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Study of Minimum-Weight Highway Transporters for Spent Nuclear Fuel Casks

Technical Report

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DISCLAIMER

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Mr. Joseph A. Hoess, Battelle Systems Safety and Security Group, was the principal investigator and principal author of this report. Mr. Vincent J. Drago, Battelle Office of Transportation Systems and Planning (OTSP), was responsible for the technical management of the study and was a contributing author to this report. Mr. Reuben W. Peterson, of OTSP, provided technical direction to this study and contributed to this final report. Finally, this study would not have been possible without the assistance and cooperation of the many staff members of organizations contacted during the study for data and information.

ABSTRACT

There are Federal and State limits on the maximum tractor-trailer-payload combination and individual axle loads permissible on U.S. highways. These can generally be considered as two sets, i.e., legal-weight and overweight limits.

The number of individual shipments required will decrease as the capacity of the spent nuclear fuel cask increases. Thus, there is an incentive for identifying readily available minimum-weight tractors and trailers capable of safely and reliably transporting as large a cask as possible without exceeding the legal gross combination weight (GCW) of 80,000 lb or selected overweight GCW limit of 110,000 lb.

This study identifies options for commercially available heavy-duty on-highway tractors and trailers for transporting proposed future loaded spent nuclear fuel casks. Loaded cask weights of 56,000 and 80,000 lb were selected as reference design points for the legal-weight and overweight transporters, respectively.

The study approach basically consisted of (1) defining transporter configurations; (2) gathering tractor, trailer, and major component descriptive and weight data for commercially available equipment; (3) identification of possible tractor and trailer-weight-saving options; (4) estimation of minimum tractor and trailer weight and weight savings with various lightweight options; (5) and gathering of data on expected future (5 to 10 yr) reduction in tractor, trailer, and major component weight.

The technical data on tractor and trailer characteristics obtained indicate that is possible to develop a tractor-trailer combination, tailored for spent nuclear fuel transportation service, utilizing existing technology and commercially available components, capable of safely and reliably transporting 56,000 and 80,000-lb spent nuclear fuel casks without exceeding GCWs of 80,000 and 10,000 lb, respectively.

FOREWORD

The National Waste Terminal Storage Program was established in 1976 by the U.S. Department of Energy's predecessor, the Energy Research and Development Administration. In September 1983, this program became the Civilian Radioactive Waste Management Program. Its purpose is to develop technology and provide facilities for safe, environmentally acceptable, permanent disposal of high-level waste (HLW). HLW includes wastes from both commercial and defense sources, such as spent (used) fuel from nuclear power reactors, accumulations of wastes from production of nuclear weapons, and solidified wastes from fuel reprocessing.

The information in this report pertains to the technical analysis studies of the transportation program of the Office of Civilian Radioactive Waste Management.

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1.0 INTRODUCTION

This minimum-weight transporter study is one of a group of four that represent a total systems approach to developing highway transporter and cask specifications for the transportation of spent nuclear fuel within the U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management Program (Figure 1-1). In addition to this study which identifies a range of transporter characteristics and weight options, studies will be conducted to develop estimates of operational factors, cask capacity vs. gross weight options, and life-cycle costs and exposure estimates. The results of these four studies will be synthesized to support a decision on the final selection of cask-transporter systems specifications. The decision will be based on DOE policy and program objectives and made in the context of current regulations.

This study identifies options for commercially available heavy-duty on-highway tractors and trailers for transporting proposed future loaded spent nuclear fuel casks. Loaded cask weights of 56,000 and 80,000 lb were selected as reference design points to facilitate the collection, examination, and presentation of study information. Emphasis was placed on identifying minimum-weight tractors and trailers capable of safely and reliably transporting a 56,000-lb cask without exceeding a gross combination weight (GCW)* of 80,000 lb, and an 80,000-lb cask without exceeding a GCW of 110,000 lb.

No specific safety or reliability studies were conducted. However, in no case do tractor, trailer, or component loadings exceed the commercial rated capacities of selected components. Additional reliability-related features include use of air suspension and steel tractor and trailer frames. Additional safety-related features include good to excellent braking (i.e., inclusion of an engine brake, automatic brake slack adjusters, and antilock braking); maximum governed road speed of 55 mph; and sufficient power to maintain moderate speeds up grades.

1.1 BACKGROUND

Federal and State regulations limit the maximum tractor-trailer combination and individual axle loads permissible on U.S. highways. These limits are of two categories: legal-weight and overweight limits. All 50 states have adopted uniform Interstate highway (i.e., legal) weight limits permitting a maximum GCW of 80,000 lb. The overweight limits vary greatly from State to State and require permits from each State traveled through for each shipment.

The number of individual shipments required will decrease as the size of the spent fuel cask used increases. Thus, there is an incentive for identifying readily available minimum-weight tractors and trailers capable of safely and reliably transporting as large a cask as possible without exceeding the legal GCW of 80,000 lb.

* GCW = The gross combination weight of the tractor and trailer, including all fluids, driver(s), payload, and accessories.

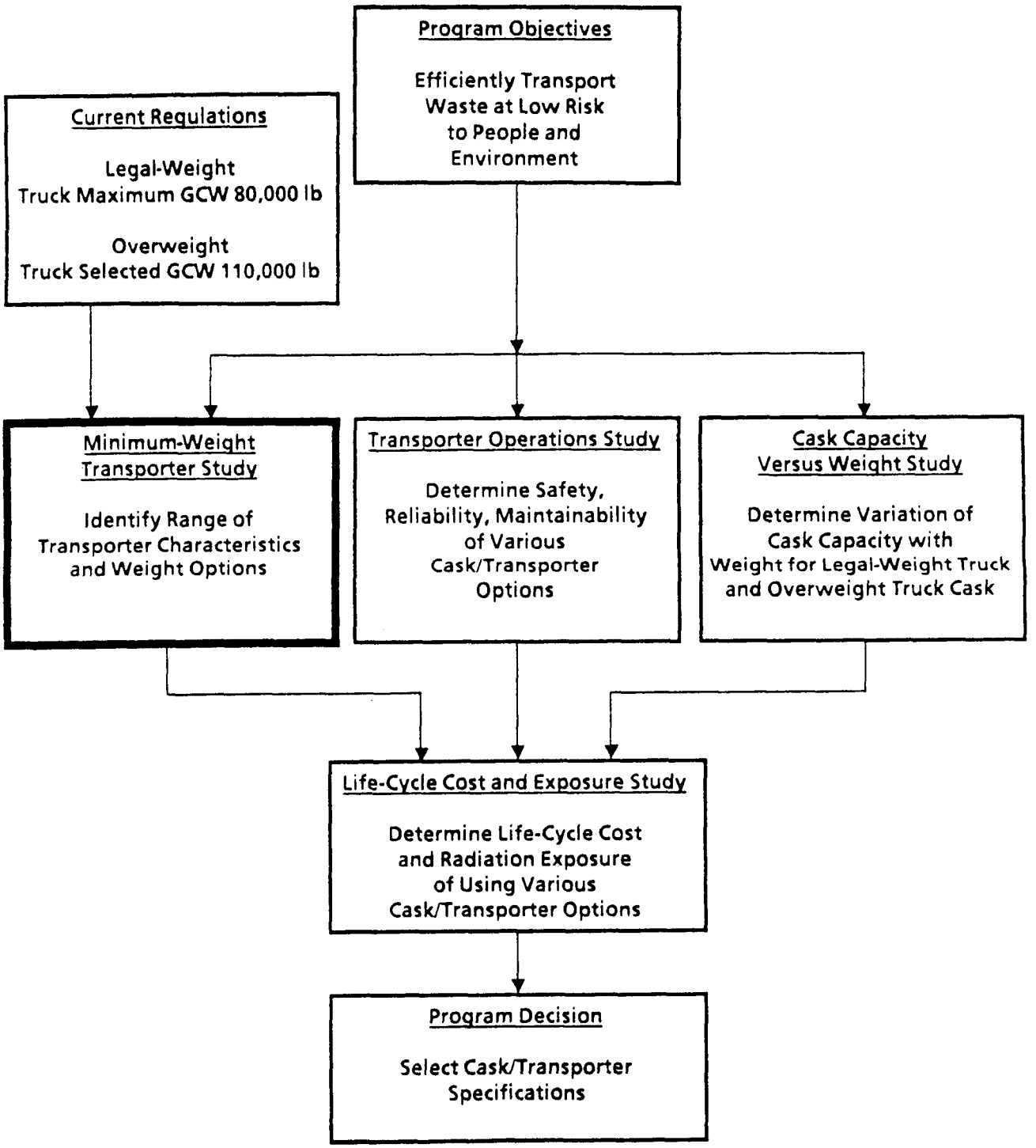

Figure 1-1. Total Systems Approach to Cask/Transporter Specification

The same reasoning applies to overweight shipments, in which case the GCW limit was set at 110,000 lb to enhance chances of widespread State permit acceptance*.

1.2 SCOPE

The scope of this study included examination of commercially available legal-weight and overweight on-highway spent nuclear fuel cask transporters (i.e., tractor-trailer combinations) with GCWs of 80,000 and 110,000 lb, respectively**. Both present (as of 1987) and future (5 to 10 years) availability of tractor-trailer combinations were studied to identify minimum-weight tractor-trailer options in those time periods.

