CONSIDERATION OF STATUTORY TRUCK WEIGHT LIMITS WHEN RECONSTRUCTING COMMERCIAL MOTOR VEHICLE COLLISIONS

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Abstract

The lawful allowable weights are often a consideration in the reconstruction of commercial vehicle collisions. The reconstructionist must be cautious not to assume that a vehicle that has exceeded the statutory limits has necessarily exceeded the design weight limits of the commercial motor vehicle. Nor should the reconstructionist assume a vehicle that is at or below the statutory weight limits necessarily is being operated within safety requirements for the subject commercial vehicle. This paper will discuss weight considerations and the basis for weights, which should be considered by the reconstructionist in commercial vehicle collisions.

Definitions

The USDOT, Federal Highway Administration (FHWA) pursuant to the Bridge Formula Weights defines:

***Gross Weight**-the weight of a vehicle or vehicle combination and any load thereon. The Federal gross weight limit on the interstate system is 80,000 pounds.*

***Single-Axle Weight**-The total weight on one or more axles whose centers are not more than 40 inches apart. The Federal single-axle weight limit on the Interstate System is 20,000 pounds.*

***Tandem-Axle Weight**-The total weight on two or more consecutive axles more than 40 inches but not more than 96 inches apart. The Federal tandem-axle weight limit on the Interstate System is 34,000 pounds.*

The Federal Motor Vehicle Safety Standards (FMVSS), pursuant to 49 CFR Part 571.3, define:

***Gross axle weight rating or GAWR** means the value specified by the vehicle manufacturer as the load-carrying capacity of a single axle system, as measured at the tire-ground interfaces.*

***Gross combination weight rating or GCWR** means the value specified by the manufacturer as the loaded weight of a combination vehicle.*

***Gross vehicle weight rating* or *GVWR** means the value specified by the manufacturer as the loaded weight of a single vehicle.*

The Commercial Driver's License Standards, 49 CFR /383.3, and the Federal Motor Carrier Safety Regulations, 49 CFR /390.5, define the following terms identically as follows:

Gross combination weight rating (GCWR) *means the value specified by the manufacturer as the loaded weight of a combination (articulate) motor vehicle. In the absence of a value specified by the manufacturer, GCWR will be determined by adding the GVWR of the power unit and the total weight of the towed unit and any load thereon.*

Gross vehicle weight rating (GVWR) *means the value specified by the manufacturer as the loaded weight of a single motor vehicle.*

The following terms are typically found on bills of lading and used by shippers utilizing commercial motor vehicles (CMV):

Tare *(n). An allowance made to a buyer of goods by deducting from the gross weight of his purchase the weight of the container.....*

Net *(adj.) Obtained after deducting all container weight, etc.: distinguished from gross: net proceeds.*

When examining a bill of lading for a commercial motor vehicle, it is common to find the gross weight for the vehicle listed which is the combination of the tare (empty weight) + the net weight (load).

The vast majority of weights allowed on the highways for commercial motor vehicles are based on the BRIDGE FORMULA WEIGHTS (BFW), as published by the U.S. Department of Transportation, Federal Highway Administration[1]. The basis for the BFW's, is the foundation for the majority of the truck weight limits throughout the United States. It is derived from an interest in minimizing wear on the highway surface, with particular attention to bridges and culverts. The basic criteria for the BFW's is based on the number of axles on a particular commercial vehicle and the longitudinal spacing of those axles. The BFW is expressed as:

Formula-

$$W=500\left[\frac{LN}{N-1}+12N+36\right]$$

W = the maximum weight in group of two or more axles to the nearest 500 pounds.

L = the distance in feet between the outer axles of any two or more consecutive axles.

N = the number of axles being considered

As stated by the U.S. Department of Transportation's Federal Highway Administration:

"WHY IS THE FORMULA NECESSARY?

Bridges on Interstate System highways are used by a wide variety of traffic.

They are designed to support expected loadings. However, as trucks grew heavier in the 1950's and 1960's, something had to be done to protect bridges. The solution was to tie allowable weights to the number and spacing of axles.

Axle spacing is as important as axle weight in bridge design. A bridge is analogous to thin ice on a pond. Walking on the ice concentrates a person's weight on the small area covered by the individual's feet, and the ice may break. Lying down, however, spreads the same weight over a much larger area, and the ice is less likely to break."

The BFW's and tables (Appendix A), are used to determine the maximum allowable gross weight, axle weight, tandem axle weight and axle group weights of a commercial vehicle in operation on the highways. They do not consider the manufacturer's GVWR or GAWR of the motor vehicle, only the actual weight that is transmitted to the highway.

Very few state agencies, with the exception being situations where oversize and overweight permits are issued, ever require proof the manufacturer's GVWR of the commercial motor vehicles that they are licensing or weighing at routine roadside inspections and permanent weigh stations. Federal or State laws, in the majority of cases, do not address the issue of vehicles operating in excess of the manufacturer's GVWR. The primary issue is to insure proper licensing fees have been paid.

When a reconstructionist is considering the weight of a commercial motor vehicle, it is important to consider the manufacturer's GVWR, in addition to whatever statutory weight limits are allowed for the subject vehicle. The GVWR is also an element as to the applicability of many CMV regulations.

Vehicle Identification and Certification

The Vehicle Identification Number and Certification requirements pursuant to 49 CFR Parts 565 through 567 mandate manufacturers of motor vehicles, as well as second and third stage manufacturers of motor vehicles, identify the vehicle, both by a vehicle identification number (VIN), manufacturer, date of manufacture by month and year, the GVWR , and GAWR(s). A permanent and/or tamper resistant sticker or plate must state: *"This vehicle conforms to all applicable Federal Motor Vehicle Safety Standards in effect on the date of manufacture shown above."*

To conform with FMVSS 49 CFR, §571.121 S5.3.1.1– Air Braked Vehicles – the vehicle must be capable of meeting the minimum deceleration standards when "(a) loaded to its gross vehicle weight rating…"

In the event the vehicle is manufactured in multiple stages, such as a "cab-chassis" (truck delivered absent a truck body), the label shall indicate: *"Incomplete vehicle manufactured by.."* and indicate *"This cab chassis conforms to Federal Motor Vehicle Safety Standard Nos._____"* and list the applicable safety standards that it did

conform with on the date of manufacture for the "cab- chassis".

