SAFETY IMPLICATIONS OF ALLOWING TRUCKS WITH GROSS WEIGHT OF 6,501/10,000 POUNDS TO DRIVE 55 MPH ON NON-LIMITED ACCESS HIGHWAYS OF LESS THAN FOUR LANES

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY OF FINDINGS

(1) A 6,501/10,000 pound truck can stop in a shorter distance when traveling at 45 mph than at 55 mph. Persons who believe that lower speed limits save lives because drivers are better able to control their vehicles offer no resistance to such lower speed limits. However, the objection to Code of Virginia § 46.1-193(1) (c) arises because it imposes a lower speed limit upon a specific class of vehicles, rather than upon all vehicles.

(2) A 1963 study[3/] indicated that passenger cars did not greatly differ from 5,000-10,000 pound trucks in their average braking capabilities at 20 mph. The latest study on the subject, the results of which have not yet been released, indicates this difference may be significantly greater today. The latest study, if the preliminary figures are verified, would seem to indicate that a significant "ability-to-stop" difference does exist between cars and light trucks, with trucks requiring about 27% more stopping distance. The preliminary nature of these findings is emphasized.

(3) Virginia's speed restrictions are among the most stringent in the country. More than twenty states follow the Uniform Vehicle Code guidelines and do not differentiate between cars and trucks in their statutory speed limits; state highway commissions are merely authorized to differentiate speed limits for certain types of vehicles on certain highways after appropriate administrative determination. This approach seems to be the trend. For example, North Carolina, in 1974, repealed its law which required trucks over one-ton rated capacity to travel at or below 45 mph on open highways. The one-ton rated capacity class probably encompasses many of the trucks to be found in Virginia's 6,501/10,00 registered gross vehicle weight category.

(4) For the states that maintain a speed differential for trucks above a certain class, the trend is clearly toward increasing the weight limit at which the lower speed limits apply. Virginia's 6,500 pound registered gross weight limit for "light" trucks ranks as one of the lowest.

(5) The Virginia speed limit of 45 mph for trucks on open highways is itself higher than only that for West Virginia, which is a 40 mph speed limit at 8,000 pounds registered gross weight; the Virginia speed limit is matched only by Wisconsin, (which has a 45 mph speed limit on county trunk highways for commercial vehicles having a gross weight of more than 10,000 pounds).

Other states having differential speed limits, Tennessee for example, allow trucks to travel at least 50 mph on open highways.

(6) Raising the speed limit for properly loaded smaller trucks not exceeding 10,000 pounds gross vehicle weight may be doing little more than reflecting the actual situation on the highways today. As an Indiana commentator observed in 1967, "The recent change in Indiana speed limits for trucks so as to provide for no differential between cars and trucks of any weight is shown to be reality."1/

RECOMMENDATION

A 1963 study by Tignor indicated that the stopping ability of a 5,000-10,000 pound truck is not significantly different from that of a passenger car, particularly when the advantage of the higher eye level of the truck driver is considered. Furthermore, Virginia's current statutes concerning differential speed limits for trucks and cars clearly do not represent the modern trend as evidenced in the Uniform Vehicle Code or even the majority position. Also, as a practical matter, there is a question as to whether the drivers of 6,501-10,000 pound registered weight trucks rigidly obey the differential speed laws.

These observations do not necessarily lead to the conclusion that the current Virginia statutes should be modified, however. The linchpin to the argument for changing the speed limits for trucks of 6,501-10,000 pounds registered gross vehicle weight should involve the finding that trucks of this size do not significantly differ from cars in their ability to operate on Virginia highways rather than the fact that laws of other states differ from the Virginia laws. A Bureau of Motor Carrier Safety study, when released, may show that today the stopping ability of a 5,000-10,000 pound truck is significantly different from that of a passenger car. Until this study has been released or other tests conducted, changing the current statutory provisions would appear premature.

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INTRODUCTION

During the 1974 license year, slightly more than 15% of the trucks registered in accordance with § 46.1-154 of the Code of Virginia were registered and licensed to operate with a gross weight greater than 6,500 pounds but less than 10,000 pounds. These trucks, 75,777 in number, were limited by § 46.1-193(1)(c) of the Code to a speed of 45 mph on non-limited access highways of less than four lanes while identical trucks registered for gross weights less than 6,500 pounds were allowed to travel these same highways at 55 mph. Here the speed limit for a truck is determined by the voluntary declaration made when the truck is licensed and registered, and there is a question as to whether persuasive reasons exist for maintaining this differential. The following provisions of the Code of Virginia serve as the basis for the discussion of the subject presented in this report.

§46.1-1(20) (a) — Definition of Pickup Truck

". . . motor vehicle designed for the transportation of property with a registered gross weight of six thousand five hundred pounds or less."

§ 46.1-154 — Fees For Vehicles Not Designed or Used For Transportation of Passengers

§ 46.1-193(1) (c) — Maximum Speed Limits on Non-Limited Access Highways of Less Than Four Lanes

"The maximum and minimum speed limits on highways of this State shall be as hereinafter prescribed.

(1) Maximum Limits . . .

(c) Fifty-five miles per hour on highways not included in (a) [limited access highways with divided roadways] or (b) [non-limited access highways having four or more lanes] if the

vehicle is a passenger motor vehicle, passenger bus, United States post office bus, pickup or panel truck or a motorcycle; and forty-five miles per hour on such highways if the vehicle is a truck, road tractor, tractor truck, or combination of vehicles designed to transport property or is a motor vehicle being used to tow a vehicle designed for self-propulsion, or a house trailer. . . ."

EMPIRICAL ANALYSIS

Most passenger vehicles on the highways today weigh from 3,000 pounds to 5,000 pounds. This weight range describes the empty weight of the 1/2-ton and 3/4-ton pickup trucks marketed by the major manufacturers. Given this similarity in the weights of passenger vehicles and empty pickup trucks, is the current Virginia highway speed differential for trucks (over 6,500 pounds registered gross weight) justifiable if the truck's load conforms to its manufacturer's recommendation? Do convincing reasons exist for differentiating between the speed of a vehicle loaded with passengers to a gross weight of more than 5,000 pounds and the speed of a truck properly loaded, within the manufacturer's recommended load specification, which weighs more than 6,500 pounds but less than 10,000 pounds?

One argument for maintaining the speed limit differential is that a truck cannot be stopped as rapidly as a lighter car in an emergency situation. Indeed, "braking distance for a loaded truck is known to be greater than for passenger cars."[2/] The braking distances for passenger cars and trucks of various weights were tested in Tignor's 1963 field study.[3/] This study, conducted in Maryland, Michigan, and California, involved selecting vehicles at random from the general traffic and requesting driver participation in the stopping distance test. Each driver was informed that the tests were voluntary and that no punitive action would be taken regardless of vehicle condition and performance.

The test consisted of a locked-wheel stop from 20 mph; the distance measured was that traveled during application of the brakes. The locked-wheel test is probably appropriate as most drivers lock wheels during emergency stops.[4/] The measurement of the stopping distance for the passenger cars and trucks of various sizes showed marked similarity between the stopping distances of the passenger cars and two-axle trucks of 5,000-10,000 pounds gross vehicle weight. The average brake system application and braking distance for all the passenger cars tested was 19.7 feet (95% confidence interval 19.5-19.9 feet) and the corresponding average for the two-axle trucks of 5,000-10,000 pounds gross vehicle weight was 22.4 feet (95% confidence interval 21.5-23.3 feet).

