The Revised ISO 362 Standard for Vehicle Exterior Noise Measurement

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The International Organization for Standardization (ISO) has developed a new measurement procedure, ISO 362:200X, for vehicle exterior noise. This proposed standard covers motorcycles, light duty vehicles, and heavy duty vehicles. The new procedure is designed to measure vehicle noise consistent with typical urban operation.

The proposed ISO 362:200X standard provides a performance-based measurement, as opposed to a design specific measurement, of exterior vehicle noise. This standard seeks to approximate real world part throttle vehicle operation with a weighted average of a wide open throttle test at a target acceleration with a constant speed test. This performance based concept is used for category L vehicles (motorcycles), category M1 vehicles (passenger cars), category N1 vehicles (trucks or multipurpose vehicles with Gross Vehicle Weight Rating, GVWR, less than 3500 kg) and M2 vehicles (small buses with a GVWR less than 3500 kg).

This work has been carried out by WG42, a joint workgroup of ISO TC43/SC1 'Noise' and ISO TC22 'Road Vehicles.' SAE has conducted a cooperative research program to evaluate the new standard with regard to procedural, technical, and practical considerations. This work was carried out under the direction of the SAE Light Vehicle Exterior Noise Committee. SAE has adopted the current ISO 362:1998 as SAE J1470.[1] The committee, in the interest of standardization, was interested in the potential application of the proposed ISO362:200X revision to SAE J1470.

Participating companies in the cooperative research program were DaimlerChrysler, Ford, Honda, General Motors and Nissan. Additional independent evaluations of the proposed standard have been carried out in Japan under the direction of the Japan Automobile Standards Internationalization Center (JASIC) and in Europe under the direction of the European Automobile Manufacturers Association (ACEA). The results of these studies have been provided to the United Nations Economic Commission for Europe (UN ECE) in conjunction with proposed amendments of ECE exterior noise regulations. The version of the standard accepted by the UN ECE GRB (Group of Experts on Noise) for consideration is given in document UN ECE TRANS/WP.29/GRB/2002/4/Rev.2.[2]

Discussion of Test Procedures

Proposed Standard. The proposed ISO 362:200X standard covers the measurement of exterior vehicle noise consistent with typical vehicle operations in urban traffic situations. The WG42 committee has had access to extensive in-use data to determine actual driving behavior in urban traffic. The findings from these studies was that light duty vehicles are driven in such a manner as to maintain traffic flow. This corresponds to partial throttle operation with the magnitude of the throttle depending on the acceleration capability of the vehicle. WG42 proceeded to design a test to measure normal urban operations. The test for heavy commercial vehicles does not use this principle due to different in-use characteristics of these vehicles. All subsequent discussion is relevant to light duty vehicles only.

To establish the operating criteria, WG42 used the in-use vehicle data which showed the most traveled speed to be 50 km/hr. The acceleration used by vehicles was fitted to in-use data. The resulting acceleration is a logarithmic function of the vehicle's power to mass index (*PMR* index, a nondimensional number) ratio:

$$PMR = \frac{P_n}{m_t} \times 1000 \text{ kg/kW}$$

To achieve stable and repeatable test conditions, the procedure has been defined to require a Wide Open Throttle (WOT) test and a constant speed test. The WOT test specifies that a target acceleration be achieved. The gear selection for this test is determined by the target acceleration. The constant speed test is run at 50 km/hr. These tests are then combined in a weighted average which is a function of the actual acceleration achieved in the WOT test and the PMR ratio. All track specifications, microphone placements and environmental criteria remain the same as specified by ISO 362:1998.

