SOME EFFECTS OF GROOVES ON TIRE/PAVEMENT NOISE

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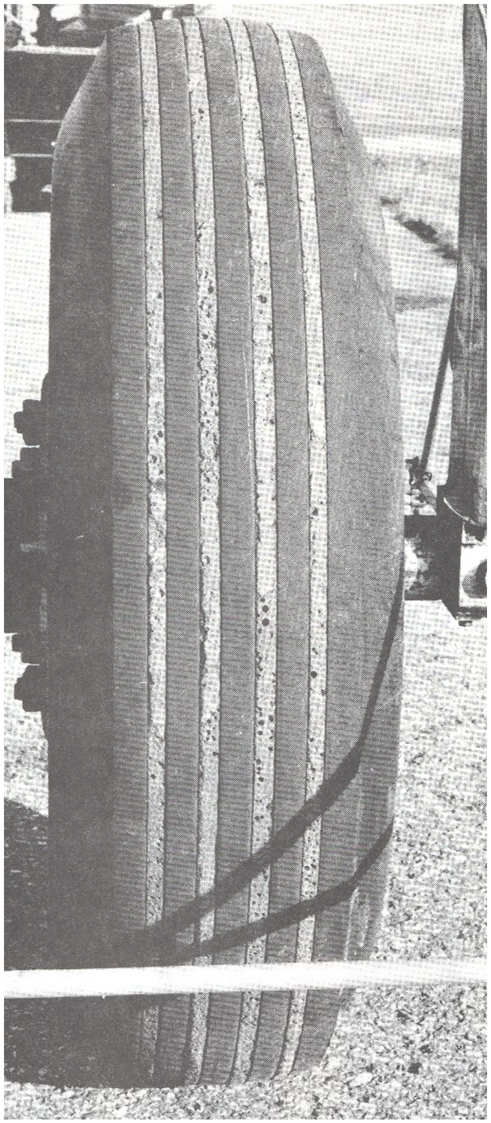
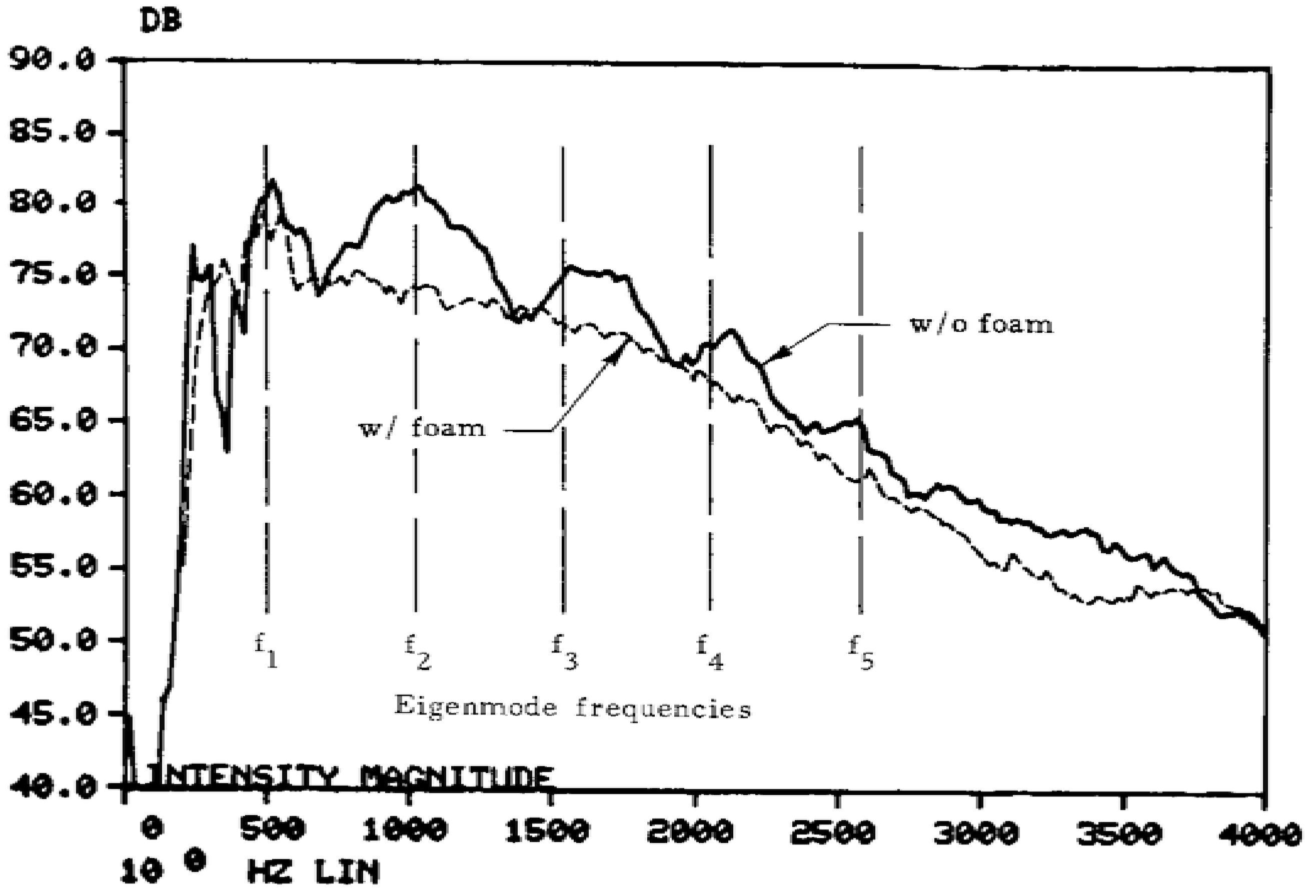
'09 DAYTON NOISE & VIBRATION TRB ADC 40

ILLINGWORTH & RODKIN, INC. Acoustics • Air Quality

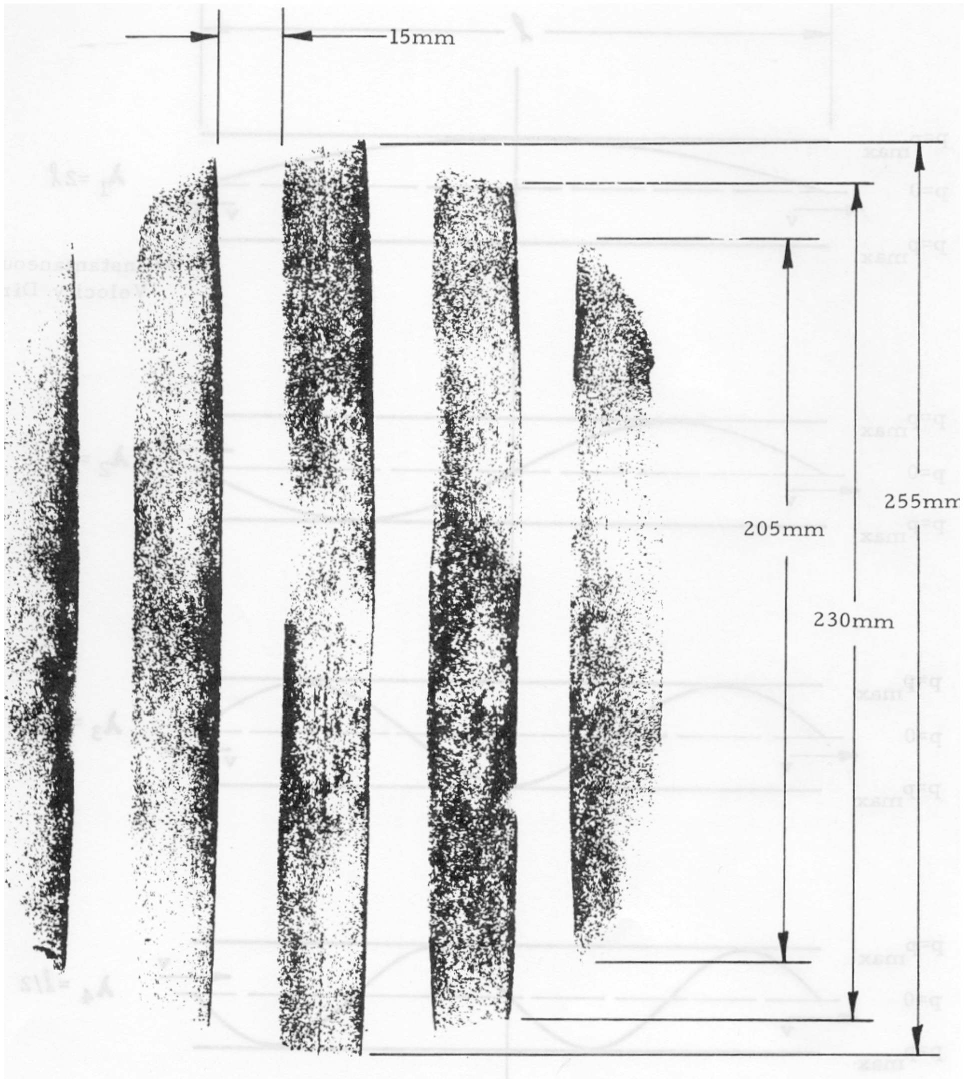
Grooves in Tires & Pavement

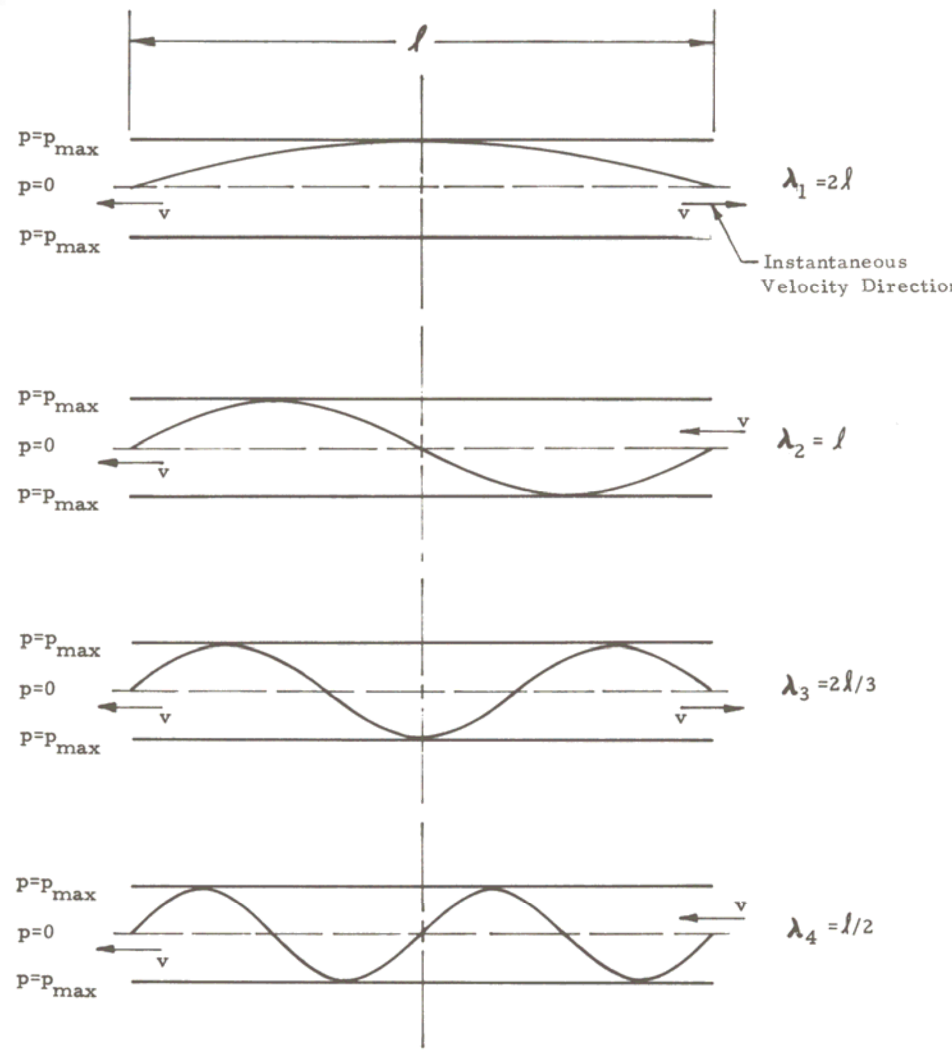
Groove Resonance in Straight Rib Truck Tire



