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800277

A Comparison of Two Stationary Measurement Procedures for Truck Exterior Sound Levels

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ABSTRACT

SAE RP J1096 and CSA Standard Z107.22 are compared in terms of their performance as predictors of pass-by sound levels measured in accordance with SAE RP J366b. The comparison is based on the results of tests on 60 diesel trucks covering a range of ages, sound levels and configurations. The CSA procedure is found to be at least as good a predictor of pass-by sound levels as RP J1096 and can be used on smaller and noisier sites. The results of some exploratory measurements of the effects of wind and temperature gradients on the repeatability of the two procedures are also presented and discussed.

MEASUREMENT PROCEDURES that are intended to form the technical basis of vehicle exterior sound level regulations must satisfy a number of criteria that tend to conflict with each other. An efficient regulation requires, inter alia, that what is measured be highly correlated with the noise impact of the vehicle on the community. A regulation that is enforceable requires a highly repeatable measurement and a regulation that is actually to be enforced must necessary be based on a simple measurement procedure. This last requirement is particularly important for regulation of the sound levels of vehicles in service.

SAE Recommended Practice J366b must be rated highly on such criteria as a basis for regulating the sound emission of a heavy duty truck at its point of manufacture. Its merits have been recognised both by the United States Environmental Protection Agency and by Transport Canada in adopting it in all essentials as the basis of their respective regulations for new vehicles. However, a drive-by procedure, such as J366b, that requires a clear site of some 7000m^2 with ambient sound levels of no more than about 70 dBA is simply impractical as a basis for effective regulation of the sound emissions from heavy trucks in service.

At a slight cost in realism, the use of a test in which the vehicle remains stationary, such as SAE J1096, provides a useful simplification. However, a relatively quiet and rather extensive measurement site is still required by this procedure. Moreover, its use of a microphone located at 1.2m above the ground raises doubts about the repeatability of results on different sites, as noted by Piercy and Embleton (1)* among others. These considerations led to the development of Canadian Standards Association (CSA) Standard Z107.22, "Procedure for measurement of the maximum exterior sound level of stationary trucks with governed diesel engines". This procedure is notable for its use of a microphone located at 7.5m from the truck centreline and 80mm above the ground.

Although the federal government in Canada has no jurisdiction over the motor vehicle once it has entered service, it is nonetheless interested in having the effectiveness of its standards for the new vehicle maintained by appropriate provincial

*Numbers in parentheses designate references listed at the end of the paper.

SAE/SP-80/456/$02.50

and municipal regulations. The Province of Ontario having indicated its intention to cite the new standard in its Model Municipal Noise Control By-Law (2), Transport Canada initiated the study described in the present paper. The primary purposes of the study were to evaluate the repeatability of measurements made using the new standard and to provide information on which a choice of maximum permitted sound level could be made for regulatory use of the CSA standard.

DESIGN OF THE STUDY

The basic approach selected was to compare the performance of CSA Z107.22 with that of SAE J1096 as a predictor of the sound levels measured according to SAE J366b. SAE J1096 was chosen as a standard of comparison since it was an existing alternative to the new standard and known to produce results in good agreement with SAE J366b. In addition, an exploratory study of the relative sensitivity of the two stationary measurement procedures to wind and temperature gradients was undertaken since it appeared possible that sound levels measured at 80mm above the ground might be significantly affected by refraction effects.

EQUIPMENT, PROCEDURES AND RESULTS

VEHICLES - A sample of 60 diesel-engined trucks was selected to cover the widest possible ranges of age, manufacture, size, configuration and state of maintenance. The oldest truck in the sample was built in 1958 while the newest was built in 1978 and still in chassis-cab form. The quietest truck recorded only 79.3 dBA while the noisiest produced 95.7 dBA in the measurements to SAE J366b. A sub-sample of 5 trucks was selected for the exploratory study of propagation effects to include various engine, exhaust and body configurations. Table A1 of the appendix to this paper contains a summary description of each of the vehicles.

MEASUREMENTS AND INSTRUMENTATION - All measurements were carried out on an extensive paved site at the intersection of two runways of a disused airfield. The surface was flat, level and relatively free of discontinuities, except for the joints between pavement slabs.

In all test procedures, simultaneous sound level readings were obtained from four sound level meters, two on each side of the truck. GenRad 1982 Precision Sound Level Meters equipped with 1/2 inch (13mm) random incidence microphones, digital read out to 0.1 dB and maximum hold circuits were used. The AC output from the sound level meters was recorded on a Bruel & Kjaer Model 7003 tape recorder to permit subsequent analysis and verification of the data. Each measurement was repeated a minimum of three times, even though the requirements of the relevant measurement procedure might have been met by the first two or three runs.