Comparison with Existing ISO 362:1998. The current ISO 362:1998 standard, which is the technical basis of SAE J1470, has the following objective:

This document specifies an engineering method for measuring the noise emitted by accelerating highway vehicles of all types (except motorcycles) in intermediate gears with full utilization of the available engine power. The method is designed to meet the requirements of simplicity and reproducibility of results under realistic vehicle operating conditions. Measurements relate to operating conditions of the vehicle which give the highest noise level consistent with urban driving and which lead to reproducible noise emissions. Therefore, an acceleration test at full throttle from a stated engine or vehicle speed is specified.[1]

As described in the above paragraph, the current ISO 362:1998 and SAE J1470 standards seek to measure the highest noise levels consistent with urban driving. Inherent to the WOT test specified in the ISO 362:1998 is the assumption that all relevant noise sources will be measured in this condition. However, tire-road noise at light throttle operation can be a significant source of traffic noise in urban environments. ISO 362:1998 does not attempt to measure this noise source. The interaction between technical standards and regulations is apparent. As vehicle designs have reduced noise associated with the engine due to regulatory requirements, noise from other sources (tire-road) have become larger contributors to the remaining, lower noise levels. As such, tire-road noise is a larger part of the soundscape in the environment. Thus, the measurement of vehicle exterior noise with ISO 362:1998 does not provide an adequate representation of real-world urban traffic noise.

The gear selection criteria of ISO 362:1998 was based on typical transmission technology at the time. For manual transmissions, the test specifies a 2nd gear test, 2nd and 3rd gear test or a 3rd gear test depending on design and performance criteria. For automatic transmissions, the gear selector is to be placed in the 'D' position. Approach speed may be increased up to a maximum of 60 km/hr or an electronic device may be used to prevent downshift to a gear not normally used in urban driving for automatic transmissions. It has been generally understood, although not specified in either the ISO 362 or SAE J1470 standards, that prevention of downshift meant the transmission should not downshift to 1st gear.

As transmission and propulsion technologies have advanced, the gear selection criteria of ISO 362:1998 do not adequately

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meet the intent of the standard. Transmissions, both manual and automatic, have moved from 4 speeds to 5, 6 and 7 speeds. Continuously variable transmission (CVT) vehicles have come to the market, as well as hybrid vehicles which use electric motors for part or all operation in urban conditions.

The proposed ISO 362:200X seeks to address each of these concerns. First, the design specific requirements (gear selection) of the current test are changed to a performance-based requirement. The performance criteria was selected to include 90% of all noise levels, i.e. noise emission of the vehicle will be below the measured value for 90% of urban operation. Gear selection, or the technical equivalent for transmissions without step gear ratios, is specified through the requirement to achieve target acceleration. Target acceleration is to be achieved while simultaneously meeting a 50 km/hr speed criteria at the microphone position, which normalizes the performance of vehicles independent of the differences in powertrain technology.

Secondly, excitation of the previously minimized tire/road noise source is improved. By including a constant speed test at 50 km/hr and a WOT test to a target acceleration, a representative part-throttle urban acceleration can be approximated. The constant speed and WOT tests are combined in a weighted average to simulate the part-throttle operation seen in actual use. Since all significant noise sources have been included, the resulting value is an improved estimate of the real-world typical urban vehicle noise. The proposed ISO 362:200X no longer seeks to measure the highest noise levels produced in urban traffic focused on powertrain noise, but rather to provide an estimate of a 90% noise level in urban traffic, including all relevant vehicle noise sources.

Evaluation of the Proposed Technical Standard

Description of the SAE Cooperative Research Program. The SAE Light Vehicle Exterior Noise Committee (SAE Noise Committee) has been following the development of the ISO 362CD (the Committee Draft version of the proposed standard) work of ISO TC43/SC1/WG42. This work has progressed to the point where the United Nations Economic Commission for Europe (UN ECE) has adopted ISO 362CD as the technical basis for amendments to ECE exterior vehicle noise regulations.

Based on this development, the SAE noise committee decided to evaluate the proposed standard for technical reasons. The SAE Noise Committee also was interested in the regulatory implications of the proposed standard. To support these goals, an SAE Cooperative Research Program was established. Participants included DaimlerChrysler, Ford, Honda, General Motors and Nissan. The author was appointed Program Manager. General Motors offered to donate the facility time at the GM Milford Proving Grounds for support of the program. The program goal was to evaluate 30-40 vehicles providing a representative sample of the North American market.

Evaluation of Proposed Technical Standard, ISO 362:200X. The SAE Cooperative Research Program performed 38 tests on 34 different vehicles, with some vehicles being tested multiple times to provide information on test repeatability. Additional testing was carried out on the measurement equipment to determine types of equipment suitable for the engine and vehicle speed measurement precision requirements of ISO 362:200X.

