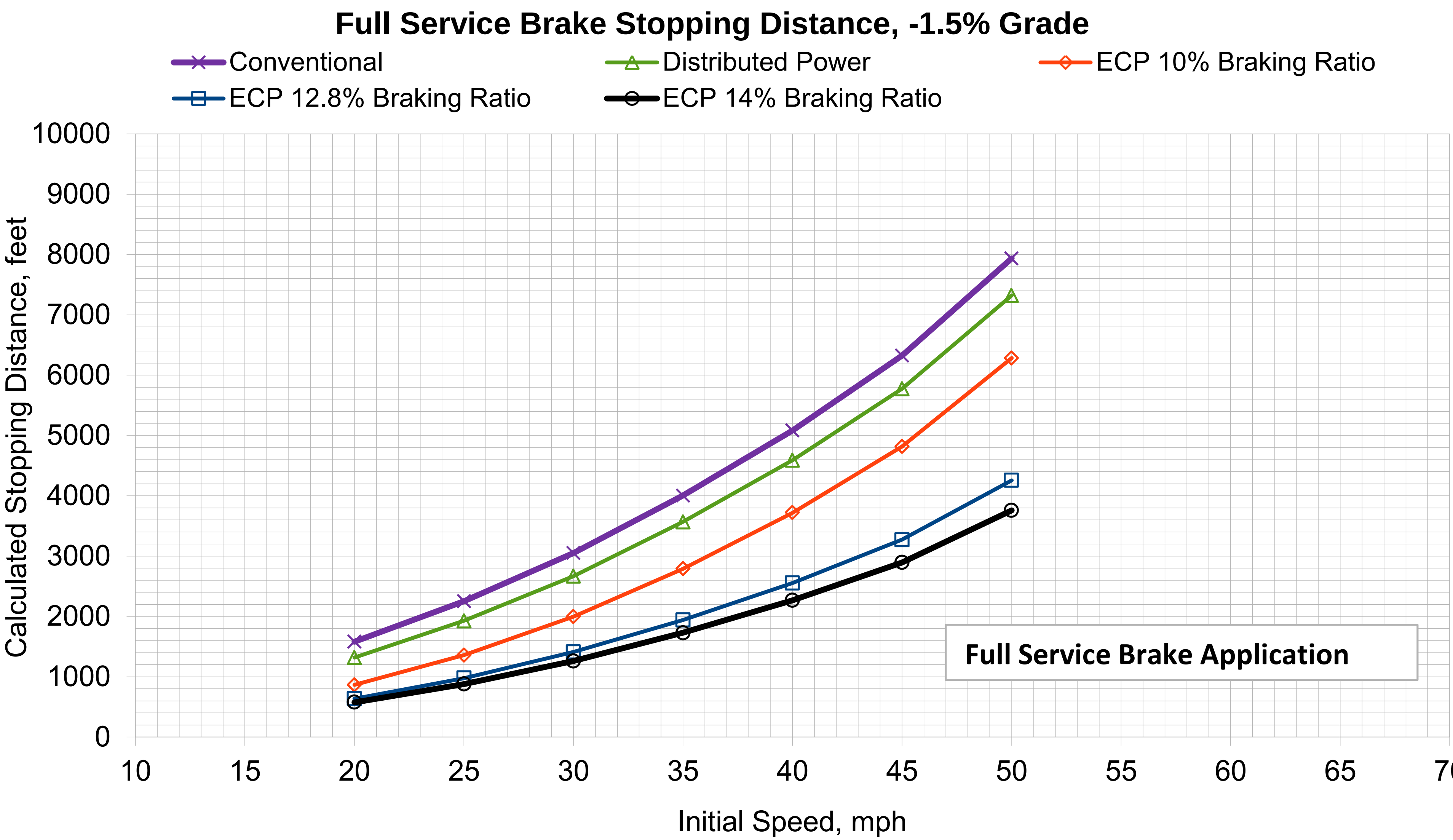
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



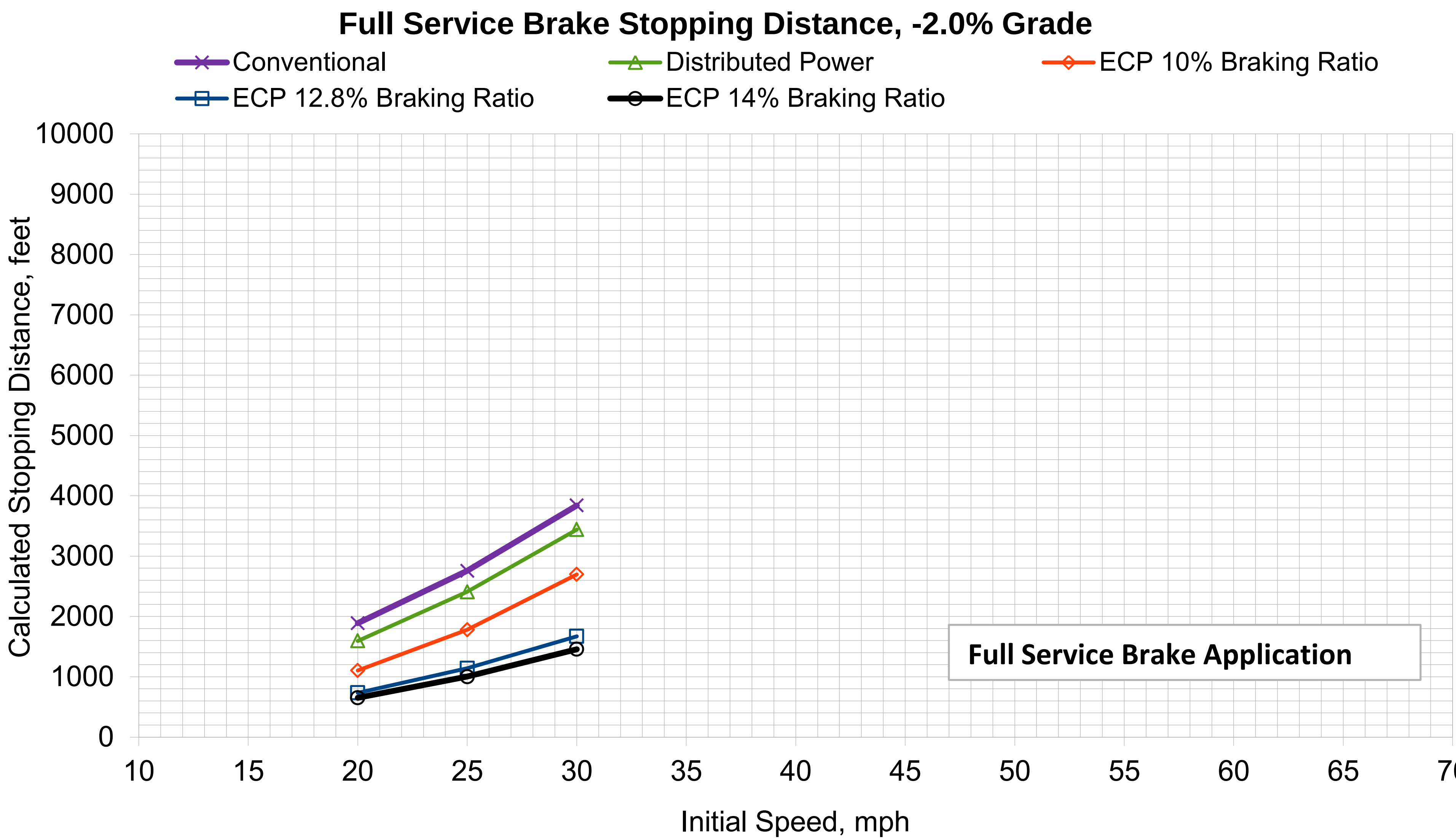
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



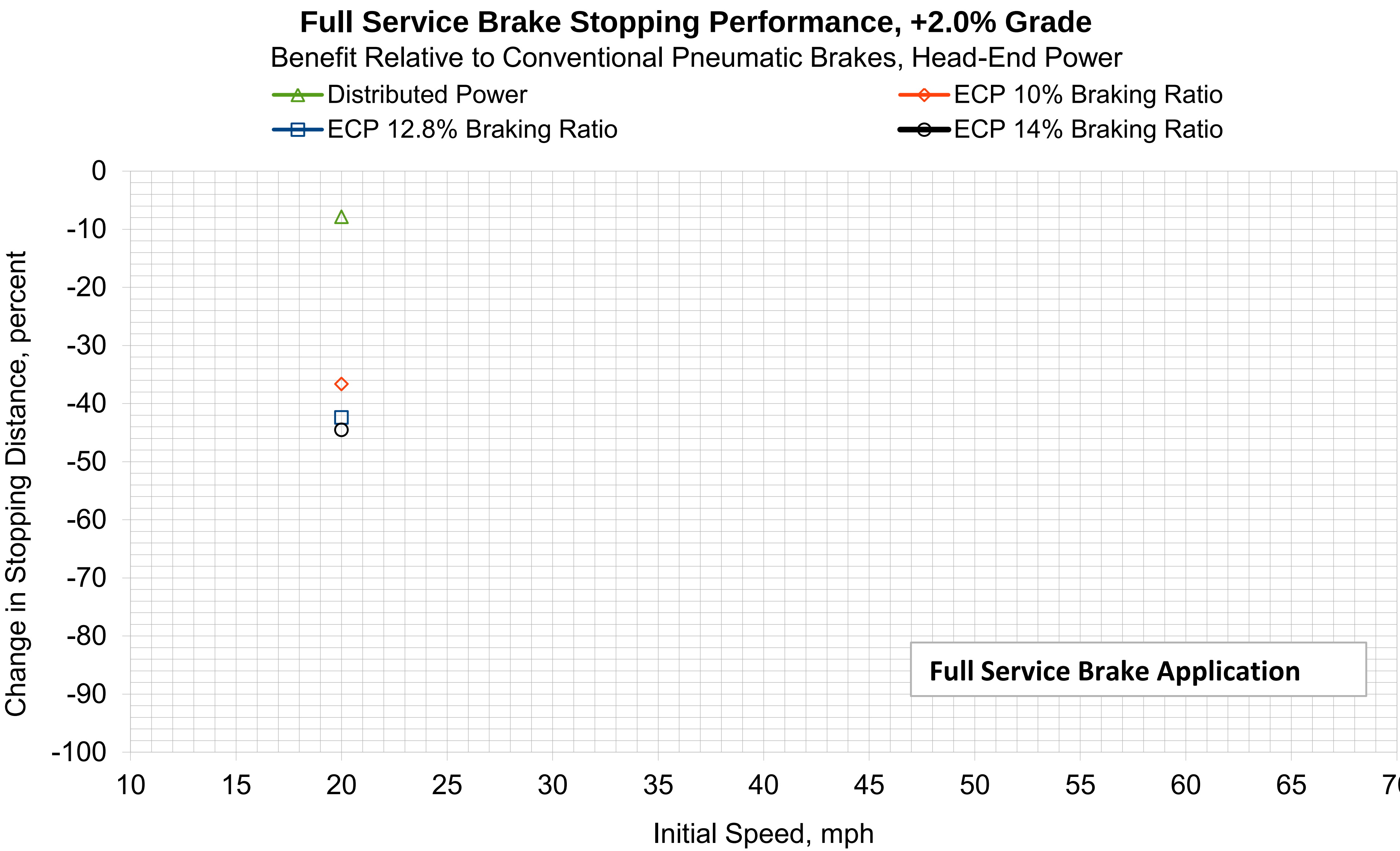
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



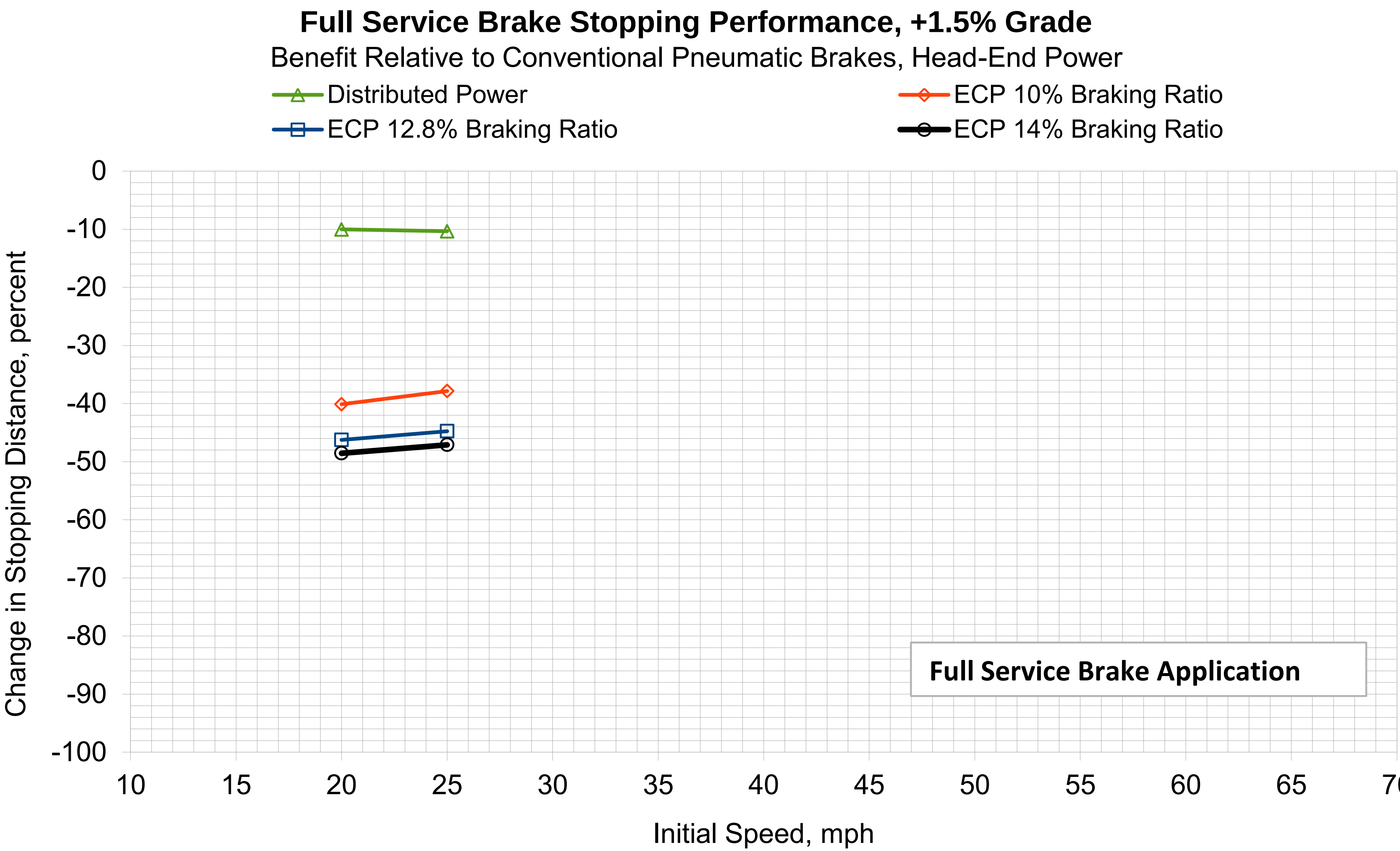
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



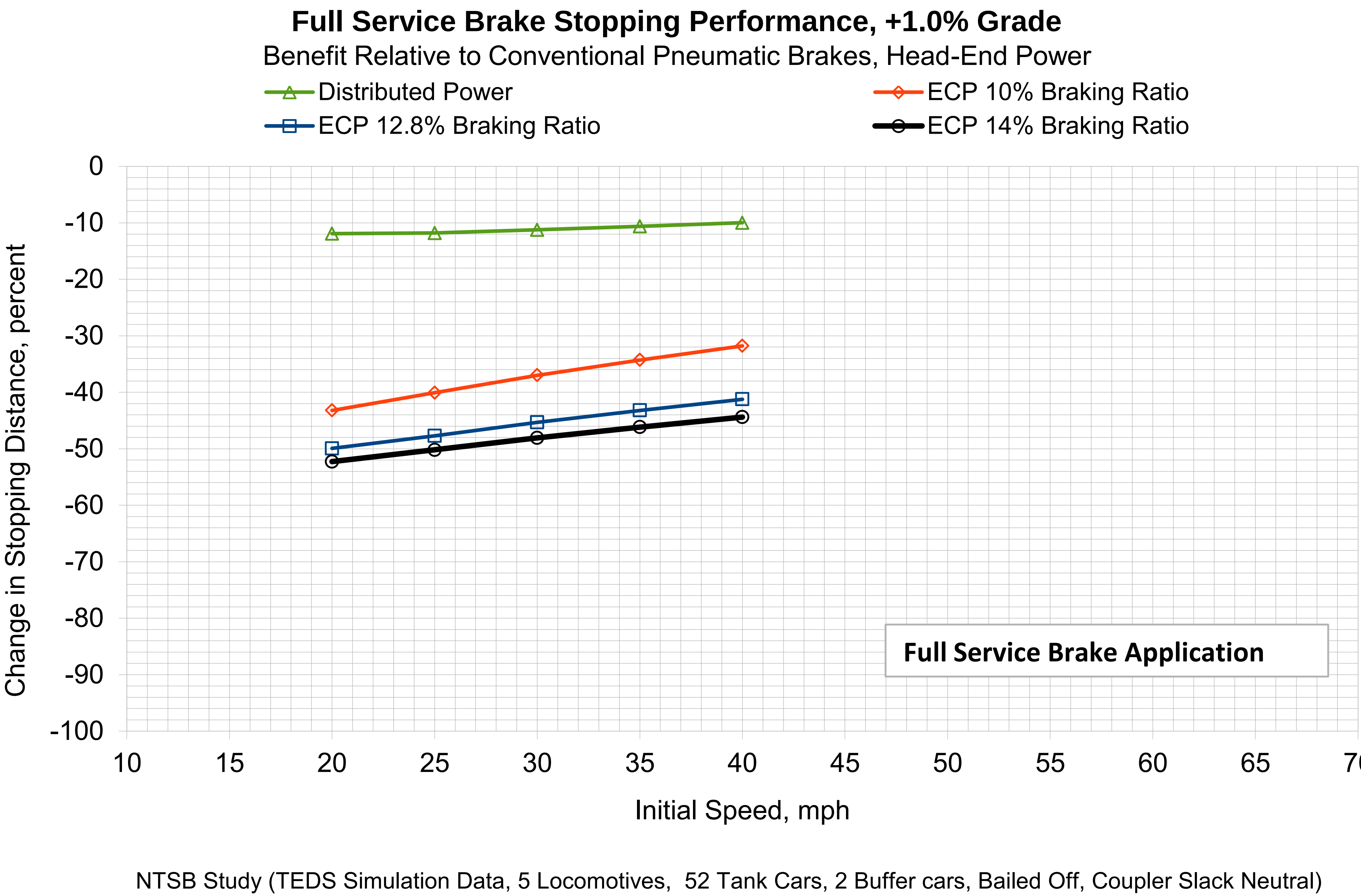
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

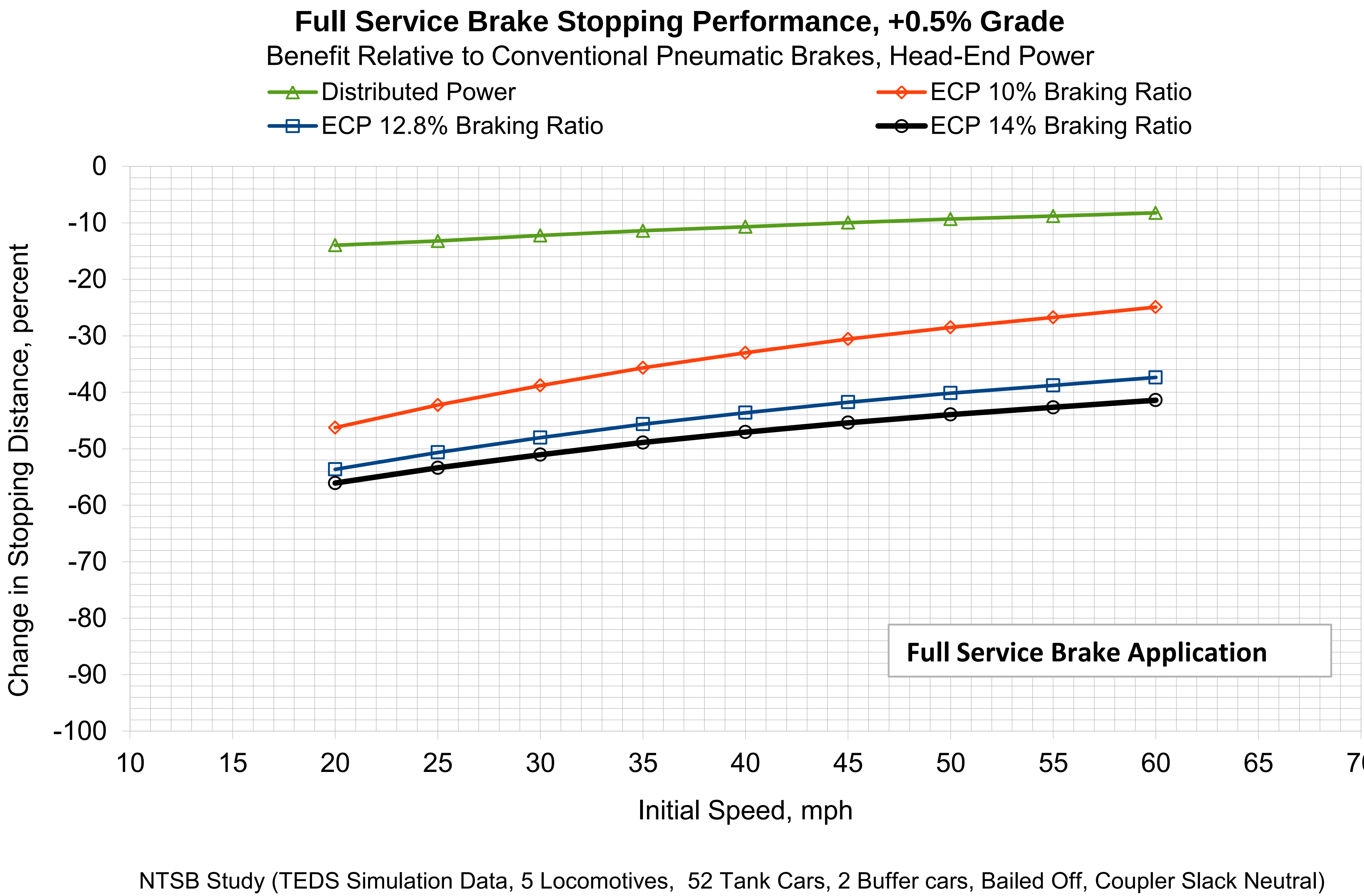


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

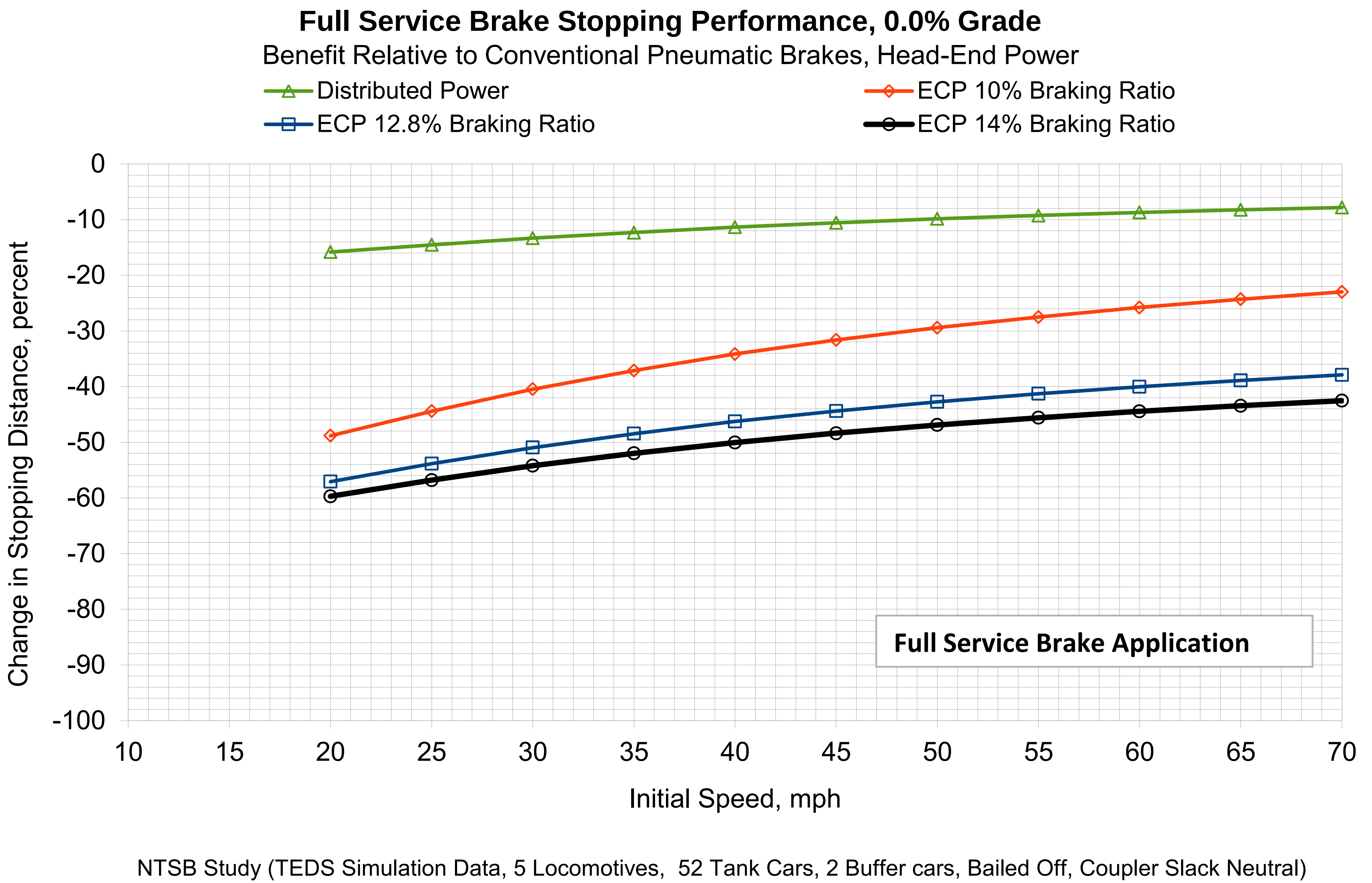


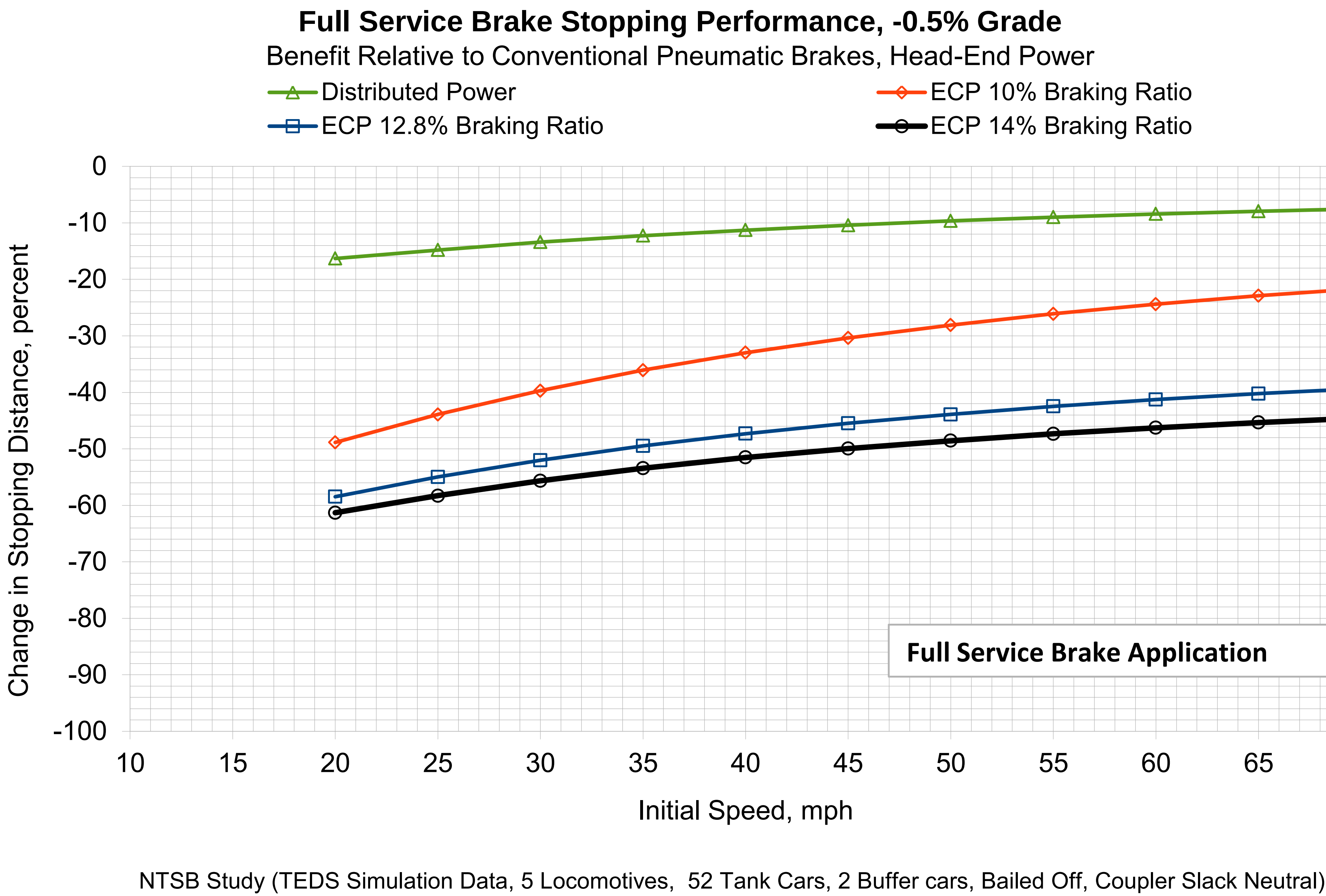
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Full Service Brake Stopping Performance, +1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

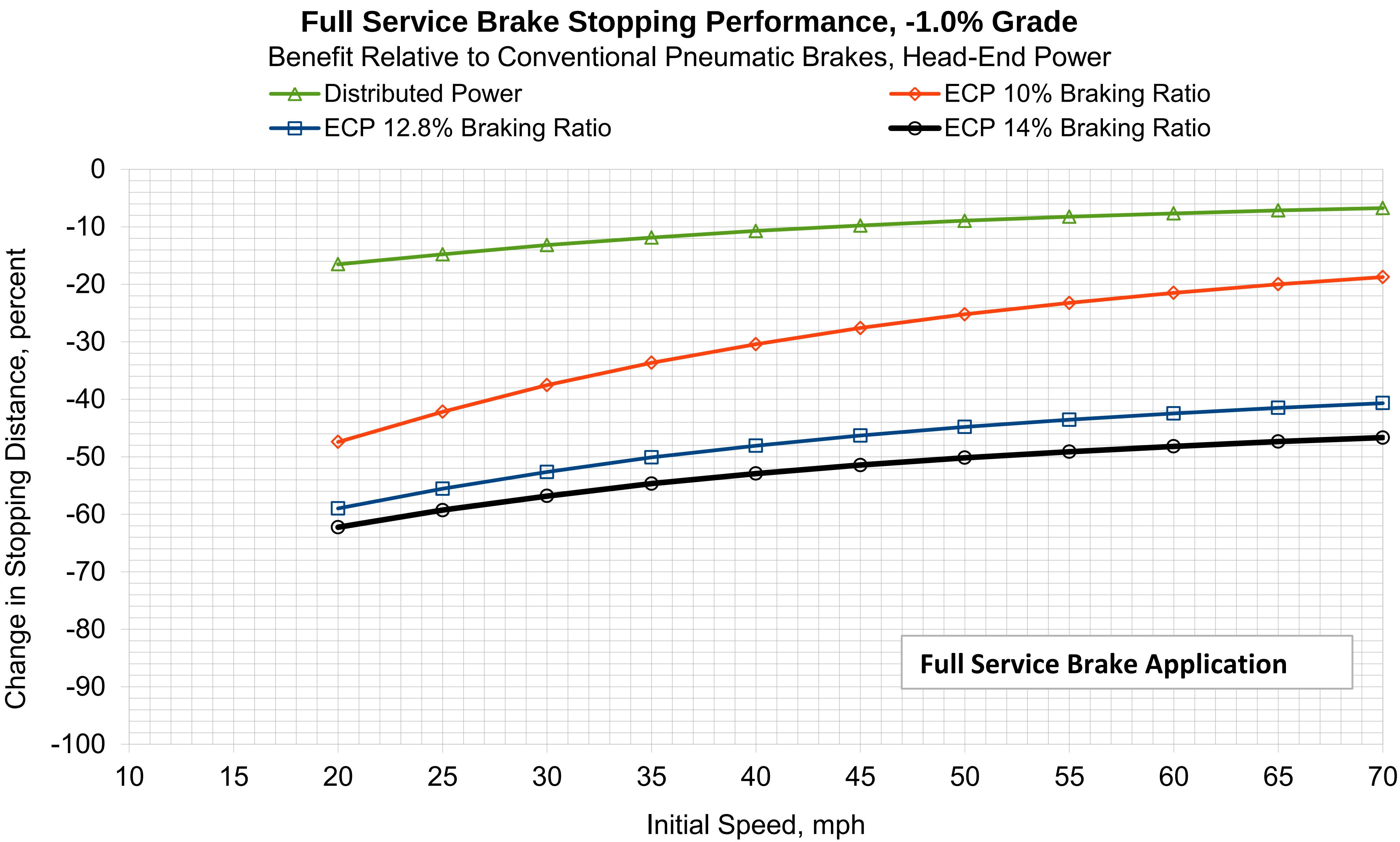

Full Service Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

A17.14


Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

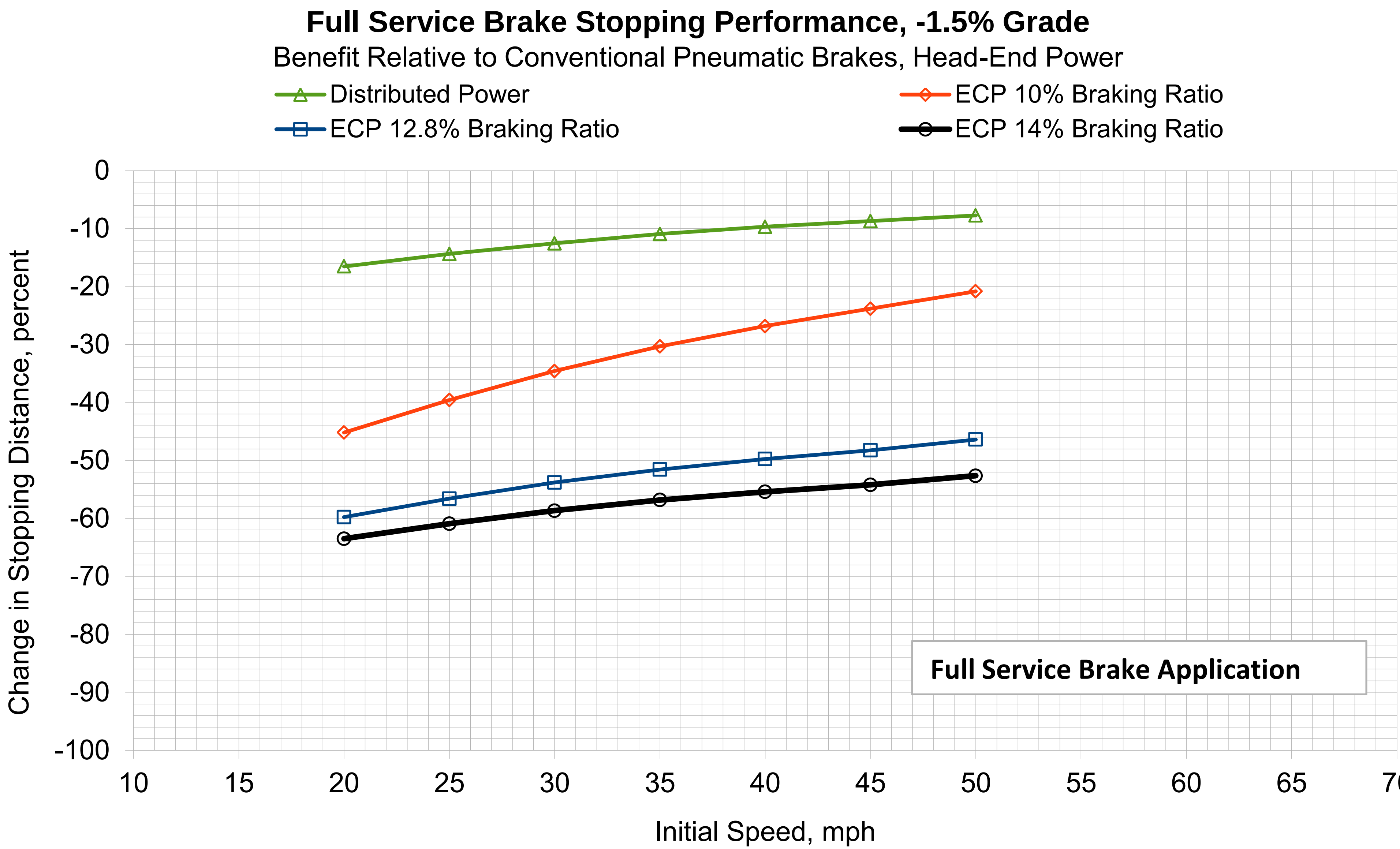

Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

A17.16



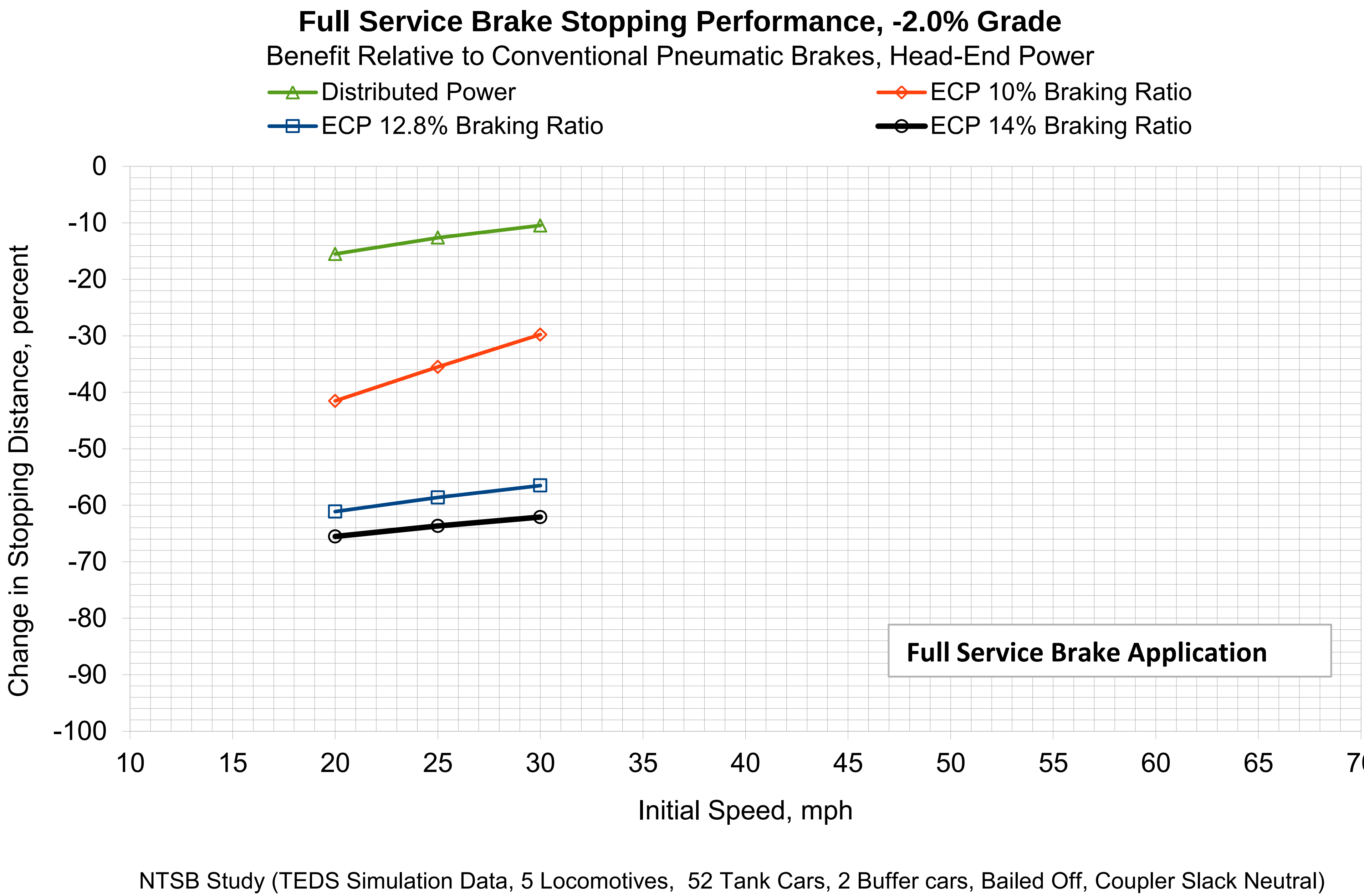
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

A17.17

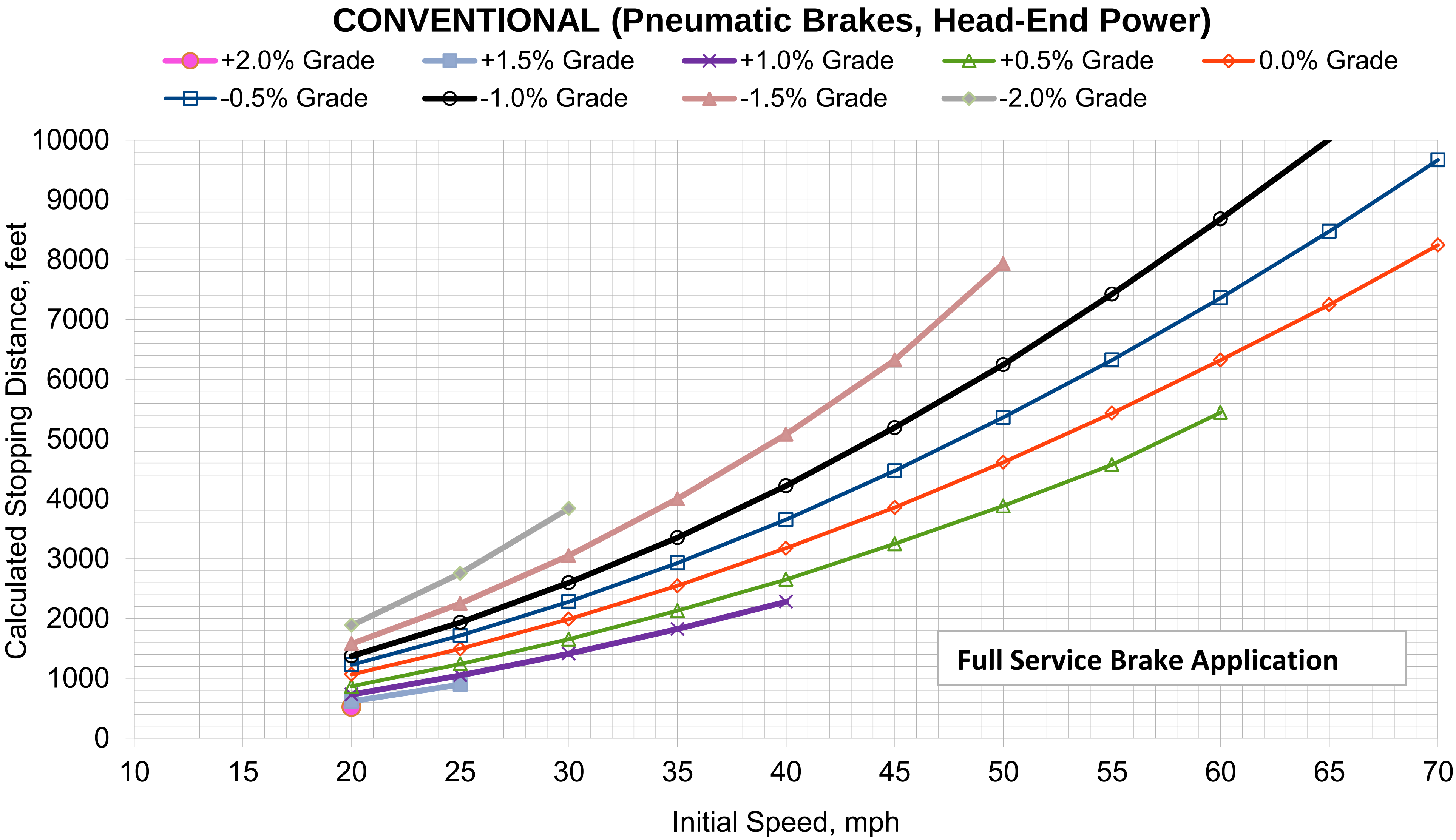


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

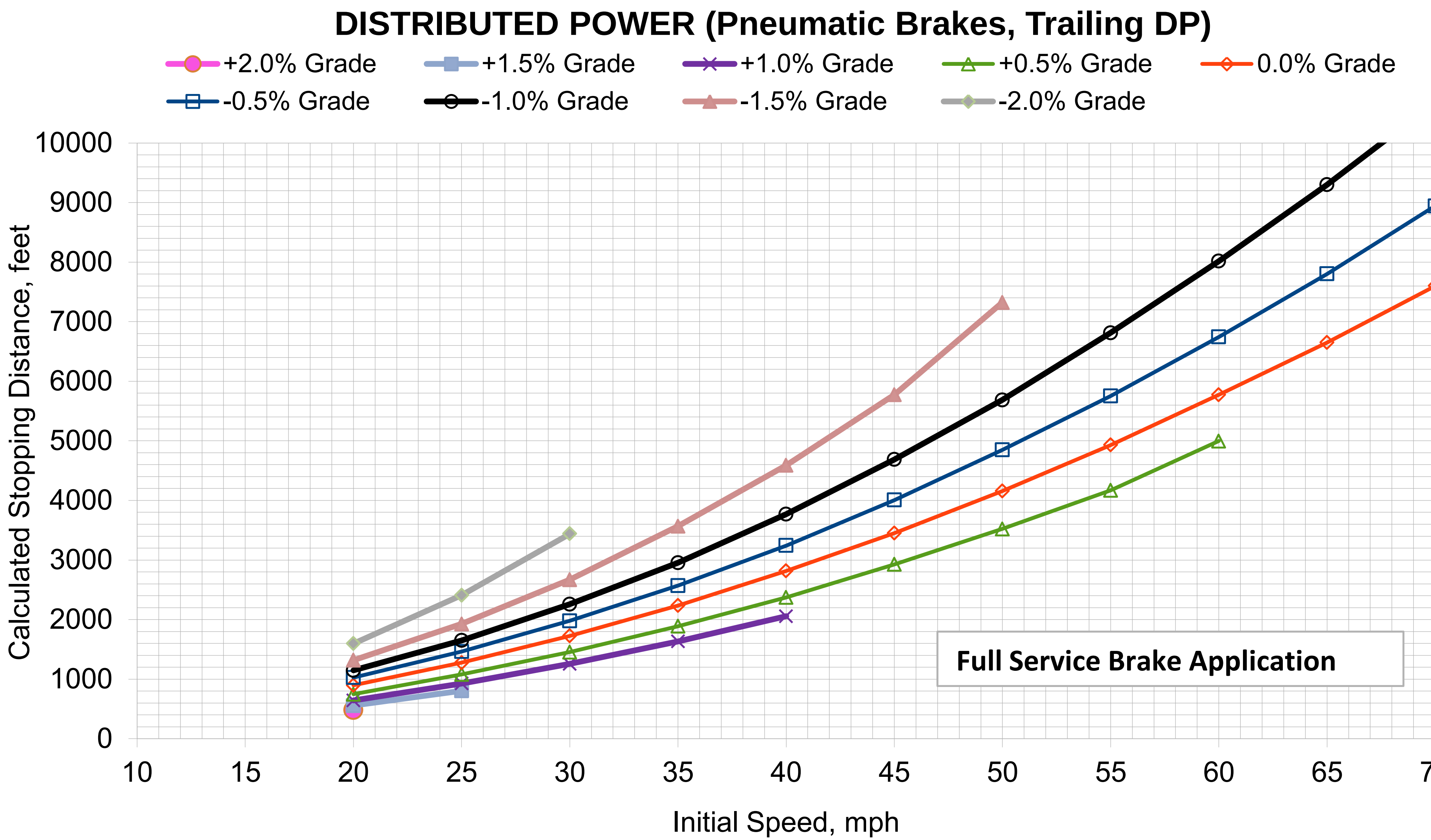
A17.18



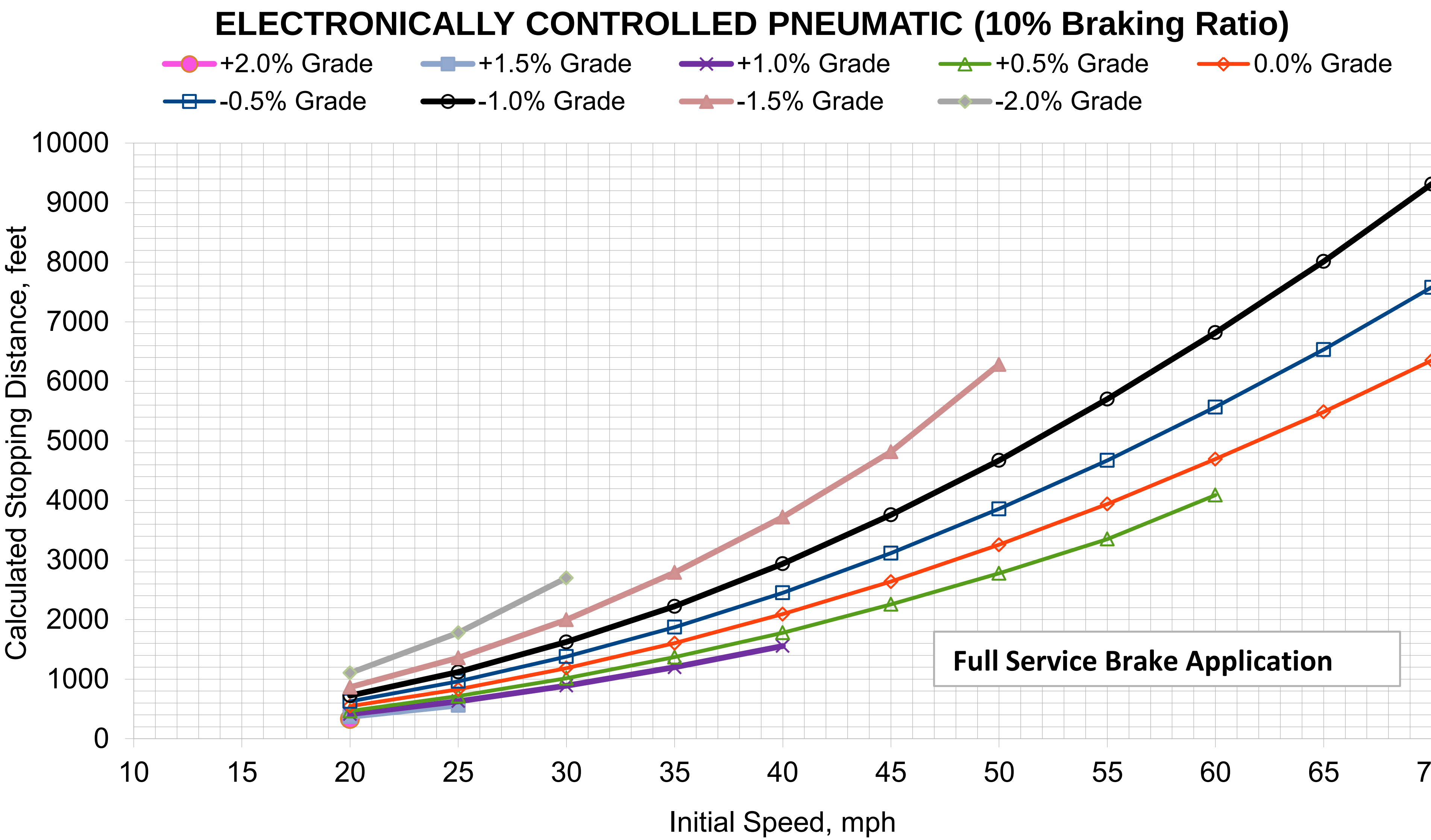
Full Service Brake Stopping Performance, -2.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



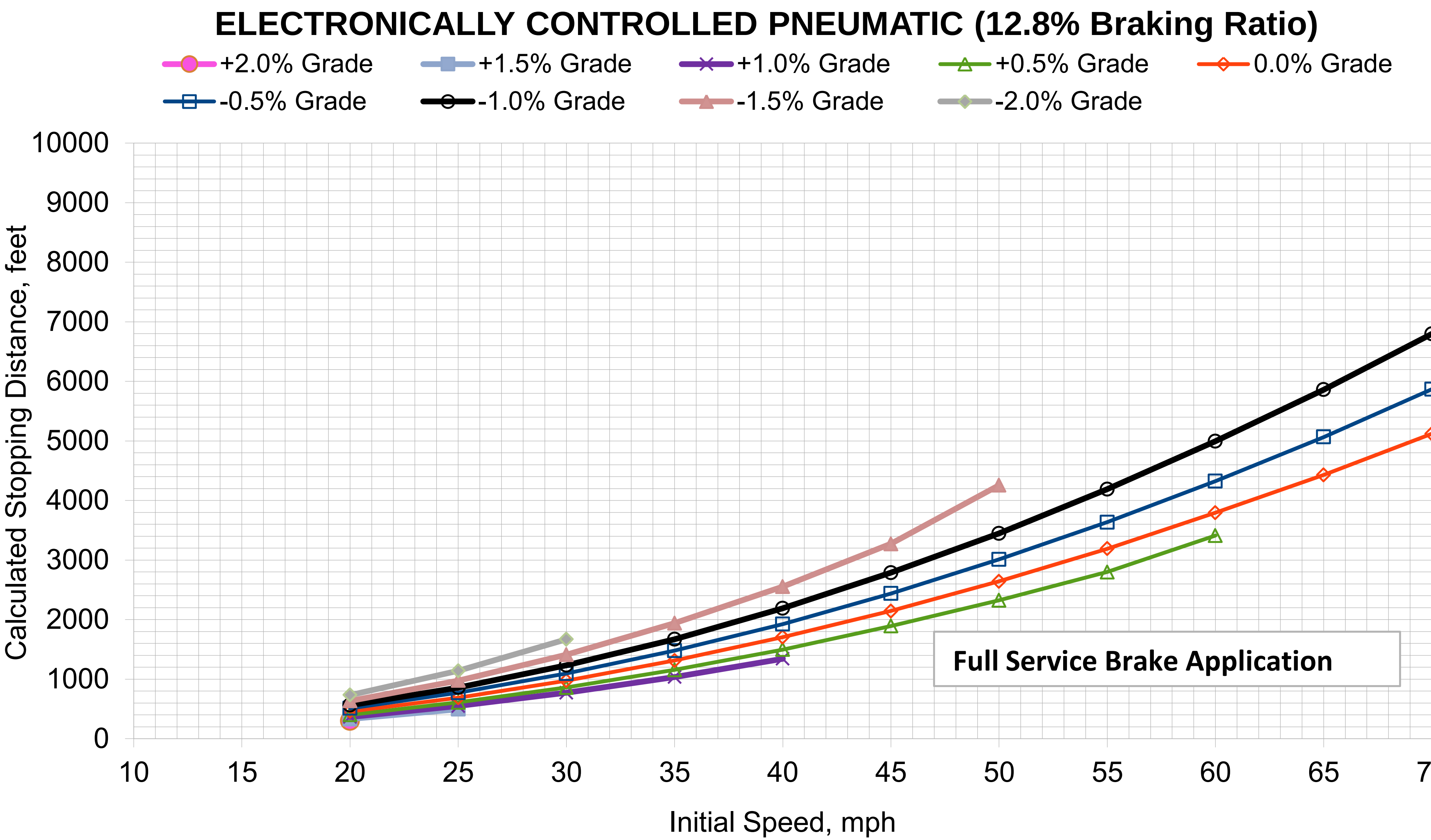
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



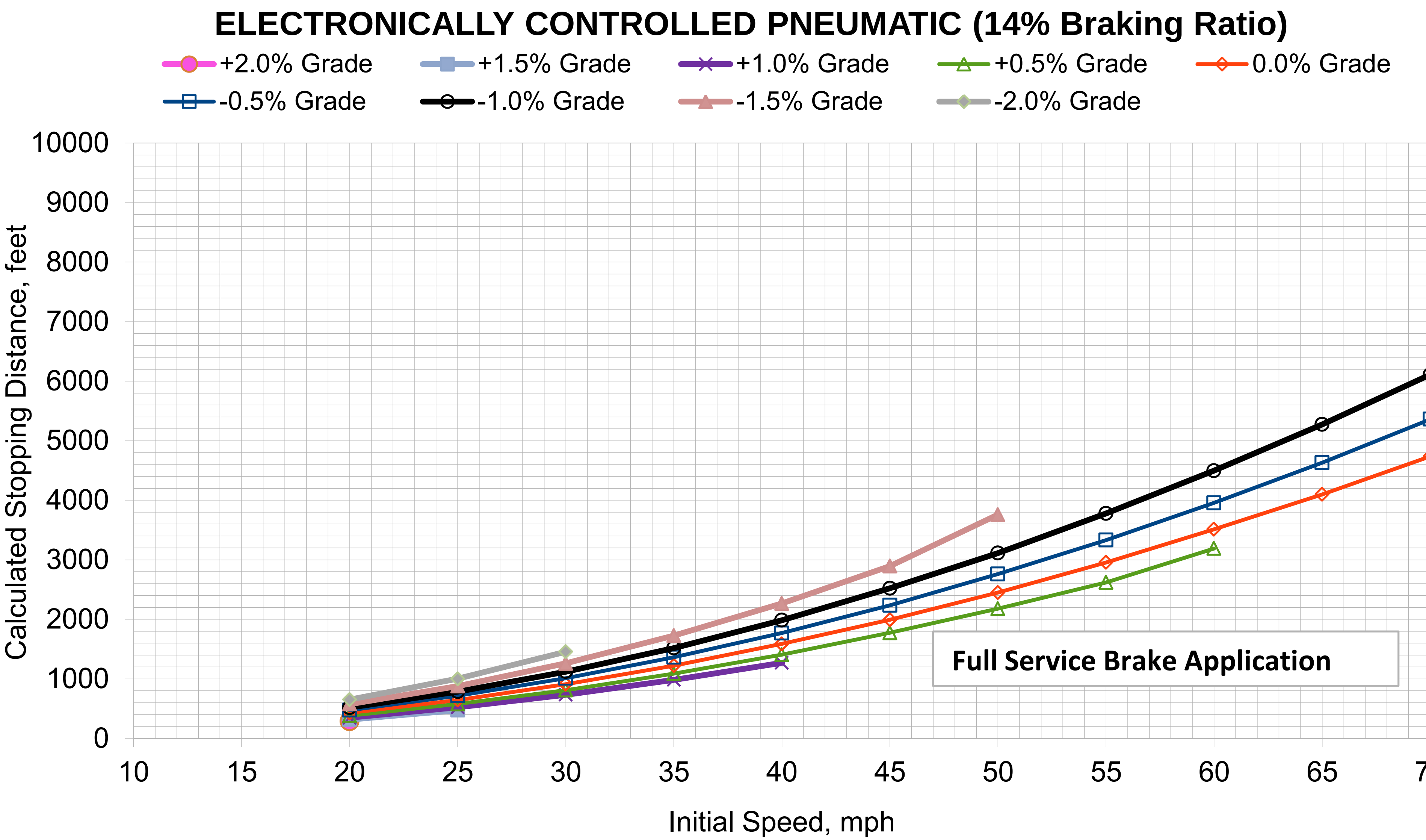
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



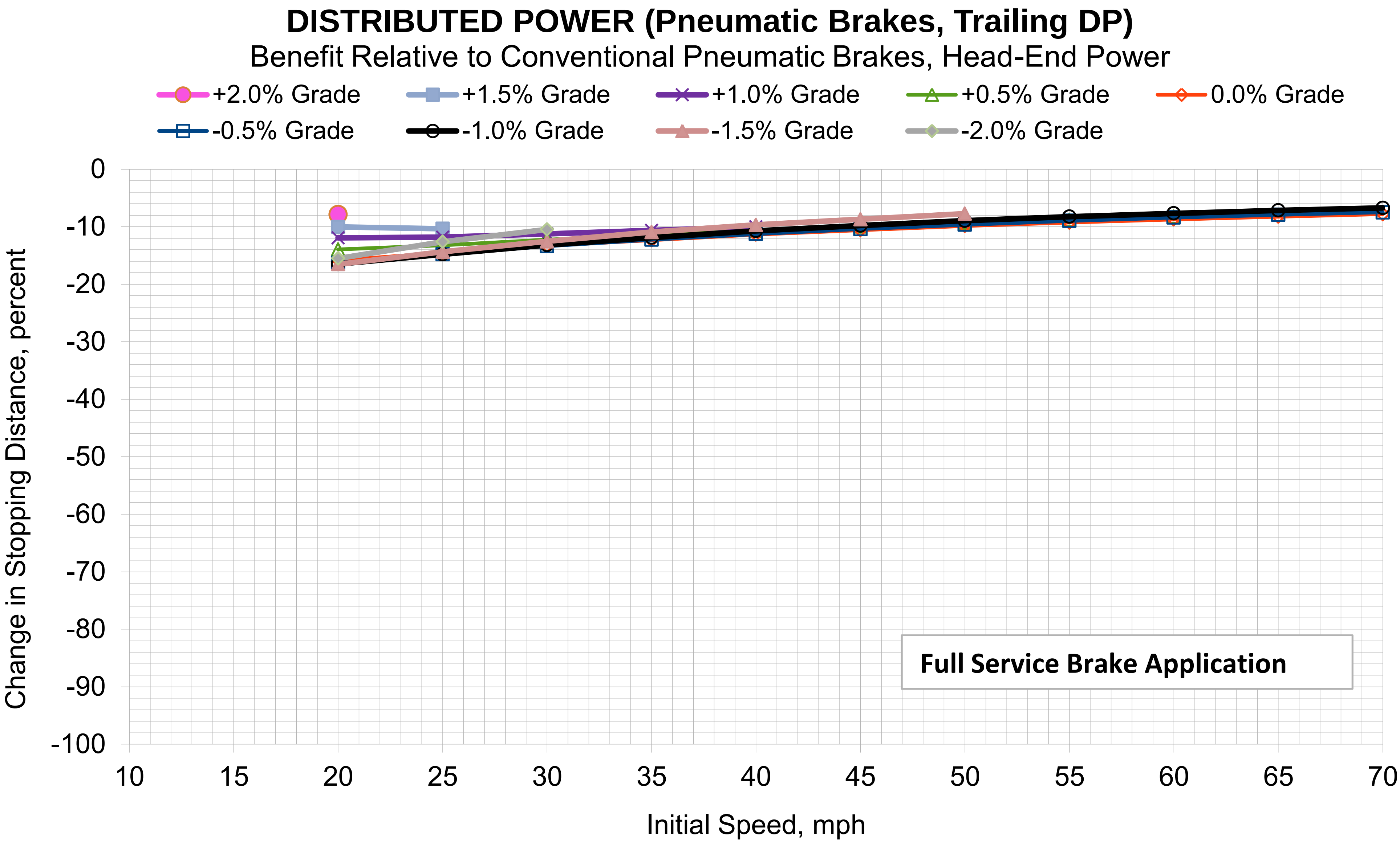
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



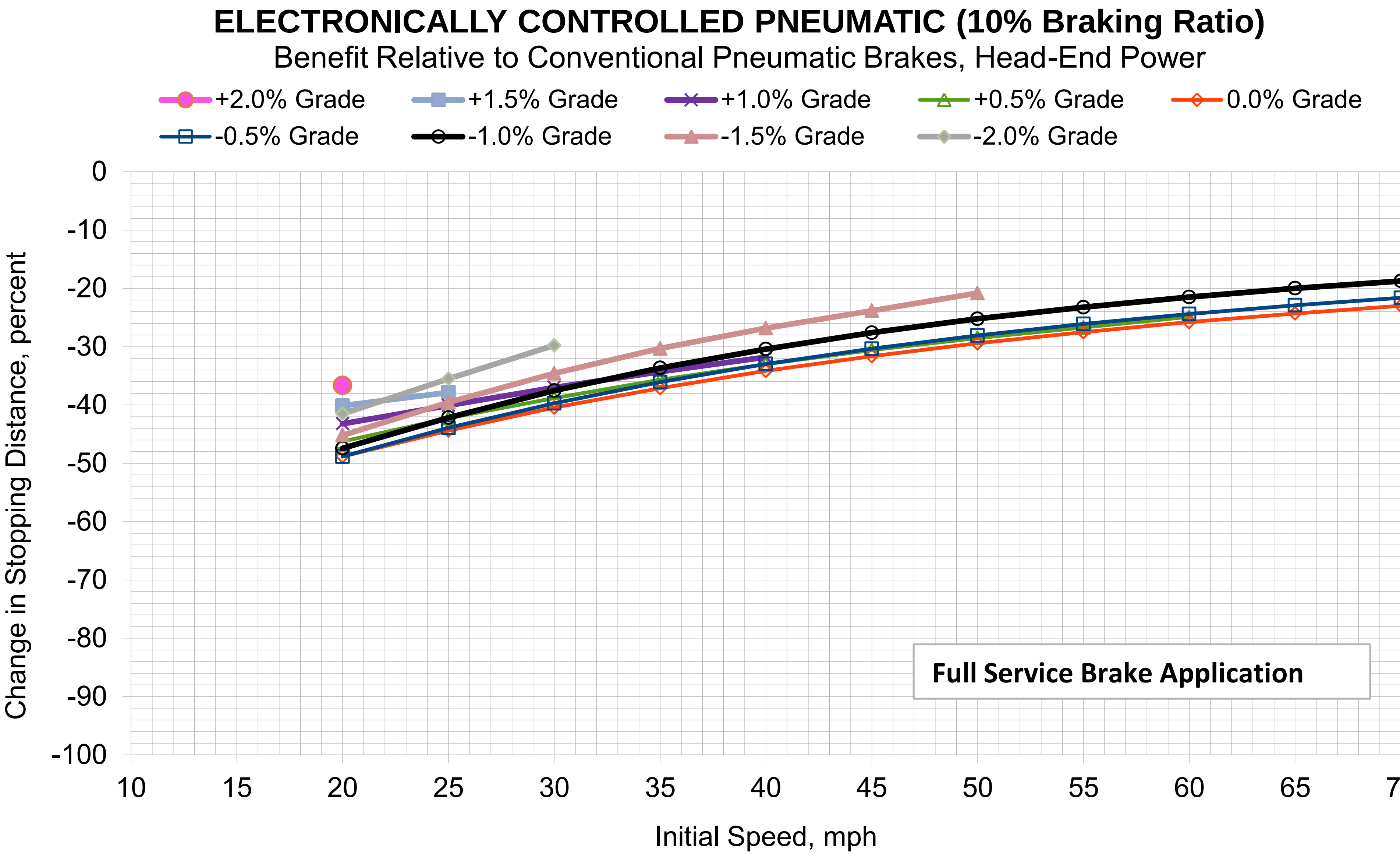
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



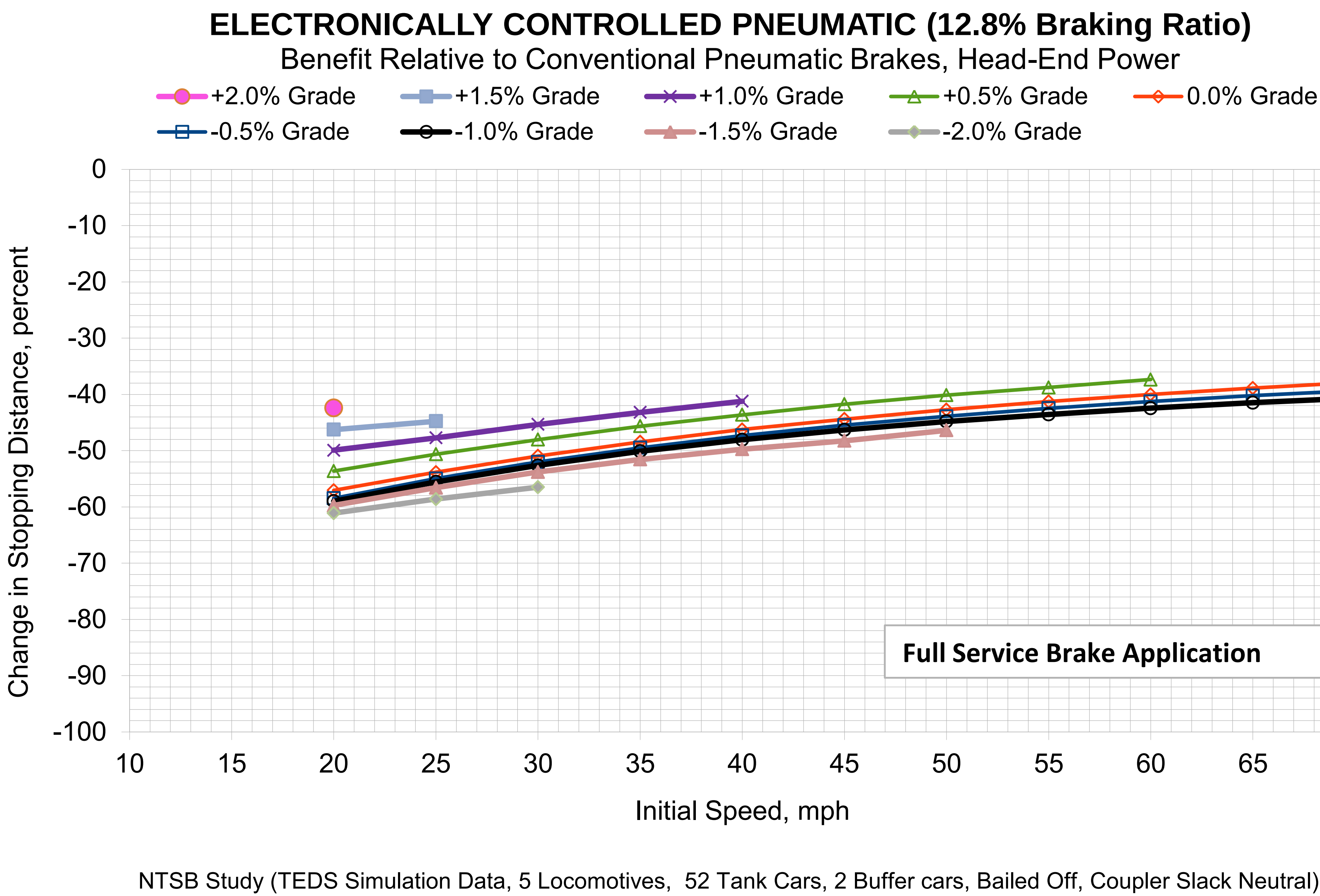
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



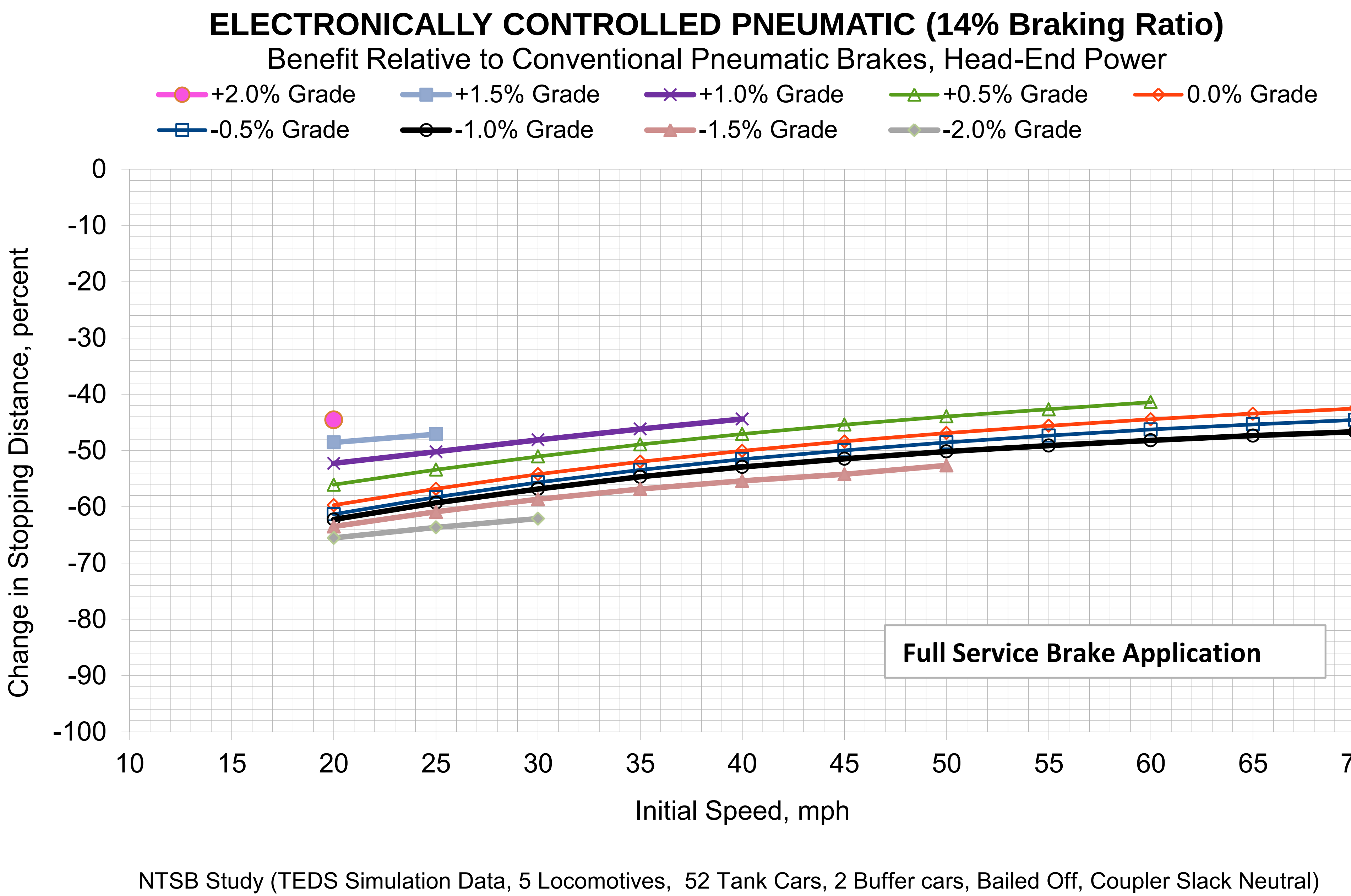
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

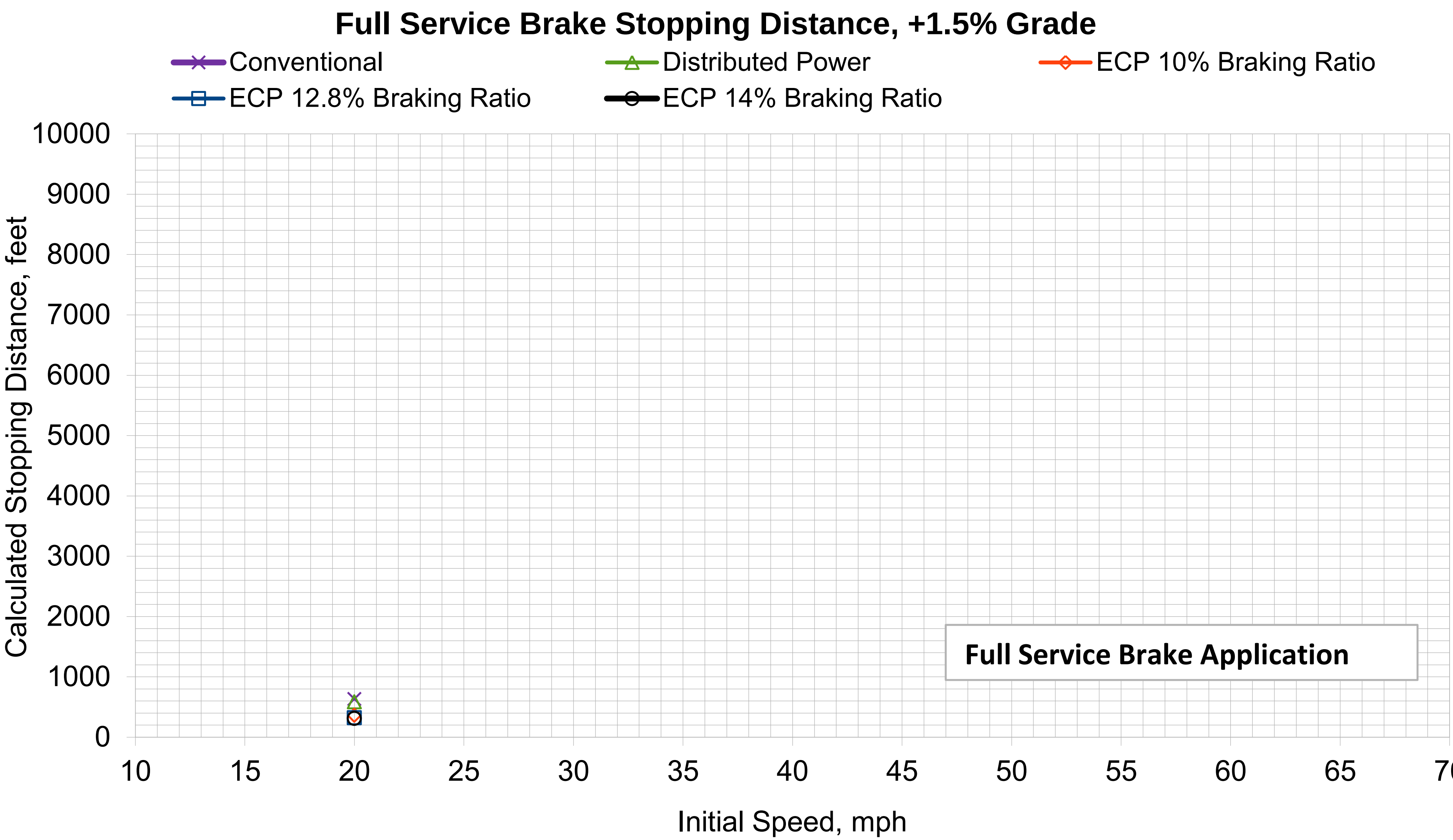


ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

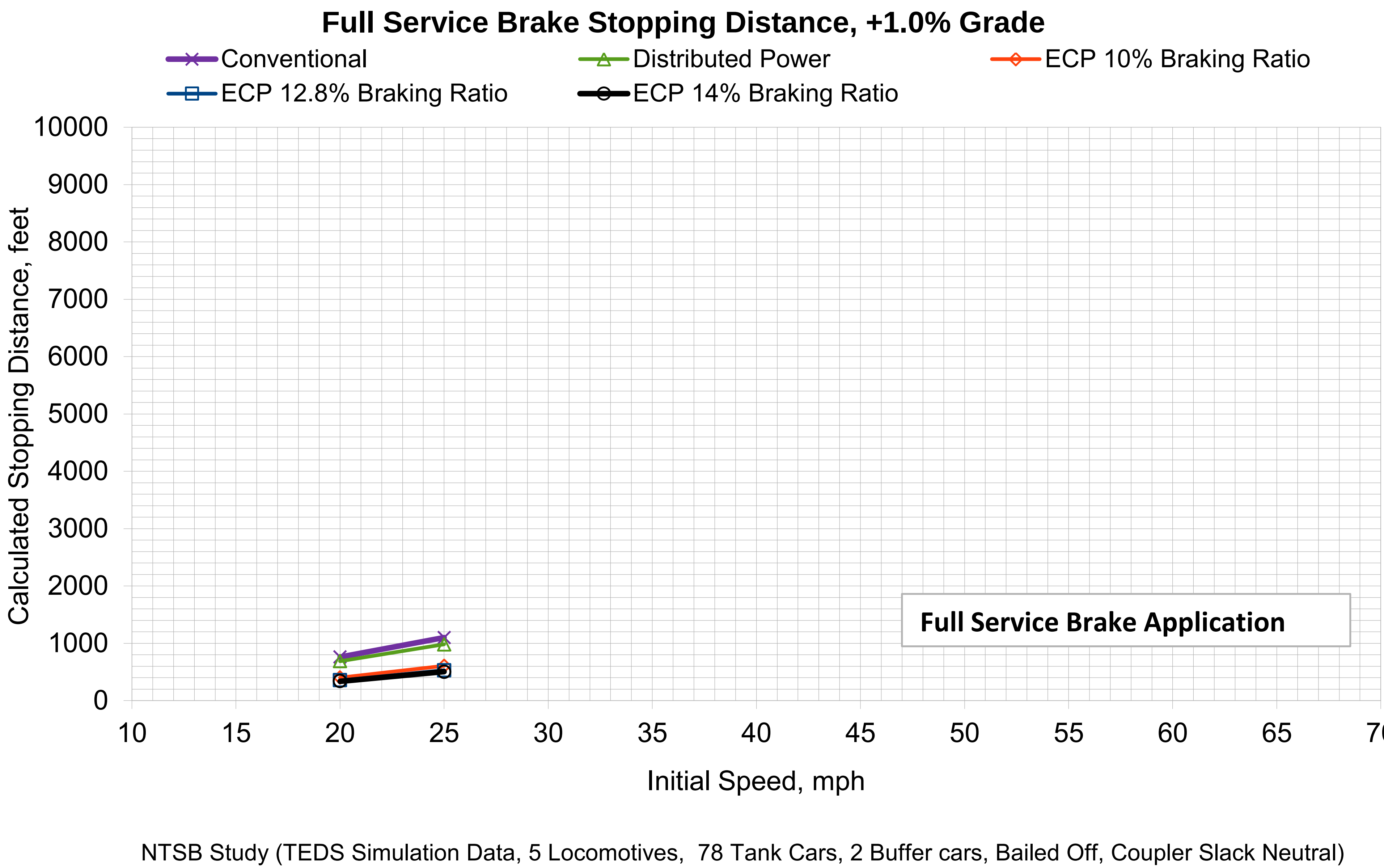

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

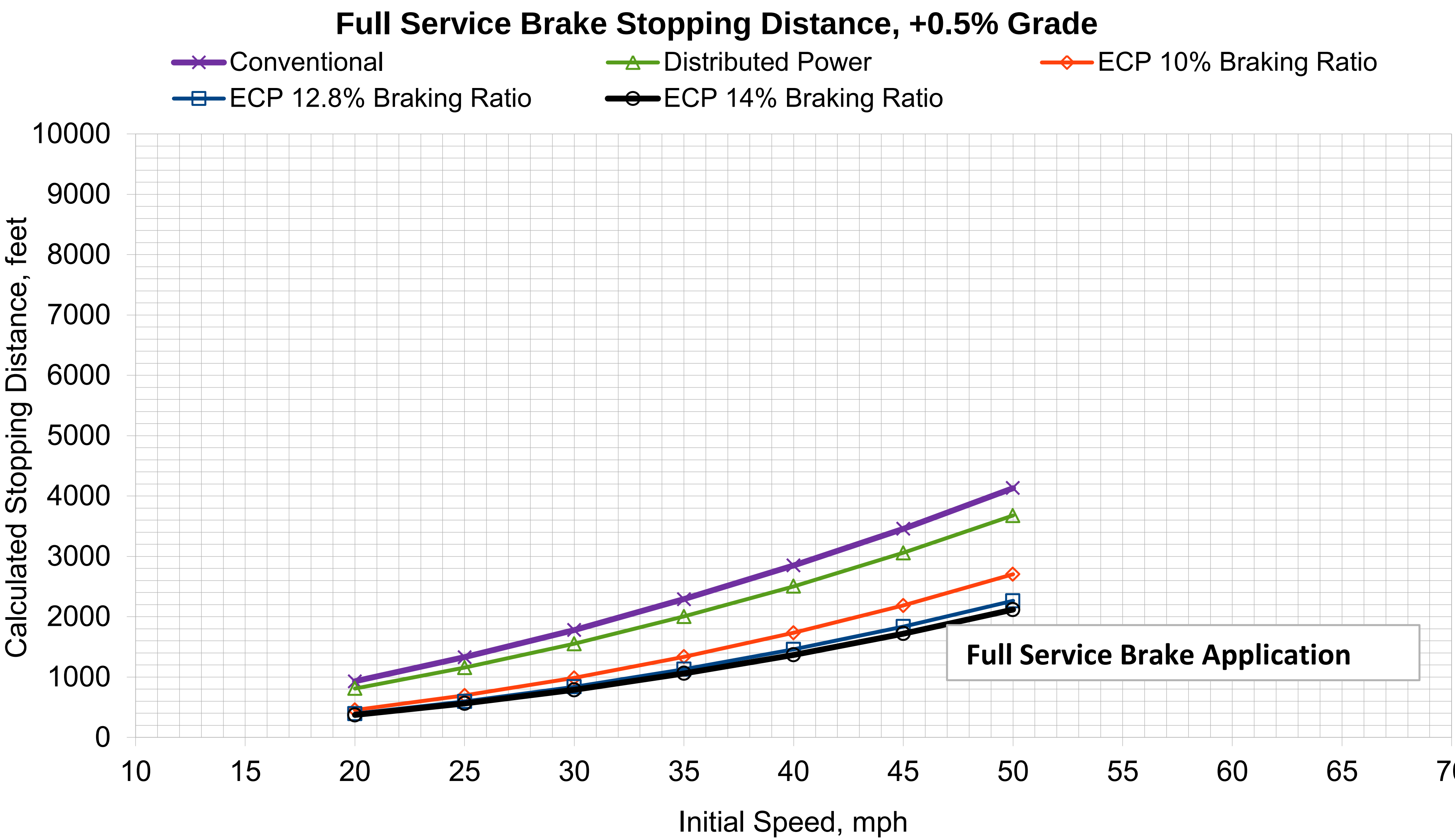
A17.28

Attachment 18: Full Service Braking, Bailed Off, 78 Tank Cars

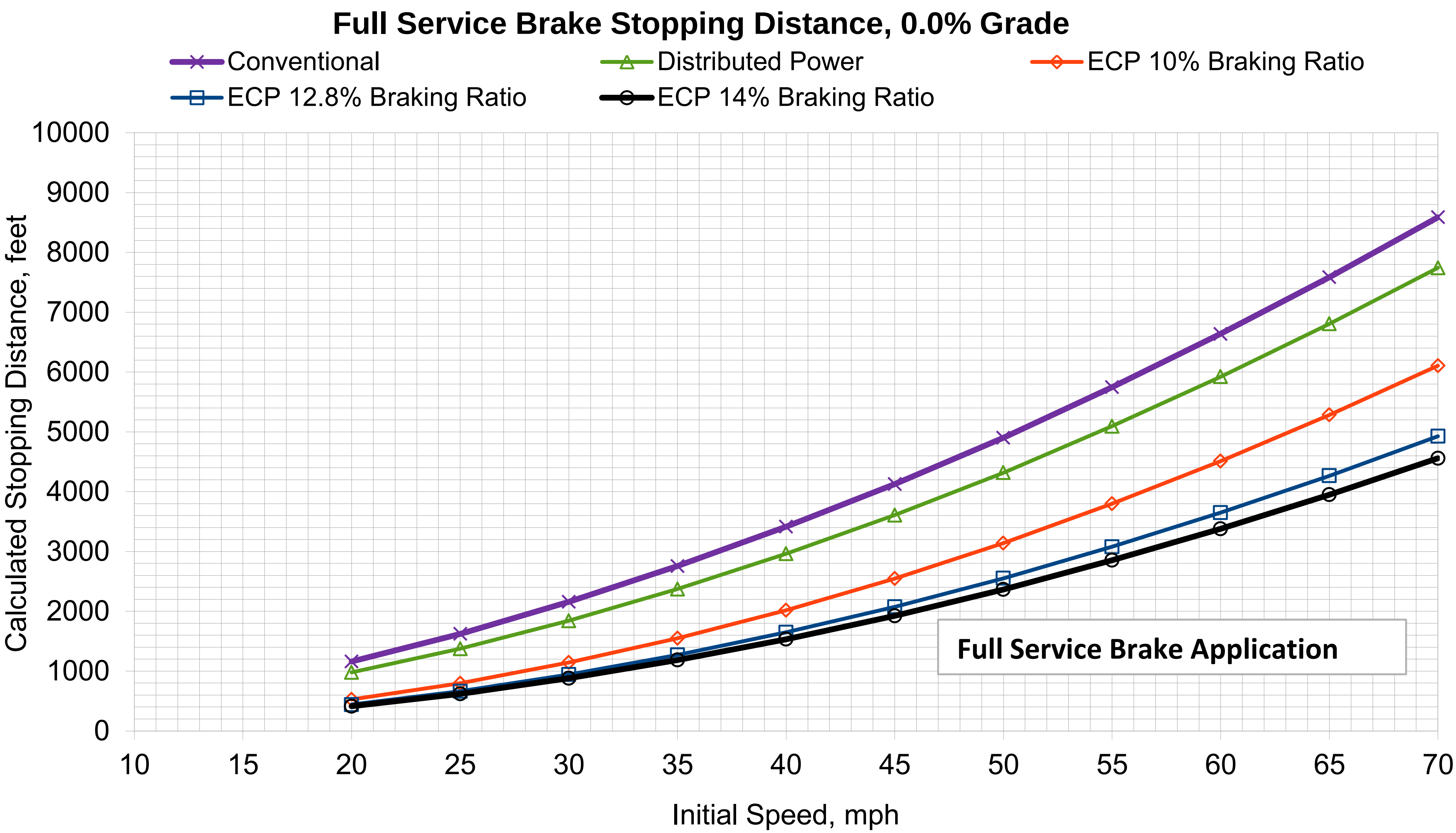


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

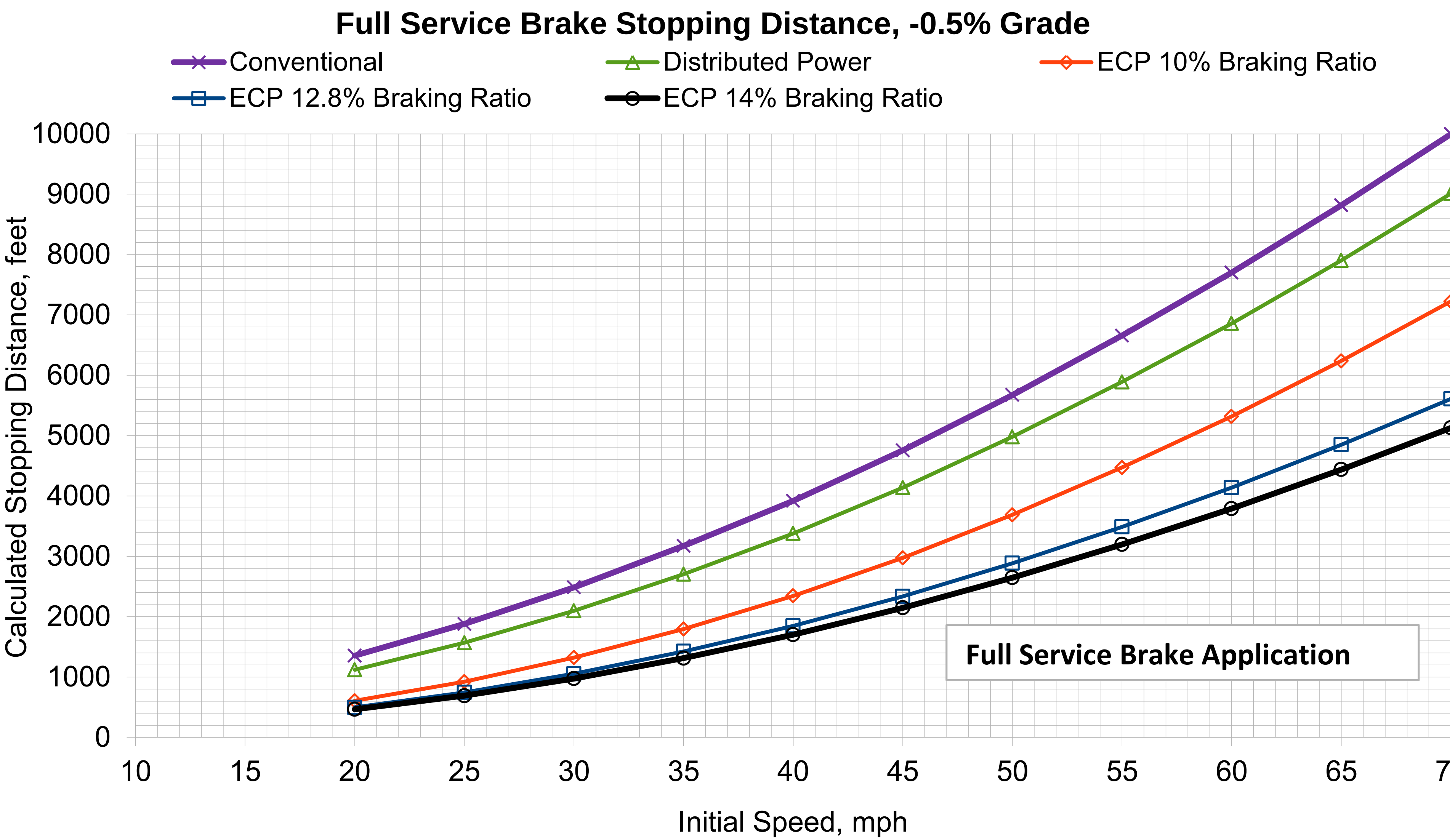

Full Service Brake Stopping Distance, +1.0% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



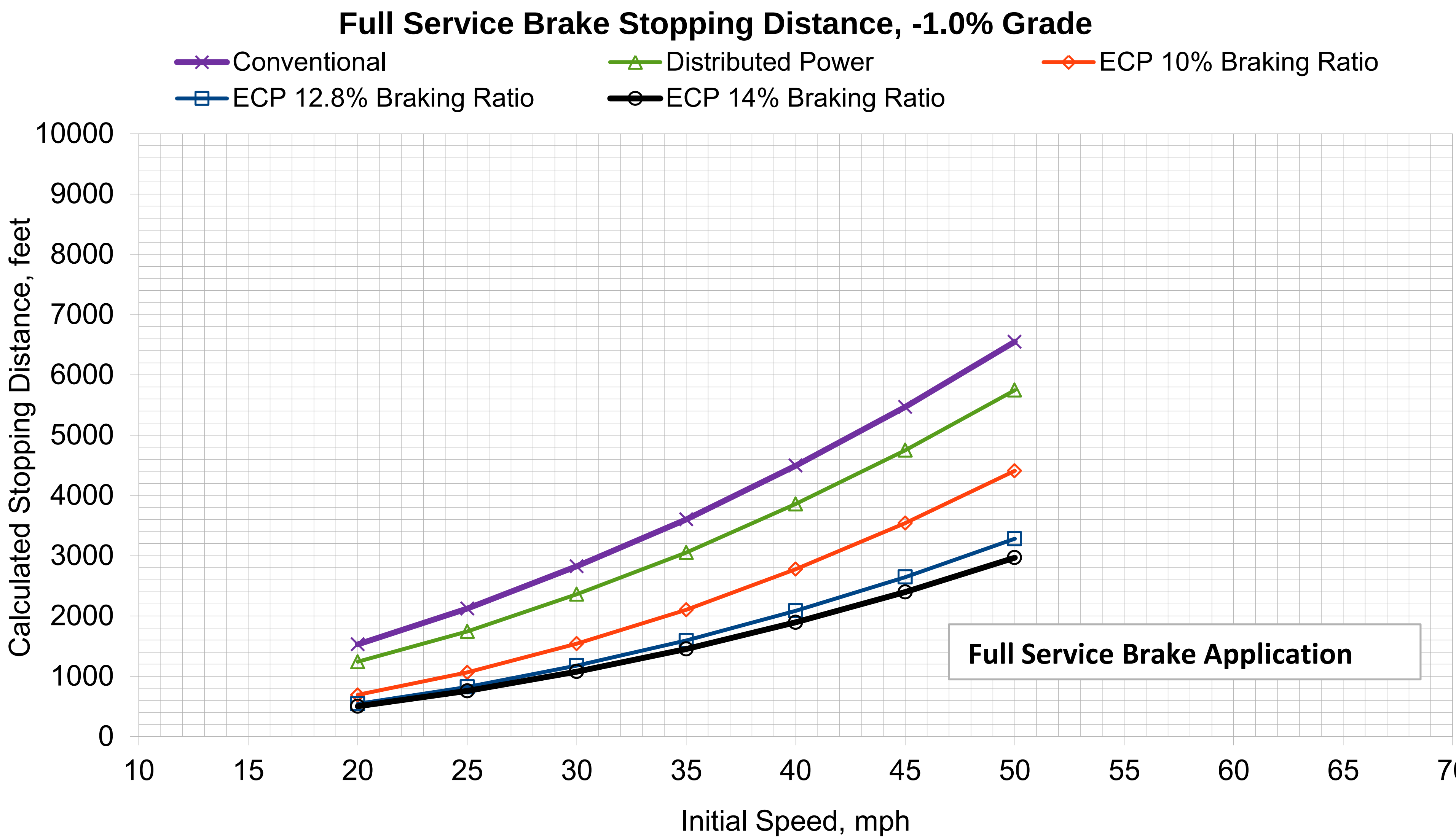
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



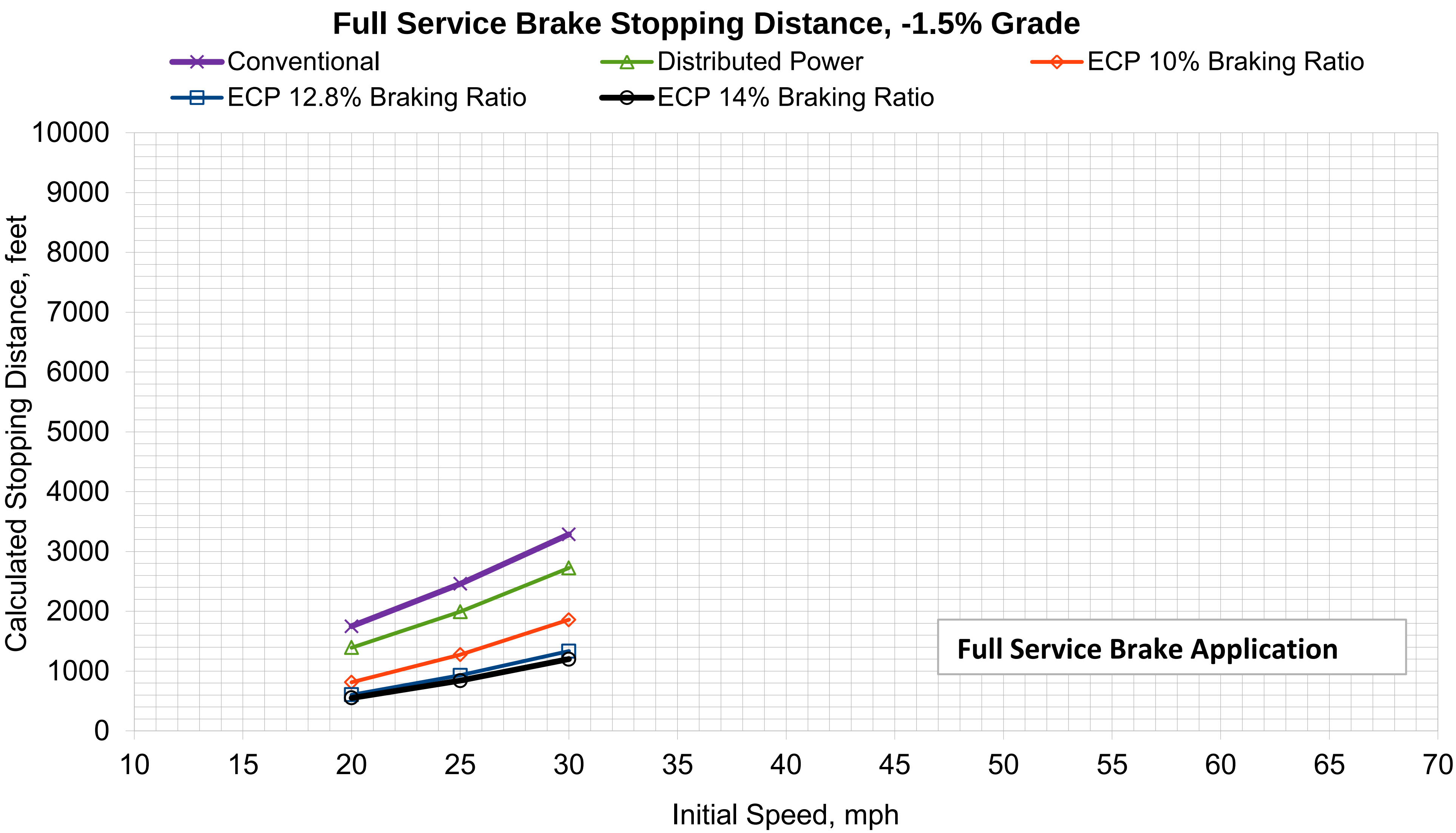
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



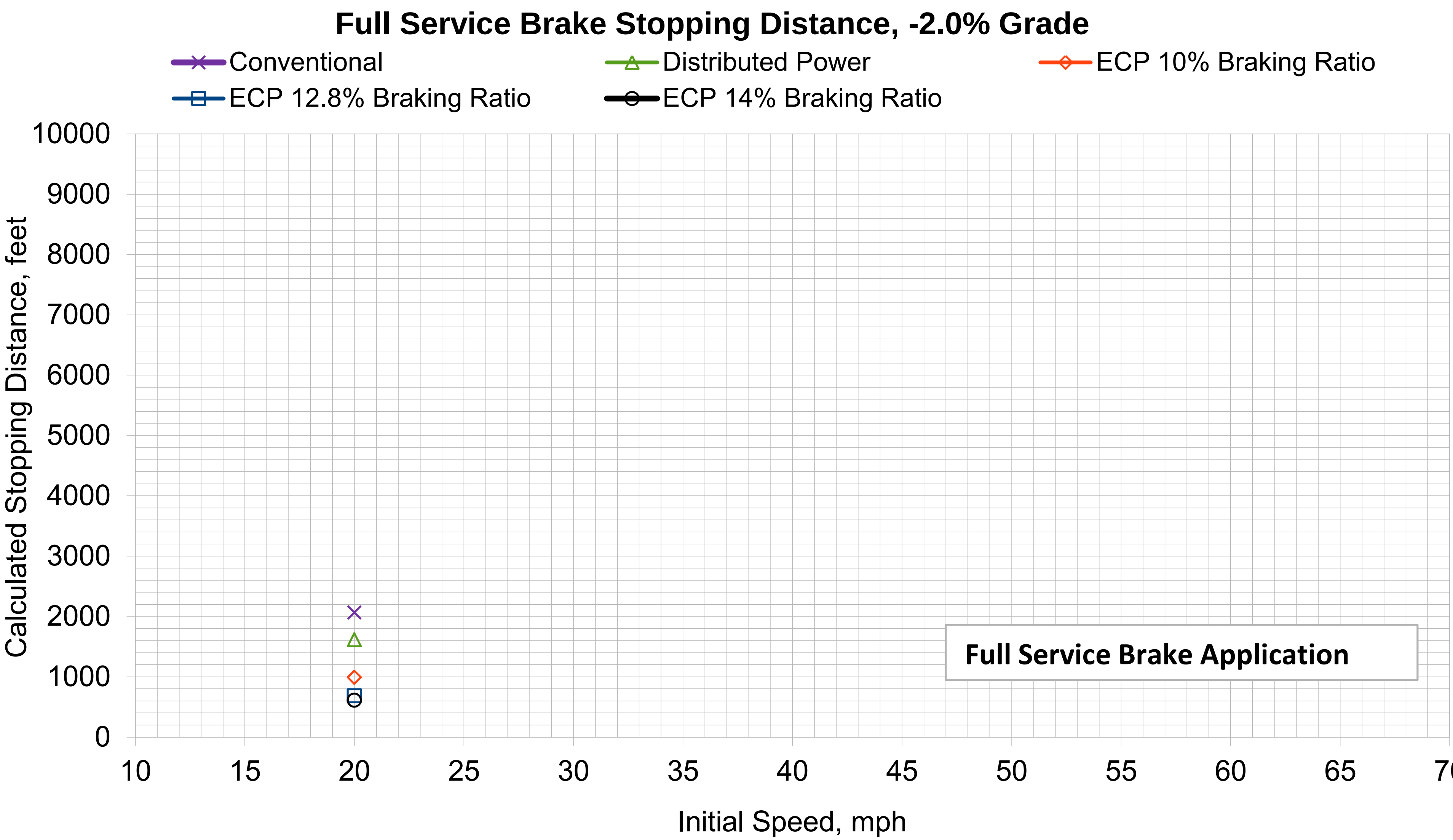
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



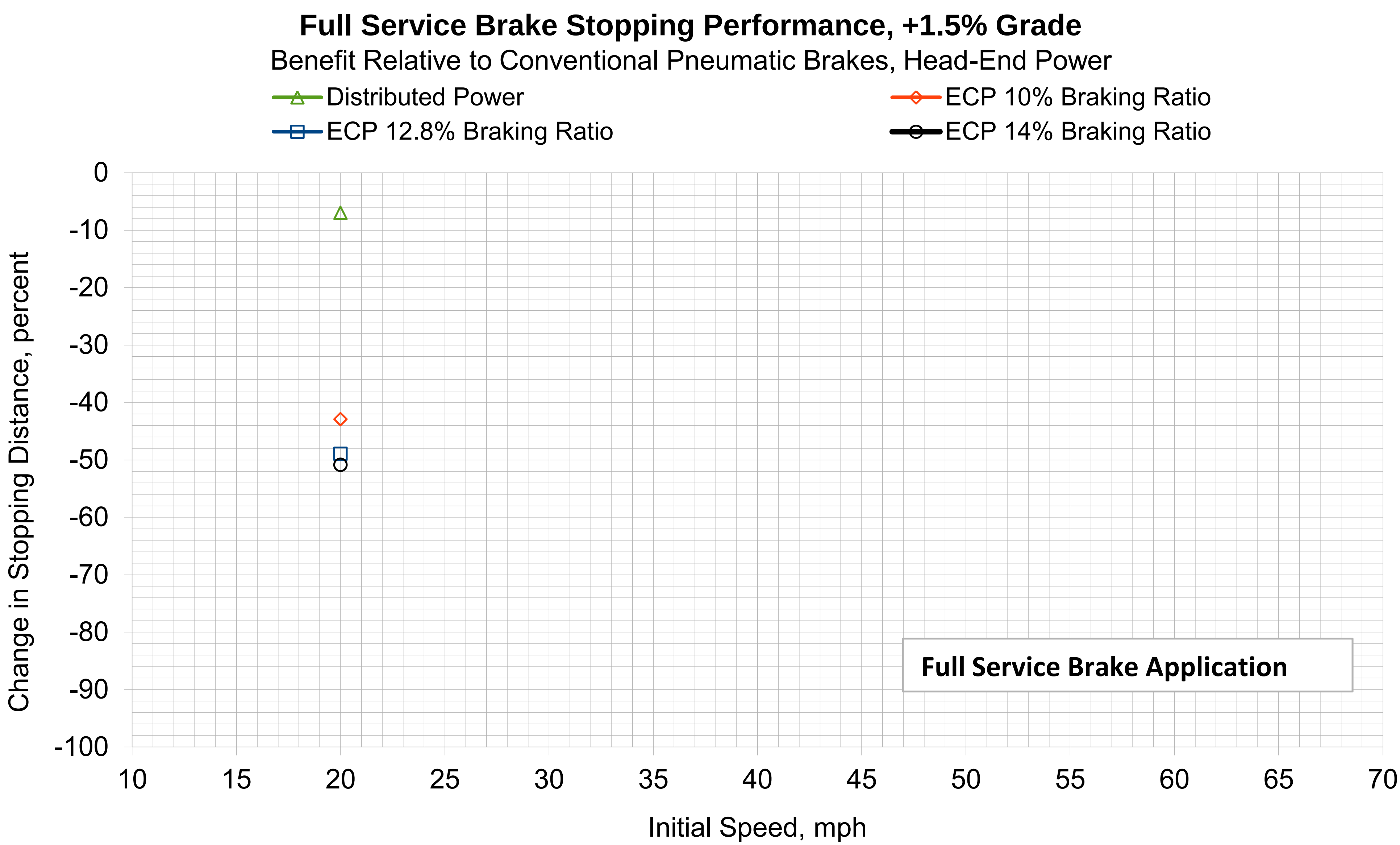
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



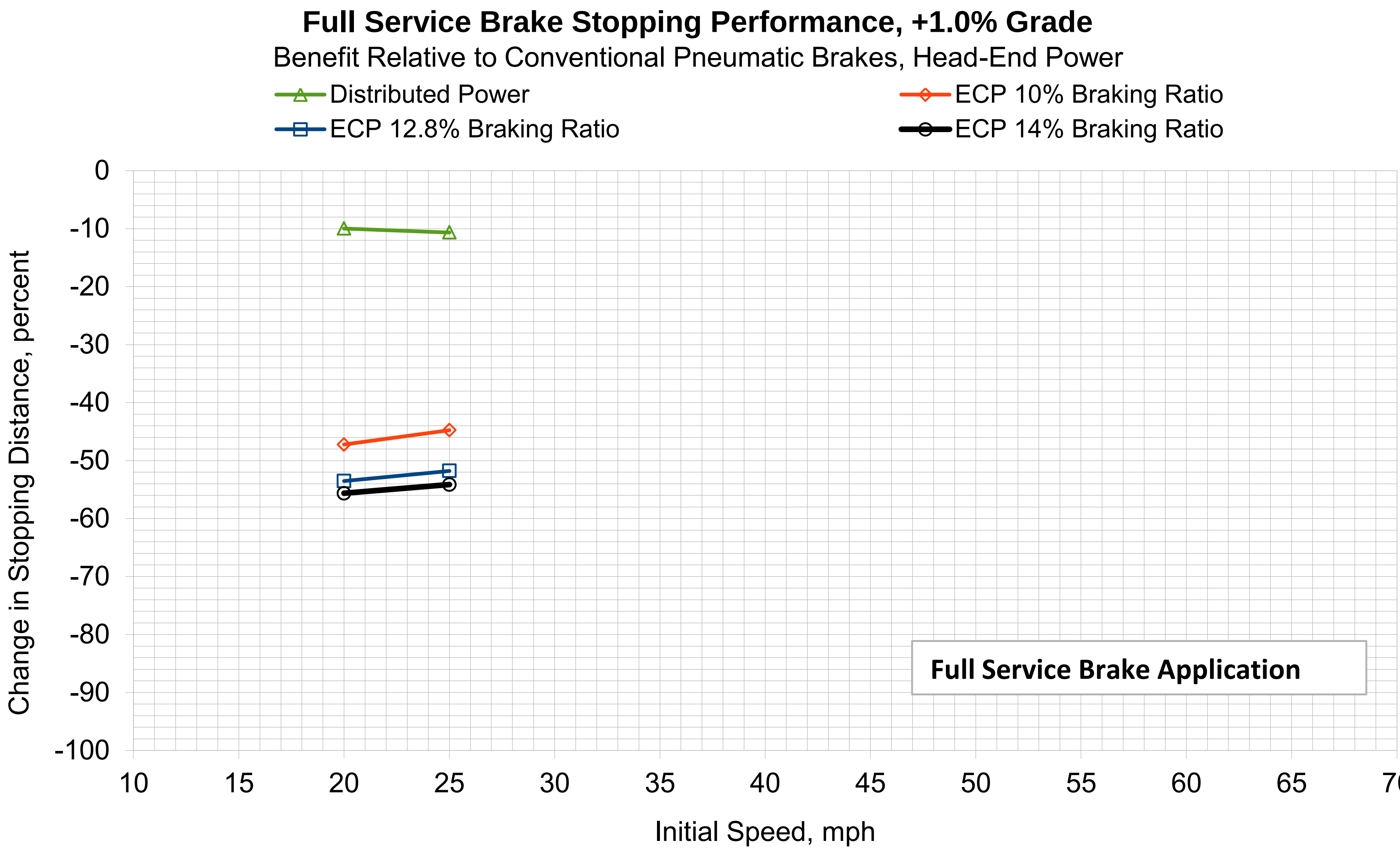
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



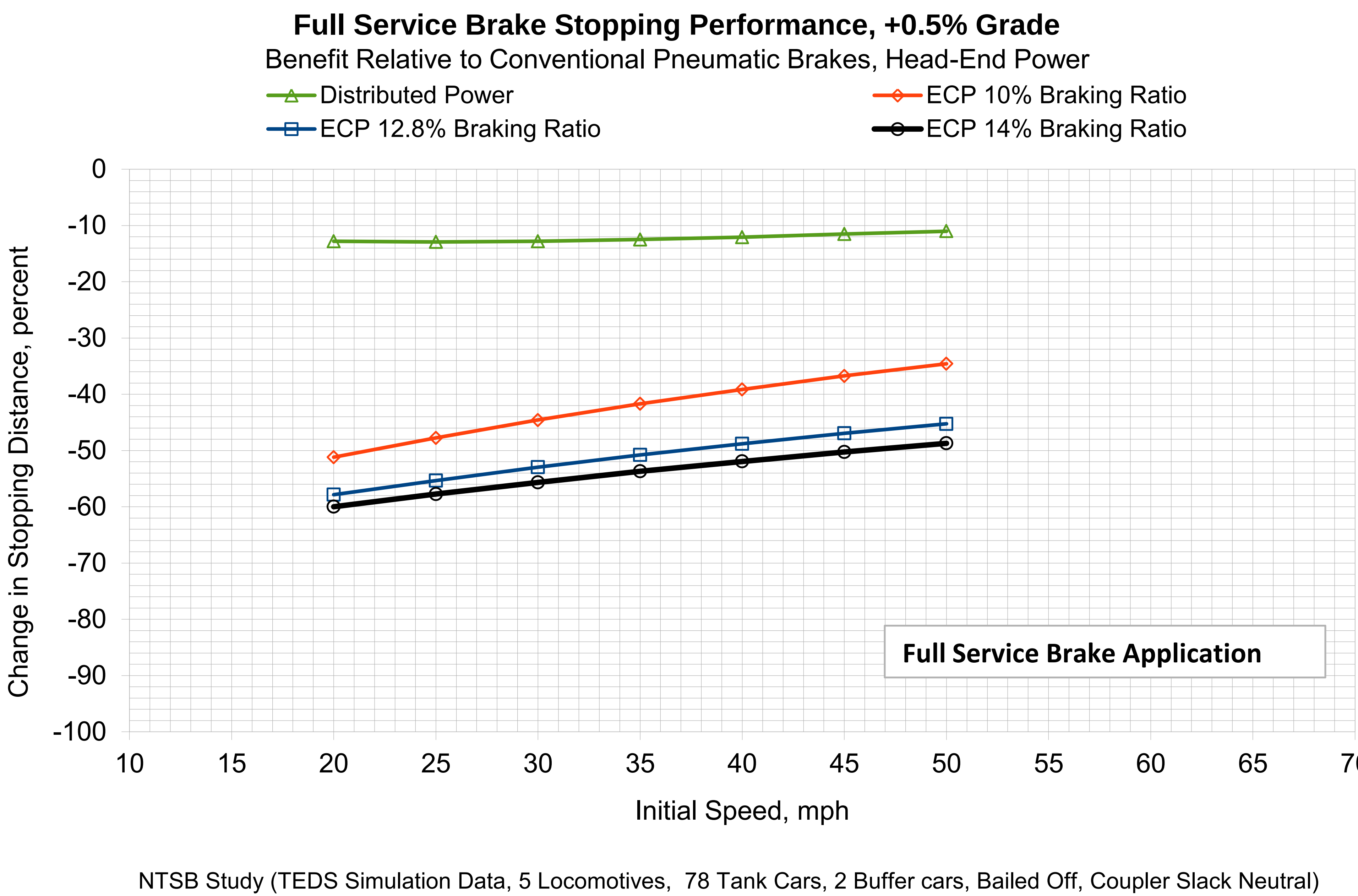
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

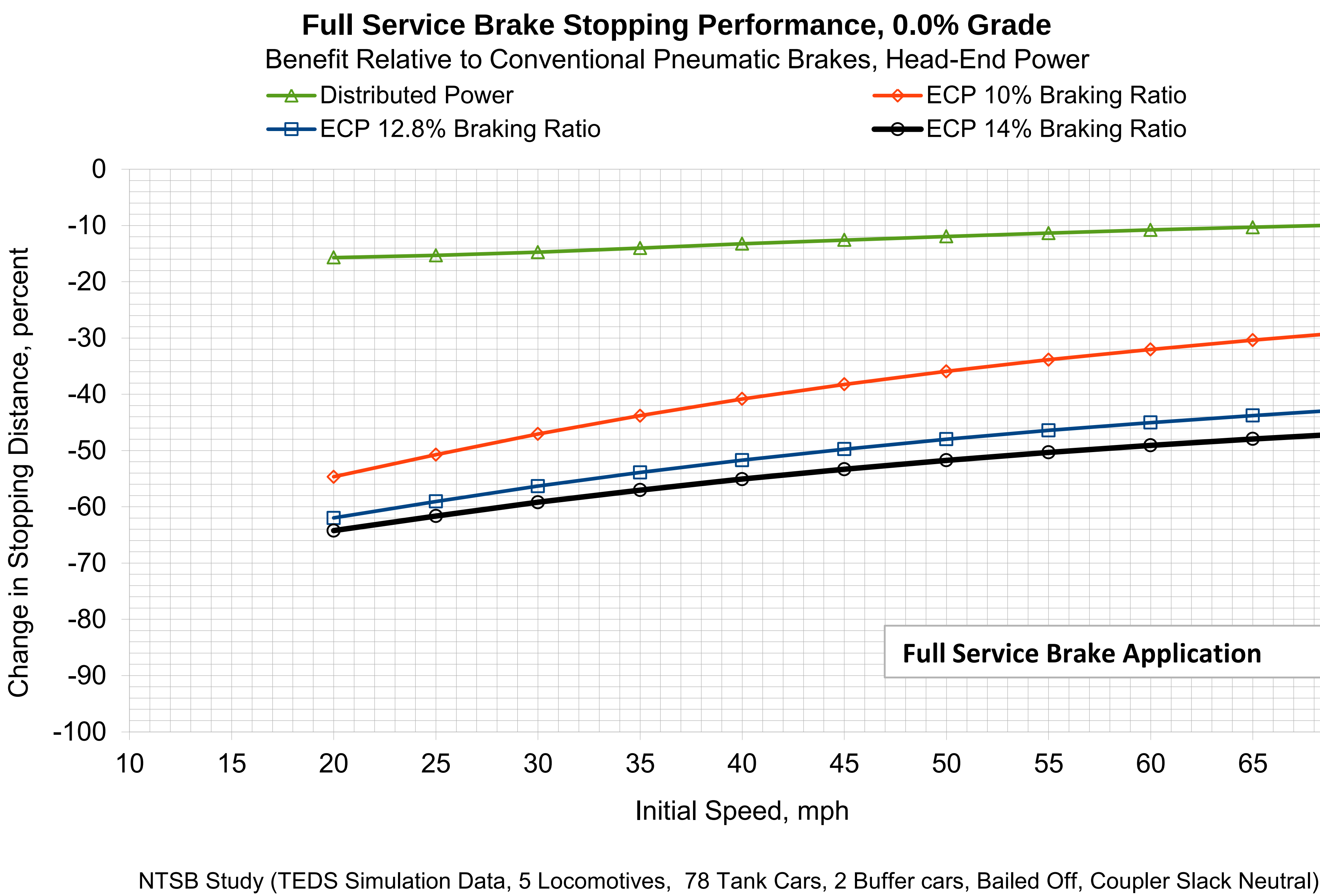


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

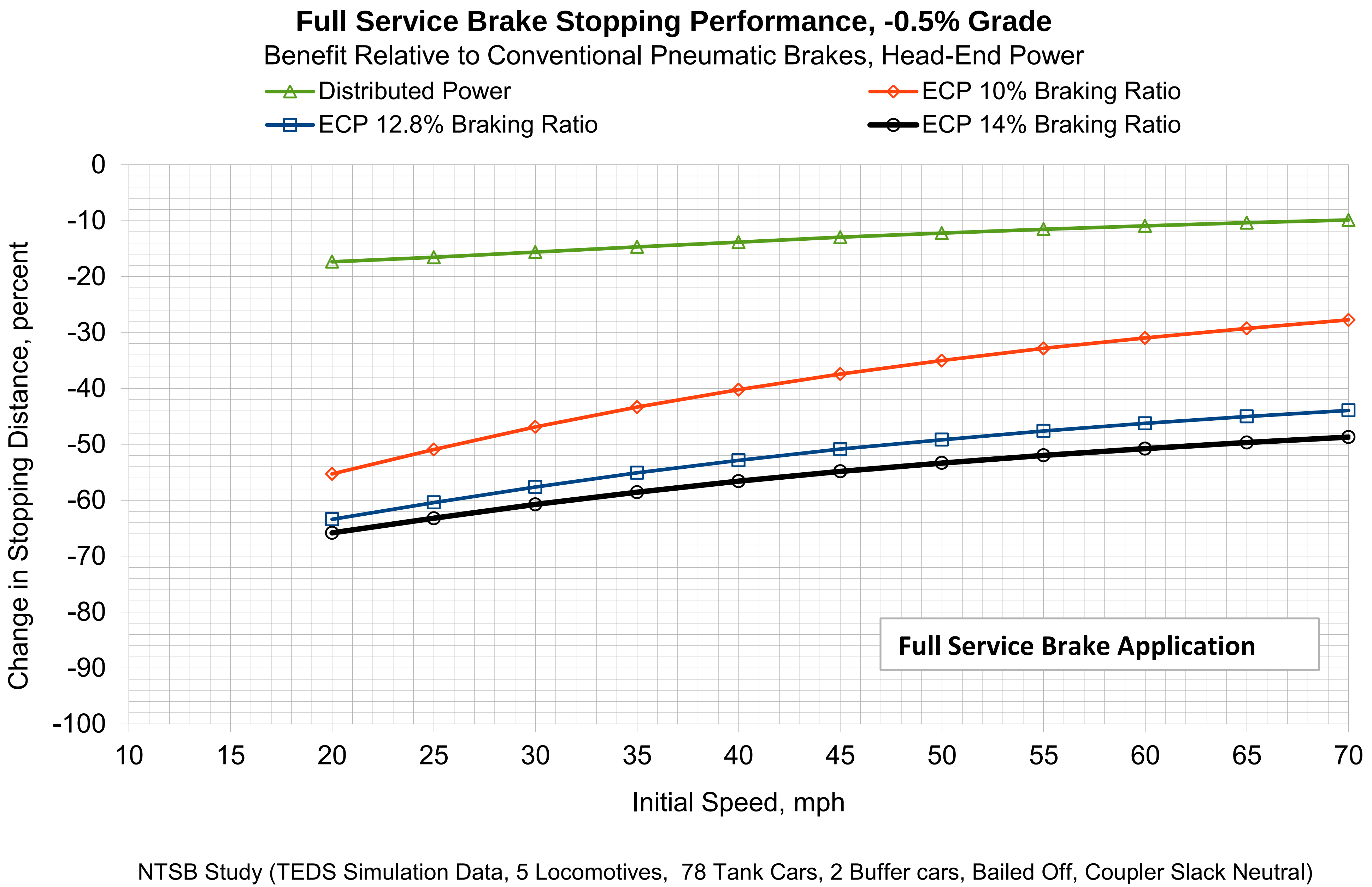


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

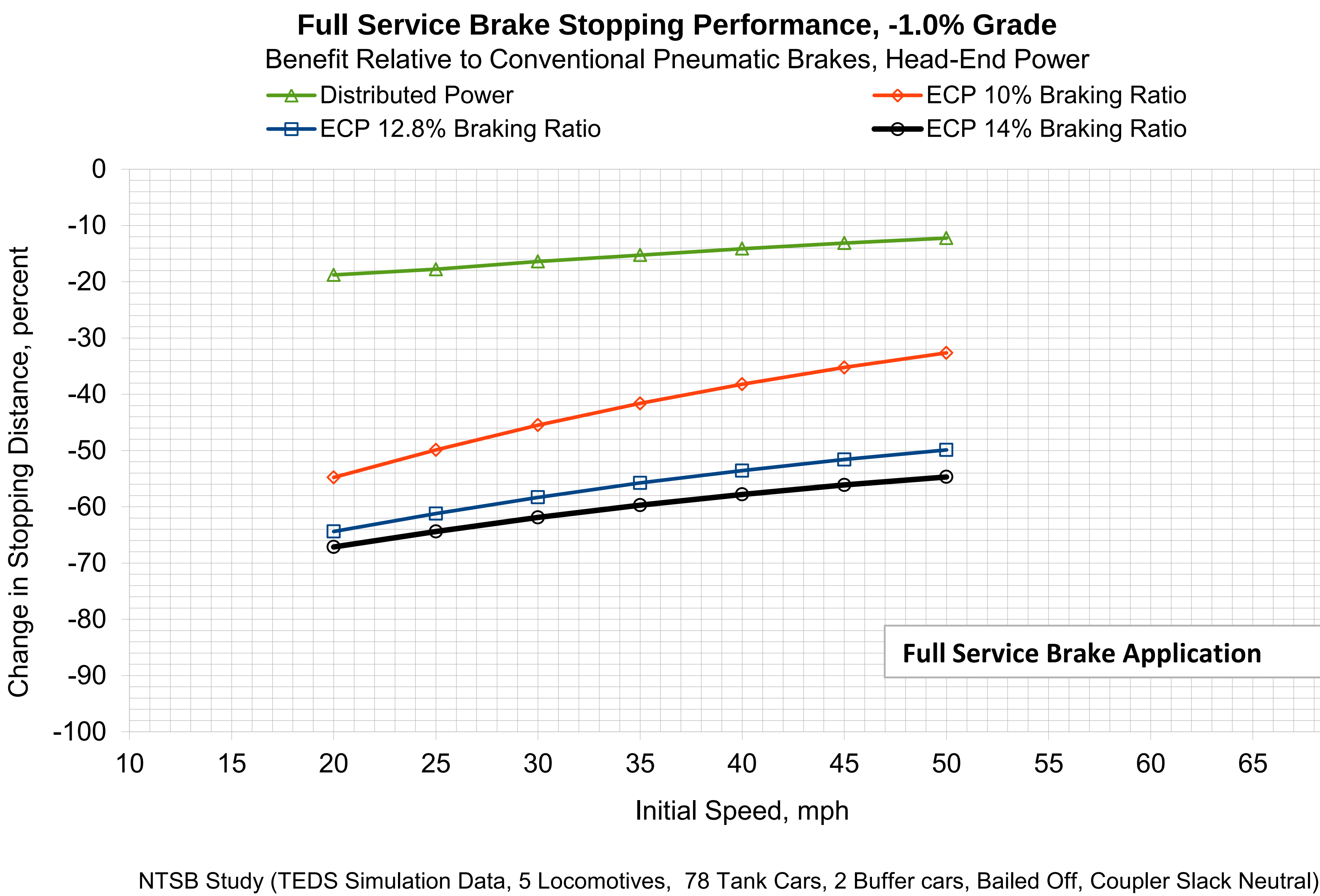

Full Service Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Change in Stopping Distance, percent
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



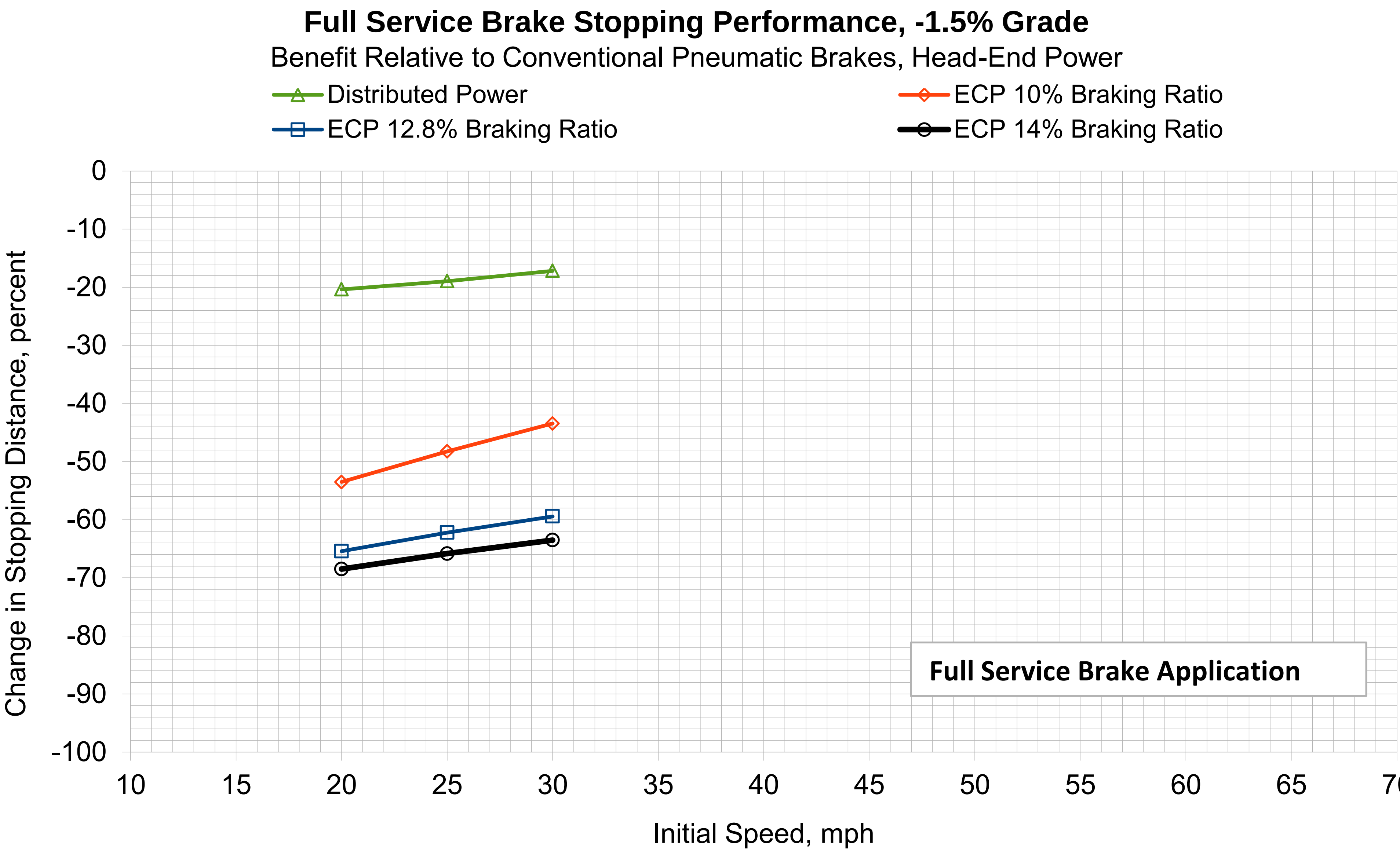
Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



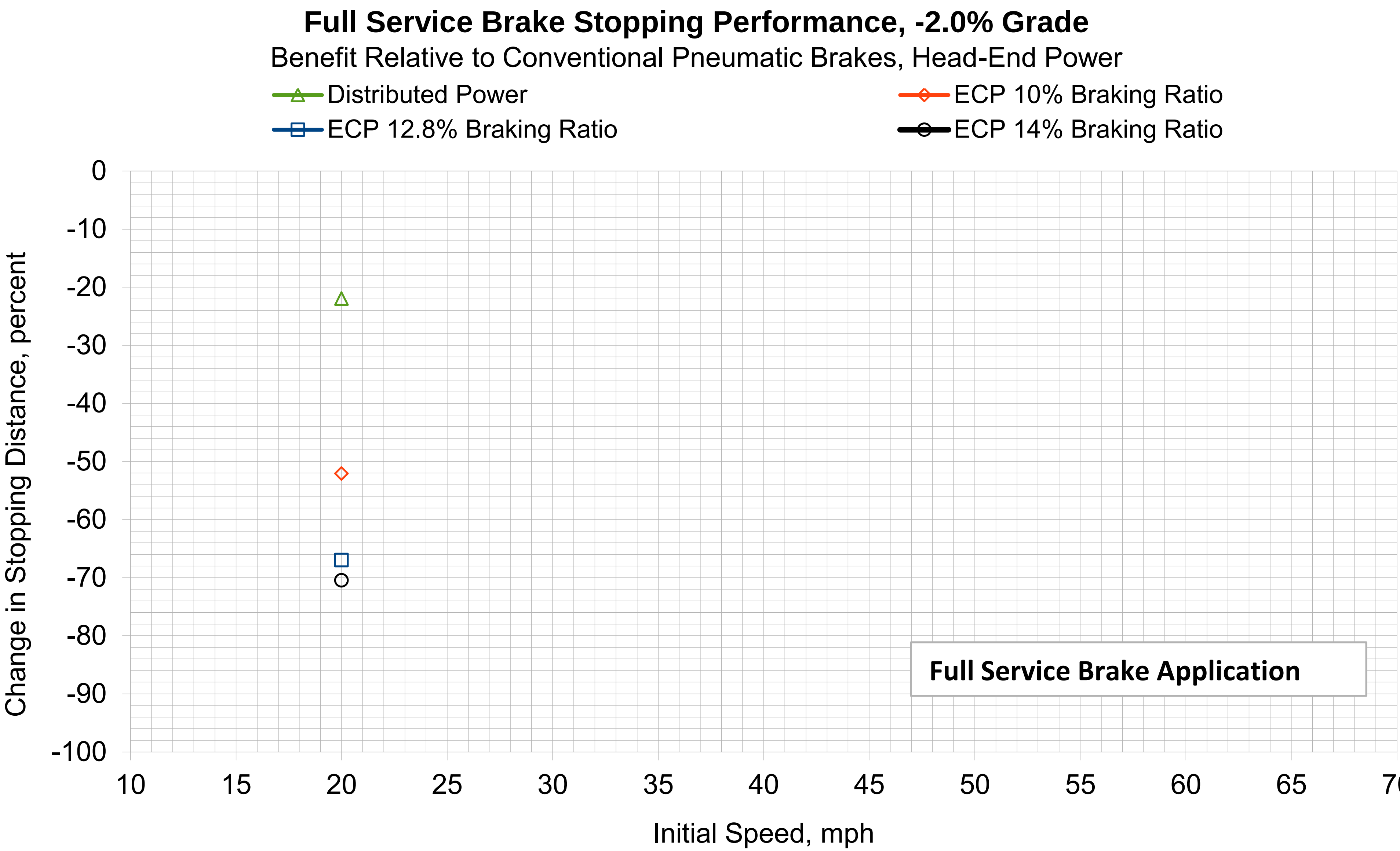
Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



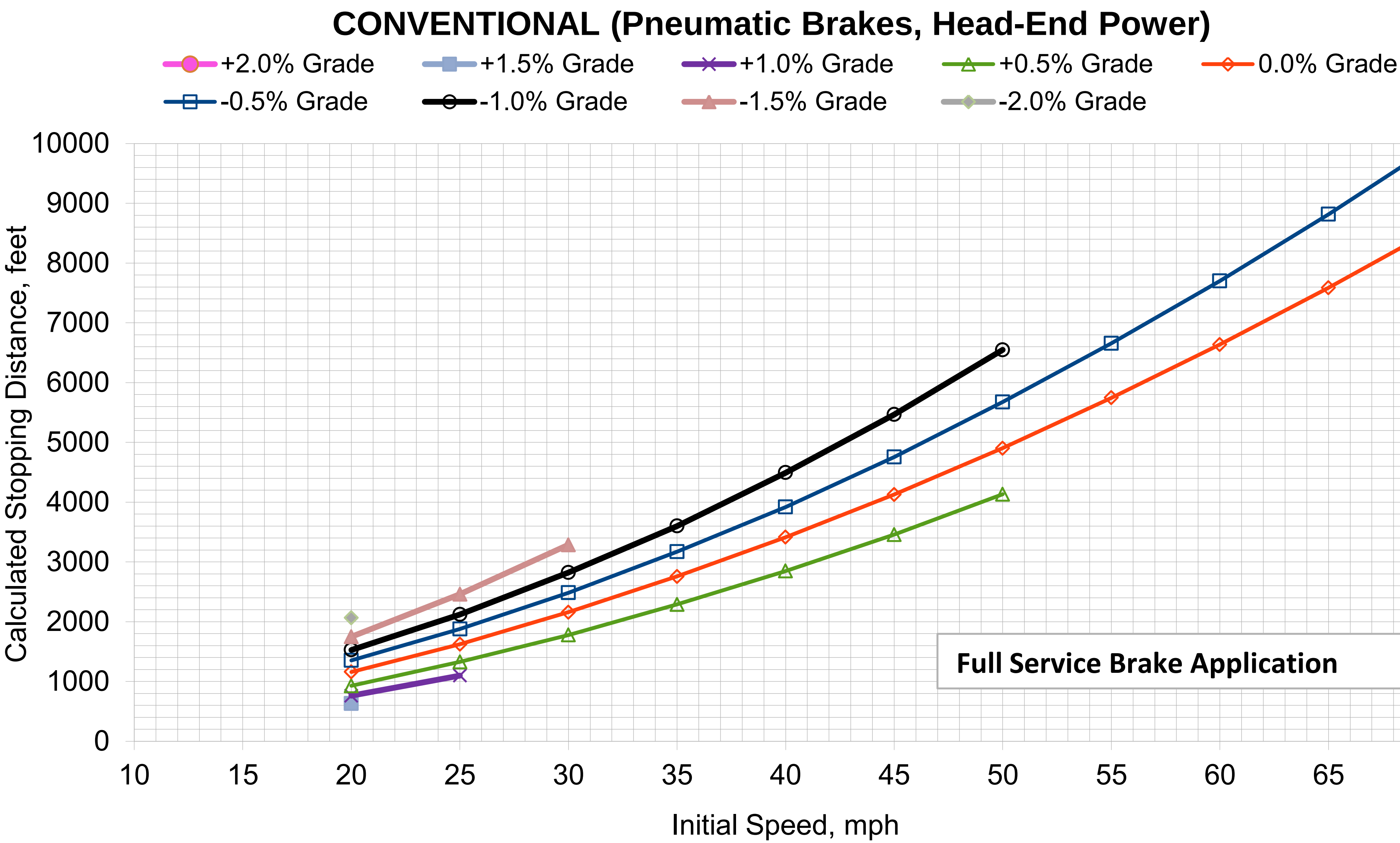
Full Service Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



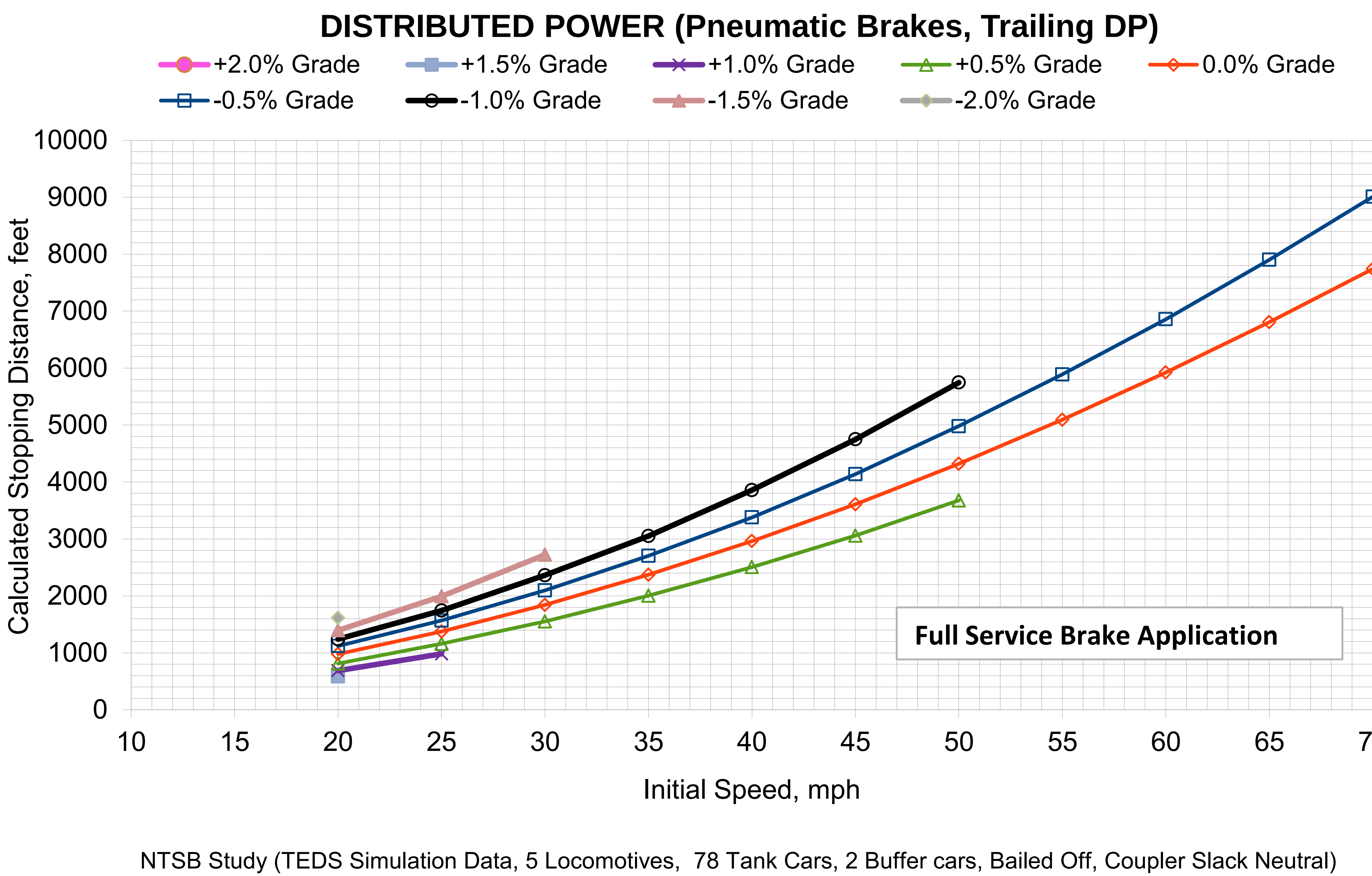
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

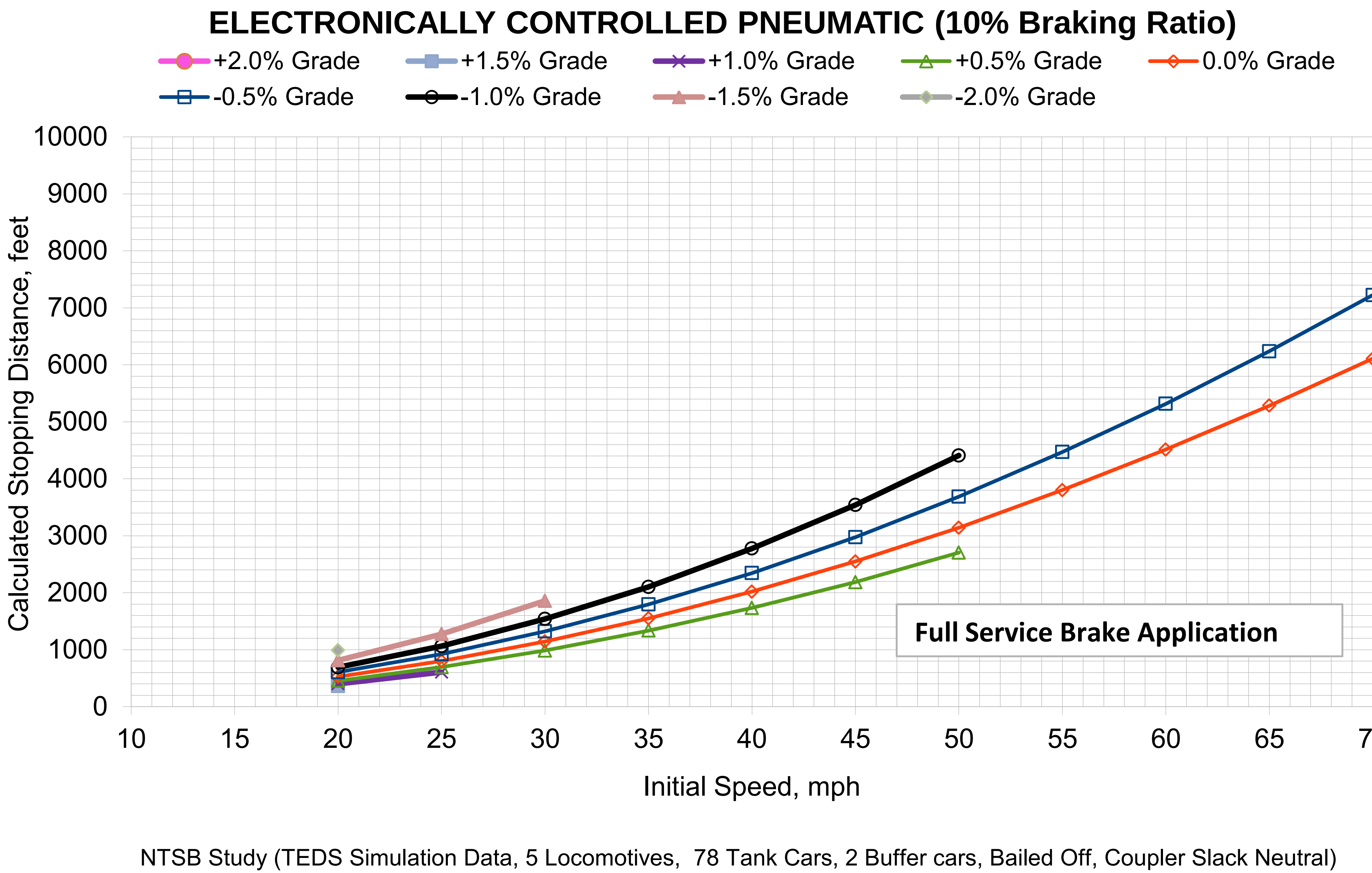


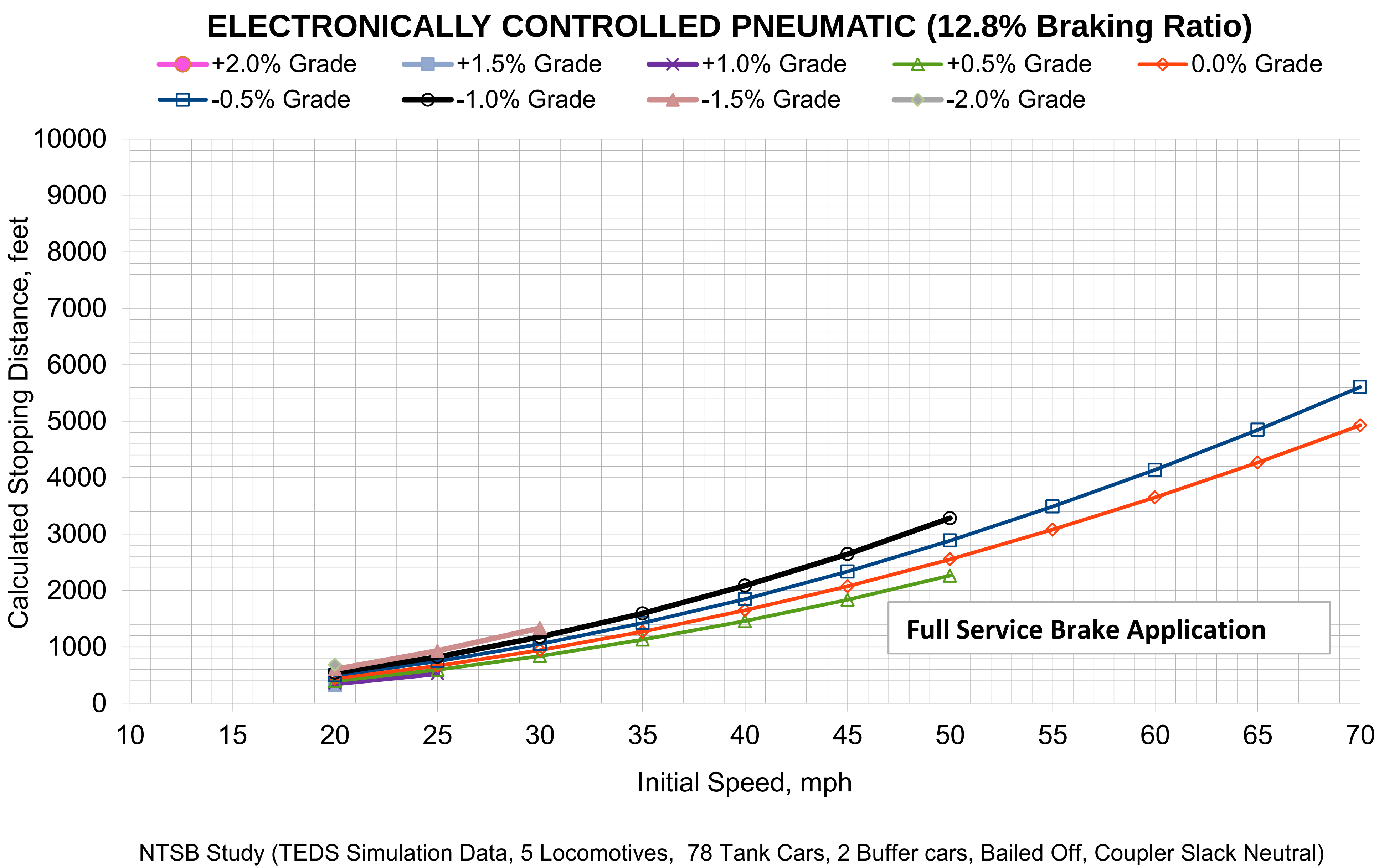
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



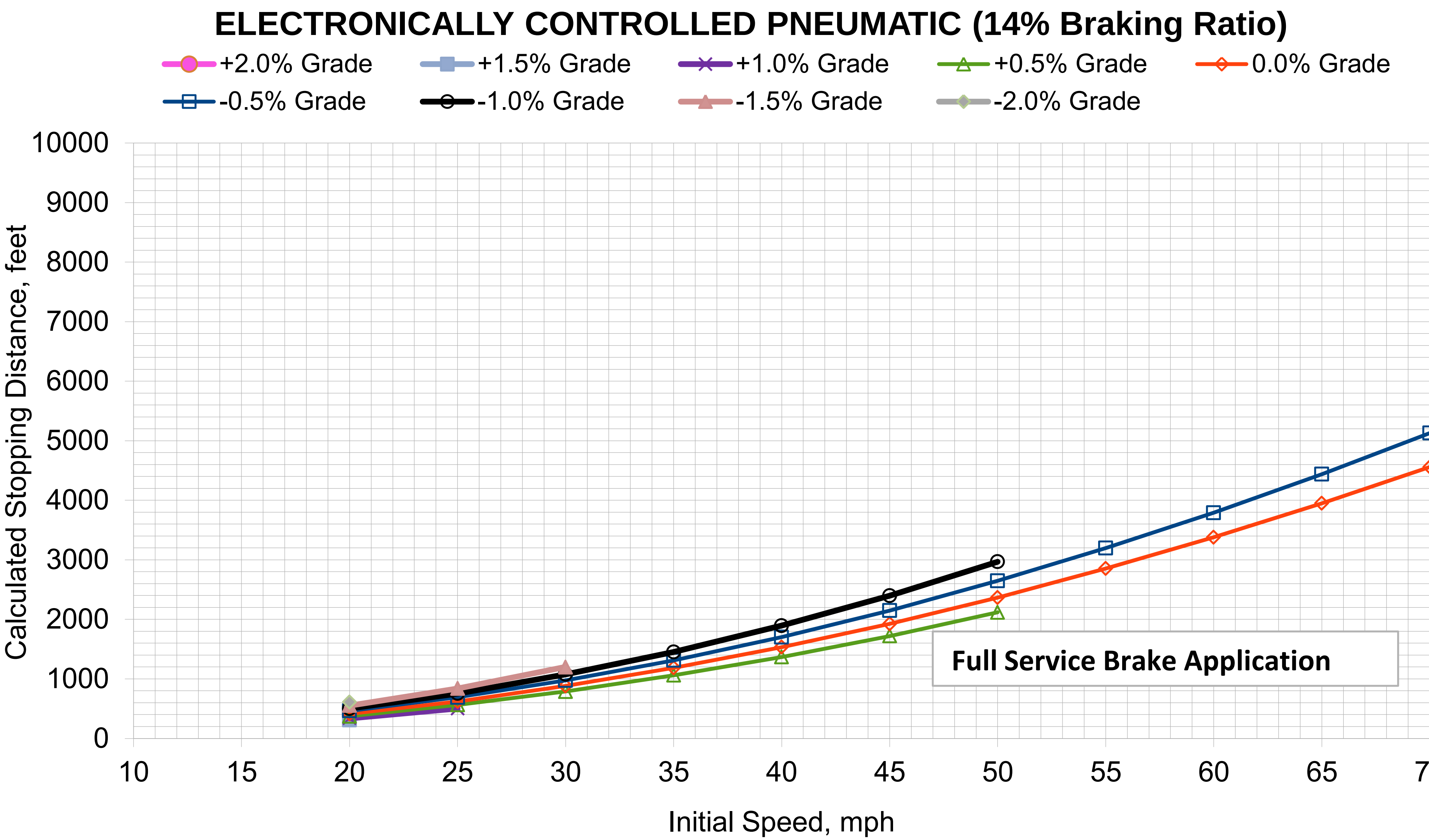
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

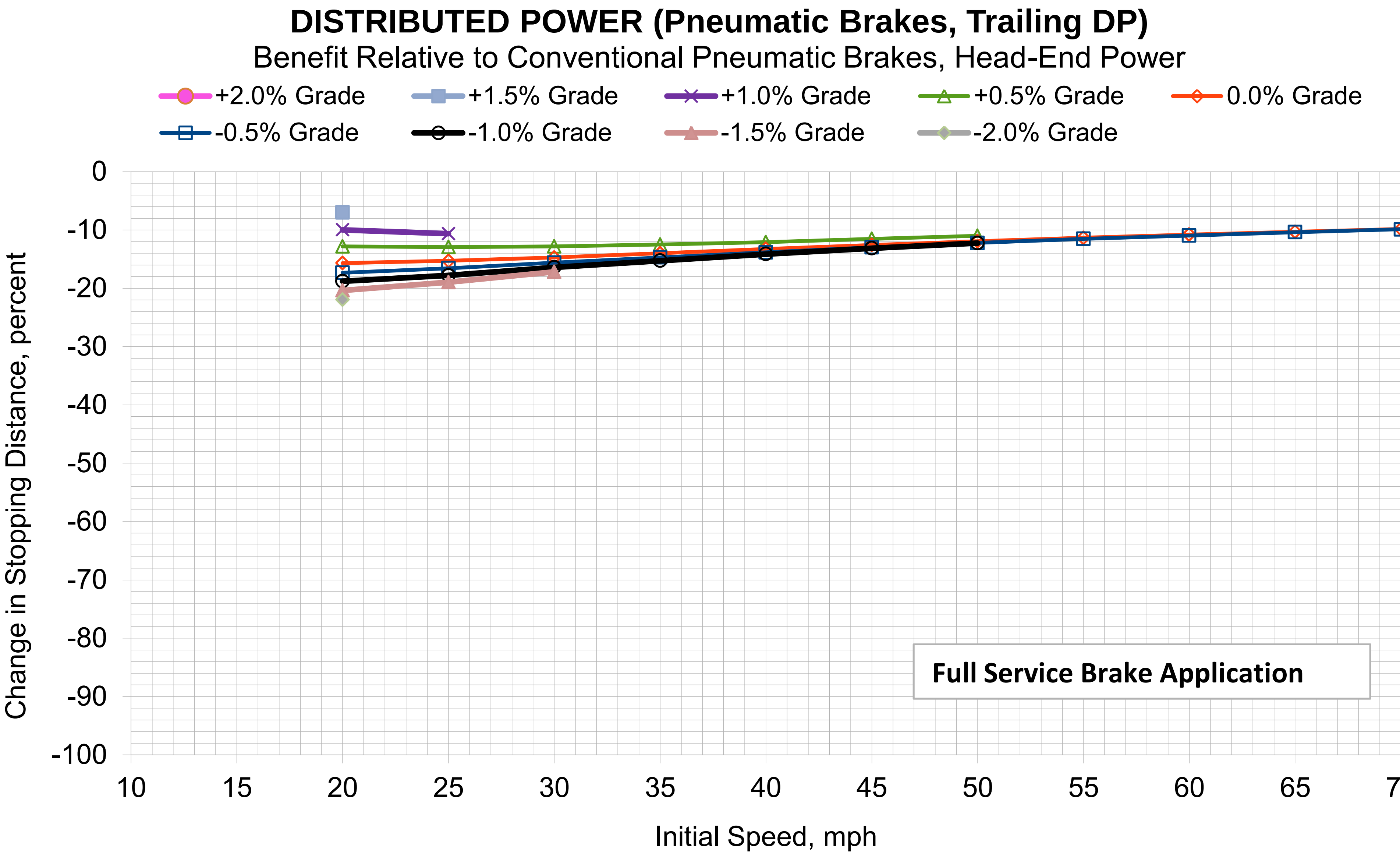

ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



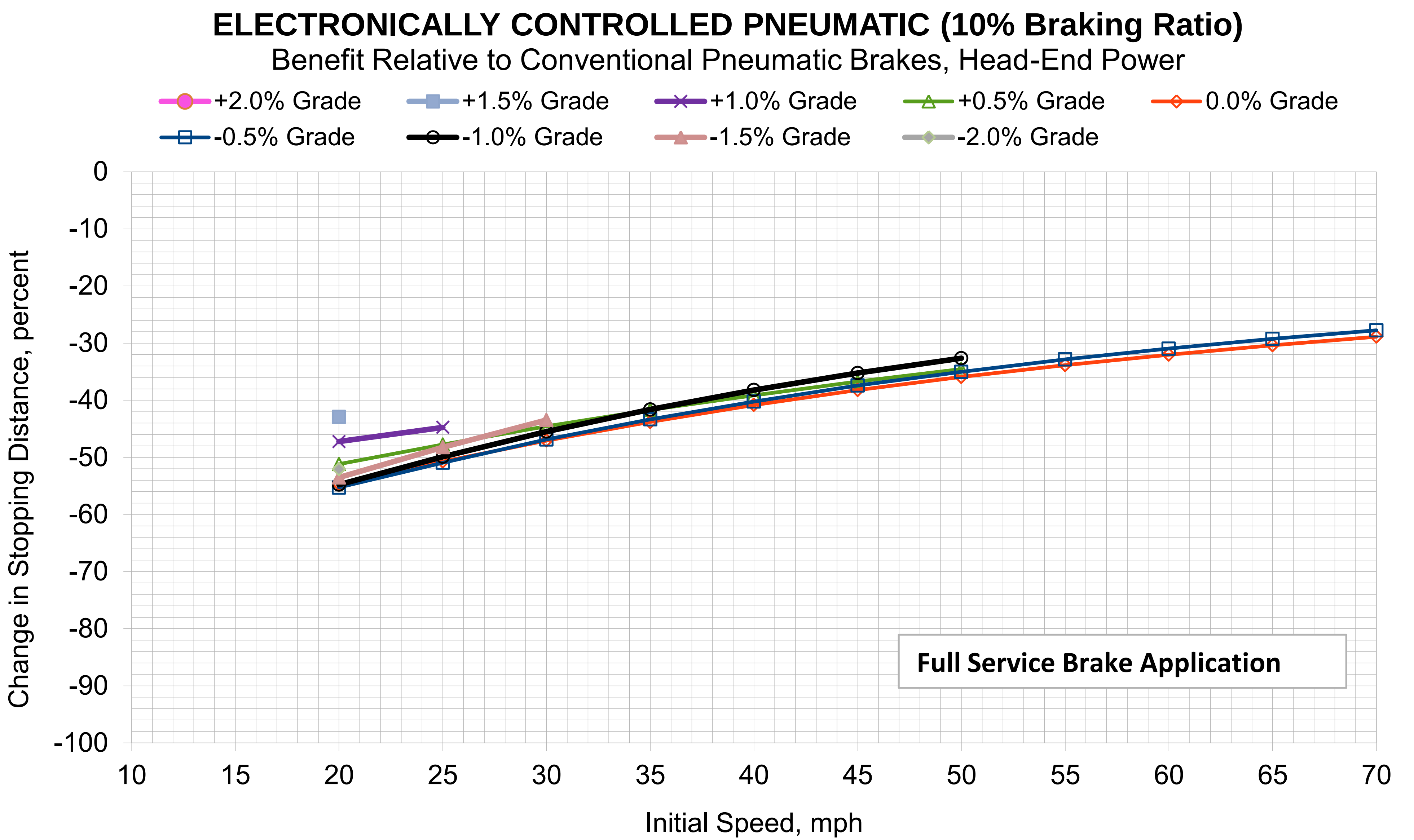
ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



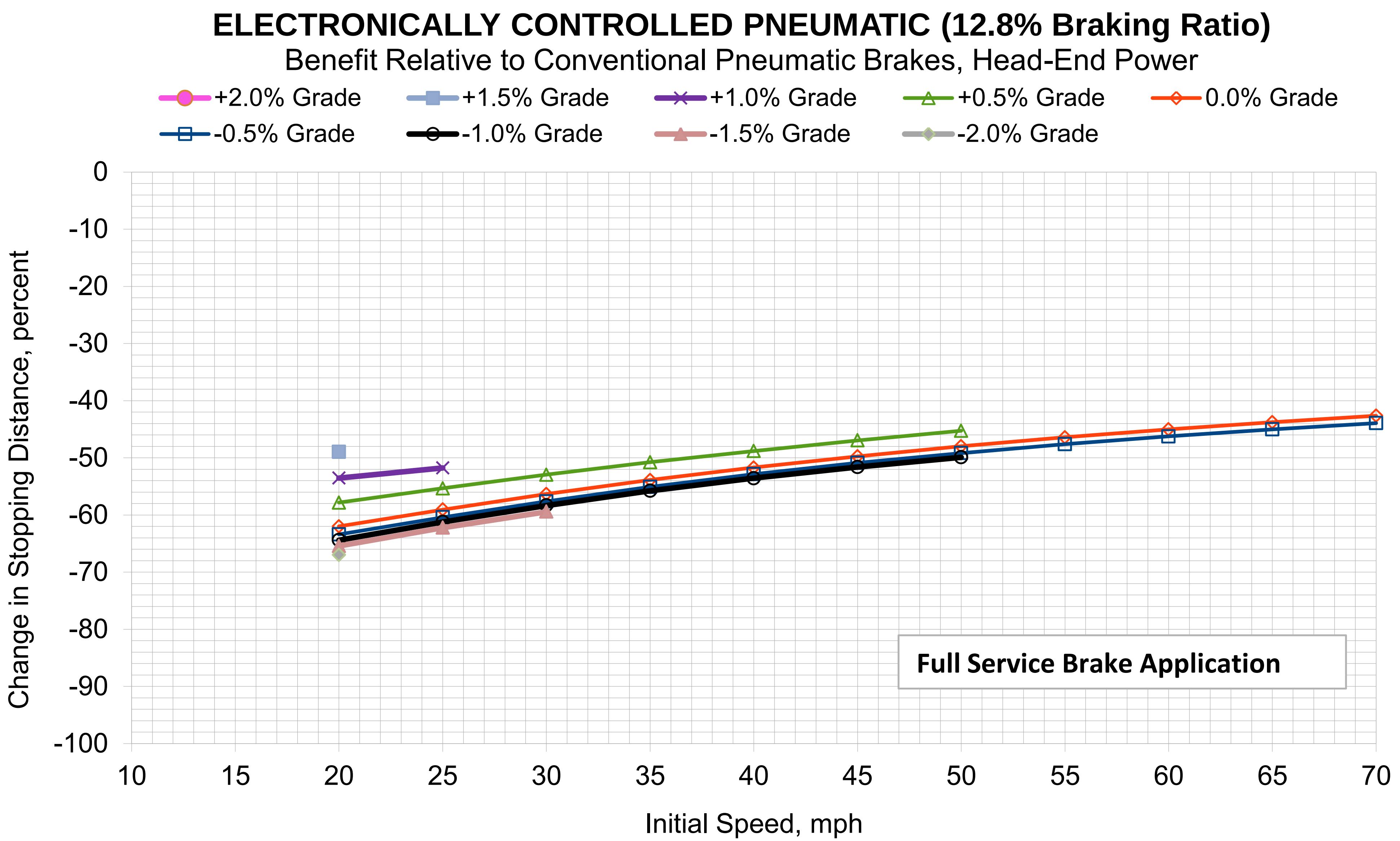
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



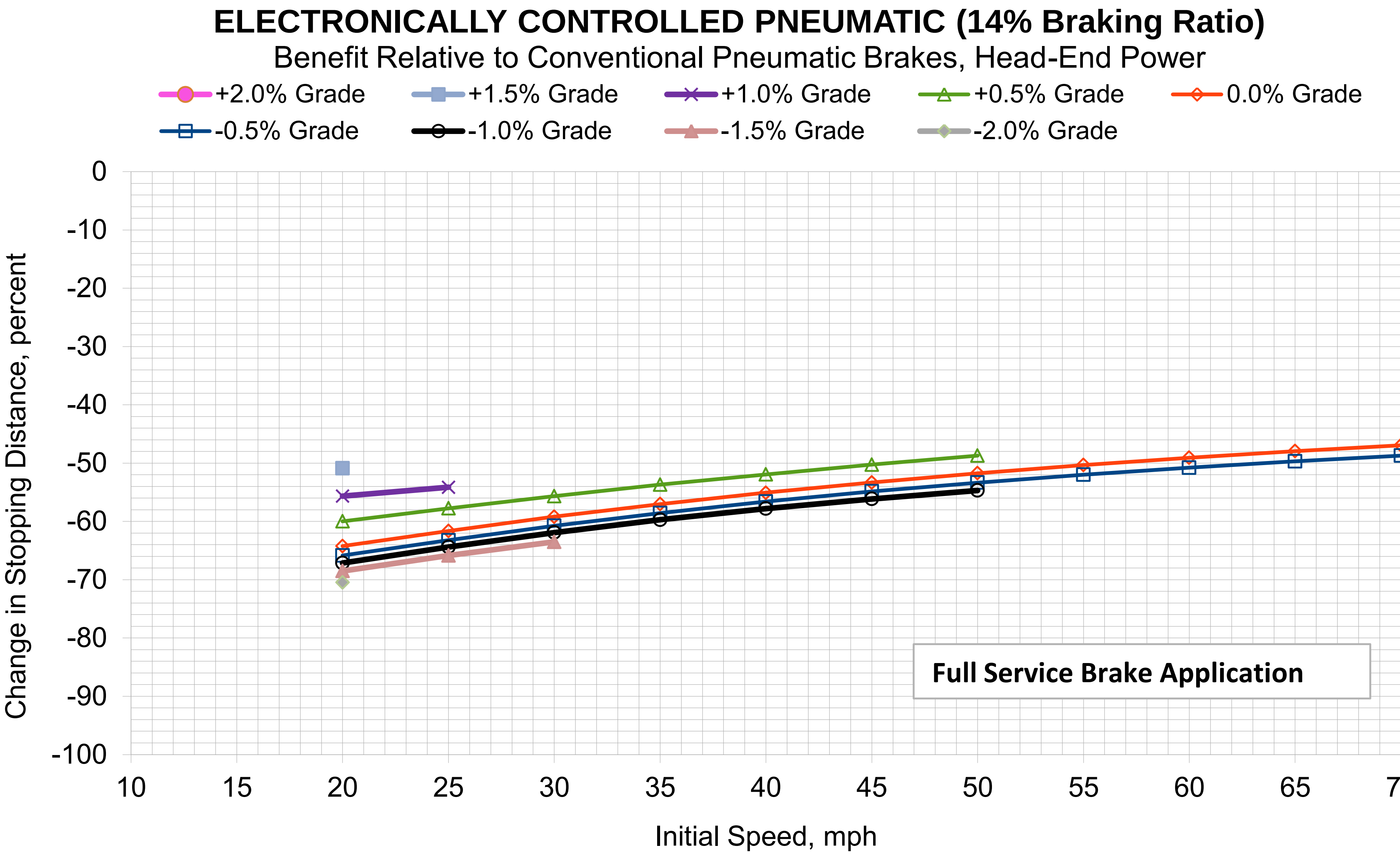
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

