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Investigative Study of the Italgrip System – Noise Analysis

FINAL REPORT



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16. Abstract The purpose of this study was to determine if Italgrip is a suitable technique to increase the safety and quality of Wisconsin roadways. The objective of this noise analysis is to identify and quantify any exterior noise impacts of the Italgrip anti-skid surface treatment on PCC pavements. Italgrip is a very thin surface treatment consisting of a two-part polymer resin placed on pavement and covered with re-worked steel slag. Although widely used in Italy, Italgrip has only been available in the United States since 1999. This study analyzes comparative data from three types of pavement surfaces: untreated transverse tined PCC pavement, pavement that was diamond ground to re-establish a smooth riding surface but not treated with Italgrip, and pavement that was diamond ground and treated with Italgrip. The effectiveness of Italgrip was tested using an exterior noise measurement procedure that has proven reliable in past Wisconsin Department of Transportation studies to evaluate different pavement structures.					
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for

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EXECUTIVE SUMMARY

The objectives of the Italgrip study are to determine if Italgrip is a suitable and cost-effective technique to enhance safety and drainage characteristics of Wisconsin roadways. The objective of this noise analysis is to identify and quantify any exterior noise impacts of the Italgrip anti-skid surface treatment on PCC pavements. Italgrip is a very thin surface treatment consisting of a two-part polymer resin placed on the pavement surface and covered with a man-made aggregate of re-worked steel slag 3 mm to 4 mm in size. The Italgrip System, in use in Italy for the last ten years, has never been used in the United States prior to 1999, but it is currently being evaluated by the ASCE/CERF – Highway Innovative Technology Evaluation Center (HITEC). In a cooperative effort with HITEC, several states with different climatic conditions will test and evaluate the Italgrip System.

The Italgrip surface treatment was installed on a section of STH 16, approximately 1.5 miles (2.5 km) north of I-94, between the on and off ramps to CTH “JJ” in Waukesha County. A 3 mm Italgrip aggregate was applied to both eastbound lanes, while a 4 mm aggregate was applied to the westbound lanes.

STH 16 was diamond ground to reestablish a smooth riding surface. Following the grinding a two-part polymer adhesive was carefully applied to the pavement surface. The Italgrip aggregate was then back-spread over the polymer. After setting a few hours, the surface was vacuum swept and re-opened to traffic. The exterior noise measurement procedure was based on the French-German controlled passby method used in previous Wisconsin Department of Transportation studies to evaluate different pavement textures.

The grinding of the PCC pavement and application of the Italgrip on STH 16 resulted in:

- No major shift in frequency spectrum when comparing the tined PCC pavement, ground PCC pavement and ground PCC pavement with Italgrip.
- A 3-decibel decrease in the noise level due to diamond grinding.
- An additional one-decibel reduction in noise level when the Italgrip is compared to the ground PCC pavement at 60 mph and 65 mph (96 km/h and 104 km/h).
- A two (2) to three (3) decibel decrease in noise level when the Italgrip is compared to the ground pavement between 1,550 and 2,000 Hz, a noticeable change in sound to the ear.
- No significant change in noise level at 70 mph (112 km/h) between Italgrip and the ground pavement.
- No significant noise level difference between the 3 mm and 4 mm aggregate.

INTRODUCTION

In the early 1990's, the impact of pavement noise in urban areas gained both state and national attention. The Wisconsin Department of Transportation took a pro-active approach to investigate both asphaltic concrete (AC) and Portland cement concrete (PCC) pavement textures and their impacts on exterior noise levels. A relationship between pavement textures and their tire/pavement noise characteristics were observed. The objective of this study is to evaluate the Italgrip system. The objective of the noise analysis is to identify and quantify any exterior noise impacts of the Italgrip anti-skid surface treatment on PCC pavements.

Italgrip is a very thin surface treatment consisting of a two-part polymer resin placed on either an AC or PCC pavement surface and covered with a man-made aggregate of re-worked steel slag, 3 mm to 4 mm in size. The Italgrip system is designed to improve the frictional characteristics of a pavement surface and is primarily intended for application in heavily trafficked areas experiencing friction problems or high accident rates over short sections of roadway.

