1 Standards

1.1 Why Standards?

Without generally agreed Standards the coaches of firm A are likely to derail on the turnouts of firm B, the locos of firm C to sit too high in front of the wagons of firm D. Henry Greenly's objectives of nearly a century ago are still relevant to us today, even though a broad framework is now accepted by most manufacturers and modellers in Gauge O. It can now be expected that wheels from one manufacturer will run through the crossings of another if both are stated to conform to the same Standard.

The introduction to the BRMSB (British Railway Modelling Standards Bureau) standards of 1950 is reproduced below, because it remains as valid today as when it was first written, probably by J N Maskelyne, then editor of *'Model Railway News'* and chairman of the BRMSB.

"In presenting these proposed standard dimensions to the modelling fraternity it cannot be too strongly stressed that they are only the recommended figures for all to use. There is nothing dogmatic about them at all, but they have been calculated to give the best possible trouble-free running, interchangeability within each gauge, together with considerations of manufacture – a very important point which the highly skilled amateur model-maker tends to overlook. In working out the dimensions the gauge has been based on a prototype measurement of about 4ft 6in, the reason for this being the unfortunate necessity of 'sharp' radius curves in conjunction with long wheelbase six-coupled locomotives with outside cylinders and valve gear. There is nothing whatever to prevent a modeller working to dead scale if he wishes, provided that he is prepared to operate on scale-radius curves with everything else in proportion. Likewise, a modeller can also adopt his own dimensions if he wishes to and is willing to operate his railway in isolation".

1.2 Historical

As modelling in Gauge O developed from the first commercial 'train sets' to the present high standard, the dimensions of track and wheelsets moved progressively nearer to true scale. In consequence, there are now no less than twelve recognised dimensional standards for these components, although some are now obsolete and of interest only to collectors. In 1950 the BRMSB published two Standards for Gauge O, originally entitled 'O' and 'OF'. These became known as Coarse and Fine Scale although more correct titles would be Coarse and Fine Standards as the scale is the same. They are the immediate progenitors of the present Guild Standards, with which they remain compatible.

At the outset, attempts were made to ensure that 'Standard O' would satisfy the needs of those who ran vehicles with wheels both tinplate and solid turned on rails both tinplate and solid drawn, It was then not possible to produce wheels which would run on both 'Standard' and 'Fine' pointwork. European, American and Australian modellers however, had adopted a different policy, disregarding the tinplate field and developing single Standards lying somewhere between the BRMSB 'O' and 'OF' Standards and generally compatible with one another. Though wheelsets complying fully with these three overseas standards are not compatible with pointwork made to either BRMSB standard, some manufacturers of ready to run rolling stock have, by slight modifications, been able to produce wheelsets able to run on track made to any of the five standards. Later, the BRMSB introduced 'Unified Standard' which, despite its name, was not fully compatible with any of the foregoing other standards, including their own. The ScaleSeven Standard however, despite ancestry going back to the turn of the last century, was never sponsored by the BRMSB.

The BRMSB ceased to exist in 1960 and their associate body the META (Model Engineering Trades Association) some fifteen years later. Consequently their published tables in due course went out of print. The committee of the Guild was then asked to reissue them for gauge O which it did in 1975. However, in the later eighties when a reprint was required, it became clear that the developments of the previous twenty years called for some revision. In 1989 therefore, following extensive research and development by the Technical Committee, revised Fine and Coarse Standards for Gauge O were published. These, while remaining fully compatible with the original BRMSB ones, removed certain anomalies in tolerances, thereby making it possible to include dimensions for a true universal wheelset.

Note that the gauge of model track was originally defined as the distance between the centre lines of the rails. This was a manufacturing convention, used when rail was formed from tinplate. Gauge O was an addition to the original sequence, inserted below the previous smallest, Gauge 1. By this convention Gauge O was 35mm between centres, which happened to give a between-rail gauge of 1 1/4in. The earliest model track was imported from Germany as was the rolling stock, hence the use of metric measurements. It was left to Henry Greenly to select a modelling scale for Gauge O. He chose 7mm = 1 ft as the best compromise between gauge and scale for that time. From the earliest days the tightness of the British loading gauge has caused problems for those modelling British prototypes. These have only recently ceased to be acute with the advent of miniature motors.

Compiled by The Manual Group
Dedicated to the memory of
Robert Ledger, C.Eng.

1.3 Scale

Scale is the relationship between the size of a model and its prototype. The British scale, 7mm = 1ft, gives a size ratio of 1:43.54, usually rounded off to 1:43.5. It is not, however, recommended that this rounded value be used for critical dimensions because unacceptable errors could result.

In North America modellers use a scale of 1/4in = 1ft; this gives a size ratio of 1:48. In Europe ratios of 1:43.5 and 1:45 are used, the 1:45 ratio being recommended by MOROP (Verband der Modelleisenbahner und Eisenbahnfreunde Europas), the modelling association in Europe equivalent to the NMRA (National Model Railway Association) in North America. It should be noted however that in France and Italy, with less generous loading gauges than Germany, the scale of 1:43.5 is in common use. At the same time, certain ready-to-run models of British prototypes, made by continental manufacturers for the British market, are built to the 1:45 scale.

1.4 Gauge

The gauge is the distance between the inner faces of the rails. In Gauge O, like the scales, this also varies slightly, although to a much lesser extent. In Britain and Europe the 'standard' O gauge is 32mm, whereas in America it is 1 1/4in (31.75mm). Before 1950 and the BRMSB standards, the British standard also was 1 1/4in. Reference to Table 1 and Appendix 1 will show that the Unified and ScaleSeven gauges also differ from 32mm. In America a new standard has been introduced known as Proto48. This, while retaining 1:48 scale, uses a more accurate gauge of 1.176in (29.87mm).

Some critical trackwork dimensions, particularly the minimum radius of trackwork, the width of wheel tread and the clearance between wheel flanges and rails, cannot be scaled exactly without imposing severe limitations on the scope of the planned layout. The minimum curve on passenger lines is 160m (8 chains) which, in O gauge, becomes 3.7m (12ft). The minimum for locomotives other than industrial and then only when running dead slow is 90m (4 chain) which becomes 2m (6ft). On most model layouts the curves are much tighter than prototype, so, on the severest curves, it becomes necessary both to widen the track gauge and also to allow more side play for certain of the coupled axles on longer locos. These modifications are easier to contain within overall scale dimensions when the gauge is reduced and consequently the wheels are closer together allowing greater sideplay. This applies particularly when building and running larger models, especially those with outside motion. Notwithstanding, the ScaleSeven Group have pioneered modelling to 1:43.54 on 33mm track, virtually exactly to scale throughout, showing that, within certain limitations which need to fully understood, this is practicable for those who take the requisite care and have sufficient perseverance.

The British scale of 1:43.54 coupled with a gauge of 32mm applies only to models of standard gauge prototypes. The builder of rolling stock running on other gauges is free to choose either to retain the 1:43.54 scale and change the gauge, or to retain 32mm gauge while altering the scale. In this way he can still claim some adherence to the family of scales and gauges comprised within the description 'O'. Variants are listed in Data Sheet D1.1.2.