To compare the effects of wind and temperature gradients on the repeatability of the two stationary measurement procedures, the sub-sample of 5 trucks was tested on two separate occasions characterised by differing temperature profiles near the ground. It was hoped to find one occasion on which a strong negative lapse rate obtained and a second on which a temperature inversion existed. In fact the latter condition was not found during the period available for experimentation. The two temperature conditions therefore both correspond with negative lapse rates, one rather stronger than the other, as exemplified by Figure 2. The temperature profiles were measured by traversing a Wallac

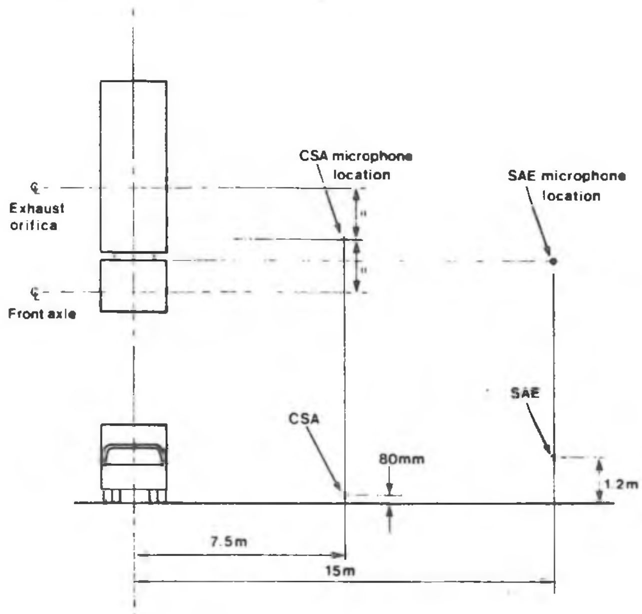

Fig. 1 - Microphone locations in SAE J1096 and CSA Z107.22

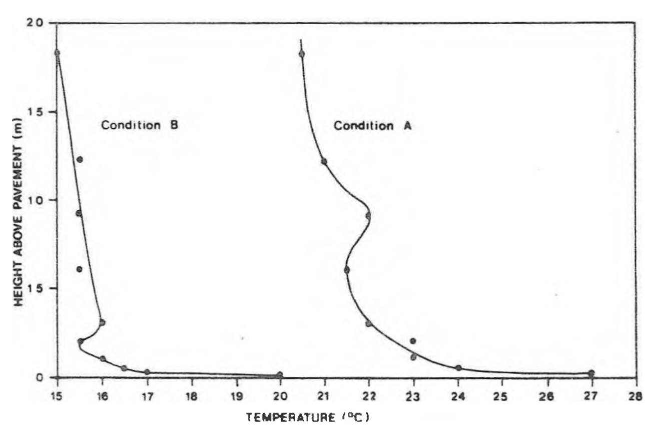

Fig. 2 - Typical tempera_ure profiles (Truck #27)

GGA 23S thermoanemometer over a range of some 1.8m above the pavement, at intervals during the sound level measurements. Under both temperature conditions, the 5 trucks were oriented with their longitudinal centrelines perpendicular to the wind direction. Measurements were made first with one side exposed to the wind and then with the other, to provide four combinations of temperature profile and wind direction. The wind speed was approximately 4.5m/s at 1.2m above the pavement for both temperature profiles.

EXPERIMENTAL RESULTS - The results of the measurements made in accordance with SAE J366b, SAE J1096 and CSA Z107.22 on the sample of 60 trucks are summarised in Table A2. The averaging procedures specified in each of the respective procedures was applied to the basic sound level observations to arrive at the tabulated values. Thirty of the trucks were equipped with engine brakes so maximum sound levels observed during the deceleration phase of the SAE J366b procedure with engine brake engaged are shown separately for such vehicles.

Tables A3 and A4 contain, respectively, the results of measurements made according to SAE J1096 and CSA Z107.22 under 4 conditions of wind and temperature gradient. In these tables, the figures shown represent the average of the highest pair of readings that were within 1 dB of each other for a given side of the truck, temperature profile and wind direction. The highest pair within 1 dB was selected from all four nominally similar observations for the given location and conditions to provide a uniform basis for comparing the results from the two procedures.

ANALYSIS OF RESULTS

DISTRIBUTIONS - The sound levels of the 60 trucks measured in accordance with each of the three procedures were plotted on normal probability scales to facilitate comparison of their distributions. Figure 3 shows the results for SAE J366b when maxima resulting from engine brake operation are excluded. The straight line in the figure corresponds with the mean and standard deviation of the sample. Figures 4 and 5 show the equivalent results for SAE J1096 and CSA Z107.22 respectively.