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* Office of Transportation Systems and Planning (OTSP), 1986. Overweight Truck Shipments to Nuclear Waste Repositories: Legal, Political, Administrative, and Operational Considerations, BMI/OTSP-01, prepared for the U.S. Department of Energy by Battelle, March 1986.

** The American Association of State Highway and Transportation Officials (AASHTO) is working cooperatively with DOE-OCRWM to evaluate the feasibility of routine permitting of overweight vehicles transporting spent fuel. The conceptual vehicle the AASHTO task force is using in its discussions with States was developed independent of this study.

2.0 OVERALL FINDINGS

The technical data on tractor and trailer characteristics obtained in the course of this study indicate that it may be possible to develop a tractor-trailer combination, tailored for the spent fuel transportation service and utilizing existing technology and commercially available components, capable of safely and reliably transporting 56,000- and 80,000-lb spent nuclear fuel casks without exceeding GCWs of 80,000 and 110,000 lb, respectively.

With respect to potential benefits from current industry programs, the principal development identified that could result in a large reduction in tractor and trailer weight in the next 5 to 10 years is the use of single, wide base tires and wheels in place of dual tires on both the tractor and the trailer. Use of a titanium trailer could result in further reduction in trailer weight, but no commercial trailer manufacturer contacted in the study had plans to develop such a trailer.

2.1 EQUIPMENT FOR CURRENT CONSIDERATION

2.1.1 Tractor Weights

Tractor weight estimates with available light-weight options range from:

- 13,210 to 14,710 lb for the 80,000-lb GCW transporter
- 16,850 to 18,050 lb for the 110,000-lb GCW transporter.

The options included in these minimum-weight estimates are listed in Table 2-1. Tractor weight-estimating work sheets are presented in Appendix B.

For safety reasons, an engine brake (i.e., "Jake" brake), automatic brake slack adjusters, and antilock braking should be added. Other options recommended by many of the people contacted include power steering, air-conditioning, and air suspension on the tandem axles. A steel tractor frame and heavier-duty Cummins BC IV engine in place of the L10 engine were also recommended for the 80,000-lb GCW transporter. Inclusion of these options increases the tractor weight estimates to:

- 14,420 to 15,370 lb for the 80,000-lb GCW transporter
- 17,330 to 18,330 lb for the 110,000-lb GCW transporter.

The options included in these weight estimates are listed in Table 2-2.

2.1.2 Trailer Weights

Trailer weight estimates with available light-weight options range from:

- 6,930 to 9,200 lb for the 80,000-lb GCW transporter
- 10,210 to 13,700 lb for the 110,000-lb GCW transporter.

The options included in these minimum-weight estimates are listed in Table 2-3. Trailer weight-estimating work sheets are presented in Appendix C.

Many of the people contacted recommended air suspension for the trailer axles, particularly for aluminum trailers. A support (landing) gear is probably also required. Use of automatic brake slack adjusters, air suspension, and a support gear increases the range of the trailer weight estimates to:

- 7,460 to 10,010 lb for the 80,000-lb GCW transporter
- 10,880 to 14,540 lb for the 110,000-lb GCW transporter.

The options included in these weight estimates are listed in Table 2-4.

Table 2-1. Tractor Options Included in Minimum-Weight Estimates

Tractor Option	80,000-lb GCW Transporter	110,000-lb GCW Transporter
Cab configuration	Cab-over-engine	Cab-over-engine
Sleeper bunk	1-person	1-person
Total number of axles	3	4
Number of driven axles	2	2
Wheelbase, inches	204	180
Engine (hp)	Cummins L10 (300)	Cummins BC IV (400)
Aluminum radiator	Yes	Yes
Transmission (forward speeds)	Fuller RT11609 (9)	Fuller RT14609 (9)
Aluminum clutch housing	Yes	Yes
Drive axle gear carrier case	Aluminum	Steel
Type of suspension	Steel spring	Steel spring
Tires	Low profile	Low profile
Aluminum disc wheels	Yes	Yes
Aluminum wheel hubs	Yes	Yes
Type of brakes	Wedge	Wedge
Centrifuse brake drums(a)	Yes	Yes
Aluminum cab	Yes	Yes
Frame	Aluminum	Steel
Aluminum bumper	Yes	Yes
Aluminum fuel tank (gallons)	Yes (80)	Yes (100)
Type of steering	Manual	Manual
Fifth wheel, fixed location	Yes	Yes
All fluids including fuel	Yes	Yes

(a) "Centrifuse" is a trade name for brake drums manufactured by the Motor Wheel Corporation. They consist of a thin steel cylinder with cast iron centrifugally cast on the inside surface. A steel end plate is welded on one end of the steel cylinder.

Table 2-2. Tractor Light-Weight Options Plus Suggested Options

Tractor Option	80,000-lb GCW Transporter	110,000-lb GCW Transporter
Cab configuration	Cab-over-engine	Cab-over-engine
Sleeper bunk	1-person	1-person
Total number of axles	3	4
Number of driven axles	2	2
Wheelbase, inches	204	180
Engine (hp)	Cummins BC IV (300)[a]	Cummins BC IV (400)
Aluminum radiator	Yes	Yes
Transmission (forward speeds)	Fuller RT11609 (9)	Fuller RT14609 (9)
Aluminum clutch housing	Yes	Yes
Drive axle gear carrier case	Aluminum	Steel
Type of suspension	Air[a]	Air[a]
Tires	Low profile	Low profile
Aluminum disc wheels	Yes	Yes
Aluminum wheel hubs	Yes	Yes
Type of brakes	Wedge	Wedge
Centrifuse brake drums	Yes	Yes
Aluminum cab	Yes	Yes
Frame	Steel[a]	Steel
Aluminum bumper	Yes	Yes
Aluminum fuel tank (gallons)	Yes (80)	Yes (100)
Type of steering	Power[a]	Power[a]
Fifth wheel, fixed location	Yes	Yes
All fluids including fuel	Yes	Yes
Engine brake	Yes[a]	Yes[a]
Automatic brake slack adjusters	Yes[a]	Yes[a]
Antilock braking	Yes[a]	Yes[a]
Cab air conditioning	Yes[a]	Yes[a]

(a) These options differ from those of minimum-weight estimates listed in Table 2-1.

Table 2-3. Trailer Options Included in Minimum-Weight Estimates

Trailer Option	80,000-lb GCW Transporter	110,000-lb GCW Transporter
Trailer configuration	Platform chassis	Platform chassis
Payload	56,000-lb cask	80,000-lb cask
Nominal trailer length in feet	42	48
Number of axles	2	3
Type of suspension	Steel spring	Steel spring
Tires	Low profile	Low profile
Aluminum disc wheels	Yes	Yes
Aluminum wheel hubs	Yes	Yes
Type of brakes	S-Cam	S-Cam
Centrifuse brake drums	Yes	Yes
Front bulkhead	No	No
Tie downs	No	No
Spare tire	No	No
Tire carrier	No	No
Support (landing) gear	No	No
Nonadjustable axle location	Yes	Yes
All deck or cross members not required for structural strength removed	Yes	Yes

Table 2-4. Trailer Light-Weight Options Plus Suggested Options

Trailer Option	80,000-lb GCW Transporter	110,000-lb GCW Transporter
Trailer configuration	Platform chassis	Platform chassis
Payload	56,000-lb cask	80,000-lb cask
Nominal trailer length in feet	42	48
Number of axles	2	3
Type of suspension	Air(a)	Air(a)
Tires	Low profile	Low profile
Aluminum disc wheels	Yes	Yes
Aluminum wheel hubs	Yes	Yes
Type of brakes	S-Cam	S-Cam
Centrifuse brake drums	Yes	Yes
Front bulkhead	No	No
Tie downs	No	No
Spare tire	No	No
Tire carrier	No	No
Support (landing) gear	Yes(a)	Yes(a)
Nonadjustable axle location	Yes	Yes
All deck or cross members not required for structural strength removed	Yes	Yes
Automatic brake slack adjusters	Yes(a)	Yes(a)

(a) These options differ from those of minimum-weight estimates listed in Table 2-3.

It was also suggested that low-bed trailers be considered to reduce the center of gravity of the load, thereby increasing stability. These have merit, but they would increase trailer weight, and thus were not evaluated in this study.

2.1.3 Transporter Weights

As indicated previously the GCW accounts for the entire weight of the vehicle and its contents, which include the tractor, trailer, loaded cask, and outfitting. Outfitting includes:

- Driver(s)
- Driver luggage and bedding
- Accessories such as physical security system, fire extinguisher, radio, spare tire, tire chains, and tools.

Outfitting for all cases was assumed to weigh 1,000 lb. Table 2-5 lists the weight breakdown of transporters by components for the 80,000-lb and 110,000-lb GCW transporters, respectively. Table 2-5 indicates that it may be feasible to carry a 56,000-lb loaded cask using an 80,000-lb GCW transporter and an 80,000-lb loaded cask using a 110,000-lb GCW transporter.