1.5 Wheel and Track Standards

As will be evident from Section 1.6 there are dimensions of both track and wheelsets which must be held within reasonably close tolerances if trains are to run without derailment. The Guild strongly recommends therefore that modellers in all gauges and scales adopt a recognised standard, choosing that which best suits their personal requirements, even if this involves a degree of compromise. In this way reliable running is most likely, trade products can be used, and interchangeability with other lines enjoyed. This recommendation should not in any way hinder the development and eventual general acceptance of improvements in standards. This is demonstrated by the example of the steady progress of 'Fine Standard' to its present position as the norm. Such pioneering work is always carried out by that small band of modellers who, having the requisite skills, seek to 'improve the breed'. When the results of such work begin to be incorporated in the products of the more progressive model suppliers and thus become generally available, the Guild must then consider whether this calls for additional standards or revisions of existing ones.

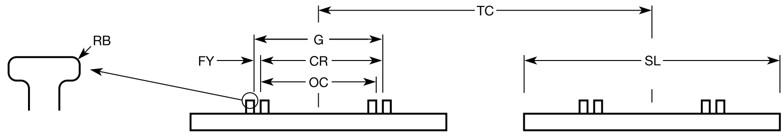
Tables 1 and 2 contain all the relevant information on these Track and Wheelset Standards. Where tolerances are not given, normal modelling building accuracy is implied. The basis of these Standards is explained in Section 1.6, though an understanding of it is not necessary in order to make use of the dimensions themselves. Section 1.7 discusses the choice of standard.

Appendix 1 lists the dimensions of a number of other standards, both historical and current, which are considered to be of interest to Gauge O modellers. D1.1.1.1 also lists relative compatibility between these standards.

Table 1

Guild Track Standards

Applicable to 4ft 8 1/2in prototype gauge 7mm = 1ft models only. Untoleranced dimensions imply normal modelmaking accuracy. For compatibility of track and wheelsets of different standards see Appendix 2.



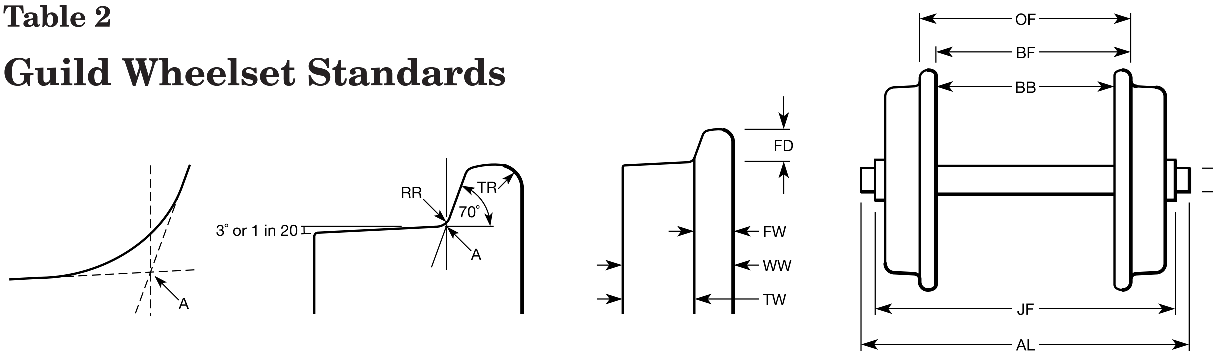
Dimension (mm)		Prototype (Typical)	Exact Scale	Fine Standard	Coarse Standard Note 2	Scale Seven	Notes
Gauge	G	1435mm 4ft 8 1/2in See Note 1	32.96	32.00 32.40	32.00 32.40	33.00 33.45	nominal & minimum maximum Note 3
Over check rails	OC	1346mm 4ft 5in	30.92	28.50	27.60	30.85 31.08	minimum maximum
Check to opp. face	CR	1391mm 4ft 6 3/4in	31.94	30.25	29.80	31.98	minimum
Flangeway (CR - OC)	FY	44mm 1 3/4in	1.02	1.75	2.2	1.00 1.08	minimum maximum
Point blade throw	PT	108mm 4 1/4in	2.48	3.0	4.0	2.6	minimum
Track centres	TC	3405mm 11ft 2in	78.17	80 90	80 90	77.5	running lines sidings Note 4
Rail Shoulder Radius	RB	12.7mm 1/2in	0.292	0.3	0.3		maximum See Note 5
Sleeper length	SL	8ft 6in	59.50	60	76		See Note 6
Sleeper width	SW	10in	5.83	6.0	9.5		See Note 6

Notes

1. 1432mm (4ft 8 3/8in) on concrete sleepers.
2. Coarse standard is retained for interchangeability with established systems. Except for track centres it is compatible with the BRMSB Coarse Standard.
3. Gauge widening on curves of above 1.6m (5ft) radius is not considered to be necessary for Fine and Coarse Standards and may increase buffer-locking, but is essential for ScaleSeven.
4. The BRMSB Coarse Standard track centres are 90mm for running lines and 110mm for sidings. If pointwork is purchased to match track to the BRMSB Standard it should be stated on the order. Centres may have to be increased to ensure clearance between long vehicles on sharp curves, but the number of permutations of vehicle length, end profile, bogie centres and curve radius makes it impractical to define a standard value for this. However, it should not be necessary to allow any increase if the recommendations for minimum curve radii given in Part 2, Section 1, Table 1 are followed.
5. The radius of the rail shoulder is specified to provide the correct wheel – rail relationship. Rail section dimensions are not specified as, within reason, any rail size can be laid to Fine or Coarse Standard dimensions.
6. These dimensions are not mandatory as they concern appearance only. Fine Standard track components can be used with Coarse Standard wheels if laid to Coarse Standard mandatory dimensions and vice versa. Sleepers laid prior to 1923 were generally 9ft long.

Table 2

Guild Wheelset Standards



Dimension (mm)		Prototype (Typical)	Exact Scale	Fine Standard	Coarse Standard Note 1	Scale Seven	Notes
Tread diameter							See Note 2
Back to back	BB	1362mm 4ft 5 5/8in	31.28	29.00 See Note 3	28.00	31.20 31.30	minimum maximum
Back to flange face	BF		32.01	30.00	29.50	31.96	maximum
Over flanges	OF			30.75	30.25		minimum
Flange width (OF-BF) or (BF-BB)	FW			0.75 1.00	0.75 1.50	See Note 7	minimum maximum
Flange depth (Normal)	FD/N			1.00 1.20	1.30 1.50	See Note 7	minimum maximum
Flange depth (Deep)	FD/D			1.30 1.50	N/A	N/A	minimum maximum
Root radius	RR	16mm 5/8in	0.36	0.50 0.70	0.50 0.70	0.36	minimum maximum
Tip radius	TR			0.25 0.37	0.25 0.37		minimum maximum
Coning				1 in 20	1 in 20		
Tread width	TW	Tread width is Wheel width minus Flange width (WW - FW)					
Wheel width	WW	See Note 6		3.50	4.40	See Note 8	minimum
Journal faces	JF	varies		37.5	38.5		maximum
Journal diameter	JD	varies					See Note 4 and 5
Axle length	AL	varies		45	46		minimum

Notes:

1 Coarse Standard wheelsets are retained for interchangeability with established systems. Refer to D1.1.1.1 for data on the use of Fine Standard wheels on Coarse Standard track and for the dimensions of a universal wheelset compatible with most recognised standards.

2 The diameter of any wheel measured at the centre of the tread shall not vary from the stated value by more than 0.15mm and the diameters of wheels mounted on the same axle shall not differ by more than 0.15mm.

3 If FW is less than 0.88m, BB must be increased in order to maintain OF at the stated dimension. Dimensions BF, OF and FD are to the intersection of the tangents to the root radius (Point A).

