National Association of S Gaugers

In concert with National Model Railroad Association
Proto: Scale Committee 636
By Randy Wilson - July, 2001

A Brief History

During the past 15 years of review of documents from various groups supporting prototype to model track and wheel relationships, one of the points that has come out is the odd cross-section of "prototype" values for track and wheels. This point has been due to the use of prototype information from some very old sources and occasionally the values have come from British, not American standards as in the Model Railway Study Group or MRSG.

The other point has been that the model values designed by the National Model Railroad Association did not scale out to prototype. This is due to the use of the (NMRA) Recommended Practice RP-25 Wheel Contour and the resultant Track and Wheel Standards based on Technical Reference paper TR1-85.

The TR1-85 paper was a milestone for model railroading and made a whole era of standardization possible. It was very literally designed around the RP-25 wheel contour. Unfortunately, the fatter tread and wide tire width of the RP-25 wheel generates some number values that are quite unprototypical. Also, it is important to realize that engineering tolerances were added to some of the dimensions, to make up for the manufacturing capability of the day.

Manufacturing capability is an important part of the model railroad industry because our hobby requires fairly close tolerances for both track and wheels. In manufacturing, we are looking at the ability to machine metal wheelsets or to build plastic injection molds for both wheelsets and sectional track. Currently, the majority of modelers in any of the Proto:Scale sizes prefer metal wheels for appearance sake. But, as Proto:Scale takes flight, plastic wheelsets will likely support the masses.

Here is the crux of the manufacturing issue; tighter tolerances mean higher cost. Making an injection mold to plus or minus .005" (0.127mm) precision will cost much less than .001" (0.025mm) precision. The companies that can produce these higher levels of precision make medical and high tech industrial molds for six to ten times the price that model railroad manufacturers can afford to pay to bring most of these products to market. If you doubt that, just look at the number of manufacturers of rolling stock and compare that to the number of track manufacturers. If a boxcar door is 0.005" off, the train won't go on the ground.

About the New Proto: Scale Values

In an effort to create a simplified method of dealing with all of these variations, certain assumptions had to be made in order to build order into the system.

Foremost in thinking about Proto:Scale is the assumption that Association of American Railroads standards will be used. As we will see later, some small concessions are made to address the manufacturing tolerances we have just mentioned.

If we are going to use AAR standards, we should use the latest standards because the industry has not stood still and we shouldn't either. If we don't do that, we have to decide when we should draw the line on standards chronology. Should it be 1935, when most of the key dimension for today's wheels were set, or should it be 1990, when the new AAR-1B profile was approved. The answer is that we are going to take the edge values

or envelope of many of these developments to create the model. A second criteria that meshes with this need is that, in Proto:48 for example, there were over 40,000 wheelsets produced before Proto:48 was even approved as a Recommended Practice by NMRA.. We have to insure that the numbers we create will "grandfather" these wheelsets in use.

Another issue is the generous gage widening allowed by TR1-85. That widening was implemented to overcome the very unprototypical minimum radius used on most model railroads of the day. It also increased the tolerance to manufacturing variances of the day. It's important to realize that TR1-85 didn't create these wider values, it simply continued the time honored practice of having them. With Proto:Scale, we assume that the modeler who wants more prototypical appearance in the track and wheels is also likely to use more prototypical radius of track work. For that reason, the unprototypical gage widening has been abandoned.

Fortunately, the AAR standards include tolerances that scale down to our models very nicely. It isn't just the model railroad that ends up with track and wheel variations. Real railroads deal with these same issues every day. This is the most important thing to understand about why Proto:Scale works. It is a reduction in scale of a concept that has been tested and improved for more than one hundred years.

The Federal Railroad Administration

The Federal Railroad Administration was created pursuant to the Department of Transportation Act of 1966 and represents consolidated government support of the railroad industry since sunsetting of the Interstate Commerce Commission in 1996. The FRA uses a track rating system of Class 1 through 9, with 9 being the highest rated at 200 mile per hour. Various standards apply to these different tracks. The value chosen for Proto:Scale is from the Class 6-9 range for Track Gage Widening. This is the strictest tolerance and highest speed rated group.

About the Spreadsheet

A new spreadsheet has been created that allows for the scale to be entered and all of the required values to be automatically generated as a result. There is one for Standard Gauge and one for 3 foot Narrow Gauge. This is much like the TR1-85 spreadsheet, but it is built around AAR specifications instead of our RP-25 wheels. The Proto:1 sheet shows the formulas used.