When a second or third stage manufacturer completes the vehicle, it must be certified as a completed vehicle appropriately noting the safety standards, which they affected, were conformed with.

In the event an axle or axles are added to the vehicle, the vehicle's manufacturer's gross vehicle weight rating must be identified and adjusted accordingly.

Example:

A cab chassis was manufactured with a 12,000 pound rated steer axle and two 20,000 pound rated drive axles for a cab chassis manufacturer's gross vehicle weight rating of 52,000 pounds as an "incomplete vehicle".

A second stage manufacturer adds a truck body to the vehicle and an additional 18,000 pound rated liftable axle with brakes and tires that conform to the applicable Federal Motor Vehicle Safety Standards.

Upon completion of the vehicle, the second stage manufacturer certifies the vehicle as having the additional axle, raising the manufacturer's gross vehicle weight rating from 52,000 pounds to 70,000 pounds.

Steer axle	**12,000#**
Lift axle (added)	**18,000#**
Drive axle #1	**20,000#**
Drive axle #2	**20,000#**
Mfg. GVWR	**70,000#**

Depending on the wheelbase of a particular vehicle, this manufacturer's gross vehicle weight rating, which is inclusive of considerations of 49 CFR 571.121 (air brakes), may exceed the allowable BFW weight limits.

To determine the statutory weight limit for this vehicle, the BFW's consider the combination of the number of axles and the longitudinal spacing of those axles. Preliminary consideration is the distance measured from the center of the forward most axle to the center of the rearward most axle, sometimes called the "**outer bridge**".

In the previous example, the second stage manufacturer added the additional 4th axle forward of the drive axle tandems. The outer bridge measurement would not have changed. If that measurement were 30 feet, the BFW would allow a maximum of 62,000 pounds, even though the GVWR for the vehicle, which includes its ability to brake, was 70,000 pounds.

If the second stage manufacturer mounted the additional 4th axle rearward of the cab chassis manufacturer's drive tandems the outer bridge would likely measure 36 feet. The BFW would be 66,000 pounds, which still less than the GVWR, but allows an additional 4,000 pounds of material to be legally transported.

Inadequate GVWR that meets BFW

Consider that an individual purchases a similar cab-chassis incomplete vehicle with a 9,000 pound rated steer axle, two 18,000 pound drive axles and adds a

12,000 pound rated axle rearward of the cab chassis manufacturer's drive axles. In this example, the GVWR would be 57,000 pounds. However, if the vehicle were equipped so as to have an outer bridge of 36 feet, the vehicle would comply with the BFW for 66,000 pounds while exceeding the GVWR and design limits for the subject vehicle.

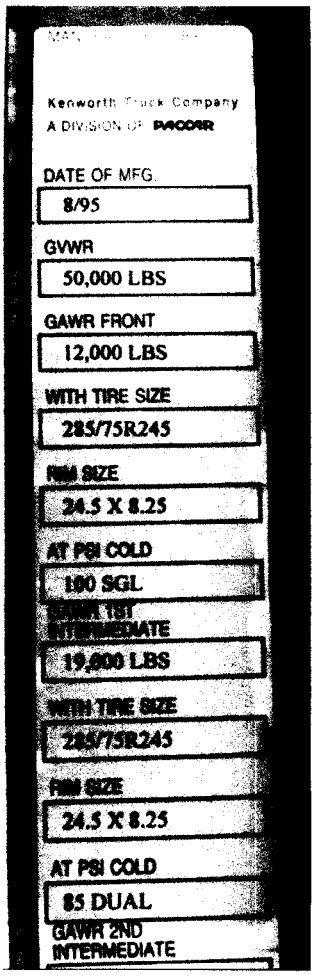
The lighter weight, lower GVWR truck would represent a direct financial incentive for the motor carrier. The initial cost of the vehicle would be significantly less while allowing greater net loads. As the axles and suspension components would be substantially lighter, reducing the tare weight, an increased net weight and billable load would be allowed. This vehicle is more likely to suffer excessive wear to overloaded essential components.

Combination Vehicles

In the case of truck tractors and semi-trailers, the reconstructionist must combine the GVWR in combination with the GVWR & GAWR of the semi-trailer(s). The truck tractor's certification with GVWR & GAWR is typically displayed inside the left doorframe (***Figure 1***). Trailers display their certification of GVWR & GAWR on a plate mounted to the left front or left side of the trailer.

In the event the certification plate is illegible or damaged, this information is often available through a dealer of the manufacturer of vehicle. A search using the Vehicle Identification Number should reflect the GVWR & GAWR information on the vehicle's "build" or "Line Set Sheet".

A typical example is a truck tractor with a GVWR of 50,000 pounds. We find the GAWR, front, 12,000 pounds (steer axle); GAWR, first intermediate, 19,000 pounds (first drive axle); GAWR, second intermediate, 19,000 pounds (second drive axle). Note the total weight of 12,000 + 19,000 + 19,000 = 50,000 pounds for the GVWR.



(***Figure 1***).

As an example of a heavy-duty semi trailer (***Figure 2***), the GVWR of the semi-trailer in this case is 84,000 pounds. GAWR, 22,000 pounds, each, of a 2-axle suspension for the suspension capacity of 44,000 pounds. The rear axles are only rated at 44,000 pounds to

conform to the Federal Motor Vehicle Safety Standards. The balance of 40,000 pounds to achieve the full rated capacity of 84,000 pounds would be carried on the forward fifth wheel plate and to the drive axles of the towing power unit.