These 1963 tests showed an improvement in the braking performance of the very light trucks (5,000-10,000 pounds) over that found in similar tests conducted in 1955; the 1955 average brake system application and braking distance from 20 mph was 26 feet for the same type truck.[5/] This decrease in the 1963 test results may not be as dramatic as would appear at first glance because the average weights of the 5,000-10,000 pound weight class of very light trucks tested differed in the 1955 and 1963 tests. Indeed, Tignor noted, "Part of the variation in average weight can be

explained by the chance selection of vehicles to be tested. However, part of the variation in weight also can be attributed to operators of commercial vehicles changing from use of one type of vehicle to another for economic reasons."6/

This improvement in braking performance for the 5,000-10,000 pound truck between 1955 and 1963, when coupled with the similarity between the brake system application and braking distance results for the cars and trucks in the 1963 tests at 20 mph, might lead to the conclusion that today the very light trucks and passenger cars are not significantly different in their ability to stop from higher speeds. This assertion could be strengthened by the fact that "it is general knowledge that trucks have a greater total height and a higher height of driver's eye than do passenger cars."7/ Conceding that the heavier truck will require a greater distance to stop once the brakes have been applied, the truck driver's ability to see farther ahead gives him the advantage in determining that a stop is needed.

However, preliminary results of a Bureau of Motor Carrier Safety study indicate that the braking performance of motor vehicles of the type tested in the Tignor study has worsened since 1963. Indications are that the average braking system application and braking distance for the passenger cars tested is approximately 22.8 feet (compared with 19.7 in 1963) and the distance for trucks of 5,000-10,000 pounds is approximately 29 feet (compared with 22.4 feet in 1963). This increased difference between car and very light truck stopping capabilities would seem to indicate that perhaps there is a significant "ability to stop" differential between cars and this weight class of trucks at higher speeds which cannot be compensated for by the truck driver's ability to see farther ahead. To be emphasized, however, is the fact that the figures cited in the latest study are preliminary figures only; the final report will not be distributed for several months. The citation of the report is made only to indicate that results from the latest study may differ significantly from Tignor's findings.

The Bureau of Motor Carrier Safety study, when released, could provide key information necessary to evaluate the propriety of changing Virginia's differential speed limit laws.

STATUTES OF OTHER STATES

In examining the differences among the state treatments of maximum speed limits for specific classes of trucks on certain of the state highways, reference is made to Appendix 1 of this report. This Appendix serves as an outline of the major breakpoints above which differential speed limits are imposed. The reader is urged to examine this outline before and after the reading of this section to gain a clear understanding of the state statutes excerpted below.

Approximately one-half of the states restrict the maximum speeds of specific light trucks on certain of their highways. The methods for determining which trucks shall be bound by the lower speed limit are varied, but may be differentiated according to:

(A) truck gross weight,

(B) truck empty weight,

(C) maximum gross weight for which truck is licensed or registered,

(D) manufacturer's rated capacity, and

(E) miscellaneous considerations.

During the past two years the effect of differential state statutes has been minimized by the passage of state laws or by the issuance of executive orders mandating the 55 mph speed limit. Nevertheless, the fact that a significant number of states have deemed these differential laws necessary provides a broad base from which to analyze the need for the present Virginia legislation.

As might be expected, laws which set different maximum lawful speeds of different types of vehicles have raised constitutional questions. The differential treatment has been justified on the basis that certain vehicles are sufficiently different from other vehicles because of their power, weight, physical characteristics, etc. to justify the differential treatment. The state may regulate the speeds of these vehicles because such regulation bears a real and substantial relationship to the public health or safety, or some other phase of the public welfare. "Equal Protection" analysis in this case requires only that all members of the same class be treated alike. See People v. Sisk, 297 Ill. 314, 130 N.E. 696 (1921); State v. Bennor, 6 N. C. App. 188, 169 S. E. 2d 393 (1969).

Compilation of Selected Statutes by Method of Differentiation

A. Truck gross weight

1. Five Thousand Pounds

(a) Iowa

Iowa Code Ann. § 321.286 sets the maximum speed for a freight-carrying vehicle with a gross weight of more than 5,000 pounds at 55 mph on primary roads and 50 mph on secondary roads. This limit compares with 70 mph (day)/60 mph (night) on primary roads and 60 (day)/ 50 (night) on secondary roads for vehicles not weighing more than 5,000 pounds.

(b) Michigan

Michigan Stat. Ann. § 257.627(e) limits a truck with a gross weight, loaded or unloaded, in excess of 5,000 pounds to a speed of 55 mph on highways and streets; this maximum can be reduced to 35 mph during the period when reduced loads are being enforced.

(c) South Dakota

South Dakota Comp. Laws § 32-25-1 considers a truck a passenger car for the purpose of determining maximum speed limits if (i) less than 83 inches wide, (ii) no projection above height of cab, and (iii) total weight does not exceed 5,000 pounds.

§ 32-25-11.2 contains South Dakota's 55 mph maximum set after the onset of the energy crisis.

South Dakota's statutes also contain authorization for the State Highway Commission, after appropriate determinations, to establish maximum speed limits for vehicles with a gross weight greater than 10,000 pounds (§ 32-25-6). Many states have provisions allowing a state agency to regulate maximum speed limits according to vehicle type under certain conditions; South Dakota is noteworthy because its legislation specifies precisely the weight of vehicles which may be regulated.

2. Eight Thousand Pounds

(a) Florida

Florida Stat. § 317.221 sets the maximum speed limit for passenger cars and trucks with a gross weight of less than 8,000 pounds at 60 (day)/55 (night) on open highways that are not interstate and do not contain four lanes with a median. The maximum allowable speed on these highways for trucks exceeding 8,000 pounds is 60/55. Section 317.821 authorizes the appropriate state officials to lower speed limits for vehicles according to weight.

(b) Illinois

Illinois Ann. Stat. Ch. 95½, § 11-601 sets a maximum speed for trucks "designed or used for the carrying of a gross weight of less than 8,000 pounds (including the weight of the vehicle and the maximum load)" at 65 mph [temporarily reduced to 55 mph] on highways outside an urban district; the corresponding limit for trucks exceeding the weight specifications is 50 mph. Note the "designed or used" language here.

(c) Montana

Montana Rev. Codes Ann. § 32-2148 states that "no person shall operate any truck with a gross weight in excess of 8,000 pounds at a speed greater than 60 mph on completed sections of primary and secondary highways"; the truck nighttime speed limit is the same as that for autos and lighter trucks.

(d) Oregon

Oregon Rev. Stat. § 483.116 sets the maximum speed for trucks at 50 mph on open highways; passenger cars have a maximum speed on these highways of 55 mph. A "truck" is defined as a vehicle designed for carrying cargo or freight which has a gross weight in excess of 8,000 pounds. The weight cutoff in Oregon had previously been 6,000 pounds; this change represents yet another state's increasing of the weight at which truck speed limits apply.

3. Ten Thousand Pounds

(a) Georgia

Georgia Code Ann. § 68-1626 sets the maximum speed for trucks with a gross weight of less than 10,000 pounds at 55 mph, the same maximum as for cars. This legislation is related to the Federal Emergency Highway Energy Conservation Act.

Several years ago, Georgia repealed a law containing various speed limits for trucks in three different gross weight categories on all highways!

(b) Nebraska

Nebraska Rev. Stat. § 39-662 lists a speed limit on open highways for cars and trucks with a gross weight of less than 10,000 pounds at 65 mph; the limit for these vehicles on non-hard surface roads is 50 mph. Section 39-666 permits trucks exceeding the 10,000 pound gross weight limit to travel at the same speeds on these roads, with the exception that a nighttime speed limit of 60 mph is imposed on these heavier trucks on "other hard surface" state roads. Section 39-663 permits the Department of Roads to set different speed limits according to different types of vehicles.