The column labeled Scale Ratio is column D in the spreadsheet and the row numbers are listed to the right of the data columns. By entering the formula in the appropriate place in column D, all of the values will calculate by entering the scale, such as 87.1 for HO (yes, that's right, it isn't 1:87, it's 1:87.1), 48 for Proto:48 and so on. The Narrow Gauge spreadsheet works the same way with no special number except the scale ratio. Notice that no reference is made to scales by the old fractional values such as 1/4" or 3/16". That is part of what Proto:Scale was meant to eliminate.

Individual Values
S3 Track

Gmin - The fundamental Track Gage Minimum defined by the AAR at 4'-8-1/2" or 56.5". While FRA regulations allow a minimum of 4'-8" or 56" exactly, model railroading has never used less than the first number.

Gmax - This value is defined by the gage widening specification (1.25") of the Federal Railroad Administration for Class 6 track which is speed rated for 110 mile per hour through Class 9 which is speed rated for 200 mile per hour.

Cmin - Check Gage Minimum is defined for FRA Class 5 and 6 track.

Cmax - Check Gage Maximum is determined by combining Back-to-Back Maximum with Flange Maximum.

Fmax - Flangeway Maximum determines the amount of support for the wheel at the frog of a turnout. At this point, the wheel must span across the effective distance of two flangeways in order to avoid dropping to the flangeway floor. In order to provide enough tread on the railhead, the Flangeway Maximum limits this gap. See Flangeway Maximum drawing.

Hmin - Flangeway Depth Minimum defines the distance to the floor of the Flangeway. For modeling purposes, it is limited to equal Dmax, the Flange Depth Maximum set in Standard S4. To limit the possibility of wheels dropping between the effective distance of two flangeways noted in Fmax, this dimension should be held as close to Hmin as possible.

Smax - Span Maximum is determined by taking the Gauge Minimum minus two times the Flange Maximum. Note the 52.938" AAR minimum Back-to-Back is slightly larger than the 52.750" Span Maximum which prevents the Back-to-Back wheel dimension from binding across the Span.

Pmax-m - Point Spread Maximum (mechanical) is specified by the American Railway Engineering Association at 4.75". While the prototype has varied from 3.5" to 5.25" gap between the stock rail and point rail in the past, this specification is current as of 1985.

Pmax -e - Point Spread Maximum (electrical) is no longer required. Because the 4.75" mechanical gap will clear the back of a wheelset by 1.094" in a worst case scenario, there is no longer a need for a separate electrical specification. This is because we are using real railroad practice instead of defining an absolute maximum envelope for error, as TR1-85 does.

S-4 Wheels

Kmax - Wheel Check Gage Maximum is equal to Track Check Gage Minimum (Cmin).

Kmin - Wheel Check Gage Minimum is equal to Back-to-Back Minimum (Bmin) plus Flange Width Minimum (FMin).

Bmax, Bmin - Back-to-Back Maximum and Minimum are both defined by AAR specification for all wheelsets per the 1997 Car & Loco Cyclopedia, page 780.

Nmax - Tire Width Maximum is defined by the AAR specification for Wide Flange Wheels at 5.719".

Nmin - Tire Width Minimum is defined by the AAR specification for Narrow Flange Wheels at 5.500".

Tmax - Flange Width Maximum is defined by the AAR specification for Wide Flange Wheels at 1.375".

Tmin - Flange Width Minimum is defined by the AAR specification for Narrow Flange Wheels at 1.156".

Dmax - Flange Depth Maximum is set at 1.300" as an upper limit for manufacturing tolerance. The actual condemning limit set by AAR is when 0.750" (3/4") wear occurs and increases the effective flange depth to 1.750". For modeling purposes, we need to have a smaller upper limit because the Standard we produce becomes an upper limit for manufacturers. The wheel geometry becomes radically different between the flange throat radius and flange top front radius when we allow model wheelsets to reach this prototype limit. We want the variance from one wheelset to another to be minimized and this limit allow a reasonable amount

of manufacturing tolerance to occur in each scale. This value also preserves the important "grandfather" clause mentioned earlier for the huge volume of 1/4"AAR wheelsets produced prior to NMRA approval of Proto:48, as well as a host of narrow gauge wheelsets in the same realm.

Dmin - Flange Depth Minimum is set at 1.000", the AAR specification for both Wide Flange Wheels and Narrow Flange Wheels.