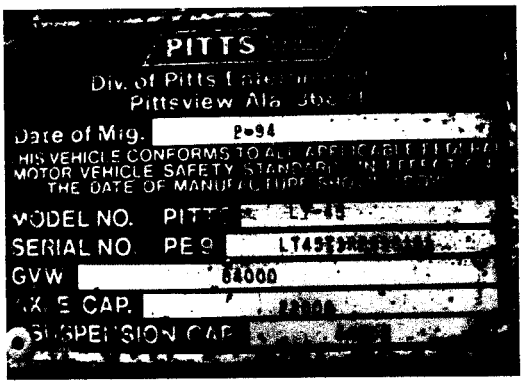


Figure 2

In this example, a reconstructionist, would consider the gross available combined weight rating of the vehicle as configured. With the 50,000 pound GVWR of the truck tractor and the 44,000 pound GAWR of the semi-trailer, the maximum potential manufacturers' design weight this vehicle can transport, including its tare weight, is 94,000 pounds (50,000 pounds + 44,000 pounds = 94,000 pounds). The truck tractor, with approximately 15,000-pound tare weight, does not have adequate GVWR & GAWR to accommodate the entire potential 40,000 pound fifth wheel load from the semi trailer. This combination could not be loaded to the full GCWR.

If we assume a 51-foot outer bridge measurement and also assuming adequate axle spacing between the truck tractor and the semi-trailer's tandem wheels (referred to as the "inner bridge"), the maximum allowable weight, pursuant to the BFW, would be 80,000 pounds. This is 14,000 pounds less than the GVWR for this particular truck tractor and semi-trailer combination.

If the vehicle were allowed a special use permit and assuming a 60-foot outer bridge measurement, it would be allowed 85,500 pounds, which is still 8,500 pounds below the GVWR.

In this example, a truck tractor and semi-trailer loaded several thousand pounds in excess of the BFW may cause excessive wear to the highway system, but in fact, is being operated under the GVWR.

Commodity Considerations

Many states have exceptions to weight limit laws that well exceed the BFW limits. Some examples include "first cut" trees, coal, loaded sea freight containers, and fuel oil during winter months. Many commodities, such as those cited, due to necessity and/or regional economic benefit, are allowed to be transported at weights, which exceed the BFW limits, under special permits or exceptions to laws. Many such exceptions dictate restricted routes, geographical boundaries and some include trips from point of origin to the first point of delivery.

There certainly is no scientific basis to assume a special commodity, when transported at greater weights, is safer to be transported in excess of the BFW limits, than it is to assume that all vehicles that conform to those limits have a chassis designed to support the weight.

Multi-axle Oversize Rigs

Many reconstructionists, as well as average citizens express both amazement and concern over multi-axle and multi-trailer rigs when operated on the highways. "Turnpike double" semi-trailers (two 45-48 foot semi trailers joined with a tandem dolly converter) are commonplace on the Kansas, Ohio and Massachusetts Turnpikes. Triple trailer combinations are seen in the northwest US. In Michigan, rigs with 11 and 12 axles transporting 180,000 pounds are a daily occurrence.

In the case of turnpike doubles, the BFW weights are normally not exceeded even when traversing bridges. This is due to the length of the vehicle which prevents an excessive or undue portion of the load (which in many cases well exceeds 100,000 pounds) to be on any one portion of a bridge span at a given time. Likewise, the 11 and 12 axle Michigan doubles, although capable of transporting extremely large volumes of material, rarely exceed more than 18,000 pounds on any given axle.

When tested, these vehicles, with properly adjusted brakes, will typically stop in distances equal to, or in some cases less than, their sister 5-axle truck tractor and semi-trailers. Other than concerns of rearward amplification from fast lane changes when operating double or triple trailers and greater roll-over potential when vehicles are loaded so as to raise the center of gravity, these vehicles actually perform surprisingly well in spite of the significantly heavier weights transported.

Absent a situation where roll-over potential is a significant issue in a particular reconstruction, the high gross weight values of these vehicles will normally have little or no effect the deceleration when compared to standard truck tractor and semi trailer combinations loaded to 80,000 pounds.

Consideration of GVWR and GAWR When Analyzing an Empty Vehicle

Considerations of the GVWR and GAWR should not be restricted to cases where the vehicle is loaded, fully loaded or loaded beyond the BFW limits. Heavy commercial motor vehicles are designed to perform at their greatest braking stability levels when their loads approach or meet the manufacturer's GVWR. When the vehicle is empty, there is a greater potential of rear wheel lockup, which can lend to losses of lateral stability and jackknife.

Vehicles equipped with heavy duty chassis', without anti-lock brakes, and high GAWRs to transport heavy loads, have a greater potential for loss of lateral stability if hard braking occurs when the vehicle is lightly loaded or empty.

Although this is common to any heavy air-braked vehicle not equipped with anti-lock brakes, the propensity is greater with a heavy-duty chassis. The brake force potential can often achieve full lockup of the rear wheels or trailer wheels on dry pavement with application

pressures as low as 30 to 40 psi. At these lower application pressures, the forward steer axle, which is now carrying proportionately more weight than any other axle on the vehicle, cannot achieve high brake forces without first locking the drive axle wheels. This significantly increases the potential of truck or truck tractor loss of lateral stability.

To maintain lateral stability, the operator of any empty air-braked vehicle (without ABS), and especially a heavy-duty air-braked vehicle must modulate the brake application to prevent loss of lateral stability. This modulation may result in a large increase in overall stopping distance.