Table 2-5. Transporter Weight Summary

	80,000-lb GCW Transporter		110,000-lb GCW Transporter	
Components	Light-Weight Options Weight Range (lb)	Light-Weight Options Plus Suggested Options Weight Range (lb)	Light-Weight Options Weight Range (lb)	Light-Weight Options Plus Suggested Options Weight Range (lb)
Cask	56,000	56,000	80,000	80,000
Tractor	13,210-14,710	14,420-15,370	16,850-18,050	17,330-18,330
Trailer	6,930-9,200	7,460-10,010	10,210-13,700	10,880-14,540
Outfitting	1,000	1,000	1,000	1,000
Total	77,140-80,910	78,880-82,380	108,060-112,750	109,210-113,870

2.2 EQUIPMENT FOR FUTURE CONSIDERATION

Use of single, wide base ("Super Single") tires with aluminum disc wheels in place of dual low-profile tires with aluminum disc wheels could save up to an additional 744 lb on the 80,000-lb GCW transporter and 1,116 lb on the 110,000-lb GCW transporter. Possible weight savings with wide base tires and wheels are not included in the above weight estimates for the spent fuel cask transporters. However, their use may be a viable option in the future and should be evaluated in detail during the cask acquisition preliminary design phase.

3.0 APPROACH

The study approach consisted of the following five tasks:

1. Definition of overall transporter configurations.

2. Gathering of tractor, trailer, and major component descriptive and weight data for commercially available components.

3. Identification of possible tractor and trailer weight-saving options.

4. Estimation of minimum tractor and trailer weights and weight savings with various light-weight options.

5. Gathering of data on expected future (5 to 10 years) reduction in tractor, trailer, or major component weight.

To minimize the number of contacts with tractor, trailer, and major component manufacturers, these tasks were conducted simultaneously for both legal-weight and overweight transporters.

The overall transporter configurations were selected through study of BMI/OTSP-01 (see reference in footnote on p. 3), and the Ohio Overweight Permit Application Manual*. The 80,000-lb GCW legal-weight transporter has 5 axles and complies with Interstate highway weight limits adopted by all 50 States. The 110,000-lb GCW overweight transporter used here has 7 axles and represents a modified version of the configuration presented in Appendix C of BMI/OTSP-01 (1986).

To gain insight into how much weight could be saved with a 6-axle, rather than a 7-axle, overweight transporter, limited consideration also was given to a 6-axle 110,000-lb GCW transporter meeting Ohio overweight permit limitations. Because many States require 7 axles for a 110,000-lb GCW transporter, the 6-axle configuration is not believed to be a viable option for 48-State operation.

Tractor, trailer, and major component descriptive and weight data were obtained via telephone and/or mail from the leading U.S. manufacturers of those items. Appendix A presents a listing of the organizations contacted during the study.

Possible tractor and trailer weight-saving options were identified through:

- Study of truck data books and major component manufacturer catalogs
- Telephone discussions with staff members of tractor, trailer, and component manufacturers
- Telephone discussions with truck fleet operators.

* Ohio Department of Transportation, 1983. State of Ohio Oversize and Overweight Permit Movements on State Highways--Application Manual.

To aid communication and to assist in defining and gathering weight data on tractors, trailers, and weight-saving options, weight-estimating work sheets were prepared for each tractor and trailer configuration being studied and were sent to the tractor and trailer manufacturers listed in Appendix A. Copies of the weight-estimating work sheets submitted by tractor and trailer manufacturers are summarized in Appendices B and C, respectively.

Estimates of tractor and trailer weights and weight savings with various light-weight options are based on the data submitted on those work sheets plus data obtained from the major component manufacturers contacted.

Data on expected future (5 to 10 years) reductions in tractor, trailer, or major component weight were gathered simultaneously with the descriptive and weight data for current components. Manufacturers were asked to identify present trends or developments that they believe will result in tractor-trailer weight reductions in the next 5 to 10 years and to estimate the amount of expected weight reduction associated with each. Only limited responses were received to this request. Those that were obtained are associated primarily with individual components rather than with the overall tractor or trailer.

4.0 TECHNICAL DISCUSSION

4.1 CASK DESCRIPTION

Two proposed future casks were considered in this study: a legal- weight cask with a loaded weight of 56,000 lb and an overweight cask with a loaded weight of 80,000 lb. Table 4-1 presents the assumed overall dimensions for those casks.

Table 4-1. Assumed Overall Cask Dimensions

Cask Dimensions	56,000-lb[a] Legal-Weight Cask	80,000-lb[a] Overweight Cask
Outside diameter, ft[b]	3.7	4.4
Overall length, ft[b]	18	18
Distance between centerline of support cradles, ft	15	15
Support pads, ft x ft	4 x 4	4.7 x 4.7

(a) Including weight of impact limiters and support cradles.
(b) Impact limiters not included.

4.2 TRANSPORTER CONFIGURATIONS

A total of three transporter (i.e., tractor-trailer) configurations were considered, a single 80,000-lb GCW configuration and two 110,000-lb GCW configurations. Figures 4-1, 4-2, and 4-3 illustrate the number, spacing, and loading of the axles for those three transporter configurations.

Because of the small diameter of the casks, vertical height clearance is not a problem and a platform (flatbed) trailer configuration was selected for all three transporters. A platform trailer will result in a weight savings relative to a low-bed trailer.

4.2.1 80,000-lb GCW, 5-Axle Configuration

The 80,000-lb GCW legal-weight transporter configuration shown in Figure 4-1 is a conventional "18-wheeler" tractor-semitrailer combination with five axles. The distances between axles and corresponding axle loads are in conformance with the federally prescribed Bridge Formula B, which is presented in Table 4-2. Federal and corresponding State regulations provide that the loading on any consecutive two or more axles may not exceed the weight computed