Wheel Gage Maximum and Minimum are listed as an arithmetical test of the Back-to-Back and Flange Thickness values in the spreadsheet.

Railhead Radius is a new specification based on AREA specifications for rail that match the AAR wheel profiles. A railhead with perfectly square edges decreases the effective track gage to less than the gage minimum requirement. A railhead with excessive edge radius effectively widens the track gage and will allow for the wheel to drop between the double width flangeways listed under Fmax in a worst case situation.

A Closing Perspective

Over the years, many different systems have been promoted for different scales. Now, all of the numbers have been generated and will serve us well. For all of those who have created track and wheel values that miss the numbers this new reference provides, there is no great cause for alarm. If history has proven anything, it is that this system of track and wheel relationships has a surprisingly high fault tolerance. It is also important to remember that the vast majority of track in these Proto:Scales has been hand laid with all the attending variations that the process generates. A human hair averages three thousandths of an inch (0.0762mm) thickness. Most of the variations observed from existing systems are within this limit. Not hitting these numbers will not preclude successful operation of a model railroad. They may increase the likelihood of derailments but so does dust on the track. Our common ground is that we all value the beauty of track and wheels that look totally authentic. So, in closing, I would urge you all to embrace the values herein, based on their prototype heritage and share in the enjoyment of a new day in the model railroad industry.

Randy Wilson - Chairman

The Proto:Scale information provided here was submitted to the National Model Railroad Association Board of Trustees for action at the July, 2001 National Convention in St. Louis, Missouri.

Association of American Railroads

Proto:1n3

Help File

Scale Ratio

S-3 Track 05-Jul-01 1

			Inch	Metric
Track Gauge	G	Max	37.500	952.50
		Min	36.000	914.40
Check Gauge	C	Max	34.750	882.65
		Min	34.000	863.60
Flangeway	F	Max	1.875	47.63
(Wing)	Wing	Min	1.750	44.45
Flangeway	F	Min	2.000	50.80
(Guard)	Guard			
Flangeway	H	Min	1.300	33.02
Depth				
Span	S	Max	32.250	819.15
		Min	31.687	804.86
Point Spread	P- m	Max	31.250	793.75
(Mechanical)				
Point Spread	P - e	Max	Not	Required
(Electrical)				

S-4 Wheels

			Inch	Metric
Wheel Check	K	Max	34.000	863.60
		Min	33.594	853.27
Back to Back	B	Max	32.875	835.03
		Min	32.438	823.91
Tire Width	N	Max	5.719	145.26
		Min	5.500	139.70
Flange Width	T	Max	1.375	34.93
		Min	1.156	29.36
Flange Depth	D	Max	1.300	33.02
		Min	1.000	25.40
Wheel Gage		Max	35.625	904.88
		Min	34.750	882.64
Railhead Radius	R	Max	0.562	14.27
		Min	0.375	9.53

Minimum radius requirement depends on wheelbase
Use Maximum Track Gauge on curves only (GMax 37.50")
Optimized Tread Profile: AAR-1B Narrow Flange Contour

Revised 6/01/2001

Association of American Railroads

Proto:1

Help File

Scale Ratio

S-3 Track

05-Jul-01 1

			Inch	Metric	Formula	Row #	
						4	
Track Gauge	G	Max	57.750	1466.85	57.75*(1/D4)	6	FRA Class 6 Track Gage Limits - 10th Ed. Track Cyclopedia, p.
		Min	56.500	1435.10	56.5*(1/D4)	7	
Check Gauge	C	Max	55.250	1403.35	+D27+D10	8	BMax+FMax
		Min	54.500	1384.30	54.5/D4	9	FRA Class 6 Guard Check Limit - 10th Ed. Track Cyclopedia, p.
Flangeway	F	Max	1.875	47.63	1.875/D4	10	
(Wing)	Wing	Min	1.750	44.45	1.75/D4	11	
Flangeway	F	Min	2.000	50.80	+D7-D9	12	
(Guard)	Guard					13	
Flangeway	H	Min	1.300	33.02	+D33	14	Corresponds with DMax
Depth						15	
Span	S	Max	52.750	1339.85	52.75/D4	16	GMin-(2*FMax)
		Min	52.188	1325.56	+D16-(0.5625/D4)	17	SMax-0.5625" Construction Tolerance
Point Spread	P- m	Max	51.750	1314.45	51.75/D4	18	10th Ed. Track Cyclopedia, p.252 3.5"-5.25" (AREA set at 4.75
(Mechanical)						19	
Point Spread	P - e	Max	Not	Required		20	Not a prototype value - PMax Mechanical exceeds safe value
(Electrical)						21	
						22	