Although the Italgrip System has never been used in the United States prior to 1999, it is currently being evaluated by the ASCE/CERF – Highway Innovative Technology Evaluation Center (HITEC). In a cooperative effort with HITEC, several states with different climatic conditions will test and evaluate the Italgrip System.

METHODOLOGY

Construction

The Italgrip surface treatment was installed on a section of STH 16, approximately 1.5 miles (2.4 km) north of I-94, between the on and off ramps to CTH “JJ” in Waukesha County. The original pavement consisted of a nine-inch (225 mm) thick, jointed, undoweled, transversely tined PCC pavement. Two different aggregate sizes were used. A 3 mm Italgrip aggregate was applied to both eastbound lanes of a 2032 foot (619 m) segment of STH 16. Similarly, a 3000 foot (915 m) segment of the westbound lanes had a 4 mm Italgrip aggregate applied to both lanes.

The first step on STH 16 was to diamond grind the pavement to eliminate surface irregularities (primarily heavy faulting). Following the grinding, the surface was cleaned with a vacuum sweeper and a two-part polymer adhesive was carefully applied to the pavement surface. The Italgrip aggregate was then back-spread over the polymer. After setting a few hours, the surface was vacuum swept to pick up the excess aggregate and re-opened to traffic. The pavement textures, transversely tined westbound inside lane and ground outside lane are shown in Figure 1a. The appearance of the pavement following application of the Italgrip 4 mm aggregate is shown in Figure 1b.



Figure 1a – Inside lane transversely tined.
Outside lane diamond ground.



Figure 1b – 4 mm Italgrip

Exterior Noise Measurements

The noise measurement procedure was based on the French-German procedure using the controlled passby method (1) where the noise from a single car is measured with the engine running. Such measurements are performed with a test vehicle under real traffic conditions. The procedure is used in Europe for classification of different road surfaces. This method is independent of the type of vehicles or tires used (provided they are selected in a suitable range). The acoustical results are only dependent on the road surface. The influence of all other vehicle noise sources is not a significant factor when all vehicle operating characteristics are kept constant for all the pavements.

Exterior noise levels were recorded with two microphones mounted 5 feet (1.5 m) above the pavement and positioned 25 feet (7.6 m) from the centerline of the nearest traffic lane, 200 feet (61 m) apart from each other. A two-microphone setup was utilized to monitor potentially significant differences between the microphones due to possible changes in vehicle speed and/or driving behavior, road and terrain conditions, uncontrolled measurement errors, etc. Selection of measurement sites was based on the FHWA's procedures for measuring highway noise, except for the measurement distance of 25 feet (7.6 m). This distance was selected to significantly reduce site variability due to ground cover sound absorption and wind effect reportedly associated with the longer, 50 foot (15.2 m) distances that are standard. The shorter distance would also require much less minimal separation distance between the test car and preceding or following car to insure the quality of the noise event data collected. In addition, the 25 foot (7.6 m) measurements versus 50 foot (15.2 m) measurements would improve signal to noise ratio by 5 dBA, reducing the interference caused when a car traveling in the opposite direction coincides with the test car passby.

The noise characteristics of the existing, transversely tined pavement, ground pavement, and the 4 mm Italgrip aggregate surface were measured adjacent to the westbound lanes of STH 16. The first microphone was located approximately 130 feet (40 m) north of the CTH JJ bridge structure over STH 16 with the second microphone located 330 feet (100 m) to the north. The noise characteristics of the 3 mm Italgrip aggregate surface were measured adjacent to the eastbound lanes of STH 16. The first microphone was located approximately 490 feet (150 m) north of the bridge with the second microphone located 290 feet (88 m) north of the bridge.

A Type 2900 Larson-Davis two-channel real-time acoustical analyzer was used for the noise measurements. To achieve a higher frequency resolution, the analyzer's Fast Fourier Transform (FFT) analysis option was used to better examine the frequency spectra associated with the pavements.

The analyzer was set to analyze noise spectra from 0 Hz to 10 kHz, providing a maximum frequency resolution of 25 Hz for the two-channel configuration. Such analyses were carried out for all the pavements to determine if any particular pavement would exhibit a prominent discrete tone. Thus, 400-line FFT sound pressure levels were recorded for each vehicle passby for 10 seconds in 0.1-second intervals. This duration was based on the time necessary for the vehicle to pass both microphones.

