AIEG TIRE SEMINAR

Tire Failure = Loss of Control

Kyle. W. Farrar
Farrar & Ball, LLP

Tire Failure = Loss of Control

Kyle. W. Farrar
Farrar & Ball, LLP

Early Considerations

- **Partial v. Full Tread Detachment**

ARNDT – “Partial separation produced the most significant vehicle disturbances. The range of vehicle responses is a continuum from minor responses… to critically destabilizing responses resulting from partial separations.” SAE 2001-06-0145.

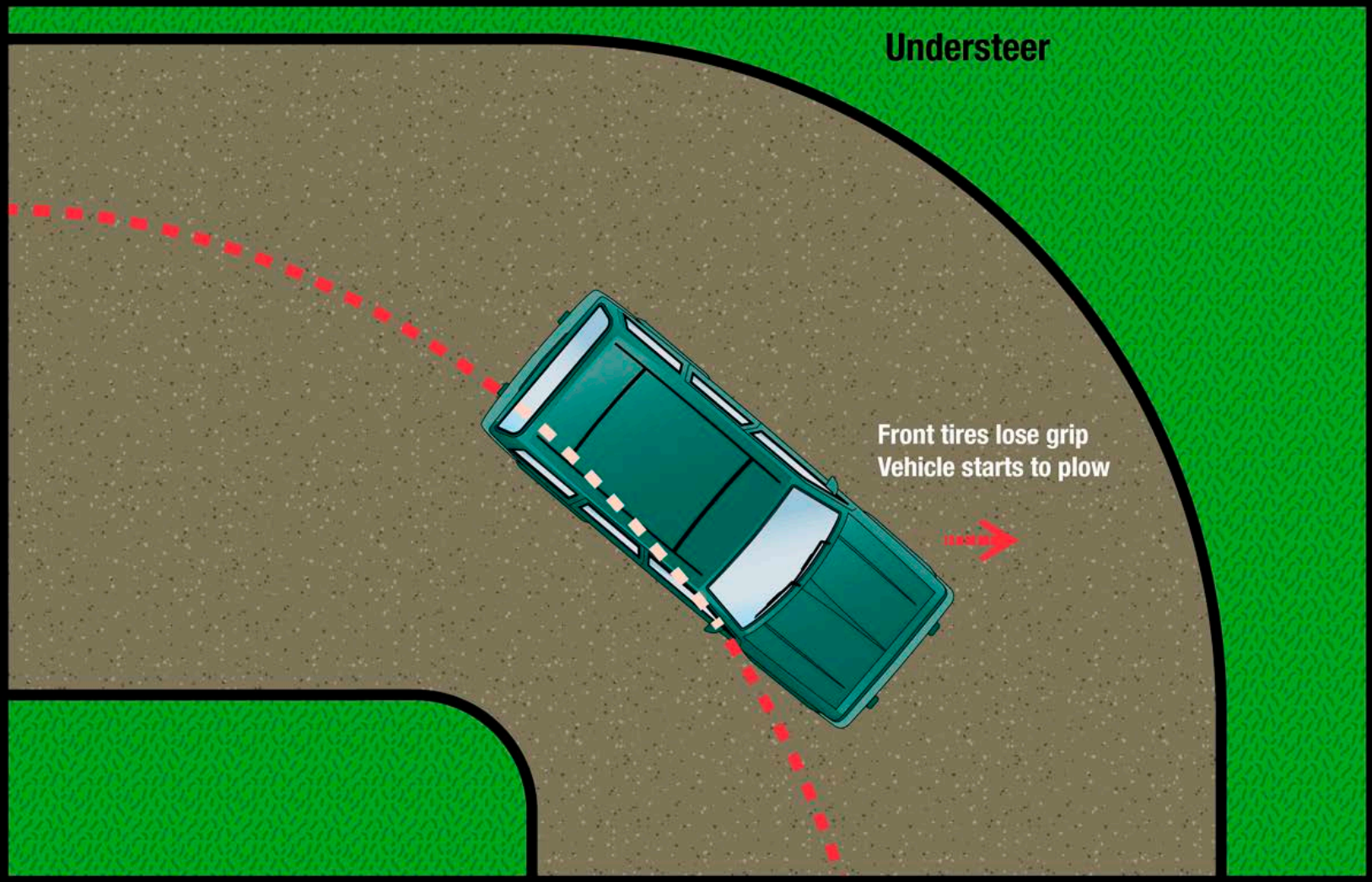
- **Front v. Rear Tread/Belt Separation**

