

TRAILER IVA DRAWBAR STRENGTH

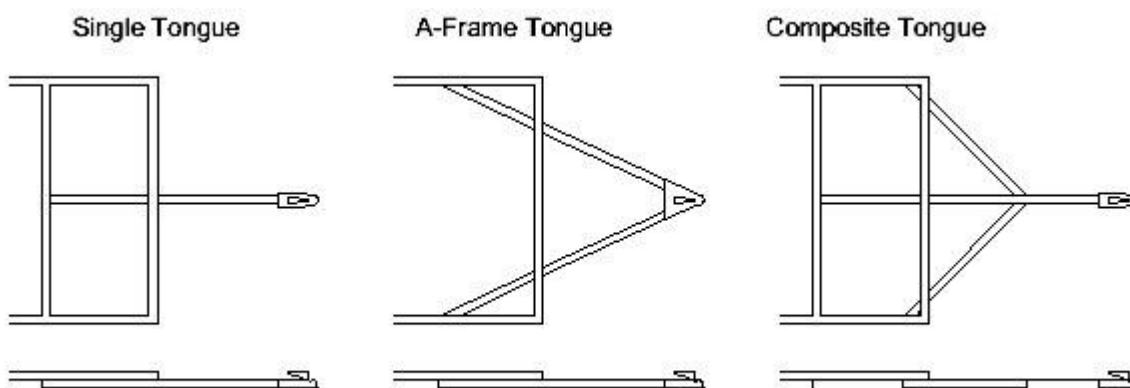
This note describes the use of the associated spreadsheet to show a trailer drawbar (or tongue) is strong enough to pass the IVA test, by satisfying international standard ISO 7641.

1. Limitations

To be able to use this spreadsheet:

- the drawbar must be fabricated/welded from mild steel (S235JR or old BS grade 40A is assumed) - higher strength steels can be analysed by changing the stresses in the spreadsheet;
- the drawbar must have a constant section (ie, not tapering) - or else the calculation is repeated for each change of section;
- the drawbar/tongue must have one or two members – so a single tongue or A-frame tongue as shown in the graphic below, but not a composite tongue;
- the nose weight or static force on the coupling, S , must be positive;
- the nose weight or static force on the coupling, S , must be less than 150kg;
- the nose weight or static force on the coupling, S , must be less than 10% of the maximum trailer mass, P .

The last of these could cause a problem for trailers with traditional American styling that puts the axle a long way back, as this will give too high a nose weight and so prevent this spreadsheet from being used.



2. Input Data

This section describes the data required for the spreadsheet.

P	Maximum Trailer Mass	kg
----------	-----------------------------	-----------

This is the maximum trailer mass (weight) that will be stamped on the chassis plate. You are the manufacturer, so you decide the maximum mass and you can reduce it if you wish – for example, to make the drawbar pass this test.

The maximum mass cannot be more than the suspension or the tyres are rated to carry (plus the nose weight on the towball). So a trailer could be rated for a maximum mass of 600kg even if the suspension units were rated for only 550kg, if the nose weight was 50kg.

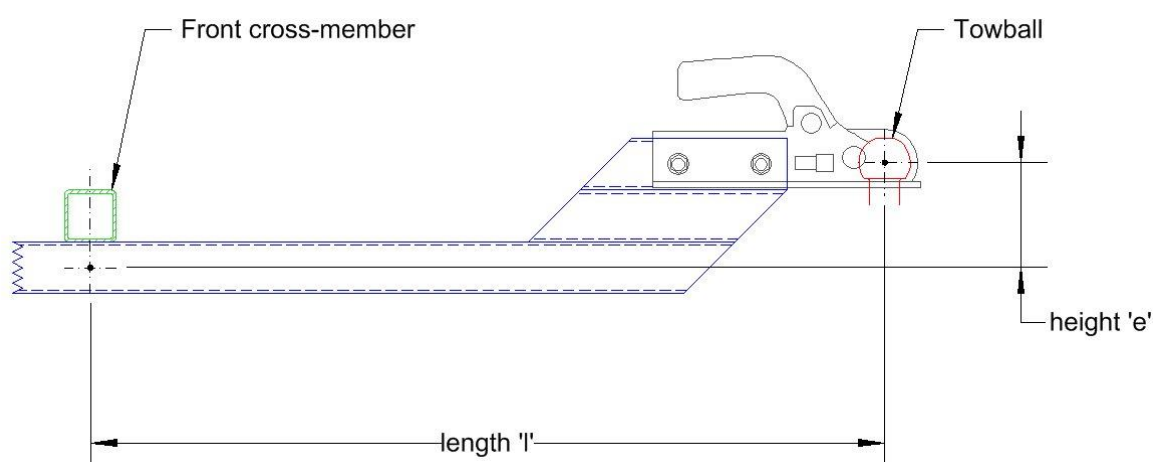
The maximum mass needs to be at least the weight of the finished trailer, plus an allowance for whatever will be carried in it, so that at any time the loaded trailer will not weight more than the maximum mass.

l	Length of drawbar, from front cross-member to towball	mm
e	Height/eccentricity, towball to drawbar at first cross-member	mm

Measure these dimensions from your design.

