

Truck weight and dimension regulations and container standards

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Truck weight and dimension regulations are changing. At the same time, there have been suggestions for new standards for cargo containers and many non-standard containers are now in use. This paper examines how well the truck regulations on the one hand and container sizes on the other mesh in producing vehicles capable of carrying the various actual or proposed containers. The primary focus is on Canada and the United States, however two European regulatory regimes are included for illustrative purposes.

1. INTRODUCTION

In 1989, Transport Canada commissioned a study on the impact of potential new container standards. (ref. 3) All modes of transport and facets of container handling were considered but one issue -- container sizes and truck weight and dimension regulations -- occupied a large part of the study. In another paper, the analysis was extended to consider containers and the new nationwide truck weight and dimension regulations -- "How well do the trucks allowed under Canada's new regulations handle containers?". (ref. 4)

This paper continues the work by broadening the focus. The primary concern is still Canadian trucks and regulations -- national standards have been amended recently. However, it is increasingly difficult to restrict the scope of such investigations to just one country. For example, there have been suggestions for changes in truck weight and dimension regulations in the United States; there is the increasing integration of the North American economies; and, there have been efforts by the International Standards Organization (ISO) to develop standards for a new (larger) container series.

There are about 400,000 TEU (twenty-foot equivalent units) movements a year between Canada and the United States, one-third by truck and two-thirds by rail with many of the latter involving truck for pickup and delivery. With the advent of North American-wide containerization, these volumes will increase. Canadian ports handled 1.3 million TEU in 1988, almost all of which were ISO containers.

While the primary focus in this paper is on Canada and the United States, examples from Europe and the UK are also included to show the difference between North American and European vehicles.

2. BACKGROUND

Containers of one sort or another have been used since at least the Second World War but the real container revolution began in 1966 when Sea-Land inaugurated the first containership using a mixture of 20ft and 35ft containers. To facilitate the exchange of these containers, the ISO began to develop standards in 1961 through its Technical Committee 104. The first standard, ISO 668, was for containers with a width and a height of eight feet, and lengths of 10ft, 20ft, 30ft, or 40ft. Shortly afterwards, an 8'6" height was recognized

and, in 1989, a height of 9'6" was agreed to for the 40ft container although it has not yet been adopted as a standard. Throughout this period, it was over-the-road movements which proved to be the most constraining aspect of acceptable container sizes and weights.

By all accounts, these ISO standards have been successful: one report suggests that less 100,000 containers in the world, out of a total population of 5 million TEU, are larger than the ISO 8ft width or 40ft length. (ref. 3) Another report suggests that 92% of all containers in the world are 8'6" high, 20ft and 40ft ISO containers. (ref. 5)

Still, there have been pressures for change: (i) improved road standards allowing larger or heavier trucks; (ii) declining freight densities, which increases the economic attractiveness of large-cube containers; (iii) attempts to make packaging and container standards more compatible as, currently, ISO containers are not optimal in terms of either pallet sizes or unit-load standards; (iv) increased enforcement of road weight limits in the United States which has led to calls for lighter containers (40% of all inbound and outbound 20ft containers are overweight and 17% of inbound and 38% of outbound 40ft containers are overweight, where *overweight* is defined in terms of US truck weight and dimension regulations (ref. 8)); (v) the spread of non-ISO containers to domestic or continental transportation systems; (vi) the development of truck weight and dimension regulations based on a more analytical consideration of pavements, bridges, and stability which has resulted in important changes in some countries.

It is not surprising, therefore, that a suggestion for a new series of container standards was made shortly after the first were adopted. Accordingly, Working Group 4 of TC 104 was given the mandate in 1982 to look into "future sizes of large freight containers." Their mandate was renewed in 1987 and the investigation continued, with the last report being given in Seoul in April, 1991.

3. TRUCK WEIGHT & DIMENSION REGULATIONS

3.1 Regulatory Regimes

Eight regimes are considered in this analysis: three in Canada, three in the United States, and two in Europe.

