STUDDED TIRES VERSUS PAVEMENT MARKINGS
A Collision Course

JOHN M. DALE*

An automobile equipped with four studded tires, each containing 72 studs, has, at all times, approximately 25 to 30 studs facing the pavement. These tungsten carbide studs protrude 0.030 to 0.060 in. below the tread surface and are designed to wear at about the same rate as the tire, so that stud protrusion should remain nearly constant. Studs do not have any built-in respect for pavement markings and impose a new dimension to the difficulty of maintaining pavement markings. Studded tires and pavement markings contribute to traffic safety each in their own way. The problem is that conventional traffic markings have, at present, a relatively short service life. The widespread use of studded tires adds an additional burden on these already overworked materials.

Pavement markings perform an important function in traffic control in that they are able to convey warnings and information to the driver without diverting his attention from the roadway. They are used to supplement the warnings and information conveyed by other devices such as traffic signs and signals. In other instances, they obtain results, solely on their own merits, that cannot be obtained by the use of any other device (1). Studded tires likewise have many outstanding advantages. Without them, many drivers might never be able to move their cars when bad weather strikes. The use of studded tires on rear wheels provides starting and pulling ability on glare ice that is 218 percent better than with regular tires. In braking from 20 mph on glare ice, studded tires on rear wheels allow a car to stop in 129 ft; with regular tires it would require 150 ft. The National Safety Council's Committee on Winter Driving Hazards now recommends placing studded tires on all four wheels because they significantly reduce the chances of skidding out of a turn (2). At present all states, except four in the Deep South, allow use of studded tires, at least during the winter months.

Studded tires, which are largely a European development, have gained unusually rapid acceptance in the United States since their introduction in 1963. The Minnesota Department of Highways was one of the first agencies to initiate studies of the pavement wear problem associated with the use of studded tires. This work was begun in the fall of 1964. Surveys of studded tire use during the 1965-66 winter indicated that 4.0 percent of the cars in the Minneapolis-St. Paul area had studded tires on their rear wheels. The following winter, use of studded tires had increased to 8.8 percent. By the 1967-68 winter it had grown to 23.4 percent, and by the winter of 1968-69 it had grown to 31.8 percent (3). This growth in the use of studded tires was also accompanied by visible evidence of pavement damage from abrasion in the wheel track areas. The Minnesota Department of Highways conducted controlled tests on an unopened

*Mr. Dale is Manager, Systems Development, Department of Automotive Research, Southwest Research Institute. The information in this article resulted from a project conducted by the Southwest Research Institute for the HRB-administered National Cooperative Highway Research Program entitled "Nighttime Use of Highway Pavement Delineation Materials."

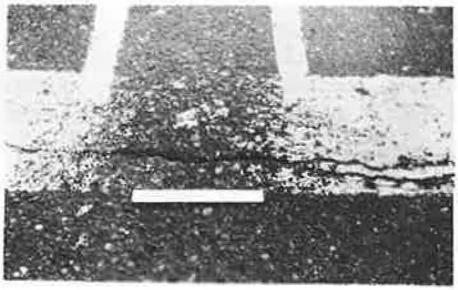

Figure 1. Wheel track area after 7,027 repetitive crossings of an automobile equipped with four studded tires (courtesy of the Minnesota Department of Highways).

section of Interstate highway with a test car equipped with studded tires on all four wheels. Figure 1 shows the damage in the wheel track area to a transverse stripe of traffic marking paint after 7,027 repetitive crossings by the test car moving at a constant speed of 50 mph. Since this was not a test of traffic marking materials, no controls were applied. Thus, it is impossible to estimate what amount of this wear is attributable to the studs and what amount of it might have occurred under regular tires. On the other hand, to have experienced this amount of damage after only 7,027 repetitions is significant in that there are many miles of pavements in the country that have average daily traffic densities per vehicle lane that are much in excess of this. Prior to the advent of the studded tire, the average useful life of traffic marking paint in longitudinal markings has been determined to be as shown in Figure 2.

