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Standard

Signalling Design Principles – Braking Distance

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3. Braking Distance

3.1. Braking Distance Concepts and Definitions: Principle 3.1

3.1.1. Introduction

This Principle addresses the concepts and definitions of braking distance and its effect on the requirements and design of a signalling system.

3.1.2. Braking Distance - Concept

Braking Distances for trains can be relatively long due to their significant mass, speed, braking characteristics, and the track gradients.

Consequently, the Braking Distances become a critical consideration when determining the position of the first warning aspect with respect to the stop signal to which it applies and especially so when trains with different Braking Distances operate over the same line.

3.1.3. Braking Distance - Definition

Braking Distance is the distance travelled by a train between the point at which the driver initiates a brake application and the point at which the train eventually comes to rest.

3.1.4. Determination of Braking Distance

In designing a signalling system, it is necessary to know the specific predetermined Braking Distance for each type of train running on a particular line.

This particular Braking Distance may be obtained from theoretical calculation or from dynamic tests performed on the trains themselves or result from a mixture of both sources of information.

Either way, many factors influencing this predetermined Braking Distance will have been considered, typically:

- the speed of the train when the brake application was initiated.
- the possibility of a train accelerating when it should be slowing.
- the fundamental rate of braking which can be achieved.
- the effects of the braking system reaction time.
- the number of brakes which may be cut out.
- the acceptable amount of wear and tear on braking performance.
- the effects of drivers' reaction time.

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- the effect of rising or falling gradients.
- % contingency.

From the above two sets of Braking Curves can be produced for each type of train, one for Service Braking and one for Emergency Braking.

3.1.5. Service Braking Distance - Definition

Service Braking Distance is the braking distance for a train when it has been subjected to a “full” service brake application.

Service Braking Distance is fundamental in determining the minimum distance between the first warning aspect given to a driver and the stop signal to which it applies.

3.1.6. Emergency Braking Distance - Definition

Emergency Braking Distance is the braking distance for a train when it has been subjected to an “emergency” brake application.

Emergency Braking Distance may be used in determining the minimum overlap distance to be provided beyond a stop signal.

> Notes: The Emergency Brake can be initiated independently of the Service Brake for example by release of the “dead man’s lever” or by a train stop mechanism where provided.
>
> Emergency Braking Distance is not necessarily less than the Service Braking Distance and is greater for some types of trains (EMU intercity sets for example).

3.1.7. Longest Braking Distance – Definition

The “longest braking distance” shall be the service braking distance of the train that takes the longest distance to stop from its maximum allowable and attainable speed at that particular brake application location.

3.2. Determination of Braking Distance: Principle 3.2

3.2.1. Introduction

This Principle addresses the method employed to determine the braking distance at any point on a line.

3.2.2. Service Braking (SB) Curves

The Service Braking curves to be used in conjunction with this Principle shall be the curves nominated in Sections 3.4 to 3.9 of this Principle.

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When designing a signalling system, the signal aspects shall be determined so as to enable the longest braking distance train, travelling at its maximum allowable and attainable speed, applying service braking at the warning signal, to come to a stand at the signal. The sighting distance of the warning signal shall not be included in the determination of the minimum signal spacing for braking when designing the system.

3.2.3. Determination of Longest Braking Distance

The longest (service) braking distance required in any particular section of a running line shall be determined from the appropriate Service Braking Curves have regard to

- the types of trains running over the particular section of line.
- the maximum speed permitted (line speed) for each type of train. Note that it is the line speed approaching the first warning signal rather than the line speed between the warning signal and the stop signal, which is most relevant.
- the service speed of each type of train in the particular section of line. (For example, some types of freight train are limited to 80 km/h maximum irrespective of line speed and an M-train simulation will show that a loaded freight cannot always attain line speed
- the gradient on the particular section of line, in particular the gradient between the warning signal and the stop signal.
- the present speed restriction, if any, applicable to the particular section of line. This may include posted speed limits and limits imposed by the Train Operating Conditions manual.

Care must be exercised in accurately identifying the “worst” braked trains running over the particular section of line for the purpose of determining the longest (service) braking distance correctly. Within the metropolitan area, the GW16 curve is the standard to be applied despite trains with longer braking distances being permitted to operate. Trains outside the GW16 performance are managed by appropriate speed restrictions.