Transportation Association of Canada (TAC): Standards were agreed to in 1988 and have recently been amended. These set out minimum dimensional and

weight limits so that a properly configured truck can operate coast-to-coast. The 12 individual jurisdictions are free to allow more permissive limits. The truck that has gained most attention under these limits is the 8-axle B-train with a weight up to 62.5 tonnes (*tne*) and enough length to handle three 20ft containers or one 20ft and one 40ft container. (A *B-train* is a tractor and two-semitrailers; no converter dolly is used to join the trailers.)

Ontario: Much of the container-hauling activity in Canada occurs in Ontario where, historically some of the heaviest axle loads and highest gross vehicle weights (GVWs) in the world have been allowed. Of equal importance, the bridge formula which controls GVW allows a high load over a relatively short distance. So for example, and in contrast to TAC limits, it is possible to have 7 and 8-axle A-trains at weights approaching (or even over) 60 tne with overall vehicle length considerably shorter than comparable TAC trucks. (An *A-train* is a tractor and two semitrailers where a single-drawbar converter dolly is used to couple the trailers.)

Québec: There is also considerable container-hauling activity emanating from the port of Montréal where, as in Ontario, heavy axle weights and GVWs are permitted. Québec has just modified its regulations so the interest is to see how well these accommodate the requirements of container trucks. Québec also allows what are known as Long Combination Vehicles (LCVs) on four lane, divided highways.

United States Federal (US): The common thread in state regulations is the limits set out under federal legislation: low axle weights and GVW limits, large dimensions and a bridge formula controlling weight distribution. These have made it difficult for truckers to handle heavy ISO containers. A full description of regulations is complex as there are many states where higher weights are allowed, where LCVs operate, or where permit practices allow "overweight," by US standards, containers to be carried.

Turner Trucks (TT): These are proposed US trucks with light axle loads but GVWs exceeding the current 36.3 tne GVW limit. They are described in a recent Transportation Research Board (TRB) study. (ref. 7) Although they have not yet been adopted, they constitute an important enough suggestion to be included in this analysis.

"Truck Weight Limit" Trucks (TWL): These are trucks proposed in another recent TRB study (ref. 8), again, not yet adopted. One of the recommendations is to allow trucks heavier than 36.3 tne under permit. For this paper, TWL trucks are those with the same axle weights and lengths as current federal limits but with GVW controlled only by the bridge formula.

Europe (EC): EC countries have adopted standards for trucks engaged in international transport as set out originally in EEC Directive 85/3 and since amended several times. EC regulations specifically recognize ISO 40ft containers by allowing two particular configurations a GVW of 44 tne -- instead of 40 tne -- when hauling such loads.

United Kingdom: In addition to EC standards, European countries have their own regulations governing weights and dimensions. The regulations from the UK, taken from a pamphlet with an effective date of February 1, 1989, have been selected as one example of these domestic European regulations.

3.2 Regulations

The following is a summary of the regulations.

Height: Limits in the eight regimes range from 4.0 m (EC) to 4.25 m (UK).

Width: In North America the limit is 2.6 m (2.59 m in the US) whereas under EEC directives it is up to 2.5 m, although refrigerated equipment is allowed a width of 2.6 m.

Length: Regulations are complex in that there are a series of controls and definitions used in each regime. The important consequences are shown in Table 1 where the common measure *box length* -- the distance from the front of the first cargo unit to the back of the last cargo unit -- is used for comparisons.

TAC: Semitrailers up to 14.65 m are allowed (16.2 m in Western Canada) as are double-trailer combinations (*doubles*) with a box length of 20.0 m for B- and C-trains and 18.5 m for truck-trailer and A-train configurations. (A *C-train* is two semitrailers with a double-drawbar converter dolly.)

Ont: Semitrailers up to 14.65 m are allowed with some at 16.2 m operating under permit. A limit on the kingpin-to-rear allows a box length on doubles of about 17.7 m.

Qué: Semitrailers are limited to 15.5 m and doubles are constrained by box length limits similar to those found in the TAC regulations. Longer doubles with two 14.65 m trailers are possible under Québec's LCV (*train routier*) permit program.