In general, traffic marking paints are not applied when the temperature is below 40 F; this means that at many locations the markings wear out by the middle of the winter and the pavement remains unmarked until the following spring. This creates a great many hazards. Since driving at night is considerably more dangerous than in the daytime, the contribution of pavement markings to safety at night is paramount. To obtain visible markings at night, traffic

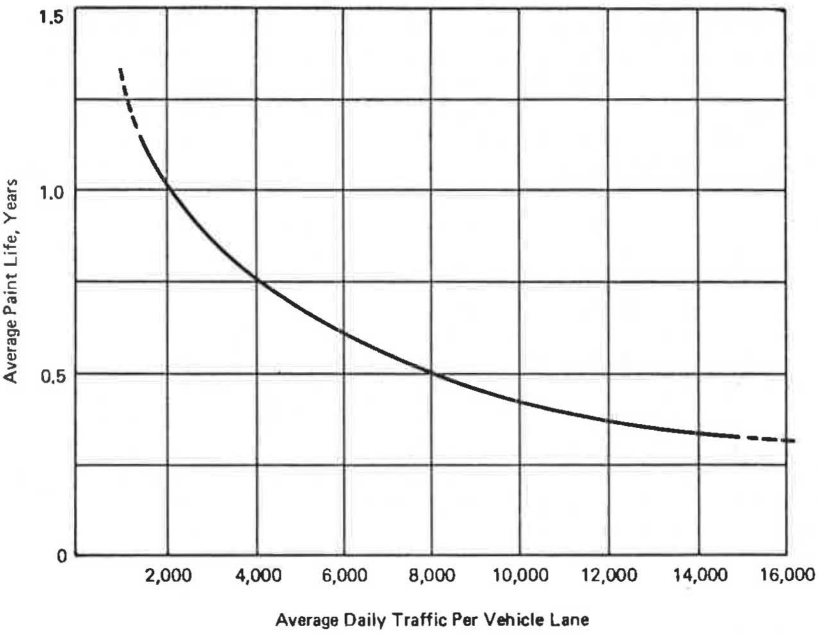

Figure 2. Average useful life of paint striping as affected by traffic density—both bituminous and concrete pavement—prior to the advent of the studded tire (4).

paint is reflectorized with small glass beads. It is interesting to consider what will happen to these small glass beads and the nighttime visibility of markings when studded tires become more prevalent. One must reason that, since the glass beads protrude above the surface of the paint and constitute the uppermost surface of a traffic marking material, they will be the first to be exposed to the abrasive and impact forces of the tire studs. Southwest Research Institute's first indication of how glass beads might be expected to perform under studded tires was gained from some experience with larger diameter glass beads. The Institute was the contracting agency for the National Cooperative Highway Research Program Project 5-5, jointly sponsored by the American Association of State Highway Officials and the U.S. Bureau of Public Roads. Attention in that program was directed to the night wet weather visibility of markings. As part of that program, experimental markings containing ¼-in.-diameter glass beads were placed at some 11 different test sites across the United States and monitored over the winter of 1968-69. At those locations outside of the snowfall areas of the country, glass bead damage and loss averaged 2 to 3 percent. Within the snowfall area, glass bead damage and loss averaged 98 to 100 percent. The damage at many locations was the result of action by snowplows, tire chains, and studded tires. There were several locations where snowplows were not used and bead damage and loss at these sites could be directly attributed to tire chains and studded tires. Following this, the Institute purchased a set of studded tires and ran them over some of the experimental markings and confirmed the fact that the studs were very effective in destroying the ¼-in.-diameter glass beads. Because of the size of the glass beads employed in these tests, it was possible to observe with the naked eye the damage that had been inflicted. The studded tires were then run over conventional markings of paint reflectorized with small glass beads. It was found that for a free-rolling tire, i.e., one that was neither accelerating nor decelerating, the stud action was primarily down and the bead damage was of two general types. If the substrate was soft, the beads were pushed in and buried. If the substrate was hard, the beads were crushed. If the tires were accelerated, gouge marks were obtained. Five mildly accelerated starts with one studded tire produced the gouge marks shown in Figure 3. Figure 4 shows a closeup of the stripe and the character of the gouge marks.