In all cases it can be seen that the central 90 per cent of the data are fairly well represented by the normal distribution. The highest and lowest sound levels tend to depart from the linear trend of most of the data however, particularly for the two stationary procedures. The difference in slope between the line shown and the trend of the points in the central region indicates the contributions of the outlying results at each end of the distribution to the sample variance. The distributions are evidently sufficiently similar that linear regression techniques are appropriate for analysis.

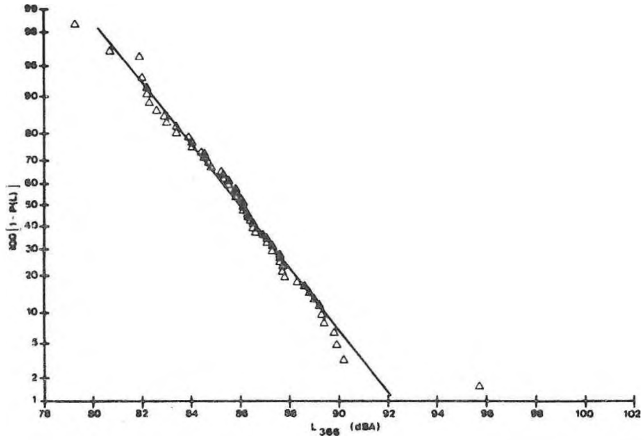

Fig. 3 - Cumulative distribution of results from SAE J366b, excluding engine brake maxima

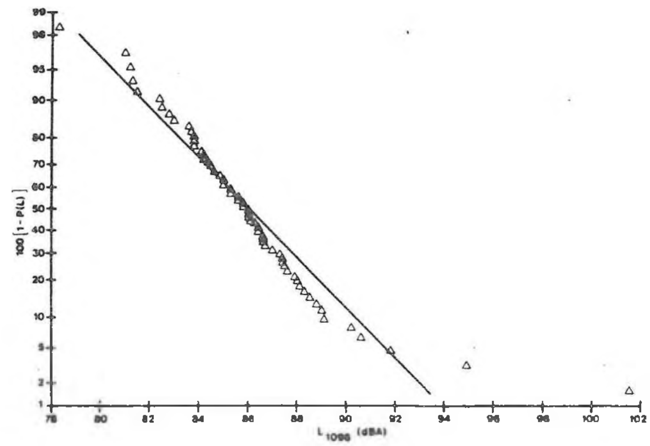

Fig. 4 - Cumulative distribution of results from SAE J1096

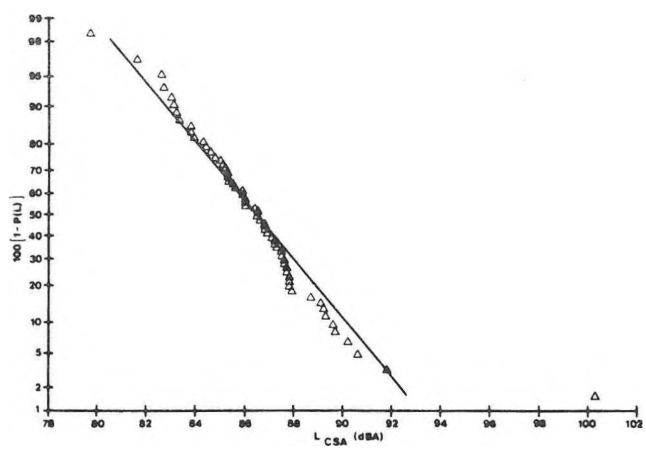

Fig. 5 - Cumulative distribution of results from CSA Z107.22

LINEAR REGRESSION ANALYSES - The sound levels of the 60 trucks measured in accordance with SAE J366b were then plotted against the levels measured in accordance either with SAE J1096 or with CSA Z107.22 and straight lines corresponding with the minimum mean square error in the SAE J366b levels were fitted. Figures 6 and 7 show the results of this procedure when maxima resulting from engine brake operation are excluded. Inclusion of maxima due to engine brake operation, which were produced by twelve of the thirty trucks so equipped, does not materially alter the correlation as can be seen from Table 1, in which the regression equations, standard errors and correlation coefficients are shown. Table 1 also includes such values for the regression of SAE J1096 sound levels on levels measured in accordance with CSA Z107.22.

It can be seen that the CSA procedure leads to standard errors that are slightly higher and correlation coefficients that are slightly lower than those resulting from the use of SAE J1096 as the predictor procedure for SAE J366b. The differences are not significant at the 95 per cent confidence level. The standard error and correlation coefficient for the regression of SAE J1096 on CSA Z107.22 are however significantly different from the corresponding values for the regressions of SAE J366b on CSA Z107.22.