—6 × 4 Tractor
—Equalizing Suspension:
Axles 2 and 3
Axles 4 and 5

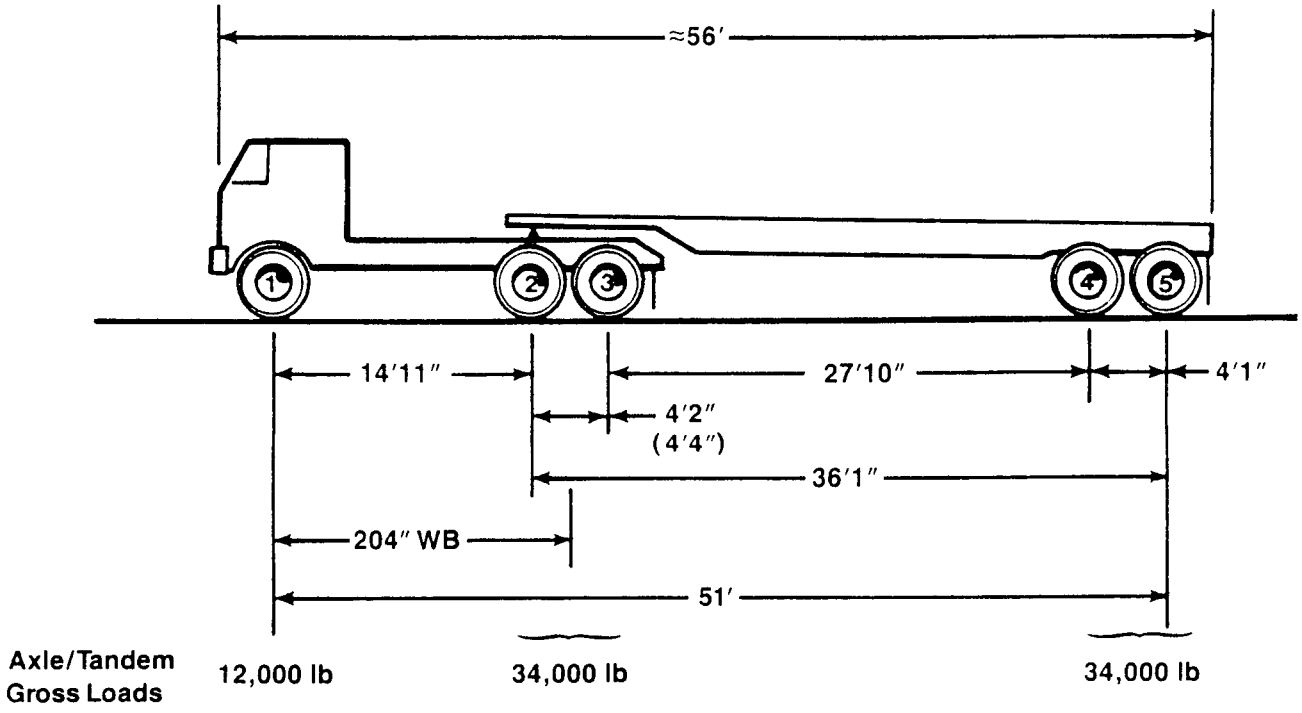

FIGURE 4-1. 80,000-LB GCW, 5-AXLE, LEGAL-WEIGHT TRANSPORTER CONFIGURATION

—8 × 4 Tractor
—Equalizing Suspension:
Axles 2, 3, and 4
Axles 5, 6, and 7

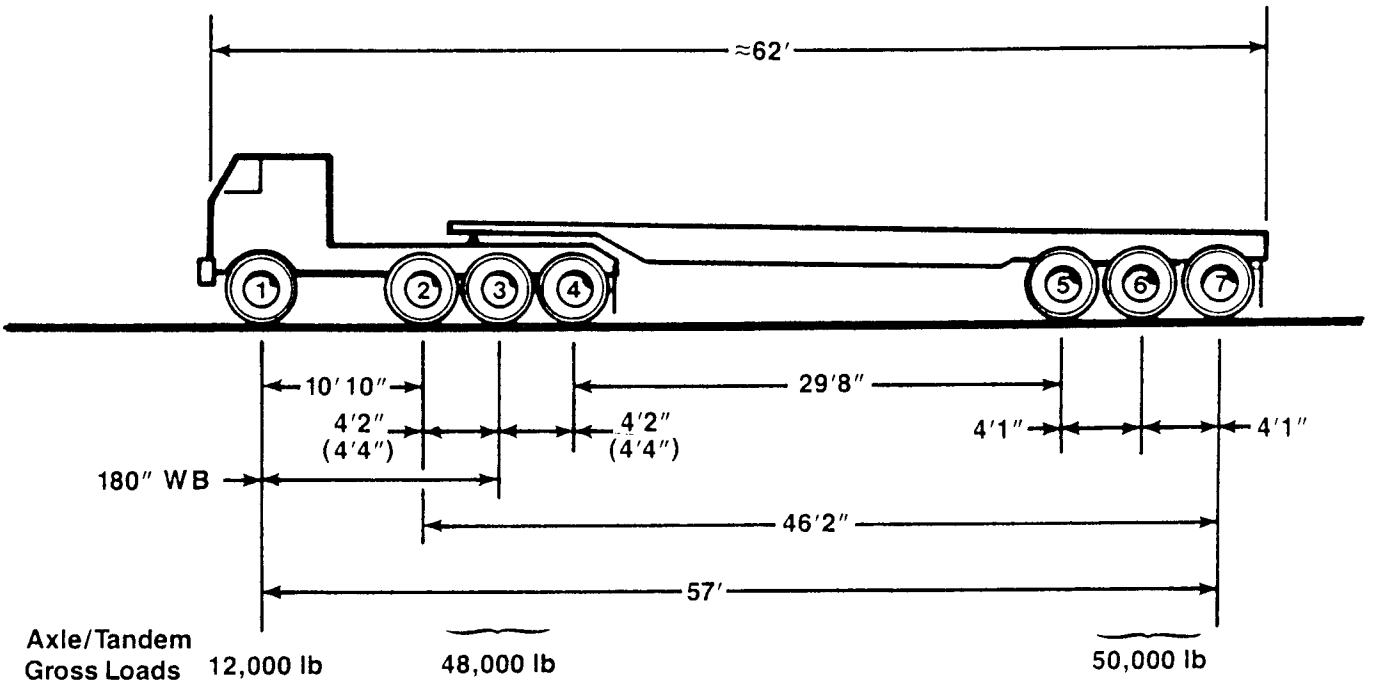

FIGURE 4-2. 110,000-LB GCW, 7-AXLE, OVERWEIGHT TRANSPORTER CONFIGURATION

—6 × 4 Tractor
—Equalizing Suspension:
Axles 2 and 3
Axles 4, 5, and 6

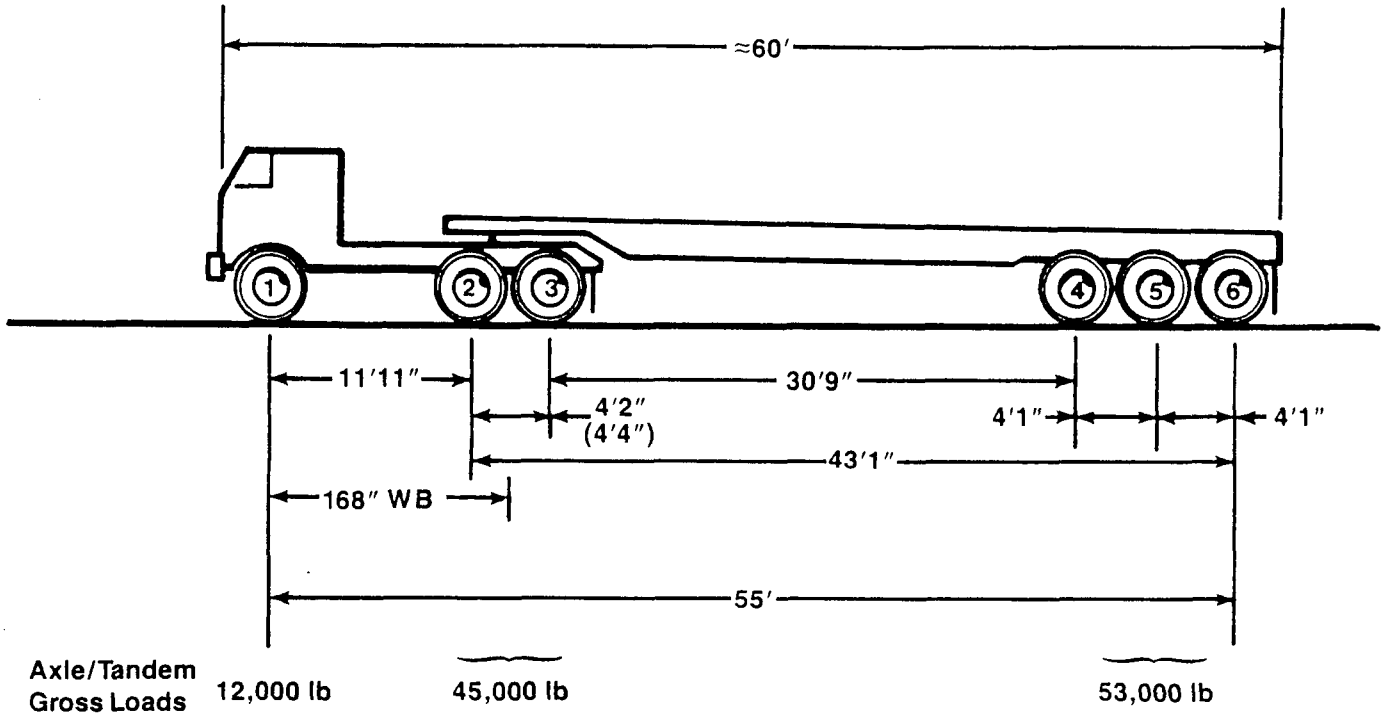

FIGURE 4-3. 110,000-LB GCW, 6-AXLE, OHIO PERMIT, OVERWEIGHT TRANSPORTER CONFIGURATION

by the Bridge Formula. The formula must be applied and satisfied for all possible axle combinations on a vehicle. In addition to the above loading limits on any two or more consecutive axles, the load on a single axle is limited to 20,000 lb, that on tandem axles not more than 96 in apart to 34,000 lb, and the GCW to 80,000 lb.

Table 4-2. Bridge Gross Weight Formula B

No vehicle or combination of vehicles may be operated on the Interstate highways when the gross weight on two or more consecutive axles exceeds the limitations prescribed by the following formula:

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

where W = overall gross weight on any group of two or more consecutive axles to the nearest 500 pounds, L = distance in feet between the extreme of any group of two or more consecutive axles, and N = number of axles in the group under consideration.

Source: Surface Transportation Assistance Act of 1982.

Federal and State laws allow two consecutive 2-axle tandems to carry a gross load of 34,000 lb each if the distance between the outermost axles is 36 ft or more. Thus, the total weight allowed for the two tandems (total of 4 axles) is 68,000 lb. This is an exception to the Bridge Formula, as the required calculated length for this axle loading is 39 ft.

As an alternative to the configuration shown in Figure 4-1, the tractor wheelbase (WB) can be reduced and the trailer length increased up to 5 ft and still meet the requirements of the Bridge Formula. However, the overall length of 51 ft or more between axles 1 and 5 must be maintained to satisfy the Bridge Formula.

4.2.2 110,000-lb GCW, 7-Axle Configuration

The 110,000-lb GCW, 7-axle, overweight (permit) transporter configuration shown in Figure 4-2 represents a modified version of the configuration presented in Appendix C of BMI/OTSP-01 (see reference on p. 3). The GCW has been reduced to 110,000 lb and the axle loads and distances between axles selected such that in no case does the loading on any combination of two or more axles exceed allowable Bridge Formula loading by more than 20%. This represents a compromise between attempts to simultaneously minimize transporter length, weight, and percent axle loading over allowable Bridge Formula loading. It is well below the maximum percentage overload routinely permitted by Ohio and many other States.

The overweight transporter configuration shown in Figure 4-2 is relatively short, i.e., approximately 62 ft overall and 57 ft between axles 1 and 7. This is only 6 ft longer than the legal-weight transporter. It is intended that only two of the three axles on the rear of the tractor will be driven.

4.2.3 110,000-lb GCW, 6-Axle Combination

Some States, including Ohio, issue overweight permits for 110,000-lb or higher GCW transporters with 6 axles. To gain insight into how much weight could be saved with a 6-axle rather than a 7-axle overweight transporter, limited consideration was given to a 6-axle, 110,000-lb GCW overweight transporter configuration meeting Ohio overweight permit limitations. The resulting overweight transporter configuration is shown in Figure 4-3.

Note the high loading on the 2-axle drive tandem. The Ohio maximum load limit for the condition shown is 46,000 lb. Loads of 45,000 and 46,000 lb on 2 axles slightly over 4 ft apart are 32 and 35%, respectively, above the 34,000-lb Bridge Formula limit. Because of the high loading on the 2-axle tandem, this configuration is not considered acceptable for 48-State operation.