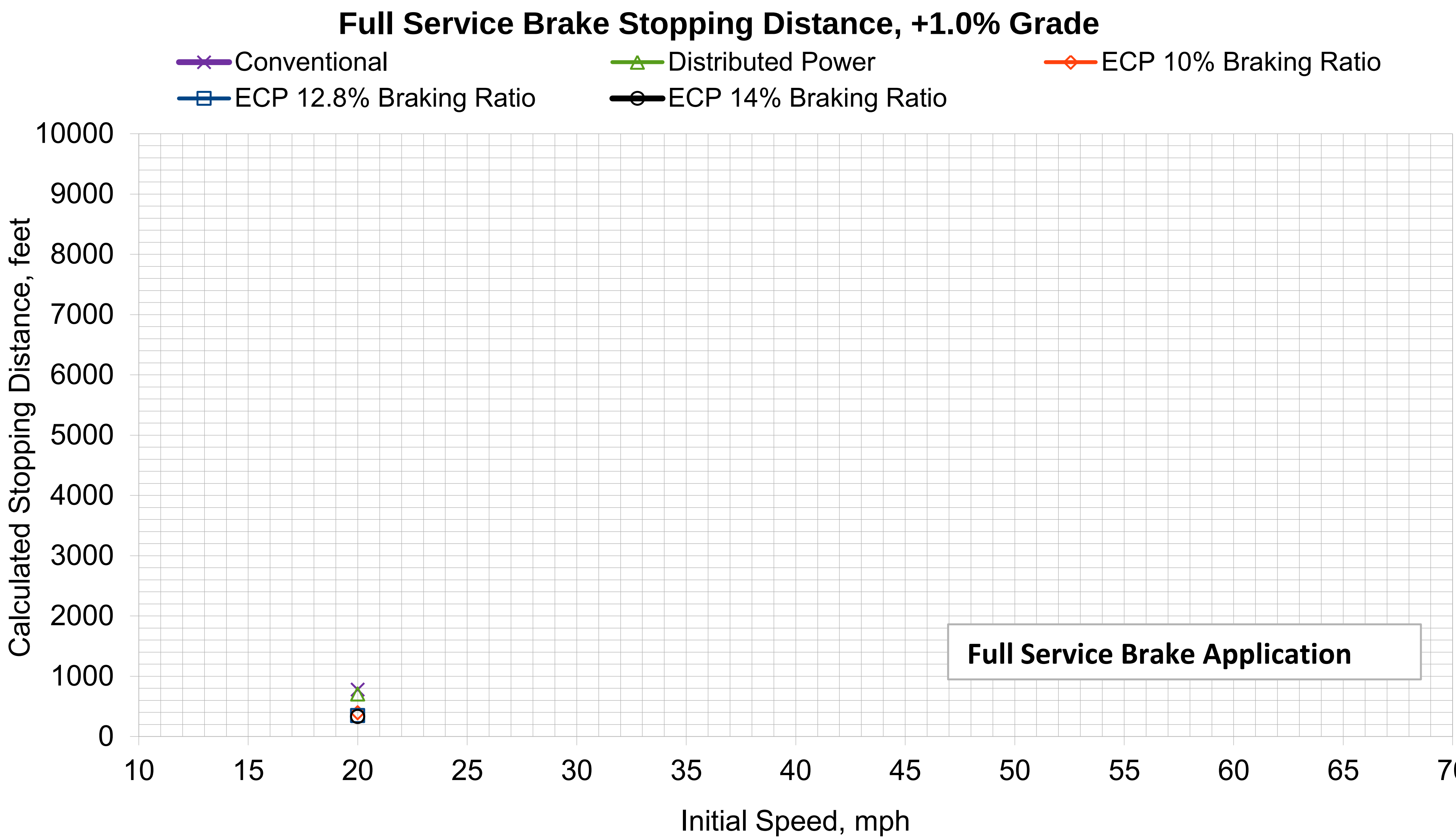


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

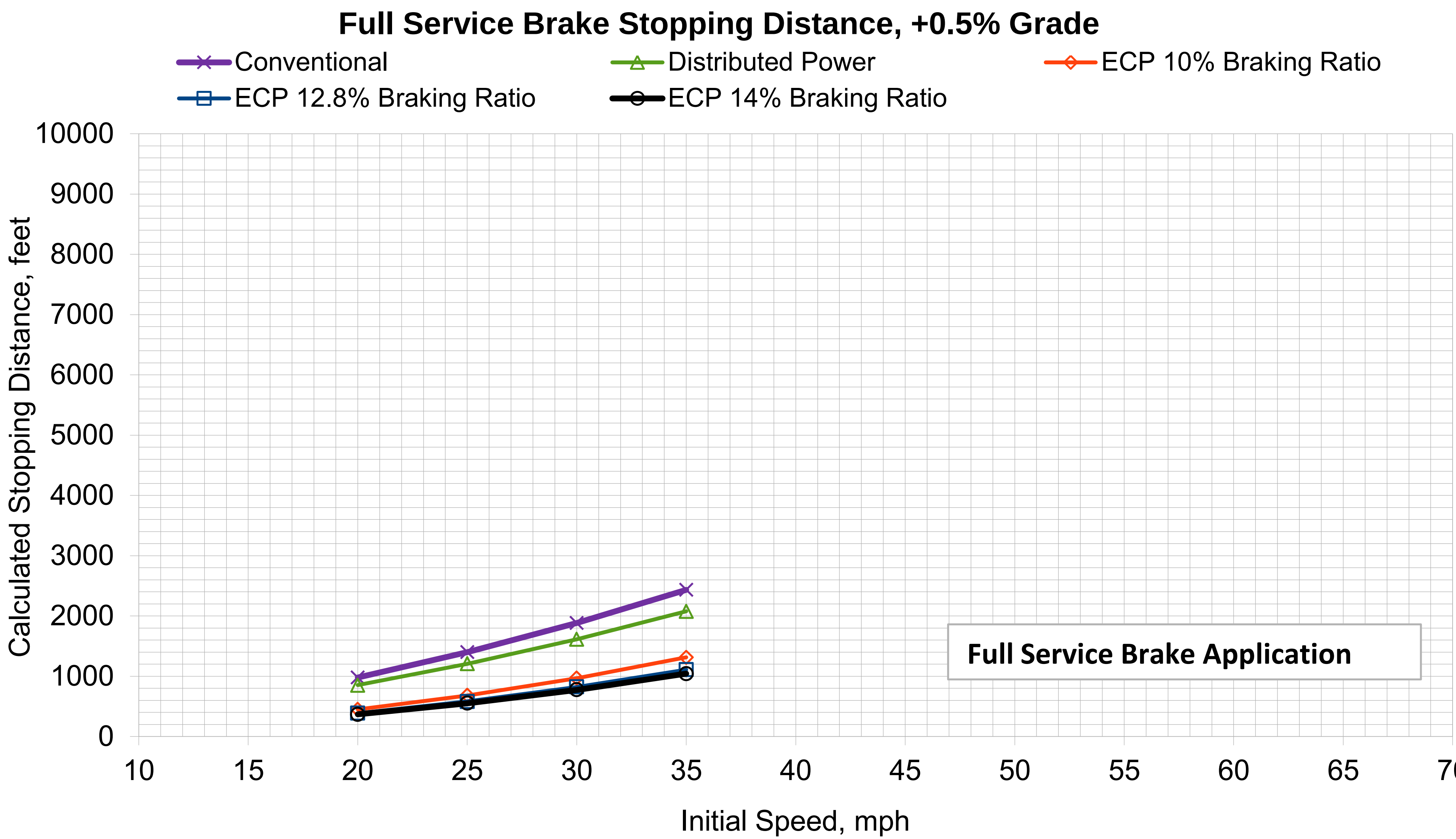


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

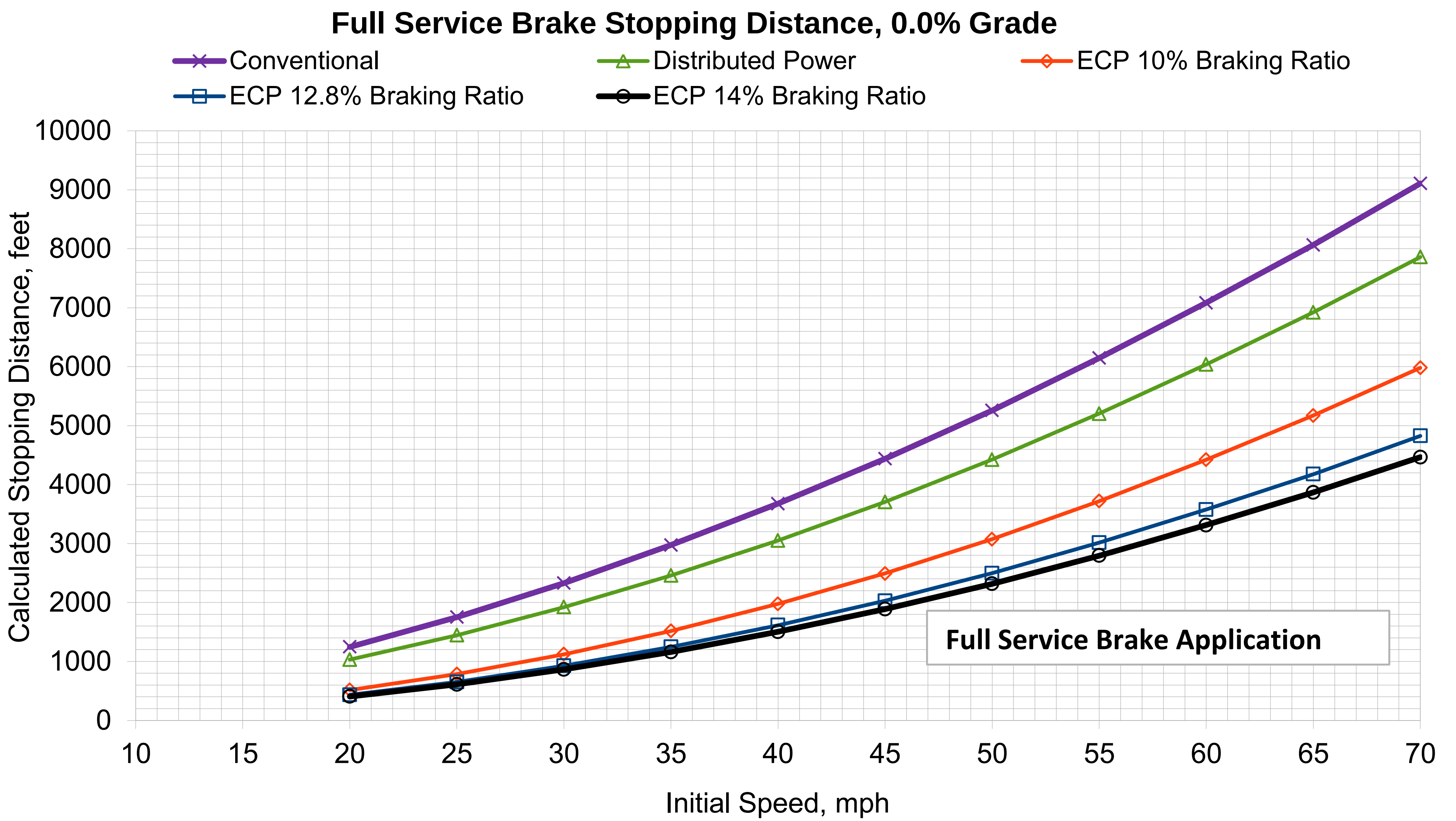
Attachment 19: Full Service Braking, Bailed Off, 104 Tank Cars



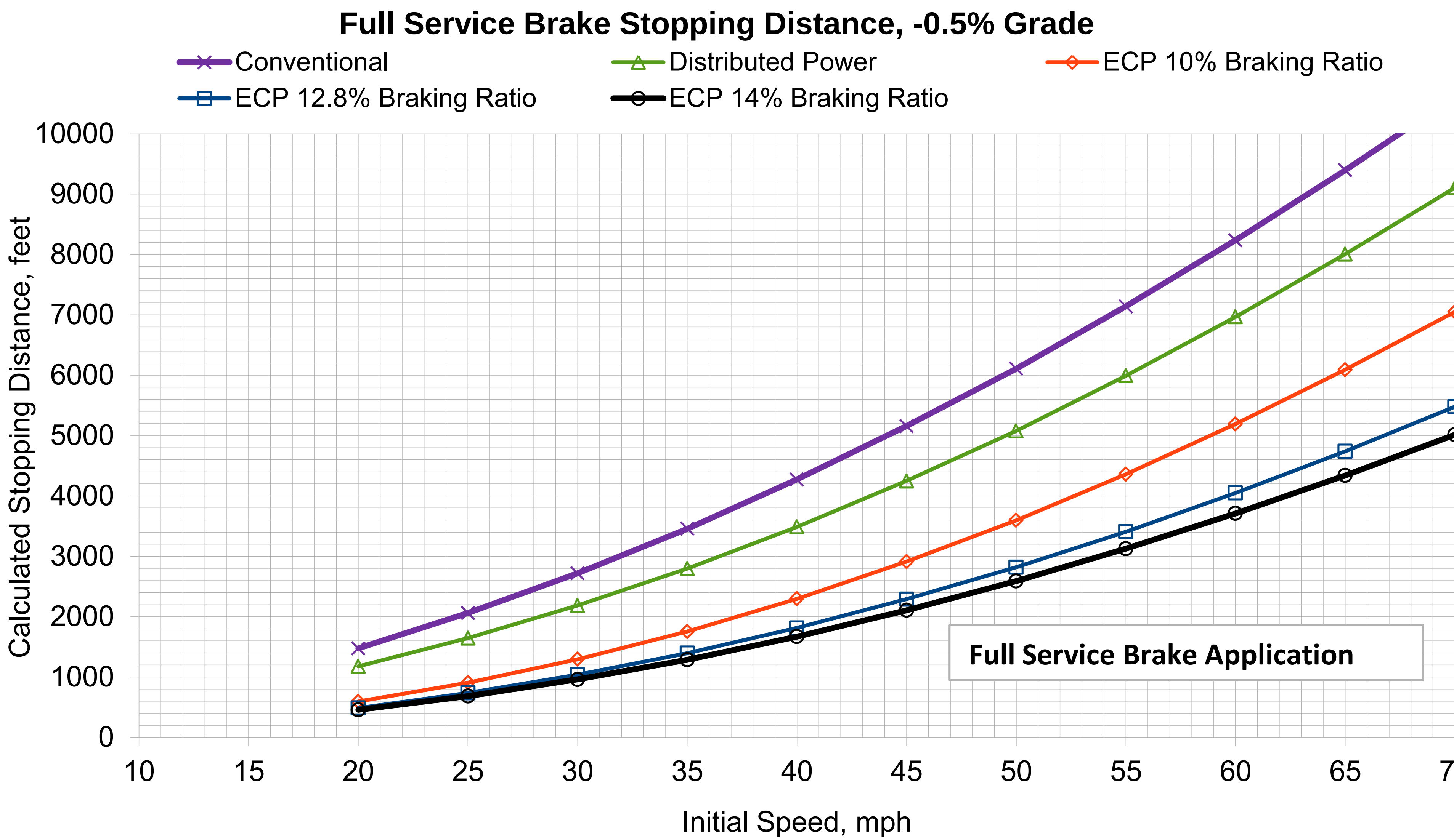
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



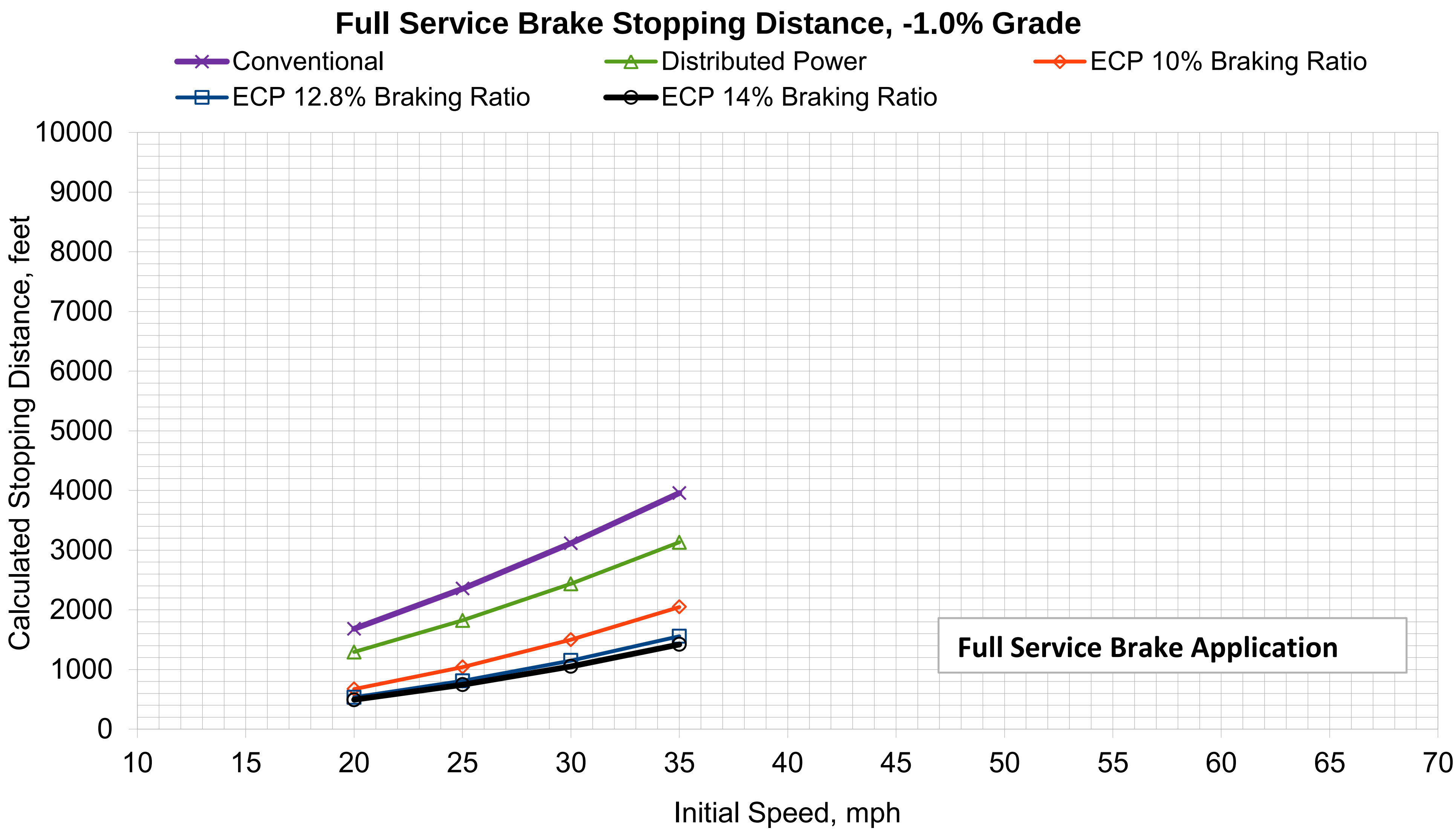
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



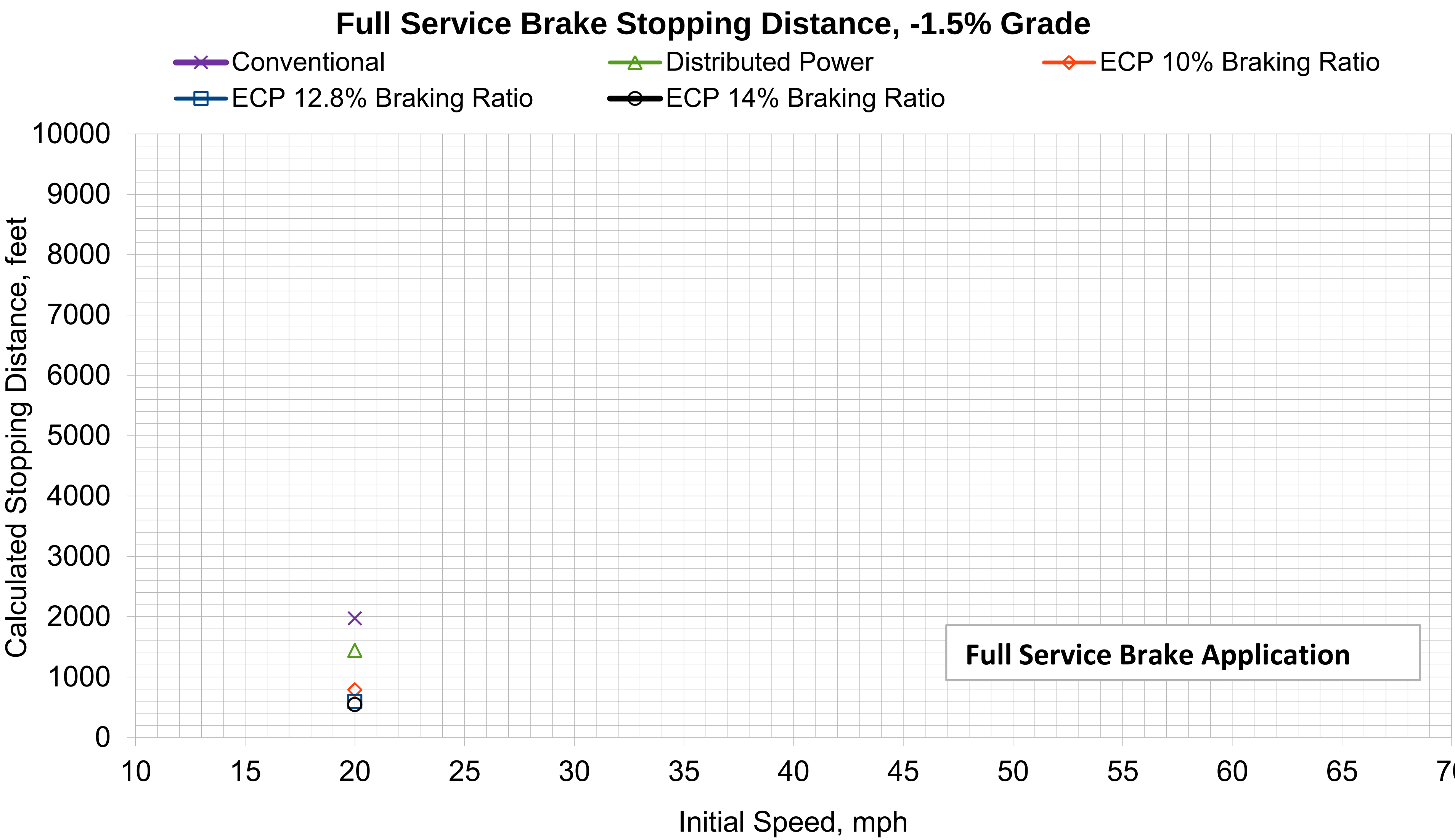
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



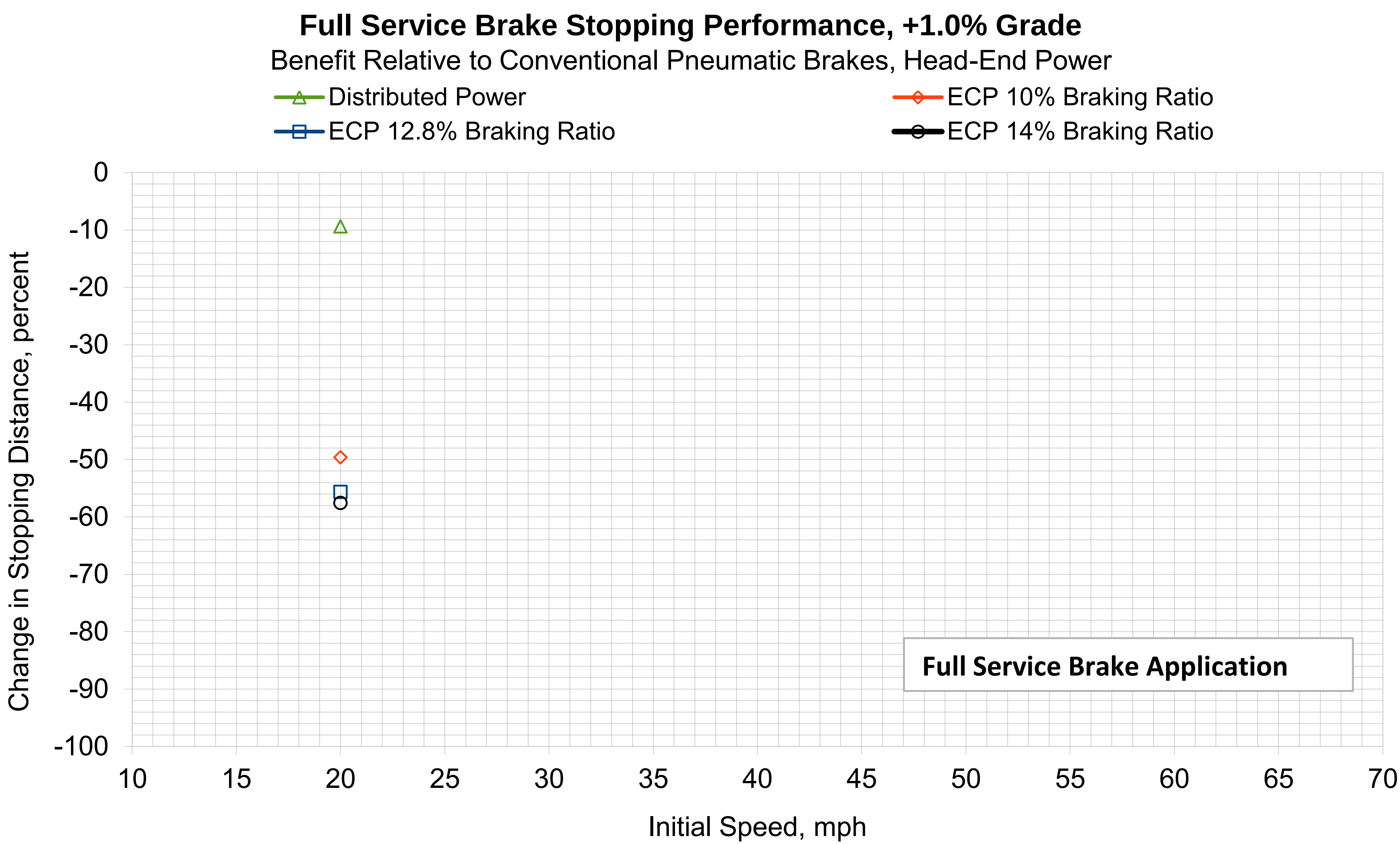
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



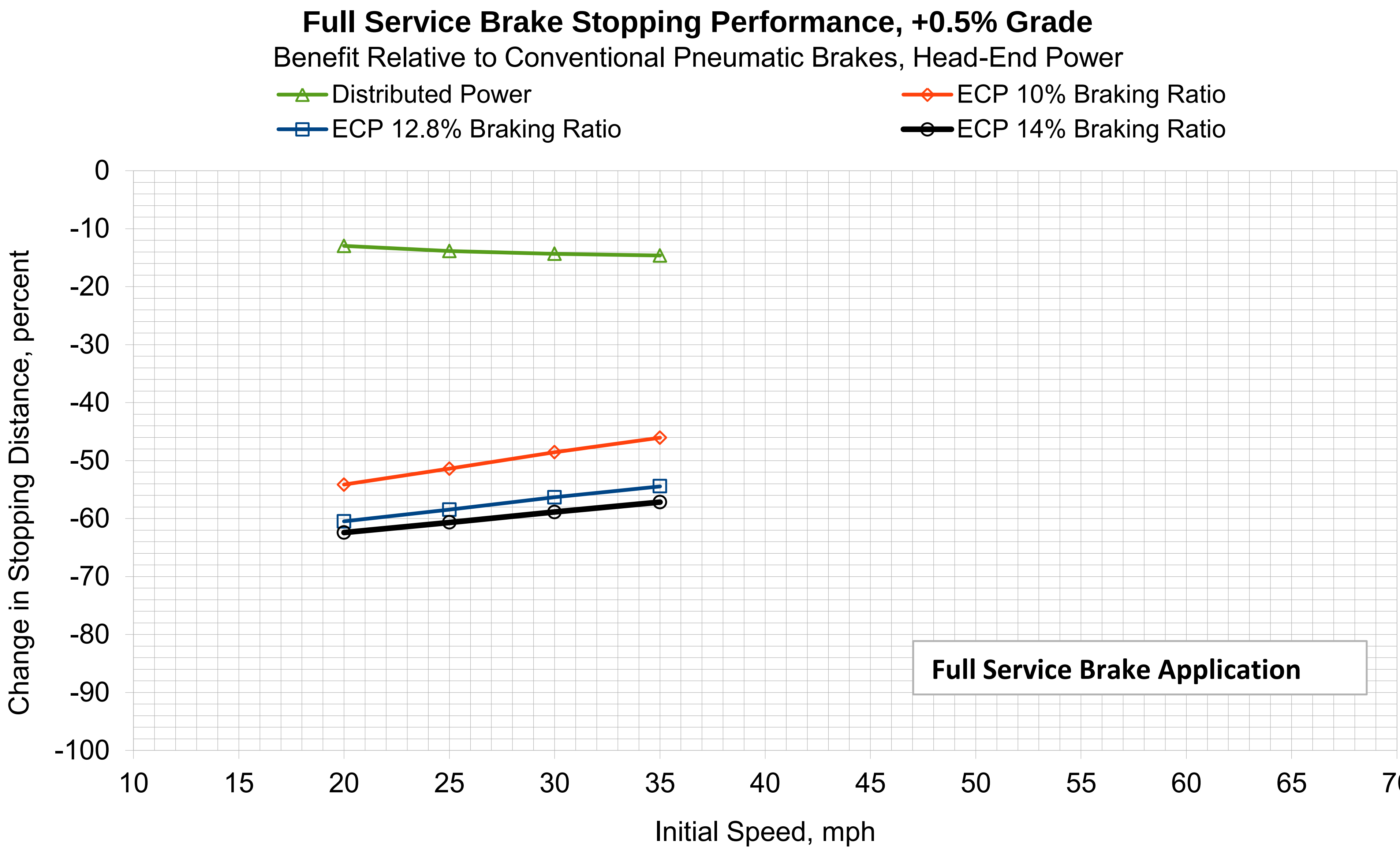
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



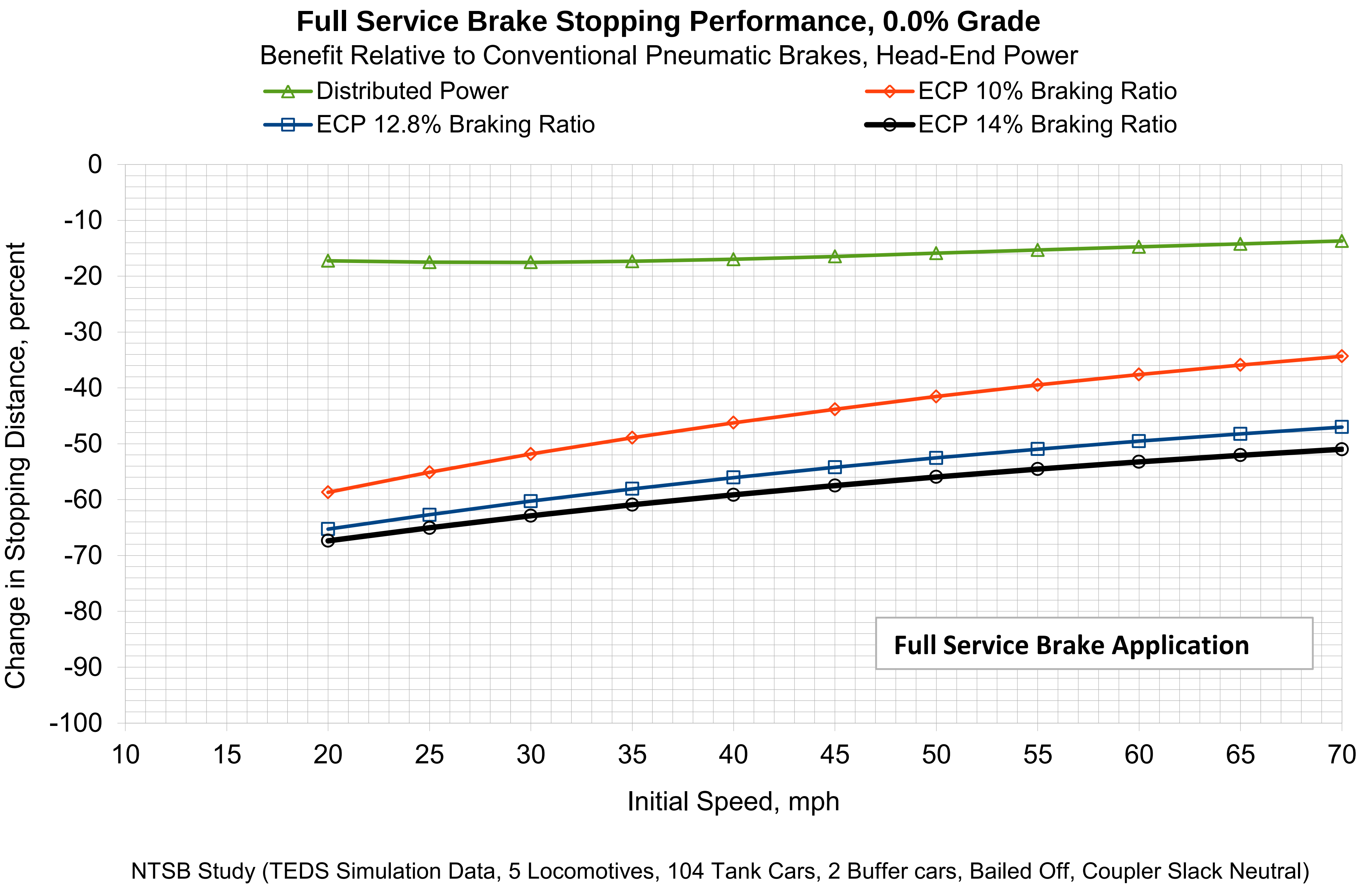
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

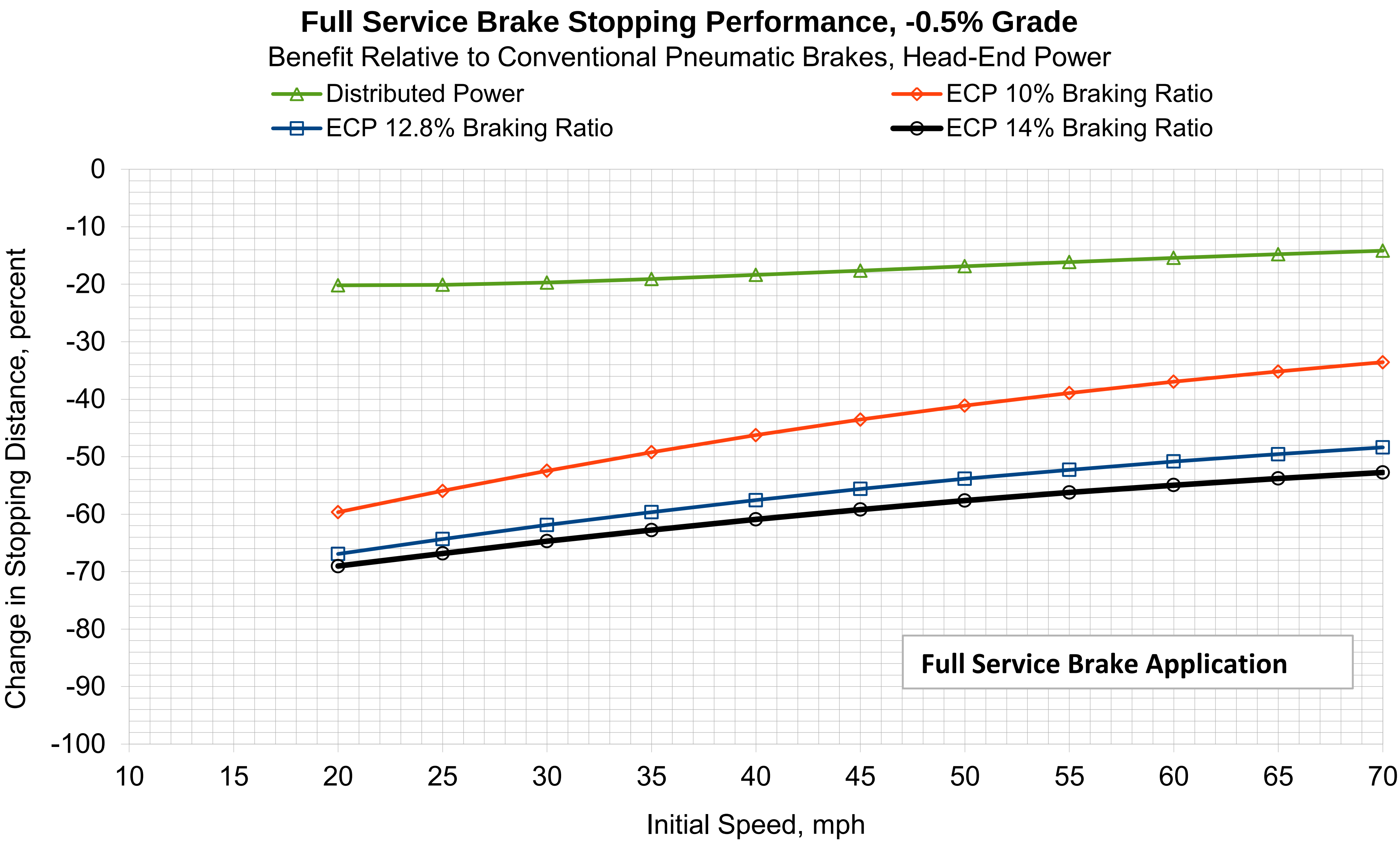


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

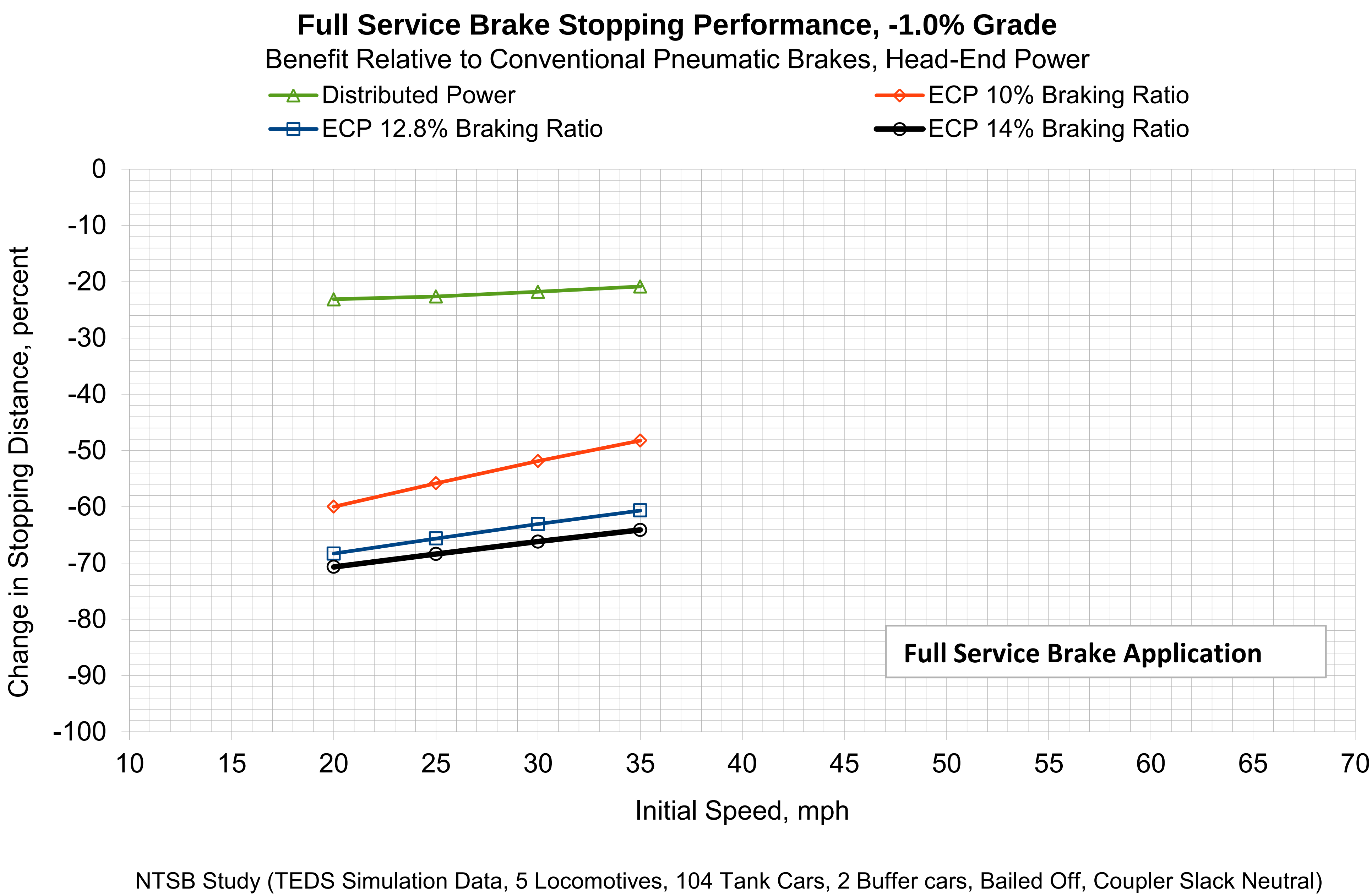


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

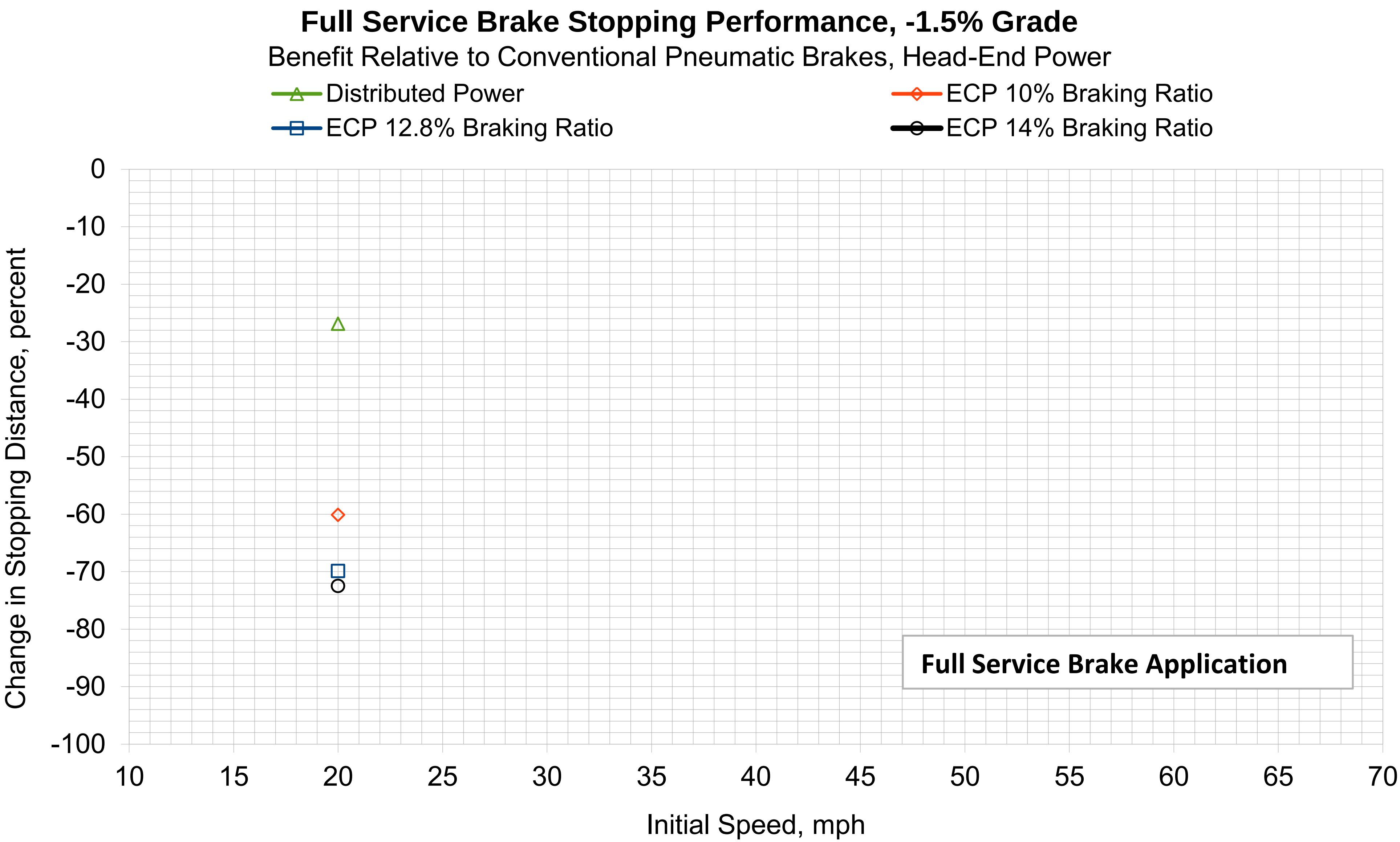

Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



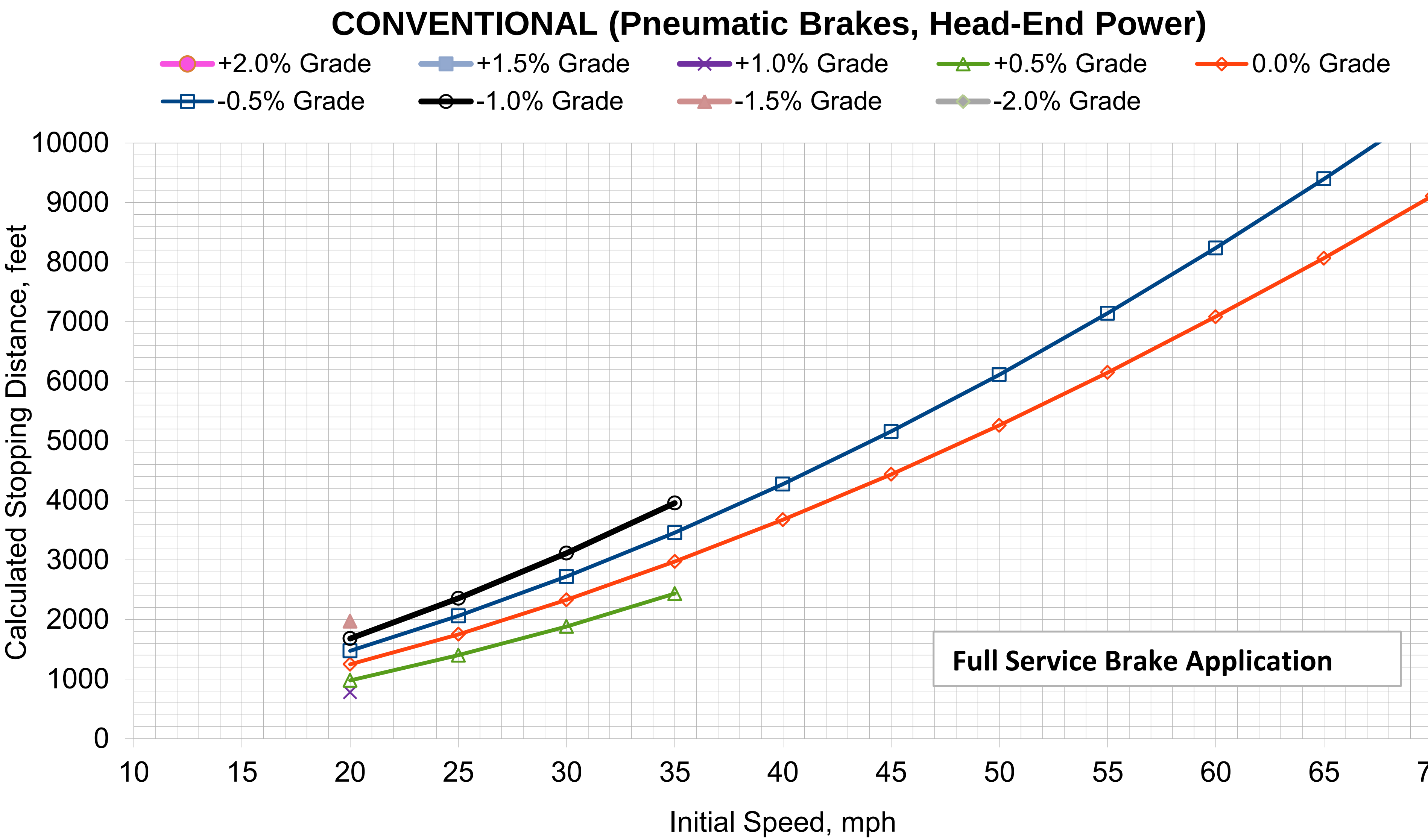
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Full Service Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Change in Stopping Distance, percent
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

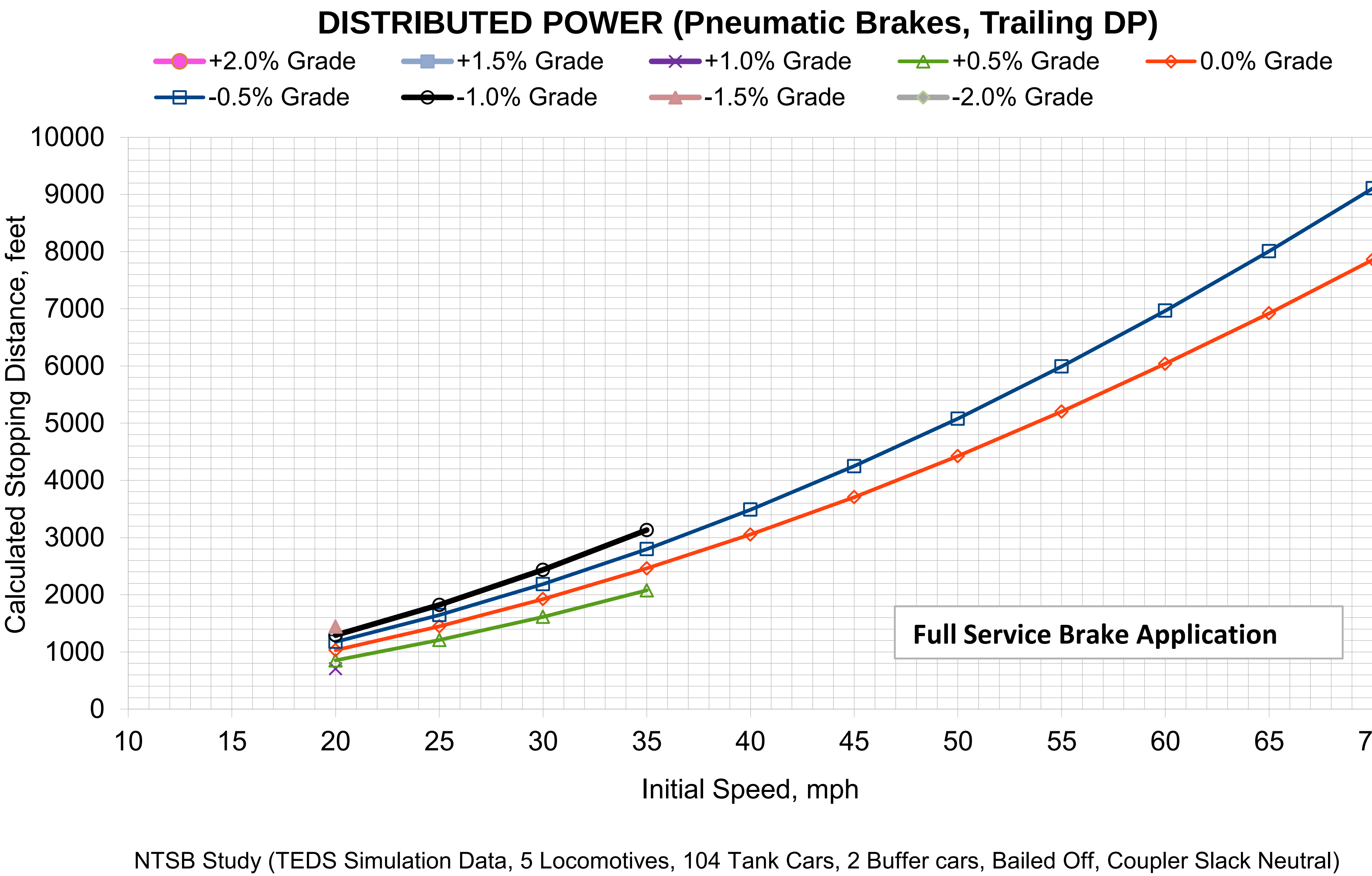
A19.12

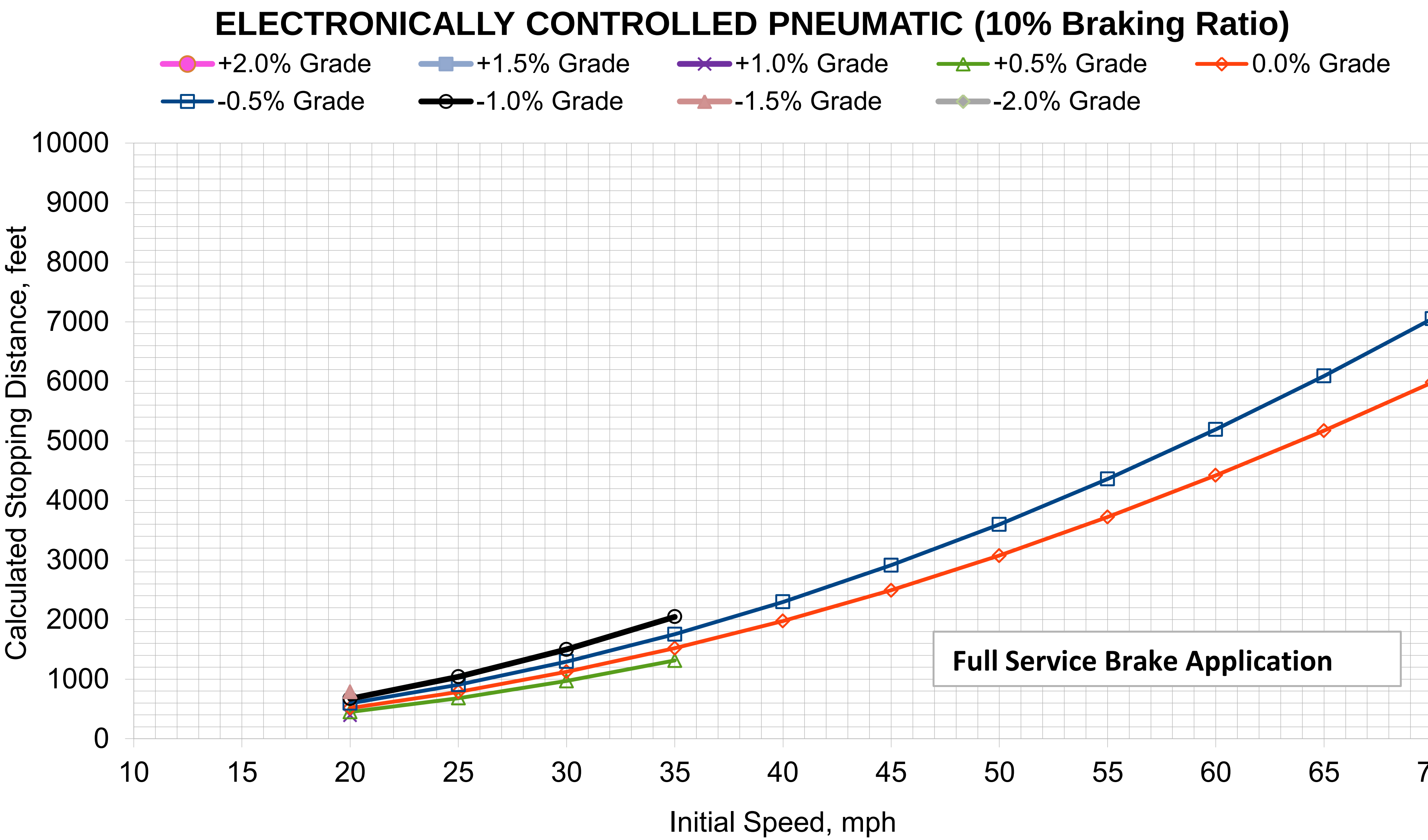


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

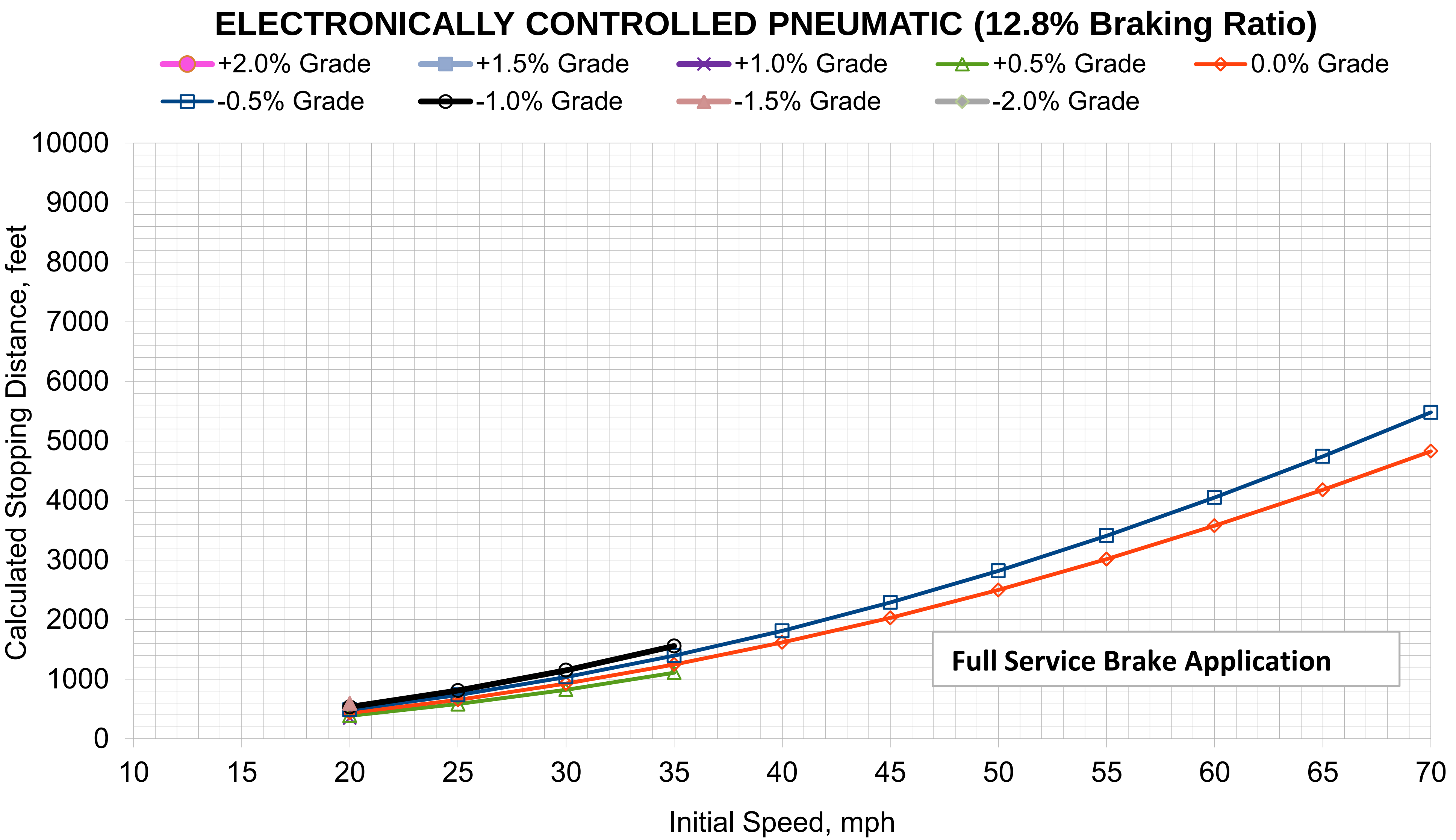


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

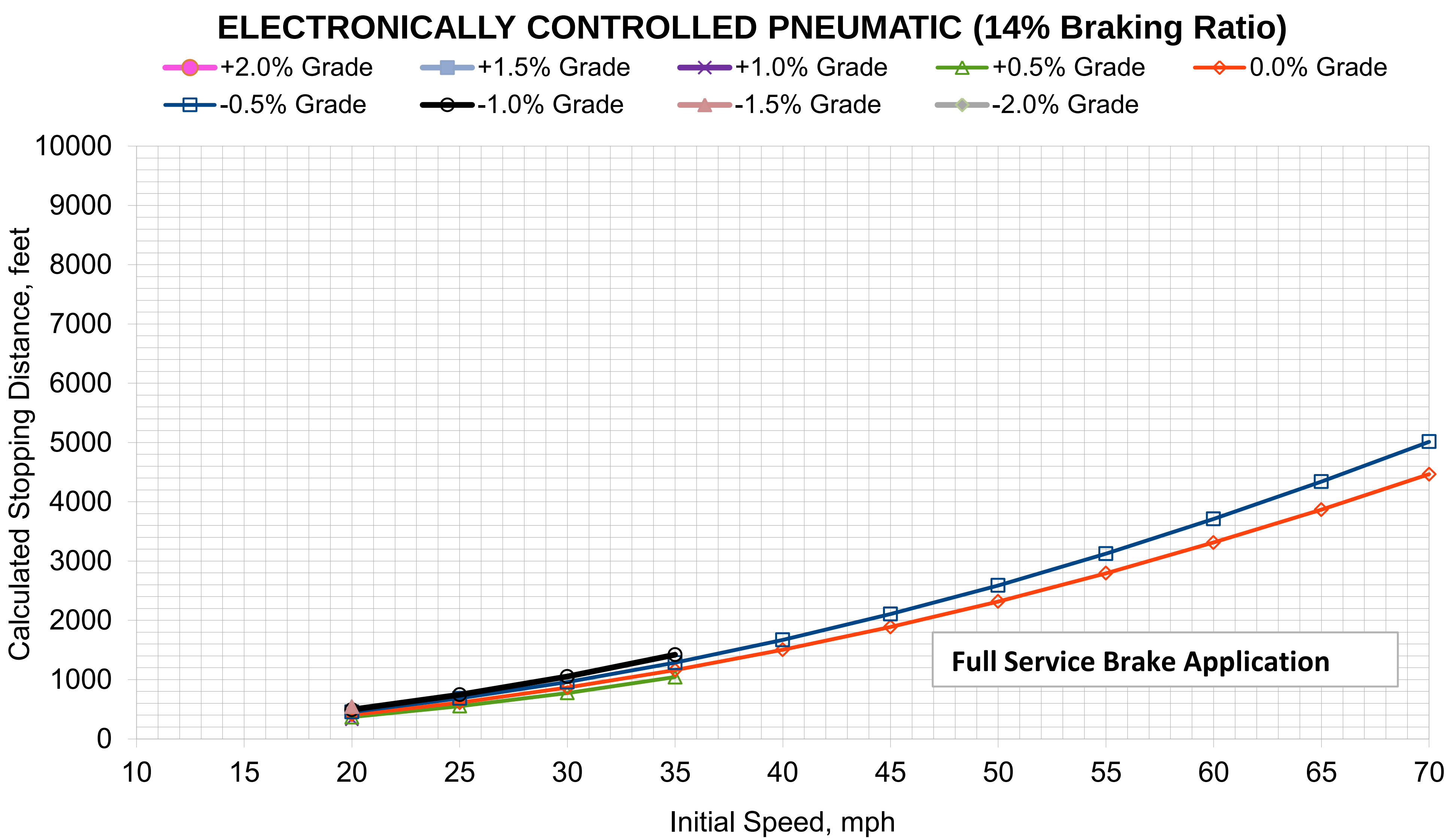

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



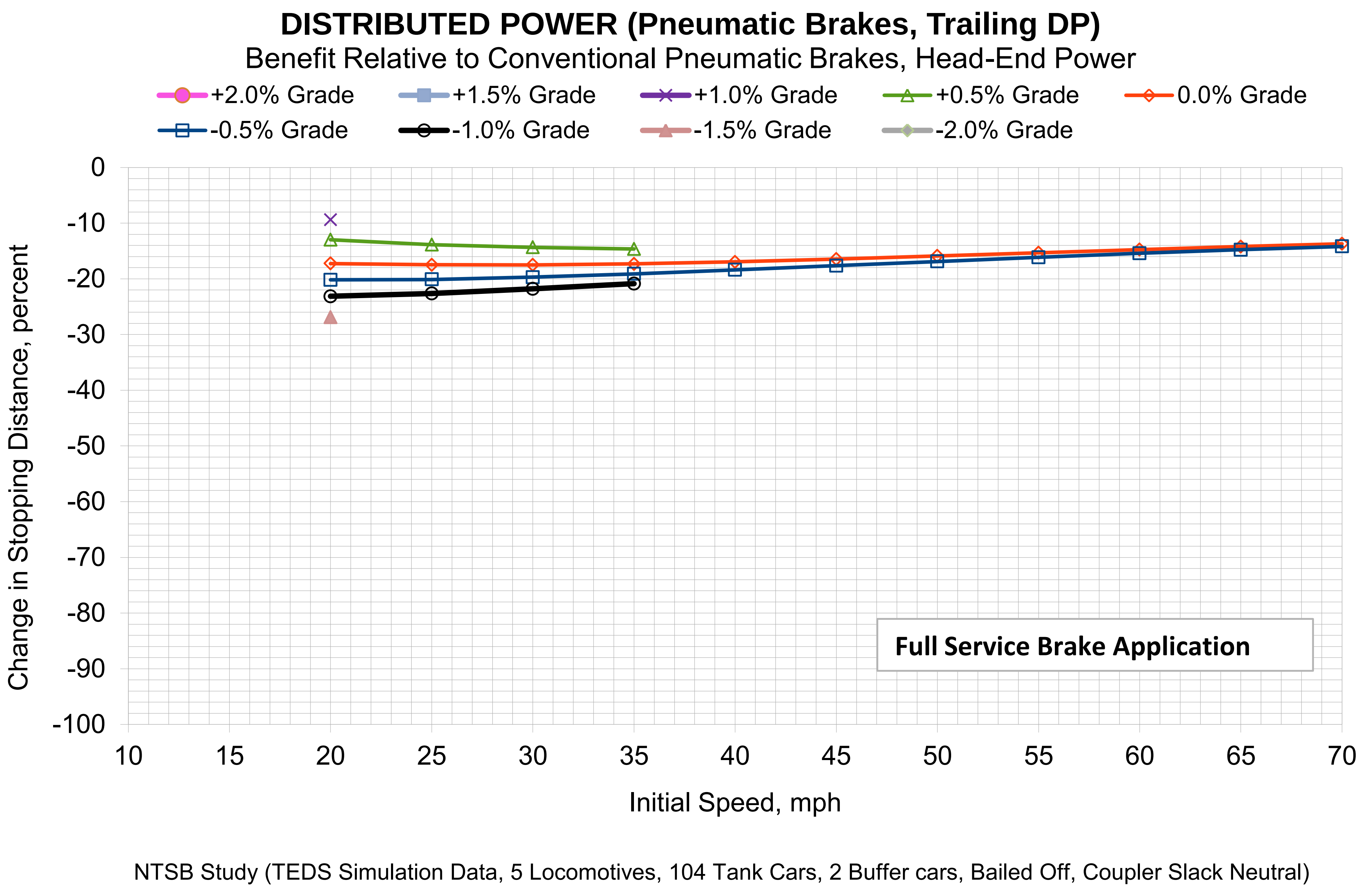
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

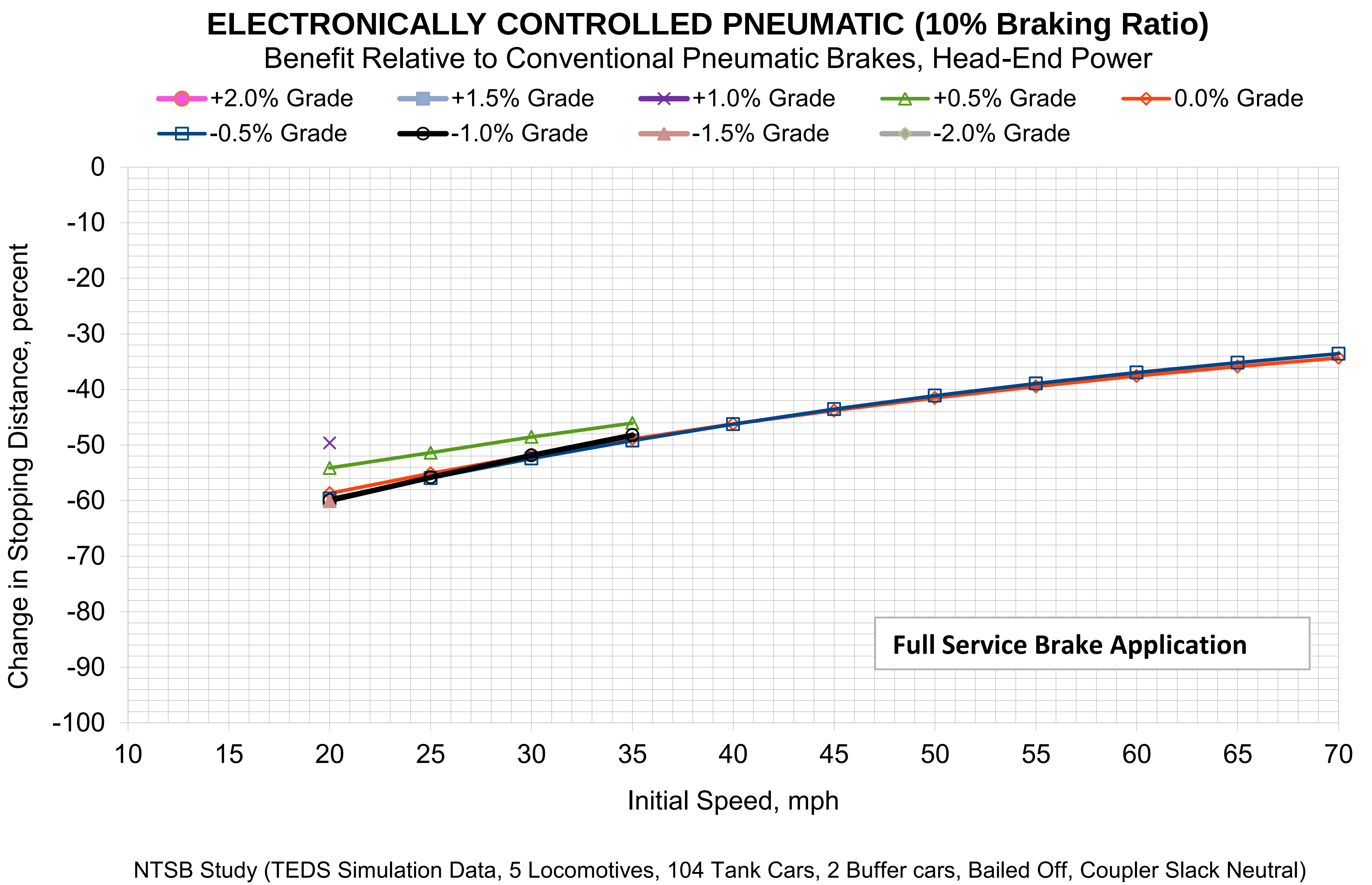


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

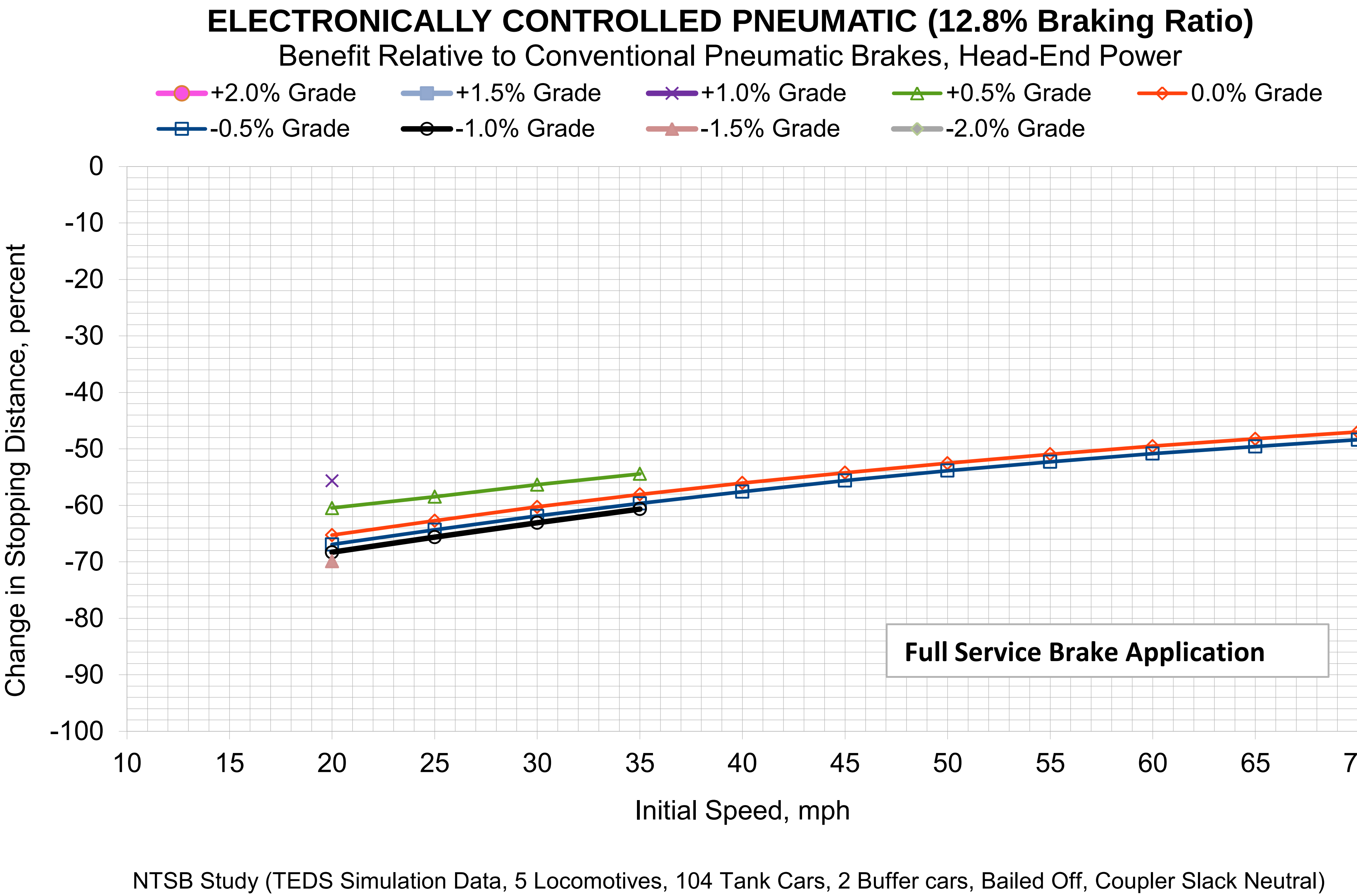


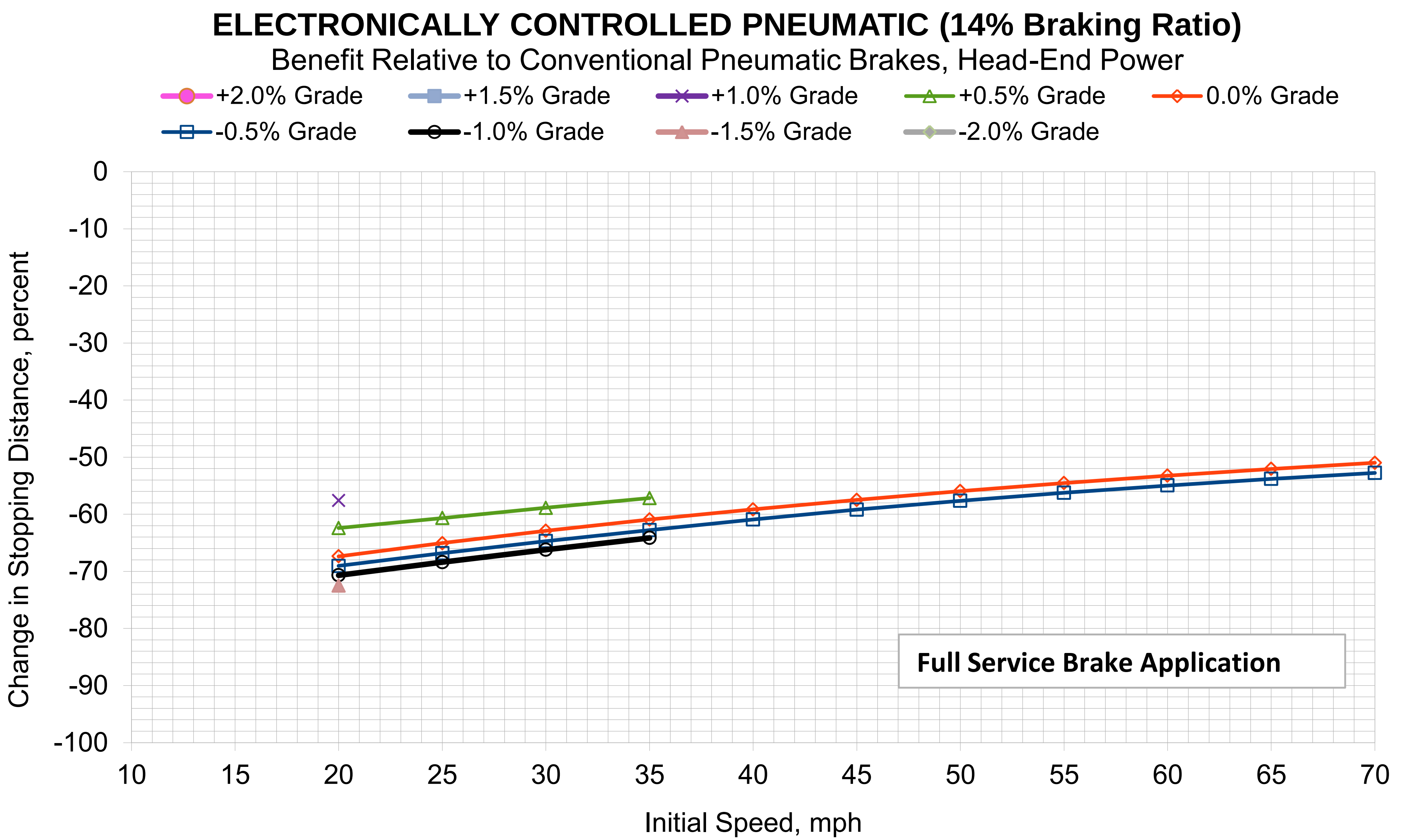
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



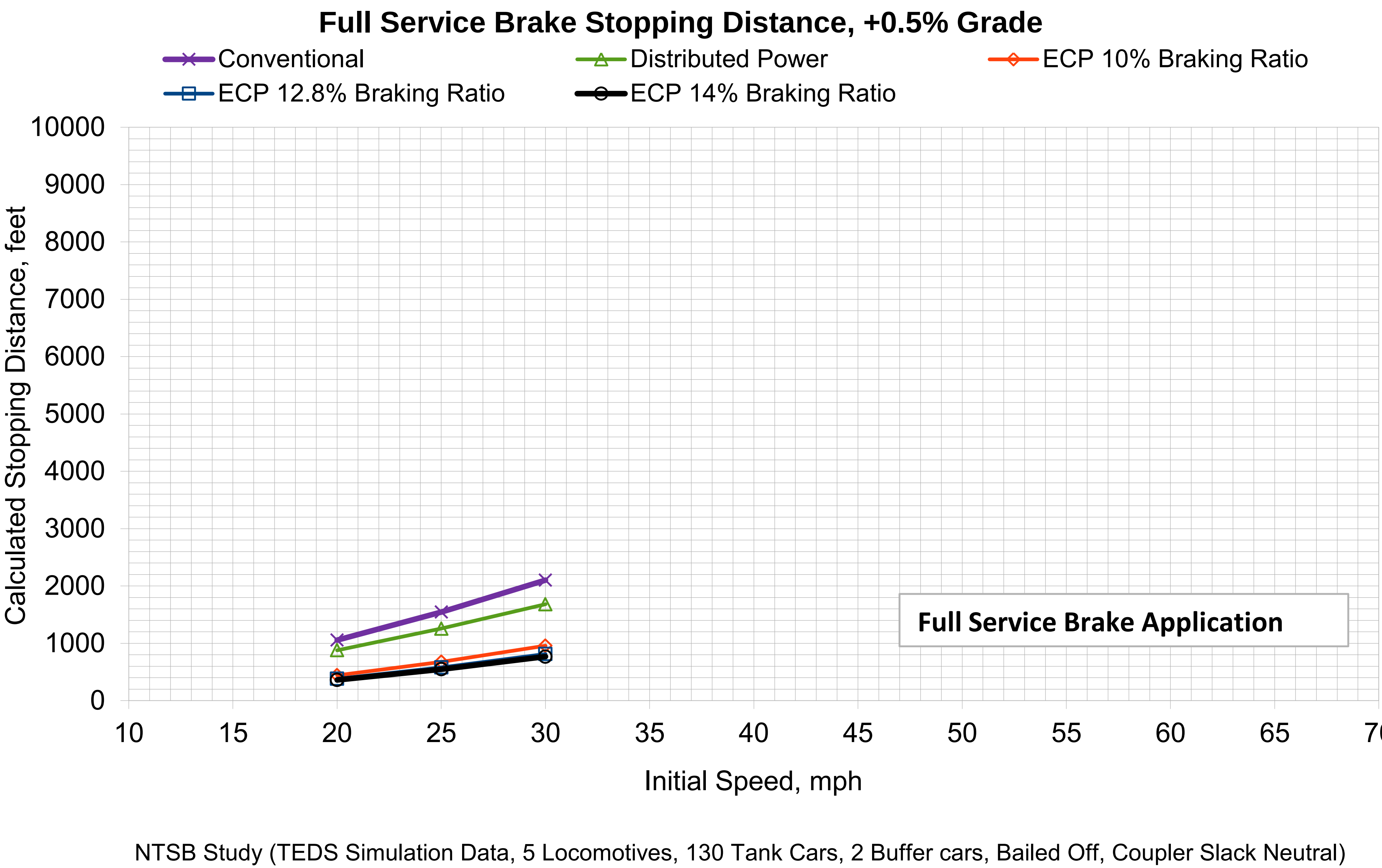
ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

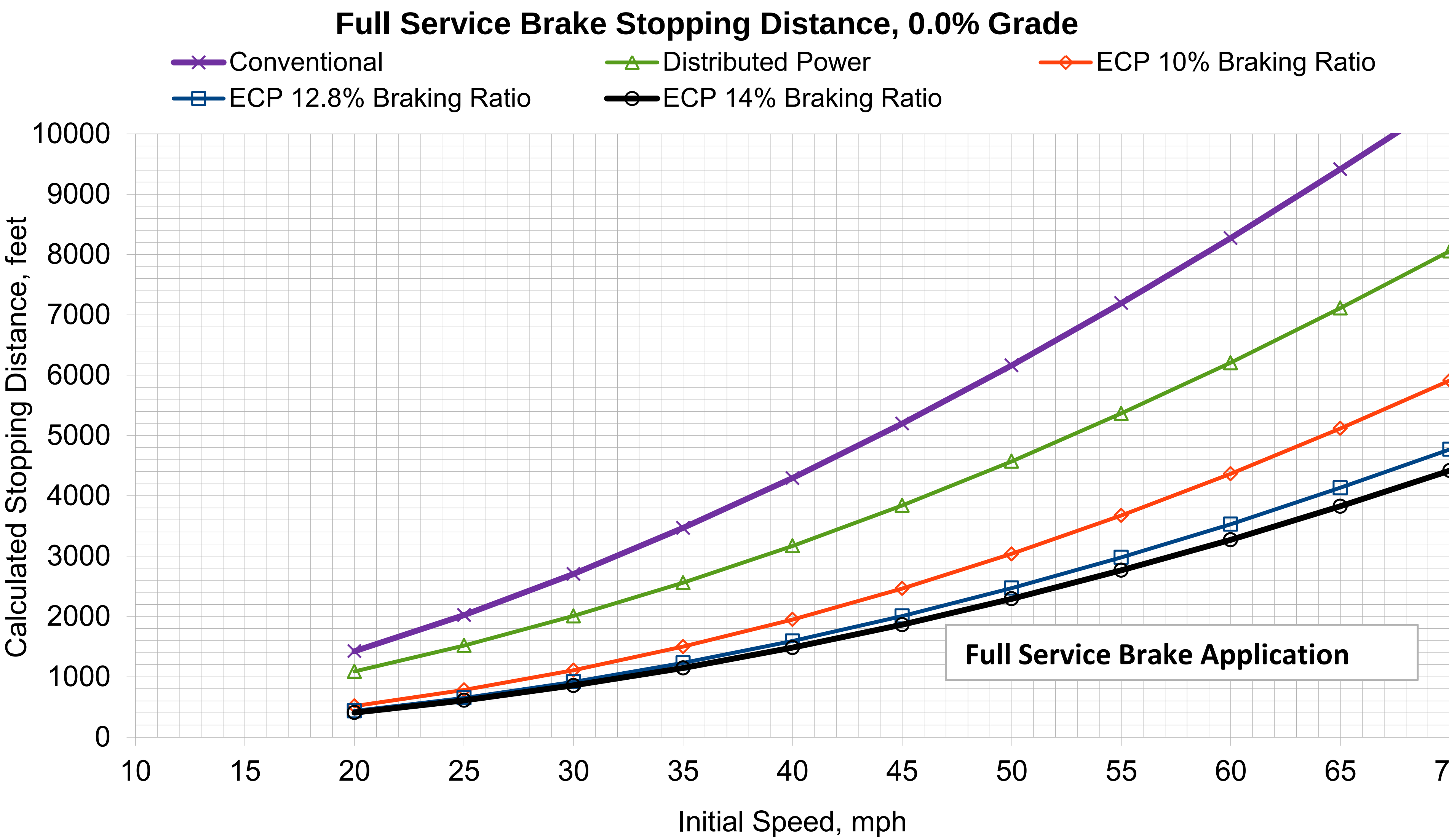

ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



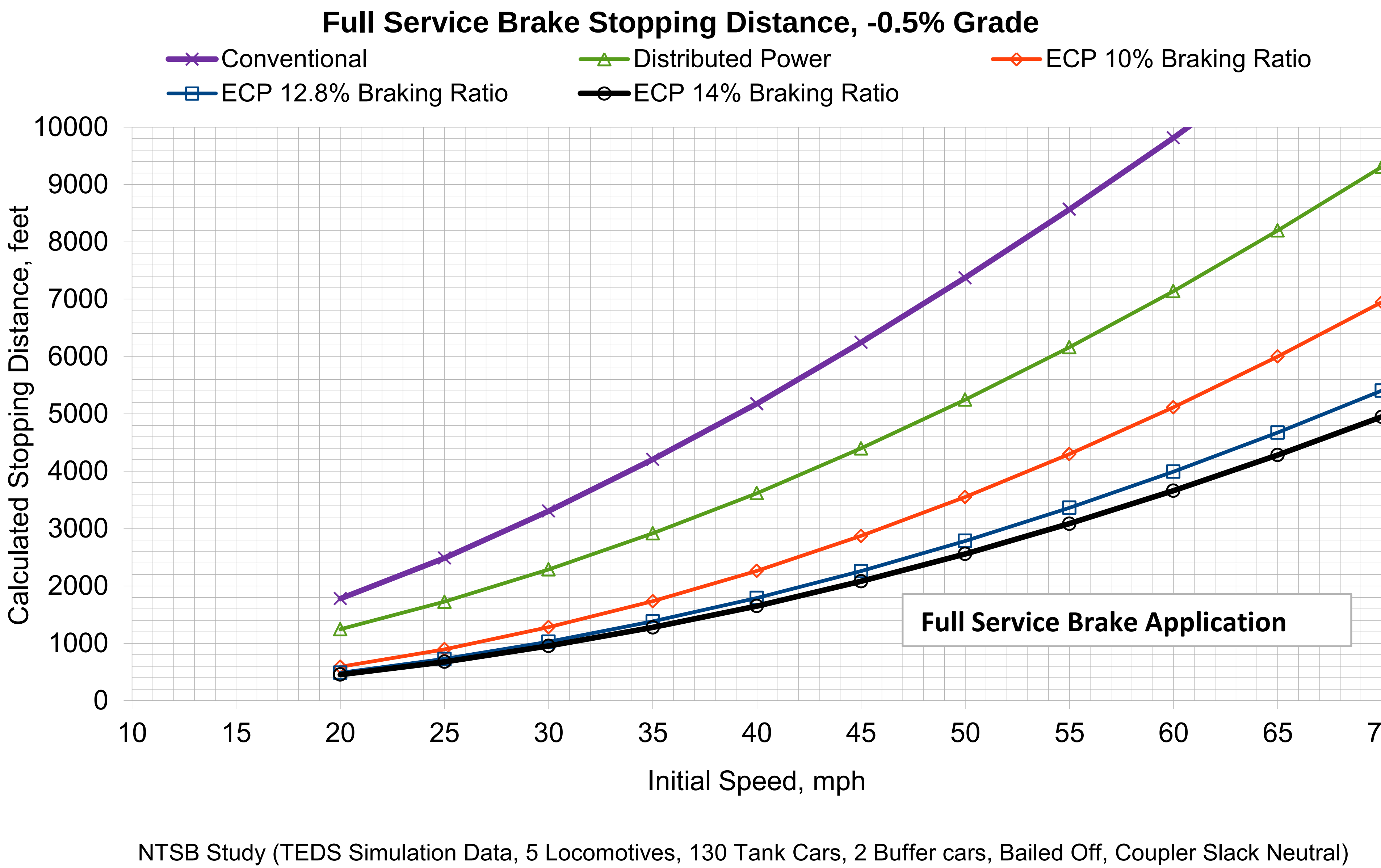
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

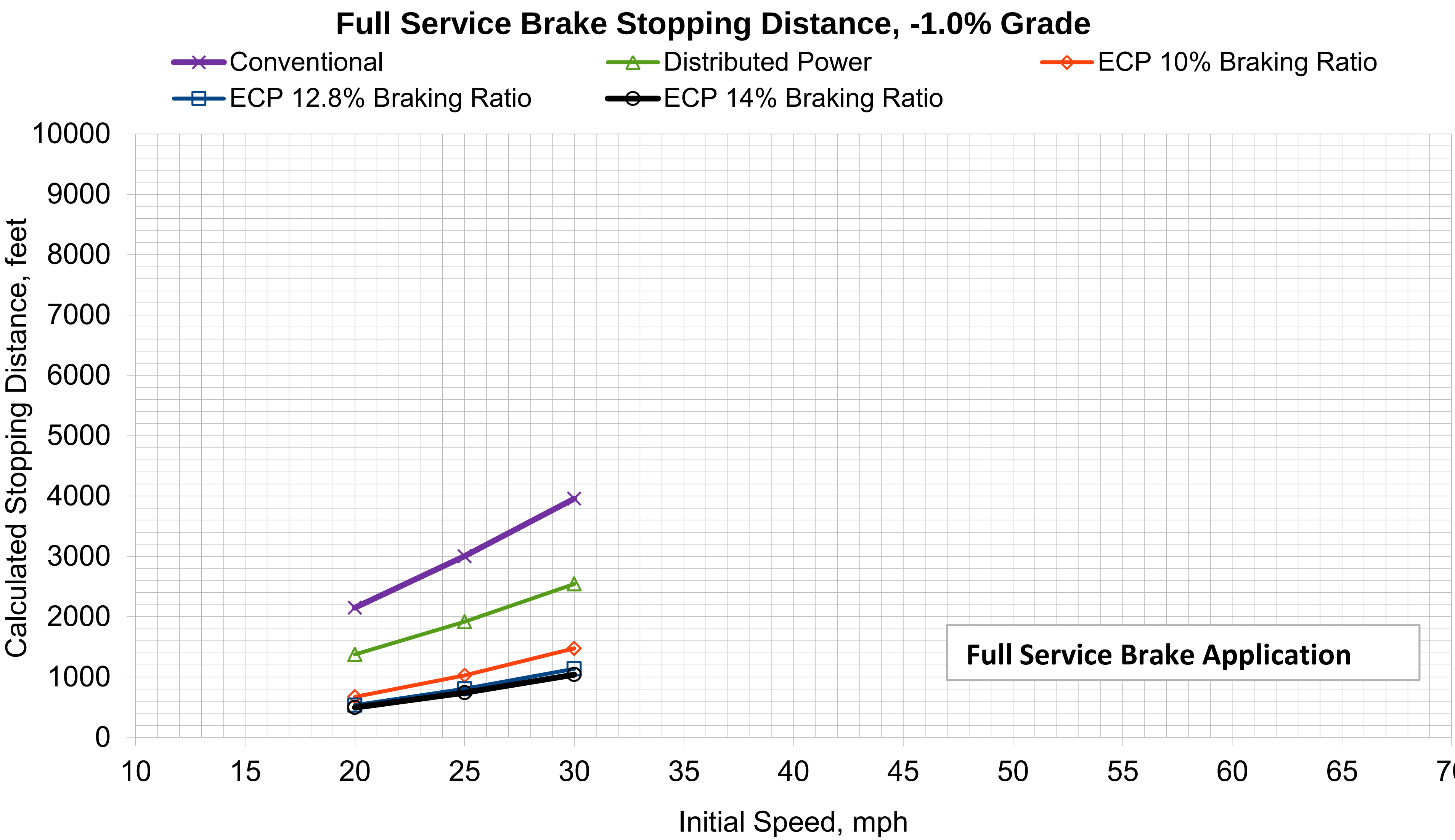
Attachment 20: Full Service Braking, Bailed Off, 130 Tank Cars


Full Service Brake Stopping Distance, +0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

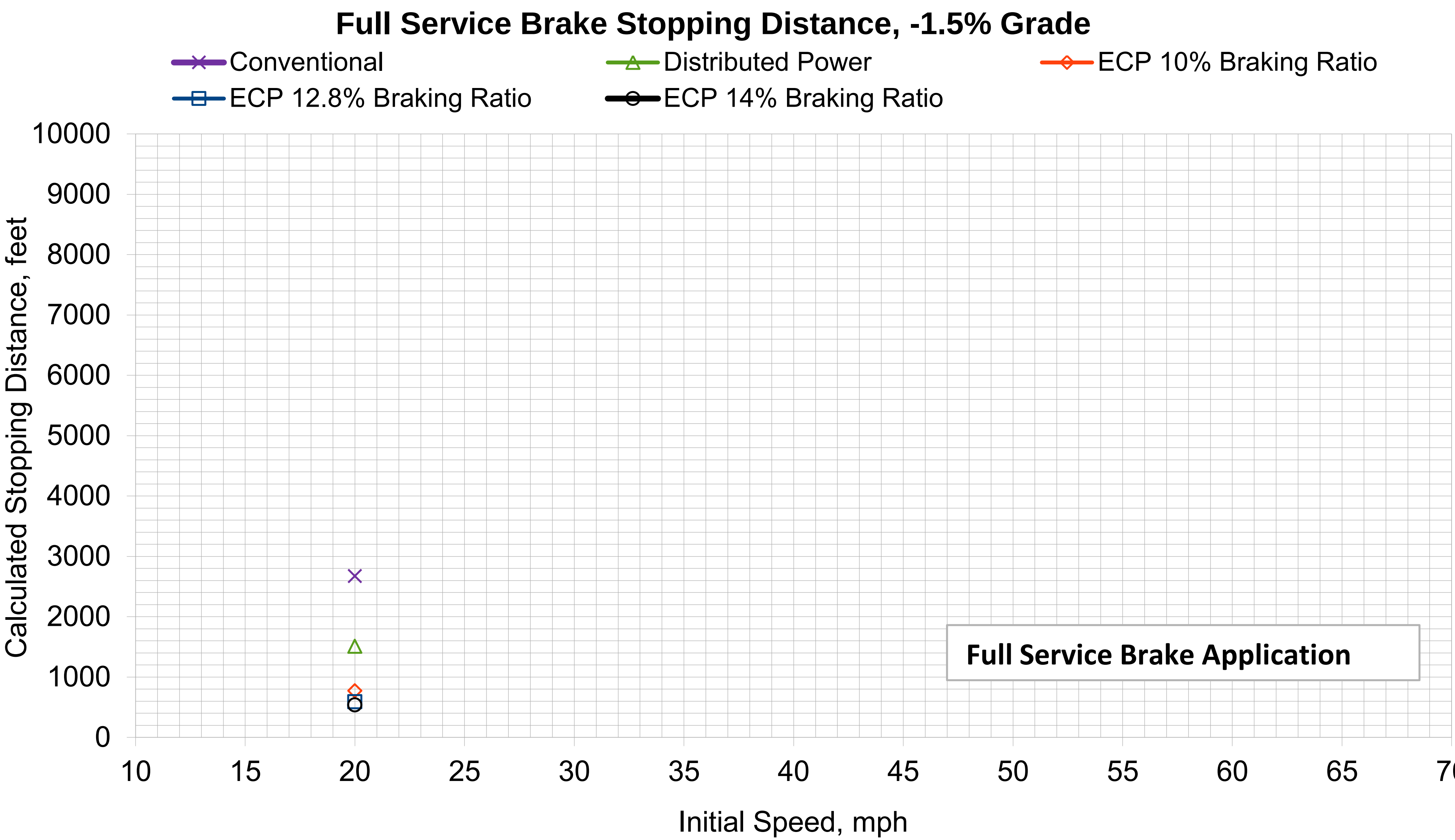


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

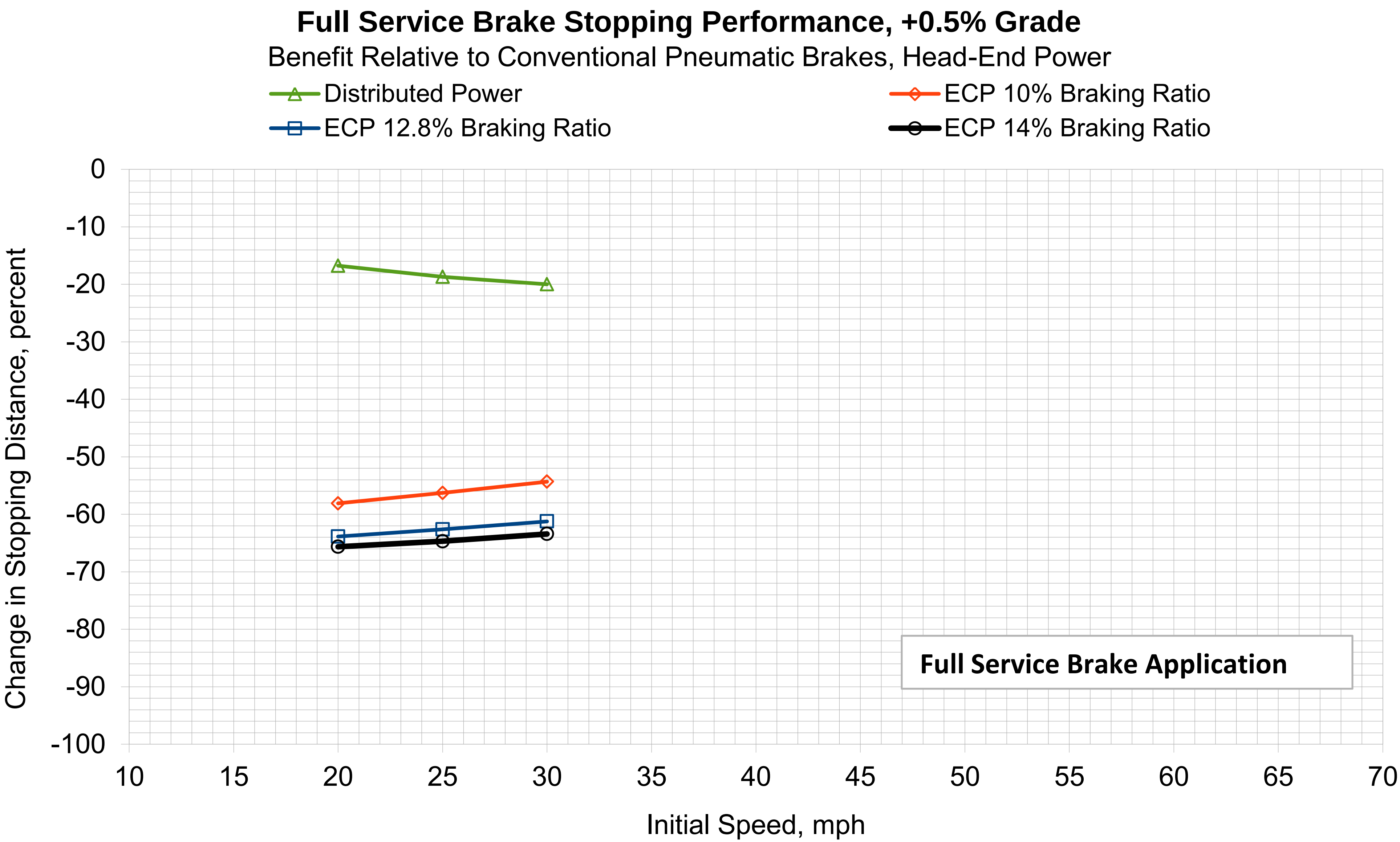

Full Service Brake Stopping Distance, -0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Full Service Brake Application
Calculated Stopping Distance, feet
Initial Speed, mph
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



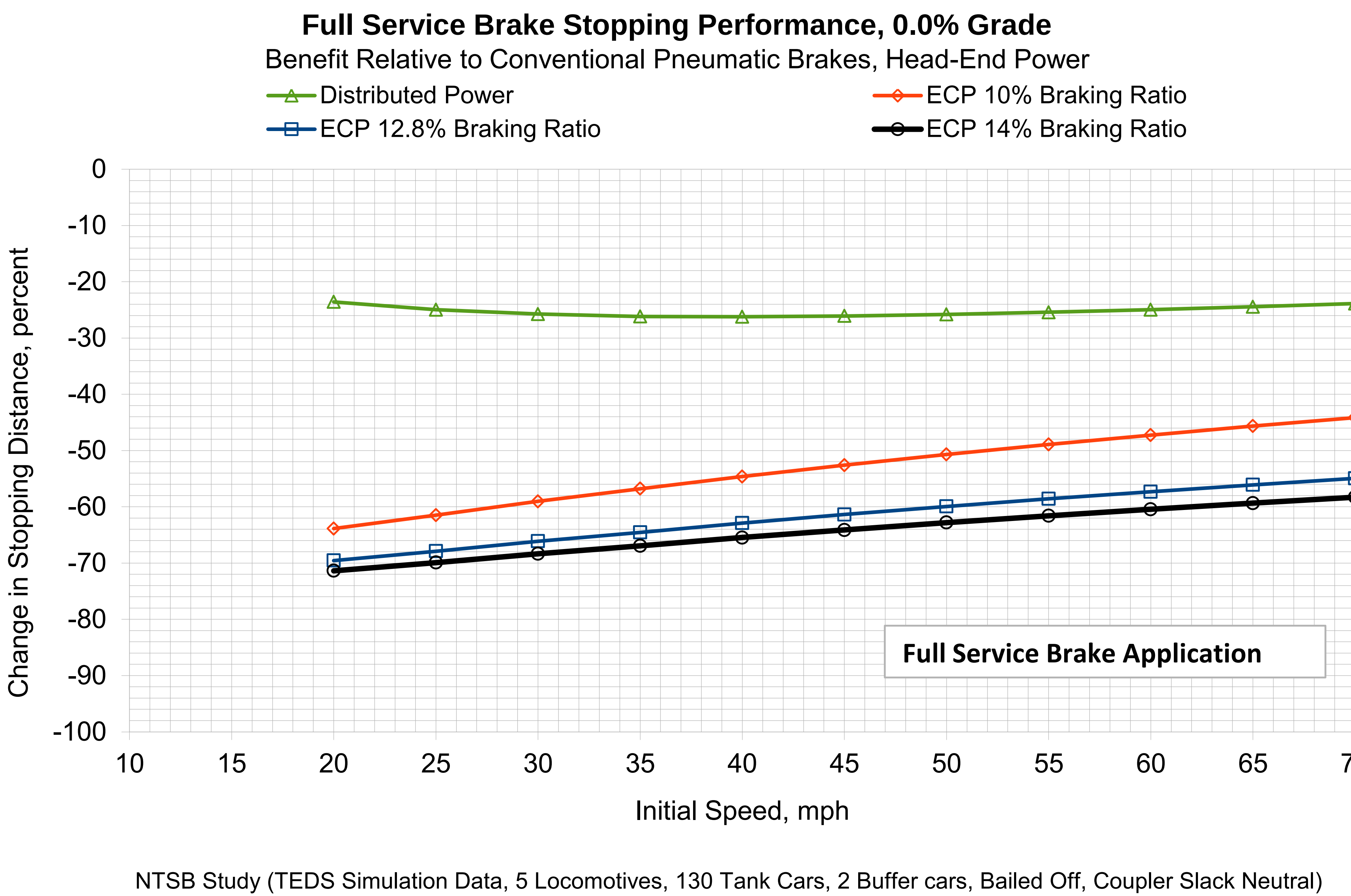
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

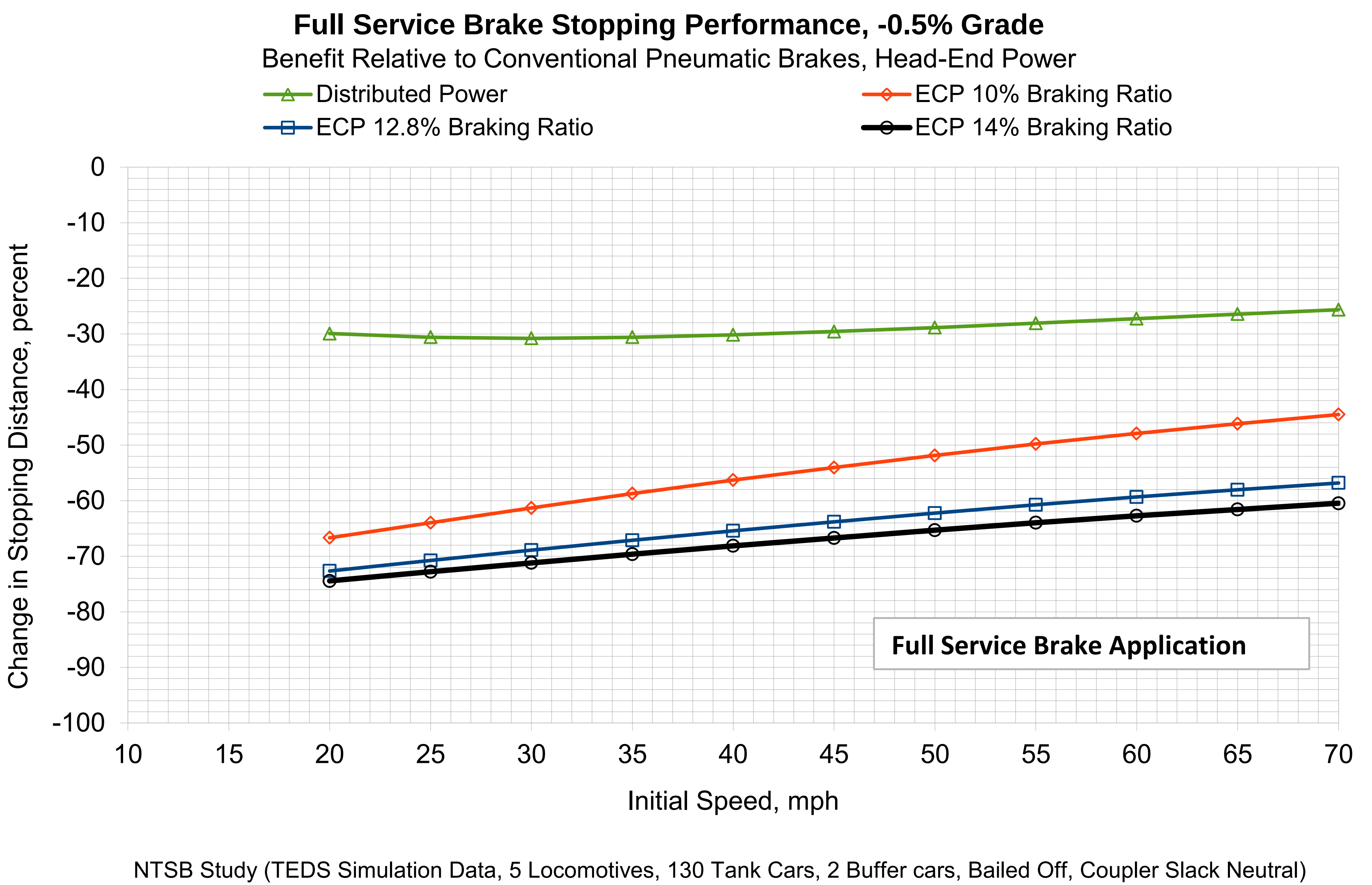


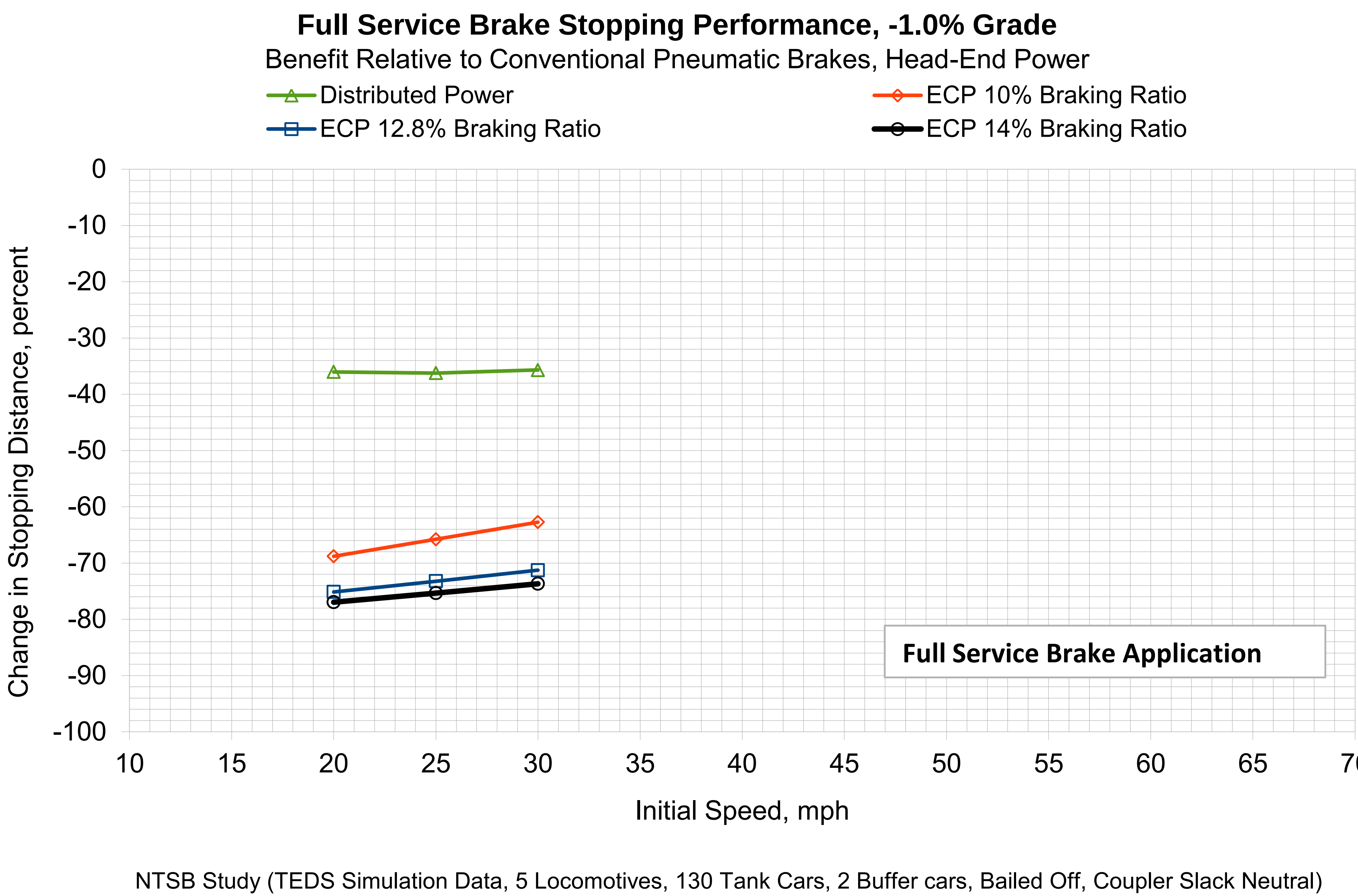
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



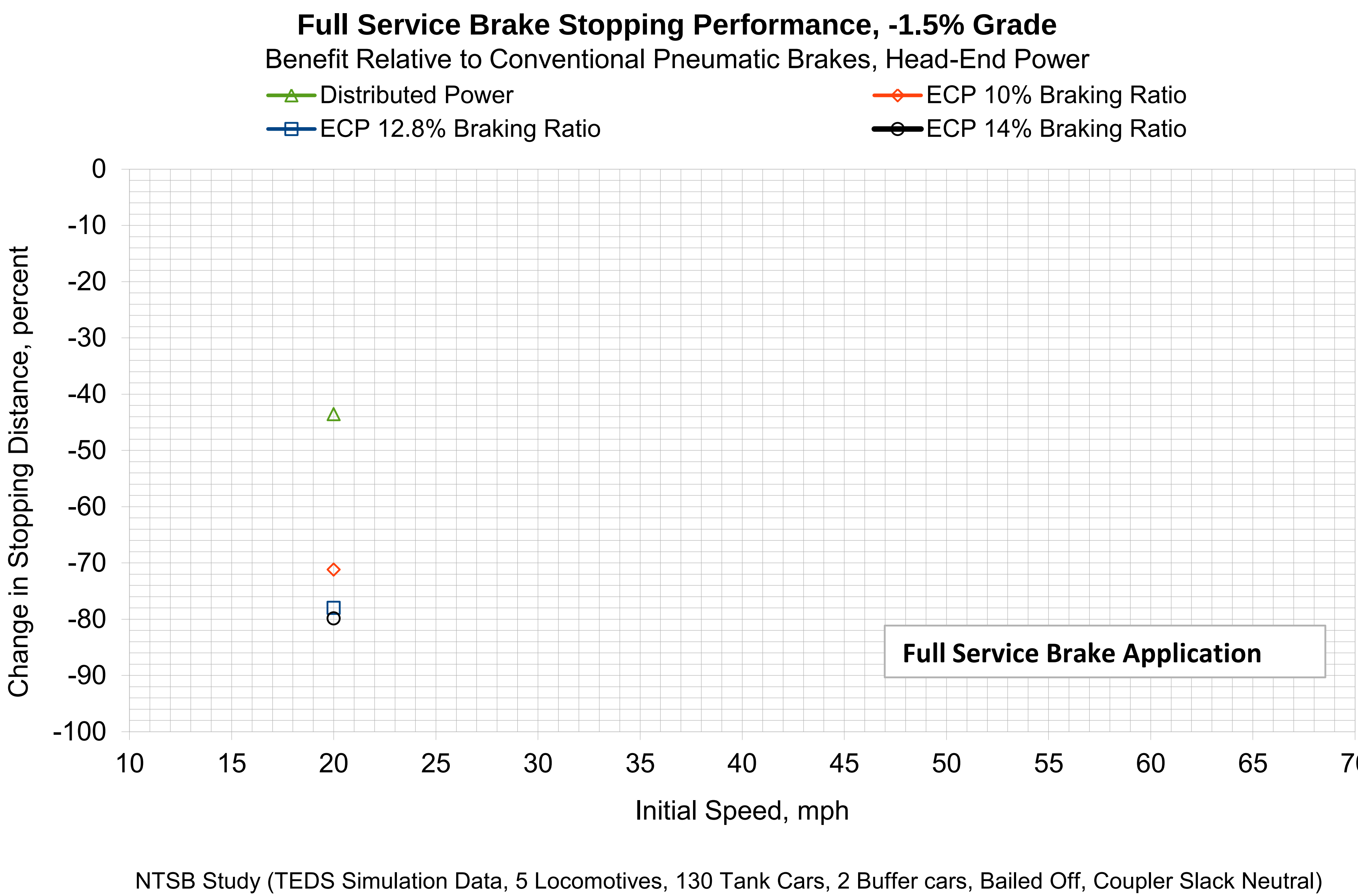
Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

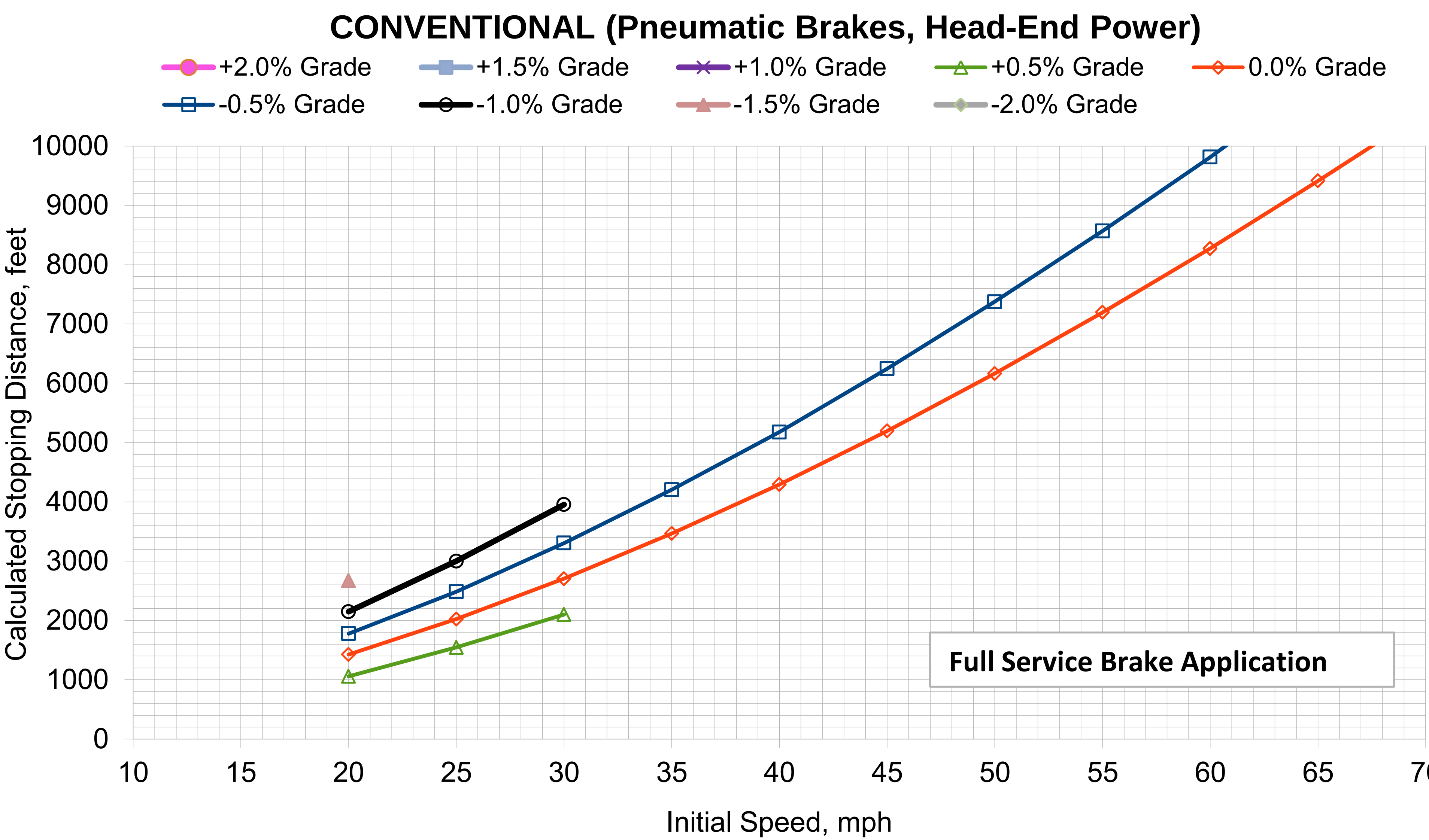
A20.8


Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

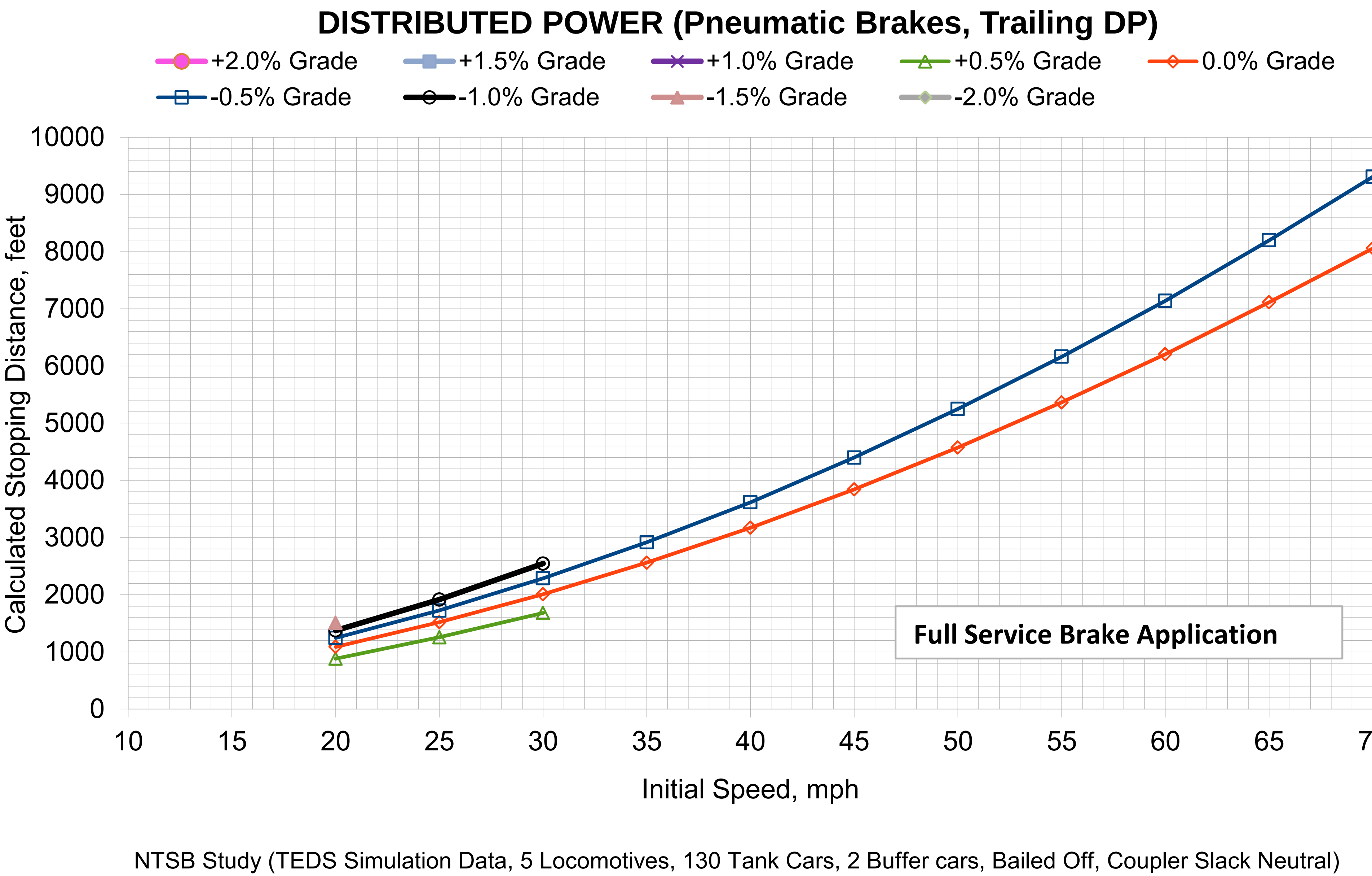


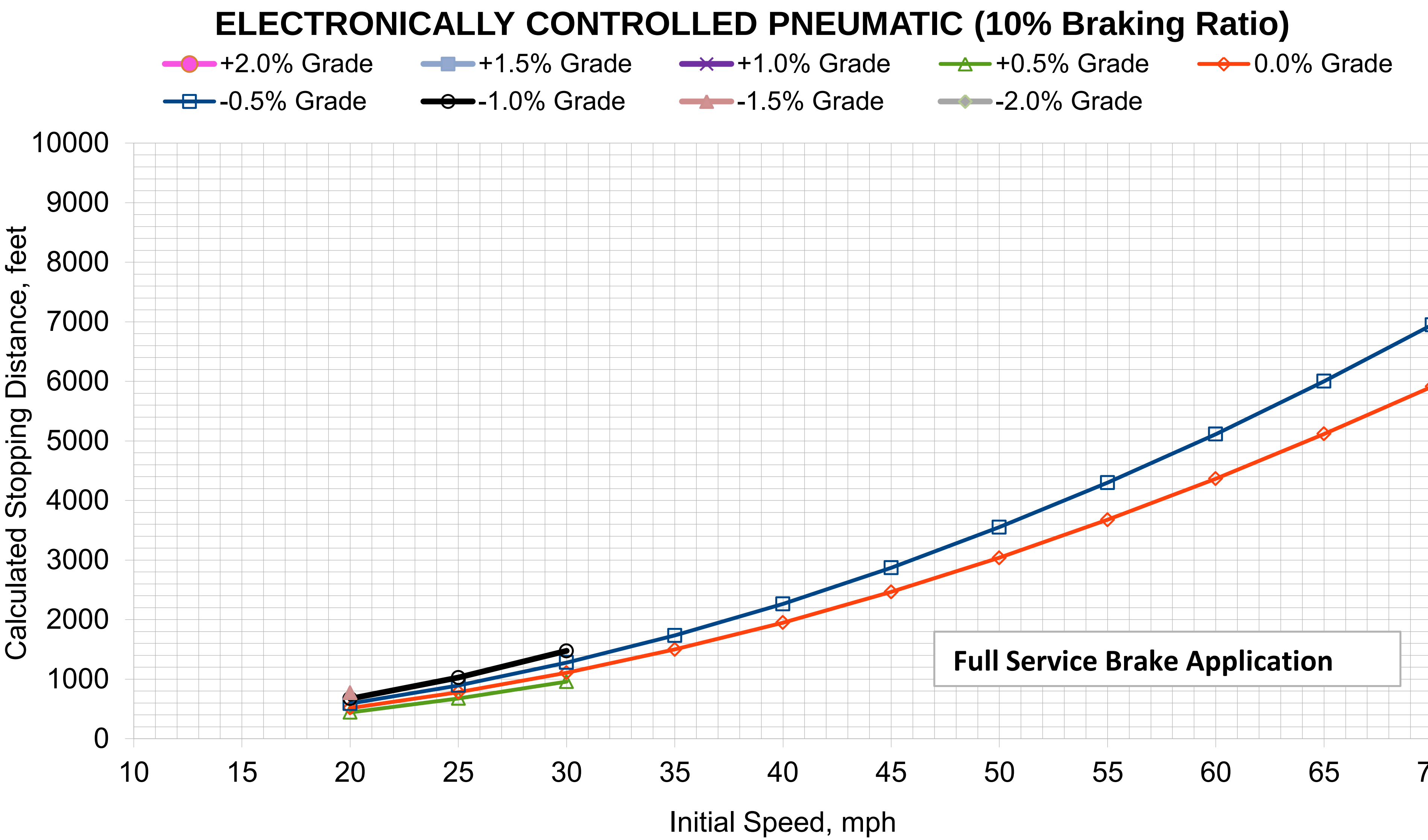
Full Service Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


Full Service Brake Stopping Performance, -1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

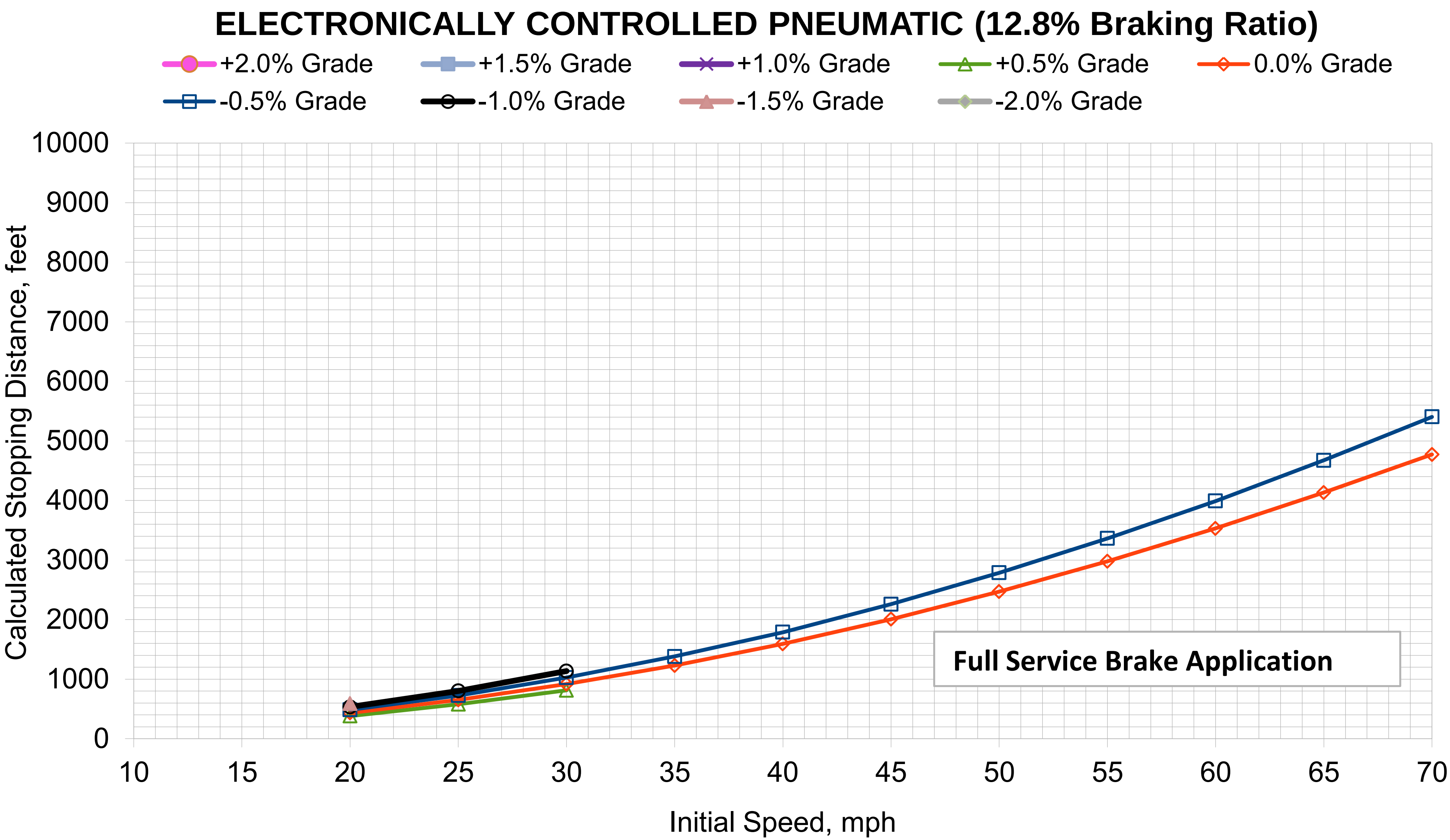


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

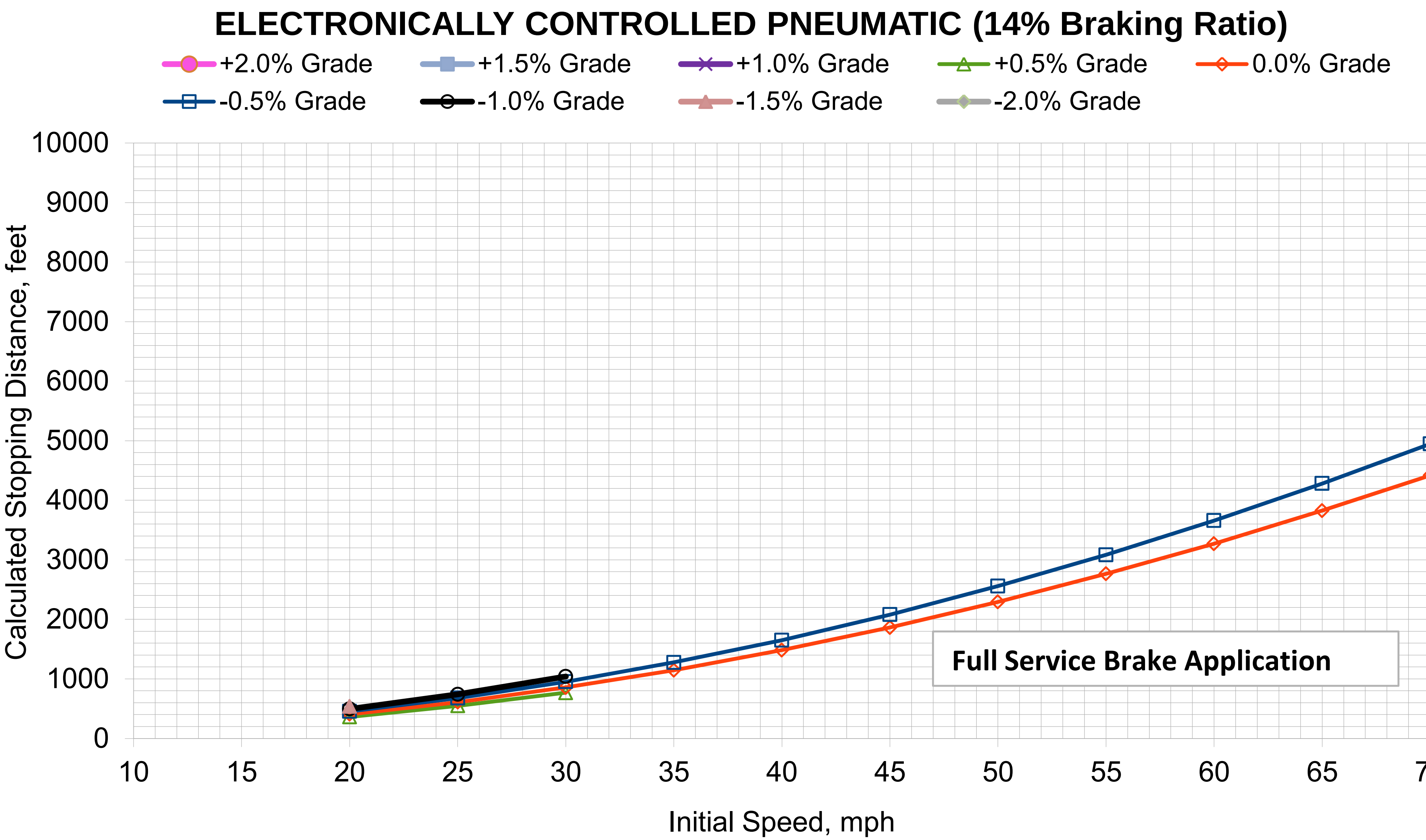

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



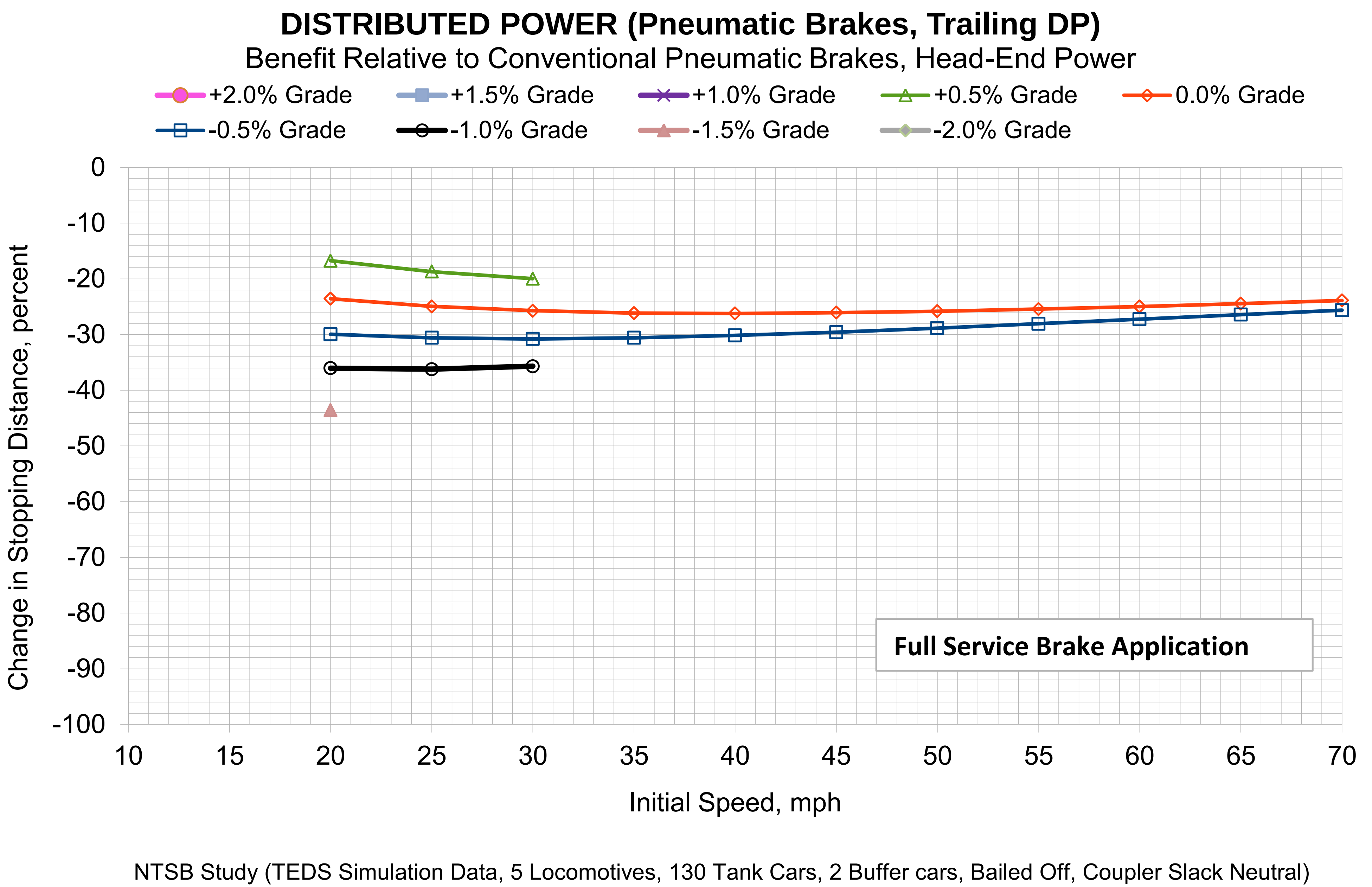
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

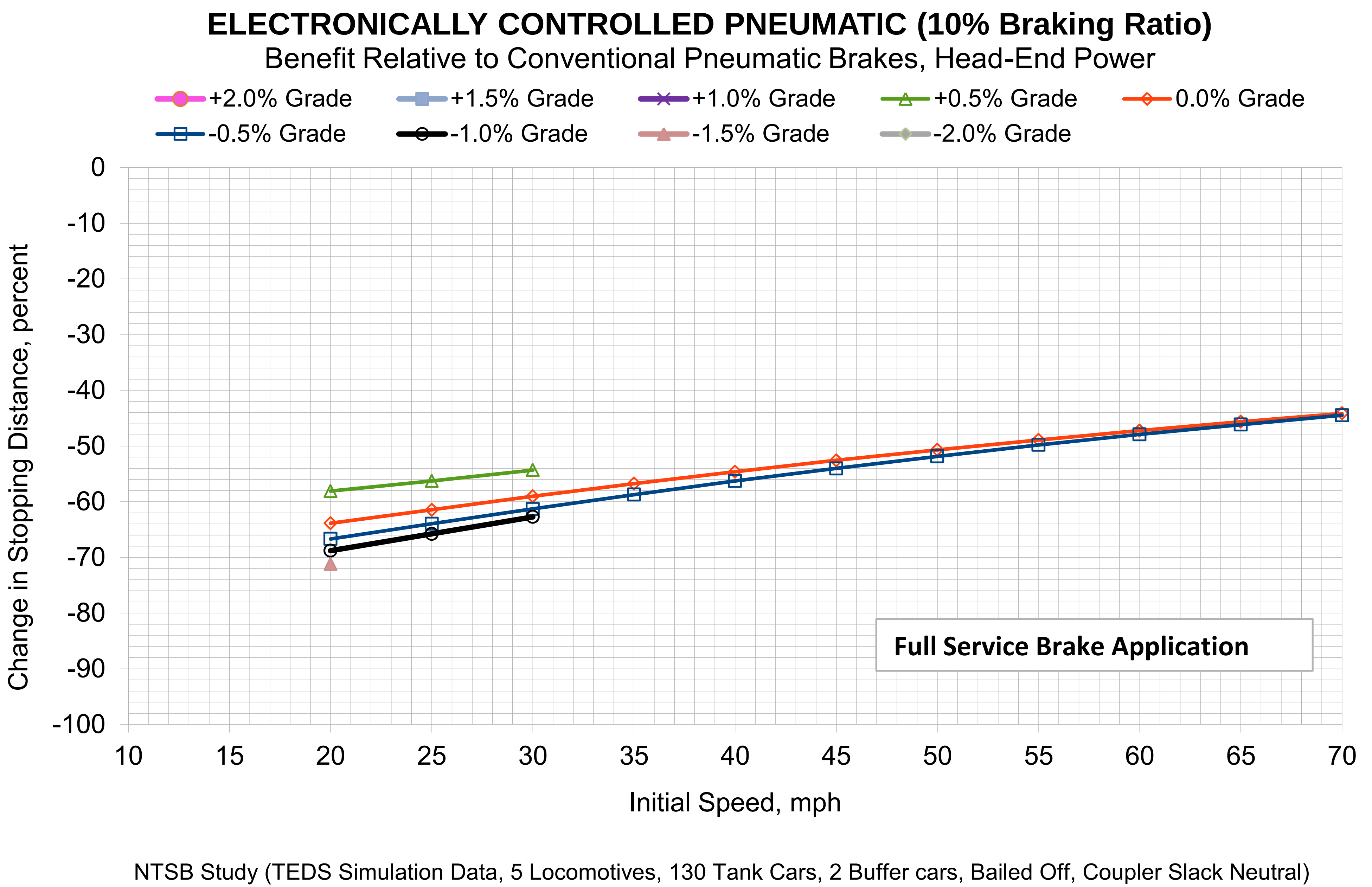


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

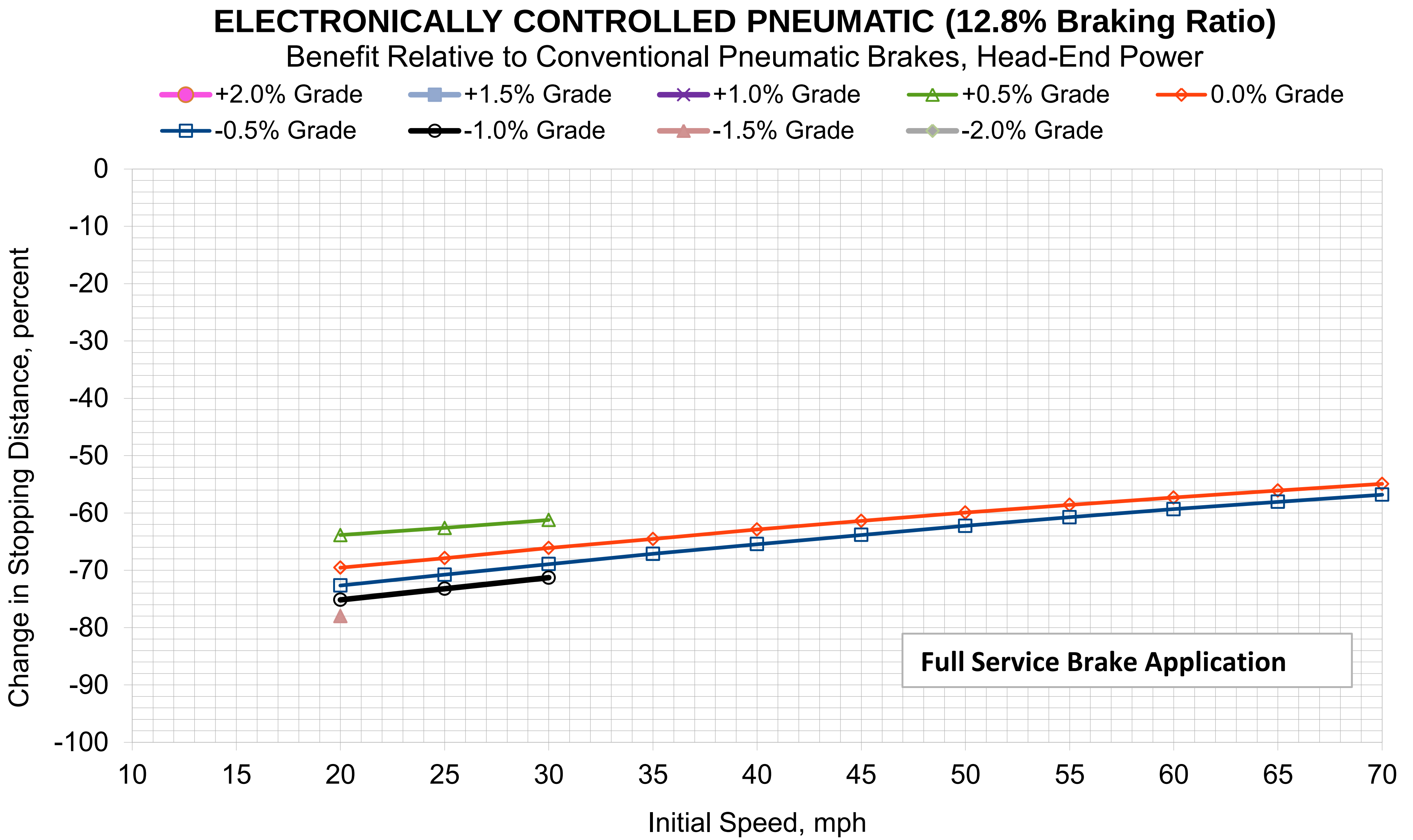


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

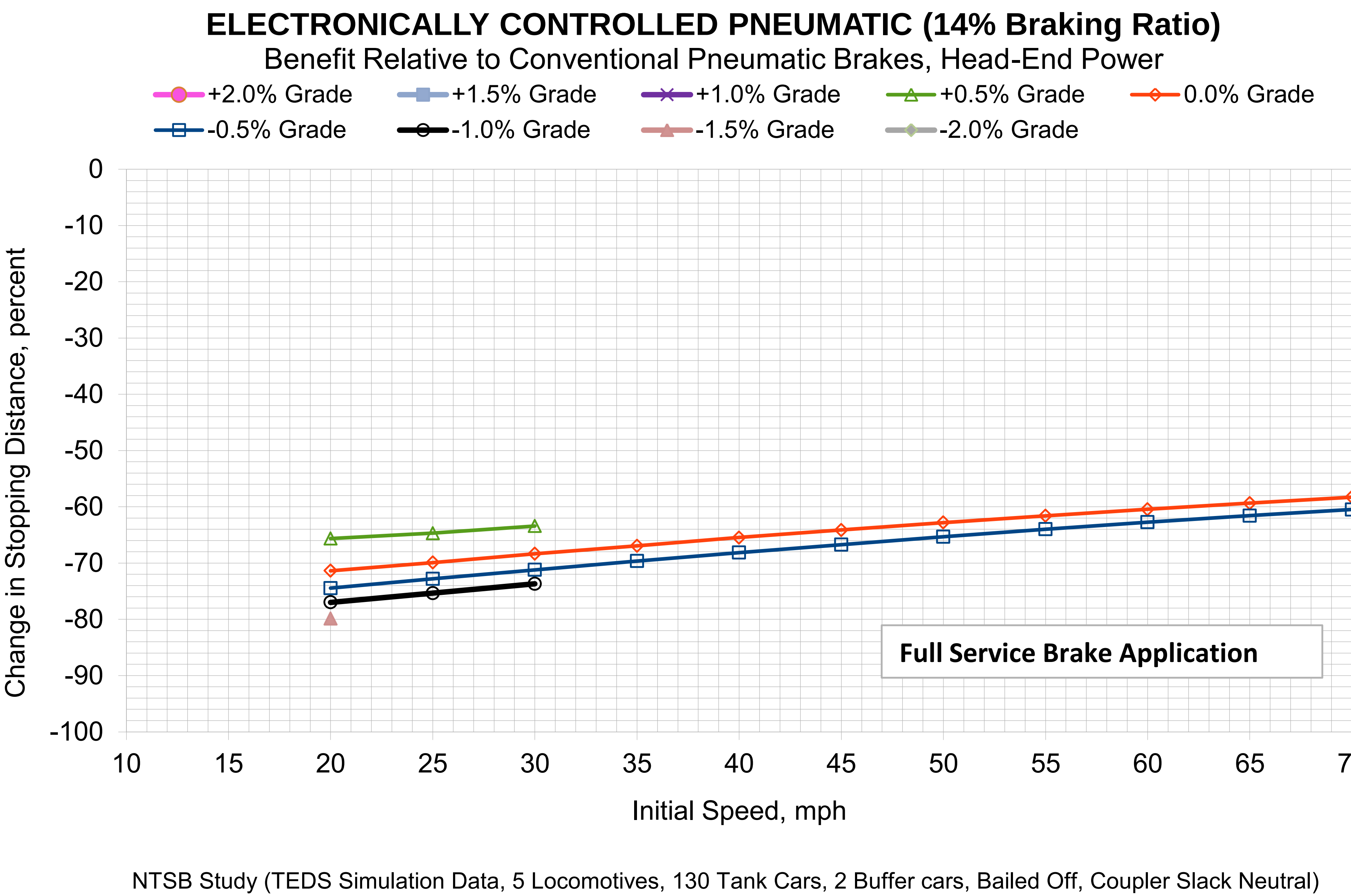

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

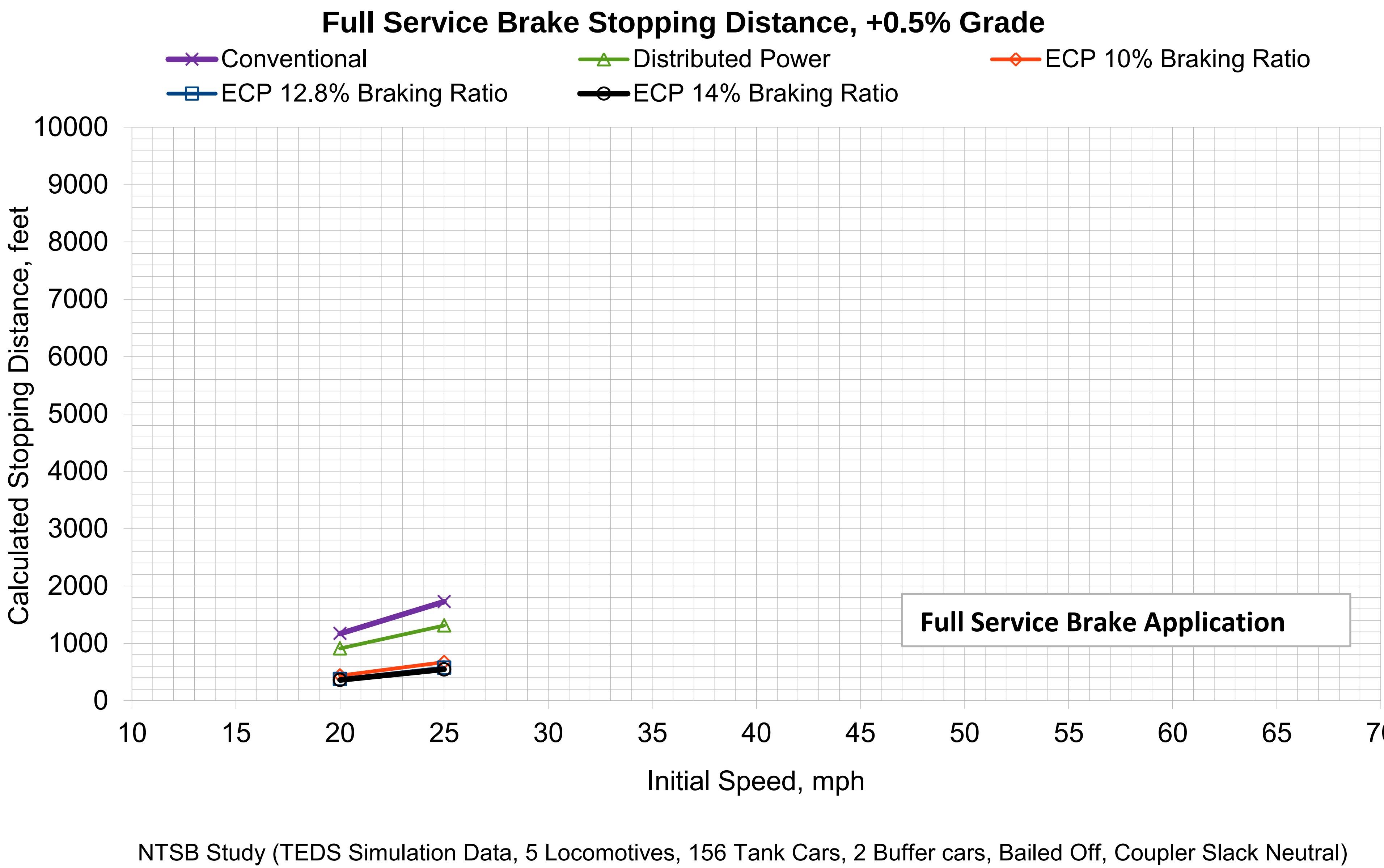


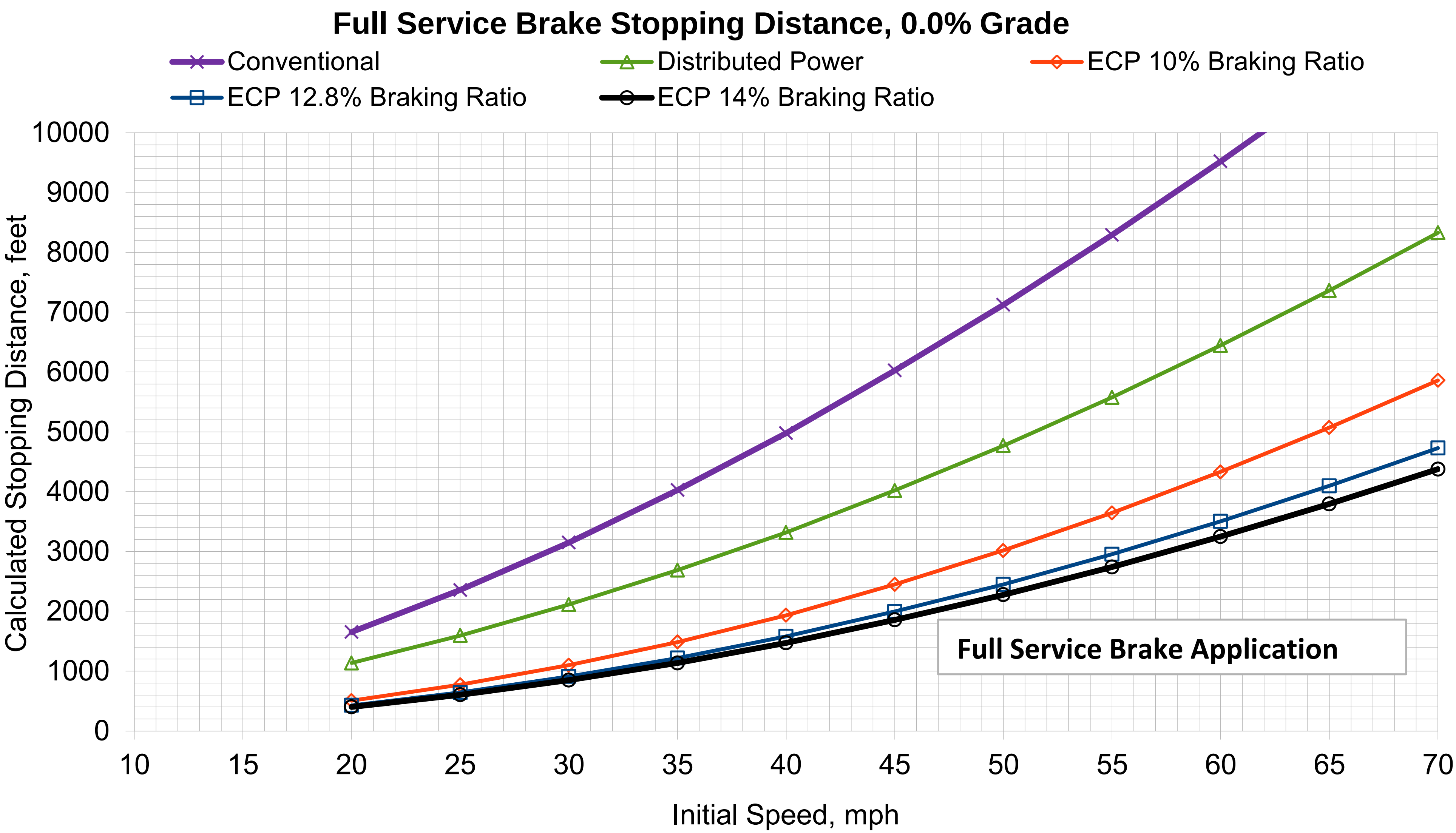
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

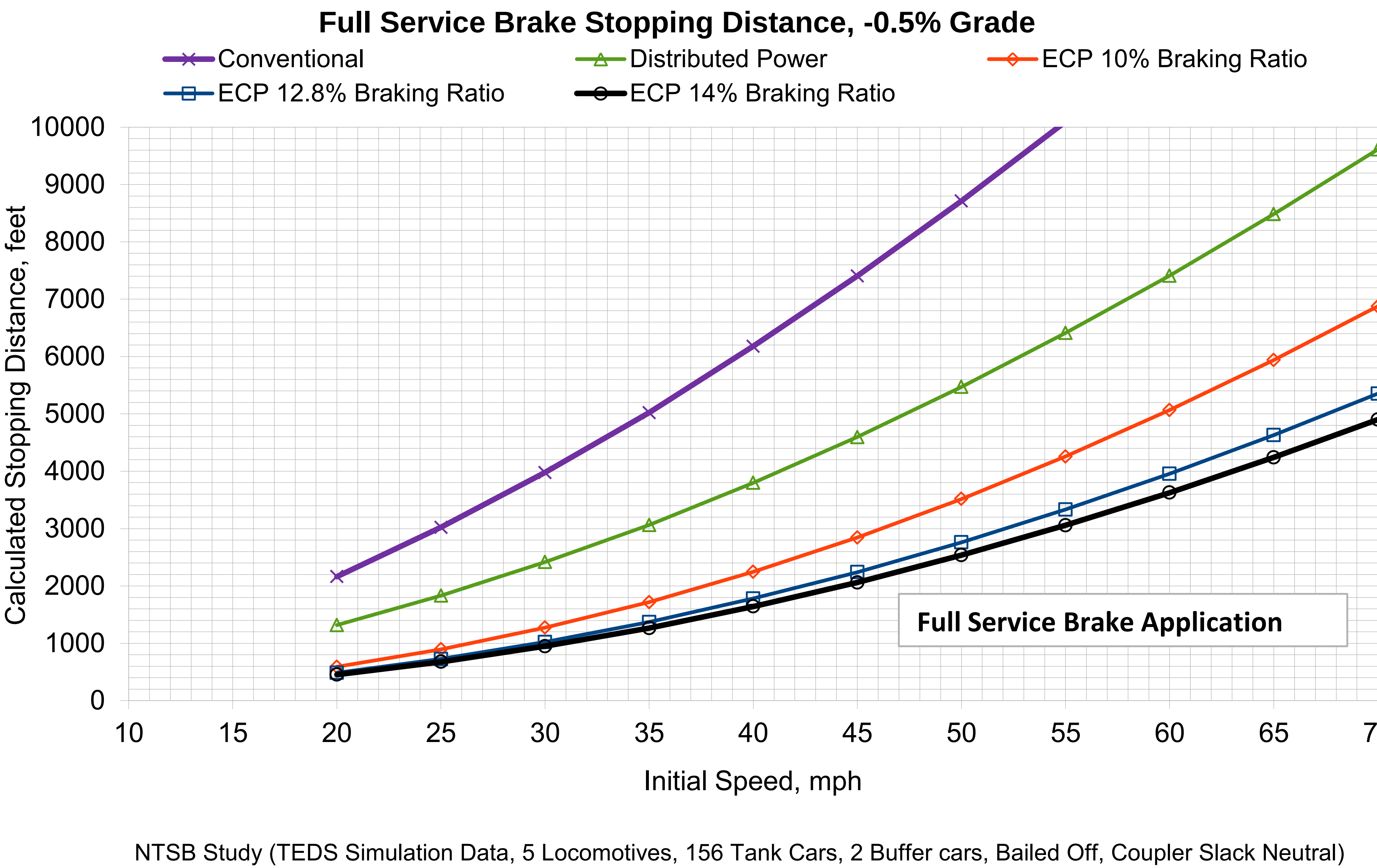
A20.20

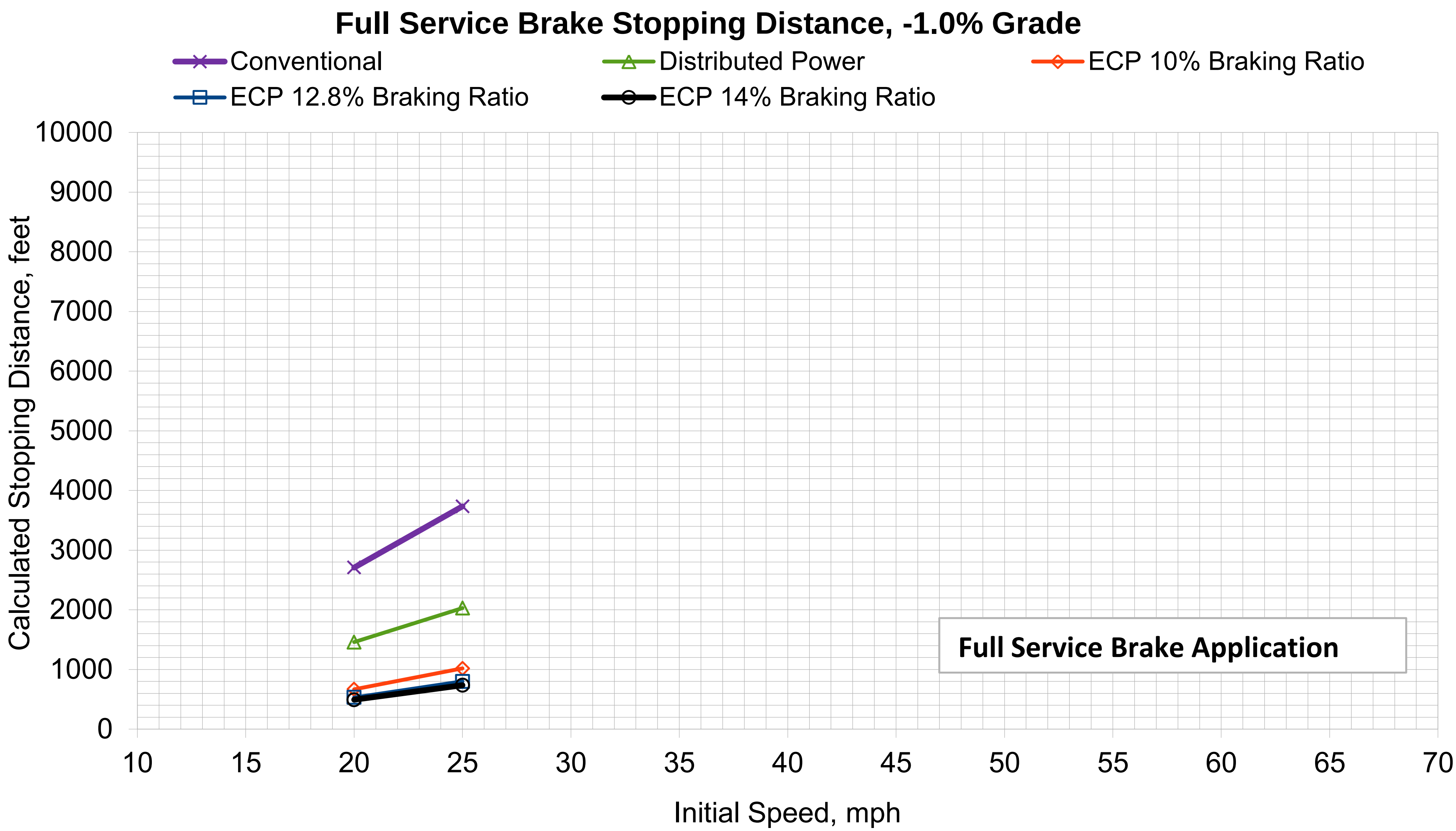
Attachment 21: Full Service Braking, Bailed Off, 156 Tank Cars


Full Service Brake Stopping Distance, +0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