Many heavy-duty air-braked vehicles reduce this effect by utilizing liftable axles. The liftable axles are necessary both to safely support and transport the weight when loaded, as well as to conform to the BFW limits. They are not necessary when the vehicle is operated empty. By raising the liftable axles, more of the empty vehicle's weight is placed on the remaining axle(s), reducing the probability of premature rear wheel lockup while also reducing wear and tear on the axles that are not necessary when empty.

Design of Commercial Motor Vehicles

The vast majority of for-hire motor freight transportation on the Interstate Highway system is accomplished through the use of 5-axle truck tractor and semi-trailer combinations. To operate in interstate commerce, the typical truck tractor and semi-trailer combination is allowed a maximum gross vehicle weight of 80,000 pounds. The target tare weight for an interstate truck tractor and semi-trailer is 28,000 pounds to 30,000 pounds for dry van and flatbed trailers and up to approximately 32,000 pounds for refrigerated units. Properly loaded, this allows net weights of loads from 45,000 to 50,000 pounds.

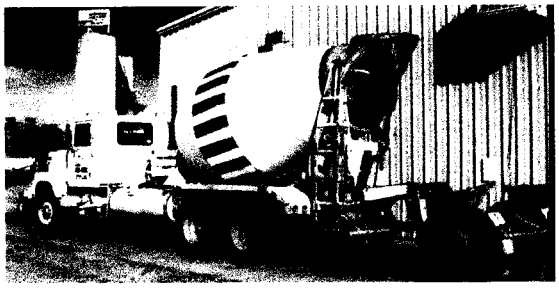
Other vehicles which are designed for special uses, such as concrete mixers, heavy hauler trailers and dump trucks, will have significantly different axle configurations. In many states the maximum allowable gross vehicle weight is most easily achieved for dump trucks by utilizing a 10-wheel dump truck power unit towing an 8-wheel dump trailer. It is typical to find a long connecting arm or "reach" for this type of unit which both accommodates dumping of the forward unit without disconnecting the semi-trailer while also conforming to the maximum potential BFW limit due to the extended overall outer bridge.

Combinations found in eastern states are long chassis dump trucks with as many as 7 axles. These units are usually equipped with 2 drive axles, one steer axle and as many as 4 liftable axles. These units, when operated with an adequate outer bridge measurement, can transport net loads that often exceed those transported by a truck tractor and semi-trailer combination.

Again, even though these vehicles carry extreme weights, if properly maintained, they can easily achieve brake forces and stopping distances within the applicable Federal Motor Carrier Safety Regulations (FMCSR) and Federal

Motor Vehicle Safety Standards (FMVSS).

Another axle configuration, which is becoming more popular, is referred to as a "strong arm." The "strong arm" is a retractable axle that is often found mounted on the rear end of a dump truck or concrete mixer. When operated lightly loaded or empty, this axle is retracted in the upright position with two tires, in the retracted position, equal to or greater than the height of the vehicle. *(Figure 3)*



(Figure 3)

When operated fully loaded, the "strong arm" axle is hydraulically dropped to ground level to support additional weight. The effect of this axle increases the stability of the vehicle while allowing greater weights to the rear of the vehicle in conformance with the BFW. These "strong arm" axles, when in use, typically increase the outer bridge of the truck by 10 feet or more.

Brakes Required On All Wheels

49 CFR ⁄393.42 requires all wheels are to be equipped with brakes (except front wheels on three of more axle trucks and truck tractors manufactured before July 25, 1980).

These are just a few examples of variations which must be considered by the commercial motor vehicle operator when transporting commodities that are of great weight or requires specific mechanical hardware that concentrates weight of the load at fixed areas of the vehicle.

The reconstructionist needs to be careful to consider the brake components and potential brake forces of each of these axle configurations when attempting to analyze the stopping ability of a particular commercial motor vehicle.

Depending on how an axle is equipped and each axle loaded, variations of tire marks can occur that does not necessarily represent any defect in brake components.

Deceleration standards of the FMVSS and the FMCSR do not require wheel lock up during full braking. In fact, on the dry pavement test of FMVSS 571.121, the steer axle may not lock during the deceleration test.

It is common to find that a commercial motor vehicle, which is loaded at or near its GVWR & GAWR, will not leave skid marks from all or any wheels under hard braking on dry pavement. Do not assume overloading or brake defects based solely on the lack of locked wheel skid marks.

Summary

This discussion is not intended to endorse violation of state or local laws as they relate to commercial motor vehicle weight limits. It is intended to alert the accident reconstructionist about the possibility of being mislead into the assumption that a heavily laden vehicle is naturally more likely to have extended stopping distances. Many other considerations, including but not limited to the GVWR, GAWR, brake temperature and operation of the vehicle need to be considered as well.

It is further important to understand that a particular vehicle with an axle configuration, which does conform to the BFW, may, in fact, be operated at a weight in excess of the manufacturer's GVWR and/or GAWR. Be careful not to assume the registered weight rating, for licensing purposes, of a particular vehicle necessarily reflects the design GVWR of that vehicle. Particular note should be taken when dealing with commercial motor vehicles manufactured in multi-stages.