3.2.4. Braking Requirements for Freight Trains

The Train Operating Conditions Manual will identify the train lengths that may operate on specific corridors. These train lengths may have different braking curves. Where a train brake performance other than GW16 applies, the normal speed signs shall be adjusted so that the correct braking distance is provided at the posted speed.

The provision of GW16 braking performance in the signalling designs is only required on those nominated lines over which freight or locomotive hauled trains operate.

3.2.5. Determination of Speed Boards

The line speed is determined by the Track Services section and published in the Train Operating Conditions Manual.

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Where the signalling is optimised to suit a specific type of traffic, such as EMU services, at the line speed, a lower speed for freight will be necessary to ensure the braking distances provided are adequate. This may result in the provision of separate general and Multiple Unit (MU) speed signs.

The signal design engineer shall ensure that the speed sign requirements are agreed with the Track Services section. Where a speed reduction is required for signal service braking and/or warning lights, the signal engineer must inform Track services of the signalling speed requirement and the reason for the speed reduction so that the Track Design database can be updated. This ensures that engineering understands that the speed reduction is for safety reasons.

3.3. Methodology for Determining Braking Distances and Speed Boards

Signalling shall be designed within the CRN area to ensure that the highest possible line speed and headway requirements for EMU passenger services are met as a priority over freight services. Exception: this rule cannot be met in area where the GW40 curve is applied as noted in Section 3.2.4. When a signalling scheme has been determined suitable for EMU passenger services, the braking distances must be checked for freight services to ensure correct general speed sign values. Where the general speed sign is determined to be less than 60 km/h for freight services in a higher speed area, consideration should be given to modifying the signal aspect sequence to achieve at least 60 km/h for the general speed sign. As a starting point, GW16 at line speed should be used in determination of freight braking distances, then the longer or poorer braked freight trains can be controlled by a lower speed on the General Speed sign. If this methodology cannot be achieved, the arrangement shall be referred to the Principal Signal & Comm. & Network Control Engineer for determination.

3.4. Braking Curves for Individual Line Sections

3.4.1. Braking Curves for Individual Line Sections

West	Braking Curve
Lithgow – Wallerawang	GW30, GW10, GX4M, GR2
Wallerawang – Charbon	GW10 Up, GW Down
Wallerawang – Tarana	GW30, GX4M, GR2
Tarana – Bathurst (Kelso)	GW30, GX4M, GR2
Bathurst – Orange	GW30, GX4M, GR2
Orange – Parkes	GW30
Orange – Dubbo	GW30, GX4M, GR2
Narromine – Cobar	GW16

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West	**Braking Curve**
Dubbo – Coonamble	GW16 (Note 1)
Nevertire – Warren	GW16 (Note 1)
Bogan Gate – Tottenham	GW16 (Note 1)
North	
Narrabri – Merrywinebone	GW16 (Note 1)
Moree – Delungra	GW16 (Note 1)
Moree – Weemelah	GW16 (Note 1)
Werris Creek – Armidale	GW16 (Note 1), XPT (<140)
Armidale – Glen Innes	GW16 (Note 1)
Binnaway – Gwabegar	GW16 (Note 1)
Casino – Murwillumbah	GW16 (Note 1), GX4M, GR2
South	
Joppa Junction – Canberra	GW16, GX4M, GR2
Cootamundra – Griffith	GW16 (Note 1)
Griffith – Hillston	GW16 (Note 1)
Junee – Griffith	GW16 (Note 1)
West Wyalong – Burcher	GW16 (Note 1)
Ungarie – Naradhan	GW16 (Note 1)
Barmedman –Rankin Springs	GW16 (Note 1)
Demondrille – Cowra	GW16 (Note 1)
Cowra – Eugowra	GW16 (Note 1)
Koorawatha – Grenfell	GW16 (Note 1)

Note 1: Branch lines generally low speed and GW16 allowance should not be an excessive requirement.