Table 1 shows full results including gear ratios, vehicle speeds during testing, engine speed during testing, and other vehicle information. Table 2 presents the results of the study showing noise levels measured under SAE J1470, the proposed

Table 1. Results of comparison testing (MT = Manual Transmission; AT = Automatic Transmission).

Vehicle Midsize Car	Power, kW	Weight, kg	GVW, kg	Eng Displ., l	PMR	No. Gears	MT	AT	Petrol	Diesel	Max RPM (S)	RPM @ PP' OLD	RPM @PP OLD 3rd
1	130	1519	–	3.4	81.9	4	–	X	X	–	5200	3119	–
2	149	1510	1854	3.4	94.1	4	–	X	X	–	5400	3220	–
3	149	1588	1758	3	89.7	4	–	X	X	–	5500	2623	–
4	183	1495	–	3.5	116.4	5	–	X	X	–	5800	3669	–
5	179	1589	2032	3.8	107.6	4	–	X	X	–	5200	2731	–
6	149	1576	1927	2.7	90.3	4	–	X	X	–	5800	2742	–
7	194	1625	2011	3.8	114	4	–	X	X	–	5200	3414	–
Vans & Midsize SUV													
8	138	1792	2430	3.4	73.9	4	–	X	X	–	5200	3194	–
9	179	1842	–	3.5	93.4	4	–	X	X	–	5800	2630	–
10	160	2016	2631	3.8	76.7	4	–	X	X	–	5000	3165	–
11	142	1932	2470	3.4	70.6	4	–	X	X	–	5500	3050	–
Large SUV													
12	190	3024	3900	5.4	61.4	4	–	X	X	–	4500	2917	–
13	216	2287	2858	5.3	91.6	4	–	X	X	–	5200	2818	–
14	220	2285	3085	4.8	93.2	4	–	X	X	–	5200	2990	–
15	236	2903	3901	6	79.1	4	–	X	X	–	5200	2641	–
16	227	2400	–	5.6	91.9	5	–	X	X	–	4900	3294	–
17	194	2655	3311	4.4	71	4	–	X	X	–	4500	2801	–
Luxury Large Car													
18	224	1840	2368	4.6	116.8	4	–	X	X	–	6000	3322	–
19	178	2010	2155	4.6	85.5	4	–	X	X	–	4900	2734	–
Small SUV													
20	142	1568	2019	4	86.2	6	X	–	X	–	4600	2995	2038
21	164	1441	2007	2.5	108.2	4	–	X	X	–	5100	3586	–
22	112	1747	2562	2.4	61.4	6	X	–	X	–	5600	3080	–
23	138	1713	2299	3.4	77.2	5	–	X	X	–	5200	2911	–
Luxury Performance Car													–
24	201	1617	2057	3.2	119	5	–	X	X	–	6800	4055	–
25	239	1900	2340	4.6	120.8	4	–	X	X	–	6400	3387	–
Pickups													
26	224	2390	3265	5.4	90.8	4	–	X	X	–	5000	2898	–
27	265	2358	2972	5.7	108.8	4	X	–	X	–	5100	3990	2437
28	254	2990	3901	8.1	82.7	4	–	X	X	–	4200	2932	–
29	224	2519	4173	6.6	86.2	6	X	–	–	X	3000	2106	1537
Sports Car										–			
30	261	1690	2225	5.7	147.9	4	–	X	X	–	5200	3301	–
31	298	1442	1691	6	196.6	6	X	–	X	–	6000	3439	–
32	172	1347	–	2	120.6	5	X	–	X	–	5300	2516	–
Small Car													
33	101	1212.5	1417	2	78.8	5	X	–	X	–	6000	4561	2881
34	98	1191	162	2	77.8	4	–	X	X	–	5600	3549	–

ISO 362:200X, and the power to mass (PMR) index for the vehicle.

Figure 1 shows the distribution of results using SAE J1470. Results have a range of approximately 10 dB from quietest to loudest. It should be noted that many state and local regulations allow for the use of either SAE J986 or SAE J1470 to establish compliance with regulatory standards.