References

1) **Bridge Formula Weights, U.S. DOT FHWA, January 1994 Pub. No. FHWA-MC-94-007 (Appendix A)**
2) **Truck Characteristics Analysis, Federal Highway Administration, Washington, DC July 1999**
3) **National Transportation Safety Board, *Heavy Air brake Performance- Safety Study,* (NTSB/SS - 92/01)**
4) **Robert D. Ervin, *Unintended Responses of Heavy Trucks to Braking of or Steering Inputs,* UMTRI/HSRI, The HSRI Research Review, March-April 1980, Volume 10, No. 5**
5) **Ronald B. Heusser, *Heavy Truck Deceleration Rates as a Function of Brake Adjustment,* SAE 910126, ISSN 0148-7191, 1991**
6) **David A. Stopper, *Heavy Air Braked Vehicle Accident Reconsturction, Determining When A Wheel Is Capable Of Locking and Estimating Air Lag Time Based On Vehicle Weight,* National Association of Traffic Accident Reconstructionists and Investigators Annual Conference, Allentown, PA, October 1999.**
7) **Code of Federal Regulations, *Transportation, 49 CFR, Parts 400-999; Part 565 Vehicle Identification, Part 566 Manufacturer Identification, Part 567 Certification, Federal Motor Vehicle Safety Standards, 49 CFR, Part 571.121, Air Brake Standards,* U.S Government Printing Office**
8) **Code of Federal Regulations, 200 399, Commercial Drivers License Standards & *Federal Motor Carrier Safety Regulations, 49 CFR, Parts 383 - 399,* U.S Government Printing Office**
9) **Commercial Carrier Journal, *The Air Brake Book, sixth edition***

Presented at:

1 Appendix A

Bridge Formula Weights

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BRIDGE FORMULA WEIGHTS

U.S. Department
of Transportation

Federal Highway Administration

January 1994

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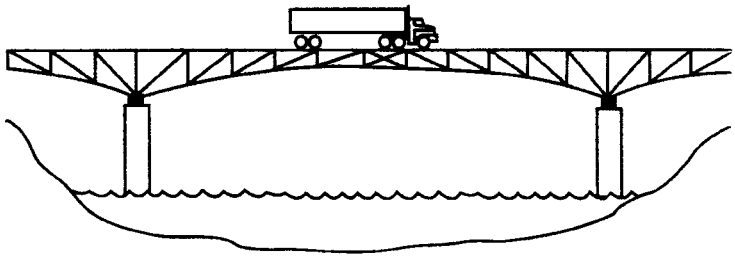
$$W = 500\left[\frac{LN}{N-1} + 12N + 36\right]$$



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HIA-20/10-98(10M)

Three questions are addressed by this pamphlet with regard to the Bridge Formula: What is it? Why is it necessary? How is it used?

WHAT IS IT?

$$W = 500\left[\frac{LN}{N-1} + 12N + 36\right]$$

W = the maximum weight in pounds that can be carried on a group of two or more axles to the nearest 500 pounds.

L = the distance in feet between the outer axles of any two or more consecutive axles.

N = the number of axles being considered.

This formula limits the weight on groups of axles in order to reduce the risk of damage to highway bridges. Allowable weight depends on the number of axles a vehicle has and the distance between those axles. However, the single- or tandem-axle weight limits supersede the Bridge Formula limits for all axles not more than 96 inches apart.

WHY IS THE FORMULA NECESSARY?

Bridges on Interstate System highways are used by a wide variety of traffic. They are designed to support expected loadings. However, as trucks grew heavier in the 1950's and 1960's, something had to be done to protect bridges. The solution was to tie allowable weights to the number and spacing of axles.

Axle spacing is as important as axle weight in bridge design. A bridge is analogous to thin ice on a pond. Walking on the ice concentrates a person's weight on the small area covered by the individual's feet, and the ice may break. Lying down, however, spreads the same weight over a much larger area, and the ice is less likely to break. Consider trucks crossing a bridge:

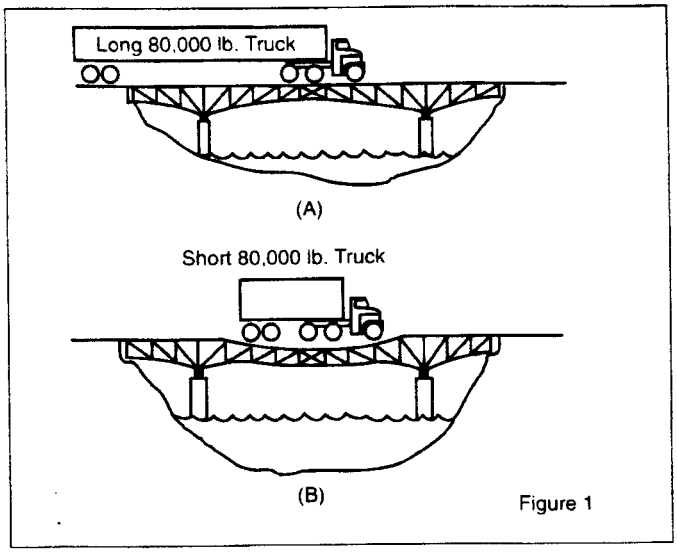

Figure 1

In Figure 1(A), the stress on bridge members as the longer truck rolls across is much less than that caused by the short vehicle in Figure 1 (B), even though both trucks have the same total weight and individual axle weights. The weight of the longer vehicle is spread out, while the shorter vehicle has all of the weight concentrated on a small area.

The Federal-Aid Highway Amendments of 1974 increased the weights allowed on the Interstate System to 20,000 pounds on a single axle, 34,000 pounds on a tandem axle, and 80,000 pounds gross weight (23 U.S.C. 127). But Congress balanced this concession to productivity by enacting the Bridge Formula. The result is that motor vehicles may be loaded to the maximum weight only if each group of axles on the vehicle and their spacing also satisfy the requirements of the Formula. This prevents the vehicle from overstressing bridges in the same way that a person lying down on thin ice would minimize the risk of breaking through.

Until 1982, Federal law set only upper limits (or ceilings) on Interstate System weight limits. A few States retained significantly lower weight limits which eventually became barriers to long-distance truck traffic. In 1982, Federal law was amended to make Interstate System weight limits, including the bridge formula limits, both the maximum and the minimum weights (i.e., floors and ceilings) that States must allow on the Interstate System.

HOW IS THE FORMULA USED?

Some definitions are needed to use the Bridge Formula correctly.

Gross Weight—the weight of a vehicle or vehicle combination and any load thereon. The Federal gross weight limit on the Interstate System is 80,000 pounds.