All noise measurements were performed with a 1996 Ford Taurus, Figure 2, operating at speeds of 60, 65 and 70 mph (96, 104, and 112 km/h). A minimum of three valid runs was needed to collect enough data for each speed. To prevent contamination of data, only runs with no or insignificant opposite traffic were considered valid for car passbys. All measurements were performed on dry pavements, with wind velocity less than 15 mph (24 km/h).

Field measurement quality control practices consisted of:

- the visual observation of surrounding traffic during passbys to ensure a necessary separation between the same class of vehicles (e.g. 45.8 m or 150 ft for cars),
- driver's observations of their actual speed achieved and maintained,
- direct comparisons between noise data from similar tests performed, and
- elimination of events recorded with significant noise interference (airplanes, etc.).

Quality control of the measured data included review of the field notes and validation that the "passby peaks" exceeded the background noise levels by at least 10 dBA.



**Ford Taurus Test Vehicle with Tire Close-up
FIGURE 2**

Data Summary and Processing

The noise field data were transformed into a spreadsheet format for each of the test runs to identify the noise spectrum associated with the maximum noise levels, L_{max} , during vehicle passbys. This procedure, performed separately for each analyzer's channel, consisted of identifying the maximum overall sound pressure level (A-weighted), and the values immediately preceding and following the maximum. These three values along with associated (three) sets of 400-line FFT frequency spectra were logarithmically averaged to obtain a representative passby spectrum for each channel. Finally, all of the test runs' data, both the A-weighted and frequency spectrum values were averaged. The resulting data sets were considered representative of the particular pavement, at a certain vehicle speed. Individual noise levels for each vehicle speed and test section were graphed to allow comparisons.

ANALYSIS

Exterior Noise

The analysis is presented graphically in Figures 3 through 8. The first three Figures, 3 through 5, present the noise spectrum of the westbound lanes for the three different pavement conditions, transversely tined, ground and with Italgrip at three different speeds, 60, 65, and 70 mph (96, 104, and 112 km/h). Figures 6 through 8 present a comparison of the 3 mm and 4 mm Italgrip aggregate at all three speeds.

Trends observed in previous studies for the Wisconsin Department of Transportation and the Minnesota Department of Transportation are apparent in the analysis (2, 3, 4). Examination of Figures 3 through 5 indicates that the relative changes across all spectrums are minor with little change in spectrum shape. The noise level increased with speed for all pavement conditions. The transversely tined pavement resulted in a noise spectrum similar in shape to that of a random tined pavement in previous studies. Examination of Figure 1a indicates that the tining was definitely more random than uniform. Therefore, no discrete tones were audible or apparent in the noise spectrums shown on Figures 3 through 5. The noise spectrum of the transversely tined pavement at 60 mph (96 km/h) did exhibit a tone at 550 Hz whose second harmonic appeared at 1,100 Hz. Although these individual tones appeared at both 65 and 70 mph (104 and 112 km/h), the harmonics did not appear.

Grinding the pavement resulted in a 3-decibel decrease in the noise level. This decrease was almost uniform across all frequencies above 1,200 Hz at all speeds. These results are similar to other noise level measurements of diamond ground PCC pavement (3).

The Italgrip reduced the noise level an additional one-decibel at 60 mph (96 km/h) from 79.8 dBA with the ground PCC pavement to 79.0 dBA, Figure 3. The 65 mph (104 km/h) measurements indicated the noise level decreased from 80.5 dBA to 79.8 dBA, Figure 4. Examination of Figures 3 and 4 also indicate a two (2) to three (3) decibel decrease in the frequency spectrum from 1,550 to 2,000 Hz. This decrease would be audible to the human ear and is more significant than the dBA reduction would indicate. At 70 mph (112 km/h), the change in noise level from 81.2 dBA for the ground pavement to 80.8 dBA for the Italgrip

pavement is acoustically insignificant, Figure 5. Further examination of Figure 5 indicates that the noise level reduction that was observed in the 1550 to 2000 Hz range at both 60 mph and 65 mph (96 km/h and 104 km/h) is not apparent at 70 mph (112 km/h). Therefore, the ground pavement and the Italgrip pavement would sound very similar to the adjacent public or driver at this speed.