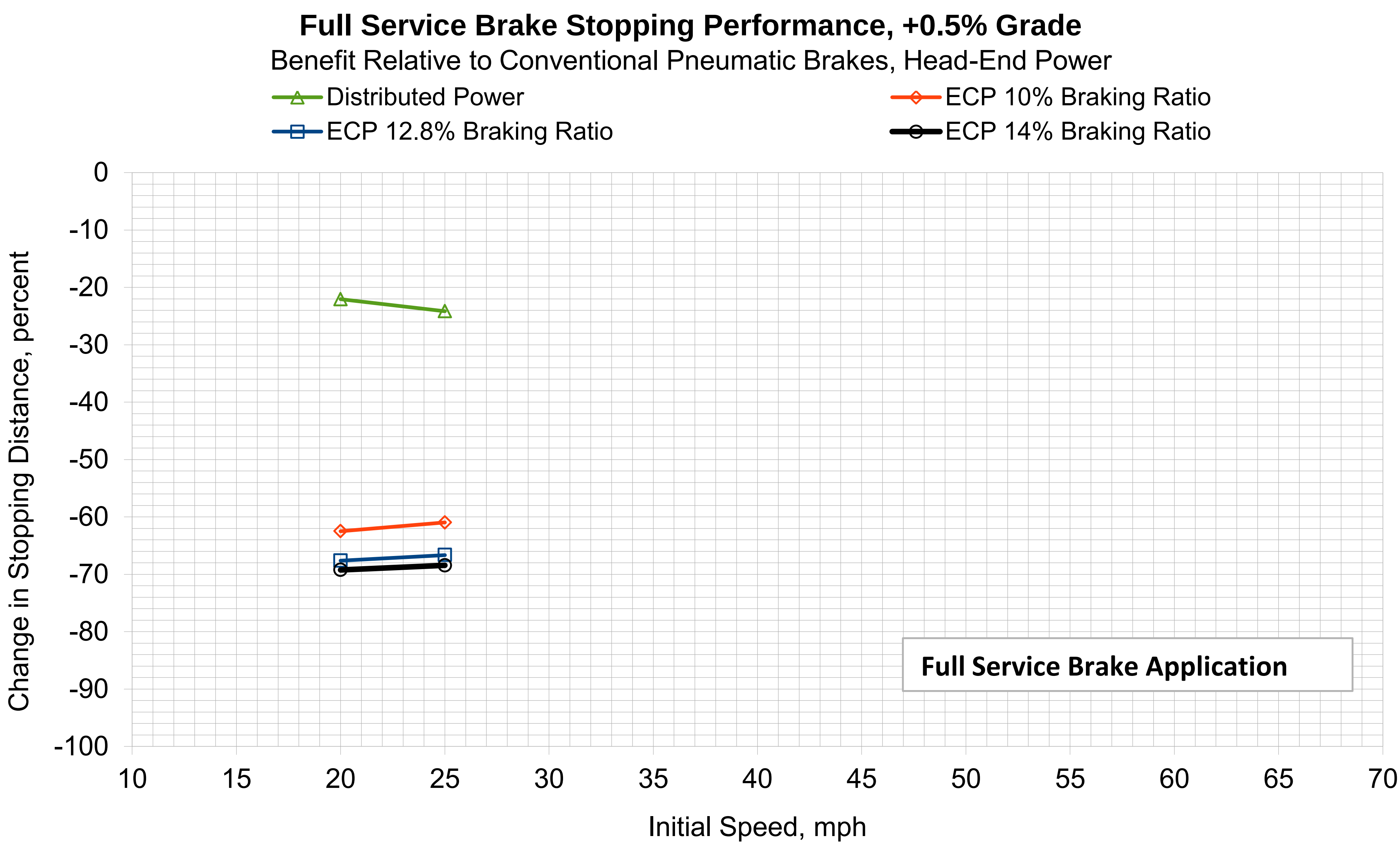


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

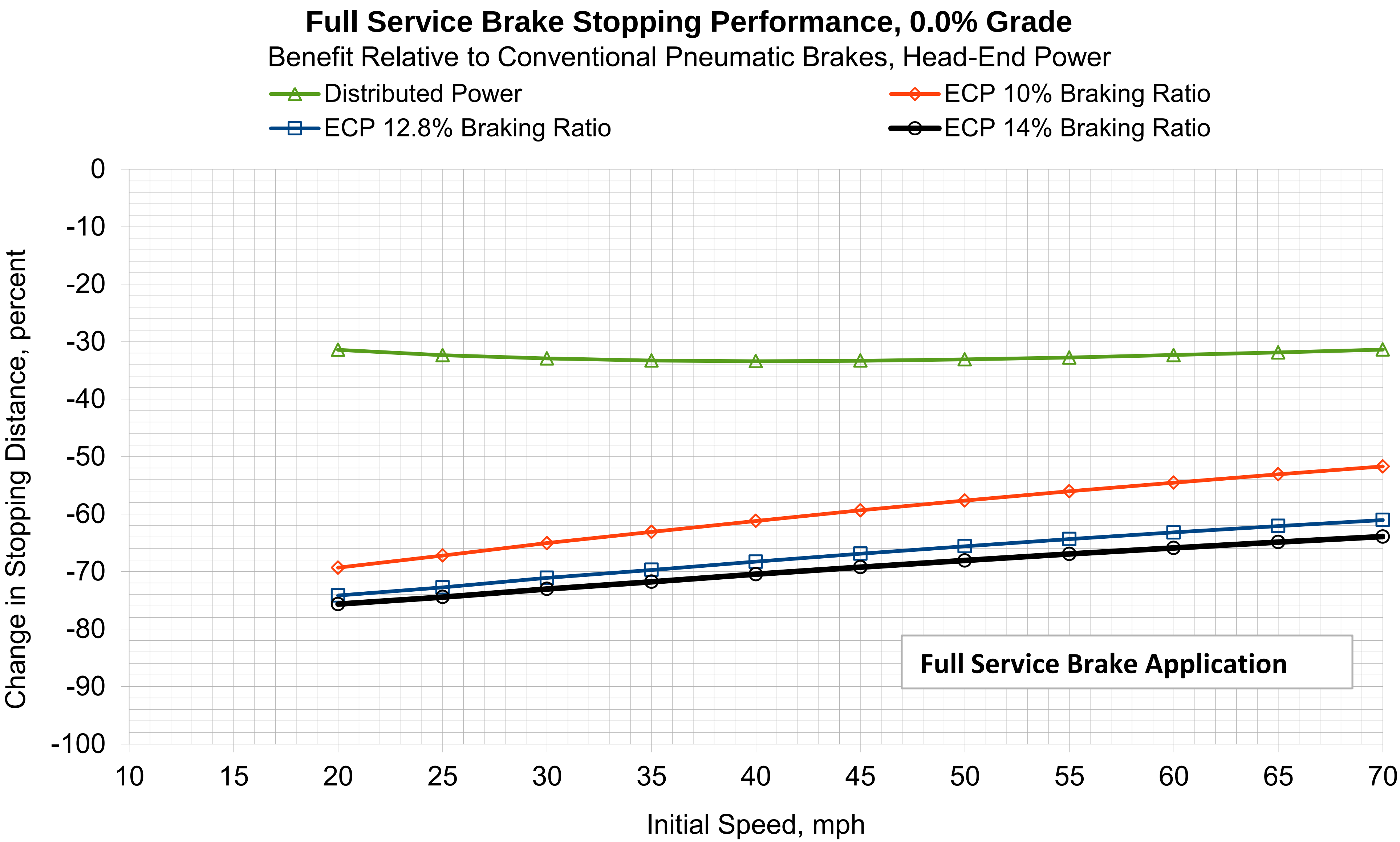

Full Service Brake Stopping Distance, -0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



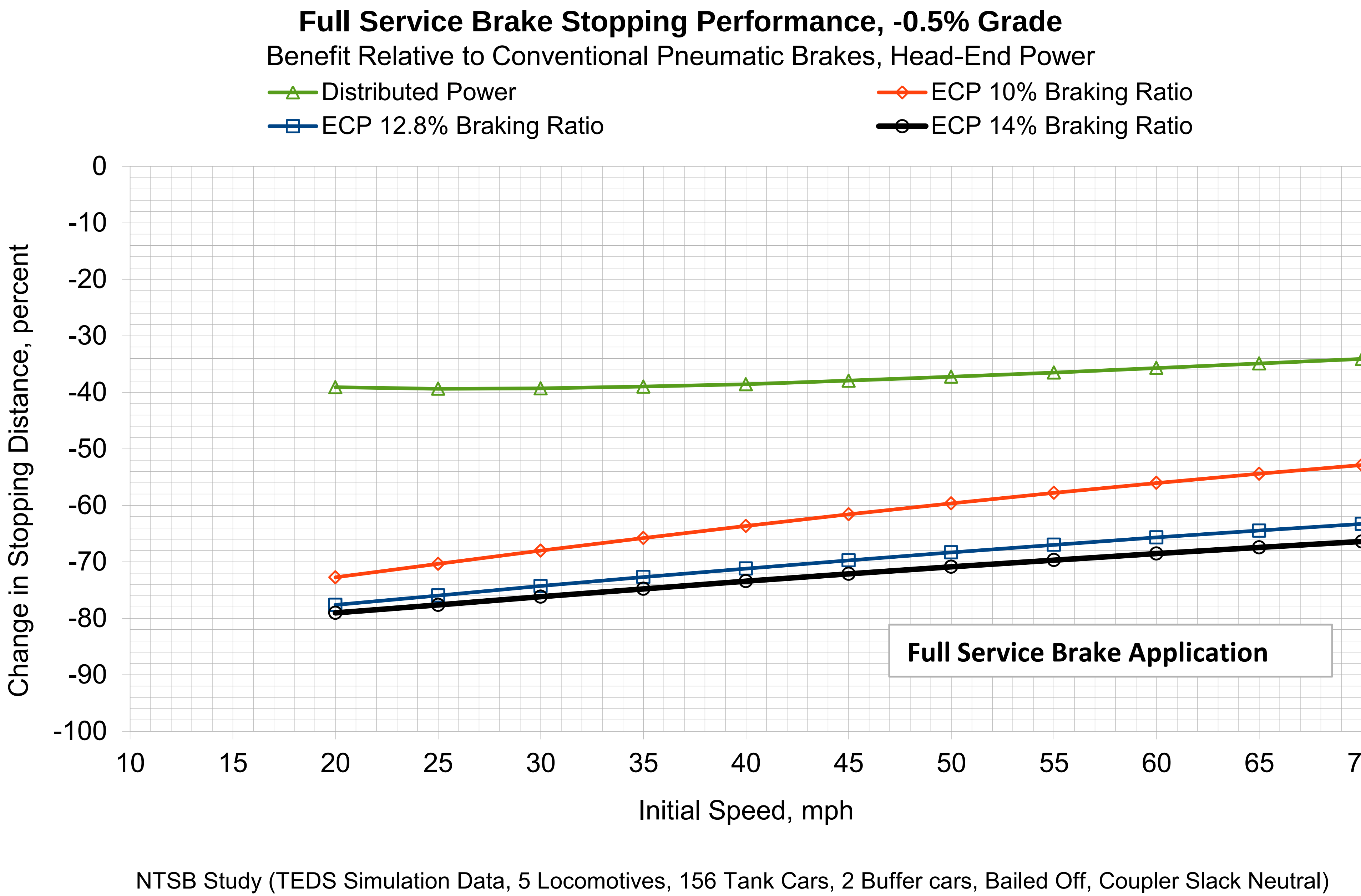
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

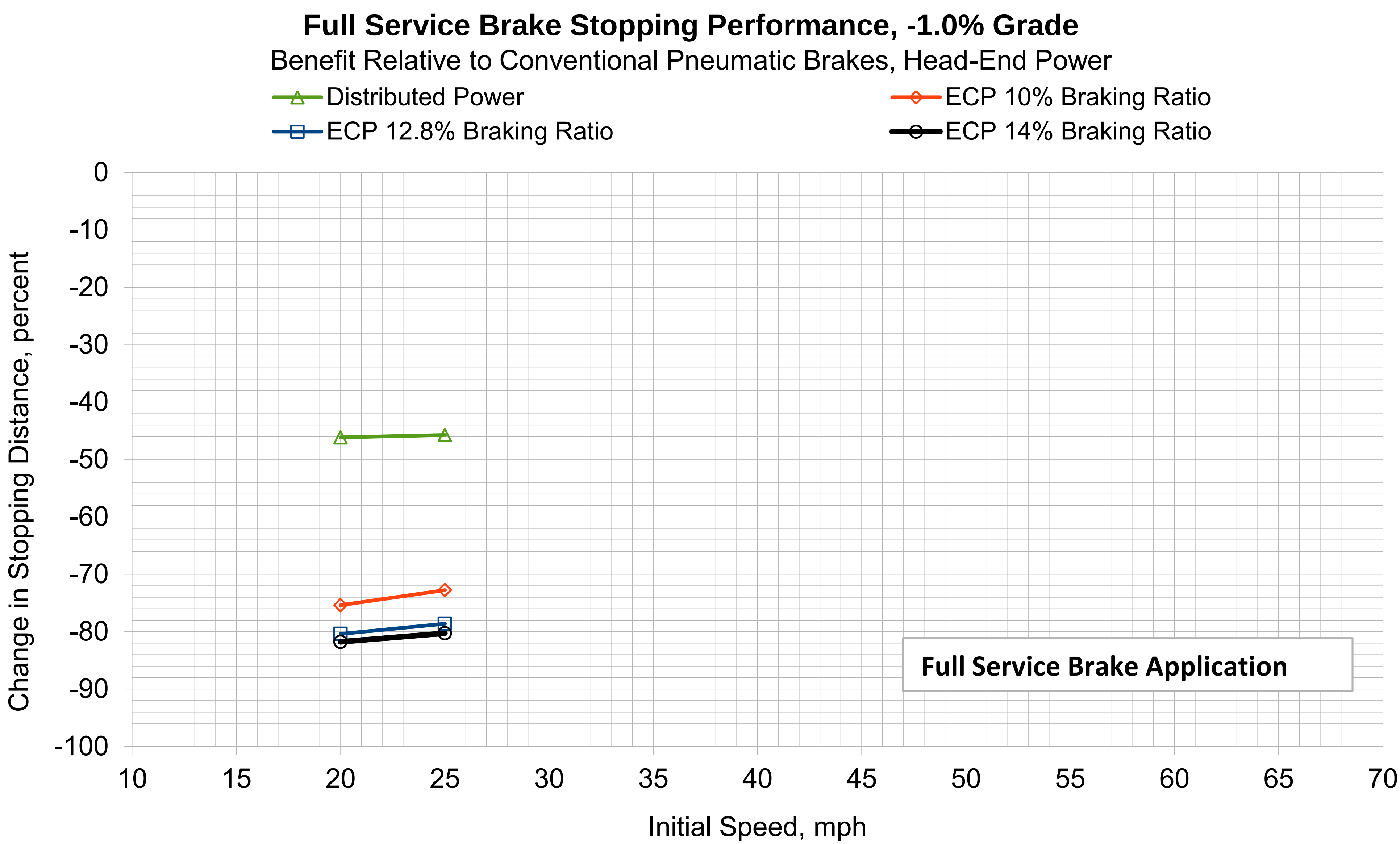


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

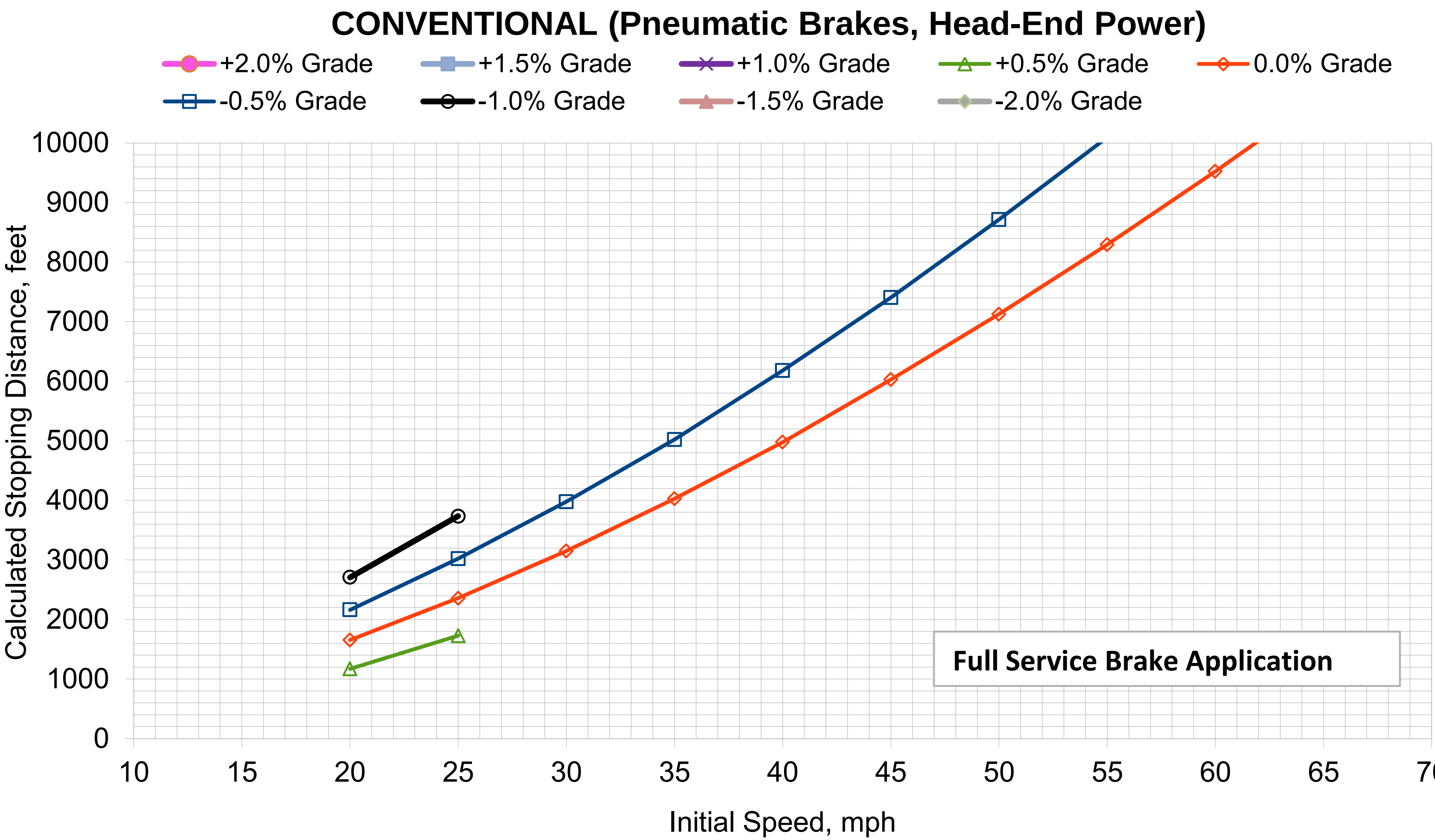


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

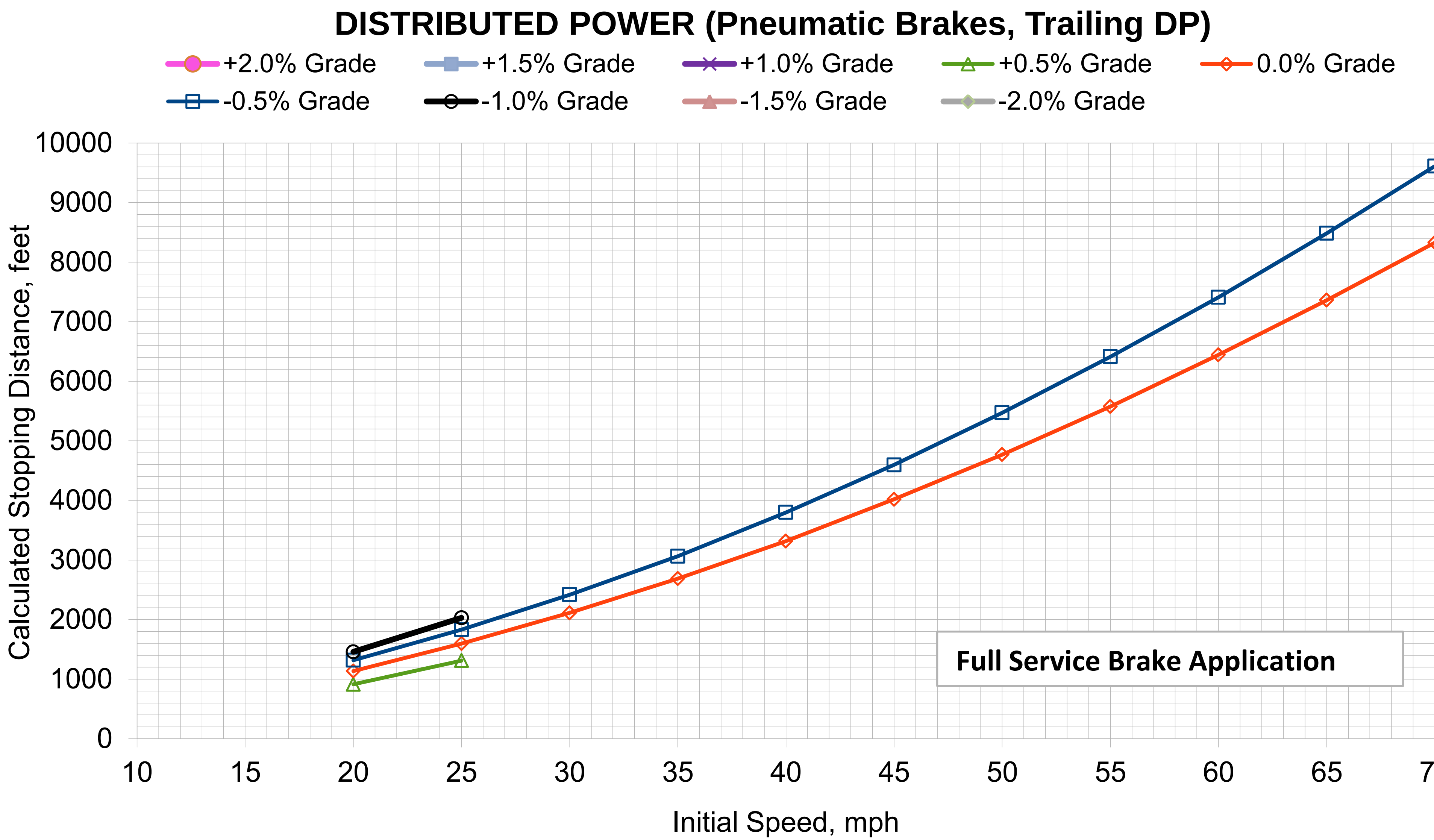

Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



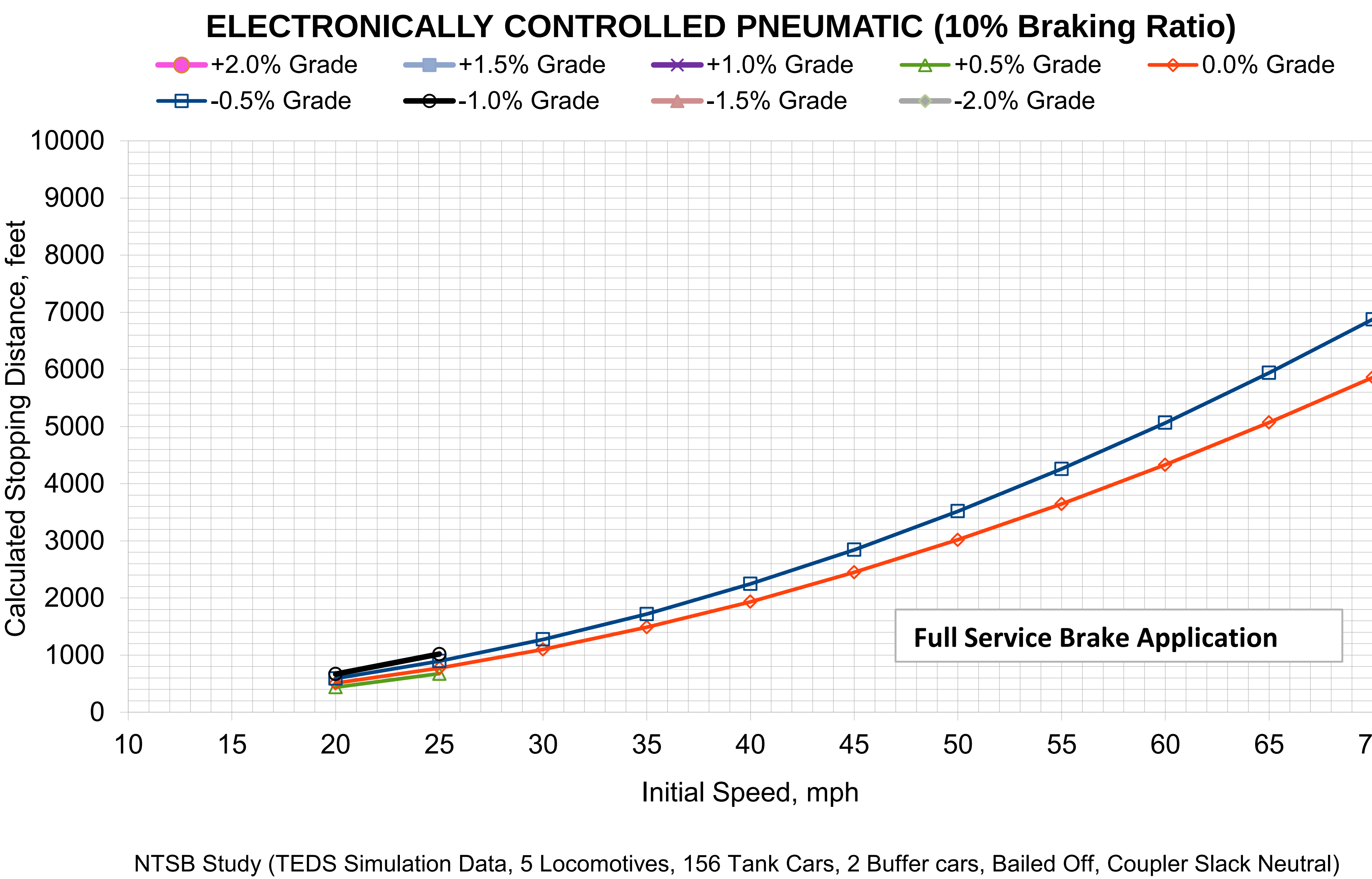
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

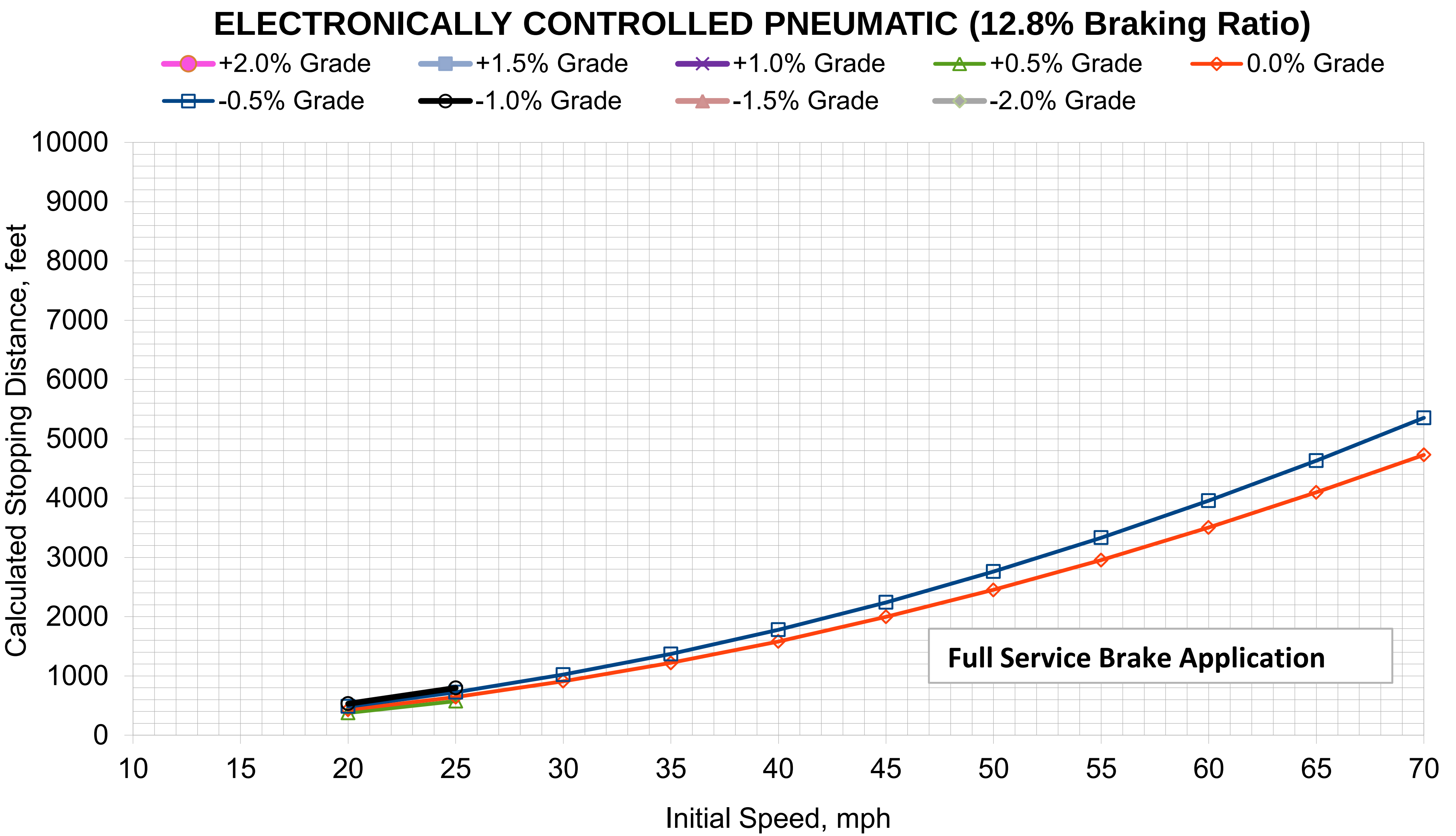


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

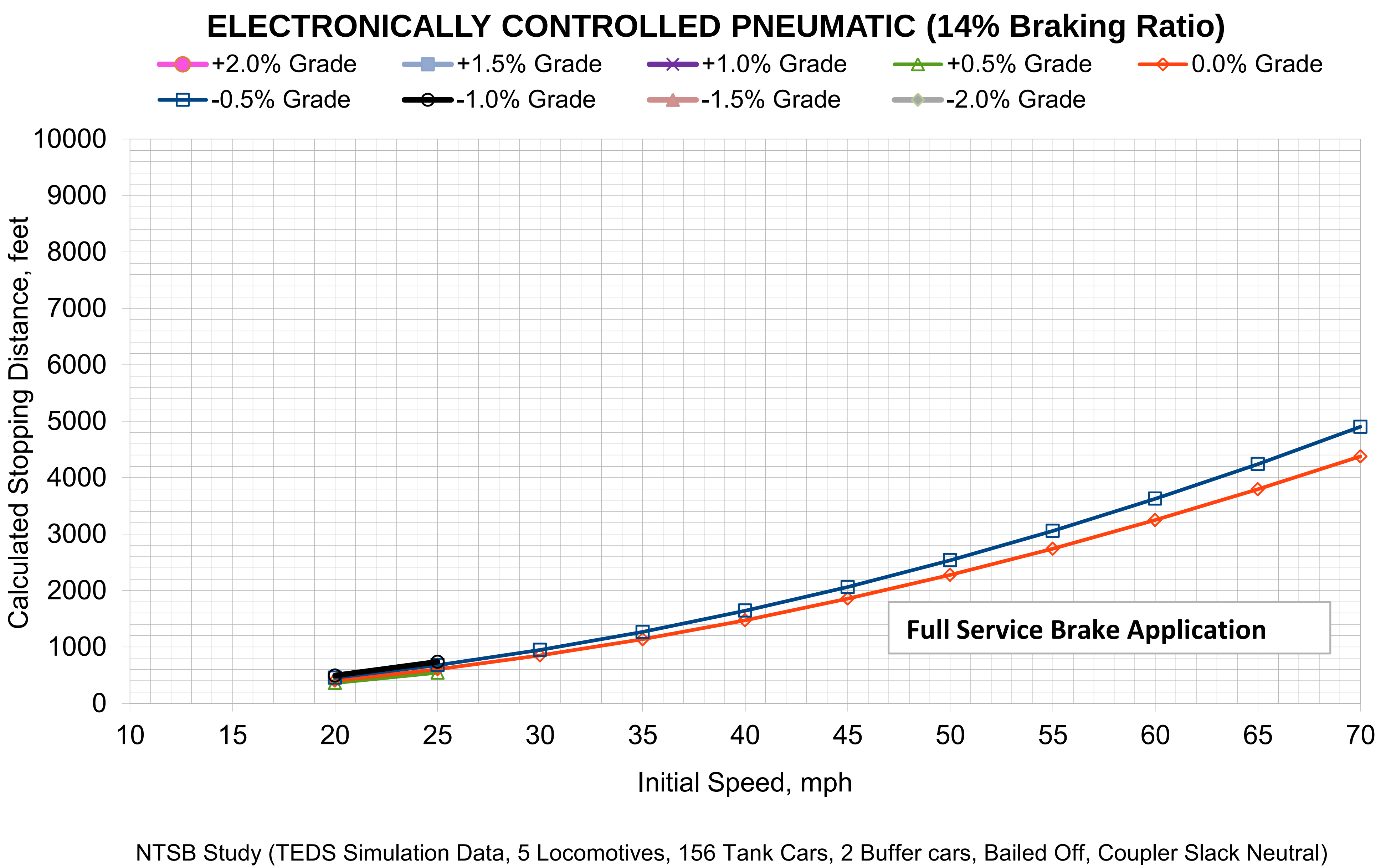


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

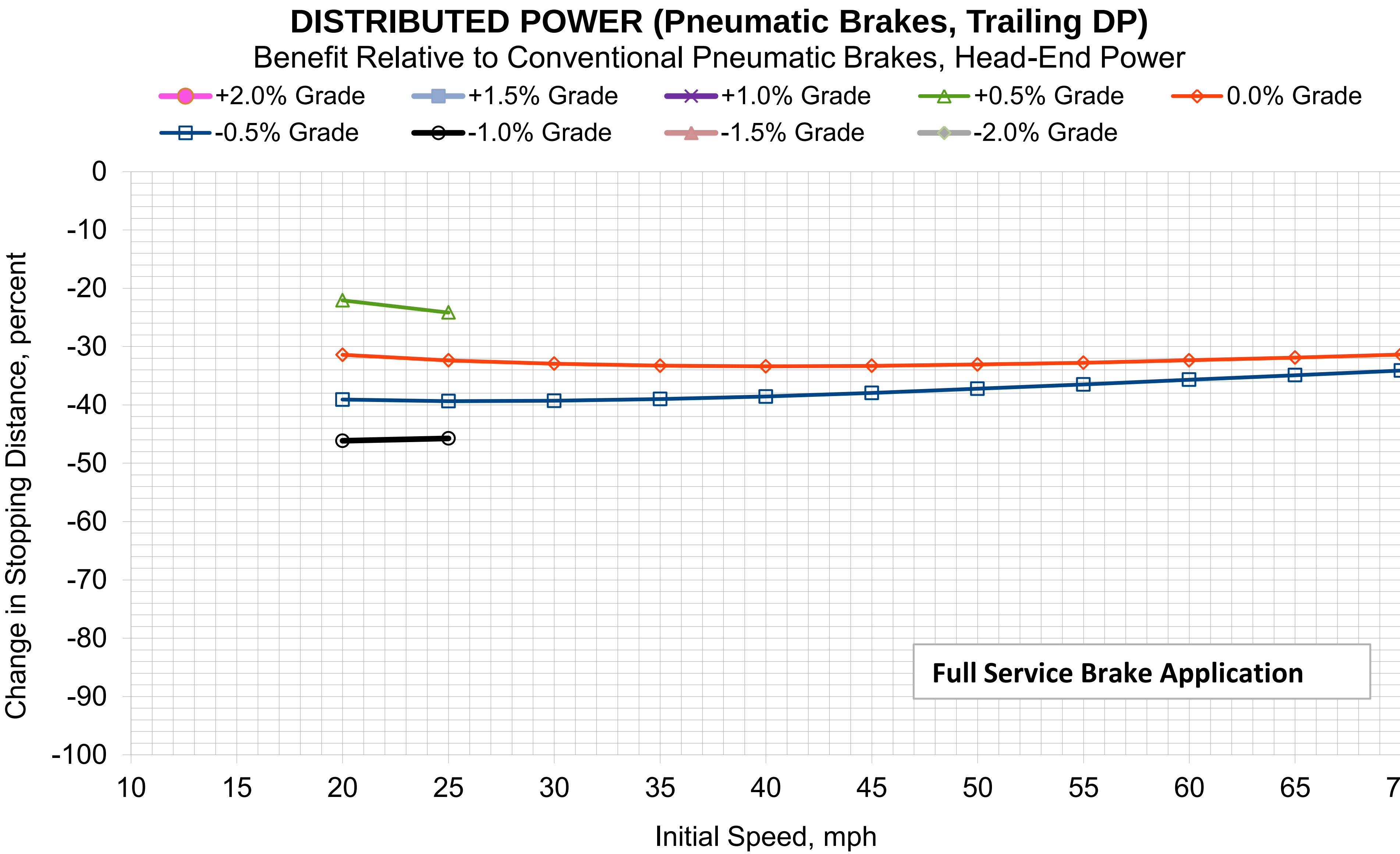

ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



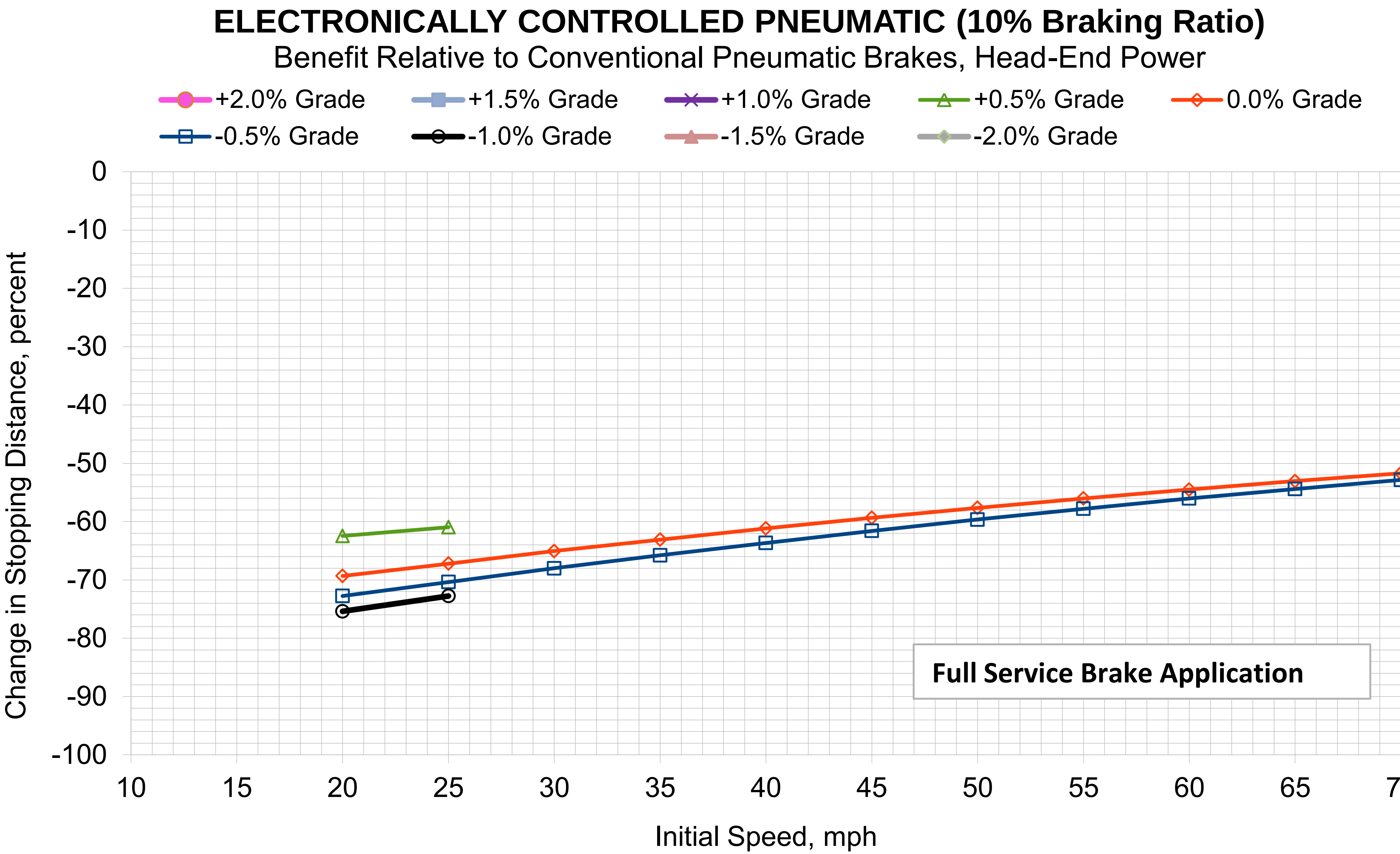
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)



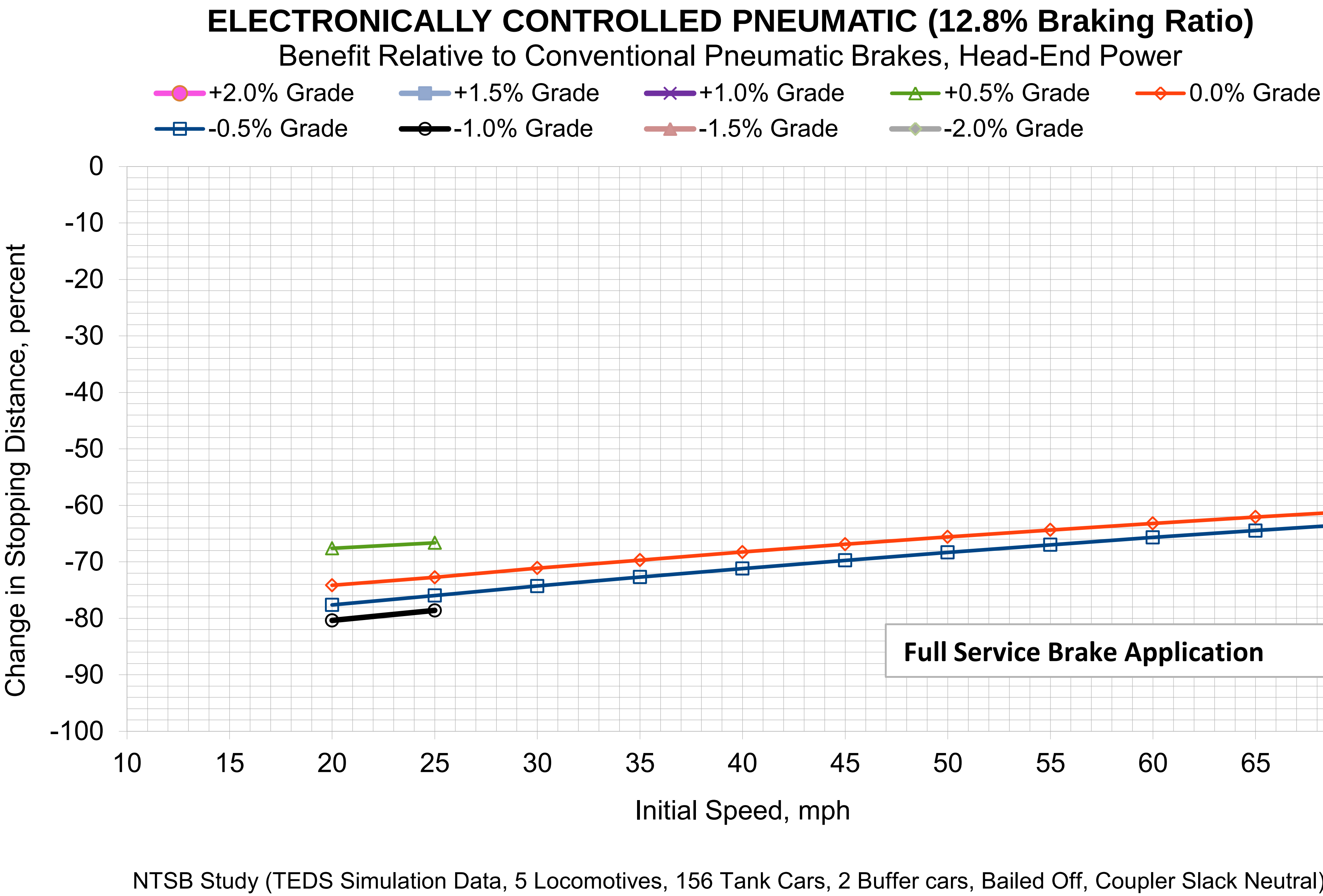
ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

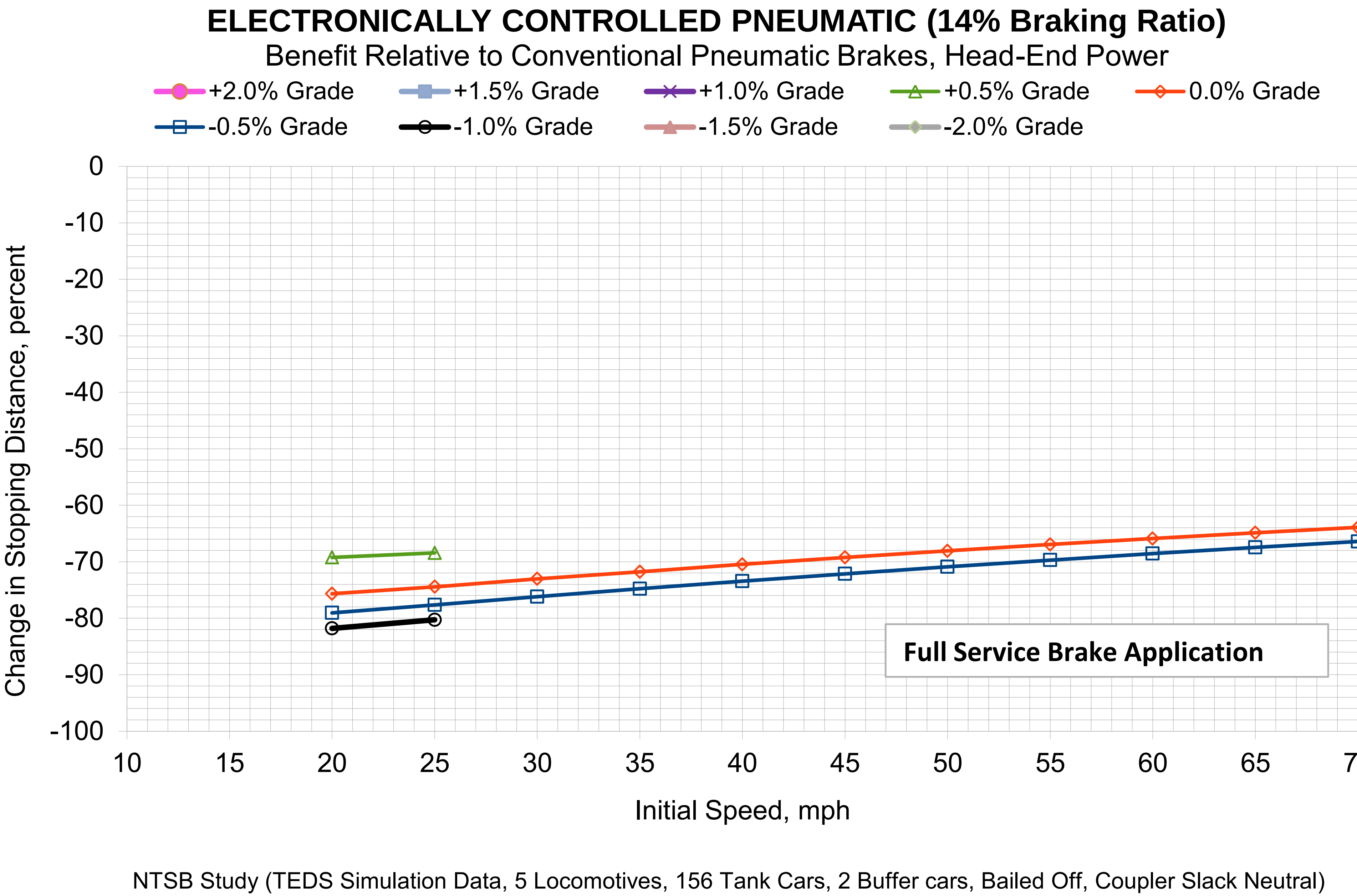


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

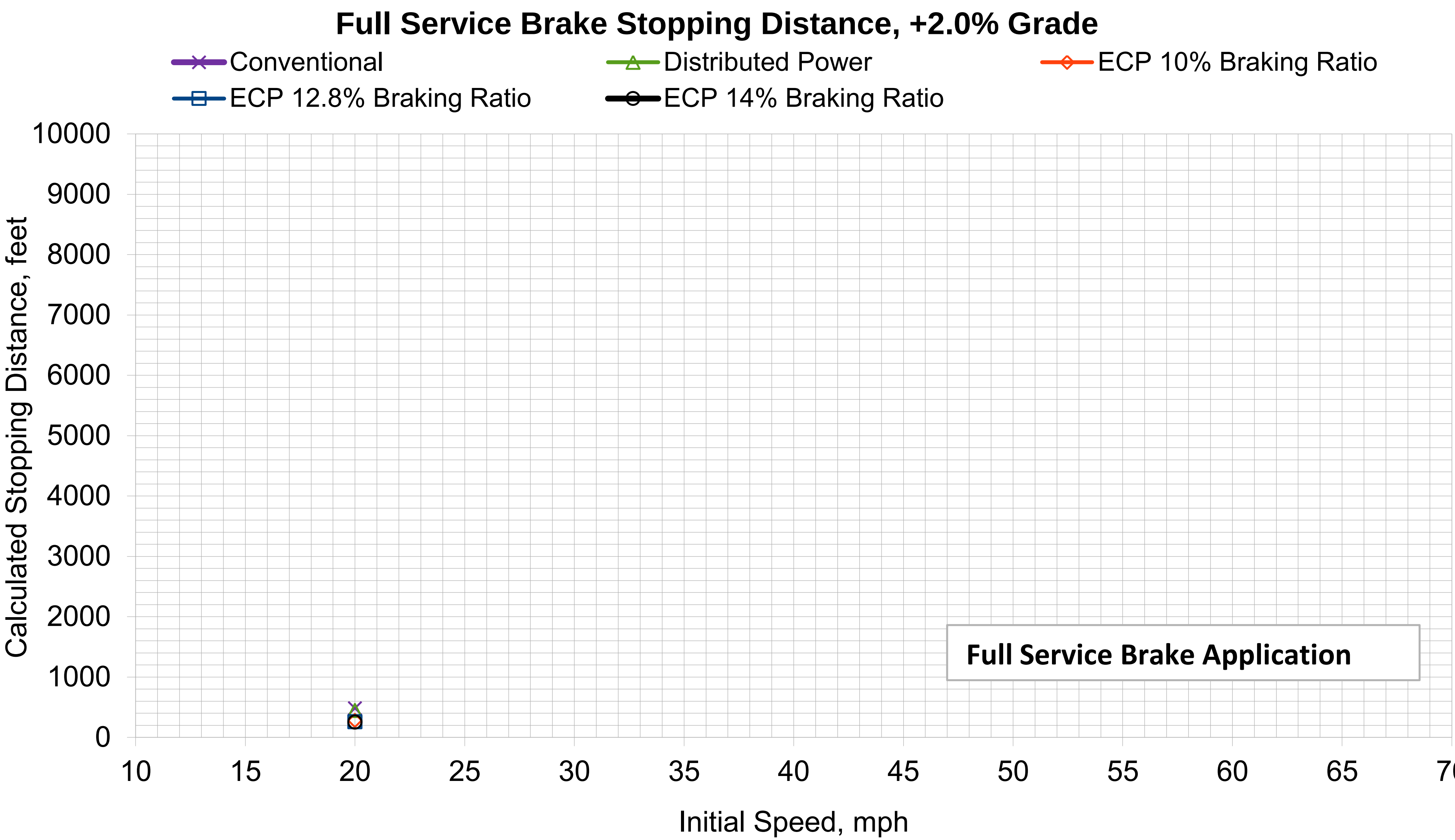


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

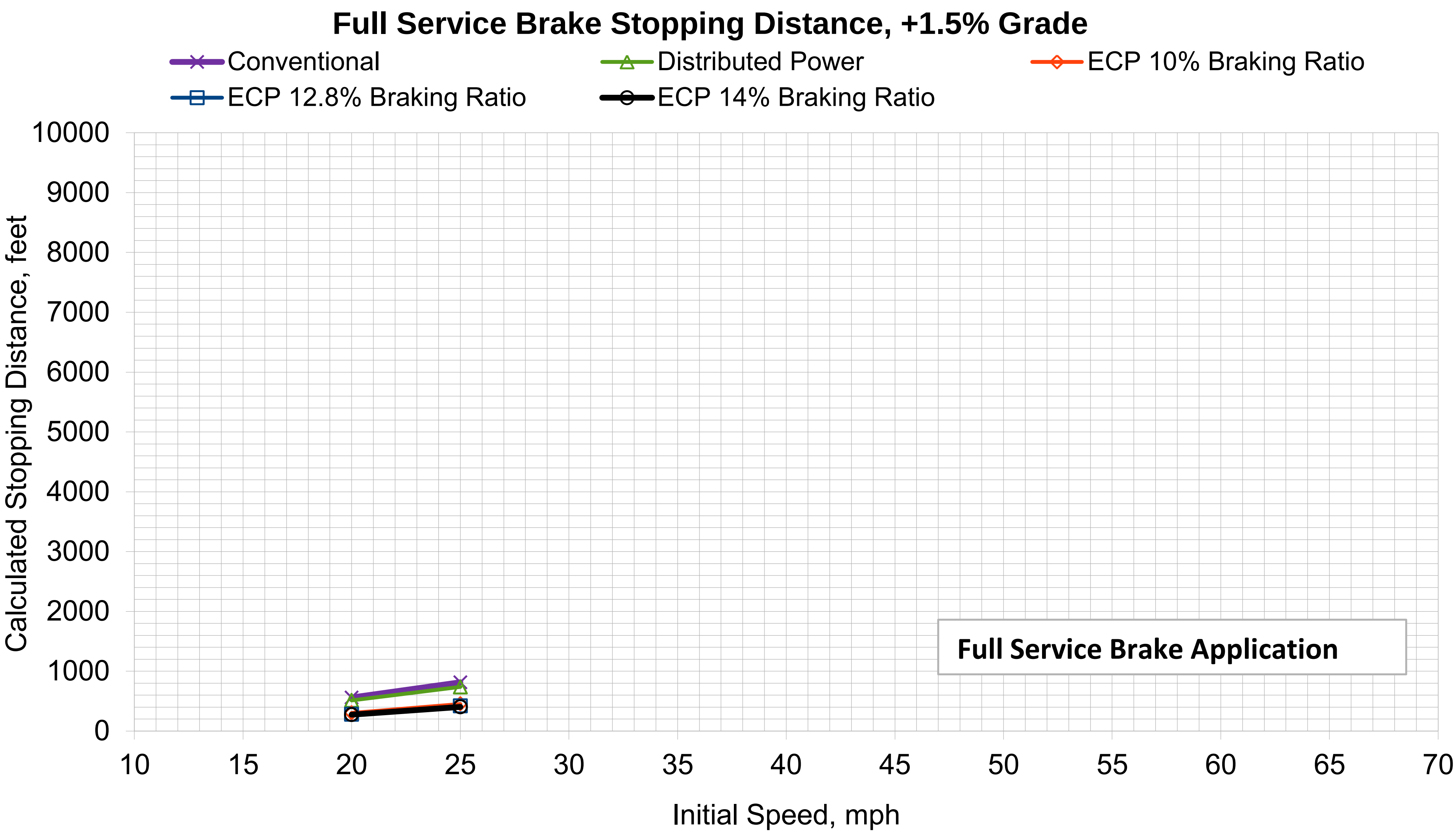

ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Bailed Off, Coupler Slack Neutral)

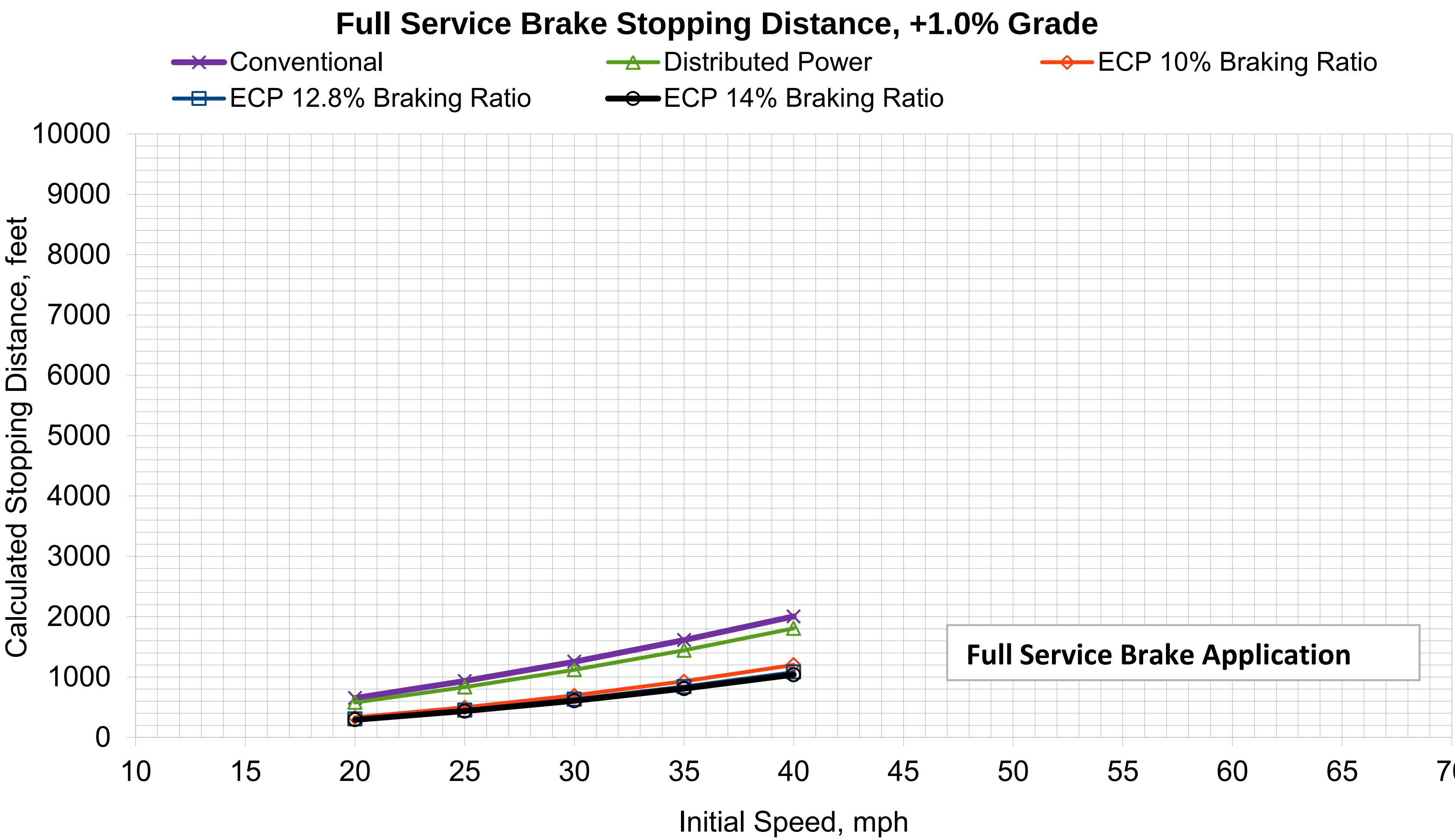
Attachment 22: Full Service Braking, No Bailoff, 52 Tank Cars



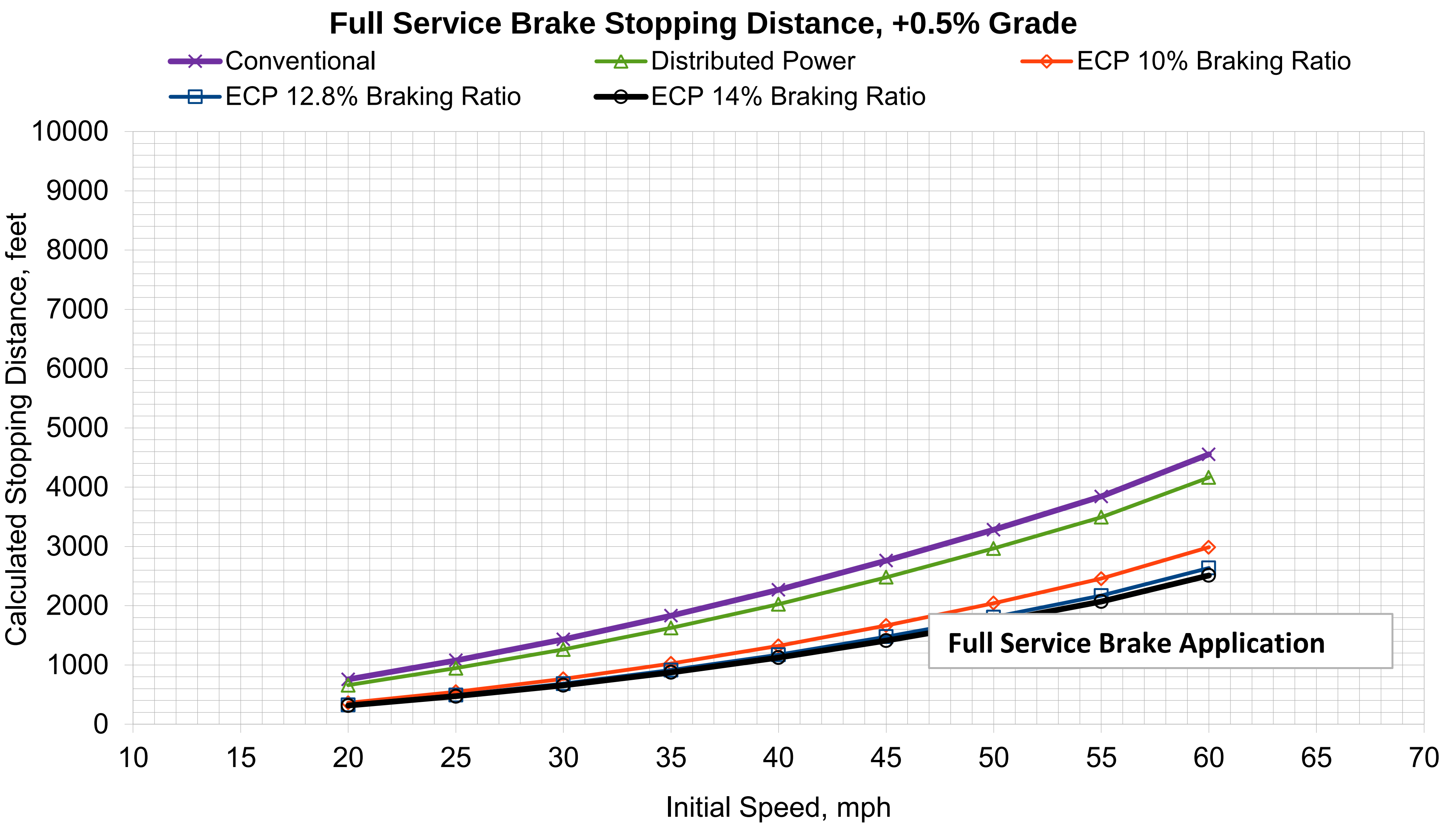
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



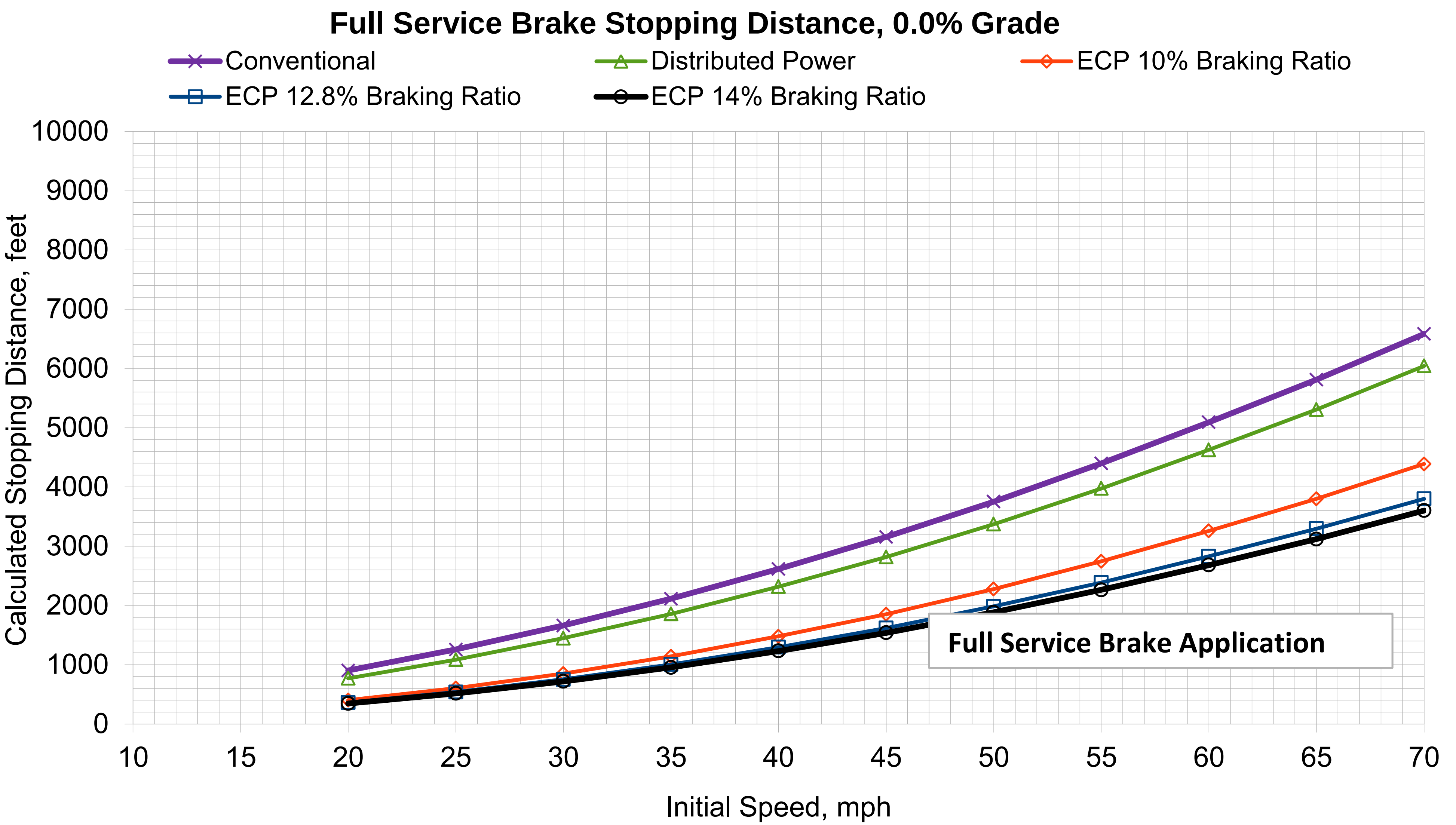
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



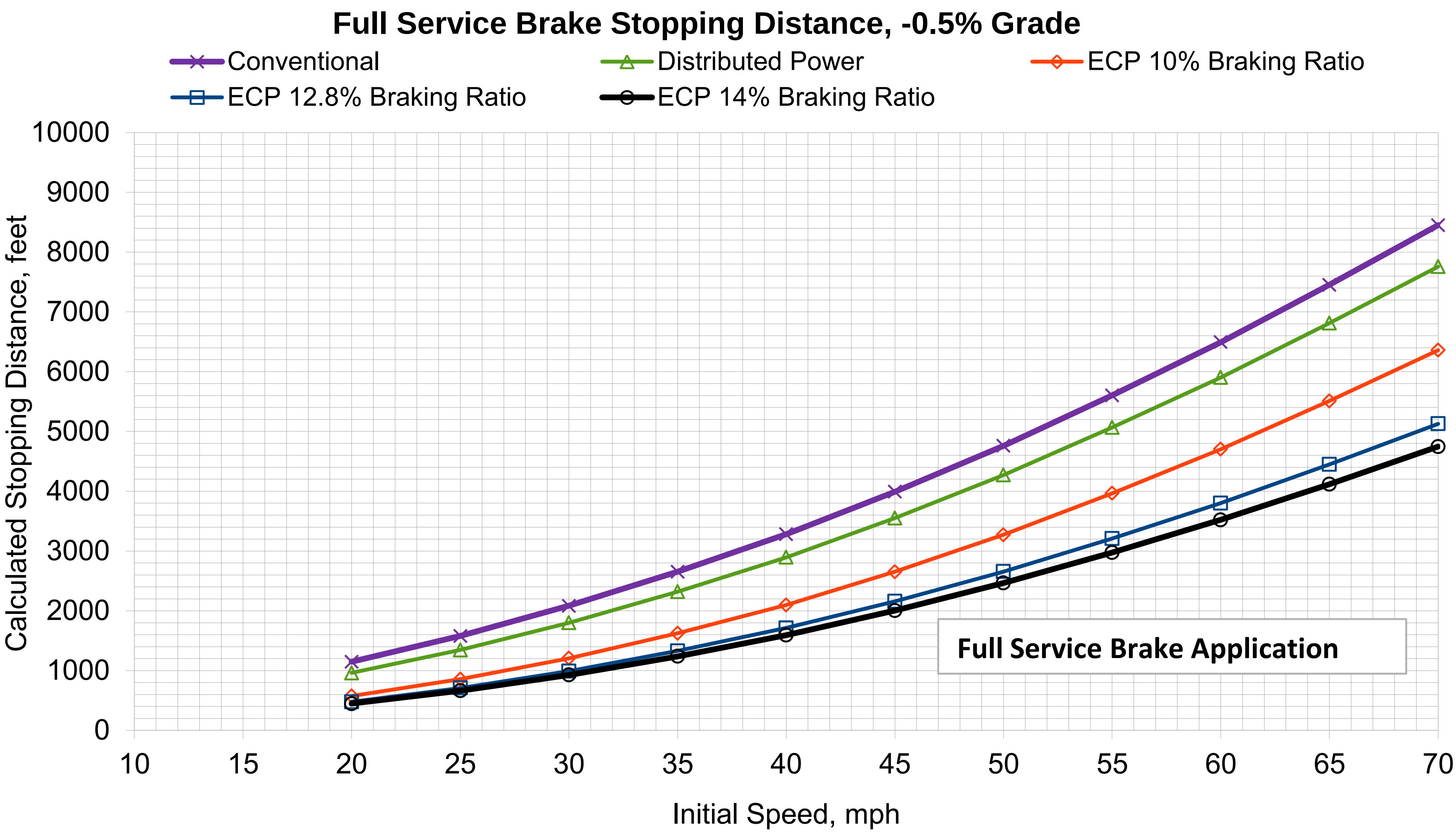
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



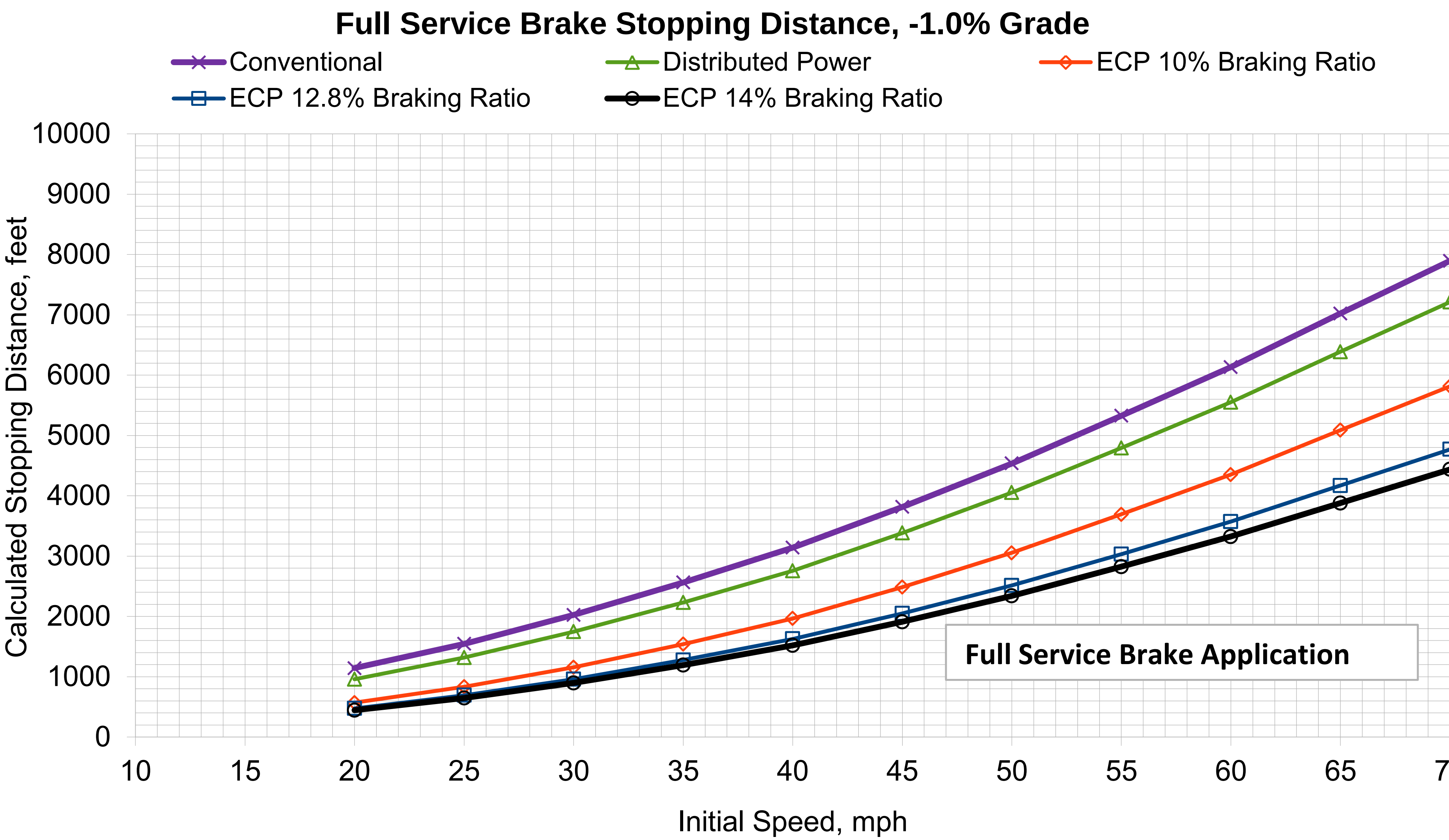
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



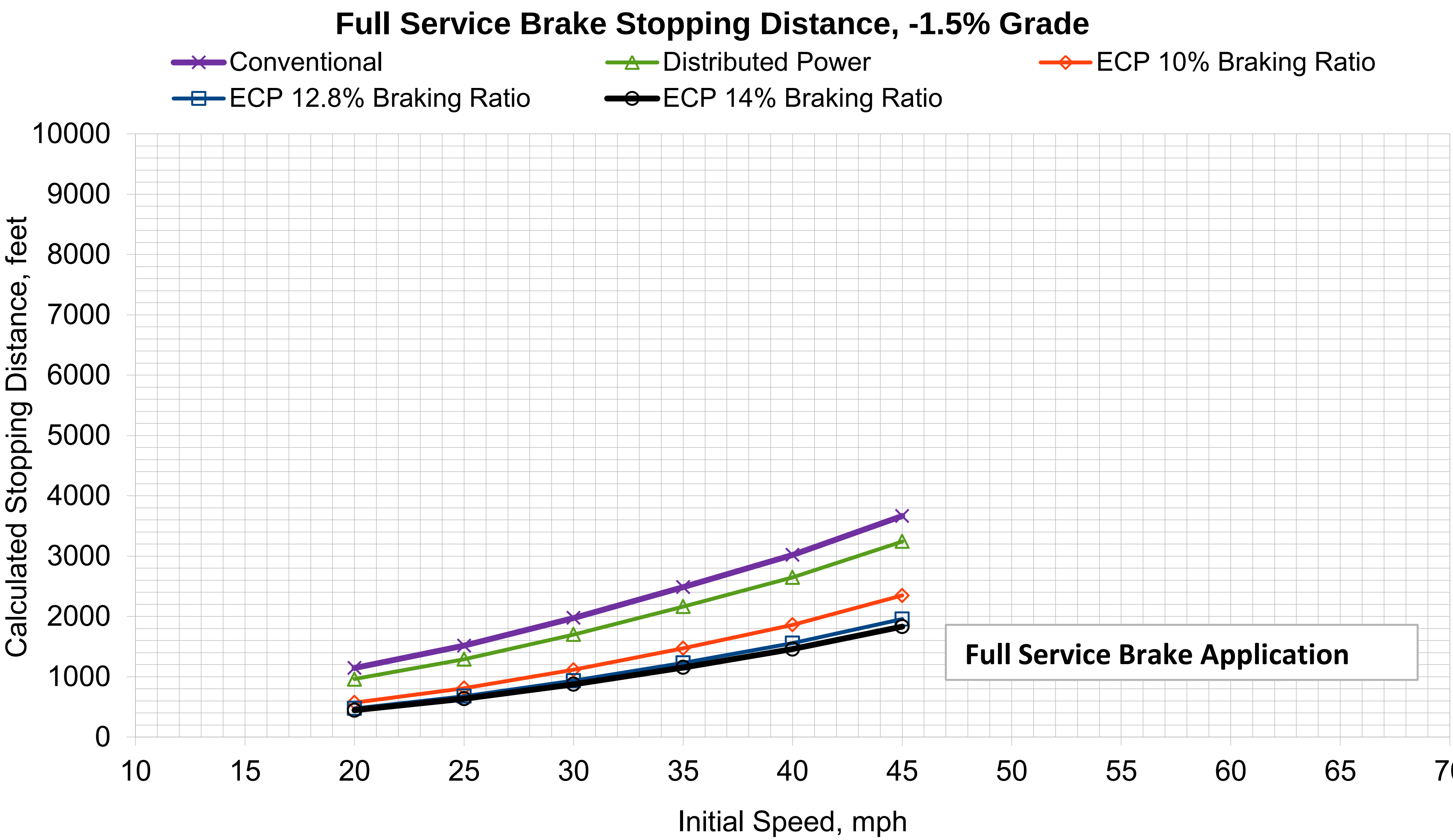
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



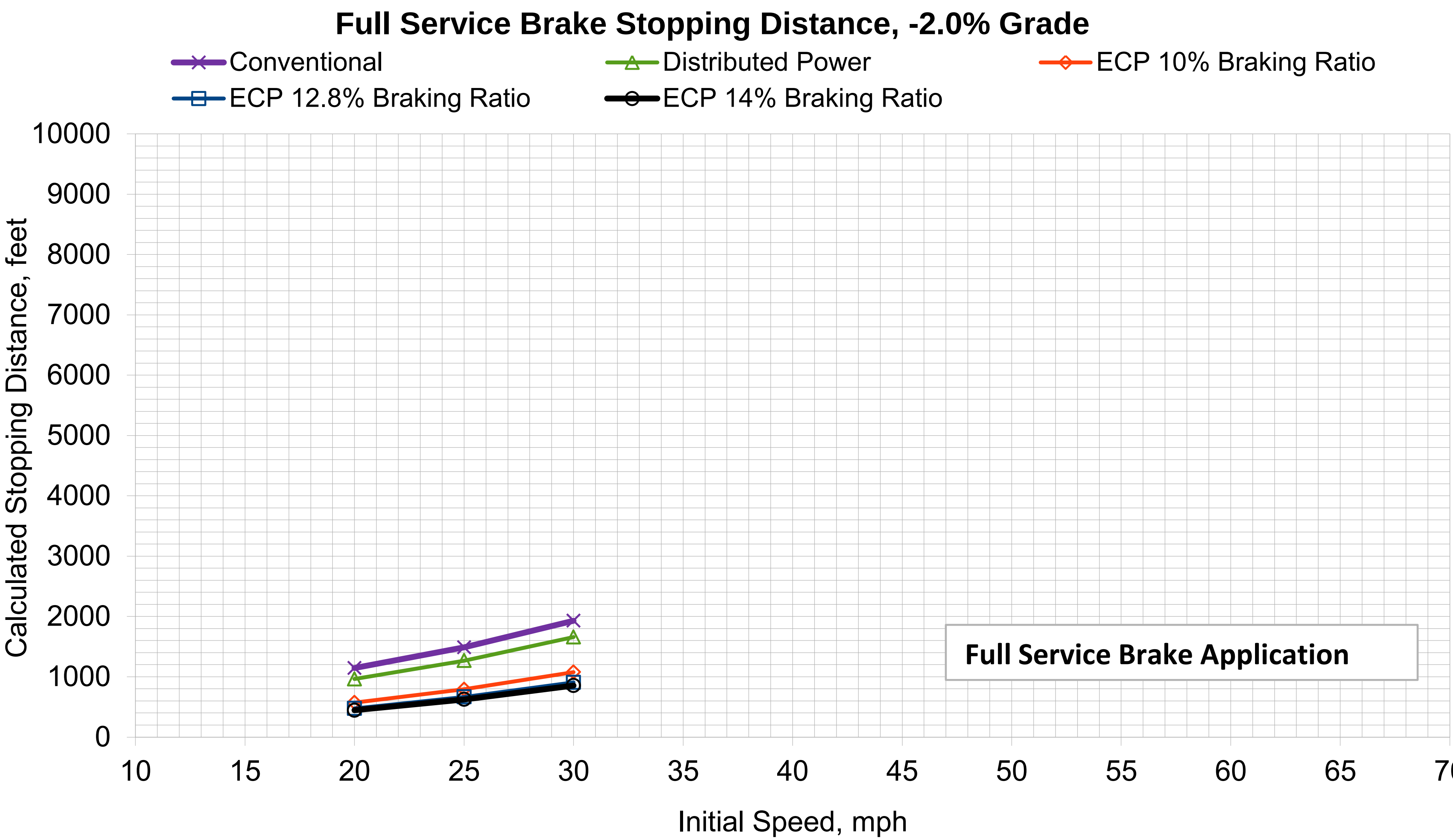
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



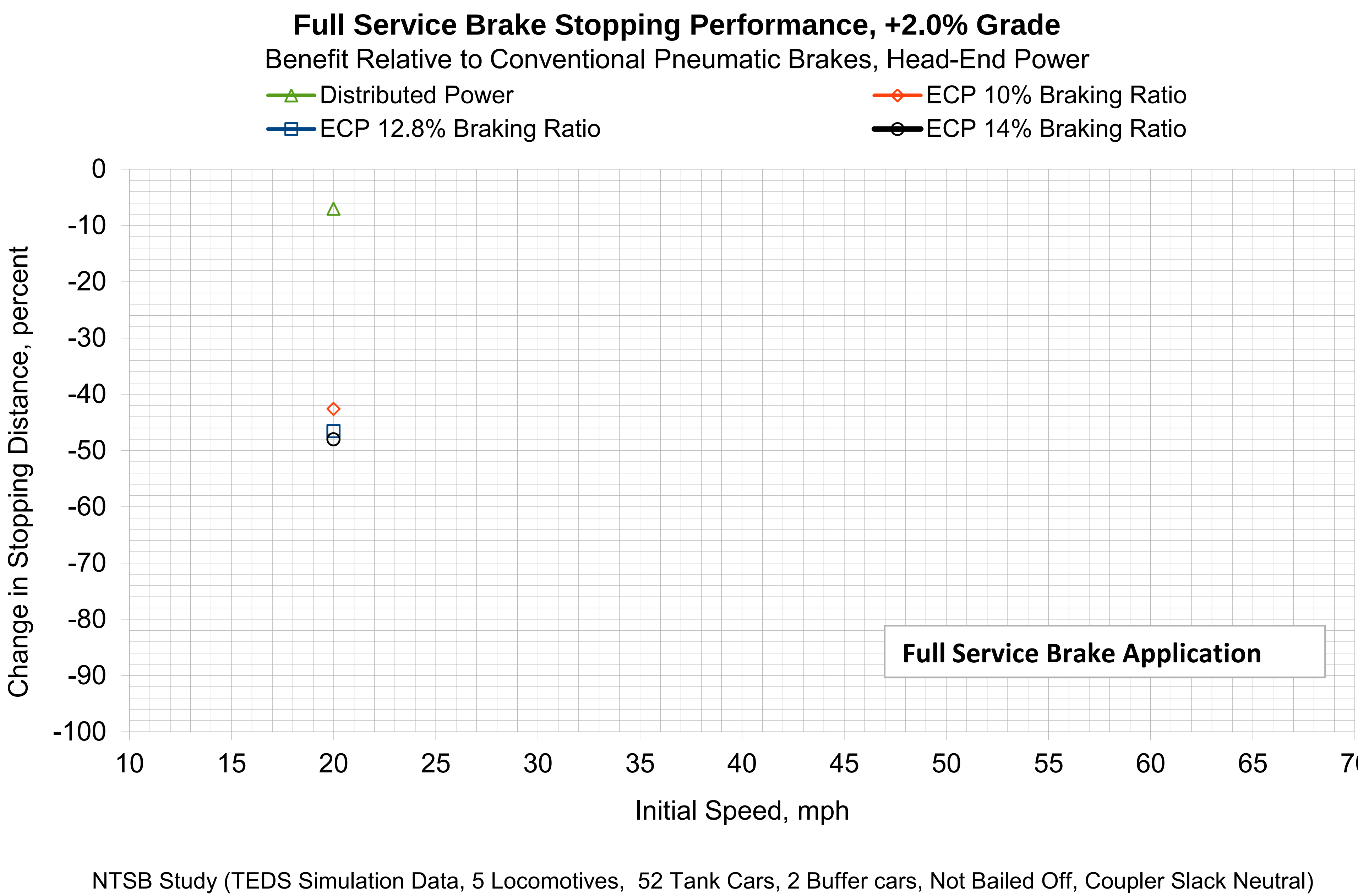
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

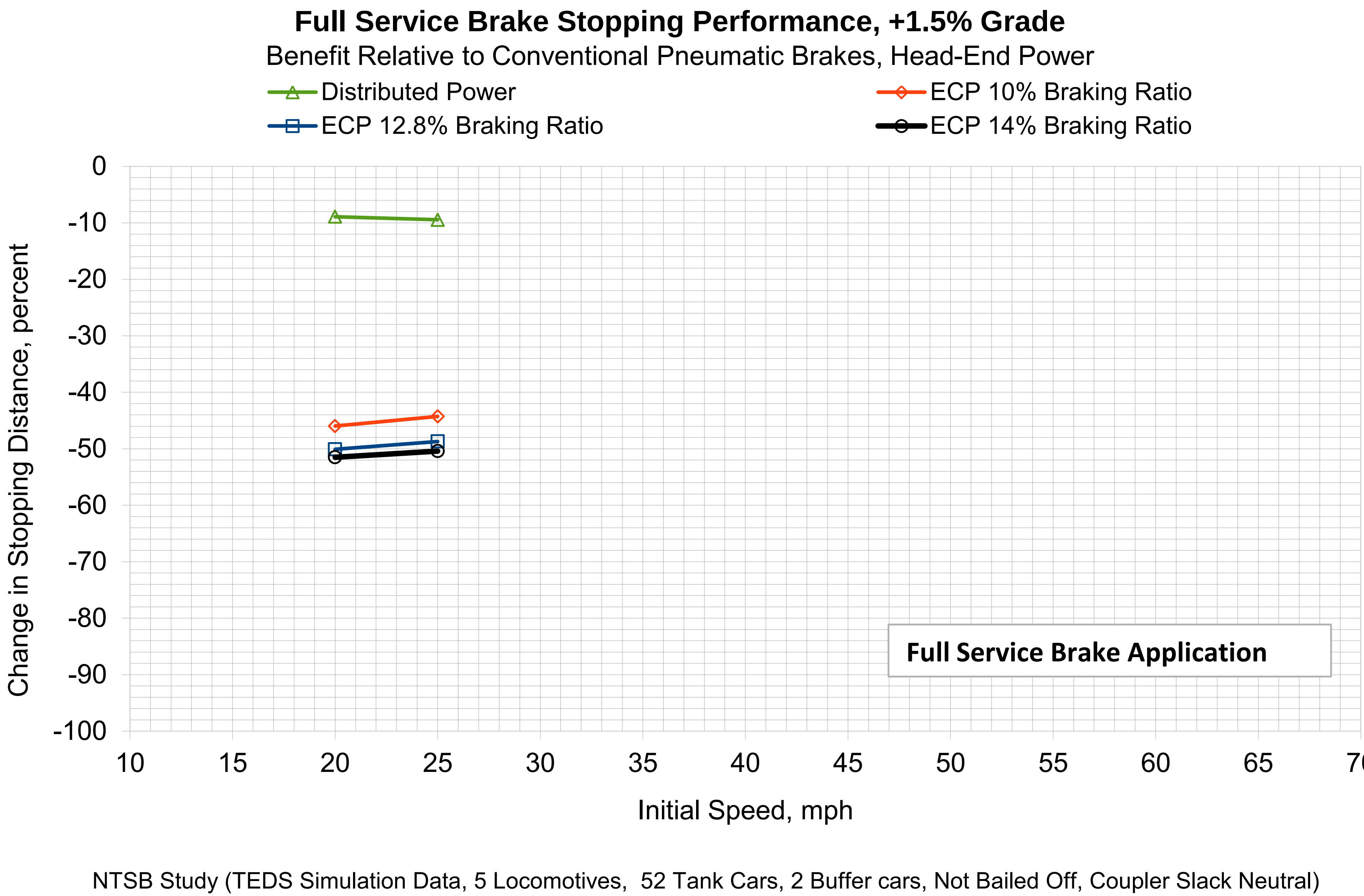


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

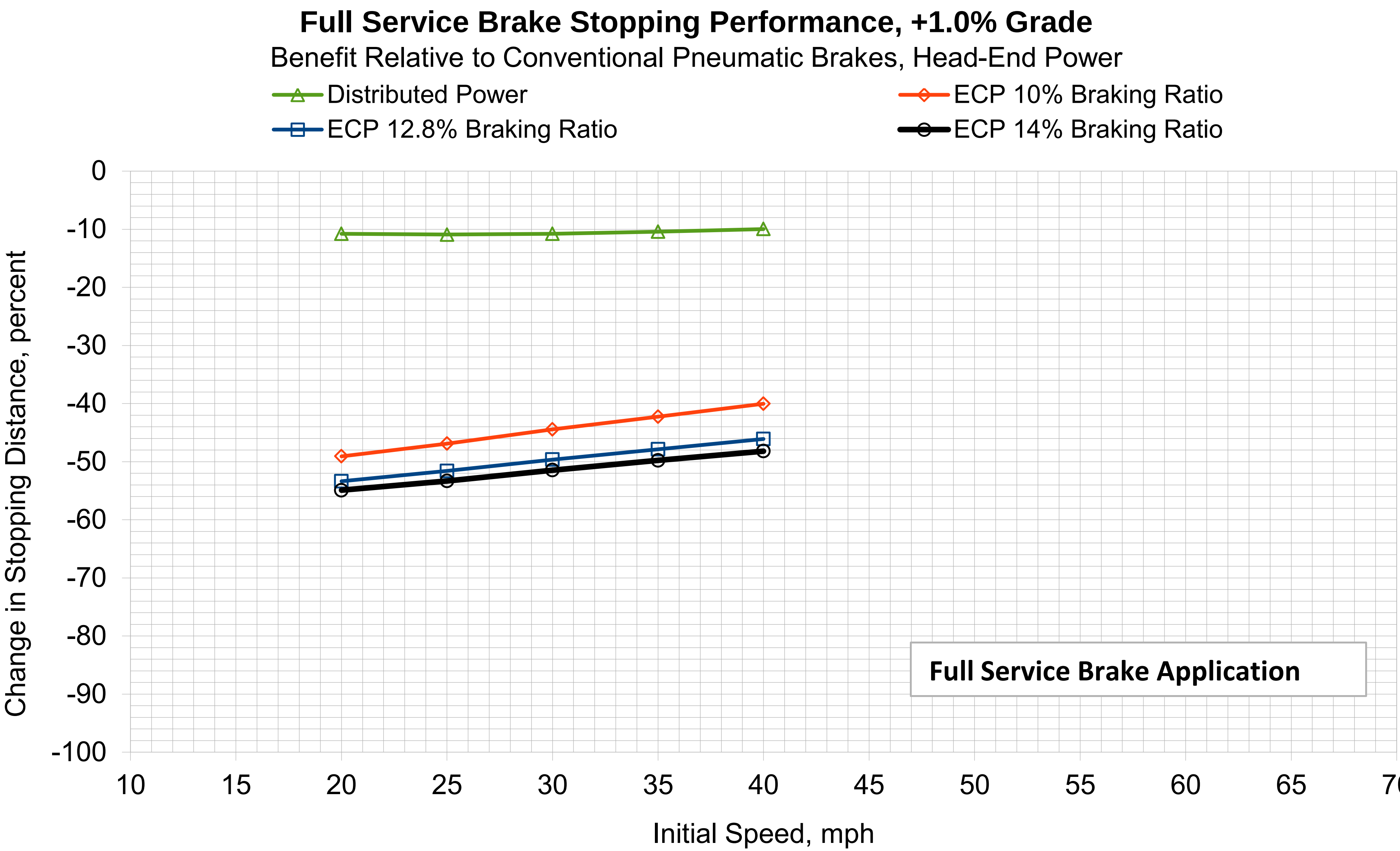


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

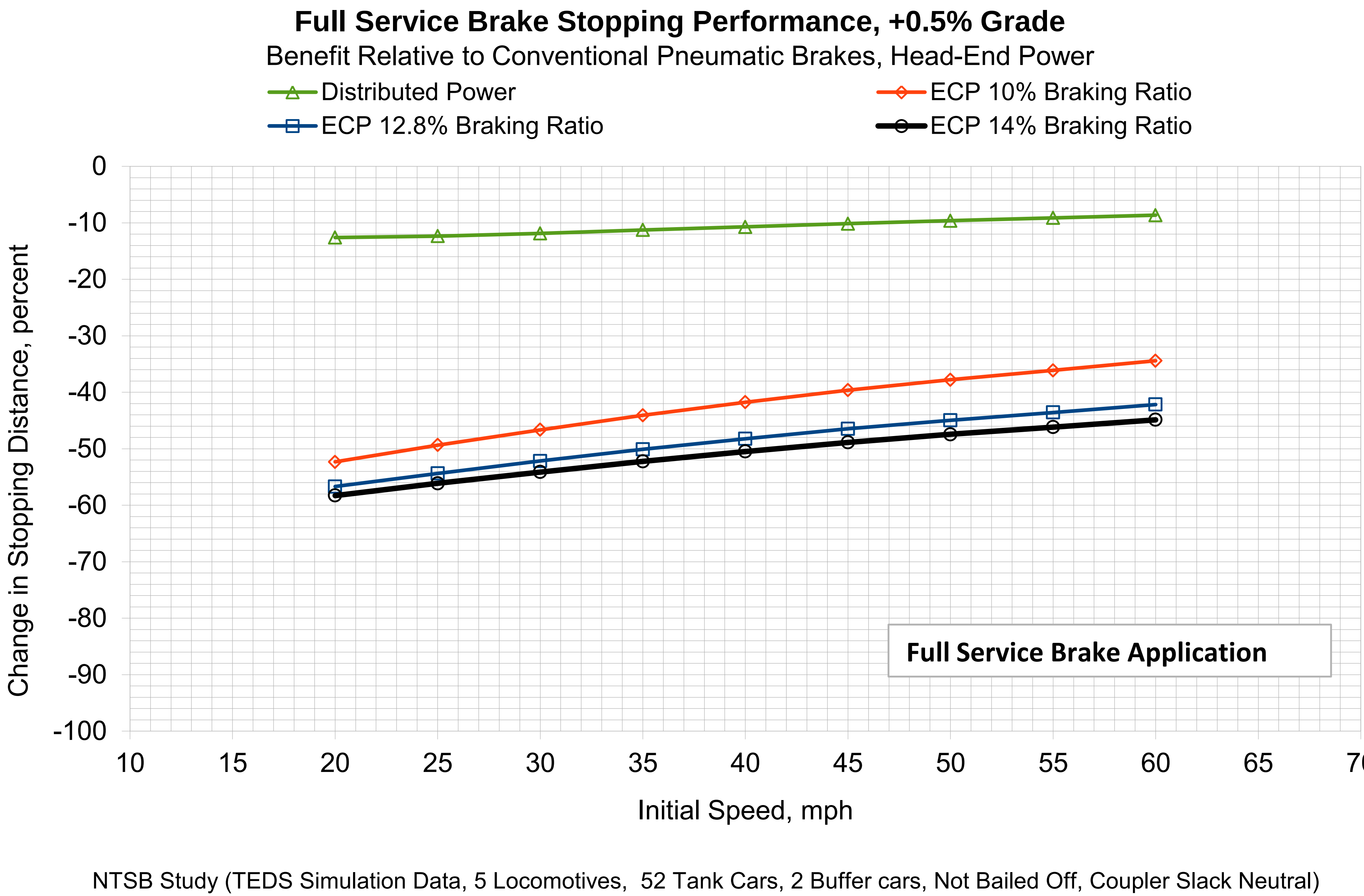

Full Service Brake Stopping Performance, +2.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



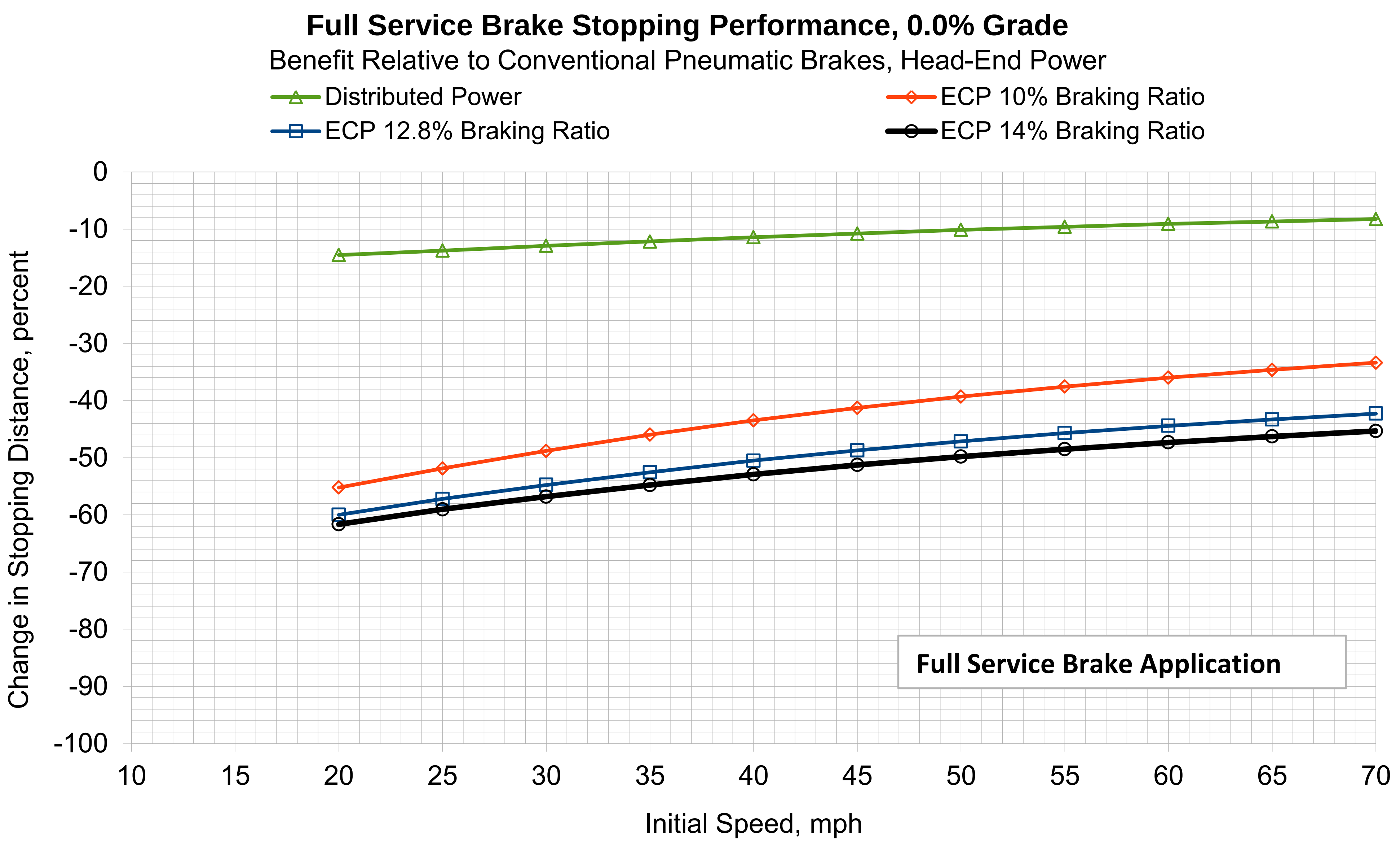
Full Service Brake Stopping Performance, +1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Change in Stopping Distance, percent
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



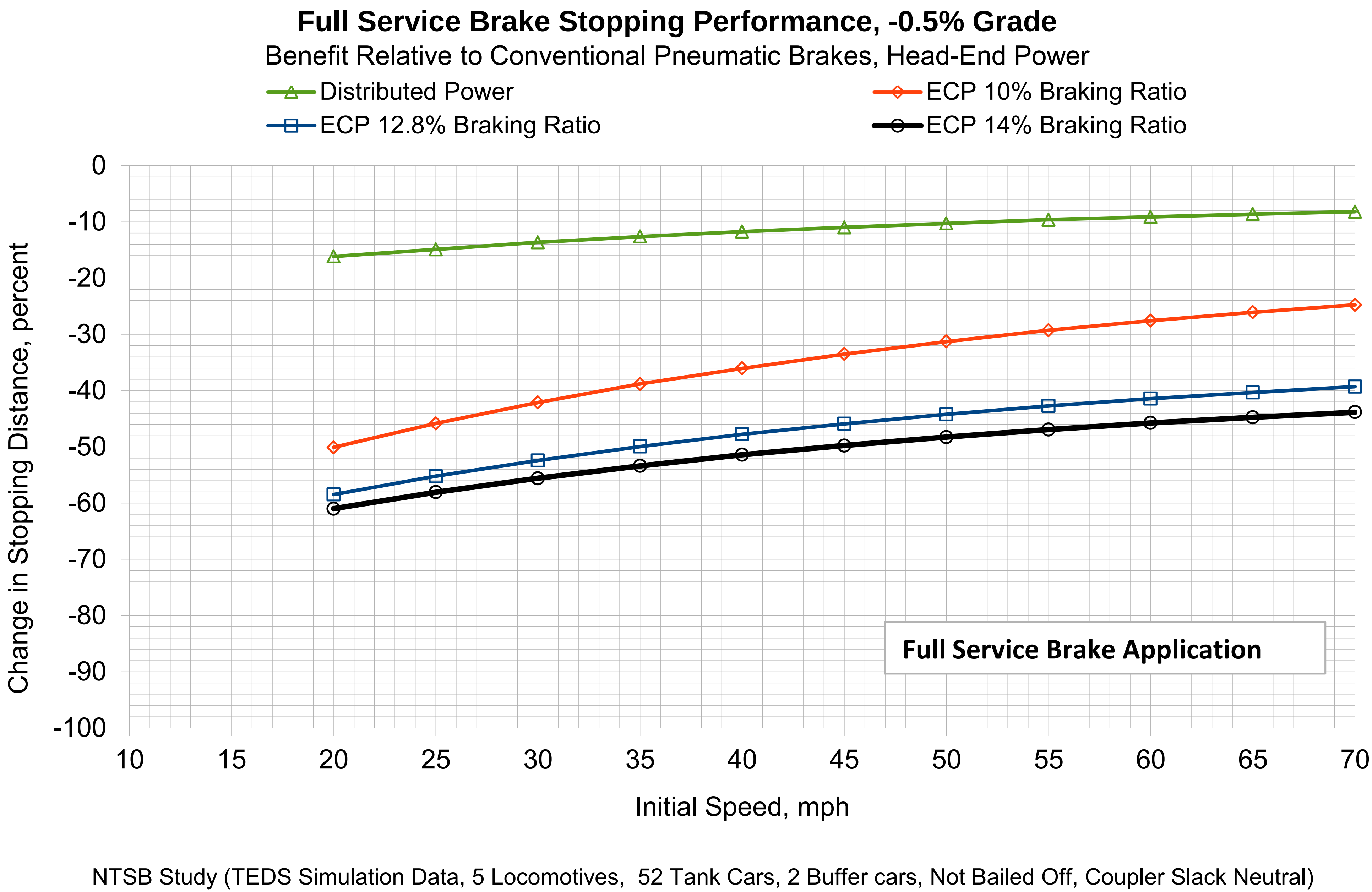
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



Full Service Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Change in Stopping Distance, percent
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

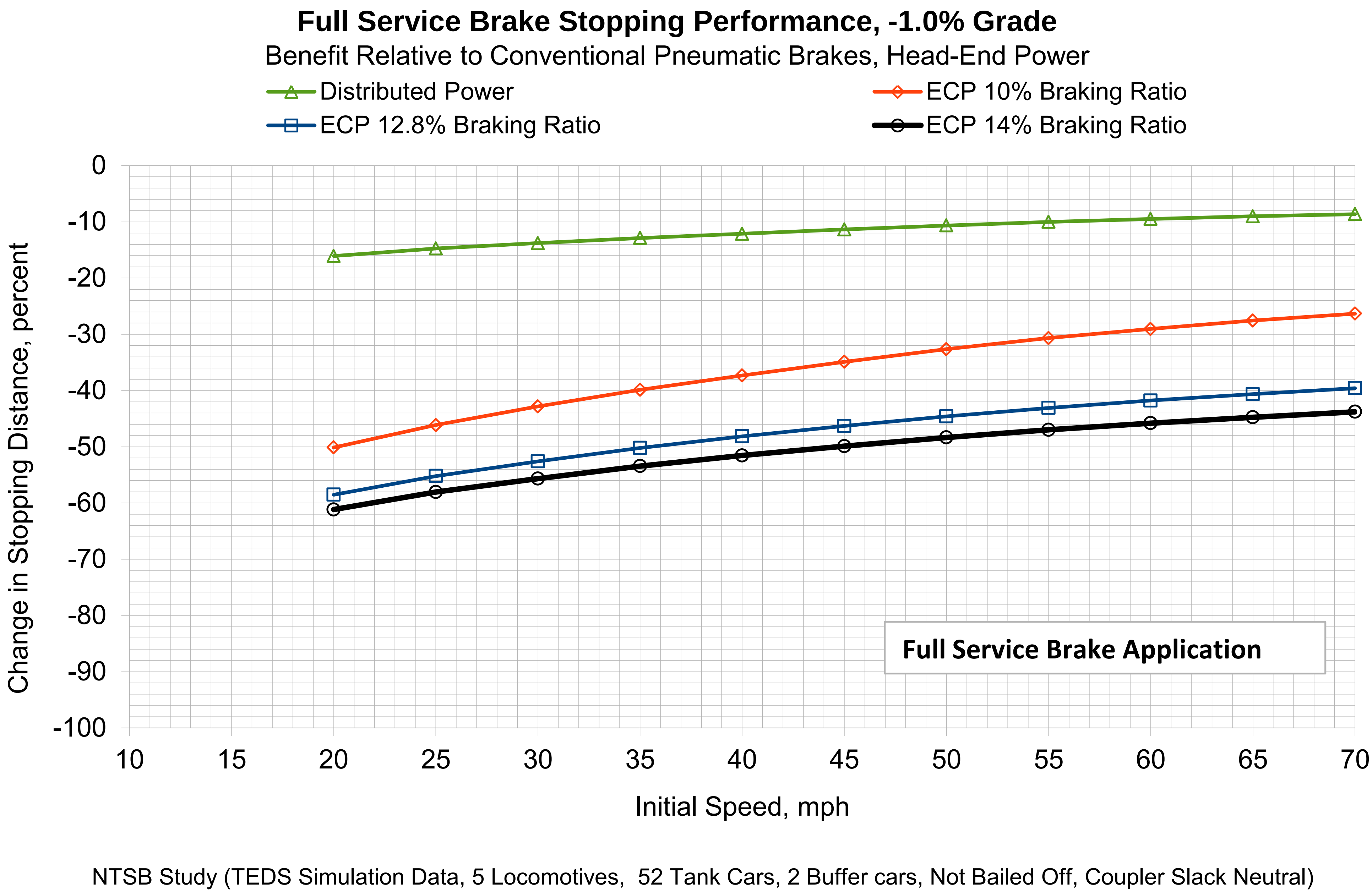


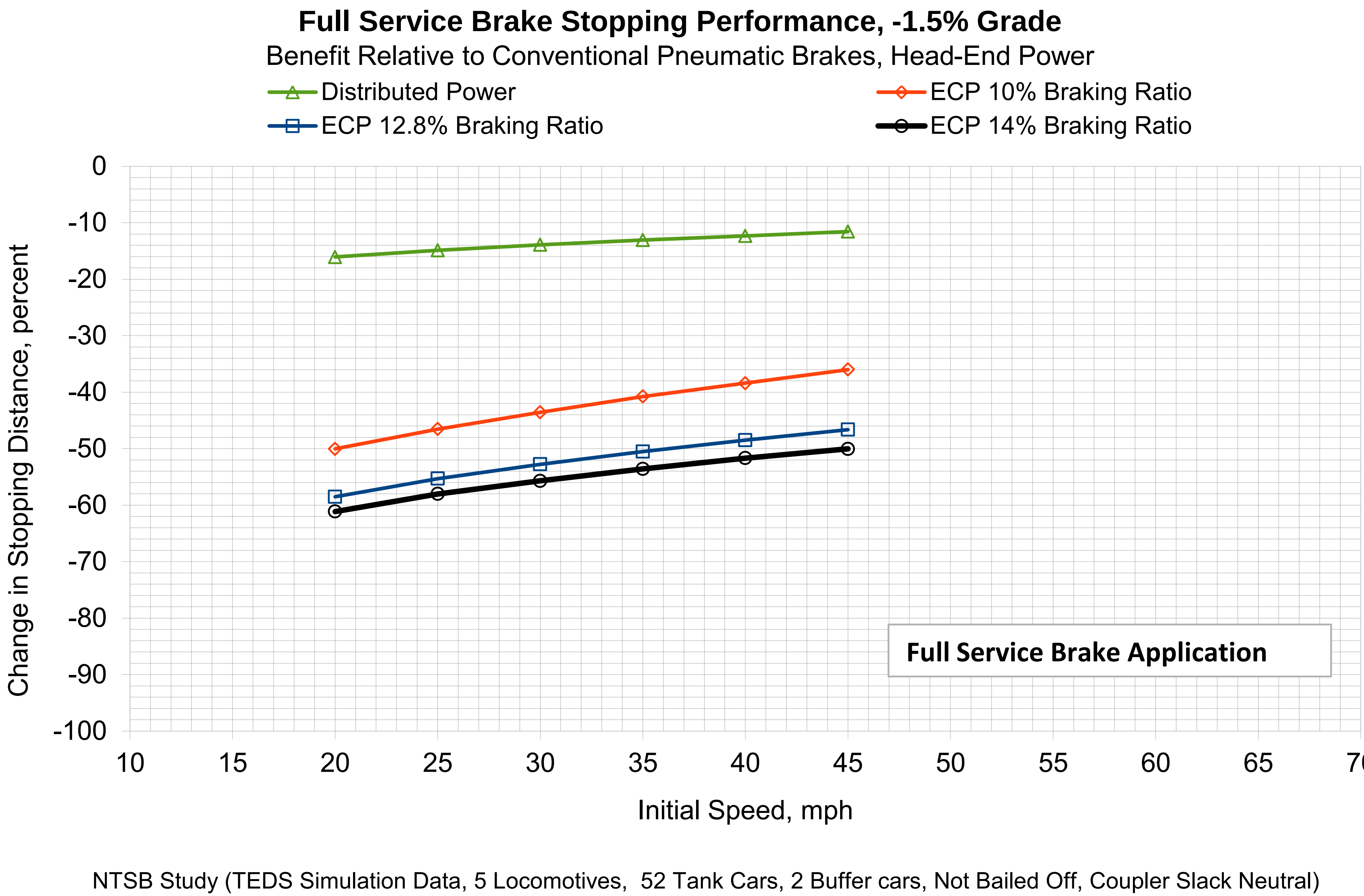
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

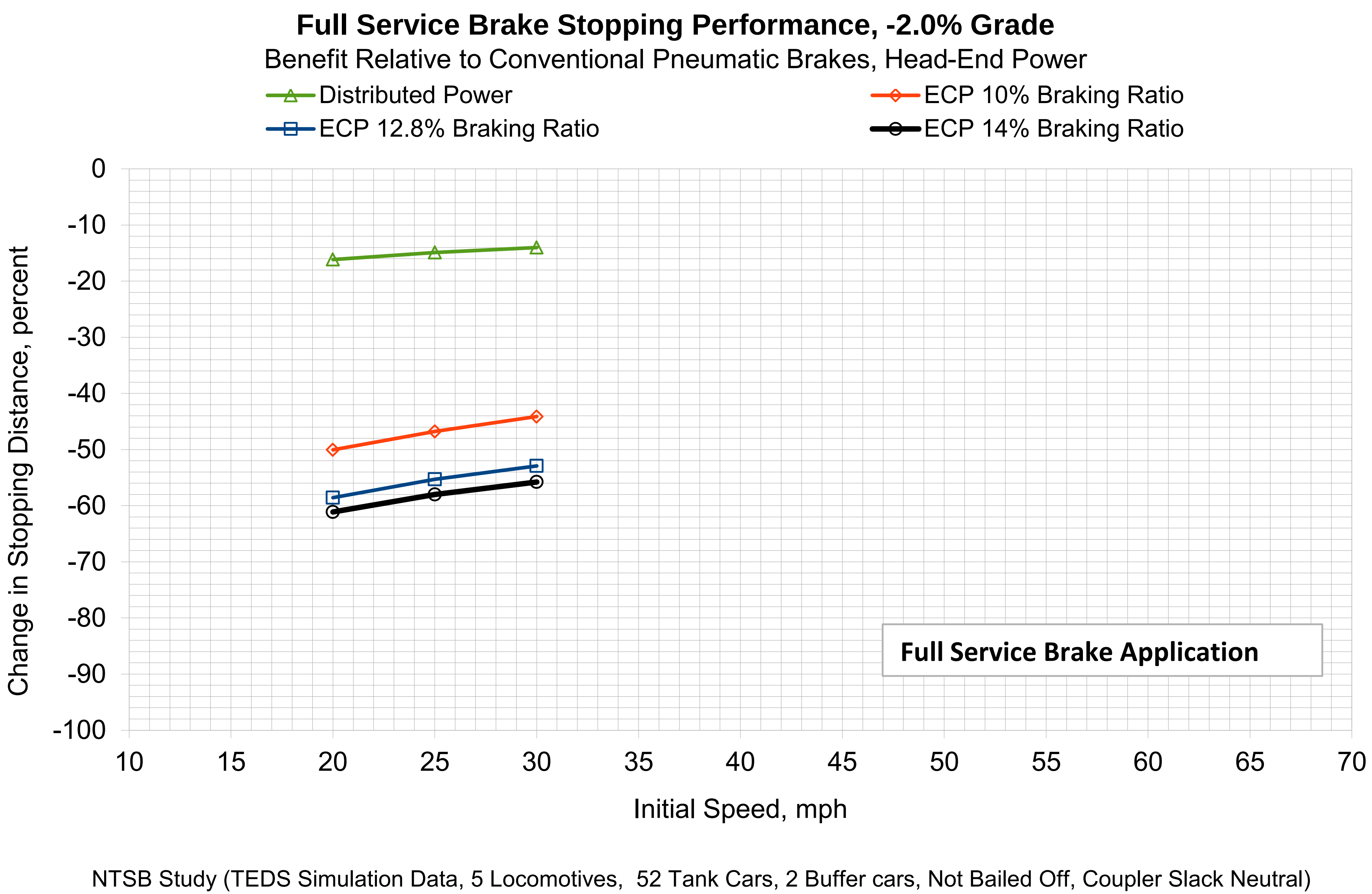


Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

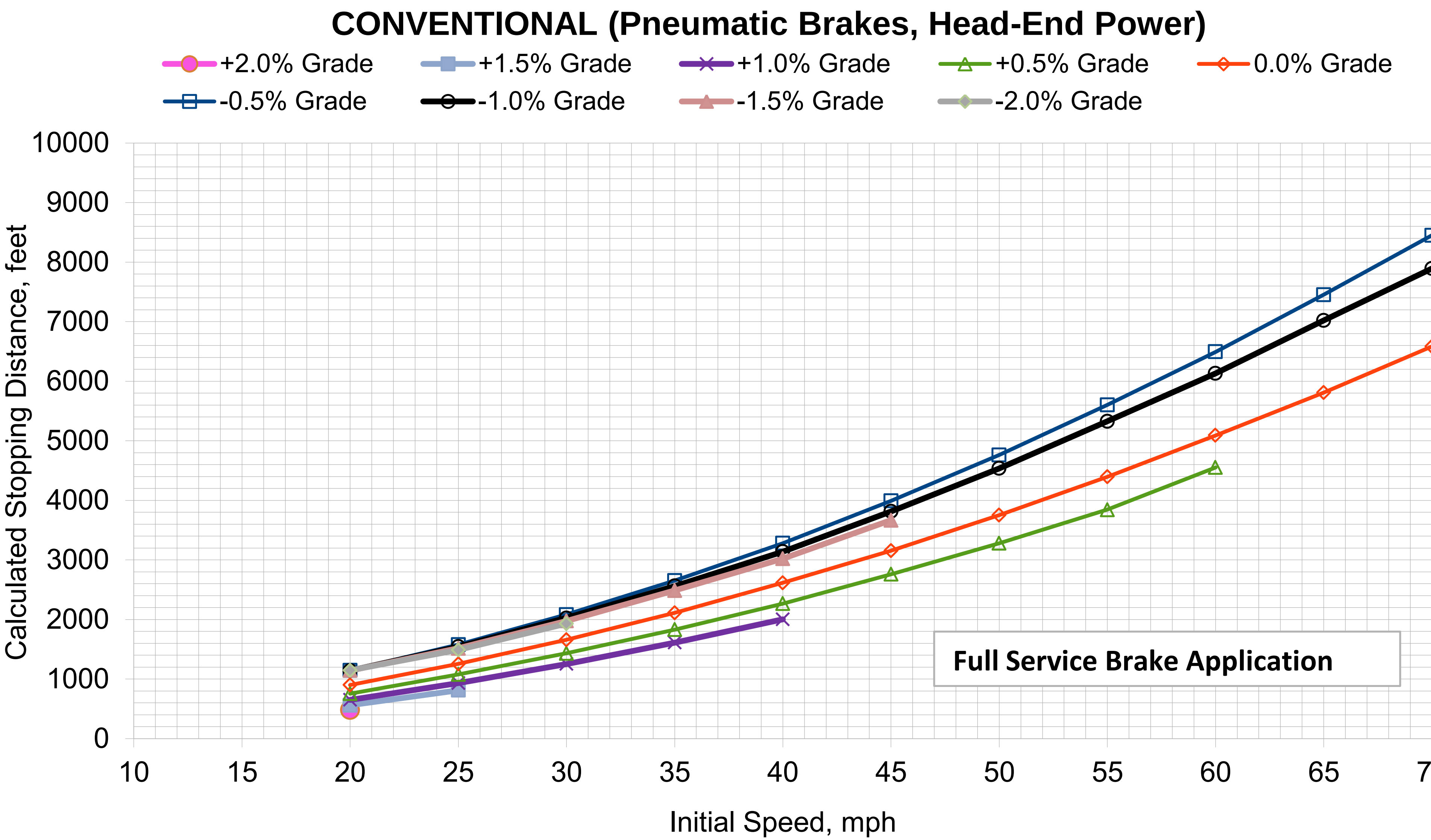
A22.16


Full Service Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

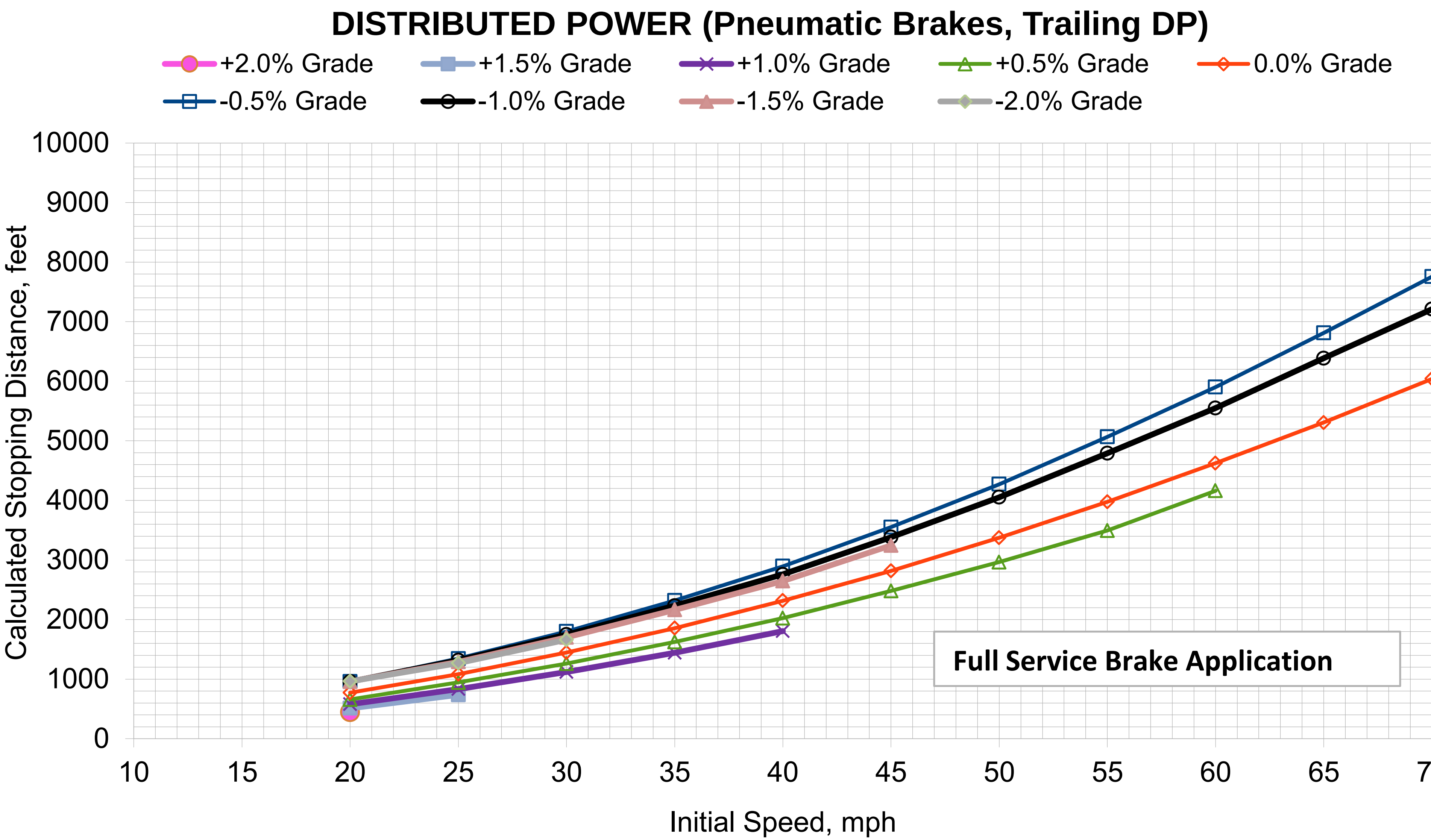

Full Service Brake Stopping Performance, -1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



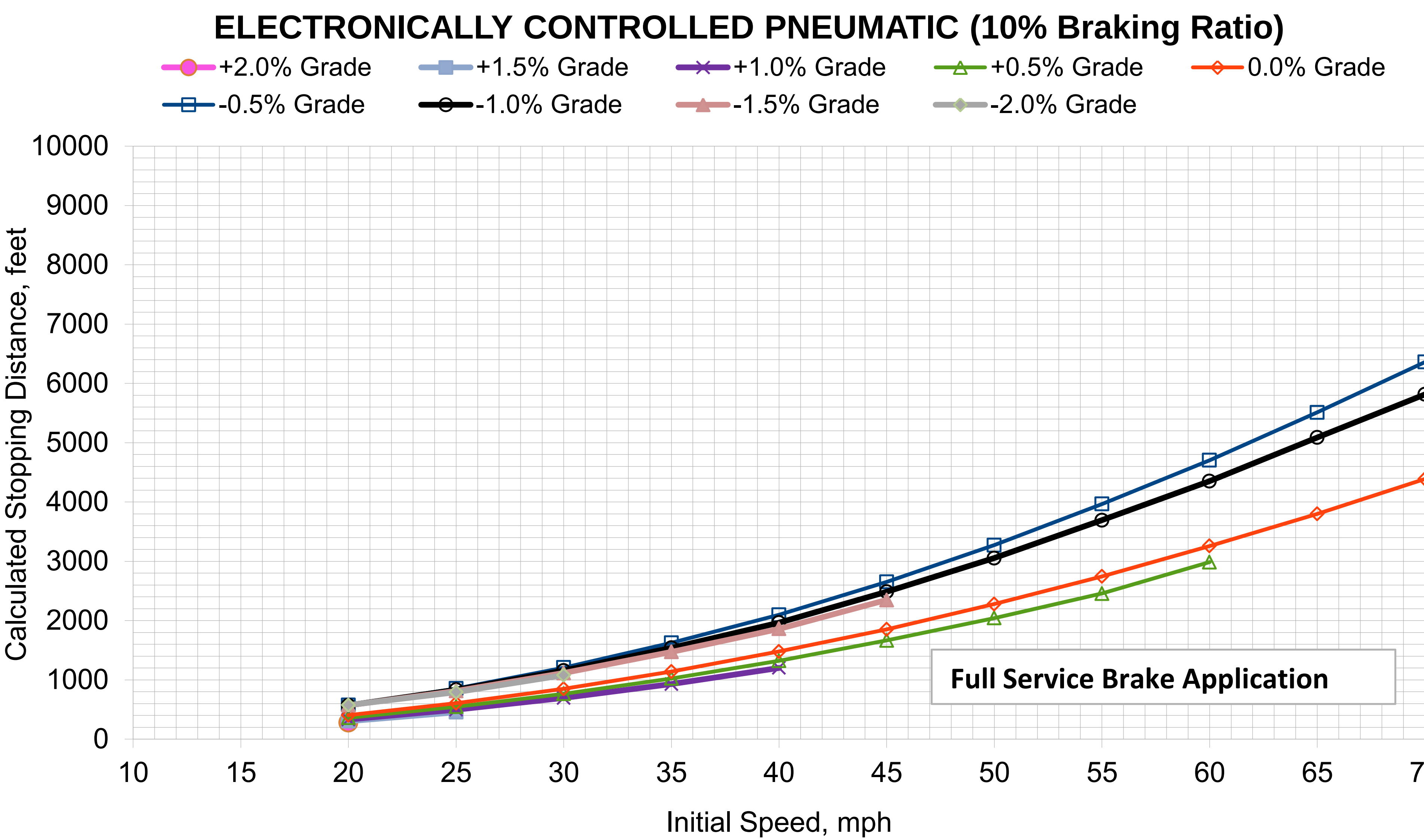
Full Service Brake Stopping Performance, -2.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Full Service Brake Application
Change in Stopping Distance, percent
Initial Speed, mph
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



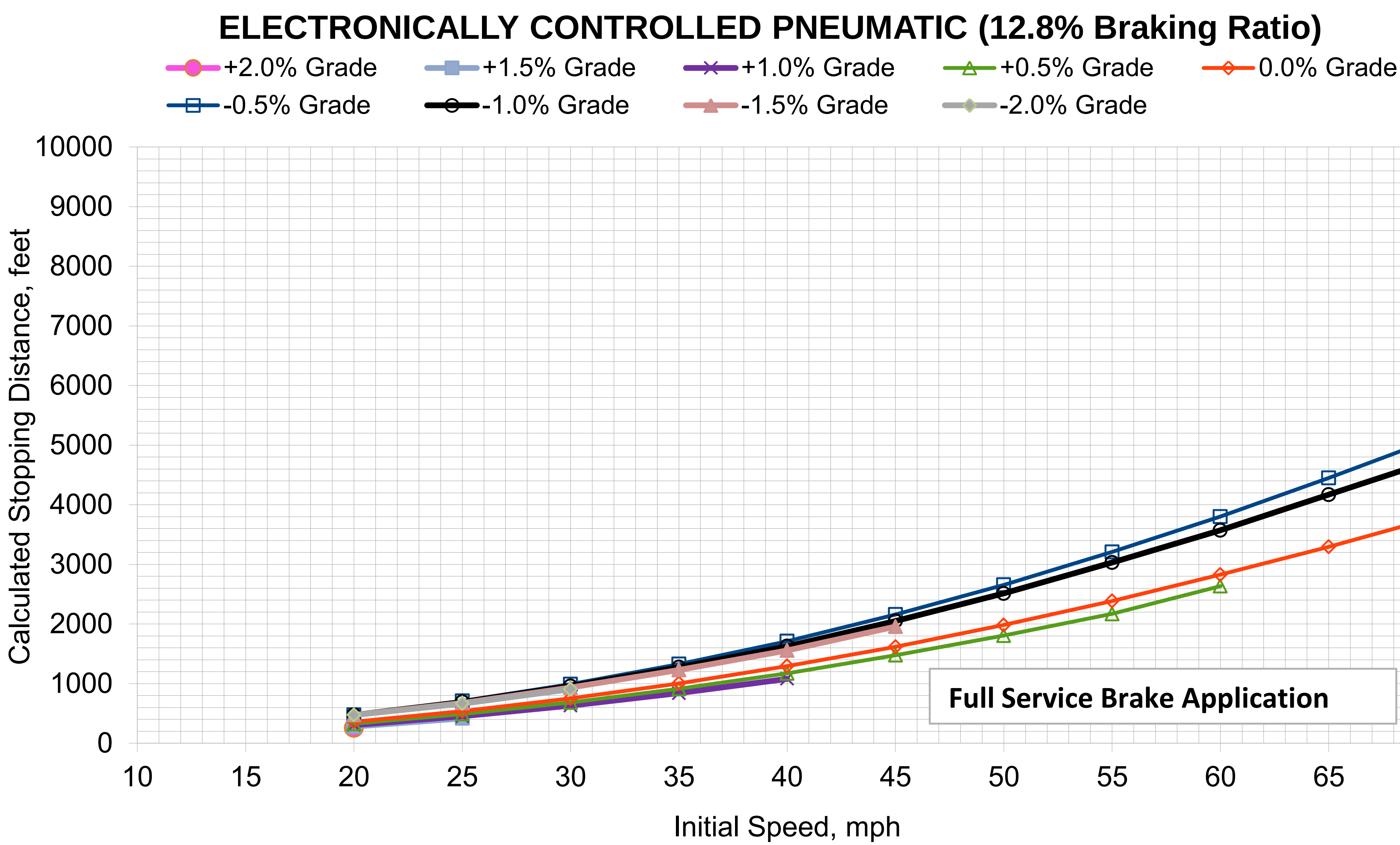
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



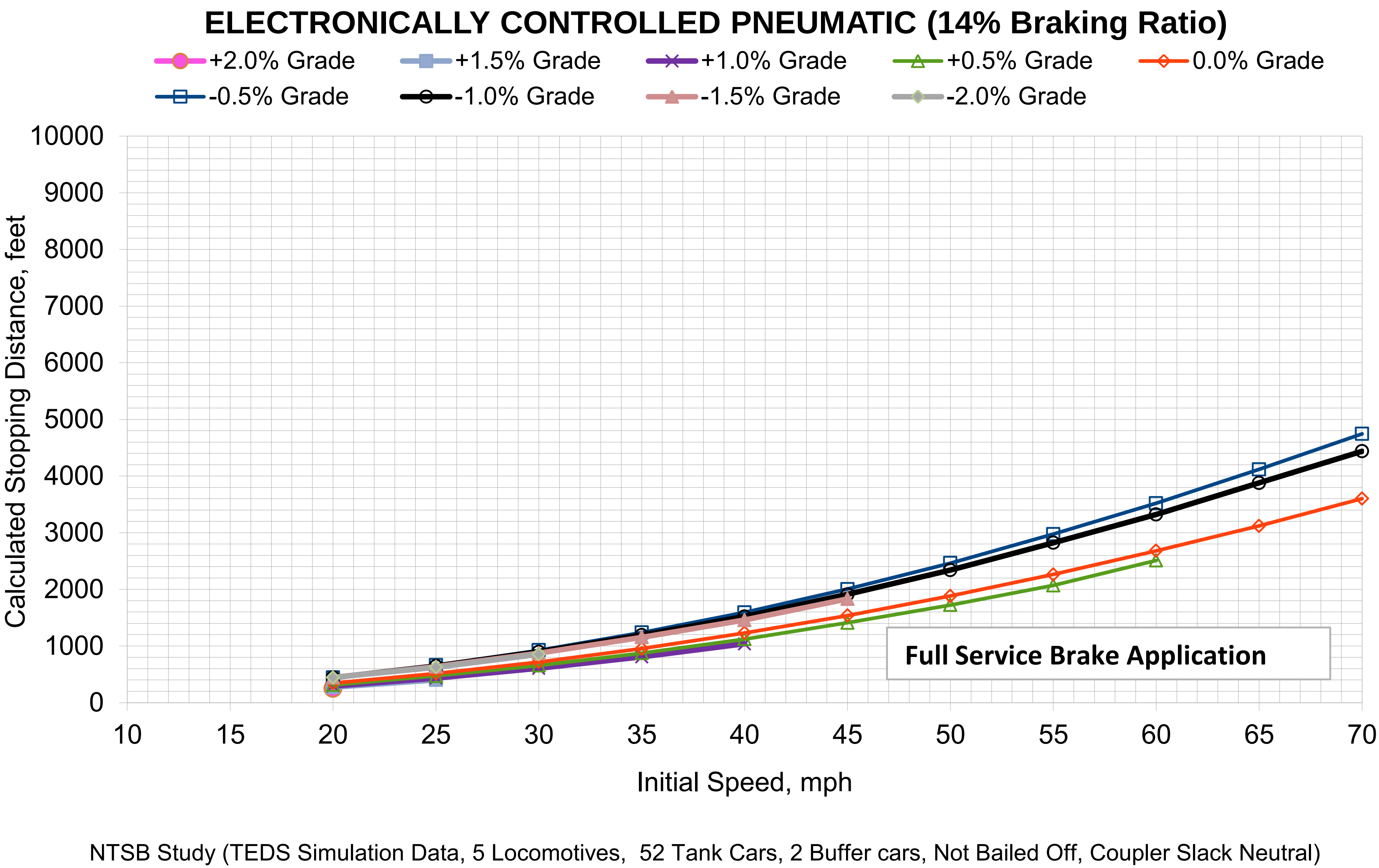
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



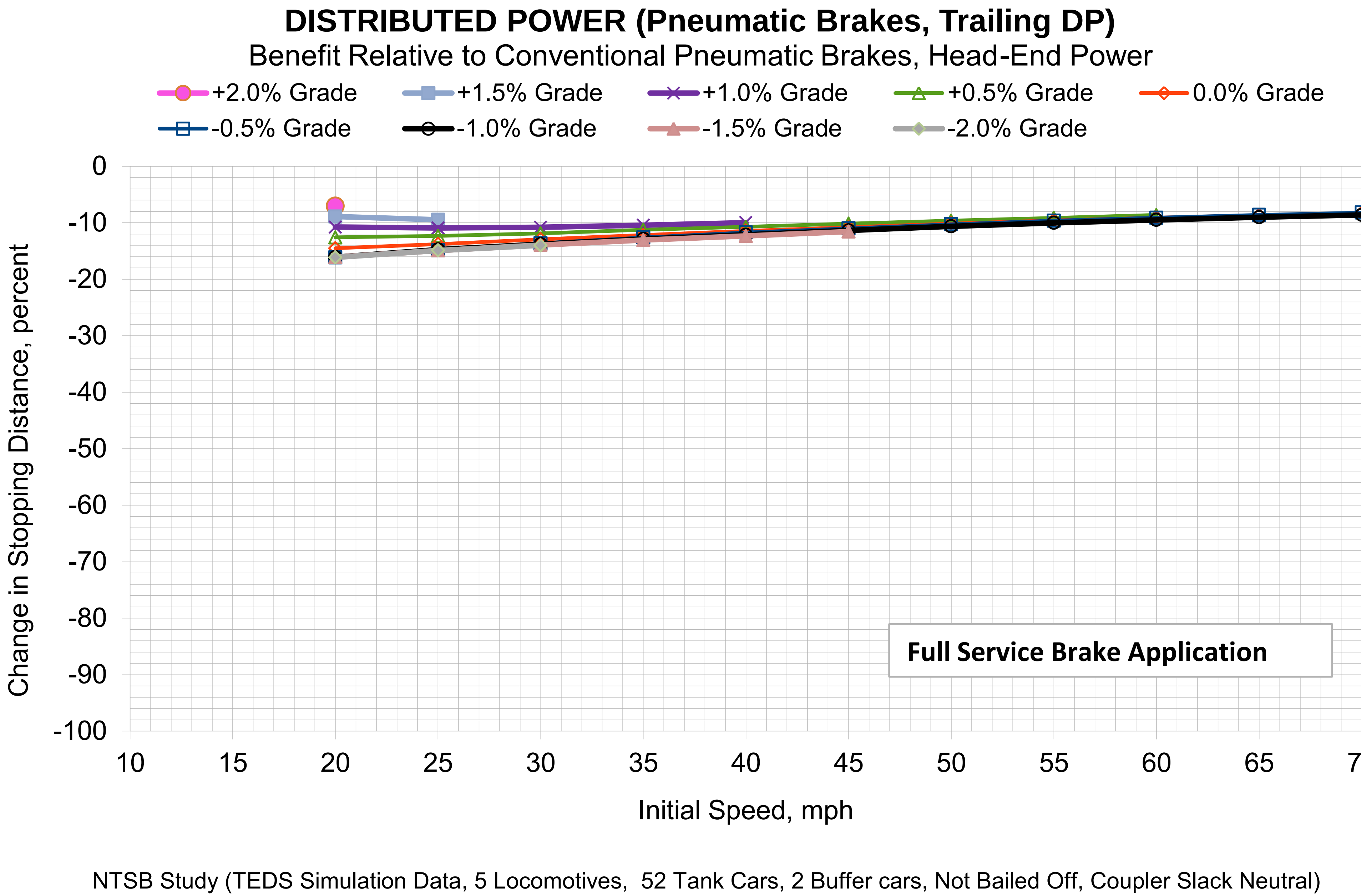
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

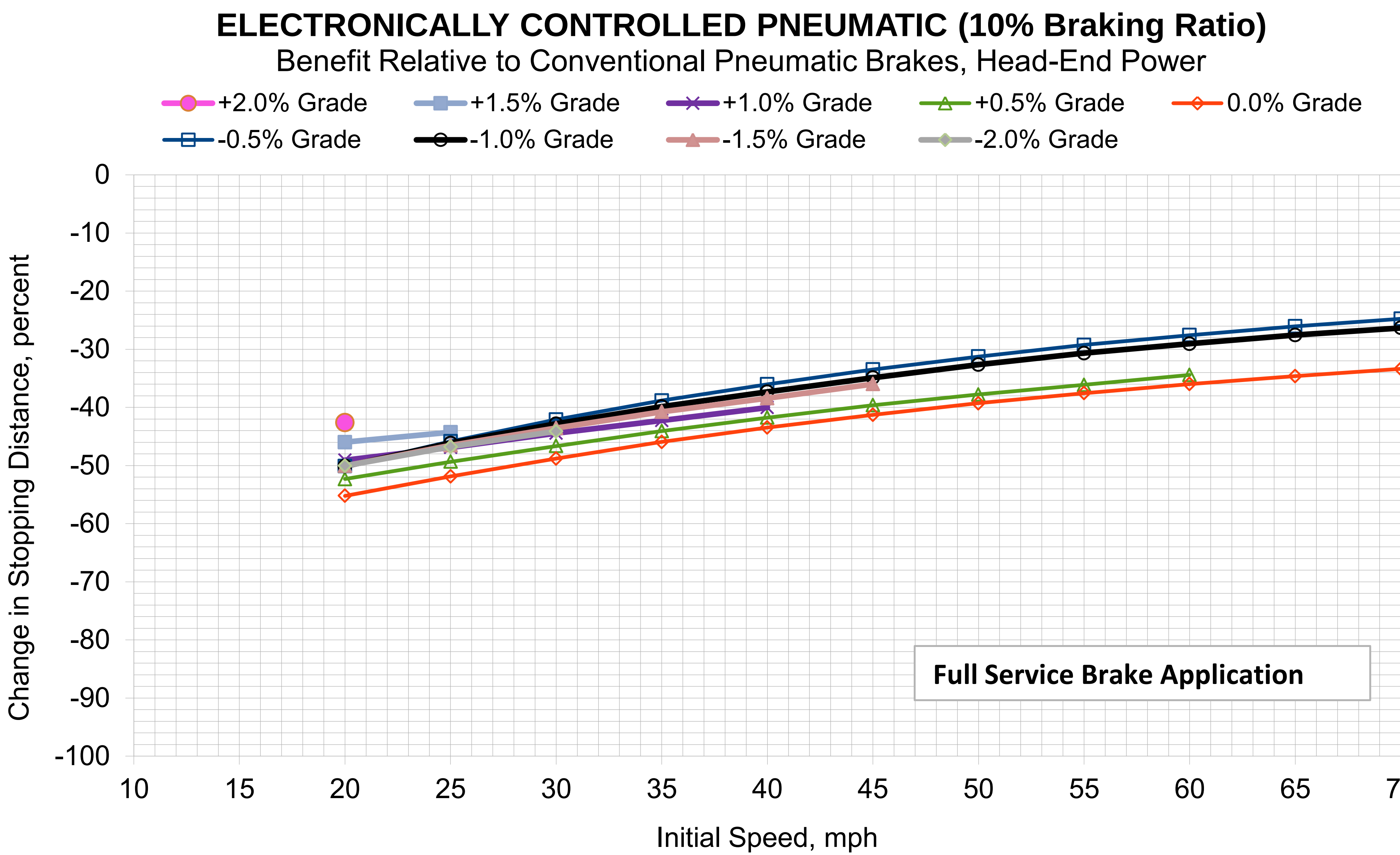


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

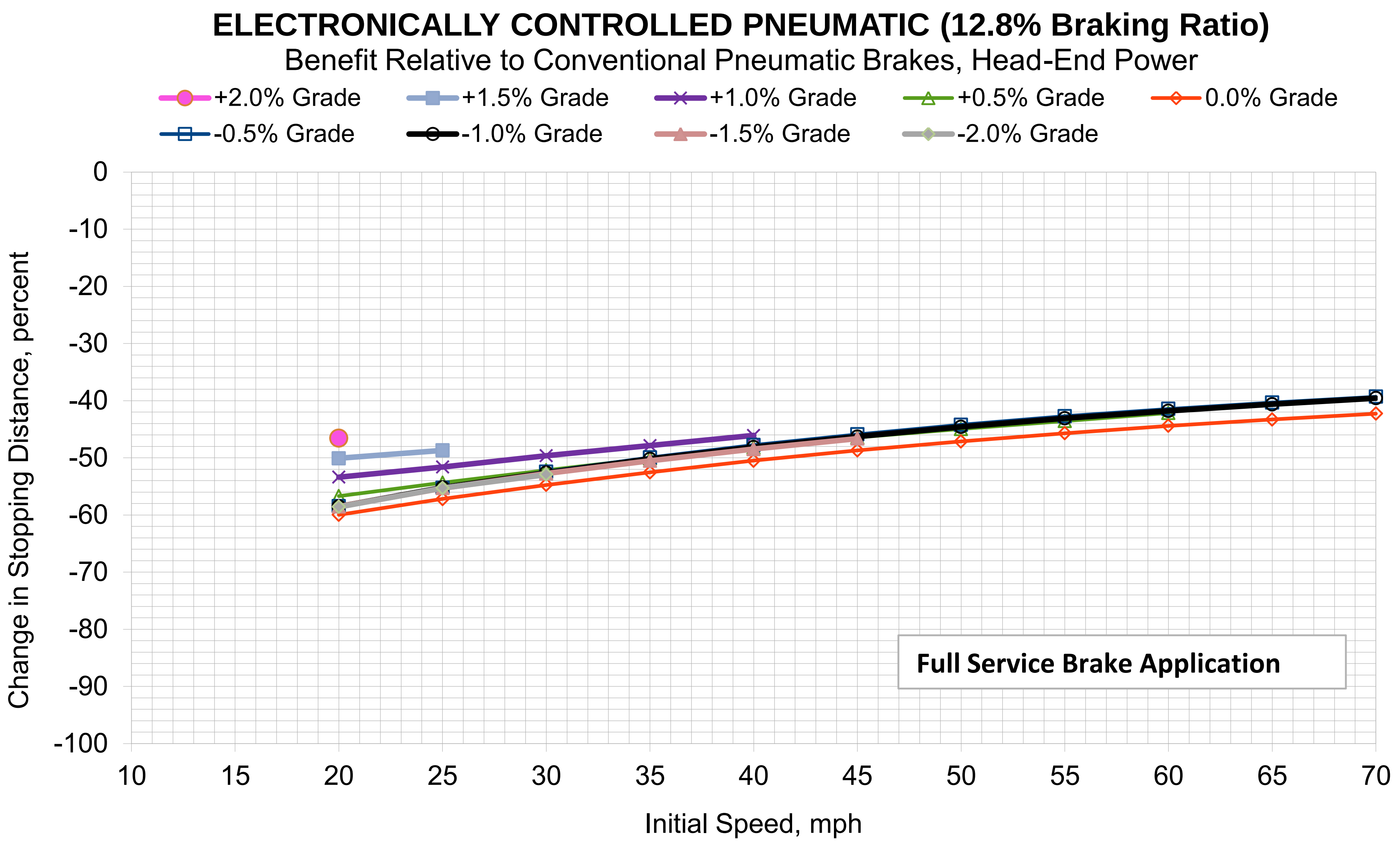

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

A22.24

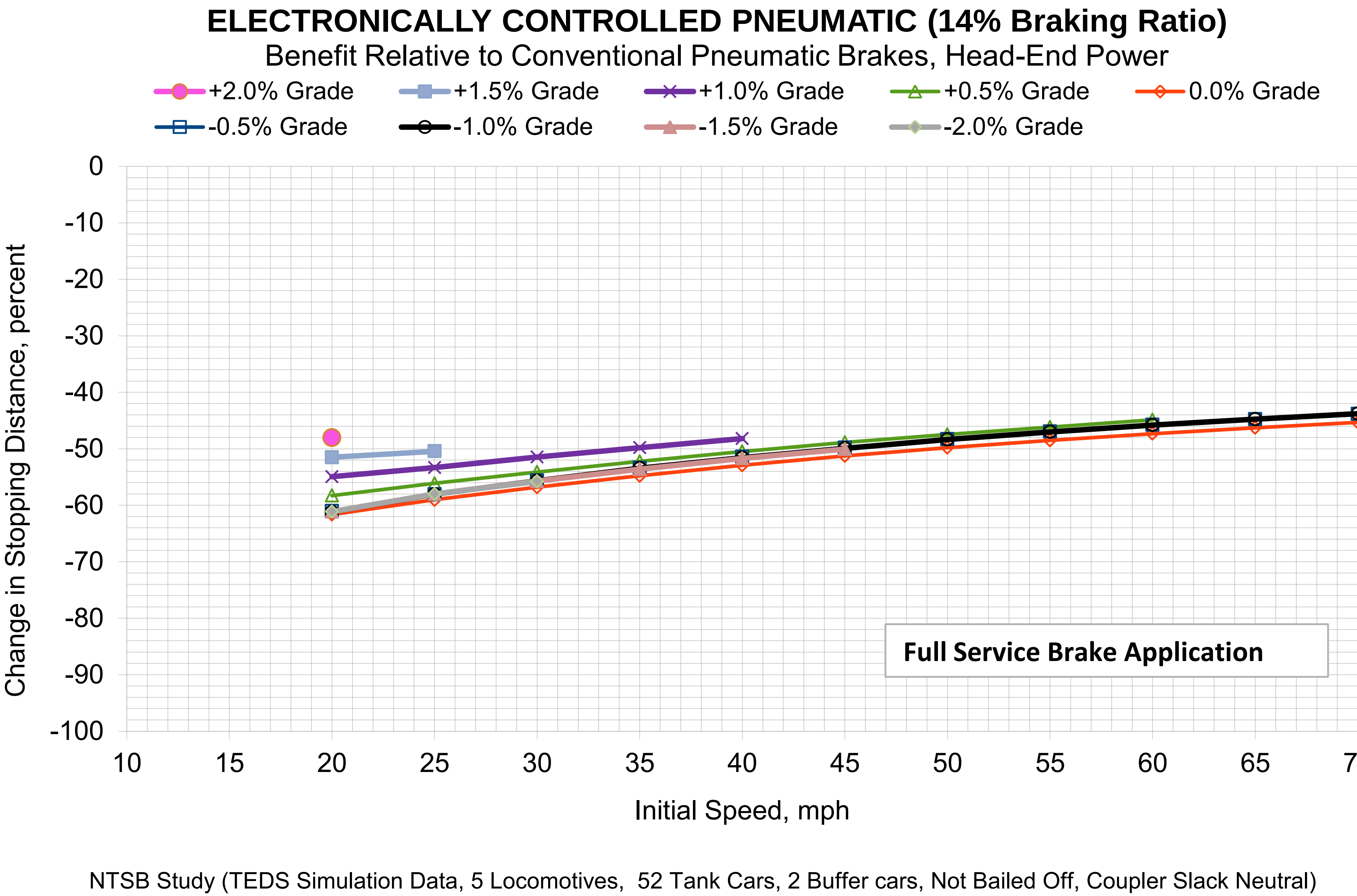

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

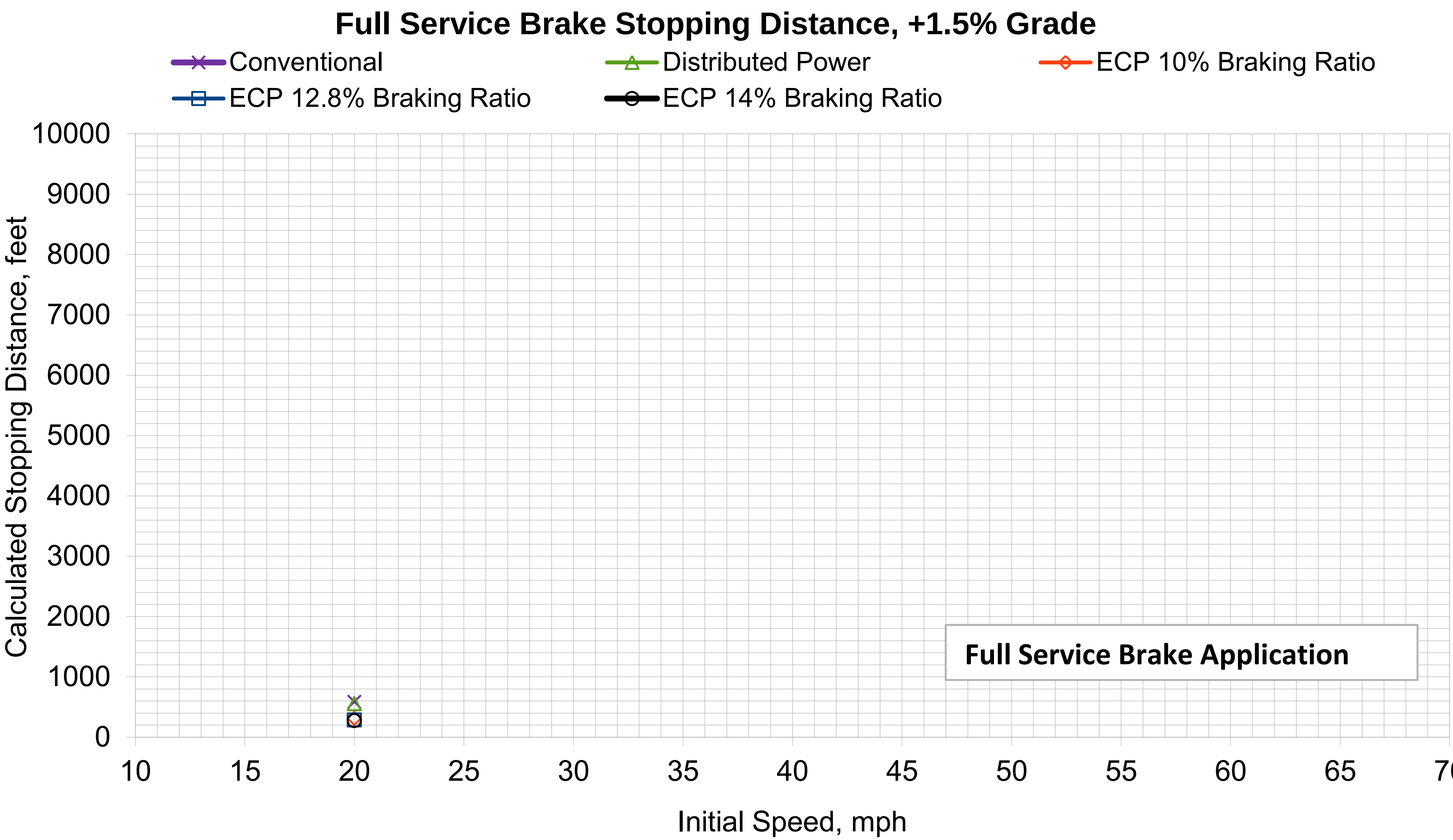


NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

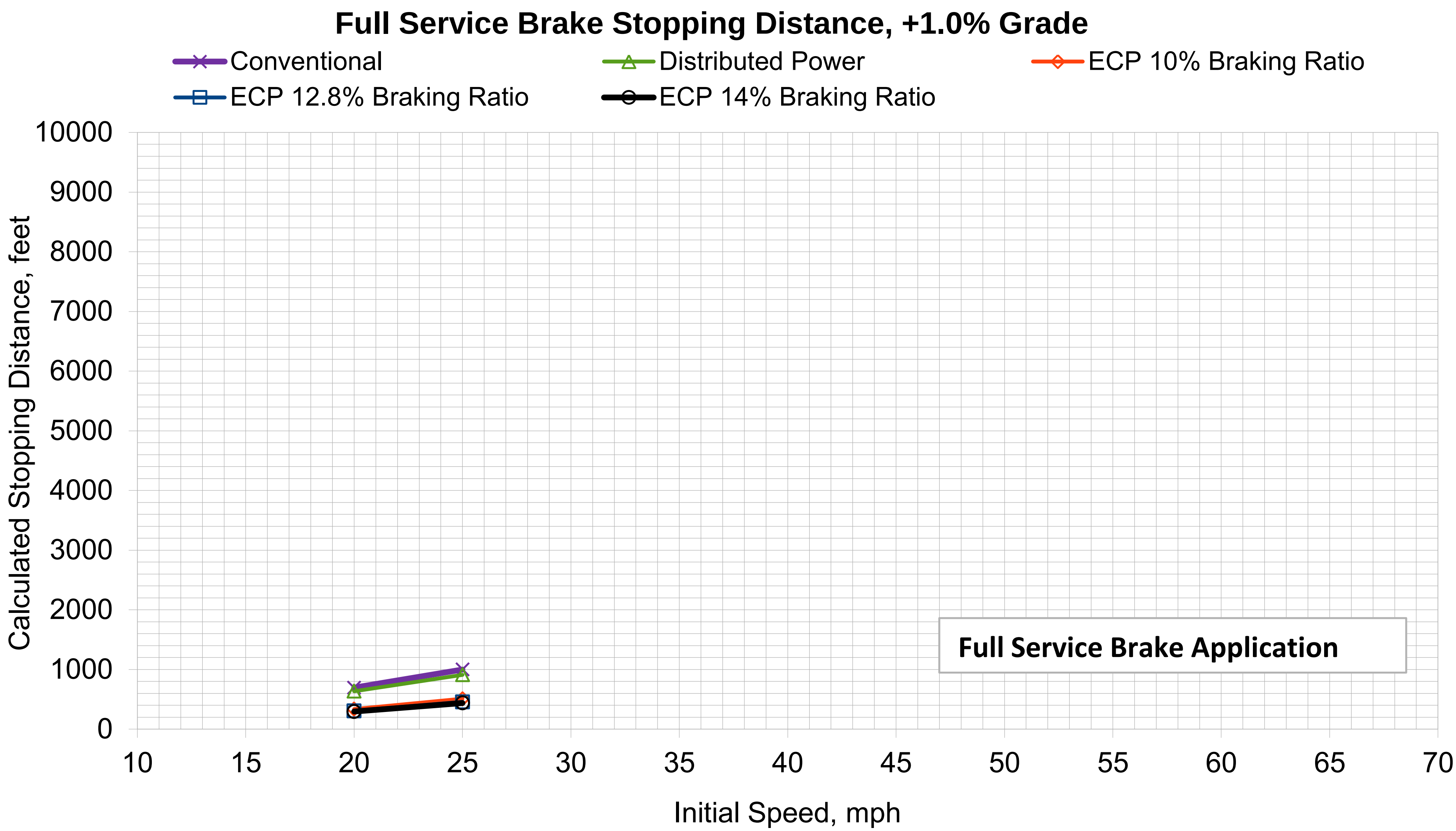

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 52 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

A22.28

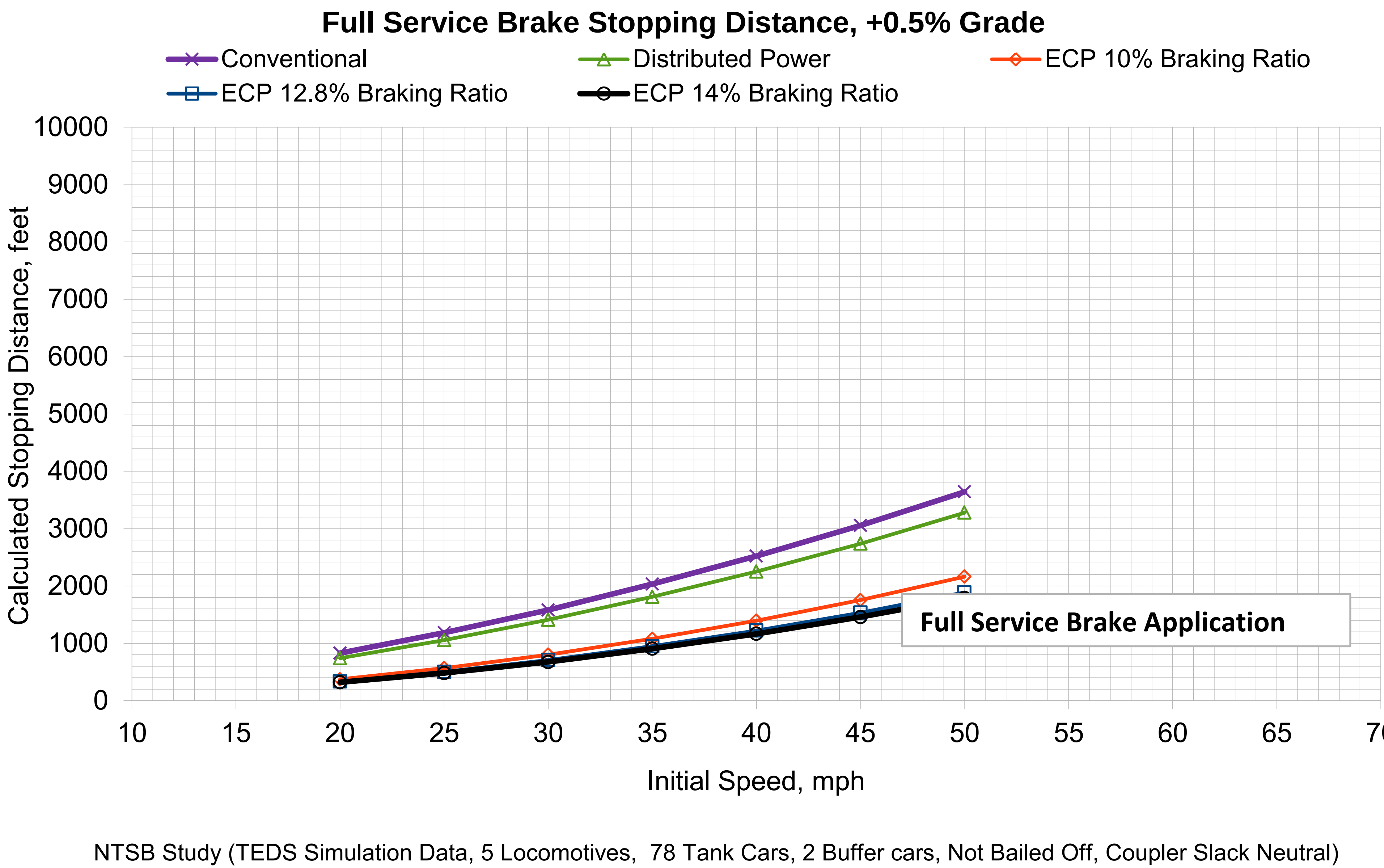
Attachment 23: Full Service Braking, No Bailoff, 78 Tank Cars



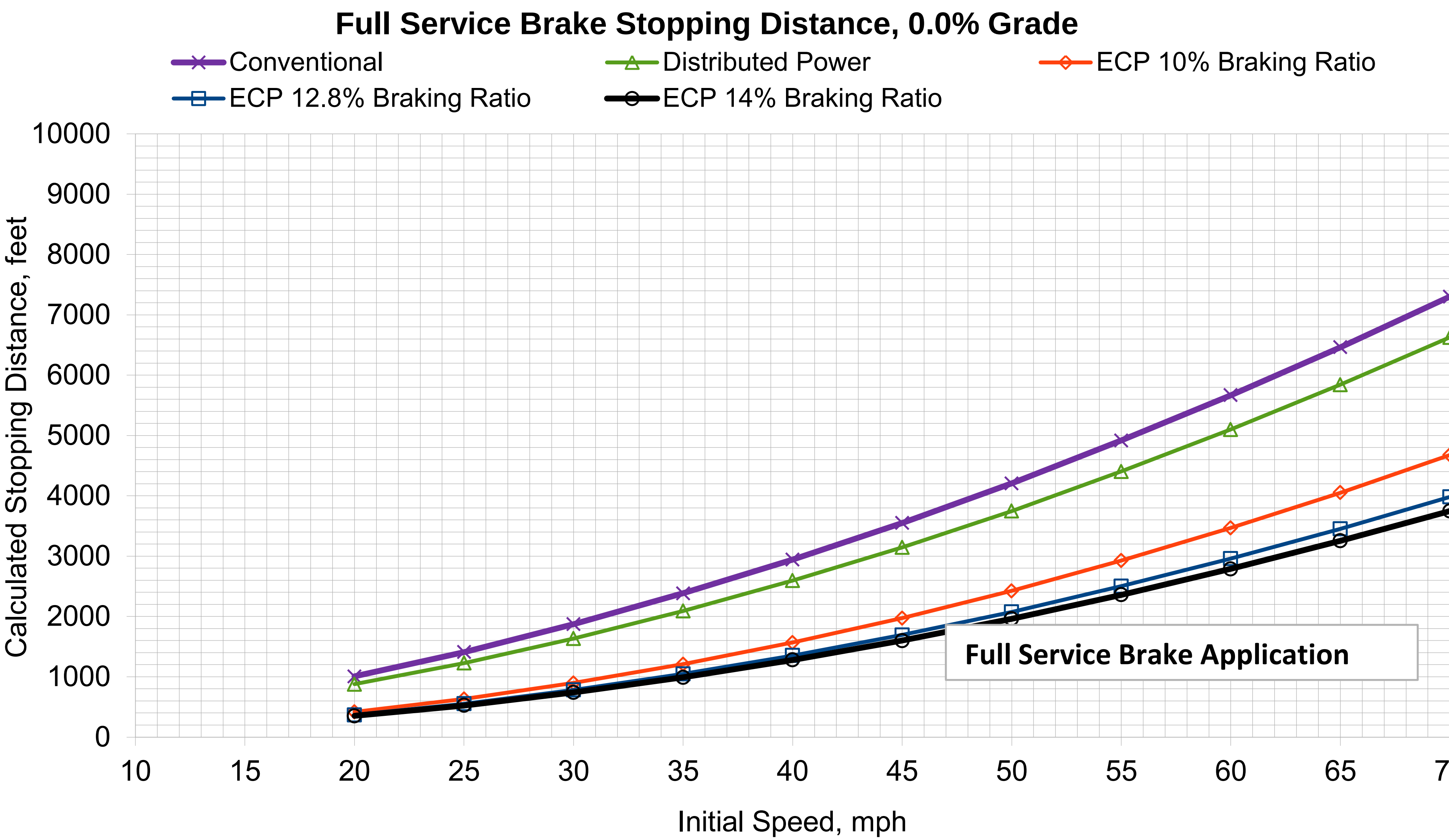
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



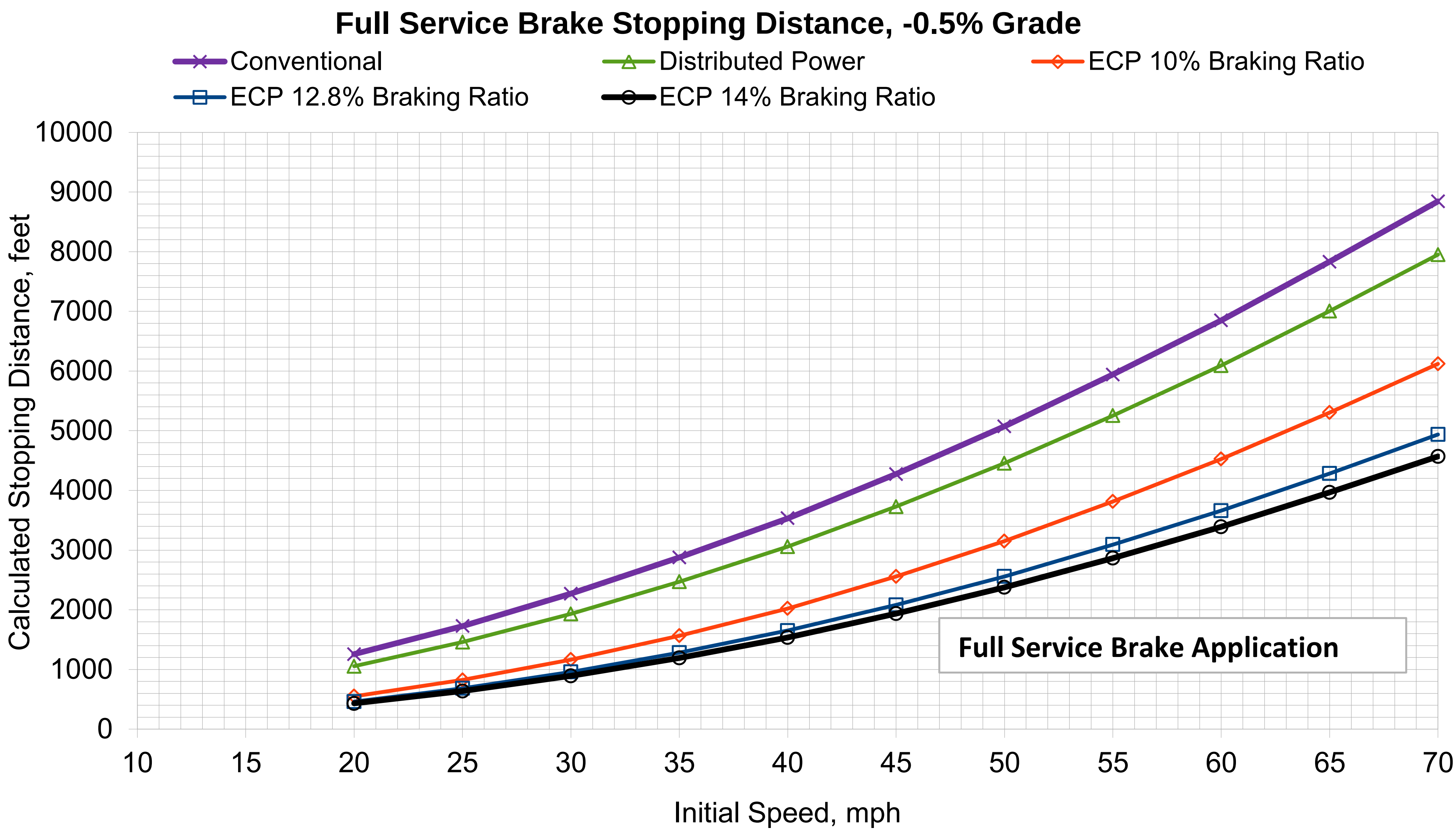
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