4.3 TRACTOR DESCRIPTION AND ESTIMATED WEIGHT

4.3.1 Tractor Description

Table 4-3 presents overall tractor specifications for the three transporter configurations discussed in Section 4.2. Tractor gross vehicle weight (GVW)* is equal to the sum of the loads on all of the tractor axles. Two wheelbases are listed to obtain data on the weight increase or decrease associated with increasing or decreasing the tractor length. One of the wheelbases listed for each tractor is equal to the wheelbase shown in Figures 4-1 through 4-3 for that specific tractor. Because the casks will not project higher than the tractor cab, the frontal area is essentially that of the cab.

For safety purposes, the tractor and trailer must be designed for heavy-duty on-highway usage and have required rated capacity for the loads carried. In addition, the transporter must have good to excellent braking, road speed limited to 55 mph, and sufficient power to move up grades at moderate speeds. In this latter respect, both 300- and 400-hp versions of the 80,000-lb GCW tractor, and 400- and 550-hp versions of the 110,000-lb GCW tractors, were considered.

During the study, it was found that no 550-hp EPA**-rated diesel truck engine is commercially available today. The major U.S. diesel truck engine manufacturers currently offer EPA-rated engines with maximum power ratings

* GVW = The gross weight of the tractor including all fluids, driver(s), accessories, fifth wheel, and trailer load on the fifth wheel.
** EPA = U.S. Environmental Protection Agency.

Table 4-3. Overall Tractor Specifications

Tractor Specification	Legal-Weight Tractor	Overweight Tractor	
Tractor illustrated in Figure:	4-1	4-2	4-3
Axle and drive configuration[a]	6 x 4	8 x 4	6 x 4
Tractor GVW, lb	46,000	60,000	57,000
GCW, lb	80,000	110,000	110,000
Front axle load, lb	12,000	12,000	12,000
Rear 2-axle tandem load (2 drive axles), lb	34,000	--	45,000
Rear 3-axle tandem load (Equalized suspension) (2 drive axles), lb	--	48,000	--
Fifth wheel load, lb	46,000 minus tractor weight[b]	60,000 minus tractor weight[b]	57,000 minus tractor weight[b]
Wheelbase, in	168 & 204	156 & 180	168 & 180
Frontal area, ft^2	74	74	74
Engine power, hp (30 mph on 3% grade)	300	400	400
(30 mph on 5% grade)	400	550	550
Maximum governed speed, mph	55	55	55
Fuel capacity, gallons	80	100	100
Duty cycle	On-highway, 200,000 mi/yr, always loaded, tractor dedicated to this application		
Reliability	High	High	High
Safety	Good to excellent braking, 55 mph governed speed, high speed up grades		

(a) First number is total number of wheels (dual tires and wheels are considered as one). Second number is number of driven wheels. These numbers divided by two give total number of axles and number of driven axles, respectively, on tractor.

(b) Tractor weight with all fluids (including diesel fuel), driver(s), and accessories.

ranging from 425 to 500 hp. All manufacturers speculated that they will have engines approaching 500 hp 5 to 10 years from now. Most tractor, engine, and trucking people contacted during this study believe that 550 hp is excessive for the 110,000-lb GCW transporter and that a range from 400 to 500 hp is adequate for that transporter.

Diesel fuel weighs approximately 7 lb/gallon. Thus, the amount of fuel carried is an important weight consideration. For purposes of this study, fuel storage capacities of 80 and 100 gallons are assumed for the 80,000- and 110,000-lb GCW transporters, respectively, to give a range of approximately 400 mi between refuelings.

4.3.2 Tractor Estimated Weight

The five leading U.S. manufacturers of Class 8 (large, heavy-duty) trucks/tractors were contacted and asked to provide weight estimates for the tractors described in Table 4-3. Those manufacturers and their Class 8 unit sales are shown in Table 4-4.

Table 4-4. Sales of Five Leading Manufacturers of Class 8 Trucks/Tractors

U.S. Truck/Tractor Manufacturer	New Class 8 Unit Sales January 1 to July 31, 1987
Navistar (International)	16,559
Freightliner	13,017
Mack	11,086
Kenworth (Paccar)	8,040
Ford	7,511
Subtotal	56,213
All others	19,381
Total	75,594

From "July Truck Sales by Manufacturer and Segment," Automotive News, p. 14 (August 31, 1987).

Weight-estimating work sheets were prepared for each of the three tractor designs described in Table 4-3 and were sent to the five companies in Table 4-4 along with the tractor descriptions shown in Table 4-3. Copies of completed weight-estimating work sheets were submitted by three of the companies and are summarized in Appendix B.

A summary of the estimated tractor weights for the 80,000-lb GCW and 7-axle, 110,000-lb GCW transporters is given in Chapter 2, Overall Findings. In addition, two manufacturers estimated an additional weight savings of approximately 1,350 and 2,450 lb, respectively, for a 110,000-lb GCW transporter 3-axle tractor in Figure 4-3, as compared to the 4-axle version in Figure 4-2.

4.4 TRAILER DESCRIPTION AND ESTIMATED WEIGHT

4.4.1 Trailer Description

Two trailer configurations were considered: one for legal-weight and one for overweight service. These trailers are illustrated in Figures 4-1 and 4-2. The trailer for the 6-axle, 110,000-lb GCW transporter illustrated in Figure 4-3 is very similar to the trailer for the 7-axle, 110,000-lb GCW transporter, so separate data were not collected for the 6-axle trailer. Table 4-5 presents the overall specifications for the two subject trailer configurations.

Table 4-5. Overall Trailer Specifications

Trailer Specification	Legal Weight Trailer	Overweight Trailer
Trailer illustrated in Figure:	4-1	4-2
Type trailer	Platform	Platform
Payload	56,000-lb cask*	80,000-lb cask*
Overall trailer length, ft	42 & 45	47 & 48
Number of trailer axles	2	3
Total axle loading, lb	34,000	50,000
Fifth wheel load, lb	Trailer weight +56,000-lb cask -34,000 lb	Trailer weight +80,000 lb cask -50,000 lb

* As described in Table 4-1.

4.4.2 Trailer Estimated Weight

The Thomas Register of U.S. Manufacturers lists hundreds of trailer manufacturers. Eleven were contacted:

- Alloy Trailers, Inc.
- City Trailer Sales, Inc.
- Dorsey Trailers, Inc.
- Fontaine Truck Equipment Company
- Fruehauf Division

- Lufkin Trailers Division
- Ravens Metal Products, Inc.
- Talbert Manufacturing Company
- Trail King Industries
- Trailmobile, Inc.
- Wilson Trailer Company.

Most of these were recommended as manufacturers of light-weight and/or high-capacity platform trailers. The others were selected as representative of the largest U.S. trailer manufacturers (i.e., tangible assets over $50 million).

Each of the eleven trailer manufacturers was contacted first by telephone, then by mail. The cask descriptions, including the concentrated loading given in Table 4-1, and general trailer specifications given in Table 4-5 were discussed and mailed to them. They were requested to recommend a specific light-weight trailer with minimum-weight optional components. Weight-estimating work sheets were prepared for each of the two trailers described in Table 4-5, and these were also sent to the eleven manufacturers. Copies of completed weight-estimating work sheets were submitted by six of the companies and are summarized in Appendix C.

A summary of the estimated trailer weights for the 80,000- and 110,000-lb GCW transporters is given in Chapter 2, Overall Findings.

4.5 MAJOR COMPONENTS

4.5.1 Engines

Required engine power ranges from 300 to 400 hp for the 80,000-lb GCW transporter and 400 to 500 hp for the 110,000-lb GCW transporter. Surprisingly, there is relatively little variation in diesel truck engine weight over this power range. All of the engines are turbocharged, and by varying the turbocharger, injectors, and engine control, basically the same size engine (i.e., same displacement) has a wide range of power ratings. Engines currently available for this application are listed in Table 4-6.

All of the engines weigh between 2,400 and 2,900 lb. except for the Cummins L10, Detroit Diesel Allison (DDA) 6V-92TA, and Mack EM6. The largest impact on transporter weight would be to substitute a Cummins L10 engine for a Cummins BC IV or Caterpillar 3406B engine in the 300 hp version of the 80,000-lb GCW transporter. The Cummins L10 would reduce tractor weight by 600 or more pounds.

The most active area for near-future engine development is in the 10.0- to 12.0-liter (600- to 700-in^3) engine class. Caterpillar planned to introduce a 10.3-liter, 325-hp, 1,880-lb engine by the fall of 1988. Maximum power for the Cummins L10 may increase to 350 hp. On the other end of the power range, power ratings for the Caterpillar 3406B, Cummins BC IV, and DDA 8V-92TA and Series 60 engines are expected to increase into the 460- to 500-hp range.