4 The journal diameter and type vary widely between manufacturers and consequently it is not practicable to recommend a preferred standard. The axle must be able to withstand without bending an impact resulting from derailment. To meet this requirement a minimum diameter of 2mm for mild steel and 1mm for hard steel is recommended. The preferred diameter for locomotive driving axles is 4.76mm (3/16in) as this is the standard bore provided on many gearwheels.

5 The outside diameter of bearing bushes varies between manufacturers. It is recommended that carriage and wagon axleboxes and bogie frames intended for use with bushes should have a pilot hole not exceeding 2.5mm in diameter and capable of being opened out to a maximum of 3.5mm.

6 Typical prototype wheel widths are as follows:
Locomotive wheels 5 3/4in, exact scale 3.35mm
Carriage and wagon wheels 5in, exact scale 2.92mm

7 Scale Seven wheel profile illustrated in Figure 6.

8 Locomotive wheel width is 3.16mm min, 3.26mm; wagon wheel width is 2.90mm min, 3.00mm max.

1.6 Determining Dimensions for Track and Wheelsets

The dimensions of track and wheelsets are so closely interrelated that they cannot be considered independently. This section sets down the fundamental principles from which the dimensions of the standard are determined. Unless these are observed, smooth running, free from derailment, will not be obtained, whether on plain track or through turnouts and crossings.

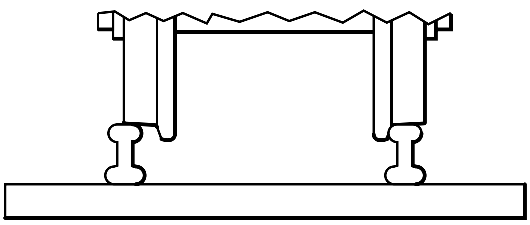


Figure 1 Tread width requirements

1.6.1 The Principles

On plain track, both straight and curved.

1. The tread of the wheel must be sufficiently wide to ensure that it is always in contact with the top of one rail when the flange of the opposite wheel is against the shoulder of the other rail (Figure 1).
2. The flange of the wheel must be of sufficient depth to guide the wheels through vertical displacements of the track, especially twist, but not so deep that it hits chairs or other means of supporting the rails.
3. Line contact must exist between wheel and rail.

Through Pointwork

Requirements 1, 2 and 3, together with the following:

4. The back-to-opposite flange face dimension of the wheelset must be less than the distance between the guiding face of the checkrail and the crossing nose (Figures 2 and 3).
5. The width of the wheel must not be less than dimension 'X' in Figure 4.

The Effect of Curvature:

6. The sharper the curve and the longer the rigid wheelbase of a vehicle the wider must be the flangeways (Figure 5).
7. The larger the diameter of a wheel for a given depth of flange and the deeper its flange for a given diameter of wheel, the wider must be those flangeways, though to a smaller extent than in case 6 above.

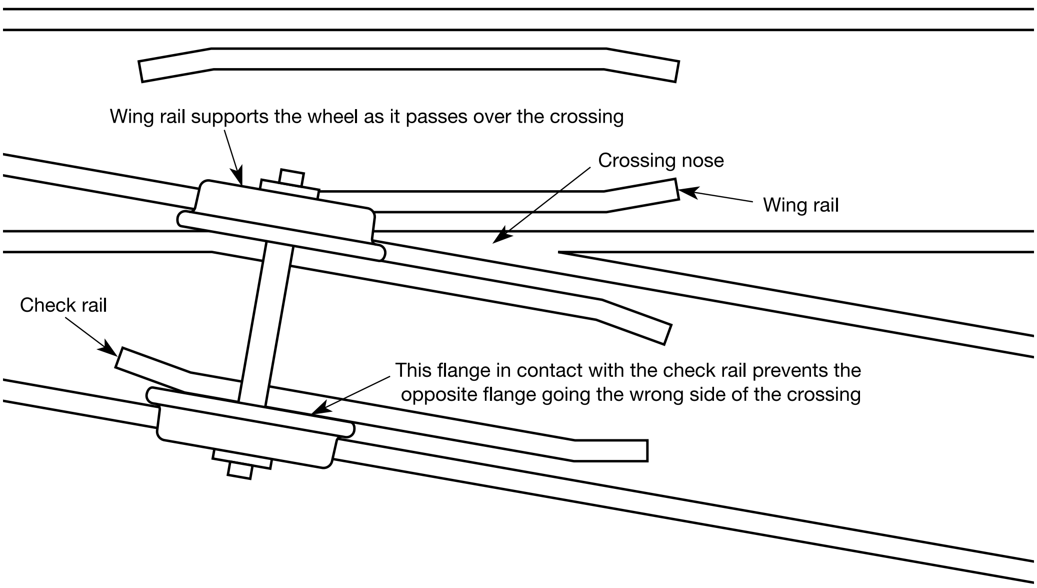


Figure 2 Function of the Check and Wing Rails

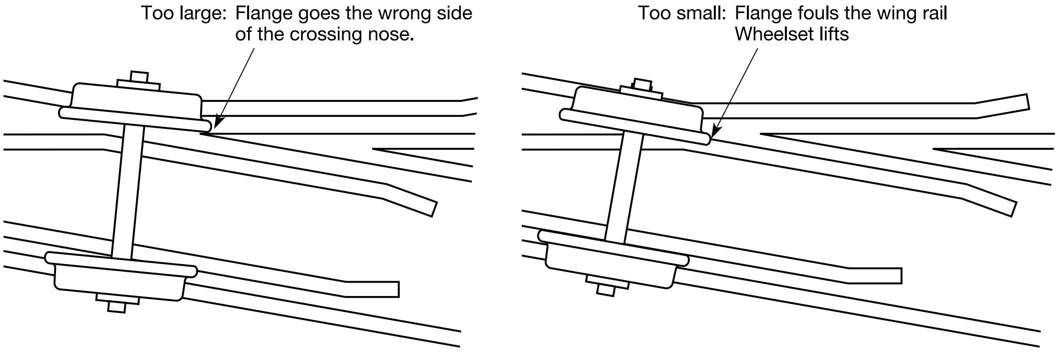


Figure 3 Effect of Error in the Back to Opposite Flange Face Dimension

1.6.2 The Principles Applied

Wheel Width: The minimum width of a wheel is determined by the dimensions of the track over which the wheelsets run. Figure 4, supplemented by the sketches on the left of Figure 7, shows that the width of a wheel should be at the very least twice the width of a flangeway; less than this and it will begin to drop into the gap at crossings. The greater the angle of the crossing the wider the wheel needs to be. It follows therefore that if the width of wheels is to be reduced, then the width of flangeways must be correspondingly reduced. However, the minimum width of flangeways is governed by the track curvature (see Figure 5). Since curves on a model railway are often much sharper than on the prototype, flangeways will have to be widened and so wheels may have to be made wider than scale.

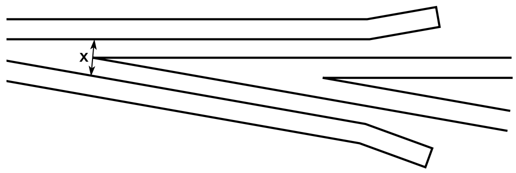


Figure 4 Minimum Wheel Width for no 'Drop-in' at the Crossing

The Flange: Though wheelsets can be produced to a high standard of accuracy, track is usually less accurate, also the typical modeller's rolling stock is often neither sprung nor equalised. Wheel flanges of scale depth may therefore be impracticable. However, they should not be so deep as to bump on chairs and tie-bars, and the shallower they are the less the drag they can exert on curves.