Figure 2 shows the results with the proposed ISO 362:200X. It is tempting to compare the average of the two methods to arrive at an equivalent level under the new method. However, this misses the point that the new method is designed to estimate part-throttle vehicle noise at a target urban speed and acceleration as opposed to wide open throttle noise at a specified gear selection. As such, it is more relevant to note that the new test both provides different test results as well as the different rankings of vehicles from quiet to loud.

As seen from the shape and range of the distribution of results from ISO 362:200X, the proposed test continues to provide the same discrimination between quiet and loud vehicles of approximately 10 dB. In addition, the new test results show a pronounced normal distribution. It was the subjective experience of the test team that the new procedure was better able to sort and distinguish both 'quiet' vehicles and 'loud' vehicles from the majority of 'average' vehicles.

In Figure 3, the difference between the two methods is presented. What is significant is the clear separation between vehicles that test in the same gear selection in both tests vs. vehicles that test in different gear selections in the ISO 362:200X test. Vehicles that have a difference of less than 3 dB, all test in the same gear selection under both procedures. In this case, the change in levels is primarily associated with the averaging

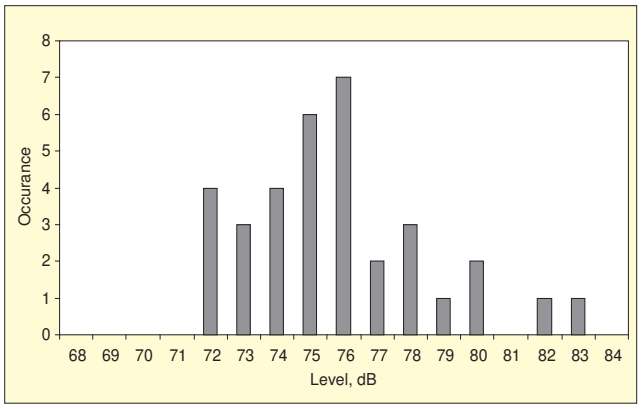

Figure 1. Results using current SAE J1470.

of the acceleration and constant speed test in ISO 362:200X. For vehicles with differences over 3.0 dB, every vehicle tested in a different gear selection between the two tests. This was due to the specification to test in fixed gears, independent of vehicle performance or the number of transmission gears in SAE J1470.

Each of these vehicles was equipped with powertrain equipment that provided the required acceleration in higher gears. This may be due to any combination of higher number of transmission speeds (5 or 6 speed vs. 4 speed) and the power to mass ratio of the vehicle. Under the SAE J1470, these vehicles are measured at accelerations significantly higher than in typical urban driving.