DISTRIBUTIONS OF SOUND LEVEL DIFFERENCES - A slightly different method of comparing the predictive performance of the two stationary measurement procedures is to look at the variance of the difference between the sound level measured using J366b and that measured using each of the other two

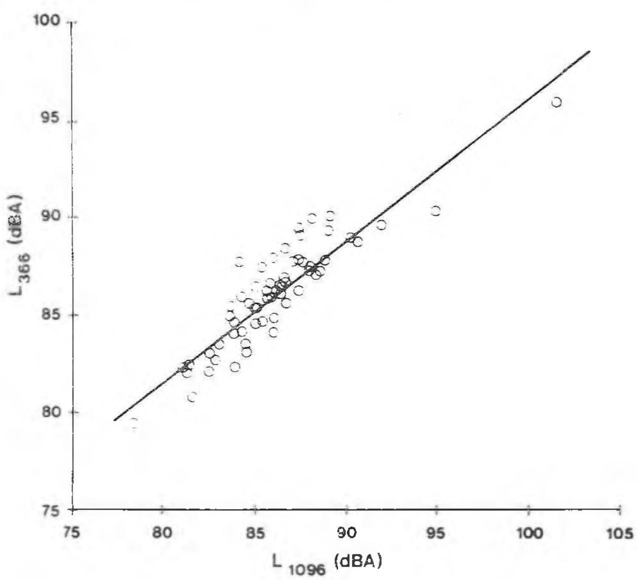

Fig. 6 - Linear regression of results from SAE J366b, excluding engine brake maxima, on results from SAE J1096

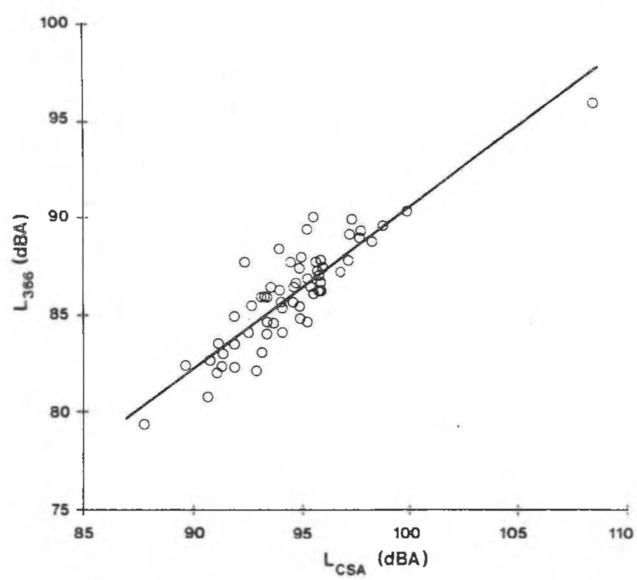

Fig. 7 - Linear regression of results from SAE J366b, excluding engine brake maxima, on results from CSA Z107.22

Table 1 - Comparison of Regression Equations (n=60)

Regression	Equation	Standard error, dBA	Correlation coefficient
J366b on J1096	$L_{366} = 24.0 + 0.721\ L_{1096}$	1.17	0.90
J366b on CSA	$L_{366} = 7.4 + 0.832\ L_{CSA}$	1.25	0.89
J366b* on J1096	$L_{366} = 15.1 + 0.827\ L_{1096}$	1.22	0.92
J366b* on CSA	$L_{366} = -4.3 + 0.959\ L_{CSA}$	1.29	0.91
J1096 on CSA	$L_{1096} = -20.1 + 1.12\ L_{CSA}$	0.97	0.96

*including maxima due to engine brake operation procedures. Table 2 shows the means and standard deviations of the difference distributions.

Table 2 - Distributions of Sound Level Differences (n=60)

Variate	Mean, dBA	Standard deviation, dBA
$L_{1096} - L_{366}$	0.08	1.51
$L_{CSA} - L_{366}$	8.51	1.34
$L_{1096} - L_{366}$*	-0.22	1.36
$L_{CSA} - L_{366}$*	8.21	1.30
$L_{CSA} - L_{1096}$	8.43	1.04

*including maxima due to engine brake operation

It is apparent that considering the difference distributions is equivalent to forcing a linear relation of unit slope between the two sound levels. Thus, for example, the second line of Table 2 is equivalent to:

$$L_{366} = -8.51 + L_{CSA} \pm 1.34 \text{ (dBA)}$$

Consideration of Table 2 shows that the difference distributions based on the CSA procedure have somewhat smaller standard deviations than those based on SAE J1096, although the differences are again not significant. The standard deviation of the differences in levels between J1096 and Z107.22 is however significantly smaller than that of the differences between J366b and Z107.22.