Certain other features of the profile of a flange should be noted. The taper on its flank should make an angle no steeper than 70˚ to the line of the axle and the nose should be well rounded. This will ensure that, combined with the action of the root radius, the flange is kept clear of any unevenness at joints, points of switch blades and crossings, and has no tendency to climb, even on very sharp curves. Where the flange is thick enough, a taper should also be turned on the back face to prevent climbing over check rails. Where this is not possible the nose must be fully rounded between back and front faces. Even on plain track, wheels lacking these features will be liable to derail or will exert excessive drag. Note that, if a flange is to have a good profile, it cannot be thinned without also being made shallower.

Profiles of Wheel and Rail: For good running the profiles of wheel and rail must be well matched. The root radius joining the flange to the tread of the wheel must be greater than the shoulder radius linking the top to the flank of the rail head. The normal point of contact between wheel and rail should be on the tread just beyond the root radius (the point shown as the Effective Diameter in Figure 6). As noted above, the face of the model flange should be tapered to no steeper than 70˚, running out to a well rounded tip (the flanges on certain small-wheeled modern freight vehicles taper at 60˚).

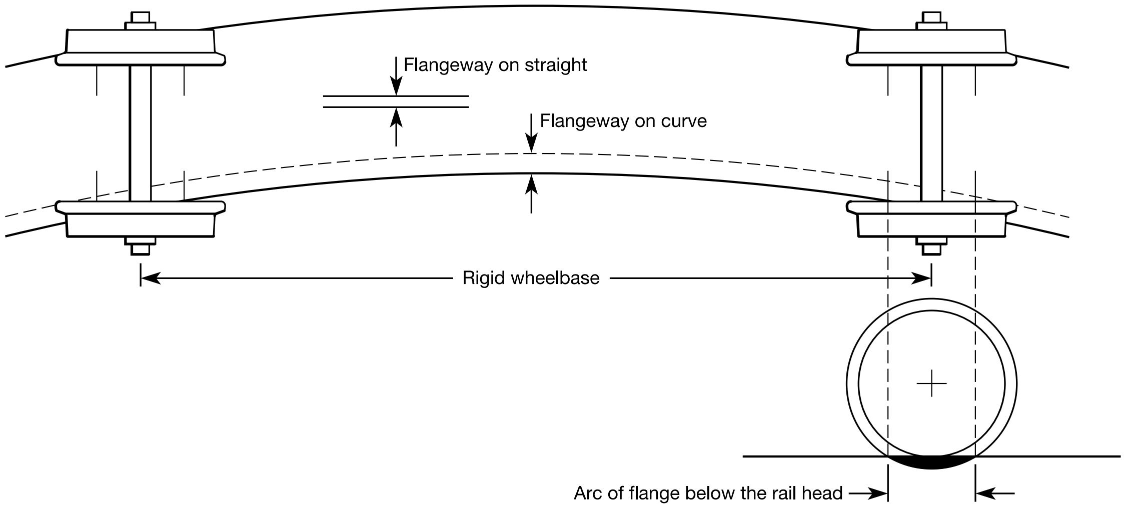


Figure 5 Effect of Curvature on the Flangeway (Exaggerated)

Through Pointwork: When wheelsets negotiate point and crossing work (P&C), the dimension from the back of the flange of one wheel to the outer face of the opposite one is of paramount importance. Figure 3 shows the crossing nose of a simple turnout with a pair of wheels negotiating the curve. If both the geometry of the turnout and the match between the wheelset and the spacing of the rails are correct, then the wheelset, its flange kept clear of the flank of the rail by the root radius between flange and tread, will tend to run through the crossing without touching the checkrail. Should there be errors in either or both dimensions, the check rail serves to prevent the wheel from hitting the nose, particularly when taking the curved road; likewise the wing rail will support the wheel as it passes over the crossing and guide it when running in the trailing direction. If a wheel is to pass over the gap between the crossing nose and the wing rail beyond the knuckle with only the very small amount of 'drop-in' which results from coning of the tread, it must be wider than dimension 'X' in Figure 4.

Switched Crossings and Universal P&C Work: On the prototype the need for higher speeds through turnouts has led to the use of movable crossings, while at the other end of the speed range and application, the turnouts found in pre-fabricated narrow-gauge contractors track, also in the Decauville 60cm gauge track used in the First World War, had a pivoted assembly supporting the switch rails. Model turnouts built on the same lines will accept wheelsets of differing standards and, as with tinplate pointwork with its pivoting switch rails, checkrails are then unnecessary. Such turnouts have been found most useful on club and group layouts on which wheels of differing standards run.

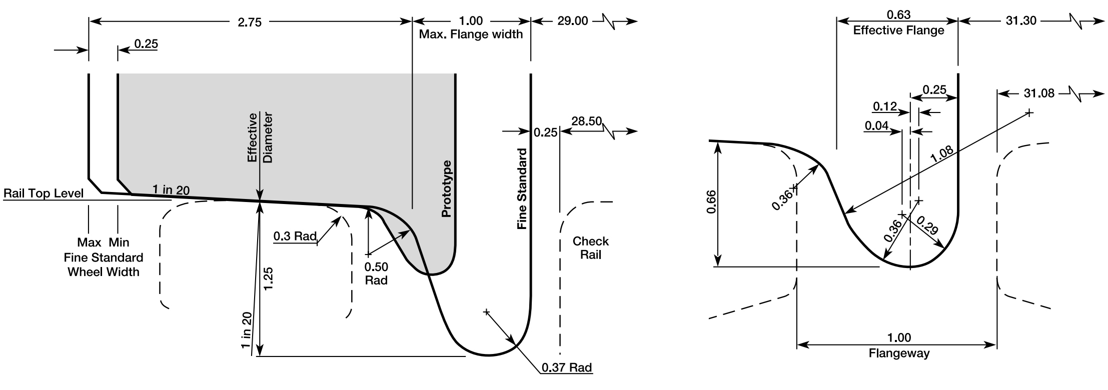


Figure 6 Prototype, Fine Standard (left) and Scale Seven (right) Wheel Profiles

Another approach to universality was used in the big exhibition layout of the Manchester Model Railway Society in the fifties. Each crossing was preceded by a length of straight track longer than the longest rigid wheelbase expected to run on the line, in this case 170mm (7in). PECO, designing their turnouts in the late sixties, adopted the same approach but reduced the length of straight to about 125mm. The width over checkrails was kept below the Coarse Standard Back-to-Back. Checkrails were essentially cosmetic. These solutions are particularly useful on layouts belonging to clubs and groups.