Front v. Rear Separation

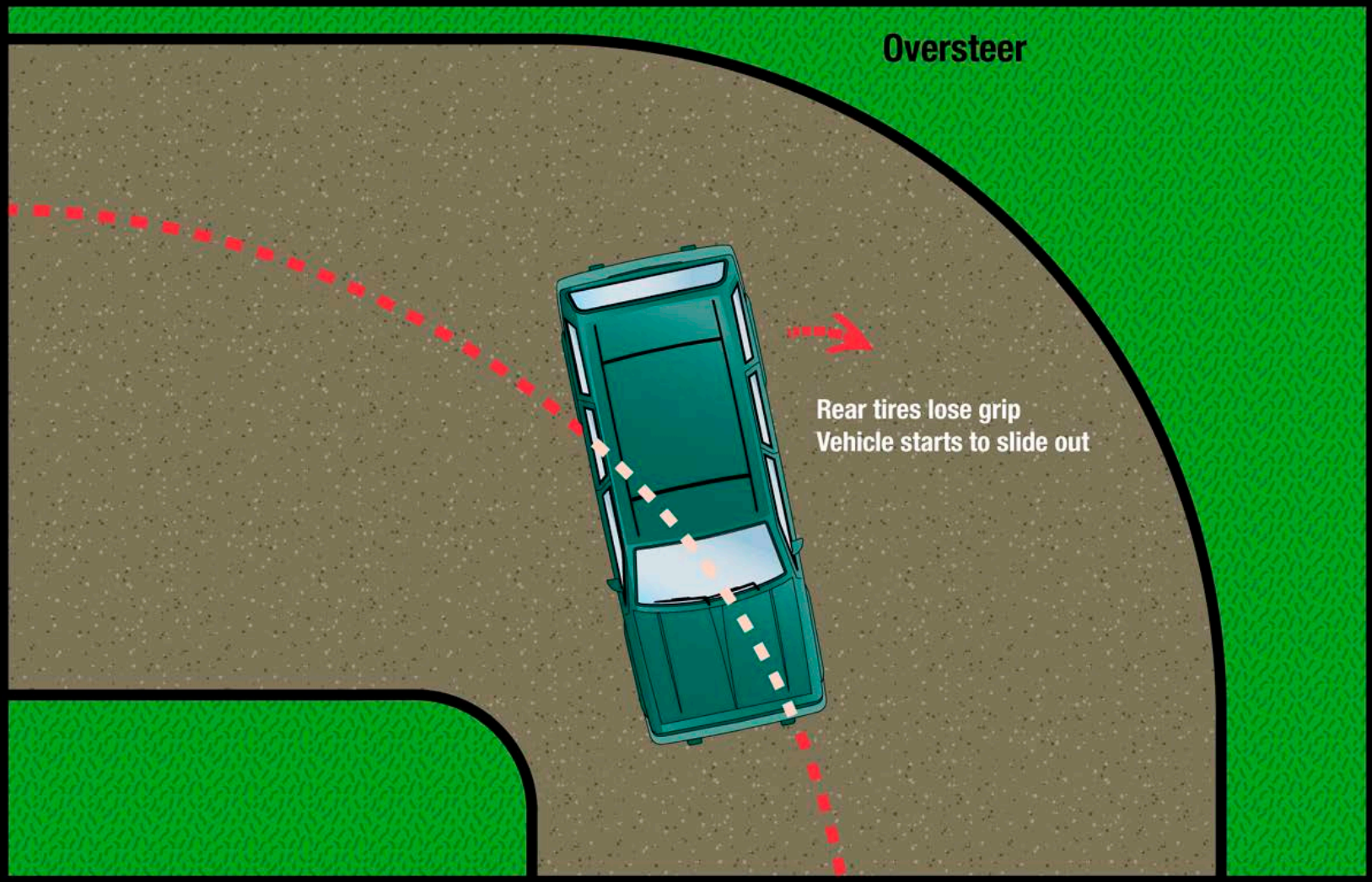
The Vehicle will pull to the side of the failed tire, regardless of whether its on the front or back.

However, the effect on the vehicle dynamics will change.

Front v. Rear Separation



Front v. Rear Separation



Front v. Rear Separation

MICKY GILBERT'S TESTING

4 Good Tires (JTR01 – End View)

Lt Front Sep (JTR03 – End View)

LT Rear Sep (JTR06 – End View)

Front v. Rear Separation

Where did the loss of control occur

Rear Tire:

LOC at Tread Sep Side

Arndt - SAE 2001-06-0145

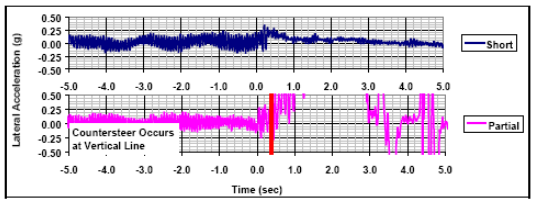


Figure 13. 1996 Ford Explorer Tread Separation Event Test, Lateral Acceleration.

Vehicle Class Differences: The primary difference between the classes of vehicles was the magnitude of

previously reported for the Bronco II in Reference 3. The single major difference between the Bronco II

Taurus results was that the Bronco II

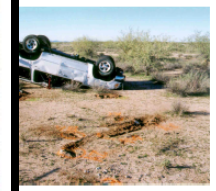
at the end of the constant radius test with

ed tire at the outboard rear wheel position.

s very difficult to control at the end of the

t spin out. This is likely due to the front

the Taurus.



plorer at Rest Following Rollover.

ip angle versus velocity is provided as

he constant steer circle turn test. This

ows the dramatically different behavior of

h four good tires when compared to the

ith a tread-separated tire located at the

osition. The vehicle with four good tires

ack around the turn up to the point of

al acceleration. The vehicle with a tread-

t the outboard rear position records a

nse across the entire range of speed and

elocity 40 percent lower than the

eved with four good tires.