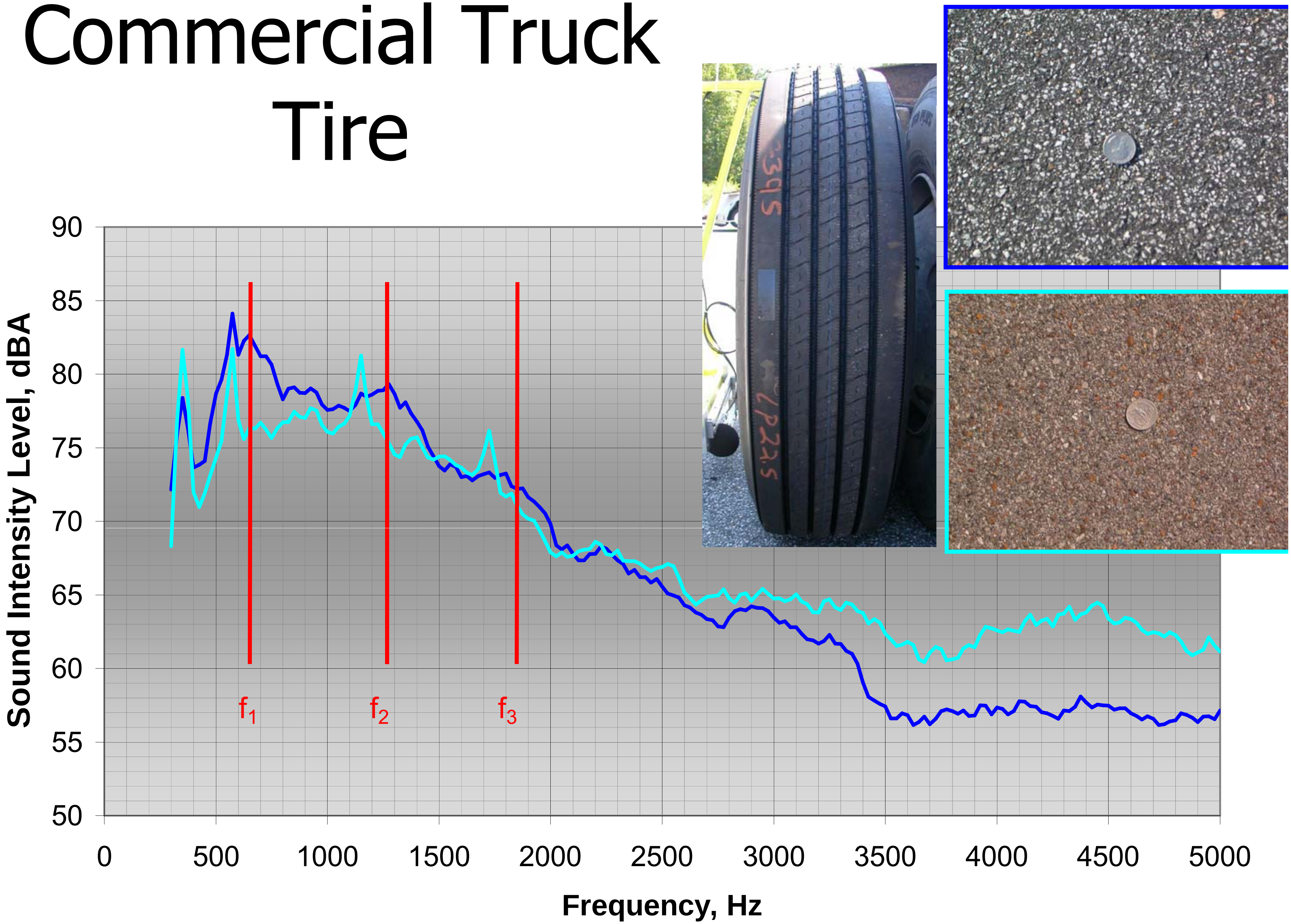


Groove Resonances

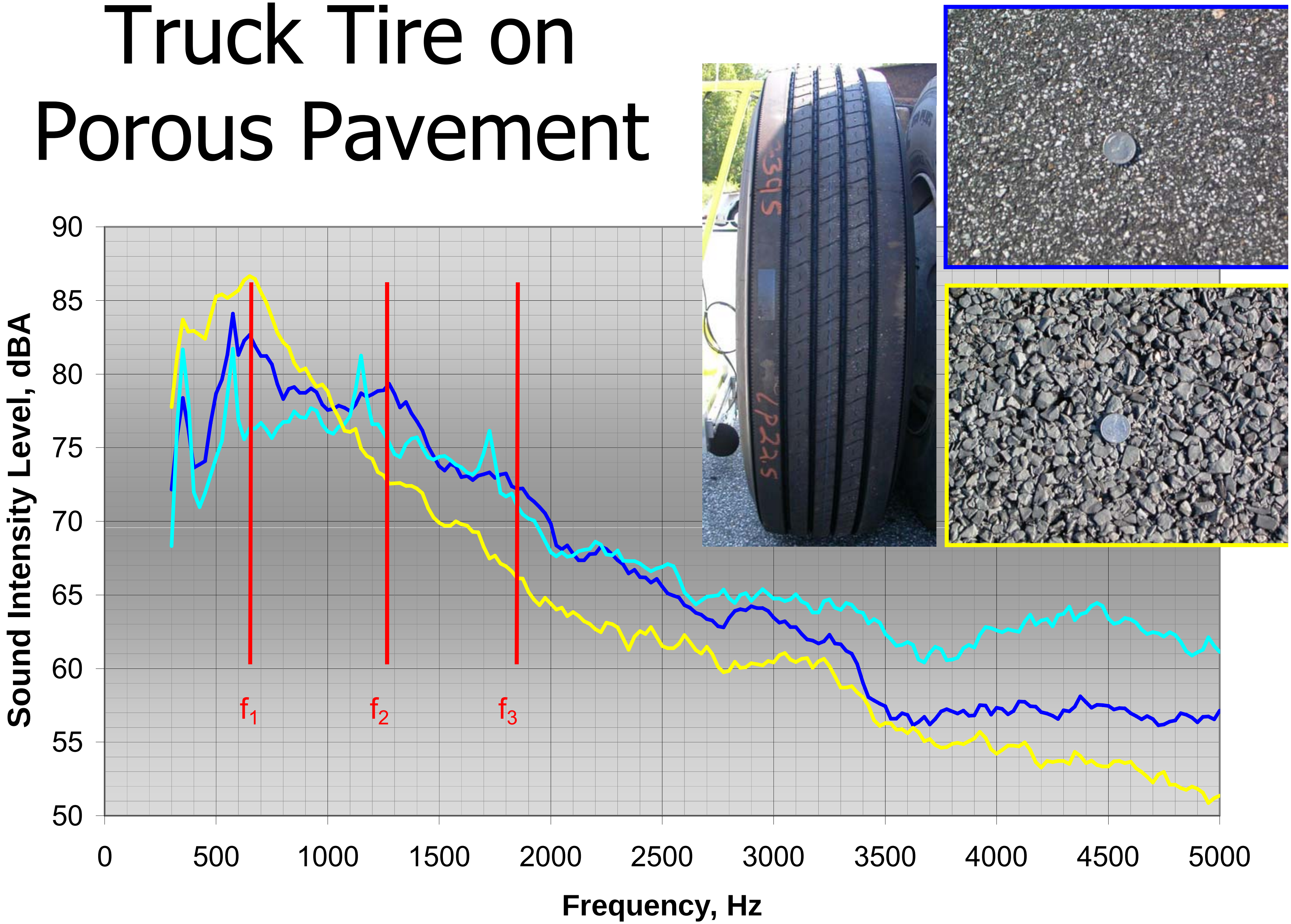




Commercial Truck Tire

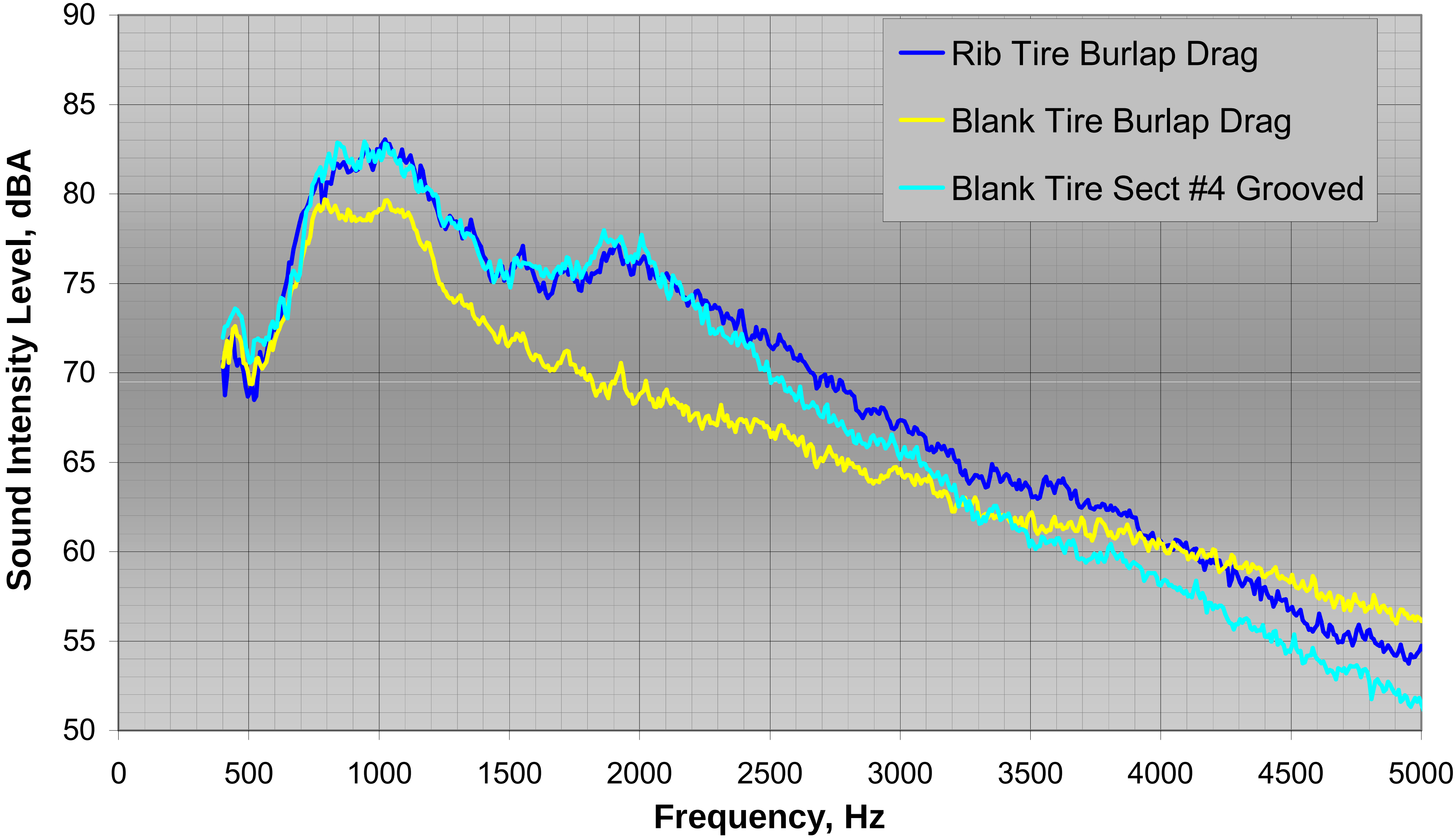


Truck Tire on Porous Pavement

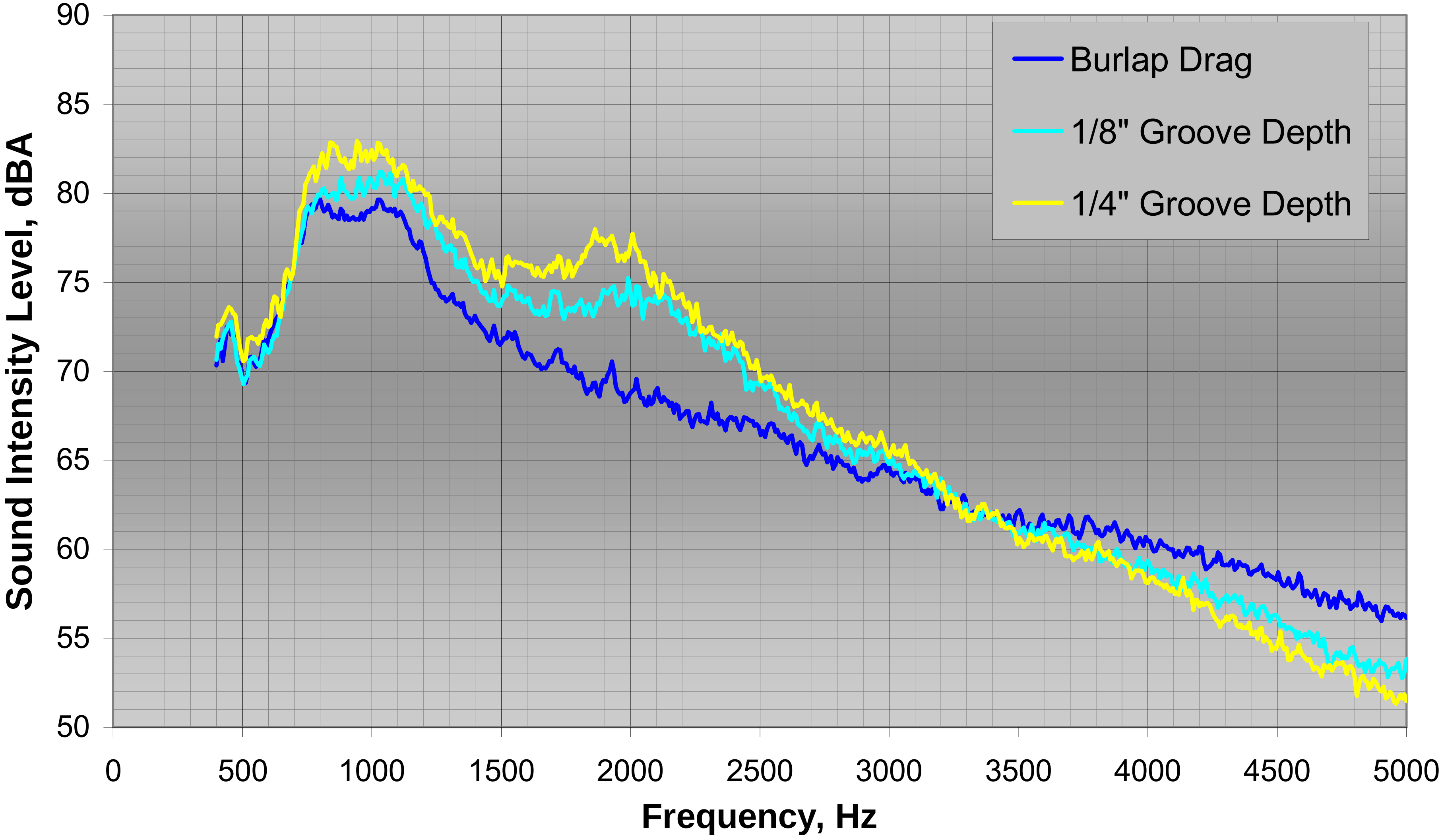