US: Federal regulations require states to allow semitrailers with a length of at least 14.63 m and doubles with two trailers of at least 8.53 m each. Most states now allow semitrailers up to 16.2 m in length and 13 allow LCVs under permit. There are also LCVs on private toll roads in other states.

TT: The Turner proposal retains the current US length limits for semitrailers (16.2 m in most states, sometimes by permit or on select roads) and increases the length of trailers used in doubles to a minimum of 9.75 m and a maximum of 10.36 m. Additionally, there is a kingpin-to-rear axle limit of 12.5 m for doubles.

TWL: Limits are the same as current US limits.

EC: The maximum length for semitrailers is about 14.0 m, given the kingpin-to-rear and kingpin setback limits. An overall length limit of 16.5 m for tractor-semi-trailers rules out the use of doubles. Truck-plus-trailer configurations have a limit of 18.35 m and a maximum trailer length of 12.0 m.

UK: Semitrailers of up to about 12.6 m are possible given the limits on rear overhang (3.2 m), *forward distance* (8.5 m), and typical kingpin setbacks. A kingpin-to-rear limit of 14.5 m for doubles constrains the available box length to about 15.4 m. Various limits, including an overall length of 19.0 m, gives a truck-plus-trailer configuration a box length of about 16.8 m.

Axle Weights: TAC and UK regulations are the only ones, of the eight considered here, which have specific limits for steering axles -- 5.5 and 6.0 tne respectively. The most common axles with standard tires have allowed weights as follows:

	Single	Tandem	Drive Tandem	Tridem
TAC	9.1	17.0	17.0	24.0
Ont	10.0	19.1	17.9	28.6
Qué	10.0	20.0	18.0	30.0
US	9.1	15.4	15.4	19.1
TT	6.8	11.3	12.7	18.1
TWL	9.1	15.4	15.4	19.1
EC	10.0	20.0	20.0	24.0
UK	8.2	15.5	15.0	18.0

Drive tandem weights shown assume that the largest spread for such axles is 1.52 m. In some cases, appropriate spreads have to be met to reach the weights

shown, and in other cases definitions are important. For example, under the TAC agreement, *tridem* is defined in terms of the load-sharing ability of three axles. In addition: (i) the TAC B-train has a limit of 23.0 tne on a tridem; (ii) single drive axles under EEC directives are permitted 11.5 tne; (iii) under some regimes, notably Ontario and Québec, 3-axle groups other than tridems are allowed, sometimes at weights higher than those shown above; and (iv) the figure for the US tridem is the most common state limit.

GVW: Many factors -- the distance from the first to the last axle (*base length*), the type of configuration, the use of the truck, the number and type of axles, etc -- determines the total allowed weight. Ignoring all these, the important point is that GVW limits are lowest in the US (36.3 tne) and highest in Canada (63.5 tne in Ontario and 62.5 tne under TAC). Potential weights under the Turner proposal could be as high as 64.2 tne and under the TWL proposal as high as 70.8 tne, although it is unlikely a permit would actually be approved at the lengths required (a base length of over 39 m).

Axle Spacing: Axle-spacing requirements are complex. To show this, consider the maximum weight allowed on a 3-S2 (a 5-axle tractor semitrailer) with the shortest possible distance between the first and last axle. To do this, assume: (i) the shortest distance from a steering axle to the first axle in a tandem is 3.0 m; (ii) steering axles have the heaviest legal loads even though in practice these rarely, if ever, can be achieved; and (iii) the shortest possible trailer length is 7.01 m with a kingpin setback of 0.45 m and with trailer axles set at the rear of the chassis. Given these assumptions, the following provides an indication of axle-spacing requirements:

	Max GVW (tne)	Base Length (m)	Tonnes/ metre
TAC	39.5	10.40	3.80
Ont	47.0	11.75	4.00
Qué	45.5	11.10	4.10
US	36.3	15.50	2.34
TT	43.1	18.30	2.36
TWL	36.3	15.50	2.34
EC	44.0	14.33	3.07
	40.0	9.61	4.16
UK	39.0	13.50	2.89

For the purpose of these calculations, a 4-S3 was used for the Turner truck (a 4-axle tractor with a 3-axle semitrailer). Also, in the UK, 3-S2's may operate at higher weights but if they do, the base length has to be increased.