(c) Wisconsin

Wisconsin Stat. Ann. § 346.58 sets a 55 mph speed limit, except 45 mph on town roads and county trunk highways, for any commercial vehicle, except motor buses, having a gross weight of more than 10,000 pounds. Wisconsin is thus one of the few states which retains a 45 mph speed limit similar to that set forth in § 46.1-193(1) (c) of the Code of Virginia.

B. Truck Empty Weight

1. Four Thousand Pounds

(a) Ohio

Ohio Rev. Code Ann. § 4511.21 lists 50 mph as the maximum speed allowed on highways outside municipal corporations by operators of trucks weighing in excess of 4,000 pounds empty weight. Cars and trucks with a lesser weight are limited to 60 (day)/ 50 (night) on these same highways.

C. Maximum Gross Weight For Which Truck Is Licensed or Registered

1. Six Thousand Five Hundred Pounds

(a) Virginia

Code of Virginia §§ 46.1-193(1) (c) and 46.1-1(20) (a)

2. Eight Thousand Pounds

(a) West Virginia

West Virginia Code Ann. § 17C-6-1 provides a maximum 55 mph speed limit for cars on open country highways. Section 17C-6-4 sets the speed limit for trucks on these same highways at 40 mph, trucks licensed at 8,000 pounds gross vehicle weight or less being permitted the same speed as passenger cars. West Virginia's truck speed limit on highways of this type was the lowest found, being 5 mph below Virginia's unusually low speed limit for non-limited access highways.

3. Nine Thousand Pounds

(a) Pennsylvania

Pennsylvania Stat. Ann. Tit. 75, § 1002 sets the maximum speed limit for commercial motor vehicles or truck tractors with a registered gross weight of up to 9,000 pounds at 55 mph except where a greater speed is authorized under the act for passenger motor vehicles; if authorized, the speed for commercial motor vehicles not exceeding 9,000 pounds registered gross weight is the same as for passenger cars.

Pennsylvania previously had a statute which equated passenger cars with commercial vehicles registered for 7,000 pounds gross weight or less for the purpose of determining speed limits. Pennsylvania's increasing of the weight limits for these commercial vehicles closely parallels the Virginia proposal to differentiate pickup trucks only if the registered gross weight is more than 10,000 pounds.

4. Ten Thousand Pounds

(a) New Jersey

New Jersey Rev. Stat. § 39:4-98.1 allows the State Highway Commission to designate lower maximum speed limit for trucks with a registered gross weight of 10,000 pounds or over. This authorization does not include, however, highways of less than four lanes.

5. Twelve Thousand Pounds

(a) Kansas

Kansas Stat. Ann. § 8-1558 sets the maximum speed on open roads at 60 mph (subject to 55 mph override for energy legislation) for trucks licensed for a gross weight of more than 12,000 pounds. Kansas in the past several years has increased the weight levels at which truck maximum speeds first attach.

(b) Missouri

Missouri Ann. Statutes § 304.010 states that no truck registered for a gross weight of greater than 12,000 pounds shall be operated at any time in excess of 50 mph. This weight limit for trucks was recently raised from 9,000 pounds registered gross weight.

D. Manufacturer's Rated Capacity

1. Three-Quarter Ton

(a) Alabama

Alabama Code Tit. 36, § 5 (1) provides that pickup trucks of a manufacturer's rated capacity of 3/4 ton or less are restricted to a maximum daytime speed of

60 mph and a maximum nighttime speed of 50 mph on open highways; pickup trucks with a rated capacity greater than 3/4 ton may not travel at a speed greater than 50 mph on these highways.

2. One Ton

(a) Texas

Texas Rev. Civ. Stat. Art. 6701d, § 166(a) provides a 60 (day)/55 (night) limit for any truck on open highways, except light trucks. A "light truck" is defined to mean "any truck with a manufacturers' rated carrying capacity not exceeding two thousand pounds and is intended to include those trucks commonly known as pickup trucks, panel delivery trucks, and carry-all trucks." The speed limit for these light trucks is the same as for passenger cars. Section 169B, comparable to provisions of other states, lowers the maximum speeds for all vehicles to 55 mph.

3. One and One-Half Tons

(a) Arkansas

Arkansas Stat. Ann. § 75-601 sets a 50 mph maximum for trucks of 1½ ton capacity or more on non-controlled access highways. Arkansas formerly had a statutory plan imposing differential speed limits according to the tonnage the truck carried and whether or not the truck had brakes on all wheels. The current statutory language containing only one breakpoint (1½ ton) would seem much more workable because of its simplicity.

(b) Tennessee

Tennessee Code Ann. § 59-852 (a) established a 65 mph maximum for cars (reduced to 55 mph by Section 59-852 (g))on open highways. The speed limit for trucks on these highways is 50 mph. "Truck" is defined as any motor vehicle of 1½ ton rated capacity or more.

E. Miscellaneous Considerations

1. Commercial Motor Vehicles

(a) Connecticut

Connecticut Gen. Stat. Ann. § 14-219 limits the speed of commercial motor vehicles operated on open highways to 55 mph.

2. Motor Trucks

(a) Kentucky

Kentucky Rev. Stat. Ann. § 189.390 sets a 50 mph speed limit for motor trucks and semitrailer trucks on open highways.

3. Freight-Carrying Vehicles

(a) Louisiana

Louisiana Rev. Stat. Ann. § 32.62 limits the speed of a freight-carrying vehicle to 50 mph on open highways.

4. Overloaded Pickup Trucks

(a) Mississippi

Mississippi Code Ann. § 63-3-501 states that "pickup trucks which are not overloaded shall be treated, for purposes of determining maximum speed limits, as private passenger cars."

The speed limit for trucks is 50 mph on open highways; in good weather the corresponding maximum for cars is 65 mph (reduced to 55 mph by Section 63-3-511)

5. Three-Quarter Ton Truck Hauling Livestock

(a) Oklahoma

Oklahoma Stat. Ann. Tit. 47, § 11-801 sets the maximum allowable speed for cars on the open highway at 65 mph (day)/ 55 mph (night). The same section specifies that pickup trucks carrying livestock

and trucks are limited to a maximum speed of 60 mph (day)/55 mph (night). "Pickup truck" applies to all vehicles having a rated load capacity of 3/4 ton or less. Oklahoma currently has 55 mph energy conservation legislation in effect.

F. Some Recent Statutory Changes

Massachusetts in 1972 imposed a speed limit for vehicles with a gross weight greater than 10,000 pounds at 5 mph below the speed limits for other vehicles on limited access and divided highways; this enactment was repealed in 1974. (Massachusetts Ann. Laws Chapter 90, § 17.)

North Carolina in 1974 repealed a statute which prohibited trucks with a rated capacity of one ton or over from traveling on open highways at a speed in excess of 45 mph. Lighter trucks and cars had been allowed to travel at 55 mph on these highways. The 1974 law equalized the speeds at 55 mph. (North Carolina Gen. Statutes § 20-141.)

New Mexico in 1973 deleted a provision which set a maximum speed of "60 mph on all highways for trucks of a rated capacity over two tons." (New Mexico Stat. Ann. § 64-18-1.1.)

The trend in the area of regulation of speeds of light trucks seems to be toward either increasing the weight of the vehicle at which the differential limit first applies or entirely abolishing the differential. More than 20 states have no statutory differences among the maximum speed allowed for different types of trucks; many of the state codes, however, contain specific authorization for the Highway Commission (or a comparable agency) to set different speed limits for different vehicle types.

