NBSIR 74-446

Pecos Truck Tire Noise Study: A Summary of Results

William A. Leasure, Jr.
and
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Applied Acoustics Section
Mechanics Division
Institute for Basic Standards
National Bureau of Standards
Washington, D. C. 20234

January 1974

Final Report

Prepared for
Office of Noise Abatement
U. S. Department of Transportation
Washington, D. C. 20590

Disclaimer

The tires and vehicles were selected for this test by the Truck Tire Noise Subcommittee of the Society of Automotive Engineers, Inc. The commercial vehicles and instruments are identified in this report in order to adequately describe the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that these vehicles and instruments were necessarily the best available for the purpose.

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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary
NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

Pecos Truck Tire Noise Study: A Summary of Results

by

William A. Leasure, Jr. and Denzil E. Mathews
Applied Acoustics Section
Mechanics Division

Abstract

The Society of Automotive Engineers, Inc. (SAE) Truck Tire Noise Subcommittee conducted a series of truck tire noise tests at the Automotive Proving Grounds, Inc. in Pecos, Texas, November 5-7, 1973. At the request of DOT, NBS participated in these tests and made simultaneous measurements with those made by the SAE committee. This report presents a summary of the results obtained during these tests.

Key Words: Acoustics; noise measurement; noise (sound); tire noise; transportation noise; trucks

PECOS TEST RESULTS

In order to address two questions concerning SAE Recommended Practice J-57 -- Sound Level of Highway Truck Tires, the SAE Truck Tire Noise Subcommittee conducted a series of truck tire noise tests at the Automotive Proving Grounds in Pecos, Texas, November 5-7, 1973. The tests were designed (1) to clarify the effect of the test surface on the results obtained utilizing J-57 and (2) to determine if the height of the truck bed above the tires significantly influences the results. The standard now specifies a 5±1 inch clearance between the bed and the tires. At the request of DOT, NBS participated in these series of tests and made simultaneous measurements with those made by the SAE Committee.

The original test matrix called for the testing of six tire types [three rib tires (rib-1, rib-2 and rib-3) and three cross-bar tires (cross-bar-1, cross-bar-2 and cross-bar-3] while running over four concrete pavements representing various surface textures (surface finishes) -- smooth, brushed, sand blasted brushed, and terrazzo finished concrete. All test tires were mounted in dual pairs on the drive axle of a 1973 GMC Astro 95 tractor. The tires were inflated as per Tire and Rim Association recommendations and the vehicle was loaded such that maximum rated tire load was achieved. Neutral rib tires were mounted on the steering axle of the vehicle. As per J-57, all runs were at 50 mph, all measurements were taken at 50 feet with a minimum of three repeat runs for any given set of test conditions. In addition, the two selected cross-bar tires were tested at 60 mph while running on the smooth and sand blasted brushed concrete surfaces.

Since time was still available, after the tests in the initial matrix had been accomplished, it was decided to run the cross-bar tires on two additional surfaces -- (1) asphalt and (2) dorset pebble. Also, some runs were made with neutral rib tires at all wheel positions except two; cross-bar-1 tires were mounted at the right outside and right inside locations. This is similar to the mix-and match studies run during the DOT/NBS work.

For the bed height studies, a Ford single-chassis, flat-bed vehicle was utilized as the test truck. Tests were run with the standard bed location and with the bed raised above its normal position. The truck was equipped with cross-bar-3 and cross-bar-2 tires and ran on sand blasted brushed and brushed concrete surfaces. NBS felt that the bed height would not be a problem since the effective source height of tire-road interaction noise is very near the tire-road interface; therefore, we made no measurements during the runs associated with the bed height investigation.

NBS otherwise made simultaneous measurements with those made by the SAE Committee; the major difference between the data being that SAE tape recorded the data and took on-the-spot A-weighted slow response sound level readings utilizing a B&K 2606 measuring amplifier while NBS made no on-the-spot readings but tape recorded the passbys utilizing the data acquisition system shown in Figure 1. The tapes were

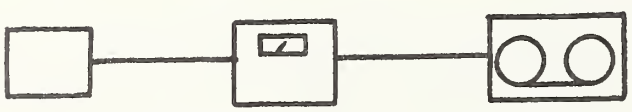


Figure 1. NBS data acquisition system.

returned to NBS for reduction and analysis. All passbys were analyzed to determine the A-weighted sound level that would be read utilizing both "fast" and "slow" meter ballistic characteristics of a sound level meter. These data are tabulated in Appendix A along with the SAE data. The reduction and analysis instrumentation are shown in Figure 2.