Table 4-6. Diesel Truck Engine Specifications

Engine Manufacturer	Engine Series	Engine Displacement, in^3	Power Range, hp	Torque Range, lb-ft	Dry Weight, lb
Caterpillar	3406B	893	285-425	1150-1450	2790
Cummins	L10	611	240-300	860-950	1930
	BC IV	855	300-444	1000-1400	2530
Detroit Diesel	Series 60	677-775	250-400	970-1400	2700
	6V-92TA	552	270-350	975-1050	2020
	8V-92TA	736	350-475	1175-1330	2415
Mack	EM6	672	250-300	-1400	2230
	E9	998	400-500	1325-1660	2900

4.5.2 Transmissions

A nine-speed transmission should be adequate for the 80,000-lb GCW transporter and nine to possibly thirteen speeds for the 110,000-lb GCW transporter. Again, transmission weight increases for increased number of speeds and/or increased torque ratings are less than might be expected.

This is illustrated by the weight of the Fuller Road Ranger series of transmissions (RT) shown in Table 4-7. All of the Road Ranger transmissions have iron housings. Aluminum housings are not available for Road Ranger transmissions.

Table 4-7. Transmission Specifications

Transmission Model	Number of Forward Speeds	Torque Rating, lb-ft	Dry Weight Less Clutch Housing and Controls, lb
RT-11609	9	1,150	589 (Iron)
RT-14609	9	1,450	616 (Iron)
RT-11613	13	1,150	652 (Iron)
RT-14613	13	1,450	659 (Iron)
RT-15613	13	1,650	665 (Iron)

Aluminum clutch housings weigh approximately 25 lb and iron housings 75 lb for a weight savings of approximately 50 lb with an aluminum clutch housing. Aluminum clutch housings are available for the RT-11600 transmissions but not for the 14600 and 15600 transmissions.

Spicer manufactures one of the lightest transmissions in the torque range of interest, but it can be used only for the 80,000-lb GCW transporter. That is their Model 1310, which has 10 forward speeds, a torque rating of 1,300 lb-ft, and a dry weight of 460 lb including aluminum transmission and clutch housings. Other Spicer transmissions have weights similar to those listed in Table 4-7 for the Road Ranger transmissions.

The manufacturers contacted forecasted no major near-term transmission weight reductions.

4.5.3 Tires, Wheels, and Wheel Hubs

Tires, wheels, and wheel hubs represent a major area for weight savings in heavy-duty on-highway tractors and trailers. Currently manufactured 80,000-lb GCW tractor-trailer combinations have 18 wheels and tires each, and the 110,000-lb GCW overweight transporter configuration being considered in this report has 26. With so many tires and wheels, a modest weight savings in one unit is multiplied into a major weight savings for the entire tractor-trailer combination.

Truck fleet operators and tractor and tire manufacturers are essentially unanimous in recommending the use of tubeless, radial tires for on-highway intercity truck operations. They most frequently cited increased fuel mileage, longer tire life, improved vehicle handling, and fewer flat tires as reasons for their choice. For these reasons, tubeless radial tires are recommended for the transporters of spent fuel casks.

Potential weight savings with tires and wheels can be divided into five options:

1. Change from conventional to low-profile tires.
2. Change from steel to aluminum disc wheels.
3. Change from all one size tire to smaller tires on tractor and trailer tandem axles than on steering axle.
4. Change from dual low-profile to single wide base tires on tractor and trailer tandems.
5. Change from 10-stud ball seat wheels with inner and outer cap nuts to 8-stud hub-piloted wheels with single cap nuts.

Options 2, 3, and 4 above result in major weight savings. Options 1 and 5 result in lesser weight savings. Options 1, 2, and 3 are in use today. Option

4 is commonly used in Europe but is not commonly used in the United States and is only considered to be a possible future option. Option 5 has been introduced recently in the United States and is expected to become more common in the next 5 to 10 years.

Table 4-8 presents estimates of tire and wheel weight savings possible with each of the options listed above. As shown, maximum savings of approximately 1,350 and 1,990 lb are estimated for the 5-axle, 80,000-lb GCW and 7-axle, 110,000-lb GCW spent fuel cask transporters, respectively.

Option 2's use of low-profile tires and aluminum disc wheels is already included in the estimated tractor and trailer weights given in Chapter 2, Overall Findings. Option 3, use of smaller tires on the tractor and trailer tandem axles than on the tractor steering axle, offers an additional estimated weight savings of 272 and 408 lb, respectively, for the subject transporters. One disadvantage with using smaller tires with lower load ratings is that more attention must be given to tire inspection and maintenance of specified tire pressure.

Option 4 consists of substituting a single wide base tire in place of narrower dual tires on all of the tractor and trailer tandem axles. For this option, eight wide base tires and wheels would replace sixteen dual tires and wheels on the 5-axle, 80,000-lb GCW transporter, and twelve wide base tires and wheels would replace twenty-four dual tires and wheels on the 7-axle, 80,000-lb GCW transporter. No change would be made to the tires and wheels on the tractor steering axle of either combination.

Use of wide base tires with aluminum disc wheels on the 5-axle, 80,000-lb GCW transporter is estimated to save 744 lb with respect to use of low-profile tires with aluminum disc wheels (Option 2). Similarly, use of wide base tires with aluminum disc wheels on the 7-axle, 110,000-lb GCW transporter is estimated to save 1,116 lb with respect to Option 2.

Wide base tires have been used in Europe for intercity, on-highway operation for over 15 years but are not commonly used for such operation in the United States. One U.S. company, Southwire Company of Carrollton, Georgia, has been operating a private fleet of 70 tractors and 110 trailers equipped with wide base tires in intercity line-haul service since 1975.

Because of differences in the footprint pattern between dual tires and single wide base tires, some States are currently studying wide base tires to determine if they should be permitted for general on-highway use or possibly have special loading restrictions placed on them. Some are also concerned about the safety of wide base tires relative to that of dual tires. For these reasons, wide base tires currently are not included as an option for the spent fuel cask transporters. However, they may be a viable option in the future.

Bridgestone Tire Company, Inc. is developing a new metric, wide base tire (Size 420/55R22.5). Prototype tires will be available in the near future with production scheduled to begin in late 1988 to 1989. They have recently conducted blow-out tests at highway speeds at the Ohio Transportation Research Center. The results of those tests have not yet been published, but a Bridgestone representative stated that they were "good."

Table 4-8. Estimated Weight Savings for Selected Tire and Wheel Options

Option Number	Tire and Wheel Option	Axle	Tire Size	Tire Weight, lb/tire	Wheel Weight, lb/wheel	Total Tire & Wheel Weight, lb/combination		Incremental Weight Savings, lb/combination	
						5-Axle 80,000-lb GCW	7-Axle 110,000-lb GCW	80,000-lb GCW	110,000-lb GCW
0	Conventional tires	Steering	11R22.5(G)	122	80	404	404		
	Single tire size	Drive	"	124	80	1632	2448		
	Steel disc wheels	Trailer	"	110	80	1520	2280		
		Total				3556	5132	N.A.	N.A.
1	Low-profile tires	Steering	295/75R22.5(G)	114	80	388	388		
	Single tire size	Drive	"	117	80	1576	2364		
	Steel disc wheels	Trailer	"	107	80	1496	2244		
		Total				3460	4996	-96	-136
2	Low-profile tires	Steering	295/75R225(G)	114	55	338	338		
	Single tire size	Drive	"	117	55	1376	2064		
	Aluminum disc wheels	Trailer	"	107	55	1296	1944		
		Total				3010	4346	-450	-650
3	Low-profile tires	Steering	295/75R22.5(G)	114	55	338	338		
	Two tire sizes	Drive	265/75R22.5(G)	100	51	1208	1812		
	Aluminum disc wheels	Trailer	"	98	51	1192	1788		
		Total				2738	3938	-272	-408
4	Wide base tires	Steering	295/75R22.5(G)	114	55	338	338		
	Two tire sizes	Drive	15R22.5(J)	186	62	992	1488		
	Aluminum disc wheels	Trailer	"	172	62	936	1404		
		Total				2266	3230	-472	-708
5	Eight-stud Hub-piloted wheels	NOTE: This option applicable to all above options.						-60	-88
						Total Potential Weight Savings		-1,350	-1,990

Advantages claimed for wide base tires include:

- Lighter weight than comparable dual tires and wheels
- Less susceptible to punctures
- Less rolling resistance
- Better ride.

Option 5, use of 8-stud hub-piloted wheels, can be used with any of the other options. In the traditional stud-piloted system, double cap nuts with spherical seats are used to both center and clamp the dual wheels. In a hub-piloted system, the hub centers the wheels and only a single cap nut per stud is required for both single and dual wheels.

Substitution of aluminum wheel hubs for steel hubs is estimated to result in a weight savings of approximately 17 lb per hub on steering and trailer axles and 35 lb per hub on drive axles. The per axle savings would be twice those values.

4.5.4 Brakes

The most common type of heavy-duty truck brake is an S-Cam drum brake. That type of brake is included in the "standard" tractor and trailer weight estimates given in Appendices B and C.

Because good braking is required for safety reasons, automatic brake slack adjusters, antiskid braking controls, and an engine brake* are recommended for this application. Weight increases estimated for these brake options are given in Table 4-9.

Table 4-9. Weight Increases With the Various Brake Options

Brake Option	Estimated Weight Increase
Automatic slack adjusters	+ 7 lb/axle
Antilock braking	+50 lb/tractor
Engine brake	+80 lb/tractor

Weight reduction options for brakes include:

- Use of wedge-type brakes
- Use of "Centrifuse" brake drums
- Use of disc-type brakes.