S-4 Wheels

			Inch	Metric		Row #	
						23	
Wheel Check	K	Max	54.500	1384.30	+D9	24	
		Min	54.094	1373.97	+D28+D32	25	
Back to Back	B	Max	53.375	1355.73	53.375/D4	26	
		Min	52.938	1344.61	52.9375/D4	27	1997 Car & Loco Cyclopedia, p.780
Tire Width	N	Max	5.719	145.26	5.719/D4	28	1997 Car & Loco Cyclopedia, p.780
		Min	5.500	139.70	5.5/D4	29	AAR Specification - Wide Flange Wheel
Flange Width	T	Max	1.375	34.93	+1.375/D4	30	AAR Specification - Narrow Flange Wheel
		Min	1.156	29.36	1.156/D4	31	AAR Specification - Wide Flange Wheel
Flange Depth	D	Max	1.300	33.02	1.3/D4)	32	AAR Specification - Narrow Flange Wheel
		Min	1.000	25.40	1/D4	33	0.300" Construction/Wear Tolerance
Wheel Gage		Max	56.125	1425.58	+D27+(2*D31)	34	AAR Specification
		Min	55.250	1403.34	+D28+(2*D32)	35	BMax+(2*TMax)
Railhead Radiu	R	Max	0.562	14.27		36	BMin+(2*Tmin)
						37	AREA Specification - Matches AAR-1B Wheel profile (1990+)

National Model Railroad Association

WHEELS PROPOSED

S4

05-Jul-2001

NAME OF SCALE	K CHECK GAGE (MAXIMUM)	B BACK TO BACK (MINIMUM)	N TIRE WIDTH (MINIMUM)	D FLANGE DEPTH (MAXIMUM)	
Proto:24	2.271	2.206	0.229	0.054	Inch
	57.68	56.03	5.82	1.38	mm
Proto:24n3	1.417	1.352	0.229	0.054	Inch
	35.98	34.33	5.82	1.38	mm
Proto:32	1.703	1.654	0.172	0.041	Inch
	43.26	42.02	4.37	1.03	mm
Proto:32n3	1.063	1.014	0.172	0.041	Inch
	26.99	25.75	4.37	1.03	mm
Proto:48	1.135	1.103	0.115	0.027	Inch
	28.84	28.01	2.91	0.69	mm
Proto:48n3	0.708	0.676	0.115	0.027	Inch
	17.99	17.16	2.91	0.69	mm
Proto:64	0.852	0.827	0.086	0.020	Inch
	21.63	21.01	2.18	0.52	mm
Proto:64n3	0.531	0.372	0.086	0.020	Inch
	13.49	9.46	2.18	0.52	mm
Proto:87	0.626	0.608	0.063	0.015	Inch
	15.89	15.44	1.60	0.38	mm
Proto:87n3	0.390	0.372	0.063	0.015	Inch
	9.92	9.46	1.60	0.38	mm
S	0.839	0.800	0.108	0.030	Inch
	21.31	20.32	2.74	0.76	mm
Sn3	0.519	0.480	0.108	0.030	Inch
	13.18	12.19	2.74	0.76	mm