G. Uniform Vehicle Code

Appendix 2 sets forth the provisions of the Uniform Vehicle Code which deal with the issue of maximum speeds for trucks. The Code, in §§ 11-801 and 11-801.1, does not generally specify limits based on the type, size, or use of the vehicle, leaving such differentiation to administrative determination under UVC §§ 11-802 and 11-803. Thus states abolishing the differentiation among speed limits for different types of trucks are moving to conformity with the Uniform Vehicle Code's guidelines.

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5. Petring, F. W., "Stopping Ability of Motor Vehicles Selected From the General Traffic," Public Roads, Vol. 29, No. 8, June 1956.

6. Tignor, op. cit., p. 77.

7. Loutzenheiser and Haile, op. cit., p. 8.

APPENDIX 1

SUMMATION OF STATES WHICH DIFFERENTIATE BETWEEN MAXIMUM SPEED LIMITS OF PASSENGER CARS AND SPECIFIC TYPES OF TRUCKS ON CERTAIN STATE HIGHWAYS

Type of Differentiation	Weight Above Which Differential Applies
A. According to Truck Gross Weight	
Iowa	5,000 pounds
Michigan	5,000 pounds
South Dakota	5,000 pounds*
Florida	8,000 pounds
Illinois	8,000 pounds**
Montana	8,000 pounds
Oregon	8,000 pounds
Georgia	10,000 pounds
Nebraska	10,000 pounds
Wisconsin	10,000 pounds (commercial vehicles)
B. According to Truck Empty Weight	
Ohio	4,000 pounds
C. According to Maximum Gross Weight For Which Truck is Licensed or Registered	
Virginia	6,500 pounds
West Virginia	8,000 pounds
Pennsylvania	9,000 pounds (commercial vehicles)
New Jersey	10,000 pounds (highways of four lanes or more)
Kansas	12,000 pounds
Missouri	12,000 pounds

*South Dakota also has specific statutory language which allows the State Highway Commission to establish maximum speed limits for vehicles exceeding 10,000 pounds gross weight. South Dakota Comp. Laws § 32-25-6.

**The Illinois law differentiates the speed limit for "any vehicle of the first division [includes cars] or a vehicle of the second division [includes trucks] designed or used for the carrying of a gross weight of less than 8,000 pounds (including the weight of the vehicle and maximum load). . ." Illinois Ann. Stat. Ch. 95½, § 11-601.

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D. According to Manufacturer's Rated Capacity

Alabama	3/4 ton
Texas	1 ton
Arkansas	1½ ton
Tennessee	1½ ton

E. Miscellaneous

Connecticut	Commercial vehicle
Kentucky	Motor trucks
Louisiana	Freight-carrying vehicles
Mississippi	Overloaded pickup trucks
Oklahoma	3/4 ton pickup truck hauling livestock

APPENDIX 2

Uniform Vehicle Code

§ 11-801 — Basic Rule

No person shall drive a vehicle at a speed greater than is reasonable and prudent under the conditions and having regard to the actual and potential hazards then existing. Consistent with the foregoing, every person shall drive at a safe and appropriate speed when approaching and crossing an intersection or railroad grade crossing, when approaching and going around a curve, when approaching a hill crest, when traveling upon any narrow or winding roadway, and when special hazards exist with respect to pedestrians or other traffic or by reason of weather or highway conditions. (Revised, 1968).

§ 11-803 — When Local Authorities May and Shall Alter Maximum Limits

(a) Whenever local authorities in their respective jurisdictions determine on the basis of an engineering and traffic investigation that the maximum speed permitted under this article is greater or less than is reasonable and safe under the conditions found to exist upon a highway or part of a highway, the local authority may determine and declare a reasonable and safe maximum limit thereon which

1. Decreases the limit at intersections; or
2. Increases the limit within an urban district but not to more than 60 miles per hour during daytime or 55 miles per hour during nighttime; or
3. Decreases the limit outside an urban district, but not to less than 35 miles per hour.

(b) Local authorities in their respective jurisdictions shall determine by an engineering and traffic investigation the proper maximum speed for all arterial streets and shall declare a reasonable and safe maximum limit thereon which may be greater or less than the maximum speed permitted under this act for an urban district.

(c) Any altered limit established as hereinabove authorized shall be effective at all times or during hours of darkness or at other times as may be determined when appropriate signs giving notice thereof are erected upon such street or highway.

(d) Any alteration of maximum limits on State highways or extensions thereof in a municipality by local authorities shall not be effective until such alteration has been approved by the (State highway commission).

§ 11-802 — Establishment of State Speed Zones

Whenever the (State highway commission) shall determine upon the basis of an engineering and traffic investigation that any maximum speed hereinbefore set forth is greater or less than is reasonable or safe under the conditions found to exist at any intersection or other place or upon any part of the State highway system, said (commission) may determine and declare a reasonable and safe maximum limit thereat, which shall be effective when appropriate signs giving notice thereof are erected. Such a maximum speed limit may be declared to be effective at all times or at such times as are indicated upon the said signs; and different limits may be established for different times of day, different types of vehicles, varying weather conditions, and other factors bearing on safe speeds, which shall be effective when posted upon appropriate fixed or variable signs. (Revised, 1962).

§ 11-801.1 — Maximum Limits

Except when a special hazard exists that requires lower speed for compliance with § 11-801, the limits hereinafter specified or established as hereinafter authorized shall be maximum lawful speeds, and no person shall drive a vehicle at a speed in excess of such maximum limits. (Revised, 1968).

1. Thirty miles per hour in any urban district;
2. Sixty miles per hour in other locations during the daytime;
3. Fifty-five miles per hour in such other locations during the nighttime.

Daytime means from a half hour before sunrise to a half hour after sunset. Nighttime means at any other hour.

The maximum speed limits set forth in this section may be altered as authorized in §§ 11-802 and 11-803.

A RESPONSE TO CRITICISMS OF THE 1971 VIRGINIA STUDY OF REFLECTORIZED LICENSE PLATES

by

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Prepared by the Virginia Highway and Transportation Research Council Under the Sponsorship of the Highway Safety Division of Virginia

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BACKGROUND

A number of states use reflectorized license plates as a safety countermeasure for the reduction of nighttime rear-end collisions. In 1970 the issue of whether to adopt the use of these plates was presented to the Virginia General Assembly for consideration. In an effort to resolve questions concerning the benefits of reflective plates a study was authorized to be carried out in Virginia [Virginia Code Annotated Sect. 46.1-103.1 (1970)].

This study was a cooperative effort of four state agencies. The Division of Motor Vehicles had the responsibility for determining the cost of implementing a reflectorization program and the Department of State Police conducted the original analysis of rear-end accident data. The Highway Safety Division's part of the study was the design of the license plate distribution plan to be used for the study and the comparative analysis of the legibility and visibility of reflectorized and enamel license plates. The Highway and Transportation Research Council performed the phases of the study that were the responsibility of the Safety Division.

A report consolidating the findings of the three phases of the study (costs, accident reduction, and legibility/visibility tests) was made to the Governor and General Assembly in January 1972. The recommendation of the three-man committee heading up the study teams was that Virginia not "require the use of reflectorized license plates until such time as they have been proven beneficial to highway safety." [1/]

Subsequent to the above recommendation, the Research Council was asked to undertake an analysis of the accident data which had been collected. This analysis was carried out and the results, which substantiated the original State Police findings, were published in January 1974. [2/] In summary, the analysis revealed no evidence that a difference existed in the number of rear-end and parked nighttime collisions of vehicles equipped with the reflectorized plates when compared with vehicles equipped with control non-reflective license plates.