Figures 6 through 8 present a comparison of 3 mm versus 4 mm Italgrip at all three test speeds. The shapes of the noise spectrum and the noise levels at each speed are basically identical for both aggregate diameters, and no major shift in frequency occurred. The noise spectrum at 70 mph (112 km/h) shows a two (2) to three (3) decibel greater decrease with the 4 mm aggregate than the 3 mm aggregate between 1,550 and 1,825 Hz. However, this change does not occur over enough of the spectrum for it to be audible to the public.

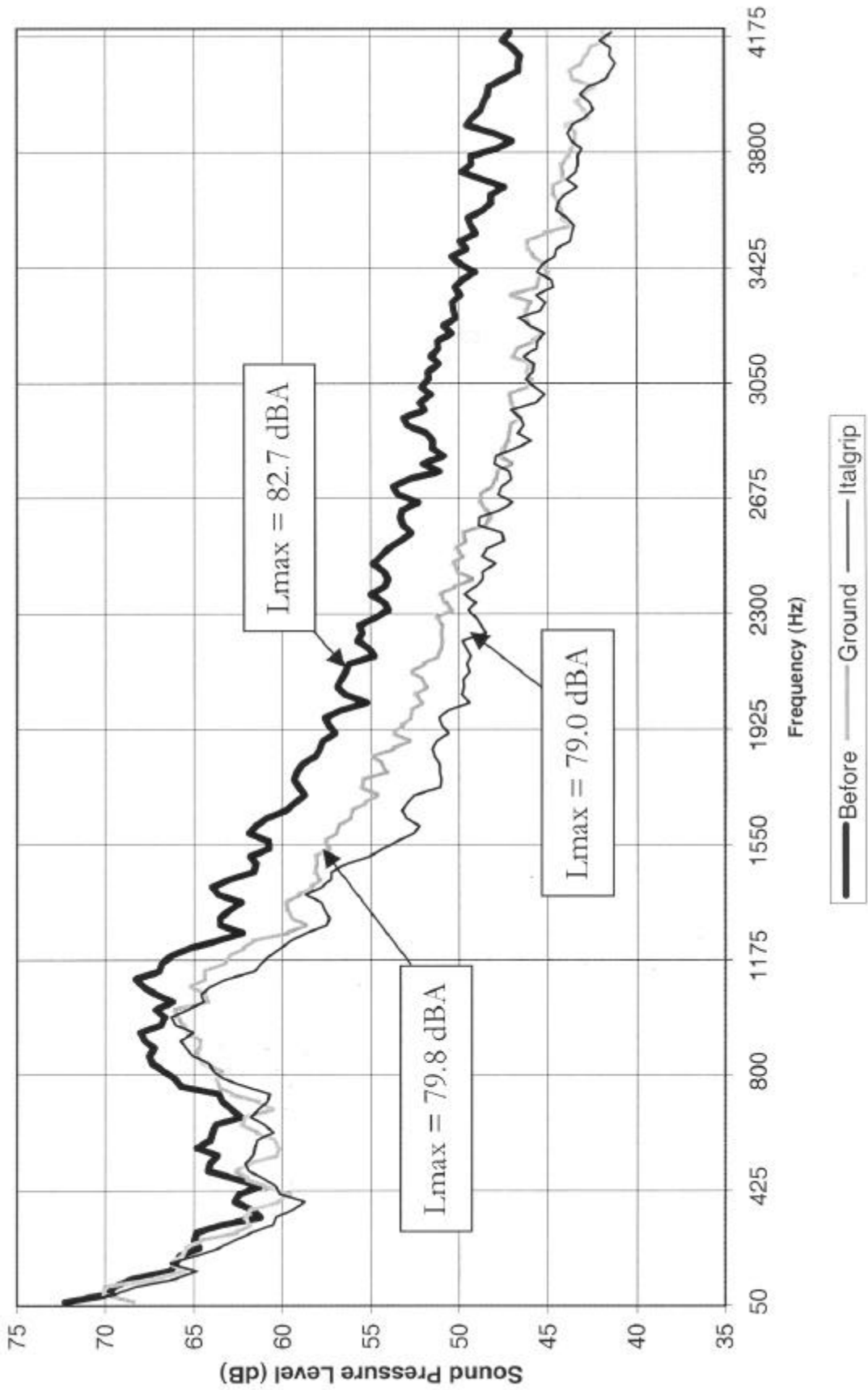


Figure 3 - Noise Level Comparison – Westbound STH 16, 60 mph (96 km/h)