Committee 636 - Proto:Scale

National Model Railroad Association

TRACK WORK PROPOSED

S3

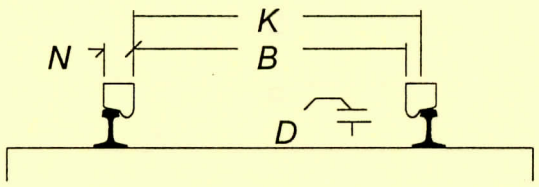
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NAME OF SCALE	G TRACK GAGE (MINIMUM)	G TRACK GAGE (MAXIMUM)	C CHECK GAGE (MINIMUM)	S SPAN (MAXIMUM)	F FLANGEWAY (MAXIMUM)	H FLANGE CLEARANCE (MINIMUM)	
Proto:24	2.354	2.406	2.271	2.198	0.078	0.054	Inch
	59.80	61.12	57.68	55.83	1.98	1.38	mm
Proto:24n3	1.500	1.563	1.417	1.344	0.078	0.054	Inch
	38.10	39.69	35.98	34.13	1.98	1.38	mm
Proto:32	1.766	1.805	1.703	1.648	0.059	0.041	Inch
	44.85	45.84	43.26	41.87	1.49	1.03	mm
Proto:32n3	1.125	1.172	1.063	1.008	0.059	0.041	Inch
	28.58	29.77	26.99	25.60	1.49	1.03	mm
Proto:48	1.177	1.203	1.135	1.099	0.039	0.027	Inch
	29.90	30.56	28.84	27.91	0.99	0.69	mm
Proto:48n3	0.750	0.781	0.708	0.672	0.039	0.027	Inch
	19.05	19.84	17.99	17.07	0.99	0.69	mm
Proto:64	0.883	0.902	0.852	0.824	0.029	0.020	Inch
	22.42	22.92	21.63	20.94	0.74	0.52	mm
Proto:64n3	0.563	0.586	0.531	0.504	0.029	0.020	Inch
	14.29	14.88	13.49	12.80	0.74	0.52	mm
Proto:87	0.649	0.663	0.626	0.606	0.022	0.015	Inch
	16.48	16.84	15.89	15.38	0.55	0.38	mm
Proto:87n3	0.413	0.431	0.390	0.370	0.022	0.015	Inch
	10.50	10.94	9.92	9.40	0.55	0.38	mm
S	0.883	0.905	0.839	0.798	0.050	0.030	Inch
	22.43	22.99	21.31	20.27	1.27	0.76	mm
Sn3	0.563	0.585	0.519	0.478	0.050	0.030	Inch
	14.30	14.86	13.18	12.14	1.27	0.76	mm

Committee 636 - Proto:Scale

National Association of S Gaugers
Engineering Group

Recommended Practice RP4
Wheels - Proto:64



Check Gage maximum	Kmax	0.852" 21.63mm
Back to Back minimum	Bmin	0.827" 21.01mm
Tire Width minimum	Nmin	0.086" 2.18mm
Flange Depth maximum	Dmax	0.020" 0.52mm

Notes:

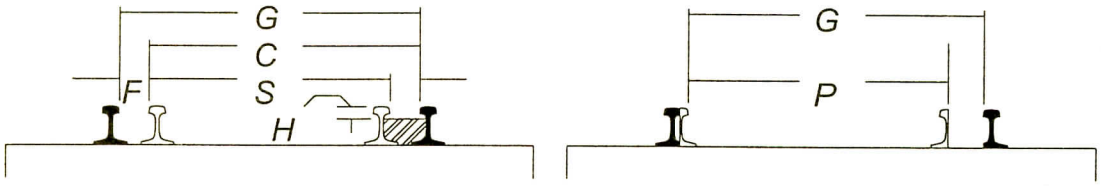
1) For further information on Track & Wheels, see NASG RP3 & RP4 Help File.

2) Wheel Contour is Association of American Railroads.

Drawn by Randy Wilson - 12/27/1995
Revised - 7/01/2001

National Association of S Gaugers
Engineering Group

Recommended Practice RP3
Track - Proto:64



Track Gage minimum	Gmin	0.883"	22.42mm
Track Gage maximum	Gmax	0.902"	22.92mm
Check Gage minimum	Cmin	0.852"	21.63mm
Span maximum	Smax	0.824"	20.94mm
Flangeway maximum	Fmax	0.029"	0.74mm
Flange Height minimum	Hmin	0.020"	0.52mm
Point Spread maximum	Pmax	0.809"	20.54mm

Notes:

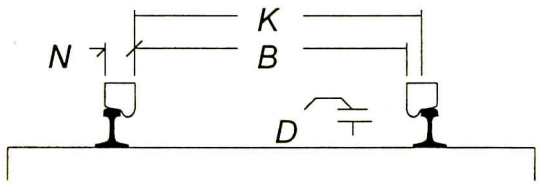
1) For further information on Track & Wheels, see NASG RP3 & RP4 Help File.

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National Association of S Gaugers
Engineering Group

Recommended Practice RP4.5
Wheels - Proto:64n3



Check Gage maximum	Kmax	0.531"	17.99mm
Back to Back minimum	Bmin	0.507"	12.88mm
Tire Width minimum	Nmin	0.086"	2.18mm
Flange Depth maximum	Dmax	0.020"	0.52mm

Notes:

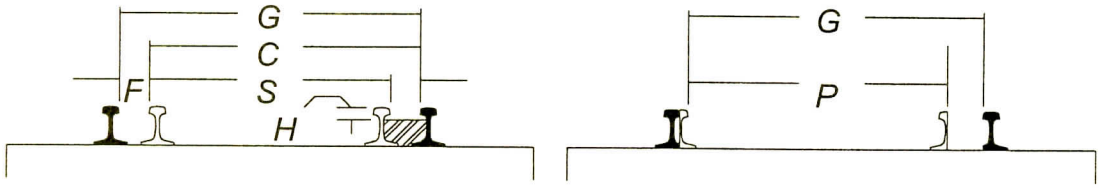
1) For further information on Track & Wheels, see NASG RP3.5 & RP4.5 Help File.