Returning to the question of comparing the two methods, a

N/S Old	RPM @ PP' NEW	RPM @ PP' NEW i+1	Delta_V New	Delta V 1470	SAE J1470	ECE R51	ISO 362:200X	ECE-New ISO	SAE - New ISO	ISO 362 L cruise	ISO 362 L wot
60.00%	3072	–	11.1	9.6	74.5	74.8	71.9	2.9	2.6	67.7	74.3
59.60%	2868	–	12.3	7	74.9	75.4	70.4	5	4.5	67.9	72.1
47.70%	2585	–	9	8.2	72.3	72.4	71.3	1.1	1	69.1	71.9
63.30%	3555	–	10.5	10.2	72.4	72.6	70.2	2.4	2.2	66	72.1
52.50%	2846	–	10.8	8.8	75.5	75.8	72.6	3.2	2.9	68.4	74.5
47.30%	3145	–	8.3	7.1	72.7	73.6	71.4	2.2	1.3	67.9	72
65.70%	2988	–	11.4	12.9	76.9	76.9	72.6	4.3	4.3	69.3	74.3
61.40%	3116	–	10.6	9.4	74	74	71.1	2.9	2.9	67.8	73
45.30%	2628	–	8.5	8.1	72.3	72.6	71.1	1.5	1.2	69.2	71.5
63.30%	3023	–	11.3	9.8	74.2	74.2	72.2	2	2	70.3	73.4
55.50%	3011	–	9.4	9.3	74.3	74.2	71.9	2.3	2.4	68.4	73.3
64.80%	2884	–	10.1	7.4	75.6	75.5	74.3	1.2	1.3	70.7	76.2
54.20%	2669	–	11.4	10.1	76.3	77.1	73.8	3.3	2.5	70.5	75.7
57.50%	2798	–	11.2	9.9	76.5	76.4	74.6	1.8	1.9	72.2	76
50.80%	2535	–	9.7	8		77.7	75.8	1.9		72.7	76.8
67.20%	3190	–	9.4	9.4	80.7	80.6	77.9	2.7	2.8	72.1	79.8
62.20%	2736	–	11.3	9.4	75.9	75.7	73.4	2.3	2.5	70.3	75.4
55.40%	2530	–	11.4	11.2	76.9	76.9	72.1	4.8	4.8	69.5	73.5
55.80%	2611	–	11.6	10	75.6	76	73	3	2.6	69	75.5
65.10%	2759	1901	10.2	9.2	76.5	76.7	74.1	2.6	2.4	71.9	75.2
70.30%	3483	–	10.2	9.6	75.7	75.8	73.3	2.5	2.4	69.1	75.4
55.00%	2923	–	8.9	7.9	77.7	78.2	73.2	5	4.5	71.9	73.8
56.00%	2834	–	10.3	9	75.8	75.6	69.5	6.1	6.3	66.7	70.9
59.60%	2731	–	11.3	14.2	76.1	76.2	71	5.2	5.1	67.4	72.8
52.90%	3303	–	11.6	10.4	76.2	76.5	72.2	4.3	4	67.2	75
58.00%	2813	–	10.7	9.8	77.9	77.6	75.6	2	2.3	70.4	78.1
78.20%	2288	–	8.3	10	79.1	79.3	74.6	4.7	4.5	70.3	74.9
69.80%	2544	–	11	12.1	80.7	81	76	5	4.7	71.6	78.4
70.20%	1978	–	10.5	8.6	78.8	78.9	77.4	1.5	1.4	75	78.5
63.50%	2256	–	14.1	16	83.1	82.7	75.3	7.4	7.8	68.5	80.4
57.30%	1561	–	11.1	20.3	78.9	79	72.7	6.3	6.2	71	73.2
47.50%	2366	–	11.9	11.3	82.7	83.5	78.3	5.2	4.4	72.1	82
76.00%	2685	–	9.6	10.1	73.4	73.6	68.7	4.9	4.7	67.3	69.2
63.40%	3474	–	7.7	7.1	73.1	73.8	72	1.8	1.1	68.9	72.5

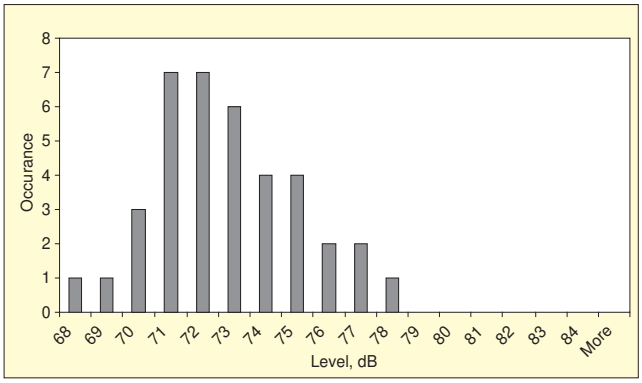

Figure 2. Results using proposed ISO 362:200X.

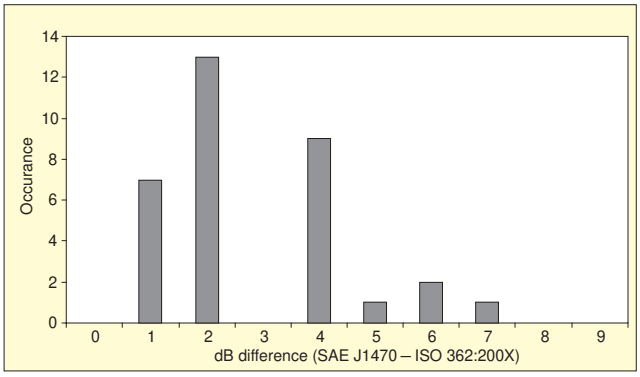

Figure 3. Differences between SAE J1470 and ISO 362:200X methods.