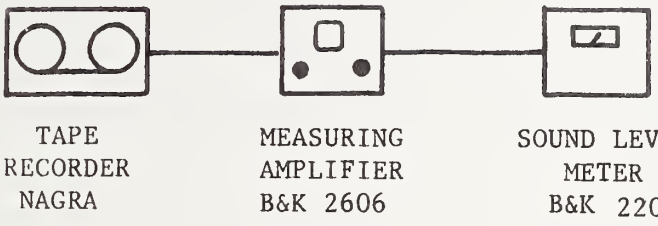


Figure 2. NBS data reduction and analysis system.

To provide some indication of the agreement between the SAE and NBS A-weighted, slow response sound level data a histogram showing L_A slow (SAE) - L_A slow (NBS) [Figure 3] was developed. It should be noted that there was good agreement between the SAE and NBS slow response data. For 80% of the runs the agreement was within 1dB; while for 95% of the runs the two sets of data agreed within 1.5dB. The distribution was not Gaussian but appeared to be biased slightly to the high side, i.e., in general the SAE data would tend to be higher rather than lower than the NBS data.

A second histogram [Figure 4] was plotted to provide an indication of the differences one could expect to observe between data taken utilizing the "slow" and "fast" meter ballistic characteristics (based on the NBS data). Based on these data (L_A fast - L_A slow), one would expect that approximately 60% of the time the difference would be on the order of

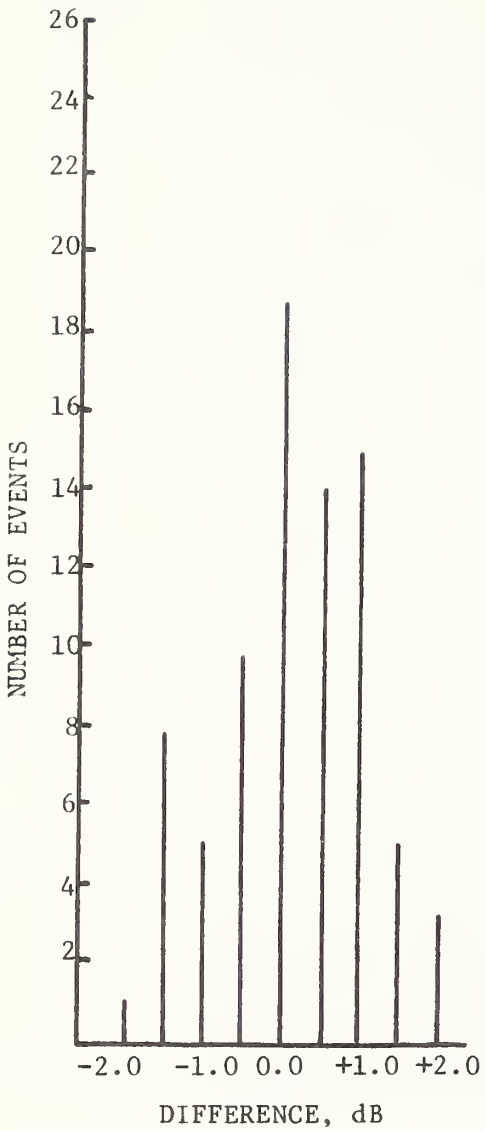


Figure 3. Histogram showing L_A slow (SAE) - L_A slow (NBS) for a total of 80 identical runs.

