Low-Profile Trailer Tank

Lawrence A. Botkin

ABSTRACT

Analysis of studies conducted by various agencies during the past few years has indicated that there are areas in which regulations could be improved and coordinated to improve the safety of the transportation of hazardous materials--particularly gasoline, which is transported in large volumes throughout the country. An improvement in transportation safety has obvious benefits to the general public. It is believed that this improvement can be achieved by adjusting weight distribution to promote better ride of the tractor in a typical tractor-semitrailer combination and to reduce the wear and tear that the vehicle causes on the highway system. Improvement in the safety of transporting gasoline would come in two areas. The dynamic stability of the tractor-semitrailer combination would be improved by (a) changing the wheel loadings of the unit to move the center of gravity of the semitrailer rearward; and (b) using the latest suspension technology to reduce the height of the center of gravity by almost 1 ft. These features are interrelated and would improve the dynamic stability of the total vehicle. There have been complaints about driver fatigue caused by rough ride of tractors that have the 12,000-lb front axle capacity that is necessary to achieve the current 80,000-lb gross weight limitation. This proposal would limit the front axle weight to 10,000 lb and thus would allow use of front axles with better ride characteristics. To test these theories, two prototype vehicles have been built and placed in operation with various customers. To date the response of the operators has been positive.

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PROPOSED VEHICLE

Improvement in the safety of transporting gasoline would come in two areas. The dynamic stability of the tractor-semitrailer combination would be improved by (a) changing the wheel loadings of the unit to move the center of gravity of the semitrailer rearward; and (b) using the latest suspension technology to reduce the height of the center of gravity by almost 1 ft. These two features are interrelated and both would improve the dynamic stability of the total vehicle. By lowering the profile of the semitrailer's tank and the center of gravity of the payload, the bumper would be placed closer to the ground; this would reduce the probability of rear underride accidents while lowering the entire tank and framing structure, which would probably reduce the probability of side underride.

In addition, the latest available technology would be used to improve product retention by adjusting the minimum thickness of the tank shell in proportion to the gross weight and by using state-of-the-art equipment to have greatest security of the manholes, fill covers, and vents. Safety would be further promoted by the use of reflective material for greatest conspicuity during times of low visibility and incorporation of a directional signal function on the side of the semitrailer to more clearly alert motorists to the intention of the driver.

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STUDIES ON HIGHWAY SAFETY PROGRAMS

The Surface Transportation Assistance Act of 1982 [P.L. 97424, Section 203(a)(1)] provides for the continuation of funding for the study of highway safety programs (1). Although data gained in publicly funded programs was used to develop the proposal explained in this paper, no federal funding has been used for implementation of this program. It is noted that the U.S. Senate amendment under "Commercial Motor Vehicle Safety: Definitions" would have further accentuated highway safety and would have authorized the Secretary, U.S. Department of Transportation, to "promulgate regulations regarding the safety of commercial motor vehicle operations both in affecting interstate and foreign commerce." Special recognition was given to hazardous material vehicles in the following statement: "Also vehicles

transporting hazardous materials would be covered because of the potential greater safety dangers in this area."

This same amendment stated, further, under "Regulatory Authority and Standards," the following: "The Senate amendment allows the Secretary to waive the application of any rule, regulation, standard, or order if such waiver is in the public interest and is consistent with the safe operation of commercial motor vehicles." Thus, while the House bill had no comparable provisions, it is the interest of the Senate that efforts to improve safety should be further emphasized. (It should be noted that the absence of provisions further emphasizing vehicle safety does not indicate that the House has any less interest in this important area than does the Senate.)

The trailer tank industry gained important information through a program conducted for the Bureau of Motor Carrier Safety (2) and through the request for industry input. The industry responses indicated that the meetings that were discussed concerning reduction of the spillage of gasoline during vehicle rollovers were satisfactorily resolved with state-of-the-art equipment. The basic leakage problems that were determined during the research program centered around obsolete and poorly maintained manholes, vents, and fittings. Stimulating replacement of existing tank fleets, portions of which are 20 years old or more, will go far toward eliminating this problem because current fittings are superior in both design and materials of construction. These features would be assured by proposed changes in motor carrier regulations that were reviewed under specific proposals providing public benefit from funds expended on this study.