RUN-TO-RUN REPEATABILITY - To evaluate the run-to-run repeatability of each of the measurement procedures, the pooled variance of all observations for the noisier side of the vehicle was computed from the expression:

$$S^2 = \frac{\sum_{i=1}^{i=60} (m_i - 1) s_i^2}{\sum_{i=1}^{i=60} (m_i - 1)}$$

where m_i was the number of nominally identical runs (usually four) and s_i^2 the variance computed over those runs. Table 3 shows a comparison between the pooled standard deviations of the various measurement procedures. The differences between all pairs of standard deviations shown are significant at the 95 per cent confidence level, except for the two sets of data from J366b with and without engine brake maxima.

Table 3 - Pooled Standard Deviations of Observations

Measurement procedure	Pooled standard deviation, dBA
SAE J366b	0.67
SAE J366b*	0.74
SAE J1096	0.53
CSA Z107.22	0.46

*including maxima due to engine brake operation

EFFECTS OF WIND DIRECTION AND TEMPERATURE GRADIENT - Since the object of the exploratory study was to assess the magnitude of possible refraction effects on the sound levels measured in SAE J1096 and CSA Z107.22, analysis was directed to examining the largest differences in sound levels attributable to these environmental parameters.

For each of the two sides of the five trucks tested, the greatest differences in measured sound levels attributable to differences in wind direction and temperature profile were extracted by inspection of the results given in Tables A3 and A4. These greatest differences were then plotted as in Figures 8 and 9 and the mean values computed.

A comparison of these figures shows that the mean and variance of the results for the CSA procedure are somewhat greater than the equivalent figures for SAE J1096. In view of the small and arbitrary sample, the results were not further analysed in detail, except to note that the largest differences observed were not associated with any particular vehicle or configuration.

To obtain a general indication of the sensitivity of the results to refraction

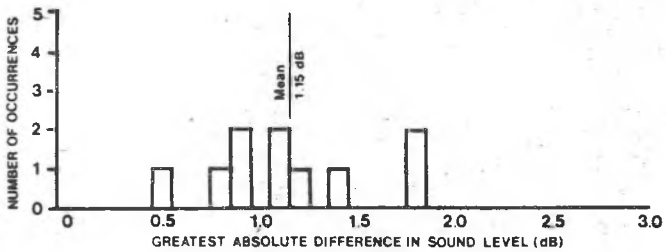

Fig. 8 - Histogram of greatest differences in results for SAE J1096 attributable to differences in wind direction and temperature profile

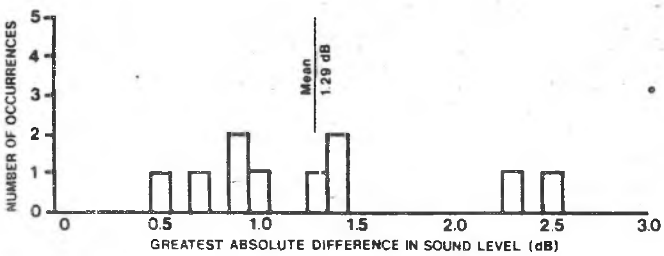

Fig. 9 - Histogram of greatest differences in results for CSA Z107.22 attributable to differences in wind direction and temperature profile

effects, specifically, the conditions were examined under which the greatest differences attributable to wind direction and temperature profile occurred. If refraction effects were predominantly responsible, then the greatest differences should have occurred most frequently when both wind direction and temperature profile differed, since the two influences would then have been additive. This analysis is presented in Table 4, where it can be seen that the greatest differences are distributed quite randomly among the three possible sets of conditions. Within the limited range of the present results, Table 4 thus implies that the repeatability of neither procedure is particularly affected by refraction effects.

Table 4 - Wind and Temperature Conditions associated with Greatest Differences in Sound Level for One Side of Truck

Measurement procedure	Temp. profile different	Wind dir. different	Both different	Total
SAE J1096	4	5	3	12*
CSA Z107.22	4	4	3	11*

*greatest difference replicated for Truck #57
**greatest difference duplicated for Truck #50

DISCUSSION OF RESULTS

CORRELATIONS BETWEEN PROCEDURES - The linear regression analyses and the comparisons of the difference distributions show in general that SAE J1096 and CSA Z107.22 are equally good predictors of the maximum exterior sound level measured by SAE J366b. On neither basis are statistically significant differences in the predictive performance of the two stationary procedures detectable.