performance-based comparison will exclude the vehicles that do not test at the same transmission condition. Using this criterion, the effective difference between the two methods is less than the raw difference between averages. Figure 4 shows the velocity change through the test section using SAE J1470. There is a general trend toward increasing velocity changes (acceleration) with the PMR of the vehicle, as well as a large range in velocity change. Figure 5 shows how the vehicle velocity change does not have any significant relationship to the PMR of the vehicle and the velocity change is within a lower overall range.

Table 2. Results of Comparison Study

Vehicle	PMR	SAE	ISO
1	81.9	74.5	71.9
2	94.1	74.9	70.4
3	89.7	72.3	71.3
4	116.4	72.4	70.2
5	107.6	75.5	72.6
6	90.3	72.3	71.4
7	114	76.9	72.6
8	73.9	74.0	71.1
9	93.4	72.3	71.1
10	76.7	74.2	72.2
11	70.6	74.3	71.9
12	61.4	75.6	74.3
13	91.6	76.3	73.8
14	93.2	76.5	74.6
15	79.1	78.1	75.9
16	91.9	80.7	77.9
17	71.0	75.9	73.4
18	116.8	76.9	72.1
19	85.5	76.0	73.0
20	86.2	76.5	74.1
21	108.2	75.7	73.3
22	61.4	77.7	73.2
23	77.2	75.8	69.5
24	119.0	76.1	71.0
25	120.8	76.2	72.2
26	90.8	77.9	75.6
27	108.8	79.1	74.6
28	82.7	80.7	76.0
29	86.2	78.8	77.4
30	147.9	83.1	75.3
31	196.6	78.9	72.7
32	120.6	82.7	78.3
33	78.8	73.4	68.7
34	77.8	73.1	72.0

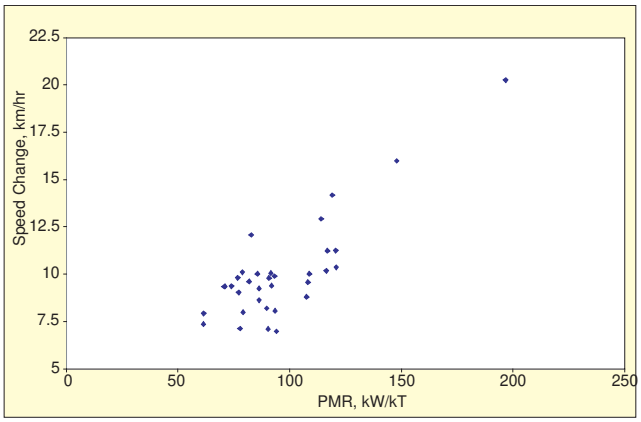

Figure 4. Speed Increase with SAE J1470.

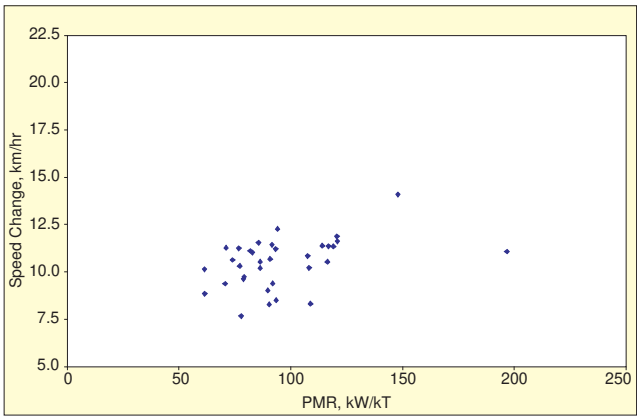

Figure 5. Speed Increase with ISO 362:200X.