These numbers, while giving an indication of axle-spacing rules and the resulting load per metre of length, do not tell the whole story. For example, while TAC and Ontario appear to be similar in terms of the load per metre, there can be a considerable difference in the placement of axles. For the TAC truck, the two tandems must be separated by 5.0 m. For the Ontario truck, the two tandems may be as close as 3.6 m.

4. CONTAINER CHARACTERISTICS

Four groups of containers are used in this analysis: ISO 20ft and 40ft containers; two suggested containers; North American containers (45ft, 48ft, and 53ft); and European wide containers (2.5 m). European swap bodies have not been included, nor have any of the standards being considered by CEN (Comité Européen de Normalisation).

	Exterior Dimension(m)			Weight (tne)
	Height	Width	Length	
ISO 20ft	2.59	2.44	6.06	20.32
ISO 20ft	2.59	2.44	6.06	24.00
ISO 40ft	2.59	2.44	12.19	30.48
ISO 40ft	2.90	2.44	12.19	30.48
new 49ft	2.90	2.60	14.93	30.48
new 20ft	2.59	2.44	6.06	30.48
NA 45ft	2.90	2.44	13.72	33.02
NA 48ft	2.90	2.59	14.63	30.48
NA 53ft	2.90	2.59	16.15	30.48
EC 2.5m	2.74	2.50	12.19	30.48

The first four containers conform to ISO standards (except the 2.9 m height). While the weight for the 20ft container is 24 tonnes, there are still many old ones in use conforming to the earlier 20 tne standard. The difference between the two 40ft containers is that the second is the high cube variety.

TC 104 has been considering new containers 2.6 m in width, about 15.0 m (49ft) in length, and up to 30.48 tne in weight. Such a container would be an improvement in three ways: pallet and unit load sizes fit into the container more easily than in the current ISO containers (less waste space and less use of dunnage); the increase in cube lowers transportation costs for anything with a density of less than about 350 kg/m³ (most general freight); and a container of about 15.0 m in length allows the development of a half size container which is also an improvement in terms of unit loads and which can be used in places where length limits rule out the use of longer containers.

The status of these suggestions is unclear as the TC 104 working group looking into future containers was disbanded at the Seoul meeting. In the meantime, the Inland Transport Committee of the UN's Economic Commission for Europe is scheduled to release its findings on the costs and benefits of larger containers sometime in 1992.

At the 1989 TC 104 meeting in London a suggestion was made to increase the weight of the 20ft container to 30.48 tne. Containers such as this are already in use. While the suggestion was not accepted, a container of this size and weight is included in the analysis. In Canada, the potential advantage of such a container is that 20ft containers are generally loaded -- almost always to the maximum weight -- with heavy, resource-based commodities on their outbound trips. (ref. 4) Any increase in payloads lowers transportation costs.

The three North American containers shown are based on specifications of American President Lines. The 48ft and 53ft containers are used in North American and the 45ft container, introduced in 1982, is used on US-Pacific routes and, in a few cases, into European ports. Not all 45ft containers are rated as heavy as the one shown above.

The European container, in a variety of lengths with 7.15 m being the most common, was developed to accommodate the *Europallet* (1.0 X 1.2 m). Two such pallets, or unit loads, fit side-by-side in the container.

5. CONFIGURATIONS

The 29 vehicle configurations used in the analysis are shown on Table 1. These have been chosen from hundreds available as the most likely candidates for hauling containers.

For tractor configurations, the first number indicates a tractor with either 2, 3 or 4 axles and the "S" indicates a semitrailer -- for example, a 3-S2 is the common (in North America) 5-axle tractor-semitrailer. A T3-4

indicates a 3-axle truck and a 4-axle trailer. Converter dollies, which convert semitrailers into full trailers, are indicated as either "A" for a single drawbar converter dolly or "C" for a double drawbar dolly. For example, the 8-axle A-train used in Ontario to pickup and deliver 20ft containers is indicated as 3-S2-A1-S2.

