Recommended Practice for

Accepting New Concrete Pavement Surfaces for Tire/Pavement Noise

Designation: CPSCP PP 1-11 **(rev 3/1/2011)**

National Concrete Pavement Technology Center

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1. SCOPE

1.1. This practice provides guidance and example specification language intended for use by Owner-Agencies in development of specific contract language when requiring the evaluation of tire/pavement noise for new concrete pavement surfaces. The overall sound intensity level is designated as the quality characteristic used for pay adjustment.

1.2. If any part of this practice is in conflict with references made, such as ASTM or AASHTO Standards, this practice takes precedence for its purposes.

1.3. The values stated are in U.S. Customary units and are to be regarded as the standard.

1.4. This practice should only be adopted after an evaluation of existing texture standards. Texture standards should be modified as necessary to minimize or eliminate prescriptive language that may conflict with the end-result practices described herein.

1.5. Users of this practice should refer to Appendix A for recommended practices for implementation.

1.6. *This specification does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this specification to establish appropriate safety and health practices and determine the applicability of regulatory limitations related to and prior to its use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*

- TP 76, Measurement of Tire/Pavement Noise Using the On-Board Sound Intensity (OBSI) Method

2.2. *ASTM Standards:*

- F 2493, Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire

2.3. *ISO Standards:*

- 13473-3, Characterization of pavement texture by use of surface profiles – Part 3: Specification and classification of profilometers

3. TERMINOLOGY

3.1. *on-board sound intensity (OBSI) method*—a standard method of test described in AASHTO TP 76 to evaluate the tire/pavement noise component resulting from the interaction of a ASTM F 2493 Standard Reference Test Tire (SRTT) on a pavement surface.

3.2. *overall sound intensity level*—an A-weighted sound intensity level measured in general conformance with AASHTO TP 76 and reported as an energy average for a given test segment.

3.3. *qualified OBSI system*—an OBSI system that conforms to all requirements and specifications found in AASHTO TP 76. The system shall also conform to current industry-accepted practices as demonstrated through comparative testing sanctioned by the Tire/Pavement Noise Research Consortium, TPF-5(135), or the Tire/Pavement Noise Technical Working Group, sponsored by the Federal Highway Administration Office of Pavement Technology.

3.4. *qualified OBSI operator*—an individual that is proficient in the principles of acoustical measurements. To be qualified, an operator shall meet the education and experience requirements for becoming a full member of the Institute of Noise Control Engineering of the USA. The operator shall have previously participated as an operator in comparative testing sanctioned by the Tire/Pavement Noise Research Consortium, TPF-5(135), or the Tire/Pavement Noise Technical Working Group, sponsored by the Federal Highway Administration Office of Pavement Technology.

3.5. *experienced OBSI operator*—a qualified OBSI operator that possesses a minimum of three years of experience conducting OBSI tests.

3.6. *standard reference test tire (SRTT)*—as defined in ASTM F 2493.

3.7. *test segment*—a 528 ± 10 ft length of pavement over which a measurement is made. While this test length does not comply with AASHTO TP 76, it is selected to both facilitate and encourage coincidence of the test segments used for ride quality testing.

3.8. *tire/pavement noise*—the sound generated by the interaction of the tire with the pavement surface as it traverses a specific length of pavement.

4. SIGNIFICANCE AND USE

4.1. This example provides specification language for evaluating and accepting tire/pavement noise on newly constructed concrete pavement surfaces using the overall sound intensity level as the quality characteristic used for pay adjustments.

5. EQUIPMENT AND OPERATOR

5.1. Provide a qualified OBSI system. Provide the Owner-Agency with documentation of the system's qualifications.

5.2. Provide the Owner-Agency with a copy of the most current calibration certificates for the calibrator(s), matched microphone pair(s), and preamplifiers used as part of the OBSI measurement system.

5.3. Provide the Owner-Agency with the date code of the SRTT (four-digit sequence printed on sidewall indicating the week and year of manufacture).

5.4. Operate the equipment in general conformance with AASHTO TP 76, with the only deviations from the standard being those cited herein.

5.5. Provide at least one qualified OBSI operator to be present during all testing. Provide the Owner-Agency with documentation of the operator's qualifications.

6. WORK METHODS

6.1. *Pavement Surface Preparation*—Prior to testing, the concrete surface should be thoroughly cleaned using a motorized broom or other means approved by the Owner-Agency. The contractor is permitted to operate construction traffic on the surface prior to testing in order to further condition the surface, but not in manner that would introduce significant damage to the pavement.