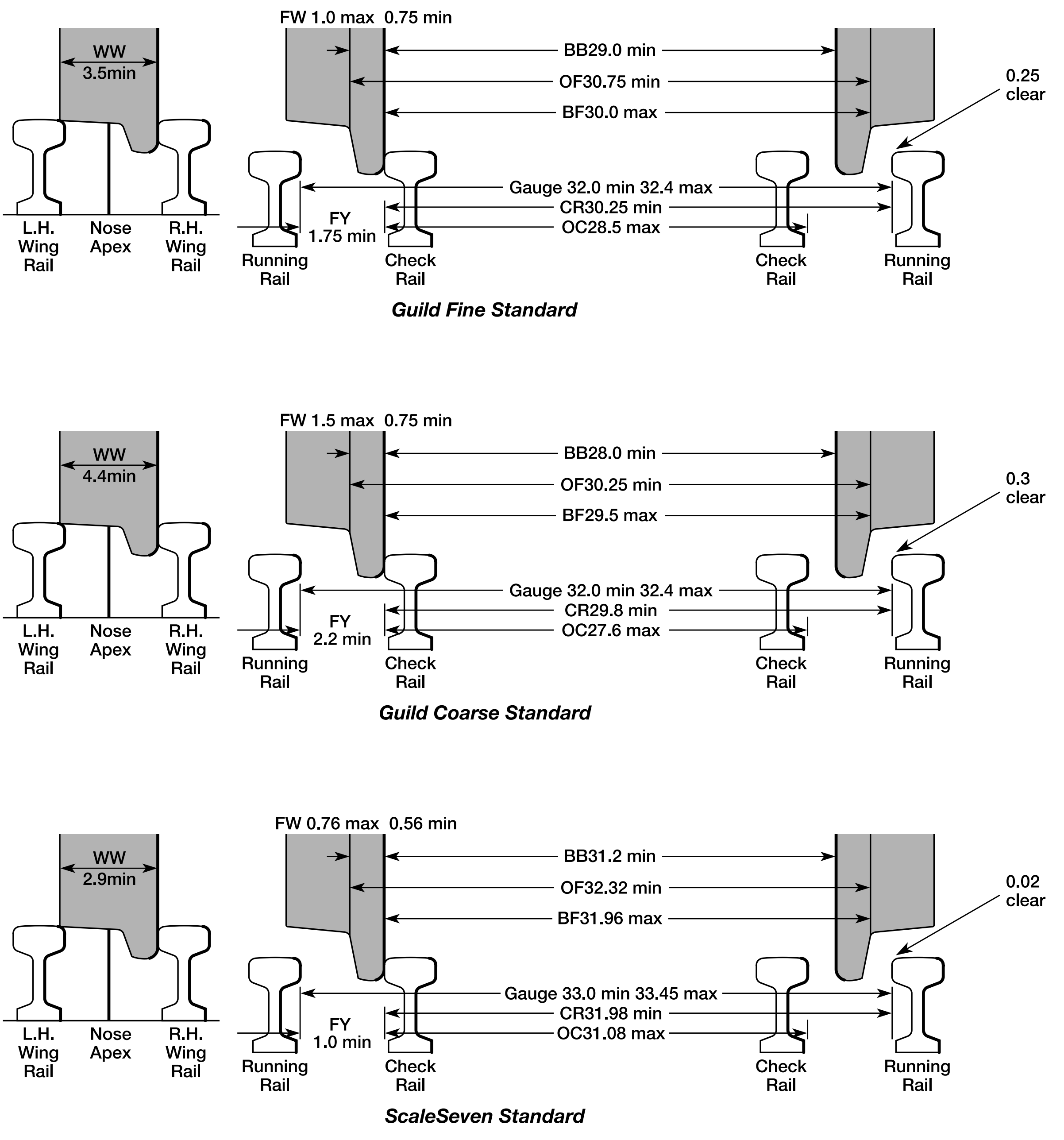


Figure 7 Comparison of the Lateral Dimensions of Track and Wheelsets (Not to Scale)

Curvature: The radius of model curves is usually very much less than the scale value (see Part 2, Section 1). In consequence, the effect of curvature on the design of model track is far greater than on the prototype. The effect is greatest on the minimum width required in flangeways (Figure 5), though wheels with bad profiles will be more liable to climb the rail. The sharper the curve and the longer the wheelbase of the vehicle, the more clearance is needed. In like manner but to a lesser degree the bigger the wheel and the deeper its flange the more likely it is that the flange will grind on the edges of the flangeway and climb out.

Calculation and practical experience both suggest that normal mainline rolling stock, with wheelsets and track made to dimensions conforming to the present Fine Standard, will negotiate P&C work with a minimum nominal radius of 1200mm (about 4ft) or very slightly less. To do so requires that track and vehicle components must be very accurately made, assembled and installed, and some gauge widening will be needed. However, for a careful modeller with average experience, a minimum radius of 1500mm (5ft.) is certainly practicable. The general recommendations given in Part 2, Section 1 leave a measure of safety to cover errors and should be regarded more as planning norms.

1.6.3 Calculating the Standards
For ease of presentation and analysis, rails and wheels are shown in Figure 7 in a stylised form. This simplification injects a small margin for error. This is particularly evident with regard to the situation at crossing noses. The root radius joining the tread and flange of a wheel serves to keep the wheel further away from the nose than calculations based on Figure 7 would suggest.

1.6.4 Checking Conformity to Standards
As mentioned above the back-to-back dimension of a wheelset is easy to measure and, in consequence, is often regarded as the only criterion of its ability to negotiate a crossing. This however is to ignore the width of the flanges. If the flange is made thinner, within specified limits, the back-to-back dimension may be increased in proportion without risk of derailment. The back-to-opposite flange dimension must not however be compromised. This dimension is not easily measured and accurately made gauge is essential. Such a gauge is illustrated in Appendix 2. This gauge may also be used to check the back-to-back dimension, the minimum dimension over flanges, the minimum wheel width and the minimum clearance of check rail entries and switch blade noses.

1.6.5 Conclusion
The drive to bring modelling standards closer to those of the prototype can only be successful if the inter-relation between the dimensions of wheelsets and of track is properly understood and correctly applied.

In presenting these three Standards, the Guild has, as its prime aim, the achievement of reliable running. A second objective is to afford the maximum of interchangeability with relevant existing standards. Throughout, it has sought to specify values for these inter-related dimensions which can be applied and maintained by typical modellers and which are at the same time conducive to economical manufacture.

1.7 Choice of Track and Wheelset Standards

It should be appreciated that these Guild Standards deal only with the critical dimensions of wheelsets and pointwork; they do not specify either the quality of workmanship or the amount of detail on a model.

The majority of Gauge O modellers now work to the Fine Standard and this is reflected in the availability of products produced by the trade. The wheelset and pointwork dimensions are the closest to exact scale of the 32mm gauge standards and are a compromise between appearance and the ability of rolling stock to negotiate curves of very much smaller than exact scale radius.

Guild Coarse Standard is an up-dated version of the BRMSB 'O' Standard. A minor change to the crossing dimensions has made it possible to run Fine Standard wheelsets over Coarse Standard track, which was not the case with crossings laid to the BRMSB Standard. It is not recommended that Coarse Standard pointwork dimensions be adopted for new systems unless it is desired to run other than Fine Standard wheelsets on them.

The ScaleSeven track and wheelset dimensions are near to exact scale but the 33 mm gauge makes the rolling stock incompatible with any of the 32 mm gauge standards. The need for larger radius curves imposes limitations on the track layout which can be accommodated in a given space.

1.8 Track Electrification Standards

1.8.1 Relationship Between Polarity and Direction of Motion

The relationship between polarity and direction of motion for 'two-rail' systems is given by Figure 8. For other systems, positive energisation of the conductor rail or wire should give forward movement, (ie. 'steam' locomotives move chimney leading). On a four rail system the outer conductor rail is regarded an positive.

When vehicles are operated in multiple, or drivers taking over trains entering their control area cannot see which way the locomotive is facing, it is an advantage to fit polarity reversal switches (with a centre-off position) to locomotives and multiple units operating on other than 'two rail' systems. Alternatively, if multiple working is not required, means of indicating the polarity of an approaching train to the driver talking over can be employed.

1.8.2 Height and Position of Conductor Rails

Conductor rail height must be limited to avoid fouling the underside of vehicles. Where four rail electrification is in operation, the centre rail must to further limited in height to avoid fouling the skate for the outside rail (Figure 9).