(J-Turn) Tests: Tests were conducted at

6, and 72 km/h. The general behavior of

ll three test speeds was similar. Data is

he 56 km/h tests in Figures 17-19. The

Figure 14. Explorer at Rest Following Rollover.

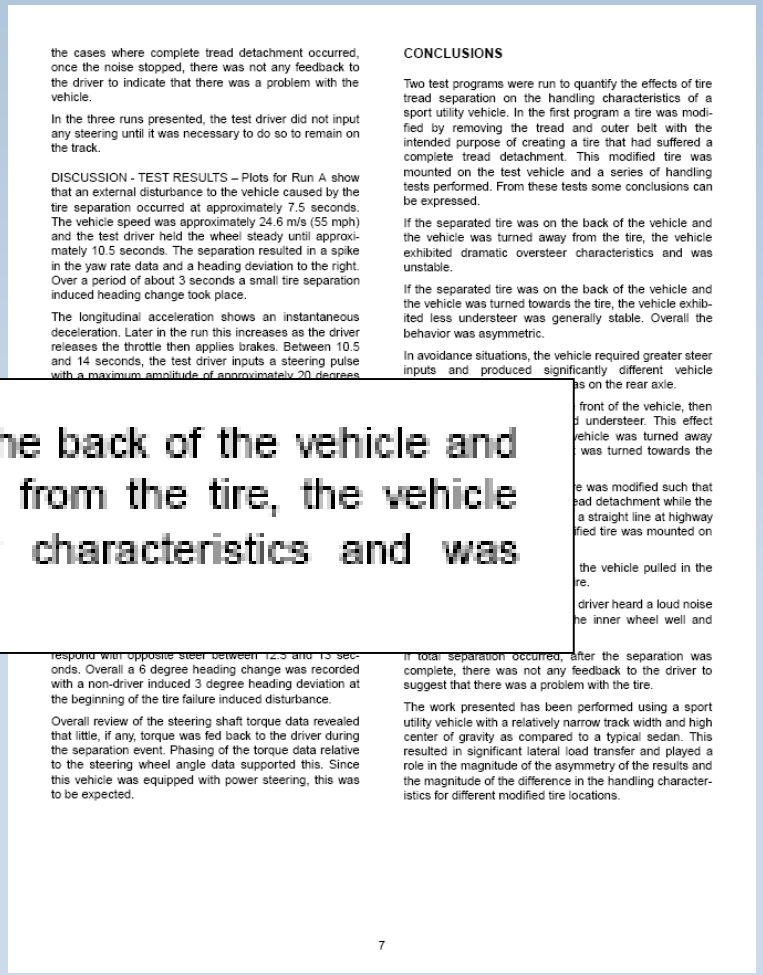
Front v. Rear Separation

Where did the loss of control occur

Rear Tire:

LOC at Opposite Tread Sep Side

Arndt - SAE 1999-01-0450



the cases where complete tread detachment occurred, once the noise stopped, there was not any feedback to the driver to indicate that there was a problem with the vehicle.

In the three runs presented, the test driver did not input any steering until it was necessary to do so to remain on the track.

DISCUSSION - TEST RESULTS – Plots for Run A show that an external disturbance to the vehicle caused by the tire separation occurred at approximately 7.5 seconds. The vehicle speed was approximately 24.6 m/s (55 mph) and the test driver held the wheel steady until approximately 10.5 seconds. The separation resulted in a spike in the yaw rate data and a heading deviation to the right. Over a period of about 3 seconds a small tire separation induced heading change took place.

The longitudinal acceleration shows an instantaneous deceleration. Later in the run this increases as the driver releases the throttle then applies brakes. Between 10.5 and 14 seconds, the test driver inputs a steering pulse with a maximum amplitude of approximately 20 degrees

respond with opposite steer between 12.5 and 13 seconds. Overall a 6 degree heading change was recorded with a non-driver induced 3 degree heading deviation at the beginning of the tire failure induced disturbance.

Overall review of the steering shaft torque data revealed that little, if any, torque was fed back to the driver during the separation event. Phasing of the torque data relative to the steering wheel angle data supported this. Since this vehicle was equipped with power steering, this was to be expected.

CONCLUSIONS

Two test programs were run to quantify the effects of tire tread separation on the handling characteristics of a sport utility vehicle. In the first program a tire was modified by removing the tread and outer belt with the intended purpose of creating a tire that had suffered a complete tread detachment. This modified tire was mounted on the test vehicle and a series of handling tests performed. From these tests some conclusions can be expressed.

If the separated tire was on the back of the vehicle and the vehicle was turned away from the tire, the vehicle exhibited dramatic oversteer characteristics and was unstable.

If the separated tire was on the back of the vehicle and the vehicle was turned towards the tire, the vehicle exhibited less understeer was generally stable. Overall the behavior was asymmetric.