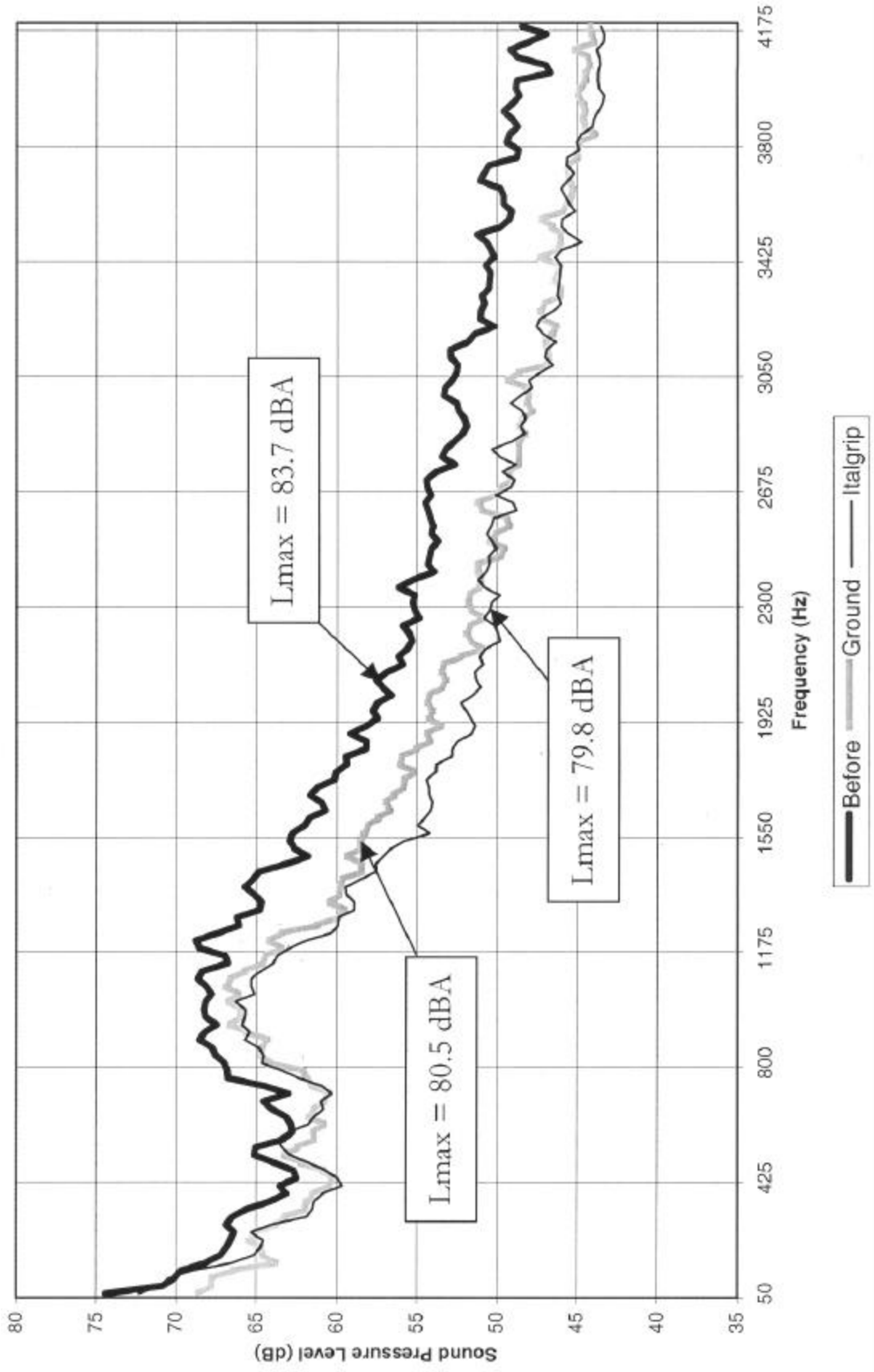


Figure 4 -Noise Level Comparison – Westbound STH 16, 65 mph (104 km/h)