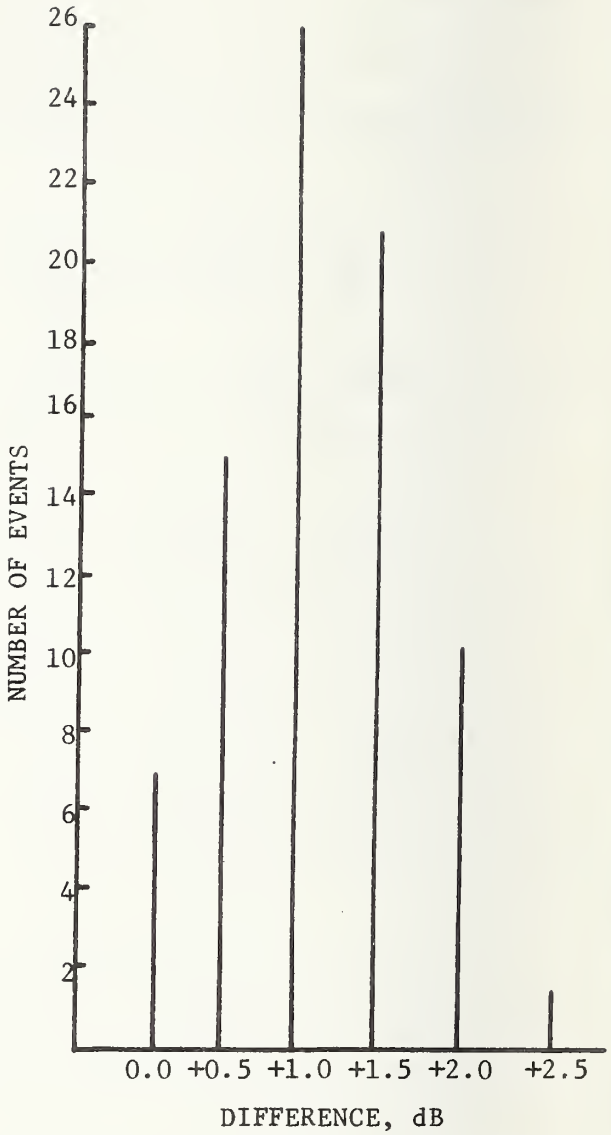


Figure 4. Histogram showing L_A fast (NBS) - L_A slow (NBS) for a total of 80 identical runs.

1.0-1.5dB; however, differences as great as 2.5dB were noted. To further investigate the meter response question, two additional plots were developed [Figures 5 and 6] to see if the differences one observes between the slow and fast response are constant for both rib and cross-bar type tires. From these data one can conclude that in general larger differences will be observed for cross bar-type tires but that the largest difference was observed for the rib-type tires. The distribution for the rib-type tires is nearly Gaussian while the distribution for the cross-bar-type tires is biased toward the greater differences.

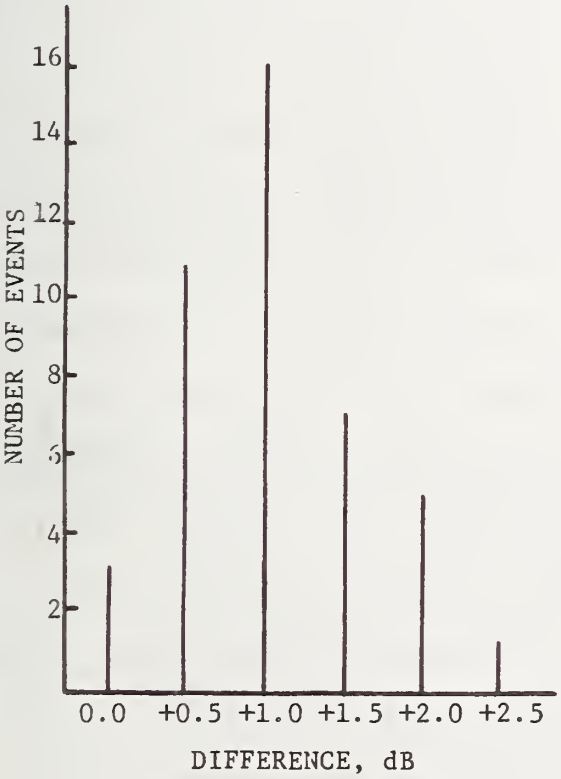


Figure 5. Histogram showing L_A fast (NBS) - L_A slow (NBS) for a total of 43 identical runs with the truck equipped with rib type test tires.