In avoidance situations, the vehicle required greater steer inputs and produced significantly different vehicle

as on the rear axle.

front of the vehicle, then
understeer. This effect
vehicle was turned away
was turned towards the

e was modified such that
ead detachment while the
a straight line at highway
ified tire was mounted on

the vehicle pulled in the
re.

driver heard a loud noise
he inner wheel well and

If total separation occurred, after the separation was complete, there was not any feedback to the driver to suggest that there was a problem with the tire.

The work presented has been performed using a sport utility vehicle with a relatively narrow track width and high center of gravity as compared to a typical sedan. This resulted in significant lateral load transfer and played a role in the magnitude of the asymmetry of the results and the magnitude of the difference in the handling characteristics for different modified tire locations.

7

If the separated tire was on the back of the vehicle and the vehicle was turned away from the tire, the vehicle exhibited dramatic oversteer characteristics and was unstable.

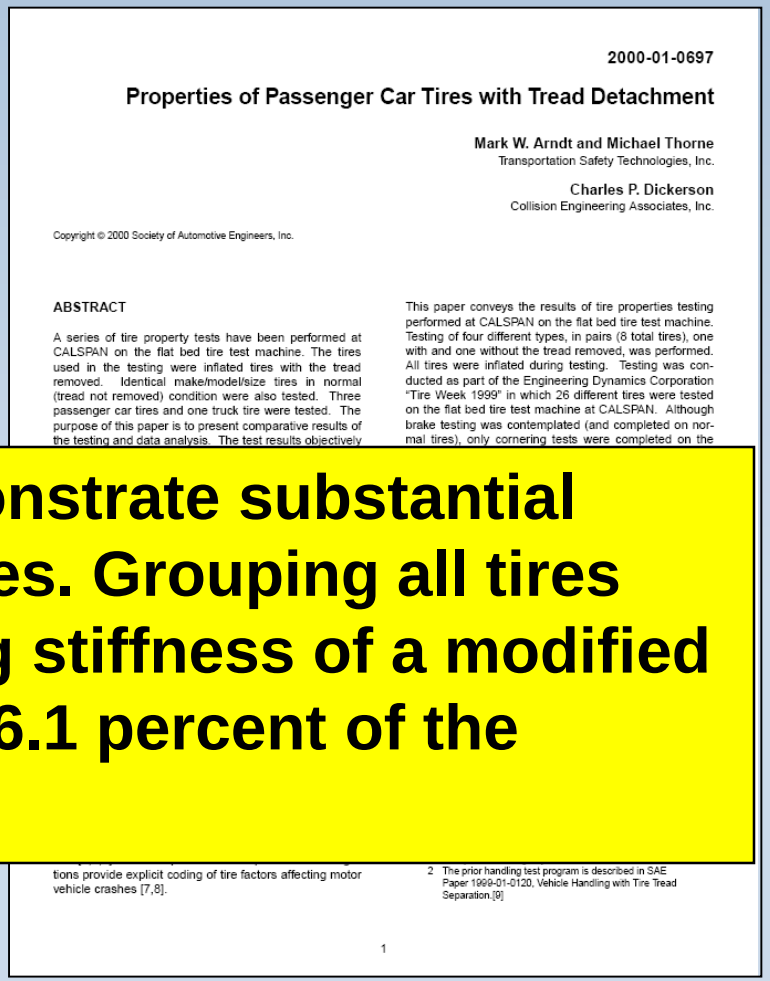
Front v. Rear Separation

Where did the loss of control occur

Rear Tire:

LOC at Opposite Tread Sep Side

Arndt - SAE 2000-01-0697



2000-01-0697

Properties of Passenger Car Tires with Tread Detachment

Mark W. Arndt and Michael Thorne
Transportation Safety Technologies, Inc.

Charles P. Dickerson
Collision Engineering Associates, Inc.

ABSTRACT

A series of tire property tests have been performed at CALSPAN on the flat bed tire test machine. The tires used in the testing were inflated tires with the tread removed. Identical make/model/size tires in normal (tread not removed) condition were also tested. Three passenger car tires and one truck tire were tested. The purpose of this paper is to present comparative results of the testing and data analysis. The test results objectively

This paper conveys the results of tire properties testing performed at CALSPAN on the flat bed tire test machine. Testing of four different types, in pairs (8 total tires), one with and one without the tread removed, was performed. All tires were inflated during testing. Testing was conducted as part of the Engineering Dynamics Corporation "Tire Week 1999" in which 26 different tires were tested on the flat bed tire test machine at CALSPAN. Although brake testing was contemplated (and completed on normal tires), only cornering tests were completed on the

tions provide explicit coding of tire factors affecting motor vehicle crashes [7,8].