Pavement vs. Tire Ribs

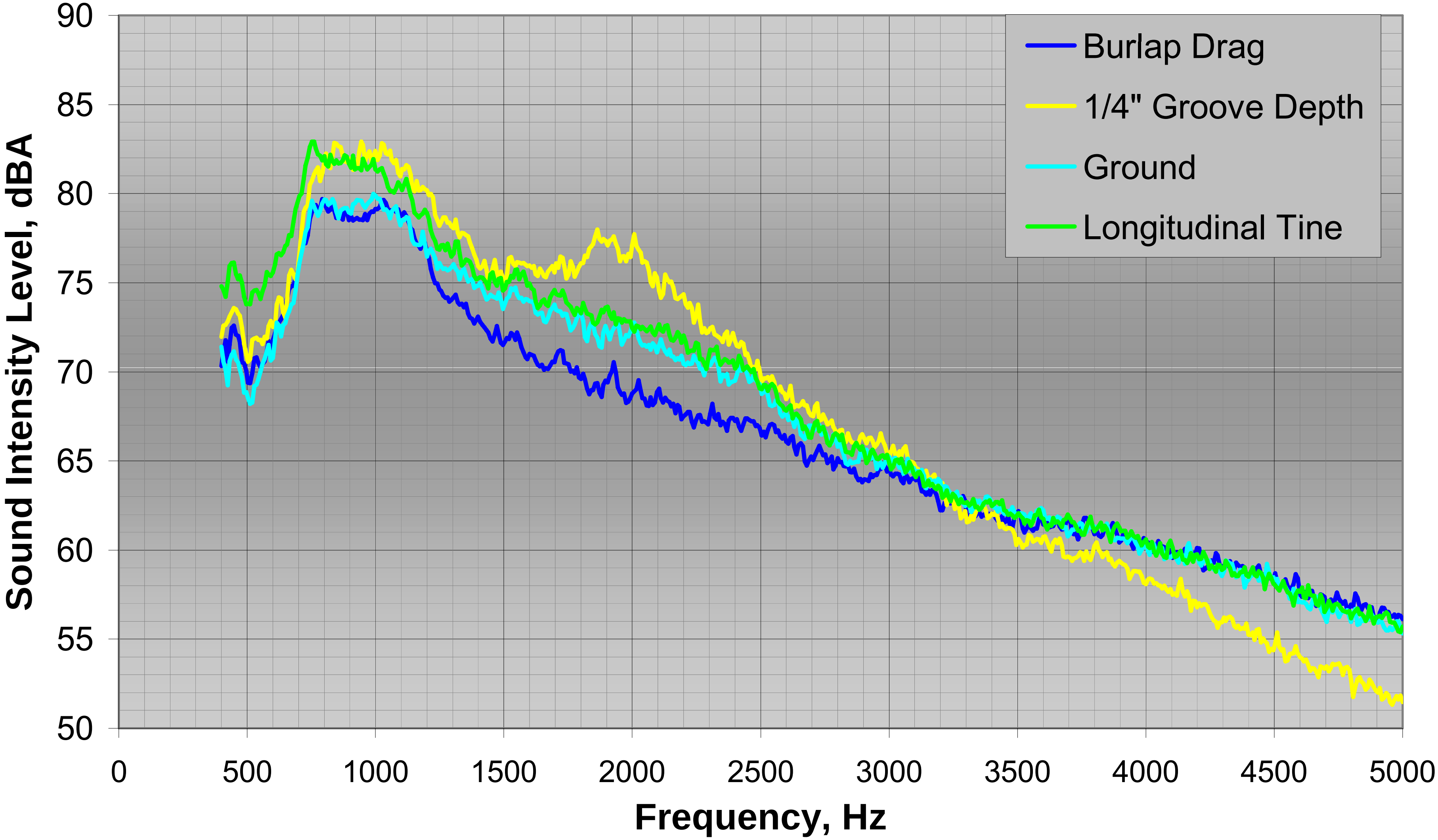
Tire Grooves and Pavement Grooves



Effect of Groove Cross-Section Area for Blank Tire



Blank Tire on Various Other PCC Surfaces