The significance of the finding of no difference between the two groups led to the presentation of the study at the fifty-third annual meeting of the Transportation Research Board. Apparently because of the uniqueness of the "no difference" finding, as well as the strong commercial interest in reflective sheeting, the validity of this finding has been questioned.

DISCUSSION

Criticisms directed at the study "Reflectorized License Plates: Do They Reduce Nighttime Rear-End Collisions?" are primarily contained in two documents. [3,4/] Most of these criticisms follow similar lines. These consultants show no flaws in the Virginia collision reduction study that would alter the conclusion, but raise several points that

deserve discussion. The following discussion will present a brief statement of the criticism(s) made, note the source, and respond to each

(1) The study design is inadequate. Kleinknecht and Hicks

Kleinknecht and Hicks have given their paper a title designed to question the strength of the experimental design of the Virginia study, but in their report they say, "our criticism of the Virginia study is not [emphasis added] related to the choice of experimental design for we believe that choice to be quite proper." 5/ Elsewhere they state that the "conclusions of the Virginia study resulted from an erroneous interpretation of the accident data." 6/ They base this statement on the following areas:

(a) The Virginia study used a two-tailed test of significance rather than a one-tailed test.

Despite the relative ease with which Kleinknecht and Hicks assert their case, there is serious debate among statisticians about the use of the two-tail vs. the one-tail test. The one-tail test was not used in Virginia because it allows for a statistical treatment of only one of the possible outcomes while the two-tailed test permits a determination of the merits of more than one outcome. In comparing "A" (the number of accidents of vehicles with reflectorized plates) with "B" (the number of accidents of vehicles with control plates) there are three possible findings: (1) the number for A is greater than that for B and therefore collisions were not reduced, (2) the numbers for A and B are not different and a reduction in collisions did not occur, and (3) the number for A is less than that for B and therefore reflectorization is beneficial because of the reduction.

Just because one concludes that reflectorized license plates should not cause collisions is not sufficient reason to ignore the fact that automobiles with these plates may be involved in more collisions than automobiles with control non-reflective license plates. One first has to determine if a difference exists and then see if it is beneficial. It is incorrect to automatically assume that there will be only benefits.

(b) The Virginia study used a .05 significance level, which is too severe a test for the sample size used.

Kleinknecht and Hicks, using the Virginia study findings and declaring one figure as the normal rate, work backwards and develop figures (see Appendix A) dealing with power, sample size, and significance levels. These tables, along with discussions of Type I (accept a false hypothesis) and Type II (reject a true hypothesis) errors, form the bases for their second position.

They developed the figures presented in their Table 3 using cost estimates for materials and costs assigned to accidents. The material costs used by these consultants were very different from the costs developed by the Virginia Division of Motor Vehicles. 7/ In the Virginia study, the author chose to use cost data developed by the state rather than the arbitrary pennies a day designation of costs frequently cited by the 3M Company and used by Kleinknecht and Hicks.

The investigators who conducted the Virginia study and these consultants both used National Safety Council figures for the cost of accidents in their analyses. In light of an article which reports on injuries to occupants in rear-end collisions even these figures may be too high. The University of Michigan Highway Safety Research Institute constructed a file of the entire set of 1972 Texas accident data and a 5% sample of the accident involved vehicles was analyzed. The authors found that "(1) injuries in rear-end crashes are less serious than those sustained in other vehicle-to-vehicle collisions, (2) Class "A", "B" and Fatal injuries [the serious types] are markedly underrepresented in rear-end crashes, and (3) 90% of all occupants of both vehicles were not injured in rear-end collisions." 8/

In their review of other relevant rear-end collision research, Huelke and Marsh found that fatalities were either nonexistent or extremely limited and that virtually all injuries that did occur were minor or not dangerous. Research is beginning to show that the value attached to losses associated with rear-end collisions is very low and certainly less than the NSC figure, which includes all accident types in the computation of an estimate. If this is the case, it would take even greater reductions in rear-end collisions to make a reflectorization program worthy of consideration.

Using material costs figures developed by the Division of Motor Vehicles and accident cost figures from the National Safety Council, the Kleinknecht and Hicks Table 3 must be completed to include a 5th column showing a reduction of 1,029 crashes. This reduction is based on the breakeven point between the additional costs for reflective materials and the NSC value associated with collisions.

Table 6 of the TRB paper presents data on the number by which crashes must be reduced before a significant statistical difference can be established. By extrapolating these figures to the total passenger vehicle population in Virginia, we can calculate the crash reduction required to show a benefit for such a reflectorization program to be 538-475=63x20=1260. A reduction of 63 crashes per 100,000 passenger vehicles is needed. A two million vehicle population was used for the calculation. A sixth column, 1260, may therefore be added to their Table 3.

Data based on either the breakeven point between material costs and accident costs or a reduction based on the collisions in the reflectorized group and that needed in the control group to be statistically different are absent from the table published by Kleinknecht and Hicks. When either figure, 1,029 or 1,260, is used the probability of a Type II error is materially changed from that found by using a difference of only 440 crashes.

A significant point in the interpretation of Table 3 in the Kleinknecht and Hicks paper is that cost assignments influence the probability of a Type II error, and these costs do NOT take into account the significance of alternate investment.

Kleinknecht and Hicks, using their Table 4 data, conclude that the Virginia study would need to have a sample size larger than the number of passenger vehicles in the state. This argument is both illogical and fallacious. It is illogical in that one can't have a part (sample) larger than the whole (population).

It is fallacious in that the vehicle population in Virginia is a finite number (i.e., has a limit) and the table should have been developed using the formula with a proper correction factor to take this circumstance into account.9/

There are several other factors to consider in determining what importance to attach to the numbers contained in Table 4. The study group sample size recommended by Kleinknecht and Hicks is based on a reduction of 440 crashes. They arrived at this figure by improperly assuming that the normal crash rate per 100,000 vehicles is 497. Yet the normal rate in unknown; what is known are the rates for the two study groups during the study period, and that these two rates do not differ statistically.

Using Division of Motor Vehicles and National Safety Council cost figures, a reduction of 1,029 crashes is needed before the two sets of cost figures balance each other. Even using the numbers presented in Kleinknecht and Hicks' Table 4, sample sizes of 100,000 vehicles are sufficiently large to determine a real accident reduction difference of 1,029 crashes at the .05 level of significance.

The Kleinknecht and Hicks position appears to be that an expenditure of nearly a million dollars per year for a reflectorization program would not be a serious error even if no benefit is derived. "Other than cause some grumbling among citizens, it is difficult to see how this error could be very detrimental to society."10/

(2) There are some significant discrepancies between State Police data and Stoke data. Hulbert and Burg

Kleinknecht and Hicks claim only that an erroneous interpretation of data was made. Hulbert and Burg imply that the Virginia State Police made tabulations for the 3M Company, subsequent to the publication of the Virginia study, with a difference in the figures somehow proving the Virginia study to be in error. The fact of the matter is that the Research Council became involved in an analysis of the reflectorized license plate data only after the recommendations were made to the Governor and General Assembly by the agencies who were studying the situation in Virginia. A member of the General Assembly suggested that "the State Police furnish the accident records to . . . the Highway Safety Division" and " . . .have the Highway Research Council . . . completely analyze and evaluate all the facts and figures . . .".11/

The State Police figures cited by Hulbert and Burg (see Appendix B) came from a report to John T. Hanna and Vern L. Hill from Colonel H. W. Burgess dated June 15, 1972, and included "all accident reports in house through June 14, 1972."12/ These figures were used by the three agencies — State Police, DMV, and Highway Safety Division— in recommending that Virginia not adopt reflectorized license plates. The figures were based upon the method chosen by the State Police to tabulate and analyze the crash frequencies of the two groups.