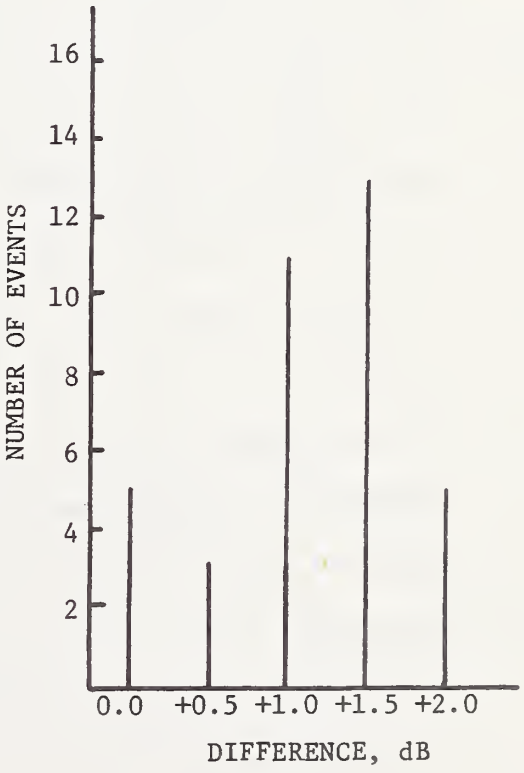


Figure 6. Histogram showing L_A fast (NBS) - L_A slow (NBS) for a total of 37 identical runs with the truck equipped with cross-bar type test tires.

In order to further emphasize the problem existing with the response of commercial precision equipment to transient signals, two sets of test runs (the three repeat runs for rib-3 and cross-bar-3 tires on the smooth concrete surface at a vehicle speed of 50 mph) were selected for further analysis. In addition to the B & K 2204 sound level meter, a B & K 3347 real-time, 1/3-octave analyzer set for fast random and slow random response and a B & K 2305 graphic level recorder set up for slow and fast response according to the specifications described in the B & K manual for the 2305 graphic level recorder were used. In addition, a second set of graphic level recorder settings were utilized. The second set was that recommended by Jerry Donavan and Tom Ketcham of B & K Instruments in their recent article in the October 1973 issue of Sound and Vibration entitled "Transportation Noise - It's Measurement and Analysis." The major difference between the two recommendations concerns the writing speed chosen. The B & K manual specifies a writing speed of 16mm/sec for slow response and 100mm/sec for fast response. The Donavan/Ketcham article on the other hand recommends a writing speed of 200mm/sec for slow response and 315mm/sec for fast response. The results are tabulated below. What these data show, of course, is the problem that exists among precision instruments concerning their response to transient signals. It is an area that is not covered well by the existing standards. These data are shown here as a cautionary measure, since it is our understanding that each participant of the Pecos test will receive a duplicate set of data tapes for further analysis. Depending on the instruments chosen for such analysis, various results can be expected.

RIB-3 TIRES

SAE	NBS SLM	NBS RTA	NBS GLR 16 mm/sec	NBS GLR 200 mm/sec
67.0	68.0	67.0	69.0	70.0
67.0	68.0	67.0	69.0	70.0
67.0	68.5	67.0	70.0	70.0

"SLOW"

NBS SLM	NBS RTA	NBS/GLR 100mm/sec	NBS/GLR 315mm/sec
69.0	68.0	71.0	70.7
69.0	68.0	72.0	71.0
69.0	68.0	72.0	71.0

"FAST"

CROSS-BAR-3 TIRES

SAE	NBS SLM	NBS RTA	NBS/GLR 16mm/sec	NBS/GLR 200mm/sec
80.5	80.0	78.0	82.0	81.5
79.5	78.0	76.0	79.0	81.5
79.5	78.5	77.0	80.0	80.5

"SLOW"

NBS SLM	NBS RTA	NBS/GLR 100mm/sec	NBS/GLR 315mm/sec
81.5	81.0	83.0	82.0
80.0	81.0	84.0	82.5
80.0	79.0	83.0	81.5

"FAST"

Results that have been obtained to date in controlled test programs exploring the variation in noise level produced by truck tires while running on surfaces with varying degrees of surface roughness indicate that the noise generated by cross-bar type tires is relatively unaffected by the surface roughness while the characteristic noise of rib-type tires generally increases slightly with increasing surface roughness. These trends are further substantiated by the Pecos study as shown in Figure 7.