Single-Axle Weight—The total weight on one or more axles whose centers are not more than 40 inches apart. The Federal single-axle weight limit on the Interstate System is 20,000 pounds.

Tandem-Axle Weight—The total weight on two or more consecutive axles more than 40 inches but not more than 96 inches apart. The Federal tandem-axle weight limit on the Interstate System is 34,000 pounds.

Interstate System weight limits in some States may be higher than these figures due to "grandfather" rights. When the Interstate System axle and gross weight limits were adopted in 1956, States were allowed to keep or "grandfather" those which were higher. In 1975, States were also allowed to keep "grandfathered" bridge formula limits which were higher than those established for the Interstate System.

Bridge Formula calculations yield a series of weights (pages 6-7). However, the single-axle weight limit replaces the Bridge Formula weight limit on axles not more than 40 inches apart, and the tandem-axle weight limit replaces the Bridge Formula weight limit for axles over 40 but not more than 96 inches apart. At 97 inches apart, two axles can carry 38,000 pounds and three axles 42,000 pounds, as shown in Figure 2.

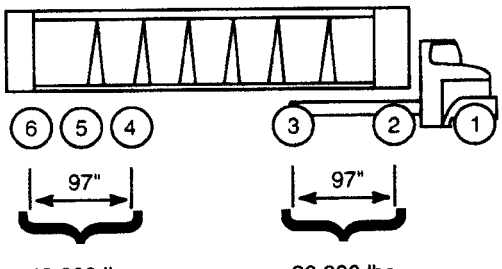

Figure 2

Federal law provides that any two or more consecutive axles may not exceed the weight computed by the Formula even though single axles, tandem axles, and gross weight are within legal limits. In other words, the axle group that includes the entire truck—sometimes called the "outer bridge" group—must comply with the Bridge Formula. But interior combinations of axles, such as the "tractor bridge" (axles 1, 2, and 3) and "trailer bridge" (axles 2, 3, 4, and 5), must also be in compliance with weights computed by the Formula (Figure 3).

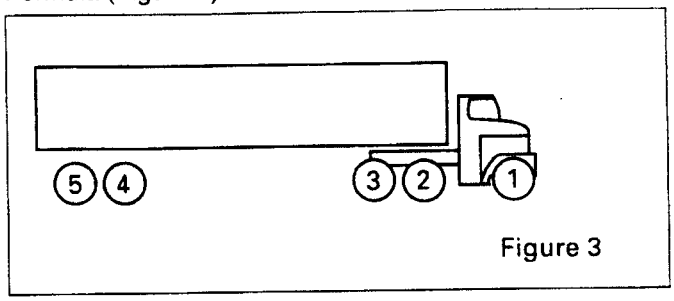

Figure 3

The most common vehicle checked for compliance with weight limit requirements is shown in Figure 3. While the Bridge Formula applies to each combination of two or more axles, experience shows that axle combinations 1 through 3, 1 through 5, and 2 through 5 are critical and must be checked. If these combinations are found to be satisfactory, all of the others on this type of vehicle will normally be satisfactory.

The vehicle with weights and axle dimensions as shown in Figure 4 will be used to illustrate a Bridge Formula check.

(Continued on page 8.)

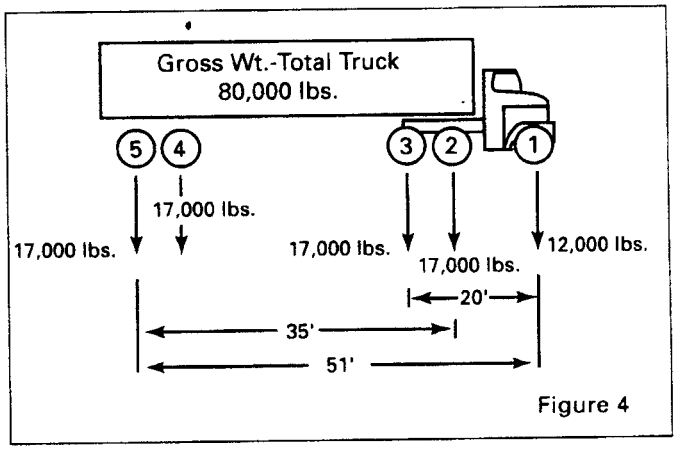

Figure 4

PERMISSIBLE GROSS LOADS FOR VEHICLES IN REGULAR OPERATION [1]

Based on weight formula $W = 500\left[\frac{LN}{N-1} + 12N + 36\right]$

Distance in feet (L) between the extremes of any group of 2 or more consecutive axles