2 The prior handling test program is described in SAE Paper 1999-01-0120, Vehicle Handling with Tire Tread Separation.[9]

1

The test results objectively demonstrate substantial differences in cornering properties. Grouping all tires together, the measured cornering stiffness of a modified tire was reduced on average to 36.1 percent of the normal tire measured properties

Front v. Rear Separation

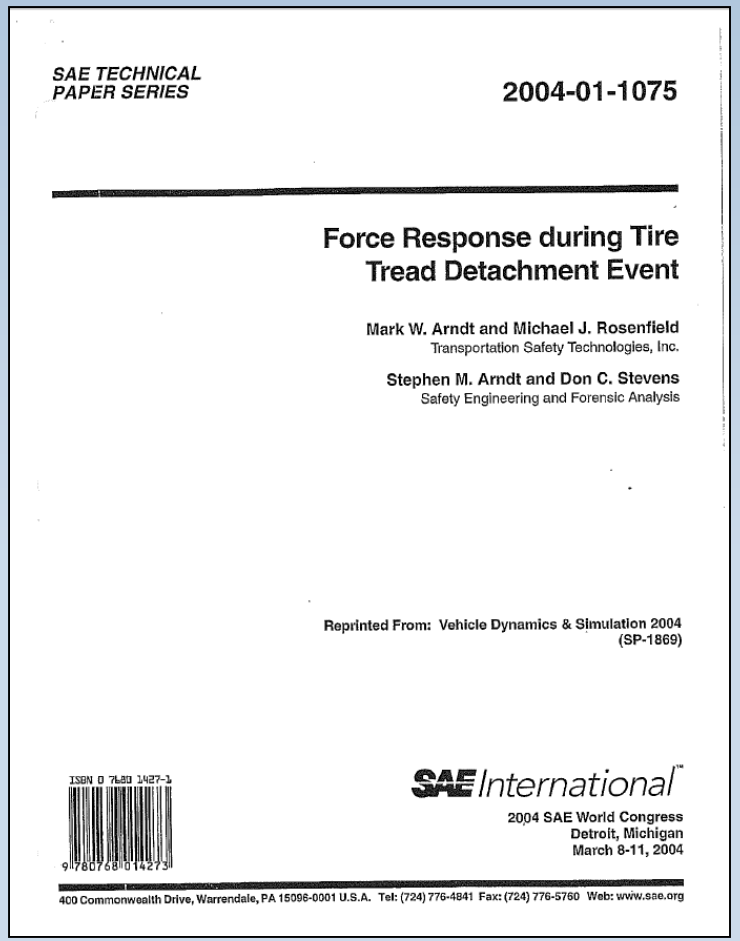
Where did the loss of control occur

Front Tire:

LOC at Tread Sep Side

Arndt - SAE 2004-01-1075

1) Demonstrates both lateral and longitudinal forces in tread sep. event;
2) Peak resultant forces range from 361 to 1151 lbs;



SAE TECHNICAL PAPER SERIES

2004-01-1075

Force Response during Tire Tread Detachment Event

Mark W. Arndt and Michael J. Rosenfield
Transportation Safety Technologies, Inc.

Stephen M. Arndt and Don C. Stevens
Safety Engineering and Forensic Analysis

Reprinted From: Vehicle Dynamics & Simulation 2004 (SP-1869)

ISBN 0 7680 1427-1

SAE International

2004 SAE World Congress
Detroit, Michigan
March 8-11, 2004

400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A. Tel: (724) 776-4841 Fax: (724) 776-5760 Web: www.sae.org

Front v. Rear Separation

Where did the loss of control occur

Front Tire:

LOC Opposite Tread Sep Side

1) Look for other contributing factors or if the vehicle is prone to oversteer – such a 15 passenger van or bus.