6.2. *Determination of Test Segments*—Unless otherwise noted in the plans or herein, test segments shall be established along the entirety of the project within each traveled lane. Test segments shall be arranged contiguously so that the pavement surface is evaluated as completely as practical. Gaps between test segments are permitted to avoid all or part of bridge structures including joints and approach slabs. Gaps between test segments are also permitted to avoid manhole covers, utility covers, areas of pavement that do not comply with the criteria for valid testing per AASHTO TP 76, and areas of pavement noted in the plans to be excluded from testing. While not mandatory, it is recommended that test segments be established in such as way to coincide with the test segments established for ride quality testing.

6.3. *Quality Control (QC) Testing*—Prior to beginning paving, the contractor shall provide a QC testing plan to the Owner-Agency for approval. The QC plan shall describe the methods and frequency of testing. Perform QC tests following the approved QC plan throughout the duration of the project. QC testing should be conducted using the OBSI Method, or an appropriate alternate to expedite feedback for process control.

6.3.1. Pavement texture measurements are an appropriate alternate method for QC testing. The method for measuring pavement texture should comply with ISO 13473-3 or similar. Approval of a specific test method should be based on the a documented correlation between: 1) measured overall sound intensity levels using the OBSI Method; and 2) estimated overall sound intensity levels calculated using the measured texture metric(s). The correlation should be developed and documented from data measured on concrete pavements of the same nominal texture type (e.g., diamond grinding, longitudinal tining). The correlation between measured and estimated overall sound intensity level should be established using data from at least 20 test segments measured per AASHTO TP 76 that include a range of overall sound intensity levels of at least 4.0 dB(A). Using the following equation, the correlation should have a standard error of the estimate (SEE) of no greater than 1.2 dB(A).

$$SEE = \sqrt{\frac{\sum_{n=1}^{N}\left(OBSI_{measured,n} - OBSI_{predicted,n}\right)^2}{N-2}} \qquad (1)$$

where:

SEE = standard error of the estimate,

N = number of data pairs used in the correlation,

n = counter from 1 to N,

$OBSI_{measured,n}$ = measured overall sound intensity level for the n^{th} data pair, and

$OBSI_{predicted,n}$ = predicted overall sound intensity level for the n^{th} data pair.

6.4. *Acceptance Testing*—The contractor shall perform acceptance testing using the OBSI method. Testing shall be performed on the finished concrete surface of the completed project or at the completion of a major stage of construction as approved by the Owner-Agency. Coordinate with and receive authorization from the Owner-Agency before starting testing. Obtain OBSI measurements within 7 days after receiving authorization and submit results to the Owner-Agency within 24 hours of data collection.

6.4.1. Unless approved by the Owner-Agency, a standard test speed of 60 mph shall be used for all OBSI testing for acceptance. If a test speed other than 60 mph is used, mandatory revisions to the overall sound intensity level limits in Section 6.7 shall be provided by the Owner-Agency.

Note 1—While a test speed of 60 mph is the most common for OBSI testing, some projects should be evaluated at lower speeds for safety considerations and/or to better approximate the anticipated traffic speeds on the facility. It is critical that comparisons of overall sound intensity level only be made if measured at the same test speed. Furthermore, the overall sound intensity levels cited in Section 6.7 must be modified if the test speed is to be modified. If possible, the highest reasonable standard test speed as designated by AASHTO TP 76 should be used; therefore, the first preferred alternate to 60 mph is 45 mph, the second preferred alternate is 35 mph.

6.5. *Verification Testing*—Within ten working days after the contractor's acceptance testing under Section 6.4 is completed, the Owner-Agency may perform verification testing using a qualified OBSI system with at least one qualified OBSI operator present during all testing. If the verification testing demonstrates an overall sound intensity level obtained over any test segment that differs by more than 3.0 dB(A) from that obtained using the contractor's equipment, then the Owner-Agency and contractor shall attempt to resolve the differences to their mutual satisfaction.

6.5.1. If the differences cannot be resolved, then Independent Assurance (IA) testing will be conducted at the expense of the Owner-Agency. IA testing shall be conducted using qualified OBSI equipment and at least one experienced OBSI operator present during all testing. Testing of the test segments that are demonstrating differences shall be conducted by the contractor, Owner-Agency, and by IA on the same day and approximate time. All test results shall be submitted to the Owner-Agency within 24 hours of data collection.

