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TIRE ROLLING RESISTANCE FOR LIGHT VEHICLES I: SELECTION OF TIRES AND TESTS FOR RATING SYSTEM DEVELOPMENT

AUTHOR: JOHN HARRIS
TRANSPORTATION RESEARCH INSTITUTE

CO-AUTHORS:
LARRY EVANS
TRANSPORTATION RESEARCH INSTITUTE
JAMES MACISAAC
DOT – NHTSA
ED TERRILL, PH.D.
AKRON RUBBER DEVELOPMENT LABORATORY, INC.

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Tire Rolling Resistance for Light Vehicles, I: Selection of Tires and Tests for Rating System Development

John Harris, Transportation Research Center, Inc.
James D. MacIsaac Jr., USDOT - NHTSA
Larry Evans, Transportation Research Center, Inc.

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Tire Rolling Resistance Test Program

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- **Testing conducted at two laboratories to evaluate lab-to-lab variability:**
  - Smithers Scientific Services, Inc. (SSS)
  - Akron Rubber Development Labs (ARDL)
    - Subcontracted to Standards Testing Labs (STL)
- **Five rolling resistance test methods evaluated**
  - Three SAE & Two ISO methods
- **Twenty five tire models included in study**
  - Included Standard Reference Test Tire (SRTT), Tire Type “M14” - ASTM F2493-06, 225/60R16 Tire

Laboratory Rolling Resistance Testing

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- **Smithers Scientific Services, Inc.**
  - 1 x machine
  - 1 y machine

- **Standards Testing Labs**
  - 1 z machine
  - 1 q machine

Selecting a Test Method

- **Five Test Methods Evaluated**
  - SAE (USA) Rolling Resistance Tests
    - J2452 Coastdown
      - Auto manufacturers use for vehicle fuel economy calculations over a range of speeds
    - J1269 Multi-Point
      - Uses four or six sets of test conditions and allows calculation of rolling resistance at a “Standard Reference Condition (SRC)”
    - J1269 Single Point
      - Runs a single test at the SRC
  - ISO (Global) Rolling Resistance Tests
    - 18164 Multi-Point
      - Four or five rolling resistance values based on four or five test conditions
    - 28580 Single Point (Draft International Standard) in ballot
      - Runs a single test

Selecting a Test Method

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Category	SAE J2452 Coastdown	SAE J1269 Multi-Point	SAE J1269 Single Point	ISO 18164 Multi-Point	ISO 28580 Single Point
Machine	1.708 m	1.708 m	1.708 m	1.708 m	>=1.708m
Measurement Method	Force, Torque, or Power	Force, Torque, or Power	Force, Torque, or Power	Force, Torque, Power, or Decel.	Force, Torque, Power, or Decel.
Surface	80 Grit	80 Grit	80 Grit	Smooth Surface (80 grit optional)	Bare or Textured Surface
Speed	Multi	80 km/h (50 mph)	80 km/h (50 mph)	80 km/h (50 mph)	80 km/h (50 mph)
Pressure	Multi	Multi	+20 kPa (3 psi) Regulated	Multi	210 kPa - SL capped 250 kPa - XL capped 100% LT Capped
Load	Multi	Multi P 90% & 50%	P 70% sw load	Multi P 50% & 90%	P 80% sw load LT 85% sw load
Reference Temp	24℃	24℃	24℃	25℃	25℃
Break-in	60 min	30-60 min	60 min	30 min	30 min/50 min
Lab Alignment Procedure	No	No	No	No	Yes