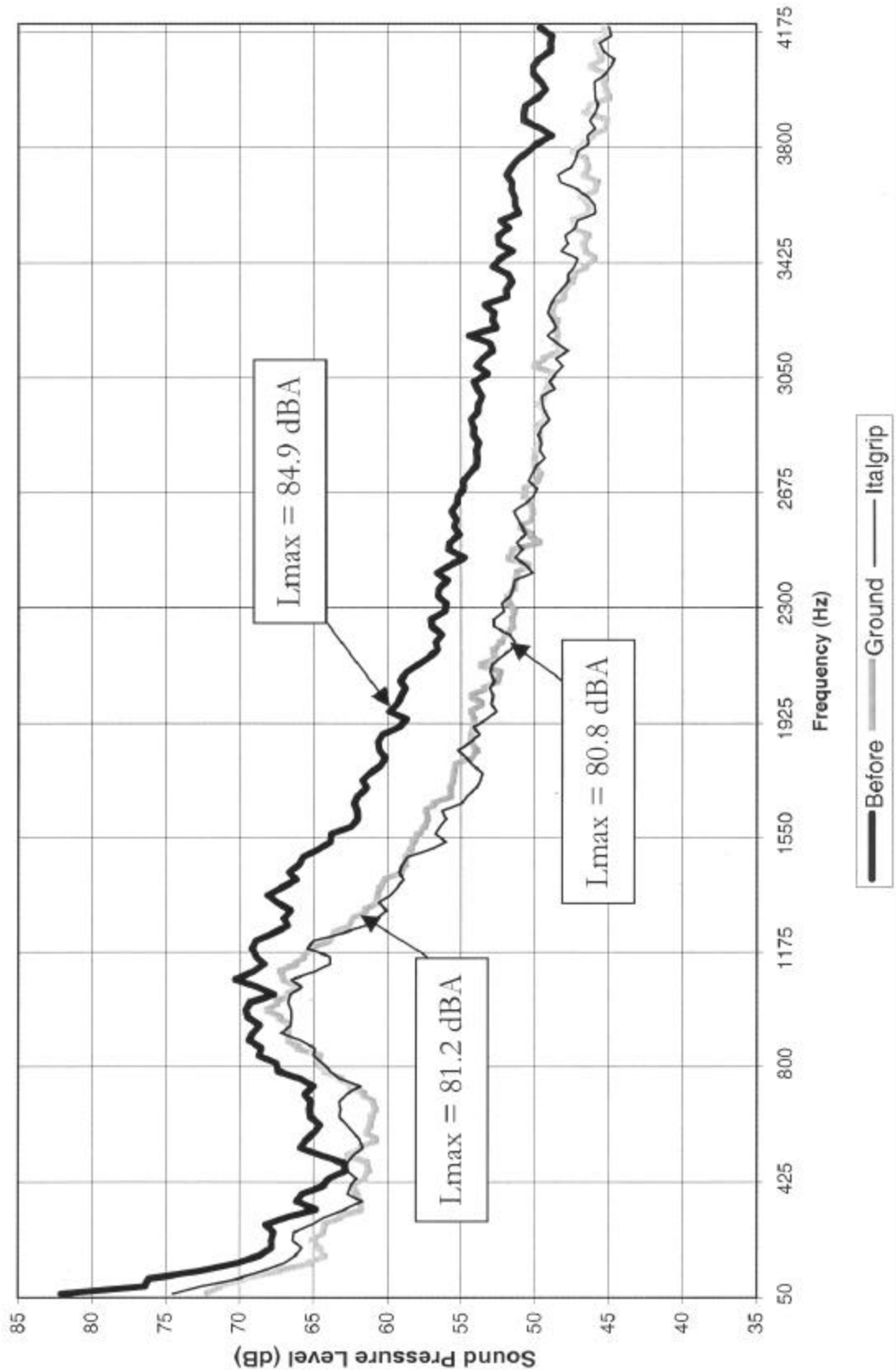


Figure 5 -Noise Level Comparison – Westbound STH 16, 70 mph (112 km/h)