Studies by the state of Michigan resulted in the passage of specific highway regulations for flammable liquid tanks (3). One feature of these regulations is the virtual prohibition of double-bottom flammable liquid tanks in recognition of the dynamic lane change stability problems that were determined by a comprehensive research program. The California Highway Patrol has conducted surveys that further emphasize the higher rollover accident rate of double-bottom tanks (4). This industry proposal will inherently lead to the elimination of double-bottom tanks by rendering them uneconomical, replacing them with a vehicle that is safer and more stable than today's semitrailer.

The double-bottom tank combination is a good illustration of a case in which the configuration of a tank vehicle found in commercial service is dictated by the road laws rather than by the preference of the manufacturer. It is therefore necessary that size and weight restrictions be addressed in some of the proposals to increase tank safety. In this manner it will be possible to establish a strong incentive for operators to upgrade their fleets with units built to improved regulations.

Improving the rollover stability of the trailer tank to the extent that is practical with the current state of the art is important in reducing the volume and frequency of hazardous materials spills as well as general improvement in highway safety. This could be accomplished without increasing the overall length of the trailer tank from the length that is being produced today; this would avoid an increase in traffic hazard for the public. Although no specific studies have been conducted to evaluate the vehicle as it is proposed in the beginning of this paper, its implementation would reduce the expected rollover frequency in a fleet by 40 to 50 percent compared with the average tank today.

It is believed that the tri-axle configuration is the most attractive configuration, considering cost, incremental weight increase, maneuverability, and increased braking capability. In a report on articulated vehicle stability problems developed by the Transport Committee of the Australian Institute of Petroleum, drivers of tank combinations report better cornering stability with tri-axle trailers than with tandem-axle trailers (5). Tri-axle suspensions are very popular in Europe; some use single tires and wide spring centers.

Figure 1 is a photograph of a low-profile tank configuration that would fit into today's fleets; it is to be compared with a conventional tank, which is shown in Figure 2. No special tractor equipment would be required, except that some care may be necessary to avoid excessive frame extensions, which would cause swing clearance problems.

Figure 3 shows how the rear of the tank can be lowered by shifting the center of gravity rearward to put 8,000 lb more on the tri-axle than on the tandem, and taking advantage of the 102-in. width (versus 96-in. width of the conventional tanks) and new low-profile tires. Figure 4 shows a similar comparative view of the front of the conventional tank compared with the low-profile tri-axle unit.