Overview of 25 Test Tire Models

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Code	MFG	Size	Load Index	Speed Rating	Model	Treadwear	Trac.	Temp.	Tread Depth	Performance Level
M14	Uniroyal	P225/60R16	97	S	ASTM 16" SRTT	540	A	B	8	ASTM F 2493-06 Reference
B14	Bridgestone	P225/60R16	97	V	Turanza LS-V	400	AA	A	11	Grand Touring All Season
M13	Michelin	225/60R16	98	H	Pilot MXM4	460	A	A	7	Grand Touring All Season
B11	Bridgestone	P225/60R16	97	H	Potenza RE92 OWL	340	A	A	11	High Performance All Season
G10	Goodyear	P205/75R15	97	S	Integrity	460	A	B	9	Passenger All Season
G11	Goodyear	P225/60R17	98	S	Integrity	460	A	B	8	Passenger All Season
G8	Goodyear	225/60R16	98	S	Integrity	460	A	B	9	Passenger All Season
G9	Goodyear	P205/75R14	95	S	Integrity	460	A	B	9	Passenger All Season
P5	Pep Boys	P225/60R16	97	H	Touring HR	420	A	A		Passenger All Season
R4	Pirelli	225/60R16	98	H	P6 Four Seasons	400	A	A	11	Passenger All Season
B10	Bridgestone	225/60R16	98	Q	Blizzak REVO1				9	Performance Winter
B15	Dayton	225/60R16	98	S	Winterforce					Performance Winter
U3	Dunlop	P225/60R17	98	T	SP Sport 4000 DSST	360	A	B	11	Run Flat
B 13	Bridgestone	P225/60R16	97	T	Turanza LS-T	700	A	B	11	Standard Touring All Season
D10	Cooper	225/60R16	98	H	Lifeliner Touring SLE	420	A	A	11	Standard Touring All Season
B12	Bridgestone	P225/60R16	98	W	Potenza RE750	340	AA	A	7	Ultra High Performance Summer
D7	Cooper	LT235/85R16	120(E)	N	Discoverer ST-C					All terrain on/off road
D8	Cooper	LT245/75R16	120(E)	N	Discoverer ST-C					All terrain on/off road
D9	Cooper	LT265/75R16	120(E)	N	Discoverer ST-C					All terrain on/off road
P4	Pep Boys	LT245/75R16	120(E)	N	Scrambler A/P					All season on-road
C9	General	LT245/75R16	120(E)	Q	AmeriTrac TR					All terrain on/off road
K4	Kumho	LT245/75R16	120(E)	Q	Road Venture HT					All season on-road
M10	Michelin	LT245/75R16	120(E)	R	Michelin LTX A/S					All season on-road
M11	Michelin	LT245/75R16	120(E)	R	Michelin LTX M/S					All season on-road
M12	Michelin	LT245/75R16	120(E)	R	Michelin X RADIAL LT					All season on-road

ASTM Standard Reference Test Tire (SRTT)

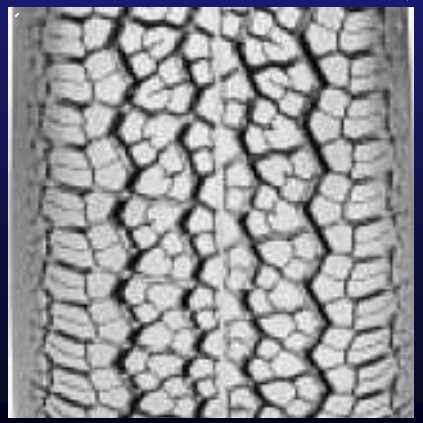
- **ASTM International (American Society for Testing and Materials)**
  - Industry and Government consensus standards organization
  - www.astm.org
- **ASTM Definition: Standard Reference Test Tire**
  - SRTT, n. A tire that is used as a control tire or surface monitoring tire.
- **Usage**
  - Test Sequence = SRTT, candidate 1, candidate 2, candidate 3, candidate 4,…. SRTT
  - Ensures consistency in testing
  - Allows rating based on % of SRTT test value

ASTM Standard Reference Test Tires

E 1136

- P195/75R14
- Established 1986
- Currently used for F 1805 Single Wheel Driving Traction (Winter Test for Snowflake Tire) and UTQG
- FMVSS 139 specifies F 1805 test to determine “winter tire” test criteria

196 mm



F 2493-06 (M14 in this study)

- P225/60R16 97S
- Established 2006
- Designed for use in braking, snow, wear and other performance tests
- In 28580 tests
  - Coefficient of Variation (C.V.) = 0.9
    STD = 0.11 lbs. Mean = 11.8 lbs.

231 mm

Overview of Passenger Tires – Axis #1

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- **One Manufacturer - Goodyear**
- **One Model - Integrity**
  - Four Sizes
- **+One Run Flat Model**

G9 P205/75R14 S

G10 P205/75R15 S

G8 225/60R16 S

G11 P225/60R17 S

U3 P225/60R17 T

Dunlop Sport 4000 DSST (Run Flat)

Overview of Passenger Tires - Axis #2

- **One Manufacturer – Bridgestone**
- **One Size - P225/60R16**
- **Six Models**
  - Q-W Speed Rating

Overview of Passenger Tires – Axis #3

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- **Four Manufacturers**
- **One Size - P225/60R16**
- **One Speed Rating - H**

