Texture and Tire/Pavement Friction

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Outcomes

- Understand vehicle, tire, geometric, and environmental factors in braking and control
- Learn what pavement surface properties control “available friction”
- Greater understanding of tire/pavement interface
- Understand how we measure “available friction” and use the data
- Questions/comments

Does This Make Sense When Measuring Friction?

- Using locked wheel testers
- Using bias ply tires
- Using smooth or ribbed tires
- Using continuous friction measurement equipment (CFMEs)
- Testing a wet surface

Wet Friction Demand Factors

Environmental

- Wet versus dry
- Temperature variations
- Seasonal variations

Wet Friction Demand Factors

Highway Design/Geometric and Facility Considerations

- Design/Posted Speed
- Straight/Flat versus Curves/Super's/Hills and Grades
- Traffic Makeup Volumes Congestion
- Intersections/Interchanges
- Water Run-off/Drainage

Wet Friction Influence Factors

Pavement Distresses

- Rutting – Ponding
- Raveling
- Bleeding/Flushing
- Cracking
- Corrugations
- Roughness
- Etc.

Wet Friction Demand Factors

Vehicle/Operator

- Speed
- Weight
- Design/Condition of Braking System
- Alertness/Reaction Time
- Tires

Wet Friction Demand Factors

Tires

- Age and Tread Depth
- Tread Pattern
- Hardness/Softness of Rubber
- Inflation Pressure
- Type and Design

Wet Pavement Surface Friction

- Strive for Sufficient Available Friction everywhere
- Sufficient Level Varies by Location (demand level)
- Available Friction is exclusively dependent on both the microtexture and macrotexture of the surface

Wet Pavement Surface Friction

Macrotexture - the texture you can see with the naked eye

- Openness of an AC surface
- Jaggedness of a chip seal
- Tining, grooving, or drag finish one sees on a PCC surface
- Controlled largely be the largest aggregate size in the mix

Wet Pavement Surface Friction

Microtexture - the finer texture more easily felt than seen

- Fine surface texture of sand and aggregate particles and degree of polish on exposed surfaces
- Bituminous coating until worn off
- Fine surface texture of sand/cement paste on a PCC surface

Wet Pavement Surface Friction

Microtexture

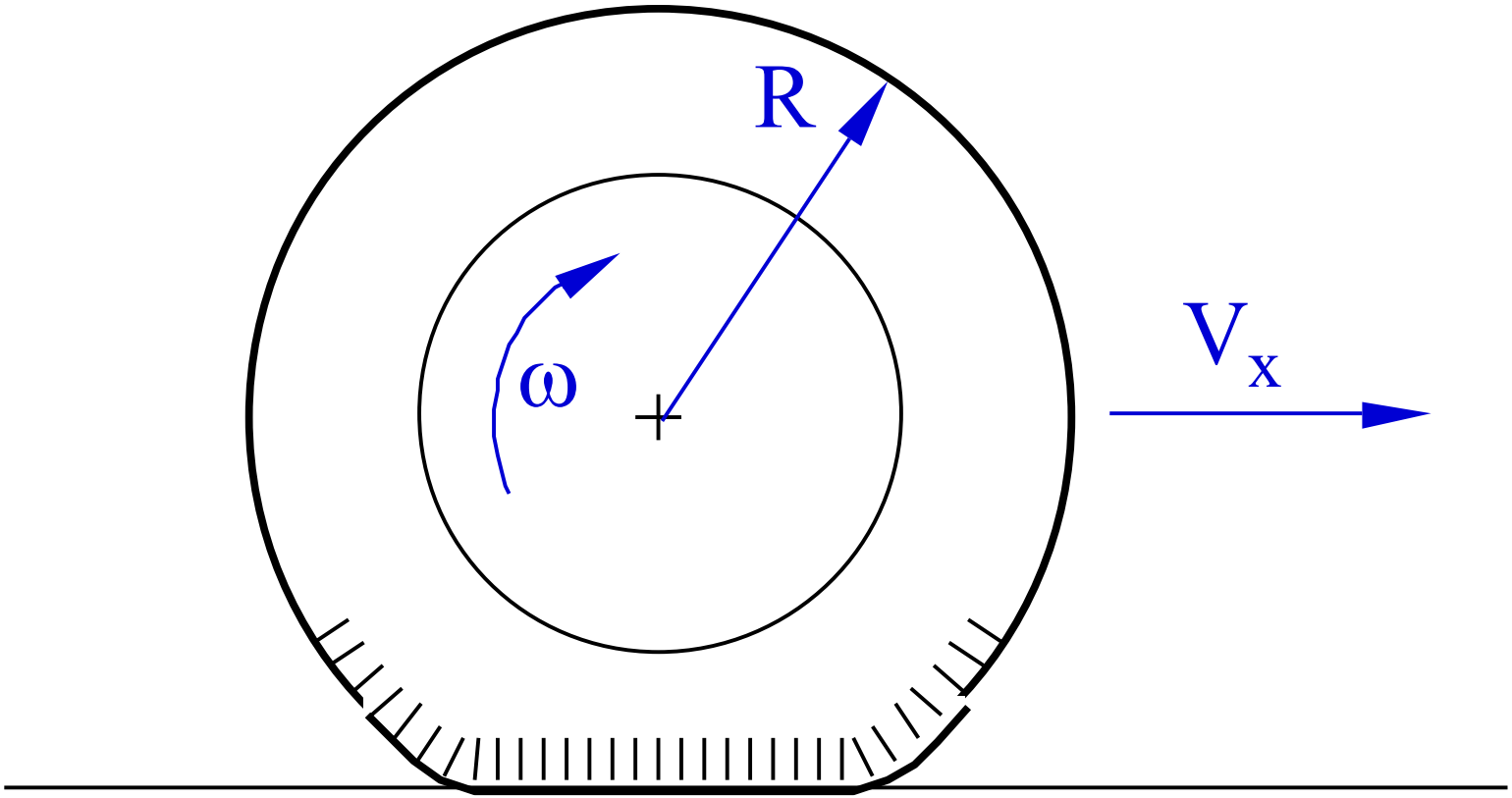
- Fine texture that interacts with tire rubber for friction (adhesion)
- Important at all speeds, more dominant at lower speeds