6.5.2. If the overall sound intensity level as measured by the IA testing is confirmed to be within 1.5 dB(A) of the Owner-Agency test results, but not confirmed to be within 1.5 dB(A) of the contractor's test results, then the contractor's method of test shall be discontinued and modified in such a way to demonstrate agreement with the IA testing. A similar requirement will apply if the IA testing confirms the contractor testing but fails to confirm the Owner-Agency. If the IA testing fails to confirm either the Owner-Agency or contractor testing, then both methods shall be discontinued and modified in such a way to demonstrate agreement with the IA testing.

6.5.3. If the contractor test results are confirmed to be within 1.5 dB(A) of the IA test results, then the original acceptance test results for the test segment(s) as measured by the contractor shall be final and will be used to establish pay adjustments. If the contractor test results are not confirmed during the IA testing, then the IA test results for the test segment(s) shall be final and will be used to establish pay adjustments.

6.6. *Evaluation and Reporting of Test Results*—The contractor shall evaluate the test results from each test segment in terms of acceptance, pay adjustments, and/or the need for corrective action. The contractor shall provide the test results and the results of these evaluations for each test segment to the Owner-Agency within 24 hours of completing testing under Section 6.4. Determine pay adjustments in accordance with Section 6.7.

6.7. *Pay Adjustment Schedule*—The pay adjustment factors from Table 1 shall be used to compute a final pay factor (incentive or disincentive). The final pay factor (PF) computed to three decimals is equal to the sum of the products of the individual pay adjustment factors shown in Table 1 divided by 100.

Table 1—Pay Adjustment Factors and Computation of Final Pay Factor for a Test Speed of 60 mph

Overall Sound Intensity Level Limit for Testing at 60 mph (dB(A)) [a] (1)	Pay Adjustment Factor (2)	Percent of Test Segments within Overall Sound Intensity Level Limit (%) (3)	Pay Adjustment (4)
< 102.0	1.##	#.#	##.#
102.0 – 103.9	1.00	#.#	##.#
104.0 – 106.0	0.##	#.#	##.#
> 106.0	0.##	#.#	##.#
	Final Pay Factor (PF) = Sum of Column (4)/100 =		#.### or 0.###

[a] The number of steps in the table as well as the Overall Sound Intensity Level Limits and pay adjustment factors should be set by the Owner-Agency.

Note 2—Overall sound intensity level limits and pay adjustment factors should be selected based on the specific project requirements and the test speed designated in Section 6.4.1. This pay adjustment table is just one style of many possible pay tables. For this table, the final pay factor is determined by taking the values in column (2) and multiplying them by column (3). The results are shown in column (4). The results in column (4) are then summed and divided by 100 to obtain the Final Pay Factor (incentive or disincentive).

Note 3—Test segments in the last category shown in Table 1 shall be designated as defective segments, and subject to corrective action per Section 6.8.

6.8. *Deficiencies and Corrective Action*—For test segments designated as defective segments, the following shall apply:

- Propose a plan and methodology to correct defective segments. Approval from the Owner-Agency must be received before proceeding with any corrective action. Corrective action must be done with the purpose of correcting the pavement surface in order to decrease the tire/pavement noise level to acceptable limits. Diamond grinding is an example of a commonly accepted methodology to reduce tire/pavement noise.
- The Owner-Agency will determine the final disposition of defective segments, which may include corrective action or require reduced pay factors per Section 6.7.
- If corrective action is taken, the corrected segments shall be retested to verify that the corrections have produced the required improvements. If the corrective action does not produce the required improvements, the Owner-Agency may allow continued corrective action or require reduced pay factors per Section 6.7.
- Unless otherwise approved by the Owner-Agency, corrective action will not be allowed on nondeficient segments to obtain incentive payments.
- All corrective action will be at the Contractor's expense.

7. MEASUREMENT AND PAYMENT

7.1. *Measurement and Payment*—The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly, but will be subsidiary to bid items of the contract. The final pay factor as determined in Section 6.7 will be applied to the unit bid price for the quantity of concrete pavement placed and accepted. The appropriate incentive or disincentives will be applied separately.

8. REFERENCES

8.1. Donavan, P., and D. Lodico. *Measuring Tire-Pavement Noise at the Source*. National Cooperative Highway Research Program (NCHRP) Report 630. Transportation Research Board, Washington, DC, 2009.

8.2. Institute of Noise Control Engineering of the USA. 1 Jan. 2011 <http://www.inceusa.org>

8.3. Rasmussen, R.O., et al. *How to Reduce Tire-Pavement Noise: Better Practices for Constructing and Texturing Concrete Pavement Surfaces.* National Concrete Pavement Technology Center, Ames, IA, 2011.