Table 1: Truck Configurations

Configuration	Box Length (m)	GVW (tne)
1 TAC T3-4	18.5	53.5
2 TAC 3-S2	14.65/16.2	39.5
3 TAC 3-S3	14.65/16.2	46.5
4 TAC 3-S2-A1-S2	18.5	53.5
5 TAC 3-S2-S2	20.0	56.5
6 TAC 3-S3-S2	20.0	62.5
7 TAC 3-S2-C1-S2	20.0	58.0
8 Ont 3-S2	14.65/16.2	47.0
9 Ont 3-S3	14.65/16.2	55.6
10 Ont 3-S2-A1-S2	≈ 17.7	63.5
11 Qué 3-S2	15.5	45.5
12 Qué 3-S3	15.5	55.5
13 Qué 3-S2-A1-S2	18.5	53.5
14 US 3-S2	14.65/16.2	36.3
15 US 3-S3	14.65/16.2	36.3
16 TT 4-S3	14.65/16.2	43.1
17 TT 3-S2-A2-S2	≈ 21.6	53.5
18 TT 3-S3-A2-S3	≈ 21.6	67.1
19 TWL 3-S3	14.65/16.2	51.7
20 TWL 3-S2-A2-S2	≈ 18+	70.8
21 EC T3-3	≈ 16.0	40.0
22 EC 2-S3	≈ 14	40.0
23 EC 3-S2	≈ 14	44.0
24 EC 3-S3	≈ 14	44.0
25 UK T3-3	≈ 16.8	42.5
26 UK 3-S2	≈ 12.6	36.5
27 UK 3-S3	≈ 12.6	39.0
28 UK 3-S2-A1-S2	≈ 15.4	39.0
29 UK 3-S2-S2	≈ 15.4	44.0

The box length is the cargo area. In cases where this is not regulated, the figure shown is an approximation. The use of a tractor with a shorter cab may increase these lengths. Where two box lengths are shown, permits or certain areas within the regulatory regime allow longer lengths.

GVWs shown are the highest legal weights. In many cases it is not possible to reach these weights. For example, the 47.0 tne 3-S2 in Ontario assumes 9.0 tne on the steering axle. In practice, this is difficult, if not impossible, to achieve.

6. ANALYSIS

There are four stages to the analysis: an examination of the dimensions of each vehicle; an analysis of the simple payload (allowable GVW given assumptions about the vehicle minus the tare weight); an analysis of axle-spacing requirements; and an analysis of load distribution. Operational considerations are ignored. For example, it is preferable to have a trailer which can stay with the container while being loaded or unloaded. For that reason, a truck-plus-trailer may not be practical for local drayage, although it might be used on terminal-to-terminal operations.

Dimensions: Height is not an issue in terms of the diversity of regulations. It can be an issue, however, where a high cube container is mounted on the wrong

trailer. For example, on a flatdeck, where the kingpin height is 1.22, a container with a height of 2.9 m will exceed the allowed height limits in most areas (1.22 + 2.9 + deck thickness ≈ 4.2 m+). On a purpose-built container chassis, a container with a height of 2.9 m has a tunnel which fits into the chassis to keep the height within legal limits.

There is one issue concerning width: 2.5 versus 2.6 metres (or 102" in some cases). All vehicles can potentially handle the ISO 2.44 m and the European 2.5 m containers; only North American vehicles can handle the 2.6 m containers. (This ignores places such as the Scandinavian countries where widths are also 2.6 m, but the only vehicles considered here are the 29 shown on Table 1.)

Length issues are more complex:

20ft: All 29 configurations can handle two 20ft containers. Only the TAC B-train can handle three. The TAC C-train, while having the same box length as the B-train, has wheelbase requirements which rule out the necessary trailer lengths for such a feat. There is a potential for LCVs in 17 North American jurisdictions to equal, or even exceed the TAC B-train but weight issues likely prevent anyone from applying for a permit to haul this many containers.