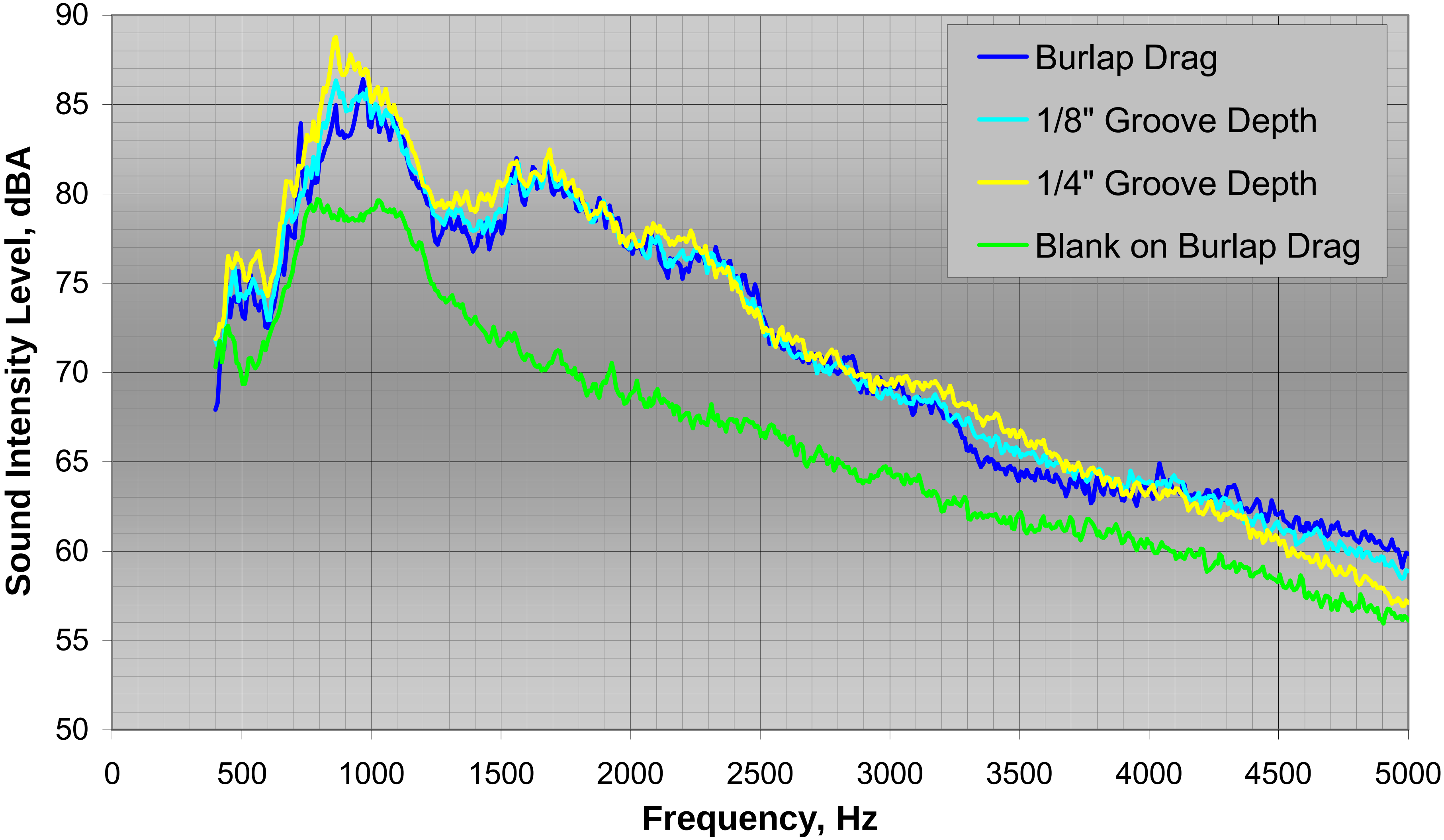
Grooves in Other Tires

ASTM E501 Rib

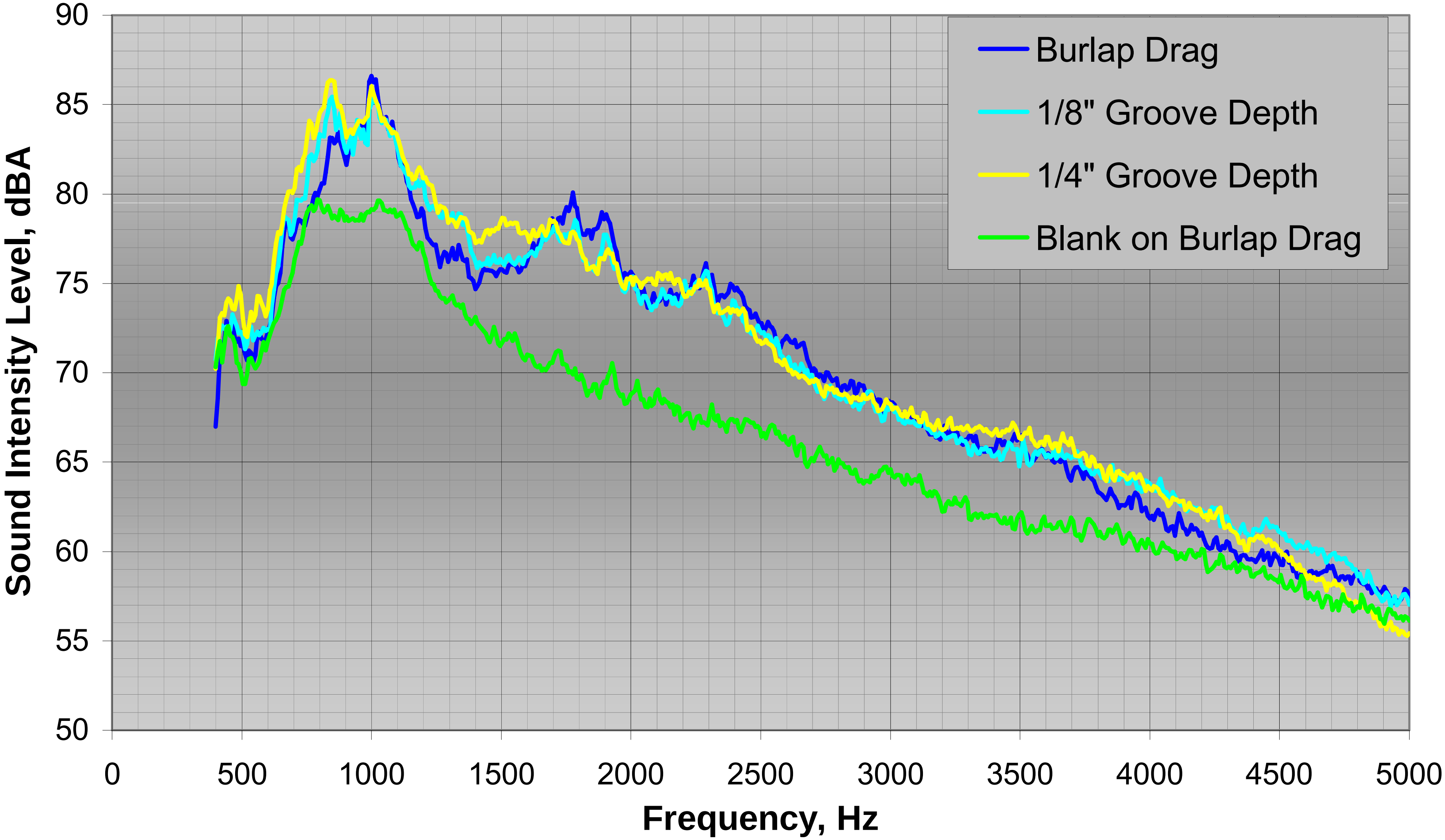
Goodyear Aquatred 3

UniRoyal SRTT

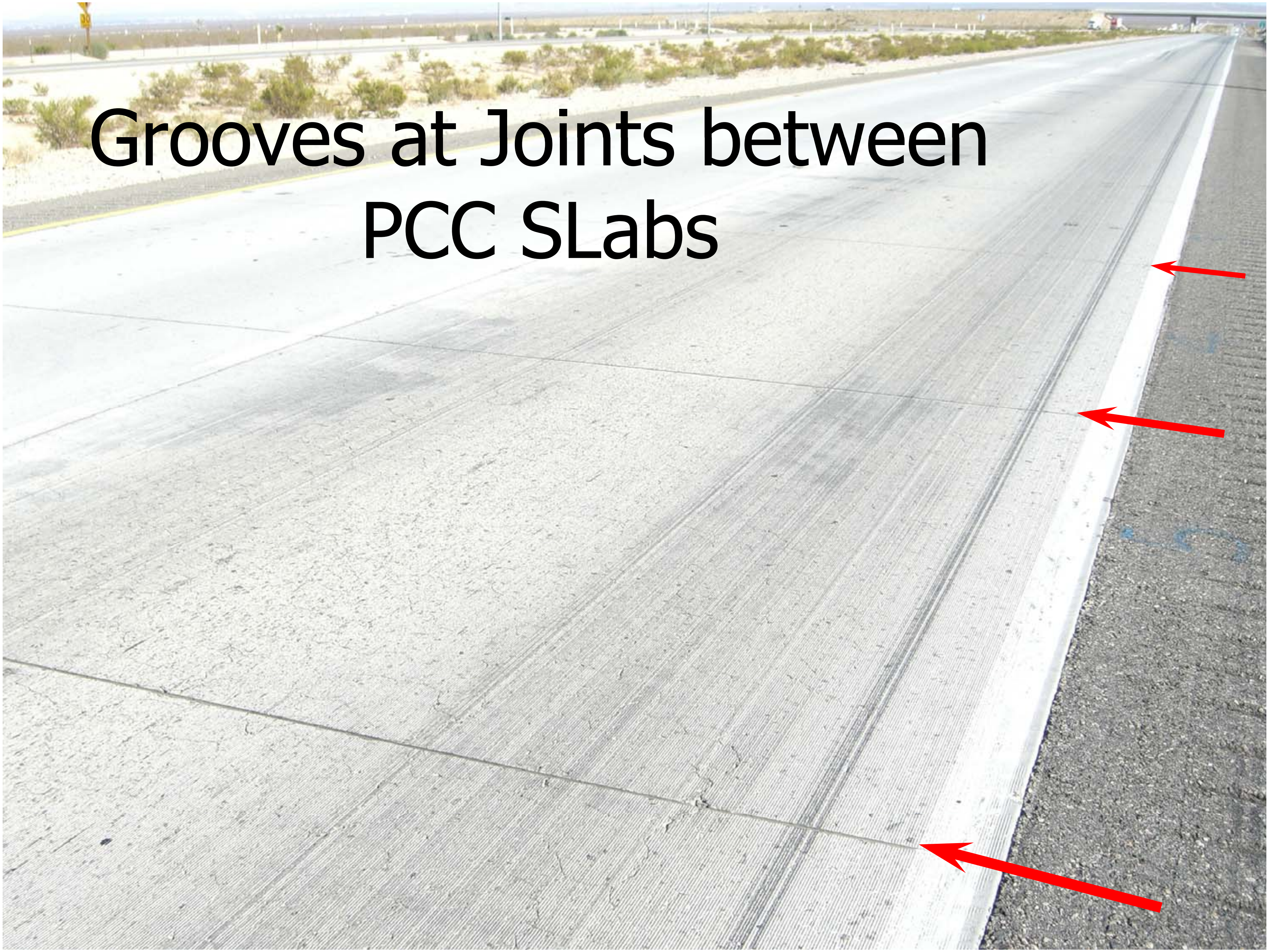
Goodyear Aquatred Tire & Pavement Comparisons