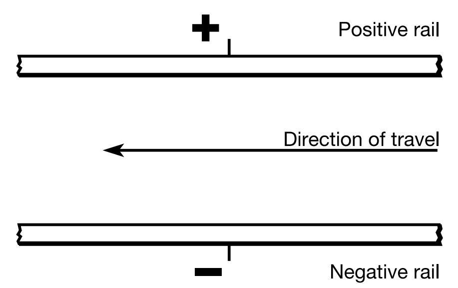


Figure 8 Relationship Between Polarity and Direction of Motion for Two Rail Systems

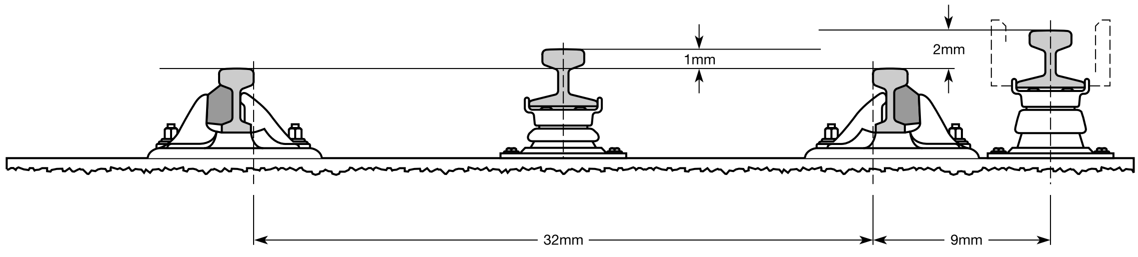


Figure 9 Limited height of centre rail when employed in four-rail track electrification

Height of conductor rail top above running rail top for three rail or outer rail of four rail track 2 mm

Height of conductor rail top above running rail for centre rail for four rail track 1 mm

Distance of centre of outside conductor rail from inside face of running rail 9 mm

1.8.3 Stud Contact system dimensions

Skates (see Figure 10)

The skate must remain substantially parallel to the rails when lifted at either extremity and must accept the stud height variation given in the next column. Failure to remain parallel to the rails win cause clatter on plain track and short circuits when negotiating crossings.

The standard skate width of 13 mm may be increased to a maximum of 19 mm, but whilst this will facilitate the installation of studs at simple turnouts the wider skate may cause problems when negotiating the diamonds of scissors crossovers and similar complex pointwork where studs in close proximity may be simultaneously energised from different controllers.

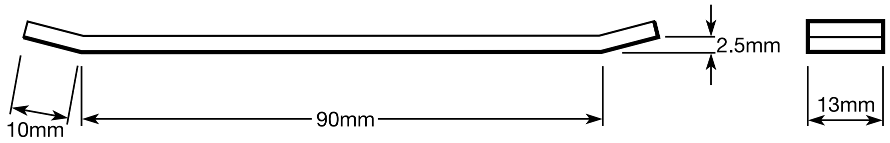


Figure 10 Standard Skate Dimensions

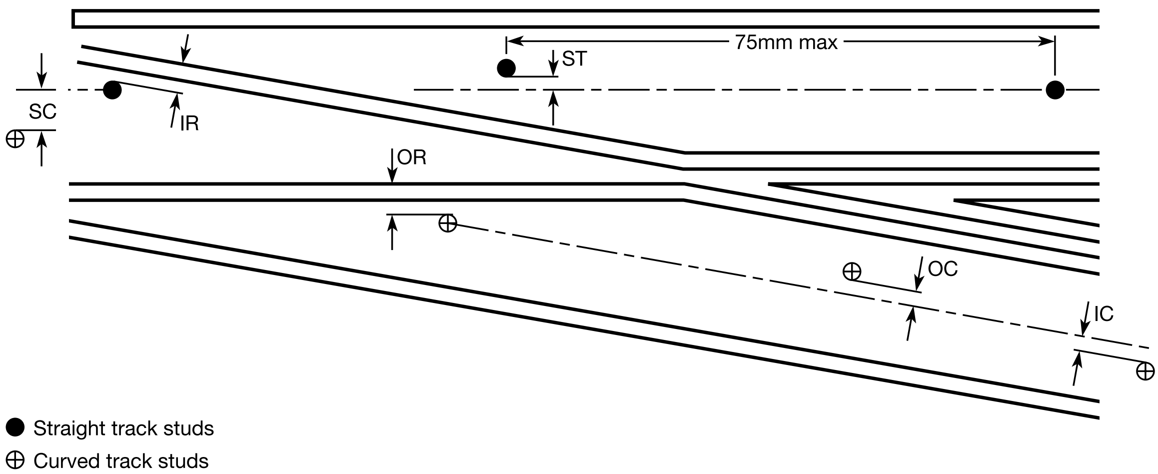


Figure 11 Limiting Positions of Track Contact Studs

Track Studs
Figure 11 shows the limiting positions for studs, not their actual position in the crossing.

Maximum stud spacing		75mm
Maximum stud height above rail top		2mm
Maximum stud depth below rail top		4mm
Maximum height variation between adjacent studs		1.5mm
Maximum distance from track centre:		
on straight track	ST	3.0mm
on outside of curves	OC	1.5mm
on inside of curves	IC	2.0mm
Minimum 'inside' distance of stud from inner rail face	IR	3.5mm
Minimum 'outside' distance of stud from inner rail face	OR	5.0mm
Minimum distance from main track centre for studs on converging track to clear skate on main track	SC	9.0mm

These limits are for use with track and wheeleets complying with the Guild Fine or Coarse Standards. They are based on curves of not less than 0.9 metre radius and vehicles with a maximum rigid wheelbase of 140 mm with the skate placed symmetrically within it. Sharper curves may require closer stud spacing.

Stud spacing and height variation are maximum values which can be reduced if preferred. There is no standard for stud head diameter which can be as small as 1.5 mm.

1.9 Limiting Dimensions of Structures and Rolling Stock

Due to the fact that lineside structures are often not exact scale models of prototypes, their limiting dimensions are usually of more value to modellers than are those of rolling stock. Various structure dimension diagrams for Gauge O, differing only in minor detail and probably originating from the same source, have been published over the years.

Figure 12 shows the maximum size of rolling stock and lineside structures based on these working practices. Note that this model structure gauge is not a 7mm scale version of the prototype structure gauge, which is reproduced in D2.1.2, Track Spacing and Limiting Dimensions.

A variable offset for curvature, E, is included in the structure gauge. E is the amount by which the lineside structures must be further from the track to avoid being hit by rolling stock on curves. E varies from 0 for straight track (in which case the top of the structure gauge is circular) up to 30mm for long wheelbase vehicles on 800mm (2ft 6in) curves, where the top of the structure gauge is a straight line 105mm from rail height. E can be calculated for specific curves following the methods given in Part 2 Section 1.3.

The vehicle profile diagram shows overall dimensions so that modellers can check whether models of unusual or overseas prototypes will clear 'standard' structures. Again this is not an exact scaling of a prototype vehicle profile diagram, which varies between railways and also between sections of the same system which may originally have been independent companies, but models built to scale will automatically take account of these variations. Figure 12 includes limits for the clearance to the under-side of vehicles, including that to gearwheels. This is particularly important for stock operating over raised third rail or stud contact systems.

A prototype vehicle profile diagram makes allowance for spring deflection and wheel wear, but this will not concern the modeller except to note that prototype wheels can wear by as much as 75mm (3in) in diameter. This reduction may be useful if a wheel of 'as new' diameter is not available for a particular model or if it is necessary to provide additional clearance because of sharp curves or over-scale flanges.