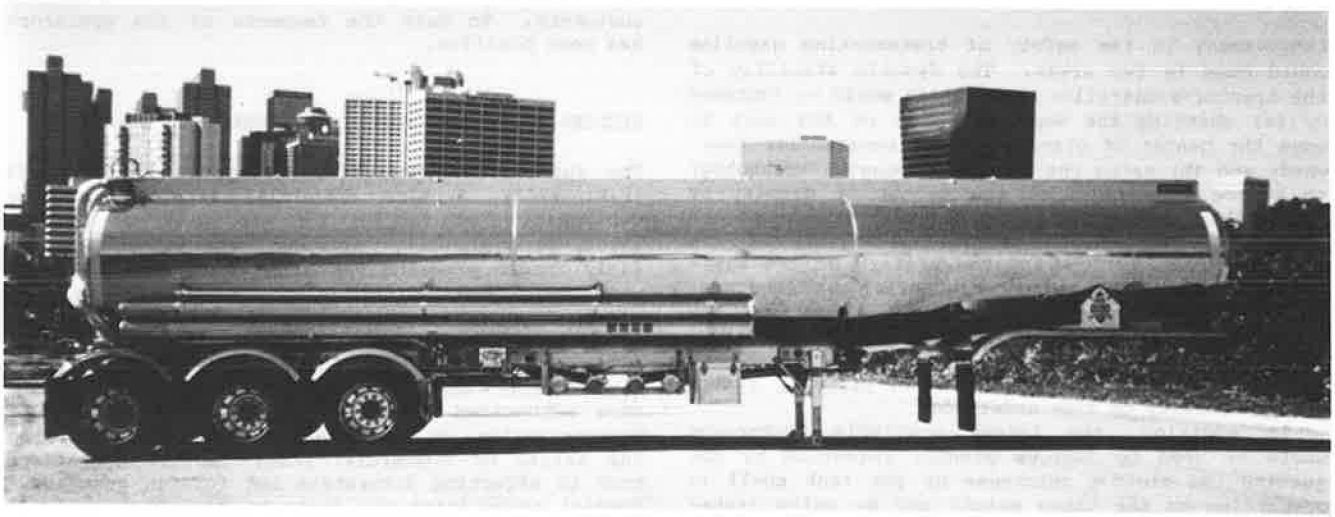

FIGURE 1 Low-profile tank configuration.

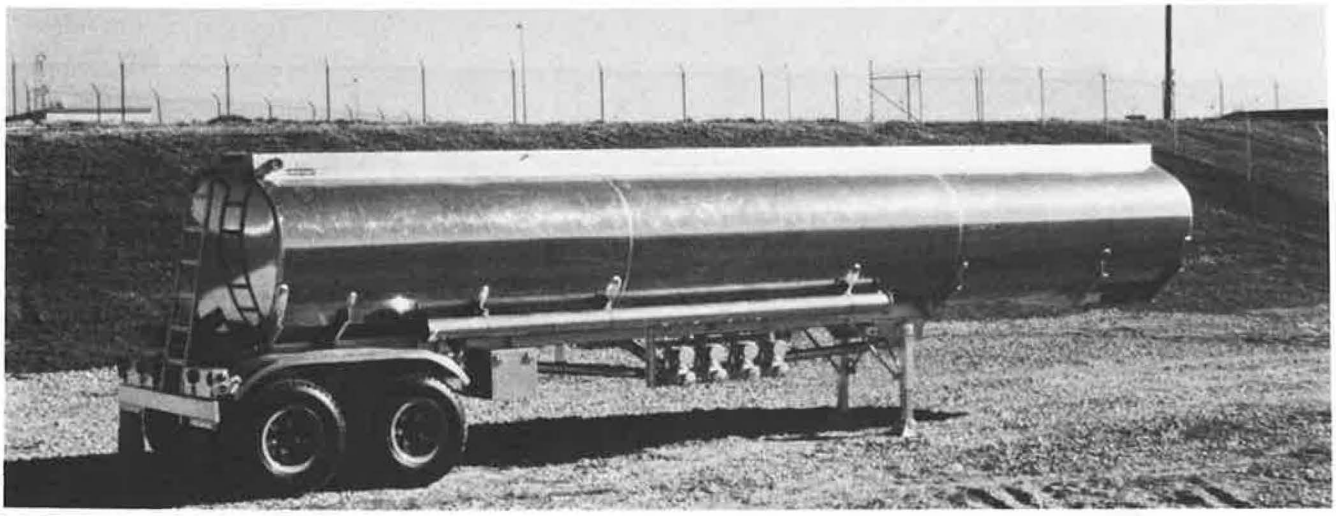

FIGURE 2 Conventional tank.

The wider base and lower height that result provide greater rollover stability. In addition, it is believed that moving the center of gravity of the tank rearward, as is the case in tri-axle design, reduces the tendency for oversteering (6), and thus also reduces the tendency to jackknife.

The reduction in the front axle load from 12,000 lb to 10,000 lb will permit the use of tractors that have better ride characteristics, thus improving driver comfort. A more comfortable driver should be a safer driver, which should contribute to the total improvement desired. Another reason for the reduction in front axle weight is to increase the trailer suspension load so that it is the primary determinant of the trailer's roll stability.