Wet Pavement Surface Friction

Macrotexture

- Allows space for water to evacuate
- Decreases hydroplaning potential
- Allows tire to contact the surface when wet (lets microtexture work)
- Increasingly important at higher speeds
- Deforms tire tread – hysteresis friction

Tire in Contact with Pavement



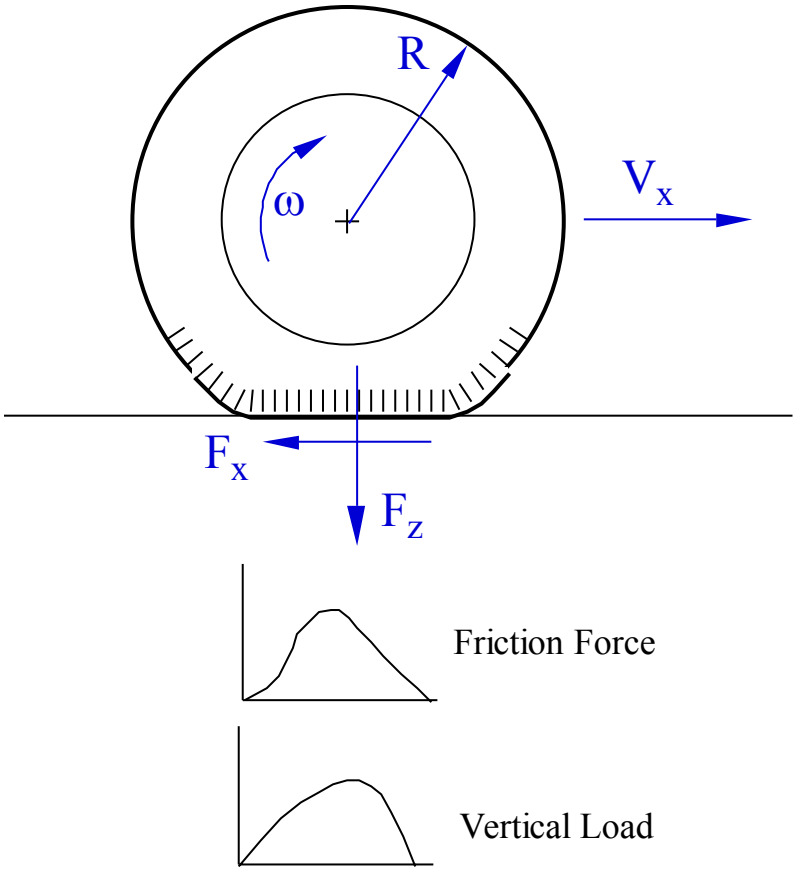
Source: Steve Karamihas UMTRI

Longitudinal Slip, Traction