Figure 13 shows the recommended requirements for buffer positioning on rolling stock. If these are maintained it will ensure that vehicles will couple and run together.

It must be appreciated that, in common with other Guild standards, the dimensions are based on British prototype practice and so will ensure adequate clearance for models of British rolling stock. This will not necessarily be the case for models of overseas prototypes built to a scale of 7mm = 1ft as their overall dimensions are usually greater.

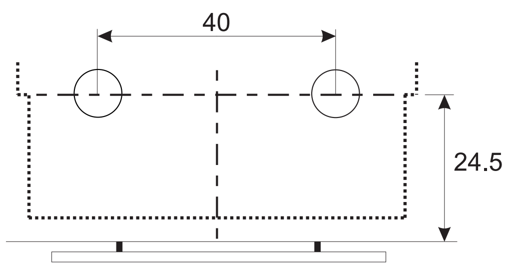


Figure 13 Recommended Buffer Position

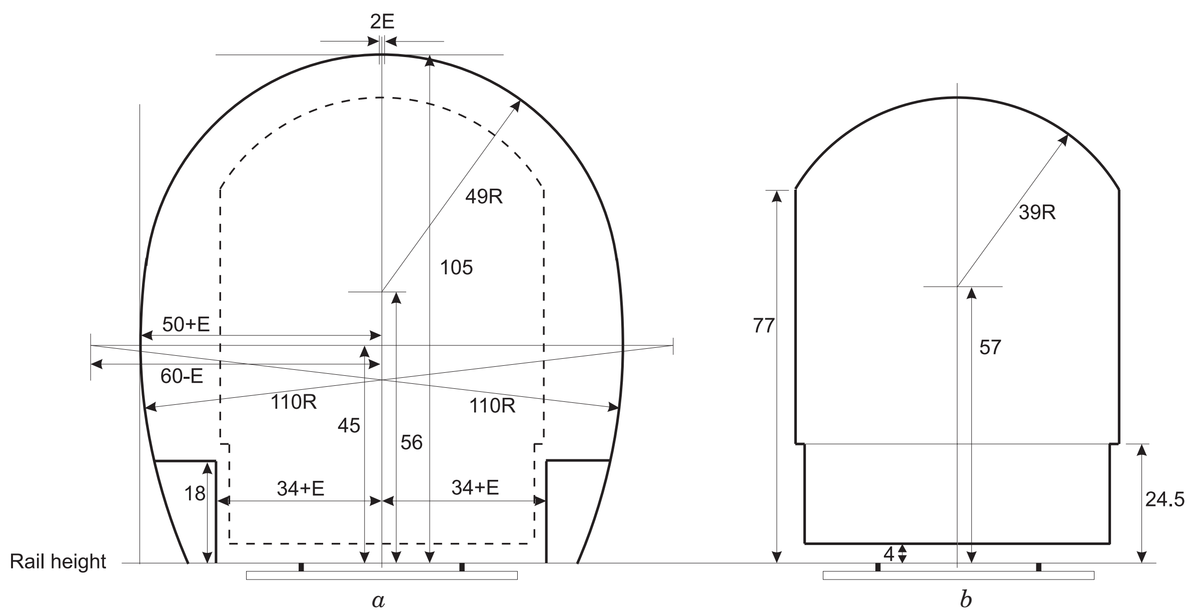


Figure 12 Limiting Dimensions a) Structure b) Vehicles

1.10 Tramway Standards

1.10.1 Introduction to Tramway Standards

The Standard specifies only the critical dimensions which govern compatibility between the car, track and overhead line. Methods of construction of rolling stock, track and overhead equipment are described elsewhere in the Manual. The relationship between the critical dimensions of the wheelset and track is the same as in railway practice, but turnouts for street running using grooved rails differ from railway ones in that the groove guides the wheelset through the turnout without the need for check and wing rails. Also drop in at crossings is minimised by the flange being supported by the bottom of the rail groove. Off-street track for tramway and rapid transit systems uses railway type rails and turnouts.

It was hoped that a comprehensive survey would lead to the publication of a single standard for track compatible with at least the majority of wheelsets used by modellers but this has not proved to be possible. This is because there are two well established systems, one using the HO/OO gauge wheel tread profile and the other the O Gauge Fine Standard profile. Also, some modellers reduce the gauge from 32mm to 31.5mm because the reduced clearance to the wheelset flange gives smoother running of short wheelbase cars. This reduction does not affect compatibility with 32mm gauge wheelsets.

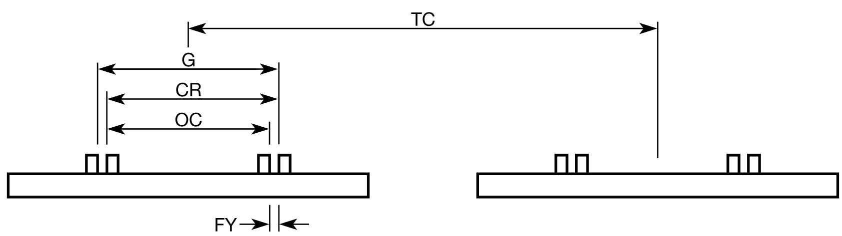
As in the case of railways, the gauge of prototype tramways varies and if the scale of the cars is kept constant so will the model gauge. The tables of dimensions are based on 32mm gauge but the dimensions for other gauges can easily be derived from them.

1.10.2 Choice of Standard

Unlike the railway standard, where the Guild recommends the adoption of the Fine Standard for general use with the option of the ScaleSeven standard for modellers desiring to work to near exact scale dimensions, a similar recommendation cannot be made for the tramway modeller. Both the established wheelset standards are equally acceptable but it is not possible to specify track dimensions which will accept both. The modeller must therefore make his own choice in the knowledge that his cars will only be able to run on track built to the standard compatible with their wheelsets.

Table 3 Guild Tramway Track Standards

Applicable to 4ft 8½in prototype gauge 7mm = 1ft models only. Untoleranced dimensions imply normal model-making accuracy.



Dimension (mm)		Prototype (Typical)		Exact Scale	TM1	TM2	Notes
Wheel profile					HO/EM	Guild Fine	
Gauge	G	1435mm	4ft 8 1/2in	32.96	32.00	32.00	minimum See Note 1
Over inner faces	OC	1378mm	4ft 6 1/4in	31.65	30.00	28.50	maximum
Check to opp. face	CR	1407mm	4ft 7 3/8in	32.30	31.00	30.25	minimum
Flangeway	FY	29mm	1 1/8in	0.66	1.00	1.75	minimum
Track centre distance	TC	2440mm	8ft	56	64	64	See Note 2
Outer rail to kerb	TK	2900mm	9ft 6in	66.5	66.5	66.5	See Note 3

Notes for Table 3

1. Gauge and flangeway widening on curves:
   Widening is not necessary on radii above 400mm, suggested increases for 60mm wheelbase cars are in proportion to the following:
   On 280mm radius increase gauge by 0.5mm and flangeway by 0.6mm.
   On 150mm radius increase gauge by 1.0mm and flangeway by 2mm
2. The track centre distance may have to be increased on sharp curves to ensure clearance between cars, but the number of permutations of car length, end profile, wheelbase, bogie centres and curve radius makes it impractical to define a standard value. The method of calculating the minimum track centre distance on curves is given in Part 2, Section 1 of the Manual.
   The centre distance on tracks with centre poles is the pole width + 64mm on straight track with an appropriate increase on curves.
3. This distance can be reduced by agreement with property owners.