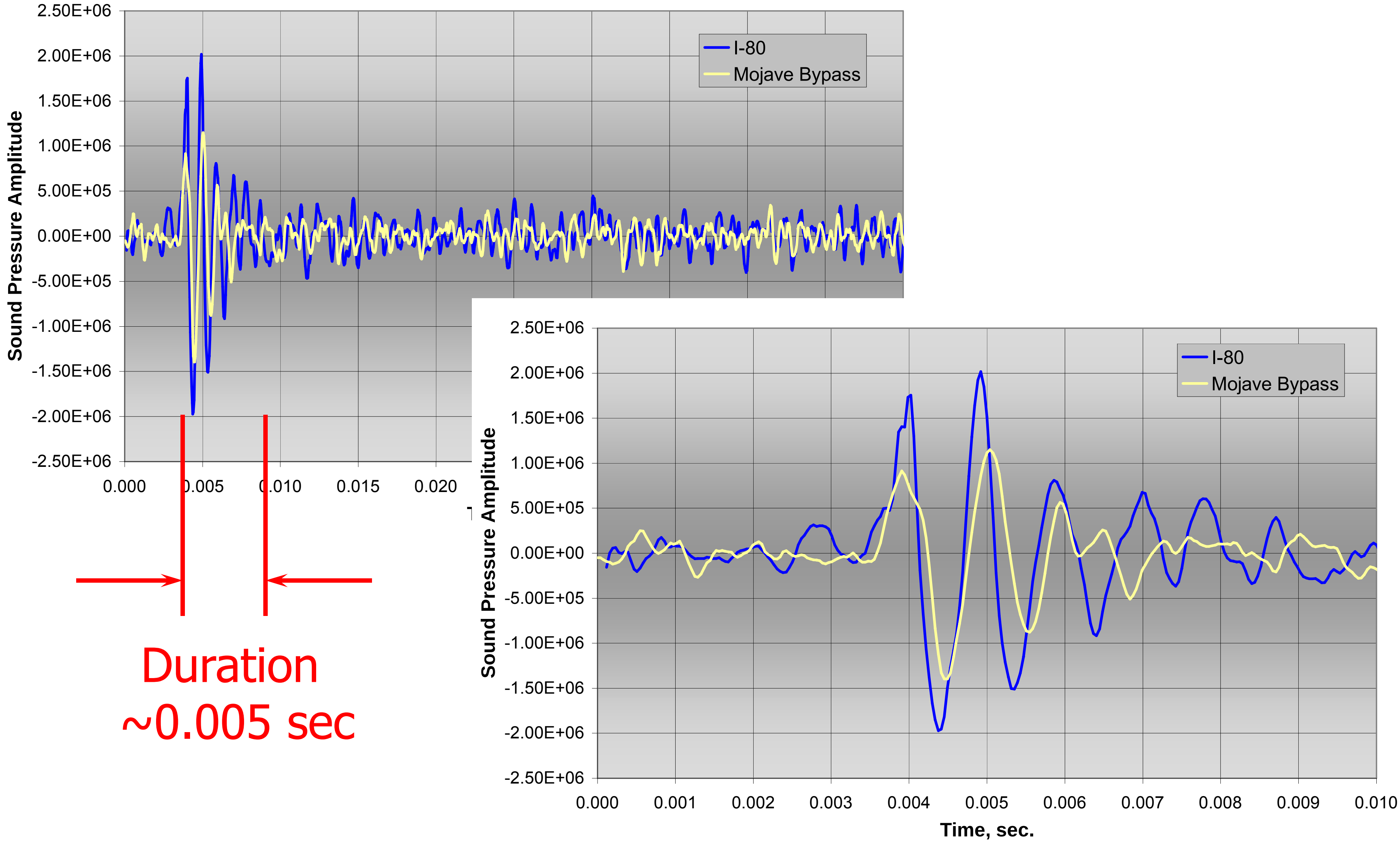
SRTT Tire & Pavement Comparisons



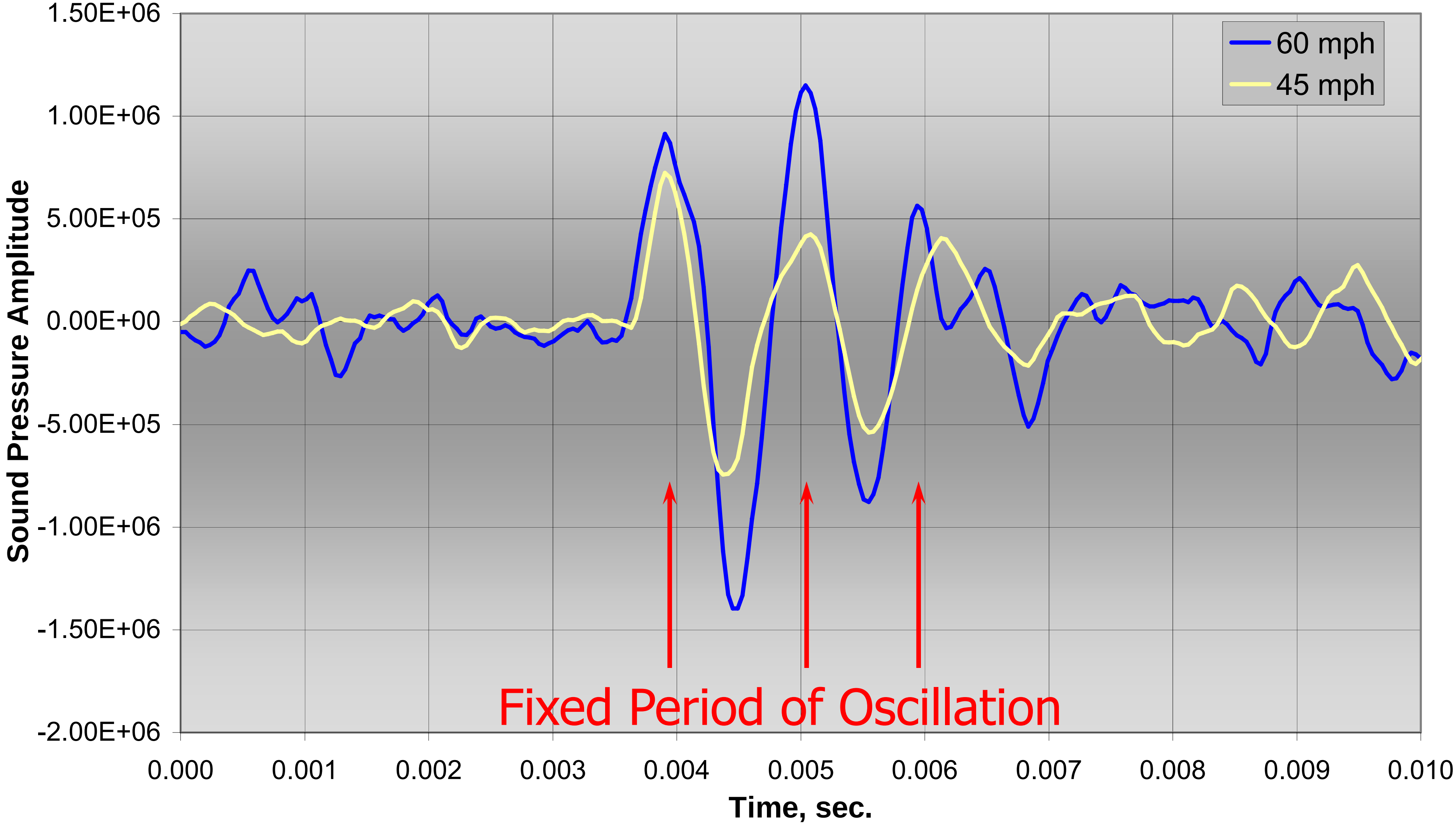
Grooves at Joints between PCC SLabs



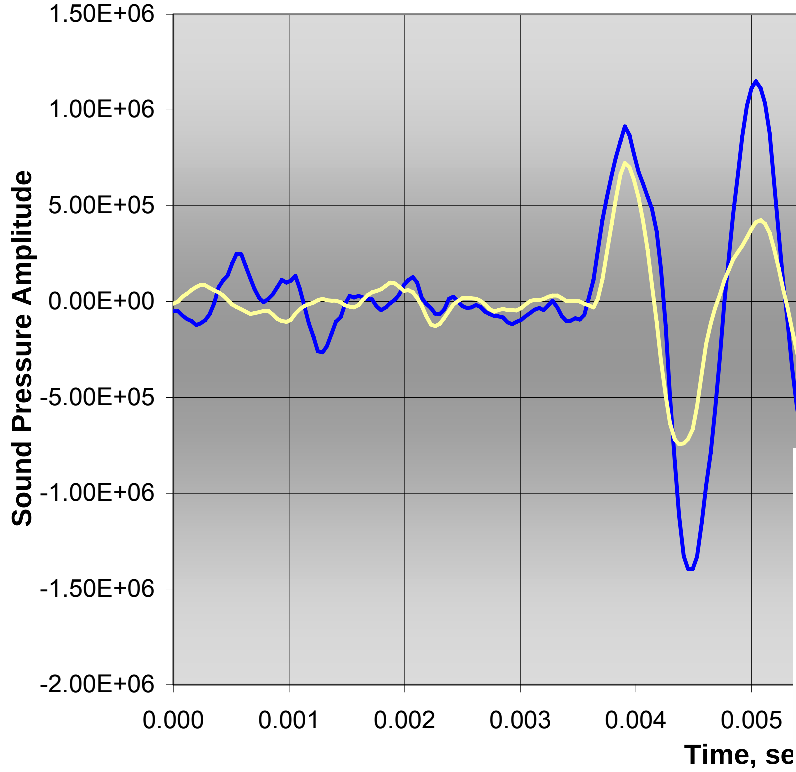
Joint "Slap" on Different PCC Pavements

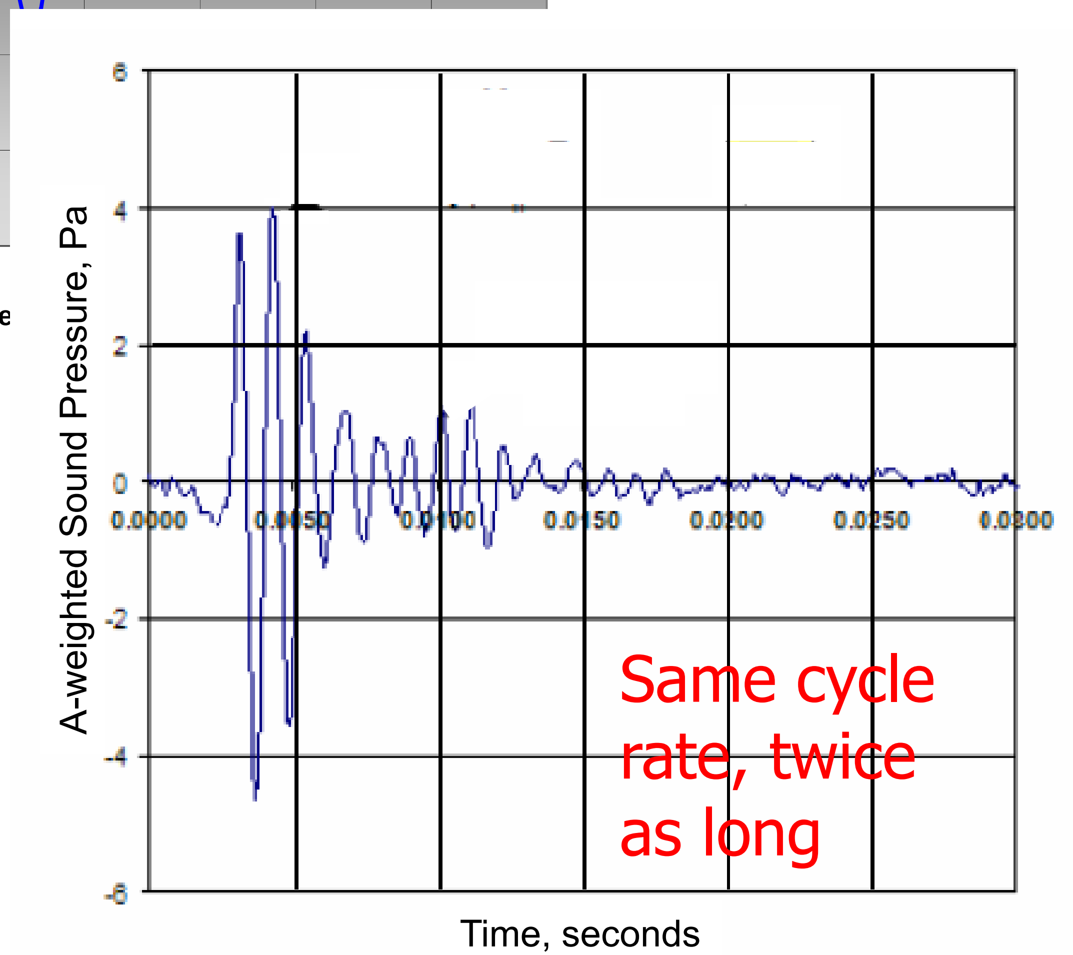


Joint “Slap” at 45 & 60 mph



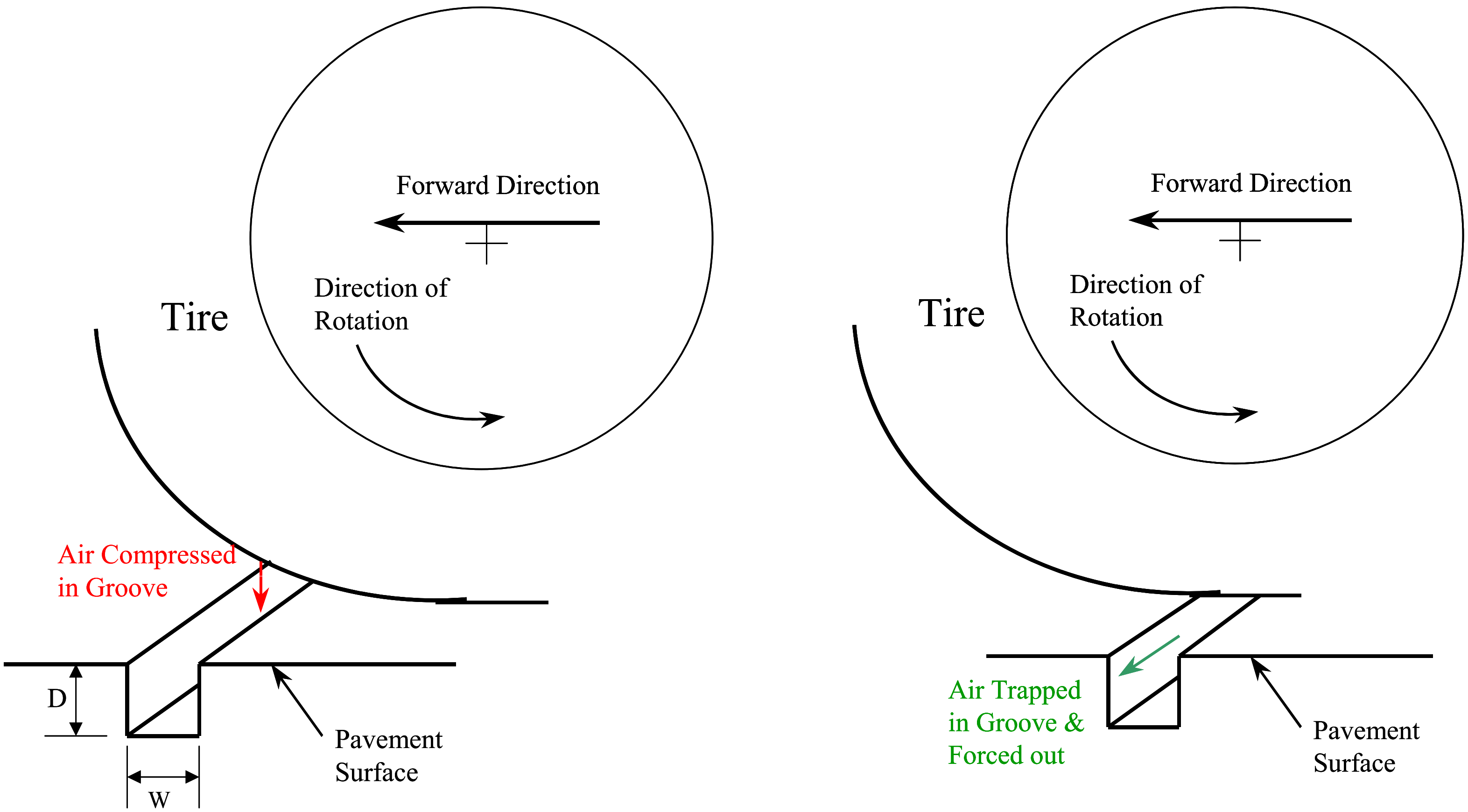
Lab Joint "Slap" at 30 mph



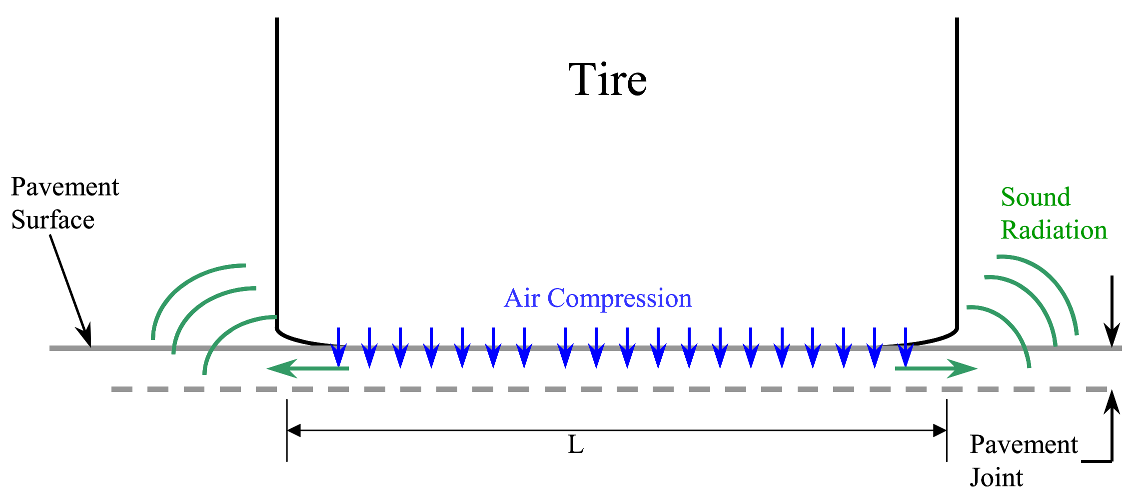


Purdue TPTA Study