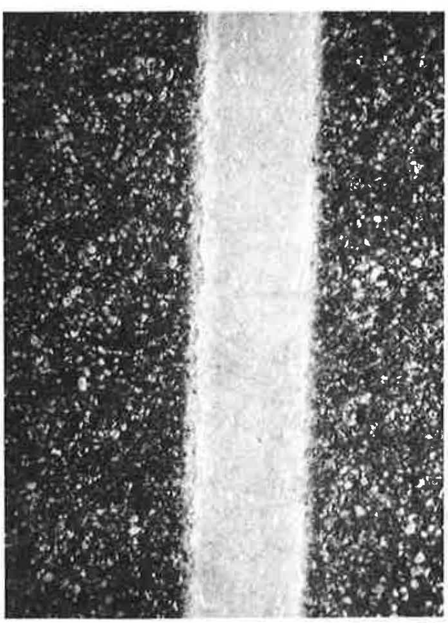

Figure 3. Gouge marks in a beaded paint stripe caused by an accelerating studded tire.

Annual application of traffic marking paints is approximately 24 million gallons, valued at approximately $50 million (5). More than 100 million pounds of traffic marking glass beads valued at over $10 million are also consumed annually (6). Paint and beads combined cost approximately $60 million annually. The total cost of marking also includes the cost of labor and equipment used to apply the paint and beads, and these costs can equal or exceed the cost of materials (7). In addition, there are hundreds

Figure 4. Closeup of tire stud gouge marks in a beaded paint line.

of miles of thermoplastic marking materials in service today. The installed costs of thermoplastic marking materials per foot are as much as 14 times more than for conventional traffic paints, but their much longer service life under heavy traffic density justifies their use at many locations. Thermoplastics are also reflectorized with small glass beads. Also, there are many different types of raised markers in service. The total annual expense in painted traffic markings, including all elements of cost, is estimated to be in excess of $100 million.

Some insight into the future use of studded tires can be gained by comparing the annual snowfall in the United States, as shown in Figure 5, with automobile registrations by state (8). This indicates that some 70 million of the approximately 100 million registered vehicles on the road are potential customers for studded tires. This is a potential market for approximately 280 million tires, whereas studded tire sales currently are only about 6 million annually (9). The future acceptance and use of studded tires is of great importance to those persons involved with the safety of the motorist, the maintenance of the highways, and the design of the next generation of pavements and pavement marking materials. Studies

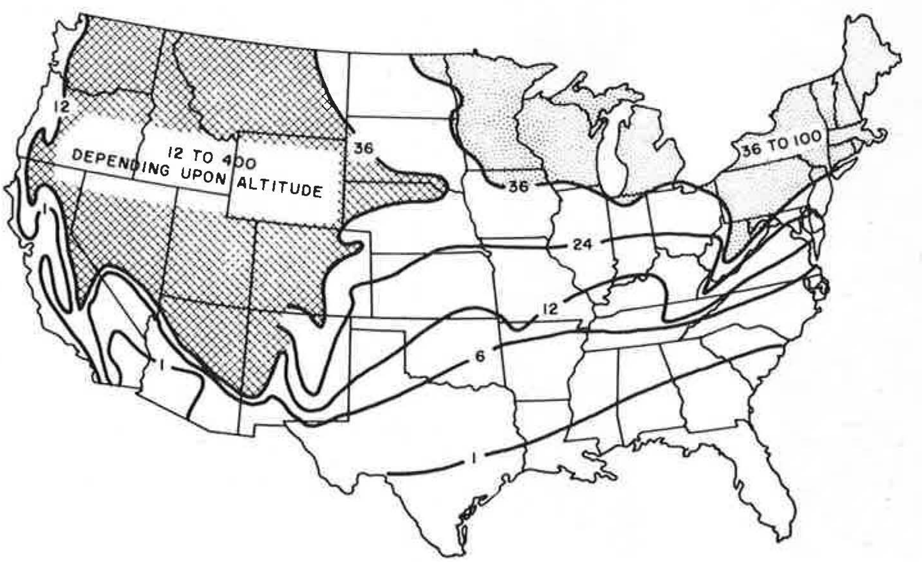

Figure 5. Mean annual snowfall in inches (source: U.S. Department of Commerce).

need to be made of the cost-effectiveness of studded tires, the cost-effectiveness of pavement markings, the rate of damage inflicted on pavement markings by studded tires, and the course of action to be recommended. The current trend appears to be toward general acceptance of studded tires, which means that highway departments must reevaluate their pavement marking practices and the materials used.

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