CSA Z107.22 is however a somewhat better predictor of SAE J1096 results than it is of SAE J366b. This is consistent with the fact that the levels in the stationary tests are determined essentially by engine and exhaust, while during a pass-by, additional sources such as tires and transmission may contribute. That the observations in the stationary test were made simultaneously also enhances their correlation.

The mean differences among the sound levels measured in accordance with the three procedures for a given truck agree well with expectations. When maxima due to engine brake operation are excluded, the mean difference between SAE J1096 and SAE J366b is less than 0.1 dB. Under a similar exclusion, the mean difference between CSA Z107.22 and SAE J366b is some 8.5 dB. This may be compared with the increment of 9 dB that would be expected to result from the difference in microphone positions, if the truck were simply a point source of broadband noise.

RUN-TO-RUN REPEATABILITY - The significant differences in the run-to-run repeatability of the three measurement procedures are also broadly consistent with expectations based on a number of published studies. The higher repeatability of CSA Z107.22 in comparison with SAE J1096 is attributable principally to the shorter measurement distance and the consequently smaller effect of atmospheric turbulence on the properties of the transmission path (3, 4). That SAE J1096 is more repeatable than SAE J366b may be due to a number of factors. It is evidently more difficult to repeat the more complex pass-by procedure exactly, while the additional turbulence induced by motion of the vehicle tends to increase the variability in the properties of the transmission path between vehicle and microphone (4). In the present study, two runs for SAE J366b were made in each direction with respect to the site whereas all stationary measurements were carried out with the same vehicle orientation. Moreover the time to obtain four sets of measurements with the vehicle stationary was appreciably less than with the vehicle in motion. Relatively slow fluctuations in local environmental conditions may therefore have contributed more to the variability of the pass-by measurements than to the stationary measurements.

EFFECTS OF WIND AND TEMPERATURE GRADIENT - The very limited range of results obtained from the exploratory study does not justify conclusions of great generality. For example, if measurements had been made at higher wind speeds and during a temperature inversion, a systematic effect of wind direction and temperature profile might have been observed. The results obtained do however suggest that, within a typical range of test conditions, neither stationary measurement procedure is noticeably affected by refraction effects.

FURTHER WORK

The study described in the present paper has addressed only the correlations among, and repeatability of, three measurement procedures for a sample of vehicles tested at one site. A question of at least equal importance for regulatory purposes is the repeatability of measurements made on a given vehicle at several sites. Further work is therefore planned to compare the site-to-site repeatability of SAE J1096 and CSA Z107.22. In particular, it will be aimed at determining whether the theoretical advantage of CSA Z107.22, in using a microphone at ground level, is realised in practice.

CONCLUSIONS

The performance of SAE RP J1096 and CSA Standard Z107.22 as predictors of the maximum exterior sound level measured in accordance with SAE RP J366b has been compared for a sample of 60 diesel trucks. It is concluded that the CSA Standard is as good a predictor of the sound level during the pass-by test as is SAE J1096.

The run-to-run repeatability of the two stationary measurement procedures has also been compared and a small but statistically significant advantage to the CSA Standard has been demonstrated.

An exploratory study of the sensitivity of both SAE J1096 and CSA Z107.22 to refraction effects induced by wind and temperature profiles suggests that neither procedure is particularly affected.

ACKNOWLEDGMENTS

The study presented in this paper is based primarily on work performed under contract by Harford, Kennedy, Wakefield Ltd for Transport Canada. The authors are grateful for the assistance provided by Dr. J.E. Piercy of the National Research Council of Canada in analysing and interpreting the results of the measurements made under several combinations of wind direction and temperature profile. The value of discussions with members of the CSA Sub-committee on Noise from Transport Vehicles is also acknowledged by the second author. This paper appears with the permission of Dr. G.D. Campbell, Director, Road and Motor Vehicle Traffic Safety, Transport Canada. The conclusions reached and opinions expressed are however entirely those of the authors.

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APPENDIX

Table A1 - Description of Sample Vehicles

Truck No.	Year of Manufacture	Manufacturer and Model	Description	Engine
1	76	Mack RS600L	10 yd. Cement Mixer	Mack ENDT 676
2	78	Kenworth W924	Cab and Chassis	Cummins NTC 400
3	78	International S2500	Cab and Chassis	Cummins NTC 350
4	69	Kenworth W923	Tractor/Trailer	Cummins NHC 250
5	74	White Freight-liner WFT-6364	Flat Deck & Pup	Cummins NTC 350
6	78	White Western Star 4864-2	Tractor	Cummins NTC 350
7	78	Kenworth W924	Tractor	GM 8V 92TA
8	69	International 559444	Tractor/Trailer	Cummins NHC 250
9	71	GMC Astro 95	Tractor	GMC DH 9782
10	78	White Western Star	Tractor	GM 8V 92T
11	78	International Transtar 4300	Tractor	GM 8V 92T
12	74	International Fleetstar 2050	Dump Truck	GM 6V 53
13	70	Ford 8000	Dump Truck	GM 6V 53
14	78	Ford 9000 Custom	Dump Truck	Cummins NTC 350
15	69	Kenworth W925	Tractor/Trailer	Cummins NHC 250
16	78	Ford 9000	Tractor	GM 8V 92N
17	70	White Freight-liner WFT-8664T	Tractor/Trailer	GM 8V 71N
18	70	White Freight-liner WFT-8664T	Tractor/Trailer	GM 8V 71N