The length is measured from the centre of the towball (not the end of the tongue) to the centre of the first cross-member of the frame, or the first bracket under the teardrop body.

The height is measured vertically from the neutral axis of the tongue (this can be taken as its middle in most cases) to the centre of the towball and this may be nearly zero. It has been exaggerated in the diagram below to make it obvious. If you're not sure, enter a small number like 50mm.



Is the trailer braked?	Yes, has brakes / No brakes
-------------------------------	------------------------------------

Odd as it may seem, the standard says that trailers with brakes need to have a stronger tongue than unbraked trailers.

Steel type/grade	Mild steel, S235JR / Grade S275JR / User-defined
-------------------------	---

The spreadsheet defaults to mild steel, S235JR, but also contains the strength of S275JR steel that is used for some structural sections. Alternatively for other grades of steel, you can choose 'user-defined' if you know of both the yield stress and the minimum ultimate stress.

Yield stress, only for user-defined steel type	N/mm²
Minimum ultimate stress, only for user-defined steel type	N/mm²

If you choose 'user-defined' steel type, enter the strength data here – if not, leave this blank.

Was drawbar manufactured by welding?	Welded / Non-welded
---	----------------------------

Different material factors ('factors of safety') are used if drawbar is attached to the rest of the frame by welding or by bolts. Input here the type of connection. If welding is used at any point on the drawbar, input welded.

3. Results

This data can now be input into the spreadsheet in the green boxes and the results will be displayed in the red boxes:

Horizontal force on coupling, D, kN	This is included in case it is needed for another part of the IVA. For example, the paperwork that comes with a coupling will say what the maximum D value is that it can be used for.
Maximum static nose weight, S max, kg	This is just a repeat of the limitations at the start of this note. and is included since the weights that are measured during the IVA inspection could show that it fails this test – be prepared.
Minimum drawbar section modulus, Z min, cm³	This is the main result of the spreadsheet – it says how strong the drawbar (or drawbars) must be to meet the standard.

4. Picking a Suitable Section

The required section modulus shows the minimum strength required for the drawbar. Look in the tables below (or also in the second worksheet of the spreadsheet) for a section that has a section modulus at least this big.

If it is a A-frame drawbar with two members, divide the required section modulus by two to give the required section modulus for each member.

To help you do this, the spreadsheet will automatically look up the smallest of each type of section that has sufficient strength for a single or double (ie, A-frame) drawbar. But beware, this may not be the best choice of section – for example, the section suggested may be too thin for an amateur to safely weld, or may be heavier or more costly than a larger-but-thinner section that is also sufficiently strong.

The ISO standard only checks the vertical bending strength of the drawbar and not the transverse strength. The IVA test says that “The trailer structure and all components including their attachment must be suitable and of adequate strength”, without defining what ‘adequate strength’ is. The Australian trailer rules require the same strength transversely as vertically and that seems a sensible choice.

With an A-frame drawbar/tongue, transverse strength will not be a problem, but with a single tongue it needs to be thought about.

One British maker of trailers to be towed by motorcycles uses a rectangular hollow section tongue that is ‘laid down’, so it is wider than it is high, as presumably they feel that transverse strength is more important than vertical strength on these particular trailers. For this reason, the suggested sections for single drawbars include rectangular hollow sections with their biggest dimension horizontal.

5. Alternatives

If you are using the spreadsheet on a trailer frame that has already been built, the required section modulus may be higher than the modulus of the drawbar section you have used.

If so, there are two options:

- shorten the length of the drawbar;
- reduce the maximum trailer weight.

Shortening the drawbar makes a big difference to the required drawbar strength, so it can be a useful way of making small changes.

Reducing the trailer maximum weight (mass) is another way of changing the required drawbar strength. As you are the manufacturer, you can decide what the maximum trailer weight should be, within some limits:

- the maximum weight must be less than the capacity of the suspension or tyres;
- the maximum weight must be more than the trailer will weigh when it goes in for the IVA test, as it will be checked;
- the maximum weight must leave enough margin for the weight of bedding, belongings, food, drink, etc that will be carried in the trailer, so that it is never on the road at a weight that is more than the maximum.