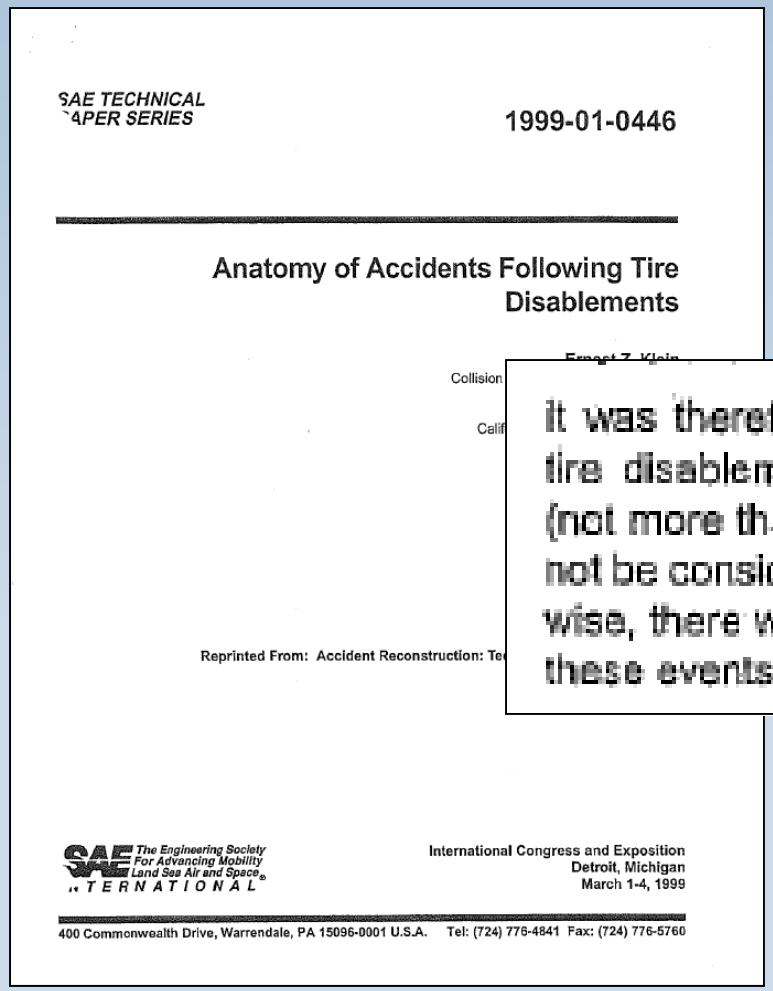
NHTSA NADS STUDY

Only study looking at real world reactions to unforeseen tread seps

1) Expected driver reaction is to counter-steer;
2) Experienced driver who are expecting a tread separation can easily control the vehicle;
3) A previously appropriate steer input can result in loss of control;
4) Knowledge of the imminent tread separation reduced the overall probability of control loss from 55% to 20%;
5) Findings from test track studies in which test drivers were aware of an imminent tread separation may underestimate the extent to which tread separation occurring in the real world leads to instability and loss of vehicle control;
6) The increased difficulty in vehicle handling and the associated increased likelihood of loss of vehicle control with decreasing vehicle understeer generalize to real-world driving.

Cross Examination Points

THE FRAUD



SAE TECHNICAL
PAPER SERIES

1999-01-0446

Anatomy of Accidents Following Tire Disablements

Collision

Reprinted From: Accident Reconstruction: Te

The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL

International Congress and Exposition
Detroit, Michigan
March 1-4, 1999

400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A. Tel: (724) 776-4841 Fax: (724) 776-5760

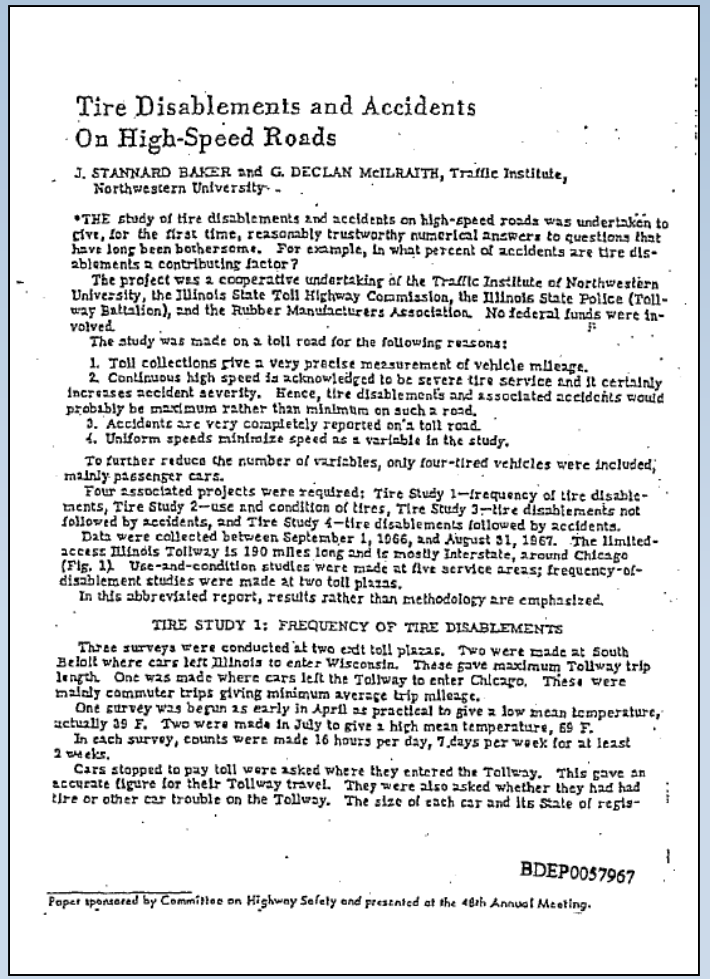
it was therefore concluded that because the number of tire disablements followed by accidents were so small (not more than 0.06%), a tire disablement by itself could not be considered sufficient cause for an accident. Otherwise, there would be many more accidents resulting from these events.

Klein & Black
1999 paper

Cross Examination Points

THE TRUTH

1) Article is from 1968 – prior to steel belted radial tires;
2) Bias Ply tires rarely suffered tread separations;
3) Article discusses tire disablements, meaning flat tires and blow outs.



Tire Disablements and Accidents
On High-Speed Roads

J. STANNARD BAKER and G. DECLAN McILRAITH, Traffic Institute, Northwestern University

•THE study of tire disablements and accidents on high-speed roads was undertaken to give, for the first time, reasonably trustworthy numerical answers to questions that have long been bothersome. For example, in what percent of accidents are tire disablements a contributing factor?