2) Wheel Contour is Association of American Railroads.

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National Association of S Gaugers
Engineering Group

Recommended Practice RP3.5
Track - Proto:64n3



Track Gage minimum	Gmin	0.563"	14.29mm
Track Gage maximum	Gmax	0.586"	14.88mm
Check Gage minimum	Cmin	0.531"	13.49mm
Span maximum	Smax	0.504"	12.80mm
Flangeway maximum	Fmax	0.029"	0.74mm
Flange Height minimum	Hmin	0.020"	0.52mm
Point Spread maximum	Pmax	0.488"	12.40mm

Notes:

1) For further information on Track & Wheels, see NASG RP3 & RP4 Help File.

2) Wheel Contour is Association of American Railroads.

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Revised - 7/01/2001

National Association of S Gaugers

Proto:64n3 Recommended Practice

Help File Ratio

S-3 Track 06-Jul-01 64

			Inch	Metric
Track Gauge	G	Max	0.586	14.88
		Min	0.563	14.29
Check Gauge	C	Max	0.543	13.79
		Min	0.531	13.49
Flangeway	F	Max	0.029	0.74
(Wing)	Wing	Min	0.027	0.69
Flangeway	F	Min	0.031	0.79
(Guard)	Guard			
Flangeway	H	Min	0.020	0.52
Depth				
Span	S	Max	0.504	12.80
		Min	0.495	12.58
Point Spread	P- m	Max	0.488	12.40
(Mechanical)				
Point Spread	P - e	Max	Not	Required
(Electrical)				

S-4 Wheels

			Inch	Metric
Wheel Check	K	Max	0.531	13.49
		Min	0.525	13.33
Back to Back	B	Max	0.514	13.05
		Min	0.507	12.87
Tire Width	N	Max	0.089	2.27
		Min	0.086	2.18
Flange Width	T	Max	0.021	0.55
		Min	0.018	0.46
Flange Depth	D	Max	0.020	0.52
		Min	0.016	0.40
Wheel Gage		Max	0.557	14.14
		Min	0.543	13.79
Railhead Radius	R	Max	0.009	0.22
		Min	0.006	0.15

Minimum radius requirement depends on wheelbase
Use Maximum Track Gauge on curves only (GMax 0.586 ")
Optimized Tread Profile: See NASG Proto:64 Tread Help File

Revised 6/01/2001

National Association of S Gaugers

Proto:64 Recommended Practice

Help File Ratio

S-3 Track 06-Jul-01 64

			Inch	Metric
Track Gauge	G	Max	0.902	22.92
		Min	0.883	22.42
Check Gauge	C	Max	0.863	21.93
		Min	0.852	21.63
Flangeway	F	Max	0.029	0.74
(Wing)	Wing	Min	0.027	0.69
Flangeway	F	Min	0.031	0.79
(Guard)	Guard			
Flangeway	H	Min	0.020	0.52
Depth				
Span	S	Max	0.824	20.94
		Min	0.815	20.71
Point Spread	P- m	Max	0.809	20.54
(Mechanical)				
Point Spread	P - e	Max	Not	Required
(Electrical)				

S-4 Wheels

			Inch	Metric
Wheel Check	K	Max	0.852	21.63
		Min	0.845	21.47
Back to Back	B	Max	0.834	21.18
		Min	0.827	21.01
Tire Width	N	Max	0.089	2.27
		Min	0.086	2.18
Flange Width	T	Max	0.021	0.55
		Min	0.018	0.46
Flange Depth	D	Max	0.020	0.52
		Min	0.016	0.40
Wheel Gage		Max	0.877	22.27
		Min	0.863	21.93
Railhead Radiu	R	Max	0.009	0.22
		Min	0.006	0.15

Minimum radius requirement depends on wheelbase
Use Maximum Track Gauge on curves only (GMa 0.902 ")
Optimized Tread Profile: See NASG Proto:64 Tread Help File

Revised 6/01/2001