If you decide to reduce the maximum trailer weight, watch out for the maximum nose weight S (static load on coupling) as this must be less than 10% of the new maximum weight. Presumably (I don’t know for sure) when the actual nose weight S is measured during the IVA test, it must be less than 10% of the maximum weight and not 10% of the weight of the trailer when tested. For a teardrop, this would be quite realistic as much of the extra weight will be added in the galley, behind the axle and so not increasing the nose weight.

The spreadsheet can now be re-run with the new drawbar length or maximum weight, to see if that has reduced the required section modulus down to less than the actual section modulus of the trailer as built. If not, keep trying different lengths and weights until a satisfactory answer is reached.

If this does not work, it may be necessary to increase the strength of the drawbar, typically by adding another section underneath it. This requires a much more complex calculation of the section modulus so contact me via the website for help.

6. IVA Evidence

The spreadsheet has been designed to be a self-explanatory statement of how the ISO standard has been met by the chosen drawbar. The IVA test will presumably want to see some evidence of this, which can be provided by printing out the page containing the calculation in the spreadsheet.

If the drawbar is not accessible to measure its wall thickness (presuming its width and depth can be measured directly by the IVA examiner), it might be sensible to have an offcut present at the IVA test.

7. Odd Behaviour

One user has noticed an odd behaviour that may look wrong – but is just how the formulas in the standard work.

The eccentricity/drawbar length ratio, e/l , is used to determine if bending of the drawbar under braking needs to be considered. The formulas in the ISO standard include this effect if the value of e/l is greater than 0.15. So if you are looking at a drawbar close to that limit, it can have the odd effect that if you shorten the drawbar, the required strength increases, and not reduces as you would expect. This is because shortening the drawbar has pushed the e/l value over 0.15 and bending under braking is not included in the calculation.

Small Print

This note and the spreadsheet have been researched carefully but no responsibility is accepted for the accuracy of the results it produces. If you require a guaranteed answer, you need to take (and pay for) professional advice.

© Andrew Gibbens 2012

Revised December 2012 to include section 7

SECTION PROPERTIES

This worksheet gives the properties of some popular sections that may be used for drawbars. Almost any section can be found at the link below:

http://www.roymech.co.uk/Useful_Tables/Sections/steel_section_index.htm

Tables below:

SHS - Square Hollow Sections (square tube)

RHS - Rectangular Hollow Sections (rectangular tube)

CHS - Circular Hollow Sections (round tube)

Equal Angle

Unequal Angle

Channel

SHS - Square Hollow Sections (square tube)

Height/ Width mm	Wall thickness mm	Section modulus cm ³	Weight kg/m	Designation
30	2.5	2.10	2.03	30x30x2.5
30	3.0	2.34	2.36	30x30x3
40	2.0	3.47	2.31	40x40x2
40	2.5	4.11	2.82	40x40x2.5
40	3.0	4.66	3.30	40x40x3
40	4.0	5.54	4.20	40x40x4
50	2.0	5.66	2.93	50x50x2
50	2.5	6.78	3.60	50x50x2.5
50	3.0	7.79	4.25	50x50x3
50	4.0	9.49	5.45	50x50x4
50	5.0	10.8	6.56	50x50x5
60	3.0	11.7	5.19	60x60x3
60	4.0	14.5	6.71	60x60x4
60	5.0	16.8	8.13	60x60x5
70	3.0	16.4	6.13	70x70x3
70	3.6	19.0	7.24	70x70x3.6
70	5.0	24.2	9.70	70x70x5
80	3.0	22.0	7.07	80x80x3
80	3.6	25.5	8.37	80x80x3.6
80	5.0	32.9	11.3	80x80x5

RHS - Rectangular Hollow Sections (rectangular tube)

Height mm	Width mm	Wall thickness mm	Major Section modulus cm ³	Minor* Section modulus cm ³	Weight kg/m	Designation
50	25	2.0	3.35	2.25	2.15	50x25x2
50	25	2.5	3.95	2.62	2.62	50x25x2.5