20ft + 40ft: Only the TAC B-train can handle a 20ft and a 40ft container. Again, the wheelbase requirements for the TAC C-train preclude the necessary trailer arrangements.

40ft: All 29 configurations can handle 40ft containers, with the following exceptions: A-trains, unless under a LCV permit in North America; trucks-plus-trailers; and B-trains in the UK.

45ft: All tractor-semitrailers, except those in the UK, can handle 45ft containers.

48ft: All tractor-semitrailers in North America can handle 48ft containers.

53ft: North American tractor-semitrailers in most jurisdictions can handle 53ft containers (most US states, about one-half the TAC jurisdictions, and in Ontario under permit).

Gross Vehicle Weight: Payloads, that is simple payloads, shown on Table 2 have been calculated as the difference between GVW and tare weight. In this case, GVWs are based on a more realistic assessment than the numbers shown in Table 1. For example, all tractor-trailers are assumed to have 5.0 tne on steering axles and drive tandems are limited to a spread of 1.52 m. Trailer length is important in some cases as the distance between axles determines total allowed weight. For example, the US 3-S2 with a 7.01 m trailer is only allowed 30.4 tne in weight because of the bridge formula. These same bridge considerations, under a variety of local rules and names, are important under TAC, Ontario, Québec, TT, TWL, and UK regulations.

Tare weights, in tonnes, are based on the following:

Truck	10.00				
Tractor	2-axle	3-axle	4-axle	for doubles	Ont/Qué
	6.00	7.71	8.71	8.62	8.62
Semitrailer	tandem	tridem			
	7.01 m (23')	2.95			
	8.23 m (27')	2.95	3.58		
	12.19 m (40')	3.18	4.26		
	13.72 m (45')	3.27	4.35		
	14.63 m (48')	3.90	4.99		
16.15 m (53')	3.90	4.99			