Maximum load in pounds carried on any group of 2 or more consecutive axles

N =	2 AXLES	3 AXLES	4 AXLES	5 AXLES	6 AXLES	7 AXLES	8 AXLES	9 AXLES
4	34,000	----------	----------	----------	----------	----------	----------	----------
5	34,000	----------	----------	----------	----------	----------	----------	----------
6	34,000	----------	----------	----------	----------	----------	----------	----------
7	34,000	----------	----------	----------	----------	----------	----------	----------
8 & less	34,000	34,000	----------	----------	----------	----------	----------	----------
more than 8	38,000	42,000	----------	----------	----------	----------	----------	----------
9	39,000	42,500	----------	----------	----------	----------	----------	----------
10	40,000	43,500	----------	----------	----------	----------	----------	----------
11	----------	44,000	----------	----------	----------	----------	----------	----------
12	----------	45,000	50,000	----------	----------	----------	----------	----------
13	----------	45,500	50,500	----------	----------	----------	----------	----------
14	----------	46,500	51,500	----------	----------	----------	----------	----------
15	----------	47,000	52,000	----------	----------	----------	----------	----------
16	----------	48,000	52,500	58,000	----------	----------	----------	----------
17	----------	48,500	53,500	58,500	----------	----------	----------	----------
18	----------	49,500	54,000	59,000	----------	----------	----------	----------
19 ----Example----	----------	50,000	54,500	60,000	----------	----------	----------	----------
20 =(see page 8)=	----------	51,000	55,500	60,500	66,000	----------	----------	----------
21	----------	51,500	56,000	61,000	66,500	----------	----------	----------
22	----------	52,500	56,500	61,500	67,000	----------	----------	----------
23	----------	53,000	57,500	62,500	68,000	----------	----------	----------
24	----------	54,000	58,000	63,000	68,500	74,000	----------	----------
25	----------	54,500	58,500	63,500	69,000	74,500	----------	----------
26	----------	55,500	59,500	64,000	69,500	75,000	----------	----------
27	----------	56,000	60,000	65,000	70,000	75,500	----------	----------
28	----------	57,000	60,500	65,500	71,000	76,500	82,000	----------
29	----------	57,500	61,500	66,000	71,500	77,000	82,500	----------
30	----------	58,500	62,000	66,500	72,000	77,500	83,000	----------
31	----------	59,000	62,500	67,500	72,500	78,000	83,500	----------
32	----------	60,000	63,500	68,000	73,000	78,500	84,500	90,000
33	----------	----------	64,000	68,500	74,000	79,000	85,000	90,500
34	----------	----------	64,500	69,000	74,500	80,000	85,500	91,000
35	----------	----------	65,500	70,000	75,000	80,500	86,000	91,500
36	----------	Exception	66,000	70,500	75,500	81,000	86,500	92,000
37	----------	(see page 10)	66,500	71,000	76,000	81,500	87,000	93,000
38	----------	----------	67,500	71,500	77,000	82,000	87,500	93,500
39	----------	----------	68,000	72,500	77,500	82,500	88,500	94,000
40	----------	----------	68,500	73,000	78,000	83,500	89,000	94,500
41	----------	----------	69,500	73,500	78,500	84,000	89,500	95,000
42	----------	----------	70,000	74,000	79,000	84,500	90,000	95,500
43	----------	----------	70,500	75,000	80,000	85,000	90,500	96,000
44	----------	----------	71,500	75,500	80,500	85,500	91,000	96,500
45	----------	----------	72,000	76,000	81,000	86,000	91,500	97,500
46	----------	----------	72,500	76,500	81,500	87,000	92,500	98,000
47	----------	----------	73,500	77,500	82,000	87,500	93,000	98,500
48	----------	----------	74,000	78,000	83,000	88,000	93,500	99,000
49	----------	----------	74,500	78,500	83,500	88,500	94,000	99,500
50	----------	----------	75,500	79,000	84,000	89,000	94,500	100,000
51	----------	----------	76,000	80,000	84,500	89,500	95,000	100,500
52	----------	----------	76,500	80,500	85,000	90,500	95,500	101,000
53	----------	----------	77,500	81,000	86,000	91,000	96,500	102,000
54	----------	----------	78,000	81,500	86,500	91,500	97,000	102,500
55	----------	----------	78,500	82,500	87,000	92,000	97,500	103,000
56	----------	Interstate Gross	79,500	83,000	87,500	92,500	98,000	103,500
57	----------	Weight Limit	80,000	83,500	88,000	93,000	98,500	104,000
58	----------	(see page 4)	----------	84,000	89,000	94,000	99,000	104,500
59	----------	----------	----------	85,000	89,500	94,500	99,500	105,000
60	----------	----------	----------	85,500	90,000	95,000	100,500	105,500

Tandem Axle Weight (see pages 4 & 5)

[1]The permissible loads are computed to the nearest 500 pounds as required by statute.

[2]The following loaded vehicles must not operate over H15-44 bridges: 3-S2 (5-axle) with wheelbase less than 38 feet; 2-S1-2 (5-axle) wih wheelbase less than 45 feet; 3-3 (6-axle) with wheelbase less than 45 feet; and 7- 8- and 9-axle vehicles regardless of wheelbase.

Before checking a vehicle for compliance with the Bridge Formula, its single-axle, tandem-axle, and gross weight should be checked. Here the single axle (number 1) does not exceed 20,000 pounds, tandems 2-3 and 4-5 do not exceed 34,000 pounds each, and the gross weight does not exceed 80,000 pounds. These preliminary requirements are thus satisfied. The first Bridge Formula combination is checked as follows:

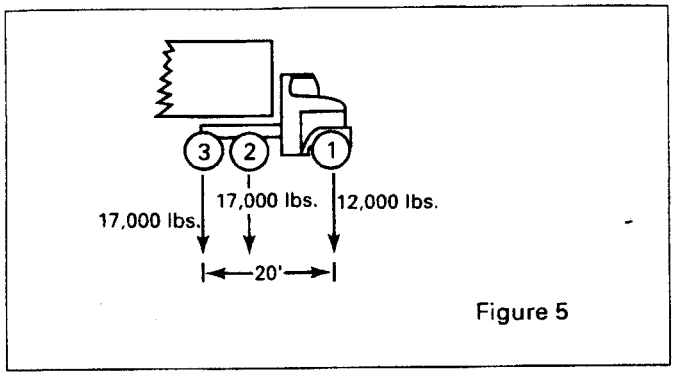

Figure 5

Check of 1 thru 3 (Figure 5)
Actual weight = 12,000 + 17,000 + 17,000 = 46,000 pounds.
N = 3 axles.
L= 20 feet.

$$W = 500\left[\frac{LN}{N-1} + 12N + 36\right]$$

$$W = 500\left[\frac{(20 \times 3)}{(3 - 1)} + (12 \times 3) + 36\right] = 51{,}000\#$$

W maximum = 51,000#, which is more than the actual weight of 46,000#, so the Bridge Formula requirement is satisfied.