The project was a cooperative undertaking of the Traffic Institute of Northwestern University, the Illinois State Toll Highway Commission, the Illinois State Police (Tollway Battalion), and the Rubber Manufacturers Association. No federal funds were involved.

The study was made on a toll road for the following reasons:

1. Toll collections give a very precise measurement of vehicle mileage.
2. Continuous high speed is acknowledged to be severe tire service and it certainly increases accident severity. Hence, tire disablements and associated accidents would probably be maximum rather than minimum on such a road.
3. Accidents are very completely reported on a toll road.
4. Uniform speeds minimize speed as a variable in the study.

To further reduce the number of variables, only four-tired vehicles were included, mainly passenger cars.

Four associated projects were required: Tire Study 1—frequency of tire disablements, Tire Study 2—use and condition of tires, Tire Study 3—tire disablements not followed by accidents, and Tire Study 4—tire disablements followed by accidents.

Data were collected between September 1, 1966, and August 31, 1967. The limited-access Illinois Tollway is 190 miles long and is mostly Interstate, around Chicago (Fig. 1). Use-and-condition studies were made at five service areas; frequency-of-disablement studies were made at two toll plazas.

In this abbreviated report, results rather than methodology are emphasized.

TIRE STUDY 1: FREQUENCY OF TIRE DISABLEMENTS

Three surveys were conducted at two exit toll plazas. Two were made at South Beloit where cars left Illinois to enter Wisconsin. These gave maximum Tollway trip length. One was made where cars left the Tollway to enter Chicago. These were mainly commuter trips giving minimum average trip mileage.

One survey was begun as early in April as practical to give a low mean temperature, actually 39 F. Two were made in July to give a high mean temperature, 69 F.

In each survey, counts were made 16 hours per day, 7 days per week for at least 2 weeks.

Cars stopped to pay toll were asked where they entered the Tollway. This gave an accurate figure for their Tollway travel. They were also asked whether they had had tire or other car trouble on the Tollway. The size of each car and its State of regis-

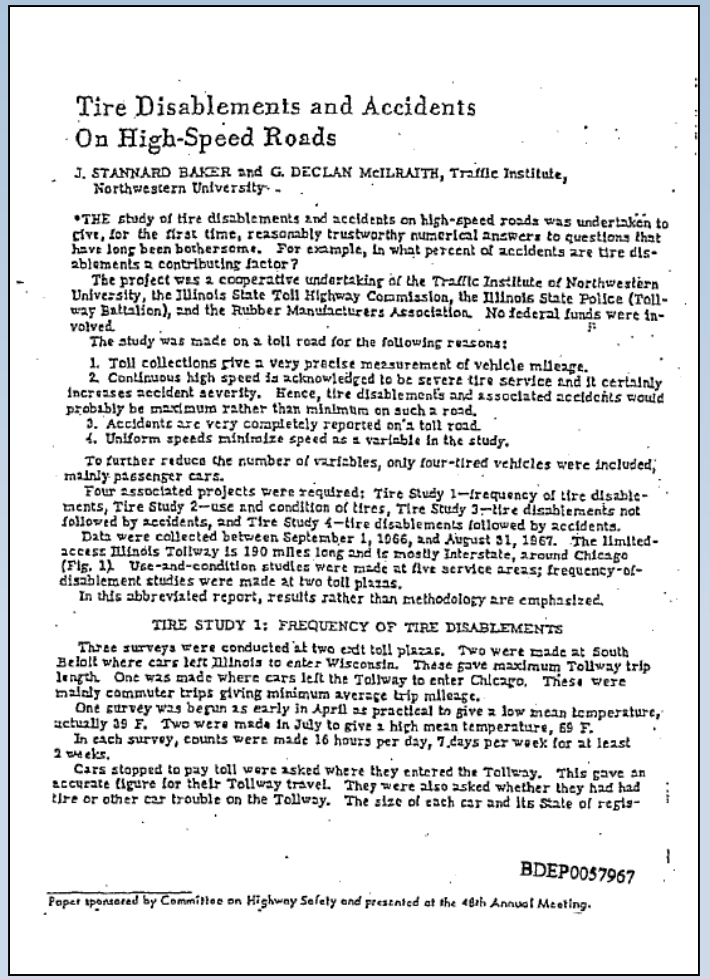
BDEP0057967

Paper sponsored by Committee on Highway Safety and presented at the 48th Annual Meeting.

Cross Examination Points

THE TRUTH

1) Article is from 1968 – prior to steel belted radial tires;
2) Bias Ply tires rarely suffered tread separations;
3) Article discusses tire disablements, meaning flat tires and blow outs.



Tire Disablements and Accidents
On High-Speed Roads

J. STANNARD BAKER and G. DECLAN McILRAITH, Traffic Institute, Northwestern University

•THE study of tire disablements and accidents on high-speed roads was undertaken to give, for the first time, reasonably trustworthy numerical answers to questions that have long been bothersome. For example, in what percent of accidents are tire disablements a contributing factor?

The project was a cooperative undertaking of the Traffic Institute of Northwestern University, the Illinois State Toll Highway Commission, the Illinois State Police (Tollway Battalion), and the Rubber Manufacturers Association. No federal funds were involved.