Table 2: Payload, Axle-Spacing, and Load-Distribution Characteristics

Configuration	GVW	Tare	Simple Payload	Container-Handling
TAC T3-4	53.5	15.0	38.5	P truck limited to 12.5tne, trailer to 26.0 tne (making this impractical for container hauling); AS shortest trailer ≈ 8.9m; LD light 20ft on truck & 20ft/24tne centred on trailer.
TAC 3-S2	39.0	10.7-11.6	27.4-28.3	AS shortest trailer ≈ 8.2m; LD 20ft/24tne centred
TAC 3-S3	46.0	12.0-12.7	33.3-34.0	P 20ft/20tne can be carried at rear; AS shortest trailer ≈ 11.4m
TAC 3-S2-A1-S2	53.5	15.7	37.9	P rear trailer limited to 12.4tne (making this impractical for containers)
TAC 3-S2-S2	56.0	14.7	41.3	P two 20ft/20tne only; AS shortest trailer ≈ 8.1m + 7.8m
TAC 3-S3-S2	62.0	15.4-16.1	46.0-46.6	P 20ft/24tne or a light 40ft on 1st trailer, 20ft/20tne on rear
TAC 3-S2-C1-S2	58.0	15.7-16.0	42.1-42.3	P rear trailer limited to 16.9tne; AS two 8.2 - 8.9m trailers are the only practical configuration
Ont 3-S2	41.0-43.0	11.6-12.5	29.4-30.5	LD some problems with 20ft/24tne on short trailers
Ont 3-S3	45.3-52.0	12.9-13.6	32.4-38.4	AS trailer length < 12.2m not practical; LD can handle heaviest container (30.48tne) but the proposed 20ft/30tne container must be centred.
Ont 3-S2-A1-S2	61.5	15.7	45.9	LD can handle two 20ft/20tne, but a 20ft/20tne + 20ft/24tne is difficult
Qué 3-S2	41.0-43.0	11.6-12.5	29.0-30.5	LD slight problem with 20ft/24tne on short trailer
Qué 3-S3	52.9-53.0	12.9-13.6	39.4-40.1	P can (just) handle two 20ft/20tne
Qué 3-S2-A1-S2	53.5	15.7	37.9	P cannot handle two 20ft/20tne
US 3-S2	30.4-35.8	10.7-11.6	19.7-24.2	P cannot handle a 20ft/20tne on short trailer, heaviest long container ≈ 24.2tne; AS trailer length > 12.2m for full GVW; LD probably cannot handle 20ft/24tne on long trailer even if well-centred
US 3-S3	33.6-36.3	11.3-12.7	22.3-24.3	AS trailer length > 12.2m for full GVW; LD heavy 20ft must be centred
TT 4-S3	40.6-41.3	13.0-13.7	27.6-28.2	AS shortest trailer ≈ 13.1m; LD can handle loads to 27.2tne but, for containers longer than 40ft, there is over-loading of rear tridem
TT 3-S2-A2-S2	50.4	15.7	34.7	P rear trailer limited to 17+tne; LD can handle two 20ft/17tne containers centred on trailers
TT 3-S3-A2-S3	64.2	16.9	47.3	P probably can handle two 20ft/24tne; LD containers must be centred
TWL 3-S3	39.5	12.0-12.7	26.8-27.5	AS trailer lengths > 13.4m for full GVW; LD can handle 20ft/24tne if centred
TWL 3-S2-A2-S2	57.6	15.7	42.0	P potential payload of 55tne if extremely long base length allowed (unlikely), for reasonable drawbars (4.0m) can (just) handle two 20ft/20tne containers
EC T3-3	40.0	12.0+	27.0+	P can handle one 20ft/24tne if second 20ft is practically empty, or, alternatively, two very light 20ft.
EC 2-S3	40.0	9.6-10.3	29.3-30.4	LD appears able to handle 20ft/24tne at rear of short trailer
EC 3-S2	44.0	10.7-10.9	33.1-33.3	P, AS, LD no apparent problems with ISO or European containers
EC 3-S3	44.0	12.0	32.0	P, AS, LD no apparent problems with ISO or European containers
UK T3-3	42.5	12.0+	30.0+	P truck is limited to about 12.8tne, trailer is limited to about 17.5tne (making this impractical for container hauling)
UK 3-S2	34.0-35.5	10.7-10.9	23.3-24.6	AS short trailer reduces GVW; LD heavy 20ft container must be centred
UK 3-S3	38.0	12.0	26.0	LD heavy 20ft containers must be centred
UK 3-S2-A1-S2	39.0	14.7	24.3	P can only handle two very light 20ft containers (making this impractical for container hauling)
UK 3-S2-S2	44.0	13.8	30.2	P can only handle two light 20ft containers (making this impractical for container hauling)

A-dolly 1.13
 B-train additional weight 0.23
 C-dolly 1.20

Payloads shown on Table 2 may not be achievable in practice. Comments on this on the table are based on axle-spacing requirements of each regime and an analysis of how the load is distributed over the axles. Load distributions were calculated using a model developed by John Billing.

Observations on container handling are made under one of three headings: **P** for significant features of payload handling not accounted for with the simple payload shown; **AS** for axle-spacing qualifications; and

LD for comments on axle-load distribution. For the most part, these are **negative** comments. That is, where it is obvious that a configuration can carry a 40ft/30tne container, there is no need to note this.

There are other observations. First, actual GVWs will be higher or lower depending on a number of factors, the most important of which -- given the assumptions about the equipment specifications -- is the degree to which weight can be transferred to the steering axle.

Second, tractor-semitrailers and doubles in North America require positive fifth wheel settings in order to put weight over the steering axle. (A positive fifth wheel setting means a fifth wheel in front of the centre of the

tandem axles.) This may not be a problem in the EC or the UK where tractor wheelbases are shorter, although it is understood that European equipment typically has positive fifth wheel settings.

Third, trailer length accounts for the range of GVWs, tare weights and payloads on the table. As length increases, GVWs increase (in those regimes with bridge formulae or comparable rules) as also do tare weights by a small amount.