$$\text{Slip} = \frac{V_x - R \bullet \omega}{R \bullet \omega} \bullet 100$$

Source: Steve Karamihas UMTRI

Braking Tire



Source: Steve Karamihas UMTRI

Longitudinal Slip, Braking

$$\text{Slip} = \frac{V_x - R \bullet \omega}{V_x} \bullet 100$$

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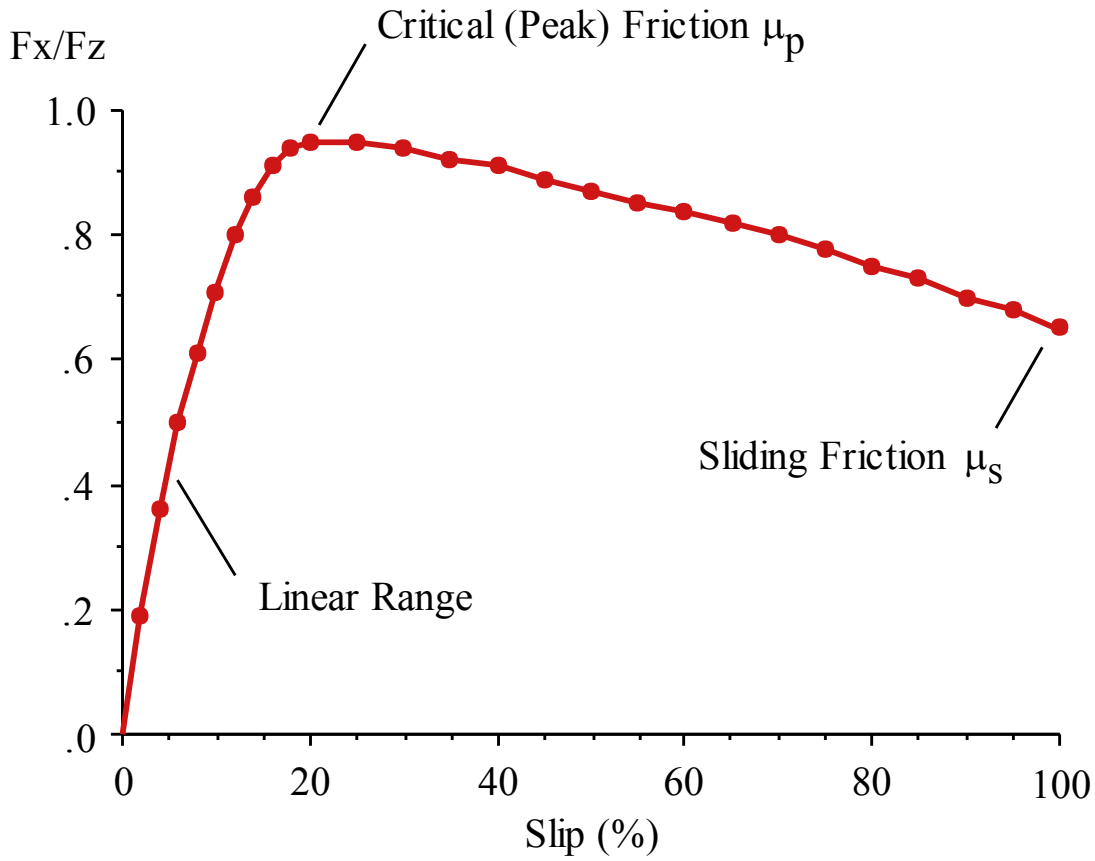
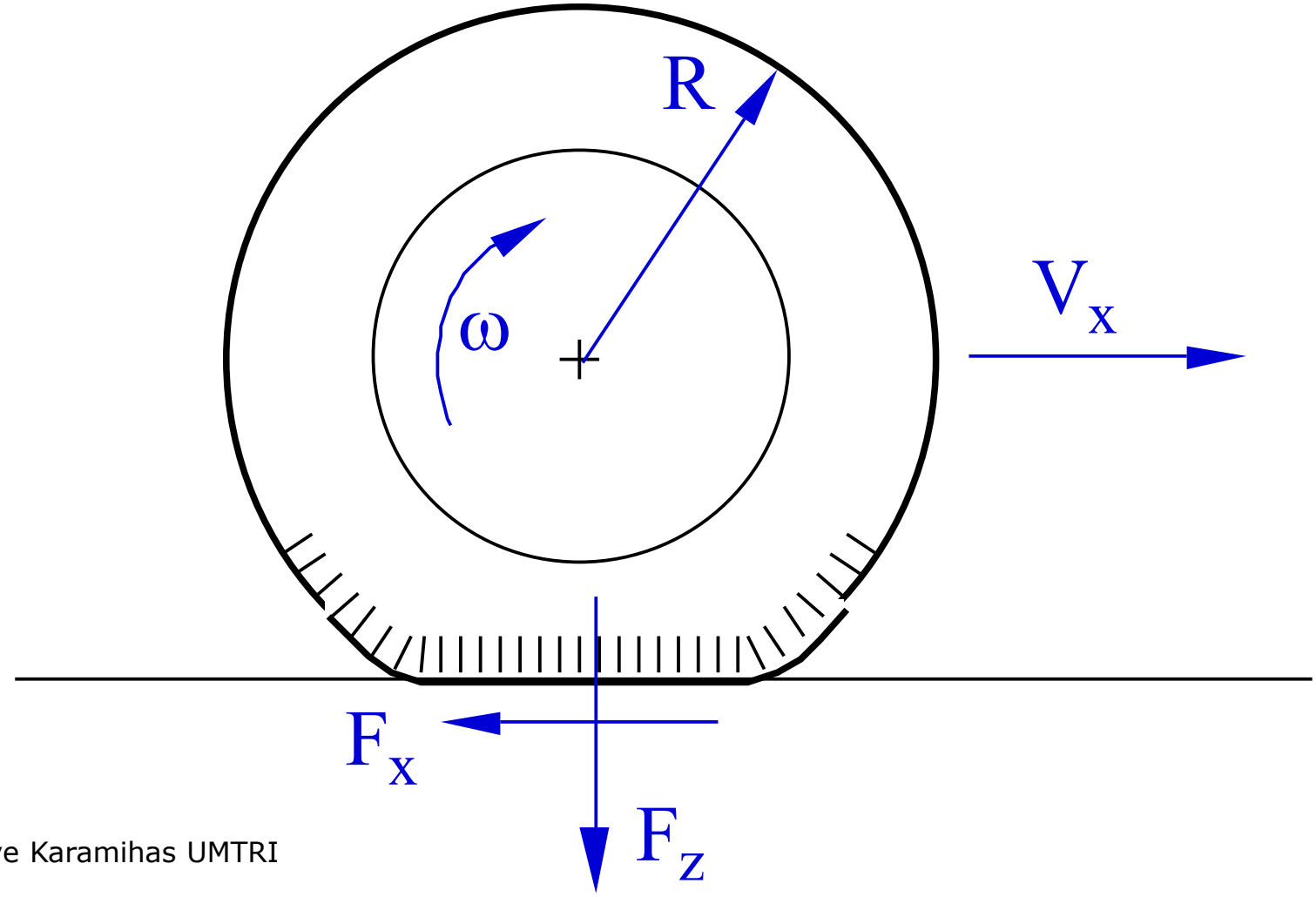
Tire/Pavement Friction