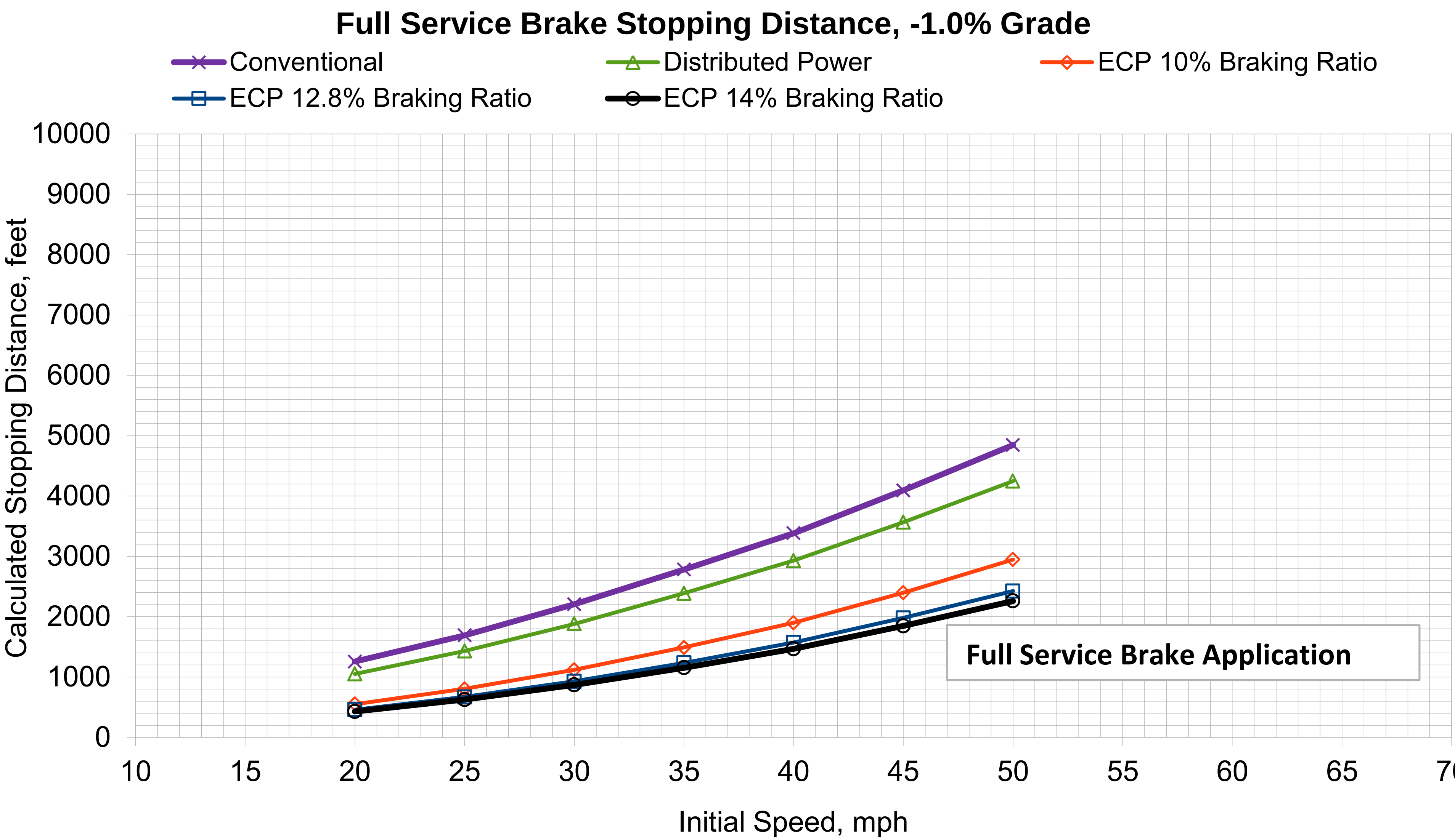
Full Service Brake Stopping Distance, +0.5% Grade
Conventional
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



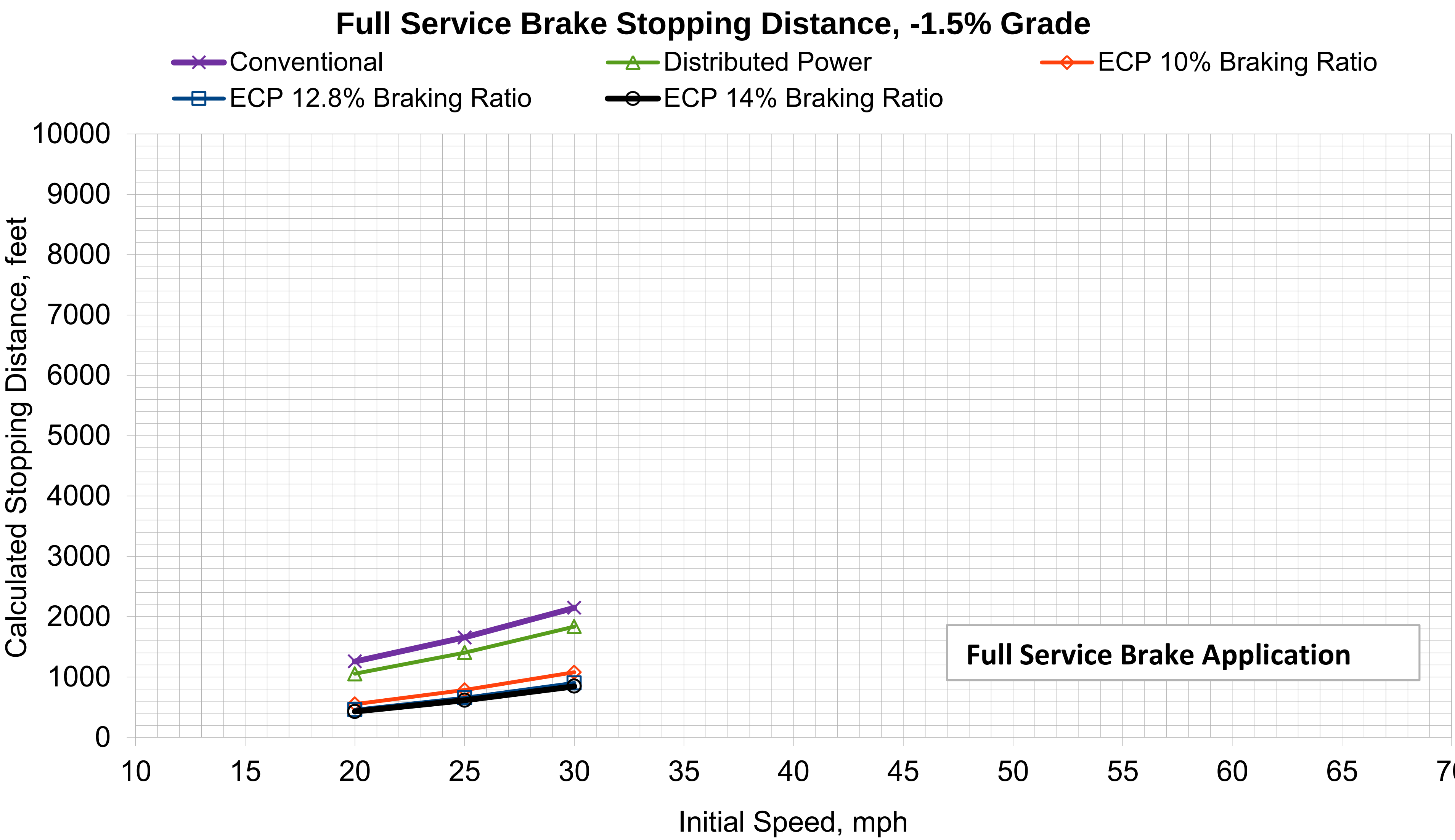
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



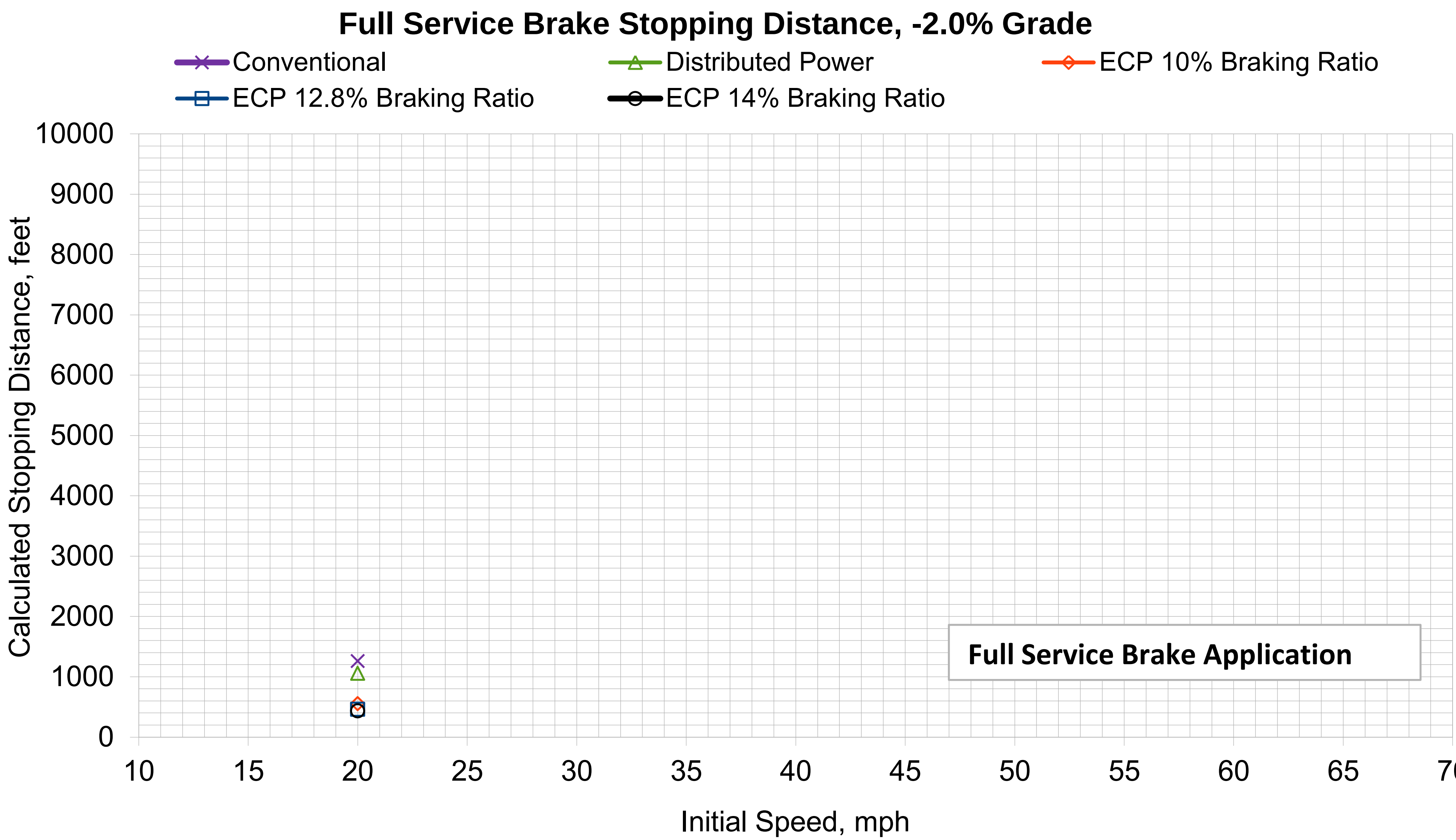
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



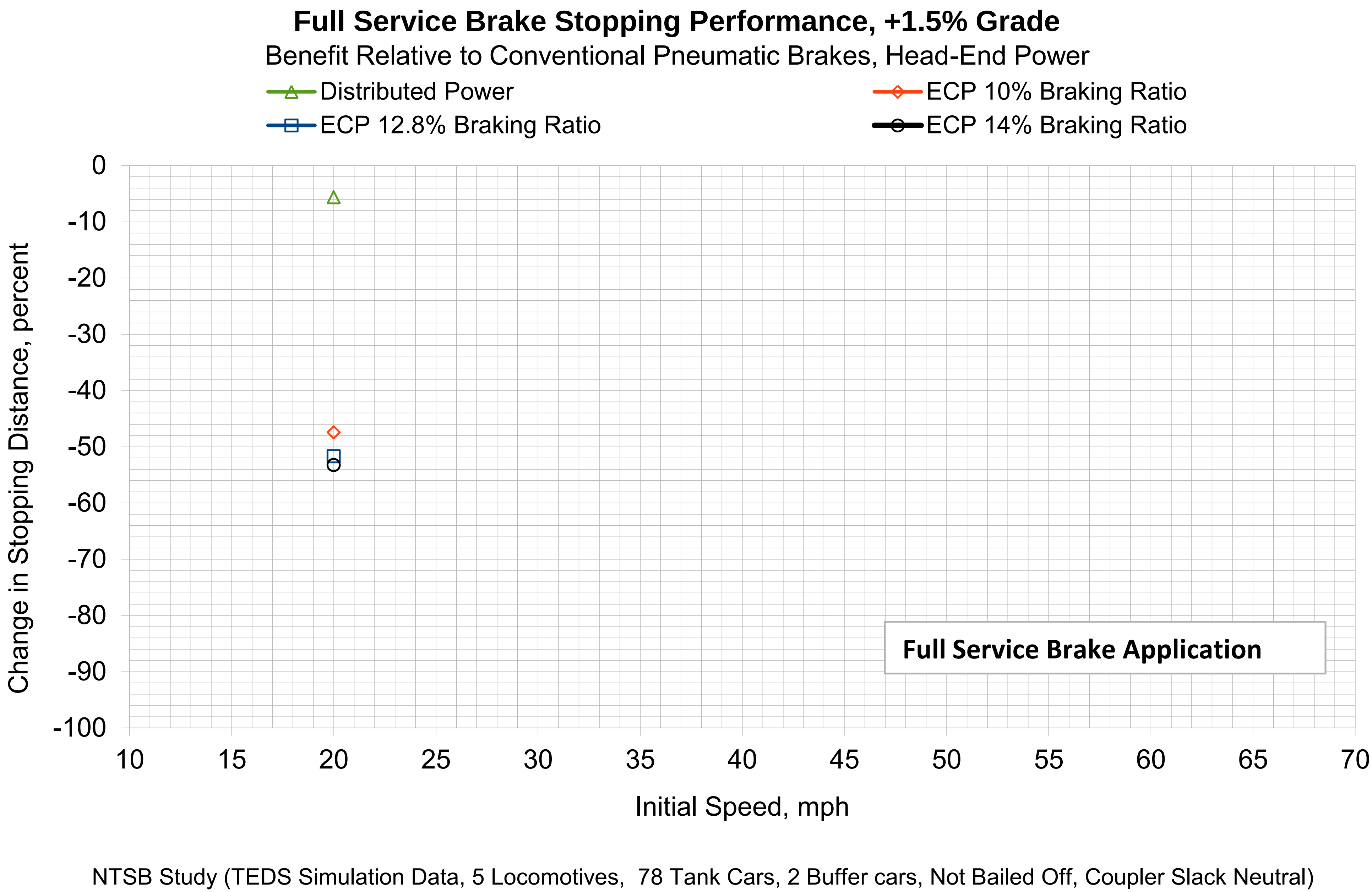
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

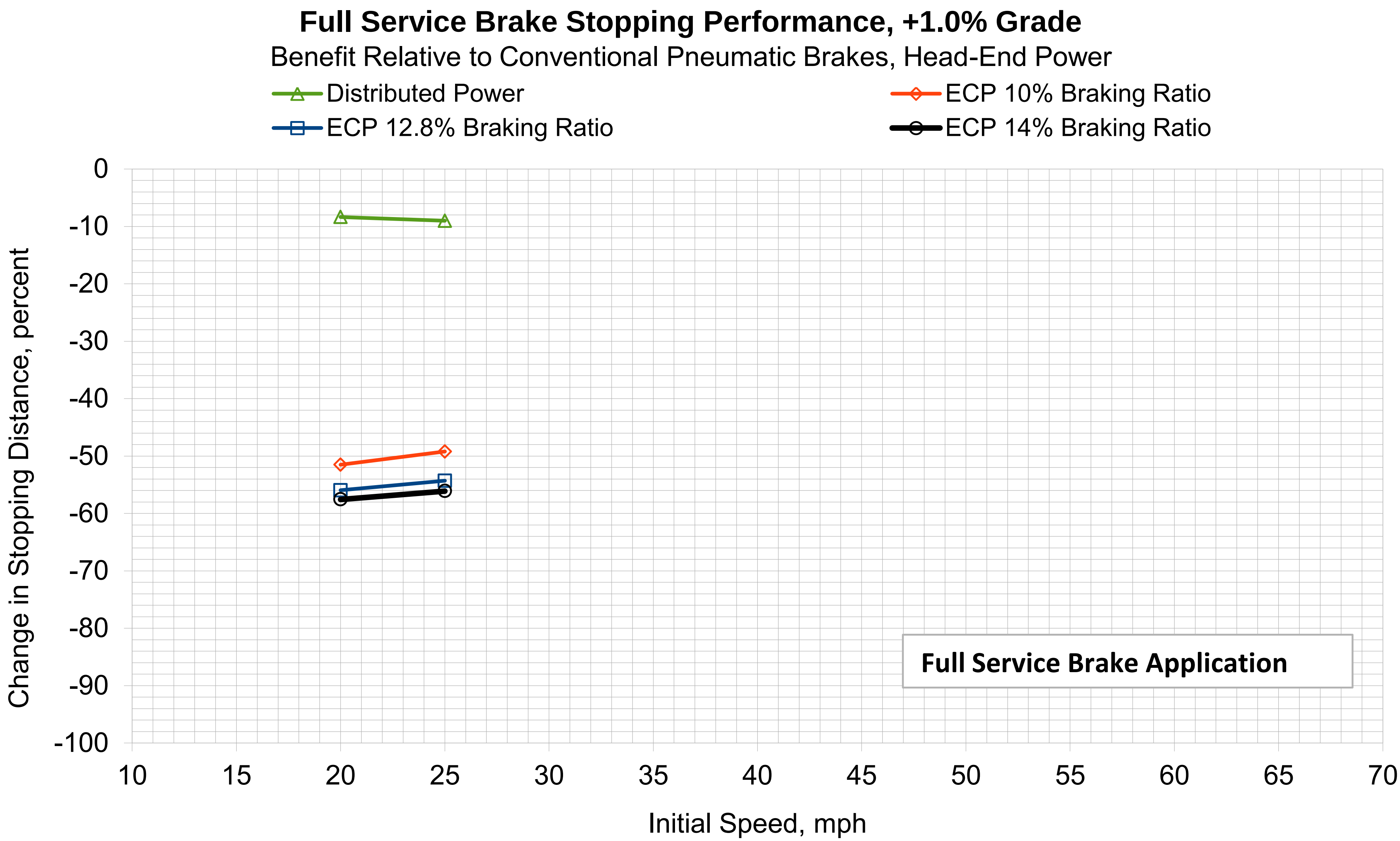


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

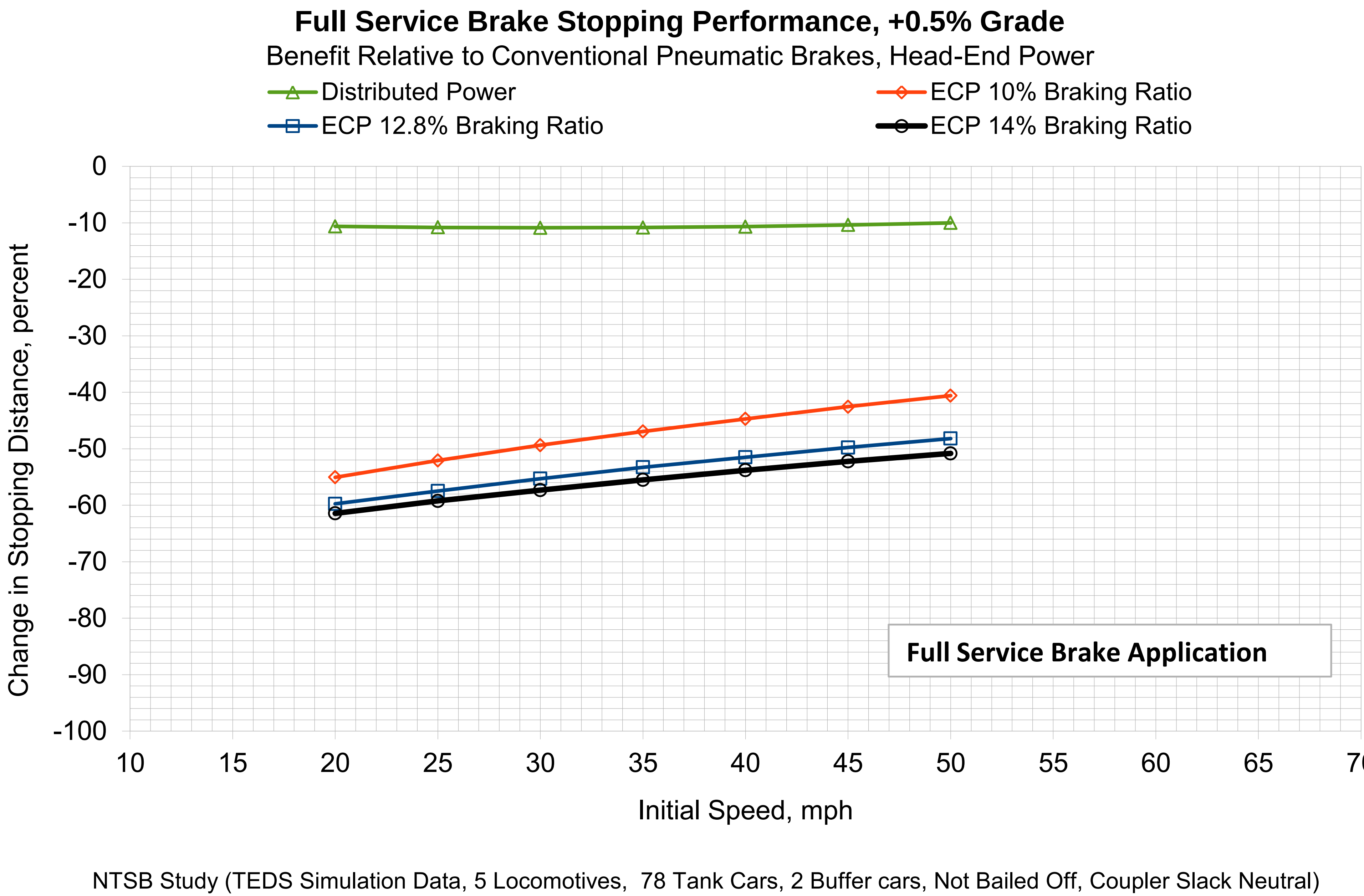


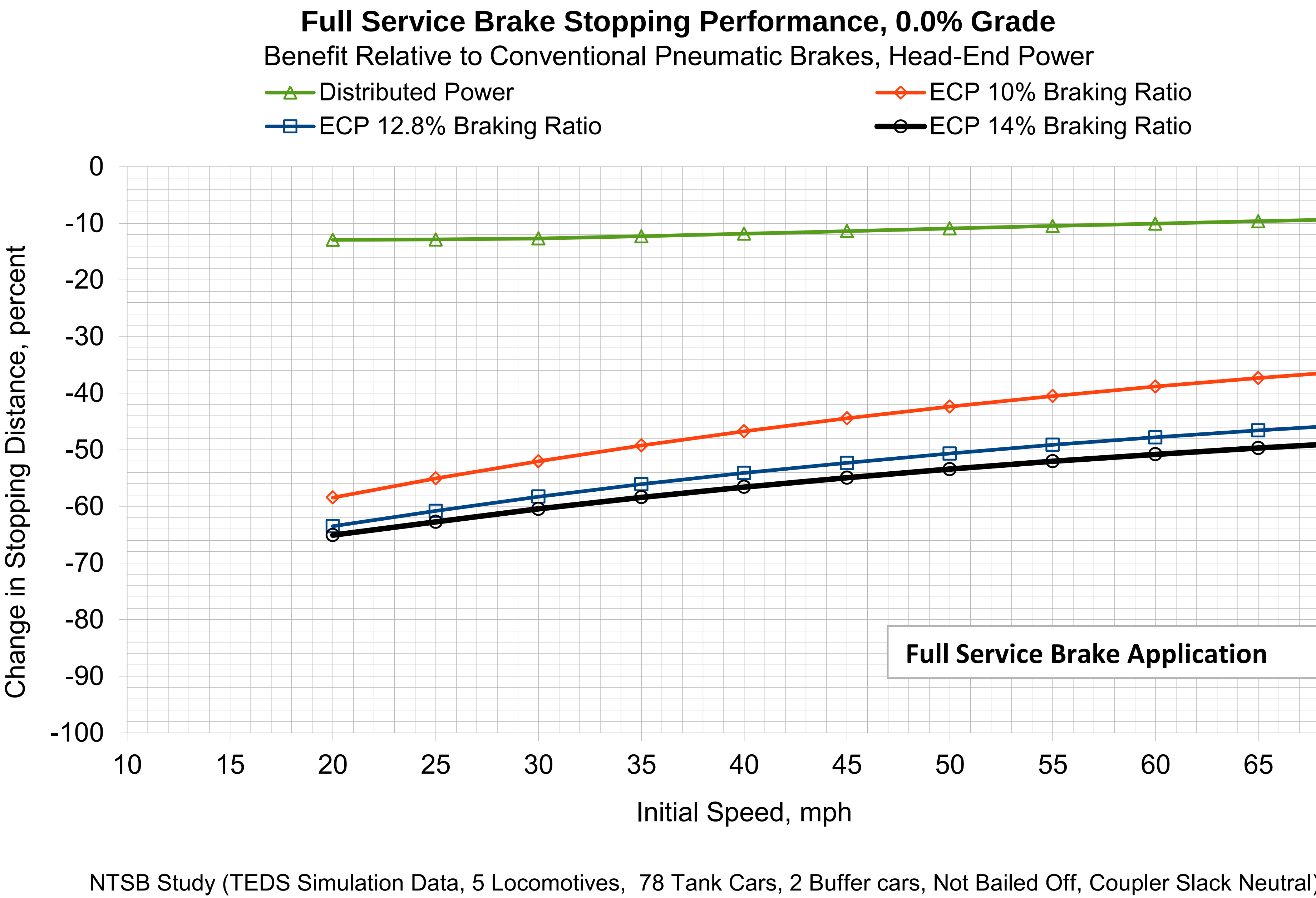
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

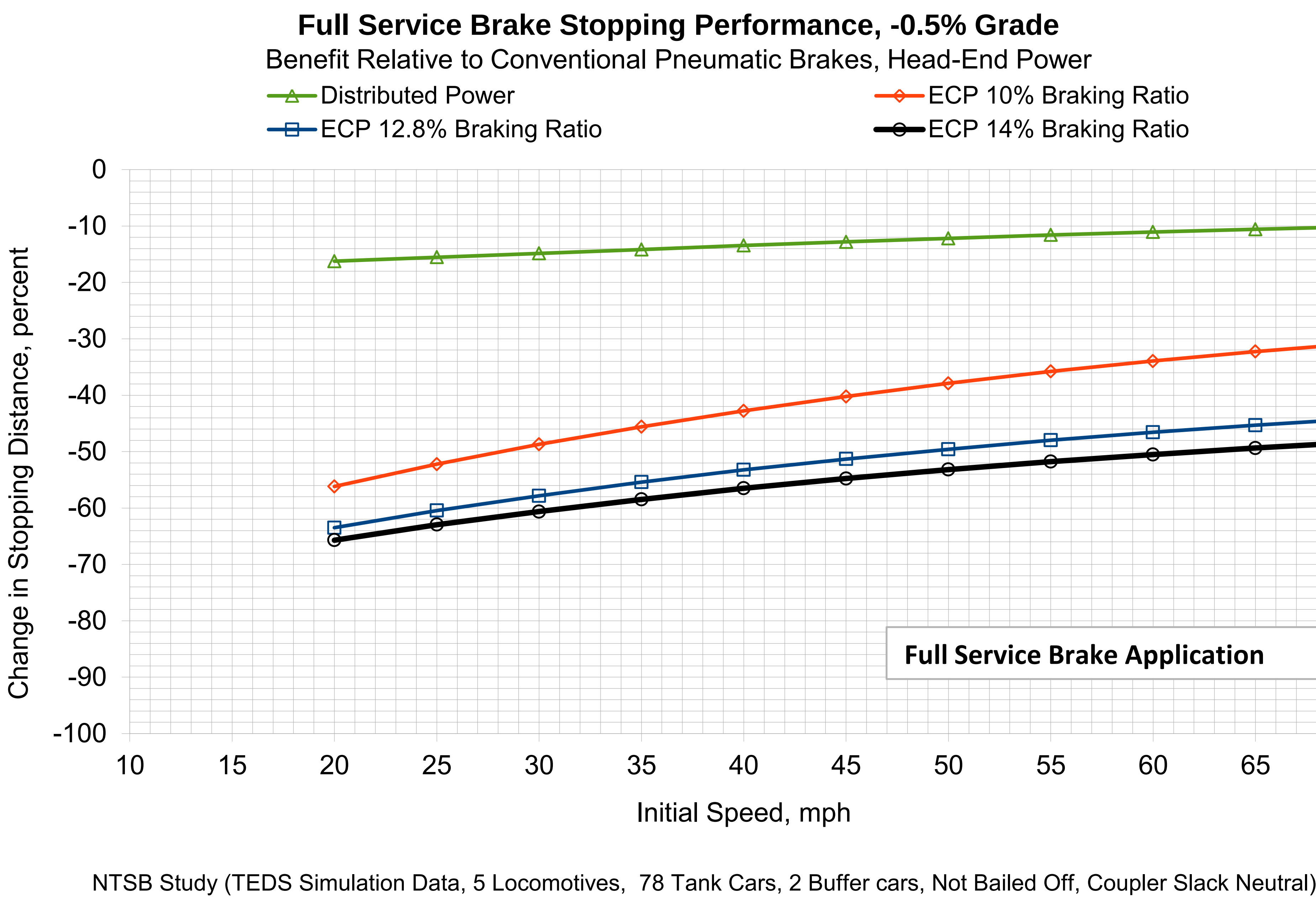

Full Service Brake Stopping Performance, +1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Change in Stopping Distance, percent
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

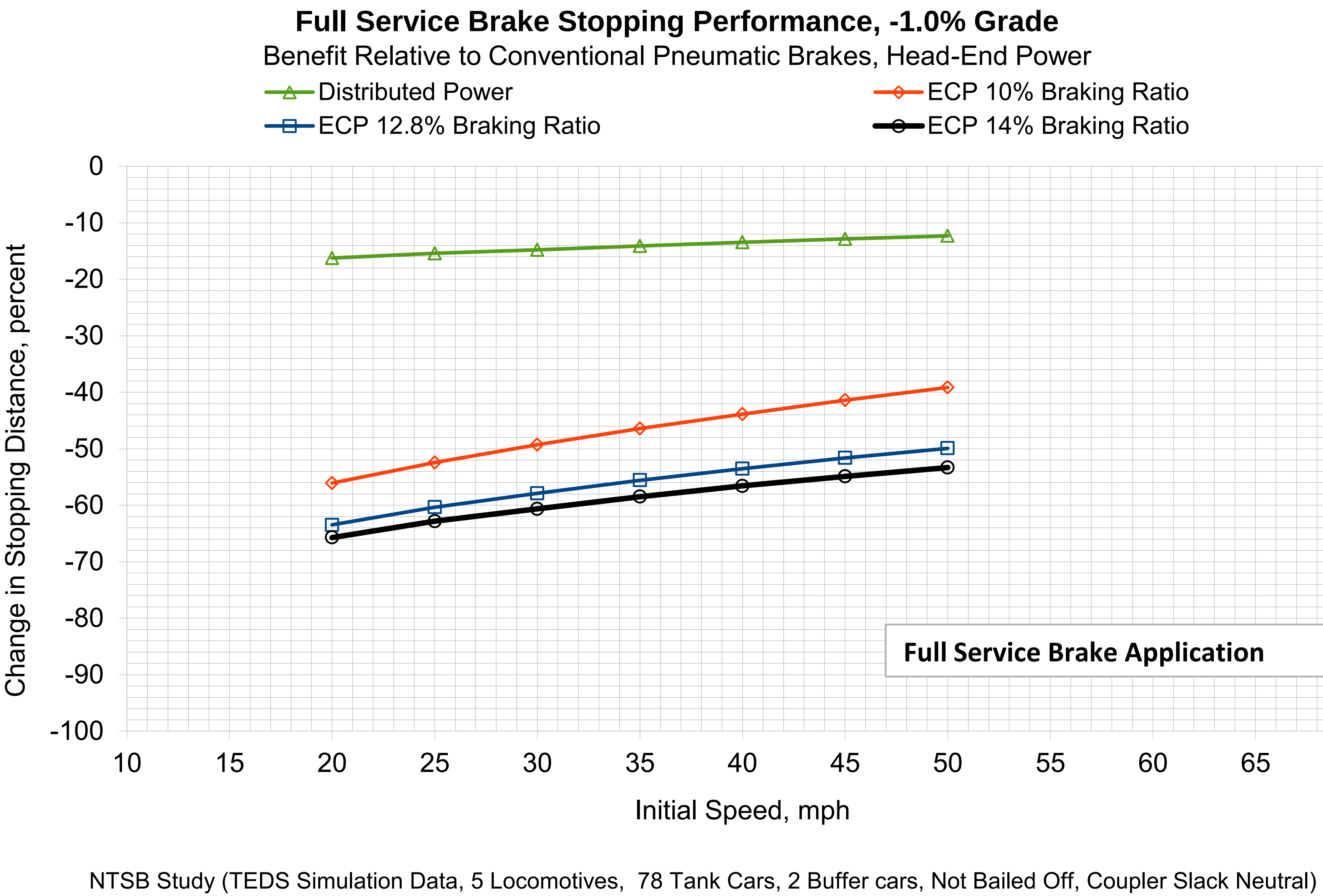

Full Service Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

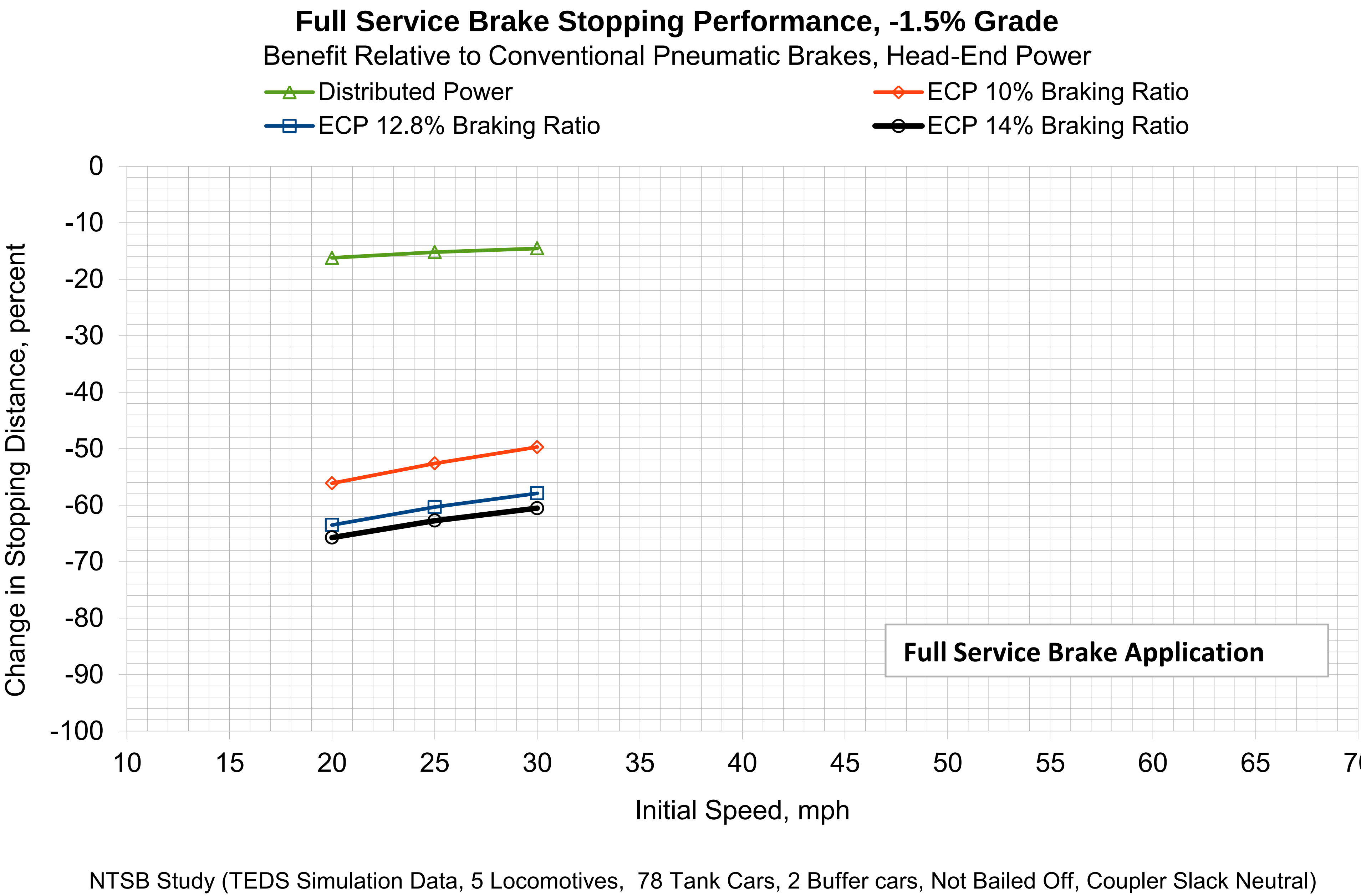

Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

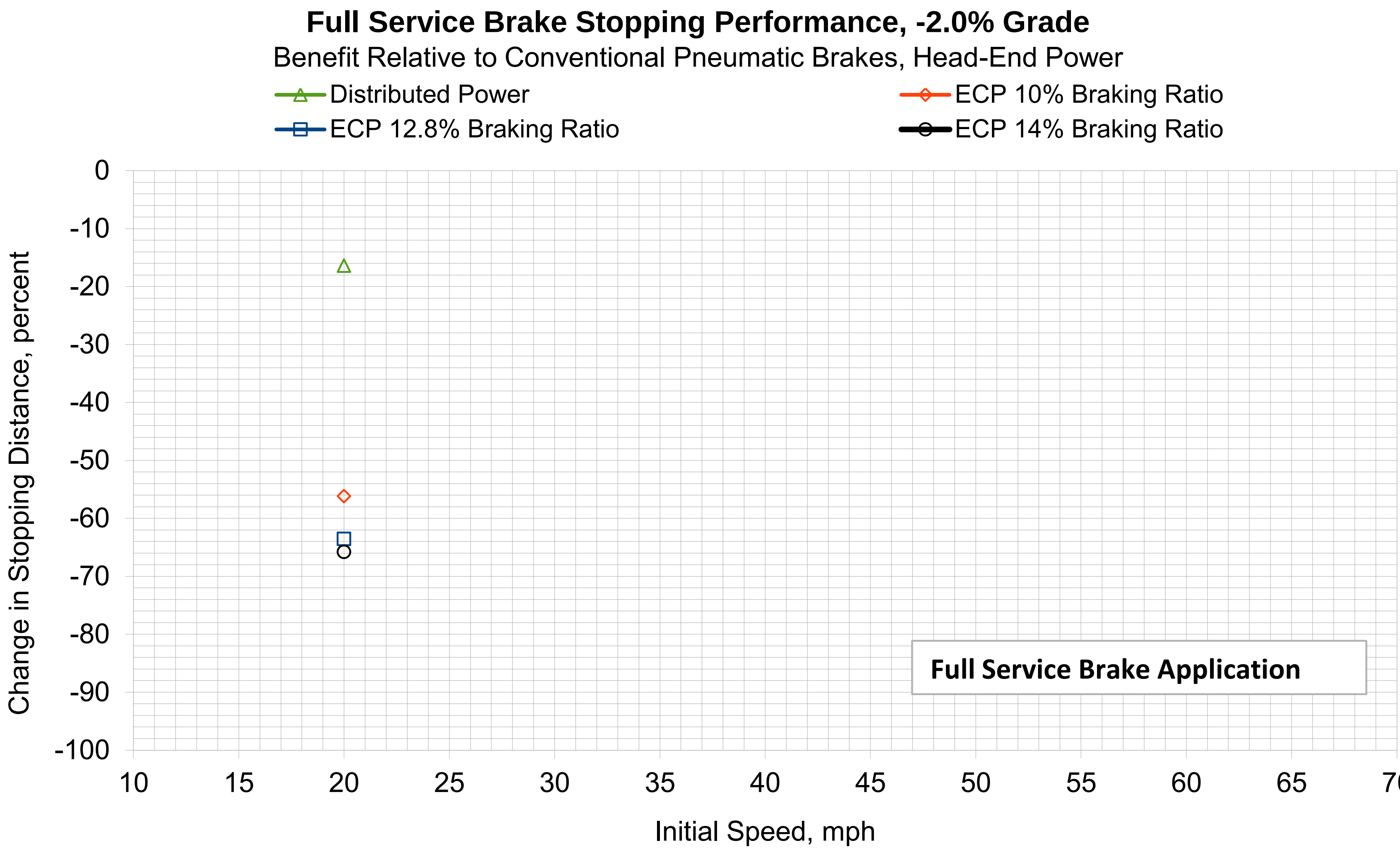


Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Change in Stopping Distance, percent
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

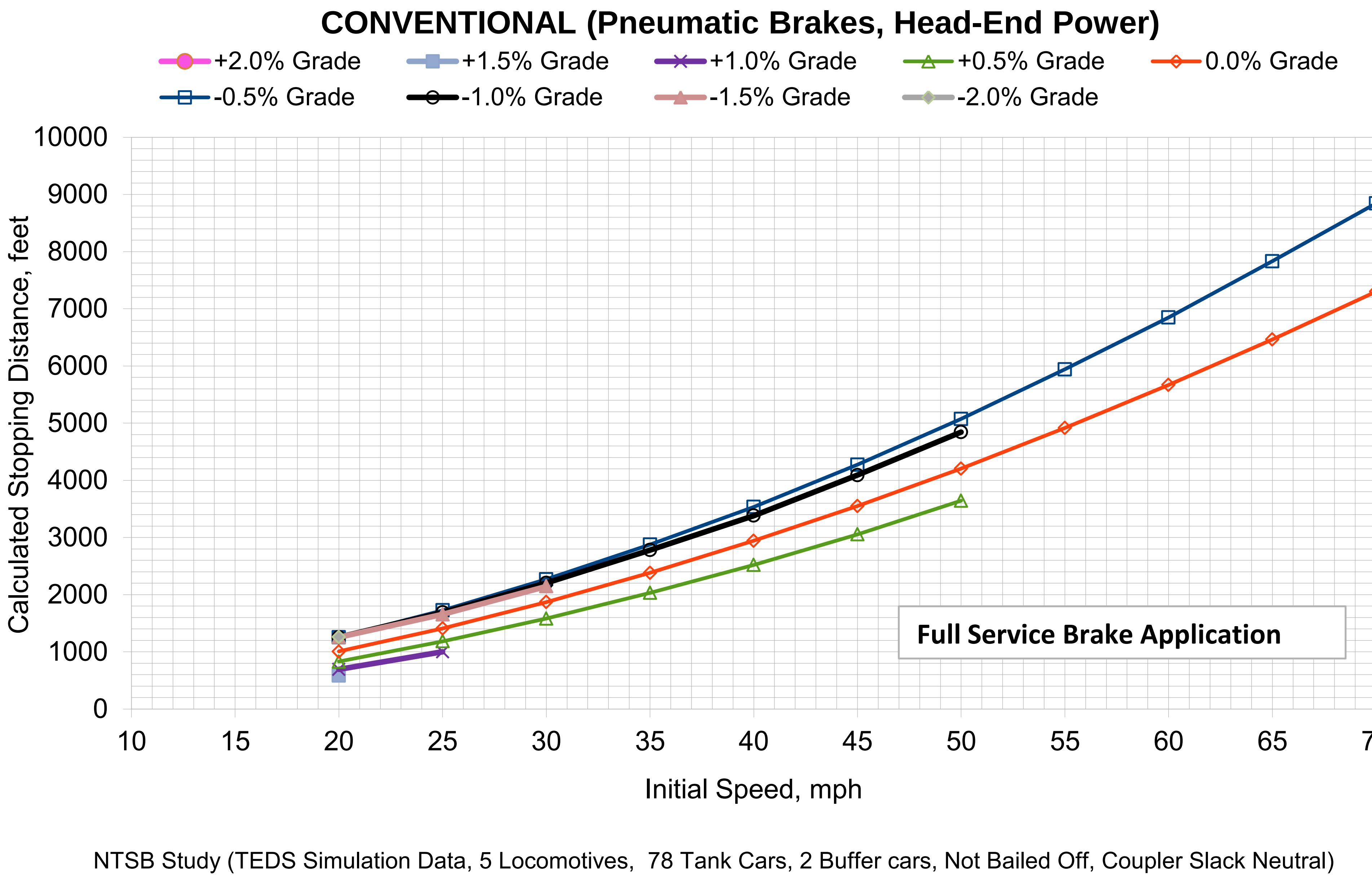
A23.14

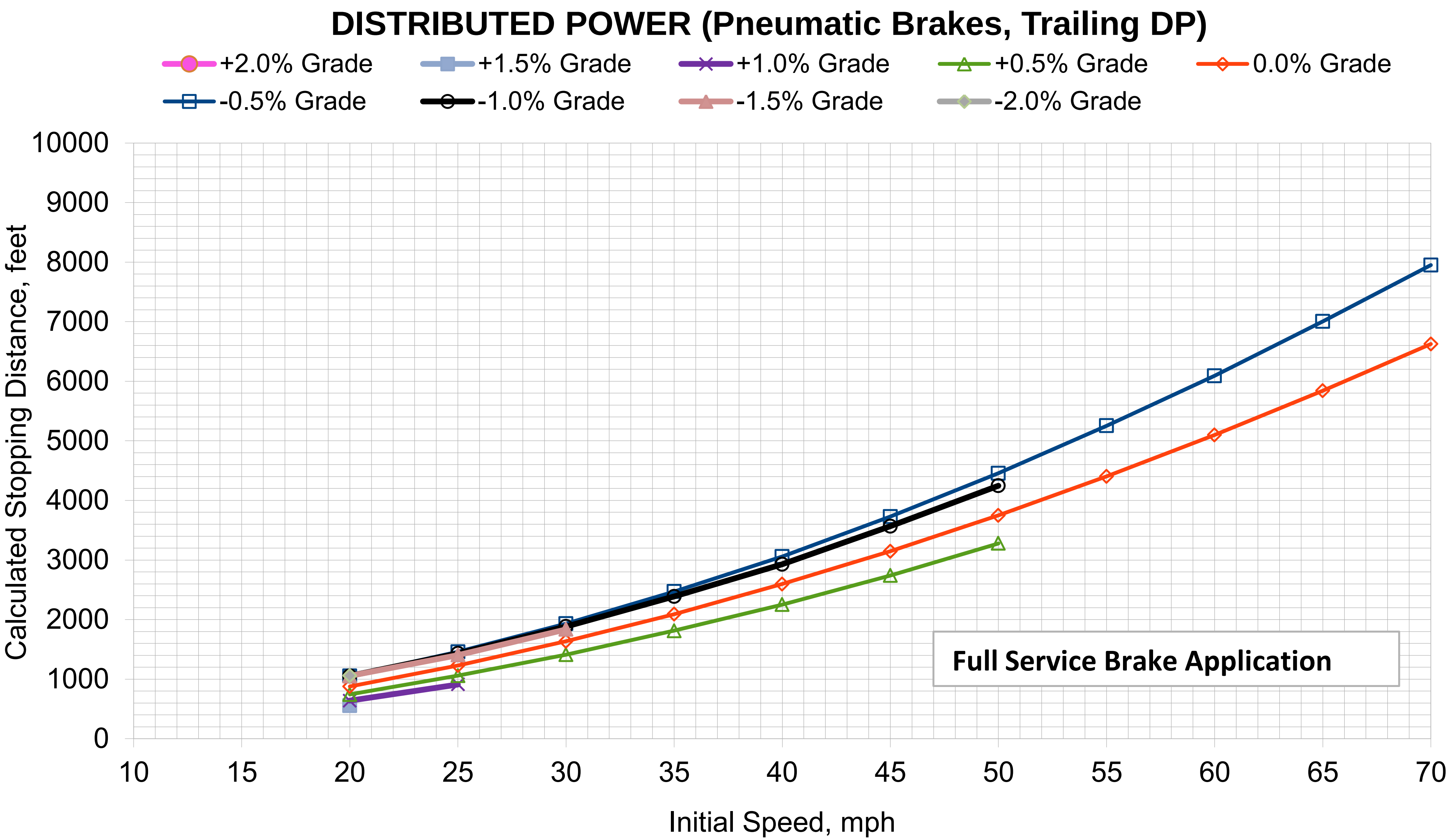

Full Service Brake Stopping Performance, -1.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


Full Service Brake Stopping Performance, -1.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

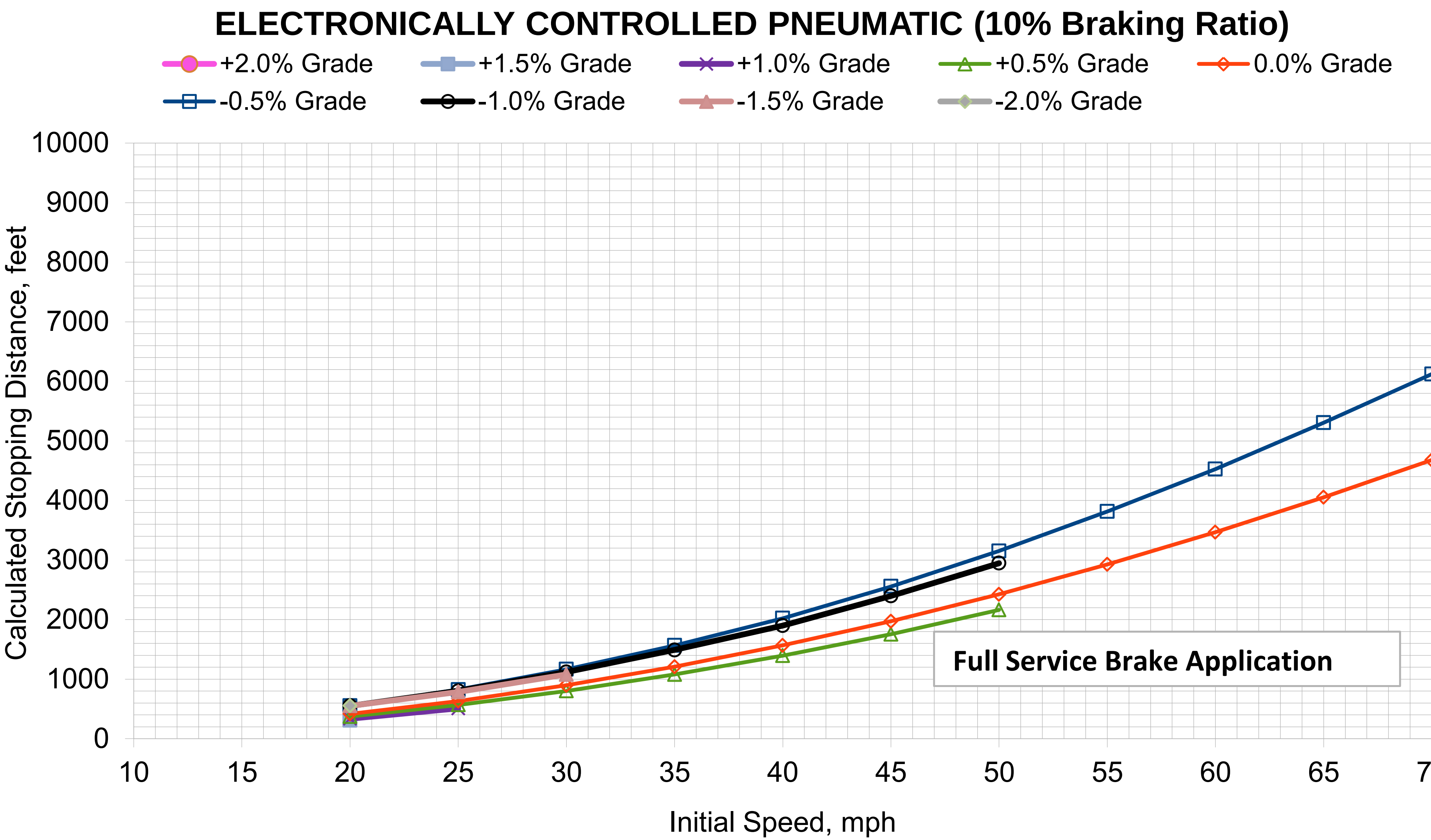


NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

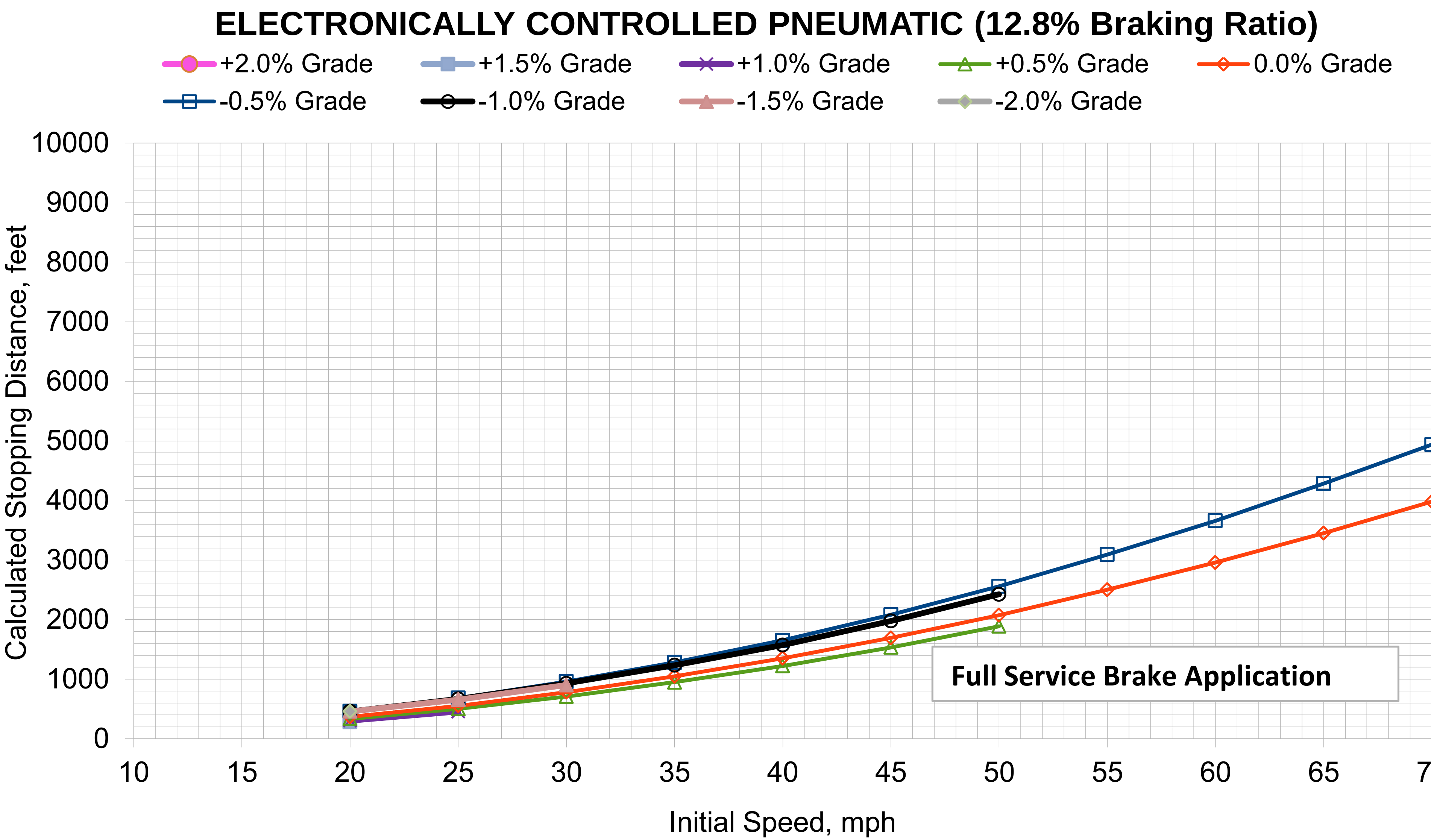

CONVENTIONAL (Pneumatic Brakes, Head-End Power)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



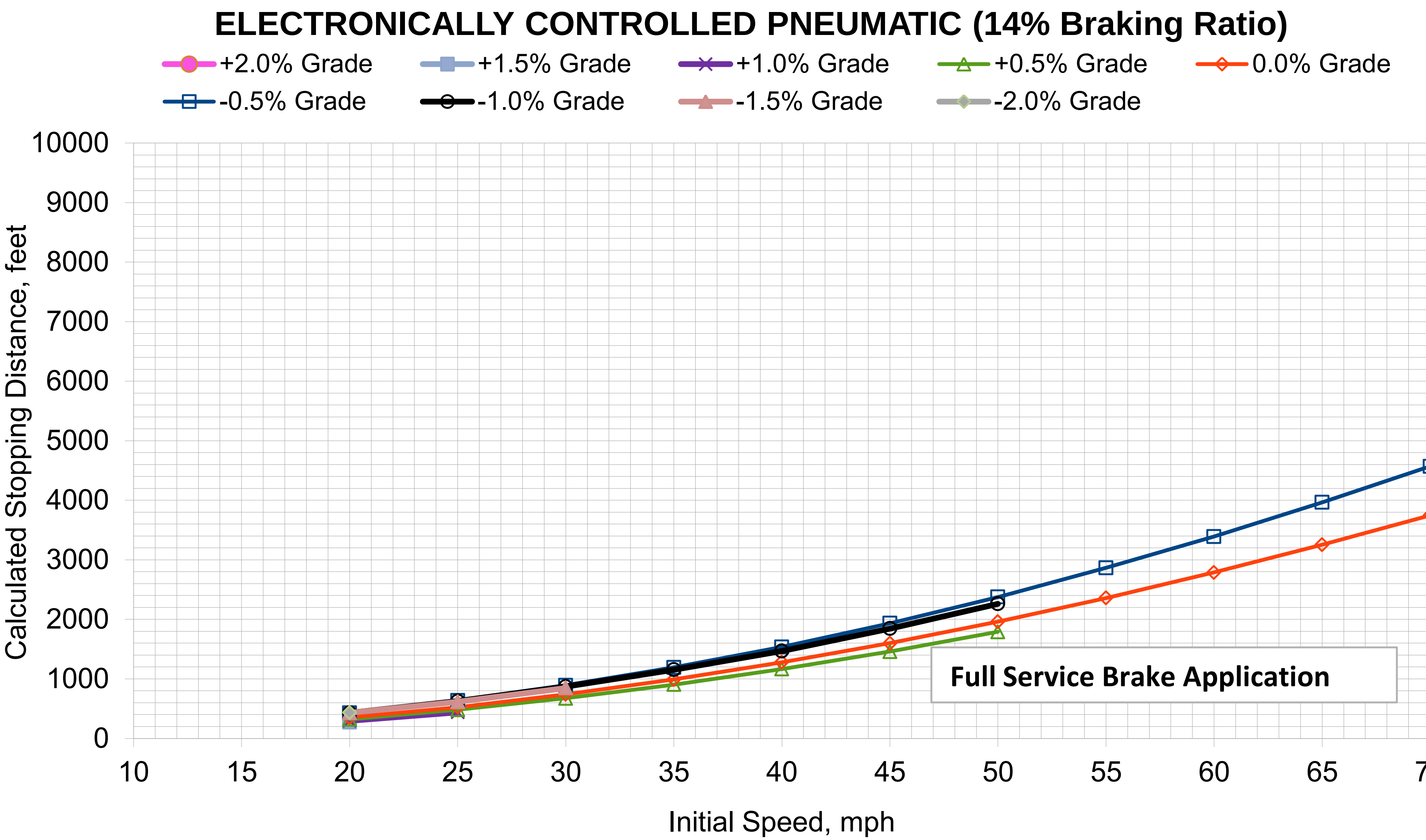
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



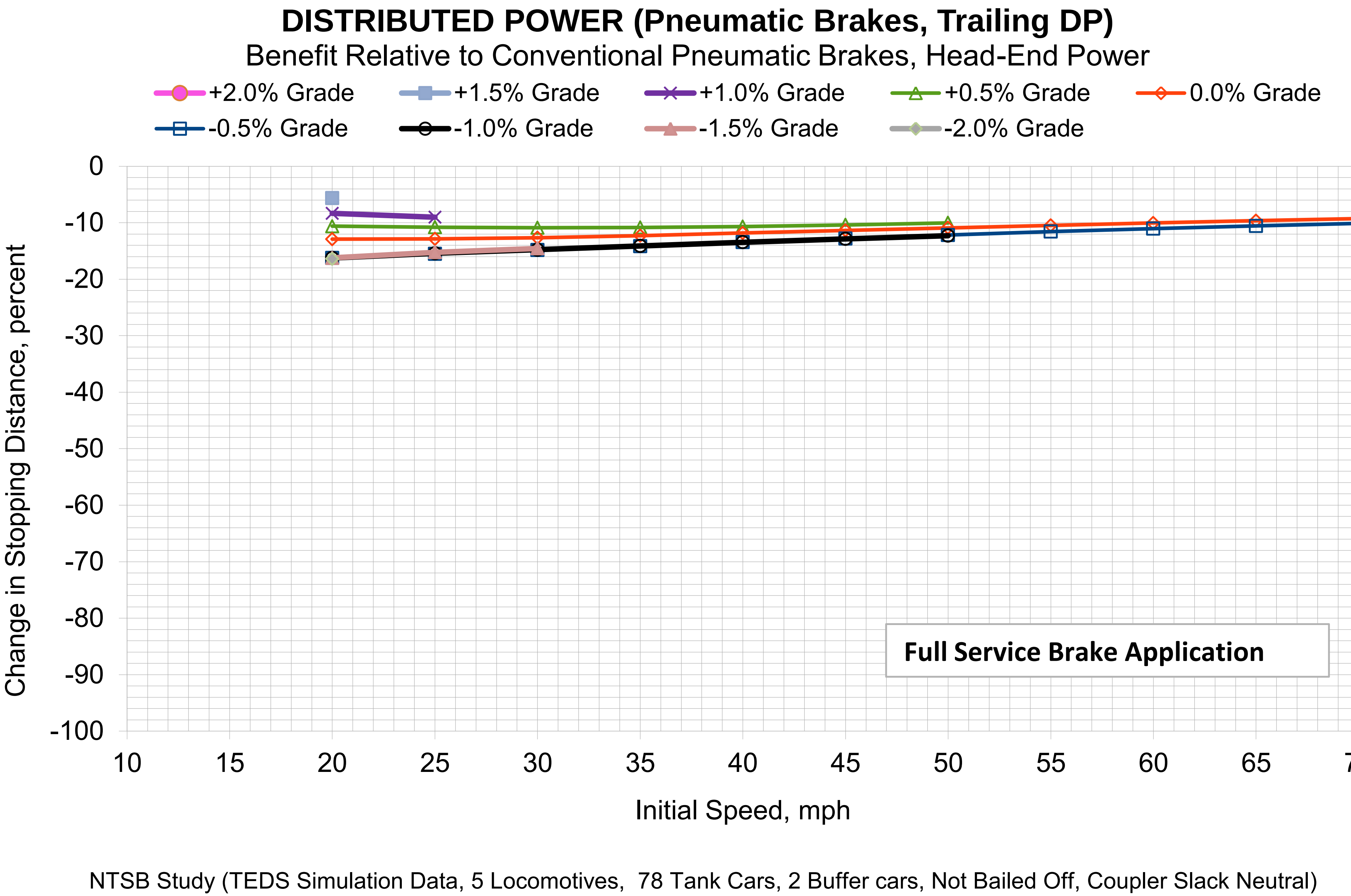
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



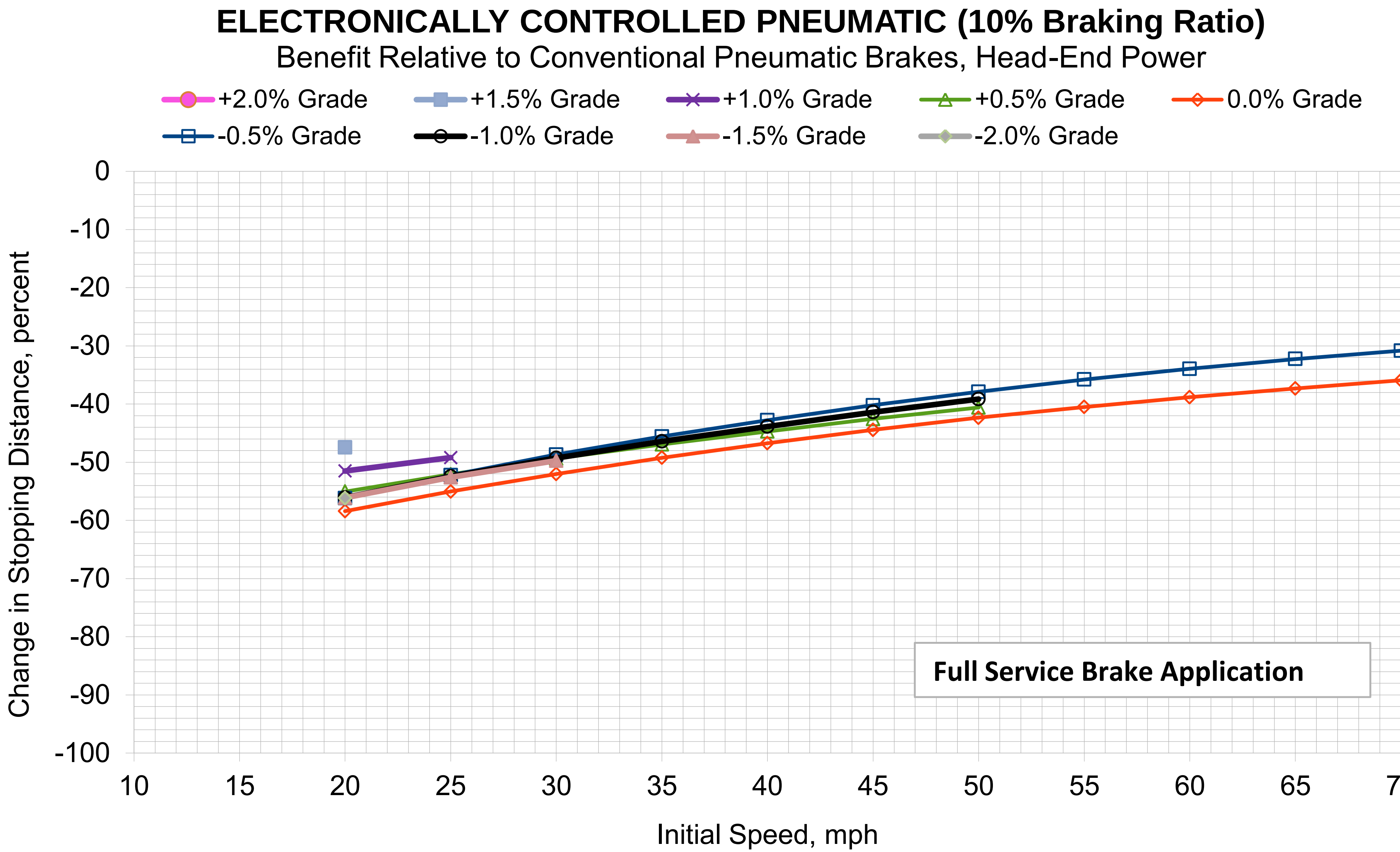
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



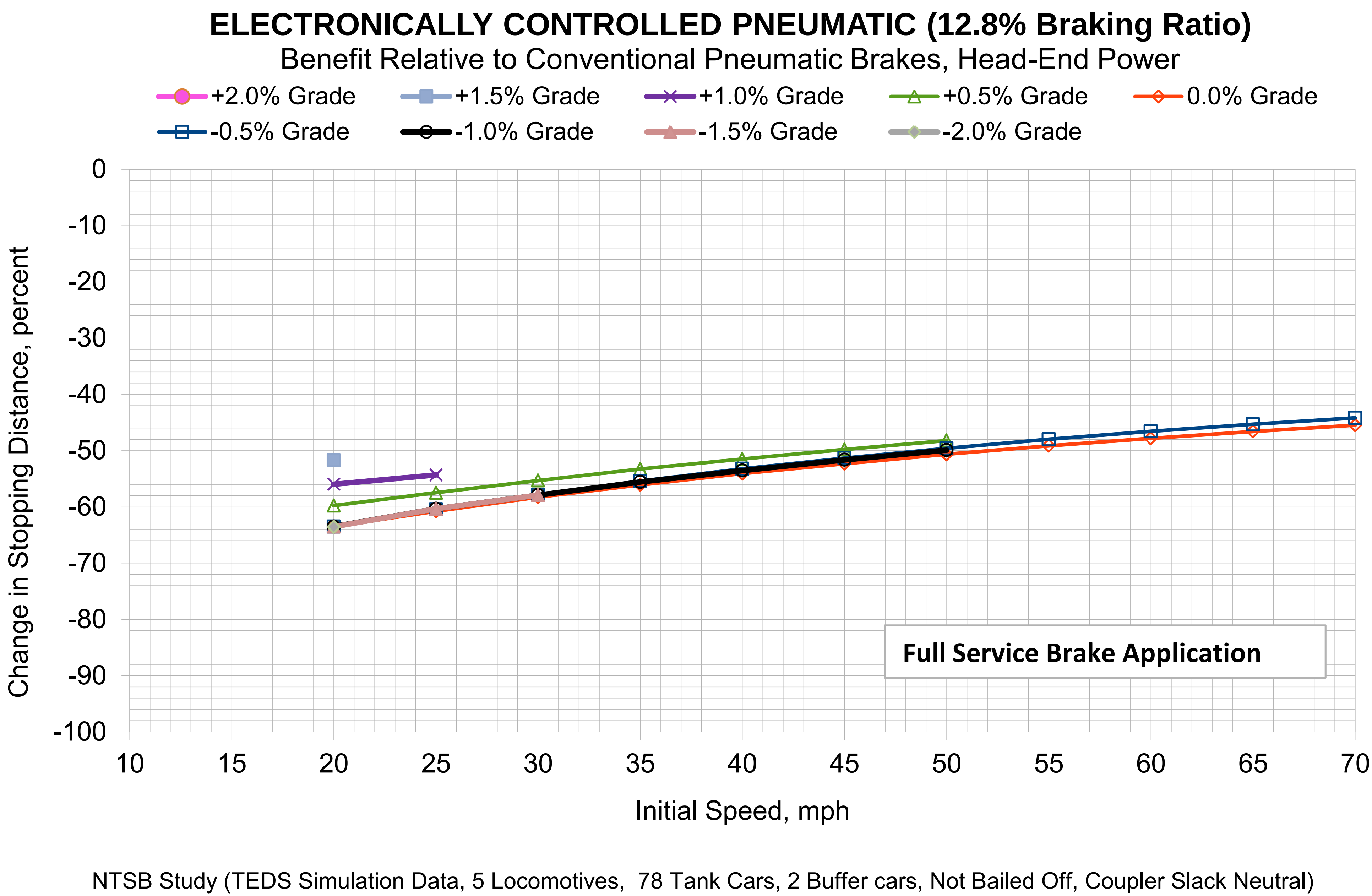
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

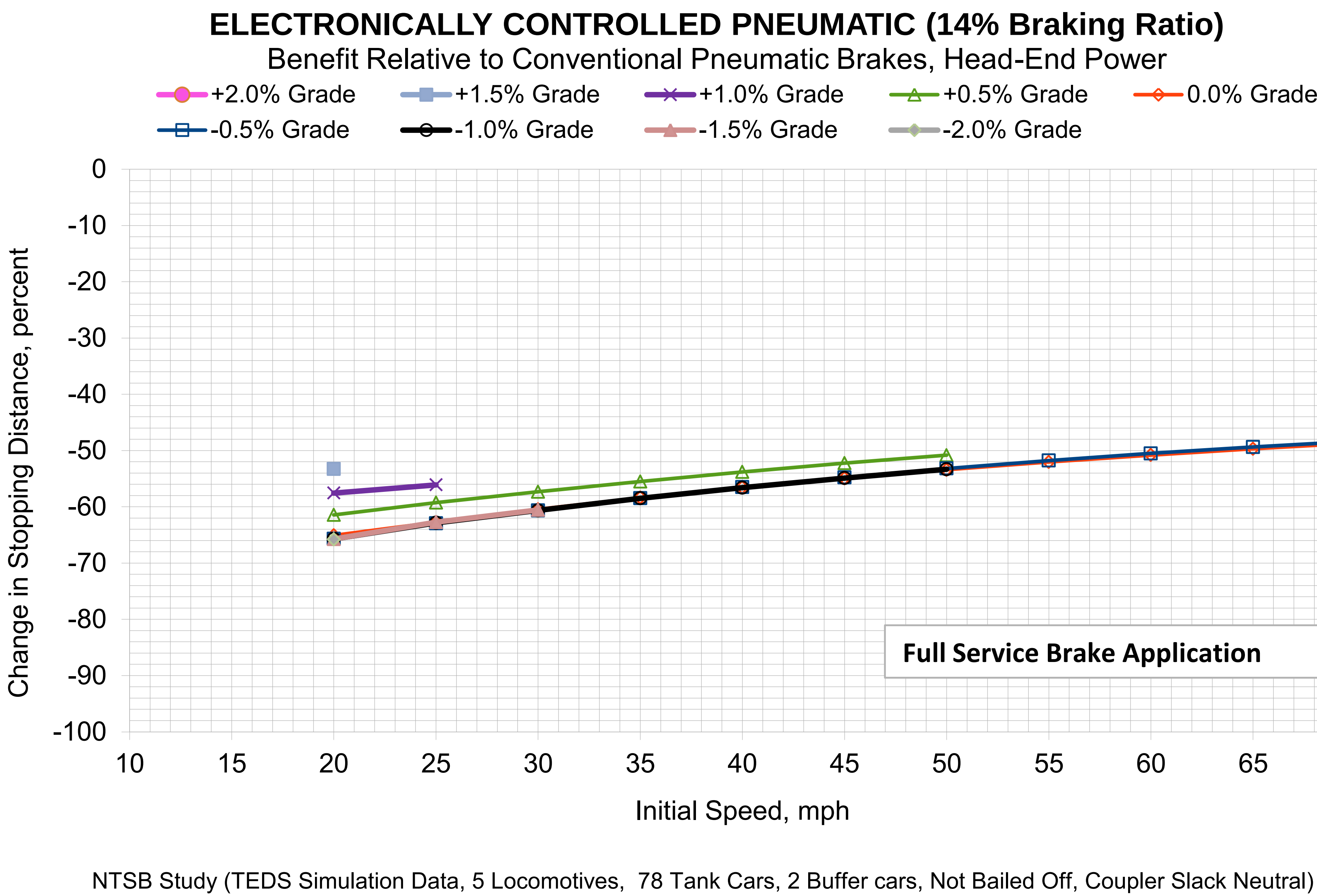


DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



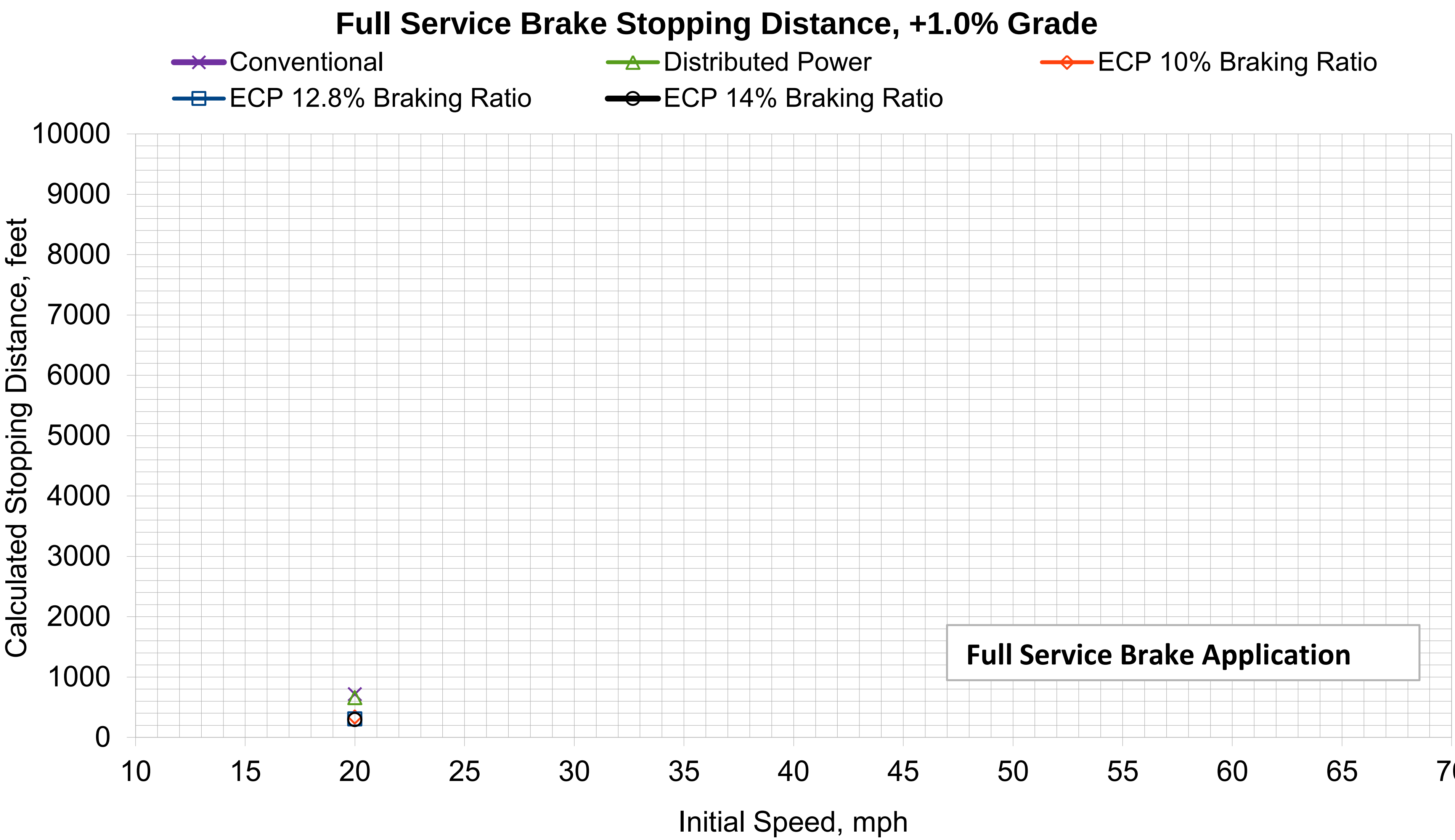
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

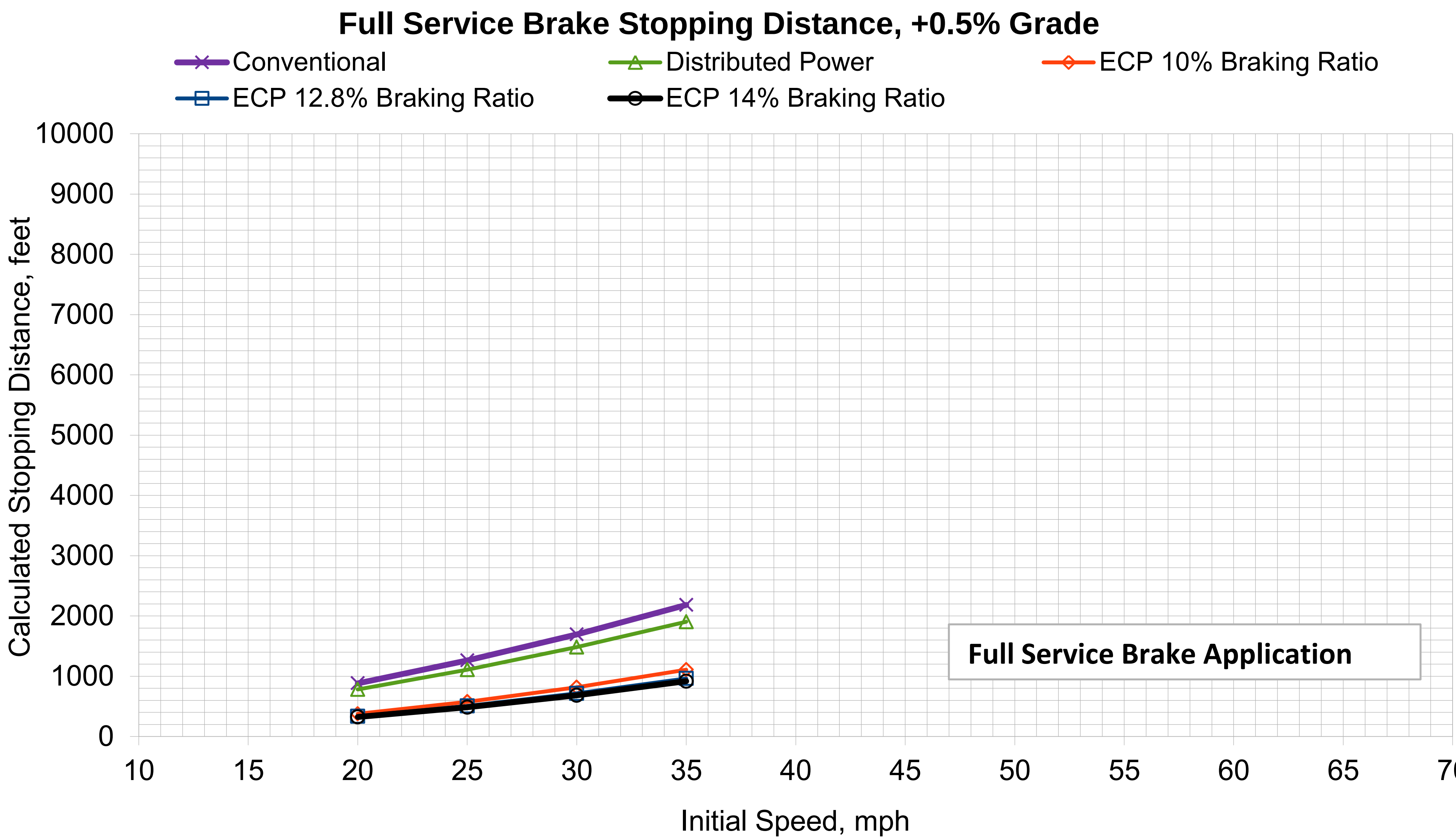


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 78 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

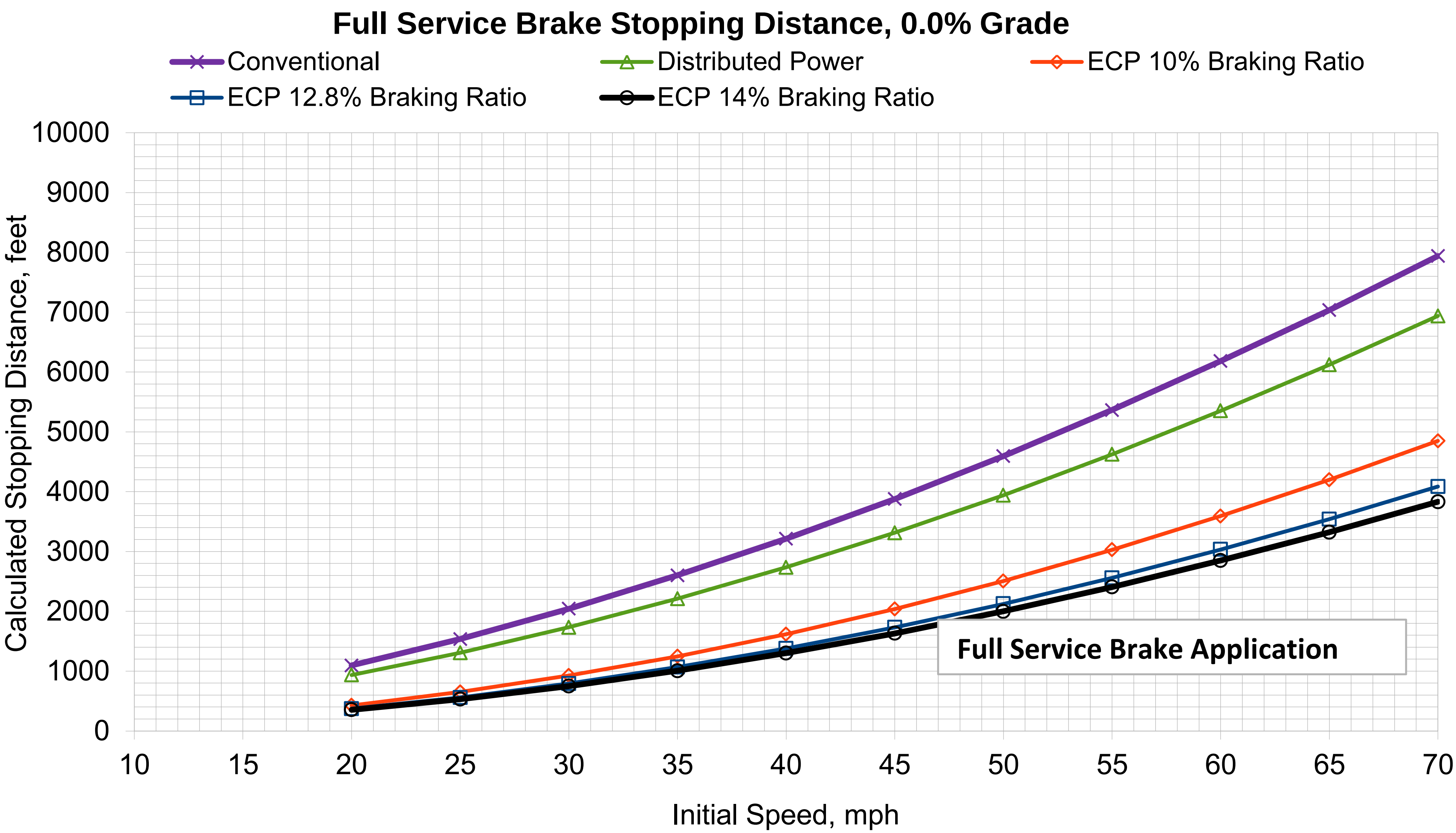
Attachment 24: Full Service Braking, No Bailoff, 104 Tank Cars



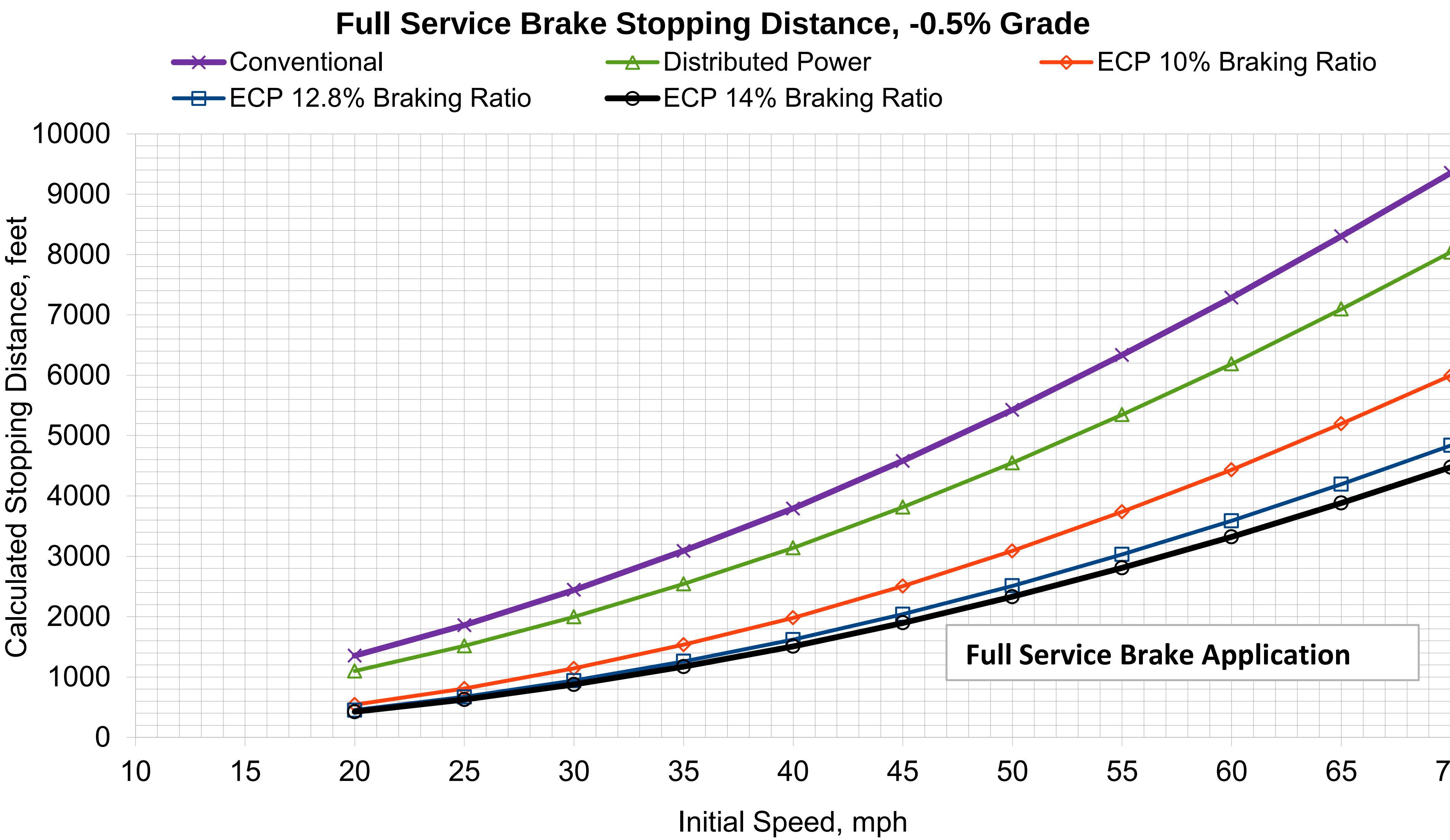
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



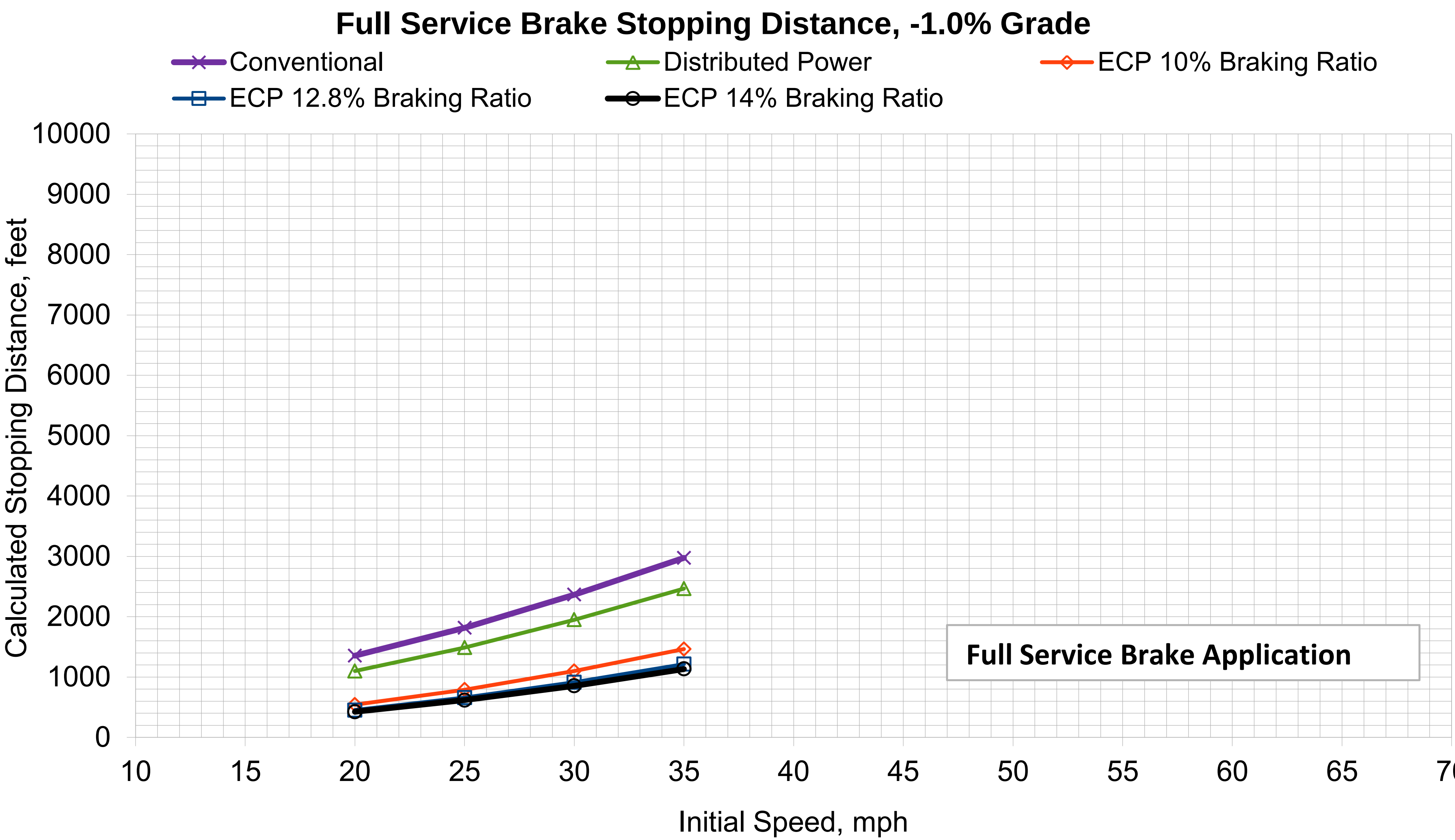
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



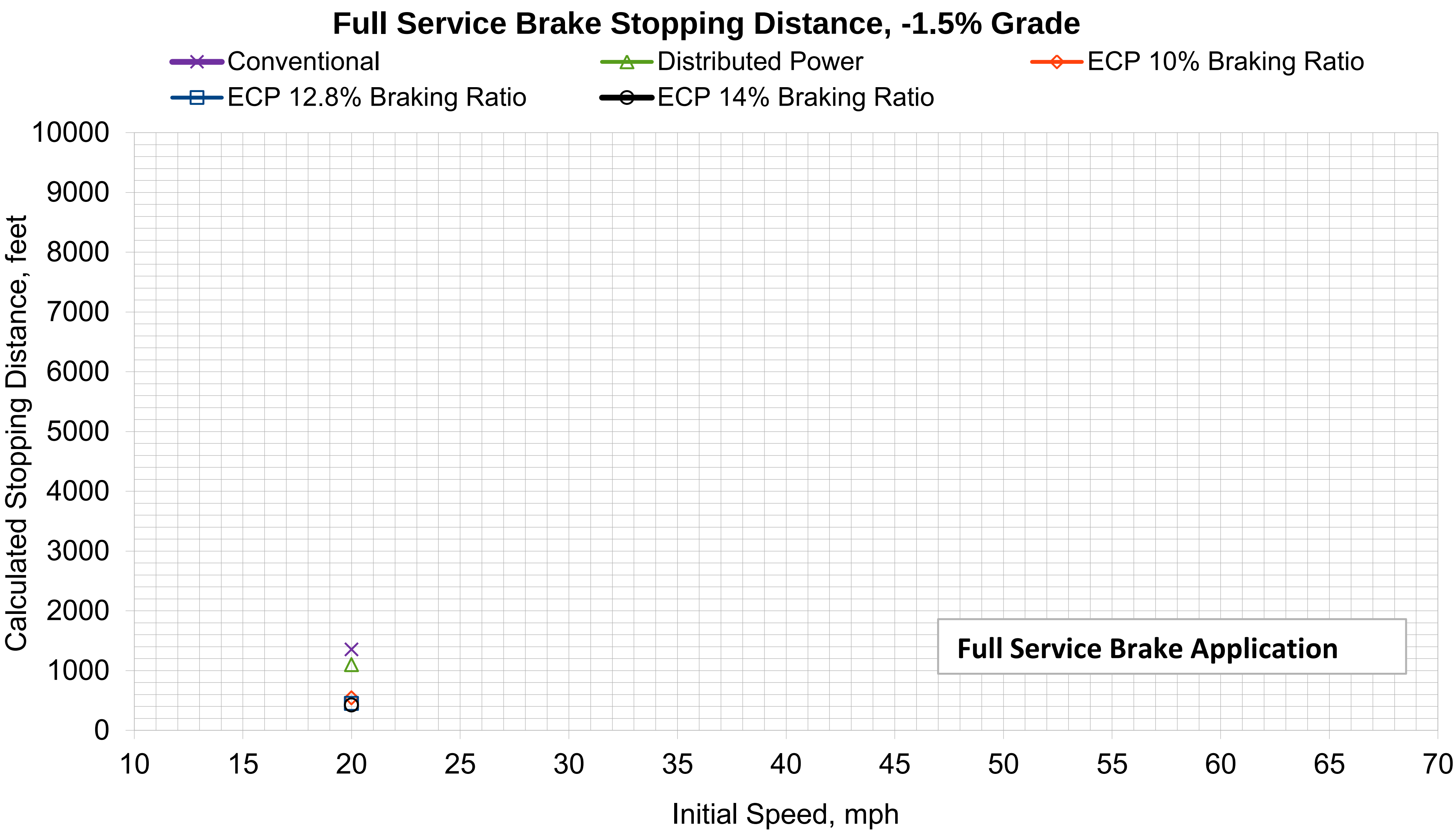
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



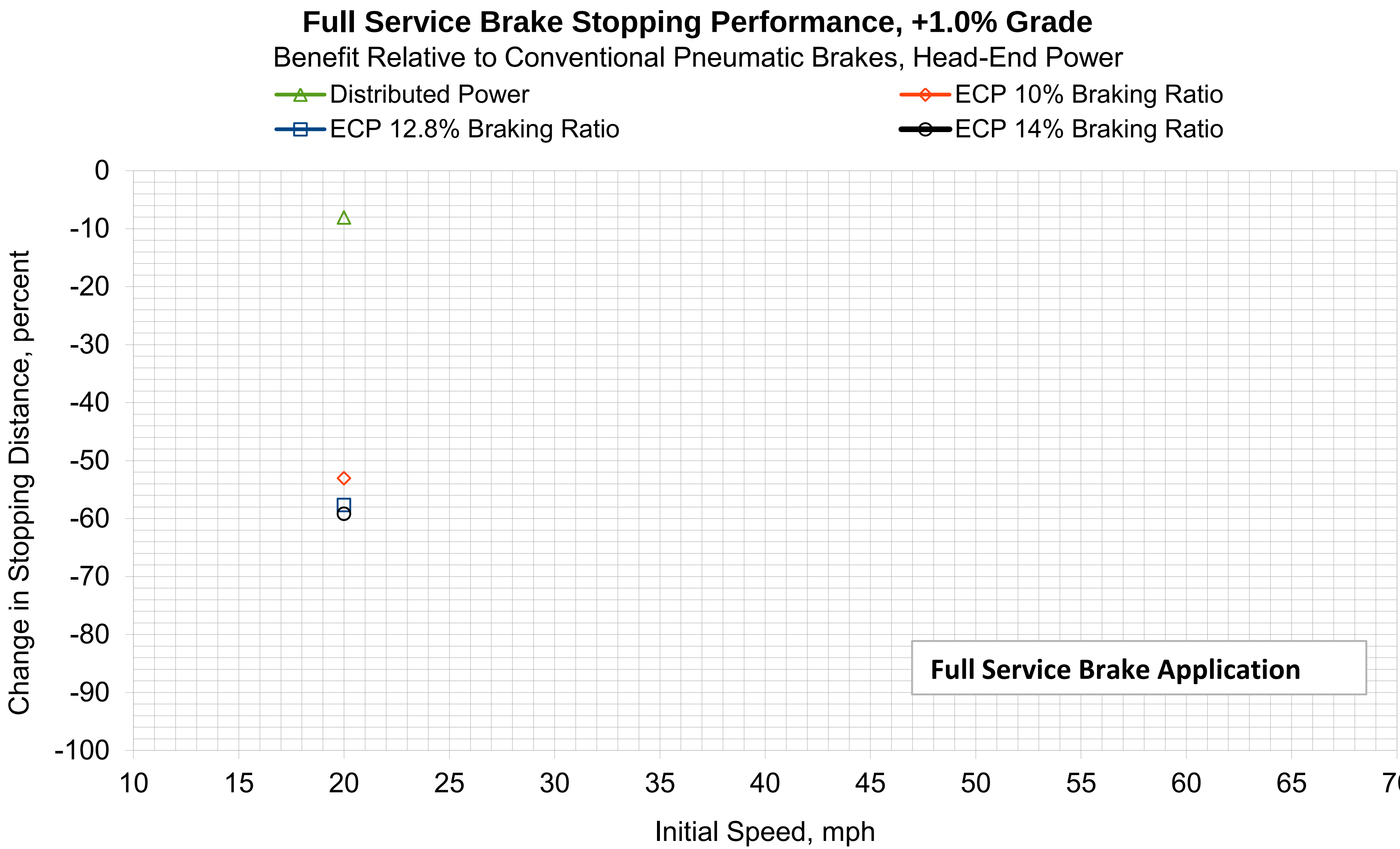
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



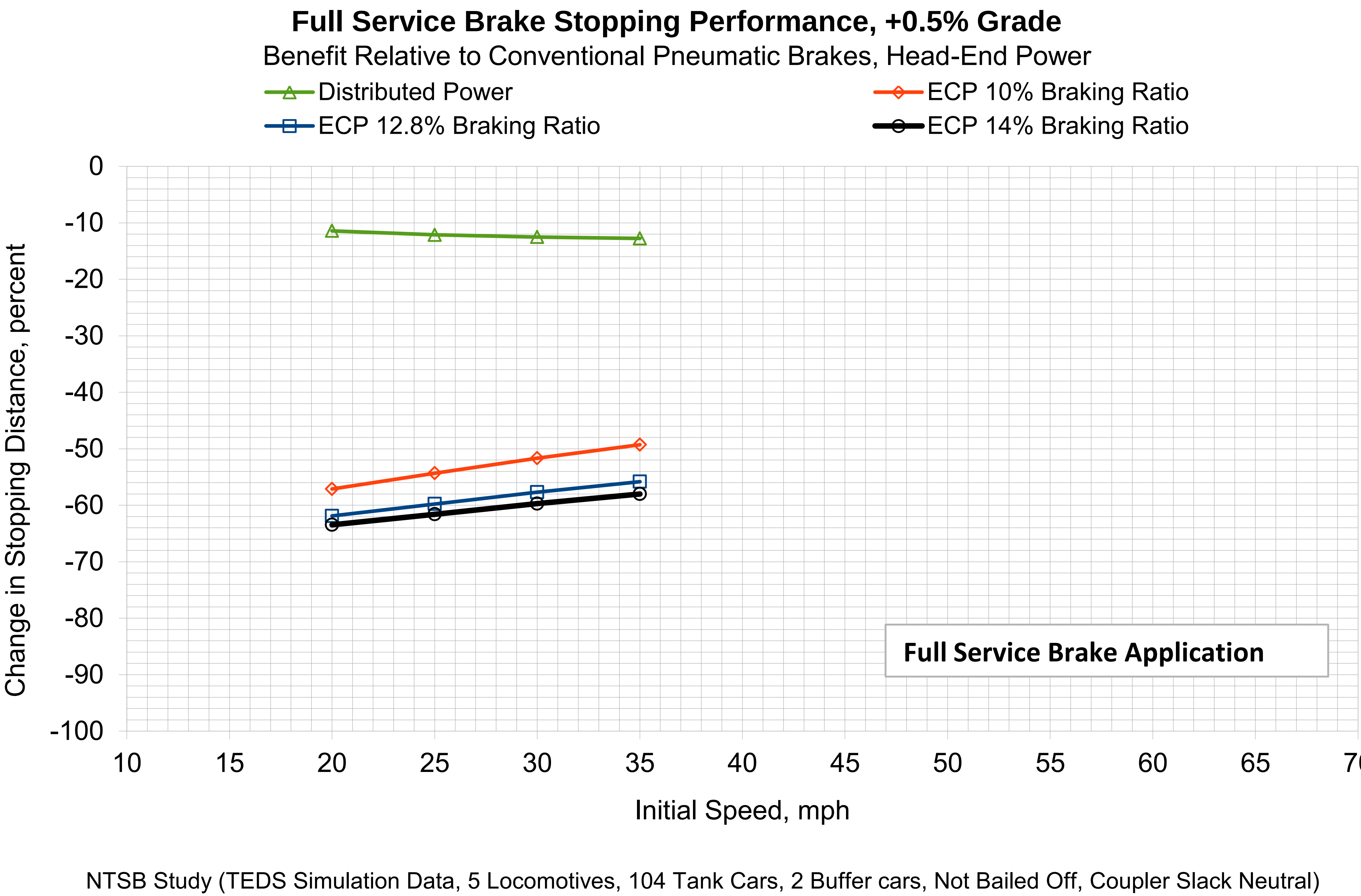
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

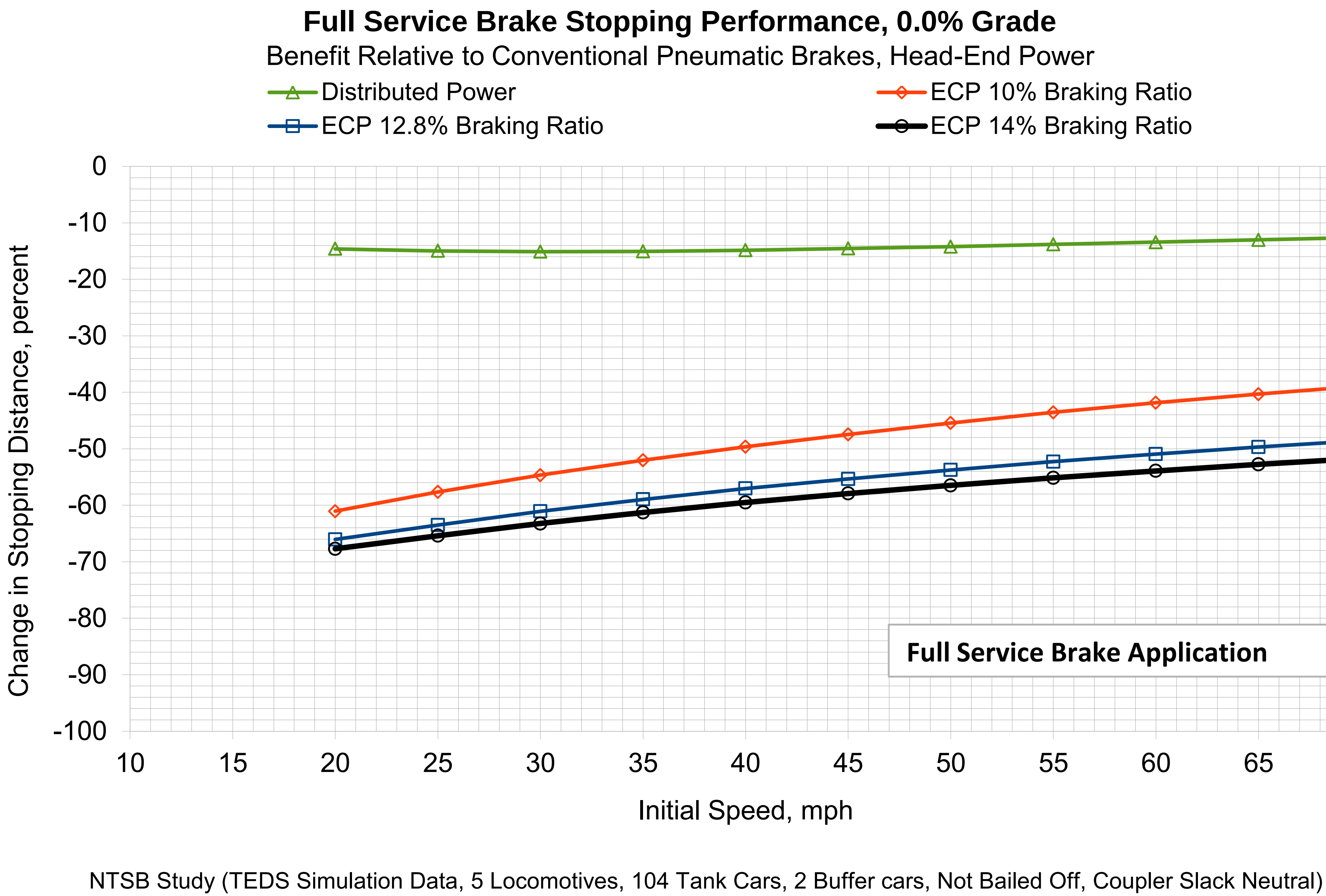


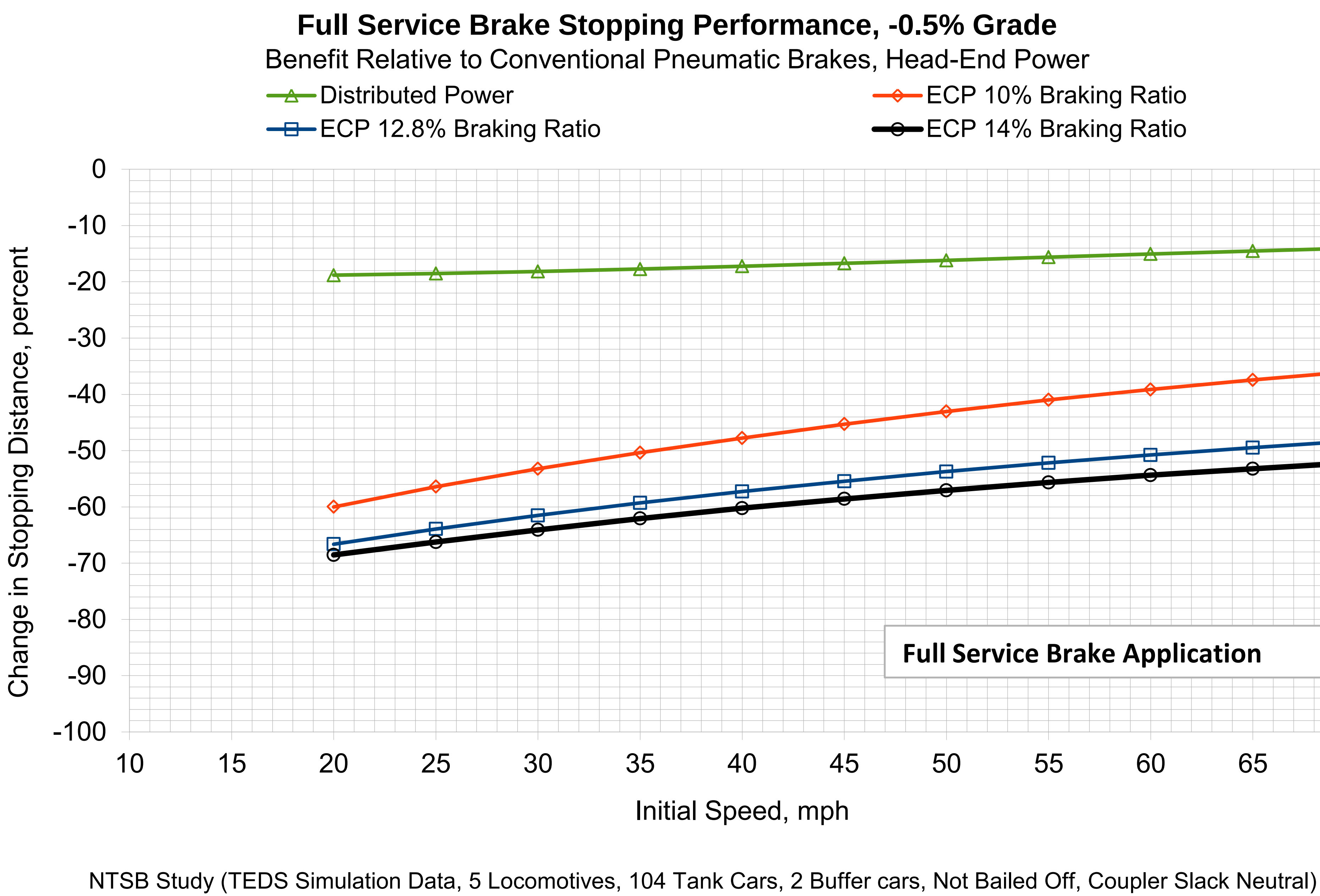
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



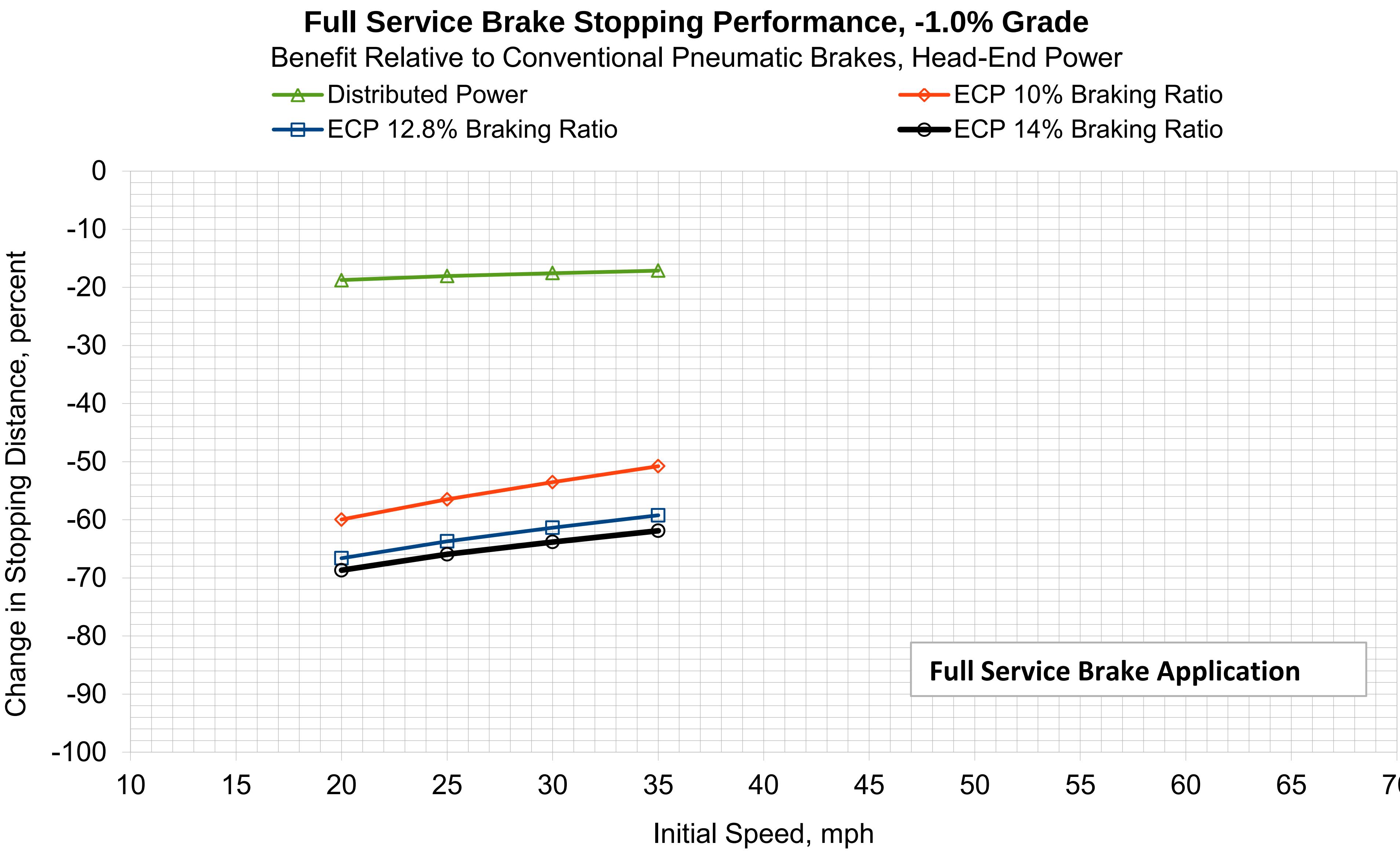
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


Full Service Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

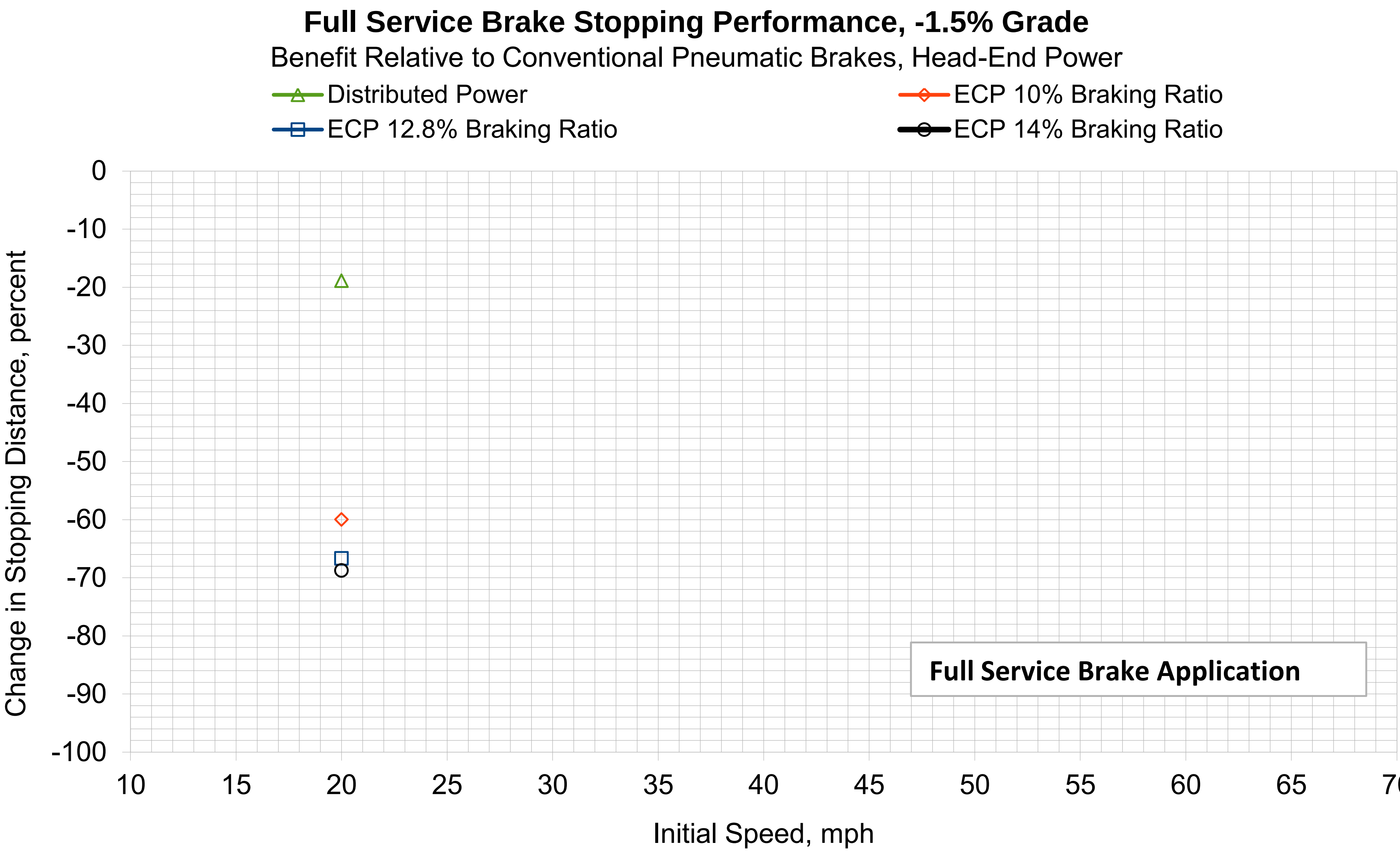

Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



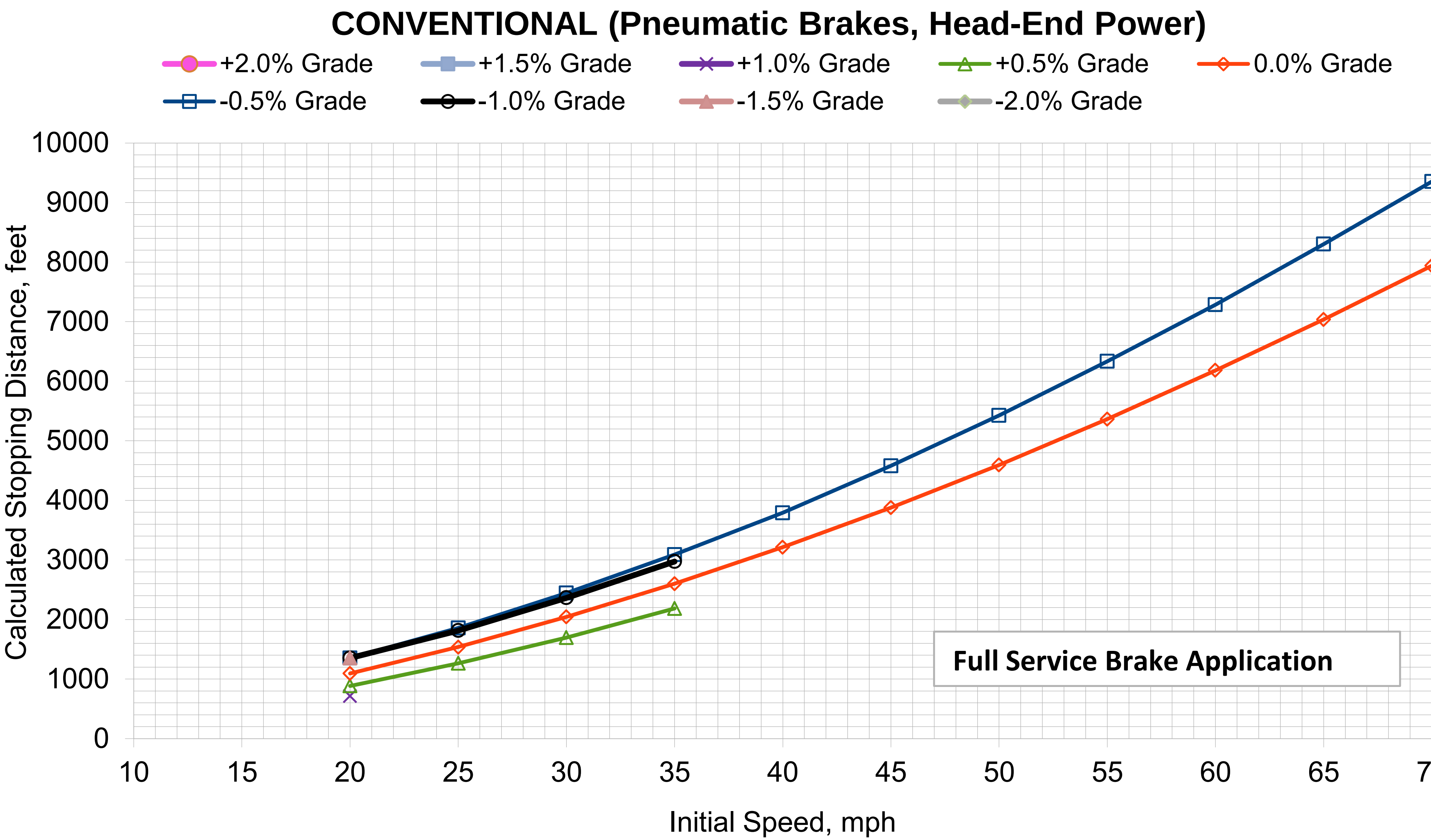
Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



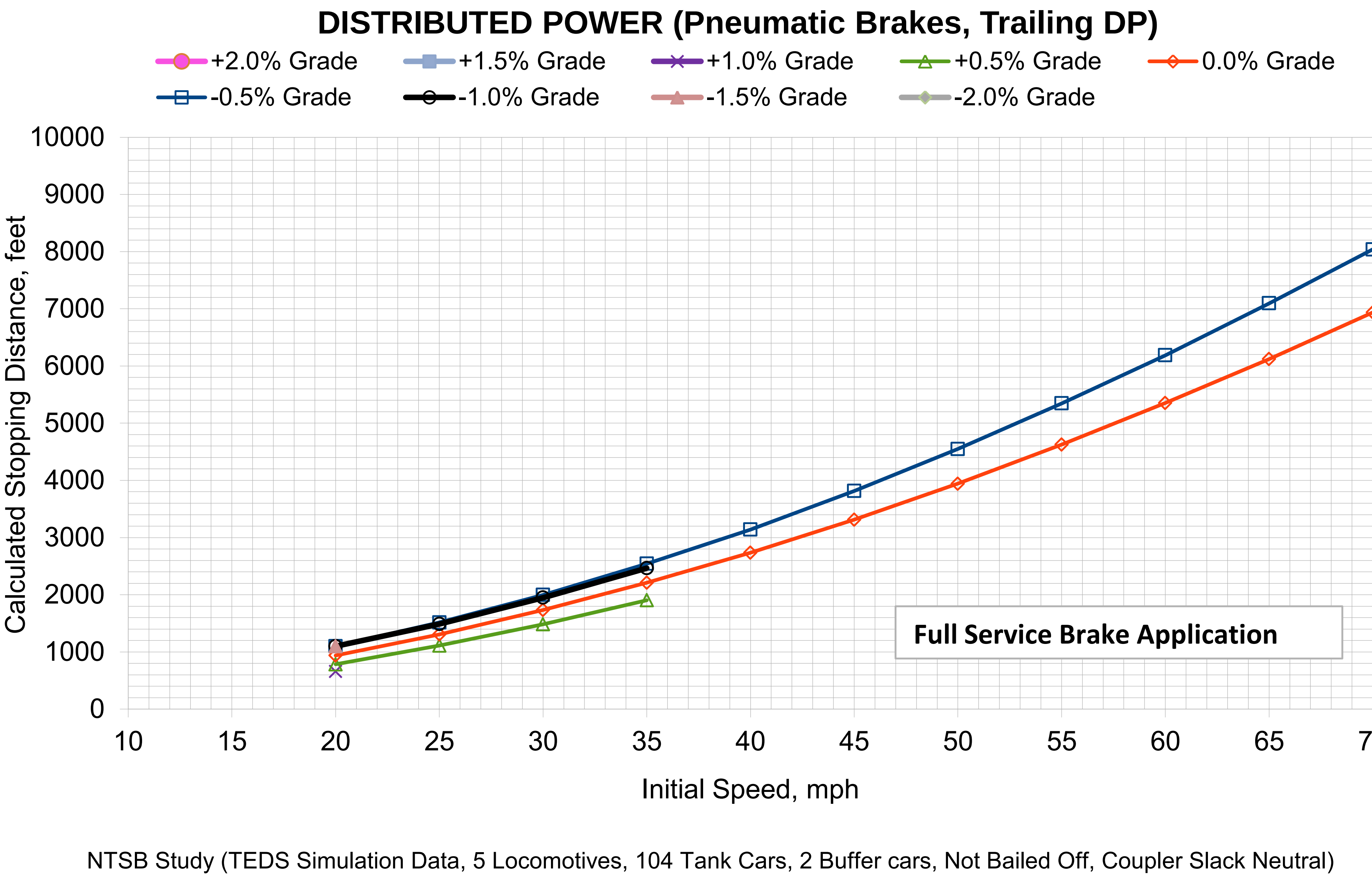
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

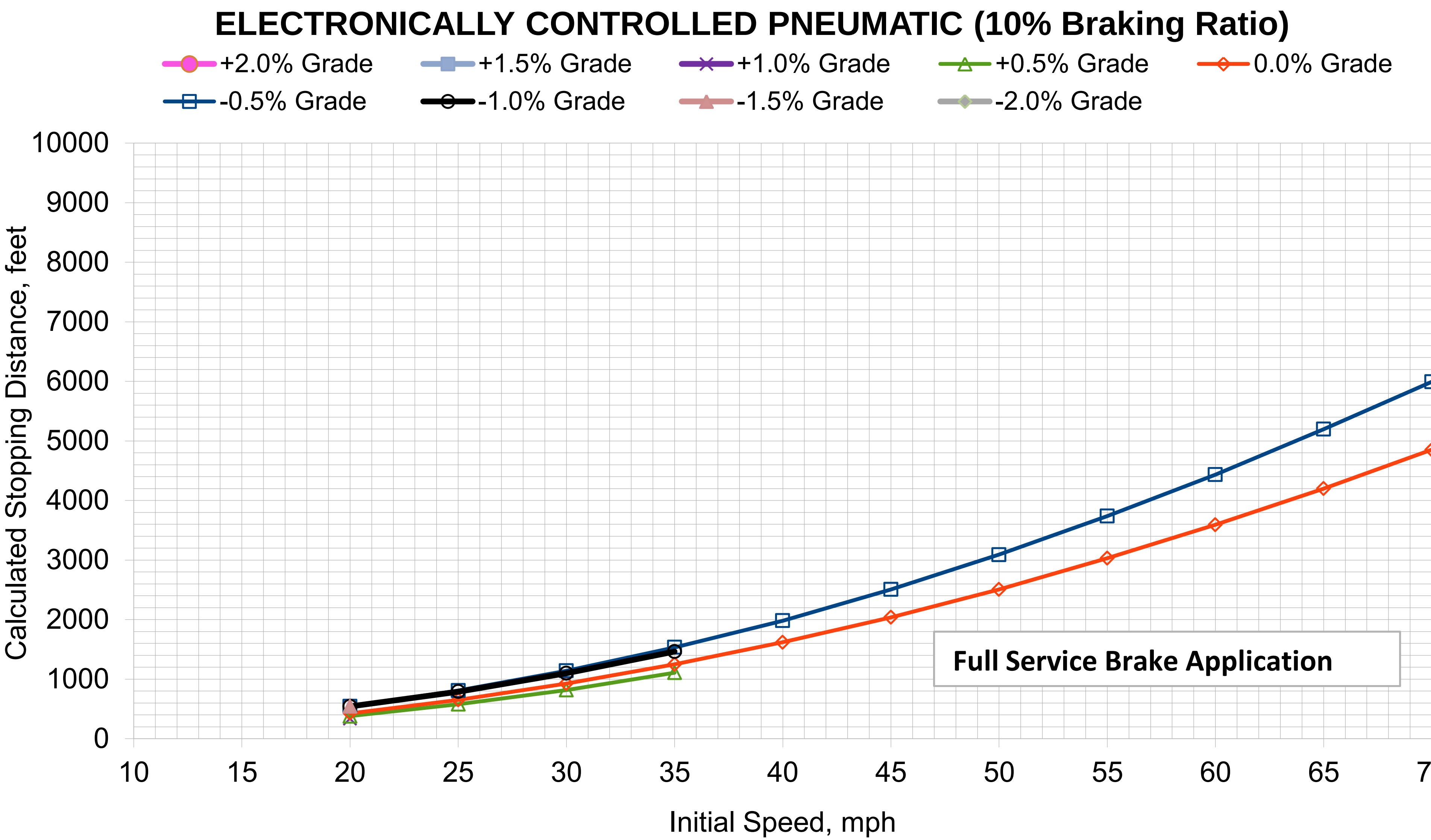


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

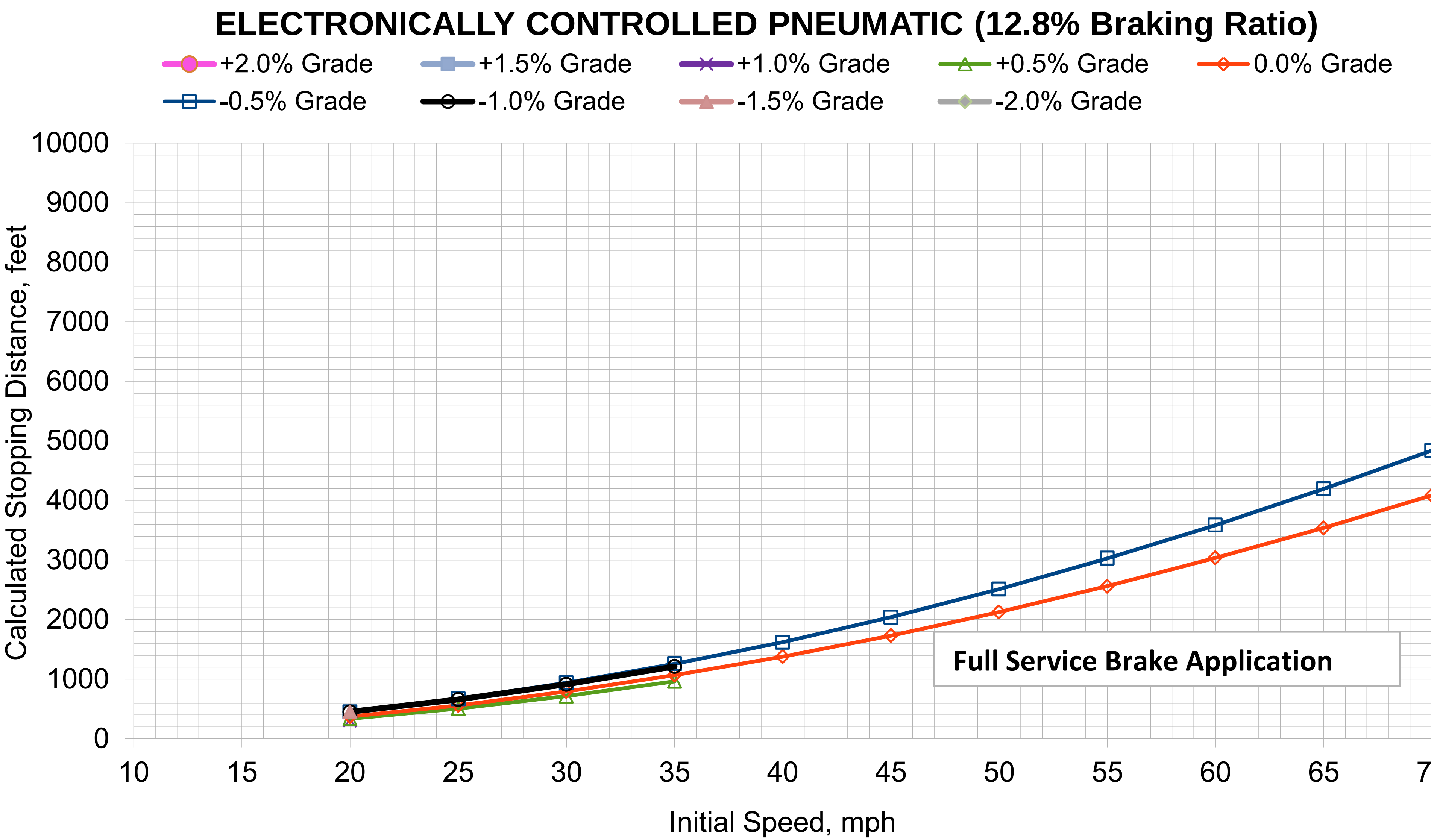


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

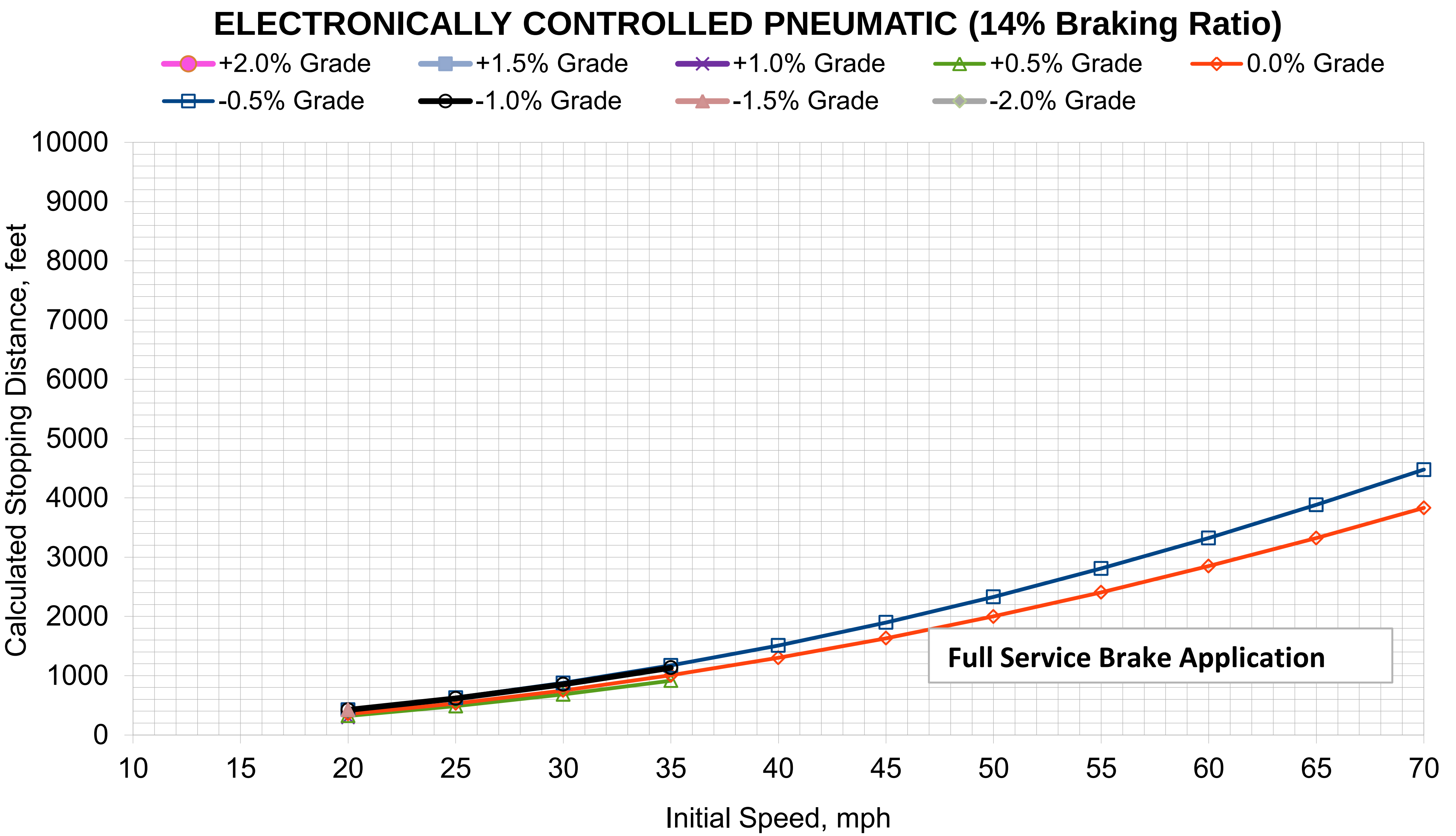


NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

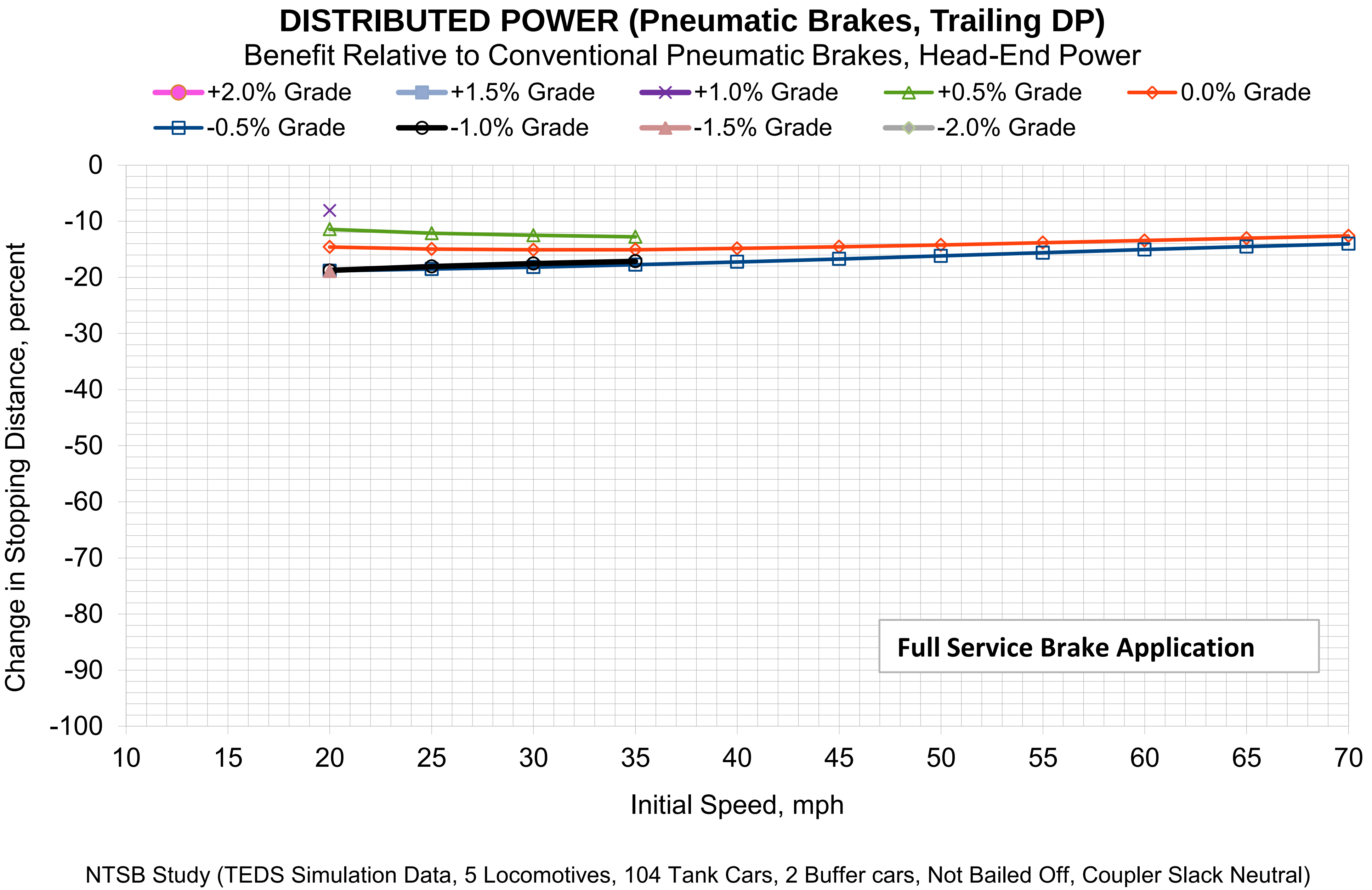


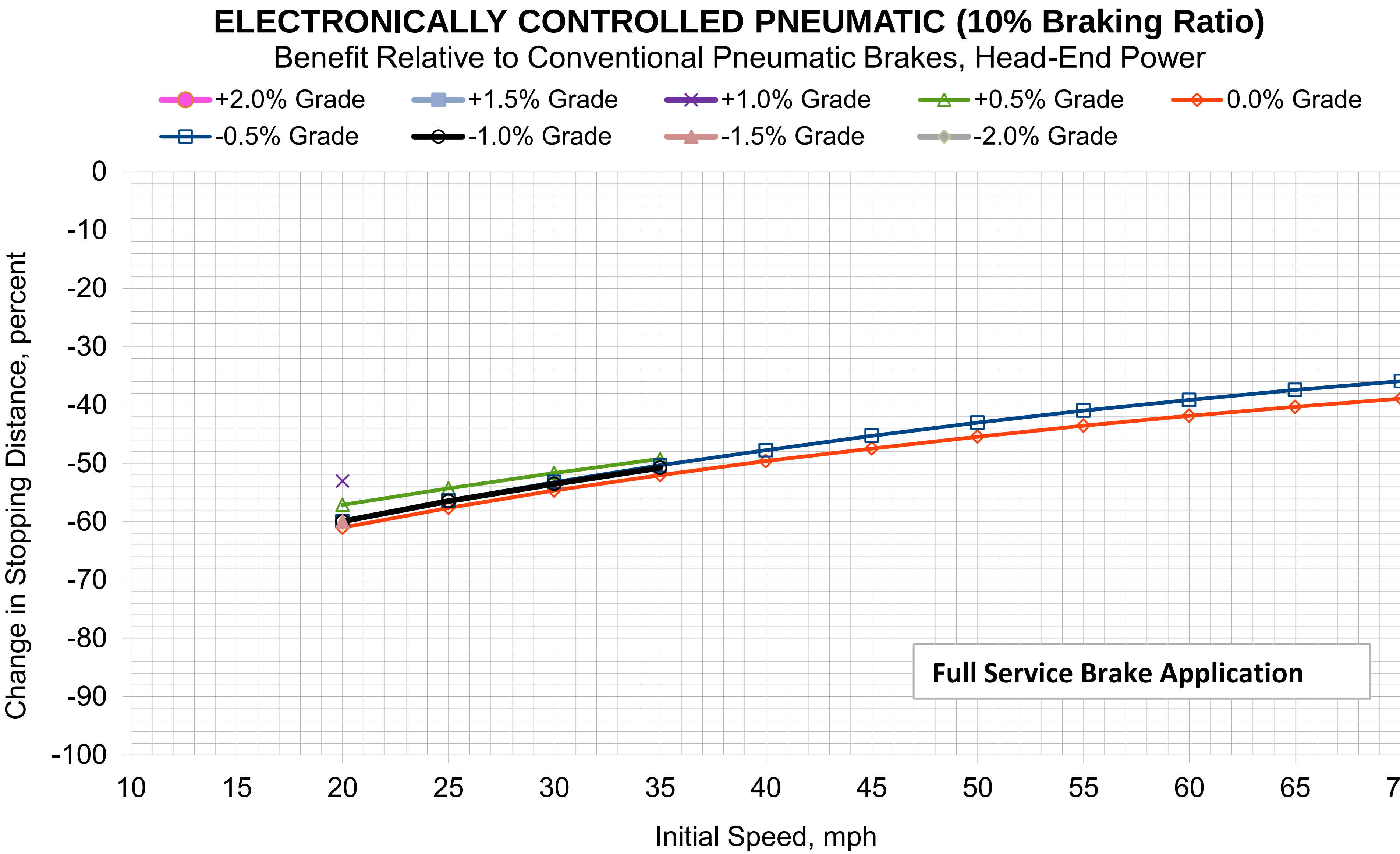
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

A24.17

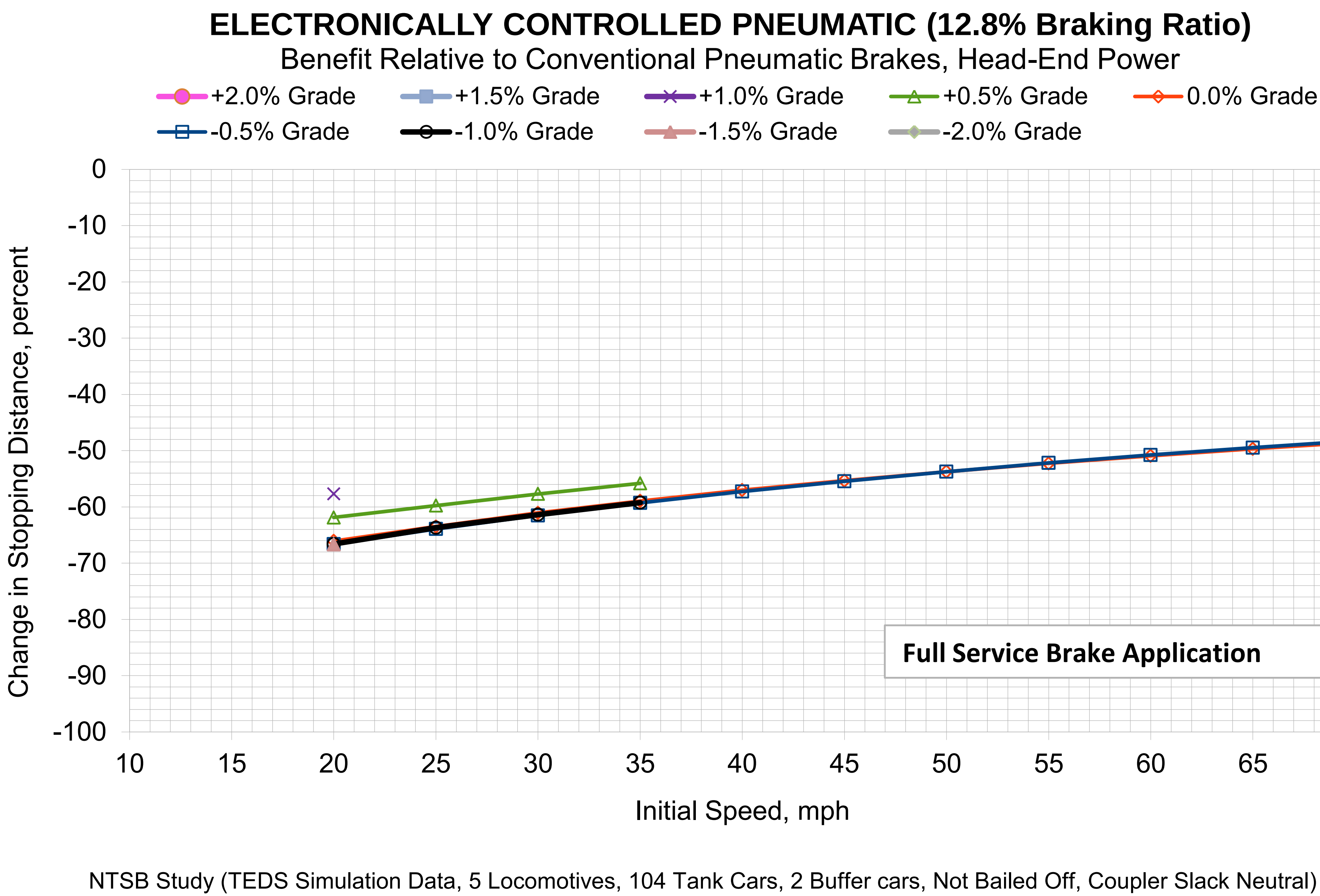


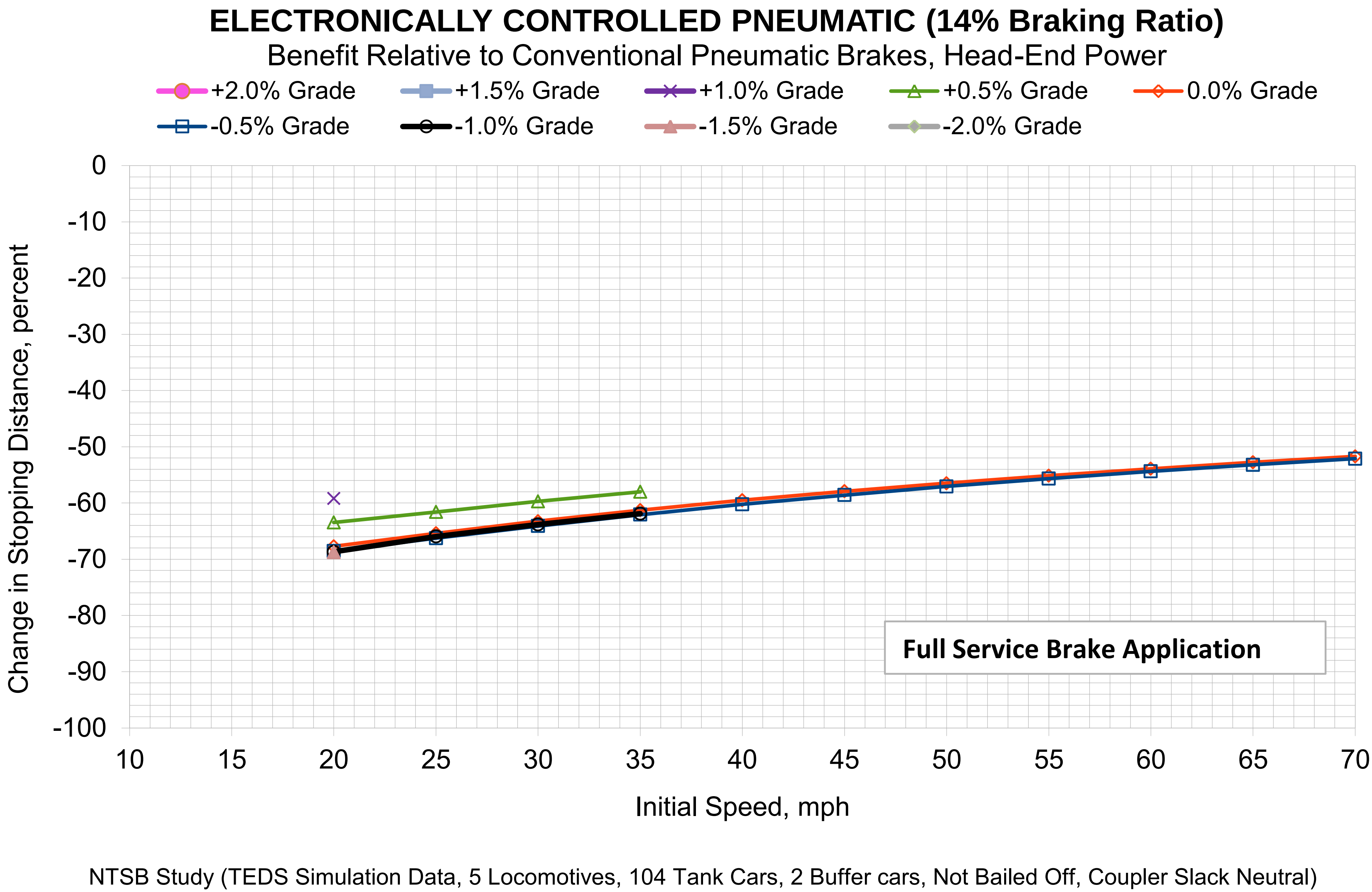
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



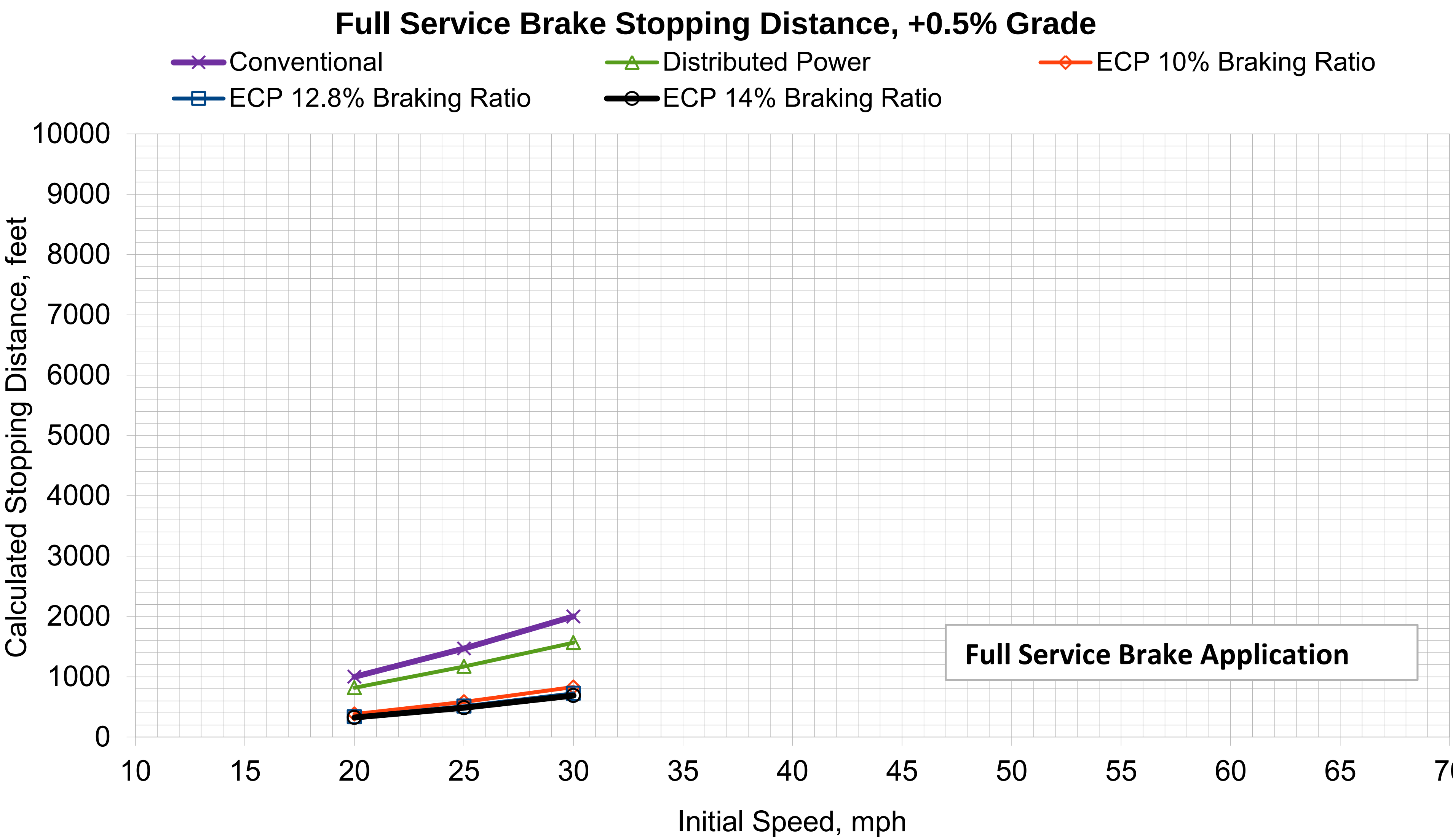
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

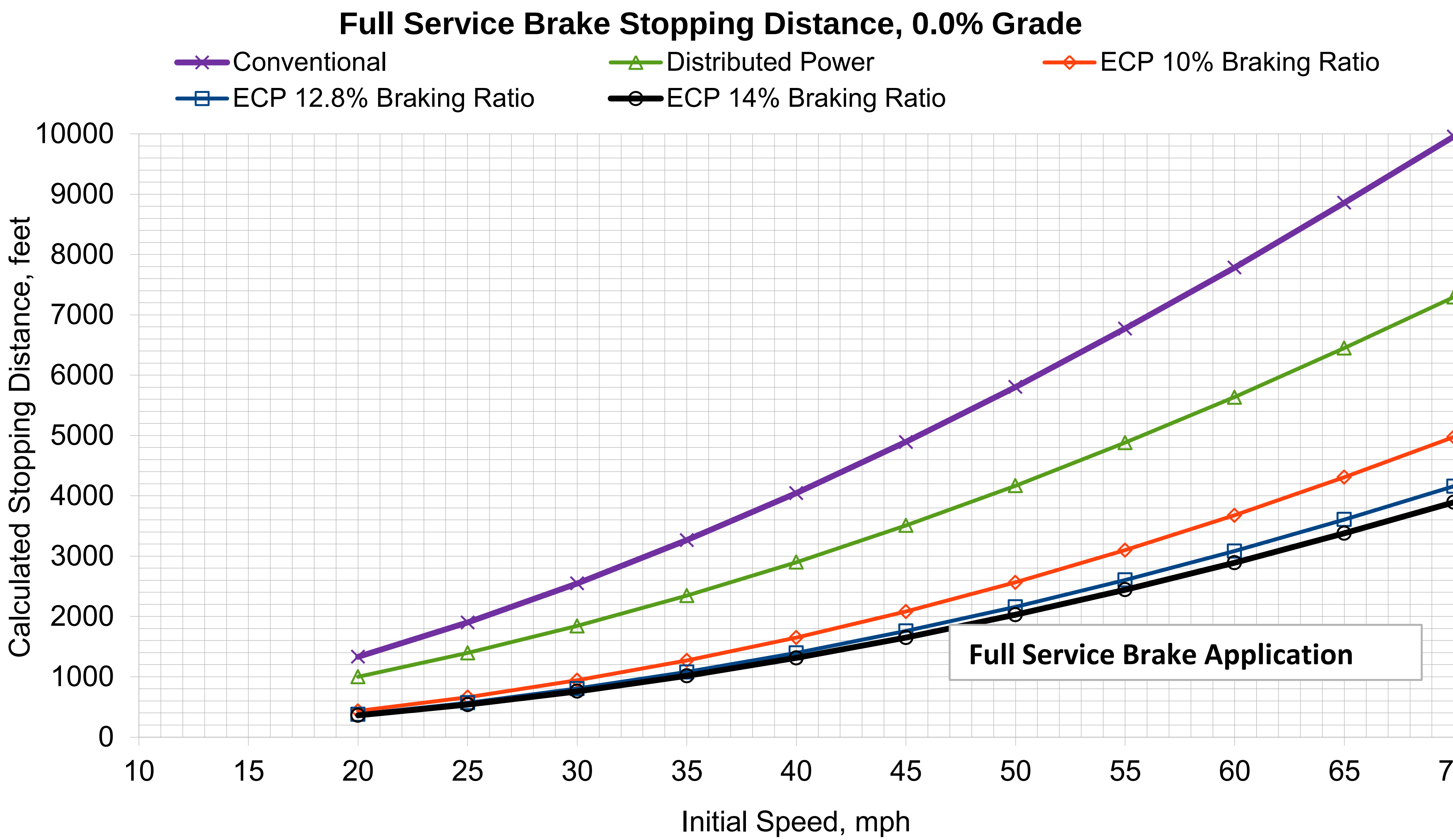

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Full Service Brake Application
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
NTSB Study (TEDS Simulation Data, 5 Locomotives, 104 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

A24.22

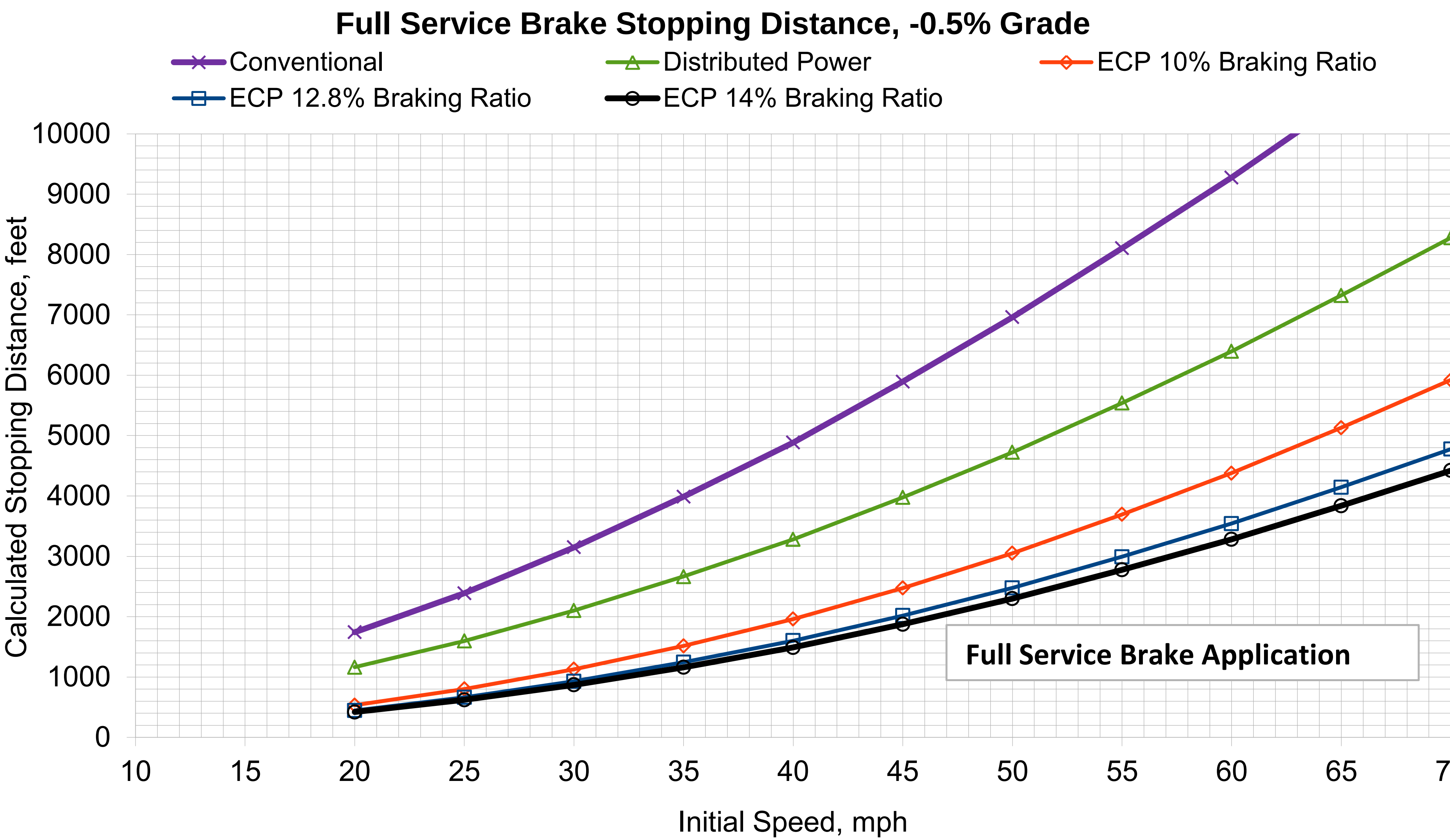
Attachment 25: Full Service Braking, No Bailoff, 130 Tank Cars



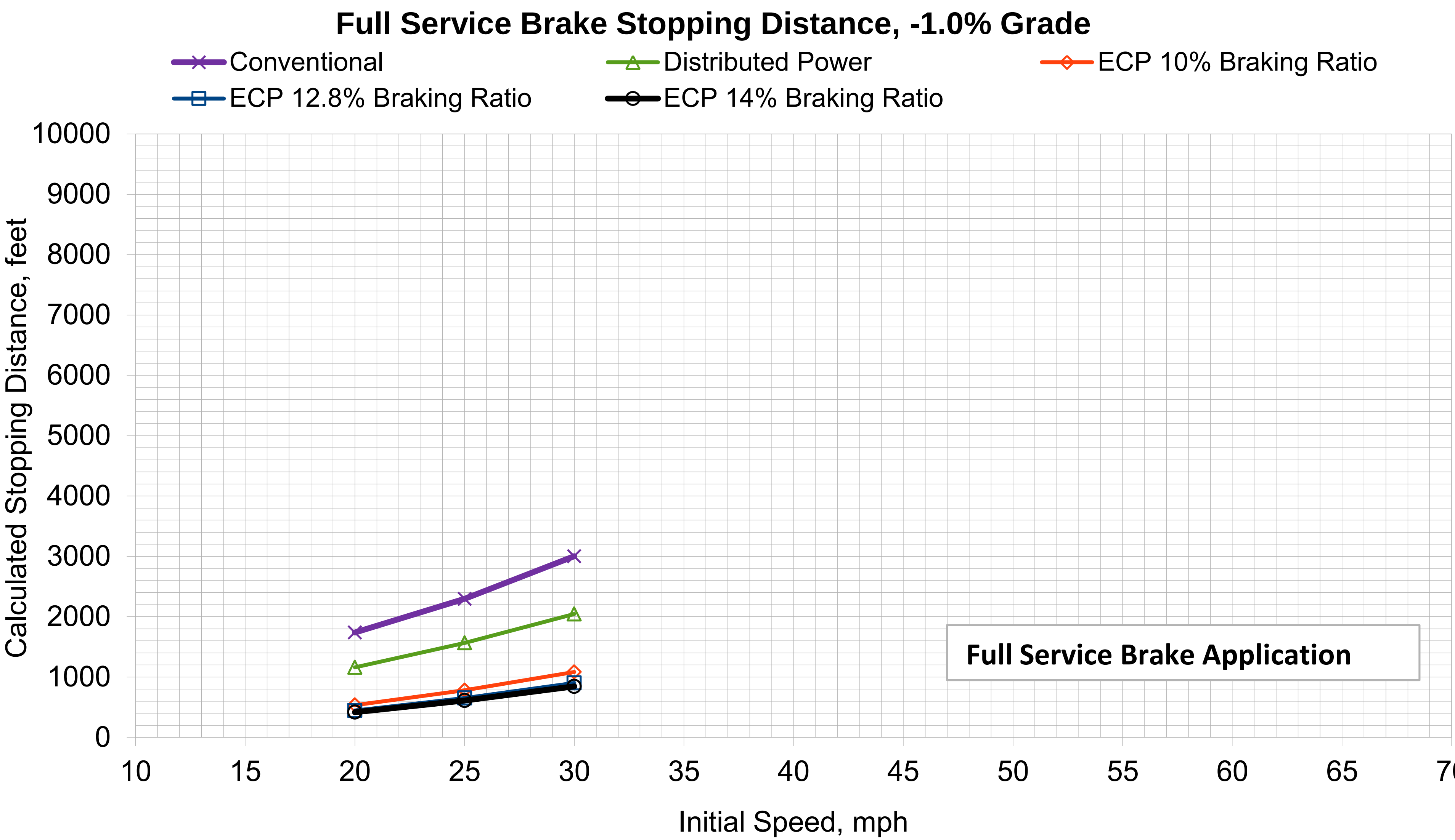
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