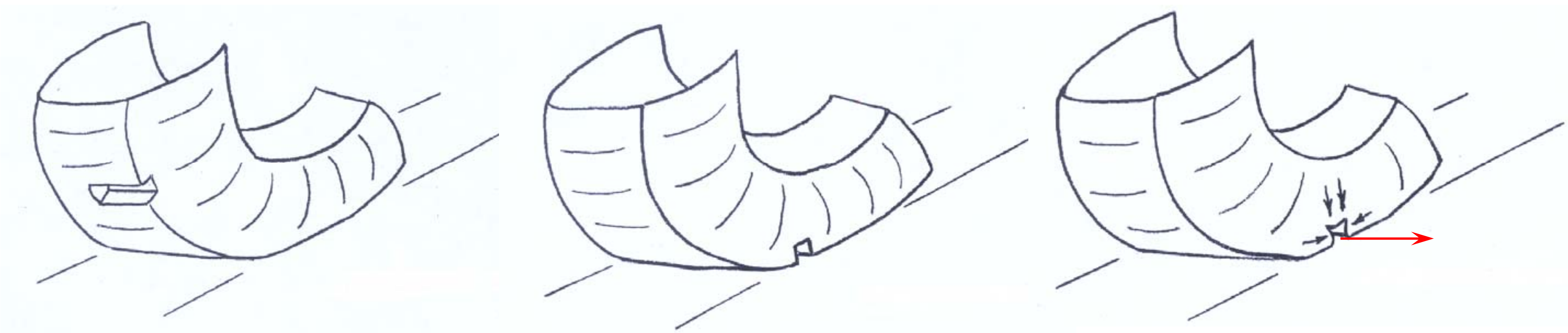
T. Dare, T. Wulf, W. Thornton, and R. Bernhard, "The Effect of Joints in Portland Cement Concrete Pavement", Purdue University Institute for Safe, Quiet, and Durable Highways



Model Concept



Air Pumping for Single Half Groove



Open groove

Groove closed, forming tube

Volume change in groove

Radiated Sound Pressure

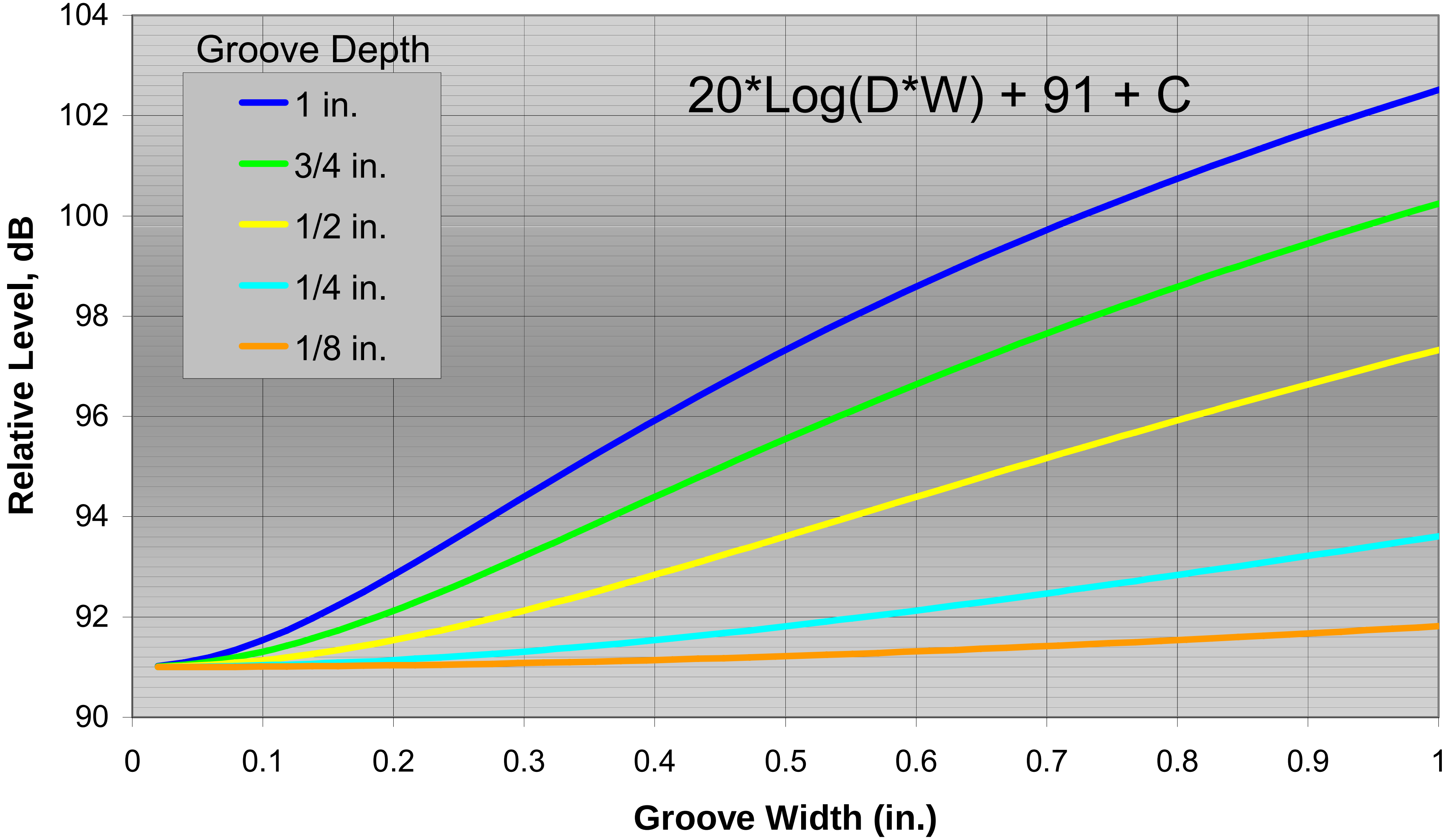
$$p(r, t) = (1/r\pi)*\rho*D*W*(dv_L/dt)$$

SPL proportional to 20*Log(D*W)