Source: Steve Karamihas UMTRI

Braking Tire



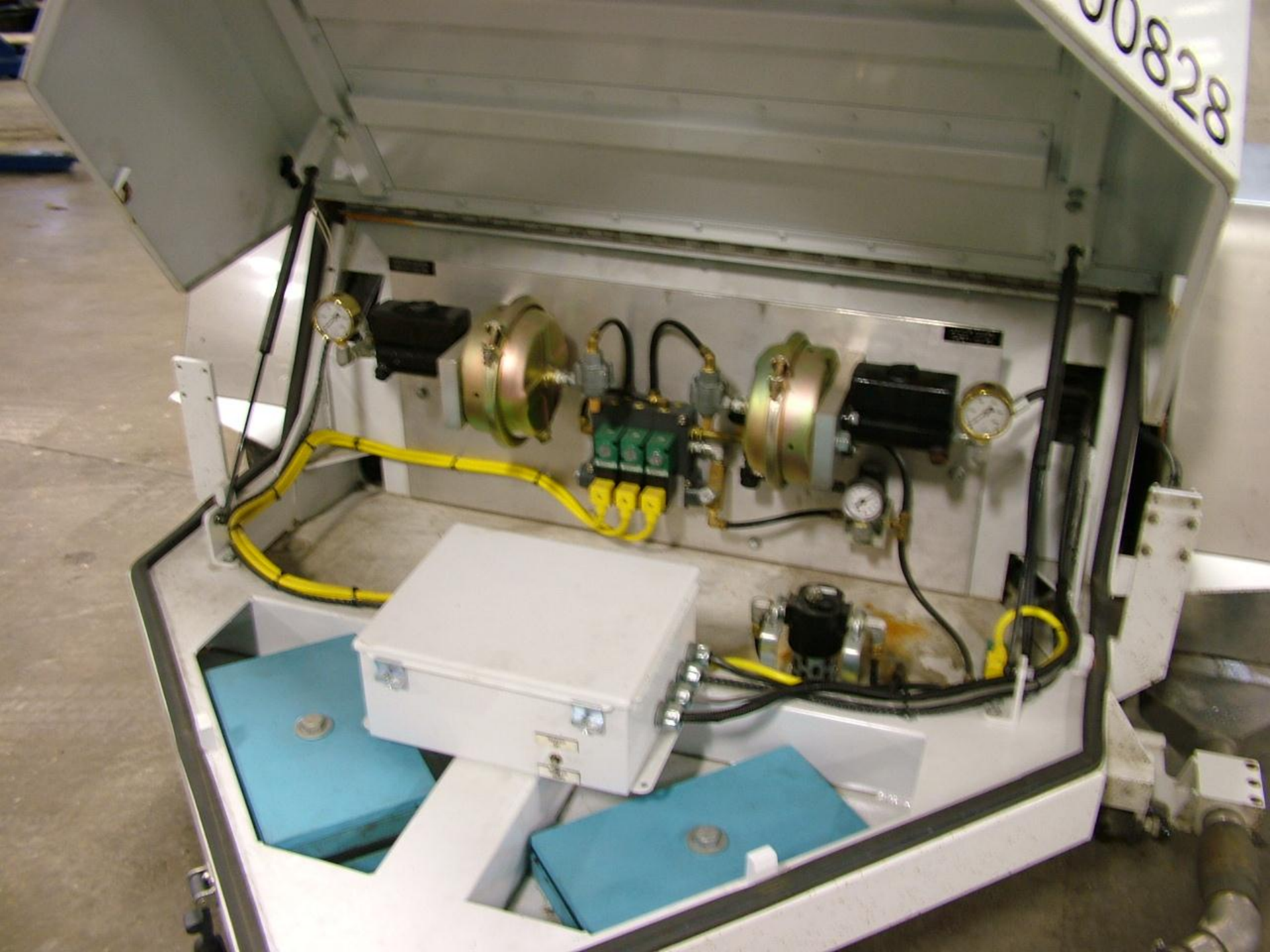
Source: Steve Karamihas UMTRI

ASTM E 274 in action

- DriveAlong.mpeg