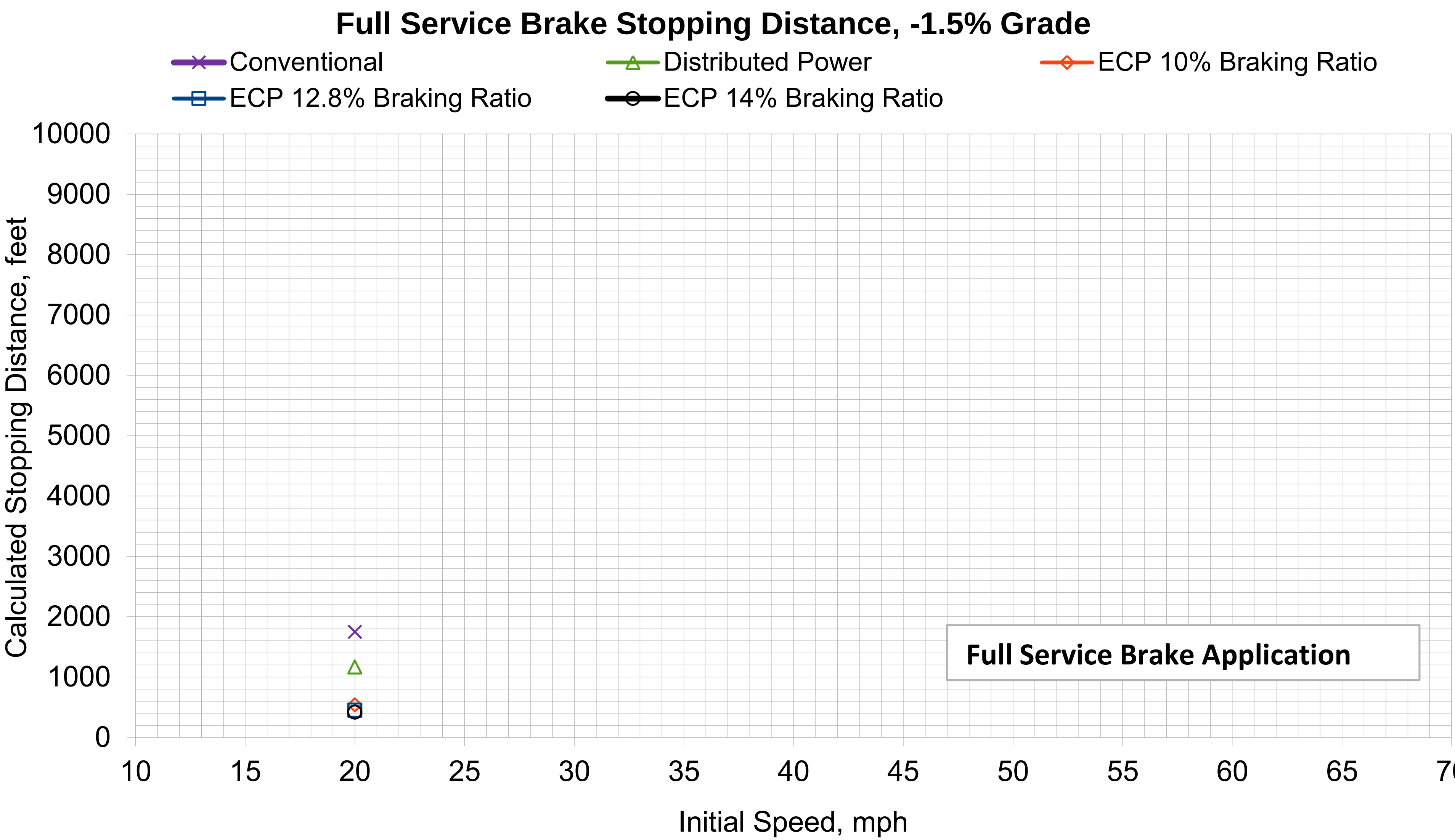
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



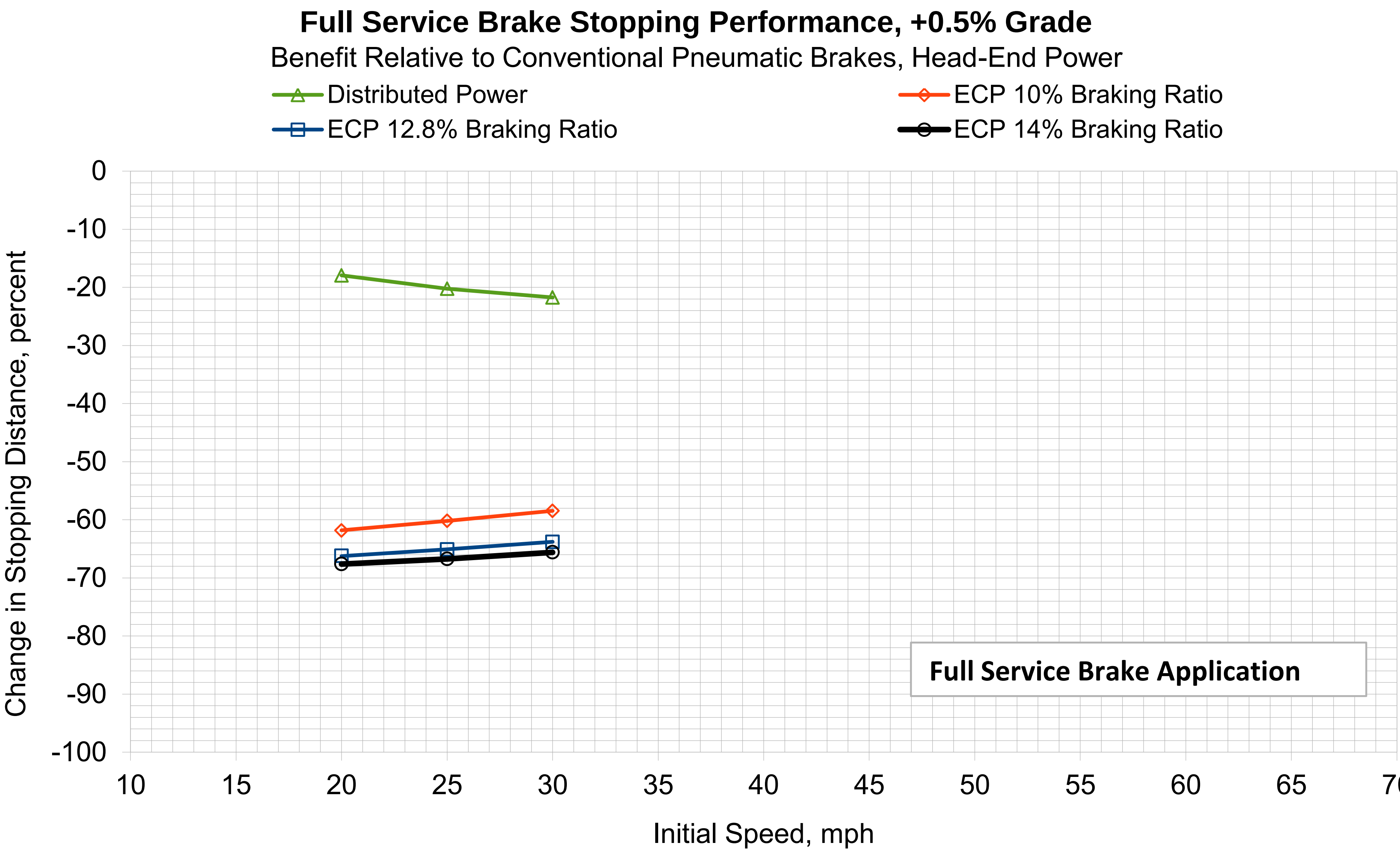
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



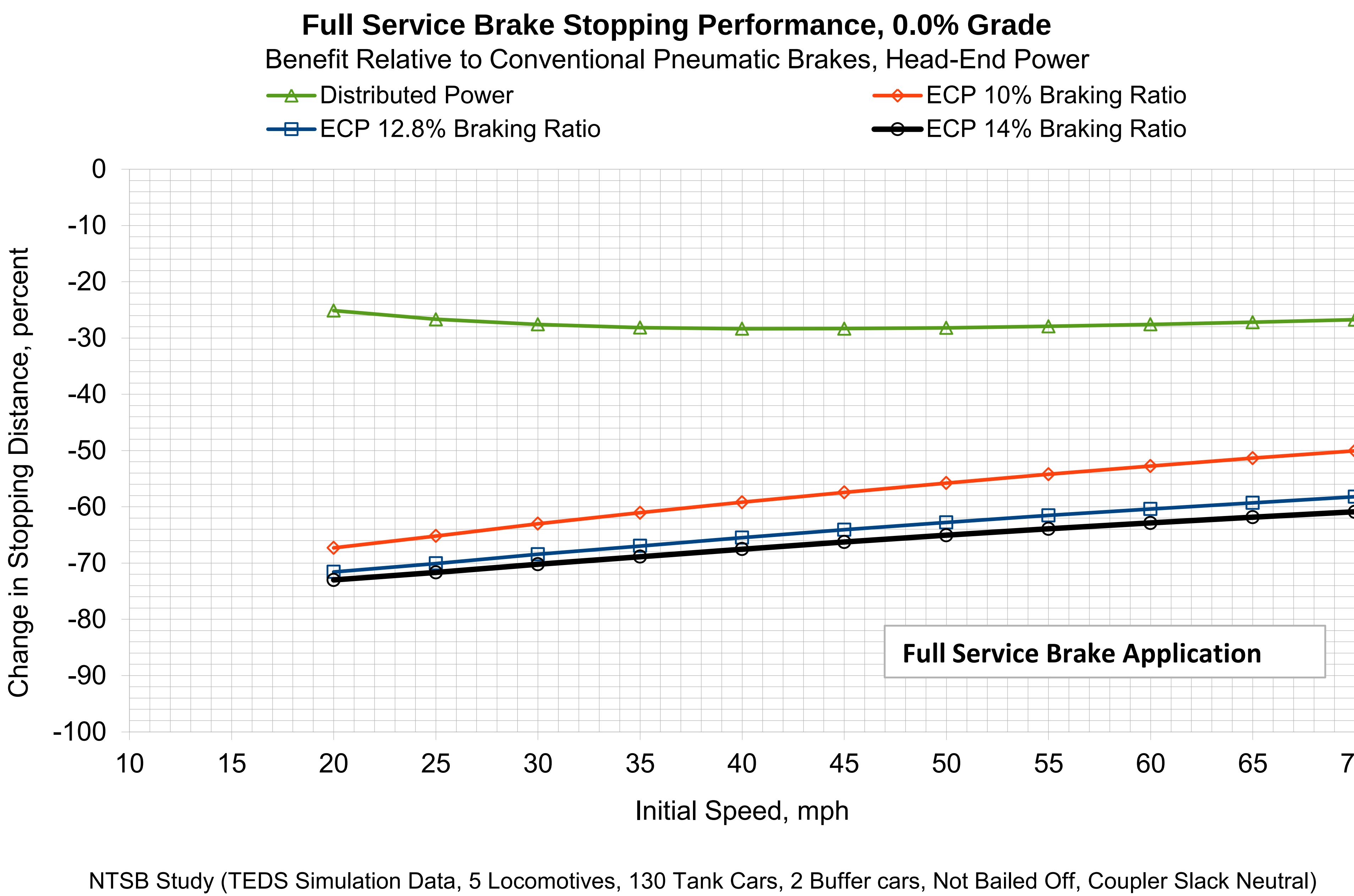
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



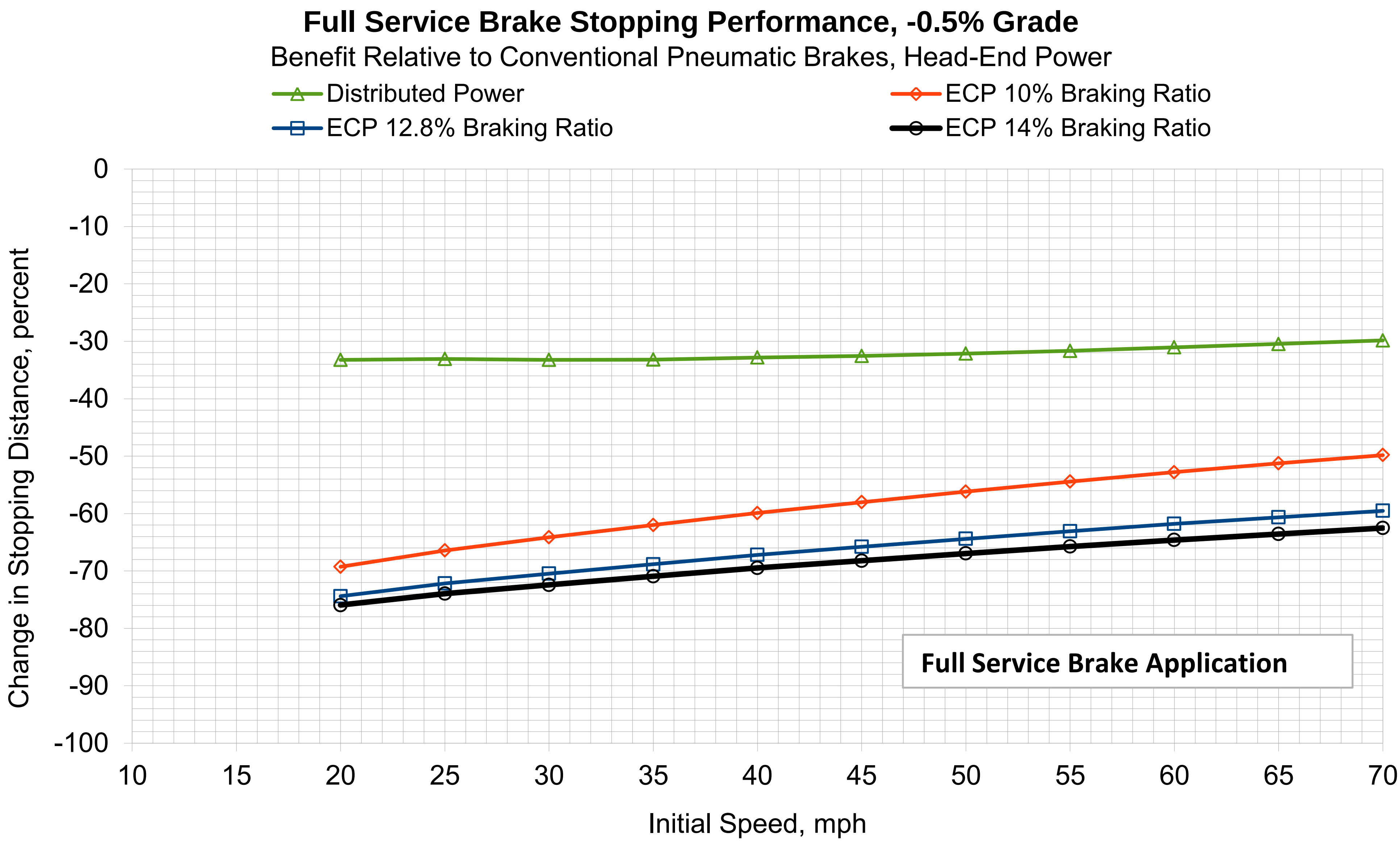
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



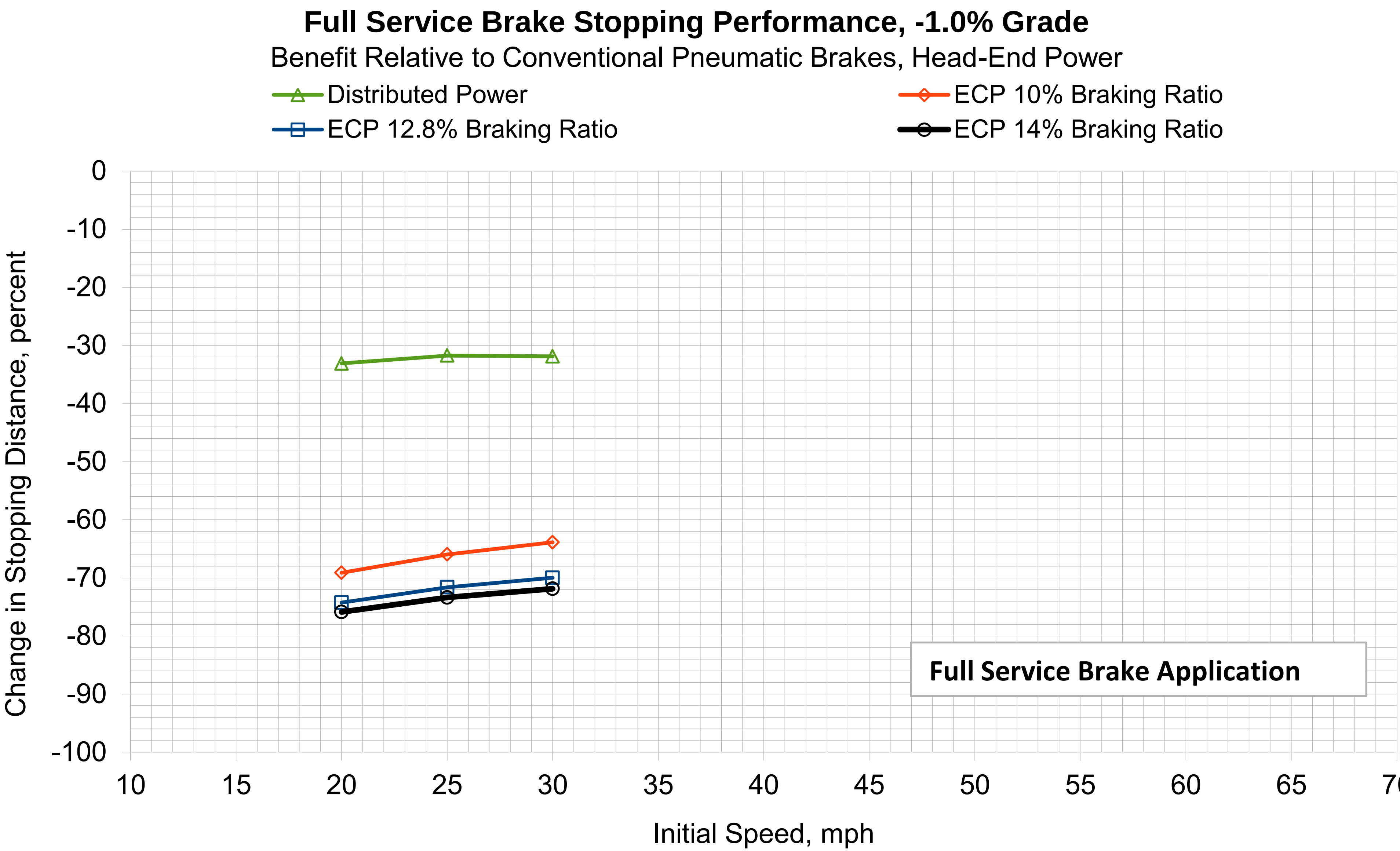
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



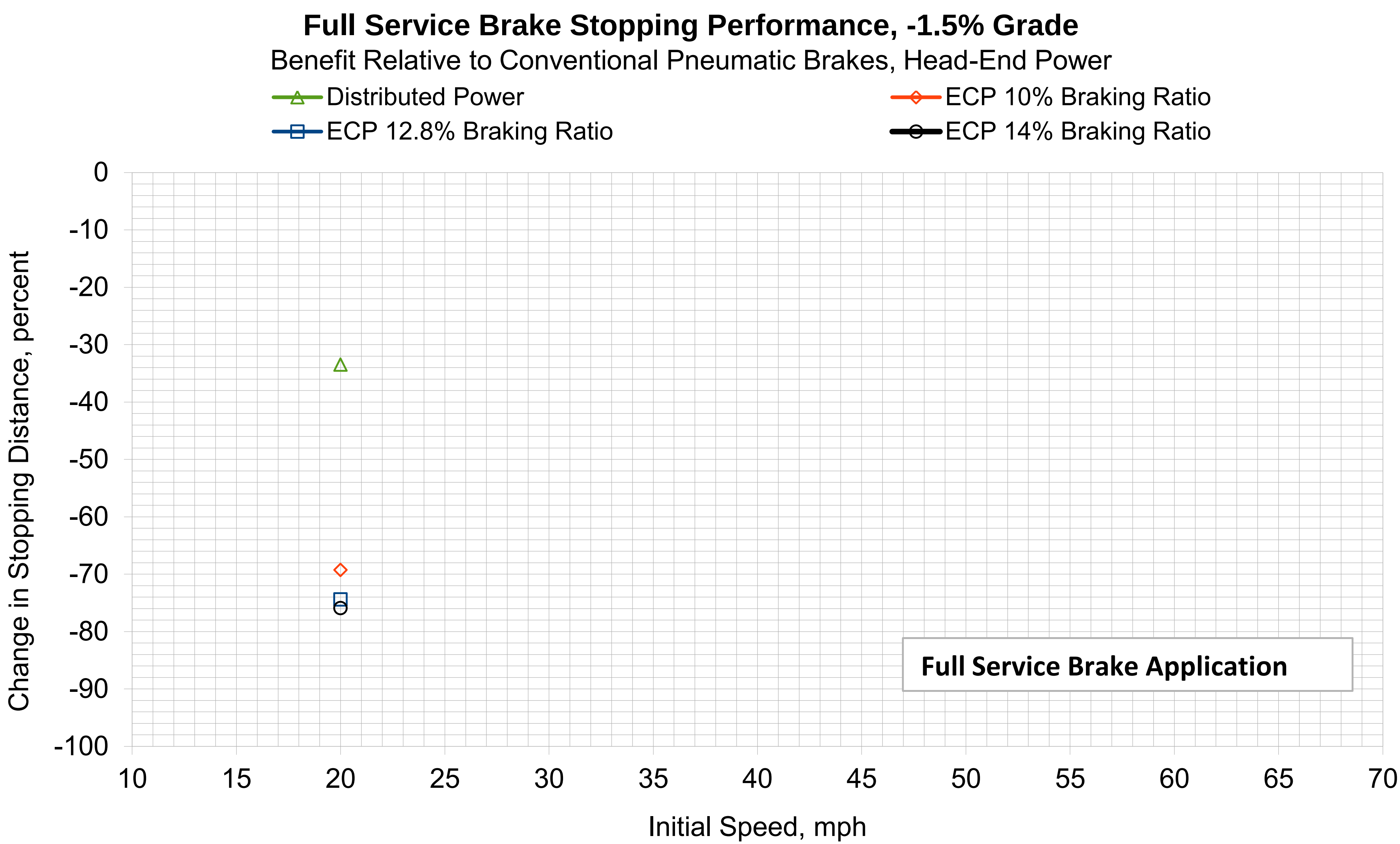
Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



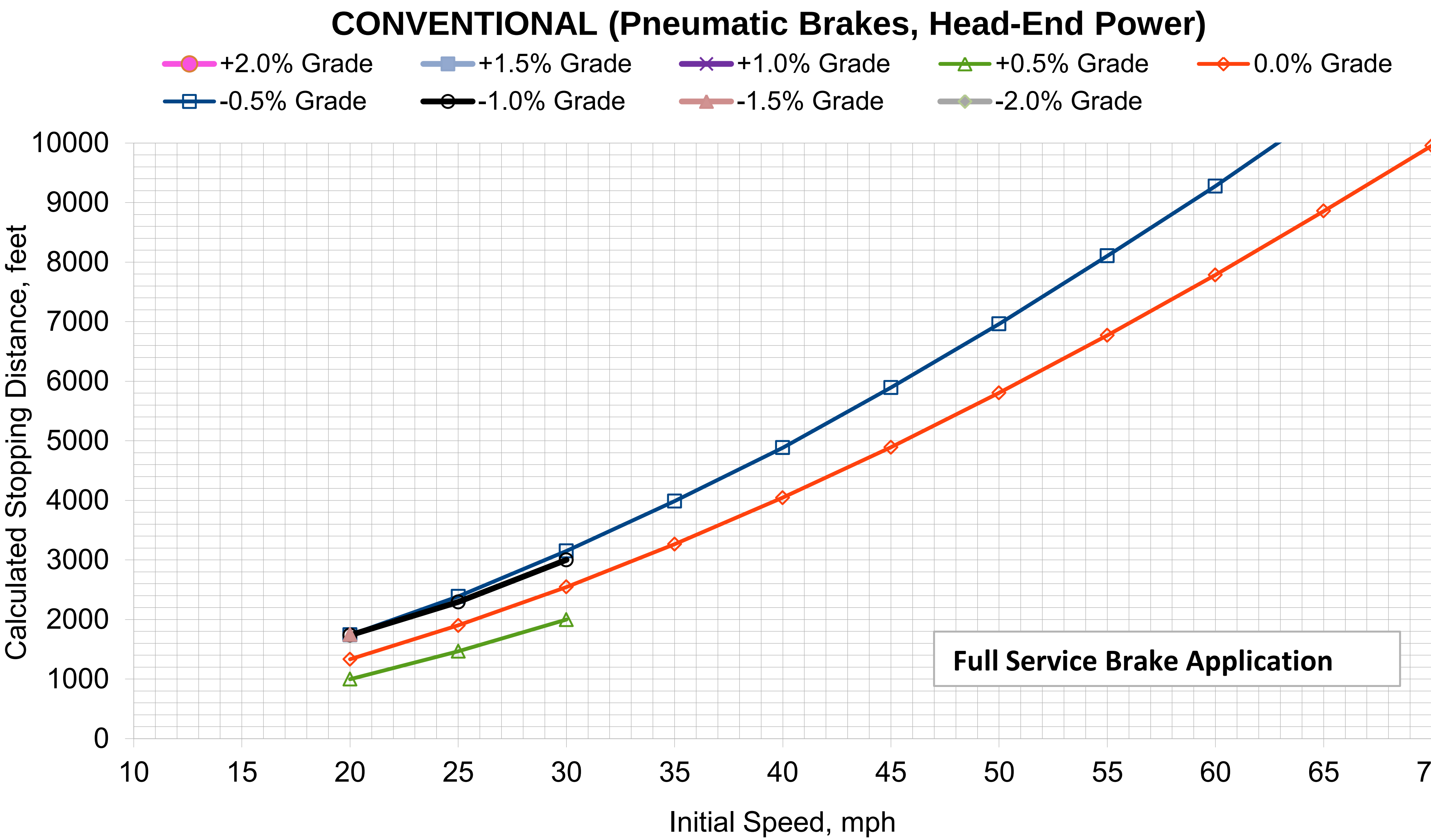
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



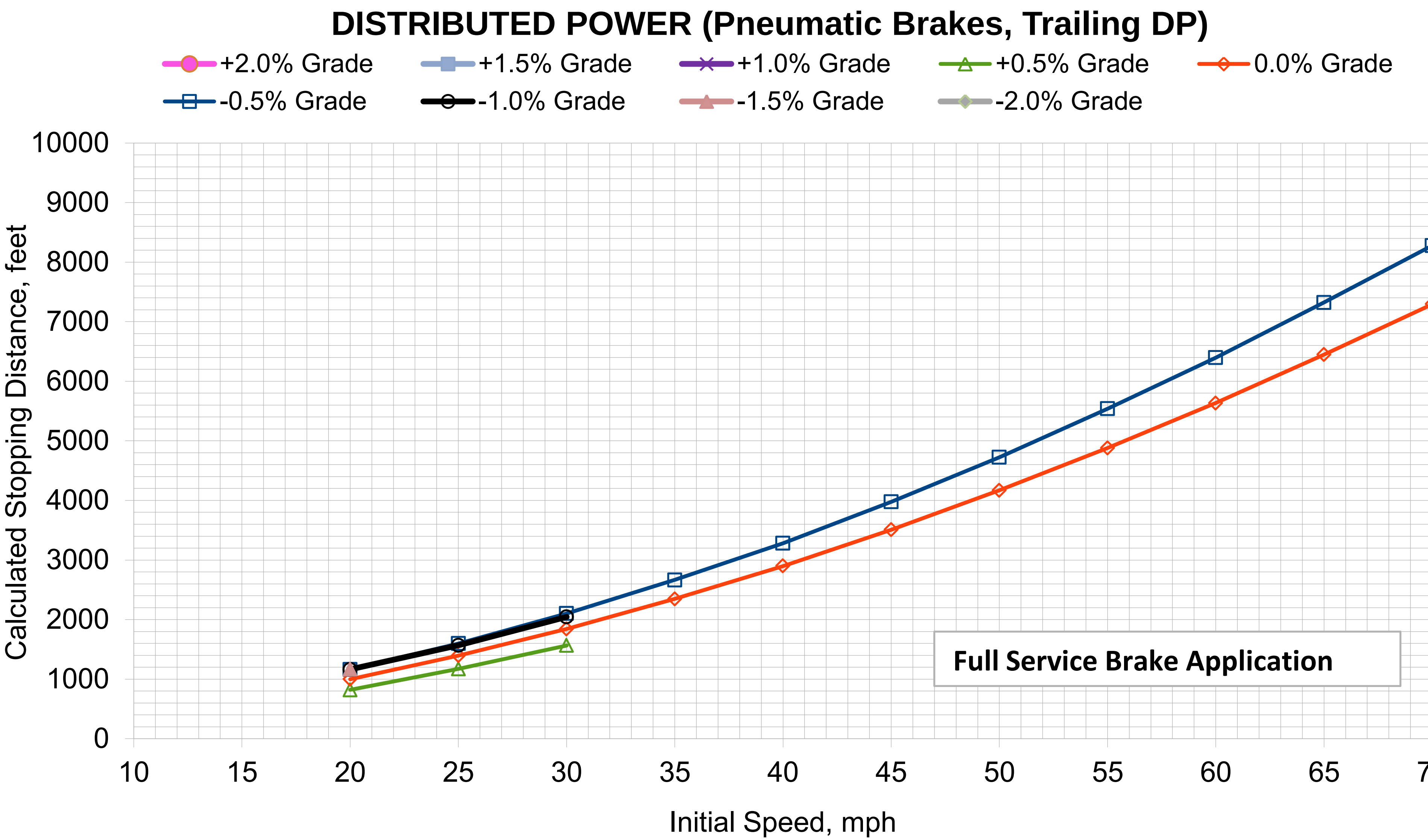
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



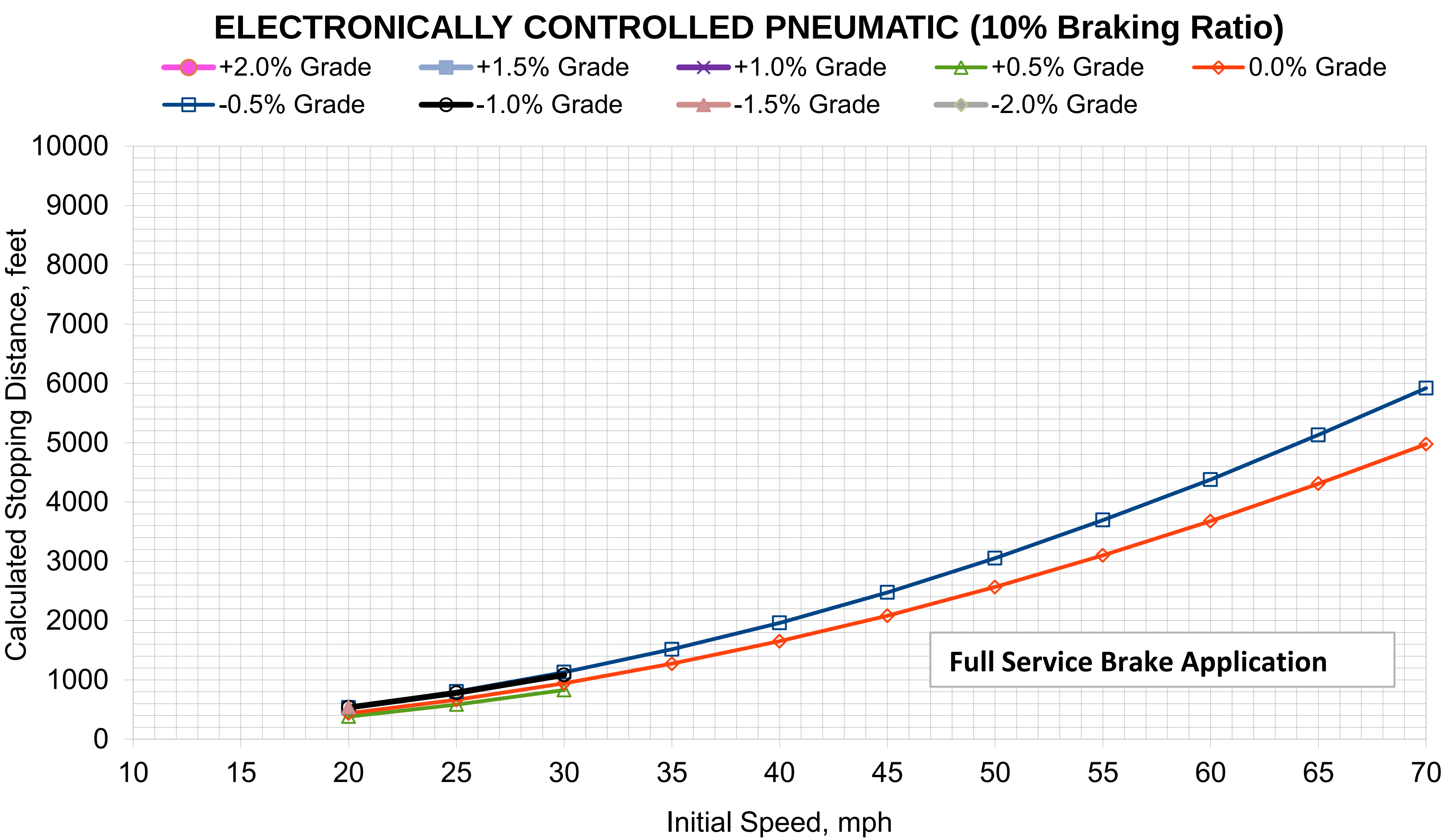
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



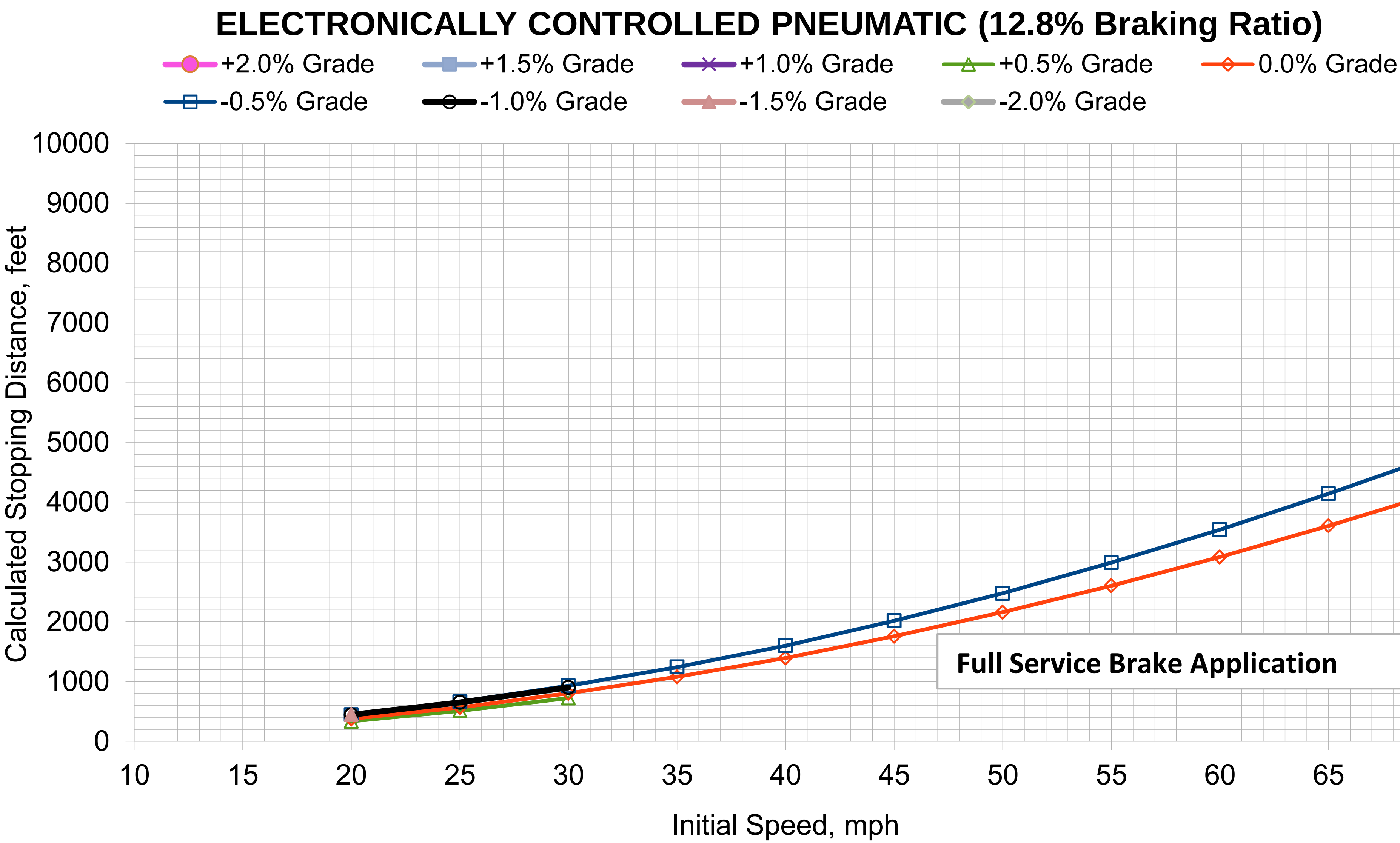
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



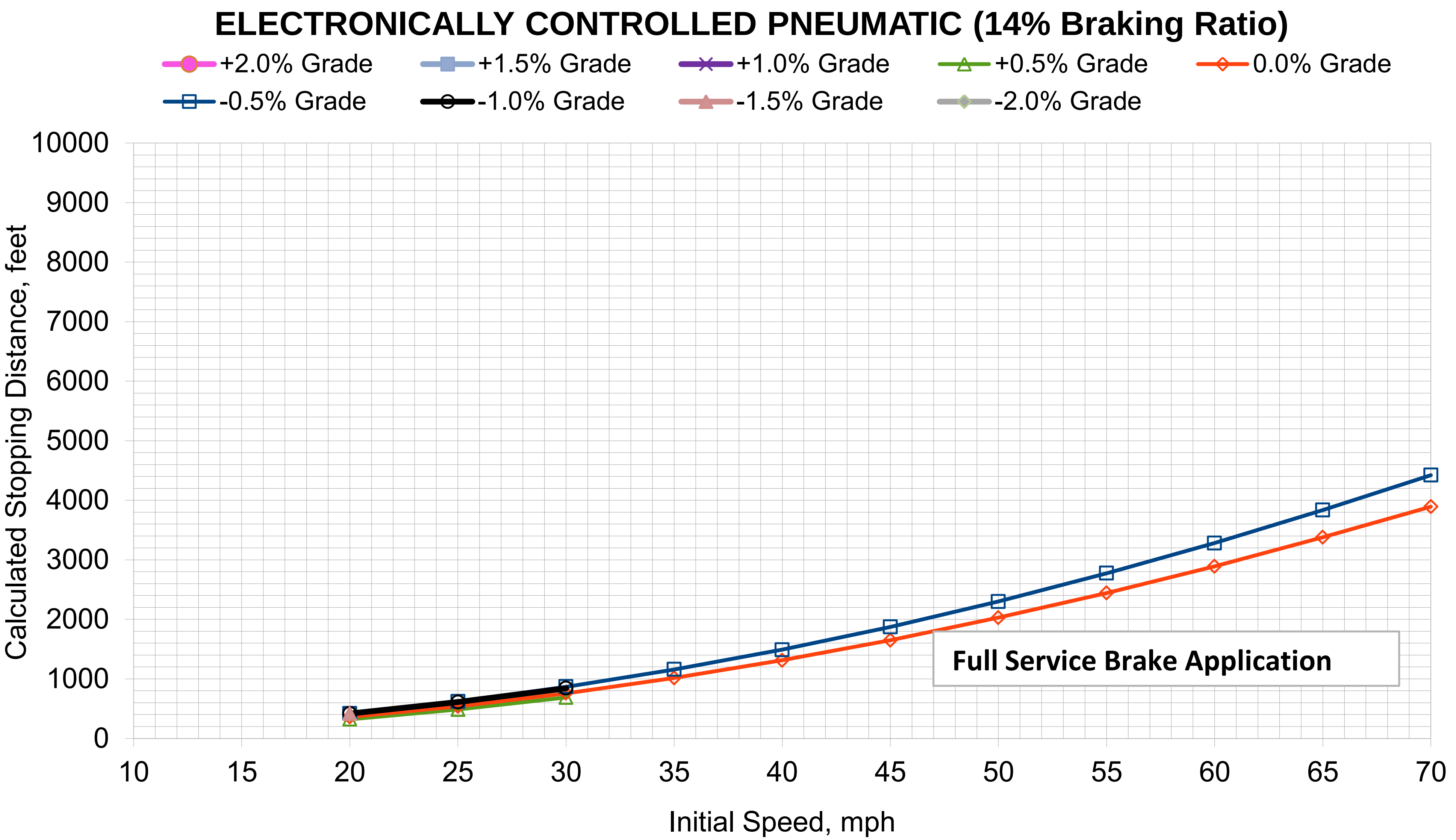
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



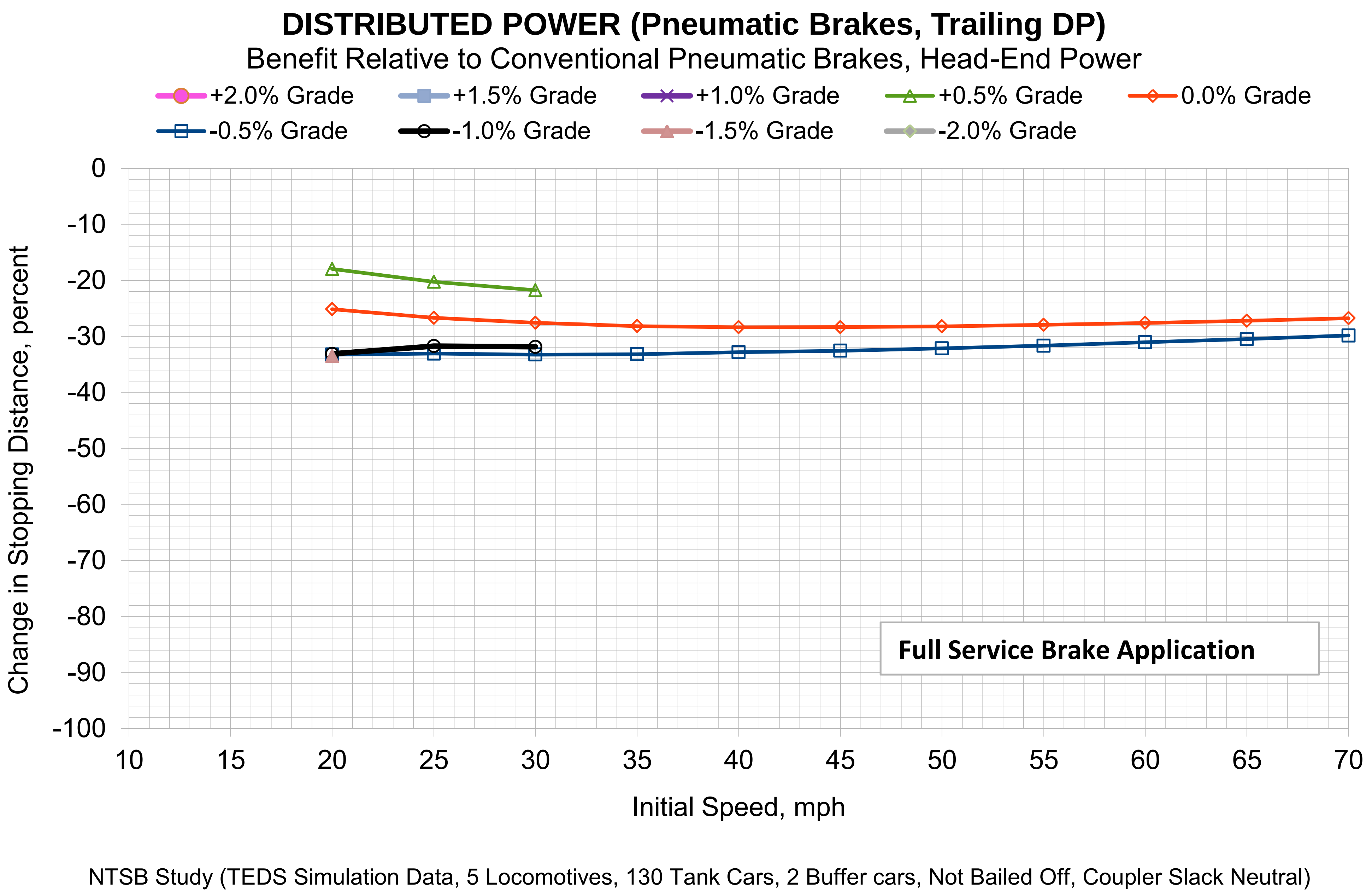
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

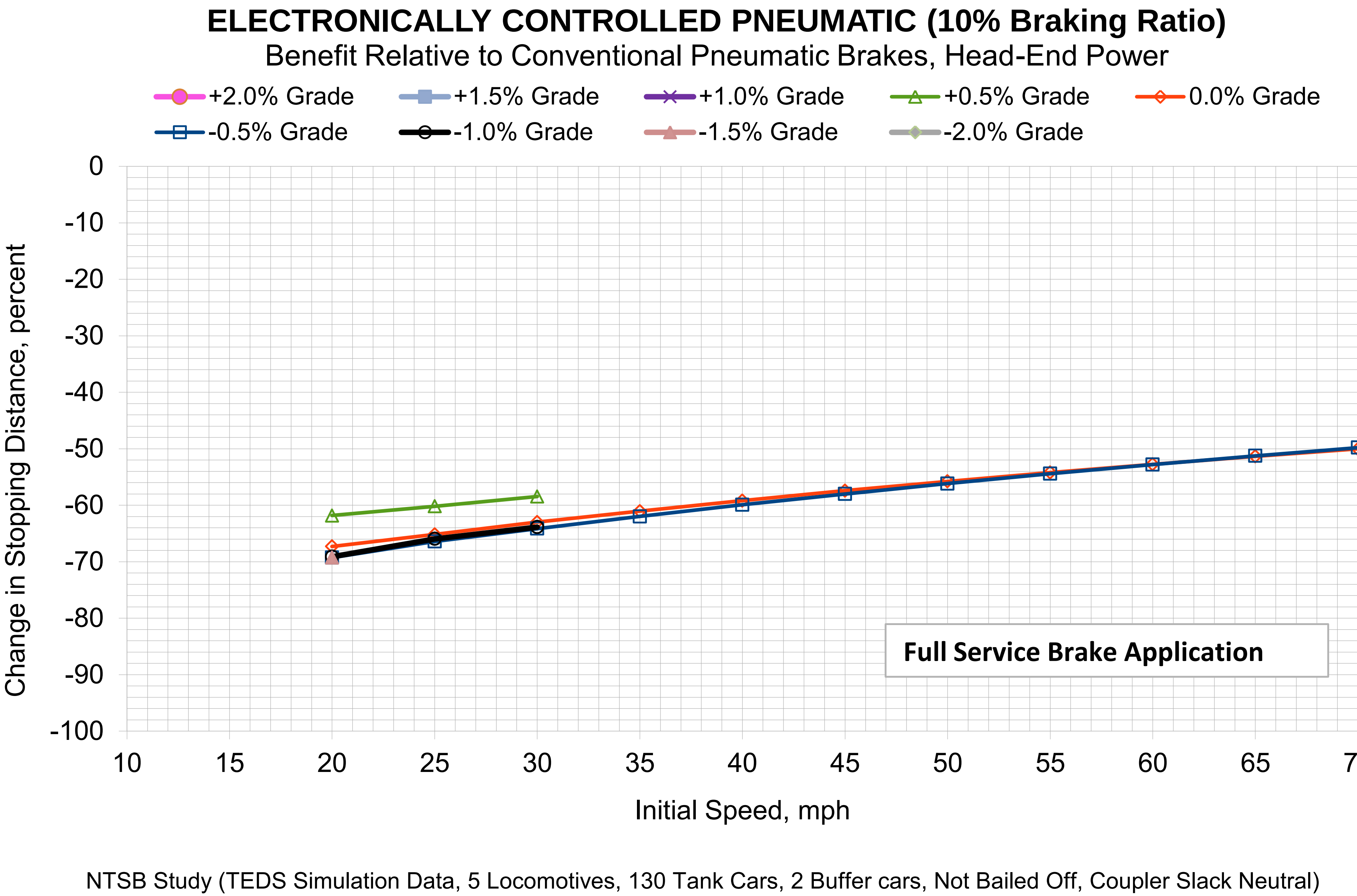


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

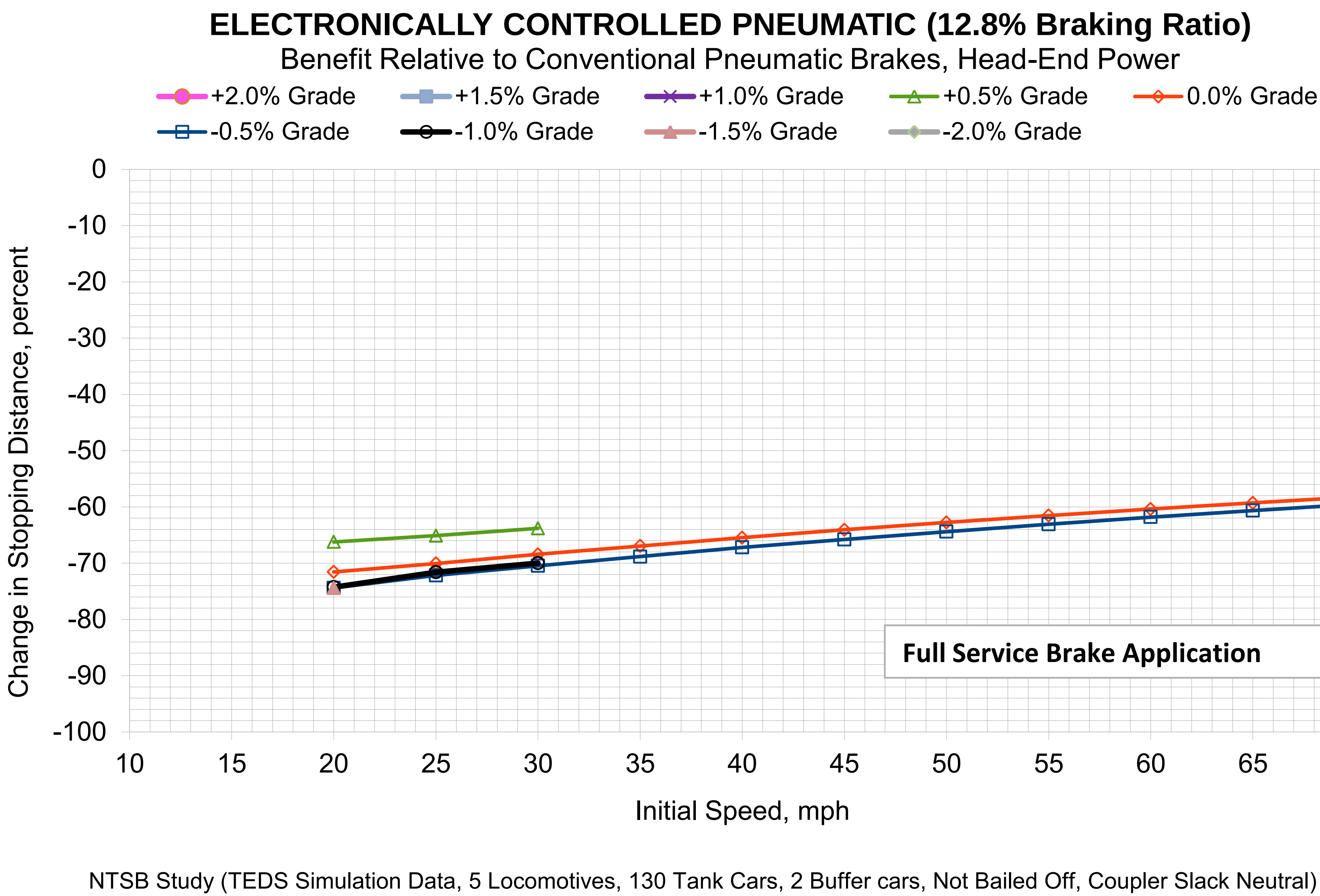


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

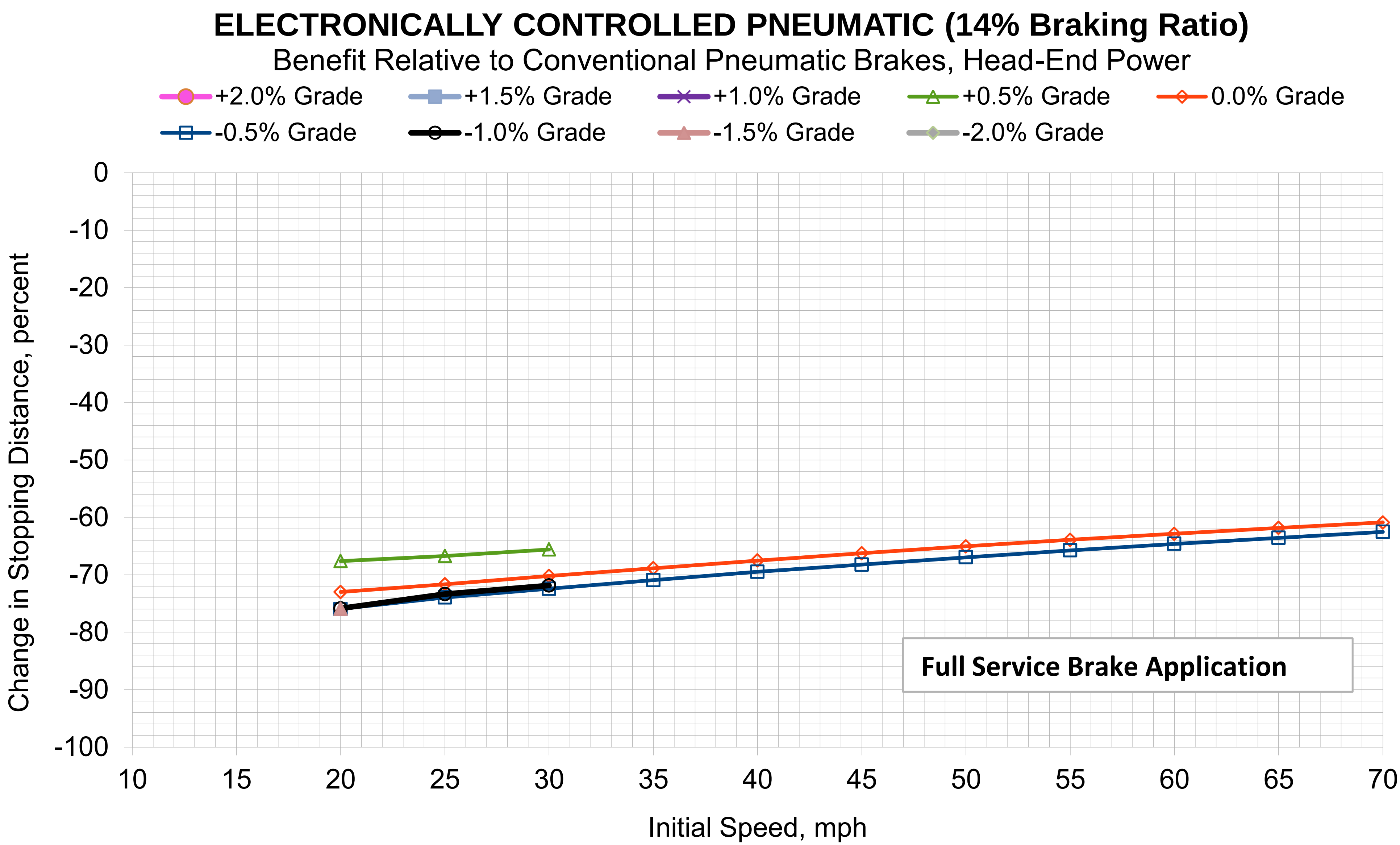

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



ELECTRONICALLY CONTROLLED PNEUMATIC (10% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

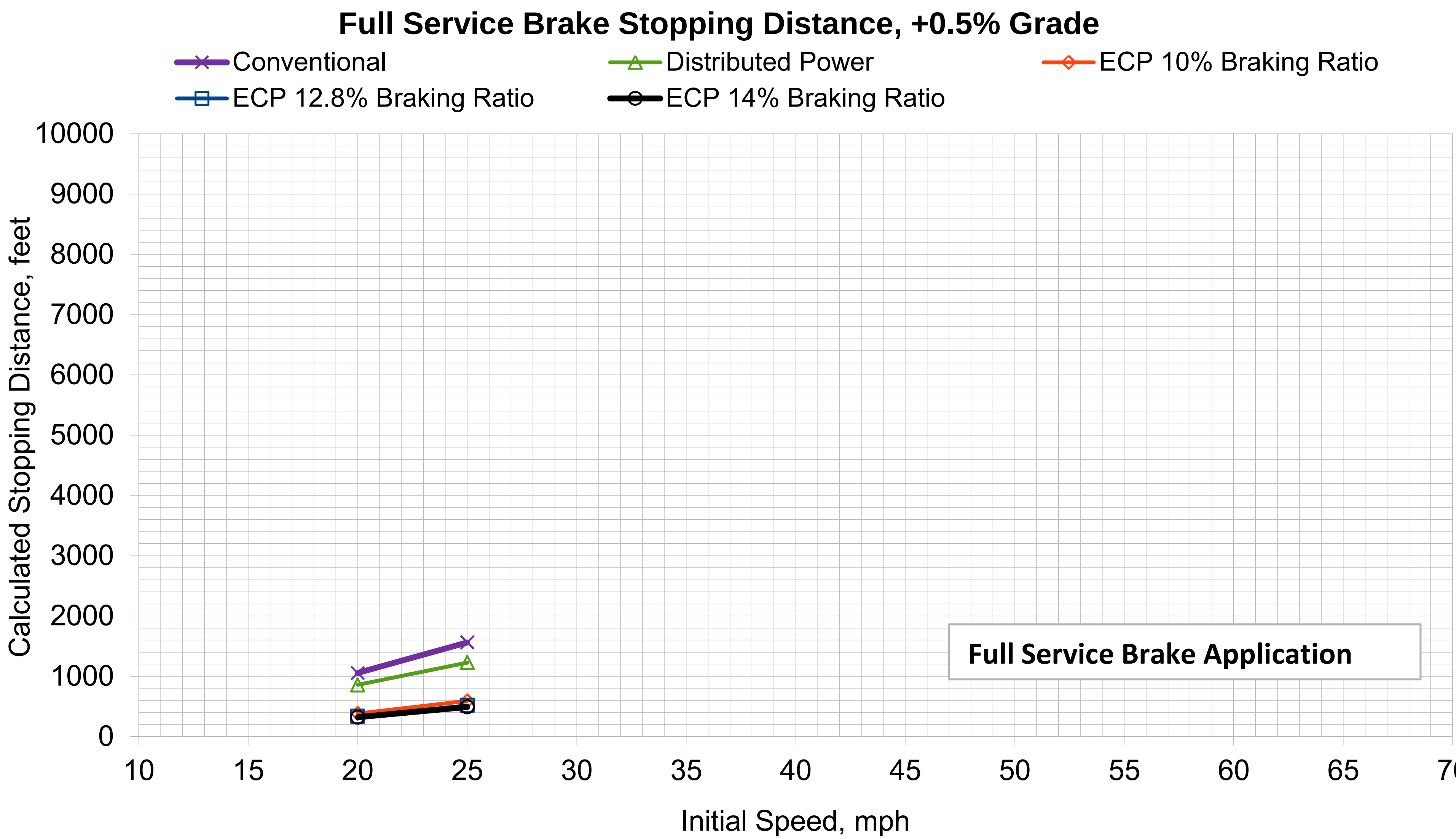


ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

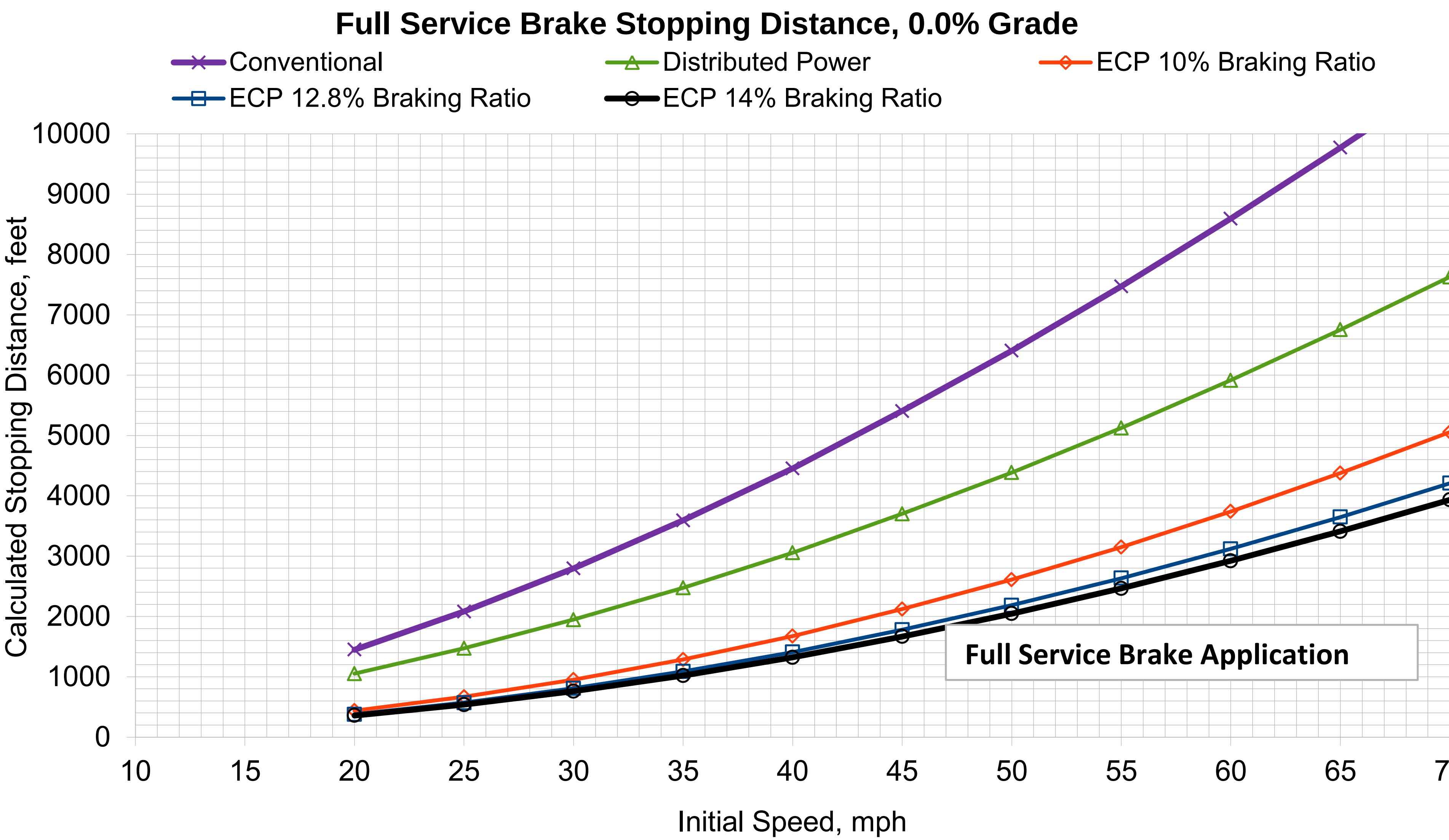


NTSB Study (TEDS Simulation Data, 5 Locomotives, 130 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

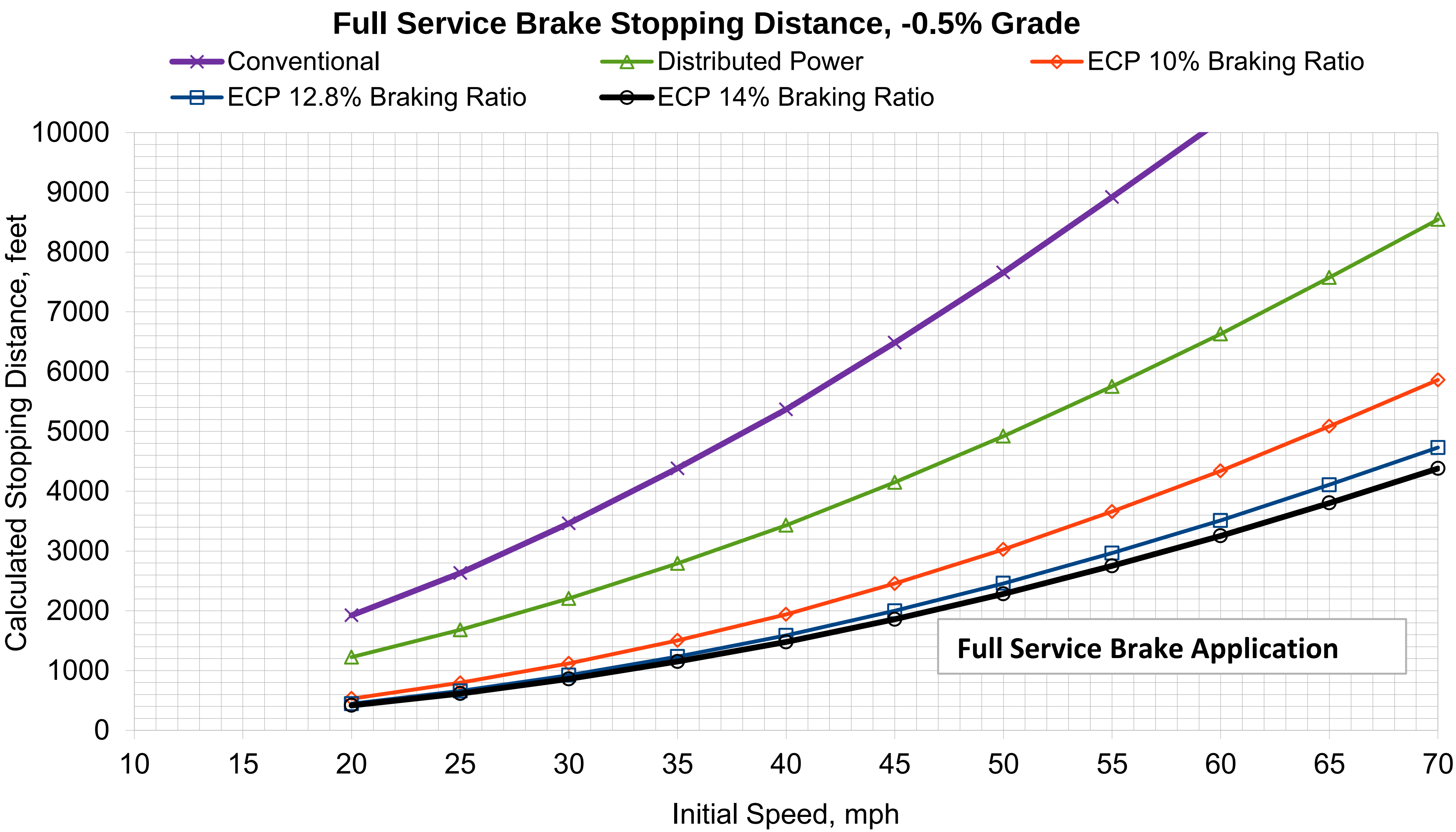
Attachment 26: Full Service Braking, No Bailoff, 156 Tank Cars



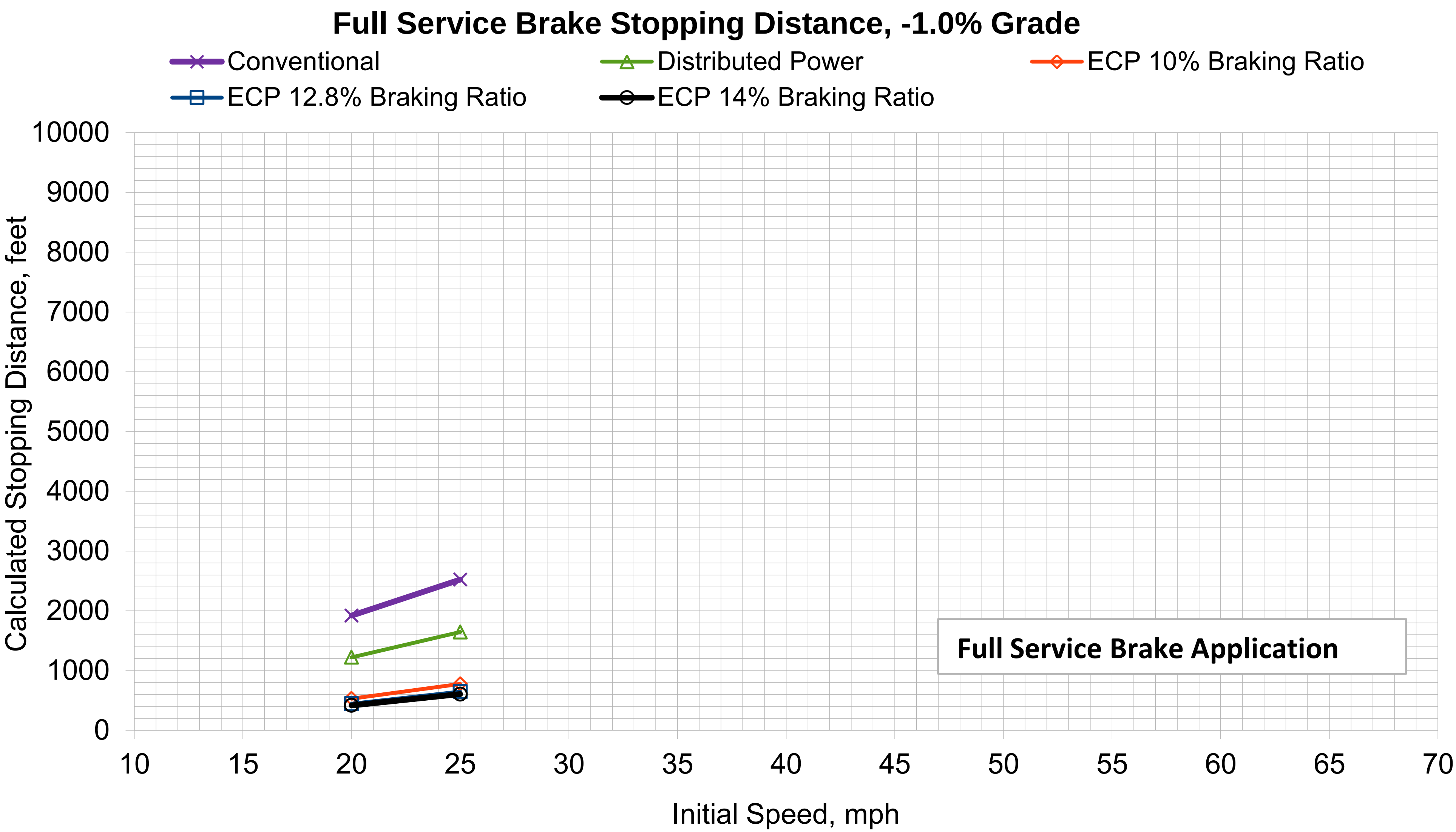
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



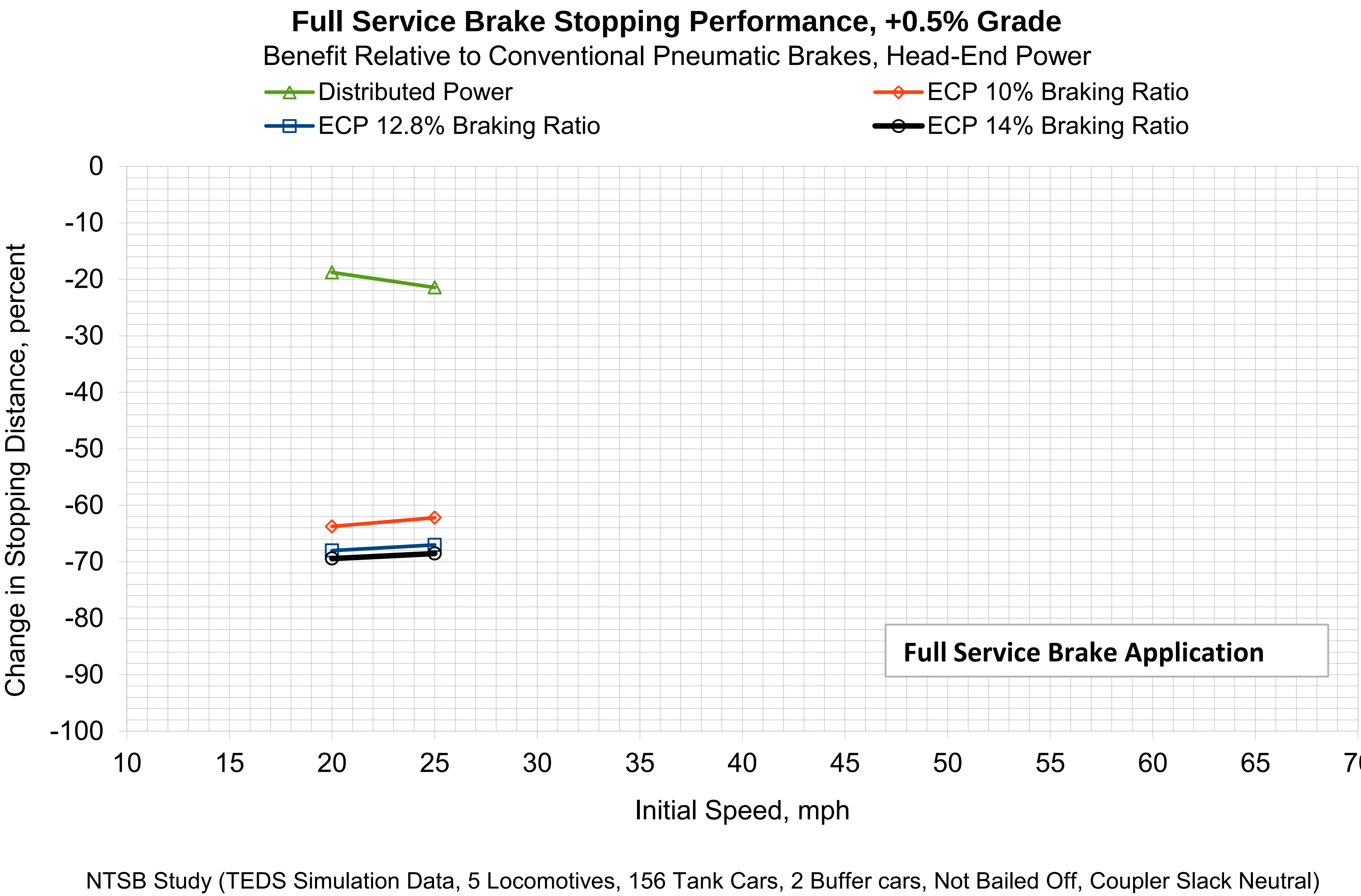
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

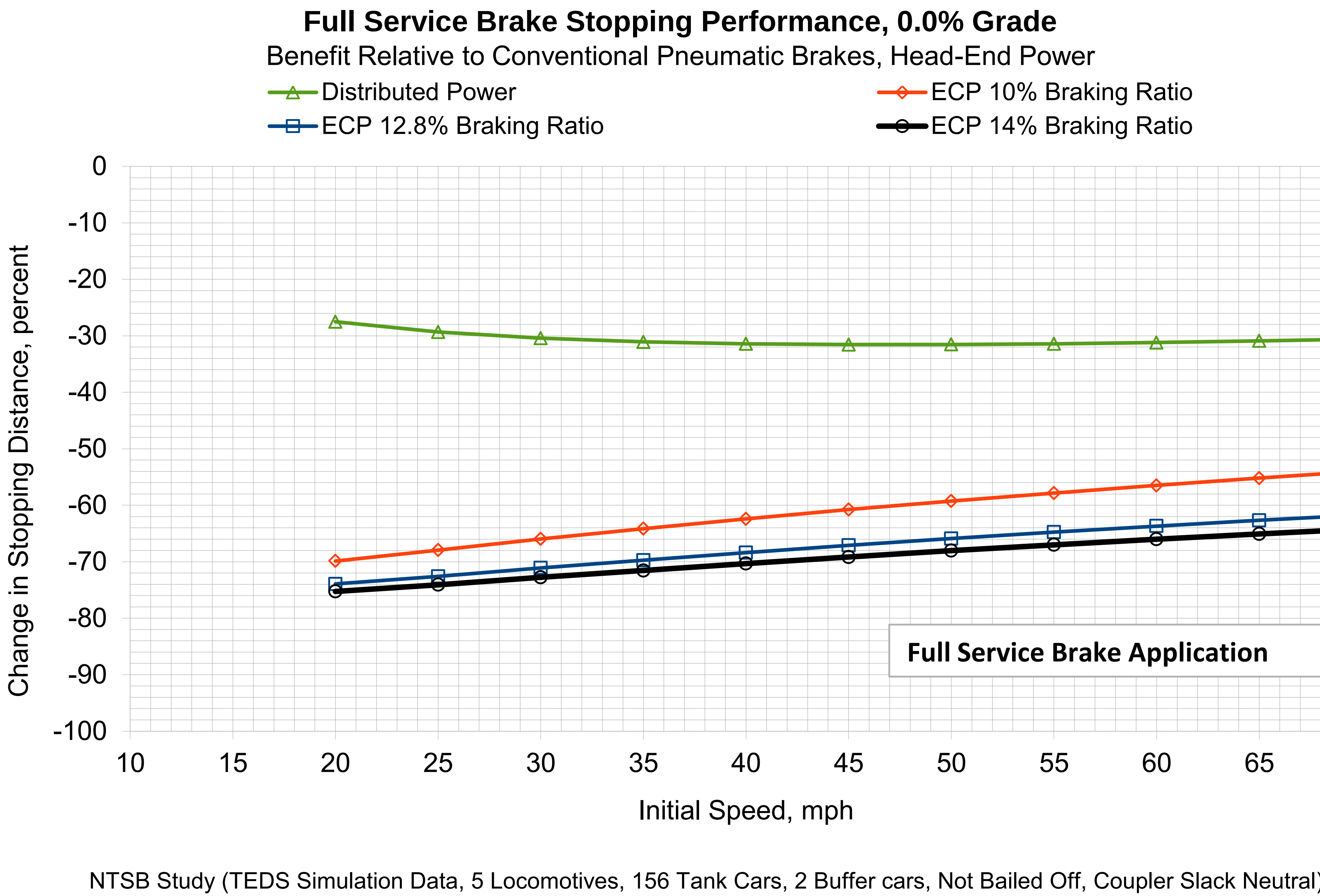


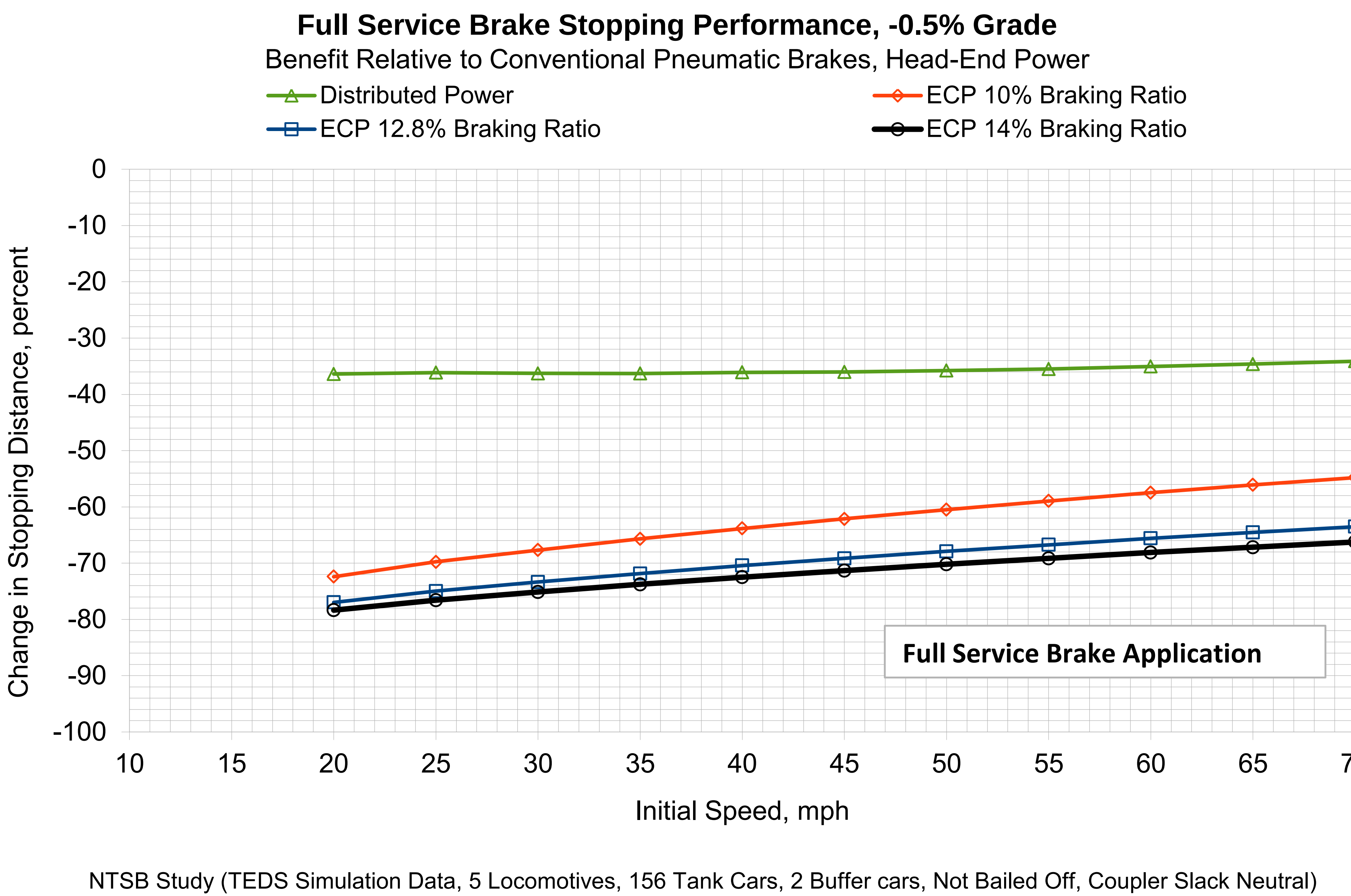
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

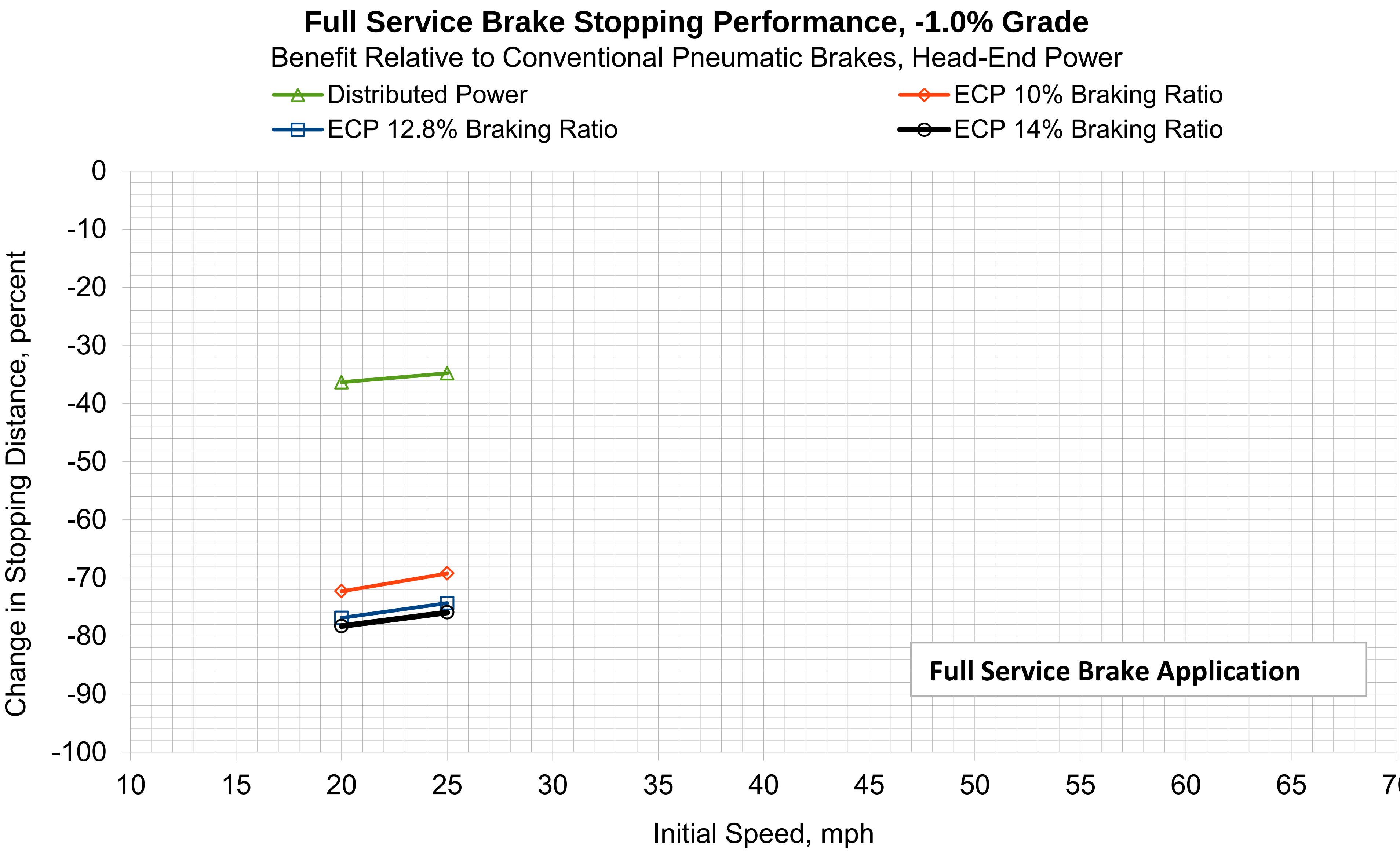


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

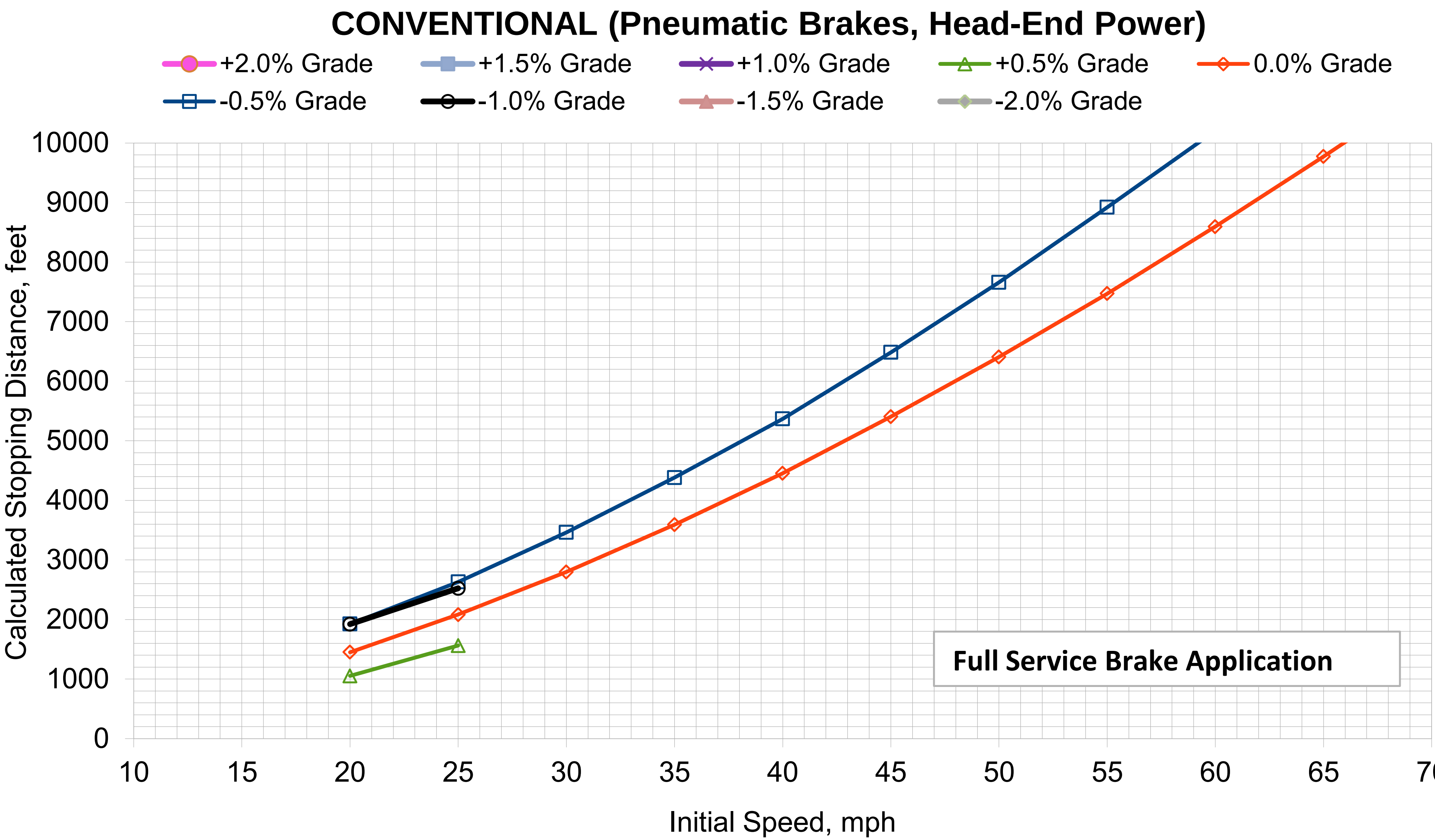

Full Service Brake Stopping Performance, +0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


Full Service Brake Stopping Performance, 0.0% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

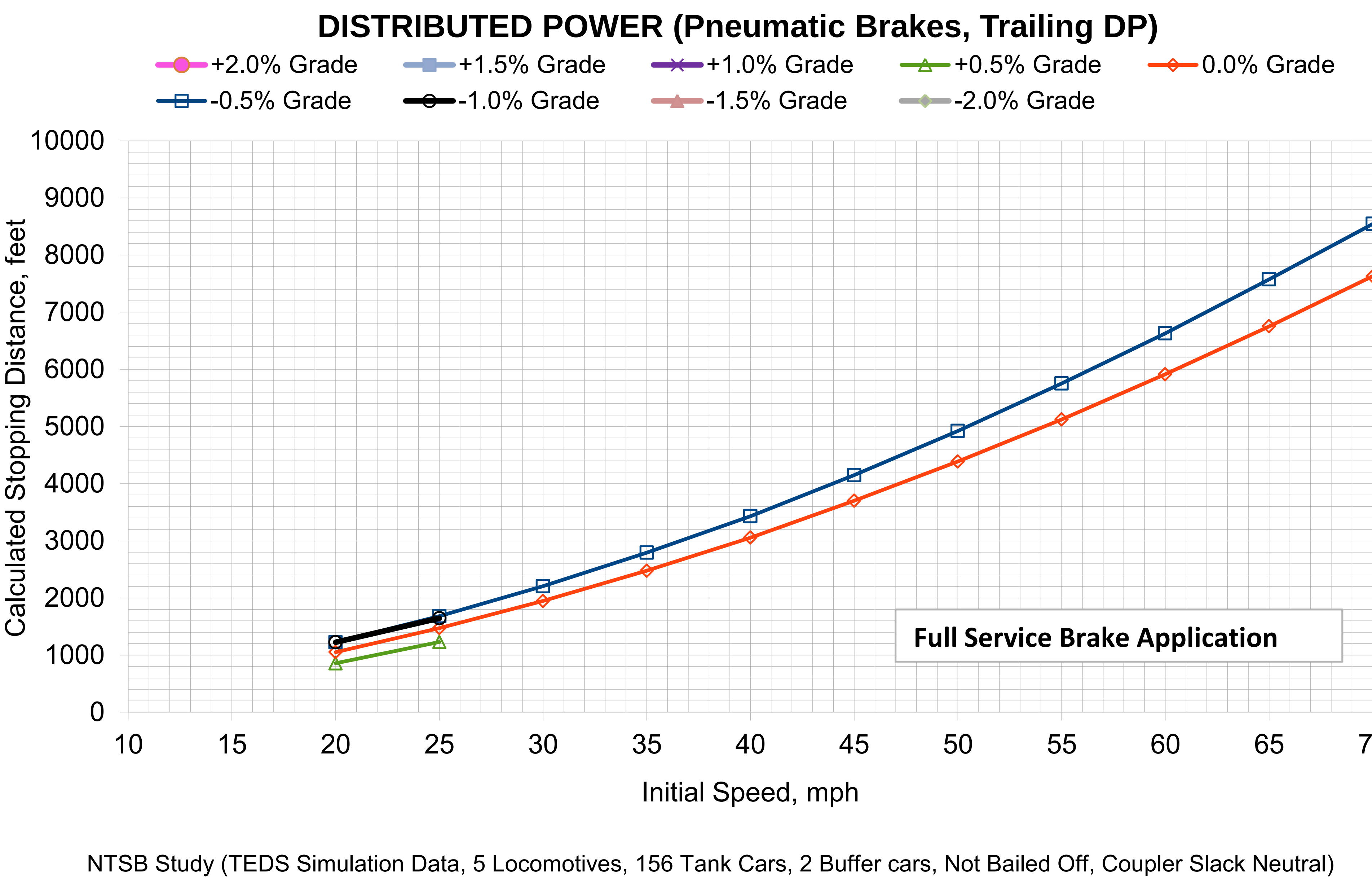

Full Service Brake Stopping Performance, -0.5% Grade
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
Distributed Power
ECP 10% Braking Ratio
ECP 12.8% Braking Ratio
ECP 14% Braking Ratio
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

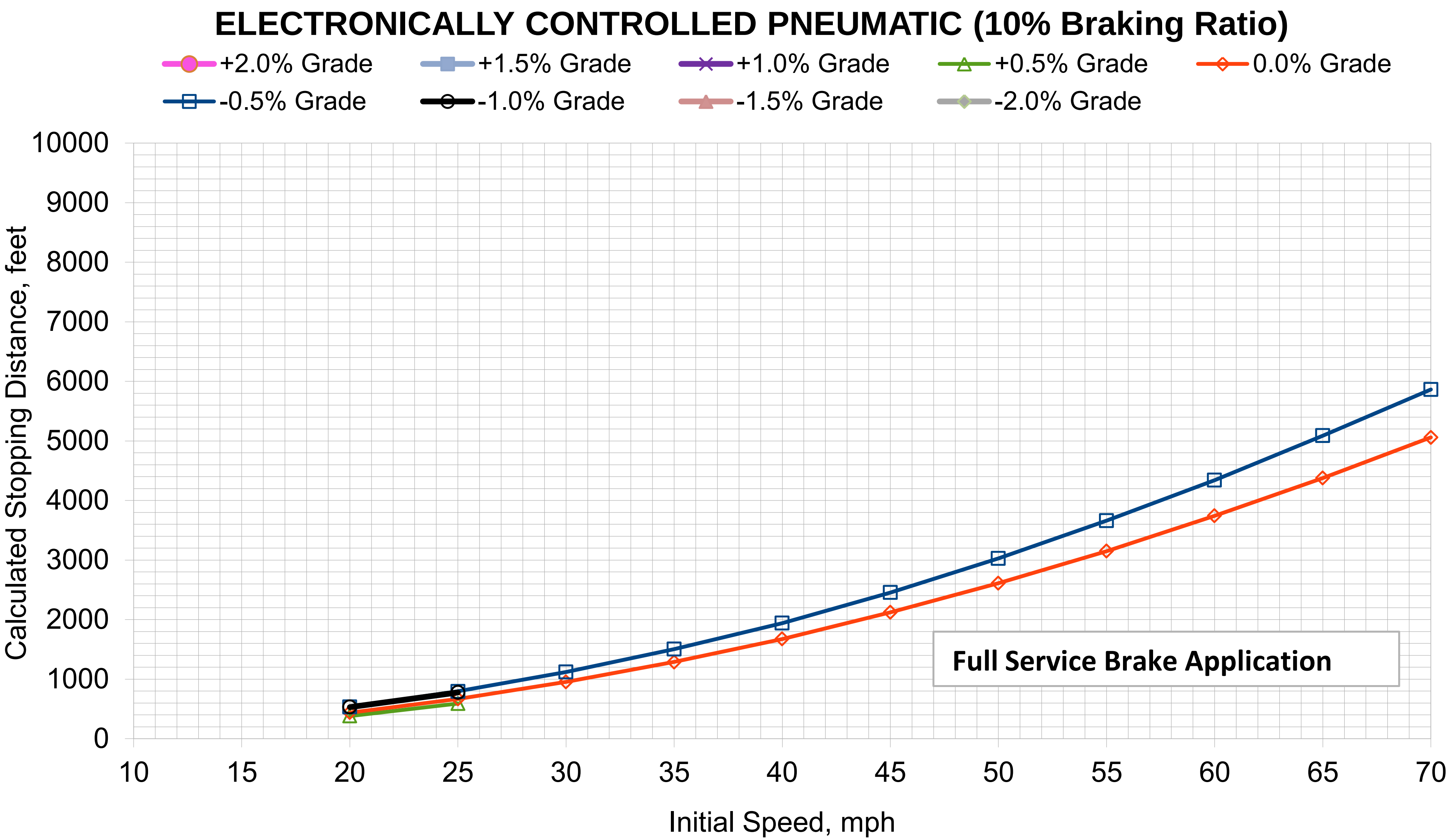


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

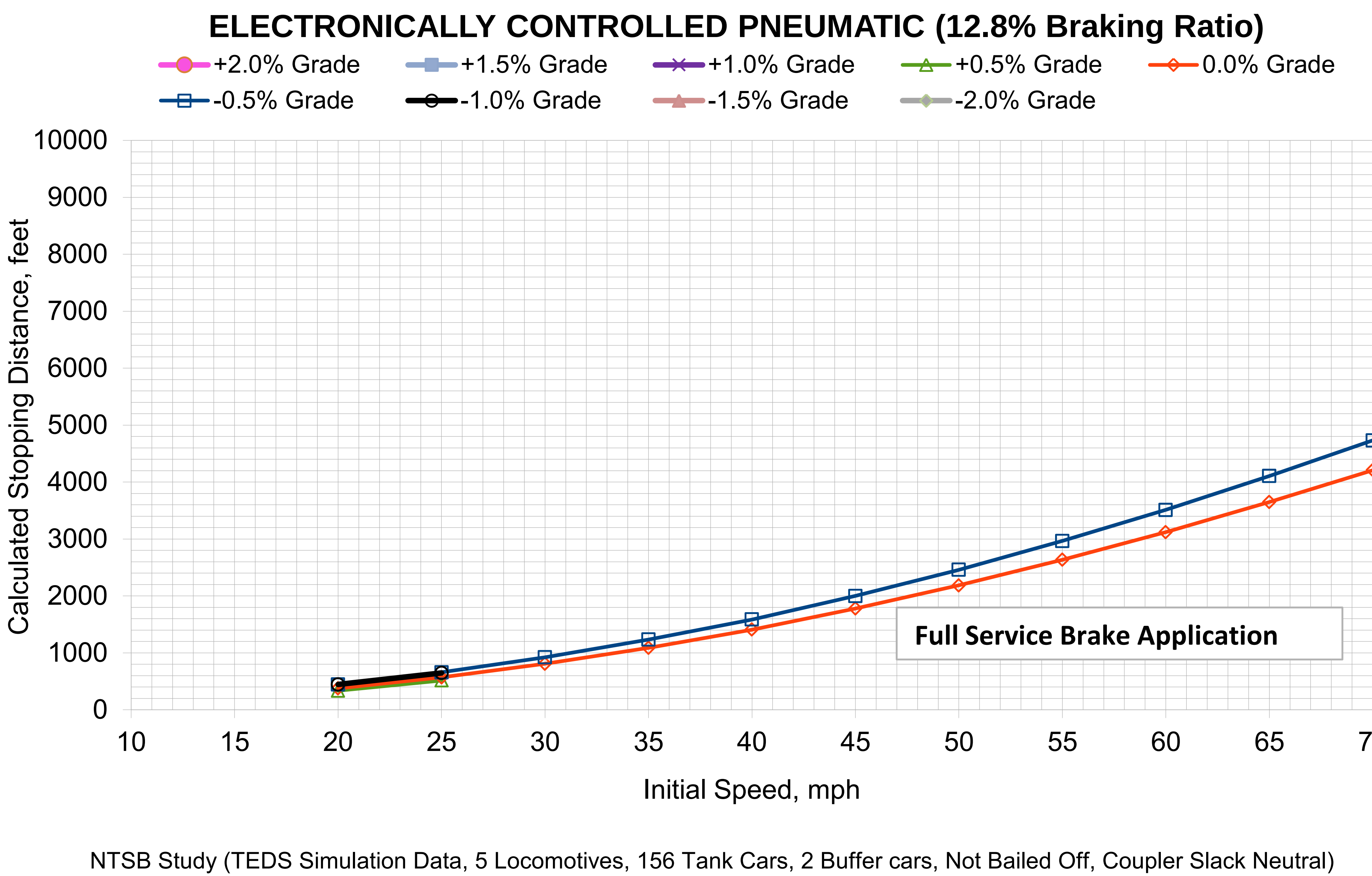


NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

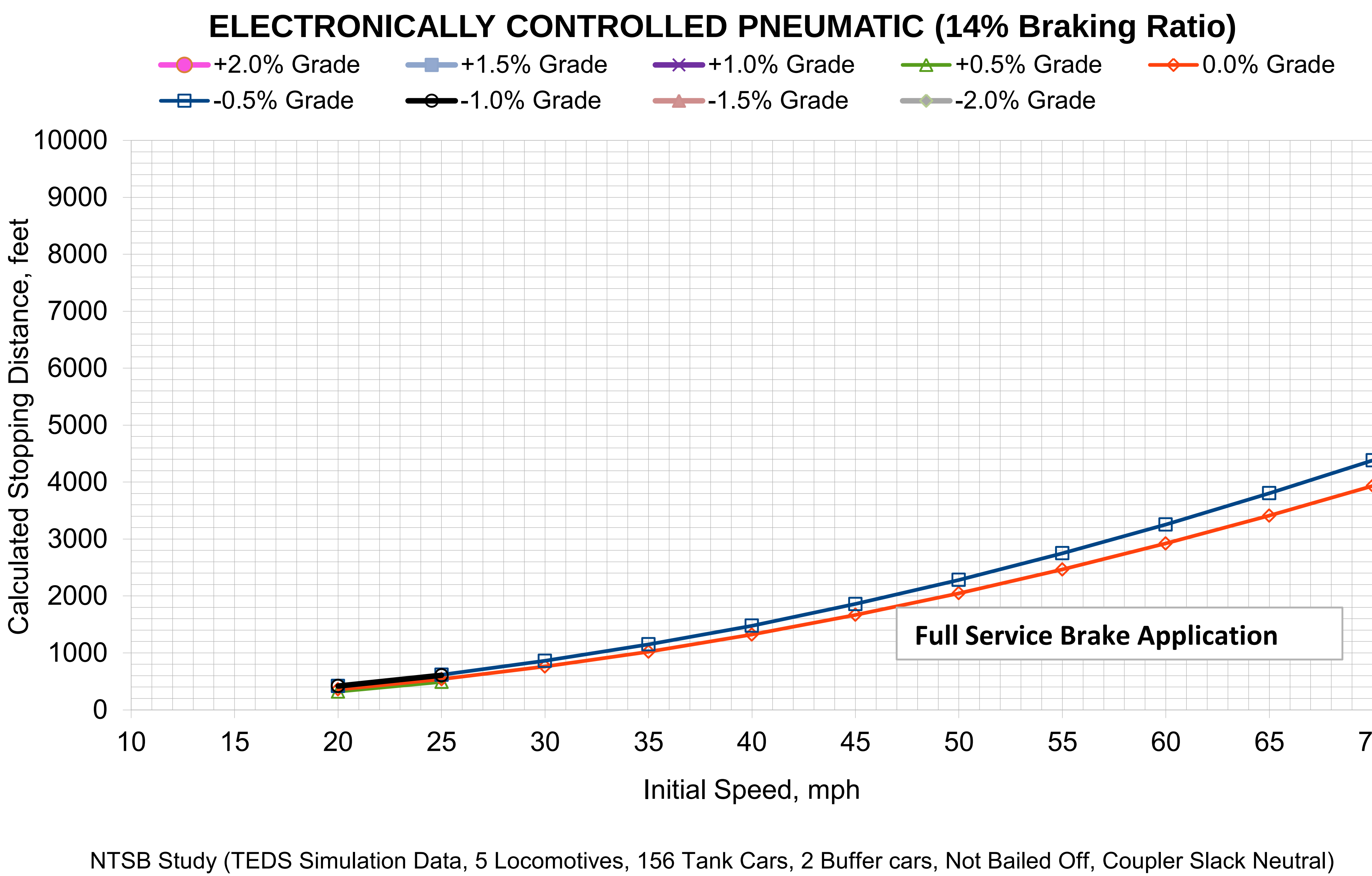

DISTRIBUTED POWER (Pneumatic Brakes, Trailing DP)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



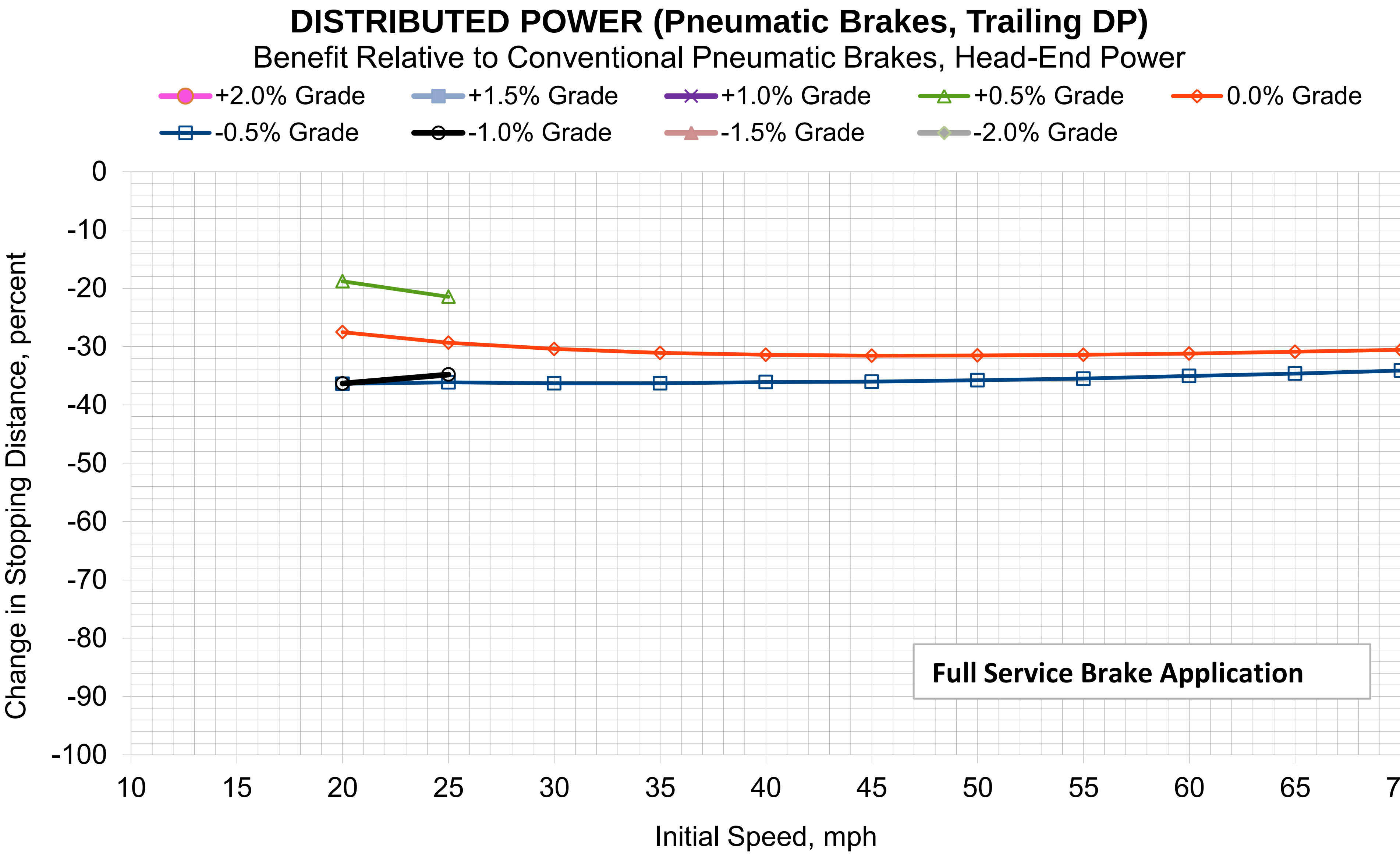
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



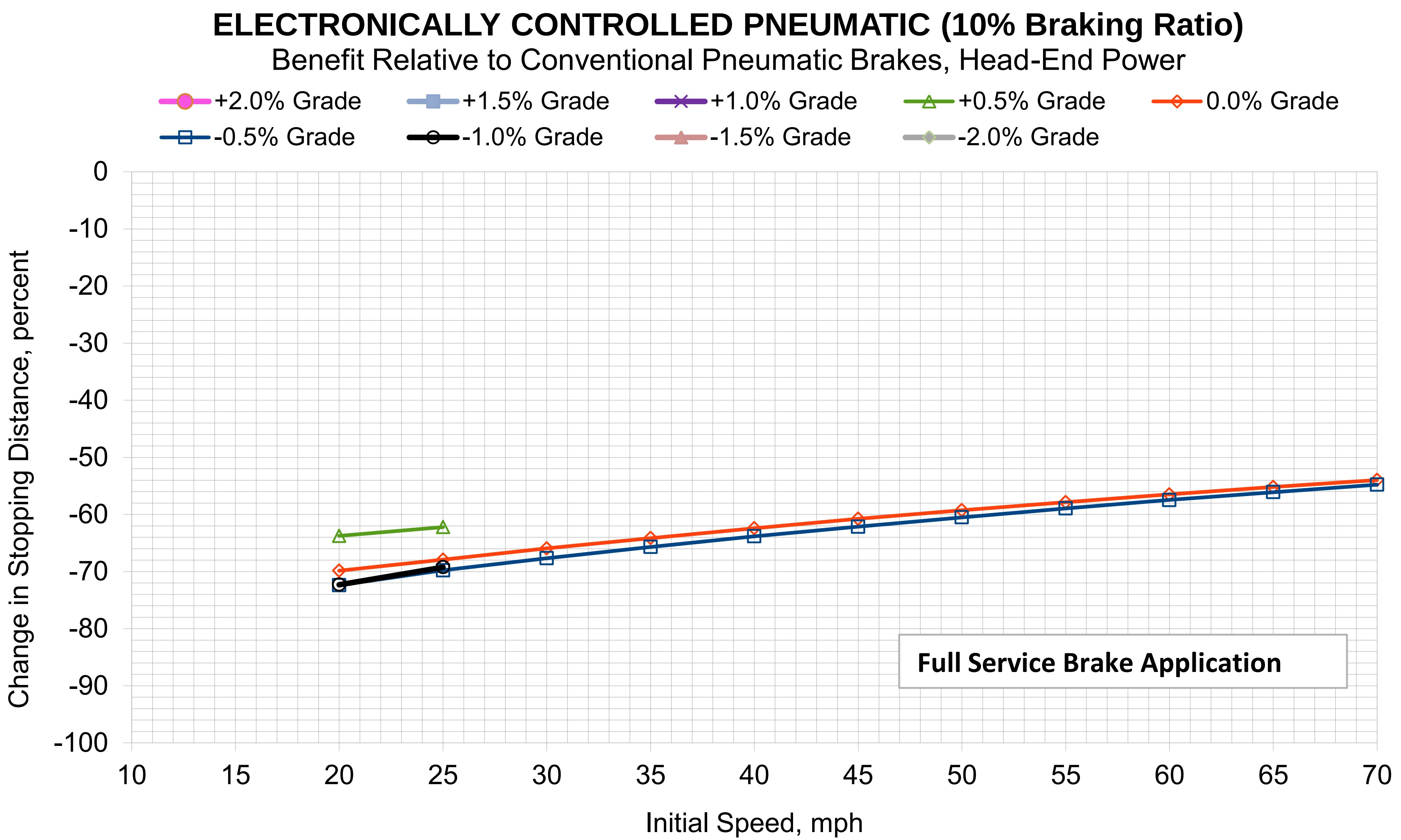
ELECTRONICALLY CONTROLLED PNEUMATIC (12.8% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)


ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Calculated Stopping Distance, feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

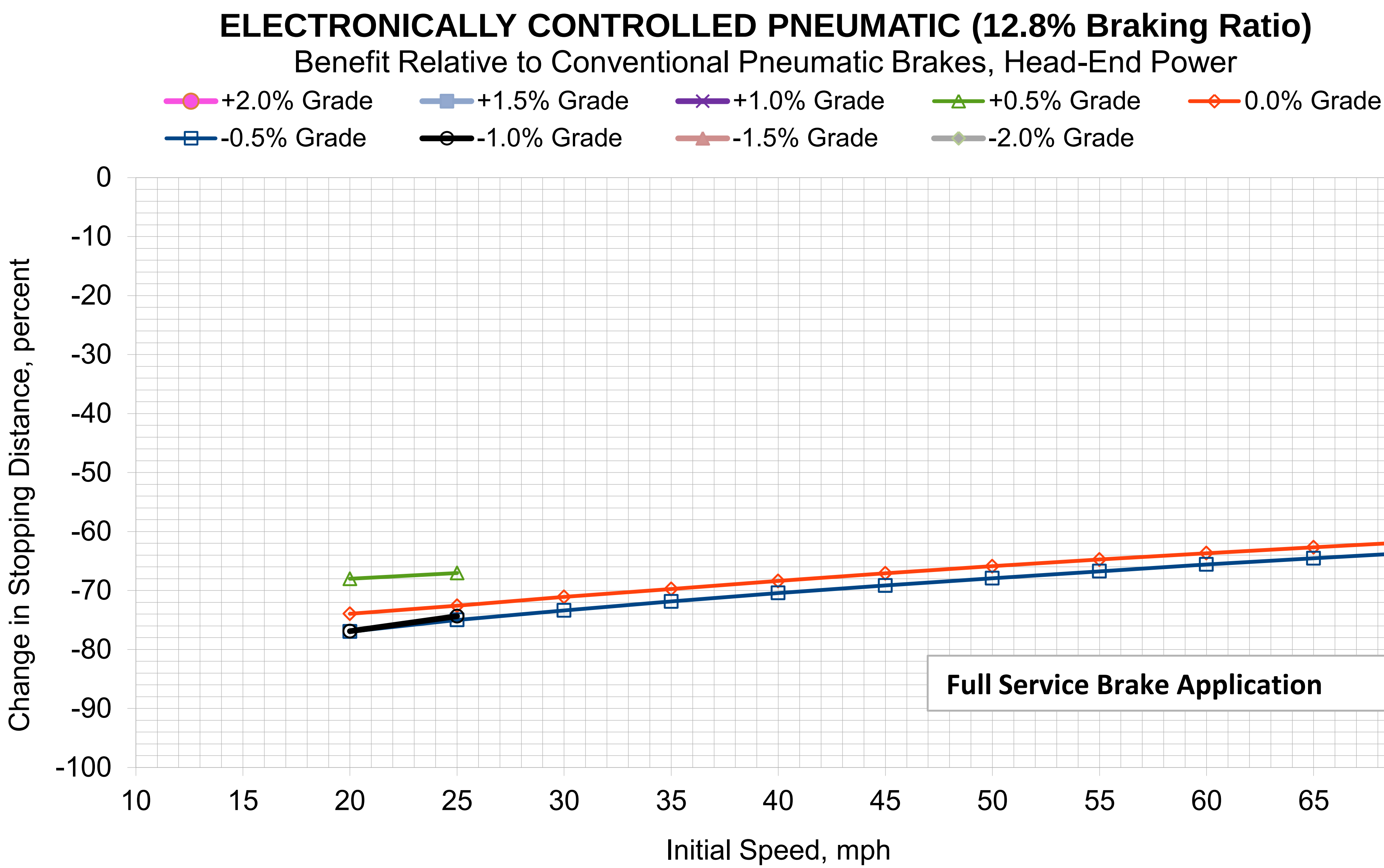
A26.14



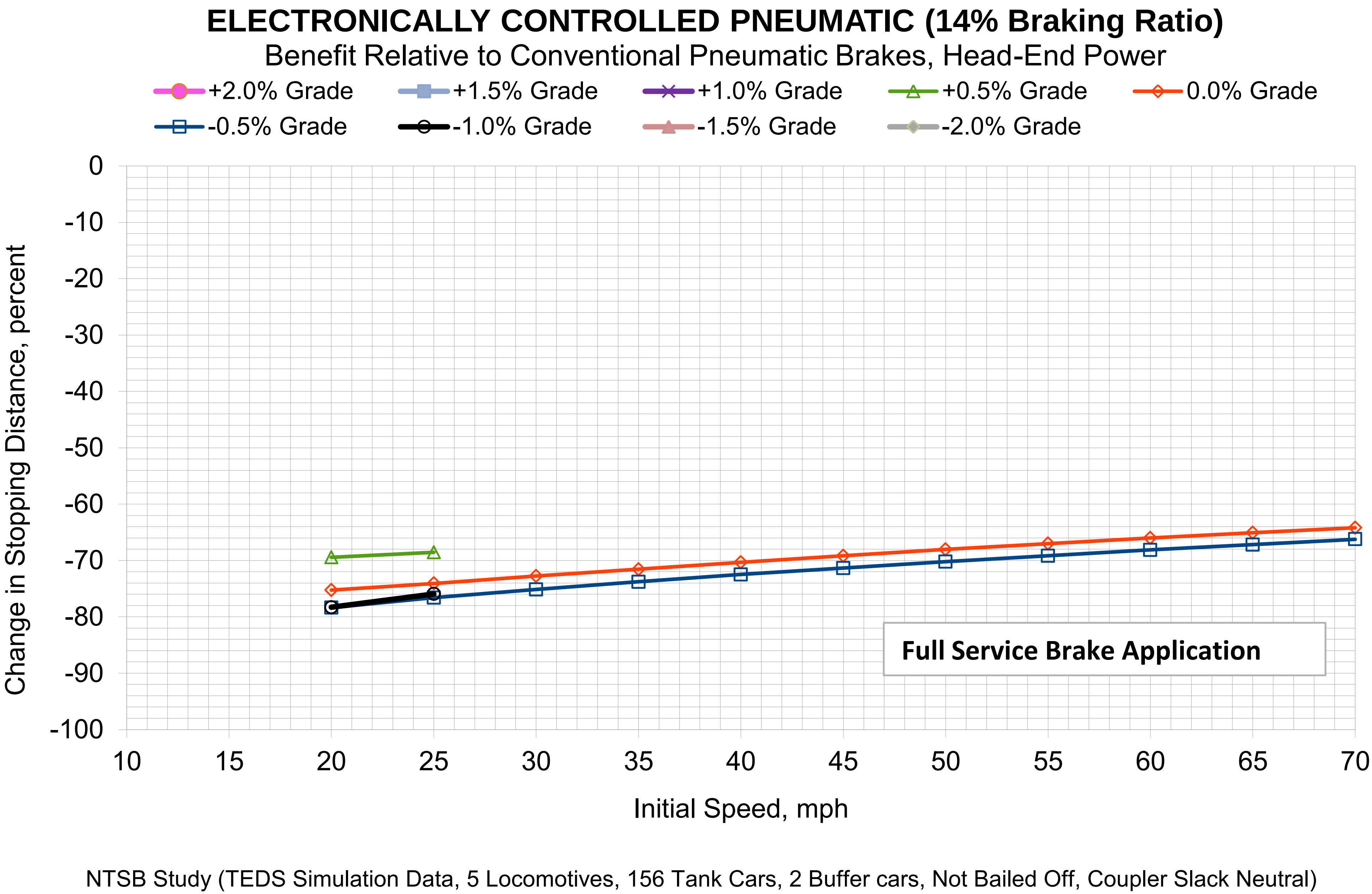
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)



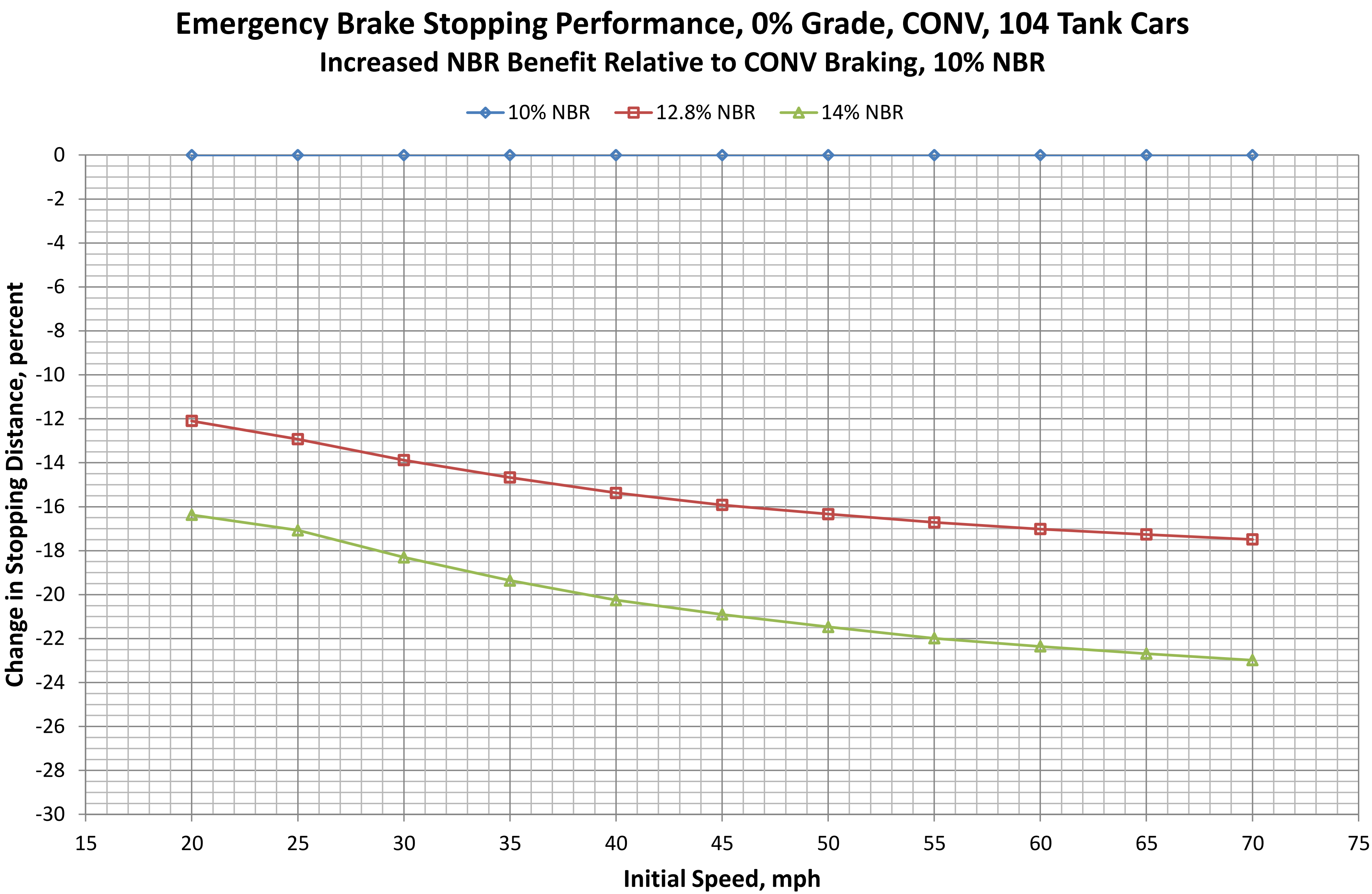
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

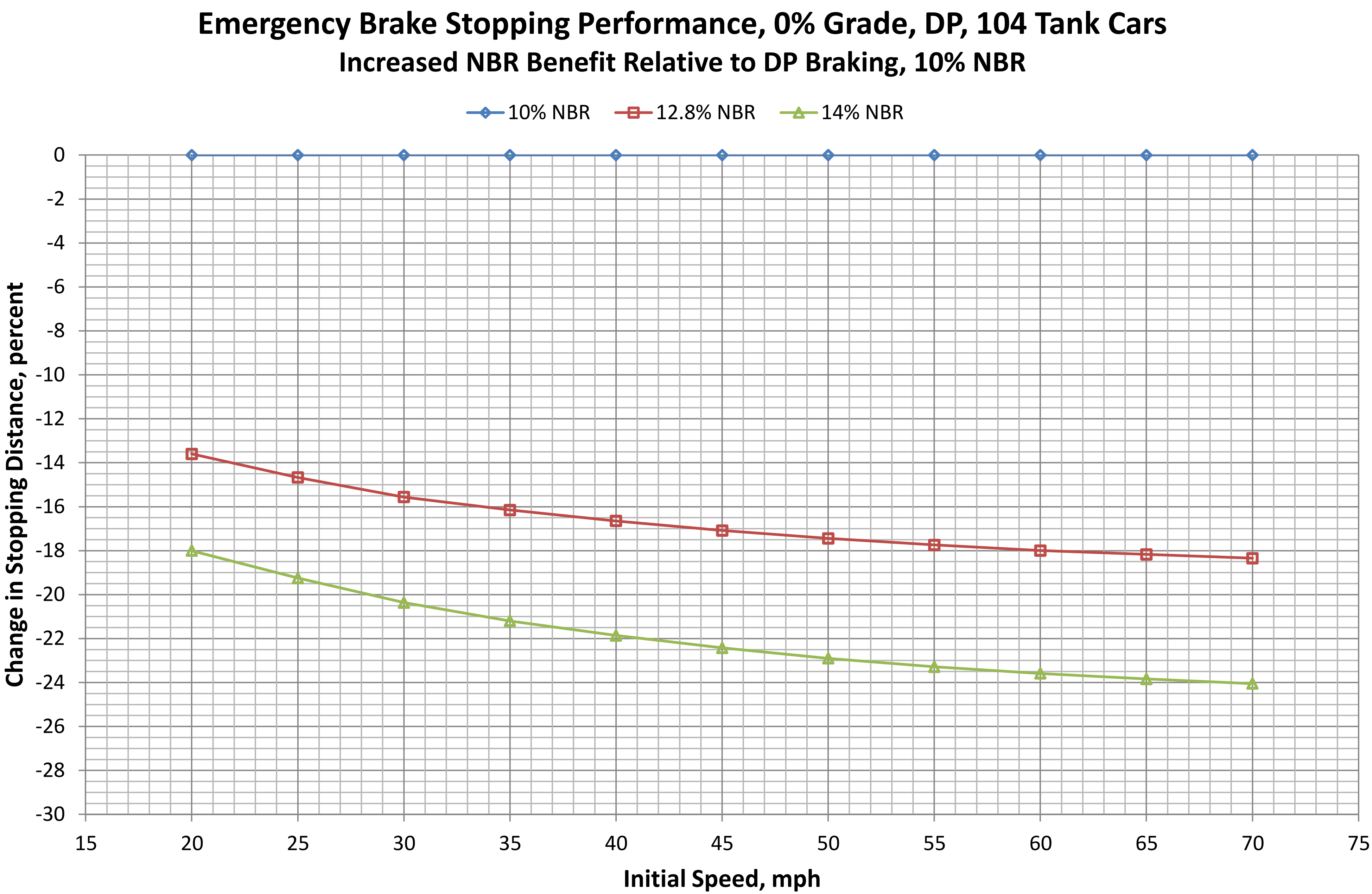


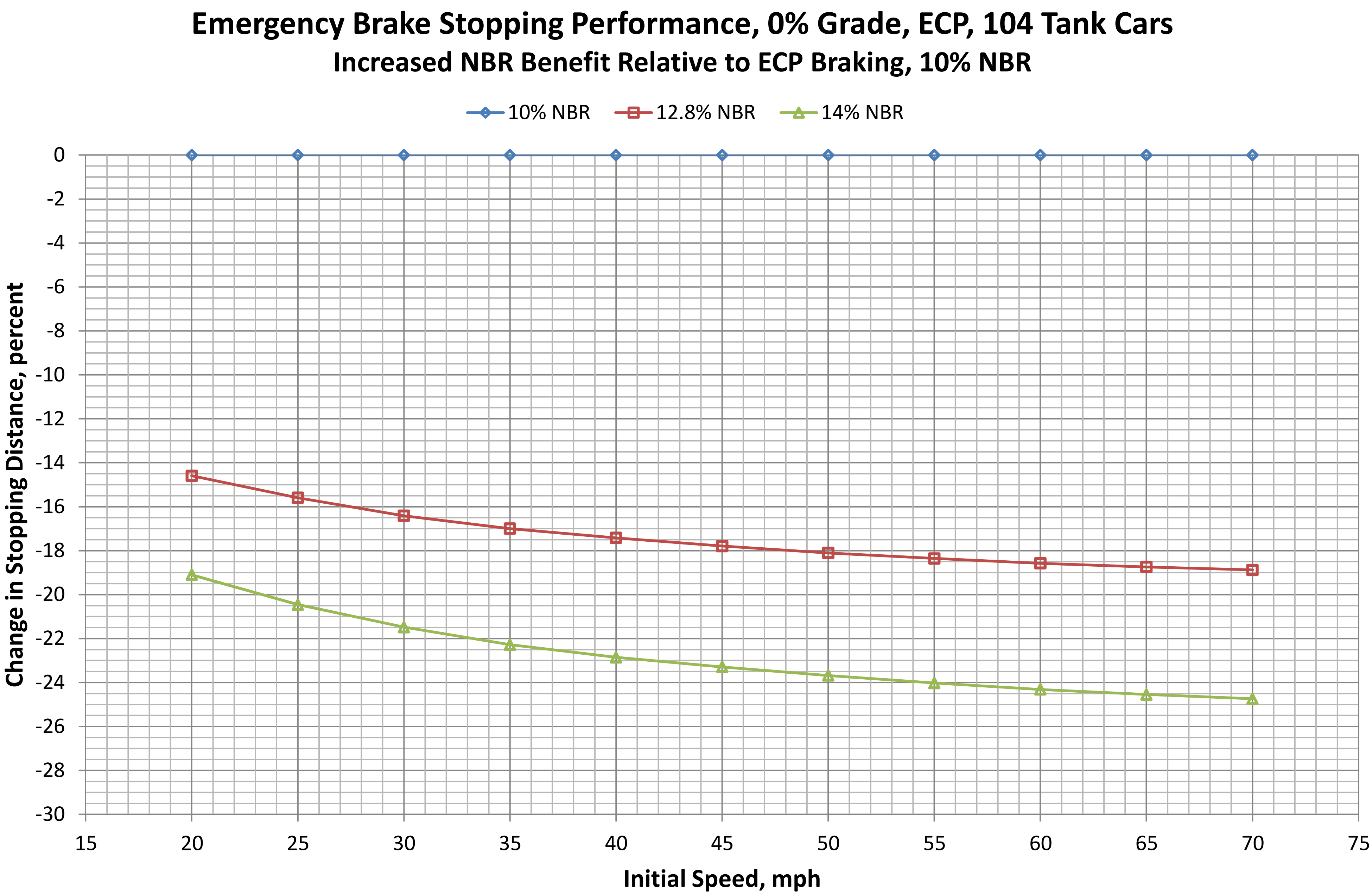
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

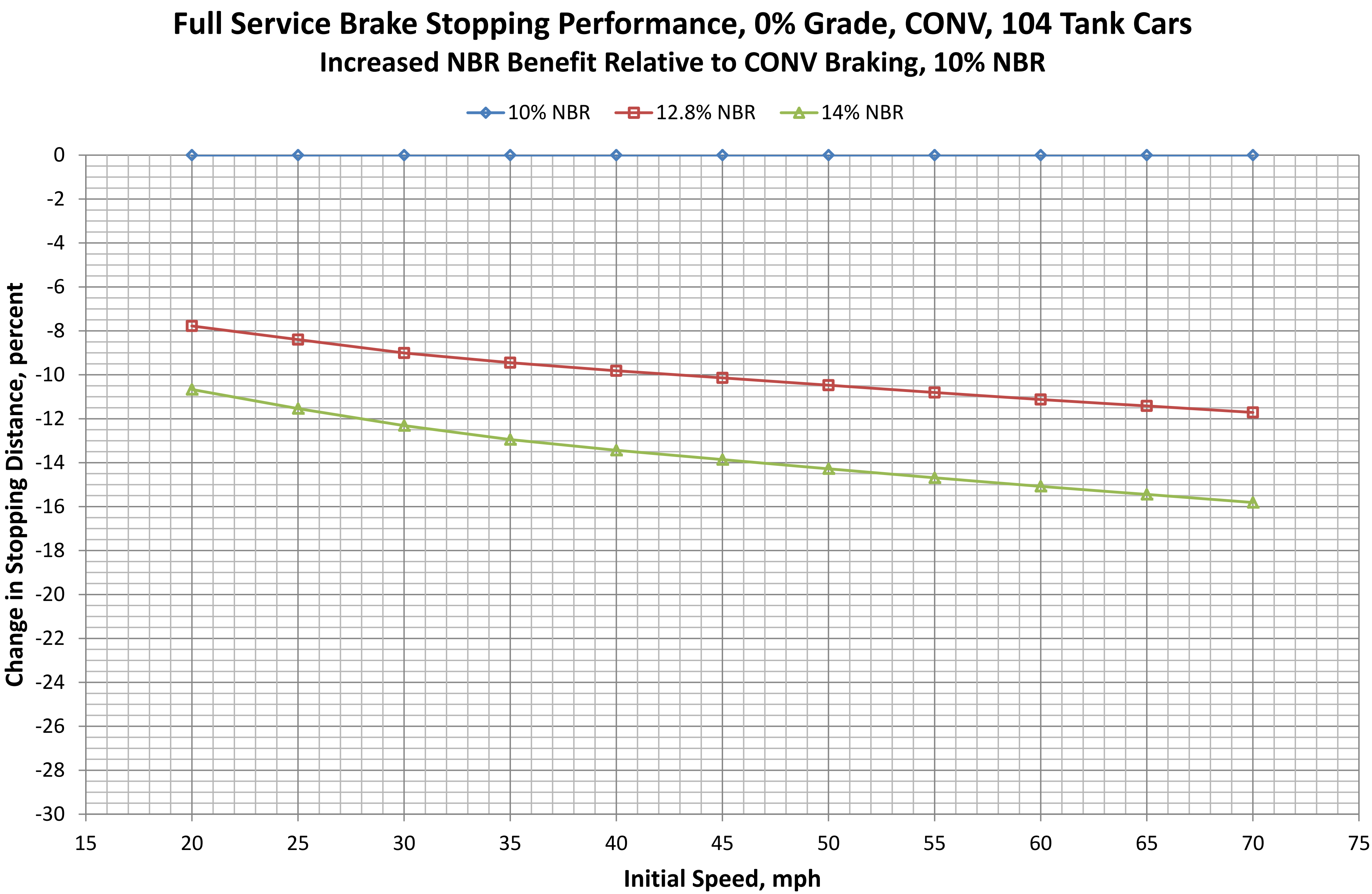

ELECTRONICALLY CONTROLLED PNEUMATIC (14% Braking Ratio)
Benefit Relative to Conventional Pneumatic Brakes, Head-End Power
+2.0% Grade
+1.5% Grade
+1.0% Grade
+0.5% Grade
0.0% Grade
-0.5% Grade
-1.0% Grade
-1.5% Grade
-2.0% Grade
Change in Stopping Distance, percent
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application
NTSB Study (TEDS Simulation Data, 5 Locomotives, 156 Tank Cars, 2 Buffer cars, Not Bailed Off, Coupler Slack Neutral)

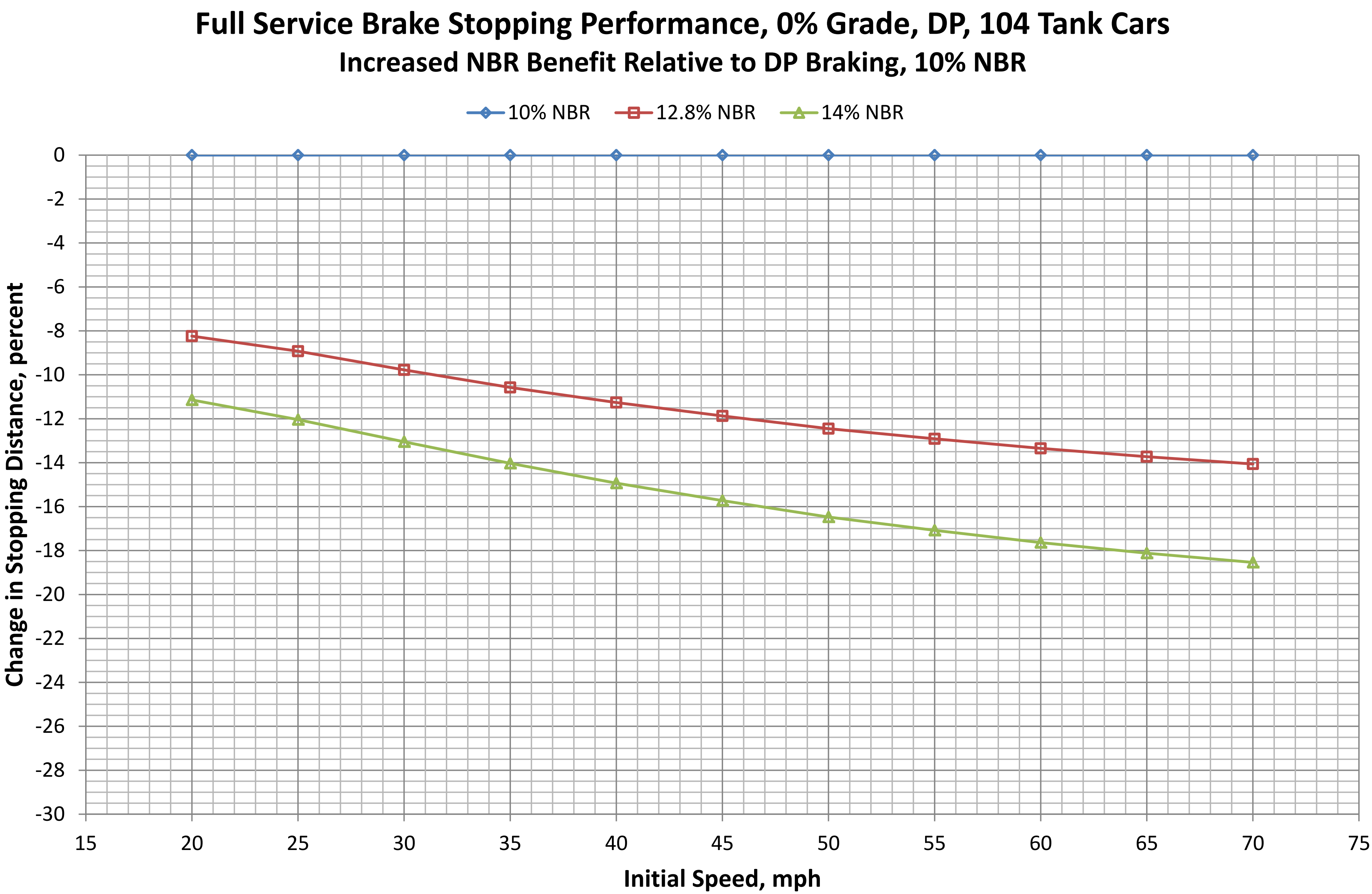
Attachment 27: CONV, DP, and ECP Increased NBR Benefits

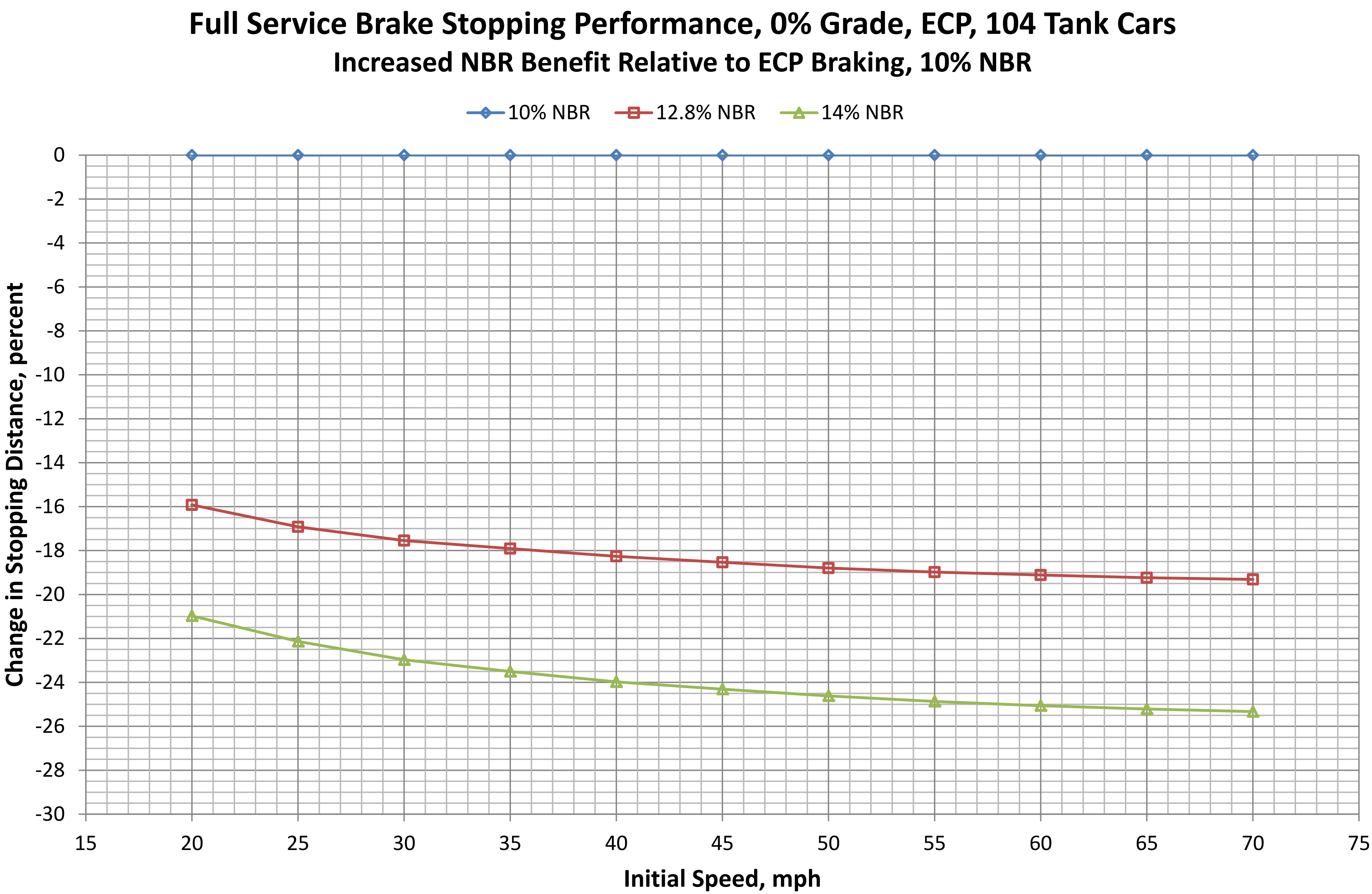

Emergency Brake Stopping Performance, 0% Grade, CONV, 104 Tank Cars
Increased NBR Benefit Relative to CONV Braking, 10% NBR
10% NBR
12.8% NBR
14% NBR
Change in Stopping Distance, percent
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph

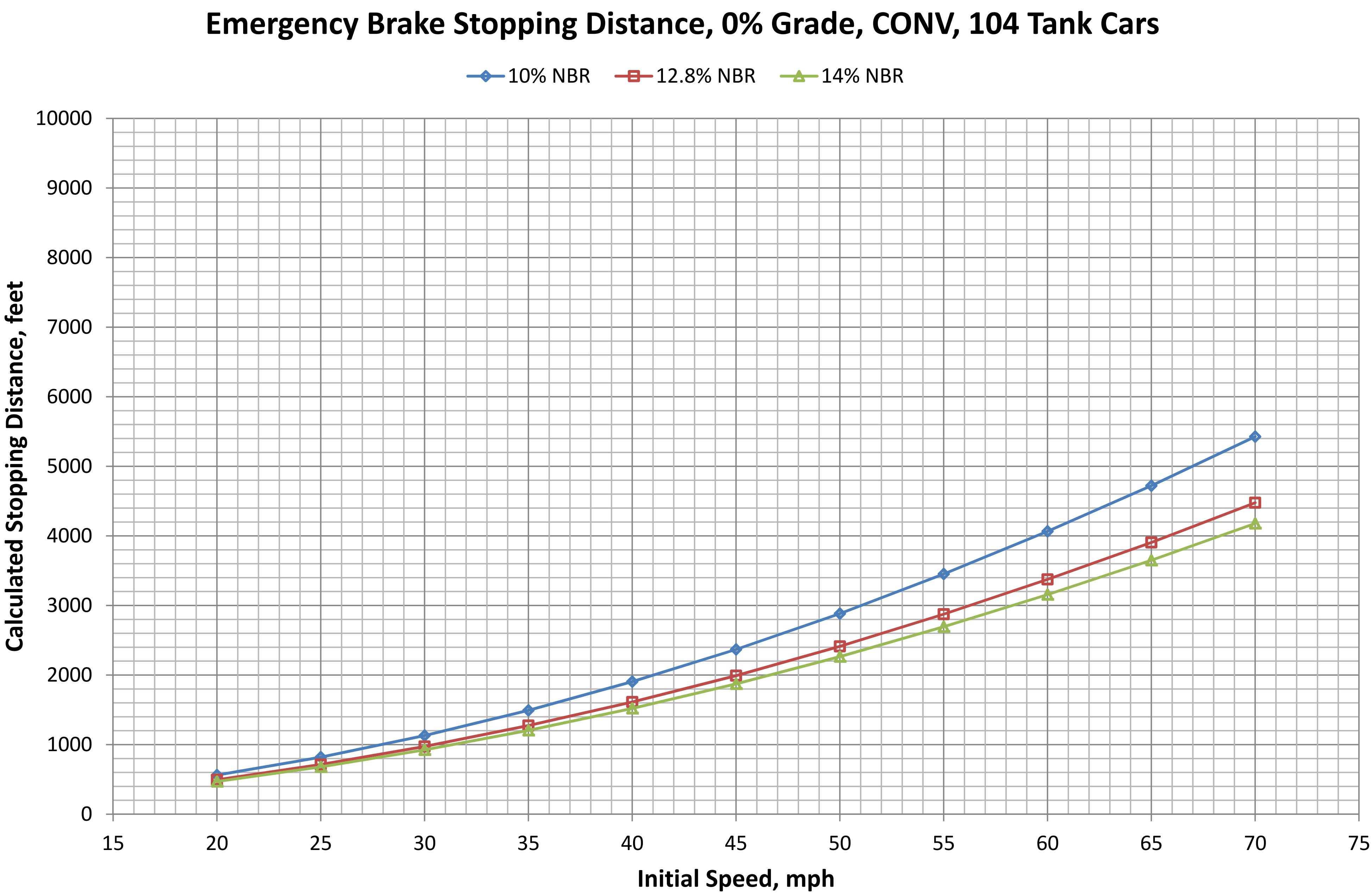

Emergency Brake Stopping Performance, 0% Grade, DP, 104 Tank Cars
Increased NBR Benefit Relative to DP Braking, 10% NBR
10% NBR
12.8% NBR
14% NBR
Change in Stopping Distance, percent
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph


Emergency Brake Stopping Performance, 0% Grade, ECP, 104 Tank Cars
Increased NBR Benefit Relative to ECP Braking, 10% NBR
10% NBR
12.8% NBR
14% NBR
Change in Stopping Distance, percent
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph

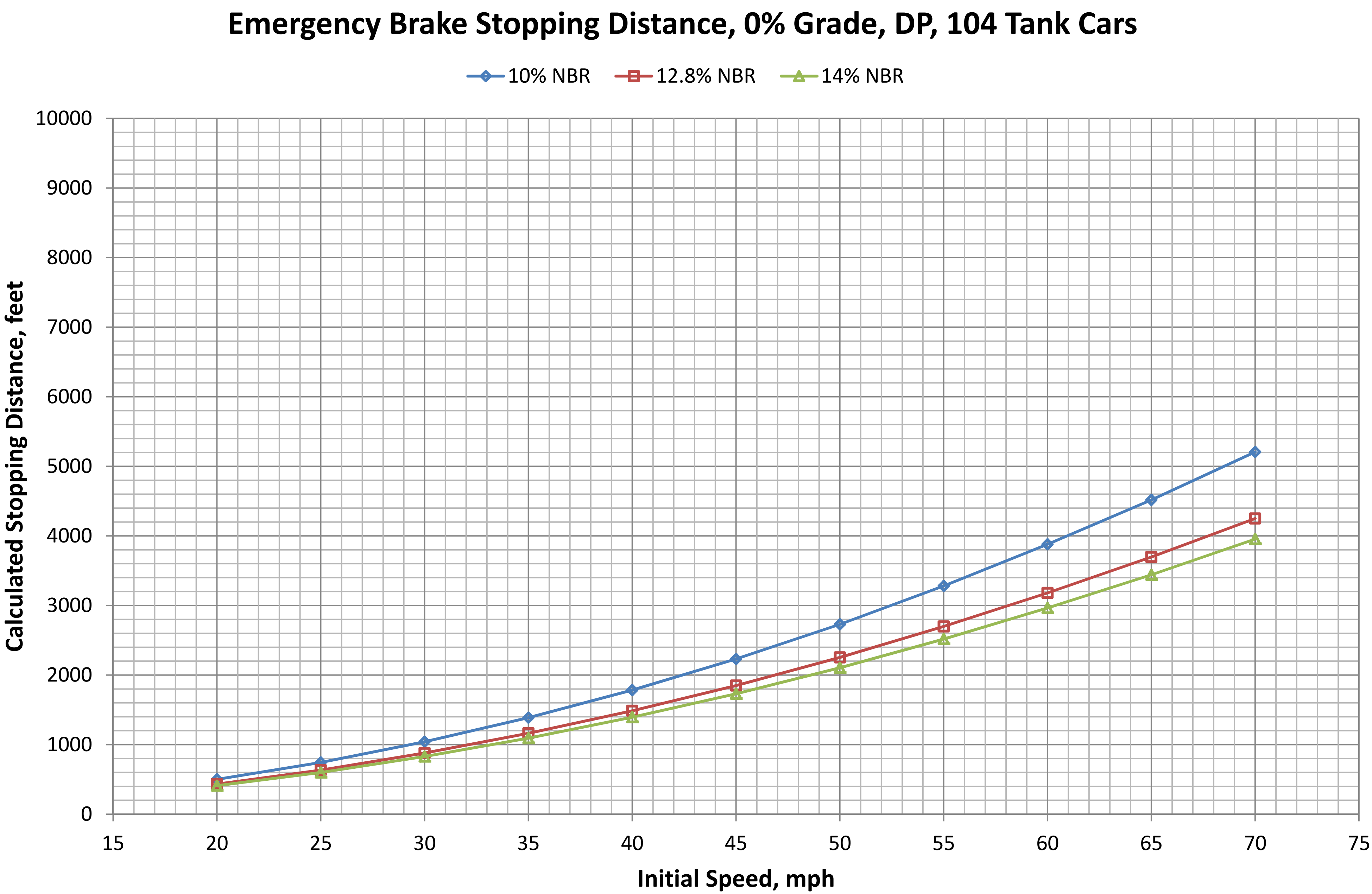

Full Service Brake Stopping Performance, 0% Grade, CONV, 104 Tank Cars
Increased NBR Benefit Relative to CONV Braking, 10% NBR
10% NBR
12.8% NBR
14% NBR
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
Change in Stopping Distance, percent
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph

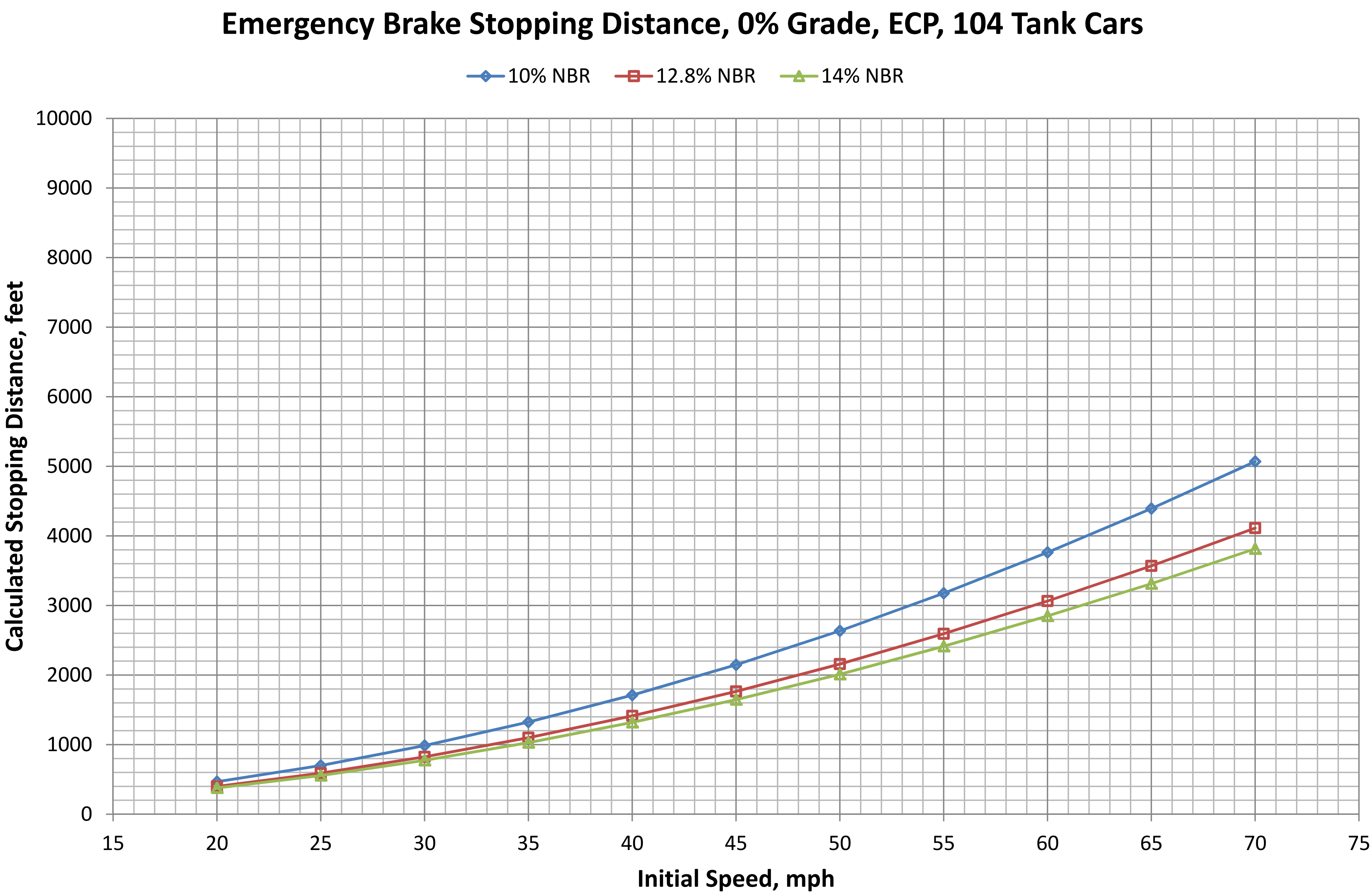

Full Service Brake Stopping Performance, 0% Grade, DP, 104 Tank Cars
Increased NBR Benefit Relative to DP Braking, 10% NBR
10% NBR
12.8% NBR
14% NBR
Change in Stopping Distance, percent
Initial Speed, mph
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
15
20
25
30
35
40
45
50
55
60
65
70
75


Full Service Brake Stopping Performance, 0% Grade, ECP, 104 Tank Cars
Increased NBR Benefit Relative to ECP Braking, 10% NBR
10% NBR
12.8% NBR
14% NBR
Change in Stopping Distance, percent
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph

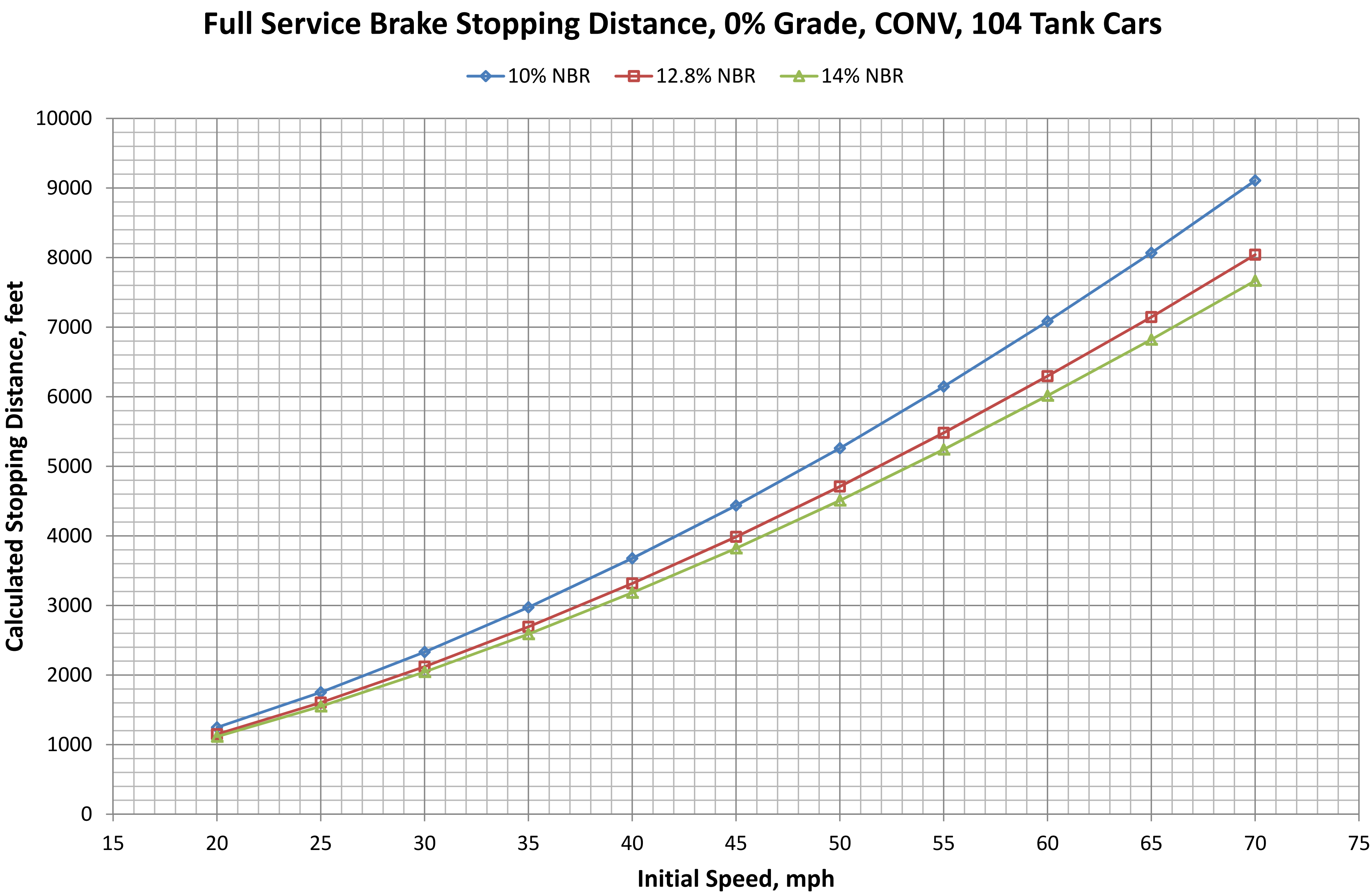


Emergency Brake Stopping Distance, 0% Grade, CONV, 104 Tank Cars
10% NBR
12.8% NBR
14% NBR
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph

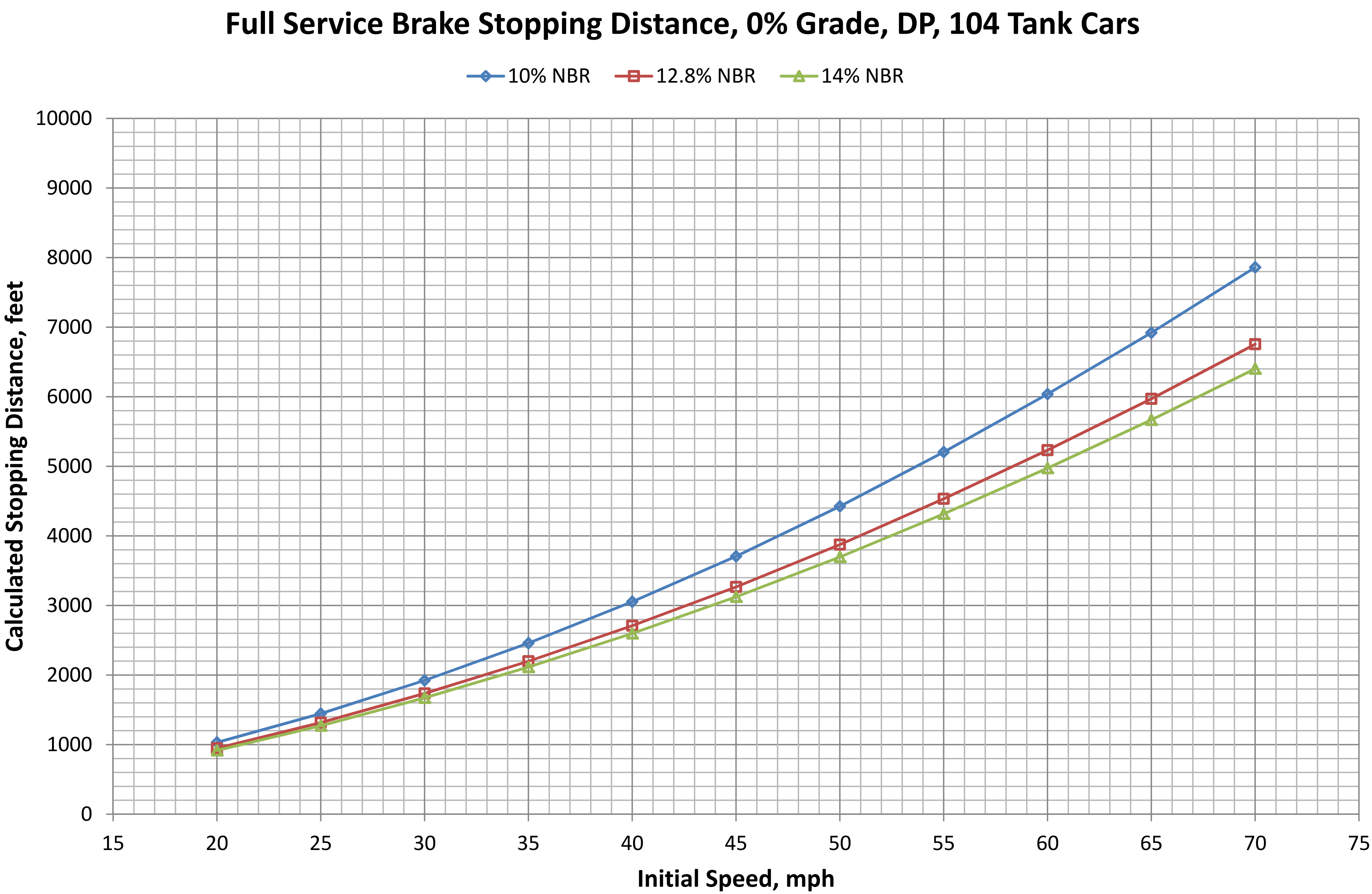

Emergency Brake Stopping Distance, 0% Grade, DP, 104 Tank Cars
10% NBR
12.8% NBR
14% NBR
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph



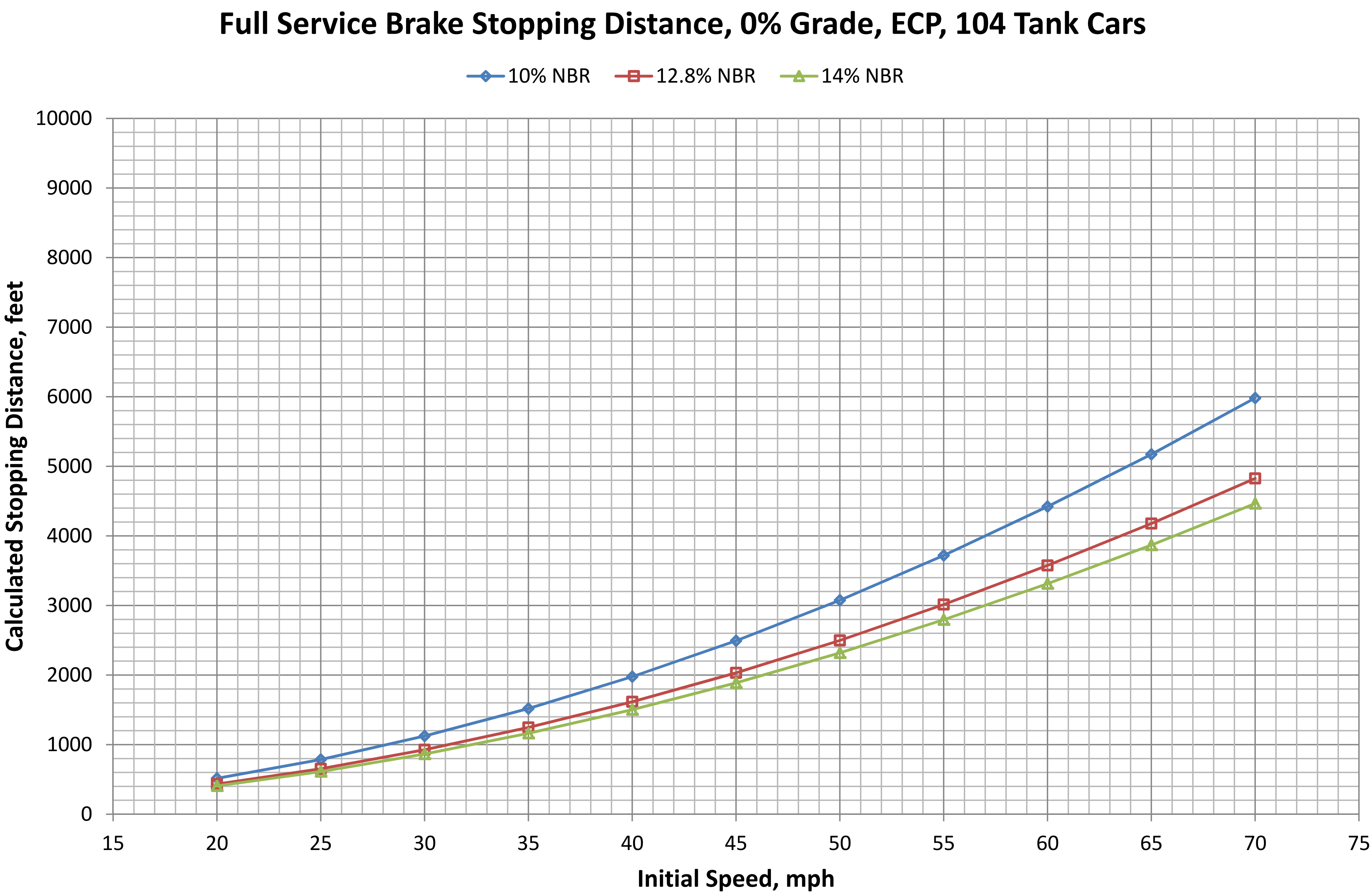
Emergency Brake Stopping Distance, 0% Grade, ECP, 104 Tank Cars
10% NBR
12.8% NBR
14% NBR
Calculated Stopping Distance, feet
Initial Speed, mph
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
15
20
25
30
35
40
45
50
55
60
65
70
75