8.4. Rasmussen, R.O., et al. *The Little Book of Quieter Pavements*. Report FHWA-IF-08-004, Federal Highway Administration, 2007.

8.5. Tire/Pavement Noise Research Consortium. *Questions and Answers about Quieter Pavements.* Transportation Pooled Fund TPF-5(135), January 2011.

9. APPENDIX A: RECOMMENDATIONS FOR IMPLEMENTATION

9.1. *Implementation Sequence*—In order to implement the recommended practice provided herein, the following implementation sequence should be employed:

- *Phase 1A: Develop "shadow" specification*—Specific language should be developed for a specification that is compatible with existing specifications and standard practices of the Owner-Agency. Since the recommended practice included herein is an end-result type specification, a review of existing concrete pavement texture specifications used by the Owner-Agency is warranted. Prescriptive language that could conflict with an end-result specification should be modified or eliminated as appropriate. As a best management practice (BMP), a shadow specification (and any requisite changes to existing standards) should be developed through a cooperative effort with the Owner-Agency and industry stakeholders, such as local representatives of the American Concrete Pavement Association. Another BMP is to begin implementation with relatively small deviations from a pay factor of 1.0. It is suggested that the extreme pay factors be established at 1.05 and 0.95, respectively.
- *Phase 1B: Field trial "shadow" specification*—A field trial of the shadow specification should include use on a job that would be typical for more widespread implementation. All aspects of the specification should be in force except for independent assurance, pay adjustments, and corrective action. A report shall be prepared by the Owner-Agency as a result of the field trial that documents the test methods and test results. While not in force, instances that could have required independent assurance should be documented, as well as the pay adjustments and/or corrective actions that would have been applied on all test segments.
- *Phase 2: Special provision*—Based on the outcome of the shadow specification field trial, revisions should be made as appropriate to the specification language. A special provision should be developed that is gradually implemented on projects that are typical for more widespread implementation. Early projects should be closely monitored, and additional revisions to the special provisions made as necessary to reflect the lessons learned. Specific changes could include modifications to the pay adjustment schedule.
- *Phase 3: Standard practice*—As the specification matures during subsequent field trials, it can subsequently be adopted as a standard practice, along with requisite changes to other aspects of the concrete pavement texturing standards to ensure compatibility.

9.2. *Other Implementation Activities*—In order to increase the likelihood of a successful implementation, additional implementation activities should be considered, including:

- *Education and training*—Tire/Pavement Noise can be a complicated topic, therefore proper education and training are needed to convey the most important and relevant principles. At a minimum, training should include design and construction practices that lead to quieter concrete pavement surfaces, along with methods for testing tire/pavement noise including OBSI and texture measurements.
- *Development of alternate test methods for QC*—In this recommended practice, a provision is given to use an "appropriate alternate" test method (namely, texture testing) in lieu of OBSI testing for QC. Research has shown that, while commonly specified, texture depth alone is not satisfactory to comply with the recommended tolerances for statistical prediction. As a result,

a recommended implementation activity would include the identification and development of a relevant and accurate provisional/standard test method for texture to be used by contractors in QC testing.

- *Development of a database of OBSI test results*—In order to define more appropriate limits of sound intensity levels for use in this practice, it is recommended that a survey of representative roadways be conducted by the Owner-Agency. Sites should include roadways of varying ages and nominal texture types. Guidance and examples of these types of surveys can be found in the products of the Concrete Pavement Surface Characteristics Program, or from the Tire/Pavement Noise Research Consortium, TPF-5(135).
- *Development of overall sound intensity level limits for other than 60 mph*—The overall sound intensity level limits shown in this recommended practice are for testing at 60 mph. Tire/pavement noise is significantly affected by test speed, and therefore if a test speed other than 60 mph is used, these limits must be changed accordingly. Unfortunately, there is not a constant and predictable adjustment between levels tested at 60 mph and levels from testing at lower speeds. In this task, OBSI testing could be conducted at varying speeds on the most commonly used concrete pavement textures. The results can be used to establish reasonable specification limits for testing at lower speeds.
- *Cost-benefit analysis for developing pay factors*—Conducting a cost-benefit analysis of noise mitigation strategies including tire/pavement noise could lead to more rational pay adjustment factors. It is anticipated that guidance for this will be available in the products from NCHRP Research Project 10-76.