The study was made on a toll road for the following reasons:

1. Toll collections give a very precise measurement of vehicle mileage.
2. Continuous high speed is acknowledged to be severe tire service and it certainly increases accident severity. Hence, tire disablements and associated accidents would probably be maximum rather than minimum on such a road.
3. Accidents are very completely reported on a toll road.
4. Uniform speeds minimize speed as a variable in the study.

To further reduce the number of variables, only four-tired vehicles were included, mainly passenger cars.

Four associated projects were required: Tire Study 1—frequency of tire disablements, Tire Study 2—use and condition of tires, Tire Study 3—tire disablements not followed by accidents, and Tire Study 4—tire disablements followed by accidents.

Data were collected between September 1, 1966, and August 31, 1967. The limited-access Illinois Tollway is 190 miles long and is mostly Interstate, around Chicago (Fig. 1). Use-and-condition studies were made at five service areas; frequency-of-disablement studies were made at two toll plazas.

In this abbreviated report, results rather than methodology are emphasized.

TIRE STUDY 1: FREQUENCY OF TIRE DISABLEMENTS

Three surveys were conducted at two exit toll plazas. Two were made at South Beloit where cars left Illinois to enter Wisconsin. These gave maximum Tollway trip length. One was made where cars left the Tollway to enter Chicago. These were mainly commuter trips giving minimum average trip mileage.

One survey was begun as early in April as practical to give a low mean temperature, actually 39 F. Two were made in July to give a high mean temperature, 69 F.

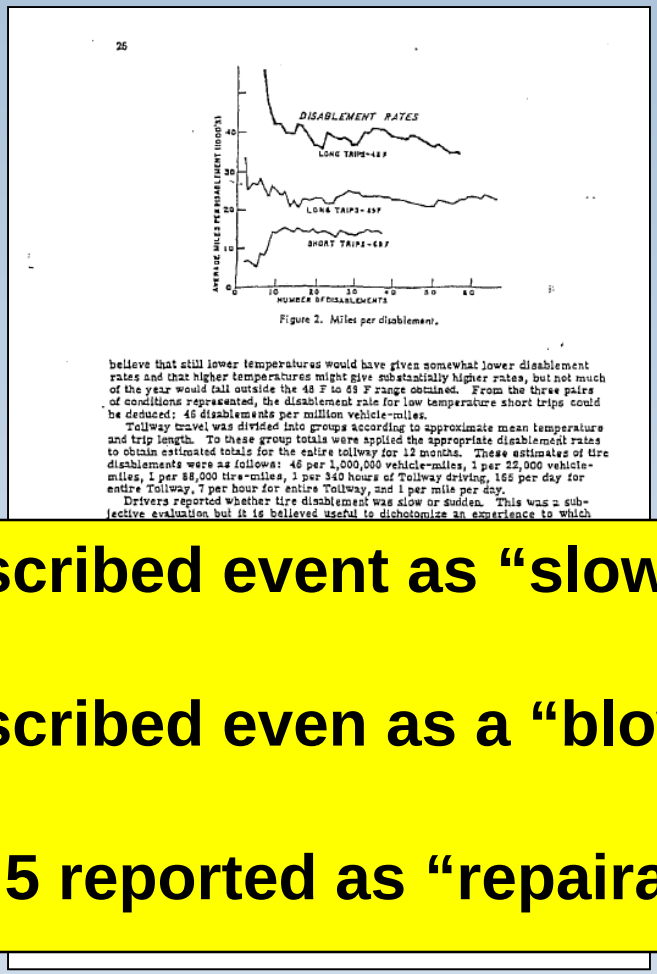
In each survey, counts were made 16 hours per day, 7 days per week for at least 2 weeks.

Cars stopped to pay toll were asked where they entered the Tollway. This gave an accurate figure for their Tollway travel. They were also asked whether they had had tire or other car trouble on the Tollway. The size of each car and its State of regis-

BDEP0057967

Paper sponsored by Committee on Highway Safety and presented at the 48th Annual Meeting.

Cross Examination Points



25

Figure 2. Miles per disablement.

believe that still lower temperatures would have given somewhat lower disablement rates and that higher temperatures might give substantially higher rates, but not much of the year would fall outside the 48 F to 68 F range obtained. From the three pairs of conditions represented, the disablement rate for low temperature short trips could be deduced: 46 disablements per million vehicle-miles.

Tollway travel was divided into groups according to approximate mean temperature and trip length. To these group totals were applied the appropriate disablement rates to obtain estimated totals for the entire tollway for 12 months. These estimates of tire disablements were as follows: 46 per 1,000,000 vehicle-miles, 1 per 22,000 vehicle-miles, 1 per 88,000 tire-miles, 1 per 340 hours of Tollway driving, 165 per day for entire Tollway, 7 per hour for entire Tollway, and 1 per mile per day.

Drivers reported whether tire disablement was slow or sudden. This was a subjective evaluation but it is believed useful to dichotomize an experience to which

48% described event as “slow leak”

52% described even as a “blow out”

2 out of 5 reported as “repairable”