Full Service Brake Stopping Distance, 0% Grade, CONV, 104 Tank Cars
10% NBR
12.8% NBR
14% NBR
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph

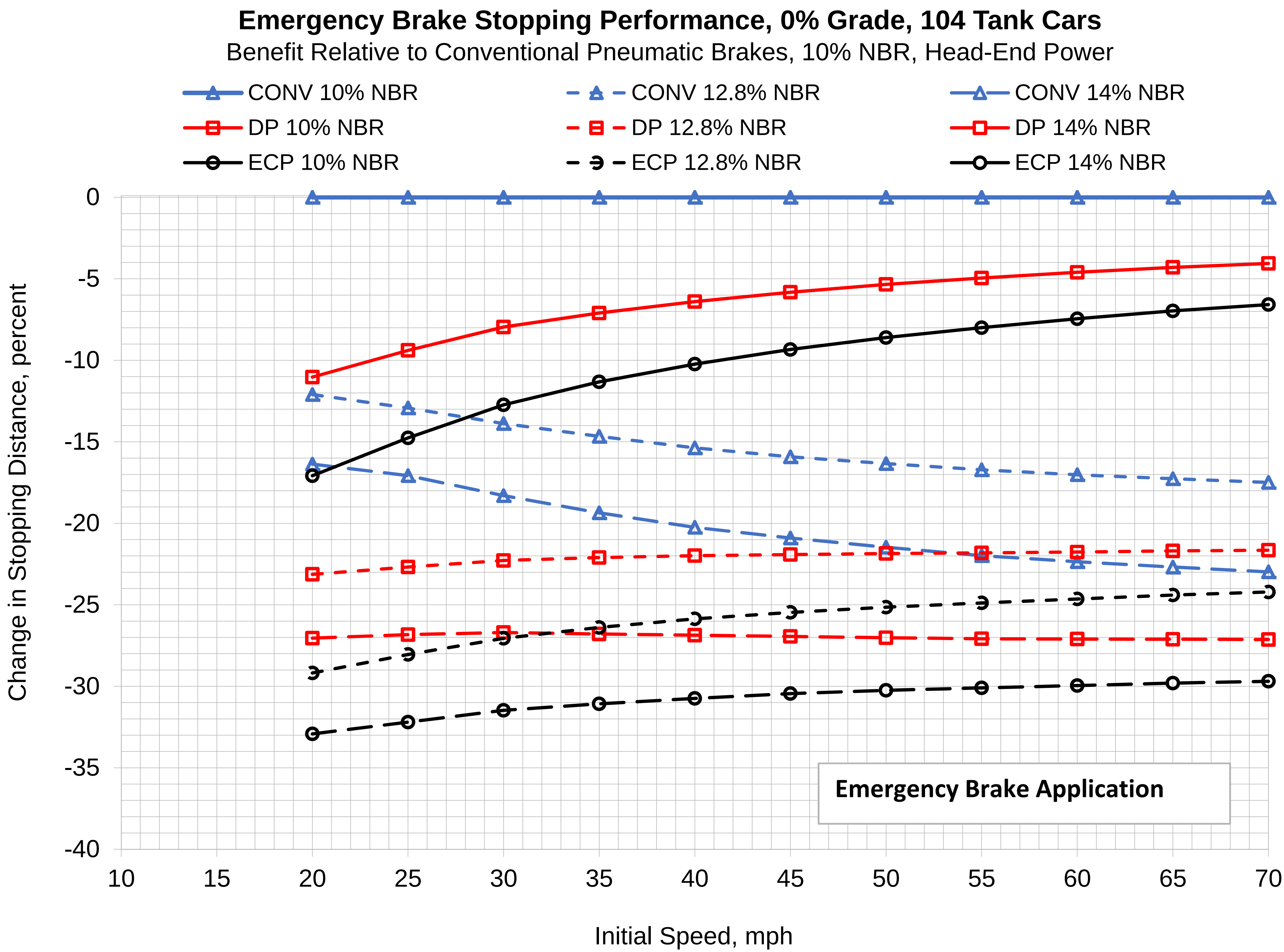
A27.11


Full Service Brake Stopping Distance, 0% Grade, DP, 104 Tank Cars
10% NBR
12.8% NBR
14% NBR
Calculated Stopping Distance, feet
Initial Speed, mph
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
15
20
25
30
35
40
45
50
55
60
65
70
75

A27.12

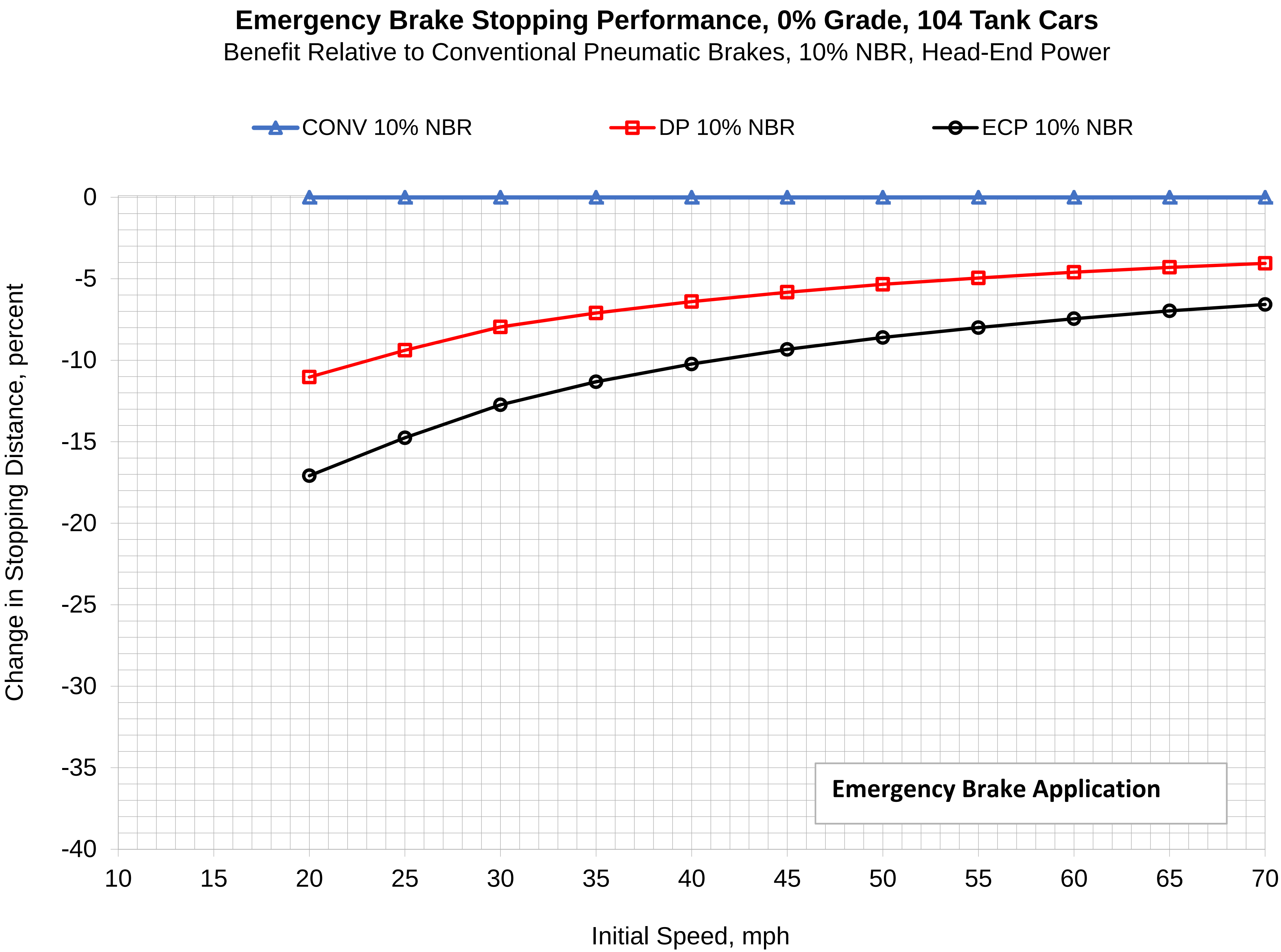

Full Service Brake Stopping Distance, 0% Grade, ECP, 104 Tank Cars
10% NBR
12.8% NBR
14% NBR
Calculated Stopping Distance, feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
15
20
25
30
35
40
45
50
55
60
65
70
75
Initial Speed, mph

Attachment 28: Increased NBR Benefit Relative to CONV 10%



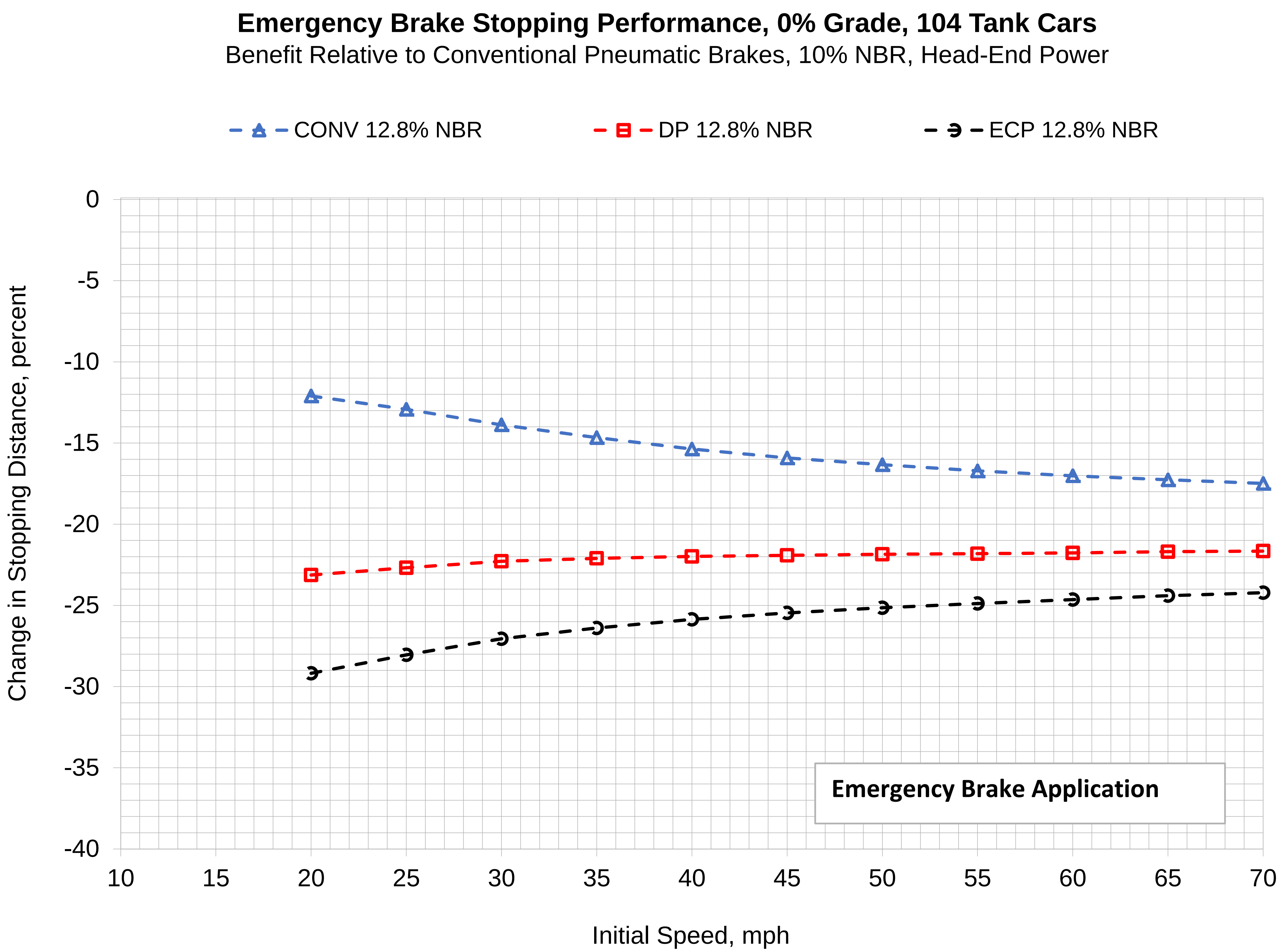
Emergency Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 10% NBR
CONV 12.8% NBR
CONV 14% NBR
DP 10% NBR
DP 12.8% NBR
DP 14% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application

A28.2

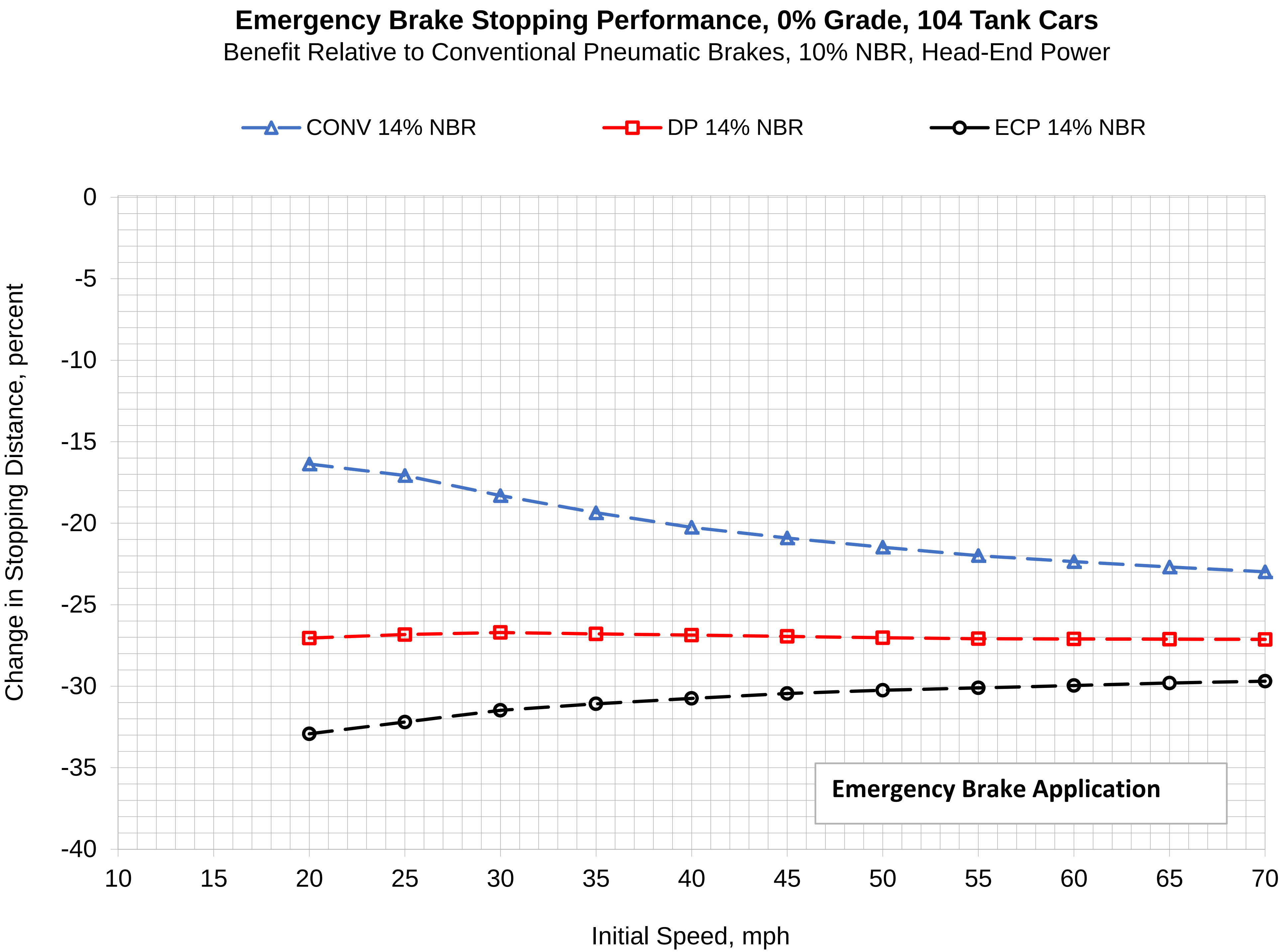


Emergency Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 10% NBR
DP 10% NBR
ECP 10% NBR
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application

A28.3

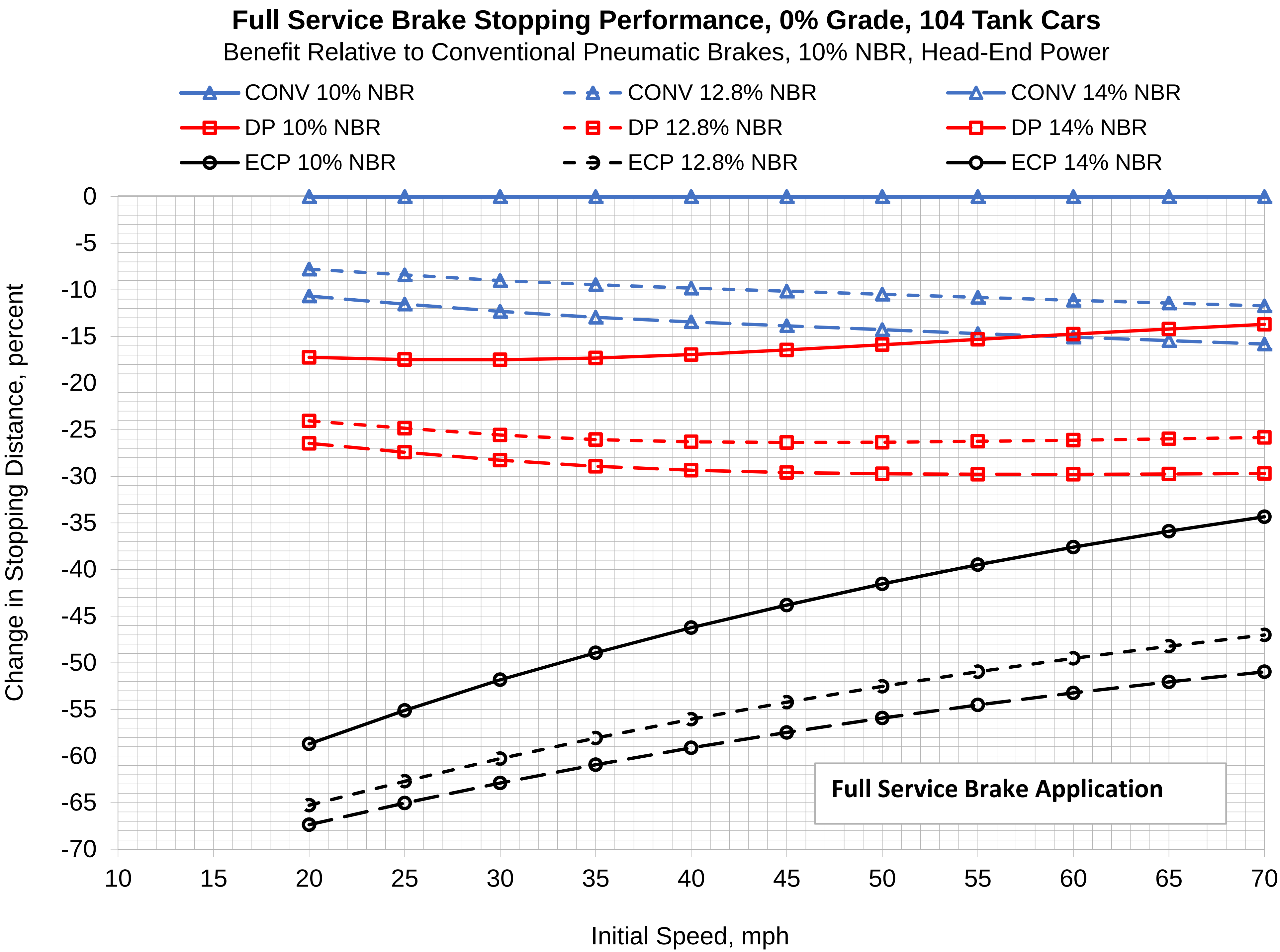

Emergency Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 12.8% NBR
DP 12.8% NBR
ECP 12.8% NBR
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application

A28.4

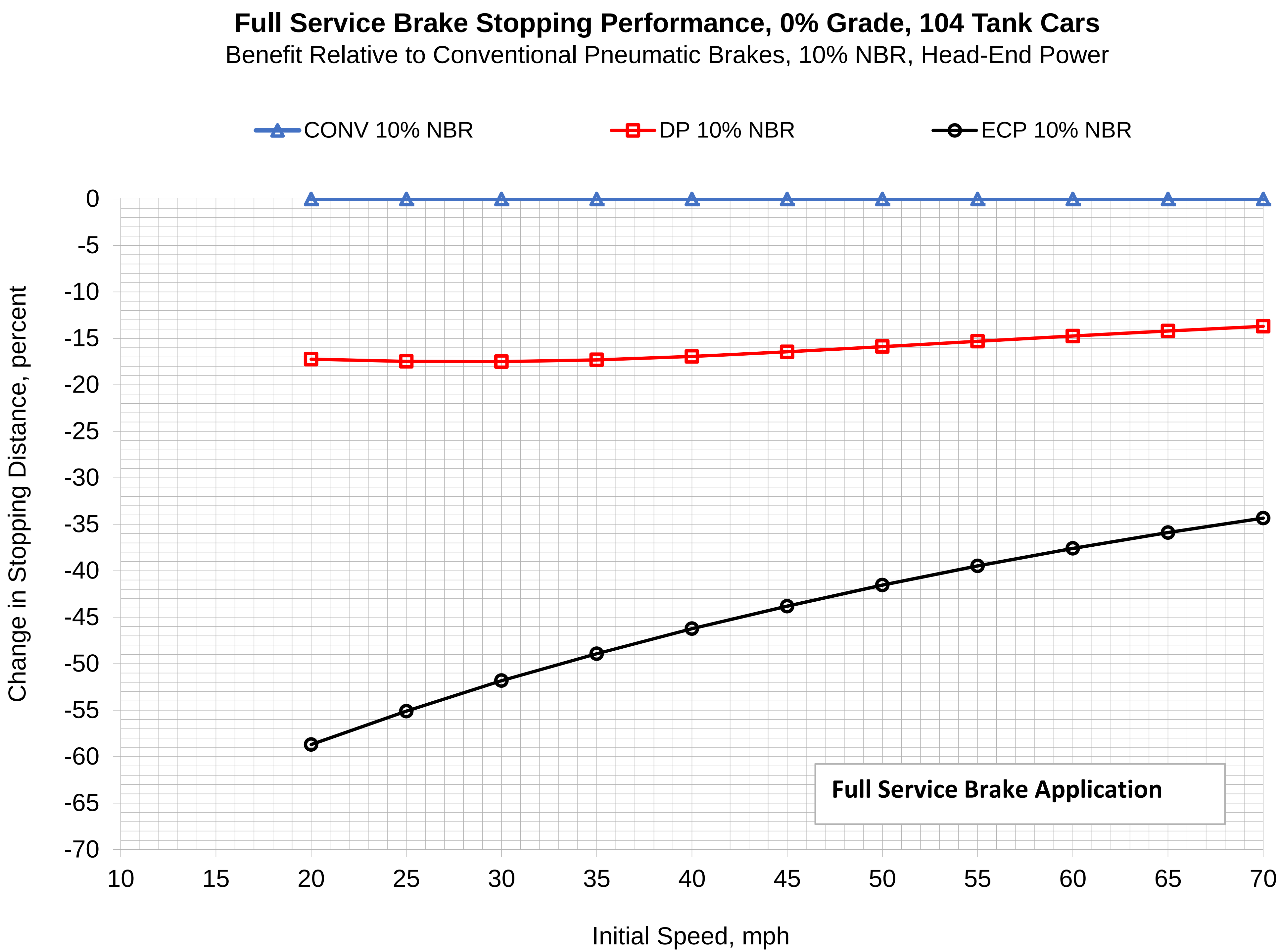


Emergency Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 14% NBR
DP 14% NBR
ECP 14% NBR
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Emergency Brake Application

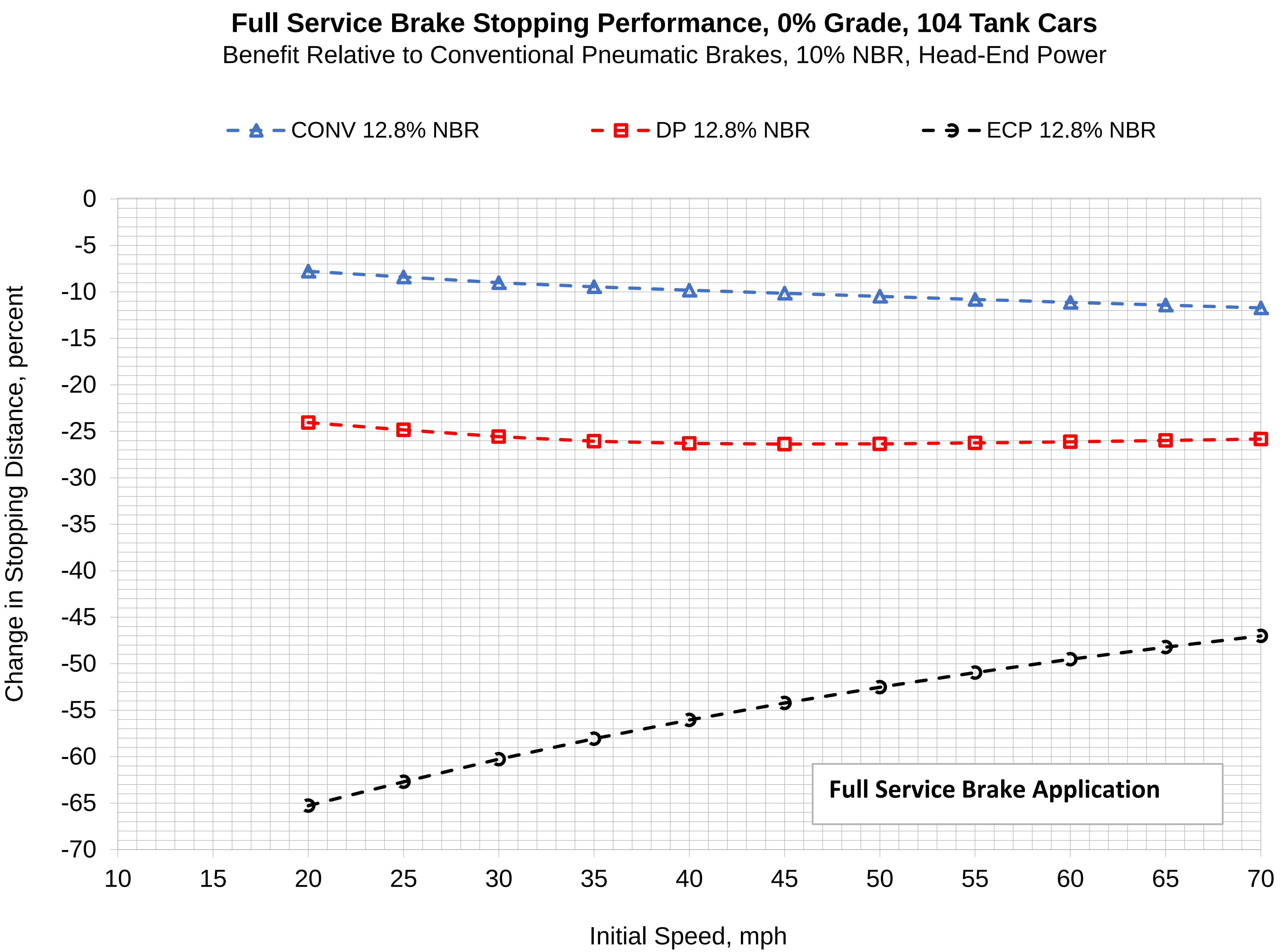
A28.5


Full Service Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 10% NBR
CONV 12.8% NBR
CONV 14% NBR
DP 10% NBR
DP 12.8% NBR
DP 14% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application

A28.6

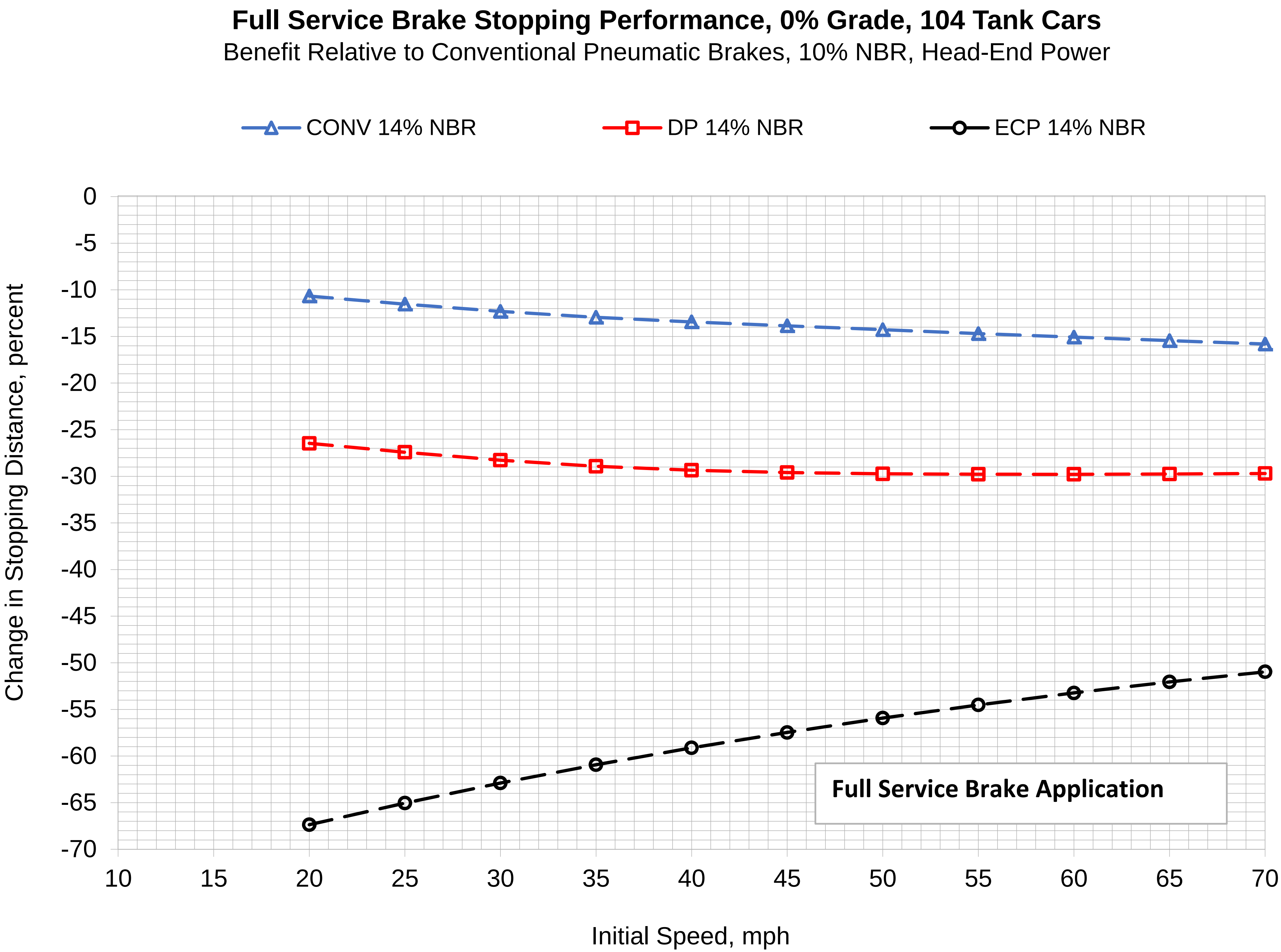

Full Service Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 10% NBR
DP 10% NBR
ECP 10% NBR
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application

A28.7



Full Service Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 12.8% NBR
DP 12.8% NBR
ECP 12.8% NBR
Full Service Brake Application
Change in Stopping Distance, percent
Initial Speed, mph
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
10
15
20
25
30
35
40
45
50
55
60
65
70

A28.8



Full Service Brake Stopping Performance, 0% Grade, 104 Tank Cars
Benefit Relative to Conventional Pneumatic Brakes, 10% NBR, Head-End Power
CONV 14% NBR
DP 14% NBR
ECP 14% NBR
Change in Stopping Distance, percent
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
10
15
20
25
30
35
40
45
50
55
60
65
70
Initial Speed, mph
Full Service Brake Application

A28.9

Attachment 29: FRA ECP Braking Report Excerpts

The following comments related to ECP stopping distance were extracted from the Federal Railroad Administration (FRA) Final Report, "ECP Brake System for Freight Service," prepared by Booz | Allen | Hamilton, released August 2006, updated March 10, 2009.

p. I-13: Shorter stopping distances estimated at 60 to 70 percent for the heavy Spoornet coal trains, and on the order of 40 percent for lighter or shorter trains, would reduce train collisions and grade crossing accidents in which stopping distance is a key factor.

p. II-7: Shorter stopping distances due to the reduction of time for the brake signal to be transmitted to each car in a long train. Stopping distances for long trains with ECP brakes can be cut to about 40 to 60 percent of the conventional brake stop distances.

In its tests, for example, New York Air Brake has found that a loaded 100-car train moving at 50 mph requires nearly 4,100 feet to stop with conventional brakes compared to only 2,500 feet with ECP – a reduction of nearly 40%.[23]

[23] New York Air Brake presentation to the first Expert Panel session, June 20, 2005.

p. III-6: III.10. Safety Benefits

There are many quantitative unknowns about the safety benefits of ECP brake systems. For example, it is clear that the stopping distance of the longest, heaviest trains with ECP brakes would be reduced by as much as 70 percent relative to the current situation with conventional brakes. For a long coal train with a current stopping distance of almost two miles, that reduction represents a material improvement in safety and potential avoidance of both en route and grade crossing collisions.

p. D-2: BNSF began working with ECP trainsets in 1994 with both TSM and New York Air Brake (NYAB) equipment, using a 60-car coal train in Beardsley, IL. Initial testing showed 30 to 70 percent reduction in stopping distance, and BNSF gained experience in operating an ECP trainset.

p. D-5: The AAR reports show approximately 60-percent decrease in stop distance for a test on a loaded BNSF taconite train of 20,000 tons, 165 cars and 6,000 feet, traveling at 38 mph:

Conventional brakes	ECP brakes
~4,500 ft.	1,830 feet

But as the AAR paper notes, the greatest advantage is not the stop distance, but the train handling improvement with graduated release.

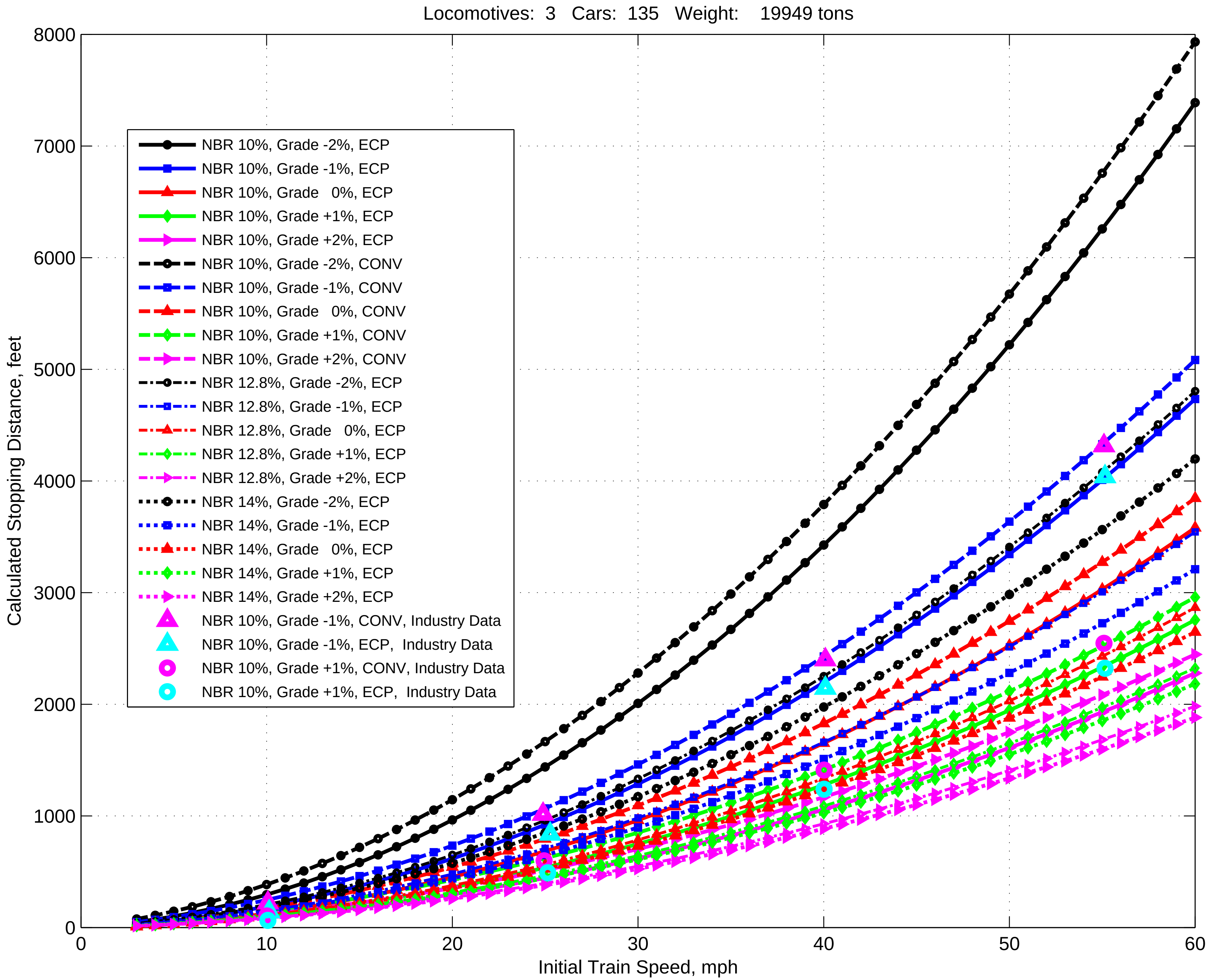
p. D-10: Shorter stopping distance on descending 1.52 percent grade at 28 mph.
Stopping distance, from 28 mph, on 1.52% descending grade:

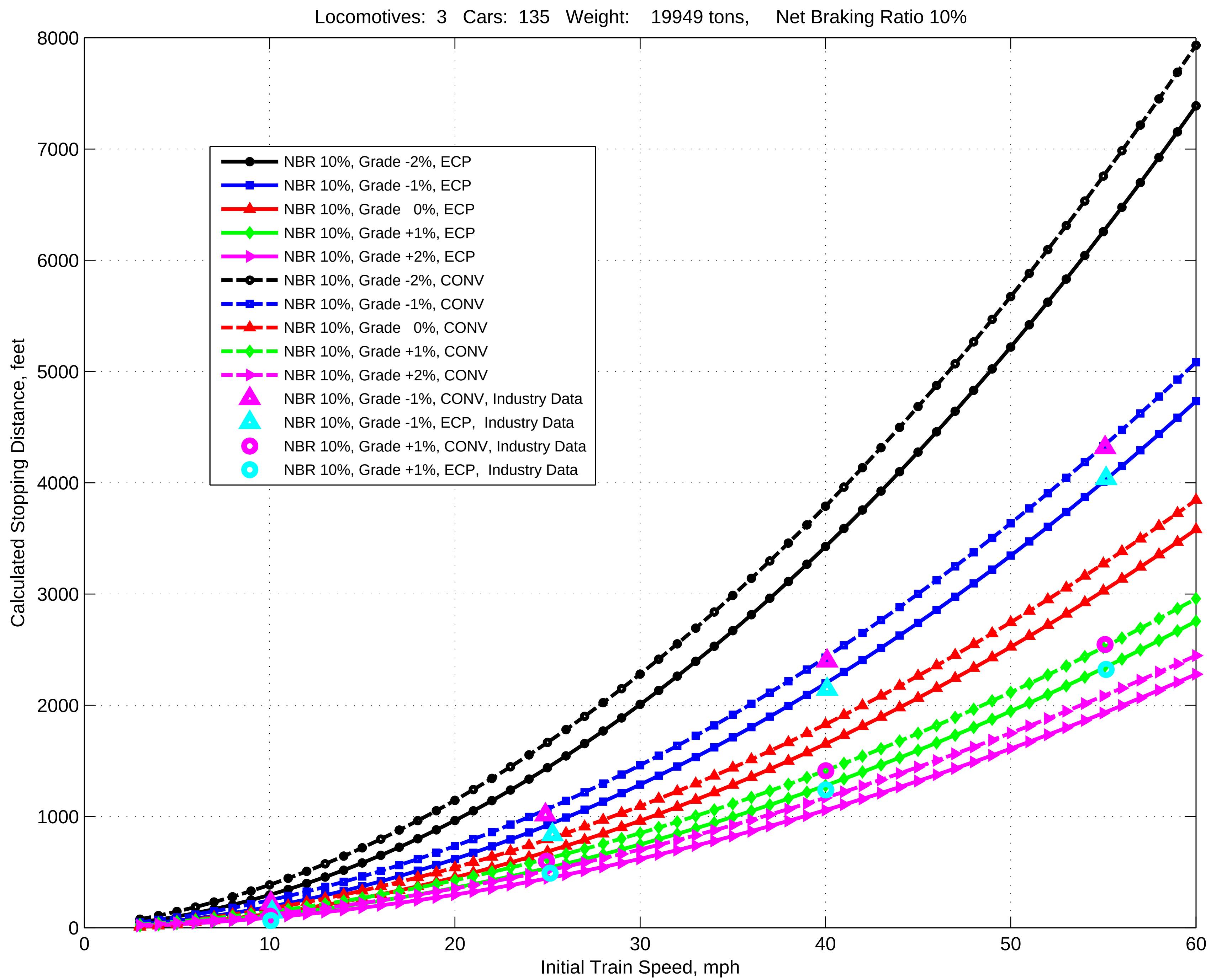
Conv.	+wired DP	ECP	Improved
4,600 ft.	3,000 ft.	1,500 ft.	~70%

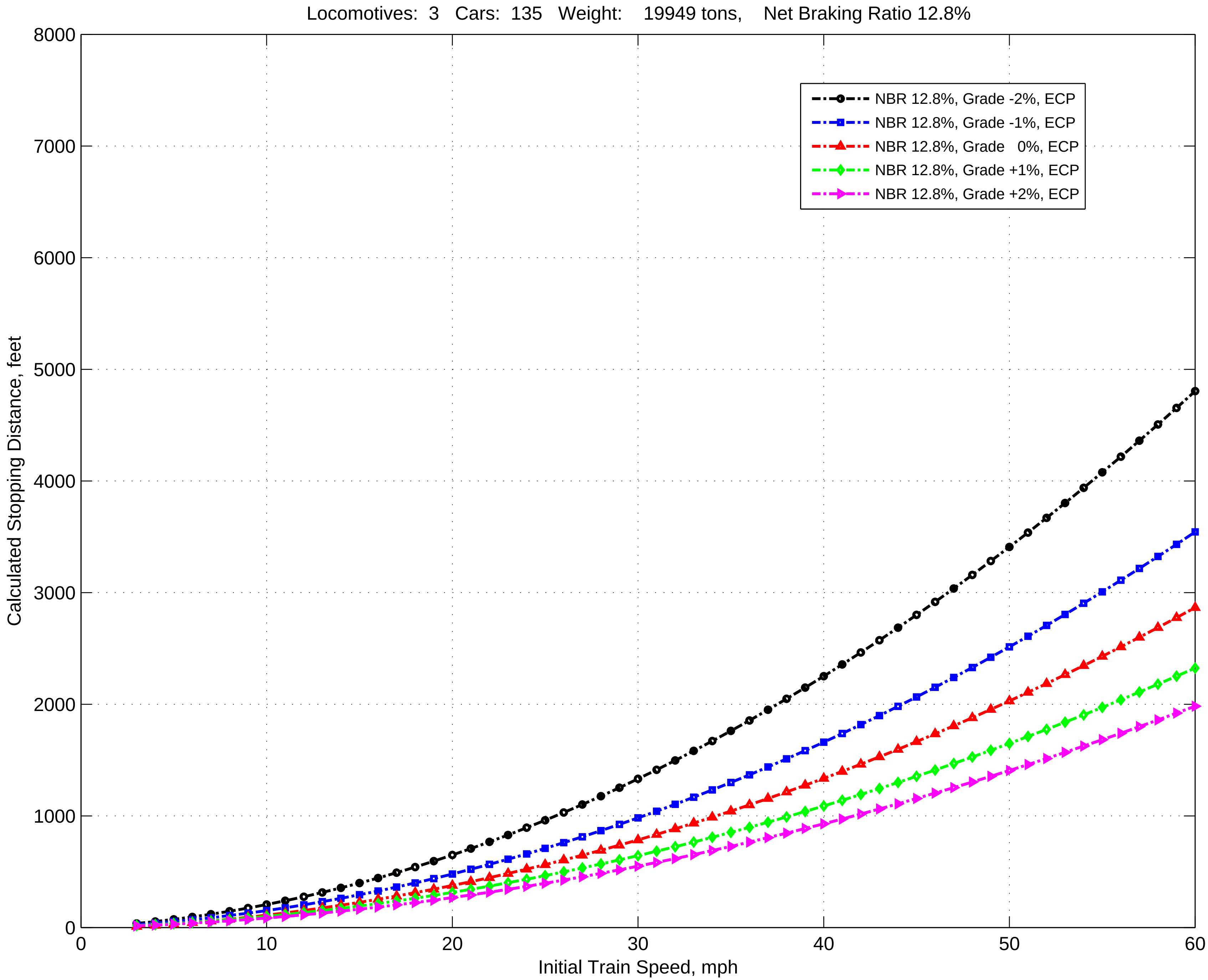
p. D-11: Reduced Stopping Distance

The first and simplest result is that the stopping distance of the train is greatly reduced with ECP brakes compared to conventional service. The exact amount of reduction depends on speed, grade, and weight of the train. Greater improvements in stopping distance seem to come with greater descending grades.

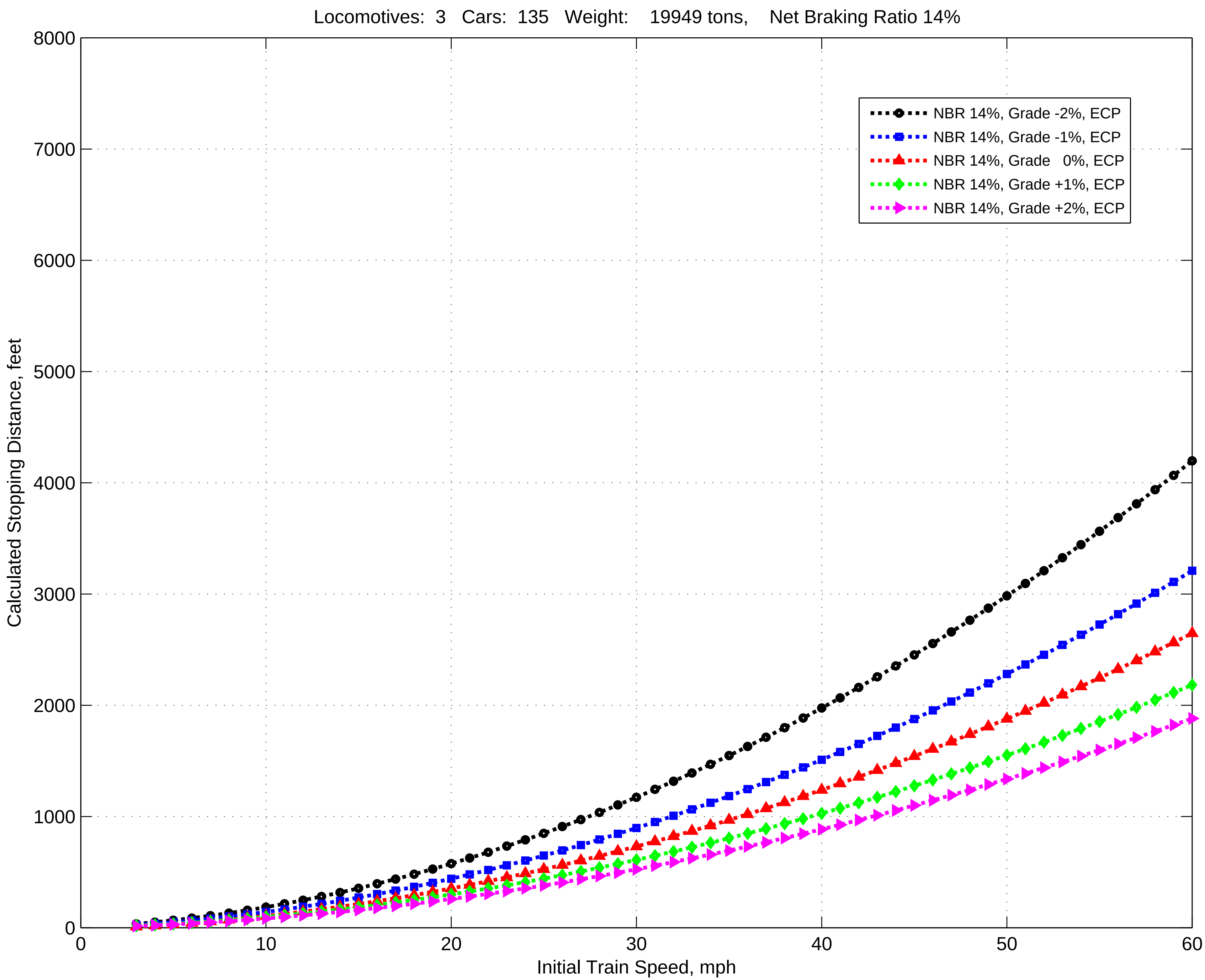
Attachment 30: Back-of-the-Envelope Distance Calculations


Locomotives: 3 Cars: 135 Weight: 19949 tons
Calculated Stopping Distance, feet
Initial Train Speed, mph
0
1000
2000
3000
4000
5000
6000
7000
8000
10
20
30
40
50
60
NBR 10%, Grade -2%, ECP
NBR 10%, Grade -1%, ECP
NBR 10%, Grade 0%, ECP
NBR 10%, Grade +1%, ECP
NBR 10%, Grade +2%, ECP
NBR 10%, Grade -2%, CONV
NBR 10%, Grade -1%, CONV
NBR 10%, Grade 0%, CONV
NBR 10%, Grade +1%, CONV
NBR 10%, Grade +2%, CONV
NBR 12.8%, Grade -2%, ECP
NBR 12.8%, Grade -1%, ECP
NBR 12.8%, Grade 0%, ECP
NBR 12.8%, Grade +1%, ECP
NBR 12.8%, Grade +2%, ECP
NBR 14%, Grade -2%, ECP
NBR 14%, Grade -1%, ECP
NBR 14%, Grade 0%, ECP
NBR 14%, Grade +1%, ECP
NBR 14%, Grade +2%, ECP
NBR 10%, Grade -1%, CONV, Industry Data
NBR 10%, Grade -1%, ECP, Industry Data
NBR 10%, Grade +1%, CONV, Industry Data
NBR 10%, Grade +1%, ECP, Industry Data


Locomotives: 3 Cars: 135 Weight: 19949 tons, Net Braking Ratio 10%
Calculated Stopping Distance, feet
Initial Train Speed, mph
NBR 10%, Grade -2%, ECP
NBR 10%, Grade -1%, ECP
NBR 10%, Grade 0%, ECP
NBR 10%, Grade +1%, ECP
NBR 10%, Grade +2%, ECP
NBR 10%, Grade -2%, CONV
NBR 10%, Grade -1%, CONV
NBR 10%, Grade 0%, CONV
NBR 10%, Grade +1%, CONV
NBR 10%, Grade +2%, CONV
NBR 10%, Grade -1%, CONV, Industry Data
NBR 10%, Grade -1%, ECP, Industry Data
NBR 10%, Grade +1%, CONV, Industry Data
NBR 10%, Grade +1%, ECP, Industry Data
0
1000
2000
3000
4000
5000
6000
7000
8000
0
10
20
30
40
50
60



Locomotives: 3 Cars: 135 Weight: 19949 tons, Net Braking Ratio 12.8%
Calculated Stopping Distance, feet
Initial Train Speed, mph
0
1000
2000
3000
4000
5000
6000
7000
8000
0
10
20
30
40
50
60
NBR 12.8%, Grade -2%, ECP
NBR 12.8%, Grade -1%, ECP
NBR 12.8%, Grade 0%, ECP
NBR 12.8%, Grade +1%, ECP
NBR 12.8%, Grade +2%, ECP

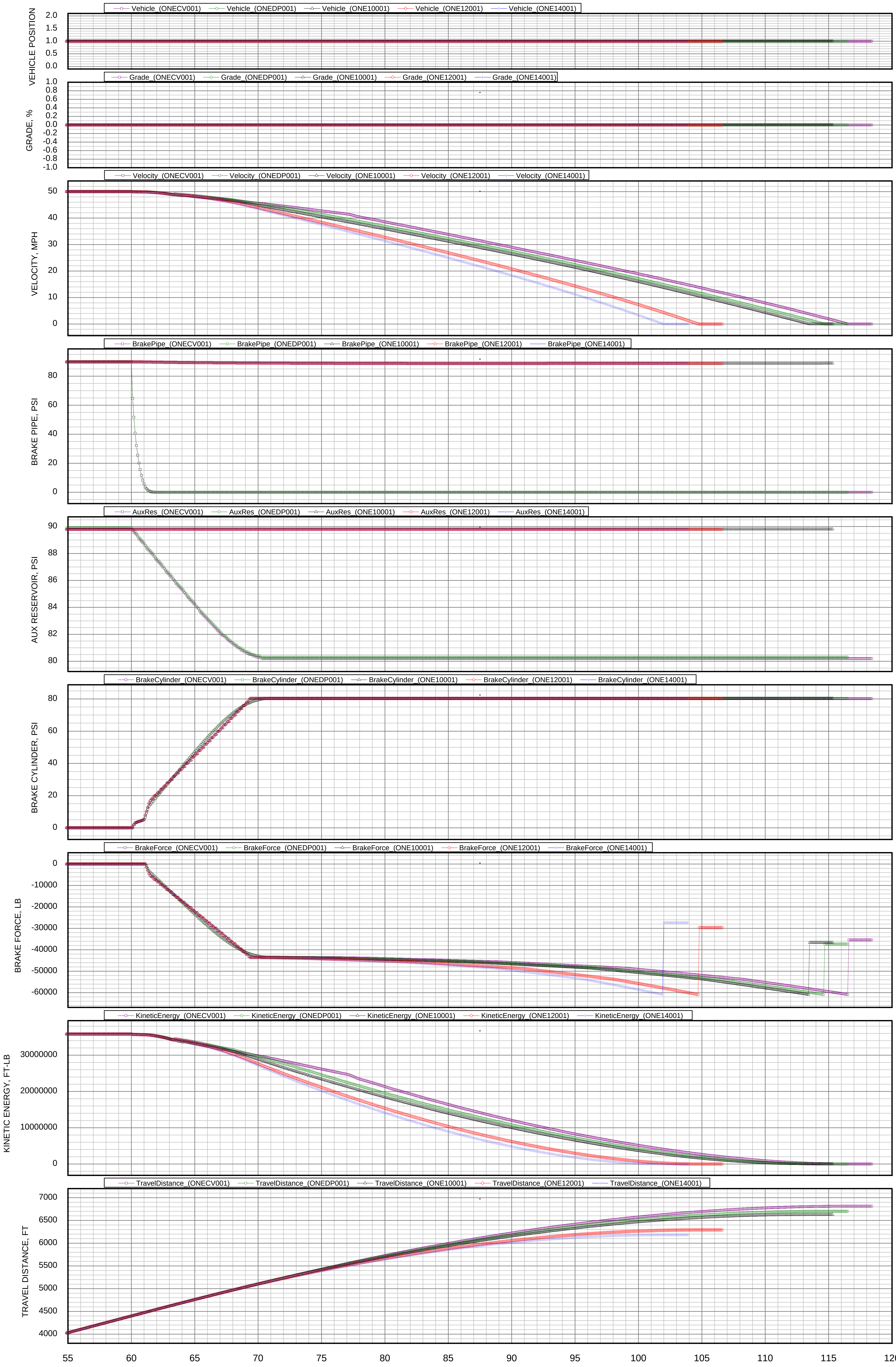

Locomotives: 3 Cars: 135 Weight: 19949 tons, Net Braking Ratio 14%
NBR 14%, Grade -2%, ECP
NBR 14%, Grade -1%, ECP
NBR 14%, Grade 0%, ECP
NBR 14%, Grade +1%, ECP
NBR 14%, Grade +2%, ECP
Calculated Stopping Distance, feet
Initial Train Speed, mph
0
1000
2000
3000
4000
5000
6000
7000
8000
0
10
20
30
40
50
60

Attachment 31: Example Calculated Brake System Pressures

Nominal Consist (Emergency braking; no bailoff; initial coupler slack neutral; 0% grade; 50 mph)

TEDS SIMULATION DATA FOR VEHICLE 001 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 1]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



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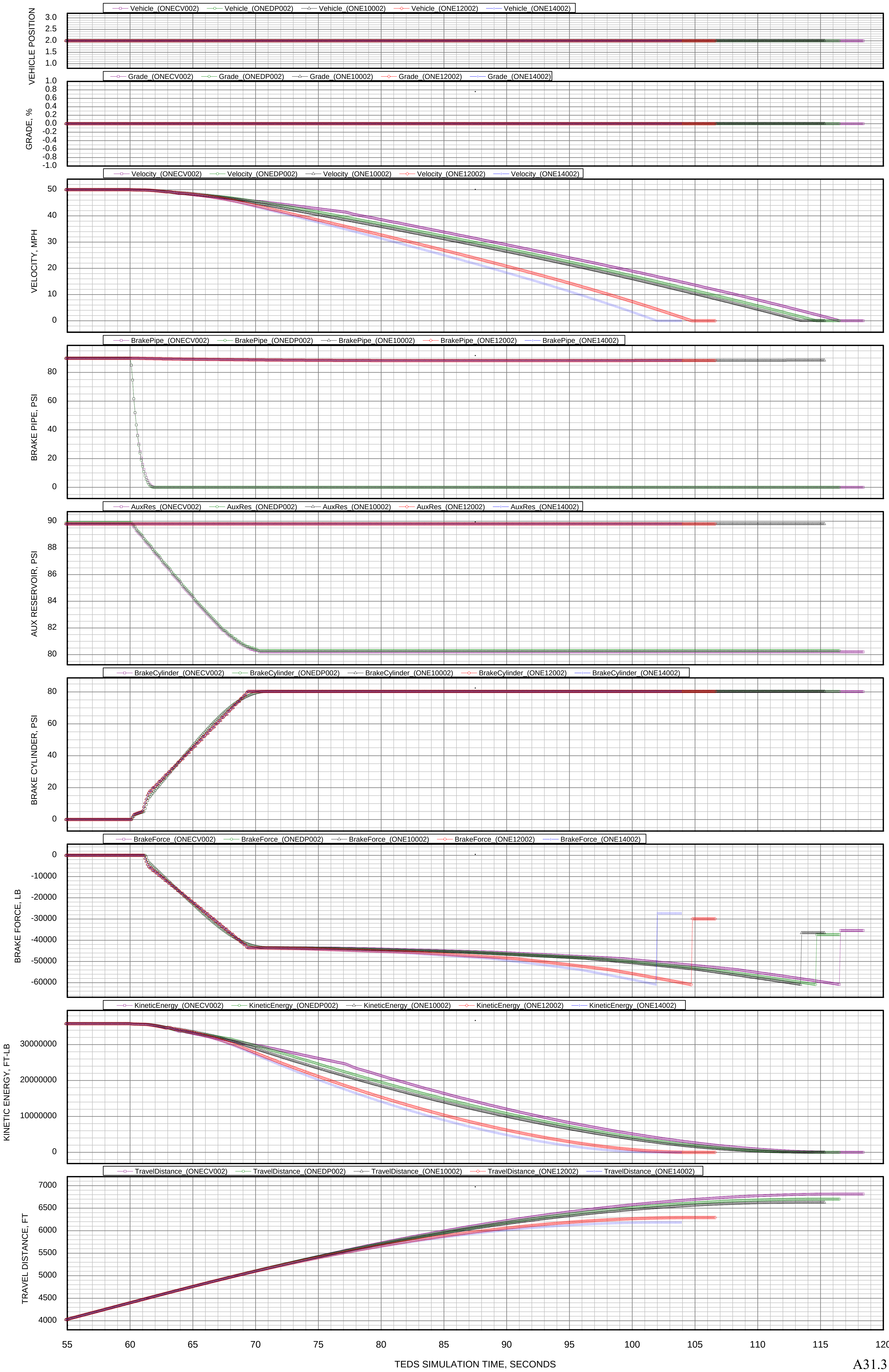
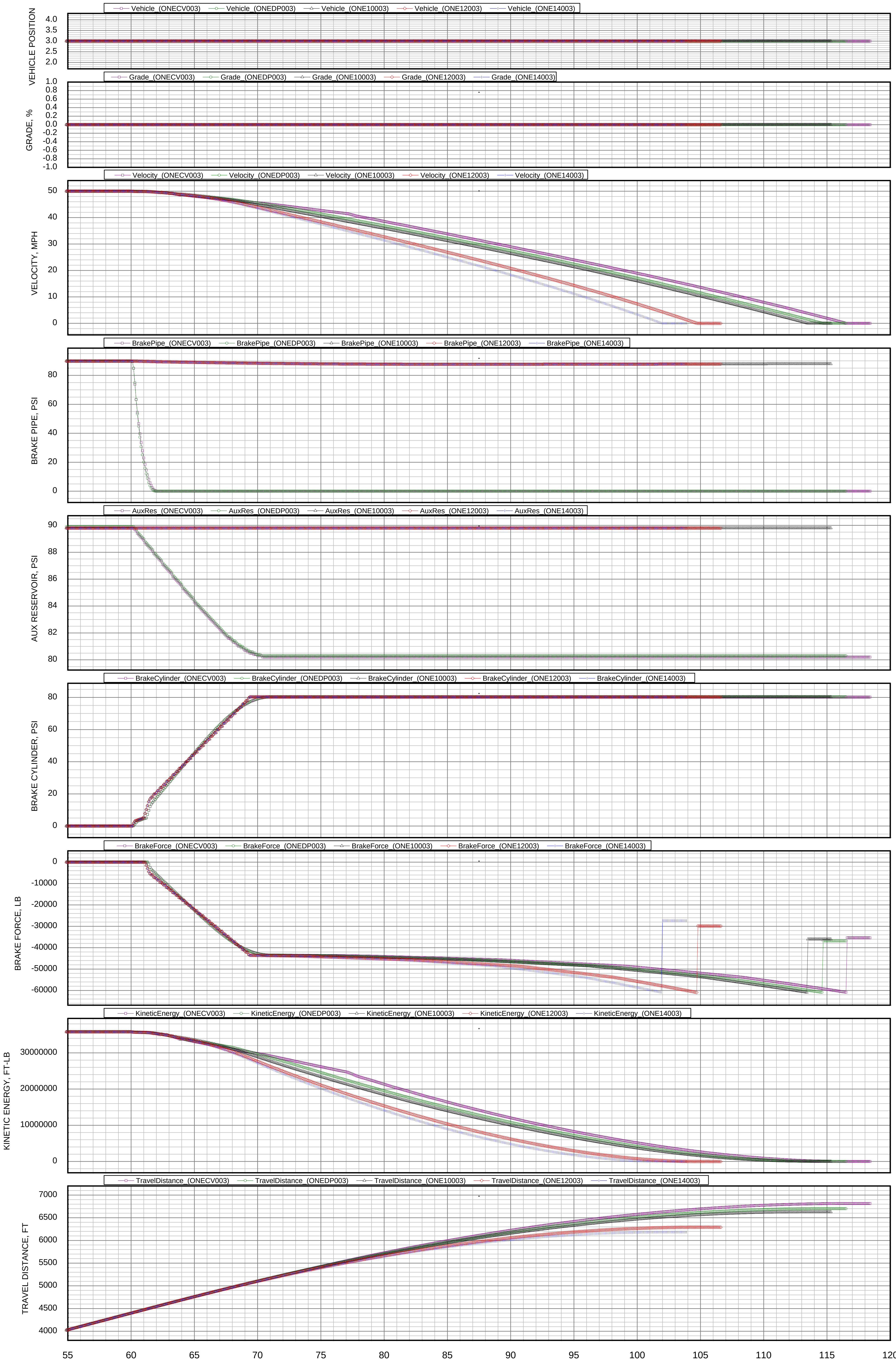
TEDS SIMULATION DATA FOR VEHICLE 002 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 2]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



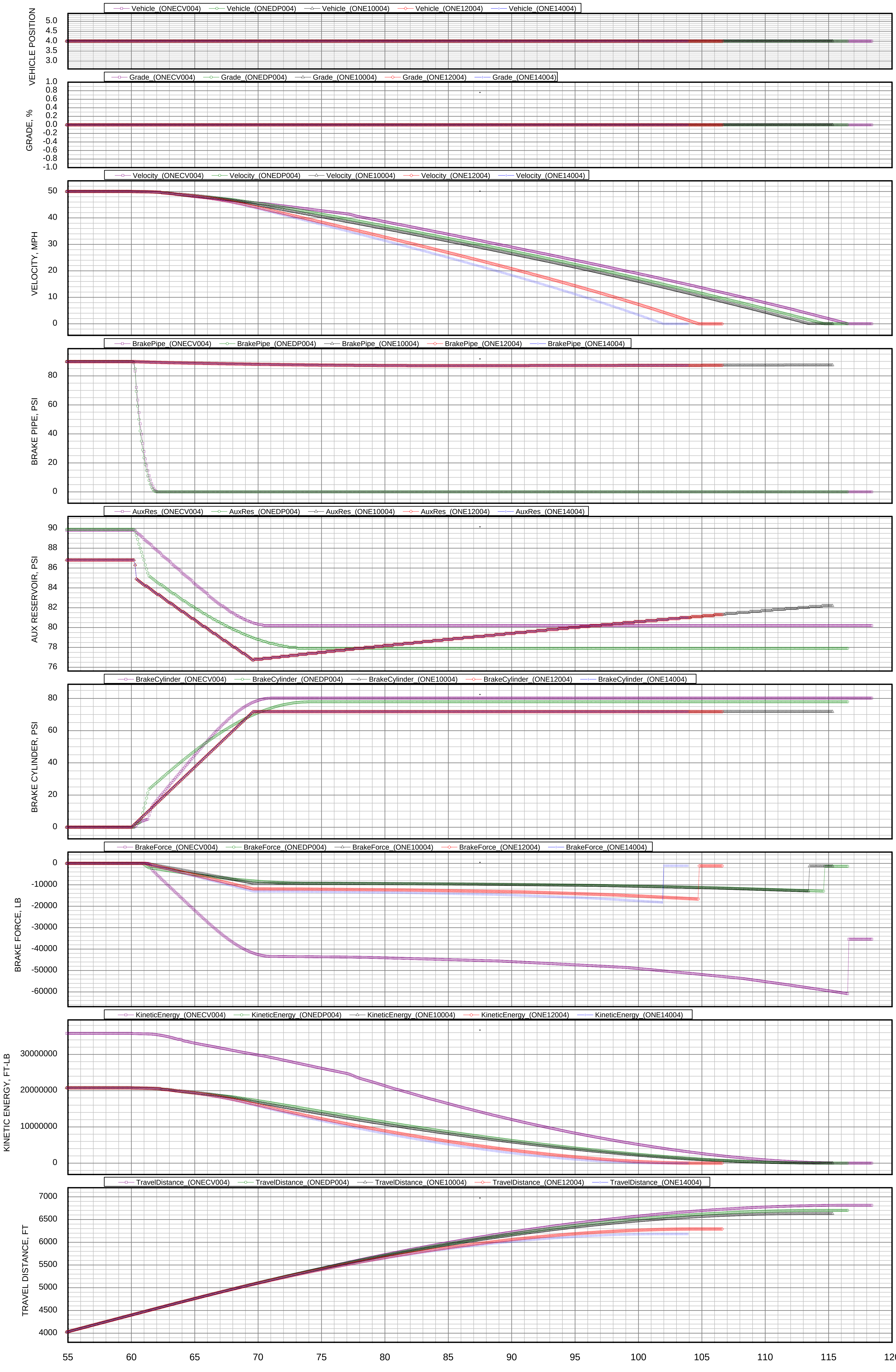
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 003 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 3]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

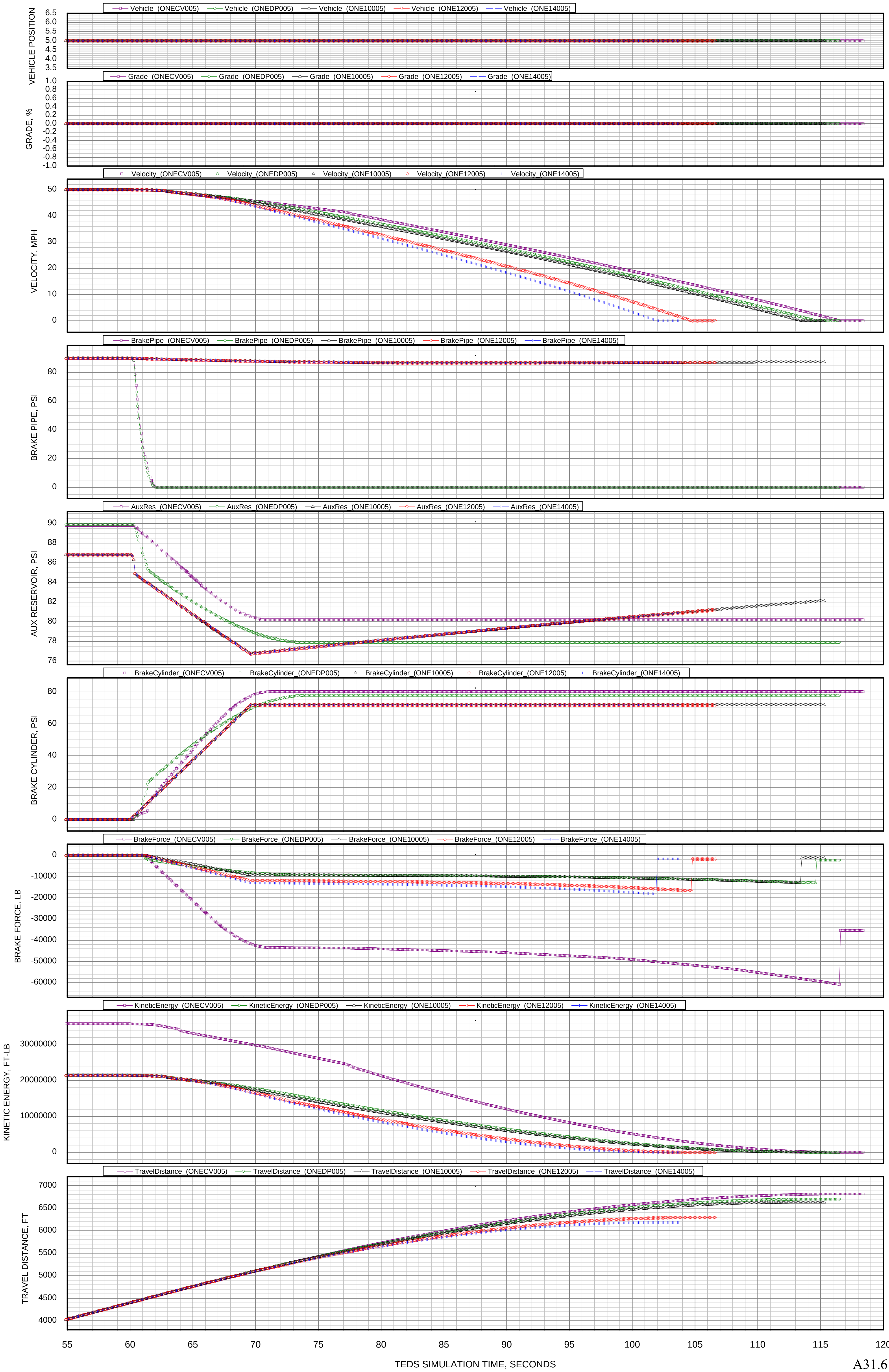
TEDS SIMULATION DATA FOR VEHICLE 004 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 4]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 005 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 5]

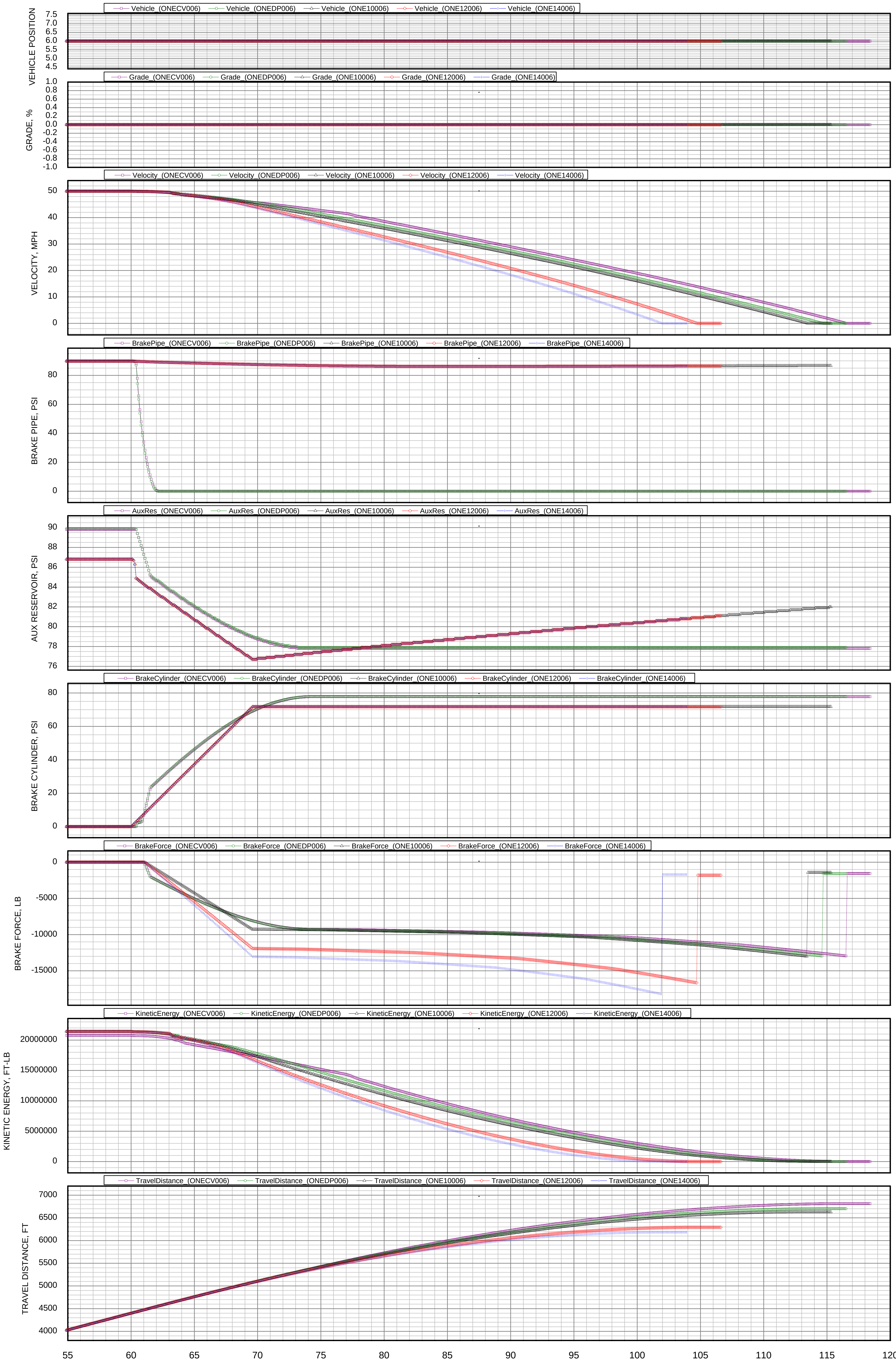
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 006 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 6]

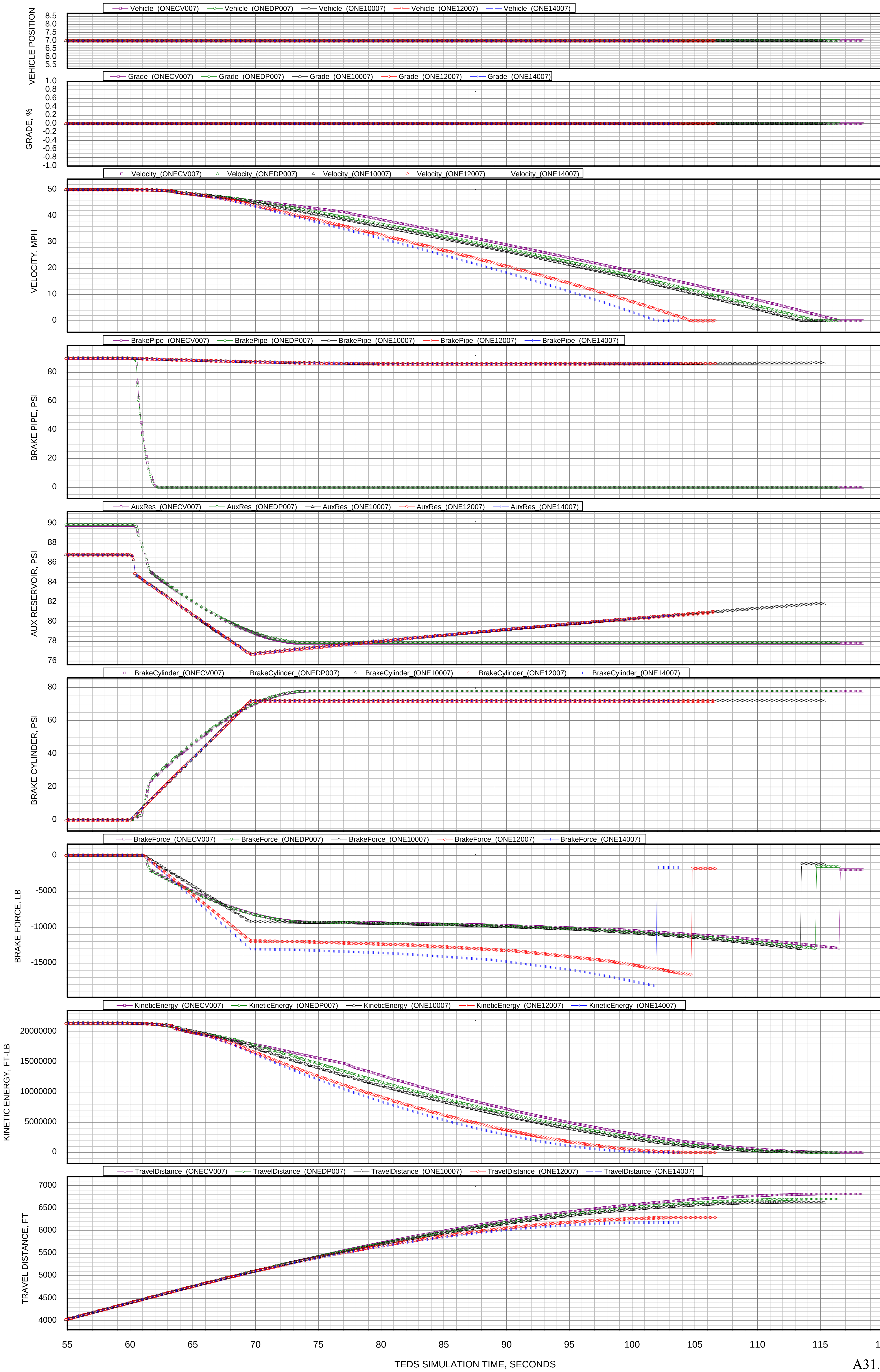
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

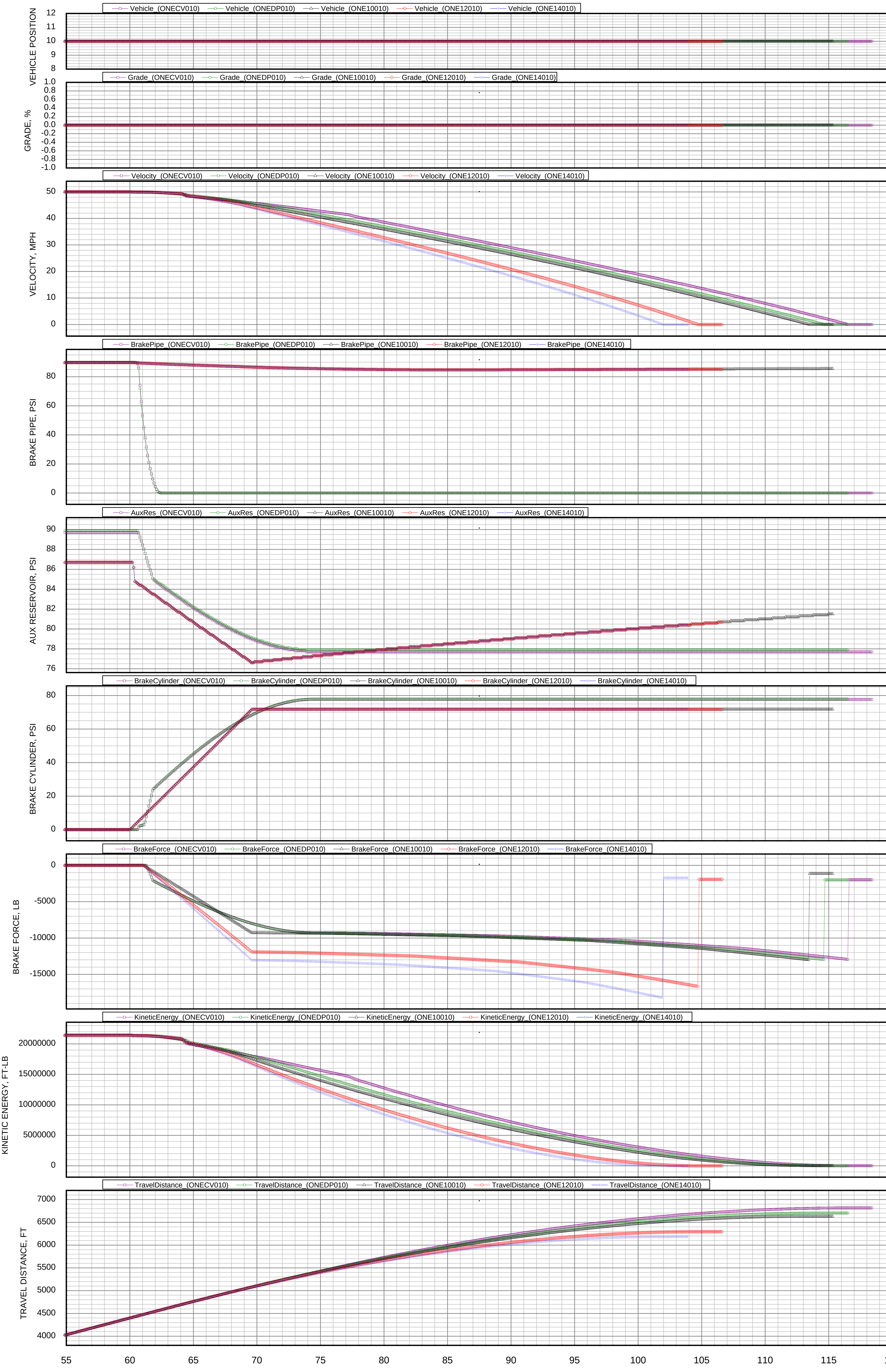
TEDS SIMULATION DATA FOR VEHICLE 007 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 7]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



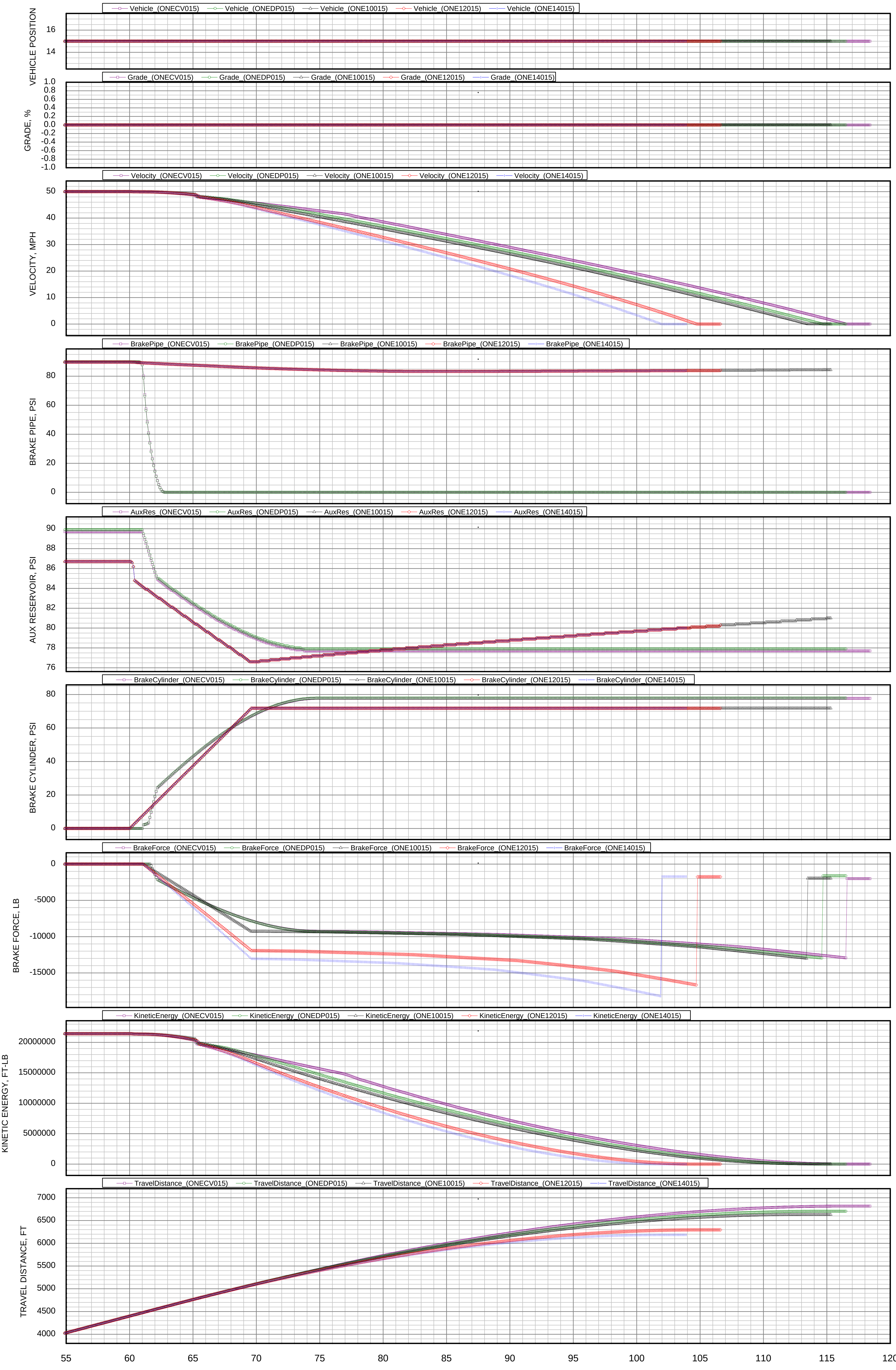
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 010 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 8]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 015 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 9]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

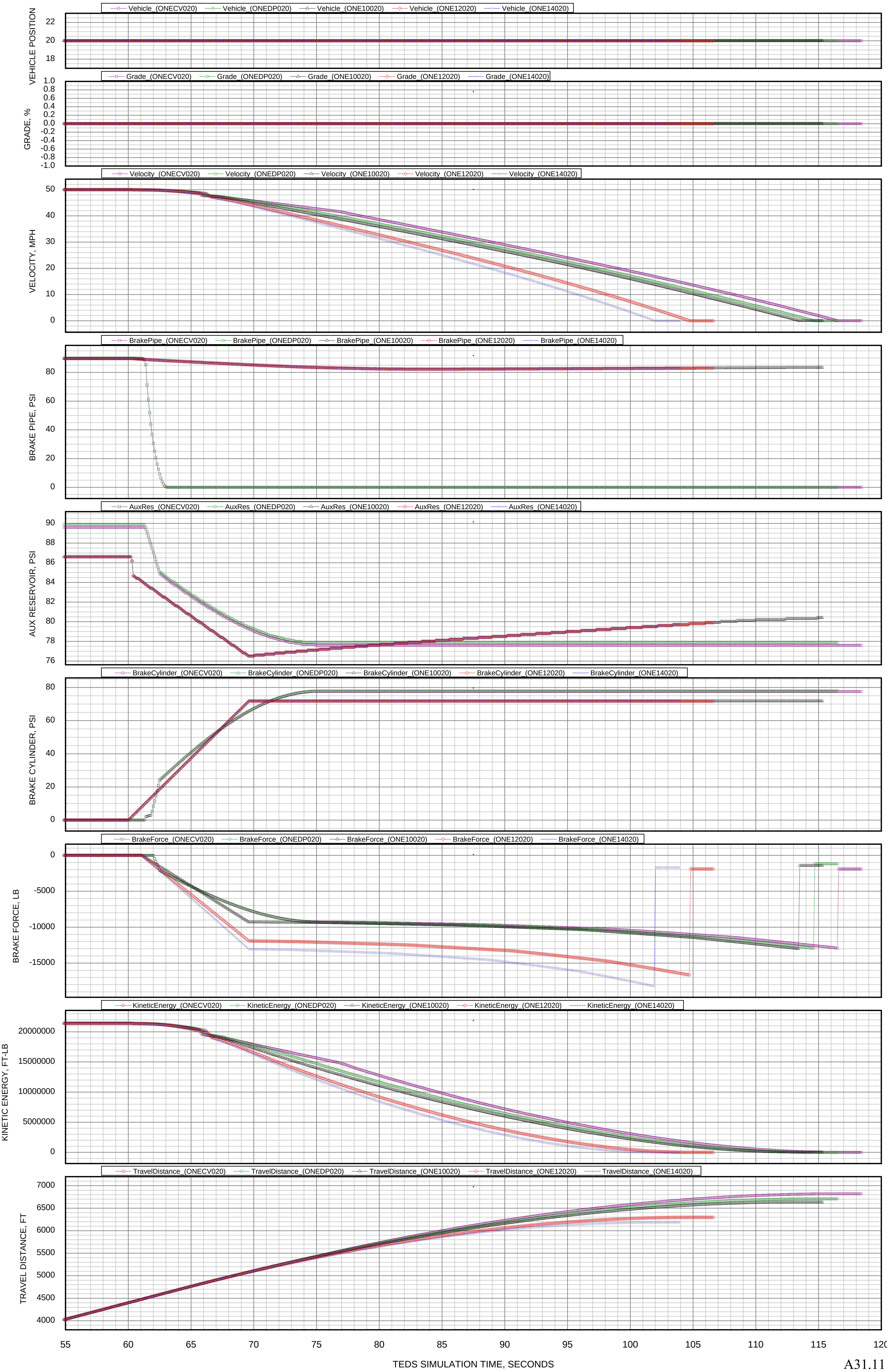


NATIONAL TRANSPORTATION SAFETY BOARD

A31.10

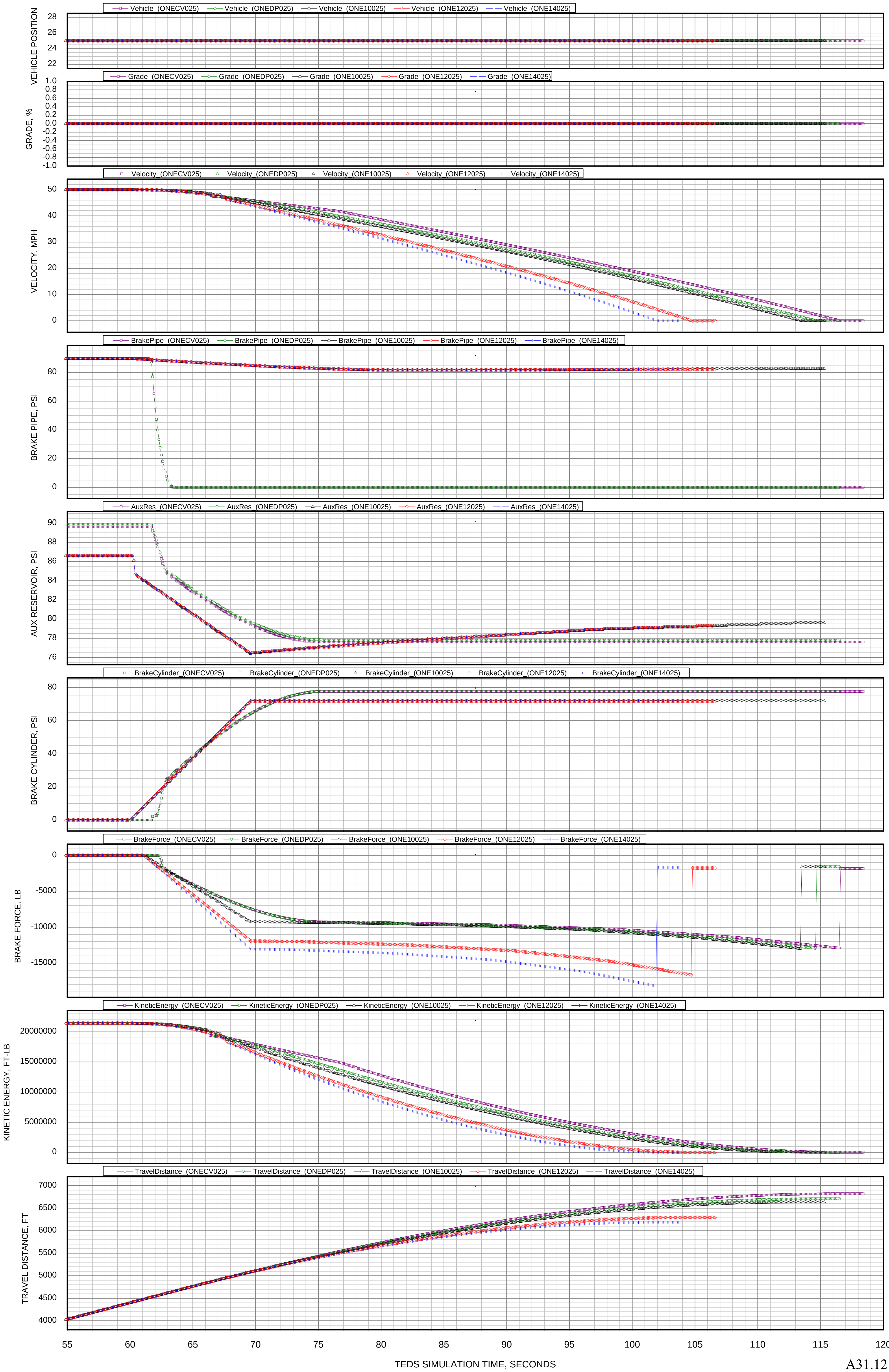
TEDS SIMULATION DATA FOR VEHICLE 020 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 10]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



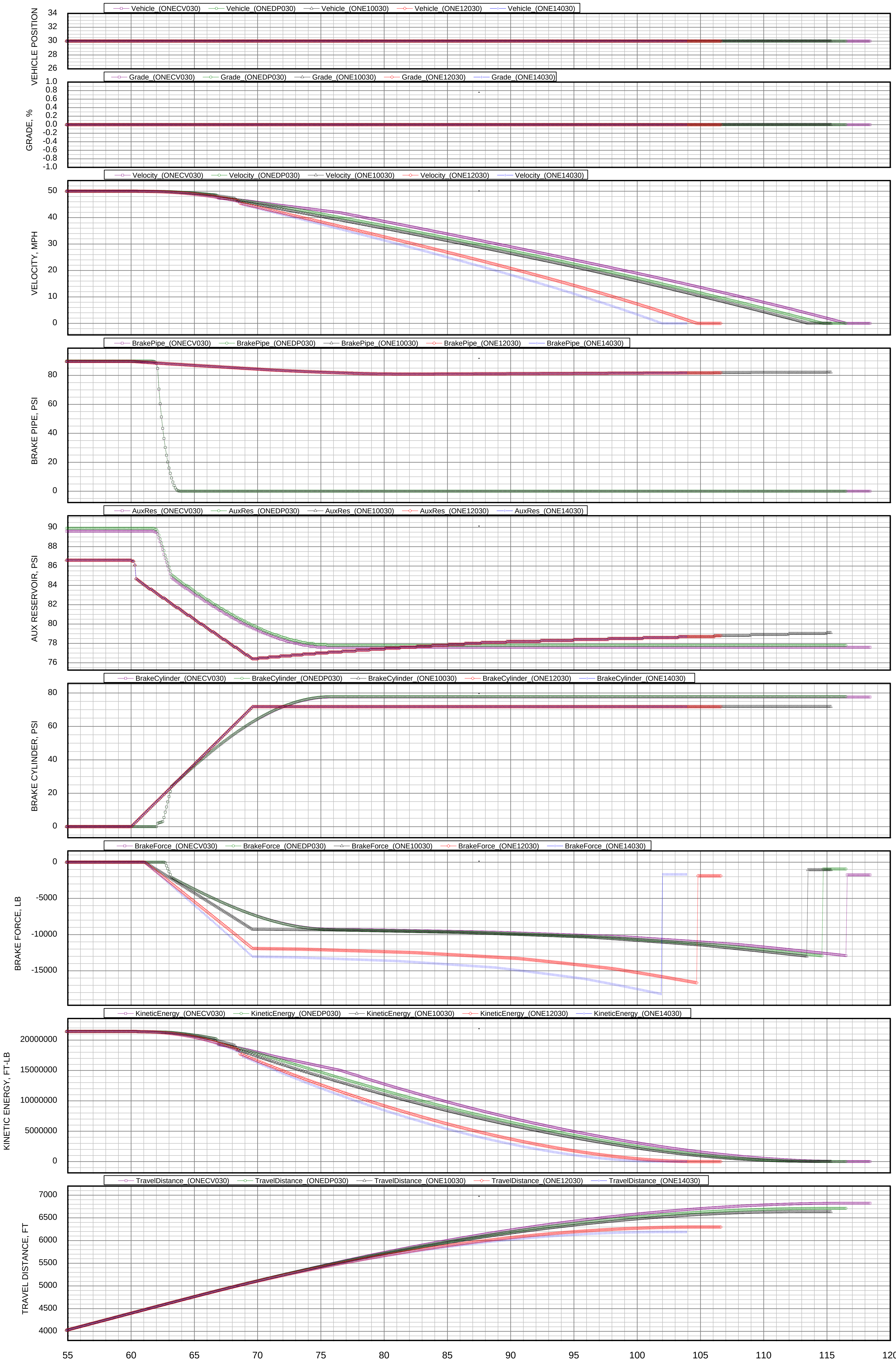
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 025 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 11]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

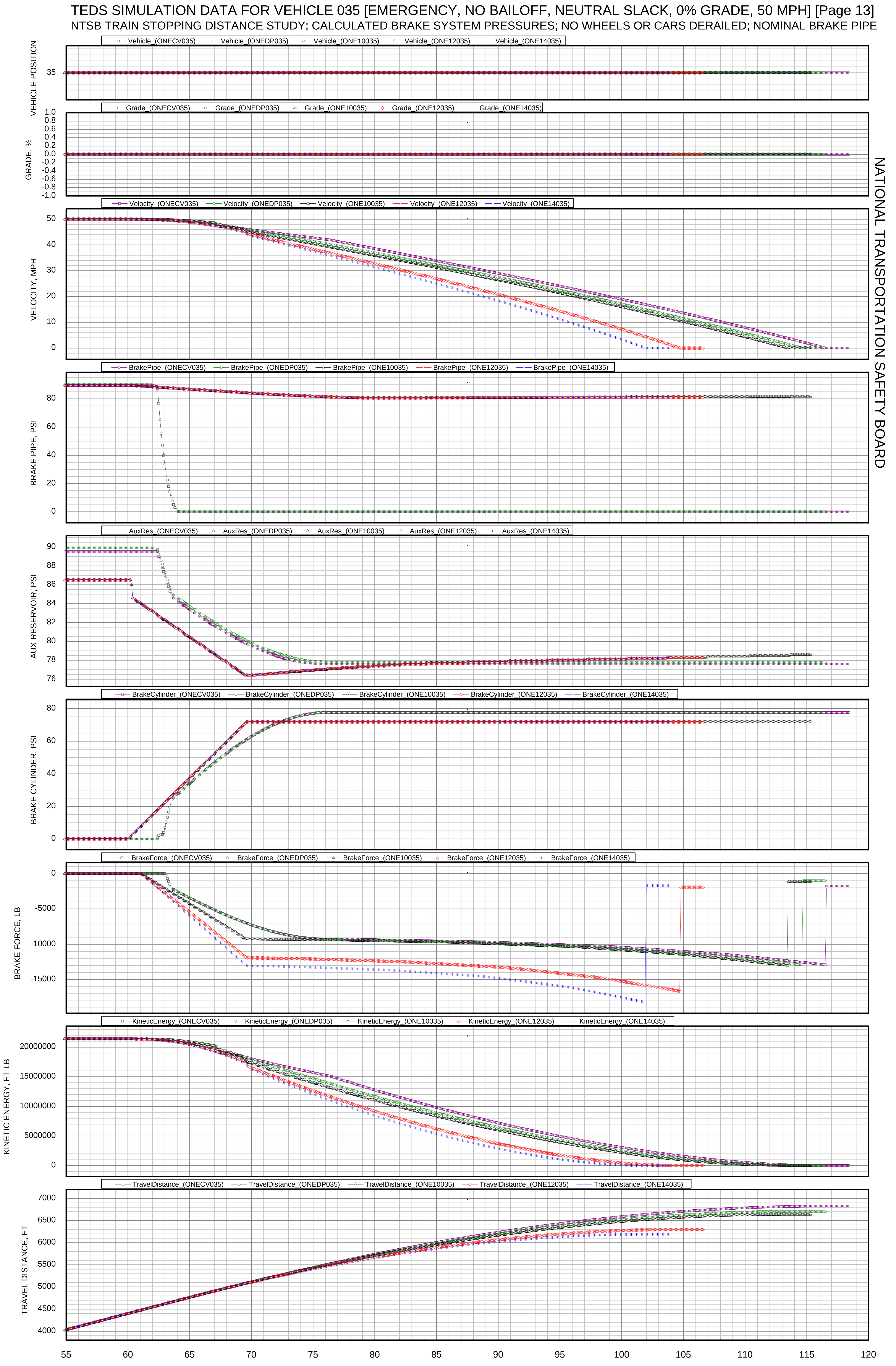


NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 030 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 12]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



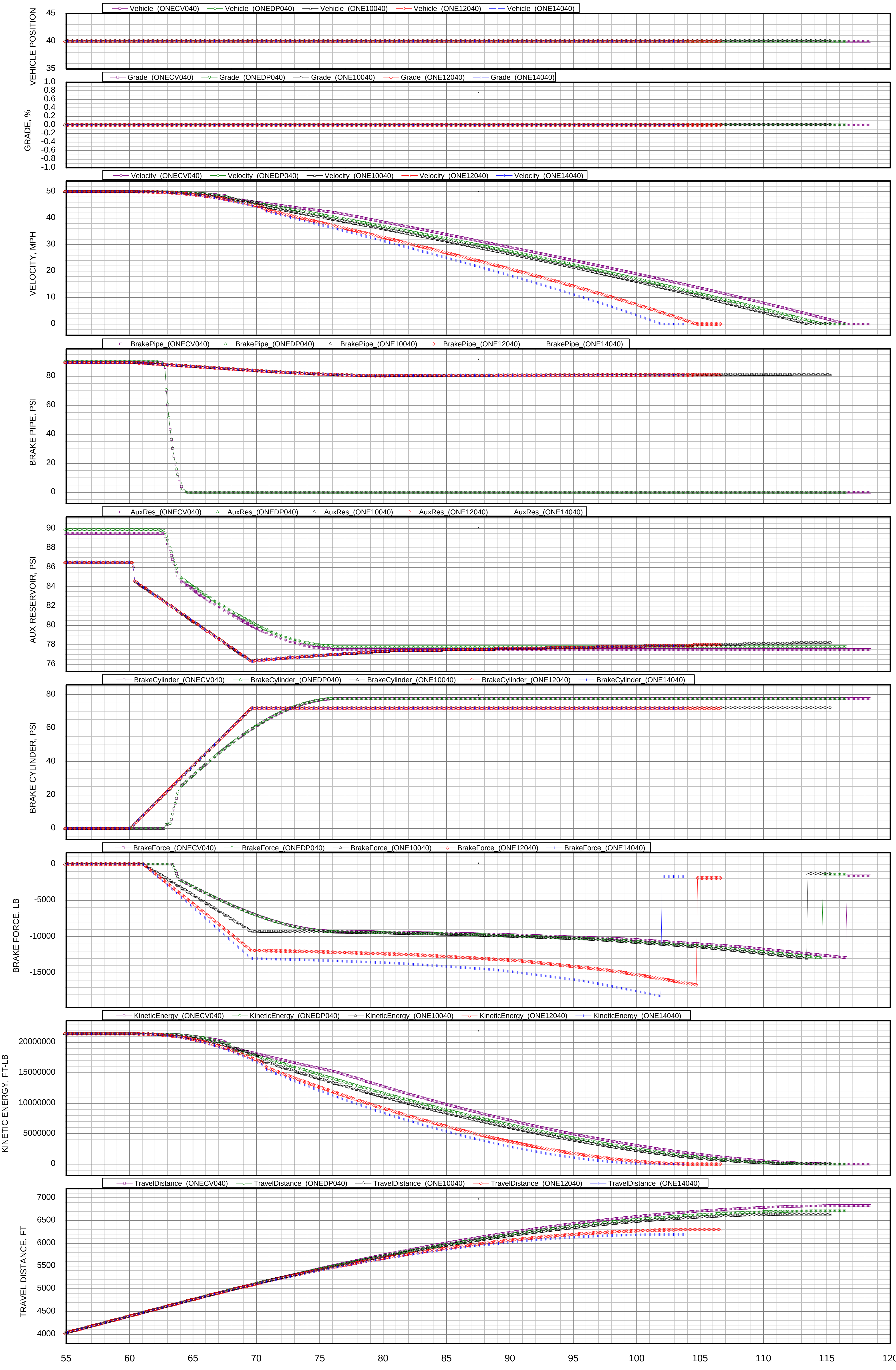
NATIONAL TRANSPORTATION SAFETY BOARD



TEDS SIMULATION DATA FOR VEHICLE 035 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 13]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE
VEHICLE POSITION
GRADE, %
VELOCITY, MPH
BRAKE PIPE, PSI
AUX RESERVOIR, PSI
BRAKE CYLINDER, PSI
BRAKE FORCE, LB
KINETIC ENERGY, FT-LB
TRAVEL DISTANCE, FT
TEDS SIMULATION TIME, SECONDS
NATIONAL TRANSPORTATION SAFETY BOARD

A31.14

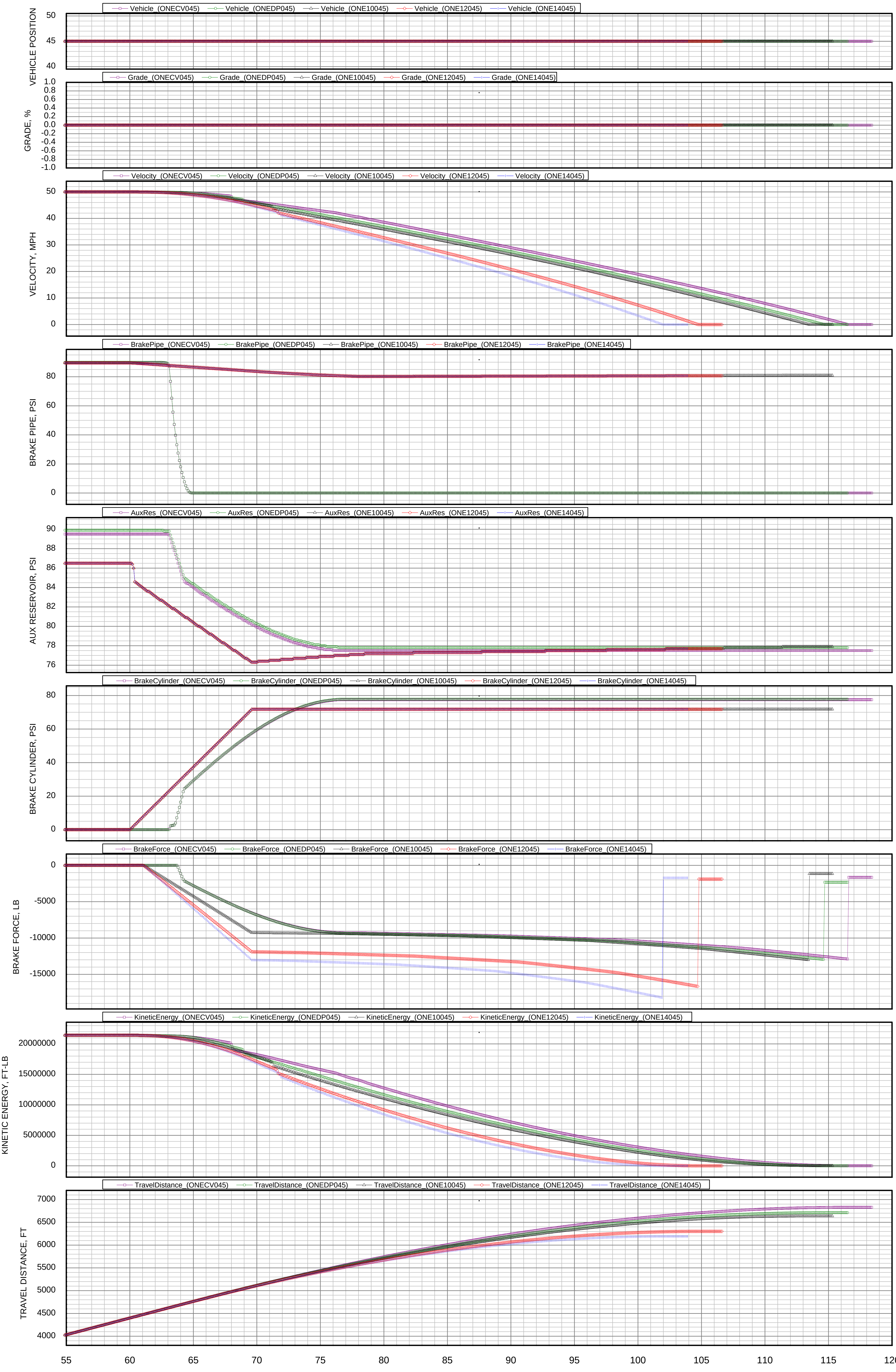
TEDS SIMULATION DATA FOR VEHICLE 040 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 14]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 045 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 15]

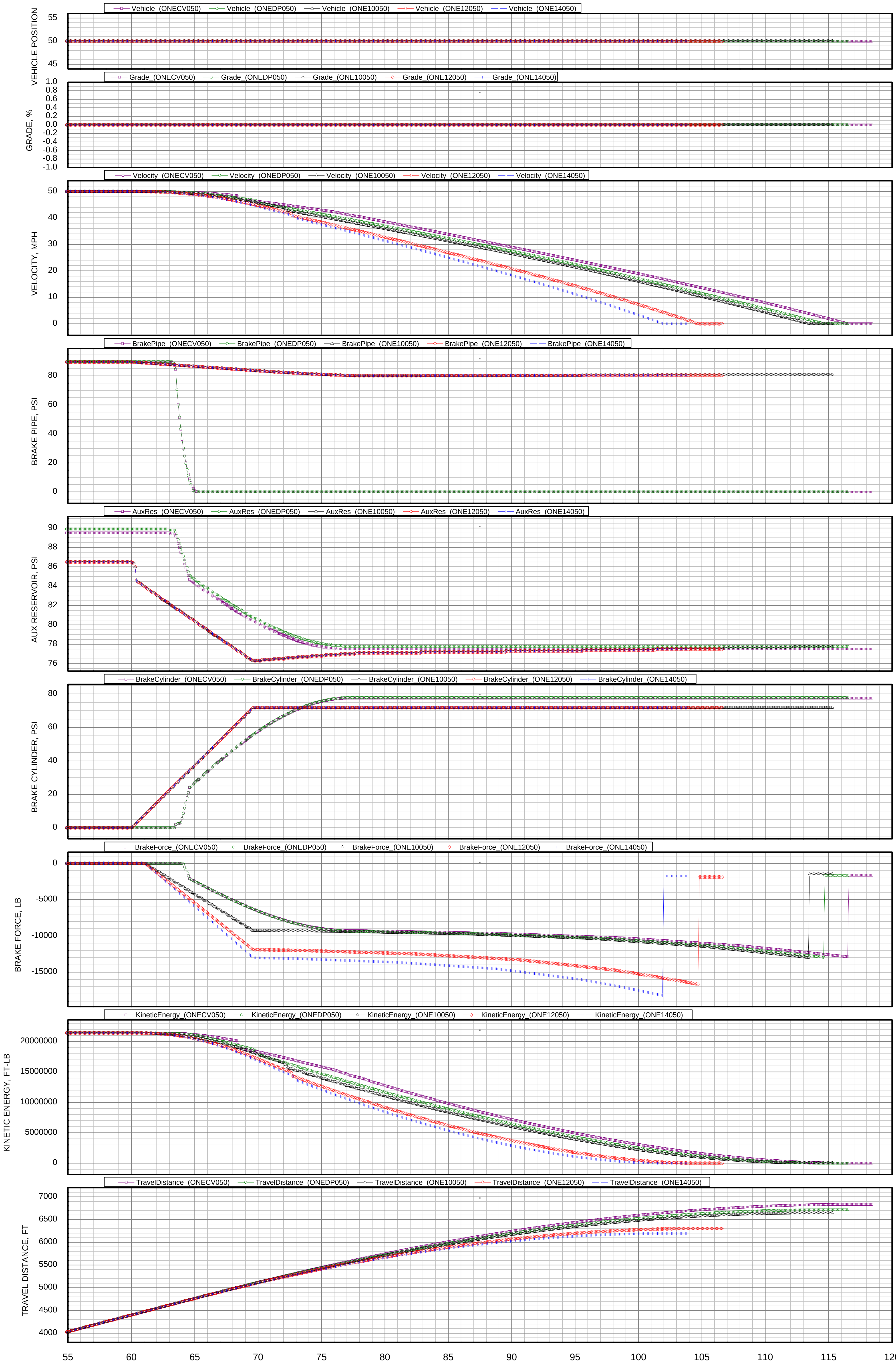
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 050 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 16]

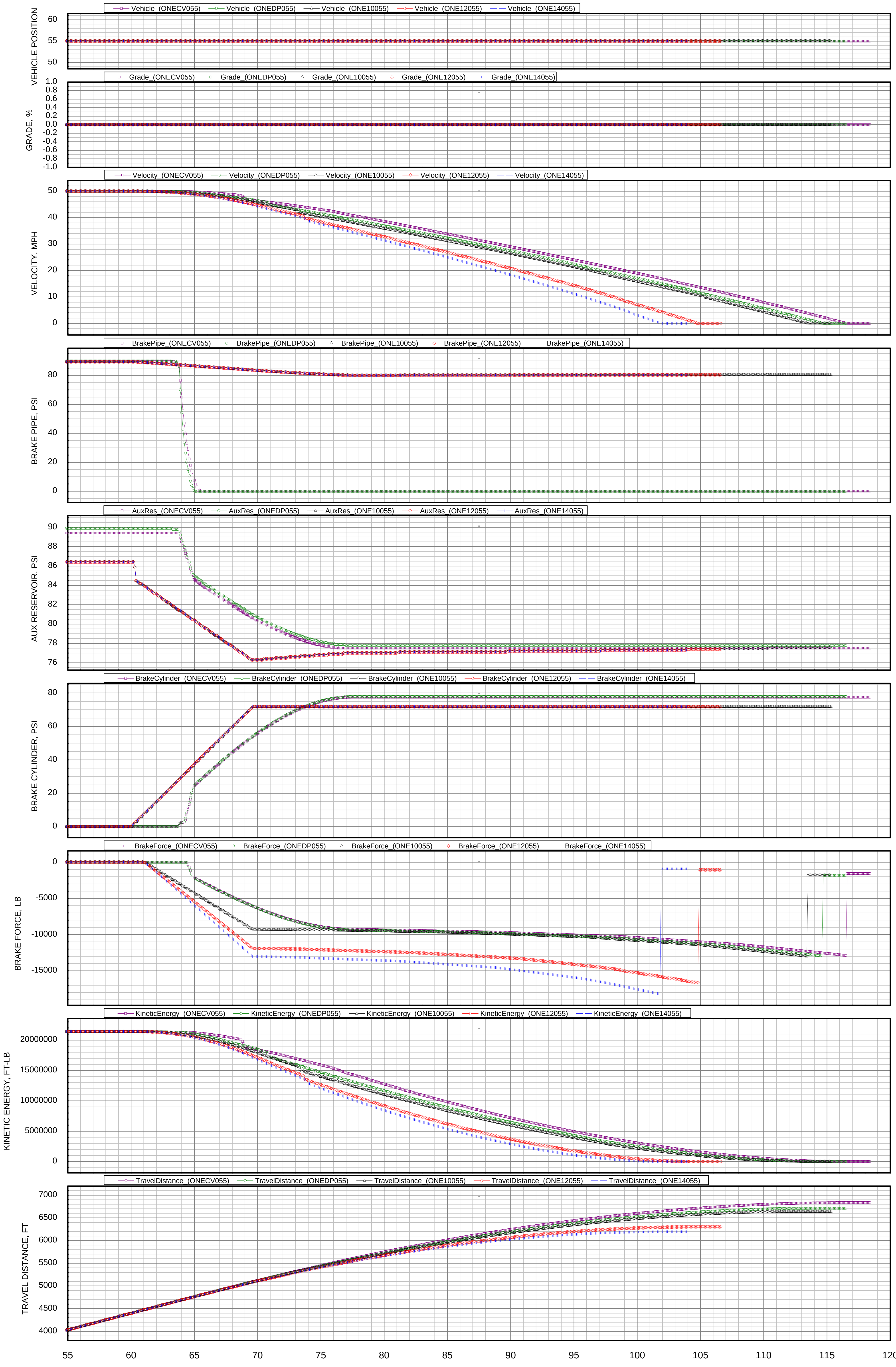
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

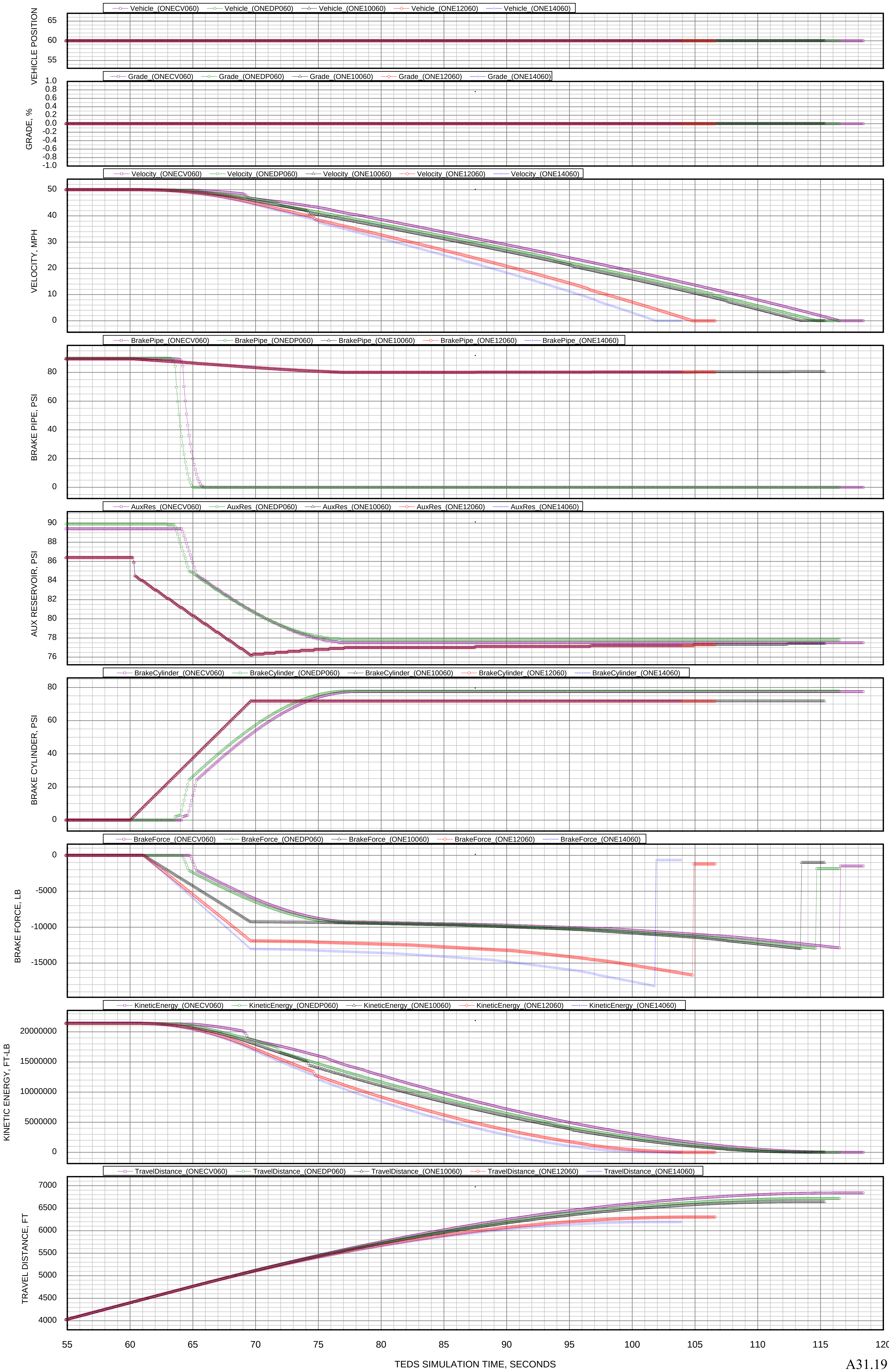
TEDS SIMULATION DATA FOR VEHICLE 055 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 17]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



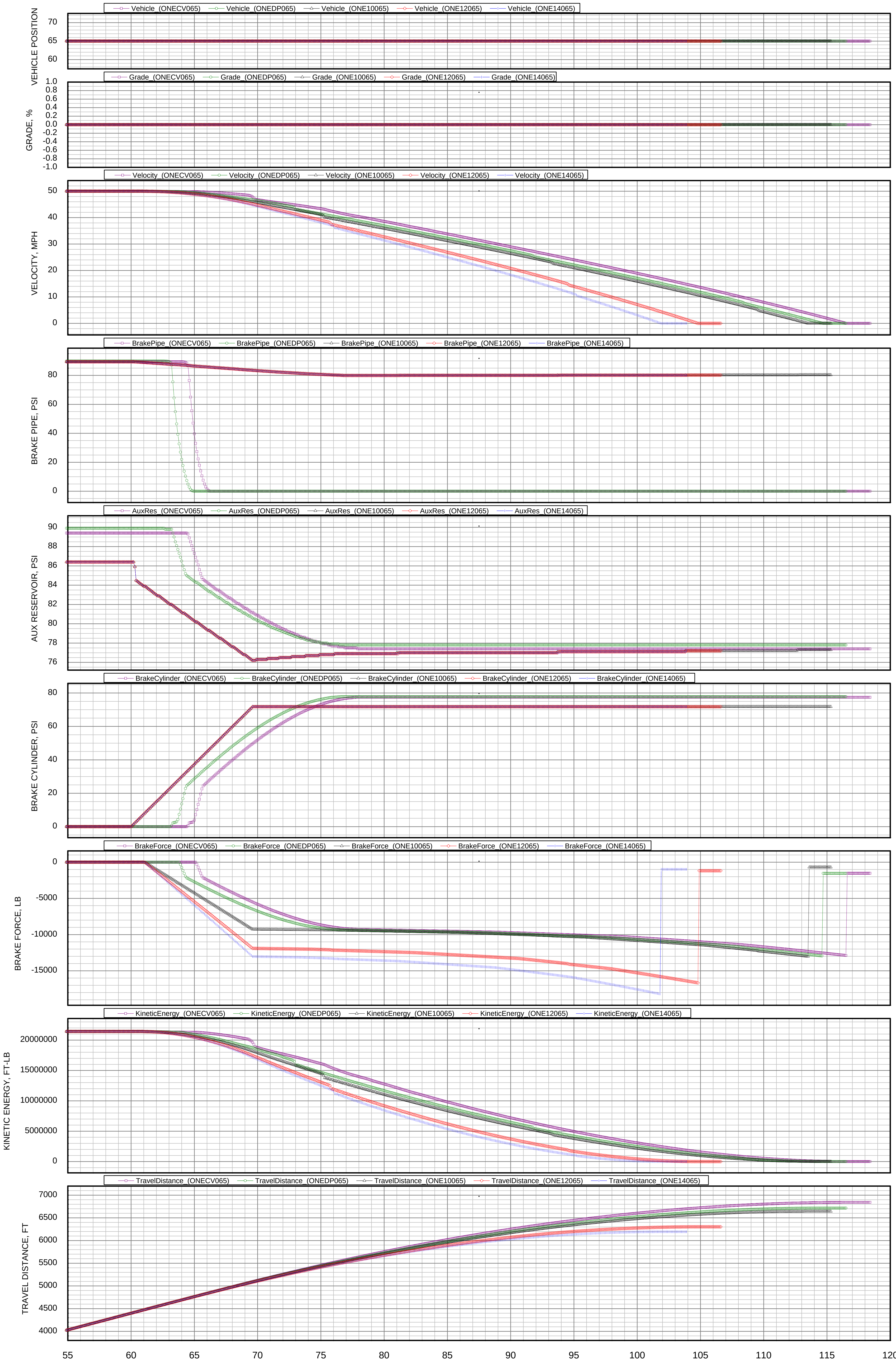
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 060 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 18]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



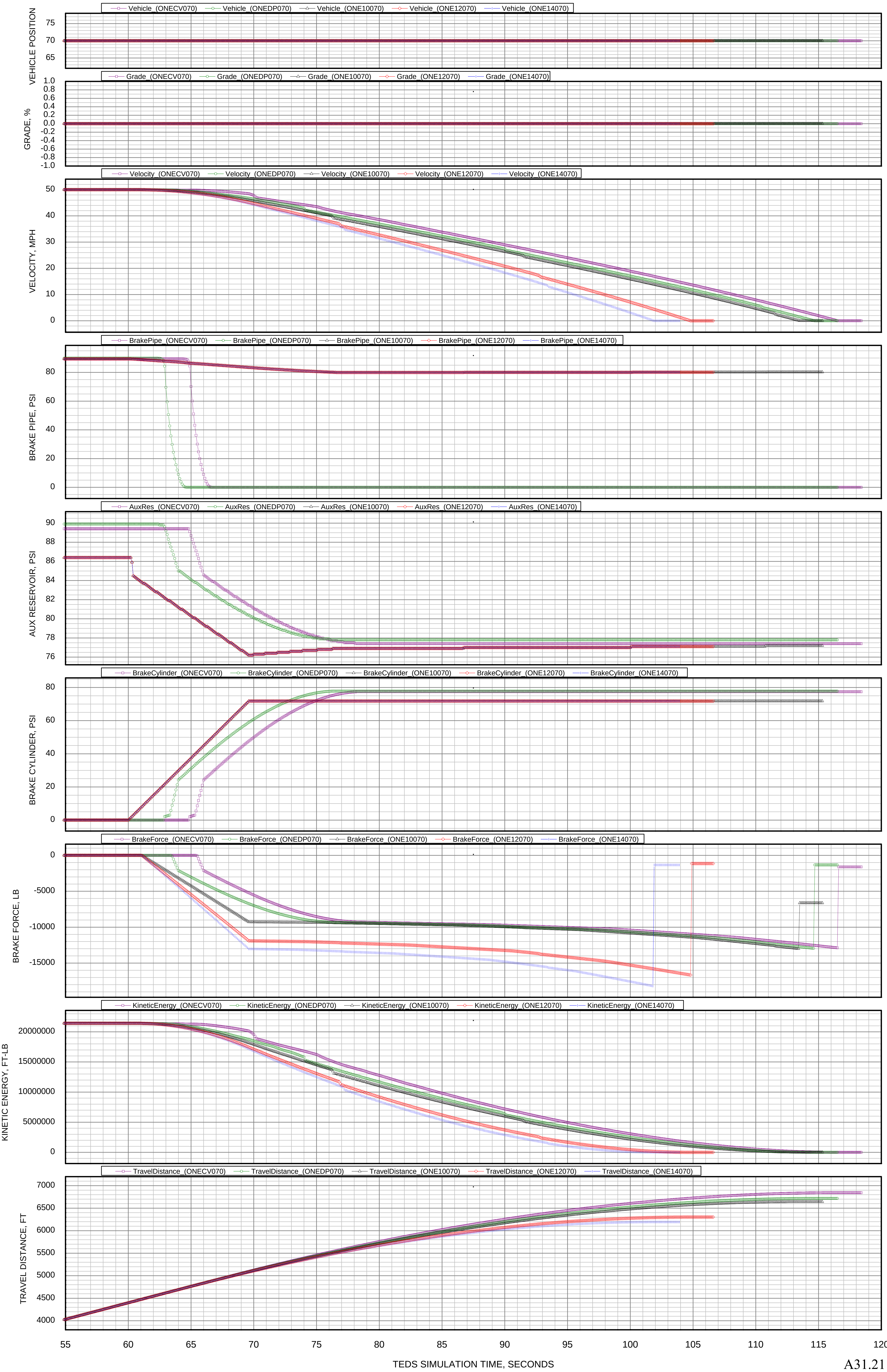
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 065 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 19]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

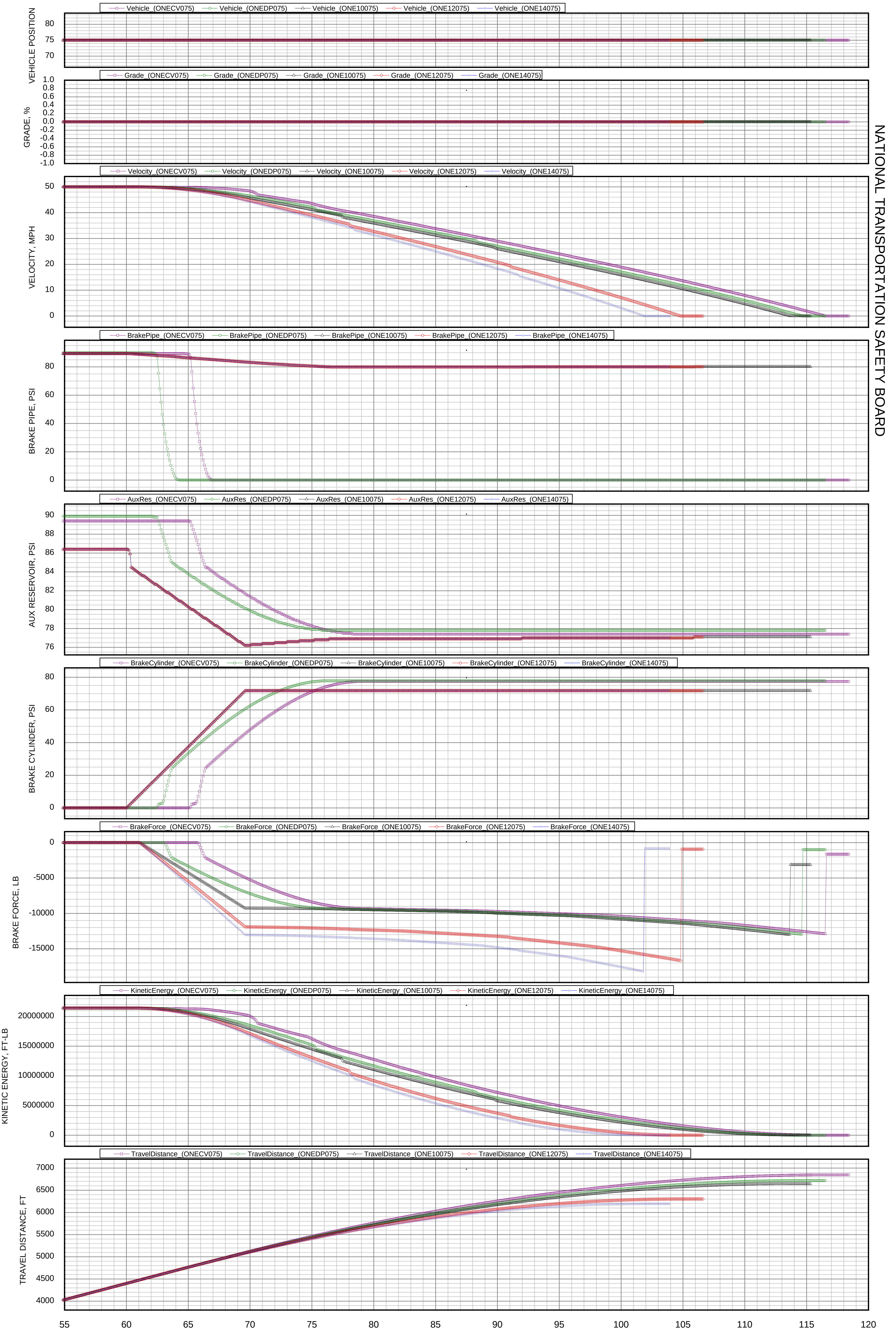
TEDS SIMULATION DATA FOR VEHICLE 070 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 20]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



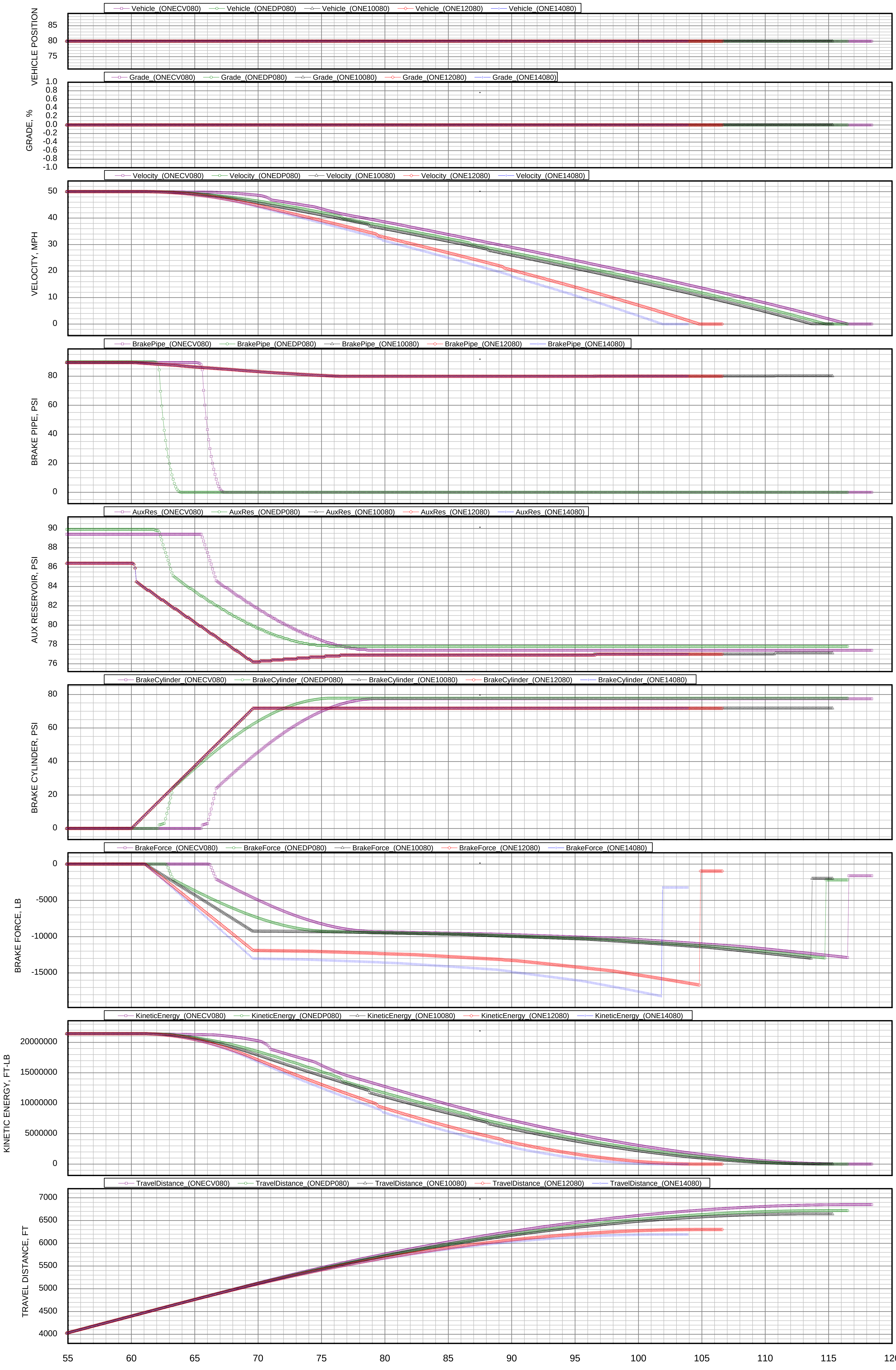
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 075 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 21]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

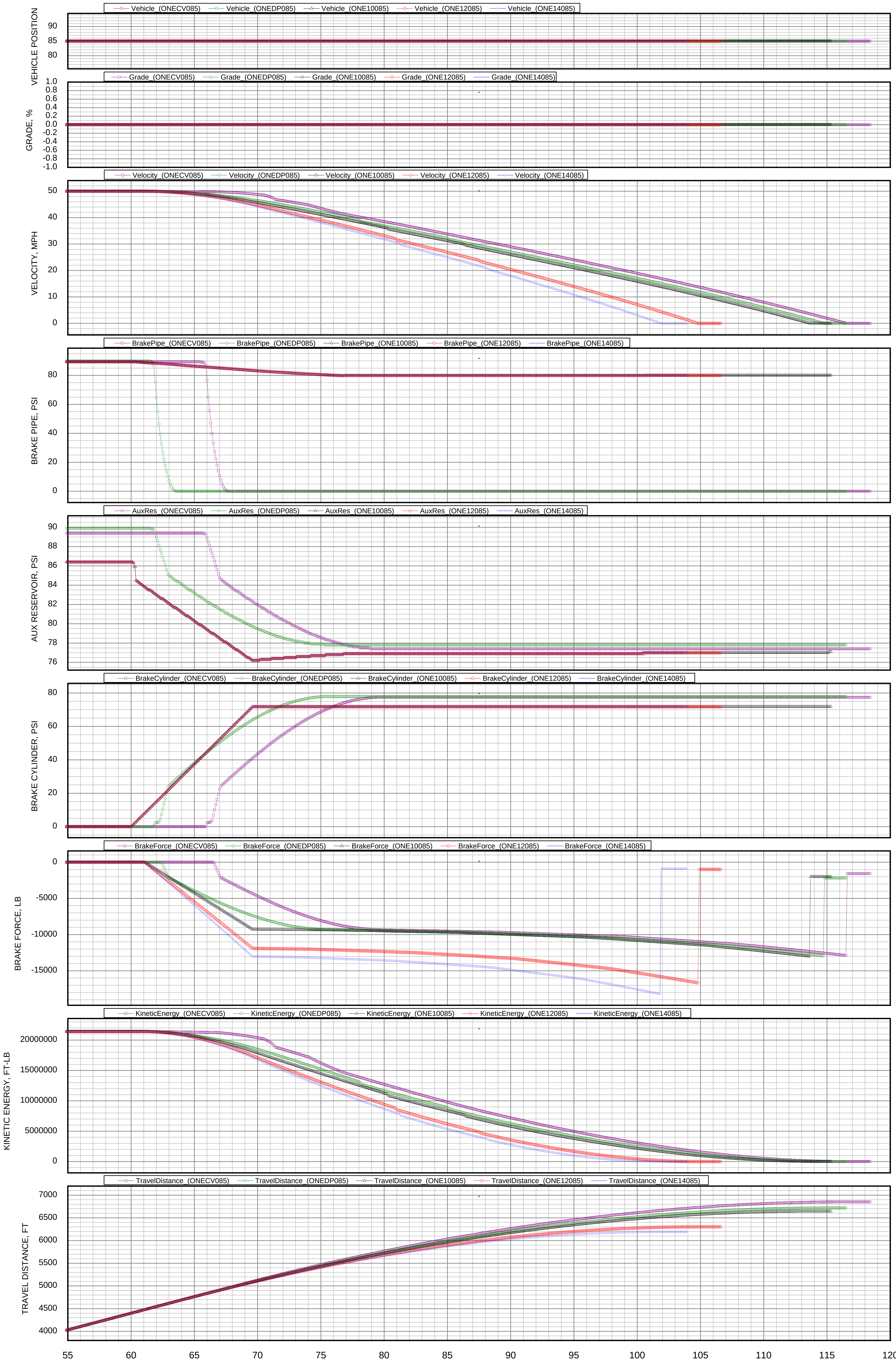


TEDS SIMULATION DATA FOR VEHICLE 080 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 22]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



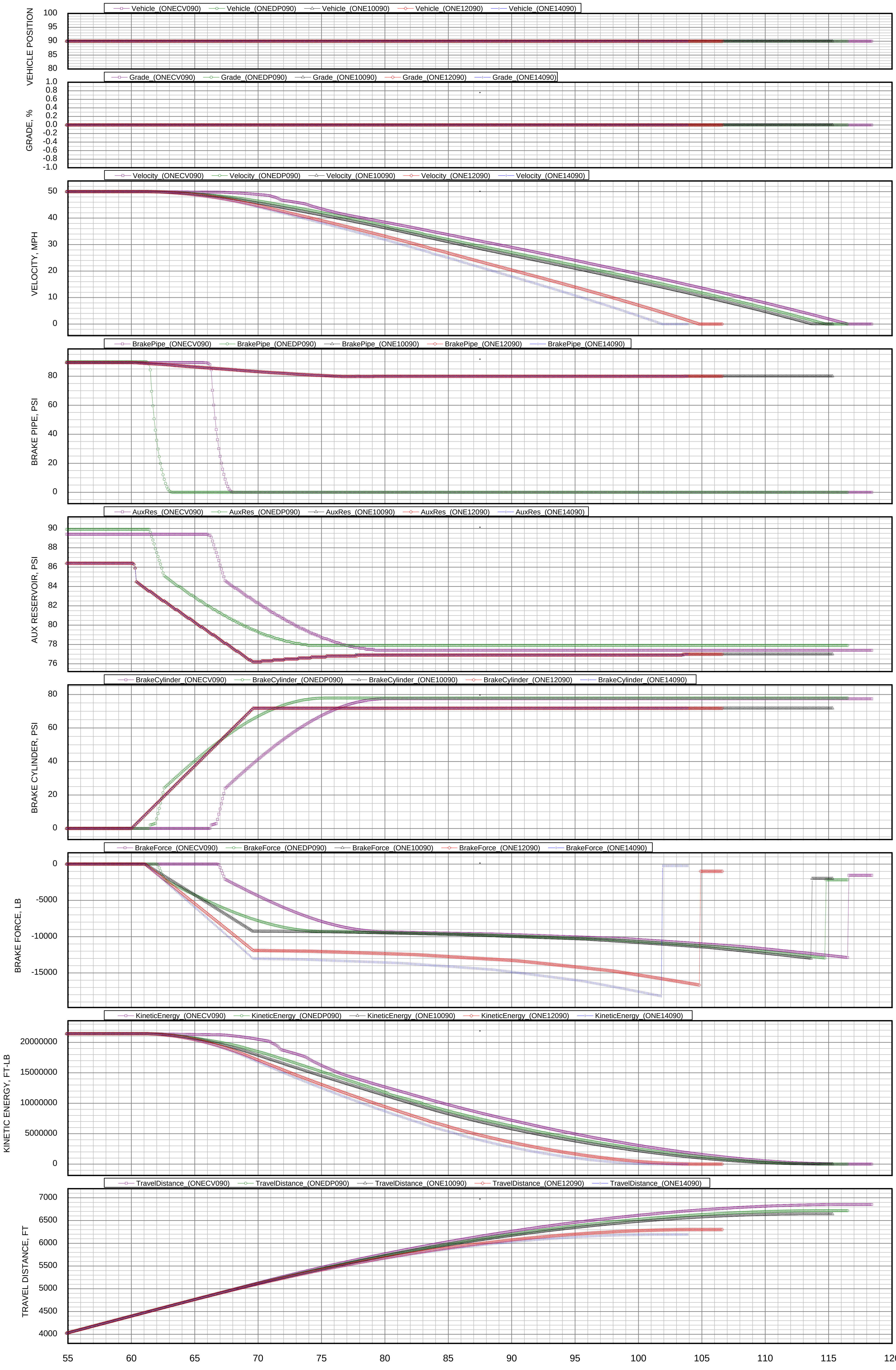
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 085 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 23]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

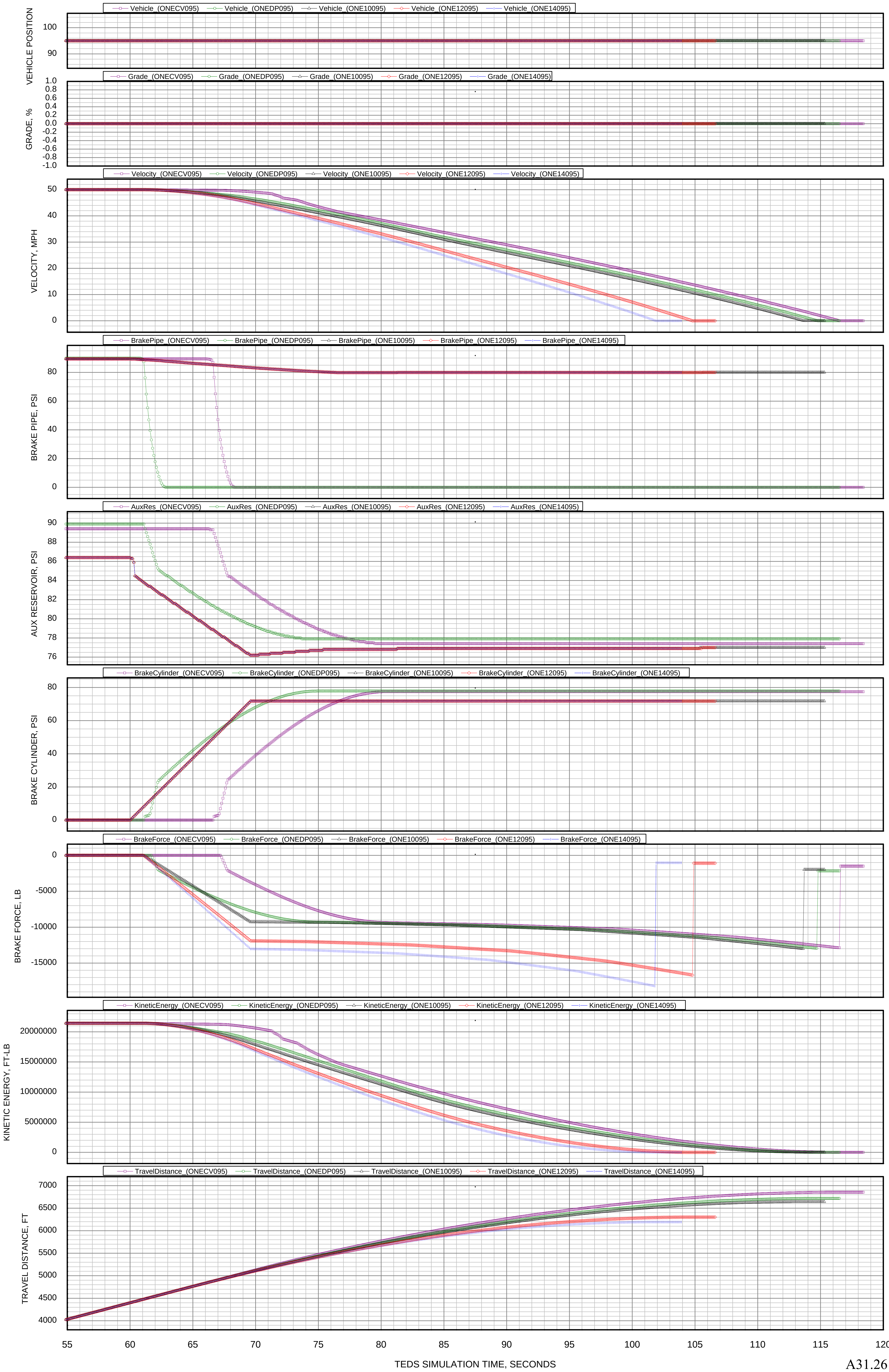
TEDS SIMULATION DATA FOR VEHICLE 090 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 24]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

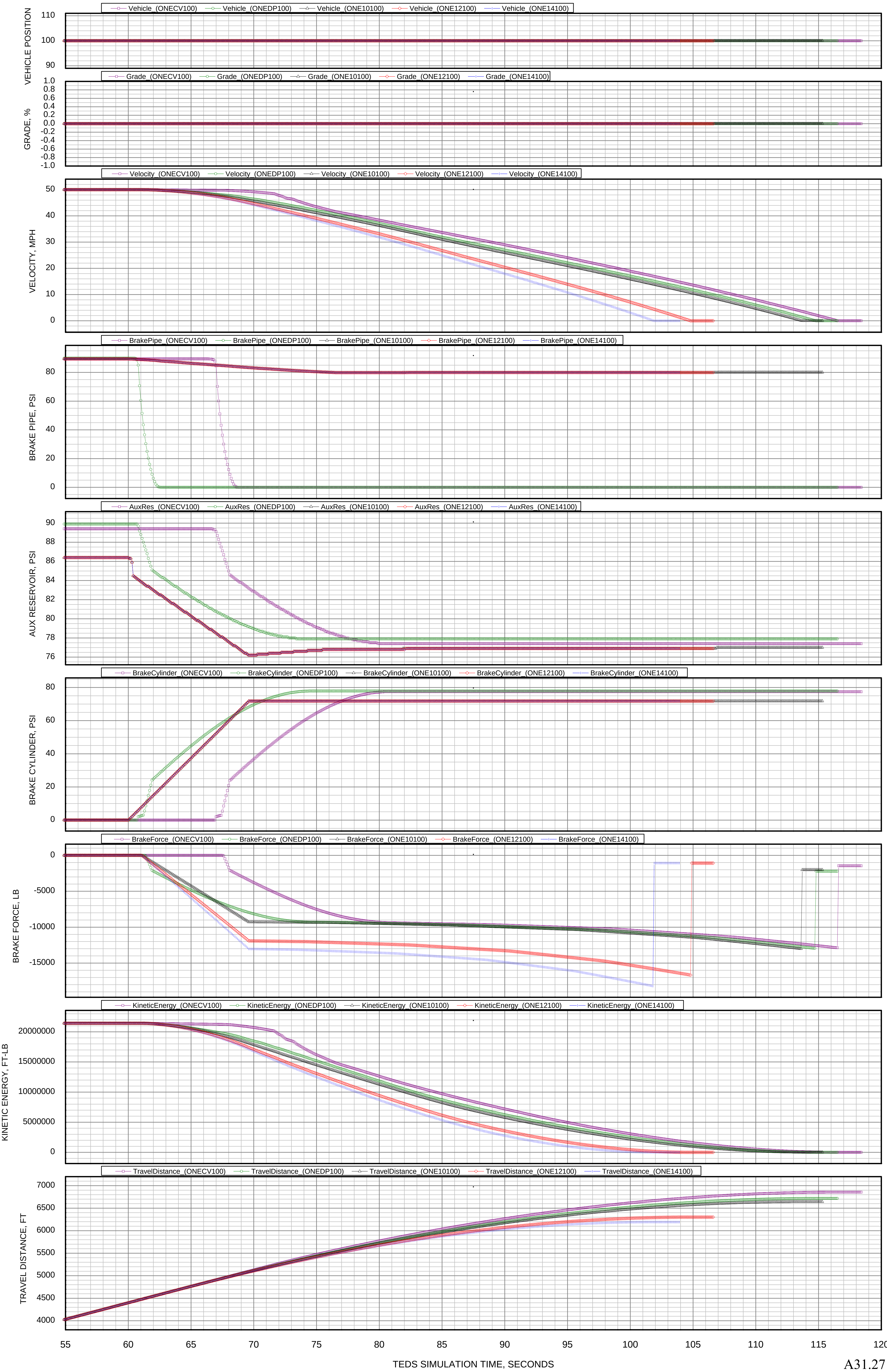
TEDS SIMULATION DATA FOR VEHICLE 095 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 25]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



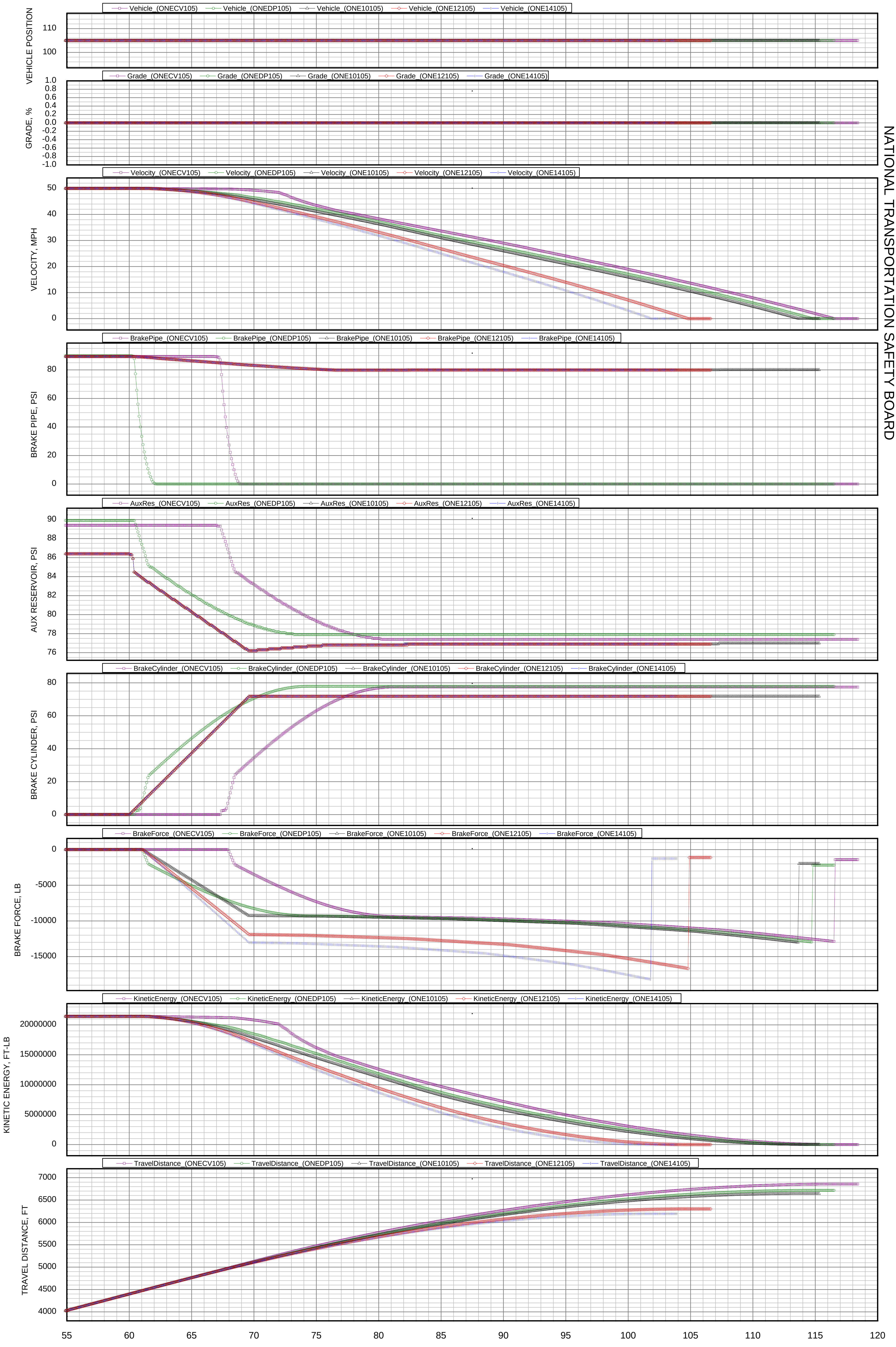
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 100 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 26]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



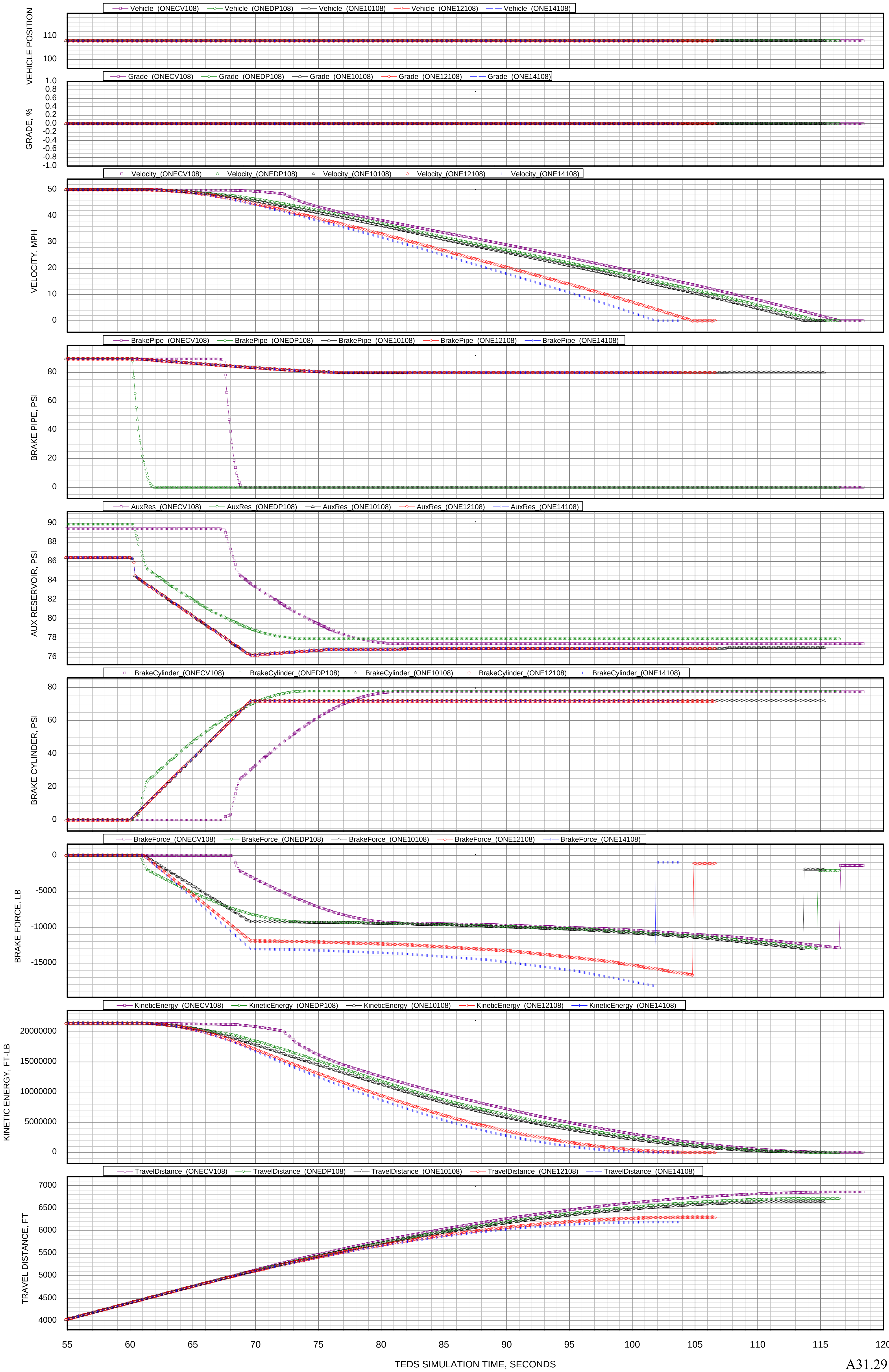
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 105 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 27]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



TEDS SIMULATION DATA FOR VEHICLE 108 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 28]

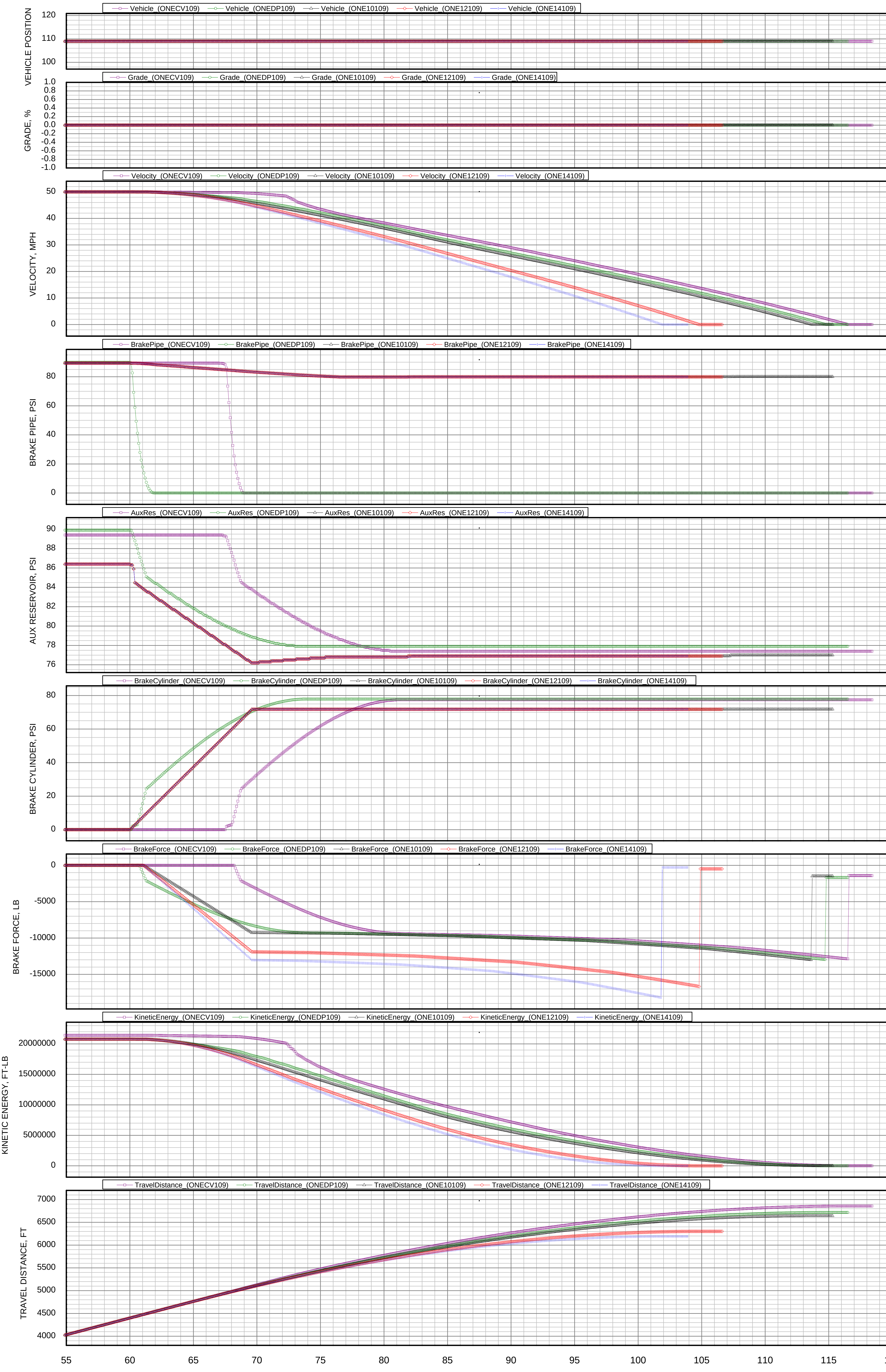
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

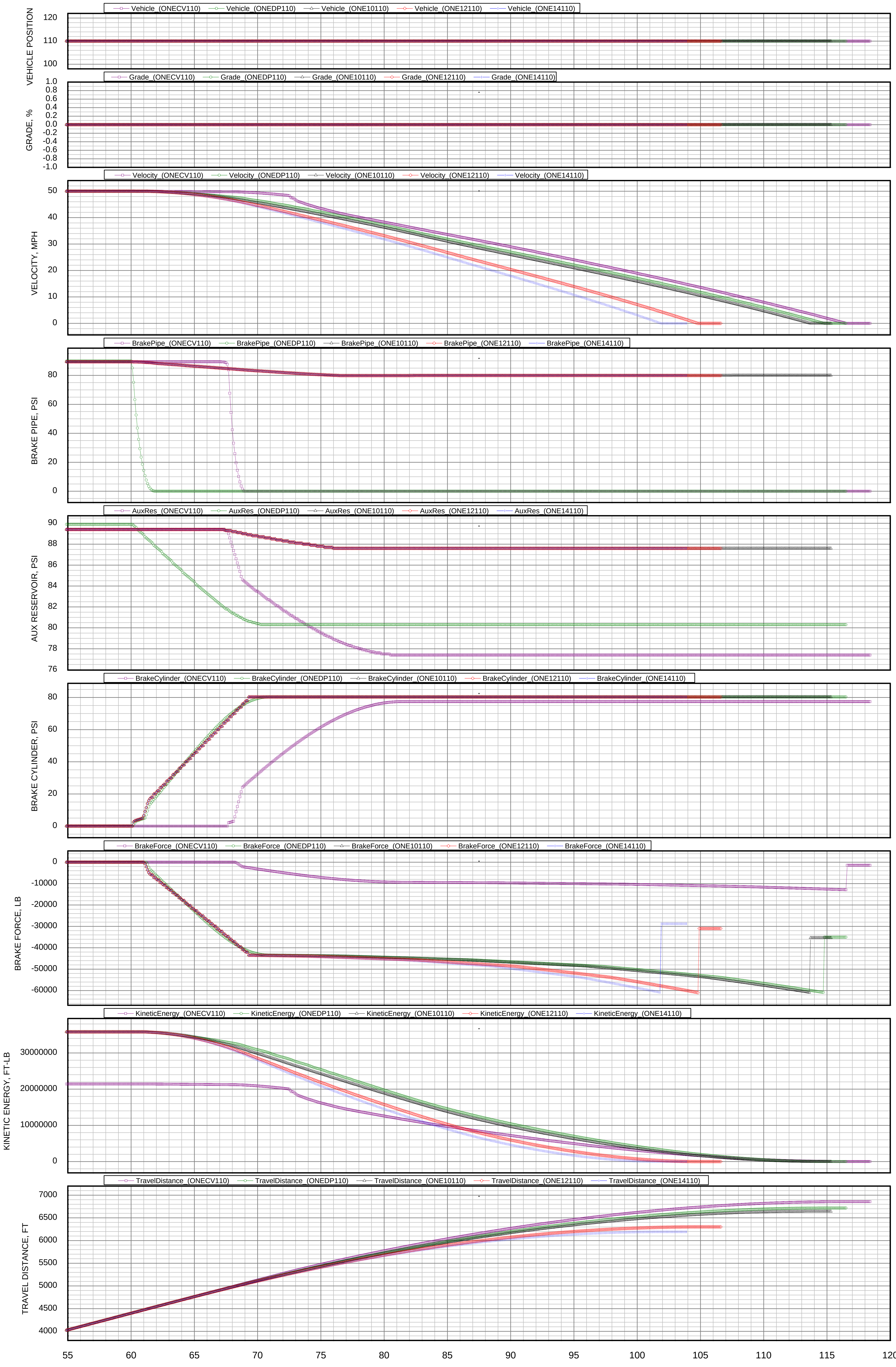
TEDS SIMULATION DATA FOR VEHICLE 109 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 29]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