Current five-axle rigs have approximately one-half (or more) of the trailer's load on the tractor. This means that the trailer suspension is limited in its contribution to roll stability. It also makes it impractical to taper the nose of the tank to lower the center of gravity in the rear. Vertical play in the kingpin fit in the coupler jaws can also

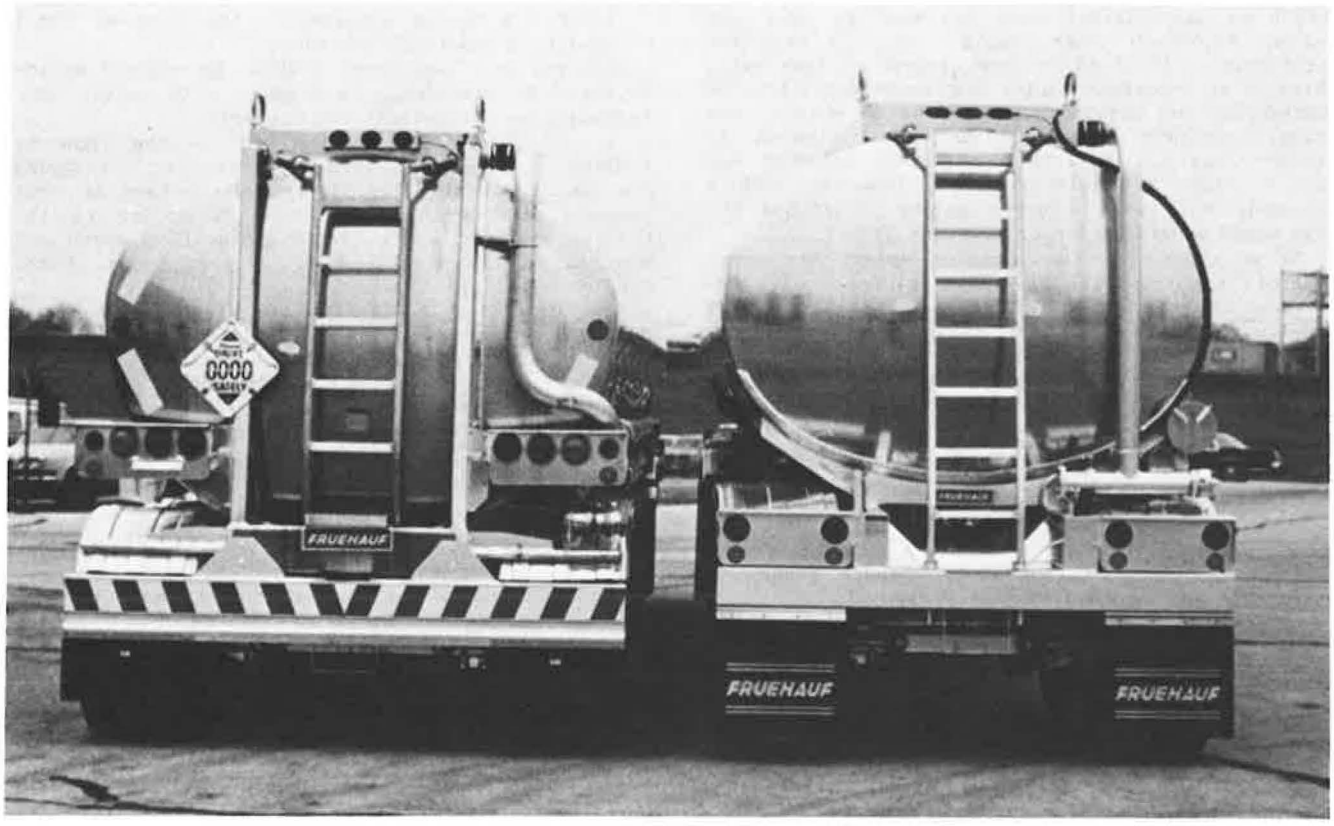

FIGURE 3 Comparative view showing how rear of tank can be lowered by shifting center of gravity rearward.