Where v_L is the velocity at the end of the tube

I. Wilken, "A Theoretical Prediction of the Noise Generated by the Compression of a Tire Cross Groove", General Motors

Increase in Level Relative to an Estimated 91 dB Texture

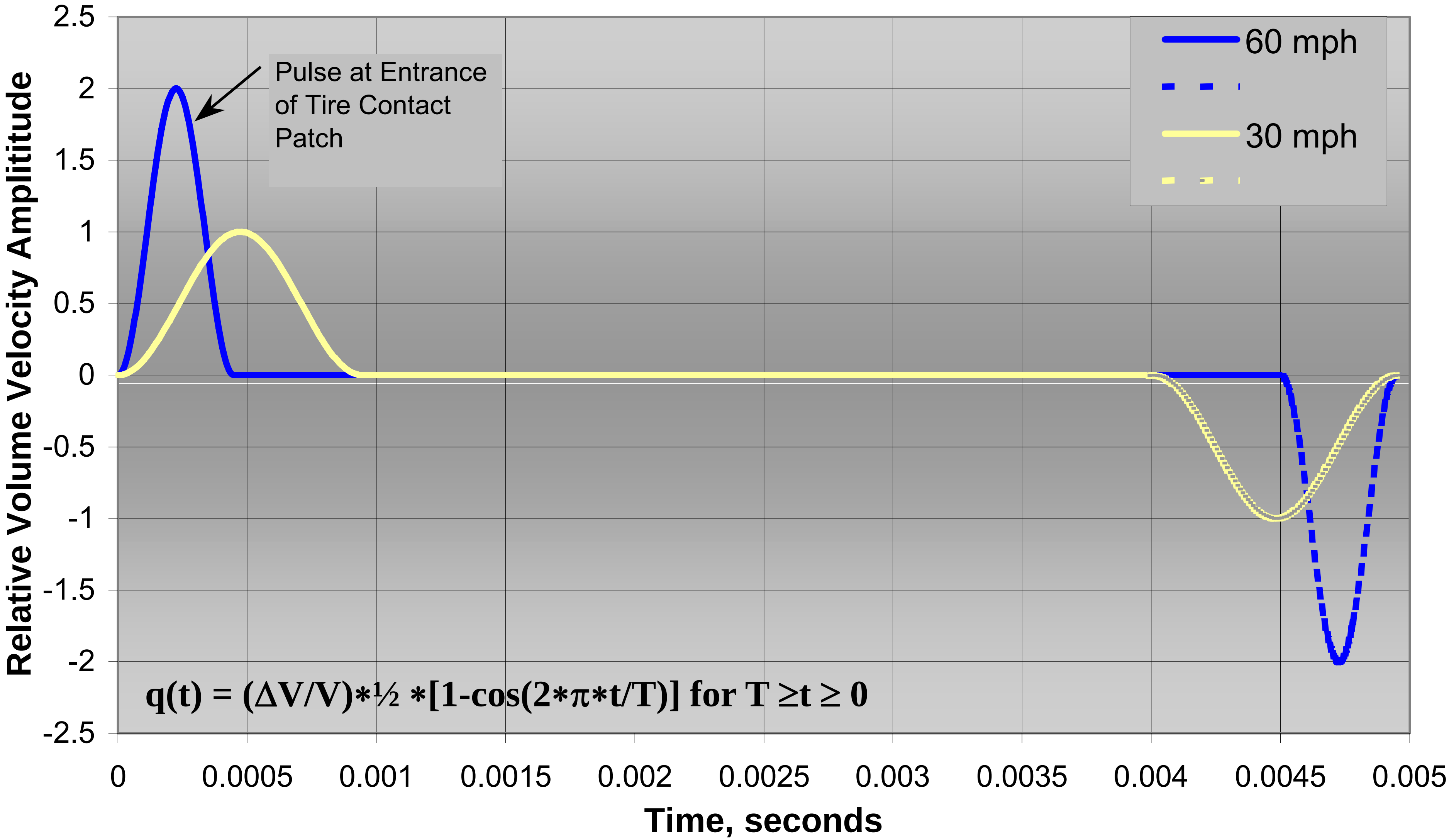


Model Calibration

- Purdue Single Groove Research on TPTA
  - 10 to 30 mph
  - Groove depth – 1″, ½″, ⅛″
  - Groove width – 1″, ¾″, 9/16″, ¼″
- Start with Purdue Results
  - Match Results at 30 mph
  - Estimate Residual Background Level
- Extend to Higher Speed
  - Separate relationship for residual & groove level
  - Use GM approach for groove calculation – volume displacement & tube resonance model

$$P(r,\omega) = V_L(\omega) * T_2(\omega)$$

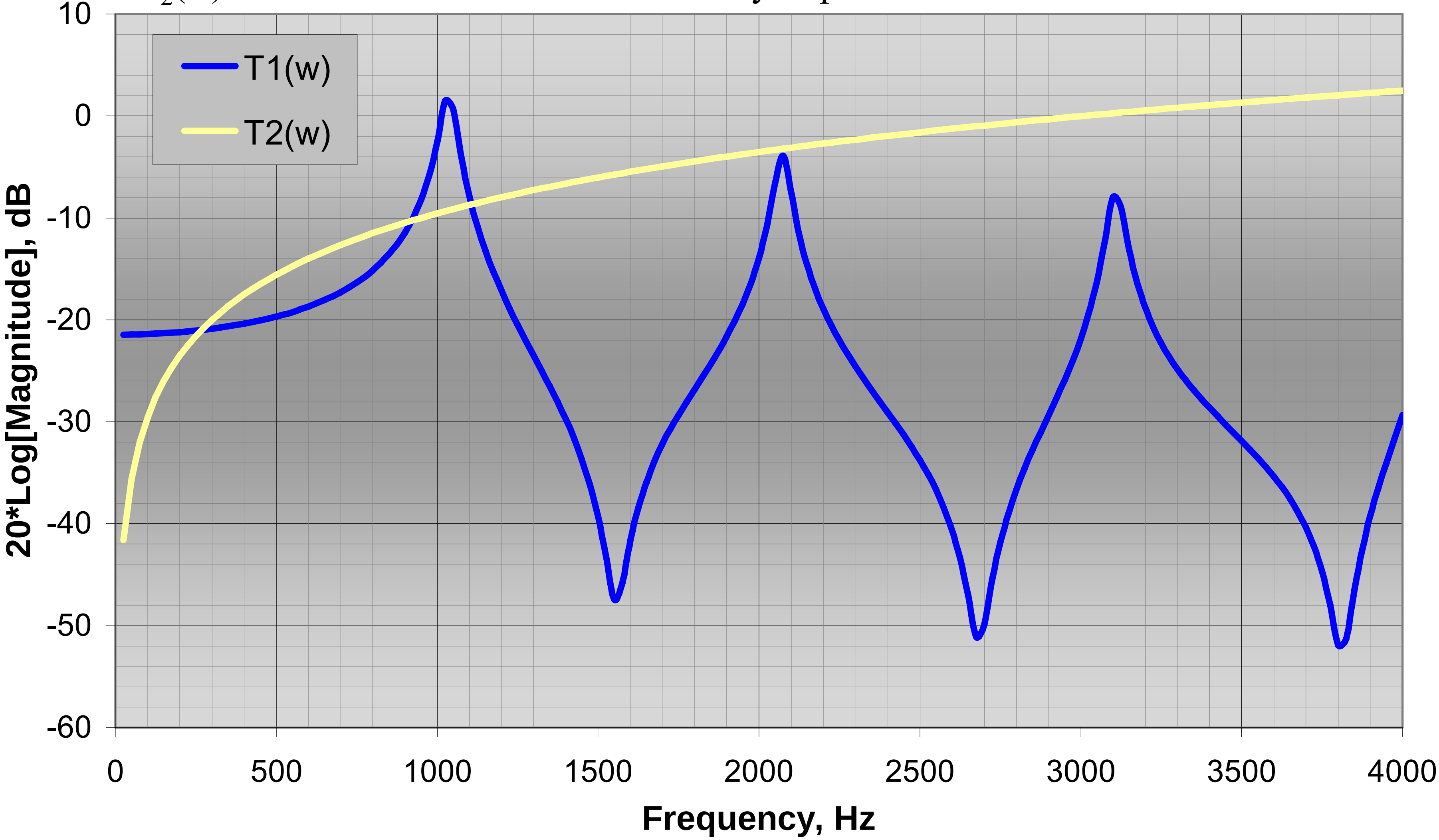
Velocity of Air Pumped from Groove



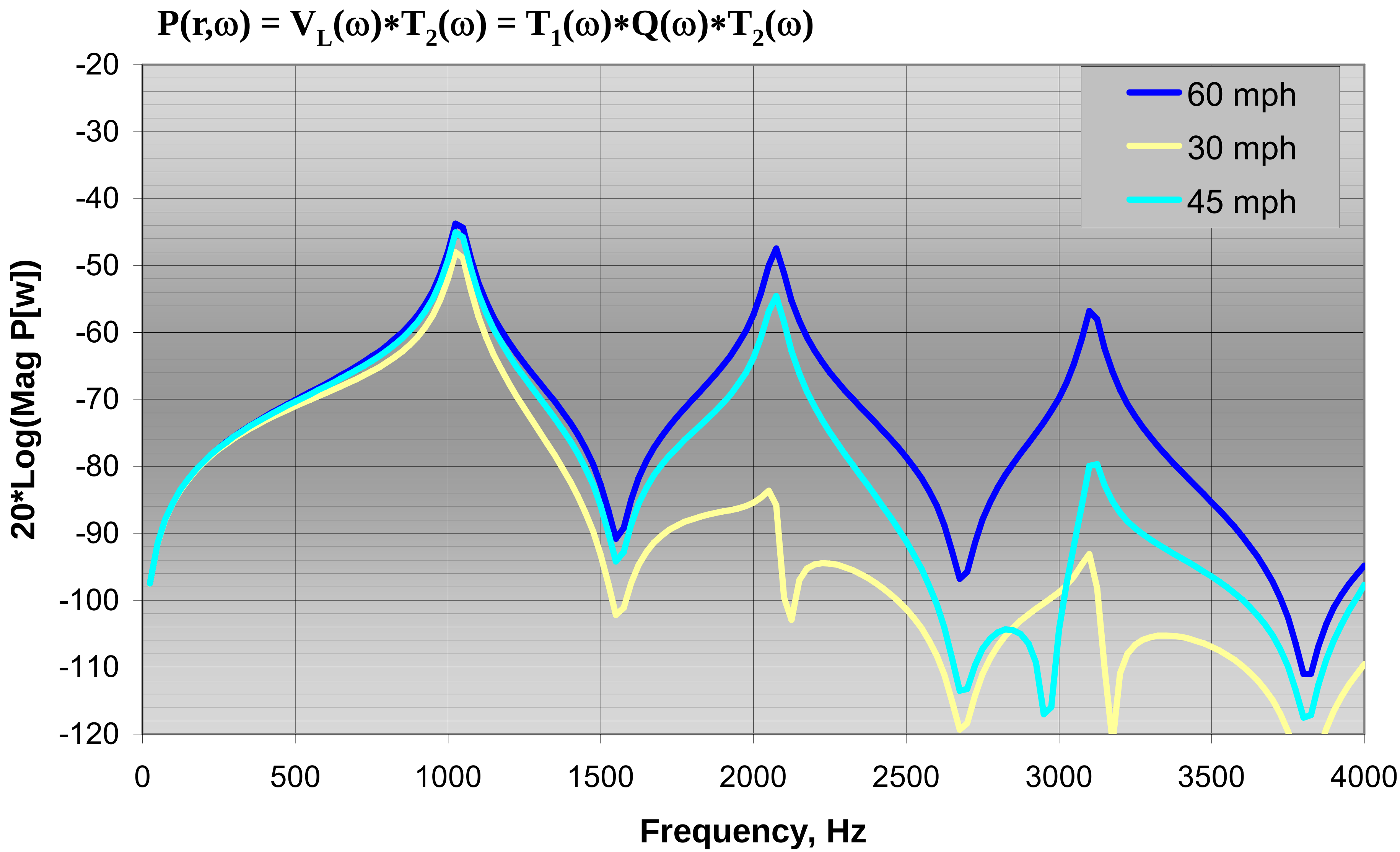
Components of Sound Generation

$T_1(\omega)$=transfer function between air displacement & velocity

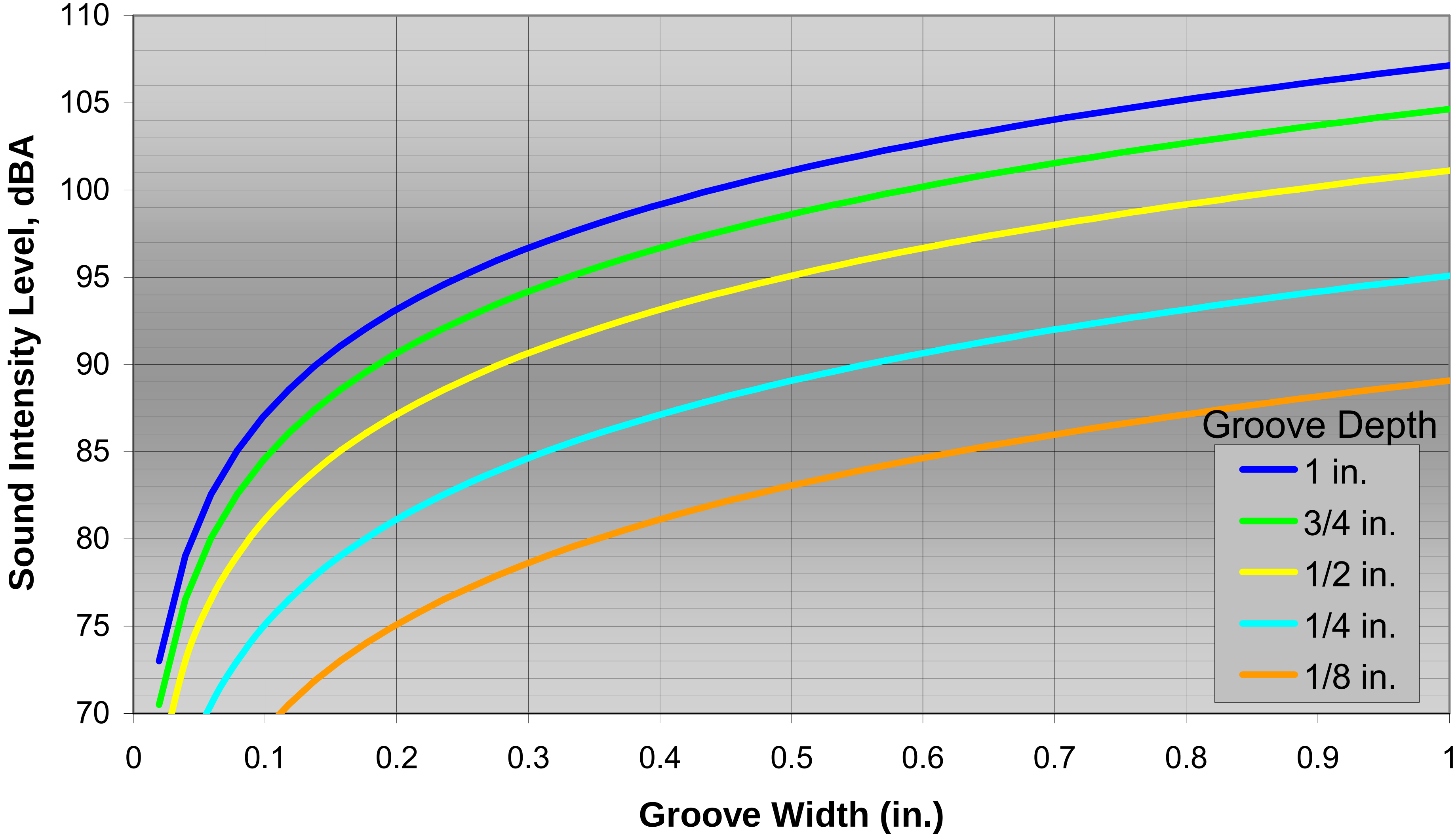
$T_2(\omega)$=transfer function between velocity & pressure