Fourth, under actual operating conditions, trucks have difficulty handling the heaviest payloads calculated here. Vehicle specifications have to be precise and loads in the container have to be evenly distributed. Further, in cases where trailers and containers are owned by one party and tractors owned and operated by another, allowances have to be made for a variety of conditions. A demonstration of this is the load shown for the US 3-S2. For the simple payload and the load-distribution analyses, this was determined to be 19.7 tne when a 20ft container is placed on a 7.01 m trailer. However, in a US study (ref. 8) involving an actual demonstration, such a configuration could not carry more than 16.8 tne.

Fifth, on the table, comments are made about the "shortest trailer." Generally, this is where some feature of the regulations makes it impossible or impractical to use a shorter trailer. The issue is this: for 20ft containers, any trailer length in excess of 6.06 m is excessive. As a practical matter, given the required room for axles and landing gear and, in some regimes, concerns about vehicle stability, the shortest trailer is 7.01 m. On the table, then, lengths longer than this resulting from such things as axle-spacing rules are noted.

Sixth, comments also are made about centring a container on a trailer. This does not mean the precise centre of the trailer. Rather, it means the container cannot sit at the rear of the trailer without overloading the trailer axles. This is a problem where truckers have to back a trailer flush to a loading dock. In some cases, this can be overcome by using trailers equipped with sliding axles -- the extendable part slides under the container to make a short trailer with the container flush at the rear. These sliding parts, though, only work for lengths of a little over 1.0 m, which is not sufficient for many of the situations analyzed here.

7. SUMMARY

Observations can be grouped under four broad headings:

Dimensional Considerations: There are three issues: height on high cube containers which can sometimes create a problem; width in terms of 2.5 or 2.6 m as an acceptable standard versus the massive investment tied up in equipment and ships which can only handle the current ISO 2.44 m; and, length in terms of the inability to agree on an acceptable new international standard longer than the current ISO 12.19 m. All configurations considered here, except those in the UK, can handle up to 14.0 m in length. Some North American configurations can handle much longer than this (to 16.2 m generally and 17.4 m in some cases) and the TAC B-train can even handle a 40ft plus 20ft container.

Weight Considerations (1): The major point is that there is a problem with heavy containers in the US. Even the proposed Turner and TWL trucks cannot handle a fully loaded (30.48 tne) long container.

Weight Considerations (2): In considering 20ft/20tne containers, the only place there is a problem is under the current US federal regulations. They can be handled, but to do so requires either centring on long trailers and/or the use of more expensive *slider* trailers (ie,

trailers where the frame and the axles slide to facilitate both docking manoeuvres and compliance with bridge formulae). A minor observation about 20ft/20tne containers is that, in five regimes, it is possible to handle two of these containers at the same time: the three Canadian regimes and some of the proposed Turner and TWL trucks.

In considering 20ft/24tne containers, the only place there is a problem is under the current US regulations (ignoring special permits). All other regimes can handle these containers on 6-axle tractor semitrailers (7-axle in the case of Turner Trucks), although often the container has to be centred.

In considering 20ft/30tne containers, these can only be handled under Canadian (all three regimes) and EC regulations.

In considering 40ft-or-longer/30tne containers, there is no configuration in the US, either existing or proposed, and there is no configuration in the UK which can handle such containers. (Again, this ignores special permits or those US states which allow weights heavier than federal regulations.)

The Integrity of the System Finally, if it is accepted that there are advantages in having international standards -- and the success of the current ISO containers suggests there is -- then there should be some concern over current trends. The proliferation of container sizes outside the guidance of international standards may pose a problem for the integrity of transportation systems in the future. There will always be, of course, a need for some diversity or "non-standard" containers. Nevertheless, there are advantages in building diversity around a common set of limits which allow "modular" variations. The recent and proposed changes in truck weight and dimension regulations, and the apparent growing diversity in these regulations, suggests that perhaps more than just road geometry, bridges, pavements, and vehicle stability are at issue in developing good regulations. It is difficult to believe, even if bridge and pavement engineers disagree over fundamentals or even if roads are built to different standards, that it is impossible to design a set of standard truck loads or multiples thereof.

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