Table A1 - Description of Sample Vehicles (Continued)

Truck No.	Year of Manufacture	Manufacturer and Model	Description	Engine
19	76	White Freight-liner WFT-5164T	Tractor/Trailer	GM 8V 71N
20	69	Kenworth W923	Tractor/Trailer	Cummins NHC 250
21	76	White Freight-liner WFT-5164T	Tractor/Trailer	GM 8V 71N
22	76	White Freight-liner WFT-5164T	Tractor/Trailer	GM 8V 71N
23	76	International Transtar II COF 4070 B	Tractor/Trailer	GM 8V 71N
24	75	Kenworth Hustler	Commercial Refuse Packer	Cummins 555
25	75	International Cargostar 1950-13	Commercial Refuse Packer	GM 6V 53
26	76	International	Tractor	GM 671N
27	78	GMC MK 9782	Tractor	GM 8V 92TT
28	78	White Freight-liner WFC-12064T	Tractor/Trailer	Cummins NTC 400
29	76	Mack Cruiseliner	Tractor/Trailer	Mack 866
30	76	International Fleetstar 2070A	Tractor/Trailer	GM 6V 71
31	76	White Freight-liner WFT-6364T	Tractor/Trailer and Pup	GM 8V 92N
32	76	International Transtar II	Tractor/Trailer	GM 8V 92
33	76	International Fleetstar 2070A	Tractor/Trailer	GM 6V 71
34	76	White Freight-liner WFT-7564T	Tractor/Trailer	GM 8V 92N
35	58	Kenworth W923	Tractor/Trailer	Cummins NTC 350
36	76	International Cargostar 1950B	Domestic Refuse Packer	GM 6V 53
37	75	Kenworth Hustler H-2	Domestic Refuse Packer	GM 6172
38	75	Kenworth	Domestic Refuse Packer	GM 6V 53
39	77	White Freight-liner WFT-8664T	Tractor/Trailer	Cummins NTC 350
40	78	Hino LA 660	Cab and Chassis	Hino EH 100
41	77	GMC MK 9672	Tractor	GM 8V 92T
42	75	White Western Star	Tractor/Trailer	Cummins KT 450
43	76	White Freight-liner WFT-7564T	Tractor/Trailer and Pup	GM 8V 92N
44	75	White Freight-liner WFT 63644	Domestic Refuse Packer	GM 6171N
45	73	International Cargostar 1950A	Domestic Refuse Packer	GM 6V 53
46	74	Hayes	Flatdeck	GM 671N
47	76	Mack RS600L	10 yd. Cement Mixer	Mack ENDT 675
48	76	Mack RS600L	Cab and Chassis	Mack ENDTB 676
49	65	GMC DFWI-701	Tractor	GM 671
50	73	International Transtar 4300	Tractor	Cummins NT 230
51	71	International M623-50	10 yd. Cement Mixer	Caterpillar 3208
52	72	White Freight-liner	Tractor/Trailer	Cummins NTC 350
53	73	Ford 9000	Tractor	GM 671
54	78	Mack Cruiseliner	Tractor	GM 8V 92T

Table A1 - Description of Sample Vehicles (Continued)

Truck No.	Year of Manufacture	Manufacturer and Model	Description	Engine
55	73	International Transtar COF 4070A	Tractor	Cummins NTC 350
56	71	International M623-50	10 yd. Cement Mixer	GM 6V 53
57	74	Hayes	Tractor	GM 671N
58	77	Scot A2HD	Dump Truck	GM 6V 53
59	69	Kenworth W923	Tractor	Cummins NH 250
60	77	Hino LB 660D	Van	Hino EH 300