Overview of 16 Passenger Tire Models

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1 Mfg. - Goodyear
4 Sizes
1 Model - Integrity
+ 1 Runflat

G9 P205/75R14 S

G10 P205/75R15 S

G8 225/60R16 S

G11 P225/60R17 S

U3 P225/60R17 T

Axis #1

Axis #2

B15 Winterforce S

B10 Blizzak REVO 1 Q

B12 Potenza RE750 W

B14 Turanza LS-V

B11 Potenza RE-92A H

B13 Turanza LS-T

M14 Reference Tire ASTM SRTT S

D10 Cooper Lifeliner Touring SLE H

R4 Pirelli P6 Four Seasons H

P5 Pep Boys Touring HR

M13 Michelin Pilot MXM4 H

Axis #3

1 Mfg. - Bridgestone
1 Size - P225/60R16
6 Tire Models

4 Mfg.
1 Size - P225/60R16
1 Speed Rating - H

Overview of 9 Light Truck Tire Models

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1 Mfg. - Cooper
3 Sizes
1 Model - Discoverer ST-C

1 Mfg. - Michelin
1 Size - LT245/75R16
3 Models

Axis #5

LT235/85R16

LT245/75R16

LT265/75R16

Axis #6

Michelin LTX A/S

Michelin LTX M/S

Michelin Radial LT

General Ameri*Trac TR

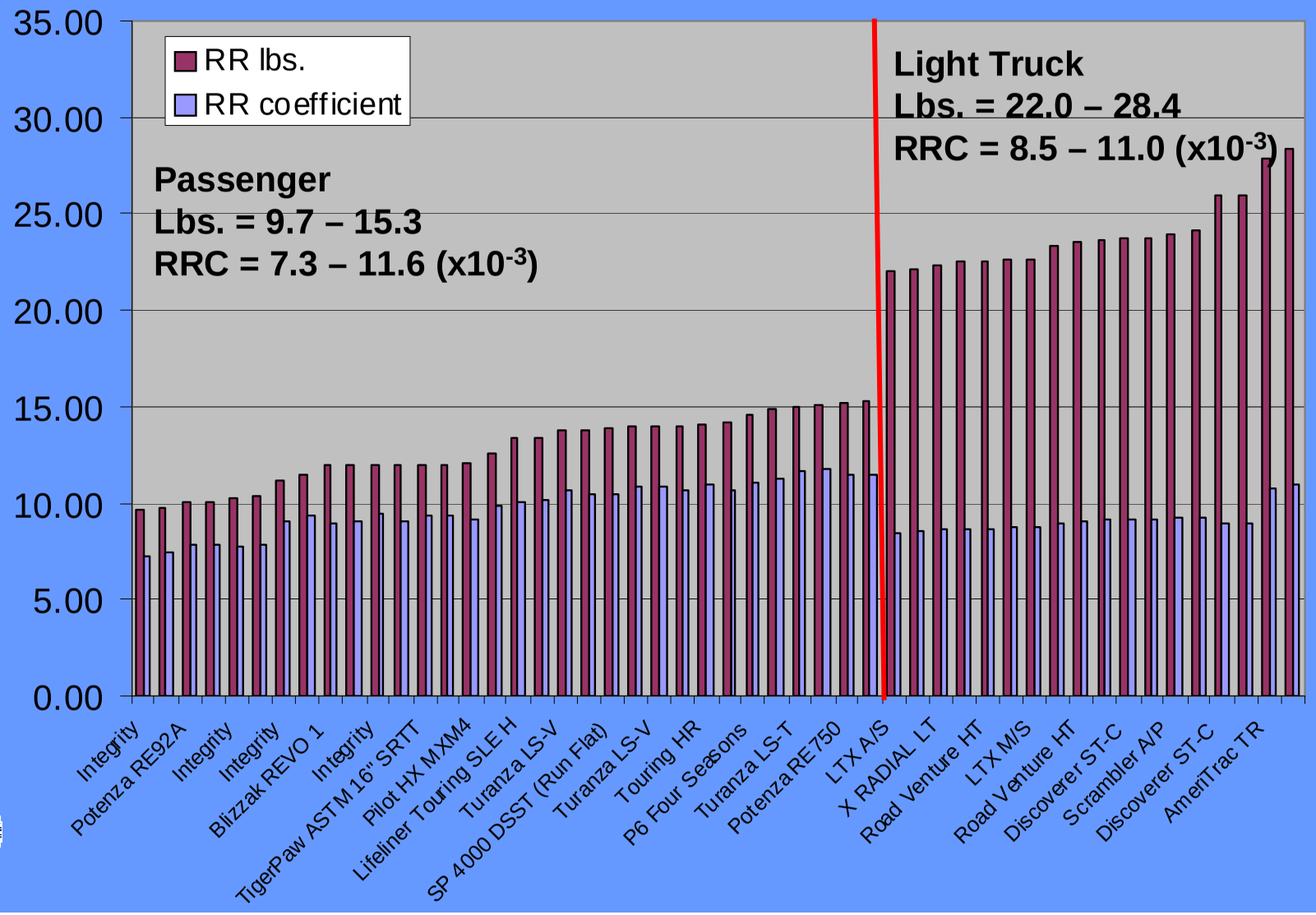
Kumho Road Venture HT

PEP Boys Scrambler A/P

Axis #7

3 Mfg.
1 Size - LT245/75R16

Data Range - Pounds Force & RR Coefficient (10^{-3})



Passenger Tire Rolling Resistance as % SRTT

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- **Axis #1 - Data range from 85.61 to 102.39% of SRTT**
  - One Manufacturer - Goodyear
  - One Model - Integrity
    - Four Sizes
  - +One Run Flat Model
- **Axis #2 - Data range from 83.97 to 124.65% of SRTT**
  - One Manufacturer – Bridgestone
  - One Size - P225/60R16
  - Six Models
    - Q-W Speed Rating
- **Axis #3 - Data range from 100.08 to 122.63% of SRTT**
  - Four Manufacturers
  - One Size - P225/60R16
  - One Speed Rating - H

Light Truck Tire Rolling Resistance as % SRTT

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- **Axis #5 - Data range from 196.62 to 215.20% of SRTT**
  - 1 Mfg. - Cooper
  - 3 Sizes
  - 1 Model - Discoverer ST-C
- **Axis #6 - Data range from 183.31 to 187.93% of SRTT**
  - 1 Mfg. - Michelin
  - 1 Size - LT245/75R16
  - 3 Models
- **Axis #7 - Data range from 191.31 to 233.54% of SRTT**