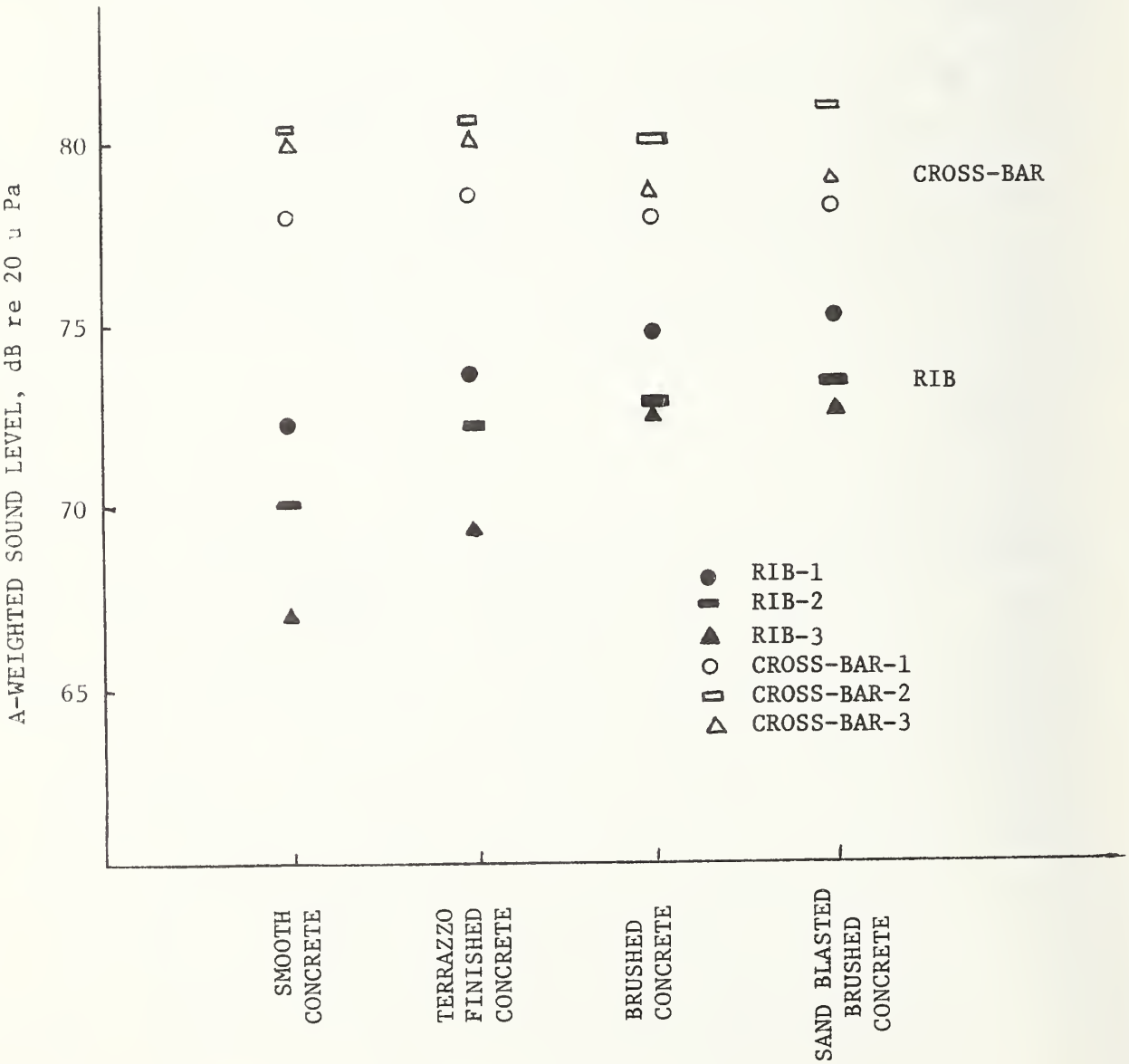


Figure 7. A-weighted, slow response sound level as per SAE J-57 versus surface finish based on the SAE COMMITTEE DATA.

APPENDIX A

SAE/NBS DATA COMPILATION

In this Appendix are tabulated the SAE A-weighted (slow response) sound level results as well as the comparable NBS results utilizing both the slow and fast meter ballistic characteristics. The average for each passby as well as the J-57 value (average at the highest two runs) are also tabulated.