After the Research Council was requested to evaluate the crash data, a copy of the accident tape used by the Virginia Department of State Police for their study of reflective license plates was obtained, and a computer program was written to provide data on rear-end and parked car collisions at night. The influence of driver age, driver experience, vehicle age, and weather conditions on accidents was recorded. Only the primary collision and the vehicle struck were tabulated for this analysis. A draft report, based on these collision data, was prepared and reached a conclusion of no difference in the number of nighttime collisions between the study groups.

The 3M Company was provided a copy of this draft, and Robert Vanstrum of that company suggested that the analysis should also include daytime crash data. The Council accepted this suggestion and agreed to add a daytime analysis to the final report.

Because the Council systems analyst on the project had recently left the staff, the Department of State Police was requested to provide additional needed data and did so. The Council initially had been interested only in vehicles struck at night, but now was concerned with the total accident picture of vehicles in situations not possibly affected by reflective sheeting. The State Police was furnished a set of tables indicating a breakdown of the Council's data needs. These data included the total accident picture of the study groups, both striking and struck, for all of the standard crash types and directions of vehicle movement. The data furnished are found in Tables 2, 3, 4, 5, and 9 (see Appendix C) of the Virginia study. [13]

Both sets of figures discussed by Hulbert and Burg, i.e. total accident State Police data and total accident Stoke data, were obtained from the Virginia State Police. The tapes were processed at different times; the first in June 1972, the second in May 1973.

Several discussions have been held with representatives of the State Police in an attempt to discover the reason for the variation in the daytime control group data. Both sets of data include striking and struck vehicles, were taken from the same tapes, and by the same analyst. The specific reason for the difference has not been identified, but several explanations have been postulated. Among these are: (1) the tapes were updated subsequent to the report of June 14, 1972, (2) a stack of cards was missing prior to the completion of the tape, (3) there was a variation in the two programs, and (4) accident reports involving nighttime crashes were expedited for the first report.

One important factor which can be established from the presentation of the data by Hulbert and Burg is that there are no differences, in practical or statistical terms, in the nighttime data or in the reflectorized data. These are the two significant categories used for determining whether there was a reduction in nighttime rear-end collisions resulting from the use of reflective license plates.

(3) By use of arbitrary time periods some accidents which happened during dusk and dawn conditions are included in analyses. Hulbert and Burg

It is agreed that there is a possibility of a misclassification of a limited number of crashes. It is not felt that an influence on the results has occurred because time period category assignments were not made in a manner to systematically bias only one of the study groups. The time periods, although somewhat arbitrary, are unbiased in the categorization of vehicles from both study groups.

All data for the study were collected from accident report forms submitted to the state in the normal manner. It was only after the reports were received by the State Police that the control or reflectorized status was recorded. Both groups received identical treatment in the designation of day and night categories with regard to the time of crash.

The previously cited HSRI study of Texas accident data considered environmental factors. Two of their findings have application to the issue currently under discussion. They are: (1) "The Texas data indicate that the occurrence of rear-end collisions does not vary with the seasons, and (2) there are slight but insignificant differences in the occurrences of rear-end collisions under varying lighting conditions of dawn, daylight, dusk and dark (with and without street lights)." 14/ In light of these facts, it is believed that the criticism of the Virginia study based on the use of the designated time periods is largely without merit.

More driving, both in miles driven and number of vehicles, and more accidents occur during daylight hours when the prevailing lighting conditions are those for which no claim of an accident reduction benefit is made for reflectorized license plates. As the total numbers of accidents were similar for each group, if one daytime category is increased it automatically decreases the complementary nighttime category. An overcounting of daylight crashes in the reflectorized group would produce an error favorable to vehicles with reflectorized plates at night. This is the opposite of the effect claimed by Hulbert and Burg.

(4) Random distribution of the plates was not achieved and therefore the study groups are not representative of the statewide driving population. Kleinknech and Hicks, Hulbert and Burg

There is nothing presented in either of the critiques by the above authors to indicate that randomization was not accomplished. The only evidence cited is that cars with reflectorized license plates had more daytime collisions than cars with control non-reflective license plates. Because of this, the authors speculate that the experimental group had a higher risk factor than the control group.

Hulbert and Burg maintain that the author of the Virginia study "did not make any effort to confirm the effectiveness of their randomization. This could fairly easily have been accomplished by checking motor vehicle department files for the principal drivers of the vehicles in both groups, supplemented by a brief questionnaire or interview of each plate recipient." 15/ It is difficult to see how the conduct of 200,000 interviews could be more simple or more accurate than a statistical analysis of crash involvement data.

One purpose of testing observed differences between the groups for statistical significance is to test for the validity of the randomization process. The underlying mathematical principles of randomization are ones which yield representative samples of the population being studied. A finding of no difference in cases unaffected by reflectorization implies that randomization was accomplished. Hulbert and Burg do not present any evidence to support their contention that randomization was not accomplished, they only speculate that this could be the case.

In the Hulbert and Burg review of the Iowa and North Carolina studies, cases cited as showing the benefits of reflective plates, it is interesting to note a lack of concern for randomization and representative samples. 16/ However, in a study which does not show a benefit it becomes an issue. On this fact alone one might question the objectivity of the authors of the critiques under discussion.

(5) The study groups are not comparable. Hulbert and Burg

The 1971 Virginia reflectorized license plate report dealt with two issues: comparability and collision reduction. The first section of the analysis involved the issue of whether the two groups, reflectorized and control non-reflective, had comparable accident experiences in situations other than for the variables of parked and rear-end collisions at night. A variety of crash data, both striking and struck, were presented in the tables and appendixes for this section of the report.

The second issue studied was whether the reflectorized group experienced fewer rear-end and parked car collisions at night. The tables and appendixes presented in this section of the report, with the exception of Table 9, involve only vehicles which were struck. The findings of no difference between the groups on both of the above issues is by now well-known.

Crash data obtained from the State Police were presented in the first section of the report. Factors representing the influence of the vehicles, the roadway and the driver were analyzed. Comparisons were carried out for total daytime and nighttime crashes and total daytime and nighttime collisions. 17/ The type of crash and the direction of vehicle travel were included in the analyses.

In Table 1 below, the Virginia study data are aggregated and show the close comparison between the reflectorized and control non-reflective groups with respect to crash involvement. The table is arranged so that the most general data are at the top and become more specific as one proceeds through the categories.

Table 1

Comparability of Study Groups

Day Plus Night — Striking and Struck

Crash Type	Reflectorized	Control
All Crashes	8607	8534
Crashes involving another vehicle	7199	7172
Other crashes	1408	1362
Rear-end and parked collisions	3153	3045
Other collisions	4046	4127

If the two groups are equivalent they should have a similarity in these data categories. Both by observation and the statistical testing of the data presented in the table one can see the close comparability of the two groups.

It was suggested by Hulbert and Burg that an error was made by not including an analysis of accident free drivers. Reflectorized plates are advertised and sold as one mechanism to prevent nighttime rear-end collisions. If it is accidents we are concerned with, a check of the demographic characteristics of the accident free drivers does not provide information useful for answering the question of the reflective material's utility in preventing nighttime collisions.