  - 3 Mfg.
  - 1 Size - LT245/75R16

Comparison of Single Point Rolling Resistance Tests

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ISO 28580 (Draft)

- 1.708m or greater Test Machine
  - Not corrected to 2m in this study
- Force/Torque/Power/Deceleration methods
- Bare or Textured Surface
- 25℃ Reference Temperature
- 80 km/h (50 mph)
- 80 Passenger / 80 LT % sidewall load
- 210 kPa Pass / 100% LT pressure
- Capped pressure
- NO break-in
- Lab Alignment Procedure

SAE J1269 Single (SRC)

- 1.708m Test Machine
- Force/Torque/Power methods
- 80 Grit Surface
- 24℃ Reference Temperature
- 80 km/h (50 mph)
- 70% sidewall load
- @ +20 kPa (3 psi) Regulated
- 60 minute break-in

ISO 28580 (Draft) vs. SAE J1269 SRC

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Disadvantages

ISO 28580 (Draft)

- Bare surface less accurate at high light truck tire loads
- Not a large database to date

J 1269 Single (SRC)

- Regulated pressure is different from highway usage
- Coefficient of Variation was 2.3

Advantages

- Harmonization - Being developed by ISO and Tire Industry as “World Standard”
- Least difference in labs studied
- Coefficient of Variation was 1.2
- Tire Industry has large data base of results from this test
- Database from J1269 Multi-Point can be used to calculate SRC result

ISO 28580 (DIS) Lab Alignment

- Includes 2 “Alignment Tires” for passenger being developed / defined by ETRTO
- Includes 2 “Alignment Tires” for light truck (C tire) being developed / defined by ETRTO
- Results corrected to 2 meter drum diameter
- Uses control tires to handle day-to-day, month-to-month variation, or out of calibration

Test Program Summary

- **Two laboratories were included in testing**
- **Five Test Methods Evaluated**
- **Twenty five tire models included in study**
- **Passenger tire rolling resistance range:**
  - Force = 9.7 – 15.3 lbs
  - RRC = 7.3 – 11.6 ($x10^{-3}$)
  - %SRTT = 83.97 – 124.65%
- **Light truck tire rolling resistance range:**
  - Force = 22.0 – 28.4 lbs
  - RRC = 8.5 – 11.0 ($x10^{-3}$)
  - %SRTT = 183.31 – 233.54%