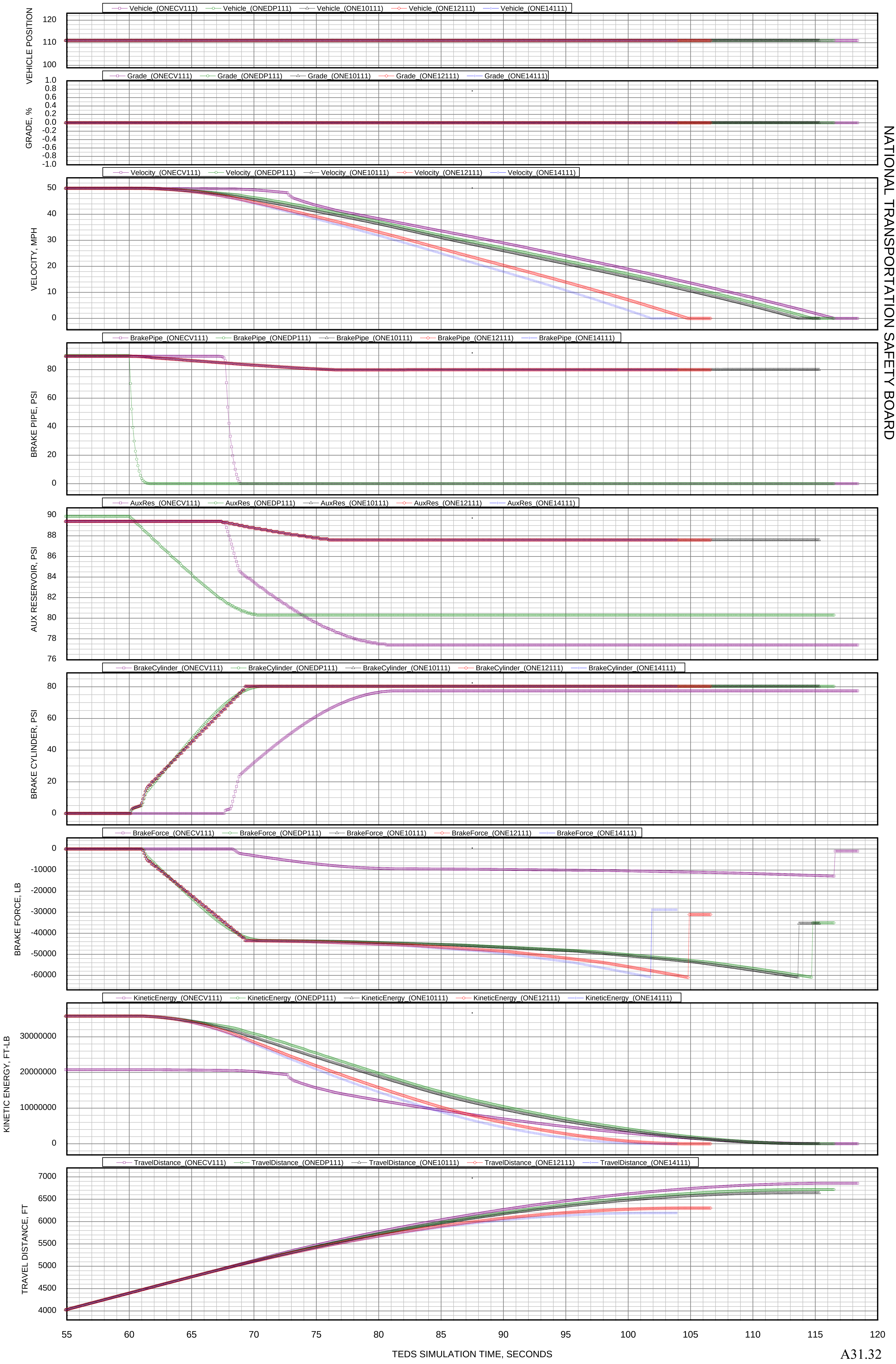
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 110 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 30]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 111 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 31]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED BRAKE SYSTEM PRESSURES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

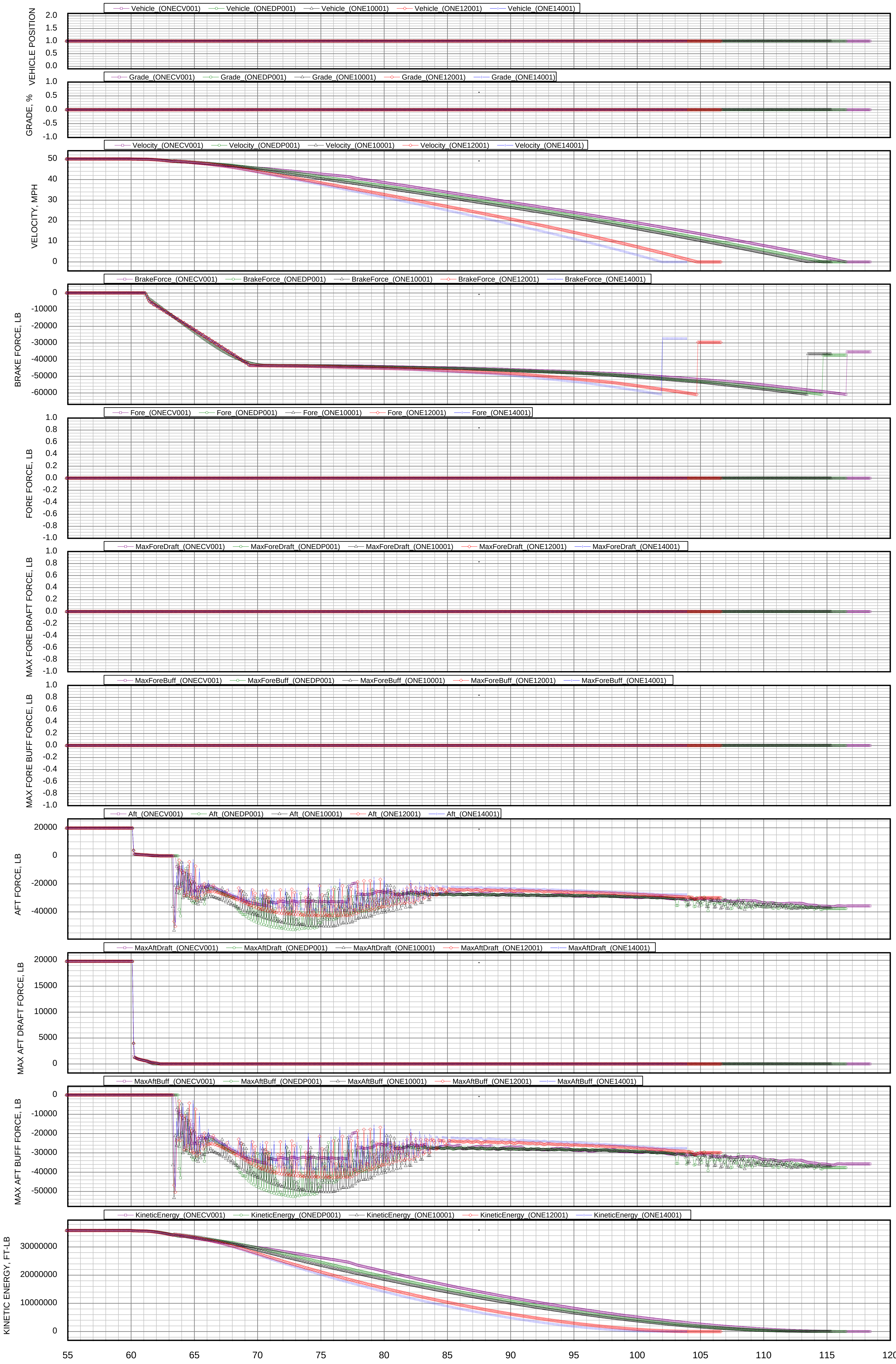


NATIONAL TRANSPORTATION SAFETY BOARD

Attachment 32: Example Calculated In-Train Forces

Nominal Consist (Emergency braking; no bailoff; initial coupler slack neutral; 0% grade; 50 mph)

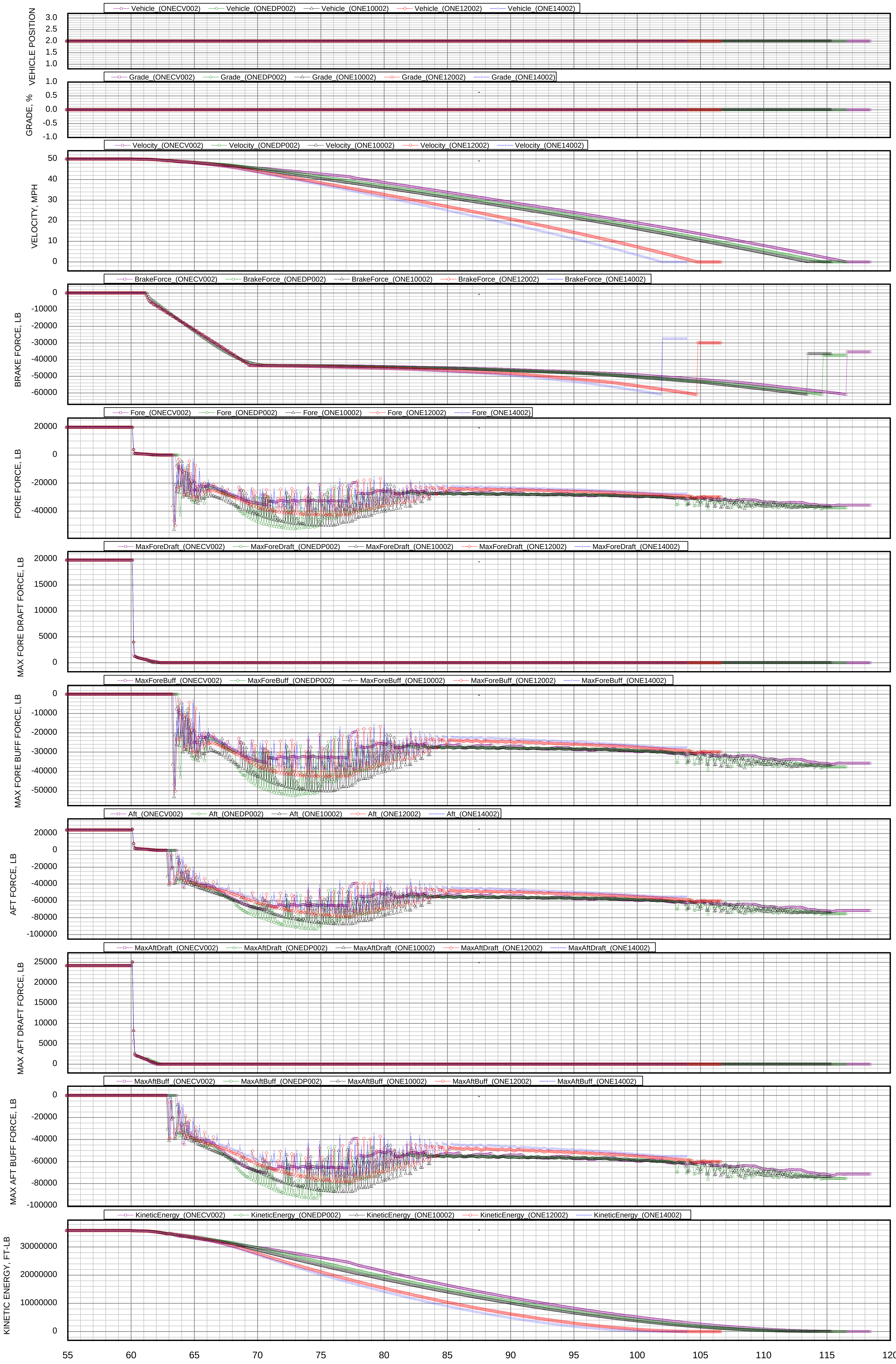
TEDS SIMULATION DATA FOR VEHICLE 001 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 1]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

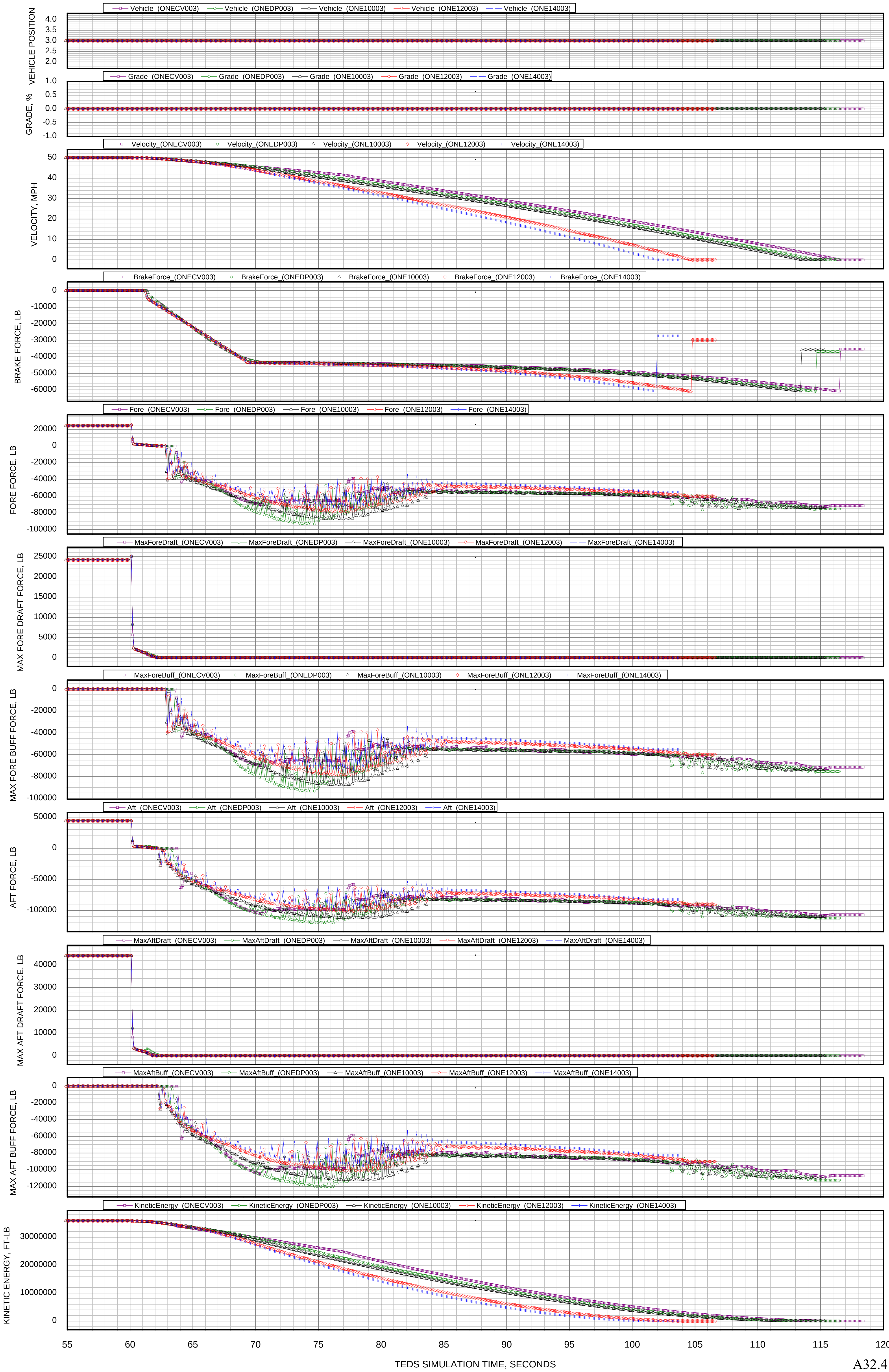
TEDS SIMULATION DATA FOR VEHICLE 002 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 2]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



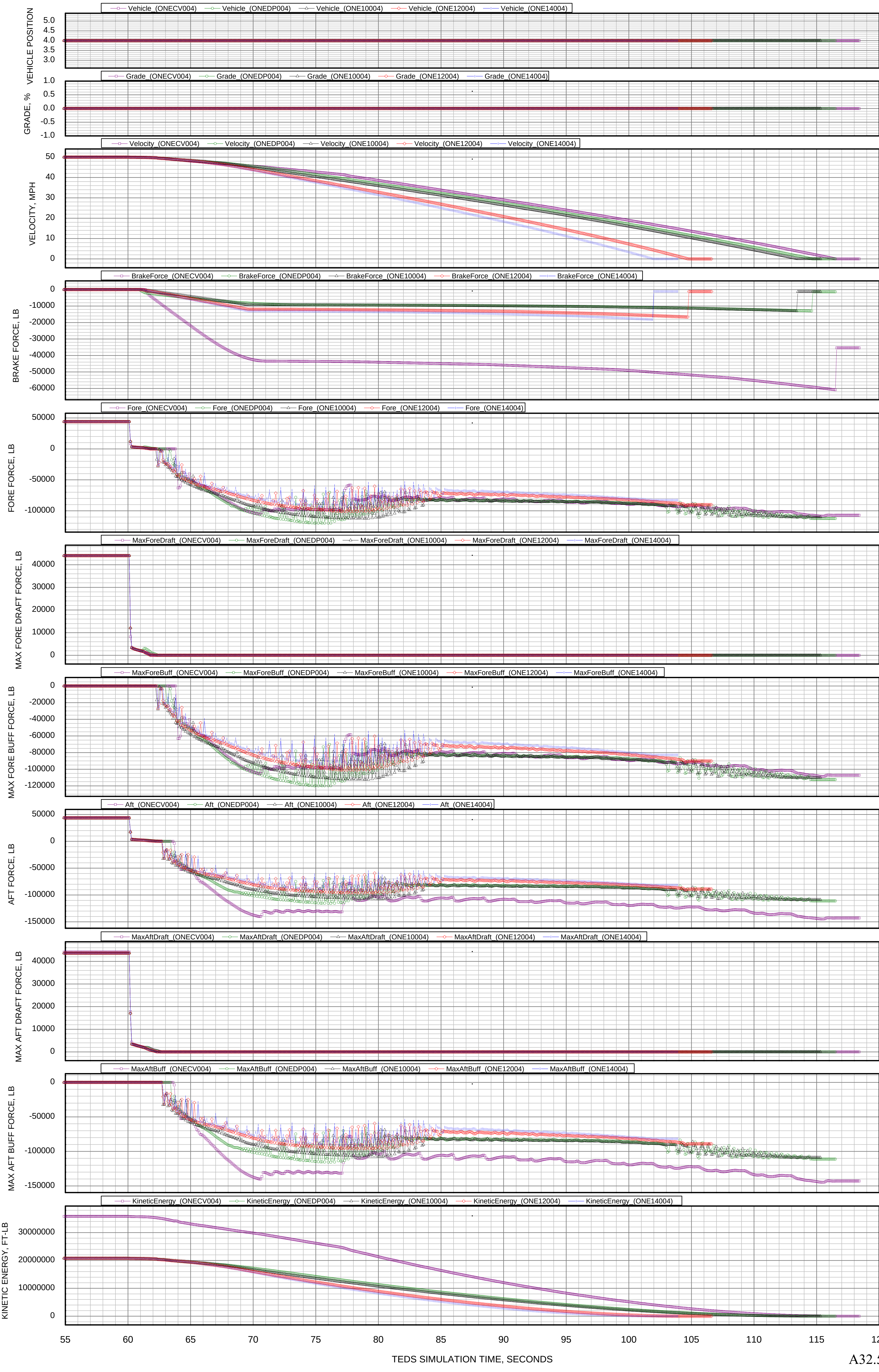
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 003 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 3]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



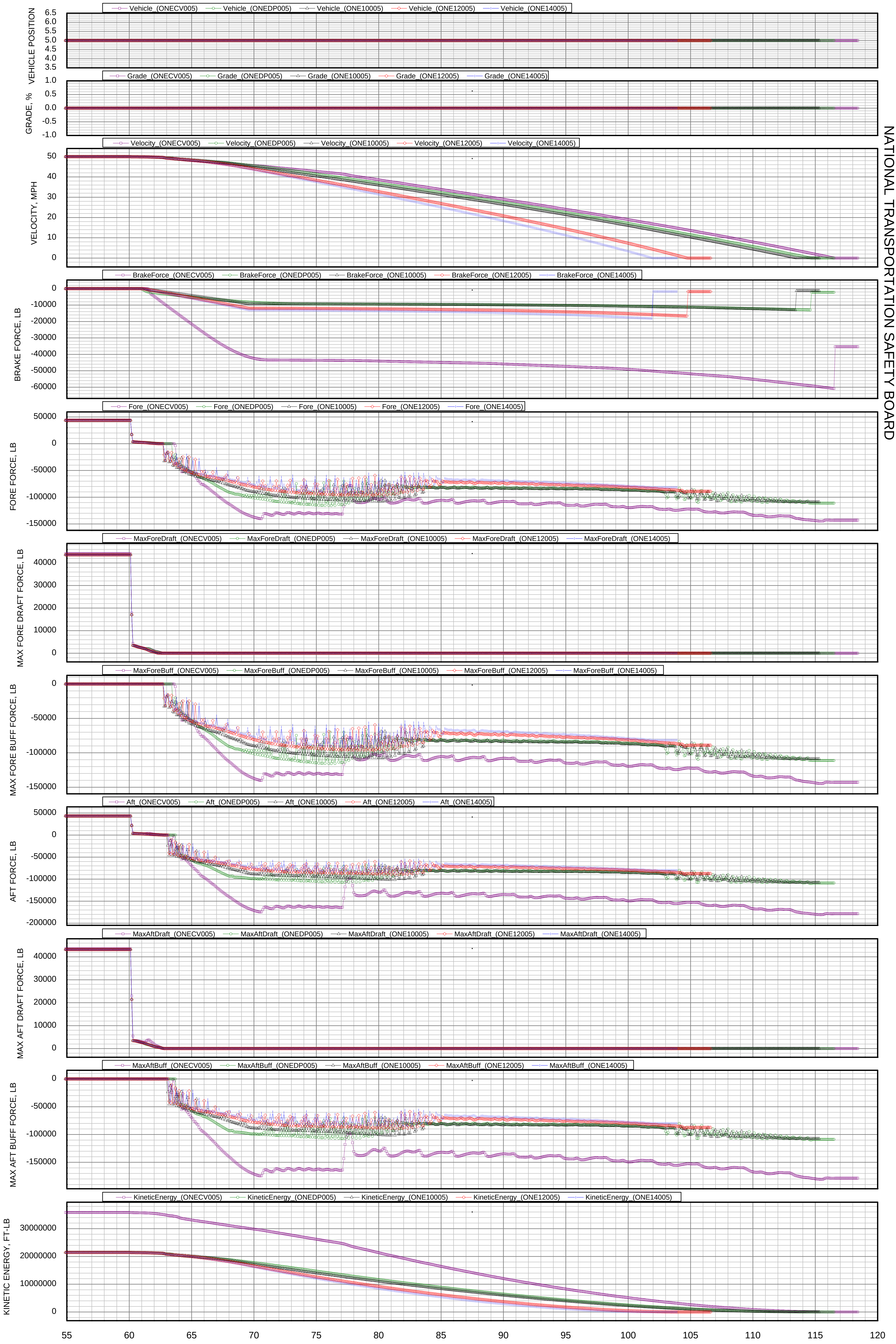
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 004 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 4]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

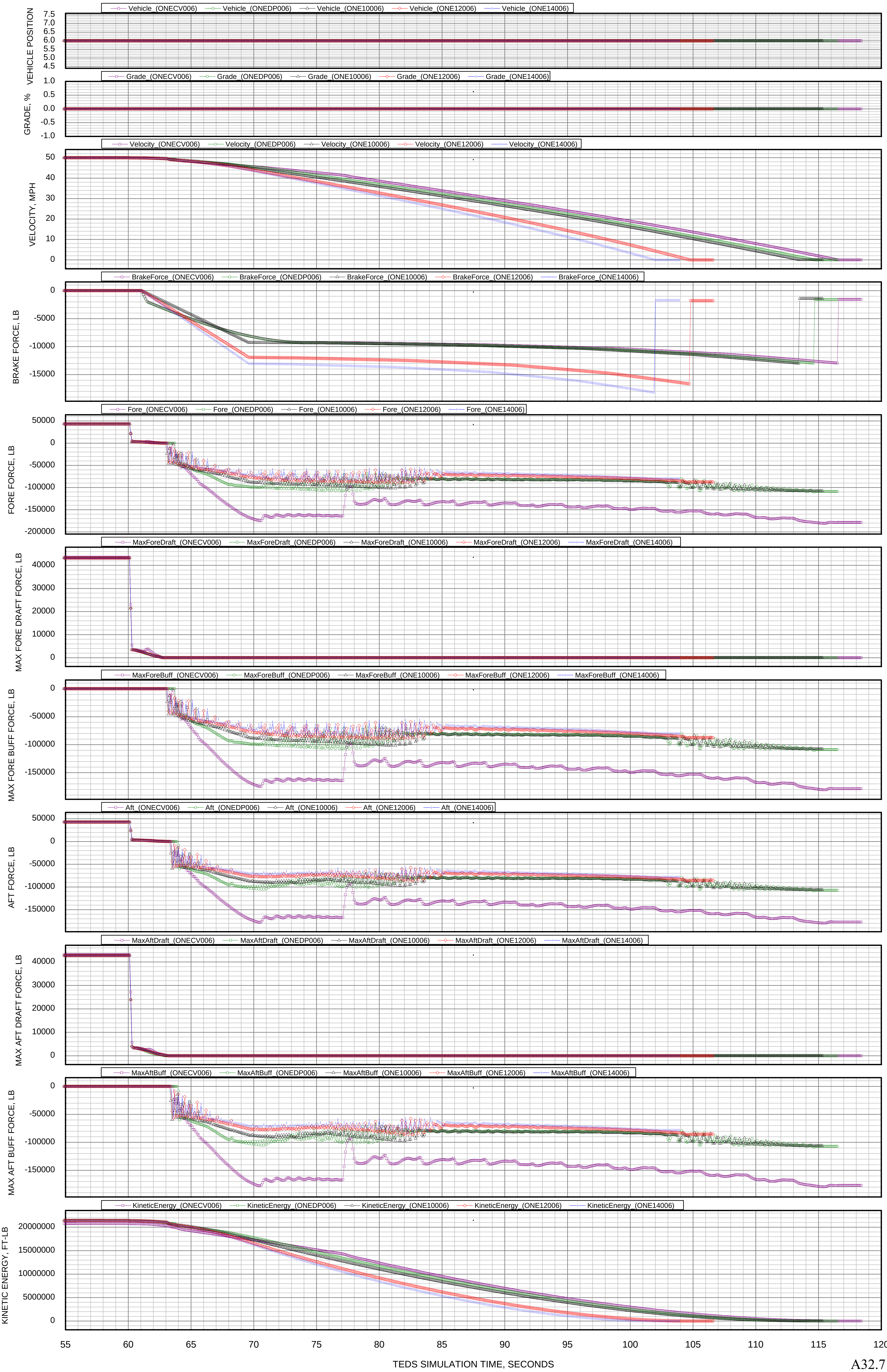


NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 005 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 5]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

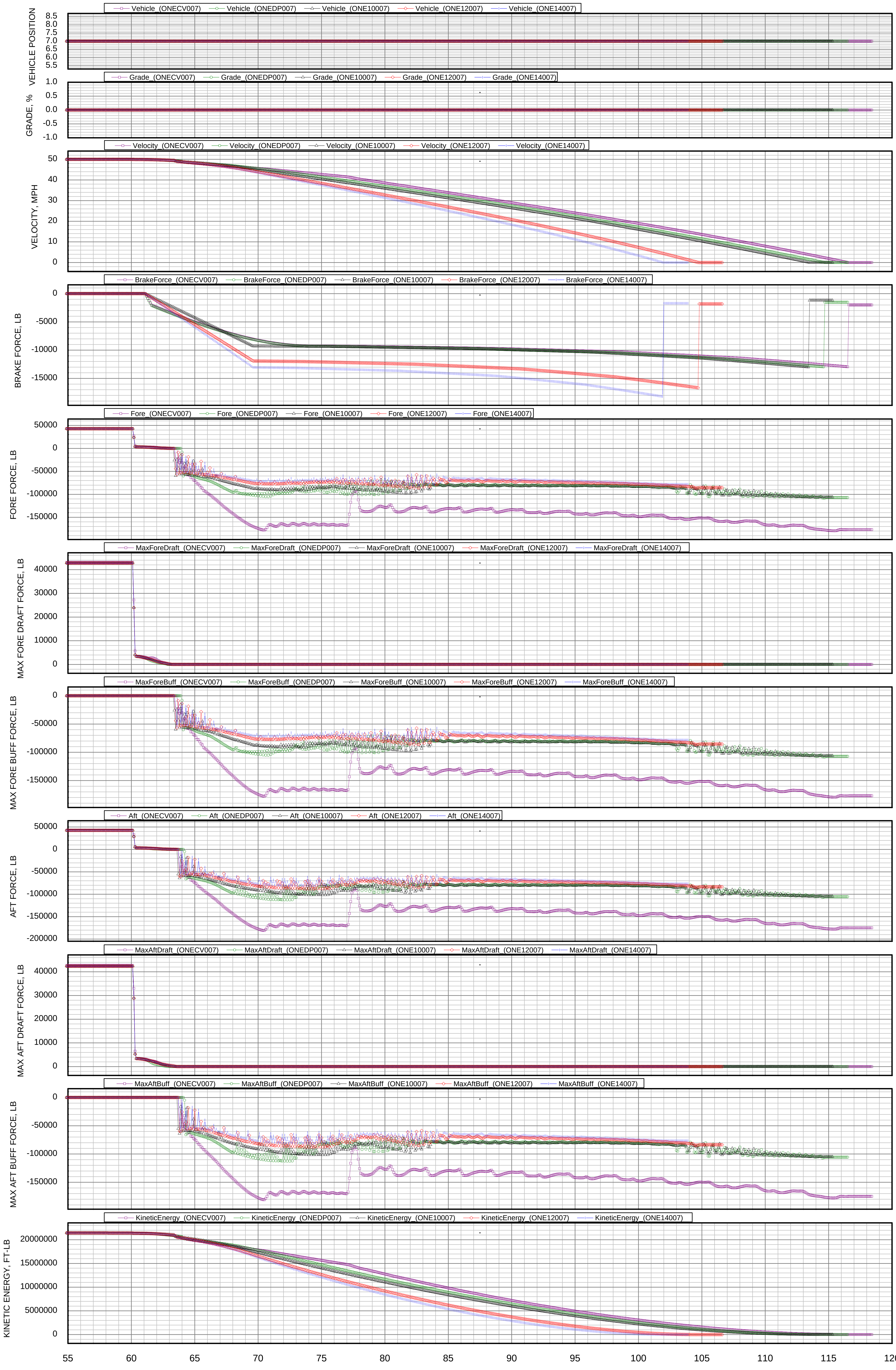


TEDS SIMULATION DATA FOR VEHICLE 006 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 6]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



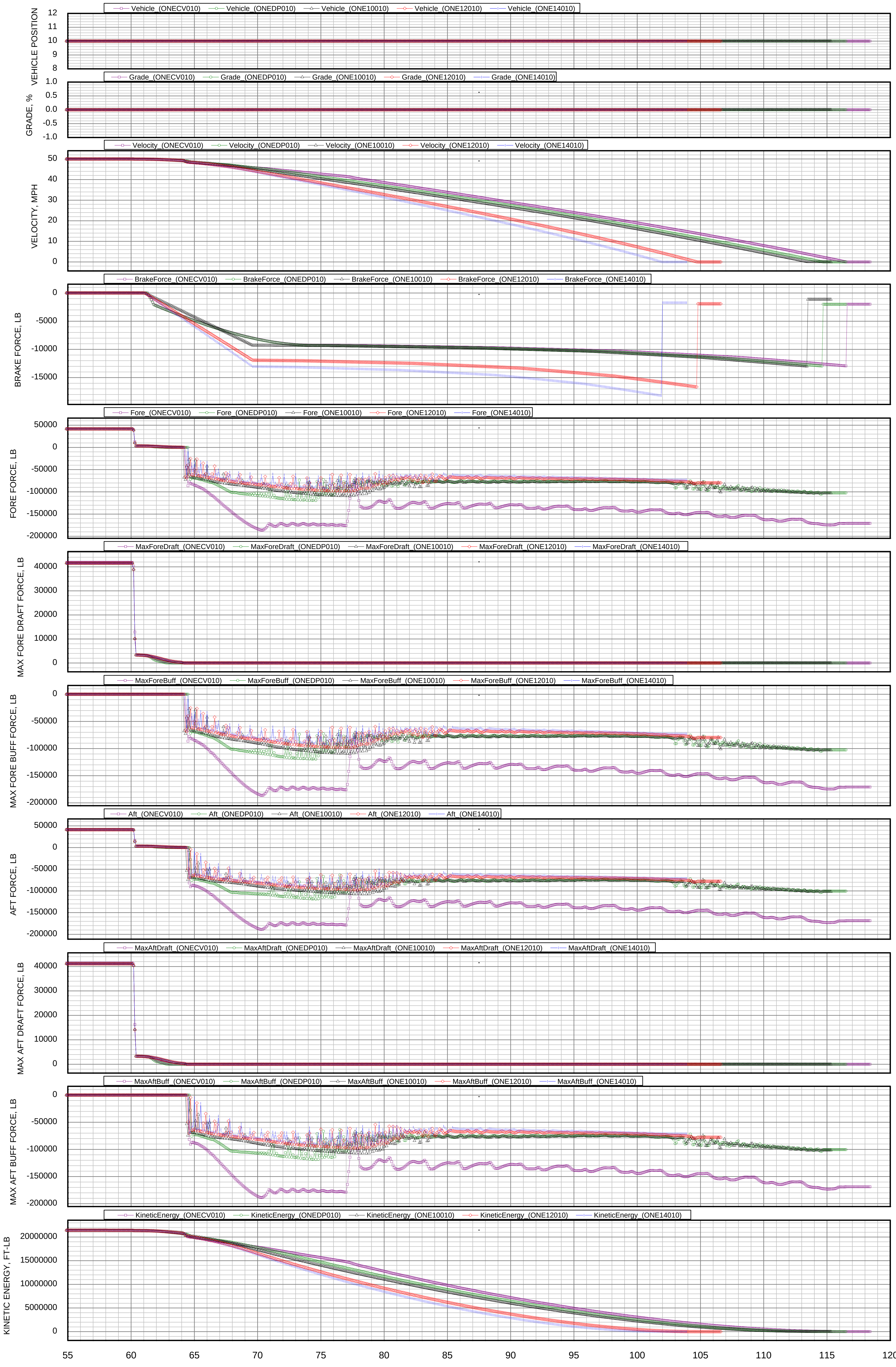
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 007 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 7]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



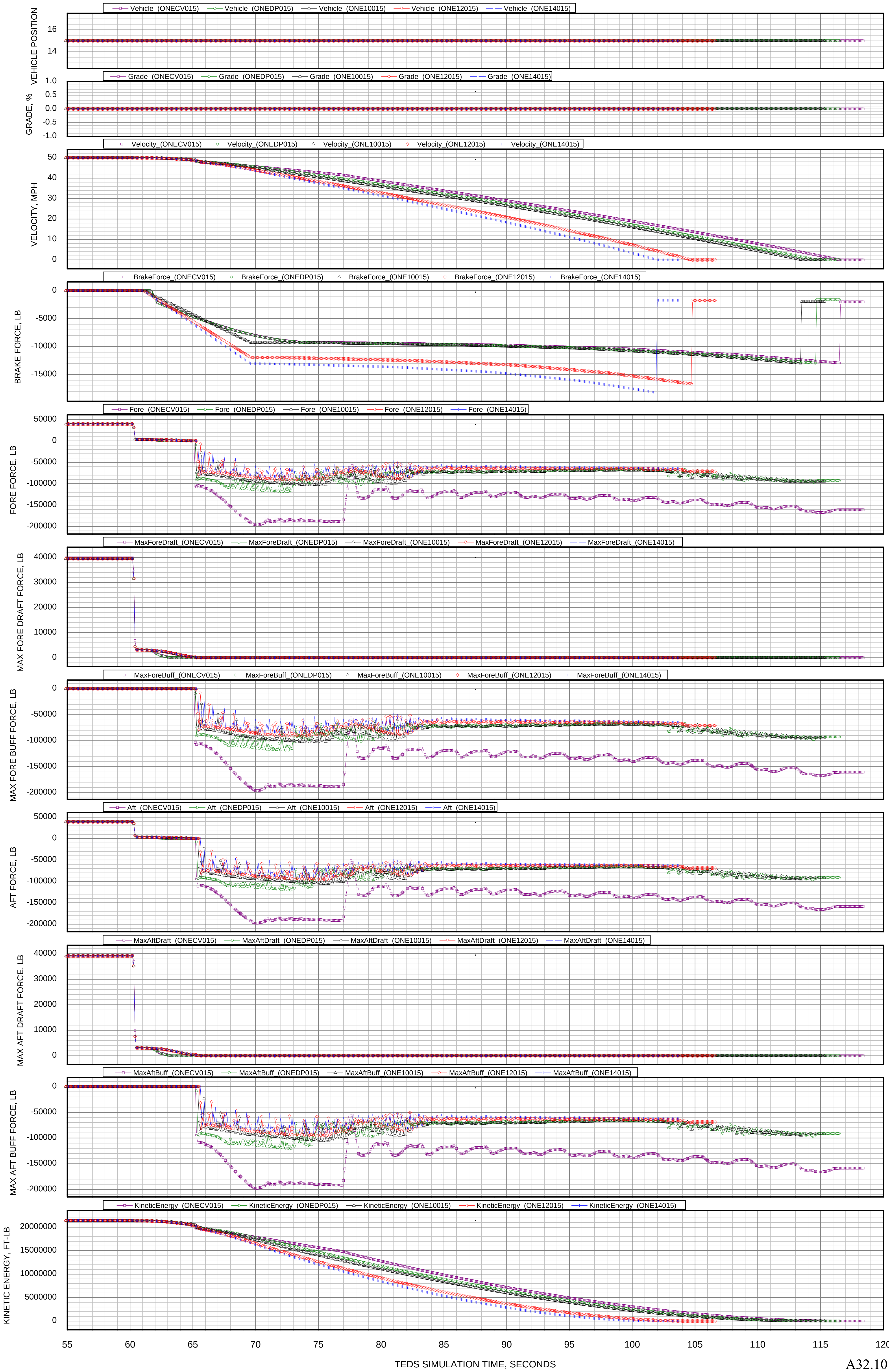
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 010 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 8]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



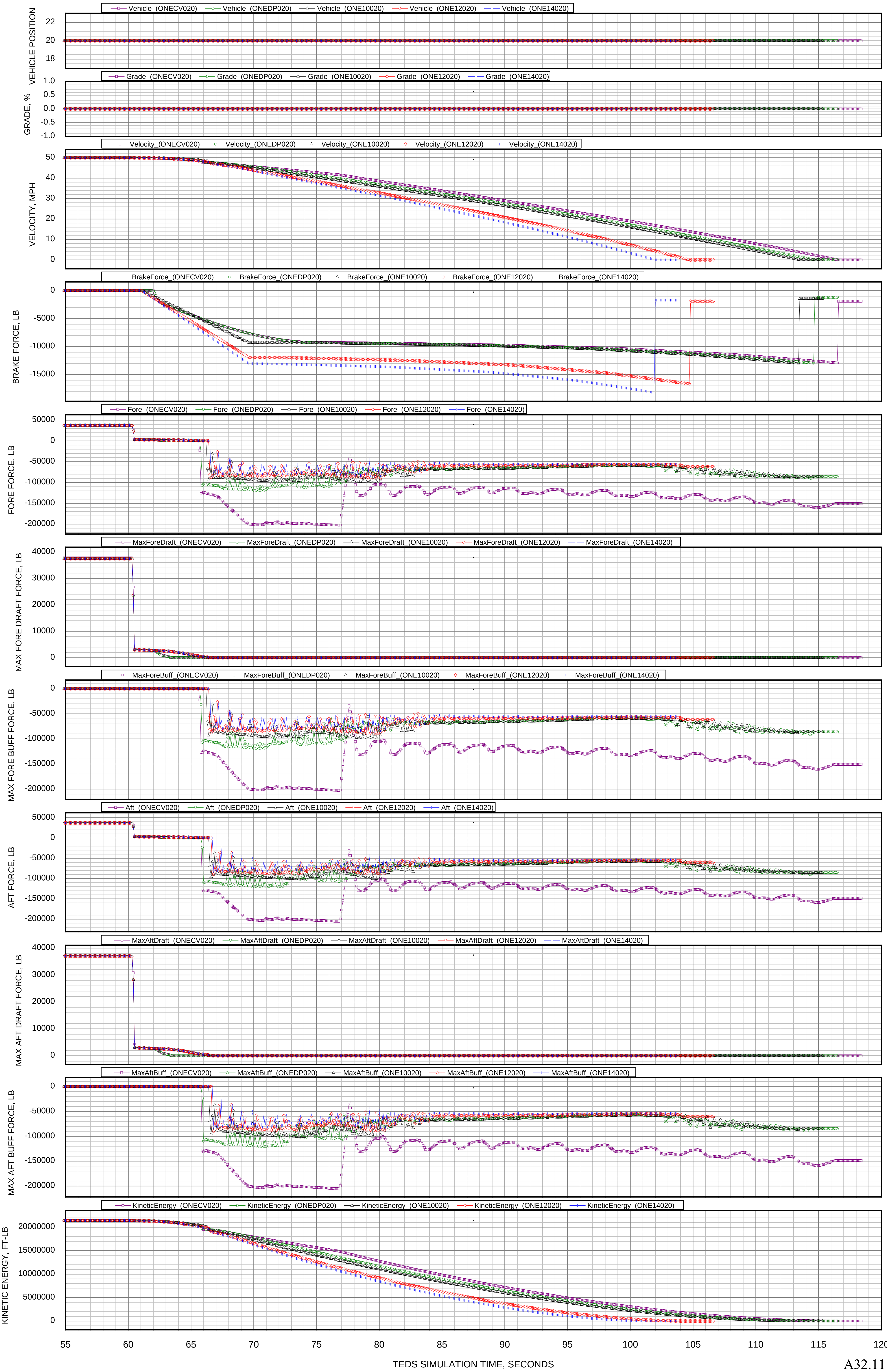
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 015 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 9]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

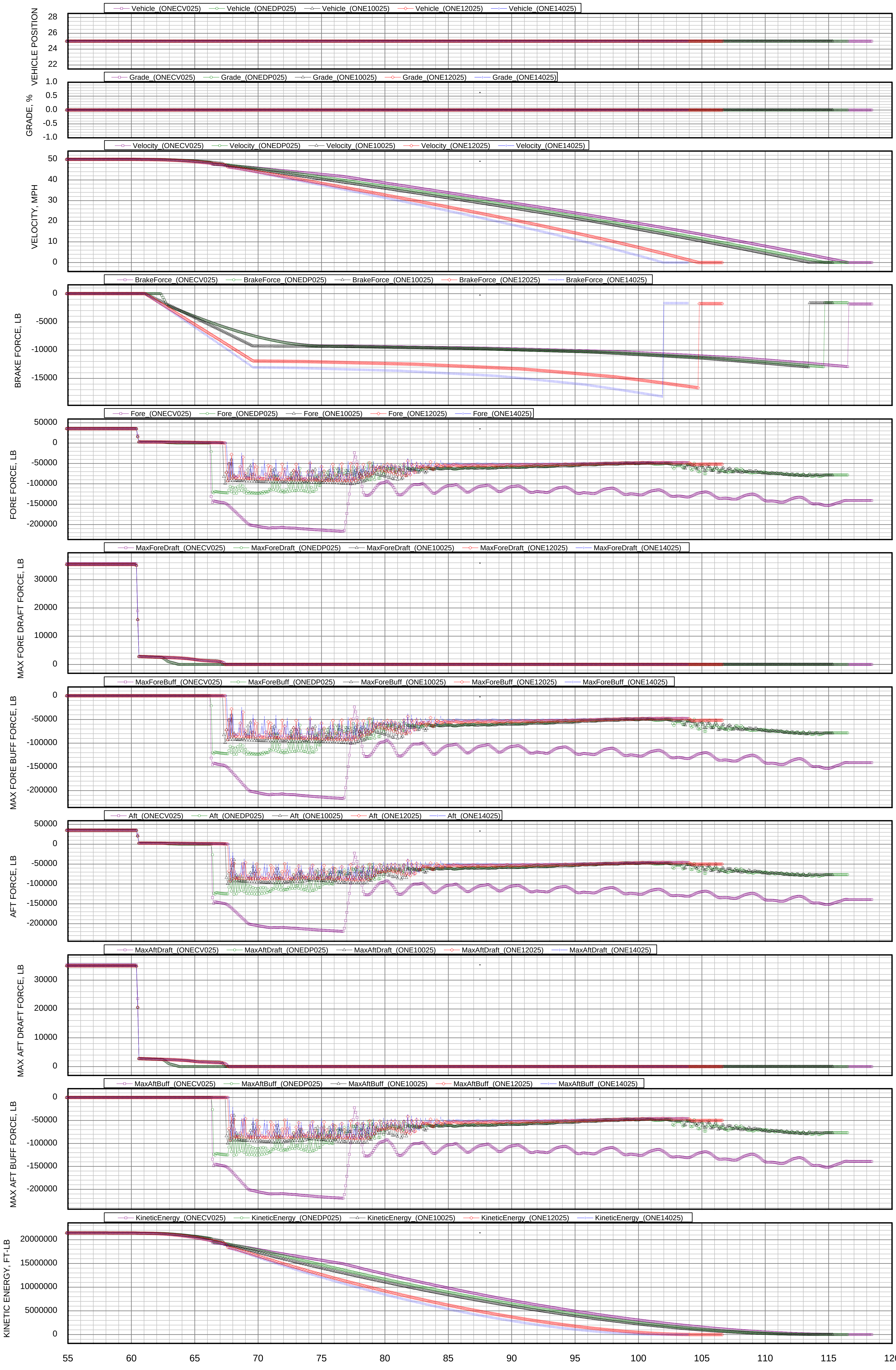
TEDS SIMULATION DATA FOR VEHICLE 020 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 10]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

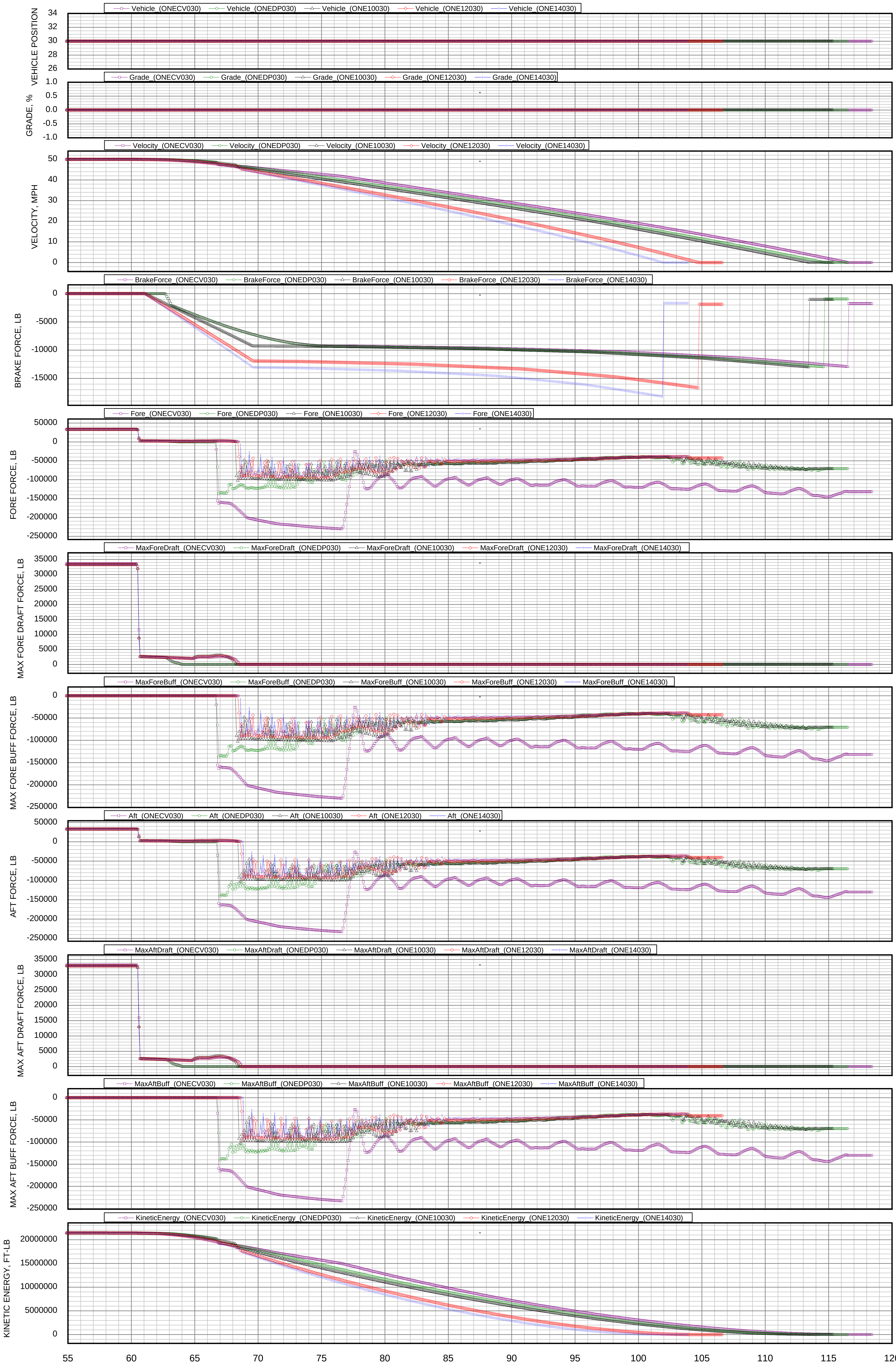
TEDS SIMULATION DATA FOR VEHICLE 025 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 11]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



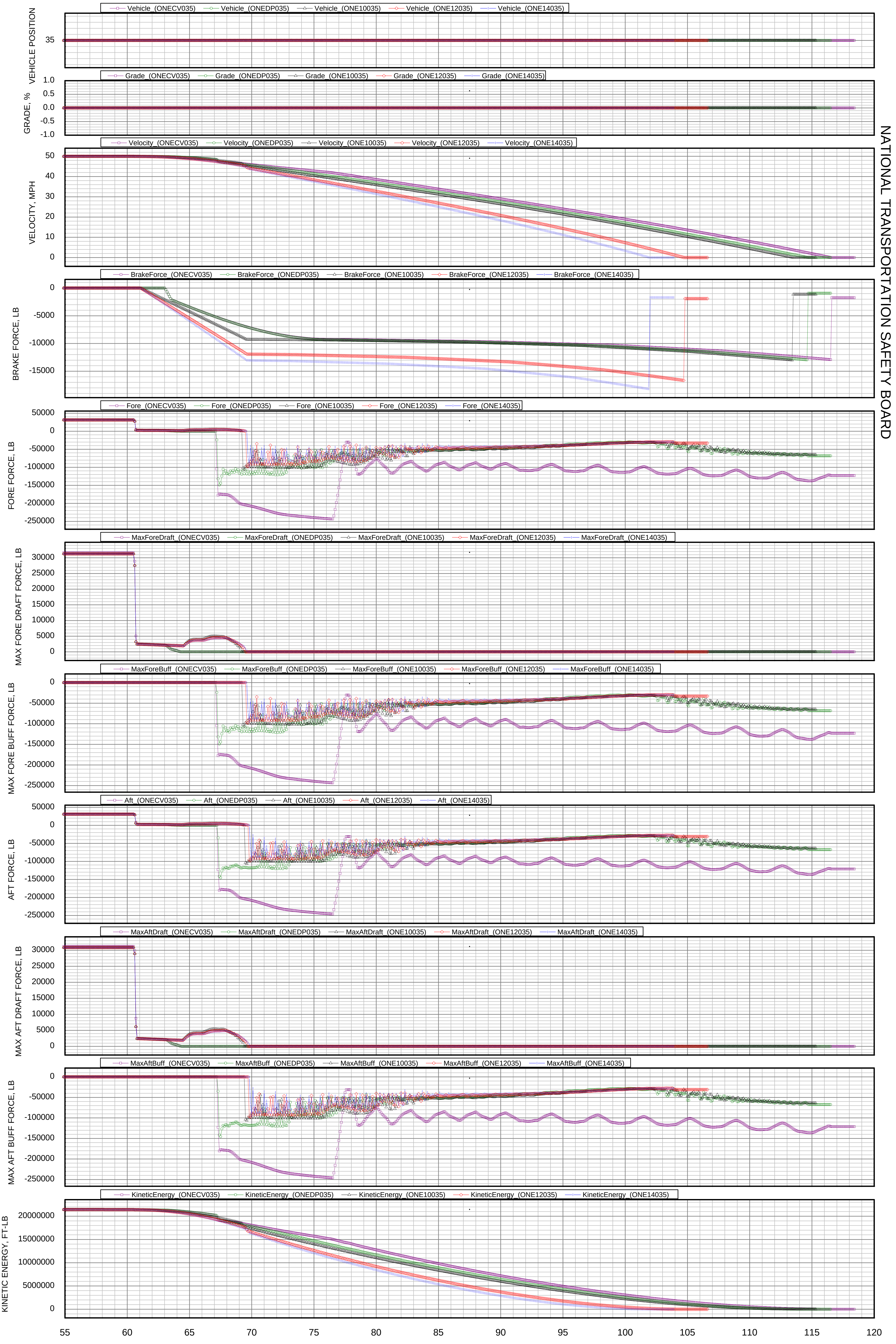
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 030 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 12]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

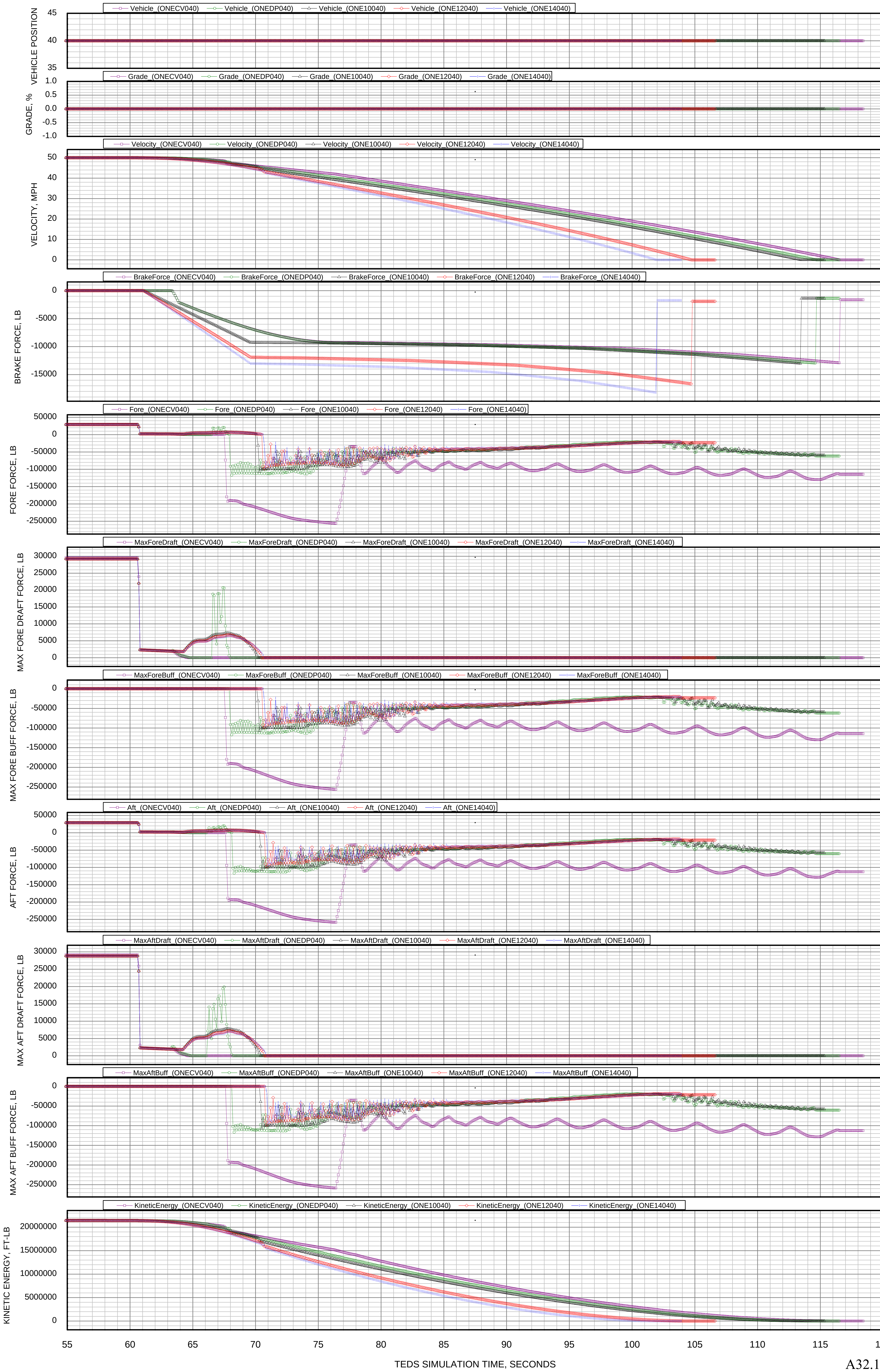
TEDS SIMULATION DATA FOR VEHICLE 035 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 13]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



A32.14

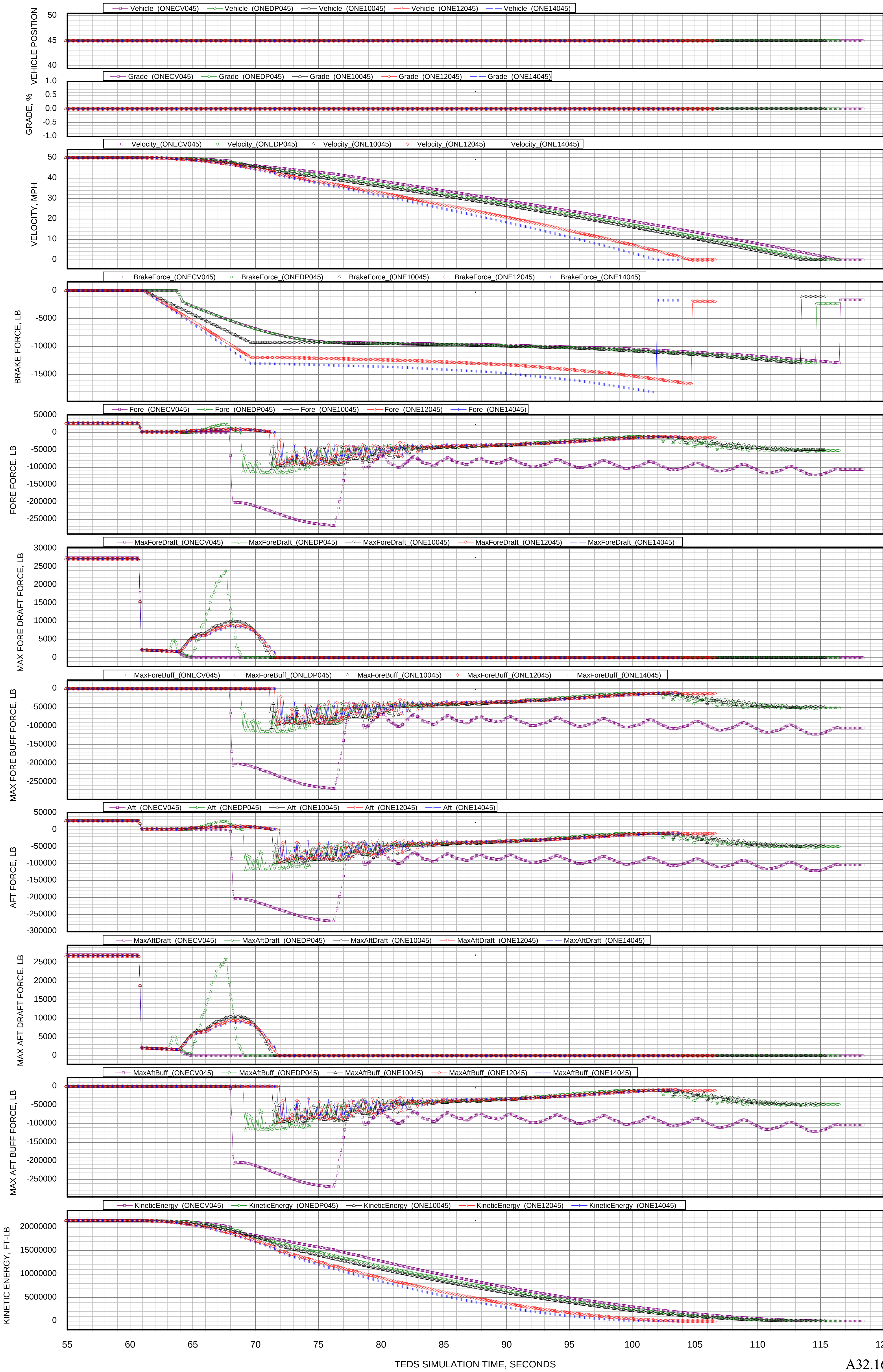
TEDS SIMULATION DATA FOR VEHICLE 040 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 14]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

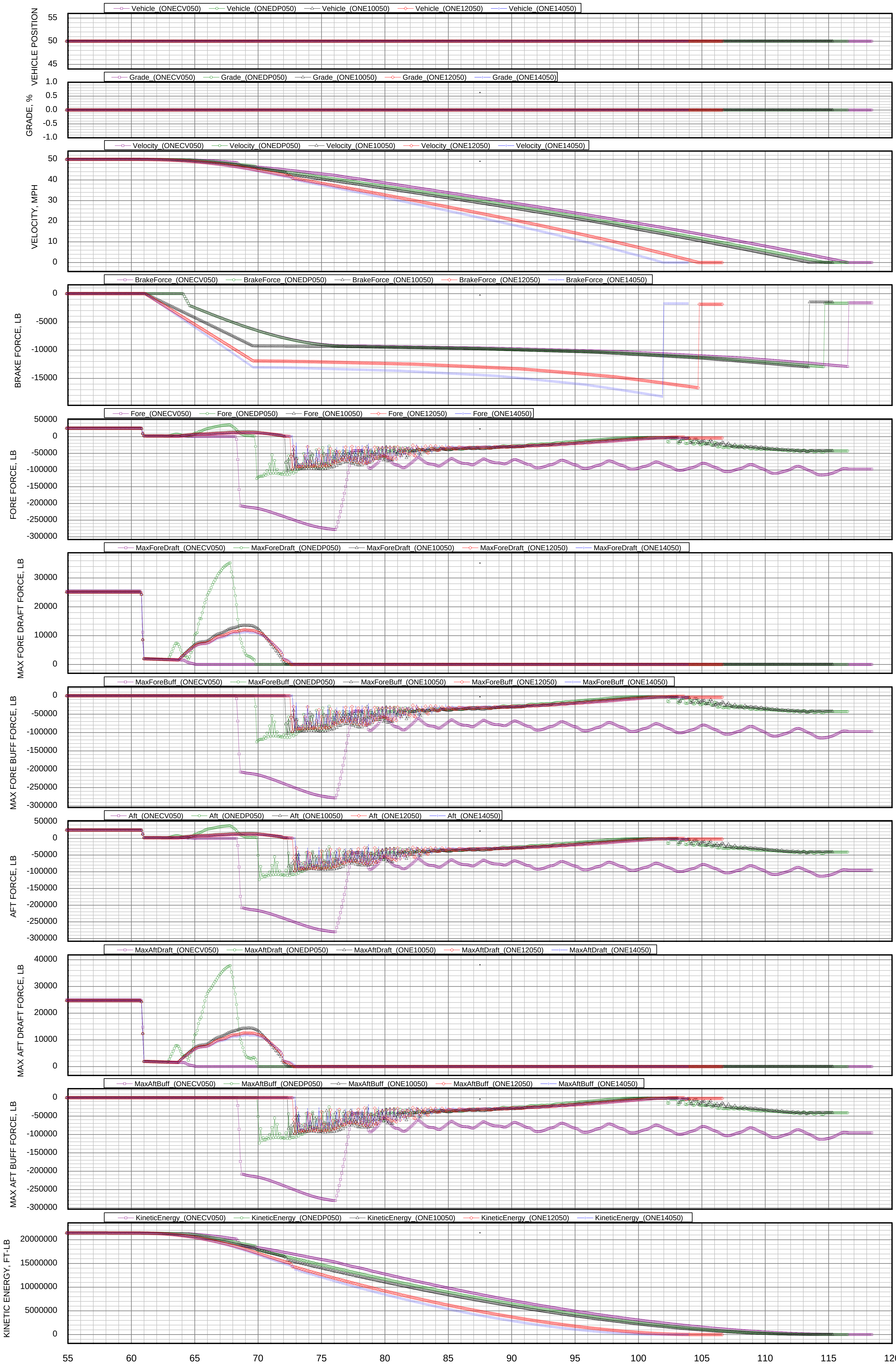
TEDS SIMULATION DATA FOR VEHICLE 045 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 15]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 050 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 16]

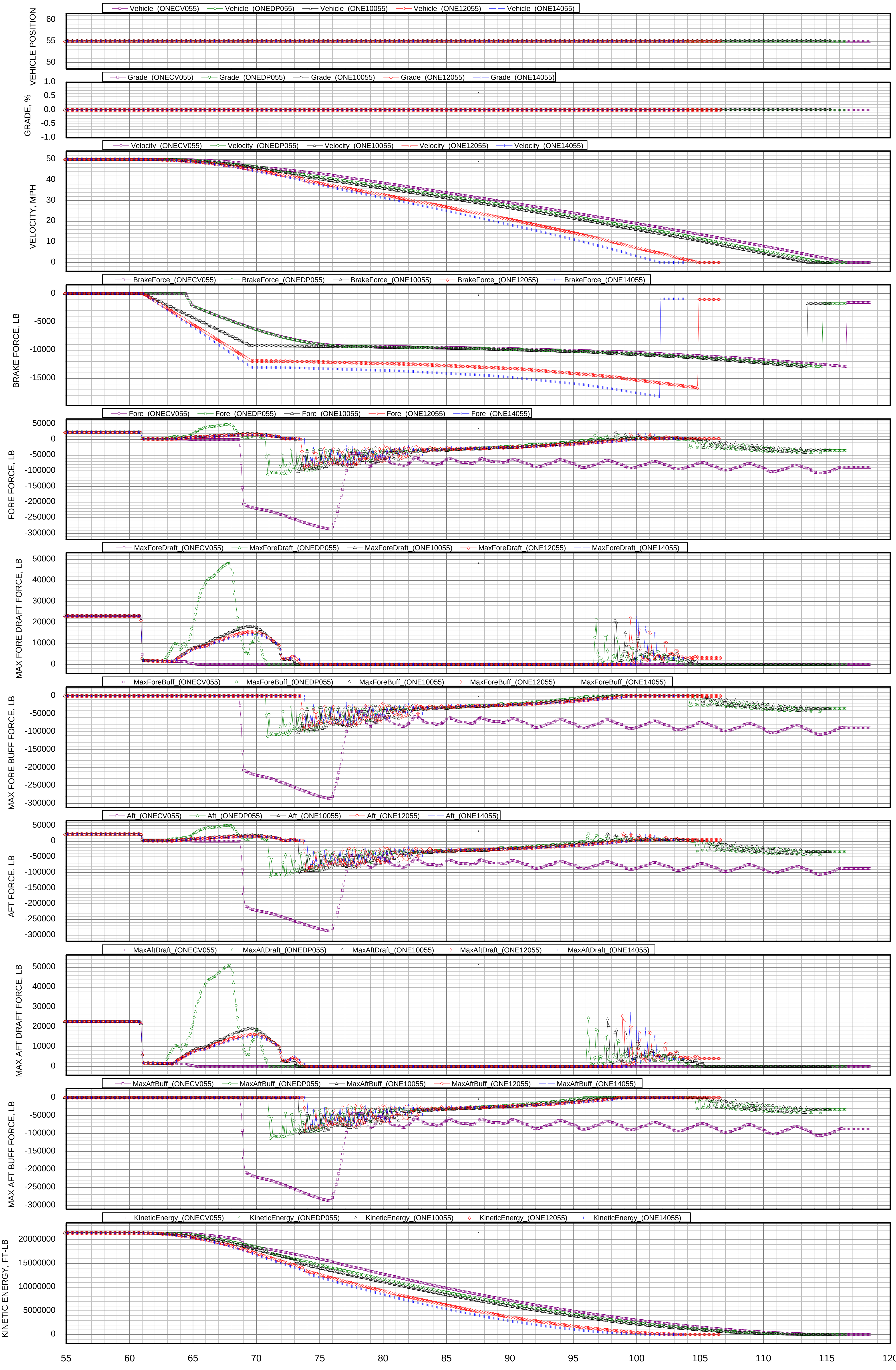
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

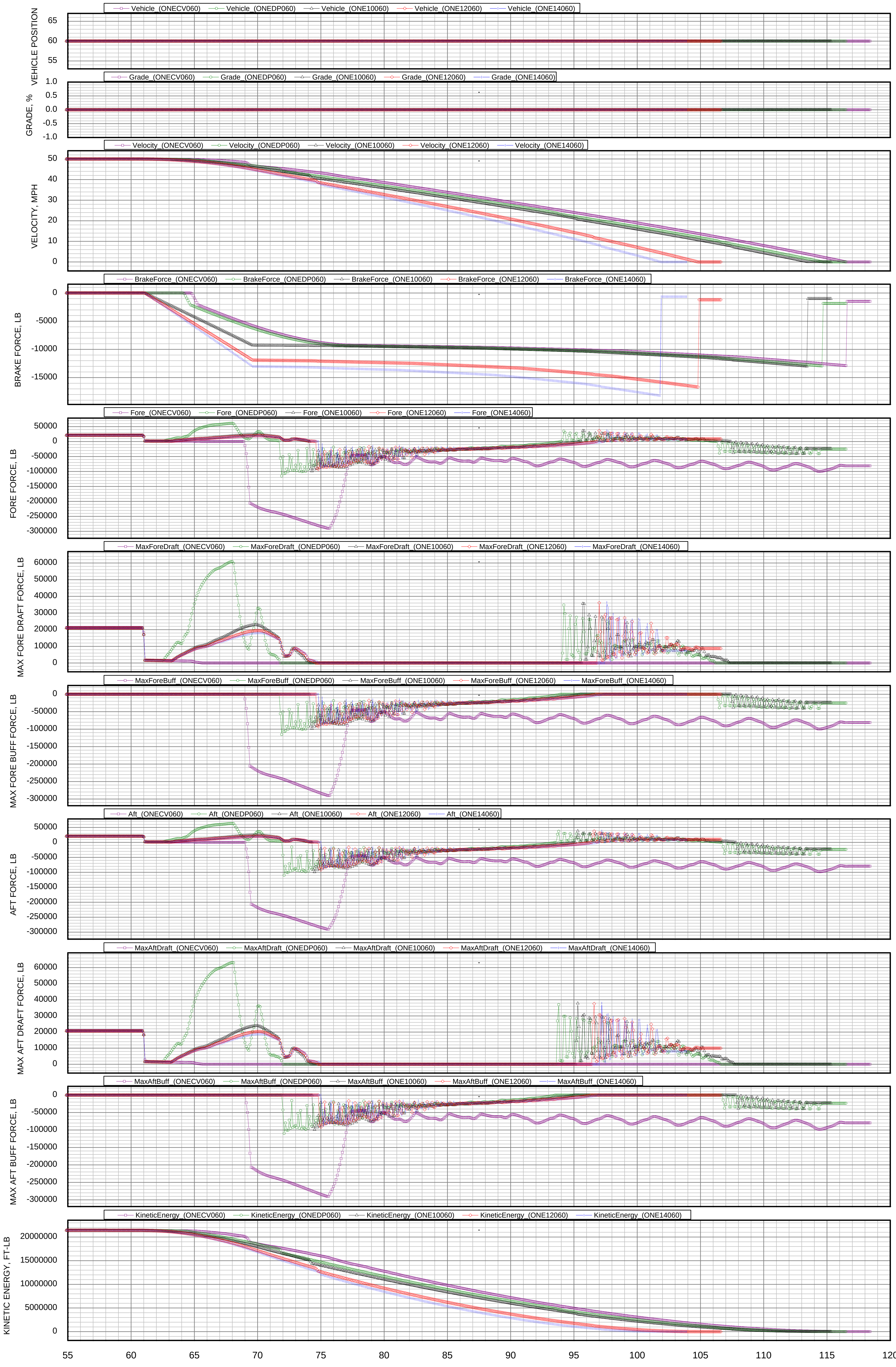
TEDS SIMULATION DATA FOR VEHICLE 055 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 17]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



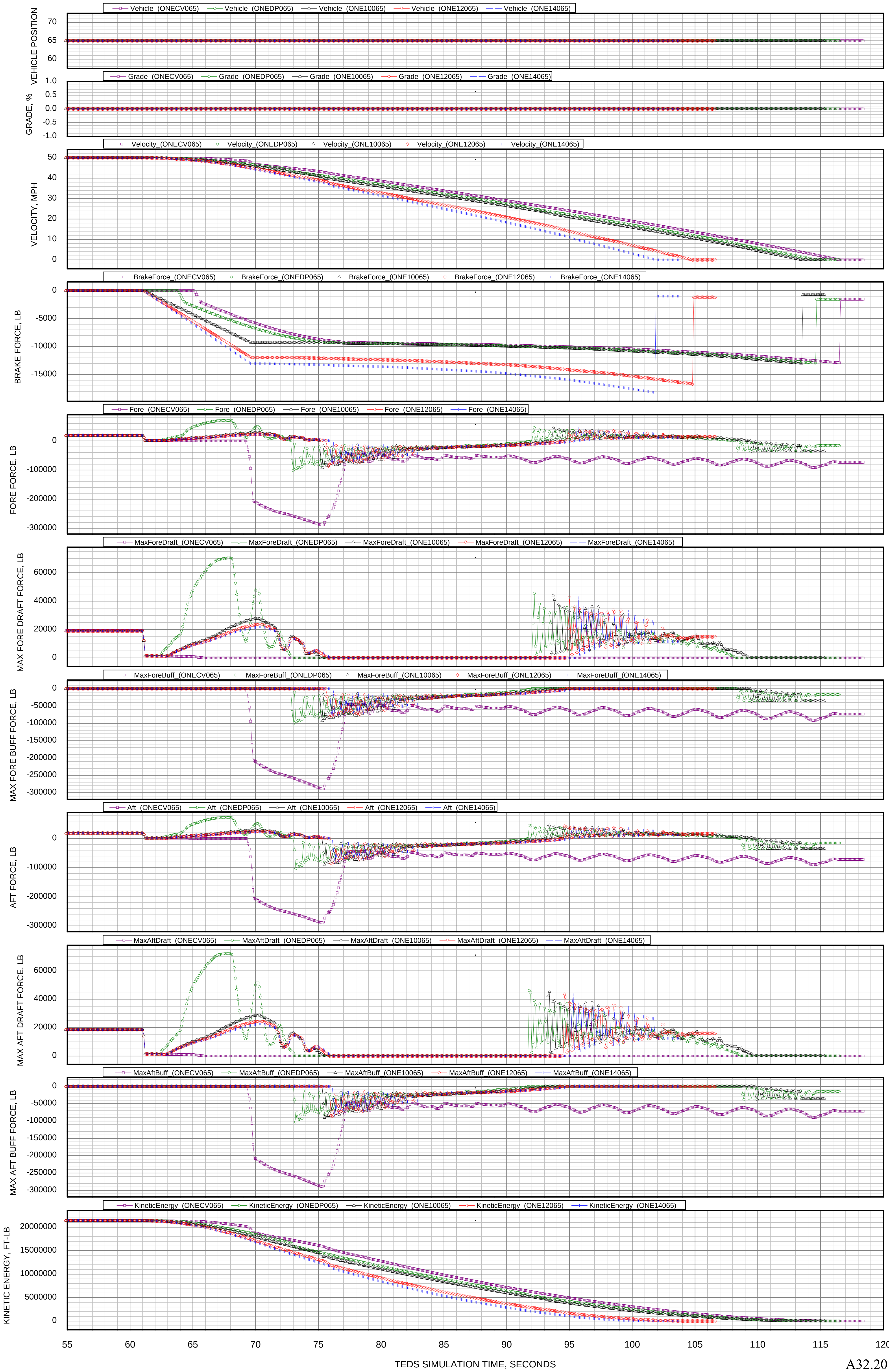
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 060 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 18]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

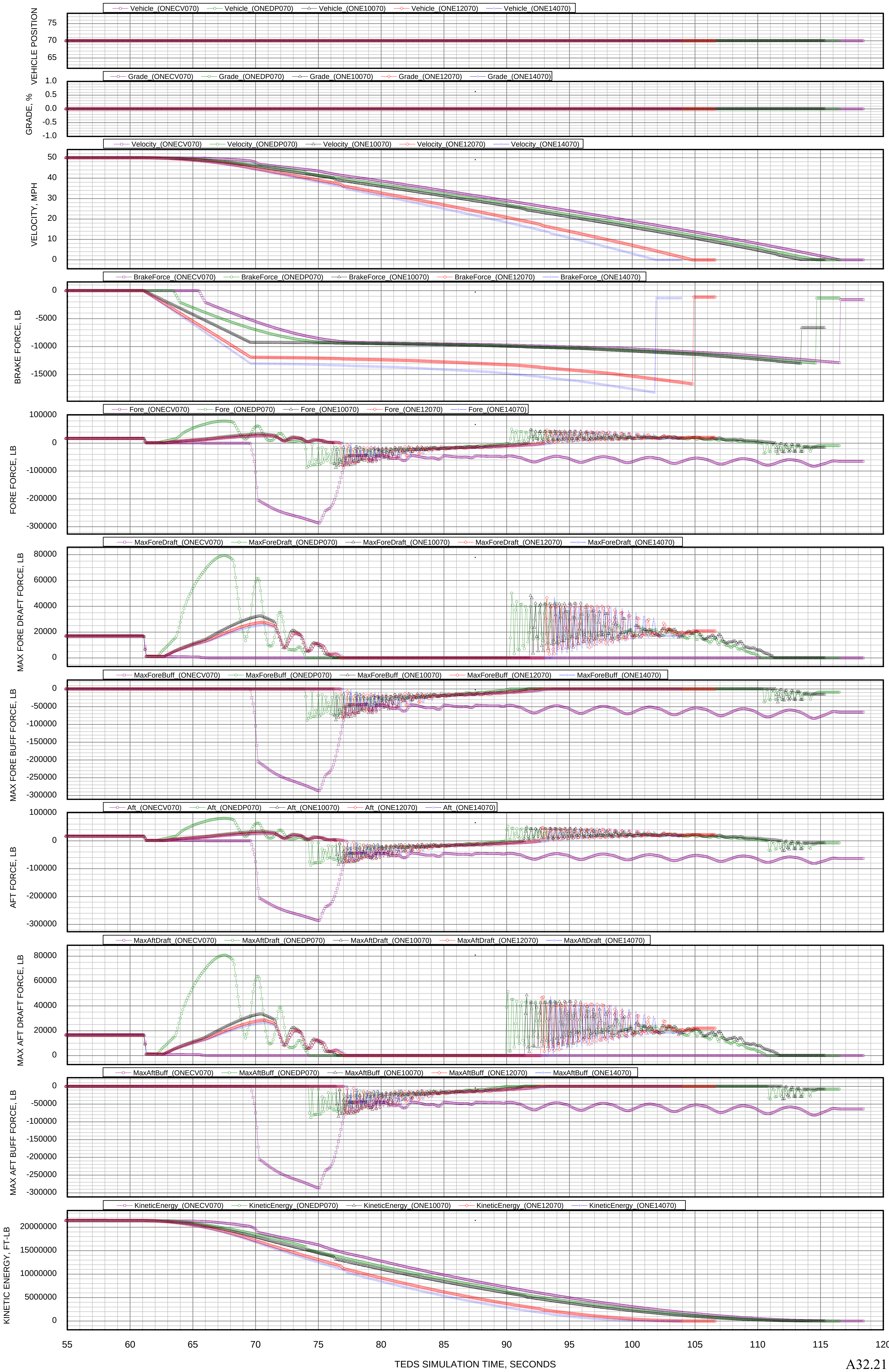
TEDS SIMULATION DATA FOR VEHICLE 065 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 19]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 070 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 20]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

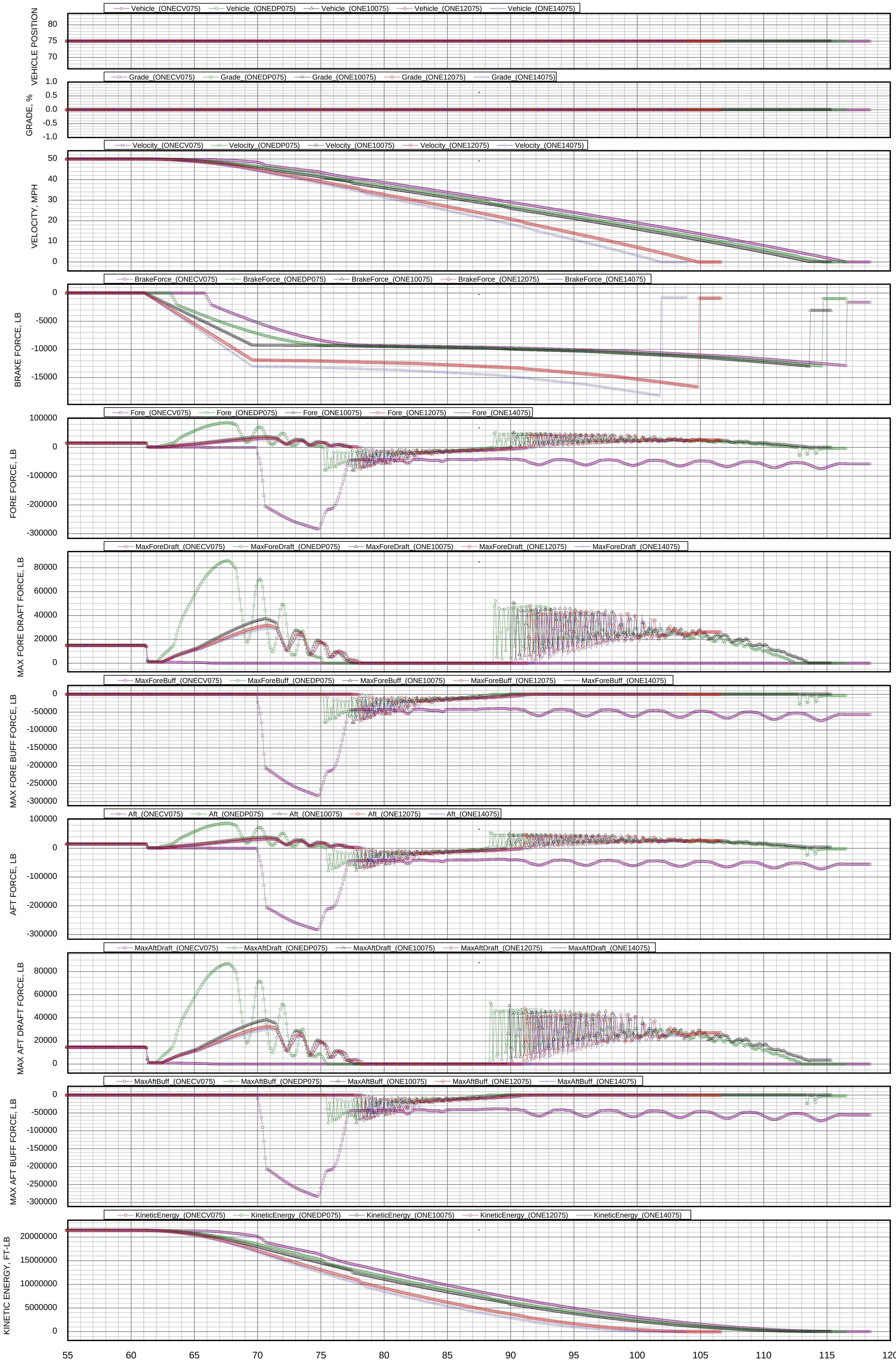


NATIONAL TRANSPORTATION SAFETY BOARD

A32.21

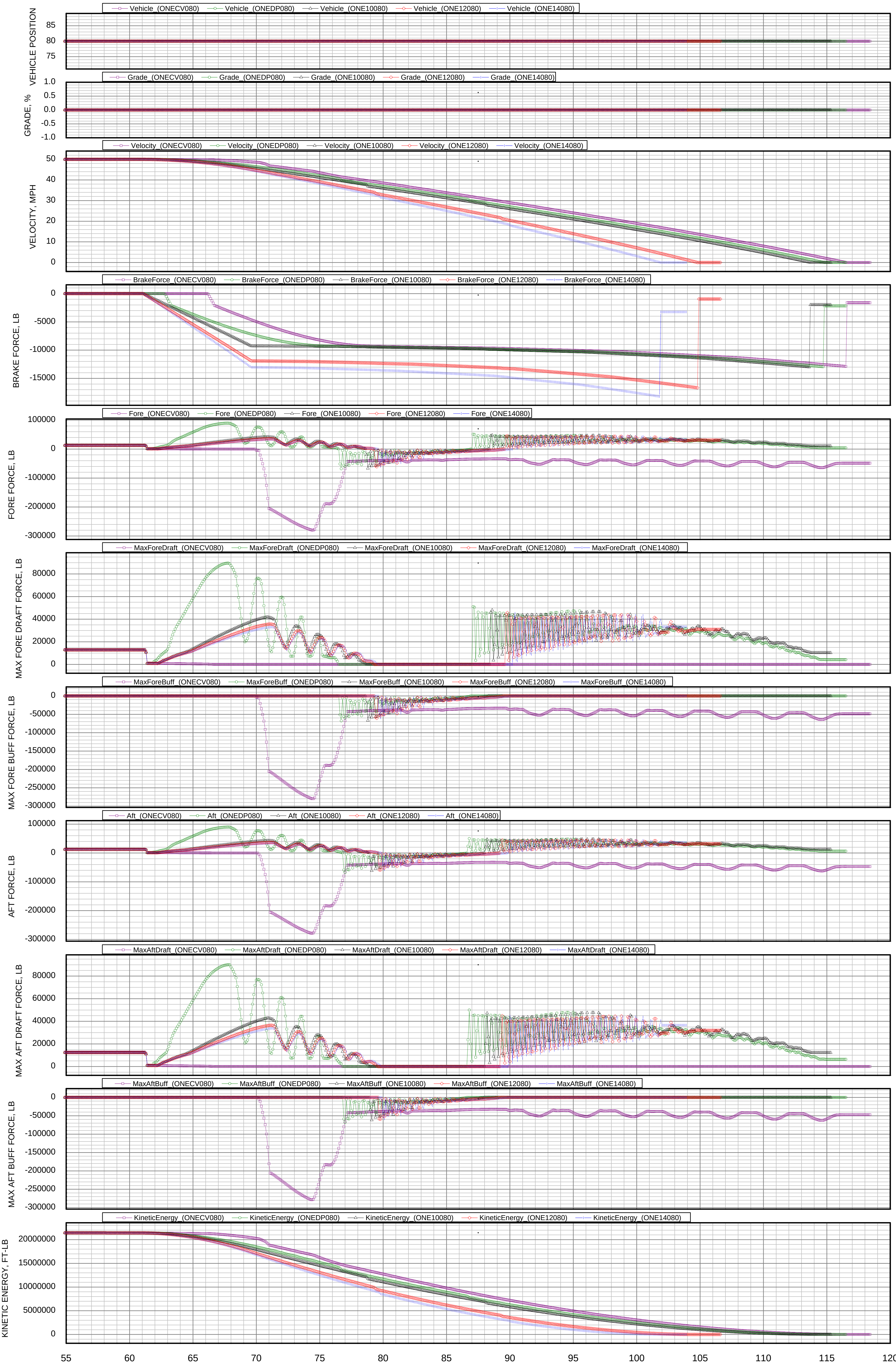
TEDS SIMULATION DATA FOR VEHICLE 075 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 21]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

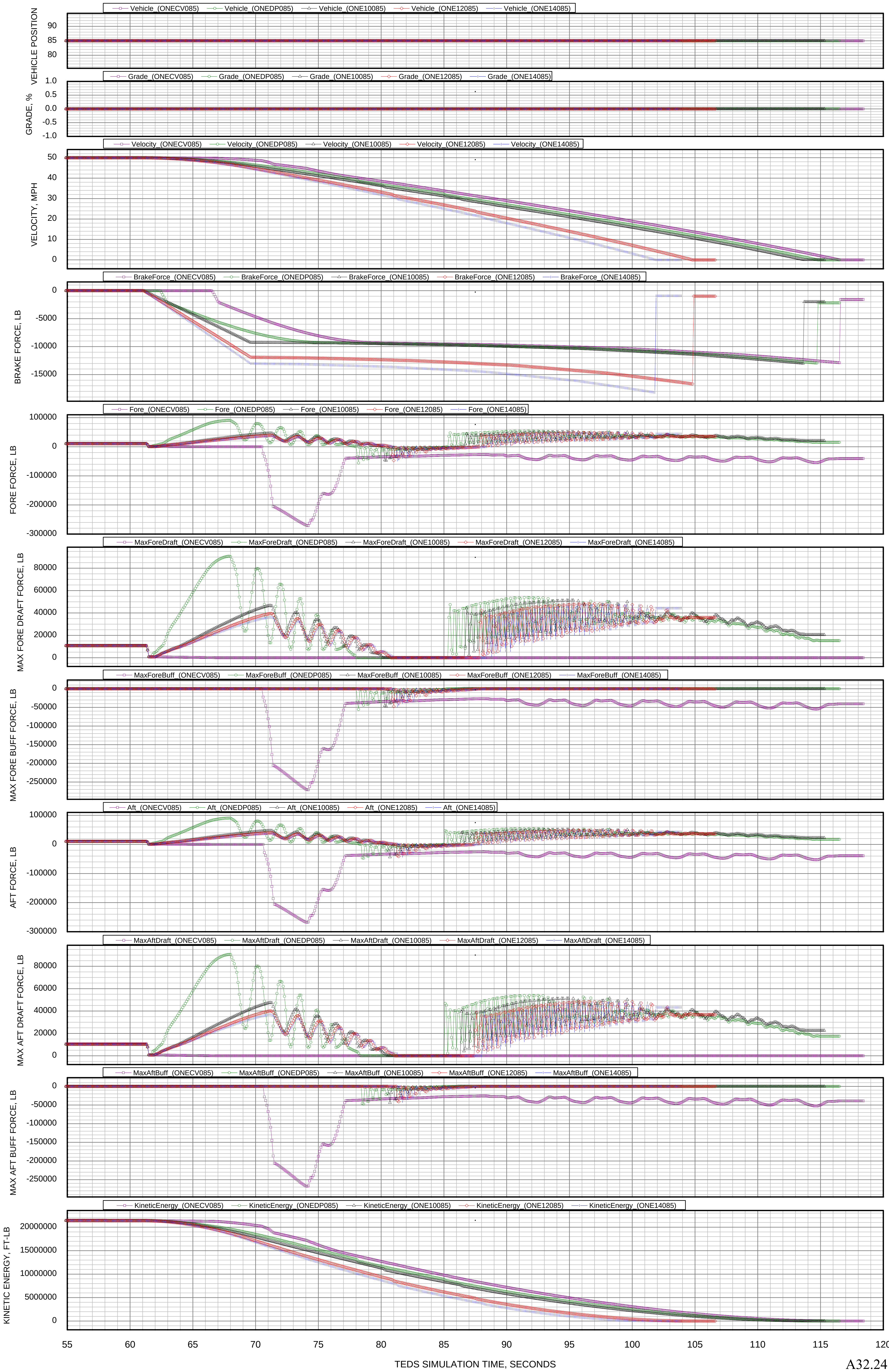


TEDS SIMULATION DATA FOR VEHICLE 080 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 22]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE

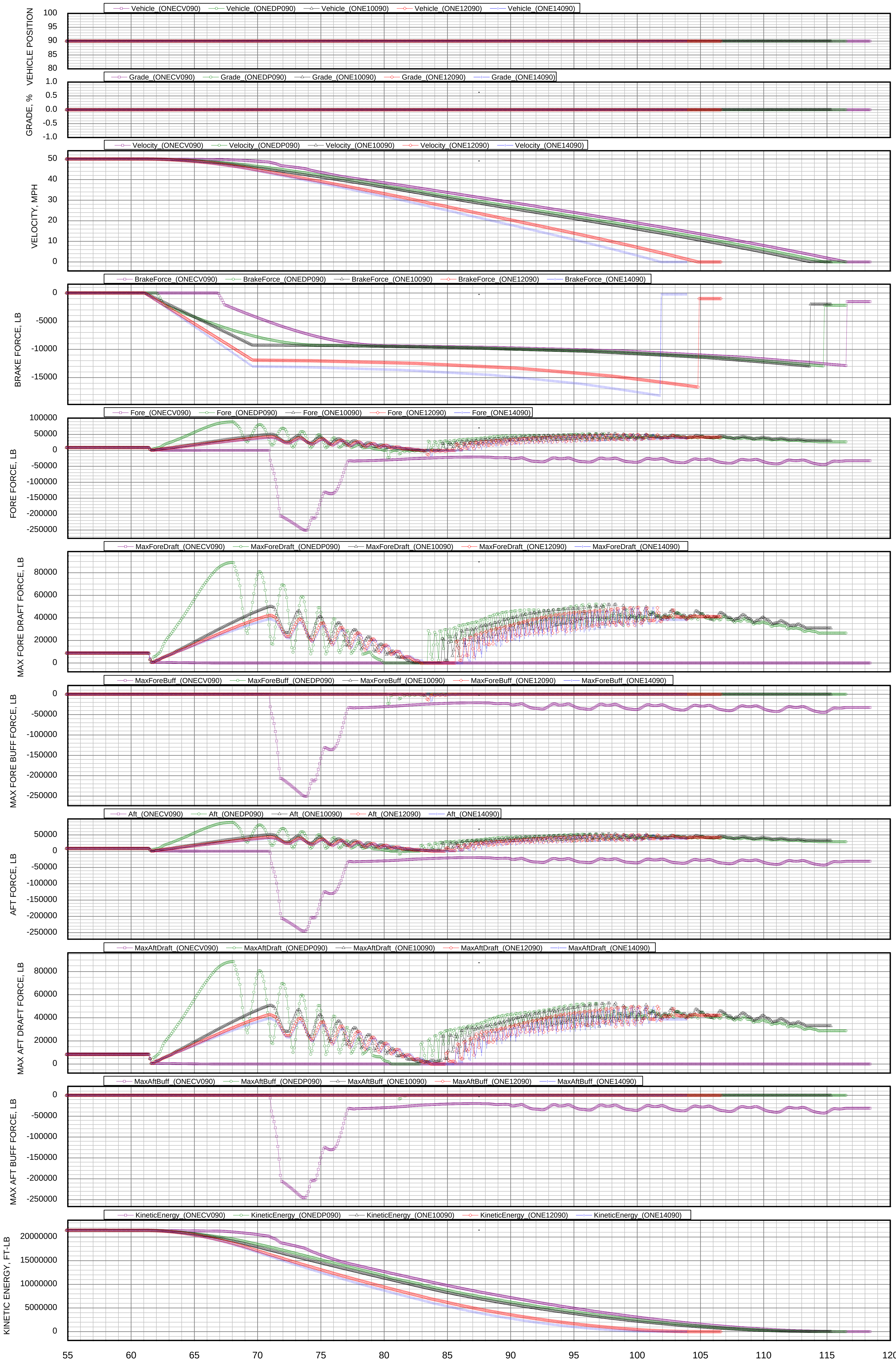


TEDS SIMULATION DATA FOR VEHICLE 085 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 23]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

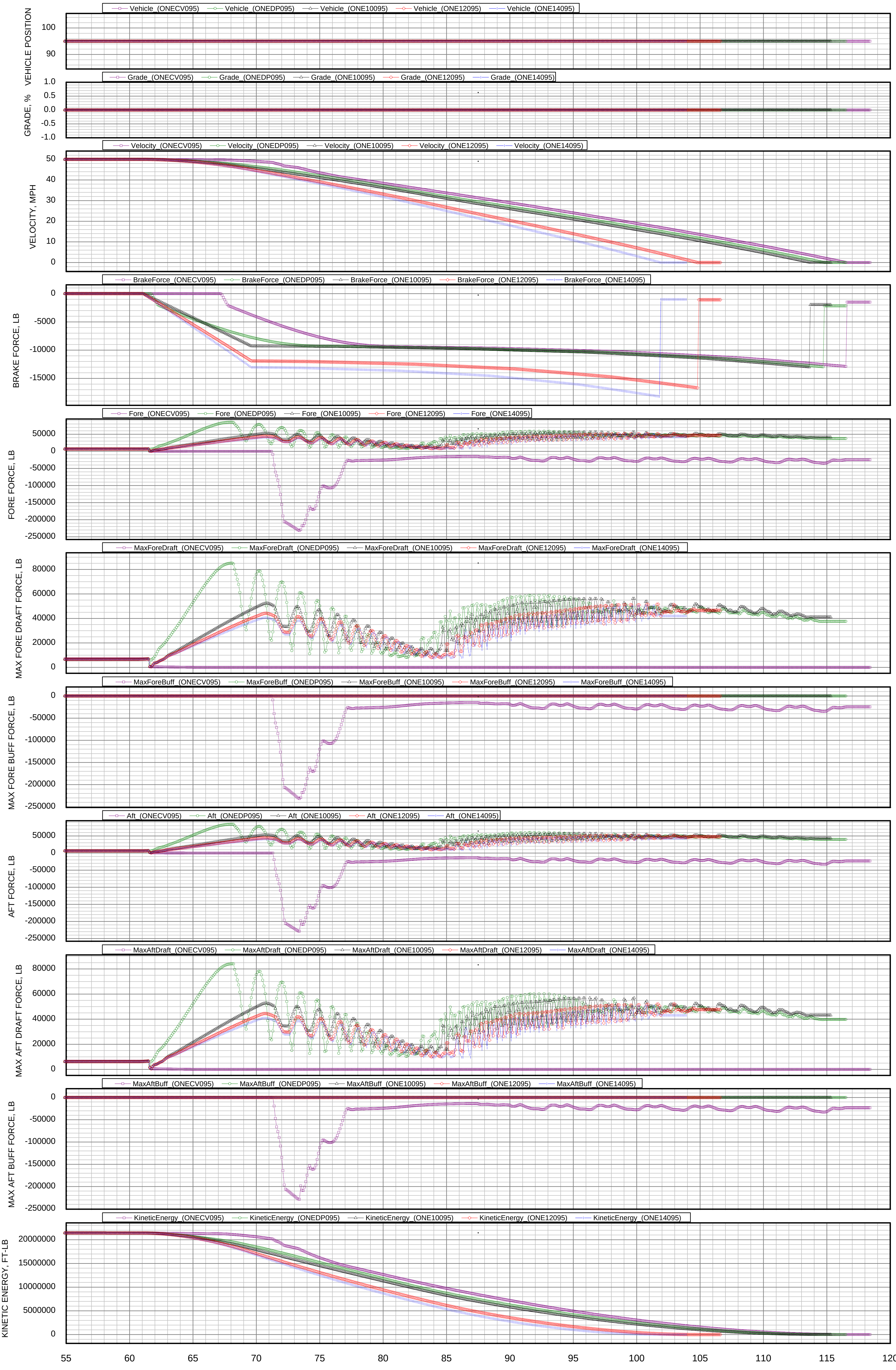
TEDS SIMULATION DATA FOR VEHICLE 090 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 24]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 095 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 25]

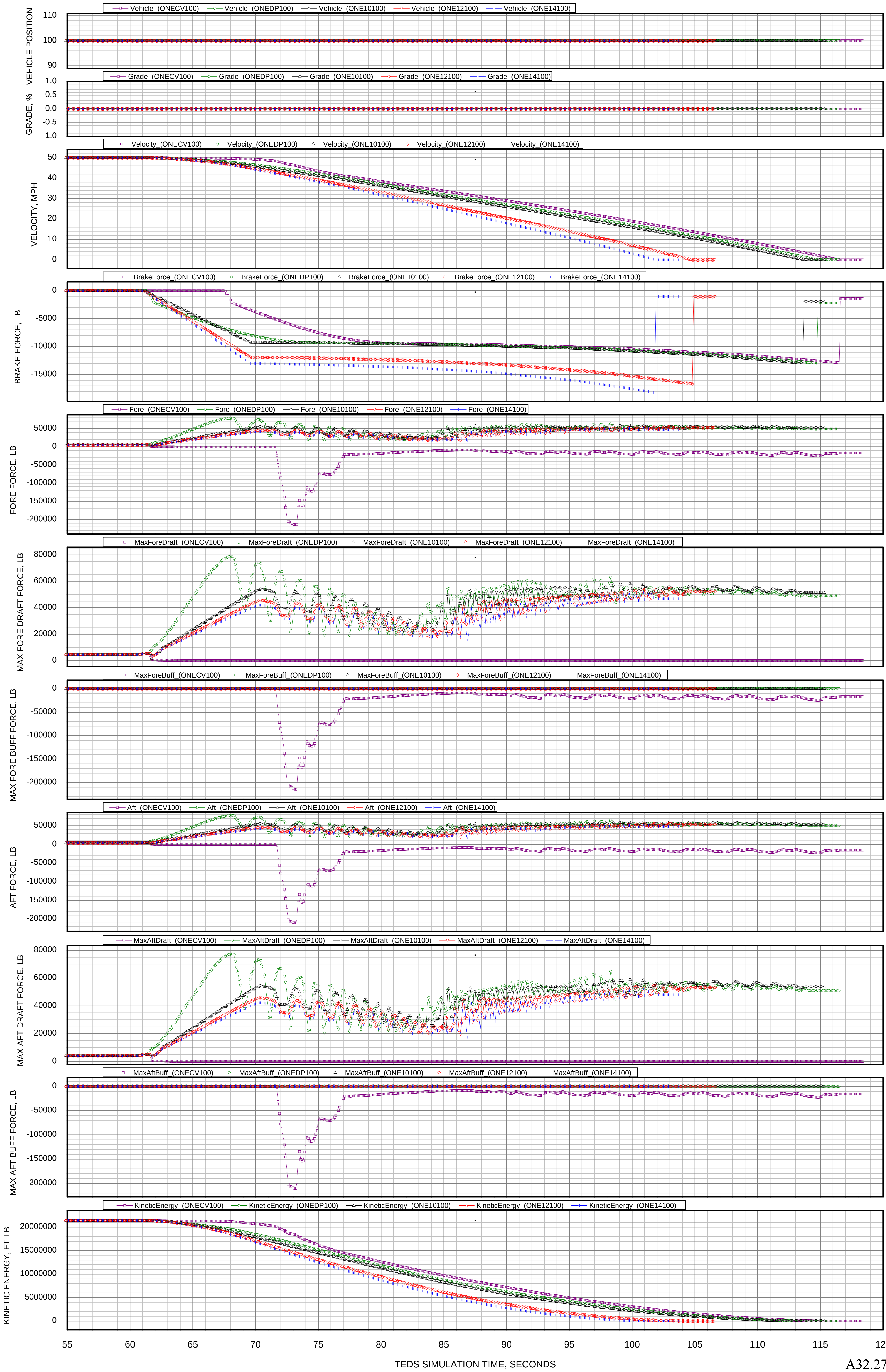
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

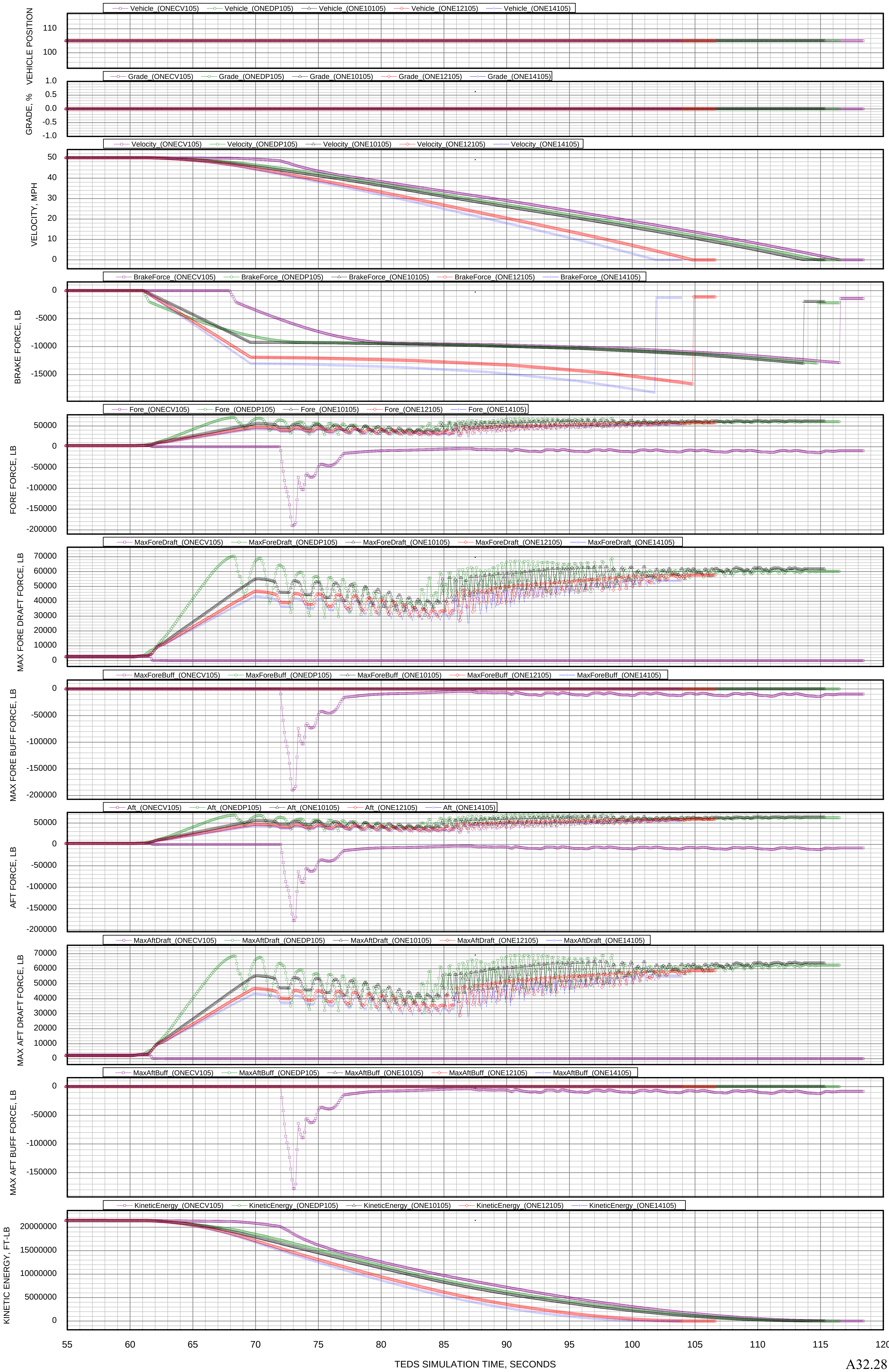
TEDS SIMULATION DATA FOR VEHICLE 100 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 26]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

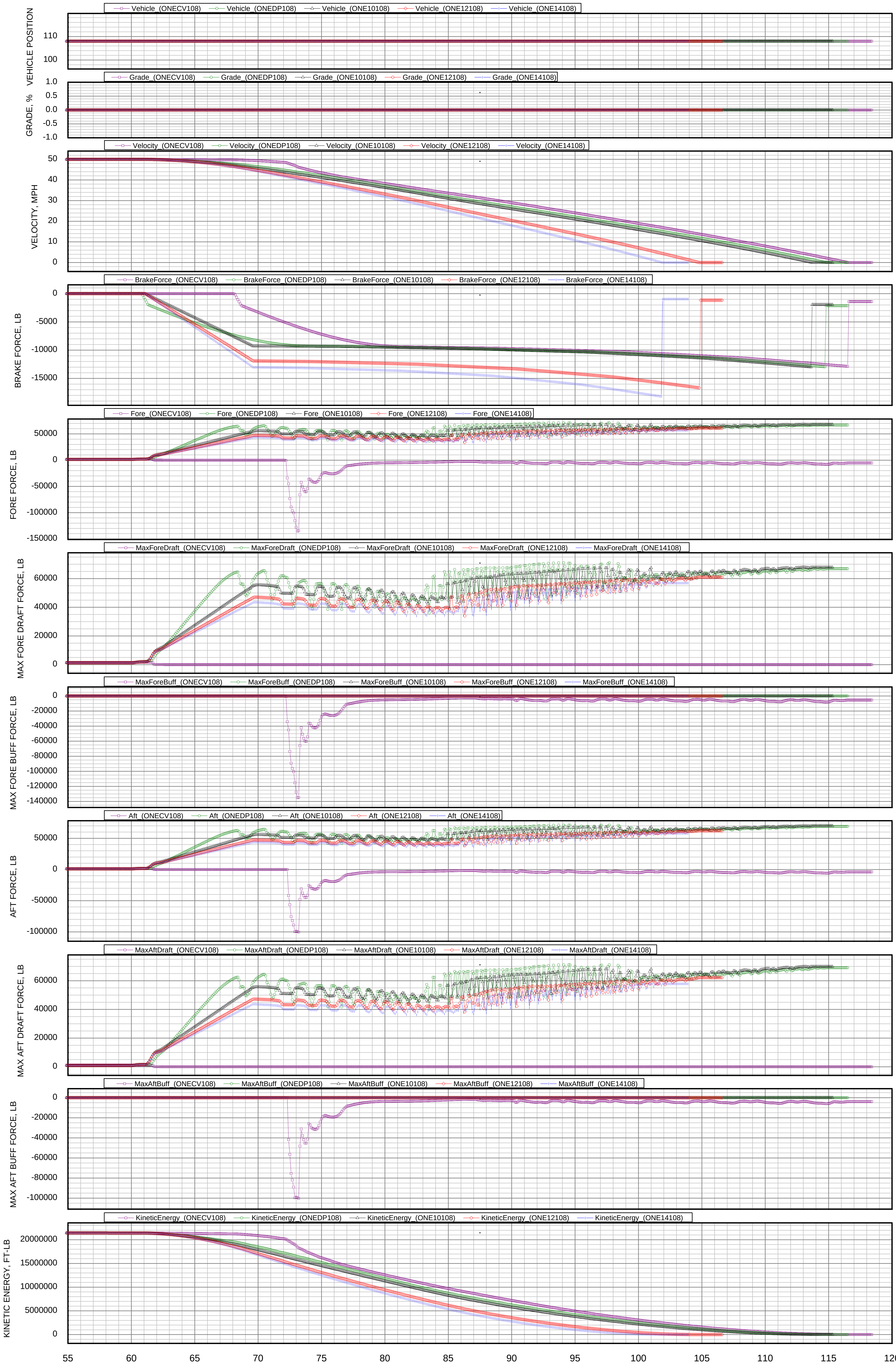
TEDS SIMULATION DATA FOR VEHICLE 105 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 27]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



NATIONAL TRANSPORTATION SAFETY BOARD

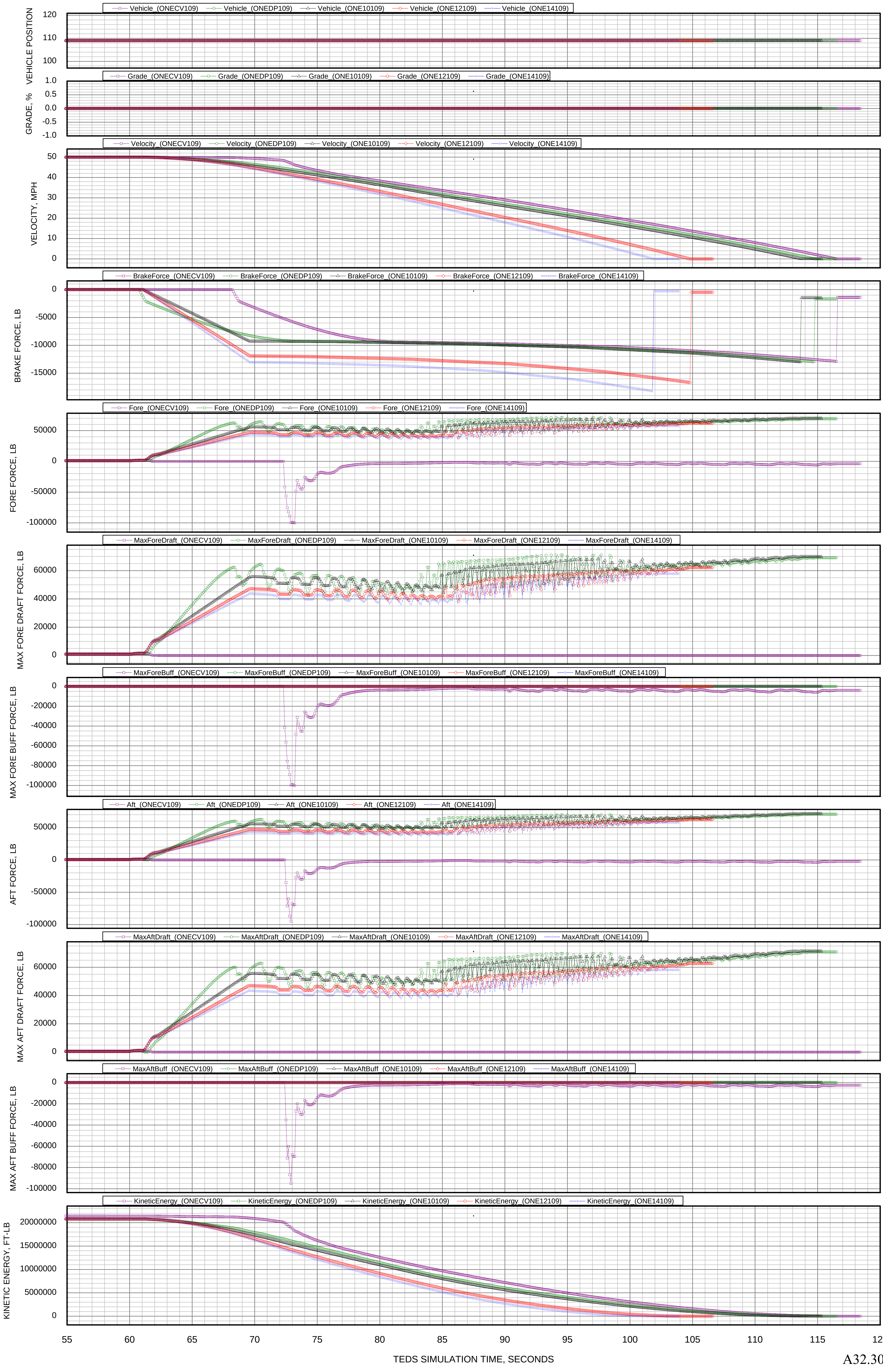
TEDS SIMULATION DATA FOR VEHICLE 108 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 28]

NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



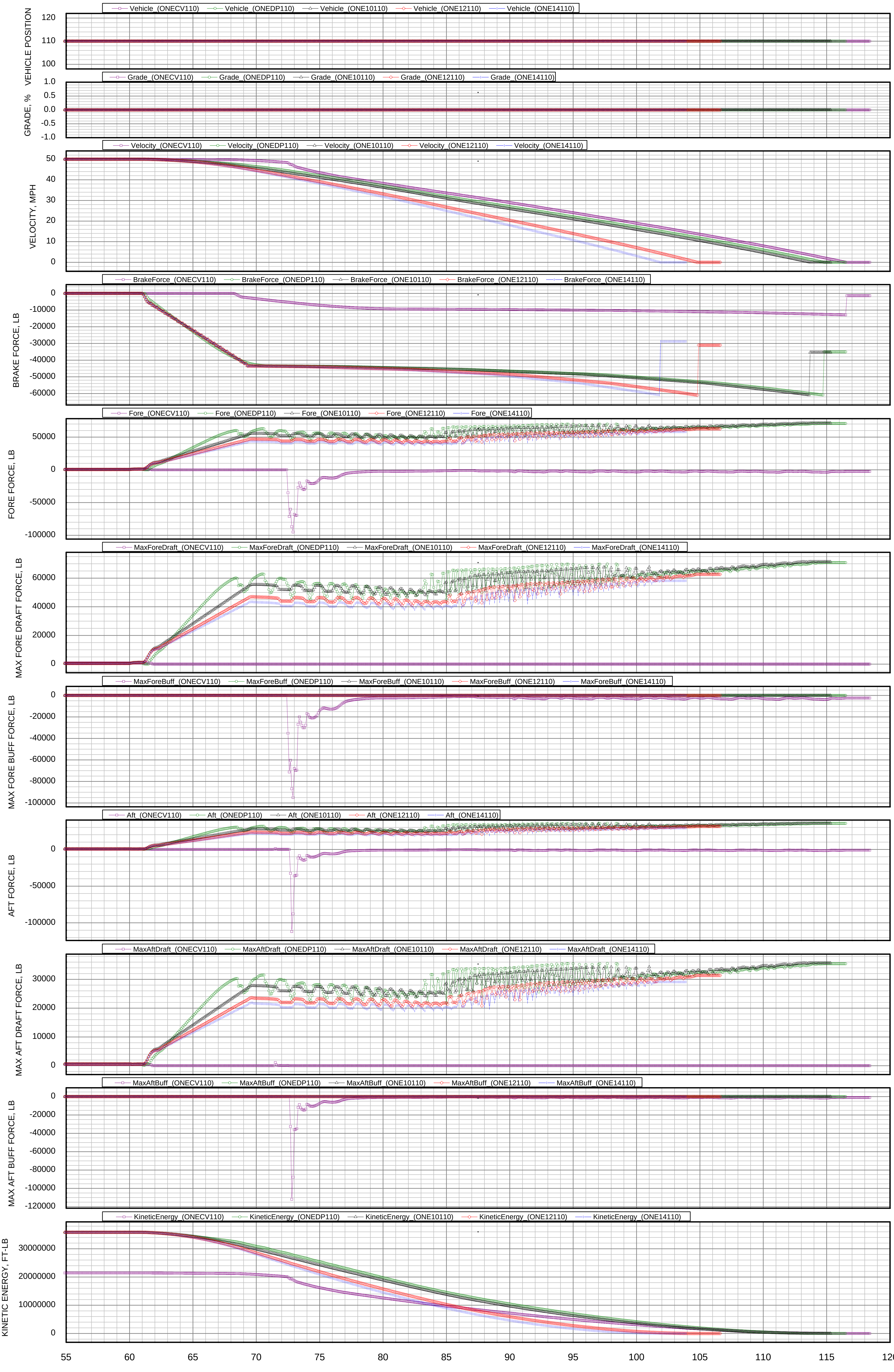
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 109 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 29]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



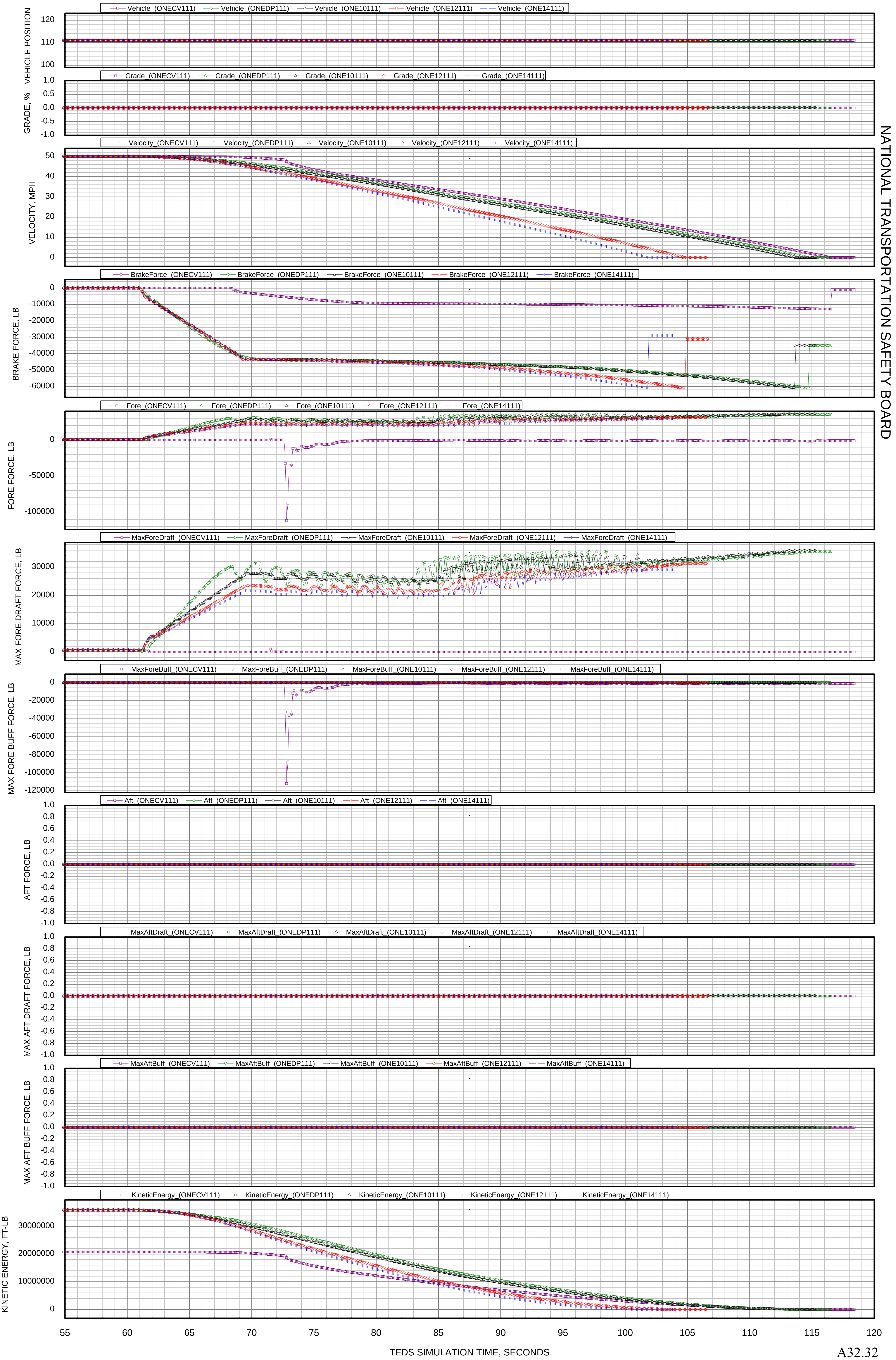
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 110 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 30]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



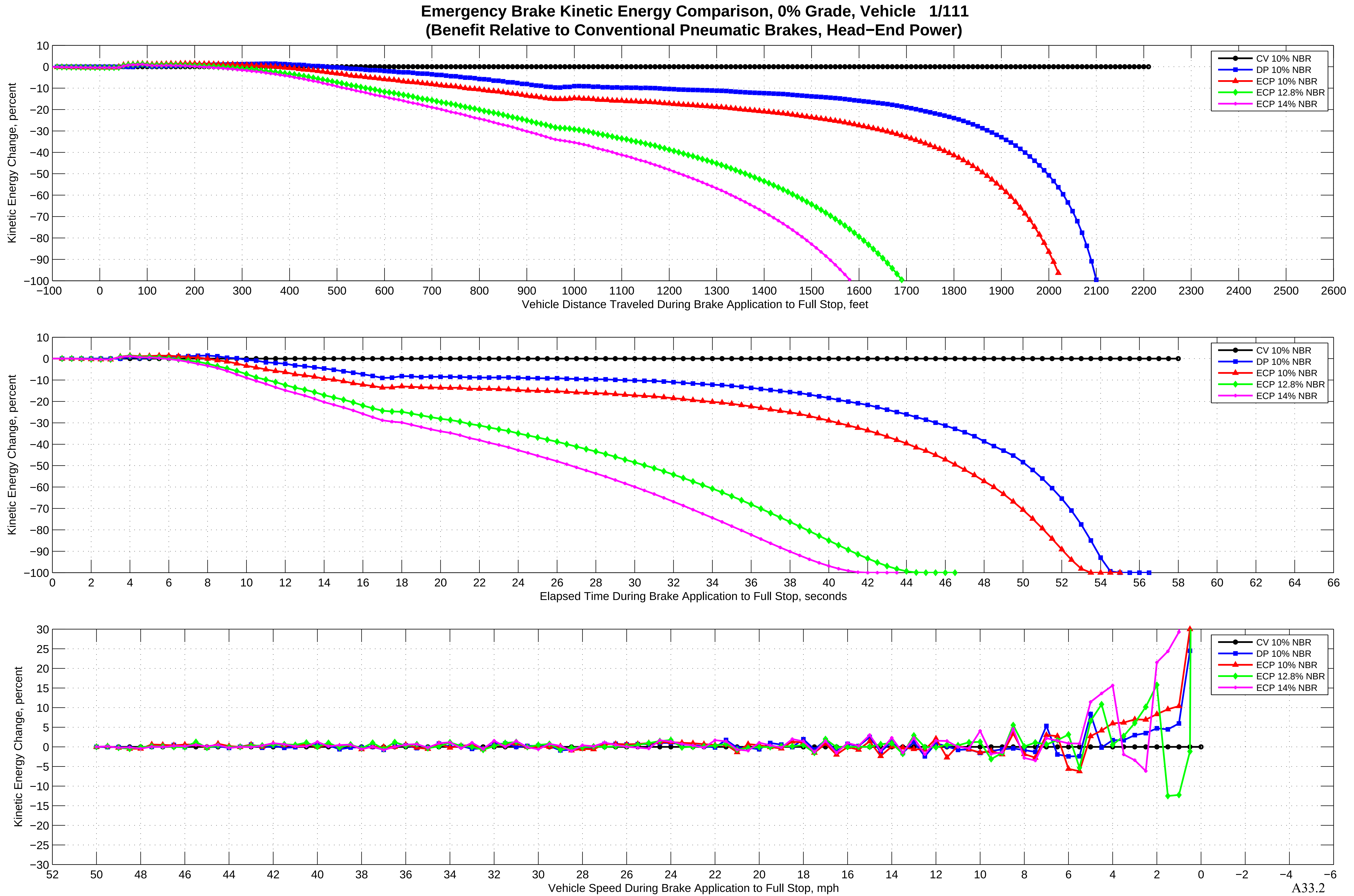
NATIONAL TRANSPORTATION SAFETY BOARD

TEDS SIMULATION DATA FOR VEHICLE 111 [EMERGENCY, NO BAILOFF, NEUTRAL SLACK, 0% GRADE, 50 MPH] [Page 31]
NTSB TRAIN STOPPING DISTANCE STUDY; CALCULATED IN-TRAIN FORCES; NO WHEELS OR CARS DERAILED; NOMINAL BRAKE PIPE



Attachment 33: Kinetic Energy Comparison Plots

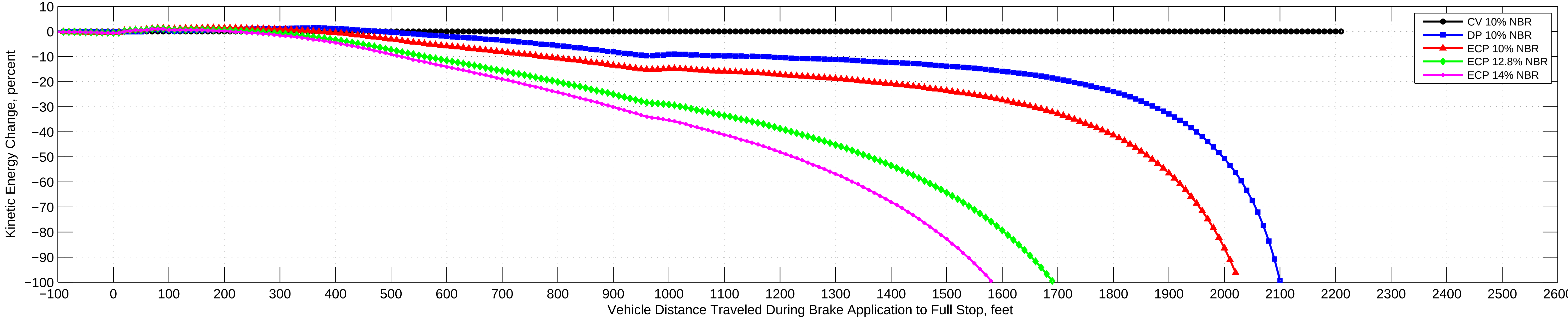
Nominal Consist (Emergency braking; no bailoff; initial coupler slack neutral; 0% grade; 50 mph)

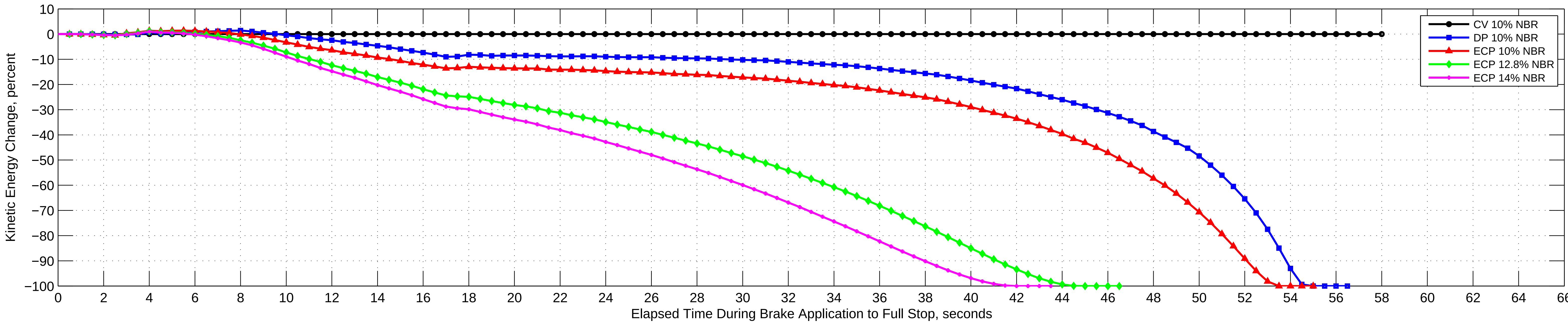


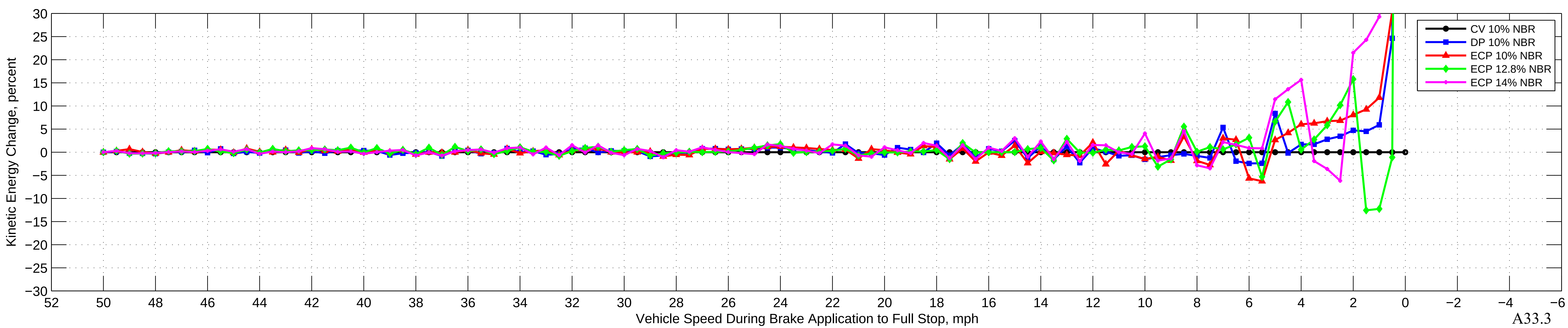
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 1/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR

A33.2

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 2/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

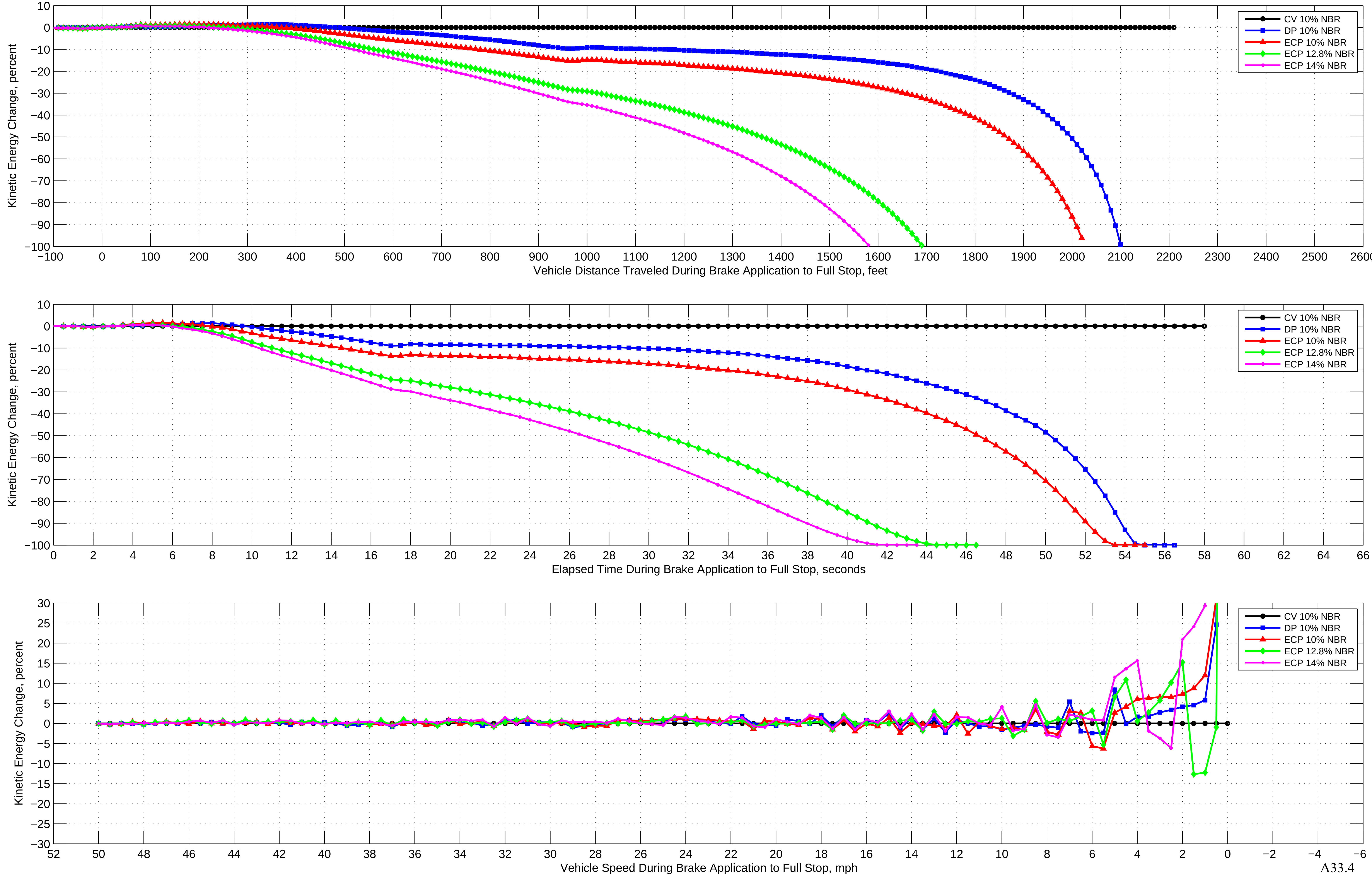


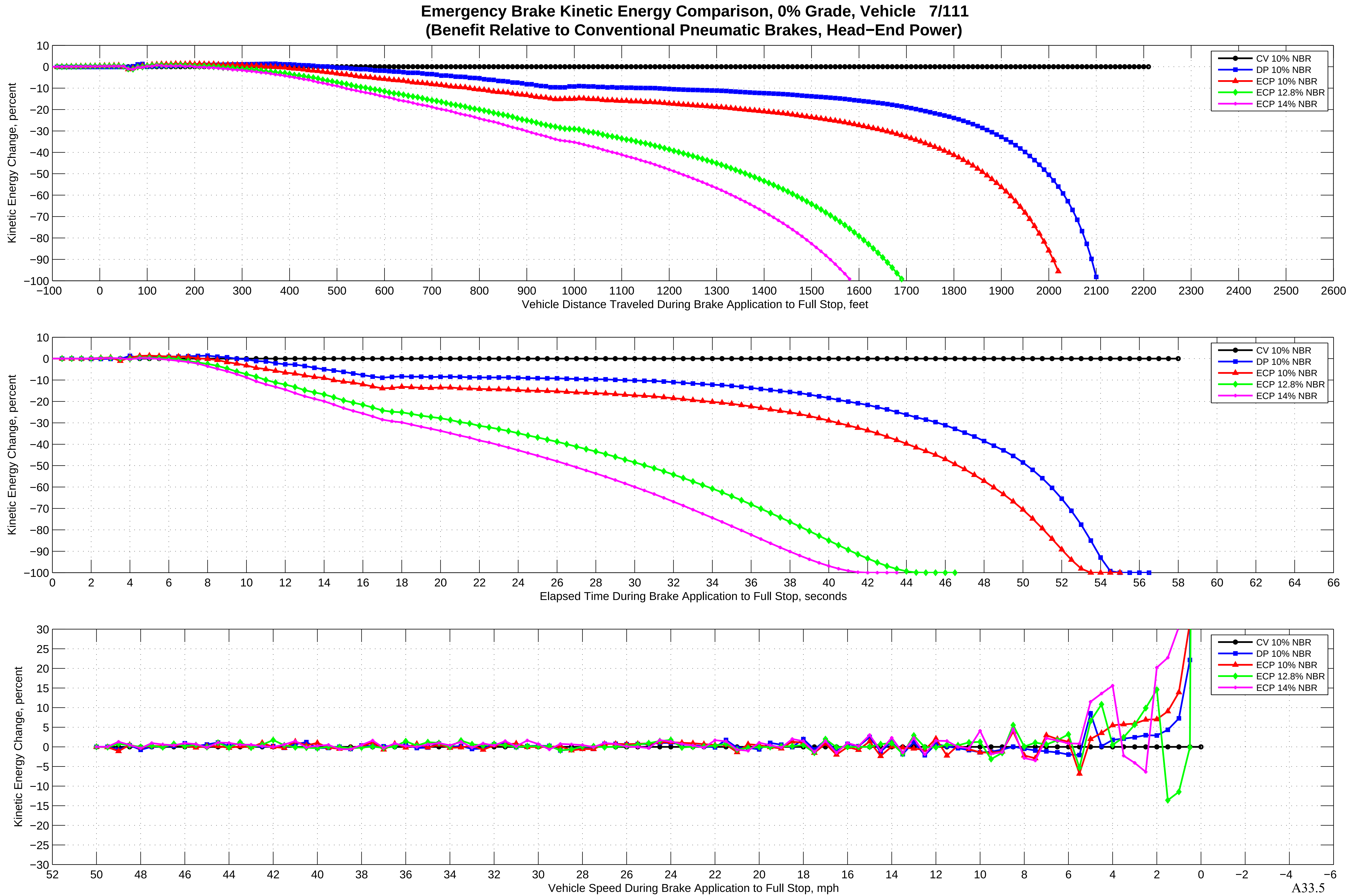




A33.3

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 3/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

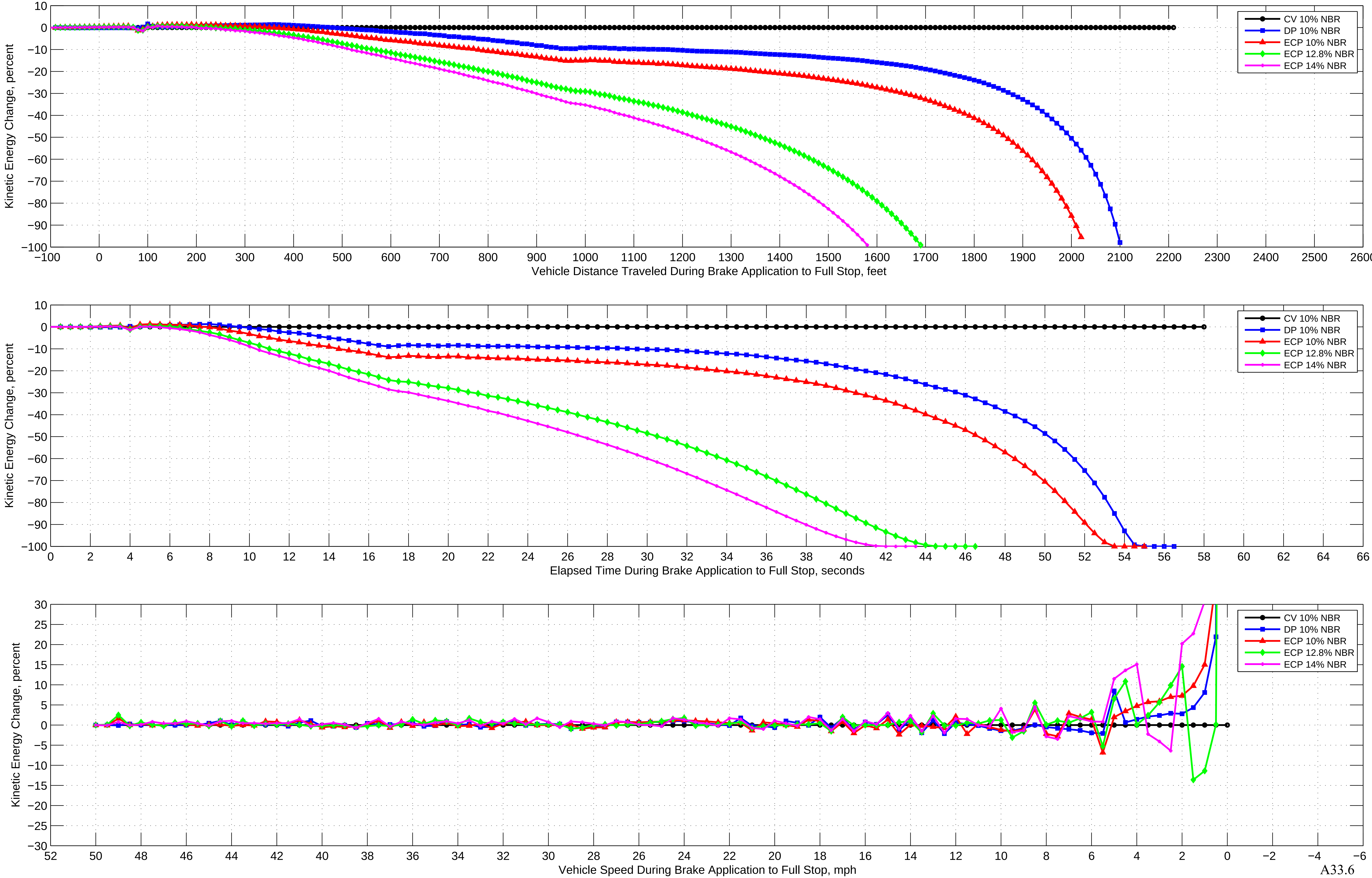




Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 7/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph

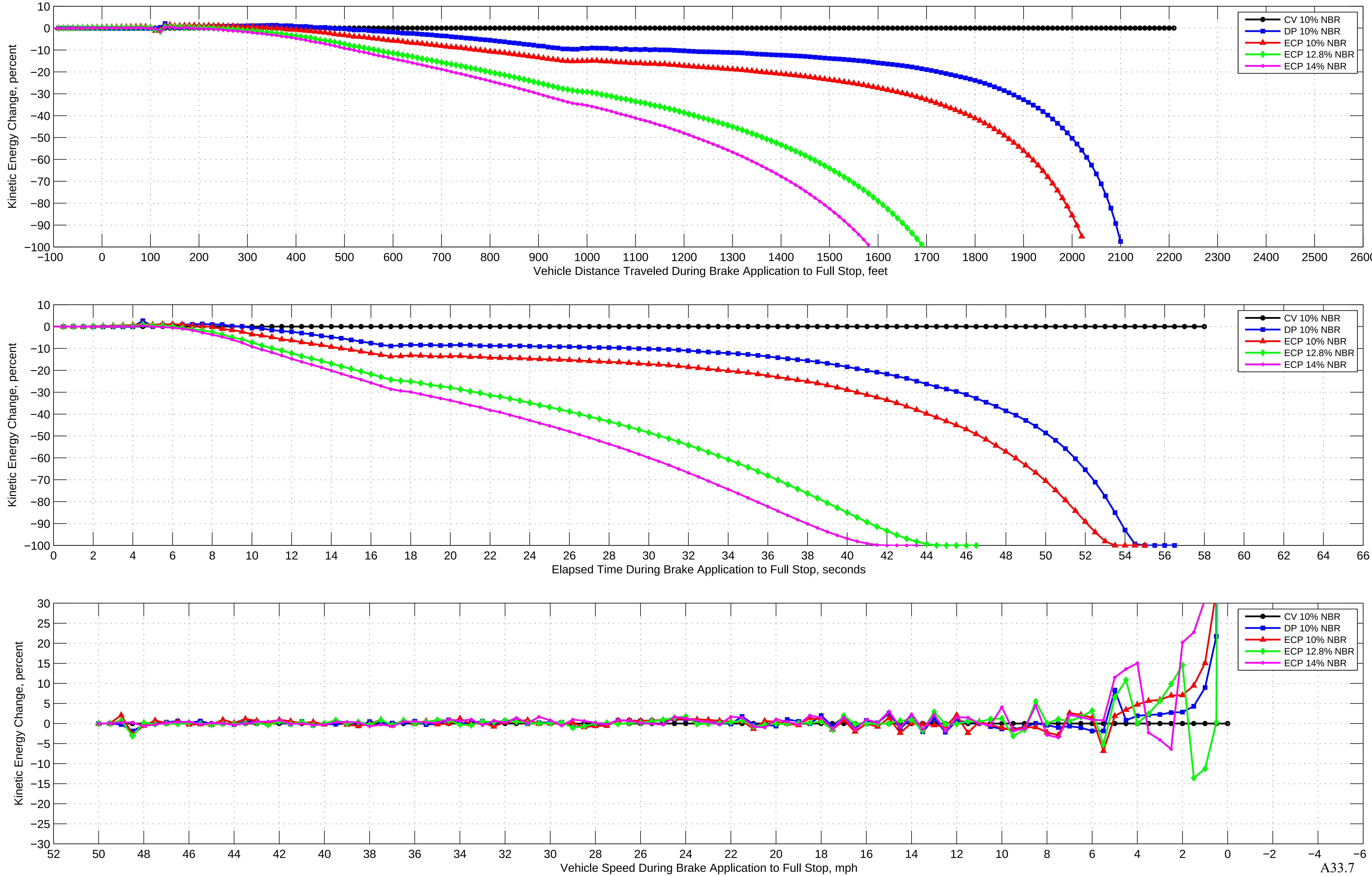
A33.5

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 8/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



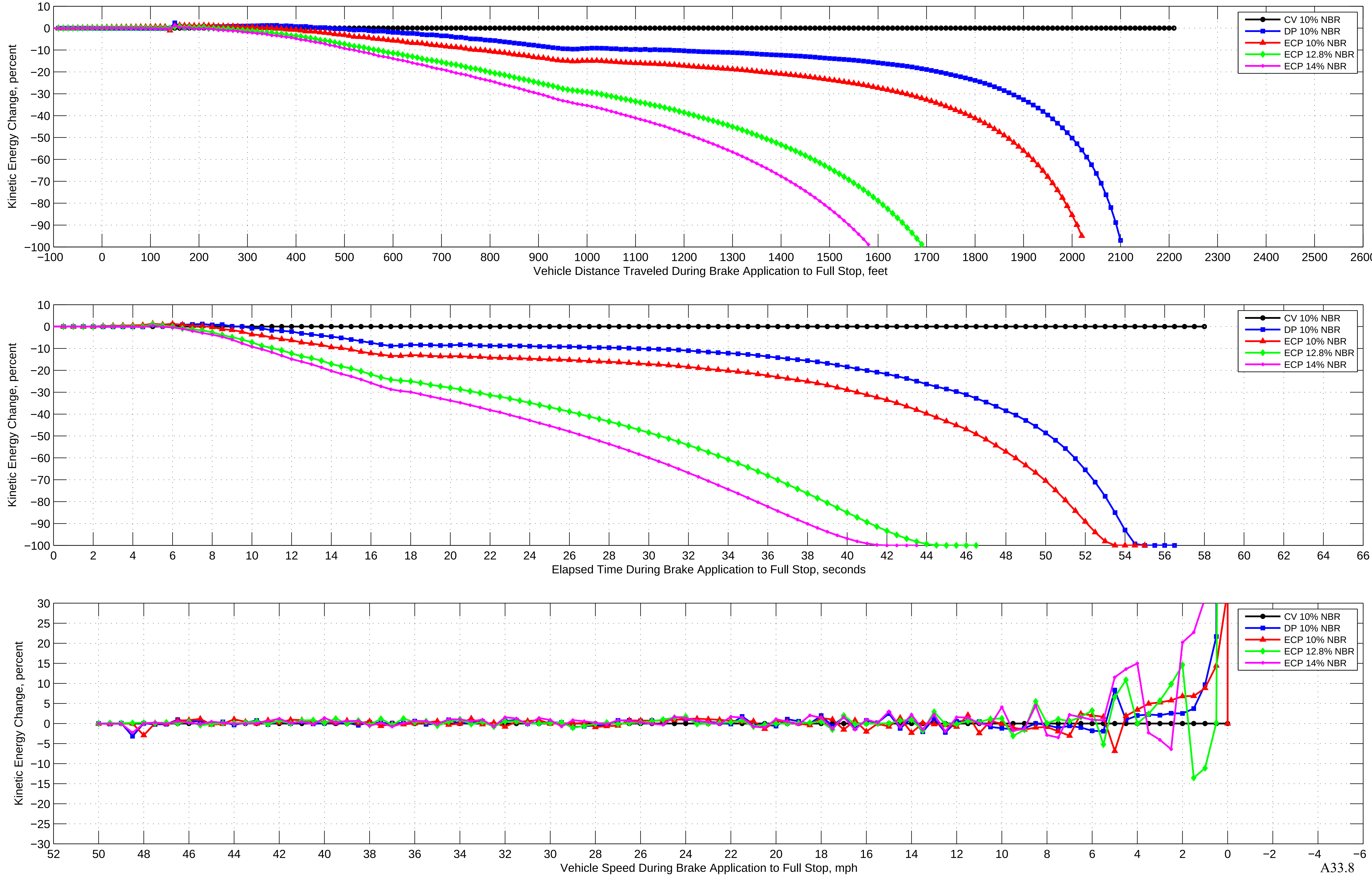
A33.6

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 10/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

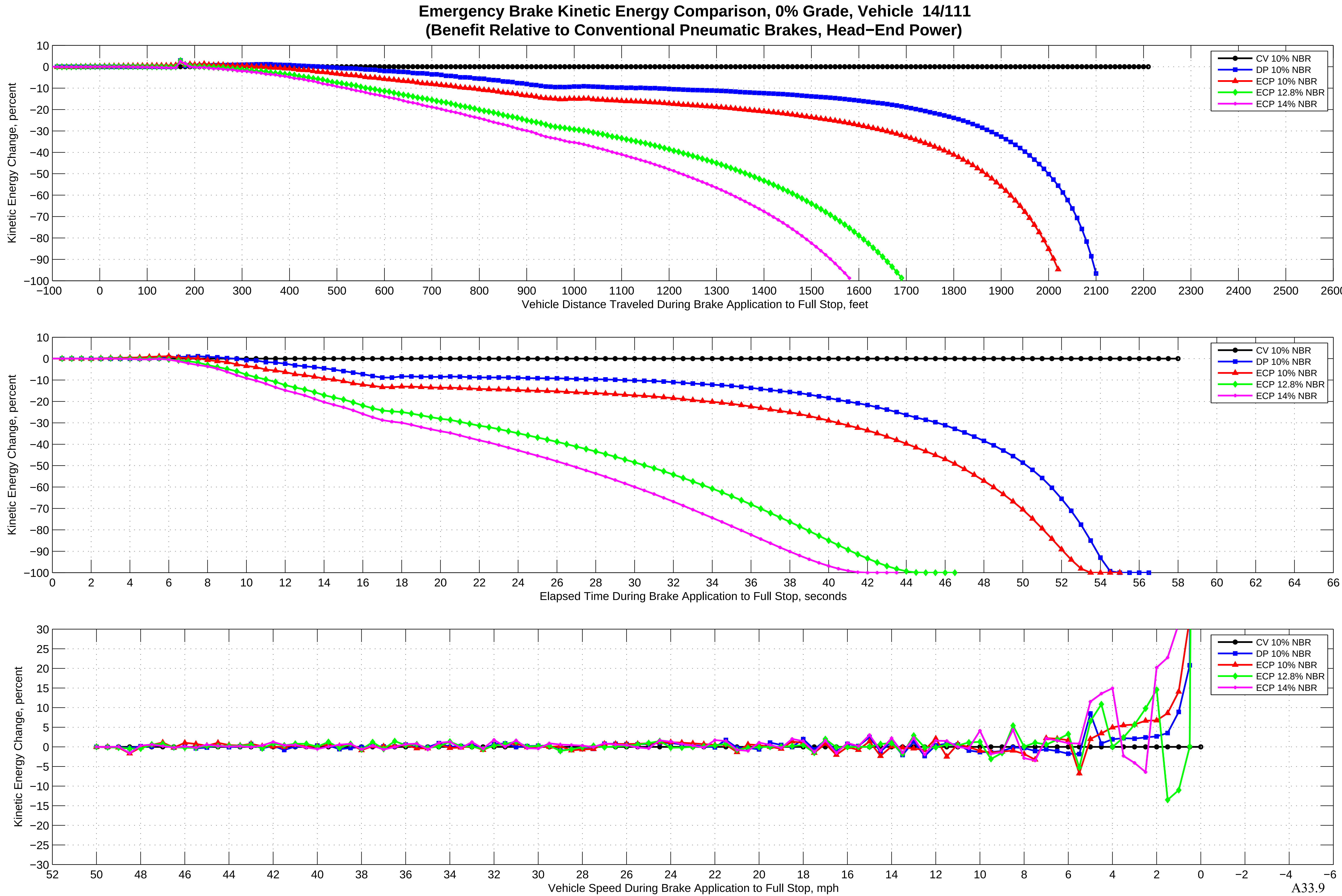


A33.7

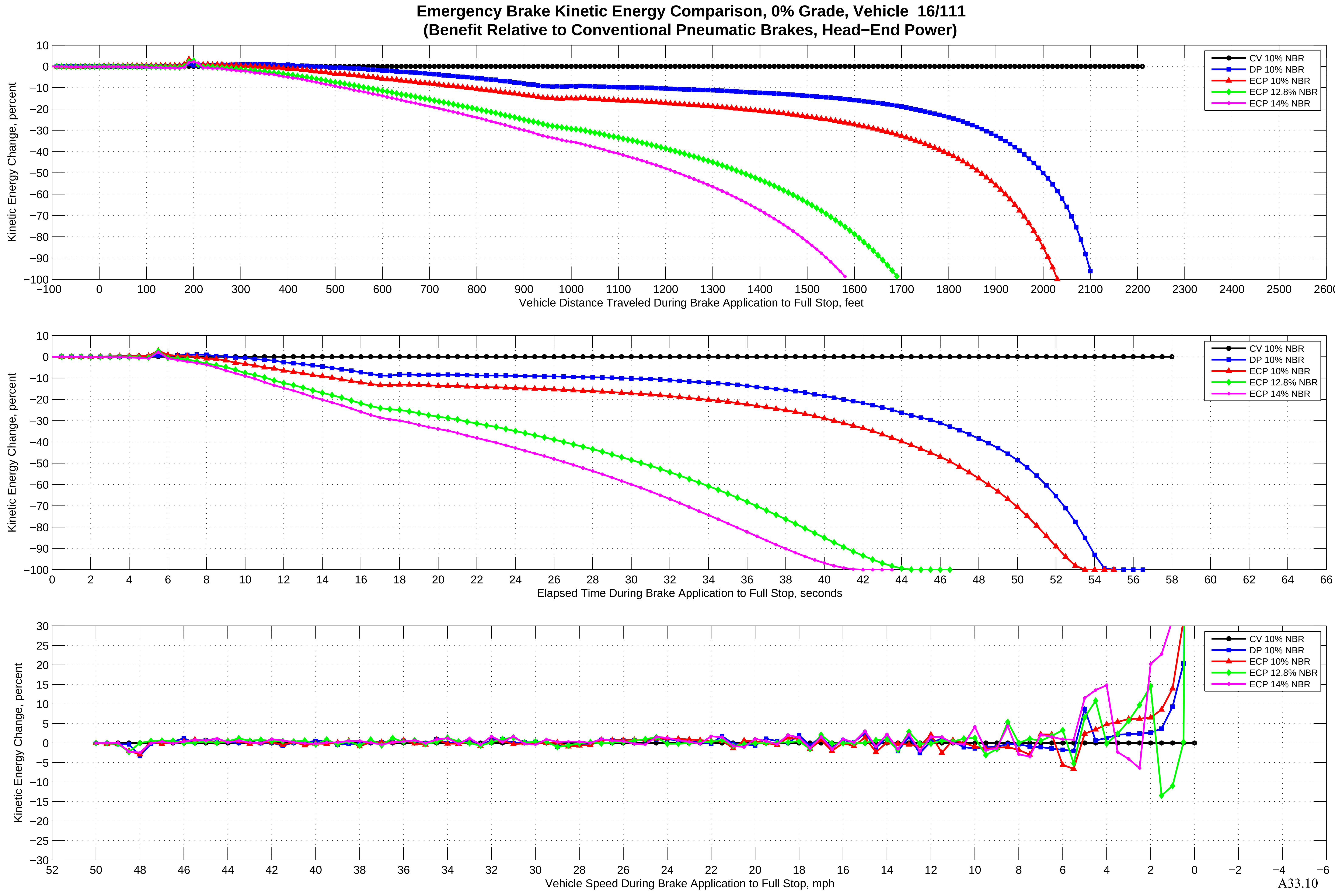
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 12/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



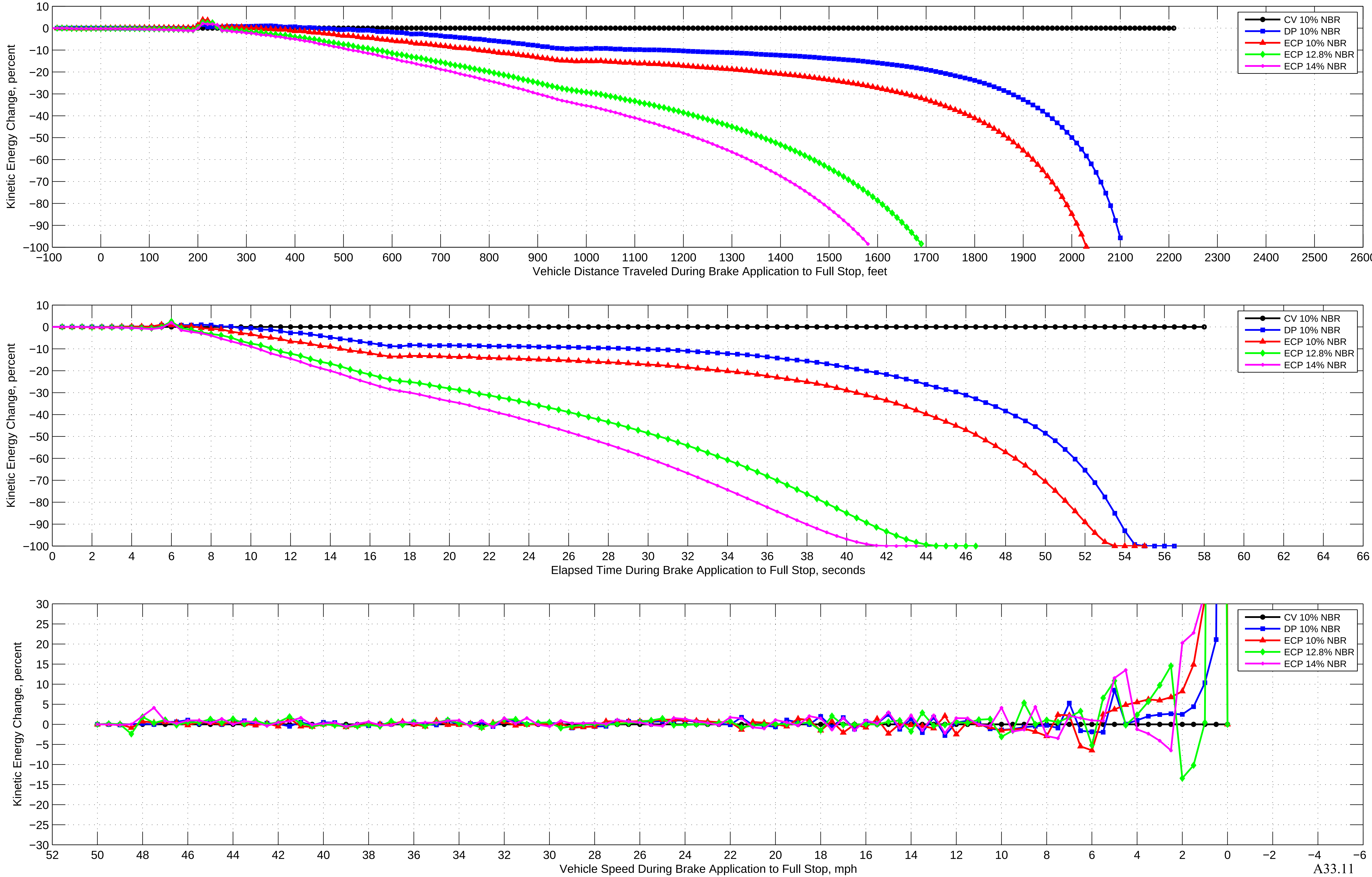
A33.8



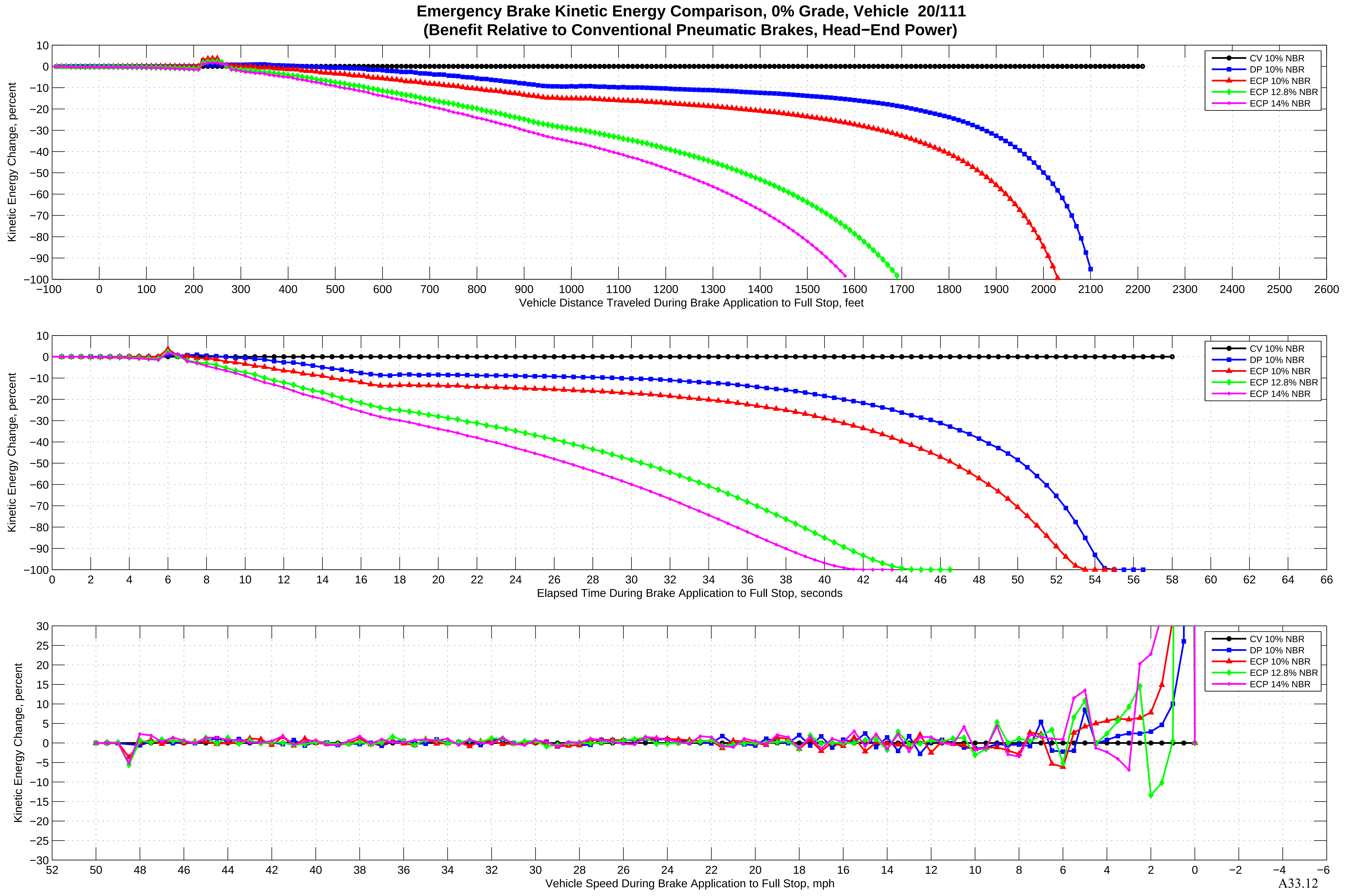
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 14/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.9


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 16/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.10

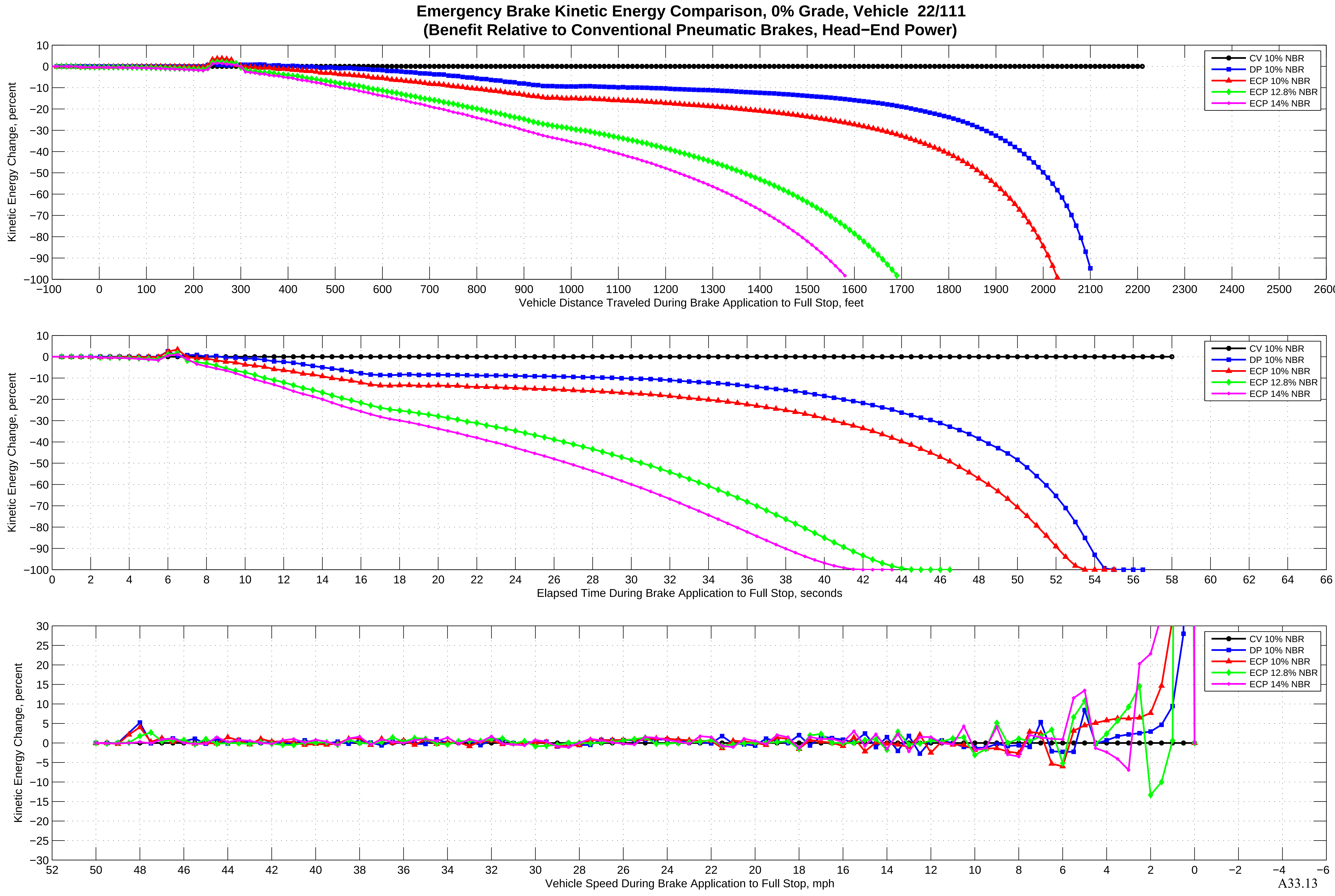
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 18/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