Braking Curves	GW16 max	Superfreighter braking (680 m train) 115 km/h
Braking Curves	GW36 max	42 NHFF loaded coal train braking 80 km/h
Braking Curves	GW10 max	84 NHFF loaded coal train braking 80 km/h
Braking Curves	GW11	84 NHFF empty coal train braking
Braking Curves	GW40	1500 m long Superfreighter braking 115 km/h max (4x81 class + 3480 tonnes) (26/10/93)

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Braking Curves	GW30	1200 m long Superfreighter 115 km/h max (4x81 class + 2760 tonnes) (29/6/93)
Braking Curves	Endeavour / Xplorer (GR2)	Endeavour / Xplorer braking 140 km/h max
Braking Curves	XPT (GX4M)	XPT braking 160 km/h max
Simulated Speed	XPT (<140)	Xplorers and Endeavours braking 140 km/h max. SIM that speed as determined by an MTRAIN simulation run.

Note: Where multiple braking curves are specified for particular sections of lines, a check needs to be made on all curves that an adequate distance is provided. As an example, a line requiring braking to GW10, GW16, XPT curves is likely to be constrained by the GW10 braking curve below 80 km/h and the GW16 braking curve around 100–115 km/h. Should XPT speeds generally exceed 140 km/h then the XPT braking curve may become the critical factor.

Should trains with poorer braking, or higher attainable speeds than those listed for the braking curves, be required to operate on the line then an analysis and safety assessment of the resulting effects on infrastructure and the train operations must be conducted.