Radiated Sound Pressure



Sound Pressure Level Produced by Grooves of Varying Area



Model Inputs

Joint Calculation

- Distance between joints
- Vehicle speed
- Groove width and depth

Pavement Noise Calculation

- Overall level – input texture generated noise level
- Texture noise level – input measured overall level

Overall Level from Joints and Specified Texture Generated Noise

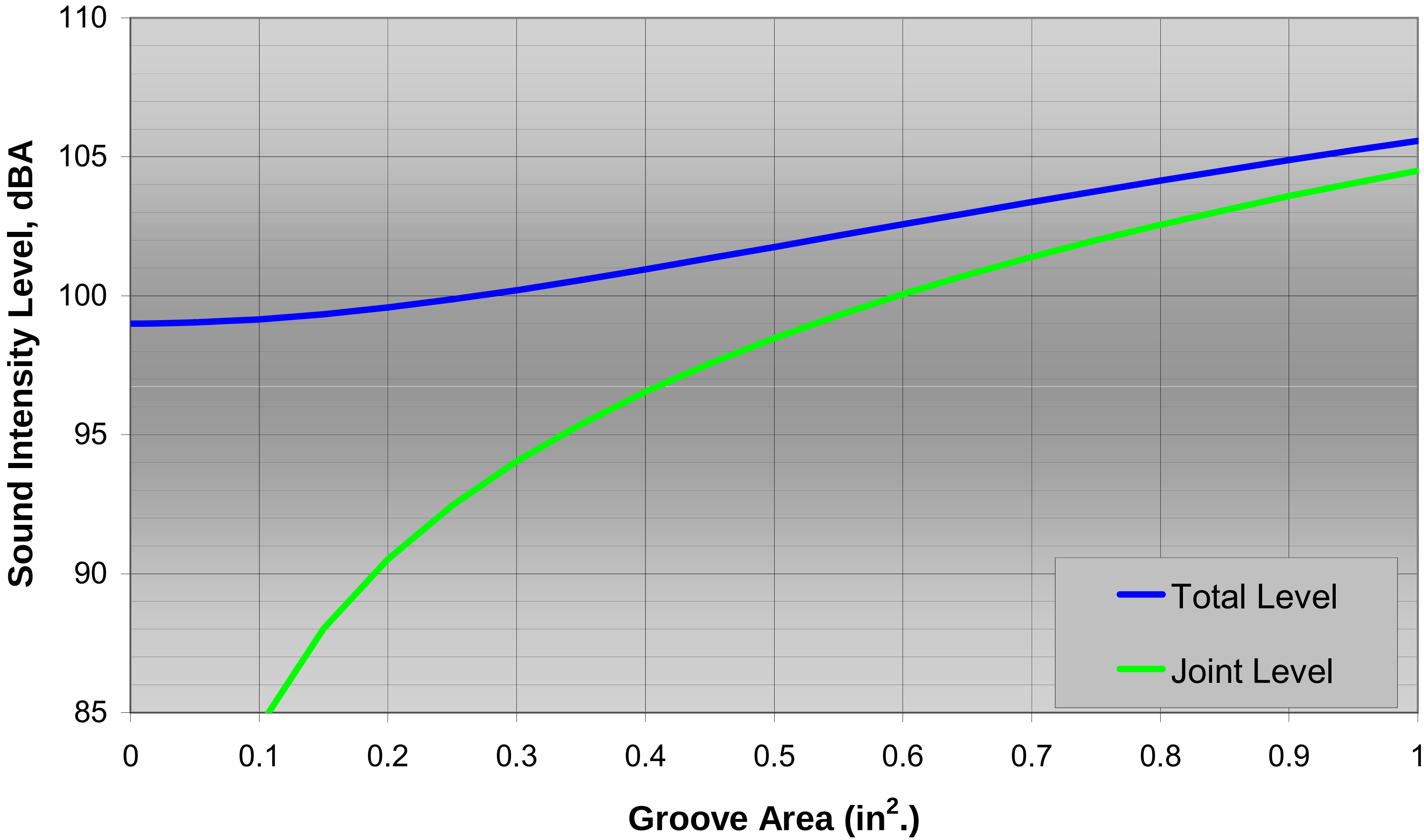
INPUTS

Distance between joints =	13	ft
Groove width	0.41	in.
Groove depth	1	in.
Speed =	60	mph
Residual level =	99	dBA
	88	ft/sec
	99.4	Level of Pulse, dBA
	96.8	Joint Slap Level, dBA

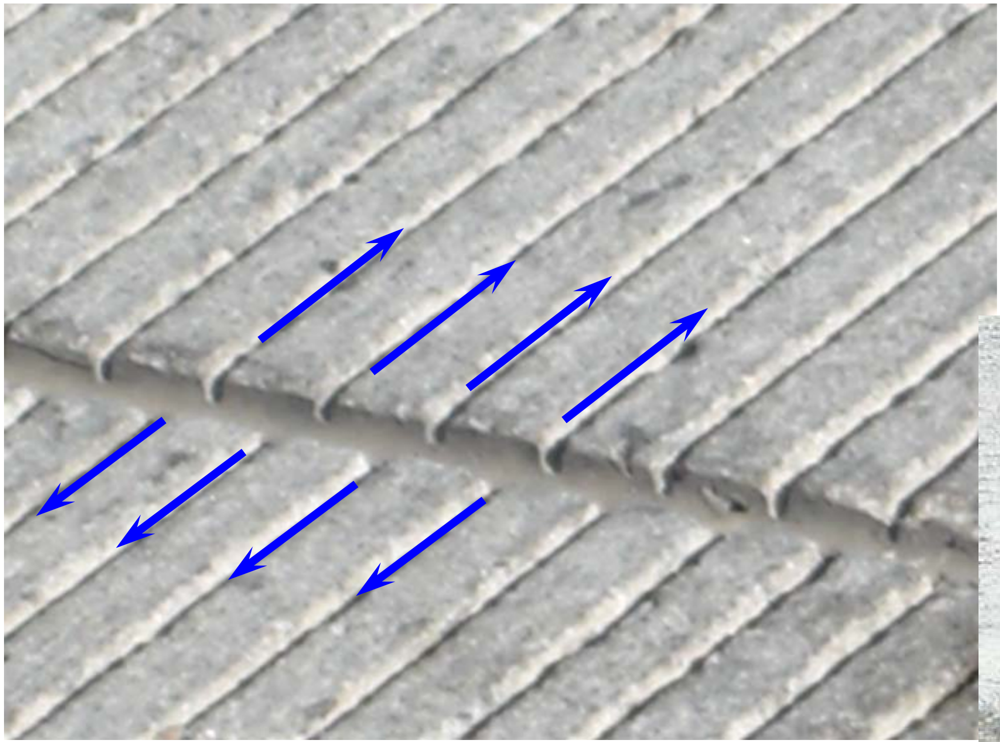
OUTPUTS

Total OBSI Level =	101.0	dBA
Δ With & Without Joints =	2.0	dB
Passby Level at 25 ft =	77.4	dBA
Passby Level at 50 ft =	70.7	dBA

Example Case – 60 mph, Residual Texture Level = 99 dBA

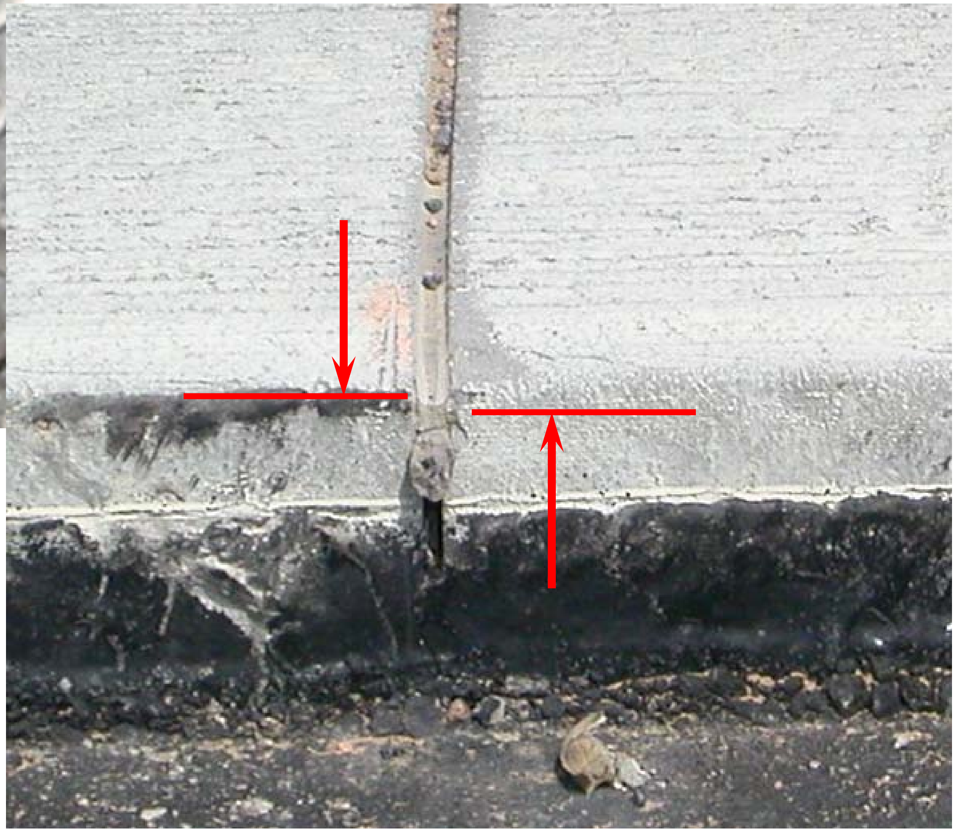


Other Considerations



Longitudinal Air Leakage

Step Height - Faulting



Summary

- For special cases, longitudinal grooves in tires and longitudinal grooves in pavement behave the same
- For typical tires, longitudinal pavement & tire grooves are negligible
- PCC lateral joint grooves show resonant radiation effects & air pumping
- Radiated sound is proportional to 20 Log groove cross-sectional area
- Hybrid model developed for prediction