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*for you file J. A.*

TO: J. Avouris  
R. Campbell


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4/24/89  
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SUBJECT: J-Turn performance of three 4X4 vehicles; a 1989 Ford Bronco II, a prototype UN46 and a 1989 Chevrolet Blazer S-10.

REQUESTED BY: Light Truck Chassis Dynamic Systems Activity - J. Avouris, Requester

OBJECT: To measure the steering wheel angle, lateral acceleration, yaw rate, roll angle, longitudinal speed and lateral speed and to determine the rollover tendency of three subject vehicles, at two loading conditions and with a number of different tires constructions and sizes, in a J-turn maneuver at speeds up to 55 MPH.

SUMMARY OF TEST RESULTS: The Bronco II, the Blazer S-10 and the UN46 prototype with the base tire and suspension did not establish a roll over response during any of the J-turn maneuvers at speeds up to and including 55 MPH. The UN46 prototype demonstrated a roll over response, established by observing two wheels off the ground and/or outrigger contact, with a number of tire, tire pressure, suspension configurations at the heavy load condition. A complete summary of the roll over response is included in Table 1.

  
D.S. Starr, Research Engineer  
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## VEHICLE DESCRIPTION:

Make and Model: 1989 Ford Bronco II  
 Veh. No. 316T656

Wheelbase: 94.1 inches

Track: Front: 57.0 inches  
 Rear : 57.0 inches

Suspension Type: Front: Twin I beam with anti-roll bar  
 Rear: Live axle with anti-roll bar

Engine: 2.9L V-6

Transmission: 5 speed manual and transfer case

Steering System: Power

Tires: Firestone FR480  
 P205/75R15 M&S

Tire Pressure Front: 35 psi  
 Rear ; 35 psi

Test Weights: light...GWR  
 Left Front = 1055...1045 lbs.  
 Right front= 1016... 989 lbs.  
 Left rear = 988...1145 lbs.  
 Right rear = 957...1102 lbs.  
 Total = 4006...4281 lbs.

Weight Distribution: (Light) 51.7% F / 48.3% R  
 (GWR) 47.5% F / 52.5% R

Ride Heights: curb .... gvw w/o  
 w/driver. outrigger  
 Left Front = 3.57..... 3.83 inches  
 Right front= 3.45..... 3.65 "  
 Left rear = 4.17..... 2.62 "  
 Right rear = 4.16..... 2.60 "

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## VEHICLE DESCRIPTION:

Make and Model: UN46 2-Dr. prototype  
 Veh. No. 316T008

Wheelbase: 102.5 inches

Track: Front: 58.6 inches  
 Rear : 58.4 inches

Suspension Type: Front: Twin I beam with anti-roll bar  
 Rear: Live axle with anti-roll bar

Engine: 4.3L V-6

Transmission: automatic and transfer case

Steering System: Power

Tires: Firestone  
 (1) P225/70R15 AS  
 (2) P235/75R15 ATX  
 (3) P235/75R15 AS  
 (4) P245/70R15 AS

Tire Pressure Front: 26,30,35 psi  
 Rear : 26,35 psi

Test Weights: light...GWR  
 Left Front = 1243...1189 lbs.  
 Right front= 1110...1096 lbs.  
 Left rear = 1099...1270 lbs.  
 Right rear = 1073...1273 lbs.  
 Total = 4525...4828 lbs.

Weight Distribution: (light) 52.0% F / 48.0% R  
 (GWR) 47.3% F / 52.7% R

Ride Heights: curb .... gwr w/o  
 w/driver. outrigger  
 Left Front = 2.54..... 2.26 inches  
 Right front= 3.40..... 3.20 "  
 Left rear = 4.86..... 3.16 "  
 Right rear = 5.38..... 3.35 "

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## VEHICLE DESCRIPTION:

Make and Model:	1989 Chevrolet Blazer S-10 Sport Veh. No. 3097653
Wheelbase:	105.5 inches
Track (with aluminum whls)	Front: 56.5 inches Rear : 55.0 inches
Track (with steel whls)	Front: 61.3 inches Rear : 59.5 inches
Suspension Type:	Front: SLA with anti-roll bar Rear: Live axle with anti-roll bar
Engine:	4.3L V-6
Transmission:	automatic and transfer case
Steering System:	Power
Tires:	Uniroyal (stock) P235/750R15 Firestone (UN46 tires) (1) P205/70R15 AS (2) P245/70R15 AS
Tire Pressure	Front; 35 psi Rear ; 35 psi
Test Weights:	light...GWR Left Front = 1199...1190 lbs. Right front= 1101...1096 lbs. Left rear = 1037...1206 lbs. Right rear = 1035...1208 lbs.  Total = <u>4272...4700 lbs.</u>
Weight Distribution:	(light) 52.6 F / 47.4 R (GWR) 48.6 F / 51.4 R