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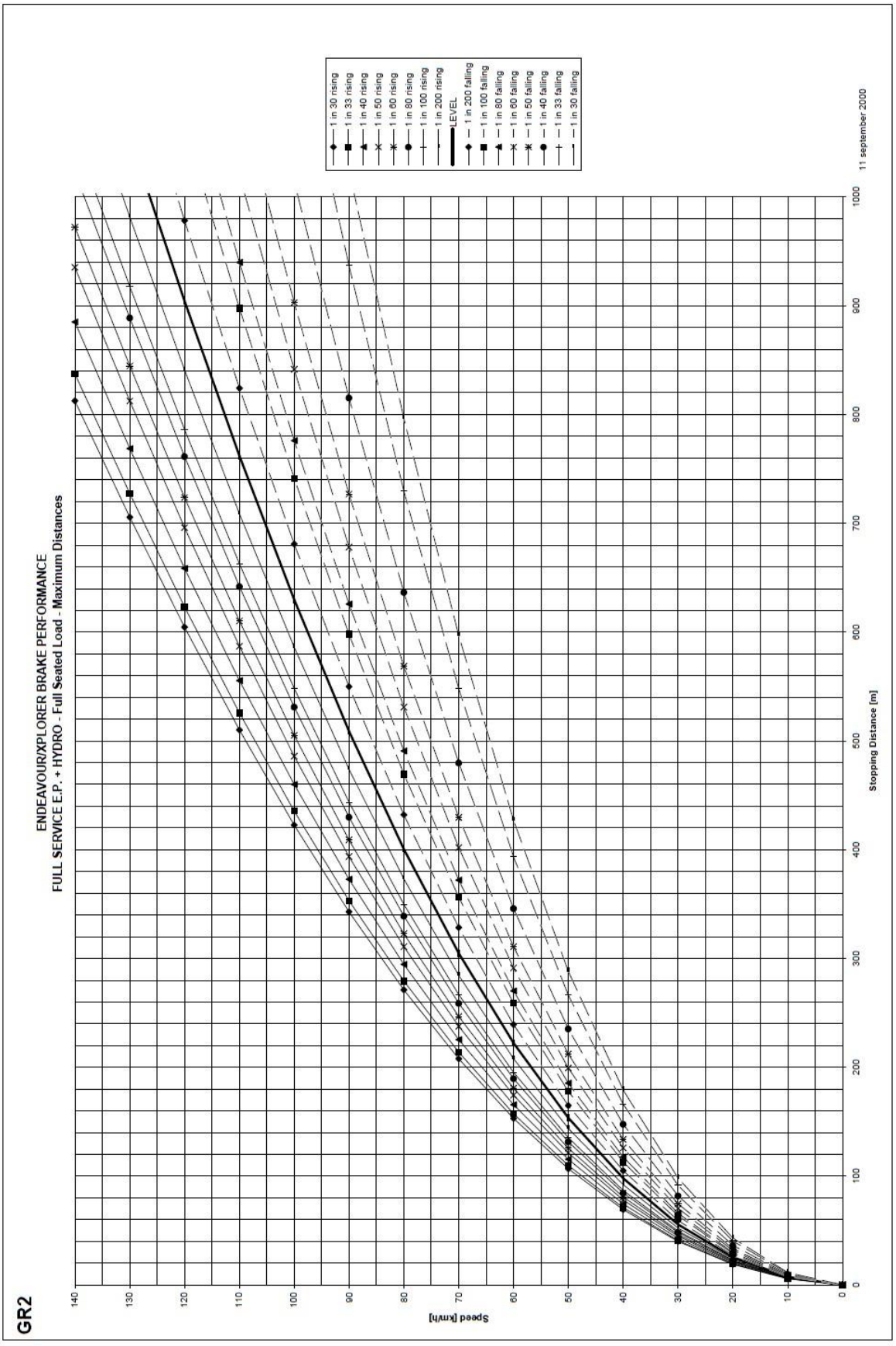