ASTM E 274 in action

- DriveBy.mpeg




ASTM E 501
ASTM E 524

ASTM E 274 Locked Wheel Friction Testing Units

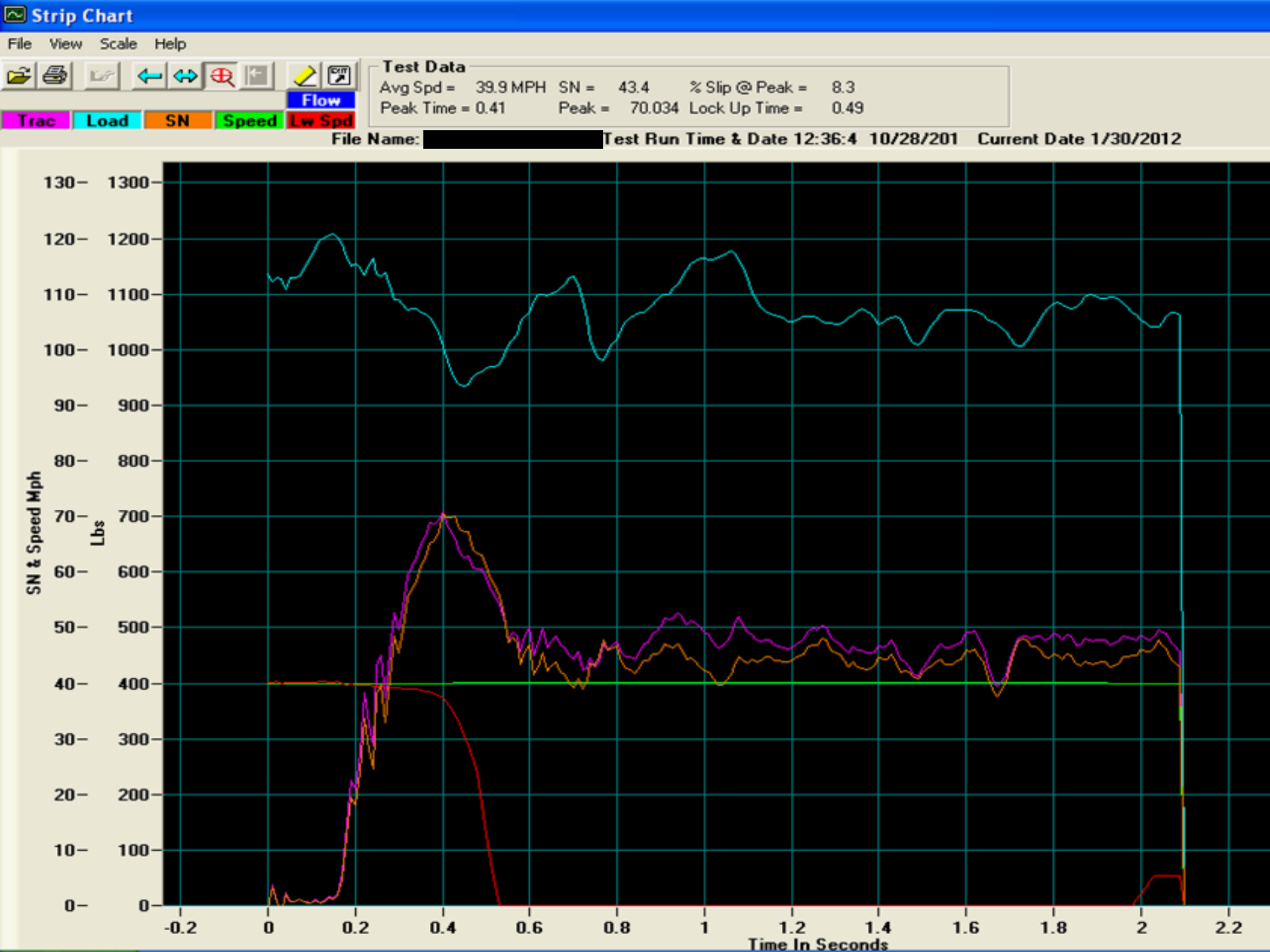
$$SN = (Fh/Fv)*100$$