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**INSTRUMENTATION:**

- Humphrey Gyroscopic Platform No. CF70-0101-1 (serial number H1) to measure corrected lateral acceleration and roll angle. The unit was mounted where the front passenger seat is normally located. The distance from the front axle spin center to the accelerometer was 47 inches for each of the vehicles
- Humphrey Yaw Rate Gyro No. RG51-0106-1 (full scale range =  $\pm 30$  deg/sec)
- Sensor Development Steering Wheel Angle and Torque Transducer Model 01002-1 ( Car #2 )
- Correxit L-head to measure longitudinal velocity
- Correxit H-head to measure lateral velocity at the rear bumper position
- Signal Conditioning Package
- Ryowa RTP-501 phillips cassette type FM Recorder to record data

**TEST PROCEDURE AND RESULTS:**

All vehicle tests were conducted at the handling pad of AFG at light and heavy (GWR) loads. The light load consists of the vehicle, driver and instrumentation. The heavy load is the light load plus full passenger load and up to 250 lbs. of cargo located behind the rear seat location, without loading the rear axle beyond its GAWR (gross axle weight rating). All tests were conducted with outriggers installed on the front and rear bumper mounts. Other non OE safety equipment installed in the vehicles included a custom fabricated roll cage, competition driver seat and 6 point competition harness restraint system.

The J-turn maneuver was conducted by driving at a constant speed (40,45,50 and 55 MPH), putting the vehicle in neutral and then rapidly steering to a preselected steering angle. Steering angles used were 180, 270 and 360 degrees. A steering stop was used to assure no overshoot. Fast steering inputs of over 500 degrees per second were attained. Data was collected during each run and wheel lift and outrigger observations were recorded.

The test matrix and roll over responses are described in Table 1. Plots of the 50 and 55 MPH tests and complete test logs are attached.

It should be noted that some of the plots for the steering wheel angle channel on the Bronco II and UN46 are misleading. A

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transducer malfunction caused the signal to indicate a -360 degree negative angle intermittently (usually during the transient ramp up of the signal). This makes determination of the ramp rate of steering wheel angle impossible on these runs. For a typical example look at the steering wheel angle trace for run #5 of the UN46. You will note the actual steer angle starts at 0° and at about 14 seconds starts to ramp up to -180°. You will note that the angle appears to overshoot to about -360 before returning to -180°. This was not the case as a steering stop was used. Similar phenomena occur in other runs. Therefore when using the steering wheel angle channel information care should be used.

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## J-Turn Tests

VEHICLE	WEIGHT	TIRE	TIRE PRESSURE	ROLL
Bronco II	heavy light	Firestone FR480 P205/70R15	35 / 35	no no
UN46	heavy	Firestone AS P245/70R15	35 / 35 26 / 26	yes yes
UN46	heavy	Firestone ATX P235/75R15	35 / 35 26 / 26 30 / 35	no no yes
UN46	heavy	Firestone FR480 P225/70R15	35 / 35 30 / 35	no no
UN46 no rear bar	heavy	Firestone FR480 P225/70R15	35 / 35	yes
UN46	light	Firestone FR480 P225/70R15	35 / 35	no
UN46	light	Firestone ATX P235/75R15	35 / 35 26 / 26	no no
UN46	heavy	Firestone AS P235/75R15	35 / 35	yes
Blazer S-10	heavy	Uniroyal P235/75R15	35 / 35	no
Blazer S-10	heavy	General P205/75R15	35 / 35	no
Blazer S-10	heavy	Firestone FR480 P245/70R15 steel wheels	35 / 35	no
Blazer S-10	light	Uniroyal P235/75R15	35 / 35	no
Blazer S-10	light	General P205/75R15	35 / 35	no
Blazer S-10	light	Firestone FR480 P245/70R15 steel wheels	35 / 35	no

Table 1: J-turn Test Matrix and Roll Over Response

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