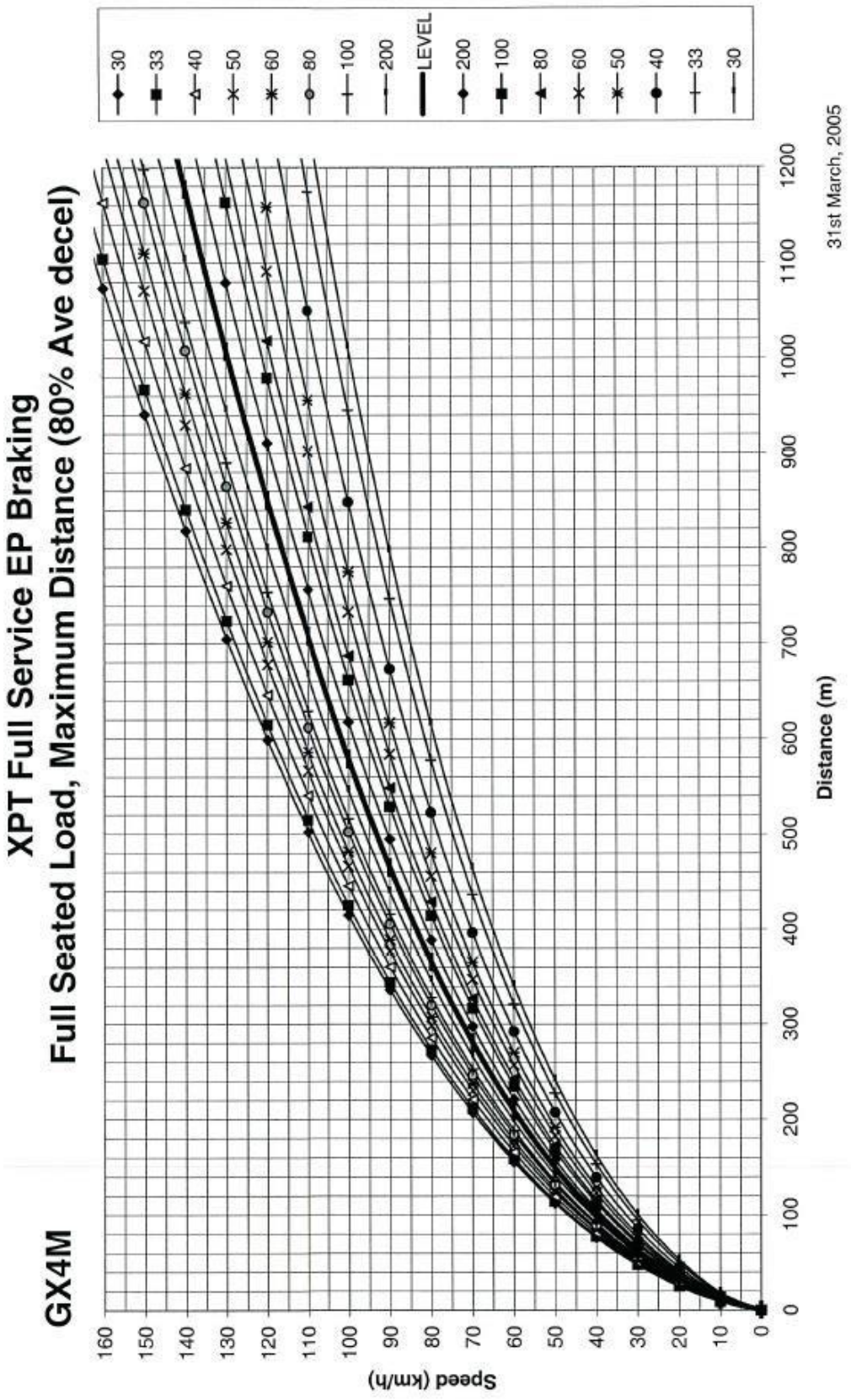
3.5. Braking Curve – GR2