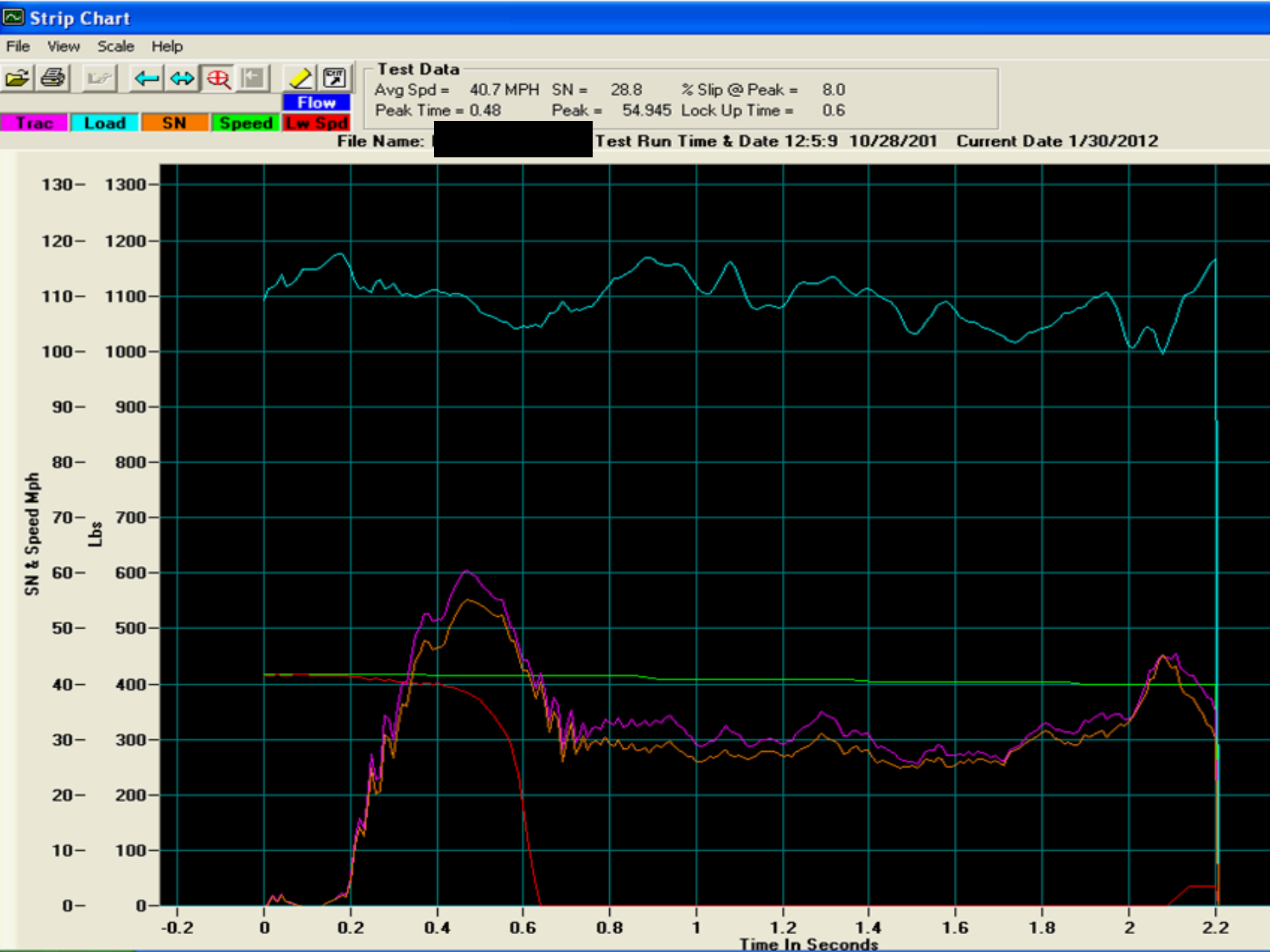
SN – skid number or friction number
Fh – horizontal force to drag locked wheel
Fv – vertical or load force on locked wheel