The critics present no evidence to support their speculative remarks concerning comparability, while the study contains a number of tables to show that the groups do, in fact, have similar accident experiences in situations unaffected by reflective license plates and are therefore comparable.

(6) The report suffers from a lack of clarity. Hulbert and Burg

This criticism refers to one aspect of the Virginia study first pointed out in the Discussions section of the Transportation Research Board's publication of the study. It was acknowledged in the Closure that the report could have been clearer. Apparently the critics have their greatest difficulty in understanding where accident data involve all accidents and where only struck vehicle data were used.

The narratives in both the VHTRC and TRB reports indicate where accident involved vehicles, both striking and struck, are tabulated for analysis and where rear-end and parked vehicles, struck only, are used for analysis. It is unfortunate that the titles to the tables were not as clear as they could have been.

It also appears that the explanation in the TRB Closure concerning striking and struck has caused additional difficulties. The analysis of the data, as previously described, was divided into two sections. The first section, that dealing with group comparability, used both the most comprehensive data and the more specific data that were available. Both striking and struck crash data were presented in this section of the report. The section analyzing collision reduction used only the more specific data in all but one table. The data presented in this section of the report, with the exception of Table 9, involve only vehicles which were struck.

In Table 2 below, the striking/struck characteristics of the data analyzed in the two reports are shown. This table is arranged to show which data were used for analyzing the comparability of the groups and which data were used to analyze collision reduction. In the VHTRC report, Tables 2, 3, 4, 5, and 9 incorporate the combination of striking and struck data. Tables 6, 7, 8, 10, 11, 12, and all the appendixes present data from the primary collision and only the vehicle struck was tabulated. In the TRB paper, Table 1, 2 and the text table present the combination of striking and struck data, while Tables 3 through 10 use only data from the vehicle struck in the primary collision.

TABLE 2

STRIKING/STRUCK CHARACTERISTICS

Comparability Groups			
VHTRC Table No.	Data Used	TRB Table No.	Data Used
2	S & S*	1	S & S
3	S & S	2	S & S
4	S & S	3	PSO
5	S & S	4	PSO
6	PSO**	5	PSO
7	PSO		
Appendixes A-D	PSO		
Collision Reduction			
VHTRC Table No.	Data Used	TRB Table No.	Data Used
8	PSO	Text	S & S
9	S & S	6	PSO
10	PSO	7	PSO
11	PSO	8	PSO
12	PSO	9	PSO
Appendixes F-I	PSO	10	PSO

* S & S = All crash involved vehicles, both striking and struck.

** PSO = Primary collision, struck vehicle only.

(7) Results are in conflict with those of other studies. Kleinknecht and Hicks

One reason for conducting a study of reflectorized license plates in Virginia was because it was felt that flaws in previous studies prevented a clear decision on their effectiveness.

The use of a control vs. experimental group design, the collection of accident data for a full year, the use of relatively large samples, and the analysis of both crashes which would not be affected by reflective materials and crashes supposedly affected by reflective materials makes the Virginia study more comprehensive than previous research studies and the results more definitive.

(8) The conclusions are not supported by the full accident data available to the author. Kleinknecht and Hicks

This criticism is baffling in light of the data presented in the report. It is not clear from their narrative but it appears that the only data Kleinknecht and Hicks consider to be missing is the daytime equivalent of VHTRC Table 8 (see Appendix C). While it might have been nice, or even interesting, to have a table like the one suggested, there is no necessity for it. The study contains all of the data necessary to answer questions of comparability and collision reduction. It is stretching credibility to suggest that if the daytime table were available it would alter the conclusions reached.

Table 3 below presents additional data for the determination of comparability between the reflectorized and control non-reflective Virginia study groups. Data presented in Table 4 below are composite data dealing with the collision reduction aspects of reflective plates. These data, and those contained in the report of the Virginia study published by the VHTRC and TRB, show that: (1) the two groups had comparable accident experiences in situations not affected by reflective materials, and (2) the study groups also had comparable accident experiences on the criterion variables of parked and rear-end collisions at night. From these two findings, it was concluded that the use of reflectorized license plates did not produce a safety benefit through a statistically significant reduction in nighttime collisions.

Table 3

Comparability of Groups
Virginia Striking and Struck Data

Category	Reflectorized	Control
All crashes	8607	8534
Day crashes	6142	6103
Night crashes	2465	2431
All collisions	7199	7172
Day collisions	5447	5401
Night collisions	1752	1771

Table 4

Night Collision Reduction
Virginia Study Data

Category	Reflectorized	Control
Rear-end		
All collisions	472	477
Struck only	307	319
Parked		
All collisions	416	413
Struck only	168	178

The final report published by the VHTRC has eleven tables and nine appendixes which present data used to compare the accident experiences of the two study groups. Kleinknecht and Hicks choose to ignore 19 out of the 20 categories of data, while speculating over the contents of a table they consider to be missing. In light of their references to missing data, their decision to ignore the bulk of the data presented in the report is an indication of their lack of concern for a complete analysis.

(9) The data indicate that the plates were effective. Kleinknecht and Hicks

This statement apparently is based on Kleinknecht and Hicks' interpretation of the data presented in Table 8 of the VHTRC report. They treat the totals (475 vs. 497) as if the numbers are absolute accident rates which would not vary if the study was replicated. The difference between the numbers leads to their calculation that 440 accidents would be reduced and therefore a reflectorization program, based on this figure and on their cost data, would be cost-beneficial.[18] The issue of costs has been discussed in a previous section of this paper.

These numbers should not be treated as The Actual Rates of accidents for each study group, because there will be variations in the number of collisions for each 100,000 vehicles. To have meaning the numbers must be compared statistically. This was done in the Virginia study and the numbers are found not to be different.

Because of Kleinknecht and Hicks' concern over these numbers, the author reviewed the original data and presents,in Table 5, a breakdown of collisions by vehicle movement and position when struck. The pairs of data are similar, and any variations which occur do not systematically favor one group. In some cases the reflectorized group was struck more often at night and in others the control group was struck more often. This is additional evidence for not using ONLY the VHTRC Table 8 totals in interpreting the results of the study.

Table 5

Vehicles Struck at Night
Virginia Study Data

Direction of Vehicles	Reflectorized	Control
Intersection		
Both going straight	28	27
One turning right, one straight	12	14
One turning left, one straight	36	43
One stopped	68	85
All others	60	59
Non-intersection		
Both going straight	48	36
One stopped in traffic	55	55
Parked properly	162	173
Parked improperly	6	5
Total	475	497

Even if one is not concerned with statistical levels, it is difficult to understand how one could view all the data presented in the report and state that one set is different from the other. Observation, logic, and the application of statistical tests all point out the similarity of the reflectorized and the control non-reflective data. Speculation over other data, cost of materials, costs to be assigned crashes, and other issues raised by the critics does not alter the homogeneity of the night-time collision data.

In those accident situations where no claim of benefit is made for reflective license plates there is no evidence of a statistical difference between the groups. In those cases where a claim of benefit is made for reflective license plates there is likewise no evidence of a statistical difference.

In attempting to demonstrate the effectiveness of reflectorized license plates by using a cost-benefit approach it is necessary to consider more than the break-even point between the costs of materials and the costs assigned to accidents. One important factor to be considered is the issue of alternate investment. It is not enough to show that reflectorized license plates are not harmful and might produce a very small reduction. Not only must there be a reduction, but it must be of a sufficient magnitude to justify it over another accident reduction countermeasure.