50	25	3.0	4.47	2.93	3.07	50x25x3
50	30	2.5	4.52	3.37	2.82	50x30x2.5
50	30	3.0	5.13	3.80	3.3	50x30x3
60	40	3.0	8.46	6.72	4.25	60x40x3
60	40	4.0	10.3	8.14	5.45	60x40x4
70	50	3.0	12.6	10.4	5.19	70x50x3
80	40	3.0	13.1	8.78	5.19	80x40x3
80	40	4.0	16.2	10.7	6.71	80x40x4
90	50	3.0	18.2	13.1	6.13	90x50x3
90	50	3.6	21.1	15.1	7.24	90x50x3.6
90	50	5.0	26.8	18.9	9.70	90x50x5
100	50	3.0	21.3	14.4	6.60	100x50x3
100	50	4.0	26.8	18.0	8.59	100x50x4
100	50	5.0	31.6	21.0	10.5	100x50x5

* minor section modulus is with larger dimension horizontal

CHS - Circular Hollow Sections (round tube)

Outside Diameter mm	Thickness mm	Section modulus cm ³	Weight kg/m	Designation
48.3	3	4.55	3.35	48.3x3
48.3	4	5.7	4.37	48.3x4
60.3	3	7.37	4.24	60.3x3
60.3	4	9.34	5.55	60.3x4
60.3	5	11.1	6.82	60.3x5
76.1	3	12.1	5.41	76.1x3
76.1	4	15.5	7.11	76.1x4
76.1	5	18.6	8.77	76.1x5
88.9	3	16.8	6.36	88.9x3
88.9	4	21.7	8.38	88.9x4
88.9	5	26.2	10.3	88.9x5
101.6	4	28.8	9.63	101.6x4

Equal Angle

Height/ Width mm	Thickness mm	Section modulus cm ³	Weight kg/m	x bar/ y bar *	Designation
40	3	1.18	1.84	10.7	40x40x3
40	4	1.55	2.42	11.2	40x40x4
40	5	1.91	2.97	11.6	40x40x5
40	6	2.26	3.52	12.0	40x40x6
50	3	1.86	2.33	13.1	50x50x3
50	4	2.46	3.06	13.6	50x50x4
50	5	3.05	3.77	14.0	50x50x5
50	6	3.61	4.47	14.5	50x50x6

50	8	4.68	5.82	15.2	50x50x8
60	5	4.45	4.57	16.4	60x60x5
60	6	5.29	5.42	16.9	60x60x6
60	8	6.89	7.09	17.7	60x60x8
60	10	8.41	8.69	18.5	60x60x10
70	6	7.27	6.38	19.3	70x70x6
70	8	9.52	8.36	20.1	70x70x8
70	10	11.7	10.3	20.9	70x70x10
75	6	8.41	6.85	20.5	75x75x6
75	8	11.0	8.99	21.4	75x75x8
80	6	9.57	7.34	21.7	80x80x6
80	8	12.6	9.63	22.6	80x80x8
80	10	15.4	11.9	23.4	80x80x10
100	8	19.9	12.2	27.4	100x100x8
100	10	24.6	15.0	28.2	100x100x10
100	12	29.1	17.8	29.0	100x100x12
100	15	35.6	21.9	30.2	100x100x15

* x bar/ y bar are distance from flange to neutral axis

Unequal Angle

Height mm	Width mm	Thickness mm	Major Section modulus cm ³	Weight kg/m	y bar * mm	Designation
60	30	5	4.04	3.37	21.5	60x30x5
60	30	6	4.78	3.99	22.0	60x30x6
65	50	5	5.14	4.35	19.9	65x50x5
65	50	6	6.1	5.16	20.4	65x50x6
65	50	8	7.93	6.75	21.1	65x50x8
75	50	6	8.01	5.65	24.4	75x50x6
75	50	8	10.4	7.39	25.2	75x50x8
80	60	6	9.29	6.37	24.7	80x60x6
80	60	8	12.2	8.34	25.5	80x60x8
100	65	7	16.6	8.77	32.3	100x65x7
100	65	8	18.9	9.94	32.7	100x65x8
100	65	10	23.2	12.3	33.6	100x65x10
100	75	8	19.3	10.6	31.0	100x75x8
100	75	10	23.8	13.0	31.9	100x75x10
100	75	12	28.0	15.4	32.7	100x75x12

* y bar is height from flange to neutral axis

Channel (note: these are usually made from higher strength steels)

Height mm	Width mm	Flange thickness mm	Web thickness mm	Major Section modulus cm ³	Weight kg/m	Designation*
76	38	6.8	5.1	19.5	6.7	76x38x7(T)
100	50	8.5	5	41.5	10.2	100x50x10(P)
125	65	9.5	5.5	77.3	14.8	125x65x15(P)
150	75	10	5.5	115	17.9	150x75x18(P)
150	90	12	6.5	155	23.9	150x90x24(P)

* Flange type - T: tapered flanges, P: parallel flanges