r subscript for ribbed test tire
s subscript for smooth test tire

standard test speed = 40 mph


Strip Chart
File View Scale Help
Test Data
Avg Spd = 40.5 MPH SN = 56.6 % Slip @ Peak = 5.6
Peak Time = 0.5 Peak = 92.691 Lock Up Time = 0.68
Flow
Trac Load SN Speed Lw Spd
File Name: [redacted]
Test Run Time & Date 10:28:47 10/28/201 Current Date 1/30/2012
SN & Speed Mph
Lbs
130 120 110 100 90 80 70 60 50 40 30 20 10 0
1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0
-0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4
Time In Seconds


Strip Chart
File View Scale Help
Test Data
Avg Spd = 39.9 MPH SN = 43.4 % Slip @ Peak = 8.3
Peak Time = 0.41 Peak = 70.034 Lock Up Time = 0.49
Flow
Trac Load SN Speed Lw Spd
File Name: [redacted] Test Run Time & Date 12:36:4 10/28/201 Current Date 1/30/2012
SN & Speed Mph
Lbs
130 120 110 100 90 80 70 60 50 40 30 20 10 0
1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0
-0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2
Time In Seconds


Strip Chart
File View Scale Help
Test Data
Avg Spd = 40.7 MPH SN = 28.8 % Slip @ Peak = 8.0
Peak Time = 0.48 Peak = 54.945 Lock Up Time = 0.6
Flow
Trac Load SN Speed Lw Spd
File Name: [redacted] Test Run Time & Date 12:5:9 10/28/201 Current Date 1/30/2012
SN & Speed Mph
Lbs
130 120 110 100 90 80 70 60 50 40 30 20 10 0
1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0
-0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2
Time In Seconds

ASTM E 274 Locked Wheel Friction Testing Units

Not a direct measure of either microtexture or macrotexture but a response to both.

- 40-50 year history
- Lane closures/traffic control not req'd
- Other friction testing devices don't measure/respond to surface texture the same

ASTM E 274 Locked Wheel Friction Testing Units

Ribbed tire – sensitive to microtexture and insensitive to macrotexture

(ribs give place to evacuate water film)

Smooth tire – sensitive to both micro and macrotexture

(relies solely on pavement to evacuate water)

ASTM E 274 Locked Wheel Friction Testing Units

A measure of the pavement's contribution of your ability to stop when the road is wet!

Ribbed vs. Smooth test tire

- Using only one gives little insight into how much micro vs. macro
- Threshold levels – different for both
- Use one, the other, or both?
  - Safety
  - Research
  - Curiosity

Available Friction

Need sufficient level of both microtexture and macrotexture

- Insufficient macro means increased hydroplaning potential, regardless of microtexture
- Pavement and tire both have to evacuate water
- Insufficient micro means increased stopping distance regardless of macrotexture
- To a point, a high level of one can make up for a marginal level of the other

Available Friction

Need sufficient level of both microtexture and macrotexture

- Can be engineered/designed
- Must consider life of the surface
- Carefully consider level of available friction required for given location

Available Friction

Can we have too much friction?