* An engine brake mounts on the head of the engine and alters the opening of the exhaust valves such that when the engine is coasting, it acts as a compressor and retards the motion of the vehicle.

Wedge brakes are smaller and lighter than equivalent S-Cam brakes. For equivalent braking performance, 15-in-diameter wedge brakes typically are used in place of 16.5-in-diameter S-Cam brakes. In addition, automatic slack adjustment is built into the wedge-actuating mechanism and a separate slack adjuster is not required. The estimated weight reduction with wedge brakes in place of S-Cam brakes (including associated drum and automatic adjuster weight reduction) is approximately 45 lb per brake or 90 lb per axle.

Centrifuse brake drums offer weight savings estimated at approximately 15 lb per drum or 30 lb per axle.

Weight estimates submitted by tractor and trailer manufacturers indicate the weight reduction with disc brakes would be less than for wedge brakes.

Wedge brakes and Centrifuse brake drums are included in the minimum-weight tractor estimates given in Section 2.1.1. S-Cam brakes and Centrifuse brake drums are included in the minimum-weight trailer estimates given in Section 2.1.2. In practice, S-Cam and wedge brakes would not be mixed on a given combination, but this is the way the manufacturers submitted their minimum-weight estimates. Aside from using wedge or disc brakes and/or Centrifuse brake drums, the brake manufacturers forecasted no major reduction in brake weight for the near future.

4.5.5 Axles and Suspensions

Both the 5-axle, 80,000-lb GCW and 7-axle, 110,000-lb GCW transporters carry 12,000 lb on their front axle and between 16,000 and 17,000 lb on all other axles. These axle loads are typical of those carried by on-highway, 5-axle, tractor-semitrailer combinations today. Thus, highly developed light-weight axles and suspensions are available in this axle load range.

Weight-saving options for axles and suspensions include:

- Use of forged aluminum front axle
- Use of aluminum gear carrier case on drive axles
- Use of taper leaf springs.

Use of an aluminum front axle can save up to 90 lb. However, such axles are not popular today and Rockwell has discontinued making them.

Use of an aluminum gear carrier case on drive axles saves approximately 45 lb per axle or 90 lb per 2-axle drive tandem.

Taper leaf springs are included on the front steering axle for the tractor weight estimates given in this report. Use of taper leaf springs on drive and trailer axles varied between manufacturers and is as indicated in Appendices B and C for tractors and trailers, respectively.

Air suspension will result in a weight increase. However, it was strongly recommended for this application by many of the people contacted during this study, particularly for use with aluminum trailers. Estimates of the weight increase with air suspension vary from 100 to 300 lb per axle.

The manufacturers forecasted no major near-future weight reductions for axles and air suspension systems, although substitution of composite materials for steel springs is possible. For example, Fruehauf plans to install fiberglass springs on a few of its trailers in the near future.

4.5.6 Frames, Cabs, and Bumpers

The main frame members for both heavy duty tractors and trailers are fabricated from either high-strength low-alloy (HSLA) steel or an aluminum alloy. All tractor manufacturers offer a steel frame as standard and sometimes an aluminum frame as an option. Trailer manufacturers typically manufacture either primarily steel trailers or all aluminum trailers.

The weight savings estimated for the aluminum tractor frame option is surprisingly low, i.e., approximately 150 lb. An additional weight savings of approximately 35 lb is estimated for an aluminum bumper. A number of people contacted during the study cautioned against the use of an aluminum tractor frame because of rigidity and durability problems.

Light-weight cabs are standard on all of the tractors considered. The cabs are typically made of aluminum. Conventional cabs have fiberglass engine hood and fenders.

The structural material used for trailer frames is either HSLA steel or aluminum. Surprisingly, the lightest trailer proposed has a steel frame. Trail King and Fruehauf proposed steel trailers consisting of a chassis only with the deck removed. Ravens proposed an aluminum trailer but could not remove the deck because it is required for structural strength.

Except for possible increased use of plastics or composite materials for the tractor cab and bumper, the tractor and trailer manufacturers forecasted no major near-future changes in materials for the subject components. A number of people contacted cited the possible use of a titanium trailer for this application. None of the trailer manufacturers contacted indicated that they were planning to develop a standard commercially available titanium trailer, but such a special trailer could be developed.

APPENDIX A

ORGANIZATIONS CONTACTED

State Overweight Permit Office

- Bureau of Permits and Communications
  Ohio Department of Transportation
  Columbus, Ohio

Shipper of Nuclear Wastes

- TRUPACT
  Westinghouse Electric Corporation
  Carlsbad, New Mexico

Trucking Companies Specializing in Overweight Shipments

- Dan Barclay Trucking and Rigging Company
  Wharton, New Jersey

- R&M Express
  Grove City, Ohio

- Tri-State Motor Transit Company
  Joplin, Missouri

Truck Fleet Operator Specializing in Use of Wide Base Tires

- Southwire Company
  Carrollton, Georgia

Heavy-Duty (Class 8) Highway Tractor Manufacturers

- Ford Motor Company
  Detroit, Michigan

- Freightliner Corporation
  Portland, Oregon

- Kenworth Truck Company
  Kirkland, Washington

- Mack Trucks, Inc.
  Allentown, Pennsylvania

- Navistar International Corporation
  Chicago, Illinois

Heavy-Duty Highway Platform Trailer Manufacturers

- Alloy Trailers, Inc.
  Spokane, Washington

- City Trailer Sales, Inc.
  New Castle, Pennsylvania

- Dorsey Trailers, Inc.
  Elba, Alabama

- Fontaine Truck Equipment Company
  Haleyville, Alabama

- Fruehauf Division
  Fruehauf Corporation
  Detroit, Michigan

- Lufkin Trailers Division
  Lufkin Industries, Inc.
  Lufkin, Texas

- Ravens Metal Products, Inc.
  Parkersburg, West Virginia

- Talbert Manufacturing Company
  Rensselaer, Indiana

- Trail King Industries
  Mitchell, South Dakota

- Trailmobile, Inc.
  Chicago, Illinois

- Wilson Trailer Company
  Sioux City, Iowa

Truck Diesel Engine Manufacturers

- Caterpillar Tractor Company
  Peoria, Illinois

- Cummins Engine Company, Inc.
  Columbus, Indiana

- Detroit Diesel Allison
  Detroit, Michigan

Truck Transmission Manufacturers

- Fuller Transmission Division
  Eaton Corporation
  Kalamazoo, Michigan

- Spicer Transmission Division
  Dana Corporation
  Toledo, Ohio

Truck Axle and Brake Manufacturers

- Axle and Brake Division
  Eaton Corporation
  Kalamazoo, Michigan

- Automotive Operations
  Rockwell International
  Troy, Michigan

Truck Air Suspension Manufacturer

- Neway Division
  Lear Siegler, Inc.
  Muskegon, Michigan

Truck Wheel Hub and Brake Drum Manufacturer

- Motor Wheel Corporation
  Lansing, Michigan

Truck Tire Manufacturers

- Bridgestone Tire Company of America, Inc.
  Torrance, California

- Goodyear Tire and Rubber Company
  Akron, Ohio

- Michelin Tire Corporation
  Greenville, South Carolina

Truck Wheel Manufacturers

- Accuride Corporation (formerly Firestone)
  Henderson, Kentucky

- Alcoa Forged Wheels Division
  Cleveland, Ohio

Truck Fifth Wheel Manufacturer

- Fontaine Truck Equipment Company
  Birmingham, Alabama

Truck Engine Air Starter Manufacturer

- Ingersoll-Rand Company
  Washington, New Jersey

APPENDIX B

TRACTOR WEIGHT-ESTIMATING WORK SHEETS

Table B-1. Weight Estimates for 46,000-GVW/80,000-GCW/6x4 Legal-Weight Tractor (Cab-Over-Engine, 204" WB, 300 hp)

Base Tractor and Options	Weight, Lbs Ford CLT-9000	Freightliner FLT-8664T	Mack MH603
Base tractor (wet)[a]	13,867	14,445	14,996
One-man sleeper	+ 331	Std	Std
Fifth-wheel	+ 378	+ 388	+ 368
Cummins L10-30 engine	Std	- 580	N/A[b]
Aluminum radiator	N/A	Std	N/A
Aluminum flywheel housing	N/A	N/A	- 68
Aluminum clutch housing	Std	Std	Std
Aluminum transmission housing	N/A	N/A	Std
Aluminum front axle	- 93	N/A	N/A
Aluminum gear carrier case (drive axles)	- 90	- 90	- 130
Taper leaf front springs	- 20	Std	Std
Taper leaf rear springs	N/A	N/A	Std
Aluminum disc wheels	- 280	- 260	- 227
Aluminum wheel hubs	- 200	Std	- 56
Wedge brakes	N/A	- 246	N/A
Centrifuse brake drums	- 82	- 115	- 50
Aluminum cab	Std	Std	Std
Aluminum tractor frame	N/A	- 150	- 67
Aluminum bumper	- 25	- 35	- 55
80-gallon aluminum fuel tank	- 270	- 5	N/A[c]
Manual steering	Std	- 75	Std
No air conditioning	Std	- 65	Std
Tractor with Light-Weight Options	13,516	13,212	14,711
Engine brake	+ 90	+ 80	+ 20
Automatic brake slack adjusters	+ 21	(d)	+ 21
Antilock braking	N/A	+ 50	N/A
Power steering	+ 60	+ 75	+ 94
Air conditioning	+ 115	+ 65	+ 105
Air suspension for rear axles	?	+ 210	+ 49
Steel tractor frame	Std	+ 150	+ 67
Cummins BC IV-300 engine	+ 924	+ 580	+ 300
Tractor with Light-Weight Options Plus Suggested Options	14,726[e]	14,422	15,367

(a) Includes 80-gallons (560 lb) diesel fuel.
(b) Mack EM6-300 engine standard.
(c) Two 63-gallon aluminum tanks included in base weight.
(d) Automatic slack adjusters integral with wedge brakes.
(e) Does not include air suspension.
N/A = Not Available
Std = Standard (included in base tractor)
\+ = Weight added to base tractor weight by including option.
\- = Weight subtracted from base tractor weight by including option.