	Brushed Concrete						Finished Concrete					
	SAE	NBS		SAE	NBS		SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	73.5	73.5	74.0	75.0	75.0	77.0	72.0	72.0	74.0	74.0	73.0	73.5
	74.0	74.0	75.0	74.7	75.0	77.0	71.0	71.5	72.5	72.5	72.0	73.5
	75.5	75.0	76.0	75.0	75.0	76.5	72.5	72.5	75.0	73.0	72.0	74.0
	74.0	74.0	74.5	----	----	----	----	----	----	----	----	----
Avg.	74.2	74.1	74.9	74.9	75.0	76.8	71.8	72.0	73.8	73.2	72.3	73.7
J-57	74.7	74.5	75.5	75.0	75.0	77.0	72.2	72.2	74.5	73.5	72.5	73.7

RIB-2

	Brushed Concrete			Sand Blasted Brushed Concrete			Smooth Concrete			Terrazzo Finished Concrete		
	SAE	NBS		SAE	NBS		SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	72.0	72.0	73.5	73.5	74.0	75.0	70.0	71.5	71.5	71.5	71.5	73.0
	73.0	73.5	74.0	73.0	73.5	74.0	70.0	70.5	71.5	71.5	72.0	73.0
	72.5	72.5	73.0	73.0	73.0	74.0	70.0	70.5	71.5	72.0	72.0	73.5
	----	----	----	73.0	----	----	----	----	----	72.0	72.0	73.0
Avg.	72.5	72.7	73.5	73.1	73.5	74.3	70.0	70.8	71.5	71.7	71.9	73.1
J-57	72.7	73.0	73.7	73.2	73.7	74.5	70.0	71.0	71.5	72.0	72.0	73.2

50 MPH

CROSS-BAR-1

	Brushed Concrete			Sand Blasted Brushed Concrete			Smooth Concrete			Terrazzo Finished Concrete		
	SAE	NBS		SAE	NBS		SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	77.5	76.0	77.0	78.0	77.0	77.5	78.0	77.0	78.5	78.5	77.5	77.5
	78.0	77.0	78.5	77.5	76.5	77.5	78.0	77.0	78.5	78.5	77.5	79.0
	77.5	76.5	78.0	78.0	77.0	78.0	78.0	76.5	77.5	78.0	76.5	77.0
	----	----	----	----	----	----	----	----	----	79.0	77.0	78.0
	----	----	----	----	----	----	----	----	----	78.0	76.0	76.0
Avg.	77.7	76.5	77.8	77.8	76.8	77.7	78.0	76.8	78.2	78.4	76.9	77.5
J-57	77.7	76.7	78.2	78.0	77.0	77.7	78.0	77.0	78.5	78.5	77.5	78.5

CROSS-BAR-2

	Brushed Concrete			Sand Blasted Brushed Concrete			Smooth Concrete			Terrazzo Finished Concrete		
	SAE	NBS		SAE	NBS		SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	80.5	80.0	81.0	80.5	80.0	81.0	80.0	79.0	79.5	80.5	79.0	80.0
	79.5	79.0	79.0	81.0	80.5	82.5	79.5	79.0	81.0	80.5	78.5	80.0
	79.5	79.0	80.0	79.5	79.5	80.0	80.5	80.0	80.0	80.5	----	----
Avg.	79.8	79.3	80.0	80.3	80.0	81.2	80.0	79.3	80.1	80.5	78.7	80.0
J-57	80.0	79.5	80.5	80.7	80.2	81.7	80.2	79.5	80.5	80.5	78.7	80.0

50 MPH

CROSS-BAR-3

	Brushed Concrete			Sand Blasted Brushed Concrete			Smooth Concrete			Terrazzo Finished Concrete		
	SAE	NBS		SAE	NBS		SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	78.5	79.0	80.0	78.0	77.0	78.5	80.5	80.0	81.5	80.0	80.0	81.0
	78.5	78.5	80.0	79.0	79.0	81.0	79.5	78.0	80.0	80.0	80.0	81.5
	78.0	77.5	79.0	78.5	78.0	80.0	79.5	78.5	80.0	80.0	79.5	81.0
Avg.	78.3	78.3	79.7	78.5	78.0	79.8	79.8	78.8	80.5	80.0	79.8	81.2
J-57	78.5	78.7	80.0	78.7	78.5	80.5	80.0	79.2	80.7	80.0	80.0	81.2