3.6. Braking Curve – GX4M



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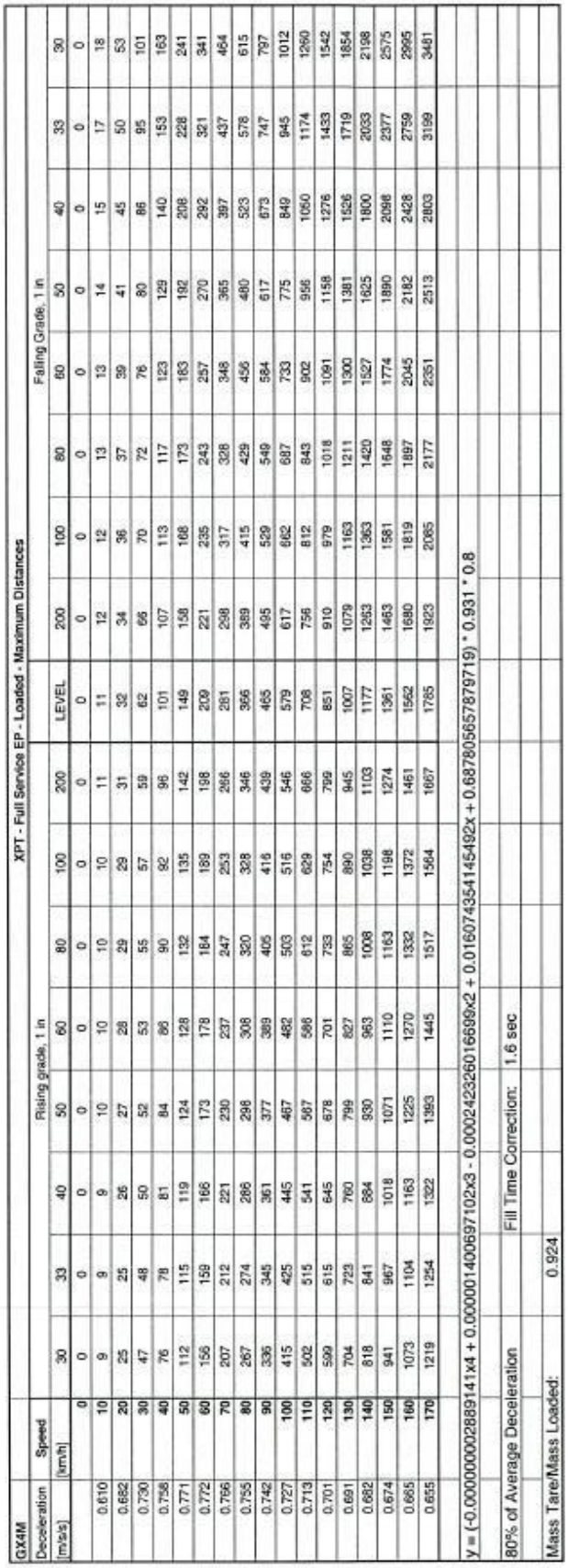
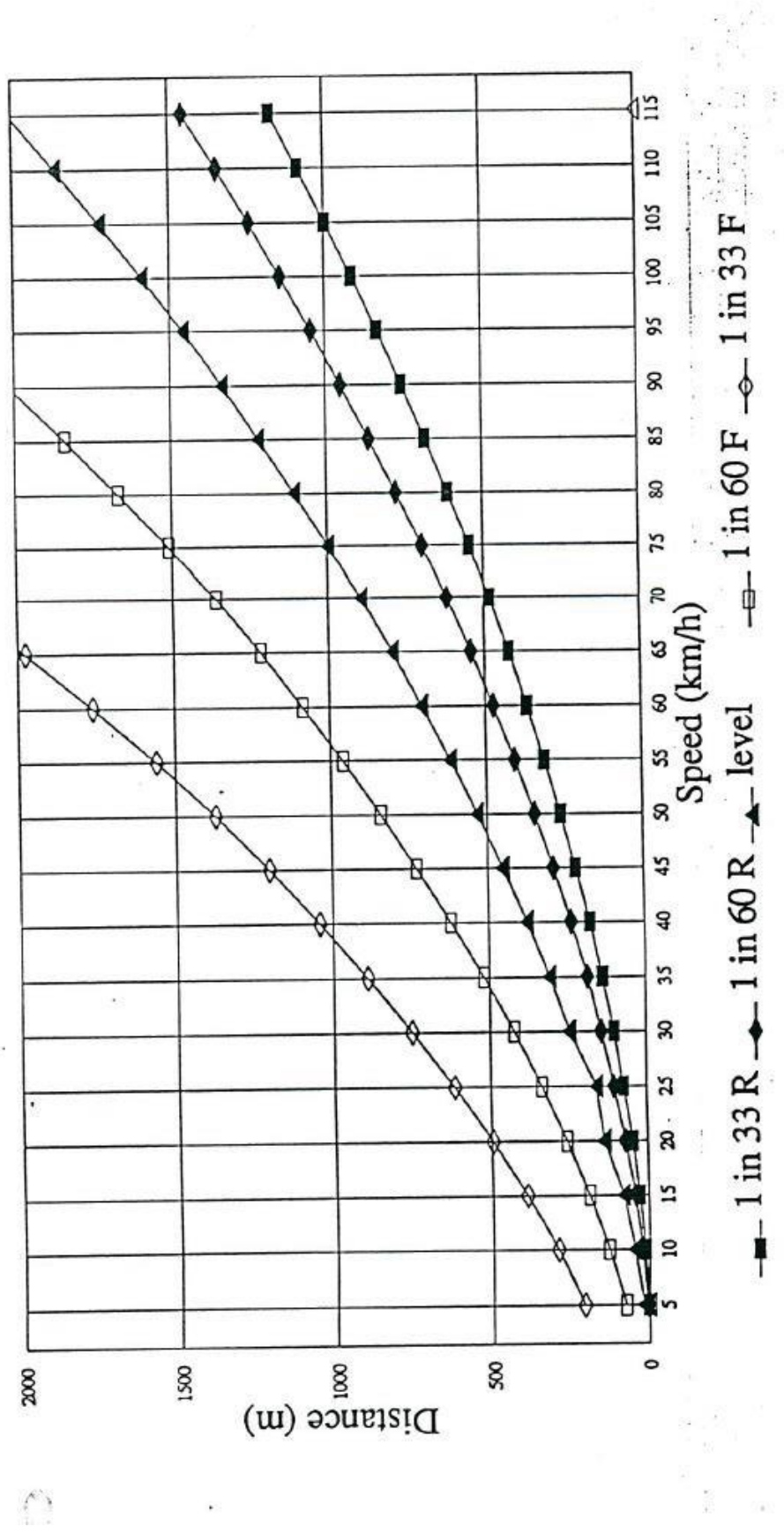
3.7. Braking Chart – GX4M