Table 4 Guild Tramway Wheelset Standards

Dimension (mm)		Prototype (Typical)		Exact Scale	TW1	TW2	Tolerance & Notes
Wheel profile					HO/EM	Guild Fine	
Tread diameter							See Note 1
Back to Back	BB	1340	4ft 6 3/4in	31.90	30.50	29.00	minimum
Back to Flange Face	BF	1410	4ft 7 1/2in	32.37	31.00	30.00	maximum See Note 2
Over Flanges	OF	1429	4ft 8 1/4in	32.80	31.50	30.75	minimum See Note 2
Flange Width (OF-BF) (BF-BB)	FW	 19.0	 3/4in	 0.44	0.50 0.50	0.75 1.00	minimum maximum
Flange Depth	FD	 13.0	 1/2in	 0.33	 1.00	1.00 1.20	minimum See Note 2 maximum
Root Radius	RR	9.0	3/8in	0.22	0.50	0.50 0.70	minimum maximum
Tip radius	TR	9.0	3/8in	0.20	10° taper	0.25	minimum on both corners
Coning						1 in 20	
Tread Width	TW	Tread width is Wheel Width minus Flange Width (WW-FW)					
Wheel Width	WW	76.0	3.0in	1.75	2.00	3.50 4.00	minimum maximum
Journal Faces	JF	varies			37.50	37.50	maximum
Journal Diameter	JD	76.0-89.0	3-3 1/2in	1.75			See Note 3
Axle Length	AL					45.00	minimum

Notes for Table 4

1. The diameters of wheels mounted on the same axle shall not differ by more than 0.15mm.
2. Dimensions BF, OF and FD are to the intersections of the tangents to the wheel tread and the flange face (point A See Table 2).
3. The journal diameter and type vary widely between manufacturers of model wheelsets and consequently it is not practicable to recommend a preferred standard. The axle must be able to withstand an impact resulting from derailment without bending. To meet this requirement a minimum diameter of 2mm for mild steel and 1mm for hard steel is recommended.

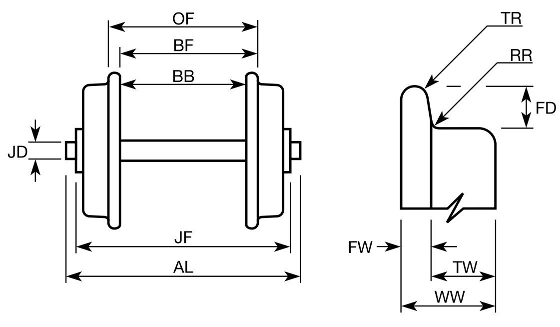
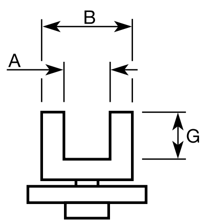


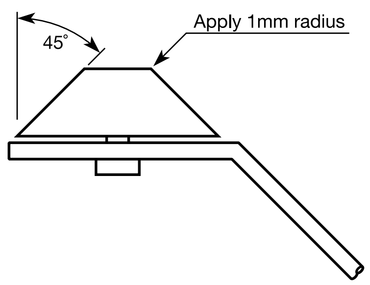
Table 5 Standard Dimensions for Overhead Equipment and Collectors

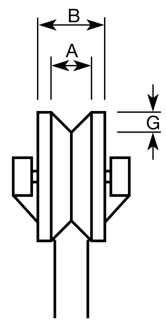
Overhead Equipment

Dimension	Minimum	Maximum
Height of contact wire from railhead	140mm	154mm
Diameter of contact wire	0.4mm	0.5mm
Maximum offset for bow or pantagraph collection		12mm on curves
Distance from track centre to kerb mounted poles	85	See Note
Distance between poles	as required to locate wire.	120ft = 840mm

Note: See Table 3, Note 2 for dimension for centre of track poles.







Trolley Pole Heads

Dimension		Swivel Head	Wheel Head
Diameter			3.2mm
Head Width	B	1.6mm maximum	1.6mm maximum
Groove Width	A	1.0mm minimum	1.0mm minimum
Groove Depth	G	0.8mm maximum	0.8mm maximum
Groove Angle			65° inclusive
Trolley Angle			20° to the horizontal

Bow and Pantagraph contact shoe length	30.00mm
Trolley, Bow and Pantagraph Collector contact pressure	8.5g to 14g (0.3oz to 0.5oz)

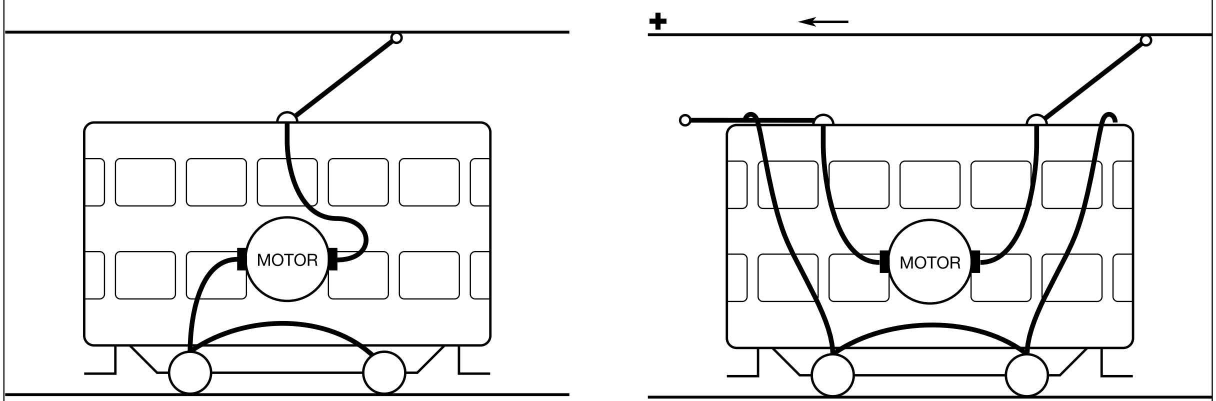
Minimum Curvature
Measured to the inner rail.
Minimum prototype radius in normal use is 45ft (= 315mm) on narrow gauge systems and 55ft (= 385mm) on standard gauge.
The minimum prototype radius for turnouts is 75ft (= 525mm).

Note: As little as 40ft (= 280mm) has been used in special cases, e.g. complex junctions at cross-roads where bogie vehicles were in operation and 25ft (= 175mm) where 4 wheel vehicles were in operation.
For model track 150mm can be used but 230mm or 305mm are preferable where space permits.

1.10.3 Relationship Between Polarity and Direction of Motion

Because the majority of trams are double-ended vehicles and run equally in either direction precise standards cannot be laid down. Where the overhead equipment is dummy and a two running rail supply is used, standard two-rail practice should be observed. That is, positive polarity on the right hand rail should cause a tram to move away from an observer standing behind it, but the direction of movement relative to the track polarity will not change if the tram is turned.

Where the overhead equipment is live, direction of movement depends on the internal wiring to the motor terminals. This is shown in Figure 14.



- The trolley pole (or bow or pantagraph collector) is connected to one motor terminal.
- Pick-up from rails is connected to the other motor terminal.
- Reversing is accomplished by operating the controller reversing switch.

- Each trolley pole is connected to its respective motor terminal.
- Trolley pole hold down hooks are connected to the rail pick-ups.
- Positive supply to the conductor wire produces forward motion with the rear trolley pole up.
- Reversing is accomplished by changing over the trolley poles.

Figure 14 Internal wiring of trolley motors