A highway safety program should return something for the investment that has been made in it. For an expense of nearly a million dollars per year to reflectorize license plates, could the state obtain a better payback by adding additional police officers for patrol activities, by implementing countermeasures to prevent wrong-way driving, by increasing intersection lighting, or through other such programs?

Since reflective sheeting is expensive and is heavily advertised and sold as a preventer of rear-end collisions at night, it is not enough to merely show that it is not harmful. Research must show that it is clearly an advantage. A finding of a benefit is the only reason such a program should be considered for implementation, and only then if the benefit is greater than that for other accident reduction programs.

Footnotes

1. Letter to The Honorable Linwood Holton, Governor of Virginia, and the 1972 General Assembly of Virginia from Superintendent of State Police, Commissioner of Motor Vehicles, and Director of Highway Safety, December 30, 1971.

2. Stoke, C. B., "Reflectorized License Plates: Do They Reduce Nighttime Rear-End Collisions?" Virginia Highway Research Council, Charlottesville, Virginia, January 1974.

3. Kleinknecht, R. E., and Hicks, J. A., "1971 Virginia License Plate Study: Powerful or Weak Experimental Design?" Prepared for the 3M Company, no date.

4. Hulbert, S. F., and Burg, A., "Are Reflectorized License Plates a Good Idea?" Prepared for the 3M Company, January 1975.

5. Kleinknecht and Hicks, op. cit., p. 5.

6. Ibid., p. 1.

7. Division of Motor Vehicles, "Virginia Reflective Safety Plates, Cost Analysis," July 9, 1973, Richmond, Virginia.

8. Huelke, D. F., and Marsh, J. C., "Analysis of Rear-End Accident Factors and Injury Patterns," Proceedings, 18th Conference, American Association for Automotive Medicine, 1974, pp. 174-199.

9. Failure to consider the fact of a limited vehicle population size causes each number in the table to be greater than if the proper formula had been used.

10. Kleinknecht and Hicks, op. cit., p. 7.

11. Letter to Governor A. Linwood Holton from Senator R. S. Burrus, Jr., March 29, 1972.

12. Boone, H., "Reflectorized License Plate Study," Department of State Police, Richmond, Virginia, June 1972.

13. In the TRB report, this data is included in Tables 1, 2, and text table.

14. Huelke and Marsh, op. cit., p. 177.

15. Hulbert and Burg, op. cit., p. 10.

16. Ibid., pp. 9-10.

17. Rear-end and parked car crashes and collisions are not included in the night comparisons.

18. Kleinknecht and Hicks, op. cit. p. 17.

Appendix A

Tables from Kleinknecht and Hicks

Table 3

POWER AND SIGNIFICANCE LEVEL

Statewide Difference in Night Rear-end Accidents (Passenger Vehicles)		200	400	440	1000
Significance Level	Difference in Accident Proportions	0.0001	0.0002	0.00022	0.0005
0.01		0.022	0.046	0.053	0.245
0.05		0.093	0.159	0.160	0.499
0.10		0.169	0.264	0.284	0.641
0.15		0.239	0.348	0.375	0.726
0.20		0.305	0.425	0.450	0.816

NOTE: Power of the statistical test to detect real differences of various magnitudes when the sample size is 100,000 per group, the normal rate is 497 accidents per year per 100,000 vehicles, and the null hypothesis is tested at several significance levels.

Table 4

SAMPLE SIZE, POWER, AND SIGNIFICANCE LEVEL

Statewide Difference in Night Rear-end Accidents (Passenger Vehicles)			200	400	440	1000
Significance Level	Difference in Accident Proportions		0.0001	0.0002	0.00022	0.0005
0.01	Power	= 70%	7,742,967	1,945,114	1,607,028	304,326
		= 80%	9,557,879	2,401,039	1,983,707	375,658
		= 90%	12,379,684	3,109,906	2,569,363	486,565
0.05	Power	= 70%	4,473,162	1,123,705	928,390	175,811
		= 80%	5,875,526	1,475,993	1,219,446	230,929
		= 90%	8,127,312	2,041,666	1,686,797	319,432
0.10	Power	= 70%	3,094,921	777,476	642,341	121,641
		= 80%	4,277,460	1,074,543	887,773	168,119
		= 90%	6,225,512	1,563,914	1,292,085	244,684
0.15	Power	= 70%	2,314,733	581,485	480,415	90,977
		= 80%	3,350,320	841,635	695,348	131,679
		= 90%	5,095,330	1,280,000	1,057,519	200,264
0.20	Power	= 70%	1,775,138	445,933	368,424	68,769
		= 80%	2,693,887	676,732	557,107	105,879
		= 90%	4,277,460	1,074,543	887,778	168,119

NOTE: Necessary sample sizes PER GROUP for various magnitudes of smallest real effect worth detecting, several values of significance levels, and for powers of 70%, 80% and 90%. The "normal" accident rate is assumed to be 497 accidents per year per 100,000 vehicles.

Appendix B

Text Table from Hulbert and Burg

	Reflectorized	Control	50% χ^2
State Police Data:			
Total night accidents	2465	2356	2.41
Total day accidents	6132	5840	7.07**
TOTAL	8597	8196	9.53**
Stoke Report: (38)			
Total night accidents (Table 1 plus table on p. 46)	2465	2431	0.22
Total day accidents (Table 1)	6142	6103	0.12
TOTAL	8607	8534	0.30

**Significant at the 0.01 level

Appendix C

Data From Virginia Study

TABLE 2

DAY COMPARISON BY CRASH TYPE

Crash Type	Reflectorized	Control
With Another Motor Vehicle	5447	5401
Other Noncollision	13	16
With Fixed Object	80	70
Overturned in Roadway	14	16
Ran Off Roadway	464	478
All Other and Not Stated	124	122
TOTAL	6142	6103
Chi-Square = 1.727 (Not Significant at the 0.05 level)		

TABLE 3

NIGHT COMPARISON BY CRASH TYPE

Crash Type	Reflectorized	Control
With Another Motor Vehicle (Minus Rear-end and Parked)	864	881
Other Noncollision	7	5
With Fixed Object	68	75
Overturned in Roadway	16	24
Ran Off Roadway	521	473
All Other and Not Stated	101	83
TOTAL	1577	1541
Chi-Square = 6.106 (Not Significant at the 0.05 level)		

Appendix C
(Continued)

TABLE 4

DAY COMPARISON BY COLLISION TYPE

Collision Type	Reflectorized	Control
Sideswipe	1620	1616
Head-On	591	617
Rear-end	1620	1510
Parked	645	645
Not Stated and All Other	971	1013
TOTAL	5447	5401
Chi-Square = 5.113 (Not Significant at the 0.05 level)		

TABLE 5

NIGHT COMPARISON BY COLLISION TYPE

Collision Type	Reflectorized	Control
Sideswipe	392	411
Head-On	249	245
Not Stated and All Other	223	225
TOTAL	864	881
Chi-Square = 0.337 (Not Significant at the 0.05 level)		

TABLE 9

NIGHT COMPARISONS BY COLLISION TYPE

Type	Reflectorized	Control
Rear-end	472	477
Parked	416	413
TOTAL	888	890
Chi-Square = 0.036 (Not Significant at the 0.05 level)		

Appendix C
(Continued)

TABLE 8

REAR-END COLLISIONS AT NIGHT

Category	Reflectorized	Control	50% Test	Calculated*
Fatal	0	1	—	6
Personal Injury	88	98	0.44	116
Property Damage	387	398	0.13	443
TOTAL	475	497	0.45	538

* The number of control collisions necessary for a significant difference at the 0.05 level.