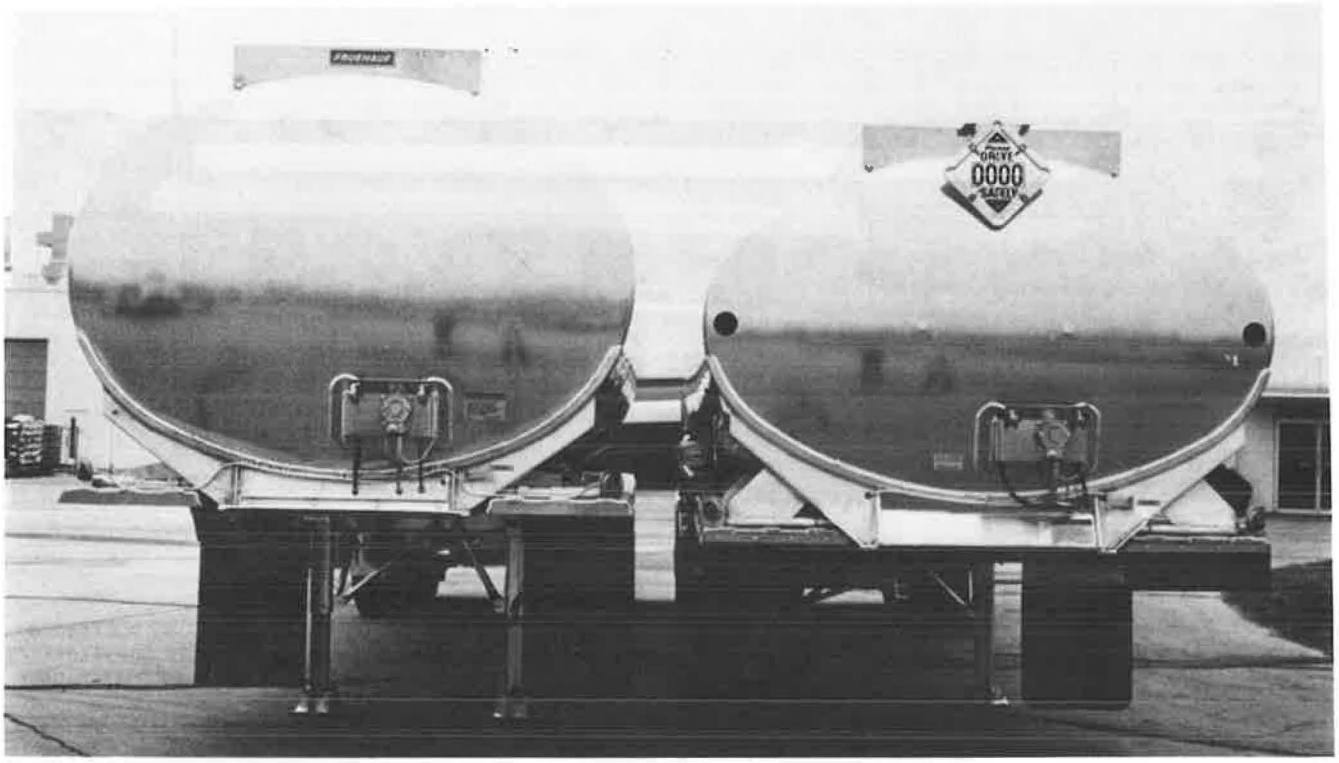

FIGURE 4 Comparative view of the front of conventional tank compared with low-profile tri-axle unit.

provide free play in the roll resistance of the tractor at a critical time.

Trailer length has been considered an important item in this design. The proposed unit is the same length as the current unit designed to meet the federal 80,000-lb gross limits. It will meet the California limit of 38 ft from kingpin to last axle, which is an important factor for maneuverability. By rearranging and reducing the loading of most of the axles, this unit reduces the equivalent kips on the highway from 2.43 to 2.13 on flexible pavement and 4.02 to 2.78 on rigid pavement, compared with a five-axle unit with a gross weight of 80,000 lb; this would provide a longer pavement life.