Example—From the Bridge Table (pages 6 & 7)
This same number (51,000#) could have been obtained from the Bridge Table by reading down the left side to L = 20 and across to the right where N = 3.

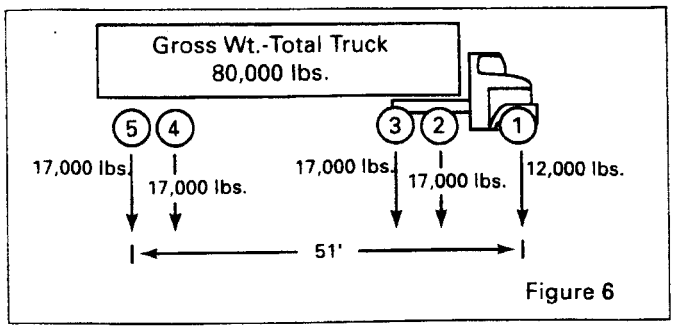

Figure 6

Now check axles 1 thru 5 (Figure 6)
Actual weight = 12,000 + 17,000 + 17,000 + 17,000 + 17,000 = 80,000#.
W maximum, from the Bridge Table for "L" of 51 feet and "N" of 5 = 80,000#.

Therefore, this axle spacing is satisfactory.

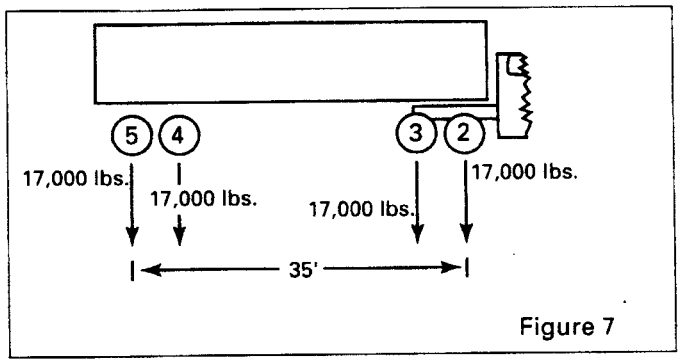

Figure 7

Now check axles 2 thru 5 (Figure 7)
Actual weight = 17,000 + 17,000 + 17,000 + 17,000= 68,000#.
W maximum, Bridge Table for "L" of 35 feet and "N" of 4 = 65,500#.

This is a violation because the actual weight exceeds the weight allowed by the Bridge Formula. To correct the situation, some load must be removed from the vehicle or the axle spacing (35 feet) must be increased.

EXCEPTION TO FORMULA AND BRIDGE TABLE

Federal law (23 U.S.C.127) includes one exception to the Bridge Formula and the Bridge Table—two consecutive sets of tandem axles may carry 34,000 pounds each if the overall distance between the first and last axles of these tandems is 36 feet or more. For example, a five-axle tractor-semitrailer combination may carry 34,000 pounds both on the tractor tandem (axles 2 and 3) and the trailer tandem (axles 4 and 5), provided axles 2 and 5 are spaced at least 36 feet apart. Without this exception, the Bridge Formula would allow an actual weight of only 66,000 to 67,500 pounds on tandems spaced 36 to 38 feet apart.

BRIDGE FORMULA APPLICATION TO SINGLE UNIT TRUCKS

The procedure described above can be used to check any axle combinations, but several closely spaced axles usually produce the most critical situation.

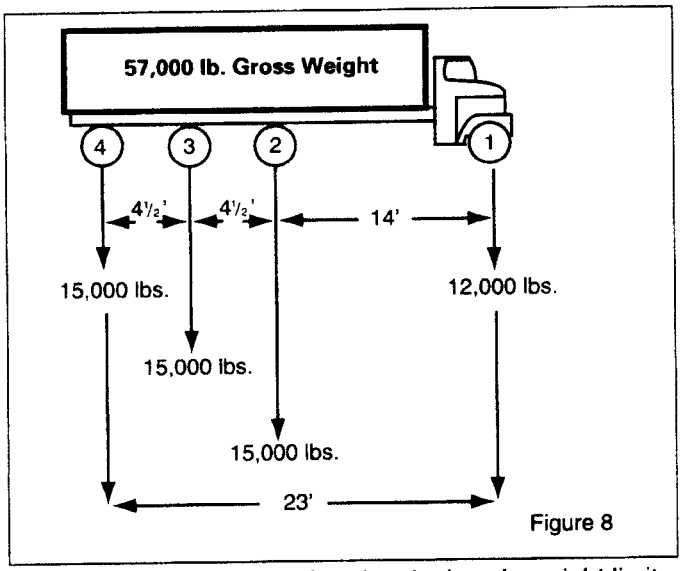

Figure 8

The truck in Figure 8 satisfies the single axle weight limit (12,000# is less than 20,000#), the tandem axle limit (30,000# is less than 34,000#) and gross weight limit (57,000# is less than 80,000#). With these restrictions satisfied, a check will be made for Bridge Formula requirements, axles 1 through 4.

Actual weight = 12,000 + 15,000 +15,000 + 15,000 = 57,000#.
W maximum for "N" of 4 and "L" of 23 feet = 57,500 from the Bridge Table.
Since axles 1 thru 4 are satisfactory, check axles 2 thru 4:
W (actual) = 15,000 + 15,000 + 15,000 = 45,000#.
W maximum for "N" of 3 and "L" of 9 feet= 42,500# (From the Bridge Table).

This is a violation. The load would have to be reduced, axles added, or spacing increased, to comply with the Bridge Formula .

CAUTION

This pamphlet paraphrases the actual provision in 23 U.S.C. 127 and 23 CFR 658 for the sake of clarity. In case of a dispute, the statue and regulations will govern.

Previous editions of this pamphlet released under the title "Bridge Gross Weight Formula", dated April 1984, remain valid. Neither the Formula nor any resulting maximum gross weight values (table entries) have been changed.