Table B-2. Weight Estimates for 60,000-GVW/110,000-GCW/8x4 Overweight Tractor (Cab-Over-Engine, 180" WB, 400 hp)

Base Tractor and Options	Weight, Lb Freightliner FLT-8684T	Weight, Lb Mack MH603
Base tractor (wet)[a]	17,503	18,406
One-man sleeper	Std	Std
Fifth-wheel	+ 388	+ 368
Cummins BC IV-400 engine	Std	N/A[b]
Aluminum radiator	Std	N/A
Aluminum flywheel housing	N/A	- 68
Aluminum clutch housing	Std	Std
Aluminum transmission housing	N/A	Std
Aluminum front axle	N/A	N/A
Aluminum gear carrier case (drive axles)	N/A	- 130
Taper leaf front springs	Std	Std
Taper leaf rear springs	N/A[c]	Std[c]
Aluminum disc wheels	- 364	- 318
Aluminum wheel hubs	Std	- 84
Wedge brakes	- 351	N/A
Centrifuse brake drums	- 150	- 70
Aluminum cab	Std	Std
Aluminum tractor frame	N/A	N/A
Aluminum bumper	- 35	- 55
100-gallon aluminum fuel tank	Std	N/A[d]
Manual steering	- 75	Std
No air conditioning	- 65	Std
Tractor with Light-Weight Options	16,851	18,049
Engine brake	+ 80	Std
Automatic brake slack adjusters	(e)	+ 28
Antilock braking	+ 50	N/A
Power steering	+ 75	+ 94
Air conditioning	+ 65	+ 105
Air suspension for rear axles	+ 210	+ 49
Steel tractor frame	Std	Std
Tractor with Light-Weight Options Plus Suggested Options	17,331	18,325

(a) Includes 100-gallon (700 lb) diesel fuel.
(b) Mach E9-400 engine.
(c) Non-driven third axle has air suspension.
(d) Two 63-gallon aluminum fuel tanks included in base weight.
(e) Automatic slack adjuster integral with wedge brakes.
N/A = Not Available
Std = Standard (included in base tractor)
+ = Weight added to base tractor weight by including option.
- = Weight subtracted from base tractor weight by including option.

Table B-3. Weight Estimates for 57,000-GVW/110,000-GCW/6x4 Overweight Tractor (Cab-Over-Engine, 168" WB, 400 hp)

Base Tractor and Options	Weight, Lb Freightliner FLT-8664T	Weight, Lb Mack MH603
Base tractor (wet)[a]	14,810	17,448
One-man sleeper	Std	Std
Fifth-wheel	+ 388	+ 368
Cummins BC IV-400 engine	Std	N/A[b]
Aluminum radiator	Std	N/A
Aluminum flywheel housing	N/A	- 68
Aluminum clutch housing	Std	Std
Aluminum transmission housing	N/A	Std
Aluminum front axle	N/A	N/A
Aluminum gear carrier case (drive axles)	N/A	- 130
Taper leaf front springs	Std	Std
Taper leaf rear springs	N/A	Std
Aluminum disc wheels	- 260	- 227
Aluminum wheel hubs	Std	- 56
Wedge brakes	- 246	N/A
Centrifuse brake drums	- 115	- 50
Aluminum cab	Std	Std
Aluminum tractor frame	- 150	N/A
Aluminum bumper	- 35	- 55
100-gallon aluminum fuel tank	Std	N/A[c]
Manual steering	- 75	Std
No air conditioning	- 65	Std
Tractor with Light-Weight Options	14,252	17,230
Engine brake	+ 80	Std
Automatic brake slack adjusters	(d)	+ 21
Antilock braking	+ 50	N/A
Power steering	+ 75	+ 94
Air conditioning	+ 65	+ 105
Air suspension for rear axles	+ 210	- 470
Steel tractor frame	+ 150	Std
Tractor with Light-Weight Options Plus Suggested Options	14,882	16,980

(a) Includes 100-gallon (700 lb) diesel fuel.
(b) Mach E9-400 engine.
(c) Two 63-gallon aluminum fuel tanks included in base weight.
(d) Automatic slack adjuster integral with wedge brakes.
N/A = Not Available
Std = Standard (included in base tractor)
+ = Weight added to base tractor weight by including option.
- = Weight subtracted from base tractor weight by including option.

APPENDIX C

TRAILER WEIGHT-ESTIMATING WORK SHEETS

Table C-1. Weight Estimates for 56,000-lb Cask Legal-Weight Trailer (42-ft Platform, 2 axles)

Base Trailer and Options	Weight, lb					
	Alloy Trailers ATCFT-42	Fruehauf Chassis Trailer	Ravens Magnum	Talbert	Trail King	Wilson CF-800
Base trailer	9,226	7,793	8,238	10,694	9,900	9,560
Structural material	Steel	Steel	Aluminum	Steel	Steel	Steel & Alum.
Aluminum disc wheels	- 272	Std	- 240	- 372	- 240	- 280
Aluminum wheel hubs	- 104	N/A	- 32	(b)	- 96	- 30
Centrifuse brake drums	(a)	- 38	Std	(b)	---	---
Disc brakes	N/A	N/A	- 120	N/A	N/A	N/A
Taper leaf springs	- 28	- 50	Std	- 568(c)	Std	N/A
No front bulkhead	Std	Std	Std	Std	Std	Std
No tie down	Std	Std	Std	- 200	- 260	Std
No spare tire	Std	Std	Std	Std	Std	Std
No tire carrier	- 75	Std	- 30	Std	Std	Std
No support gear	- 225	- 230	- 200	- 230	- 250	- 250
Nonadjustable axle location	Std	Std	Std	Std	Std	Std
Cut 1-ft off front of trailer	- 150	N/A	- 50	- 122	- 120	- 120
Remove any platform members not required for structural strength	- 500	Std	- 84	N/A	-2,000	-1,066
Trailer with Light-Weight Options	7,872	7,475	7,482	9,202	6,934	7,814
Automatic brake slack adjusters	+ 14	+ 14	(d)	+ 14	+ 14	+ 14
Air suspension	+ 778	+ 500	+ 384	+ 568	+ 266	+ 650
Support gear	+ 225	+ 230	+ 200	+ 230	+ 250	+ 250
Trailer with Light-Weight Options Plus Suggested Options	8,889	8,219	8,066	10,014	7,464	8,728

(a) Included with aluminum wheel hubs.
(b) Included with aluminum disc wheels.
(c) Air suspension is standard.
(d) Automatic slack adjusters integral with disc brakes.
N/A = Not Available
Std = Standard (included in base trailer)
\+ = Weight added to base trailer weight by including option.
\- = Weight subtracted from base trailer weight by including option.

Table C-2. Weight Estimates for 80,000-lb Cask Overweight Trailer (48-ft Platform, 3 axles)

Base Trailer and Options	Weight, lb			
	Fruehauf Chassis Trailer	Talbert	Trail King	Wilson
Base trailer	10,897	15,398	13,900	13,400
Structural material	Steel	Steel	Steel	Steel
Aluminum disc wheels	Std	- 558	- 360	- 420
Aluminum wheel hubs	N/A	(a)	- 144	- 45
Centrifuse brake drums	- 57	(a)	---	---
Disc brakes	N/A	N/A	N/A	N/A
Taper leaf springs	- 75	- 584(b)	Std	N/A
No front bulkhead	Std	Std	Std	Std
No tie downs	Std	- 200	- 297	Std
No spare tire	Std	Std	Std	Std
No tire carrier	Std	Std	Std	Std
No support gear	- 250	- 230	- 250	- 250
Nonadjustable axle location	Std	Std	Std	Std
One ft removed off front of trailer	N/A	- 122	- 140	- 160
Deck or cross-members not required for structural strength removed	Std	N/A	-2,500	N/A
Trailer with Light-Weight Options	10,605	13,704	10,209	12,525
Automatic brake slack adjusters	+ 21	+ 21	+ 21	+ 21
Air suspension	+ 750	+ 584	+ 399	+1,000
Support gear	+ 250	+ 230	+ 250	+ 250
Trailer with Light-Weight Options Plus Suggested Options	11,626	14,539	10,879	13,796

(a) Included with aluminum disc wheels.
(b) Air suspension is standard.
N/A = Not Available
Std = Standard (included in base trailer)
\+ = Weight added to base trailer weight by including option.
\- = Weight subtracted from base trailer weight by including option.