RIB-3

50 MPH

	Brushed Concrete			Sand Blasted Brushed Concrete			Smooth Concrete			Terrazzo Finished Concrete		
	SAE	NBS		SAE	NBS		SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	71.0	73.0	74.0	71.5	72.5	73.5	67.0	68.0	69.0	68.5	68.5	69.0
	72.5	74.0	75.0	72.5	74.0	75.5	67.0	68.0	68.0	69.0	68.5	70.0
	71.0	72.5	73.0	71.5	72.5	73.5	67.0	68.5	69.0	68.0	67.5	68.0
	72.5	74.0	74.5	72.5	74.0	75.0	----	----	----	69.5	68.5	70.5
	72.0	73.0	74.0	----	----	----	----	----	----	----	----	----
	72.5	74.0	74.0	----	----	----	----	----	----	----	----	----
Avg.	71.9	73.4	74.1	72.0	73.2	74.4	67.0	68.2	68.7	68.7	68.2	69.4
J-57	72.5	74.0	74.7	72.5	74.0	75.2	67.0	68.2	69.0	69.2	68.5	70.2

60 MPH

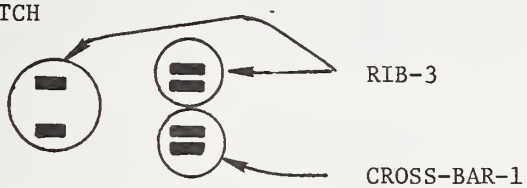
CROSS-BAR-2

	Smooth Concrete			Sand Blasted Brushed Concrete		
	SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	82.0	81.5	82.0	83.0	83.0	85.0
	82.2	81.5	82.5	82.0	82.0	83.0
	82.0	81.5	83.0	83.0	82.5	84.0
Avg.	82.2	81.5	82.5	82.7	82.5	84.0
J-57	82.1	81.5	82.7	83.0	82.7	84.5

CROSS-BAR-3

Smooth Concrete			Sand Blasted Brushed Concrete		
SAE	NBS		SAE	NBS	
La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
81.5	81.0	84.0	81.0	80.5	82.0
82.0	81.0	83.0	80.0	79.5	79.5
82.0	81.5	83.5	81.0	80.0	81.0
81.8	81.2	83.5	80.7	80.0	80.5
82.0	81.2	83.7	81.0	80.2	81.5

MIX-AND-MATCH



Terrazzo Finished Concrete			Smooth Concrete		
SAE	NBS		SAE	NBS	
La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
77.0	74.5	75.0	77.5	76.0	76.5
75.0	74.5	76.0	75.5	74.0	75.5
77.0	77.0	77.5	77.5	76.5	77.5
75.0	74.5	76.0	75.5	74.5	76.0

CROSS-BAR-1

	Asphalt			Dorset Pebble		
	SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	77.5	----*	----*	78.0	77.5	79.0
	78.0	77.0	78.5	78.5	78.0	78.5
	78.0	77.0	79.5	78.5	77.5	78.5
	----	----	----	79.0	78.0	78.5
Avg	77.8	77.0	78.7	78.5	77.8	78.6
J-57	78.0	77.0	78.7	78.7	78.0	78.7

CROSS-BAR-3

	Asphalt			Dorset Pebble		
	SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	77.0	76.5	77.0	78.5	77.5	78.0
	77.0	----*	----*	78.5	----*	----*
	78.0	----*	----*	78.5	77.5	78.0
	77.5	----*	----*	----	----	----
Avg	77.4	----	----	78.5	77.5	78.0
J-57	77.7	----	----	78.5	77.5	78.0

CROSS-BAR-2

	Asphalt			Dorset Pebble		
	SAE	NBS		SAE	NBS	
	La Slow	La Slow	La Fast	La Slow	La Slow	La Fast
	79.0	----*	----*	78.5	----*	----*
	79.5	----*	----*	78.5	----*	----*
	79.5	----*	----*	78.5	----*	----*
Avg.	79.2	----	----	78.5	----	----
J-57	79.5	----	----	78.5	----	----

*WINDS TOO HIGH FOR RECORDING ON LINEAR.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The Society of Automotive Engineers, Inc. (SAE) Truck Tire Noise Subcommittee conducted a series of truck tire noise tests at the Automotive Proving Grounds, Inc. in Pecos, Texas, November 5-7, 1973. At the request of DOT, NBS participated in these tests and made simultaneous measurements with those made by the SAE committee. This report presents a summary of the results obtained during these tests.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Acoustics; noise measurement; noise(sound); tire noise; transportation noise; trucks

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