As an experiment in improving splash and spray control, the tri-axles have been equipped with individual rolled contour fenders with "grass" textured mudflaps at the rear of each individual fender. The two intermediate flaps are provided with a slanted drain channel to drain collected water inside the tire contact area so that it is not picked up by the tires that follow. Initial driver reports indicate a significant reduction in spray in this area.

PROPOSED REGULATORY CHANGES

A discussion of the regulatory changes needed to define the proposed semitrailer follows.

Bulk Materials Transport Rrestrictions

Design Restrictions

The design of the semitrailers must be in accordance with the best available technology to promote static and dynamic stability as a highway vehicle. This includes the following criteria:

1. The track width shall be 7.5 in. or more.
2. The spring centers or their equivalent shall be as wide as practicable, considering tire clearance.
3. For a spring suspension, the freeplay shall be held to a practical minimum.
4. The rear tank section shall be mounted as low as would be practical, in keeping with weight distribution and structural requirements.
5. MC 306 tanks (as defined in the Code of Federal Regulations specifications for shipping containers, Section 178.340-1) are to have an oval pattern and manholes and vents according to the requirements set forth for structural strength and venting in the next section in this paper, Motor Carrier Regulation Changes.
6. The design outage for liquid tanks is not to exceed 5 percent.
7. The tank shall be mounted as low as would be practical, with a tapered or drop section design to lower the center of gravity.
8. Reflective material shall effectively outline the semitrailer when viewed from the rear or either side and side-mounted turn signals would be provided.

Minimum Shell Thickness

The minimum shell and head thickness shall be governed by Section 178.341-2 (Thickness of shells, heads, bulkheads, and baffler) for MC 306 tanks and Section 178.342-2 for MC-307 tanks, except minimum thicknesses shall be as follows. For tanks with gross combination weights from 80,000 lb to 86,000 lb, the minimum thickness for mild steel shall be 11 gauge for high-speed low-alloy and stainless steel 12 gauge, and 0.173 in. for aluminum (versus the current 0.151-in. aluminum that is typical). (Note that some states allow higher loads on state roads

without safety-related restrictions. To encourage the low-profile design in these areas, gross weight limits should be adjusted upward proportionately.)

Weight Restrictions

Only semitrailers for bulk materials transport that meet the design restrictions and minimum shell thicknesses set forth in the preceding two subsections are limited to the following maximum gross weights. For a tri-axle semitrailer that burdens the front steering axle of the three-axle tractor to no more than 10,000 lb: 86,000 lb maximum gross with 51-ft (instead of 53-ft) bridge for the entire six-axle group. The five-axle group, consisting of the tractor tandem plus the semitrailer tri-axle, shall be allowed 76,000-lb gross in 38 ft instead of 45 ft, referencing the federal bridge law table.

Motor Carrier Regulations Changes

Structural Strength Requirements

Revise the structural strength requirement for MC 306 (flammable liquids) tank manholes from 9 psig to 30 psig minimum. The requirement shall be:

> Paragraph 178.341-3. Closures for fill openings and manholes.
> (a) ...They shall have structural capability of withstanding internal fluid pressures of 30 psig without permanent deformation....

Venting Requirements

Revise the normal venting requirements to require "tight" rather than "breather" vents by calling for a minimum opening pressure as well as a maximum pressure and to require better rollover closure.

> Section 178.341-4. Vents.
> (b) Normal venting. ...All pressure vents shall be set to open at no less than 0.650 psig (18" water column) and no more than 1.0 psig (27.7" water column) and all vacuum vents at no less than 3.47 ounces per square inch (6" water column) and no more than 6 ounces per square inch (10.39) water column). Pressure and vacuum vents shall be designed to prevent loss of liquid through the vent in case the vehicle is rolled through an angle of 30 degrees or more from an upright position.

Conclusion

These revisions reflect the current capability of manhole and vent assemblies, and meet the recommendations of the report to the Bureau of Motor Carrier Safety. An additional benefit will be the reduction in vapor loss from tanks in transit.

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