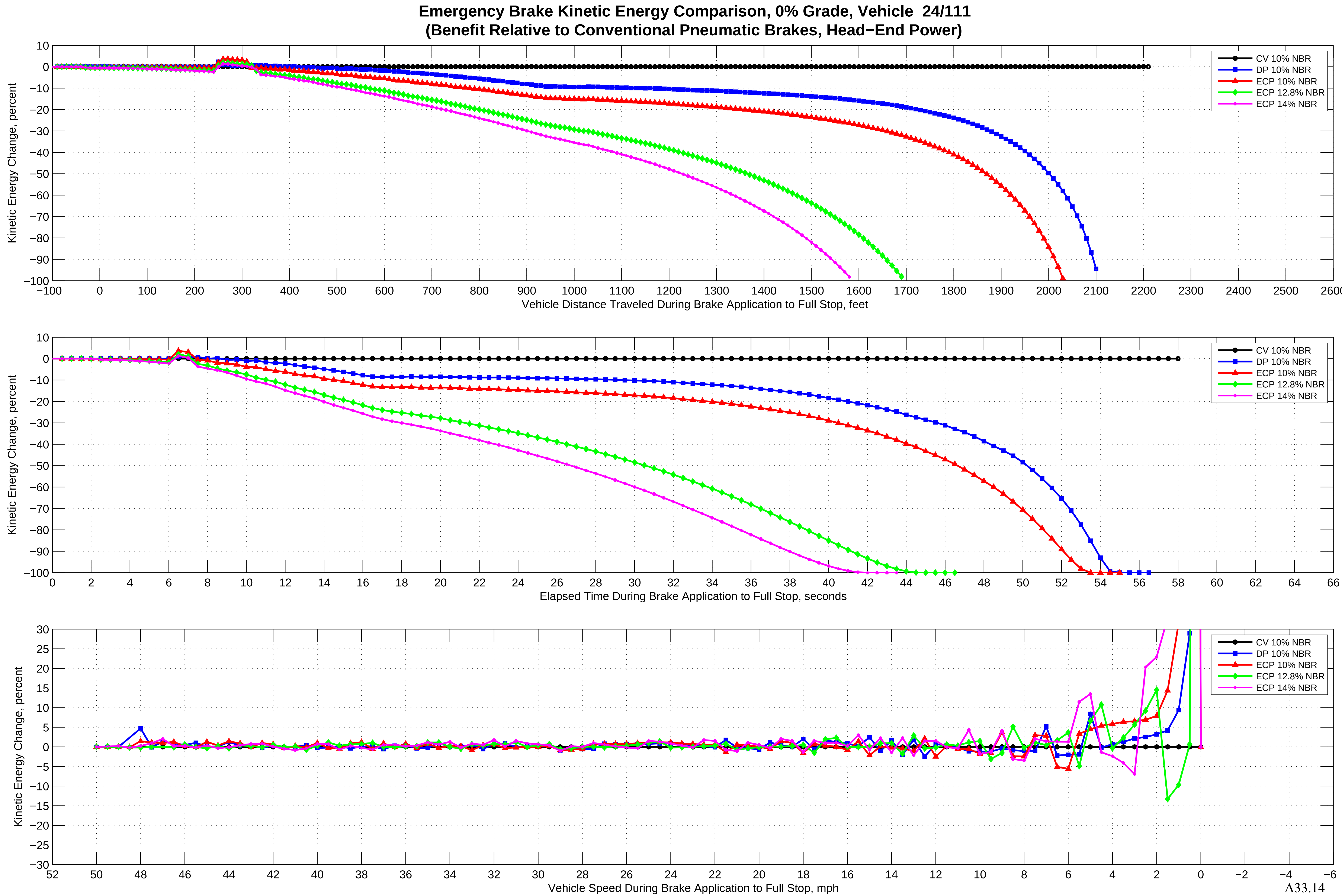
A33.11



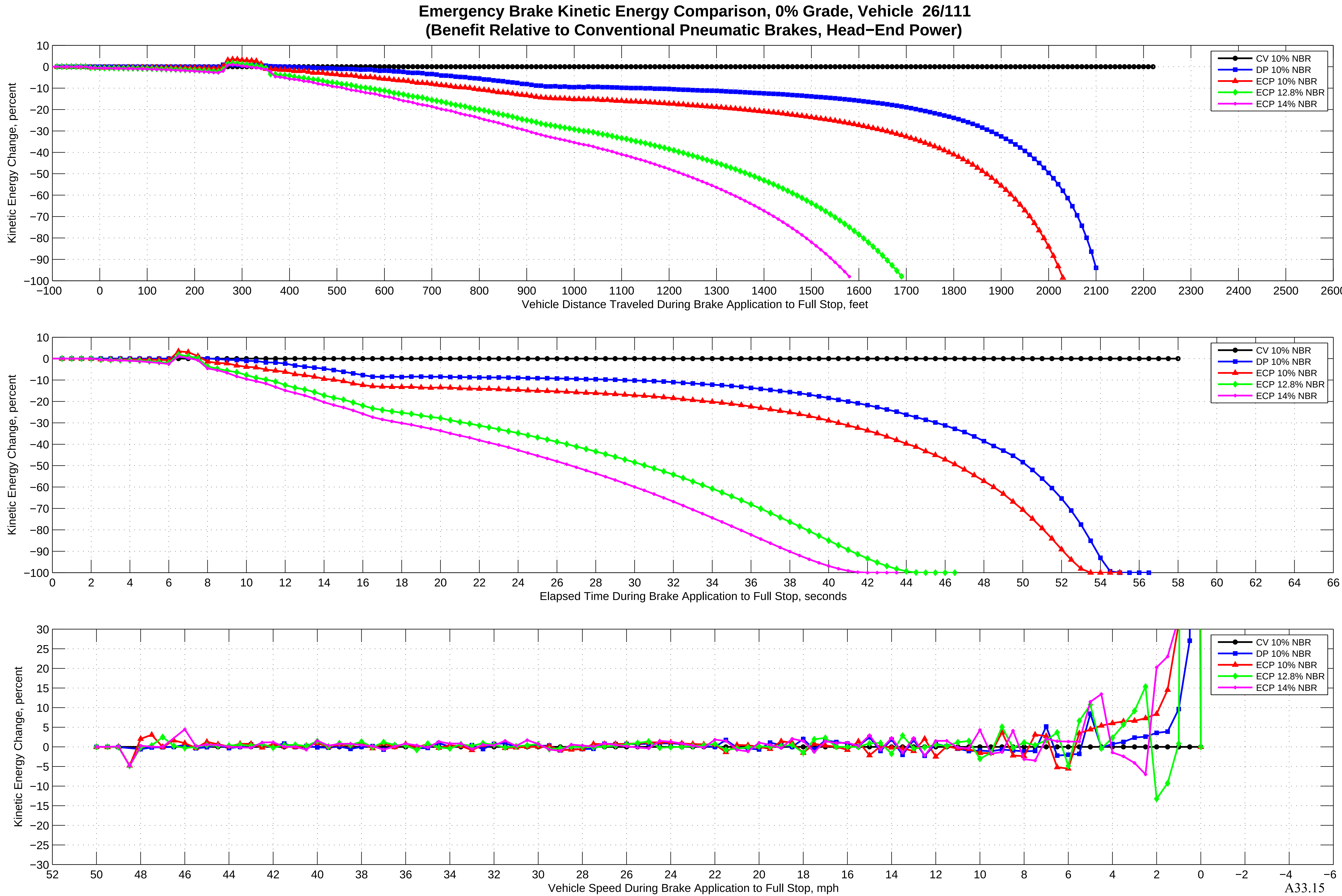
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 20/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.12



Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 22/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.13

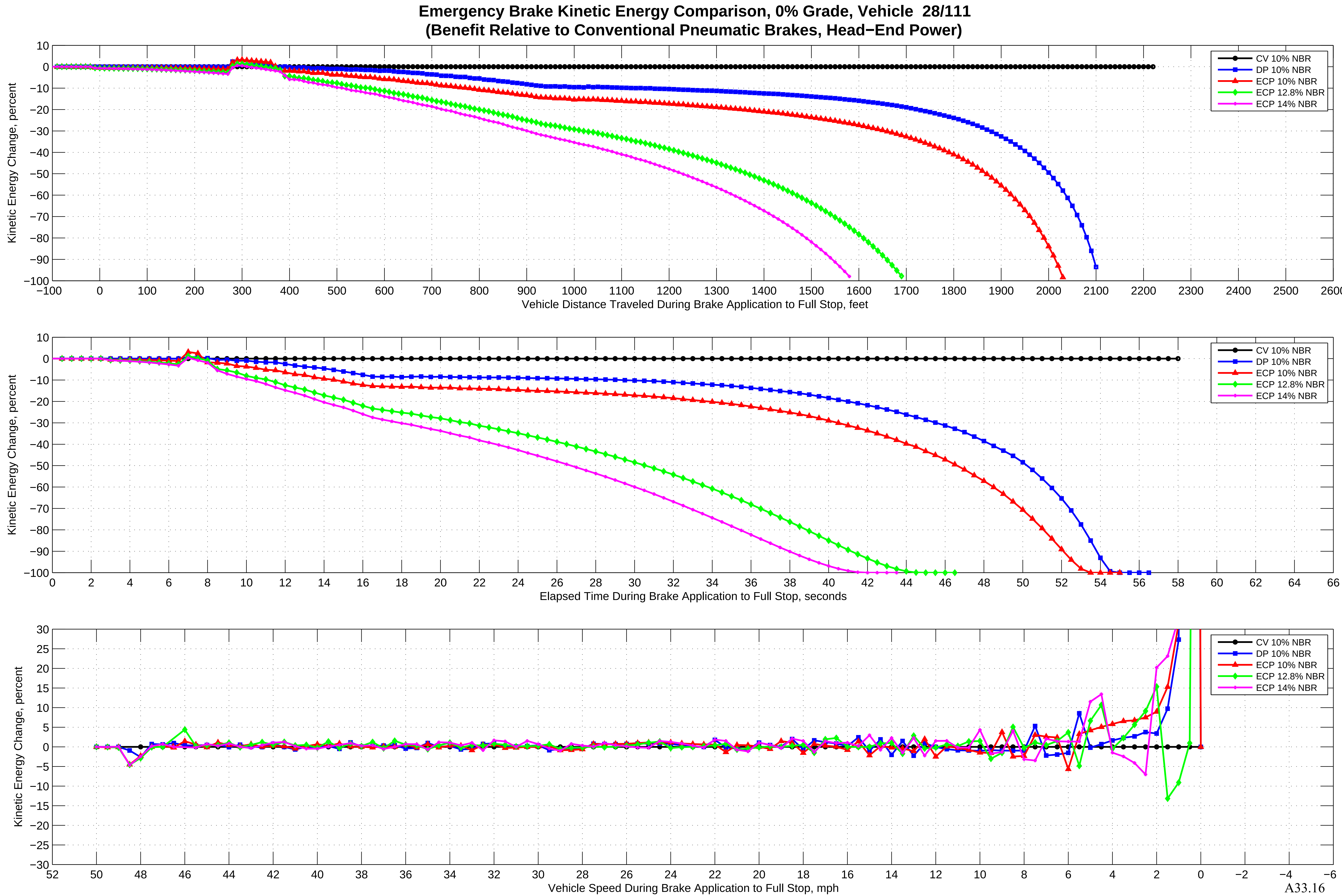


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 24/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.14

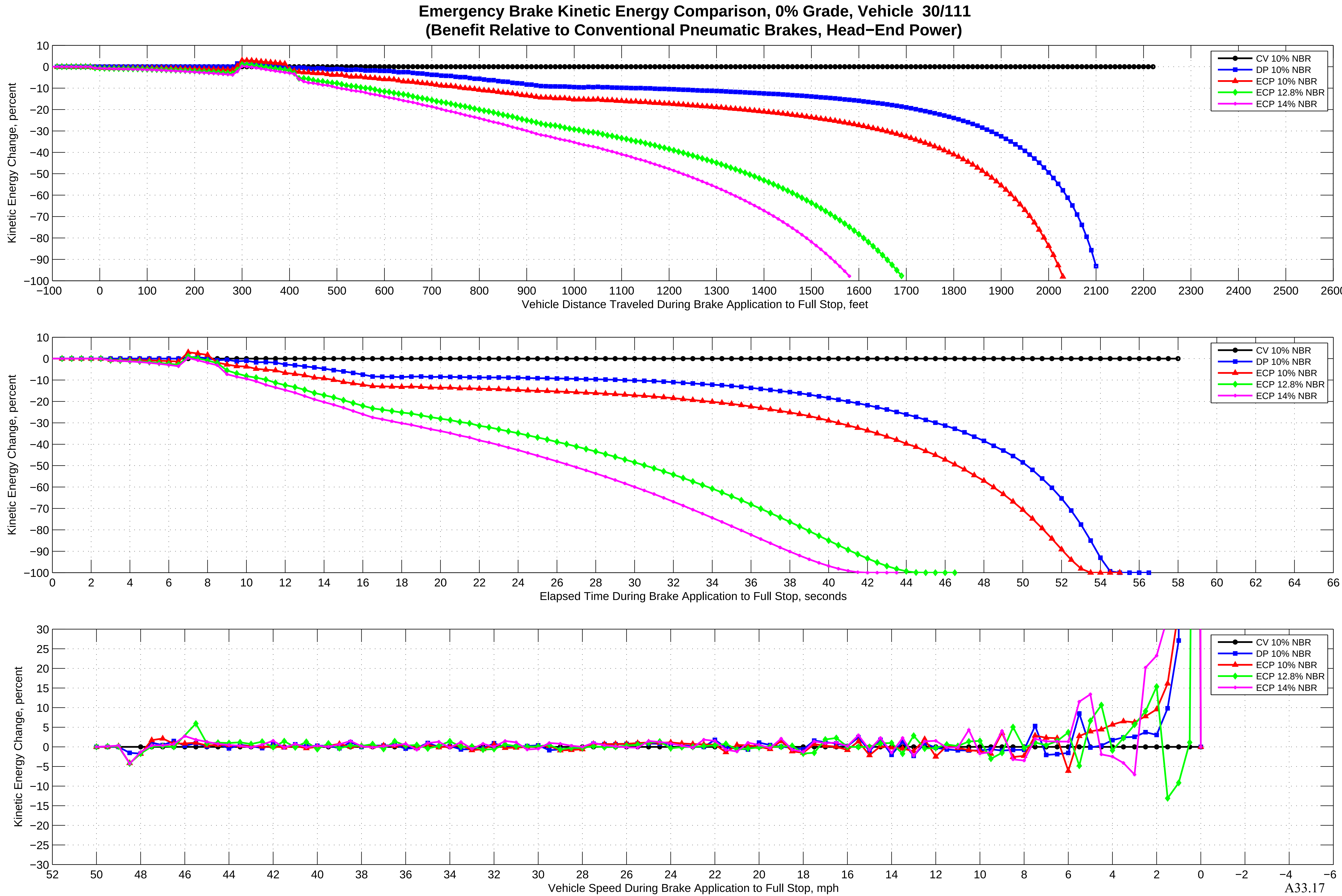


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 26/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR

A33.15

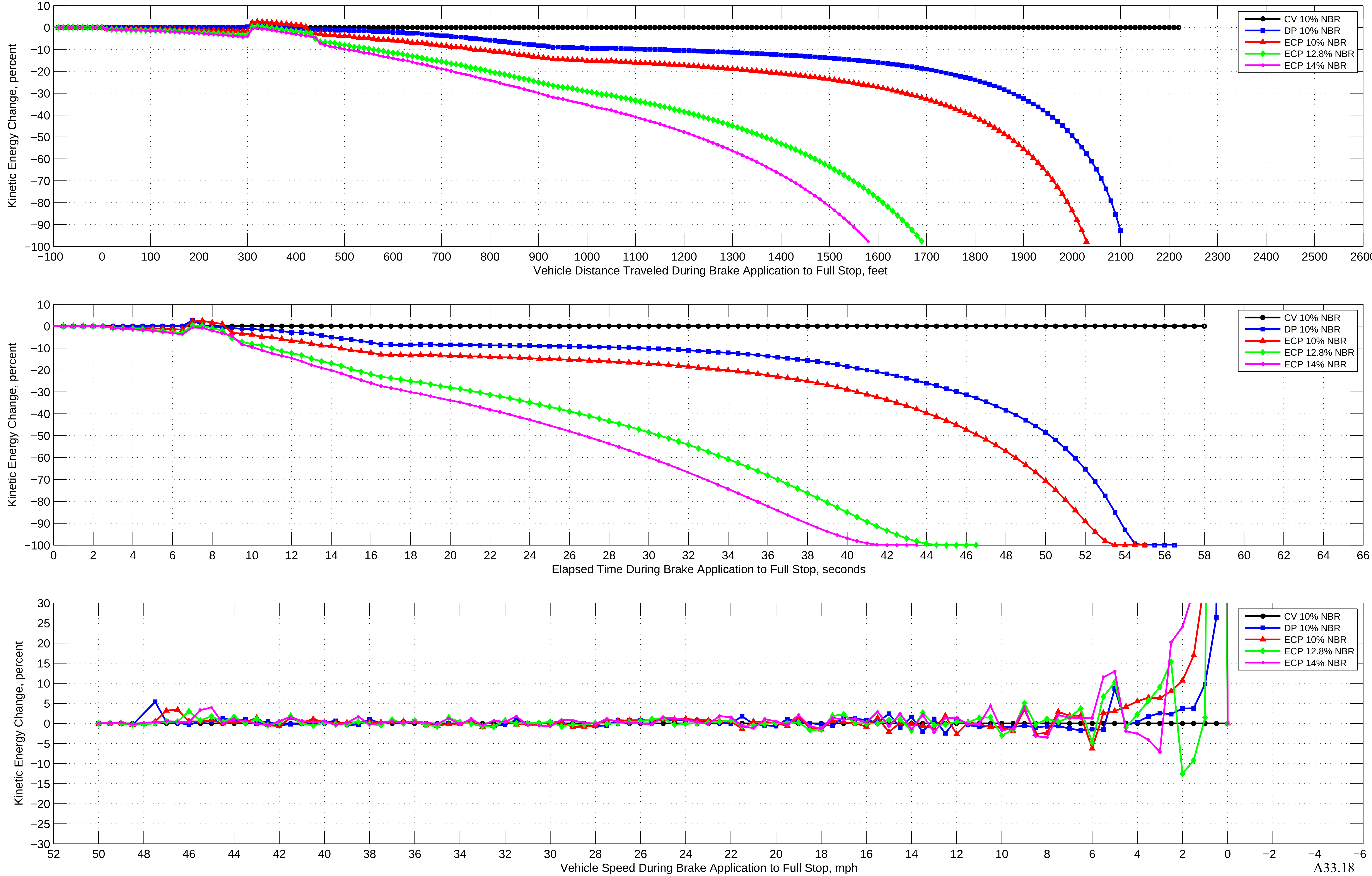

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 28/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Elapsed Time During Brake Application to Full Stop, seconds
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR

A33.16



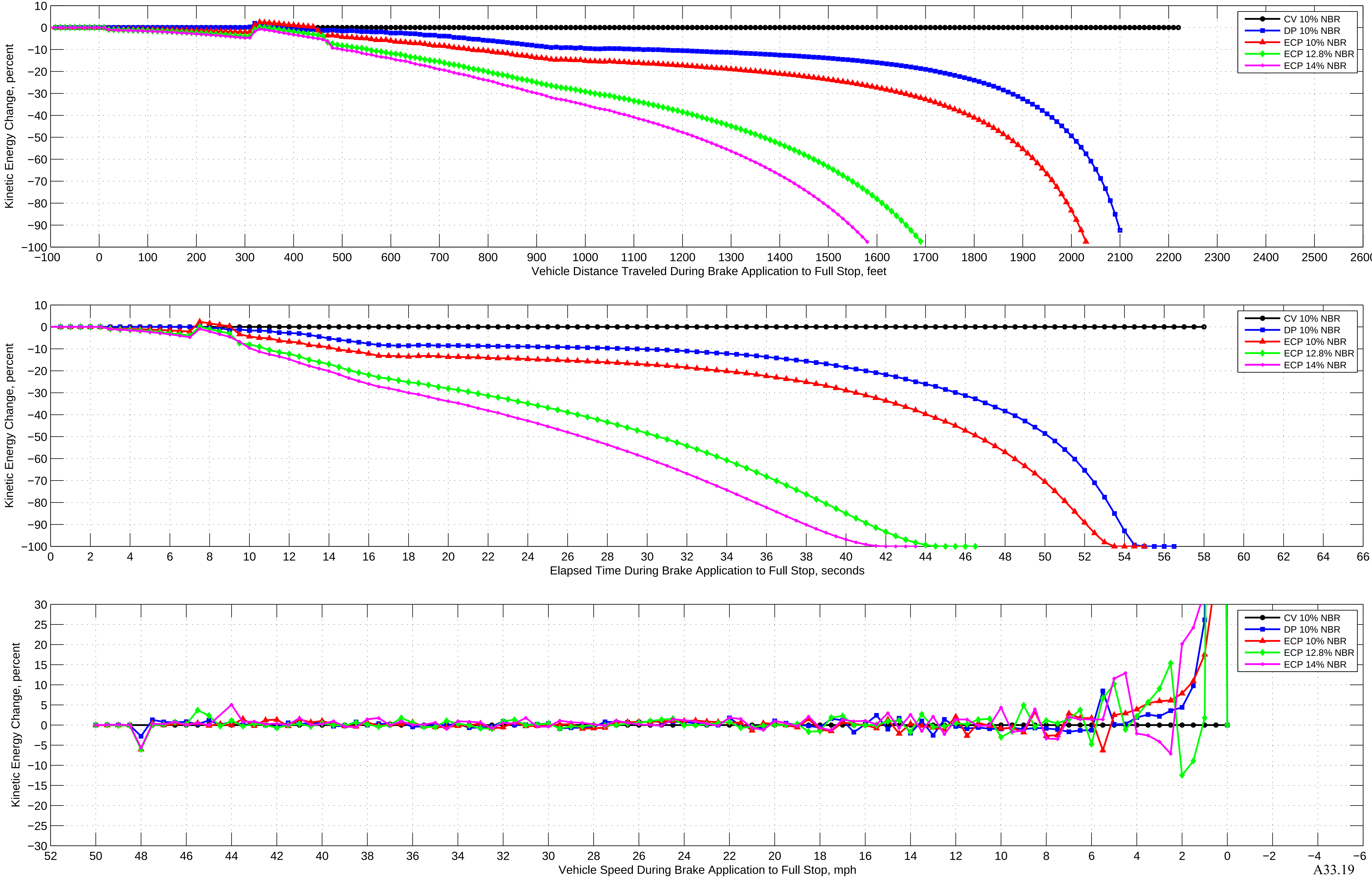
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 30/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.17

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 32/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

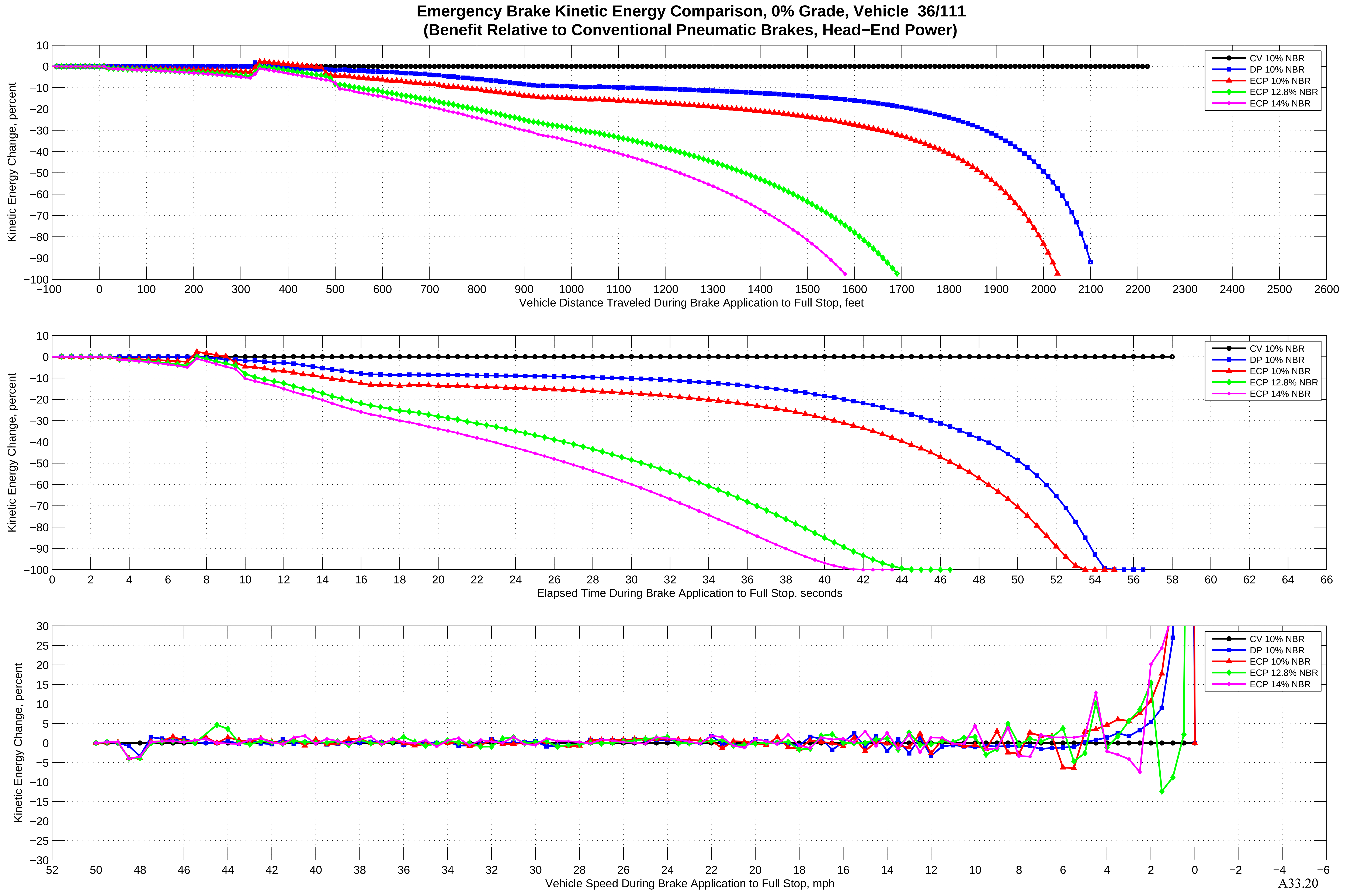


A33.18

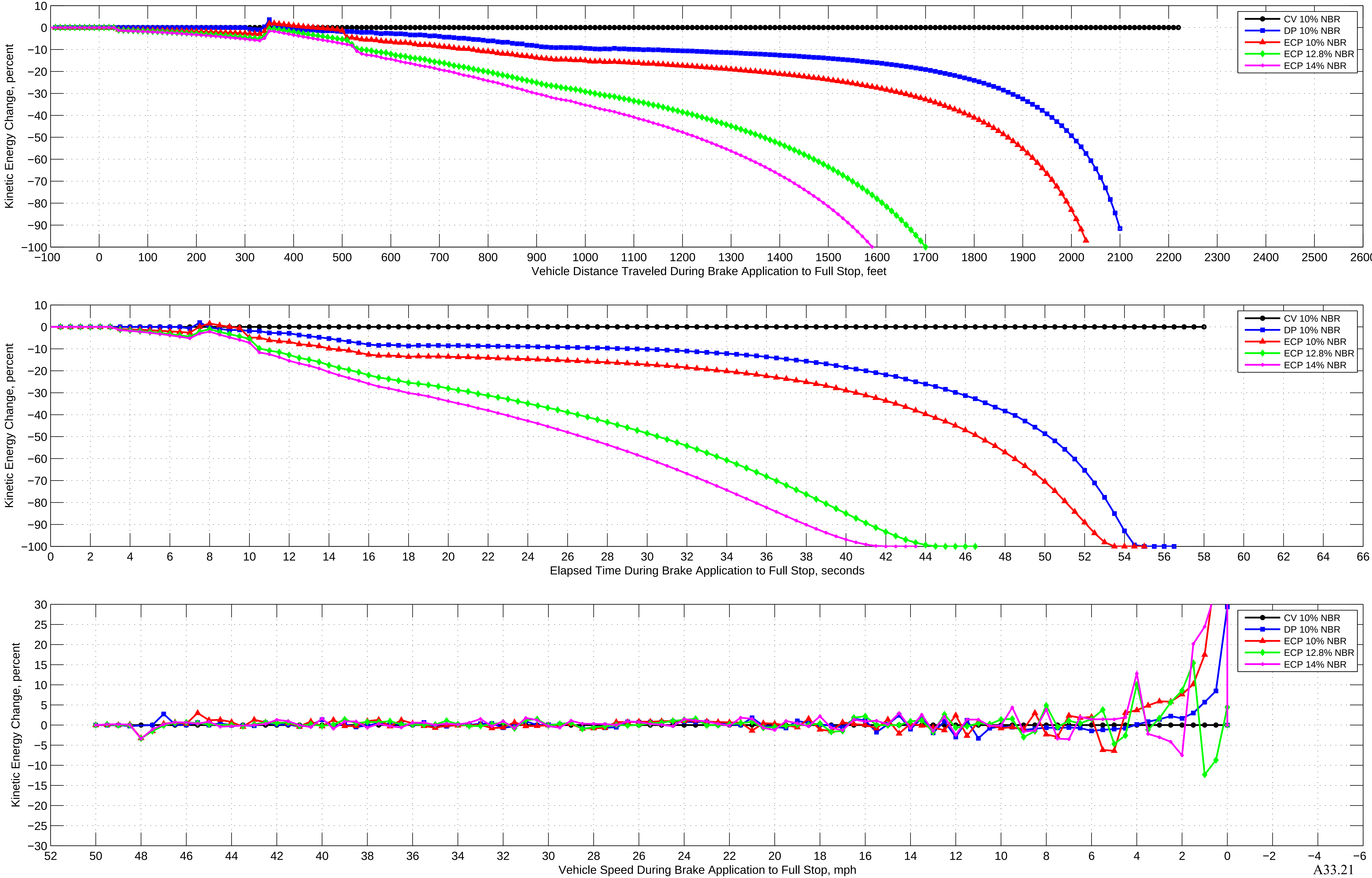
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 34/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



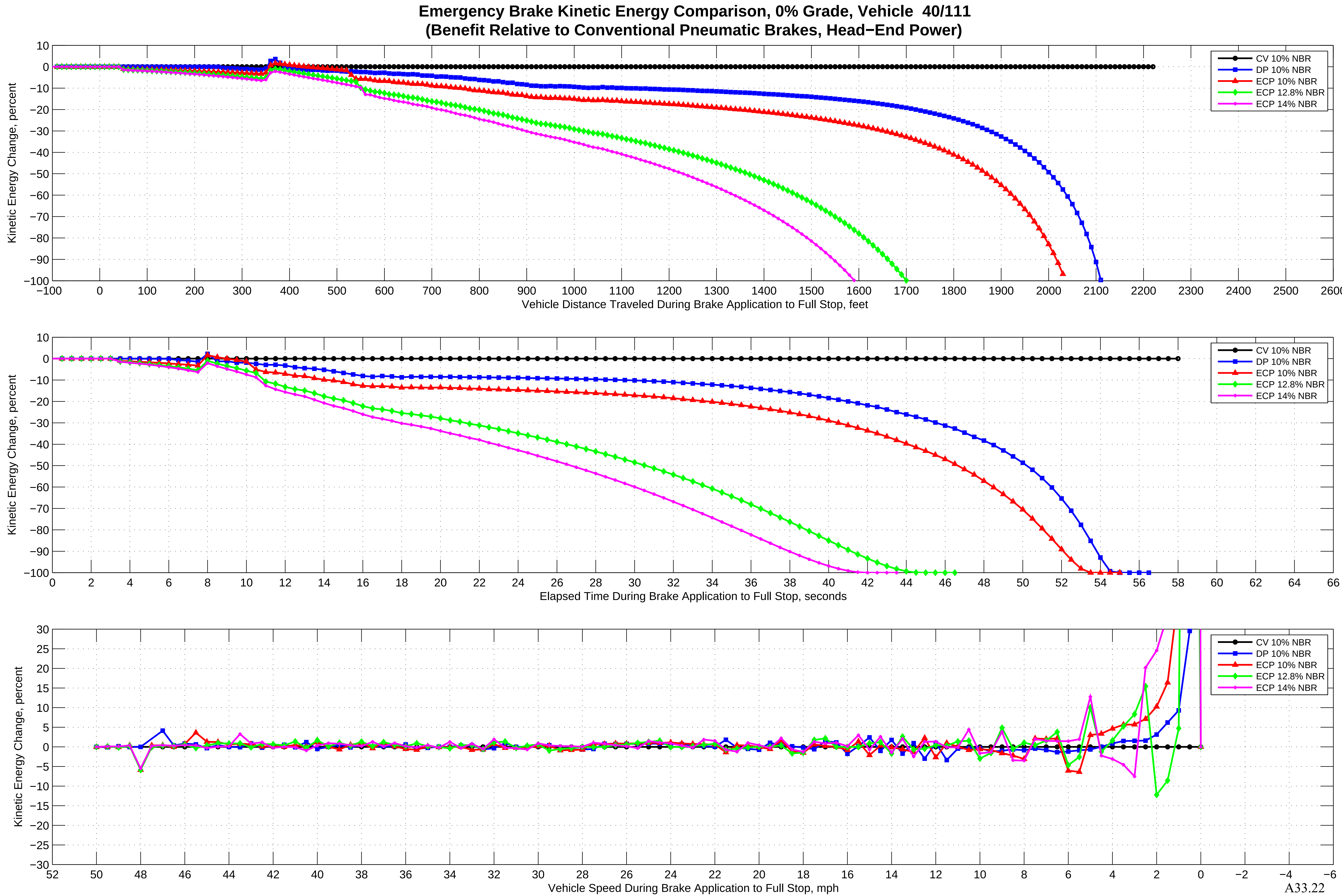
A33.19


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 36/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.20

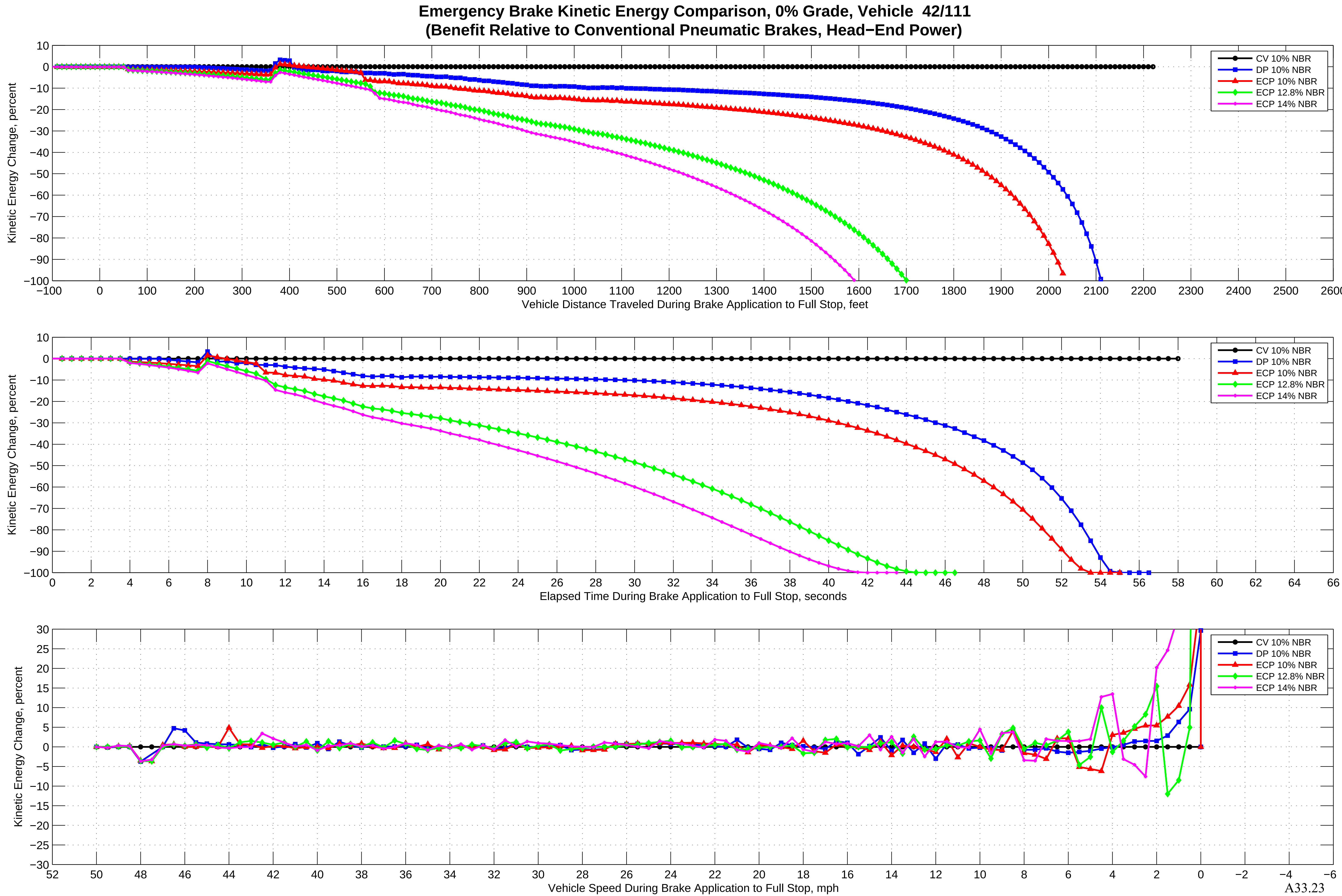
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 38/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



A33.21



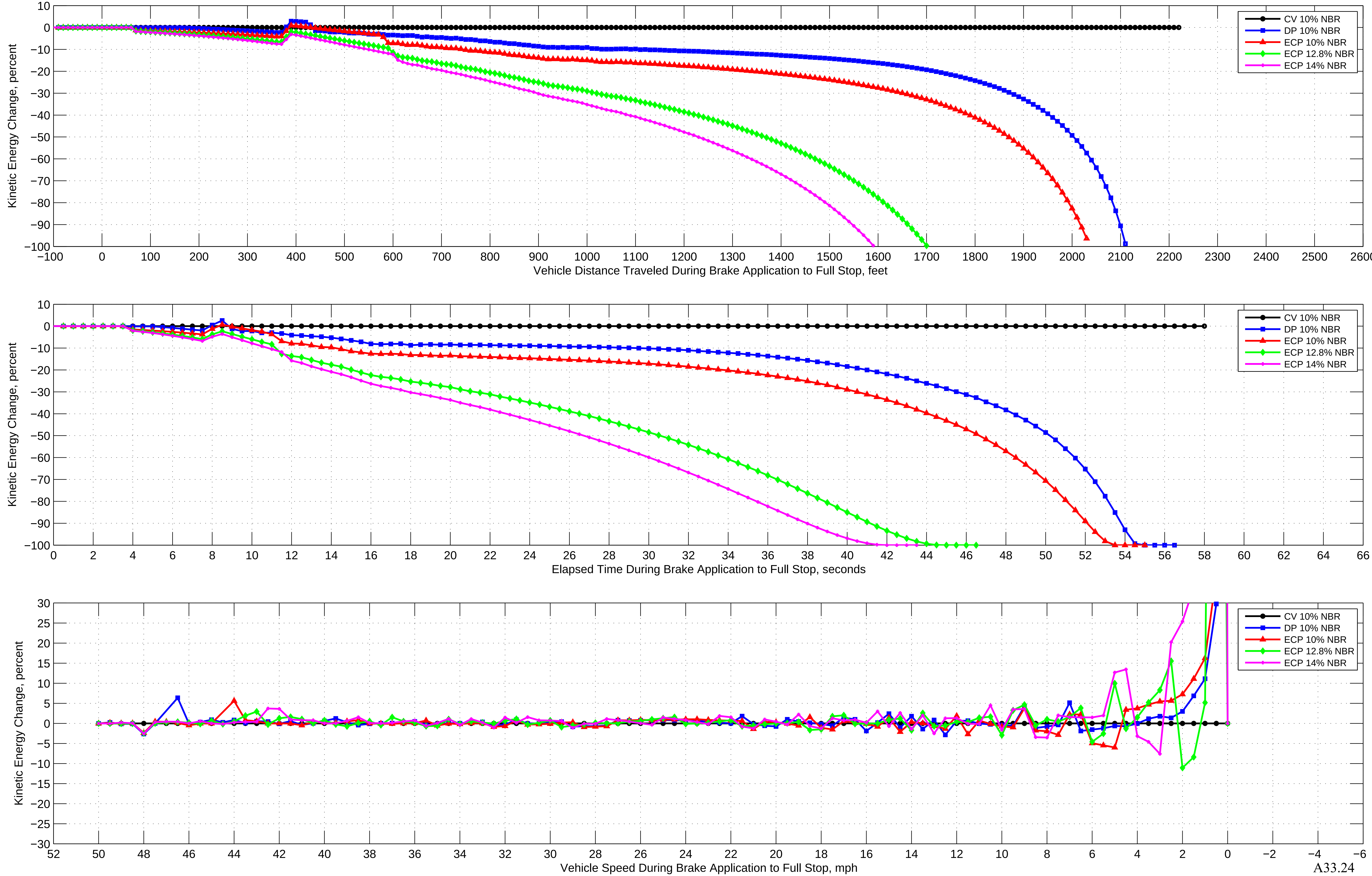
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 40/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.22



Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 42/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR

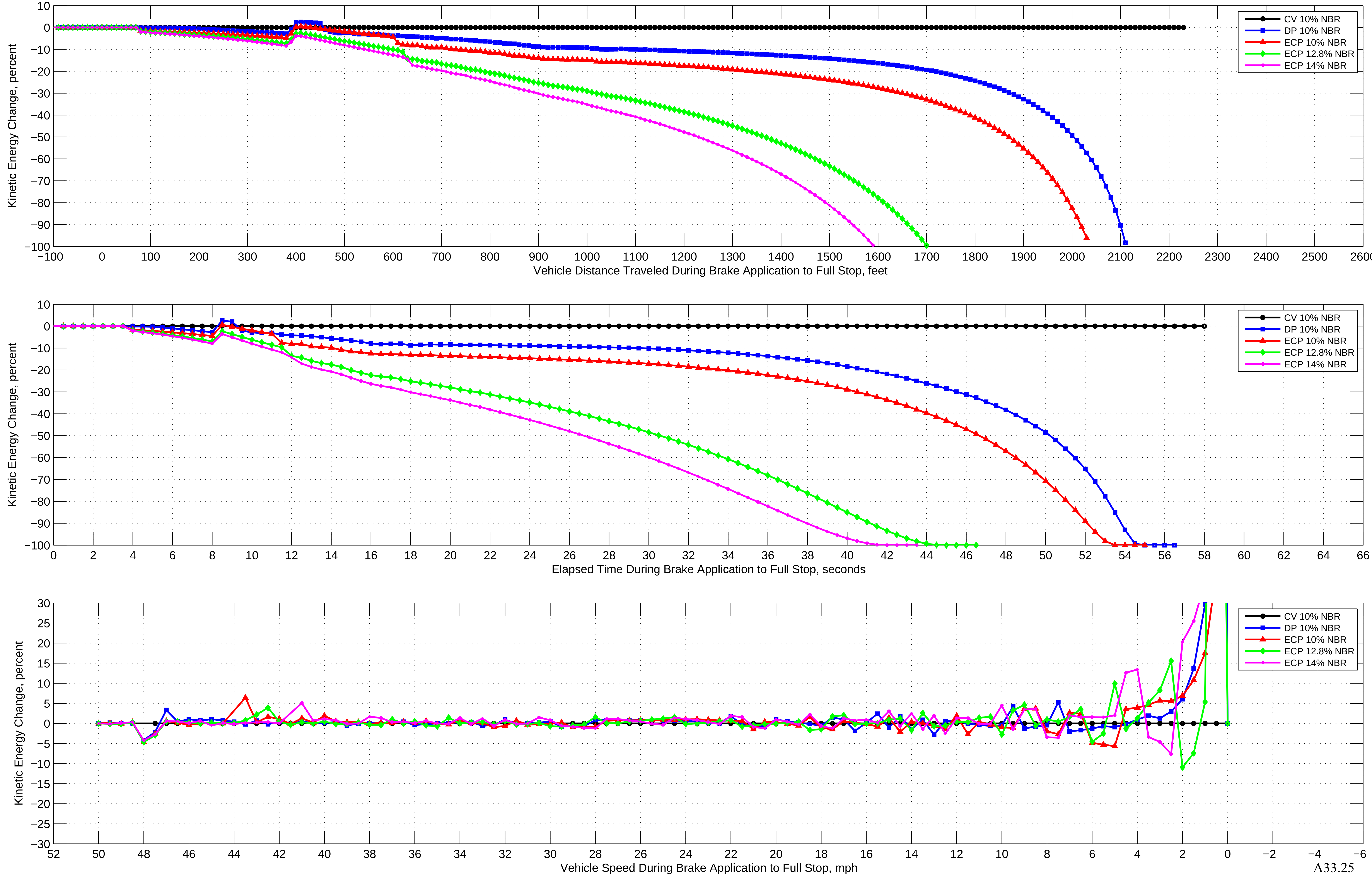
A33.23

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 44/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

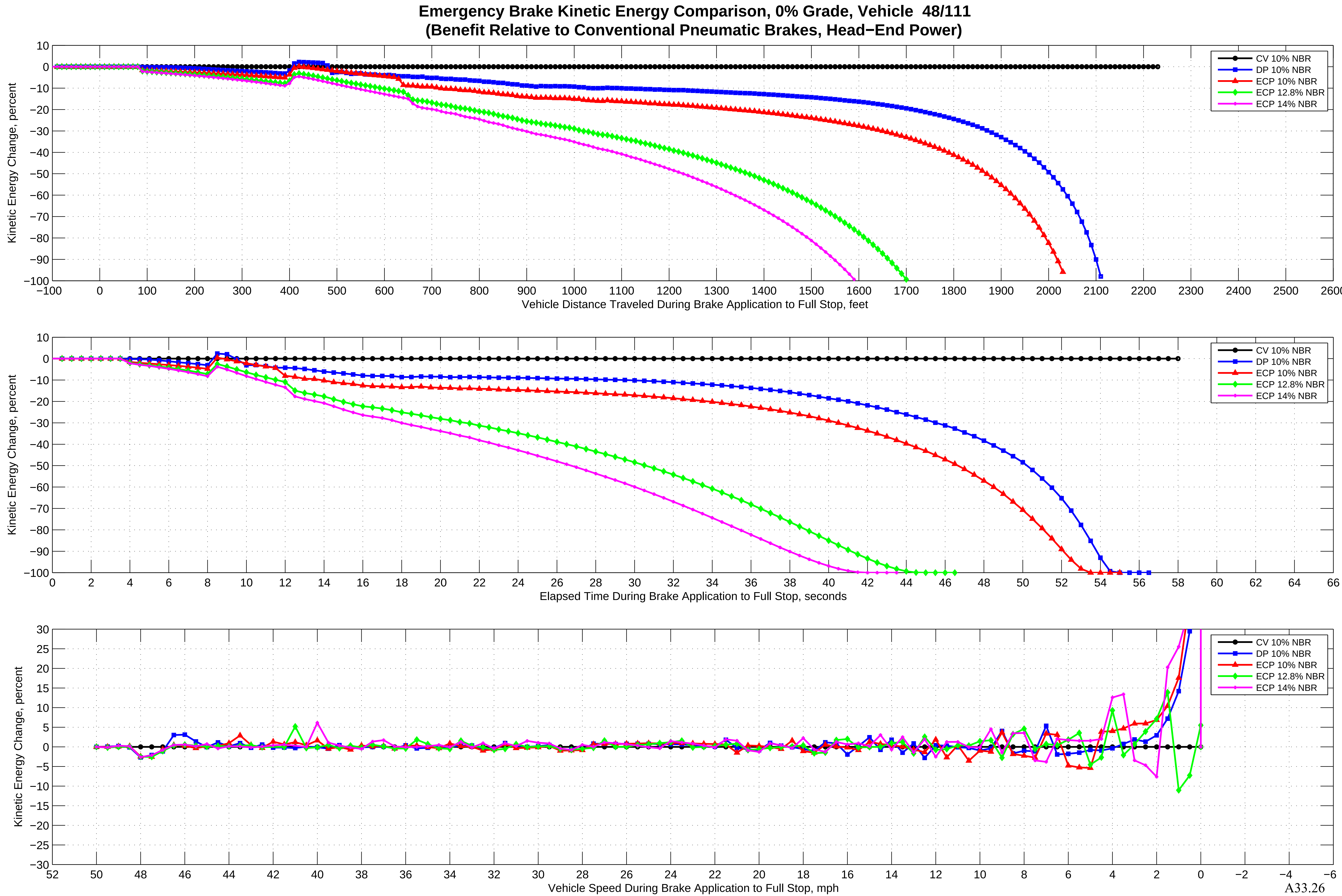


A33.24

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 46/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

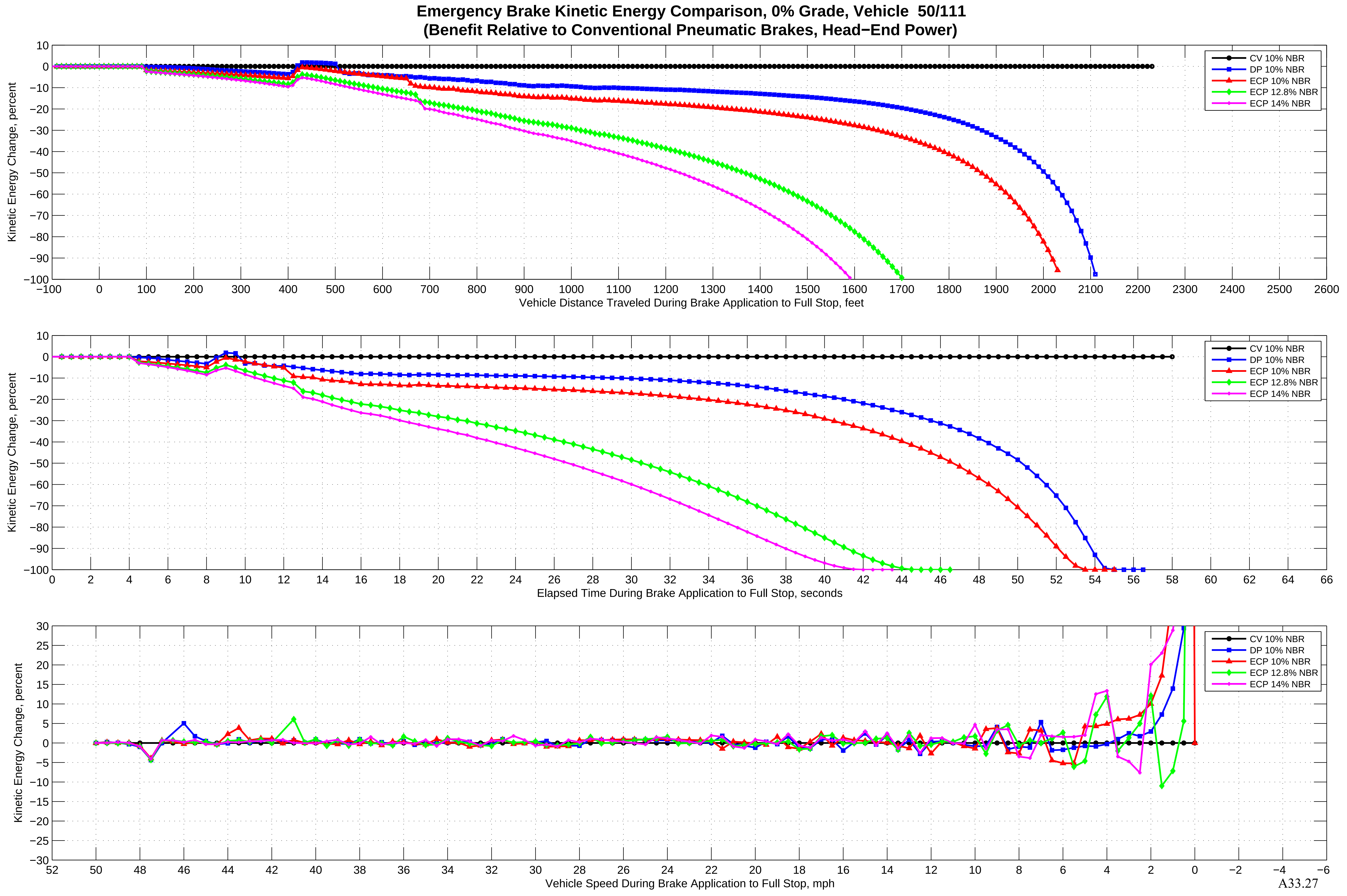


A33.25

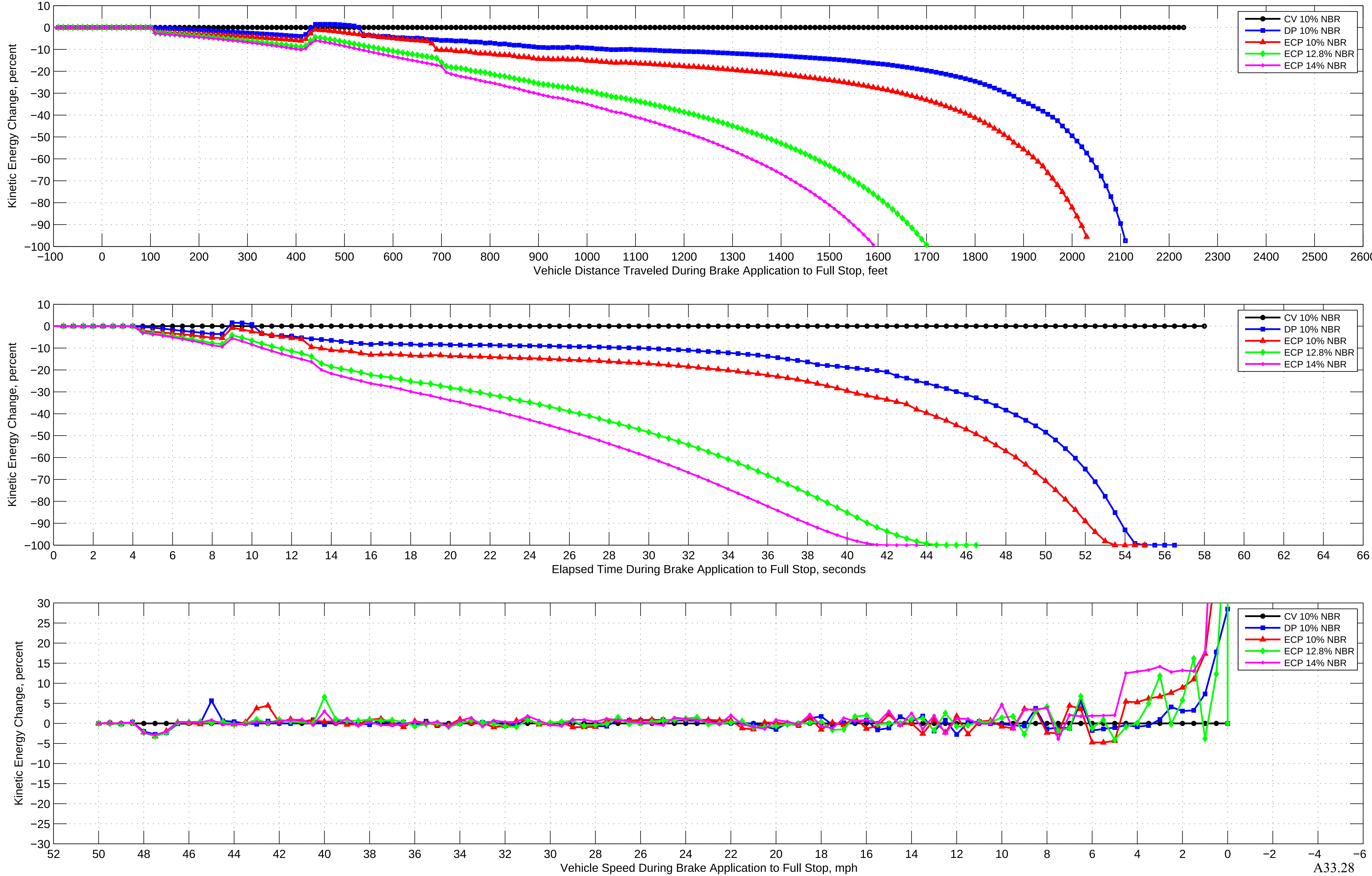


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 48/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph

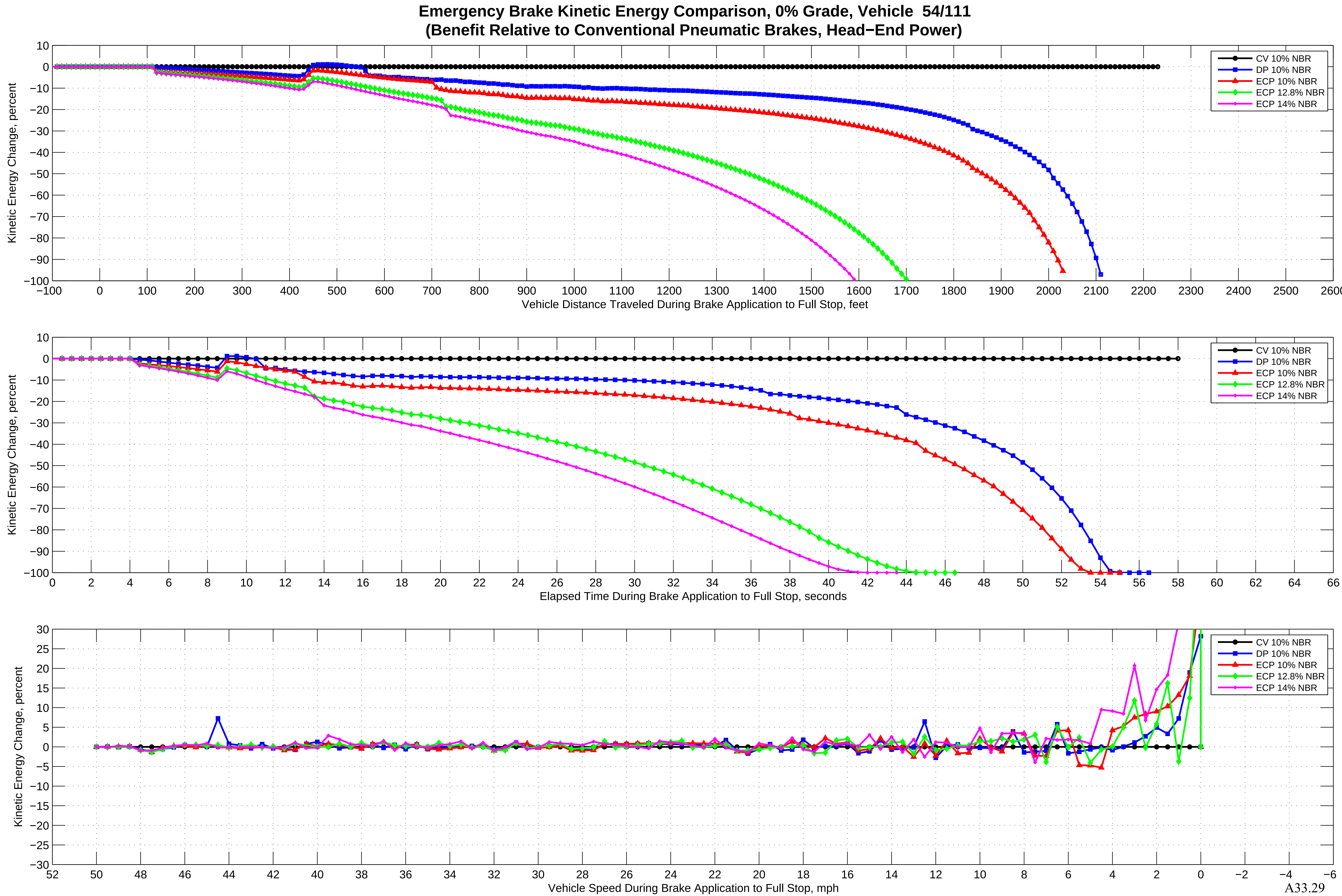
A33.26


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 50/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
A33.27

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 52/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

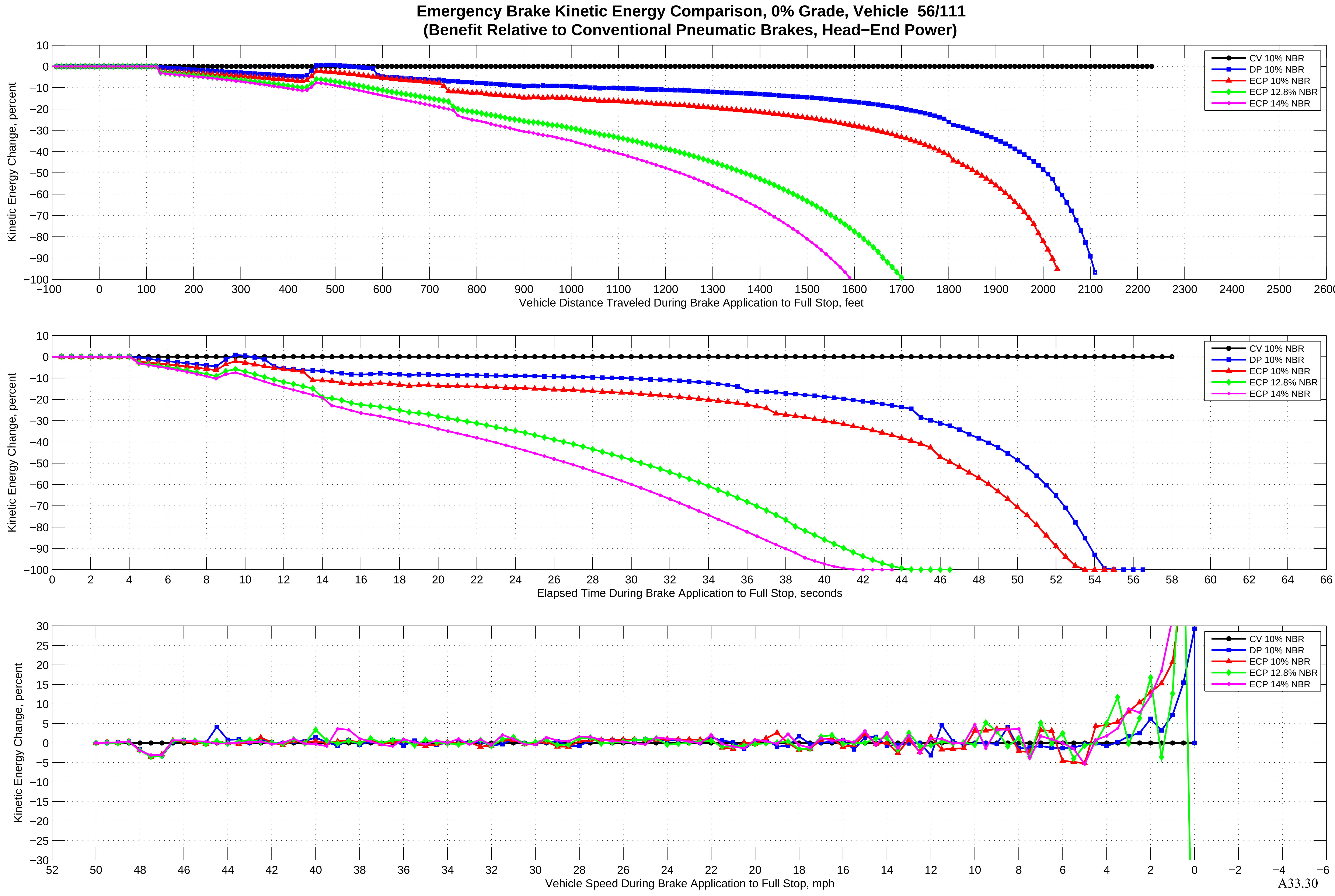


A33.28



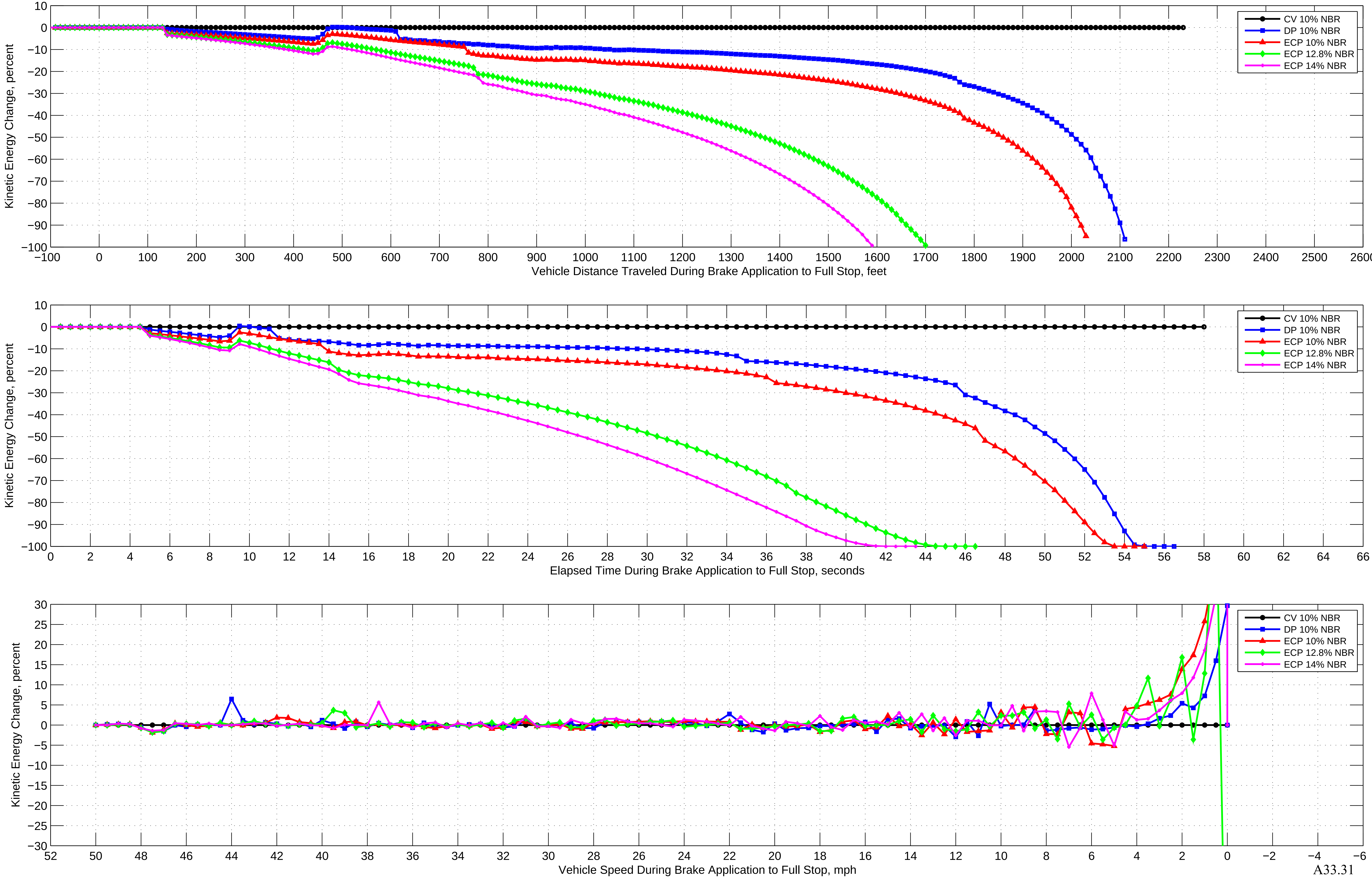
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 54/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph

A33.29



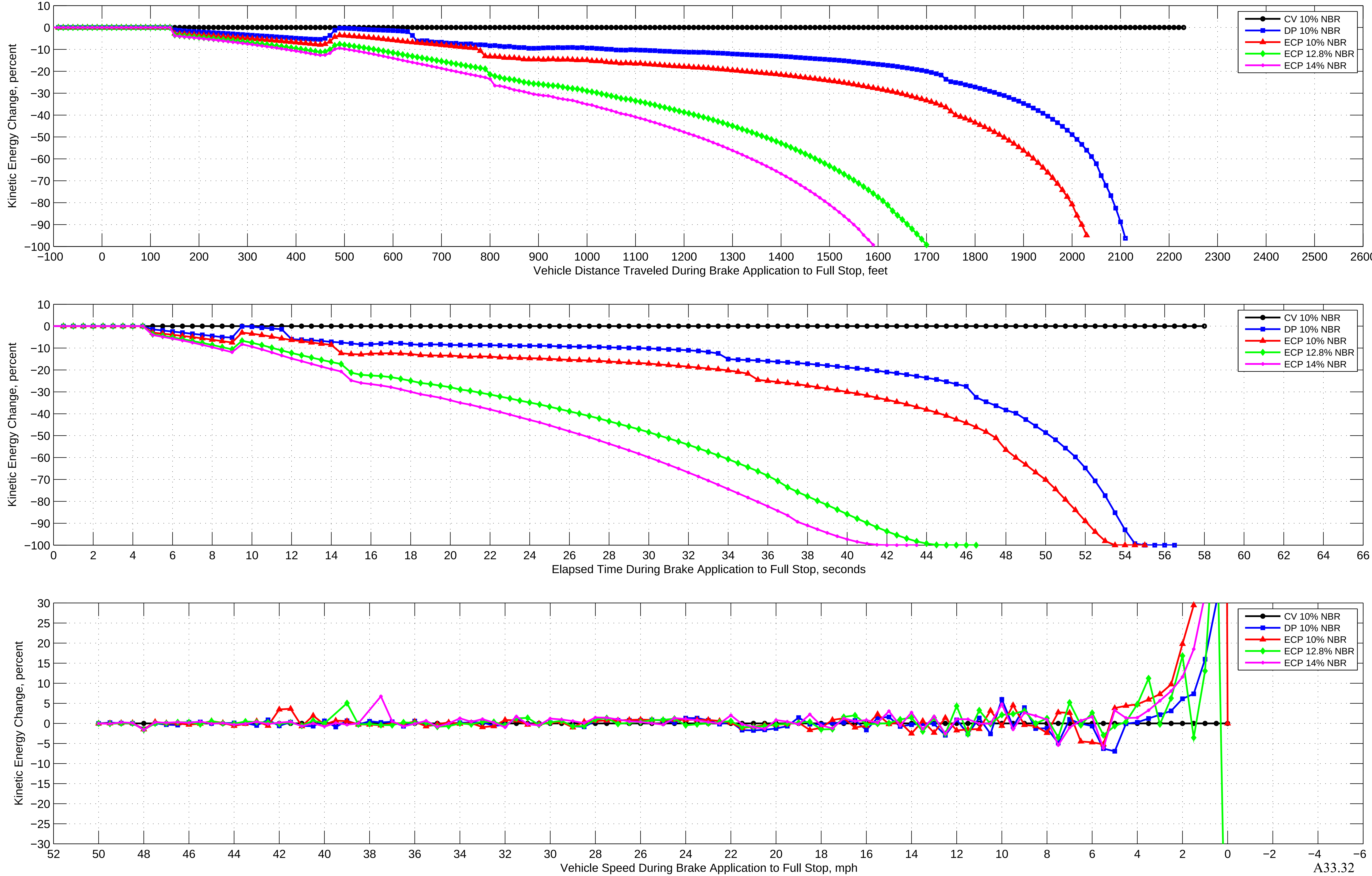
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 56/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.30

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 58/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

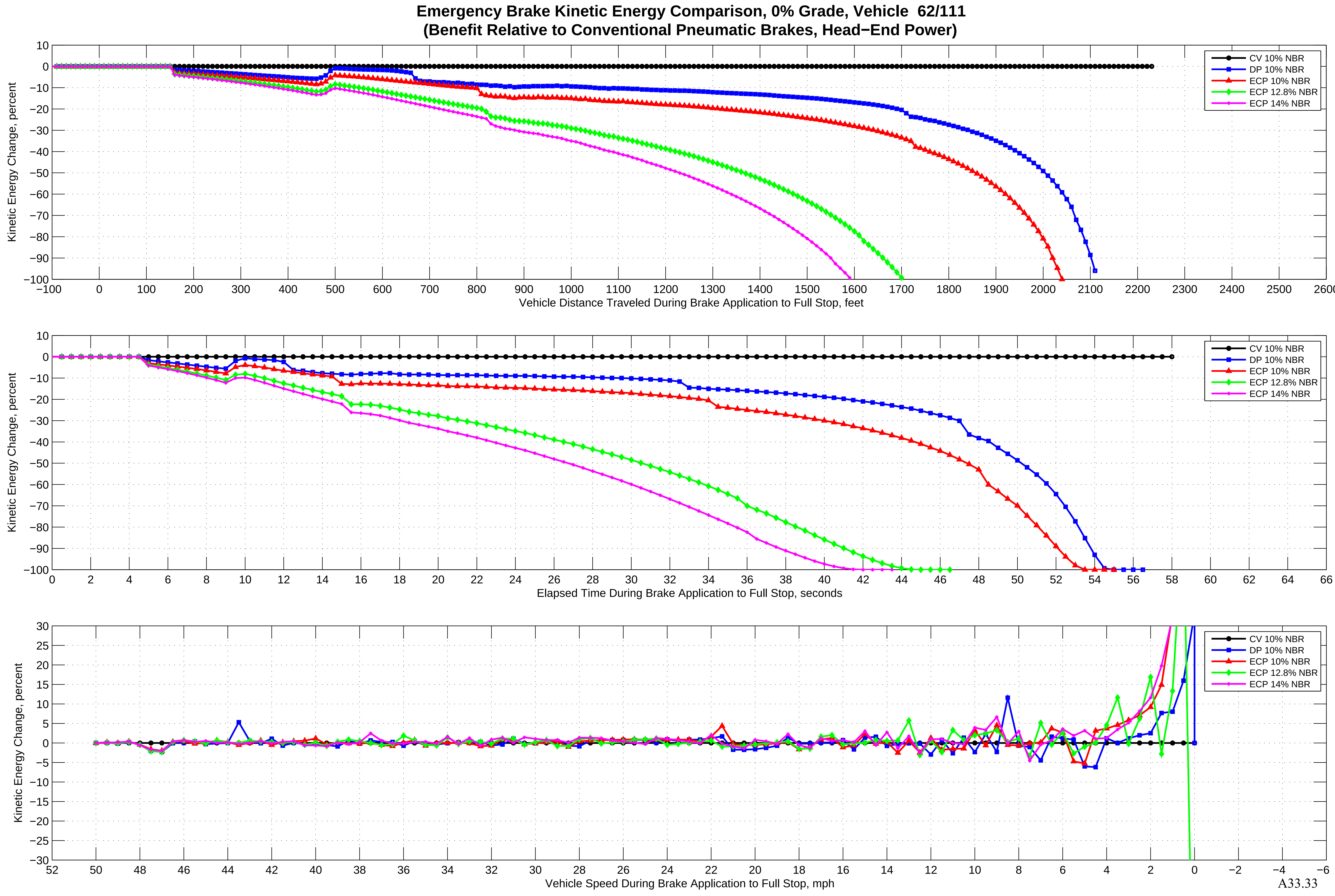


A33.31

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 60/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

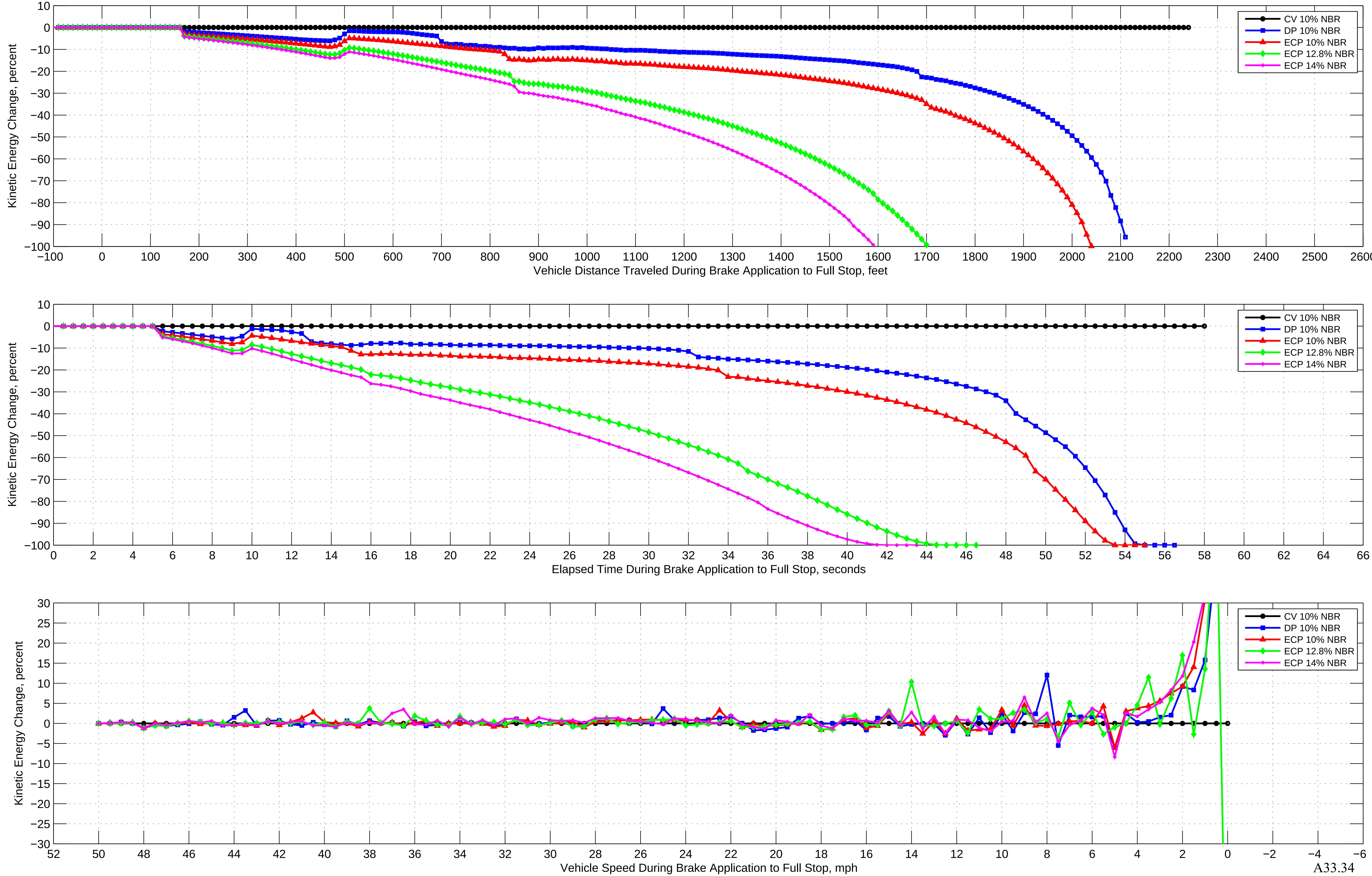


A33.32

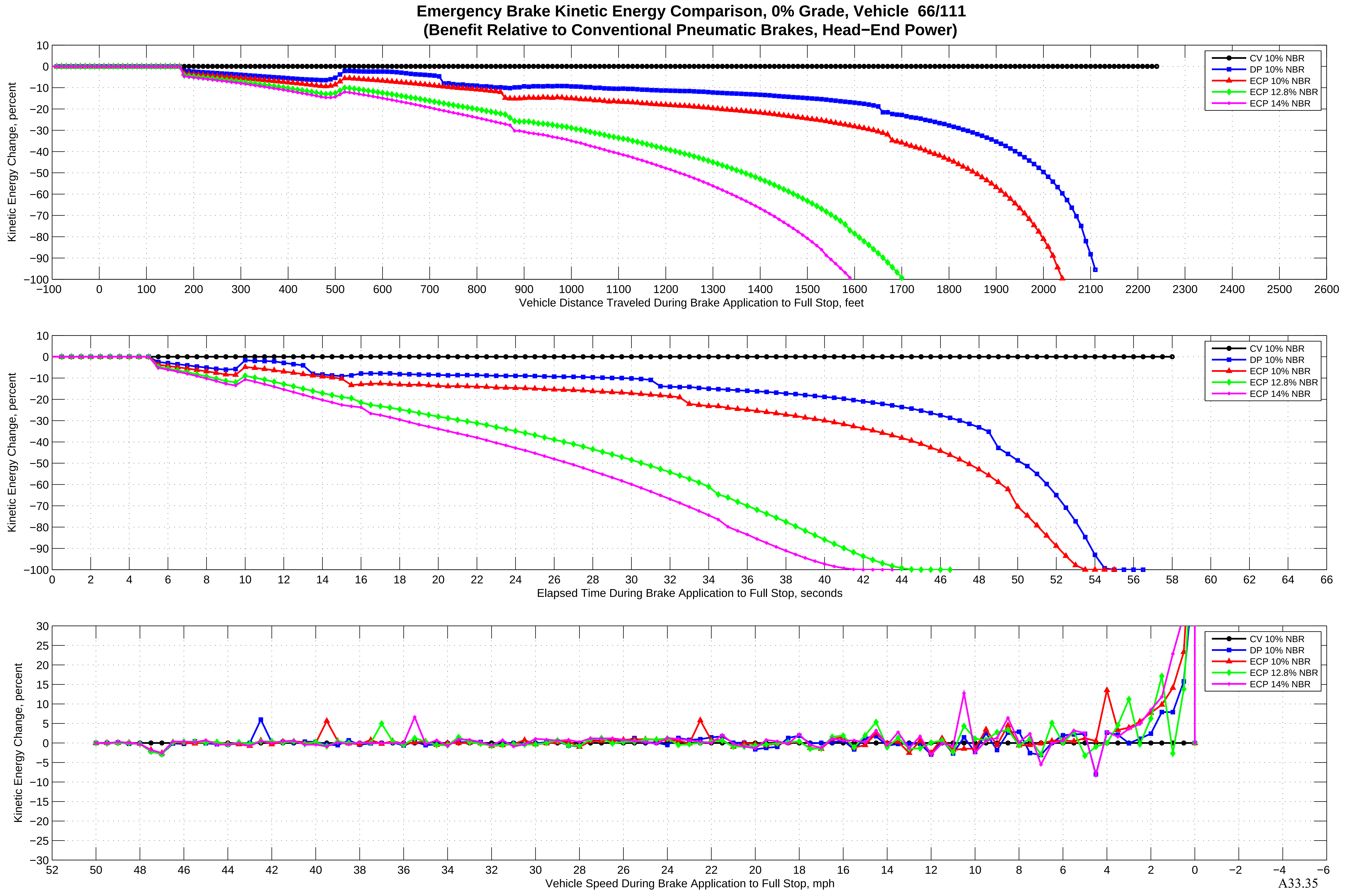


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 62/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.33

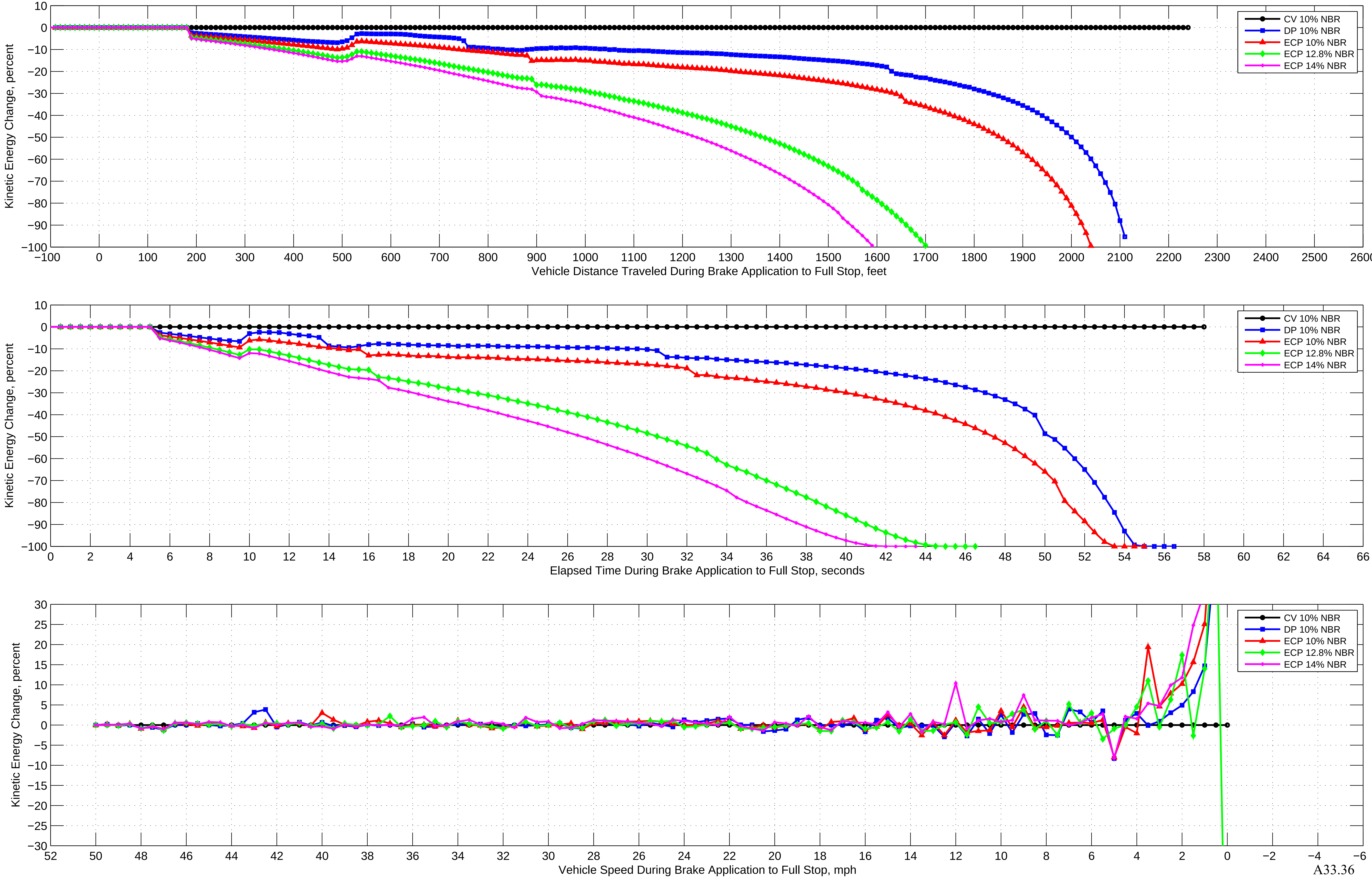
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 64/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



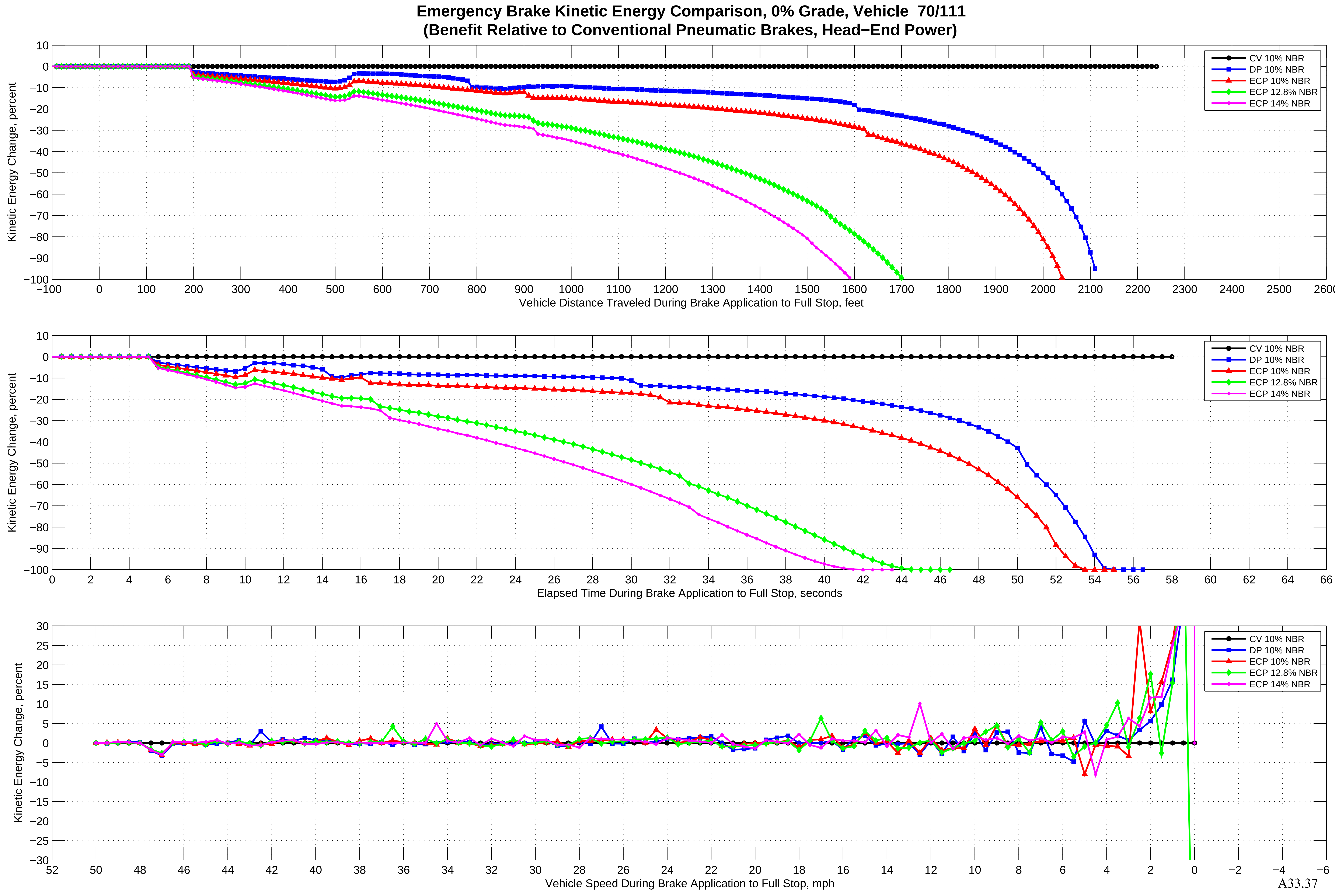
A33.34


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 66/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.35

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 68/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

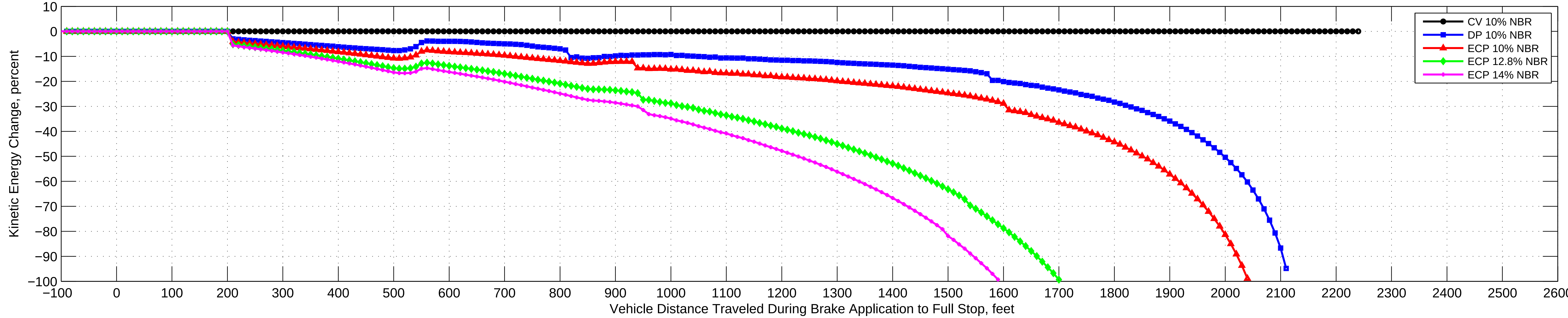


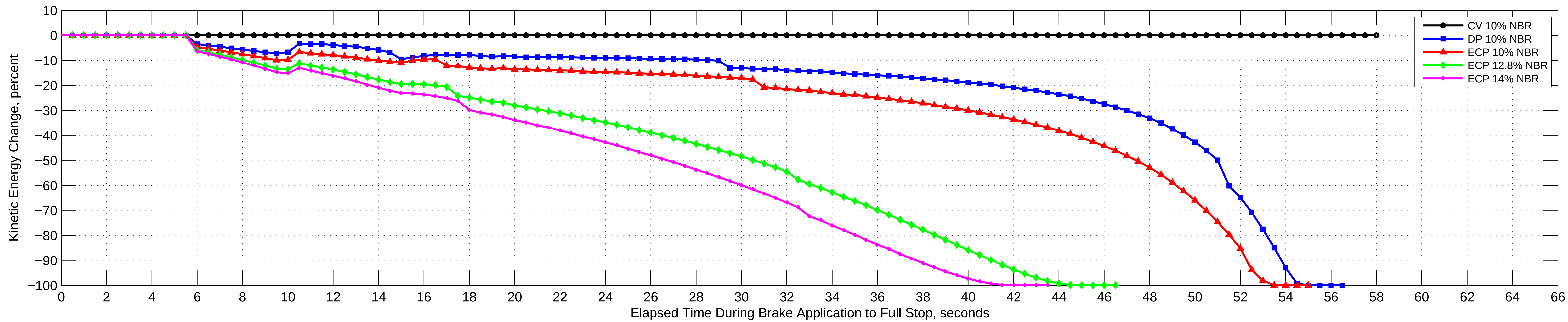
A33.36

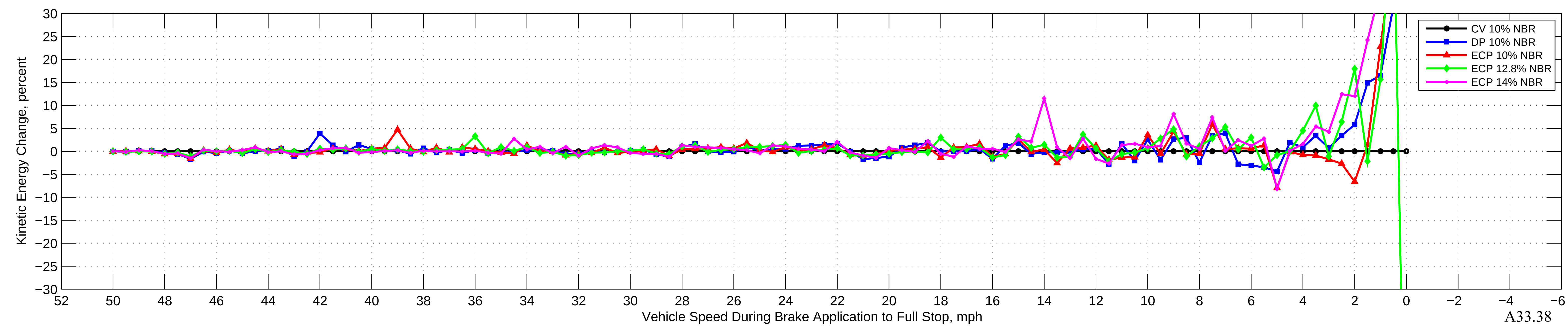


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 70/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.37

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 72/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

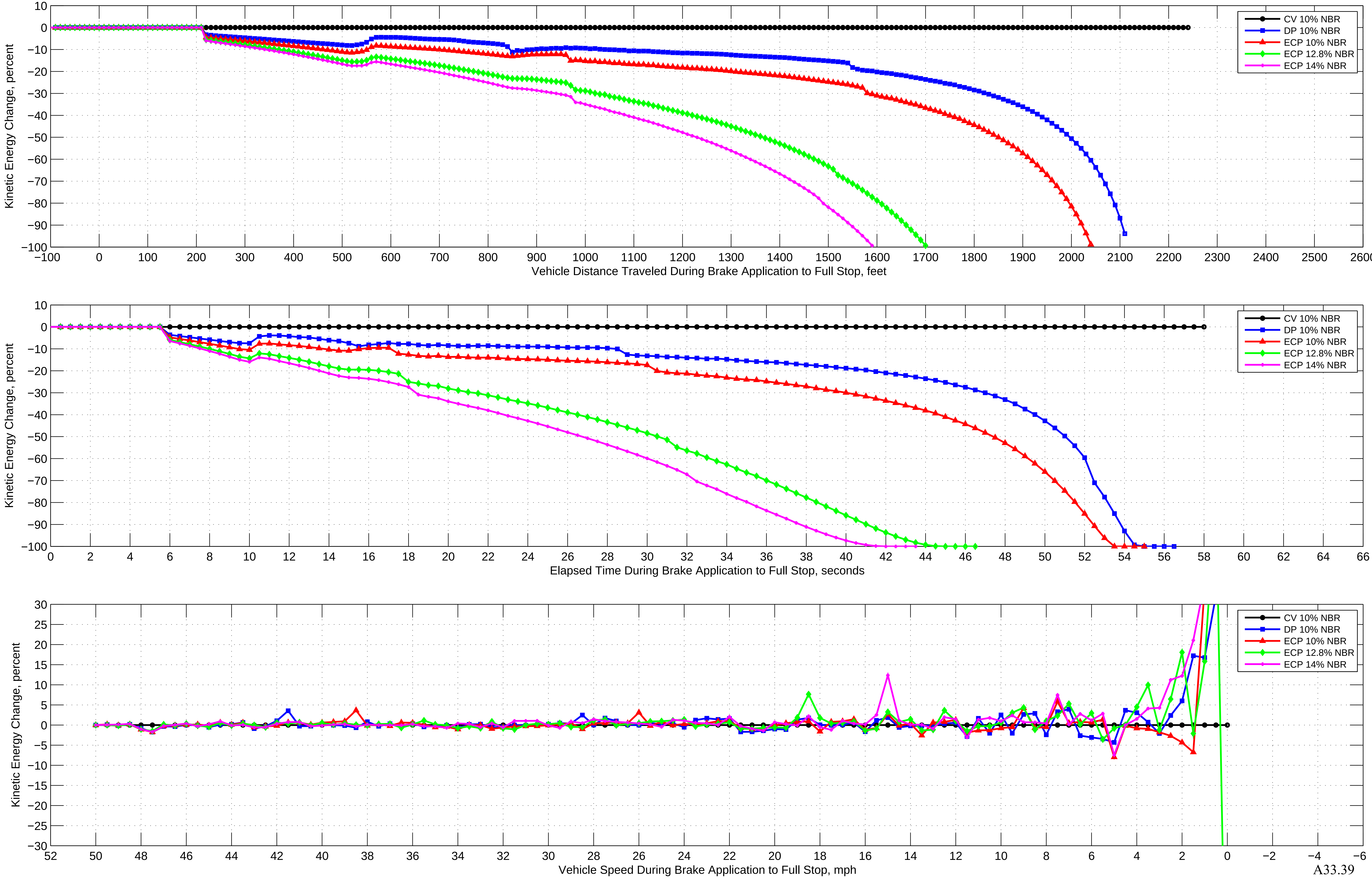






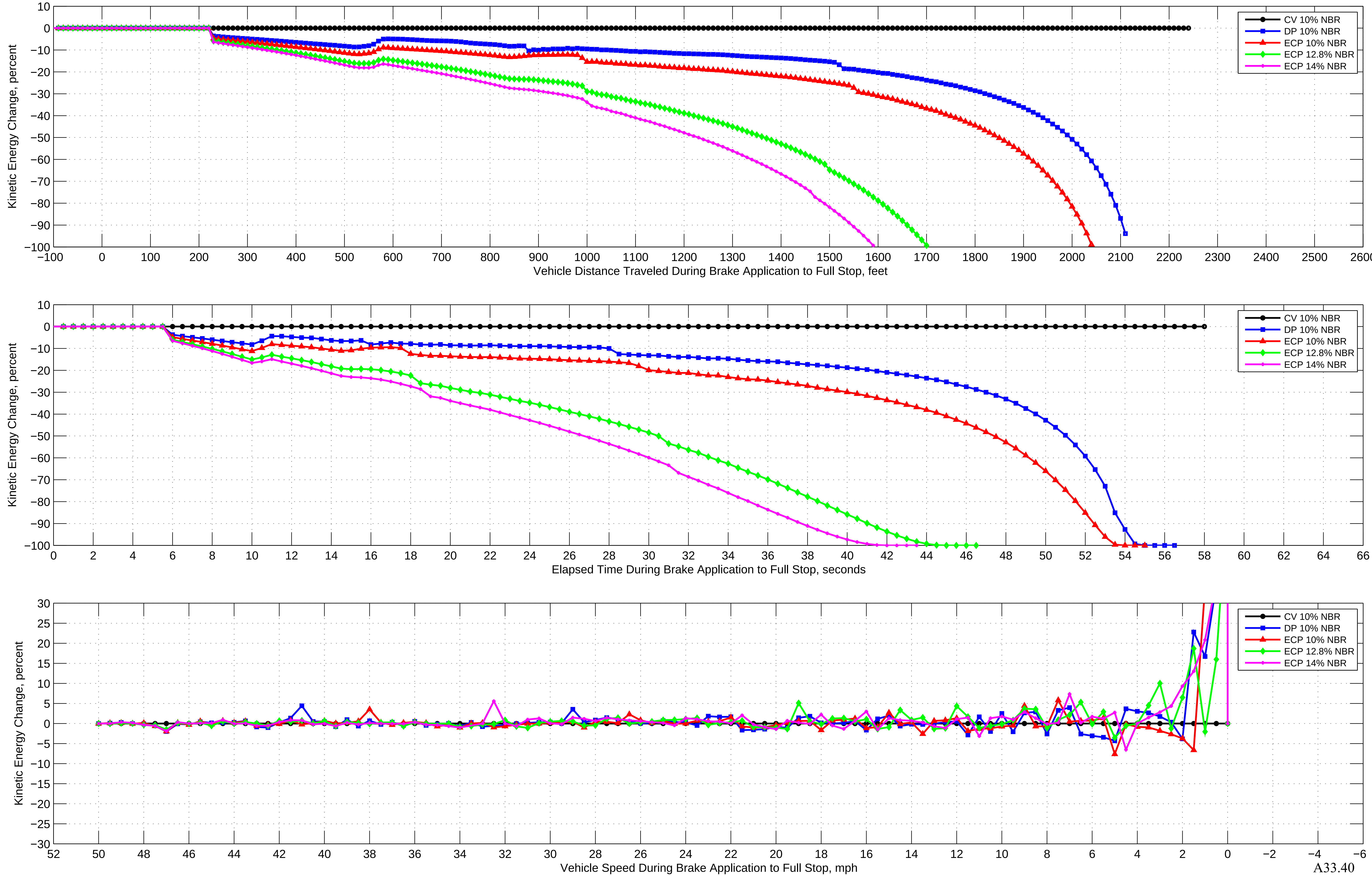
A33.38

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 74/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

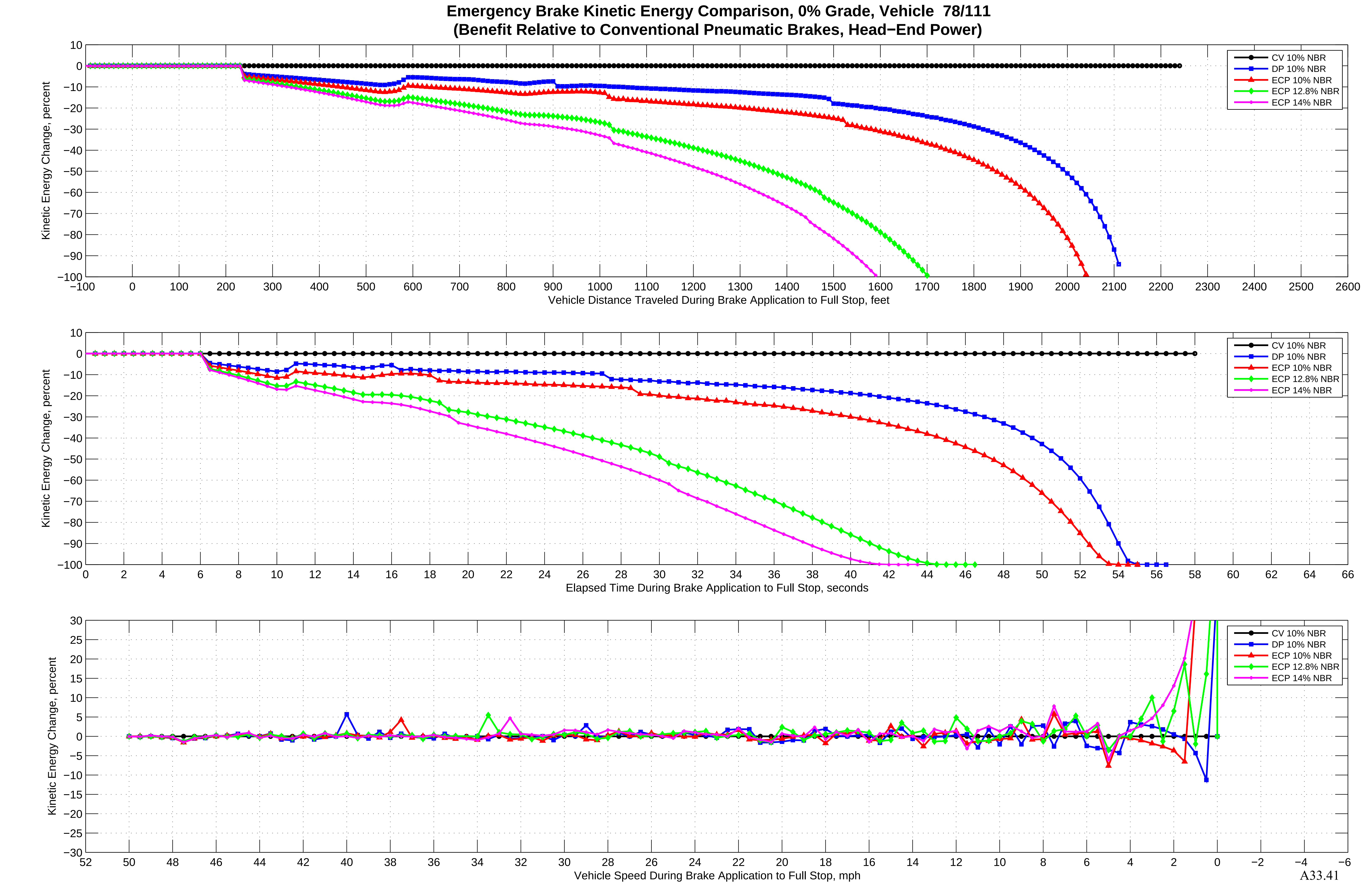


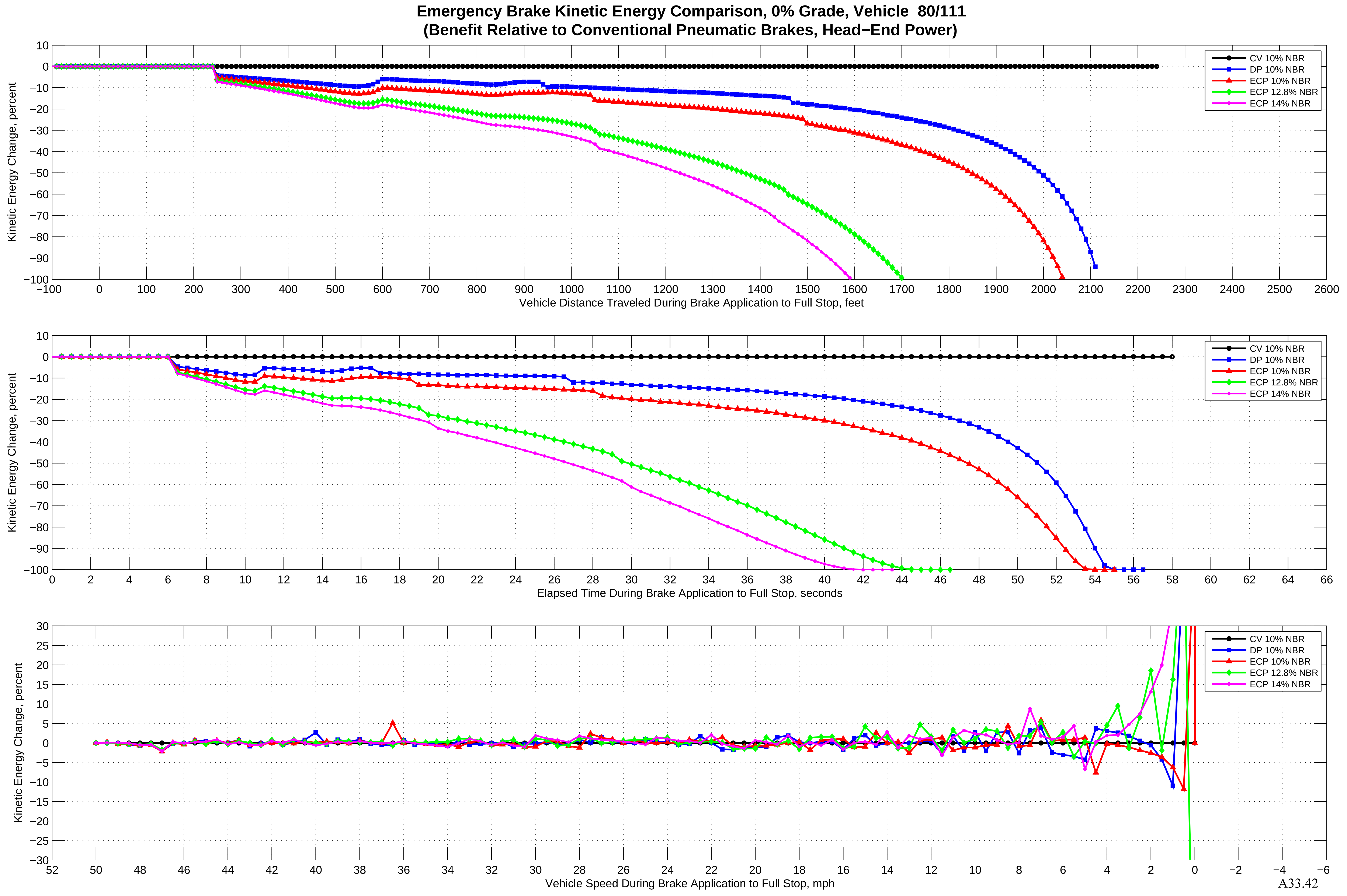
A33.39

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 76/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

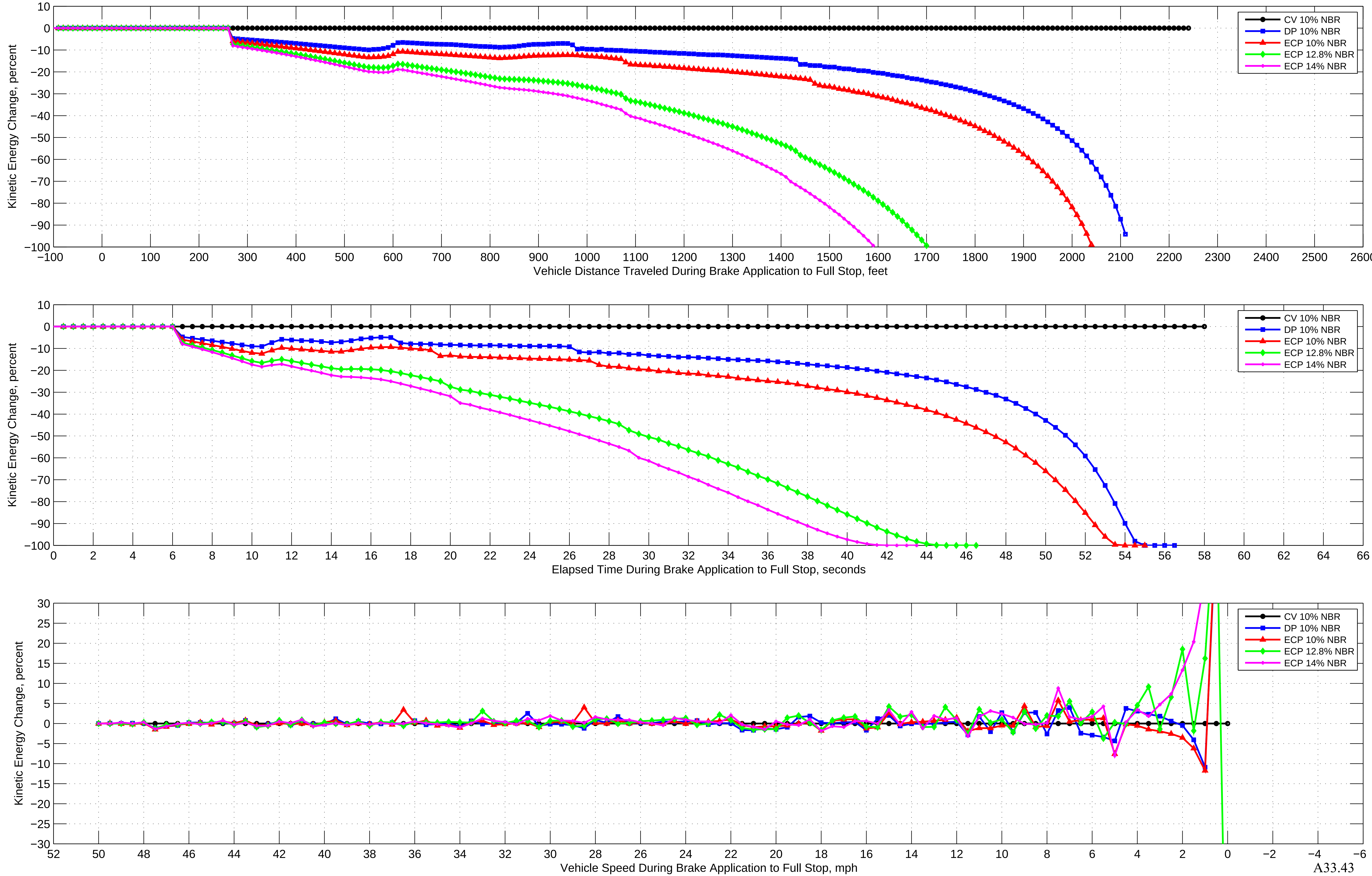


A33.40


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 78/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.41

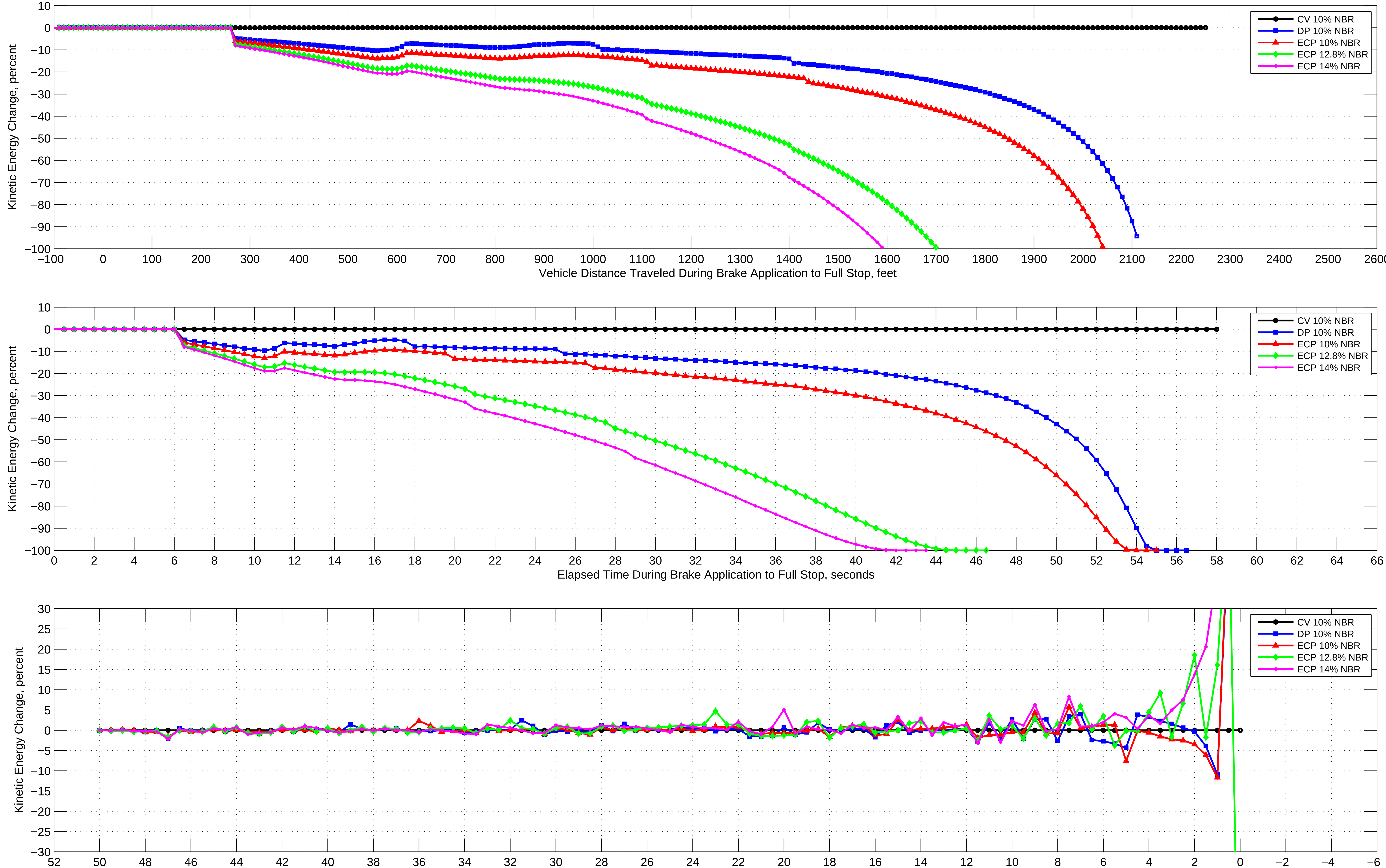

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 80/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
A33.42

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 82/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

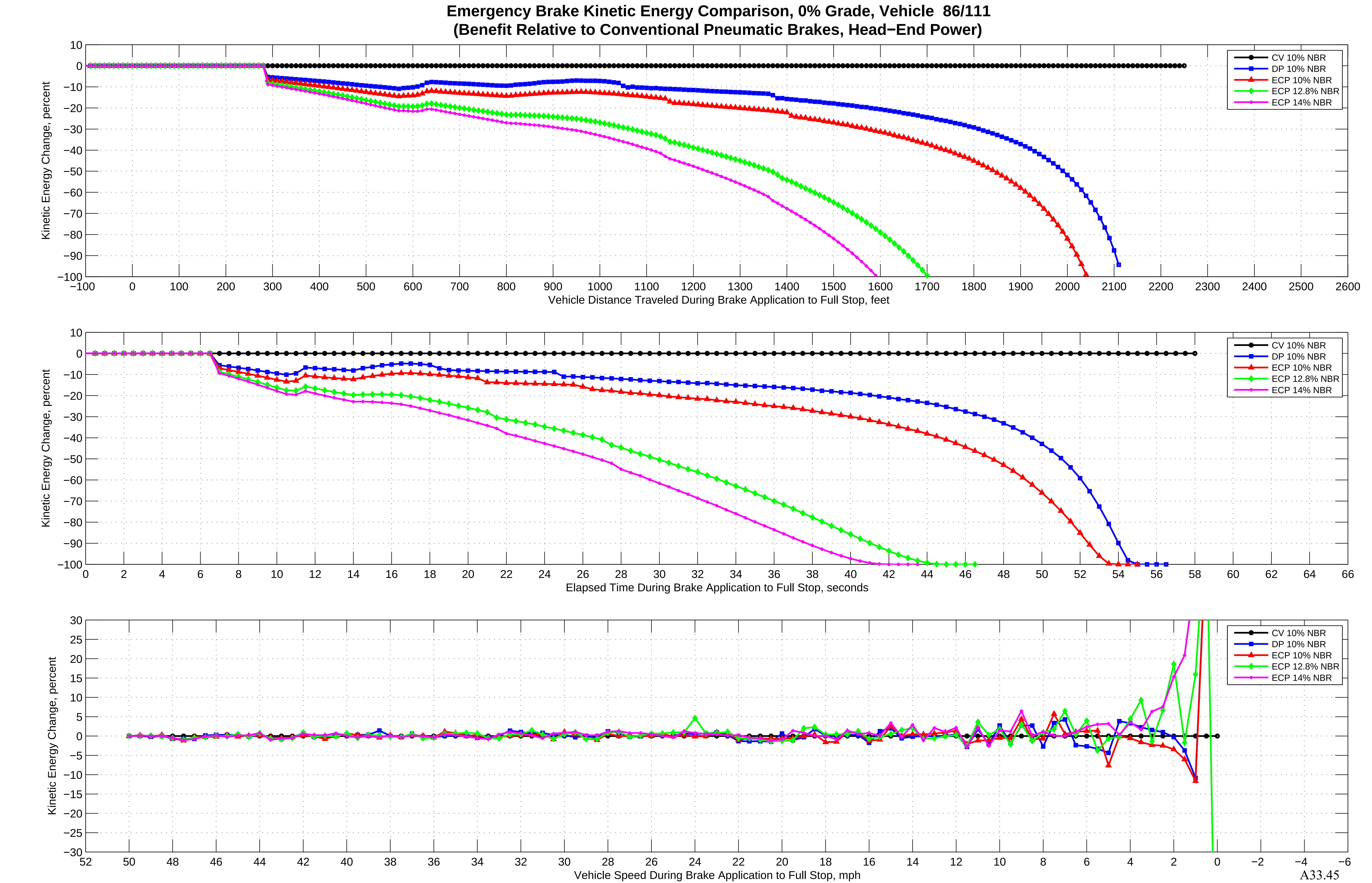


A33.43

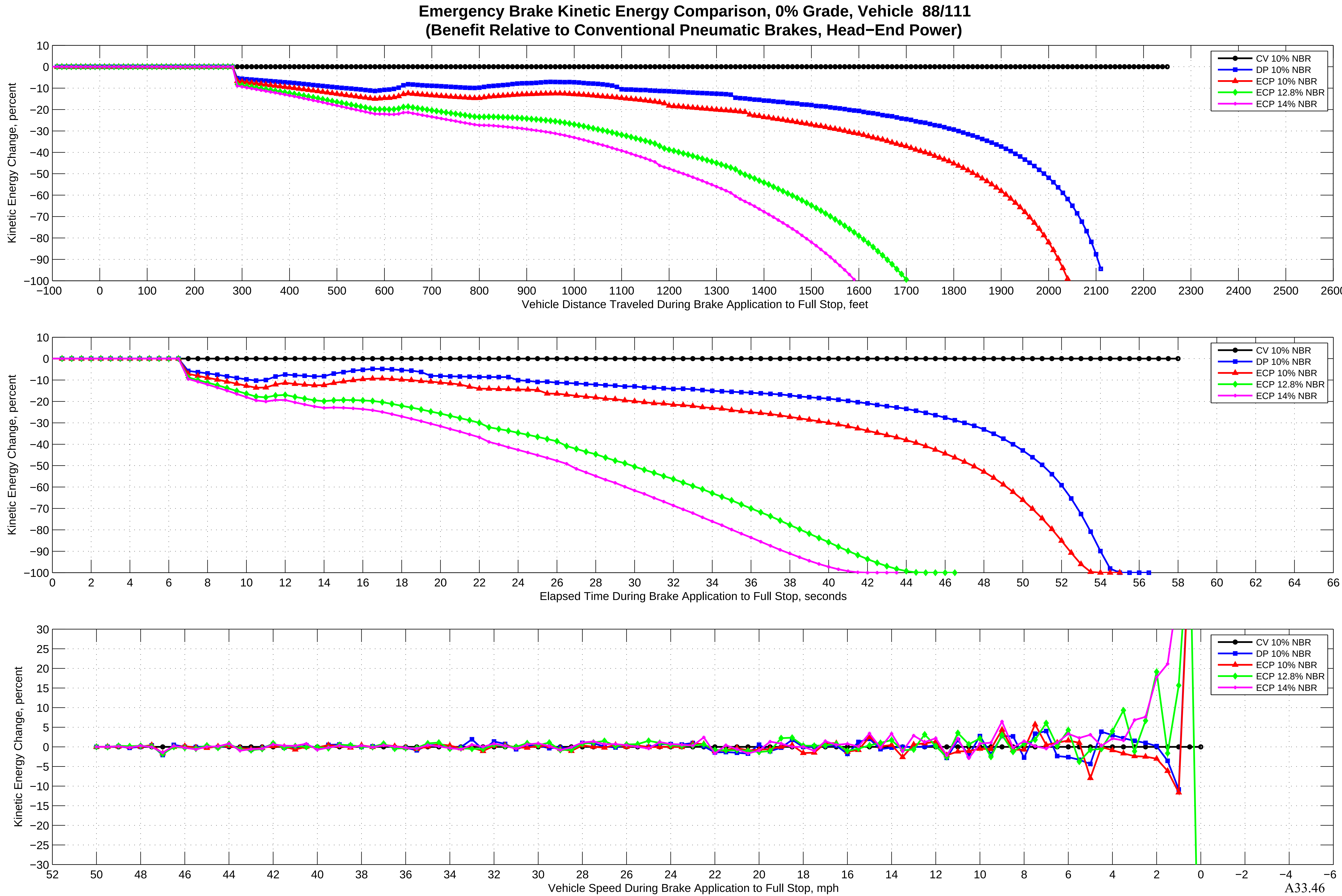
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 84/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



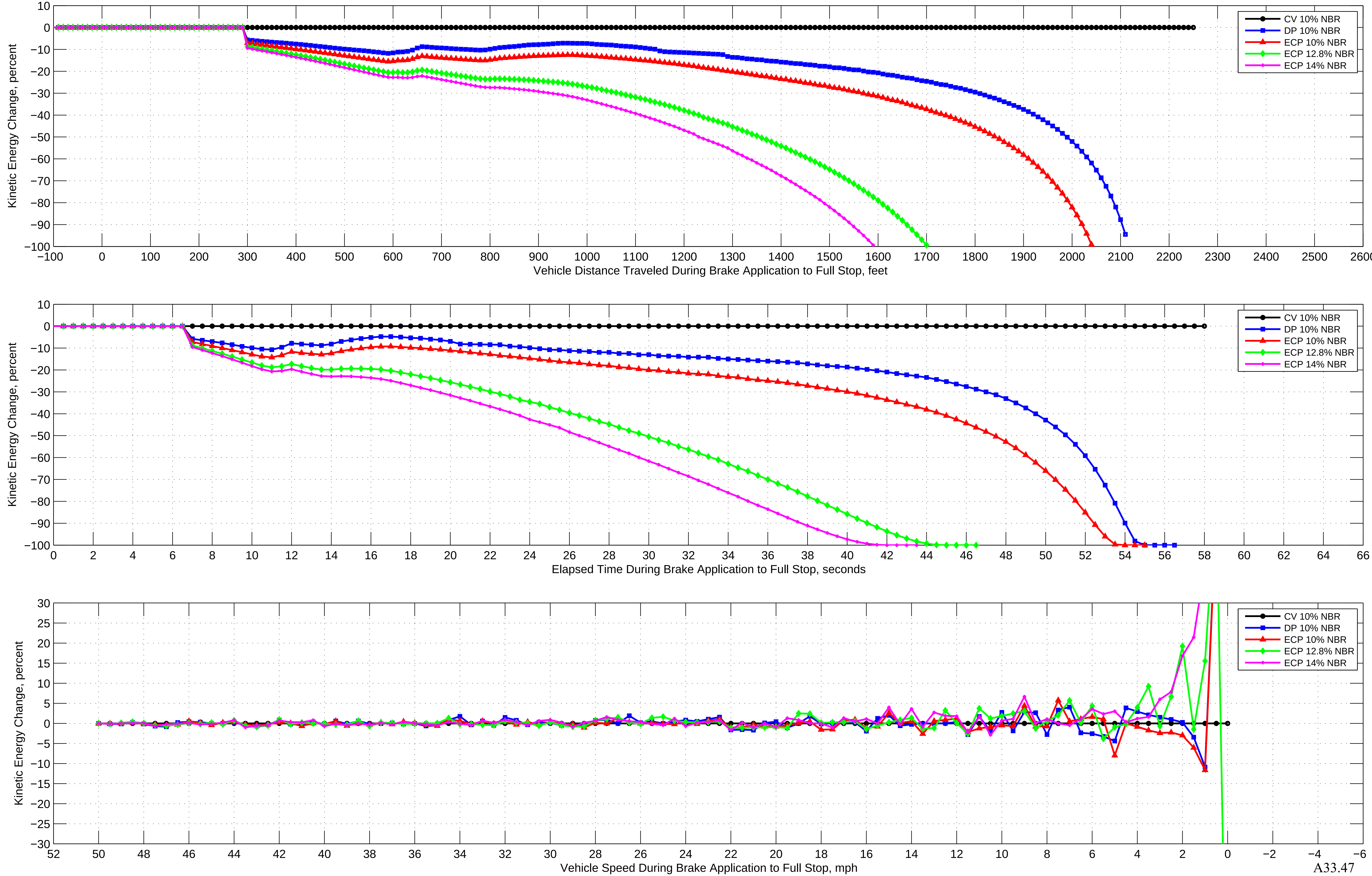
A33.44


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 86/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR

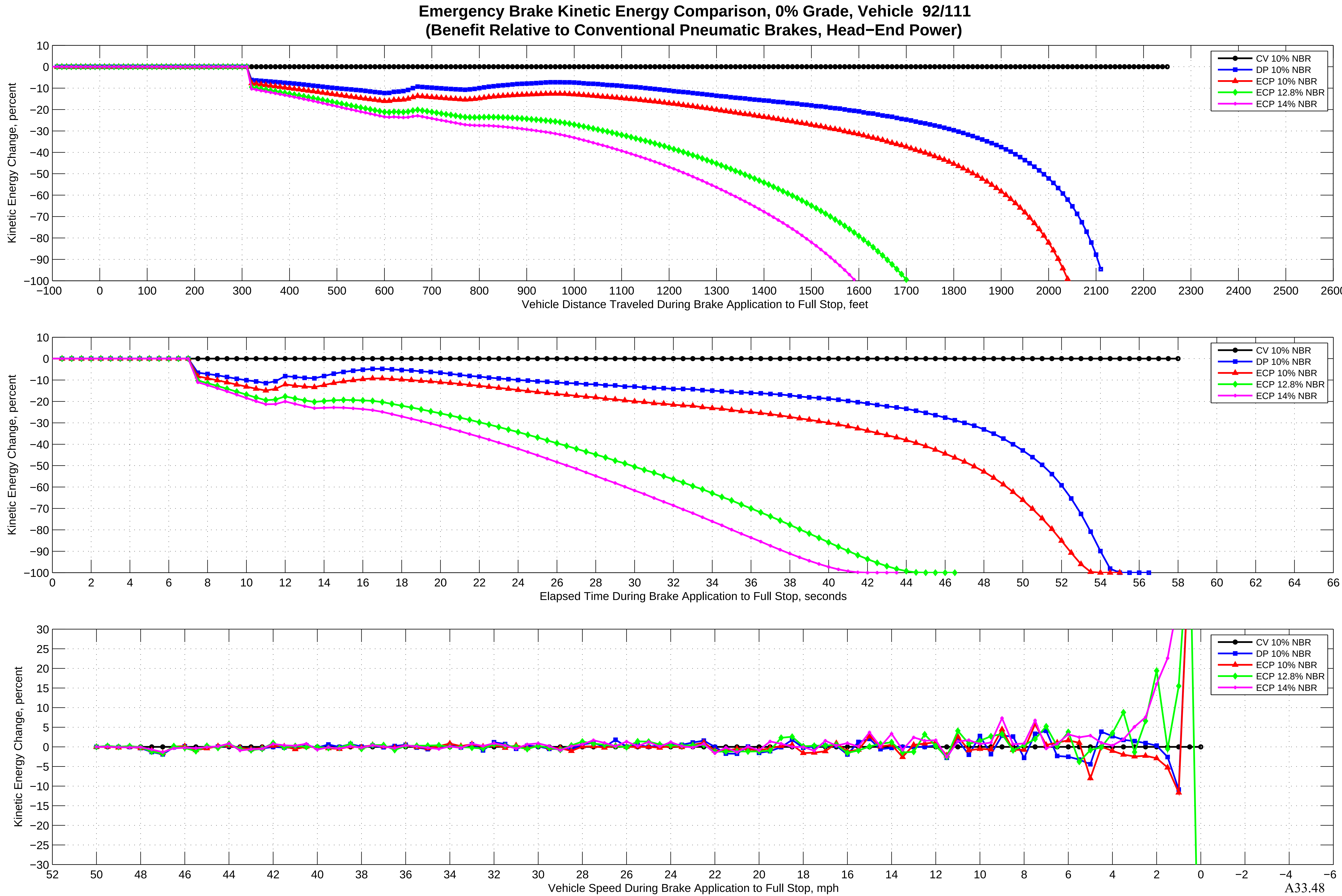
A33.45


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 88/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Elapsed Time During Brake Application to Full Stop, seconds
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
Kinetic Energy Change, percent
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.46

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 90/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)

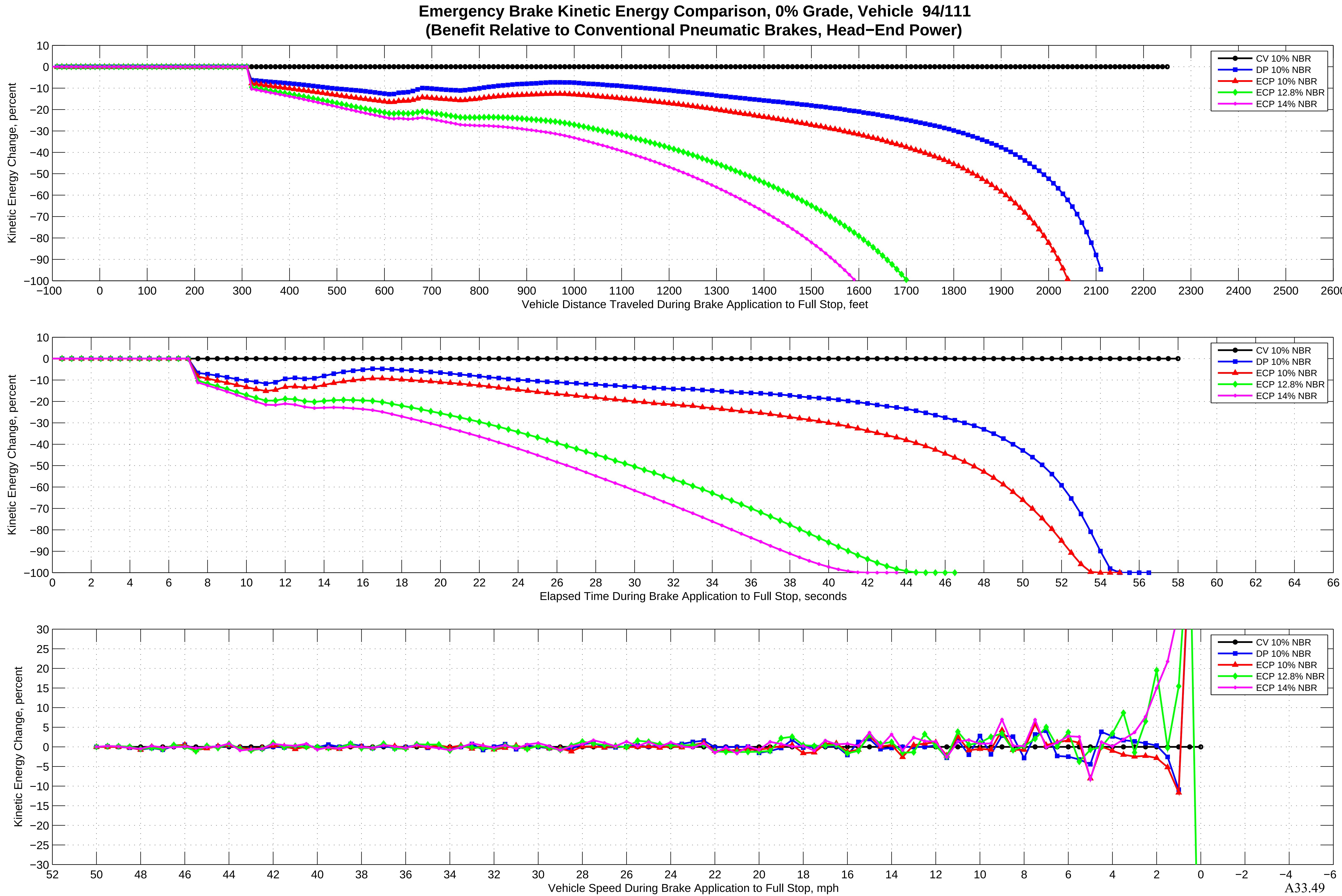


A33.47

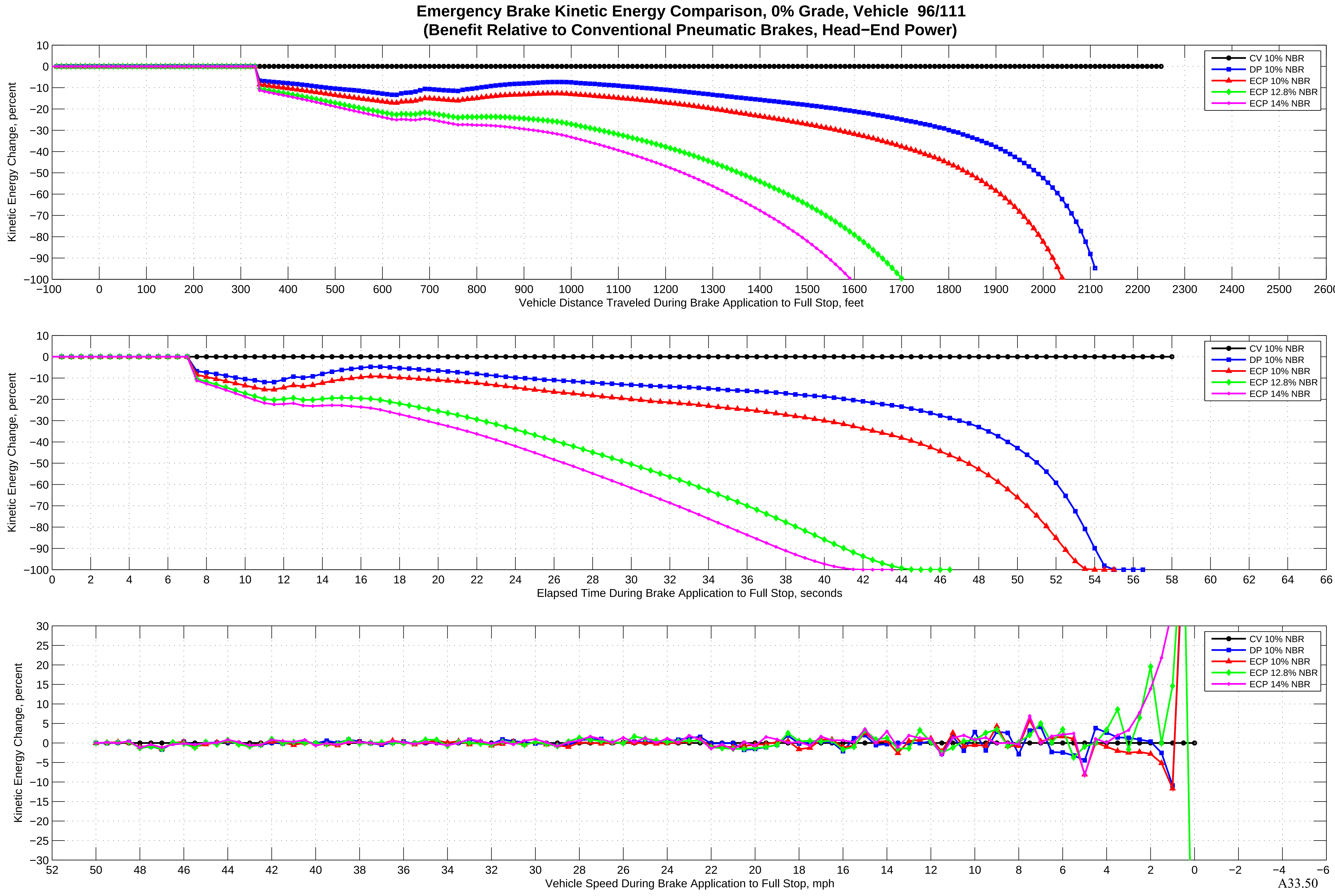


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 92/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR

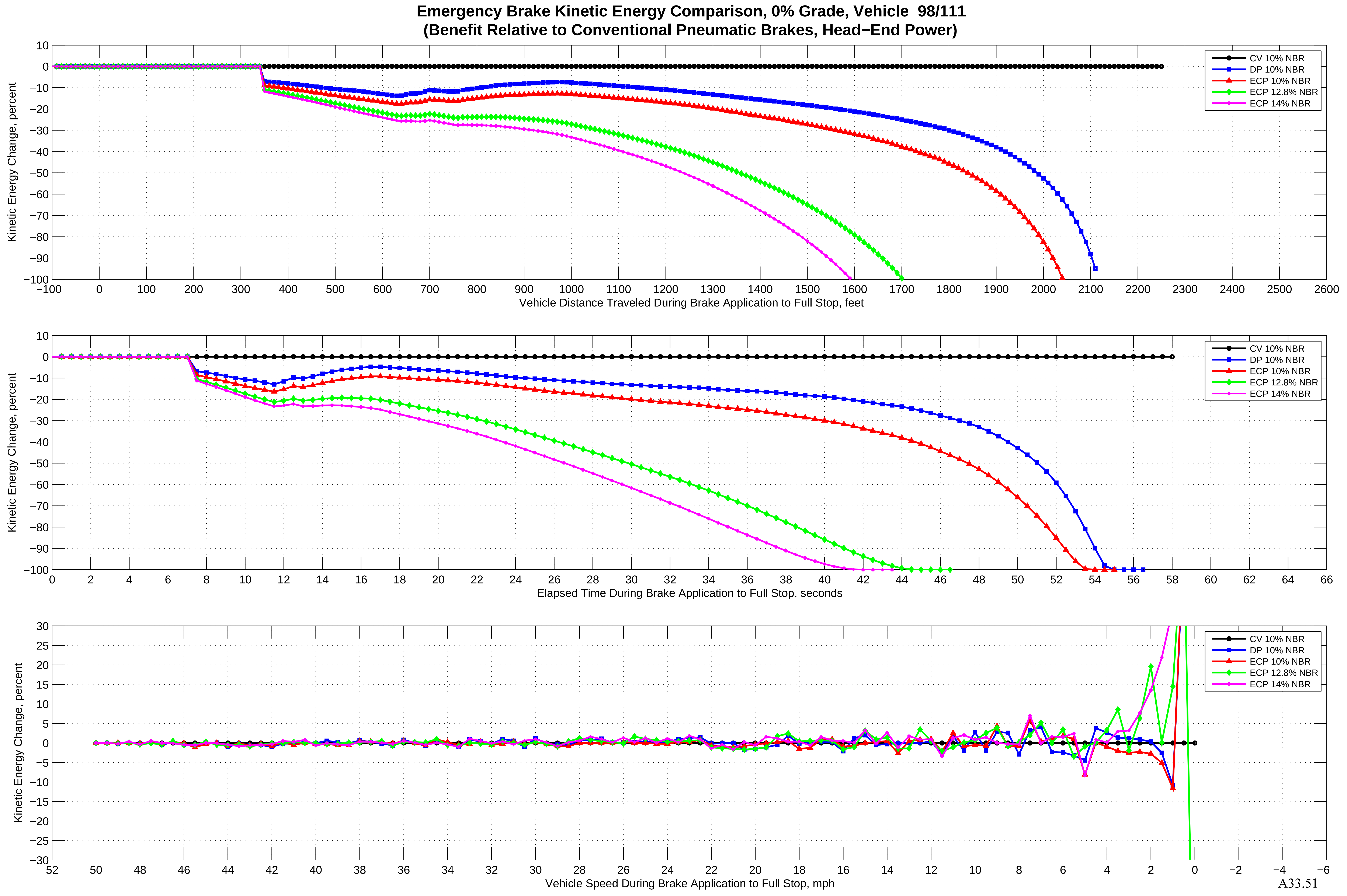
A33.48

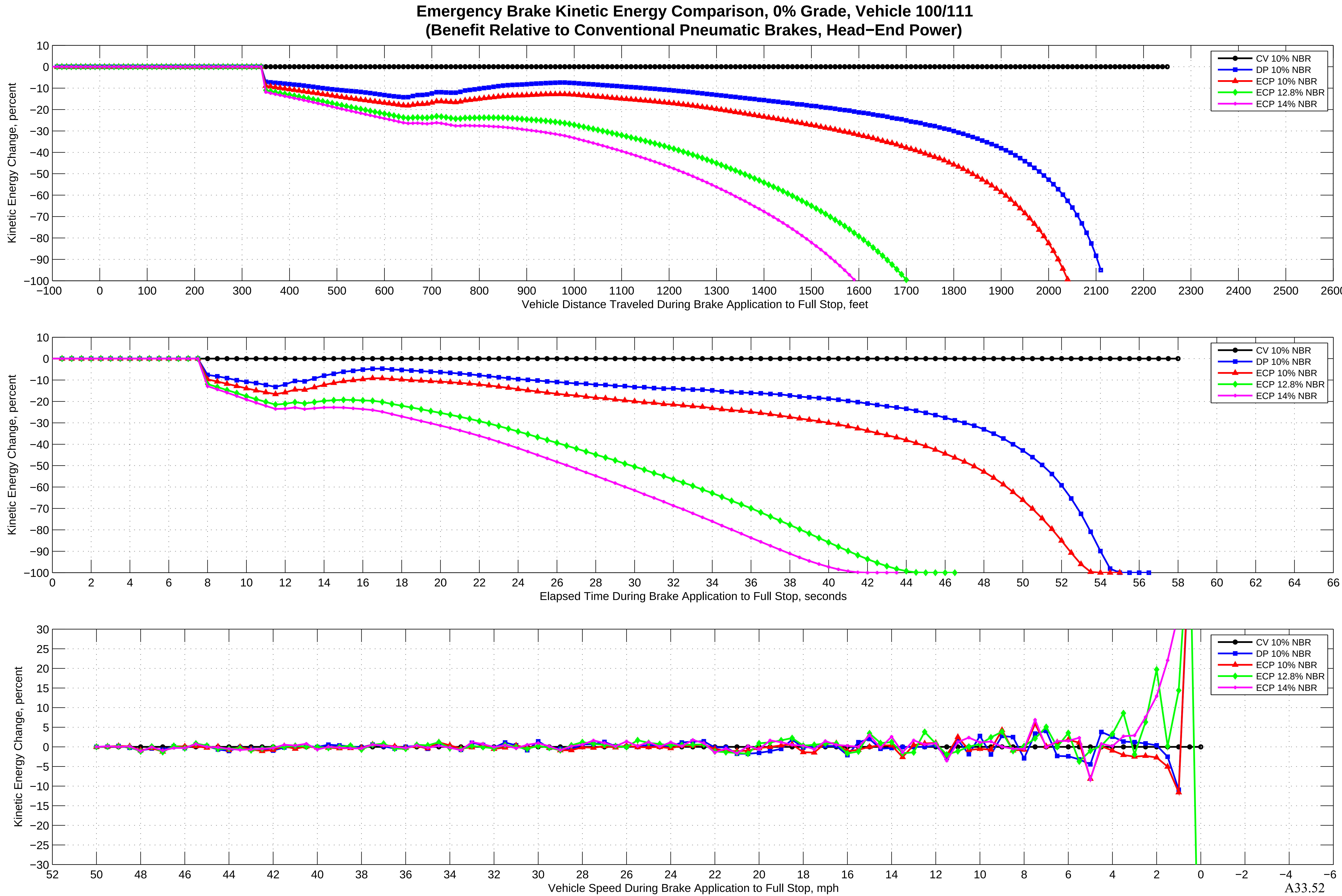


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 94/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.49

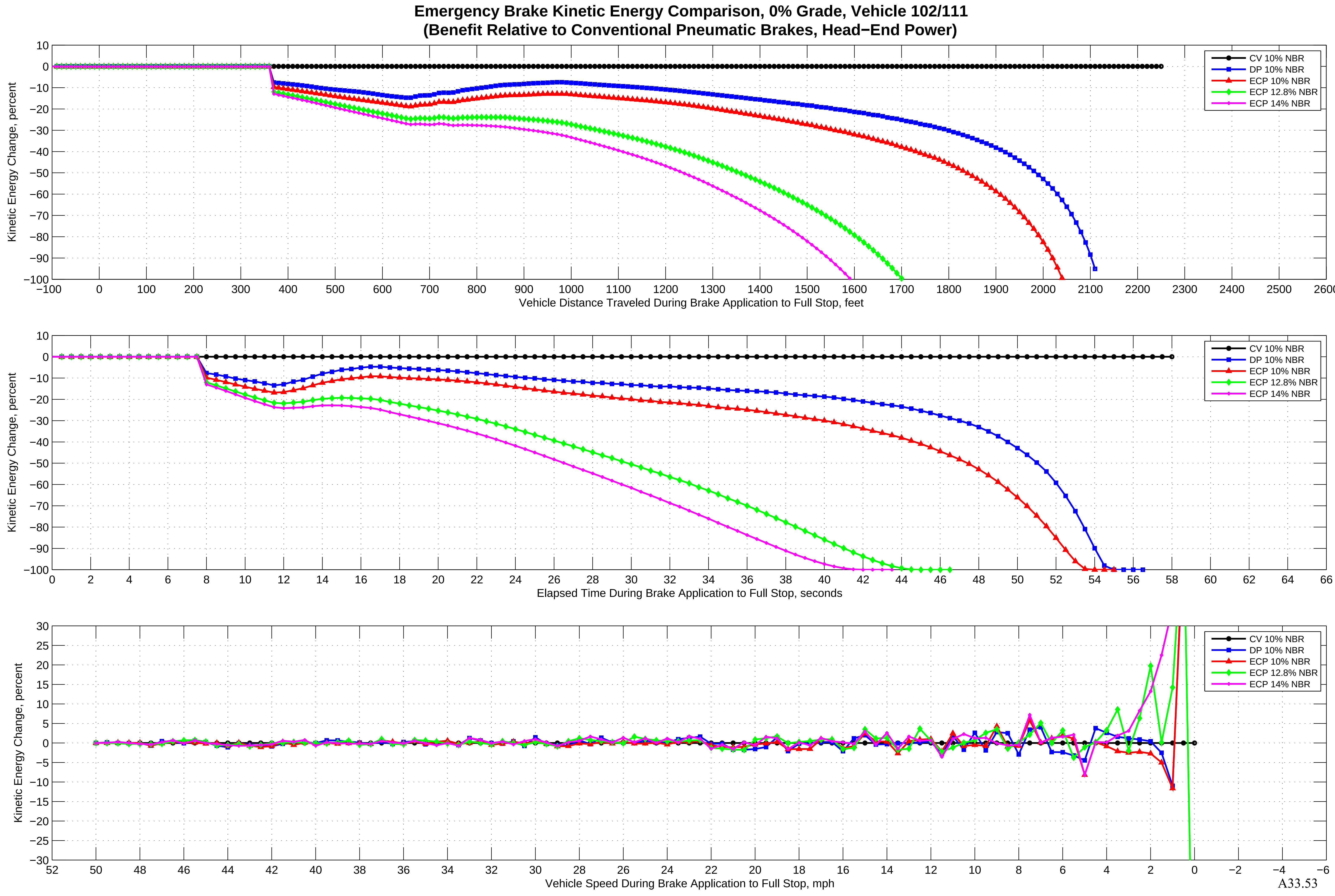


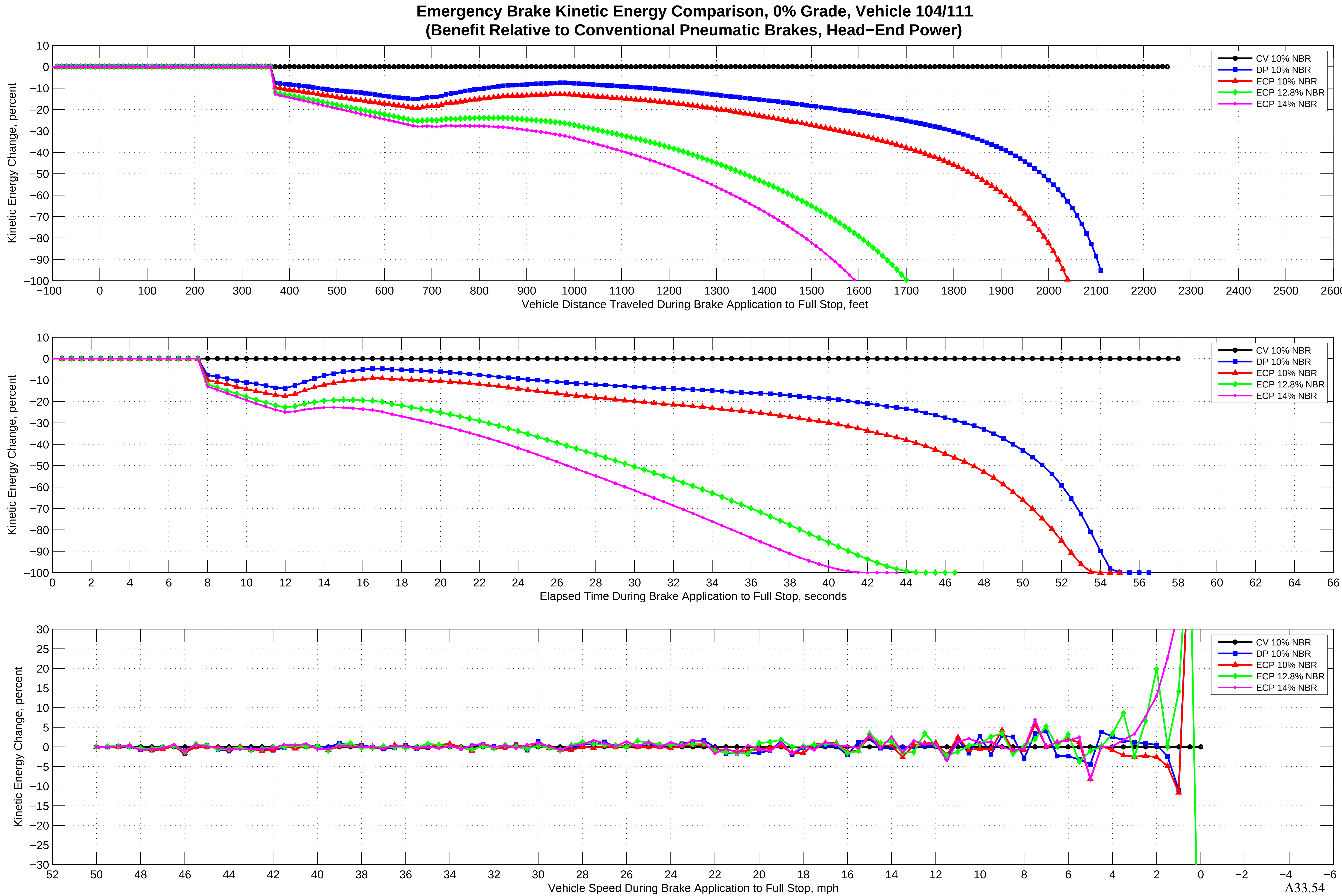
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 96/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.50


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 98/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.51



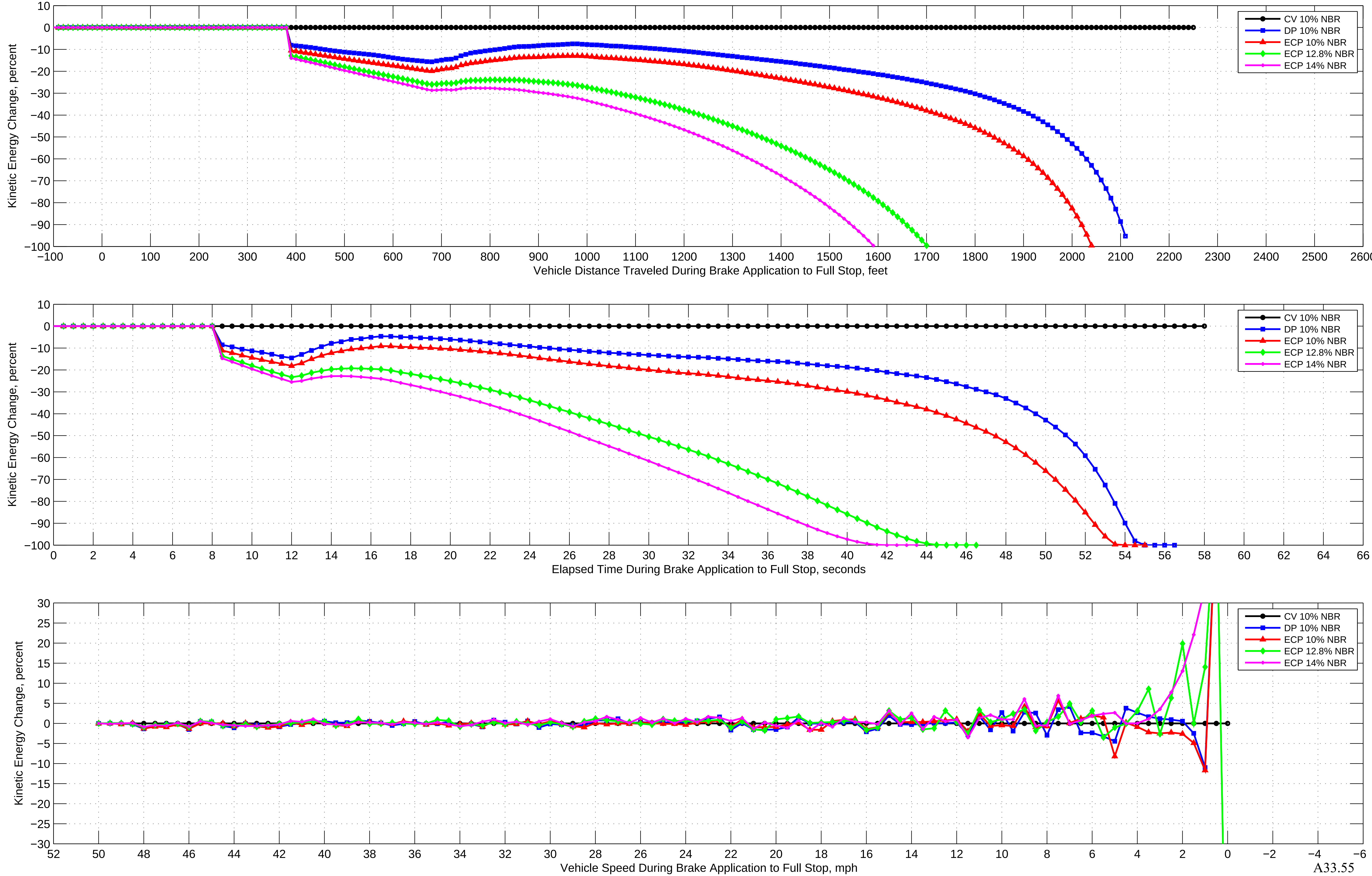
Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 100/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.52


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 102/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.53

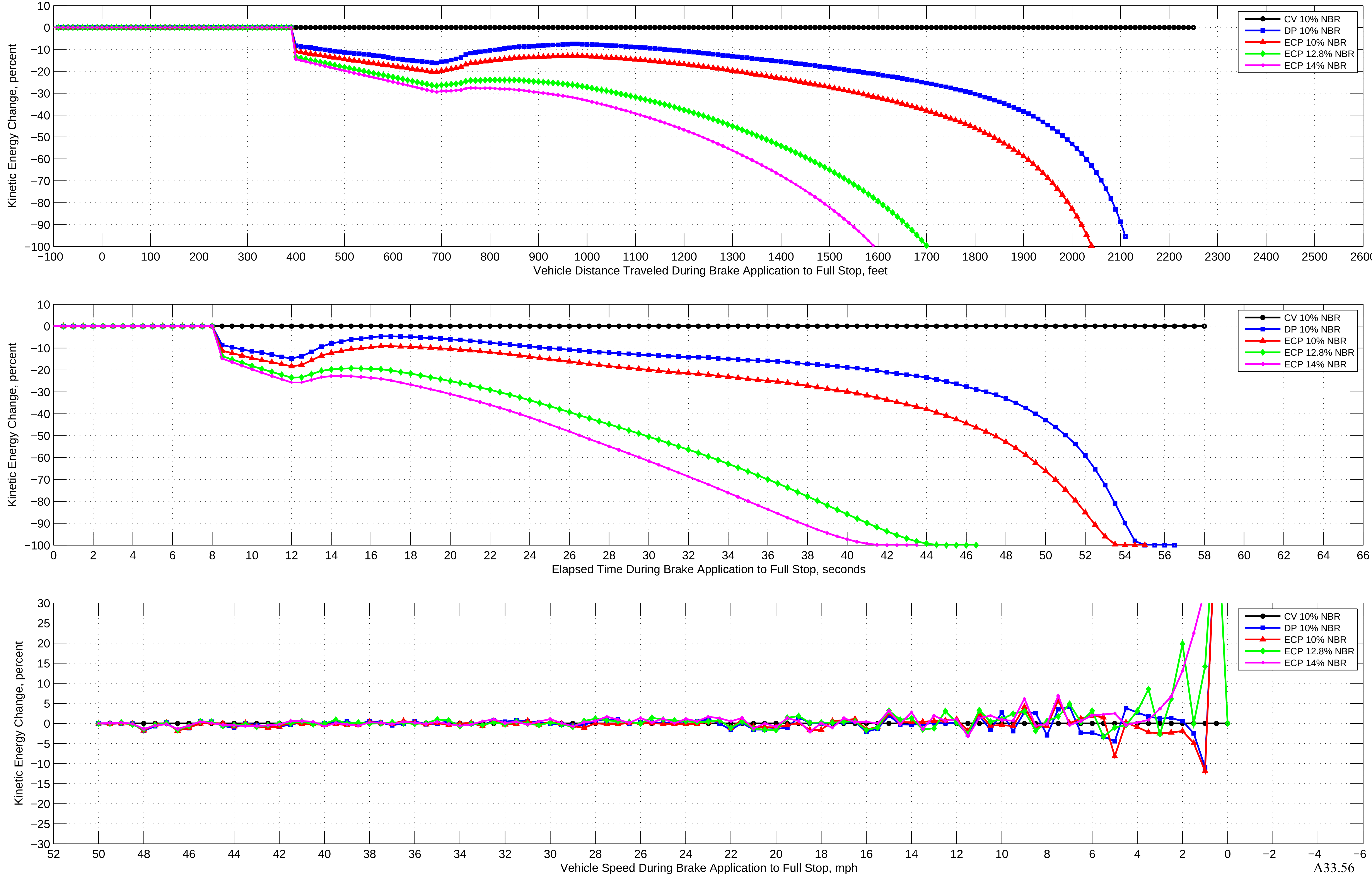


Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 104/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)
Kinetic Energy Change, percent
Vehicle Distance Traveled During Brake Application to Full Stop, feet
Elapsed Time During Brake Application to Full Stop, seconds
Vehicle Speed During Brake Application to Full Stop, mph
CV 10% NBR
DP 10% NBR
ECP 10% NBR
ECP 12.8% NBR
ECP 14% NBR
A33.54

Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 106/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



Emergency Brake Kinetic Energy Comparison, 0% Grade, Vehicle 108/111
(Benefit Relative to Conventional Pneumatic Brakes, Head−End Power)



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Attachment 34: Effect of Speed Reduction on Train Kinetic Energy

Figure 1: Effect of Speed Reduction on Train Kinetic Energy
(5 mph Decrements; Constant Mass, V_1, V_2)

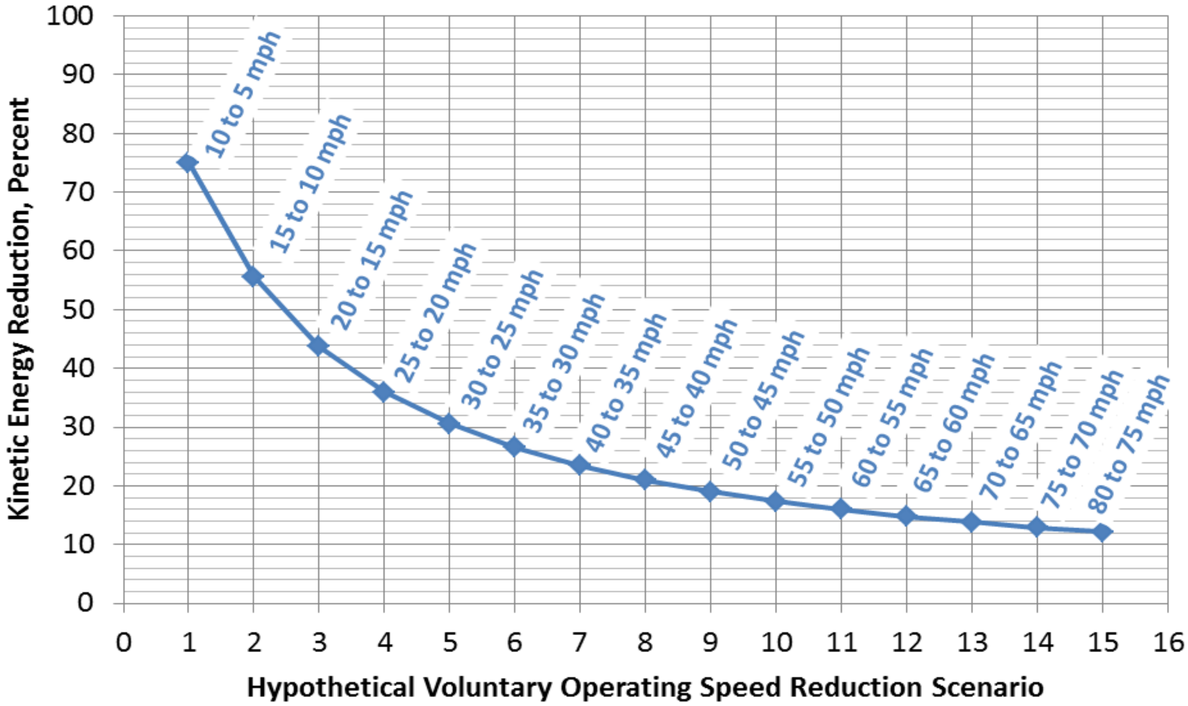

Figure 2: Effect of Speed Reduction on Train Kinetic Energy
(10 mph Decrements; Constant Mass, V_1, V_2)