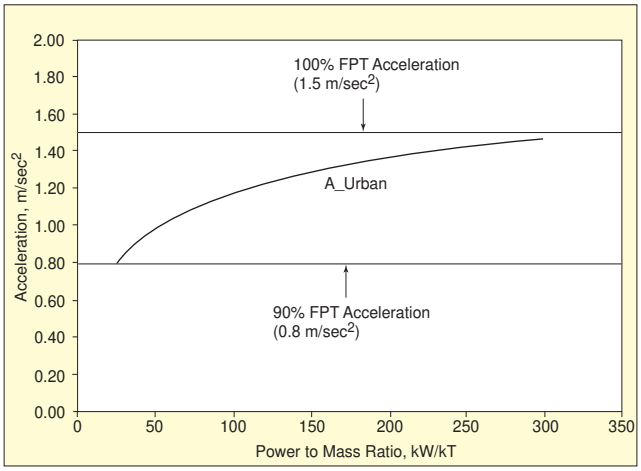

Figure 6. ISO 362:200X urban acceleration compared US EPA FTP City cycle for emissions.

Figure 6 shows how the urban acceleration defined in ISO 362:200X compares with the accelerations required from the US EPA Emissions cycle (FTP City) for city driving. The percentages expressed are time spent at or below this acceleration level, with the soak time in the FTP City cycle removed. This indicates that 90% of all acceleration, including deceleration (braking), are at a level of 0.8 m/s^2 or lower with 100% acceleration less than 1.5 m/s^2. This compares favorably with the urban acceleration curve in ISO 362:200X, which is the partial throttle result the test seeks to approximate. These results are consistent with the intent of the proposed ISO 362:200X test to require vehicle testing consistent with typical real-world operation.

Regulatory Considerations. Regulatory requirements for exterior noise of new vehicles have been set with the goal of achieving health and comfort levels of a community. Community noise levels are typically described in "Equivalent Loudness" (L_{eq}) levels, which are more dependent on typical vehicle noise emission levels as opposed to maximum potential vehicle noise emission levels that may be rarely seen in traffic. As the proposed ISO 362:200X levels are based on real-world traffic, the measured levels should be improved estimates of vehicle noise sources for use in traffic noise modeling.

New vehicle noise levels are one contributing factor in the overall community noise level. In the context of traffic noise, this includes consideration of all vehicle types (motorcycles, commercial vehicles, passenger vehicles), the pavement used, tires, speeds and traffic density, vehicle repair and maintenance, and noise performance of replacement parts. Regulatory action should consider all sources to achieve meaningful community noise improvement.

Conclusion

The results of the SAE cooperative research program indicate the new ISO 362:200X procedure meets the intent of measuring typical traffic noise and does so in a technically correct and practically achievable manner. The proposed standard addresses the design specific criteria in ISO 362:1998, which result in different operating conditions being specified for automatic transmissions vs. manual transmissions. The new performance based criteria of ISO 362:200X recognizes advances in powertrain and transmission technology that have made it difficult for design specific standards to provide objective measures. The proposed standard also provides the basis to evaluate new propulsion technologies (hybrid vehicles, fuel cell vehicles, etc.) in a technologically neutral manner.

Based on testing carried out by the SAE Light Vehicle Exterior Sound Level Committee, the proposed ISO 362:200X does achieve its objective of providing an improved estimate of vehicle noise in urban operations. The SAE Light Vehicle Exterior Sound Level Committee will continue to participate in the final definition of ISO 362:200X and will consider this standard, once it is adopted as an ISO International Standard, for revision to SAE J1470:1998.

The proposed ISO 362:200X is applicable and is expected to be used in national and international regulatory requirements for vehicle exterior noise.

Acknowledgments

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October 2006 Update

Subsequent to publication of the original SAE paper on which this article is based, the ISO 362 procedure was submitted for ballot at the ISO Draft International Standard (DIS) level. ISO 362-1 has been approved as an International Standard. The Economic Commission for Europe (ECE) and the European Union (EU) have included ISO 362-1 as part of the exterior vehicle noise regulations for new type approvals beginning in July 2007.

References

1. SAE Surface Vehicle Standard J1470, "Measurement of Noise Emitted by Accelerating Highway Vehicles."
2. UN ECE TRANS/WP.29/GRB/2002/4/Rev.2 The document may be found at: www.unece.org/trans/doc/2004/wp29grb/TRANS-WP29-GRB-infgrp07-02e.pdf.

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