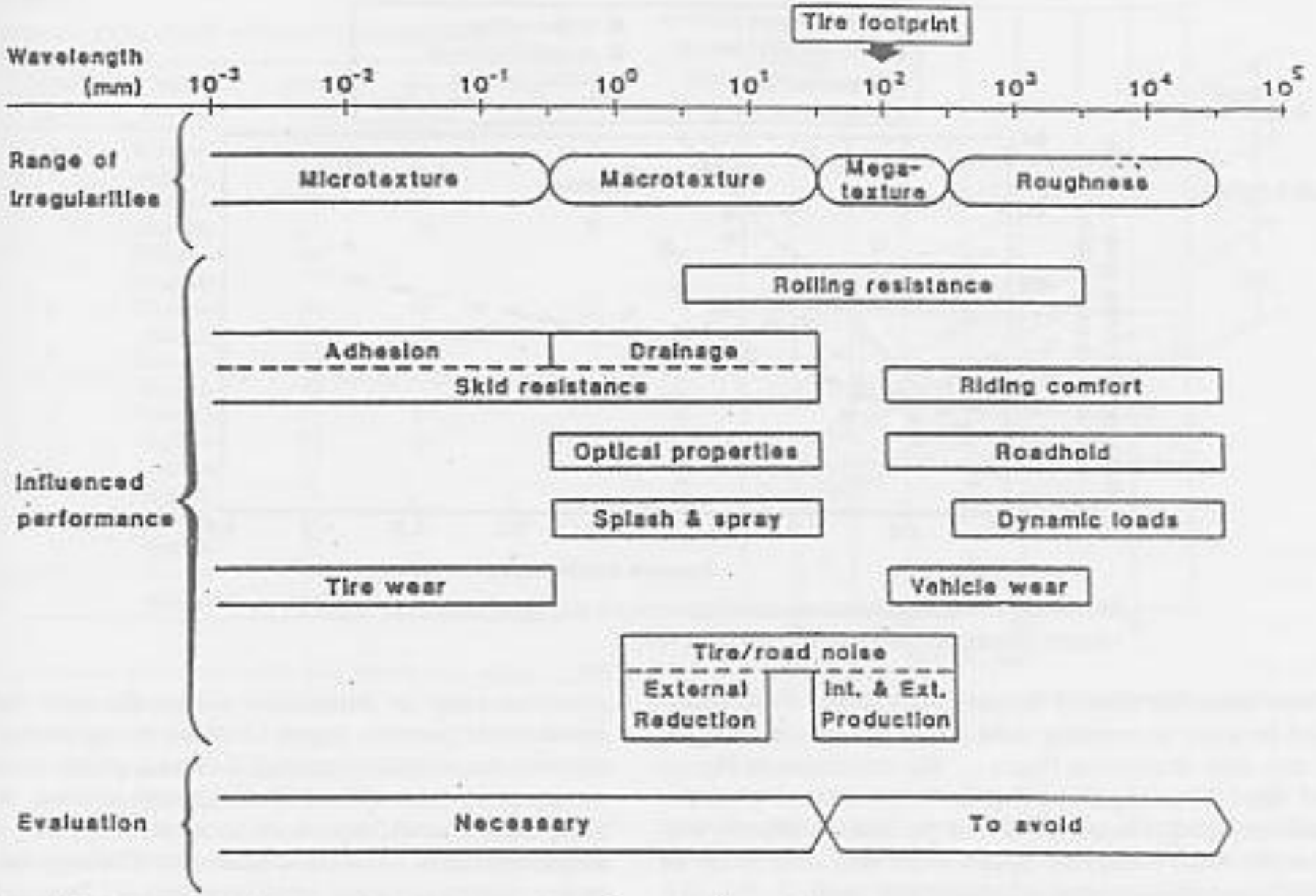
Skidding versus Rolling over?

High levels of Macrotexture may:

- Increase tire/pavement noise
- splash/spray?
- Require more snow/ice removal chemicals
- Decrease tire life

Optimize texture for all surface properties!

Influence of surface characteristics on vehicle performance. (Ayton, 1991)



Other Devices that measure friction/respond to texture

- Mu meter
- Dynamic Friction Tester (DFT)
- Continuous Friction Measurement Equipment (CFMEs)
  - Scrim
  - HFT
- British Pendulum
- Etc.

All respond to given micro and macrotexture in different ways => hard to compare different friction testing devices

Direct Measures of Macrotexture

- Sandpatch test (traffic control)
- 2-D point laser => at speed
- 3-D lines scan laser of photographic = at speed

As a community, we're improving our ability to directly measure and quantify macrotexture while microtexture can only be directly measured in laboratory environments

Acknowledgements

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Questions ???????

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THANK YOU