GX4M		XPT - Full Service EP - Loaded - Maximum Distances																				
Deceleration	Speed				Rising grade, 1 in								Falling Grade, 1 in									
[m/s/s]	[km/h]	30	33	40	50	60	80	100	200	LEVEL	200	100	80	60	50	40	33	30
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.610	10	9	9	9	10	10	10	10	11	11	12	12	13	13	14	15	17	18
0.682	20	25	25	26	27	28	29	29	31	32	34	36	37	39	41	45	50	53
0.730	30	47	48	50	52	53	55	57	59	62	66	70	72	76	80	86	95	101
0.758	40	76	78	81	84	86	90	92	96	101	107	113	117	123	129	140	153	163
0.771	50	112	115	119	124	128	132	135	142	149	158	168	173	183	192	208	228	241
0.772	60	156	159	166	173	178	184	189	198	209	221	235	243	257	270	292	321	341
0.766	70	207	212	221	230	237	247	253	266	281	298	317	328	348	365	397	437	464
0.755	80	267	274	286	298	308	320	328	346	366	389	415	429	456	480	523	578	615
0.742	90	336	345	361	377	389	406	416	439	465	495	529	549	584	617	673	747	797
0.727	100	415	425	445	467	482	503	516	546	579	617	662	687	733	775	849	945	1012
0.713	110	502	515	541	567	586	612	629	666	708	756	812	843	902	956	1060	1174	1260
0.701	120	599	615	645	678	701	733	754	799	851	910	979	1018	1091	1158	1276	1433	1542
0.691	130	704	723	760	799	827	865	890	945	1007	1079	1163	1211	1300	1381	1526	1719	1854
0.682	140	818	841	884	930	963	1008	1038	1103	1177	1263	1363	1420	1527	1625	1800	2033	2198
0.674	150	941	967	1018	1071	1110	1163	1198	1274	1361	1463	1581	1648	1774	1890	2098	2377	2575
0.665	160	1073	1104	1163	1225	1270	1332	1372	1461	1562	1680	1819	1897	2045	2182	2428	2759	2995
0.655	170	1219	1254	1322	1393	1445	1517	1564	1667	1785	1923	2085	2177	2351	2513	2803	3199	3481
y = (-0.000000002889141x4 + 0.000001400697102x3 - 0.000242326016698x2 + 0.016074354145492x + 0.687805657879719) * 0.931 * 0.8																		
80% of Average Deceleration				Fill Time Correction:		1.6 sec												
Mass Tare/Mass Loaded:			0.924															

3.8. Braking Curve – GW30



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3.9. Braking Chart – GW30

GW-30

STOPPING DISTANCE TABLE (INCLUDES 15 % ALLOWANCE)

3/4 LOADED SUPERFREIGHTER - 4 x 81 class + 46 NQJW wagons

NOTES: Train mass = 2760 tonnes (excluding locomotives)
Train length = 1280 metres (including locomotives)
Brake pipe length = 1660 metres (bifurcated brake pipe)
Full service brake application applied to locomotives and train to point of stop
Results based on tests carried out in June 1991

	GRADE (1 in X)												
	Rising					level	Falling						
	33	40	60	100			-100	-60	-40	-33			
SPEED (km/h)													
5	3	3	6	8		18	46	75	141	207			
10	14	16	23	29		48	85	128	210	291			
15	29	34	44	55		80	135	189	0	388			
20	49	58	72	89		139	192	259	383	496			
25	75	85	106	129		162	258	337	483	616			
30	105	117	144	174		246	330	423	593	751			
35	139	155	187	223		308	409	519	715	892			
40	176	197	236	278		377	497	622	842	1042			
45	218	243	290	339		452	590	729	974	1202			
50	264	292	347	405		531	688	842	1117	1374			
55	314	346	409	474		615	790	960	1268	1559			
60	367	404	475	547		704	898	1087	1431	1760			
65	423	465	545	627		797	1012	1220	1603	1976			
70	483	530	619	708		895	1130	1362	1789	2208			
75	546	599	697	796		998	1257	1511	1986	2460			
80	614	670	779	887		1105	1389	1670	2199	2732			
85	684	746	865	981		1218	1530	1838	2426	3026			
90	758	826	953	1080		1335	1676	2016	2669	3345			
95	835	908	1046	1182		1458	1831	2203	2929	3692			
100	914	994	1143	1289		1587	1993	2402	3207	4053			
105	998	1083	1244	1401		1722	2164	2613	3499	4408			
110	1084	1176	1348	1517		1862	2346	2836	3788	4769			
115	1174	1273	1457	1638		2009	2533	3060	4081	5142			

Calculated from STOPDIST programme
Parameters used (speed km/h, decel m/s/s) - (1 , .83), (45 , .63)(115 , .49)
Brake delay - 0 seconds Brake cylinder build up time - 56 seconds

SRA of NSW FreightRail Brake Engineers
Date: 29-Jun-93