Table A2 - Measured Sound Levels in dBA

Truck No.	SAE J366b Accel'n	SAE J366b Decel'n	SAE J366b Engine Braking	SAE J1096	CSA Z107.22
1	83.8	84.8	-	83.7	91.9
2	85.5	84.0	84.0	86.7	94.0
3	79.3	77.2	-	78.3	87.7
4	87.7	85.2	87.1	87.4	95.8
5	89.8	87.4	88.2	88.1	97.3
6	85.8	83.4	86.2	85.8	93.0
7	84.0	82.5	82.4	84.2	92.4
8	89.3	87.8	87.8	87.4	95.2
9	87.3	86.9	87.1	88.0	95.9
10	82.2	80.3	82.4	83.8	91.8
11	86.1	85.0	-	86.1	93.9
12	89.2	84.4	-	39.0	97.7
13	88.8	83.6	-	90.2	97.6
14	87.1	84.9	-	87.9	95.6
15	86.5	83.8	88.6	86.6	95.8
16	84.5	80.9	-	85.3	95.1
17	95.7	88.2	99.0	101.5	108.3
18	89.4	84.7	94.2	91.8	98.6
19	85.8	83.5	86.3	84.2	93.3
20	86.5	85.2	86.9	85.8	94.6
21	86.3	85.2	86.1	86.4	94.5
22	87.3	83.5	86.6	85.3	94.8
23	85.2	82.0	82.7	85.0	94.0
24	86.9	83.8	-	88.3	95.7
25	84.4	83.4	-	85.0	93.6
26	87.8	82.1	-	86.0	94.9
27	82.3	80.8	-	81.3	89.6
28	83.0	81.4	84.2	84.5	93.1
29	81.0	81.9	82.2	81.2	91.0
30	87.7	83.1	-	88.8	97.1
31	84.0	82.3	85.1	86.0	94.0
32	83.9	80.7	84.1	83.8	93.3
33	85.8	82.6	-	85.6	93.2
34	84.5	81.7	-	83.8	93.3
35	84.7	82.8	87.9	86.0	94.8
36	85.3	84.4	-	84.9	94.8
37	86.8	86.3	-	86.6	95.2
38	87.2	87.6	-	87.6	95.6
39	88.3	86.5	87.6	86.6	93.9
40	87.6	86.1	-	87.0	94.4
41	83.4	80.6	82.6	84.4	91.1
42	89.9	89.4	89.6	89.1	95.5
43	86.1	82.6	85.7	87.3	95.8
44	86.3	83.4	-	85.0	93.5
45	82.6	80.8	-	82.8	90.7
46	88.6	86.0	-	90.6	98.2
47	84.2	85.3	-	83.6	92.6
48	80.7	79.0	80.2	81.5	90.6
49	86.1	82.2	-	85.6	95.7
50	83.4	79.8	-	83.0	91.8
51	82.9	82.1	-	82.5	91.3
52	86.0	83.9	83.9	86.4	95.5
53	86.4	83.5	-	86.3	95.3
54	82.2	79.8	81.9	81.0	91.2
55	89.0	86.1	86.2	87.5	97.2
56	85.3	85.5	-	84.6	94.5
57	87.1	82.4	-	88.5	96.7
58	90.2	86.9	-	94.9	99.8
59	87.6	83.9	86.7	84.1	92.3
60	82.0	81.7	-	82.4	92.8

Table A3 - Measured Sound Levels in dBA from SAE J1096 under Four Combinations of Wind and Temperature Profile

Truck #	Side of Truck	Temperature Condition A		Temperature Condition B	
		Upwind	Downwind	Upwind	Downwind
27	Left	84.3	84.2	84.8	85.0
	Right	84.3	84.5	83.6	84.1
40	Left	86.4	86.0	86.2	85.9
	Right	86.7	87.0	87.3	85.5
50	Left	83.8	83.7	83.5	84.4
	Right	84.8	83.7	84.0	84.0
57	Left	89.9	89.9	88.7	89.9
	Right	92.4	92.9	91.2	91.1
60	Left	82.9	82.2	81.8	82.1
	Right	82.3	82.3	83.1	81.7

Table A4 - Measured Sound Levels in dBA from CSA Z107.22 under Four Combinations of Wind and Temperature Profile

Truck #	Side of Truck	Temperature Condition A		Temperature Condition B	
		Upwind	Downwind	Upwind	Downwind
27	Left	91.6	92.6	92.2	91.8
	Right	91.3	91.7	91.6	91.8
40	Left	94.4	95.0	94.2	94.1
	Right	94.7	95.2	94.2	93.8
50	Left	91.3	92.7	91.4	93.8
	Right	92.1	92.1	93.0	93.5
57	Left	96.0	96.1	95.9	96.8
	Right	98.3	98.7	98.2	98.9
60	Left	89.9	92.2	90.4	91.4
	Right	90.9	91.8	90.6	90.5

Correction: 8 dB should be added to all sound levels in the abscissa of Figure 5.