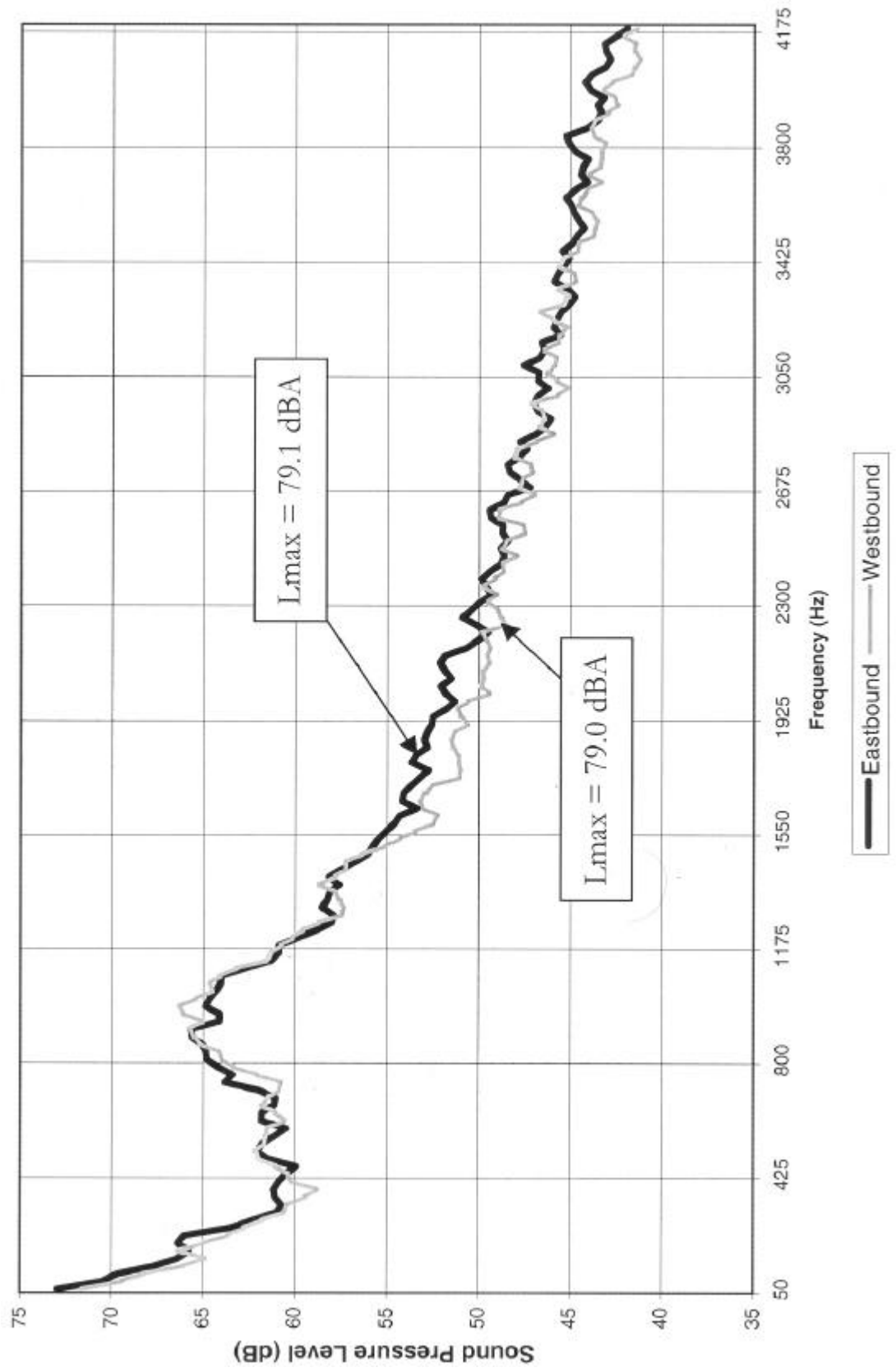


Figure 6 - 3-mm 4-mm Italgrip Comparison – STH 16, 60 mph (96 km/h)

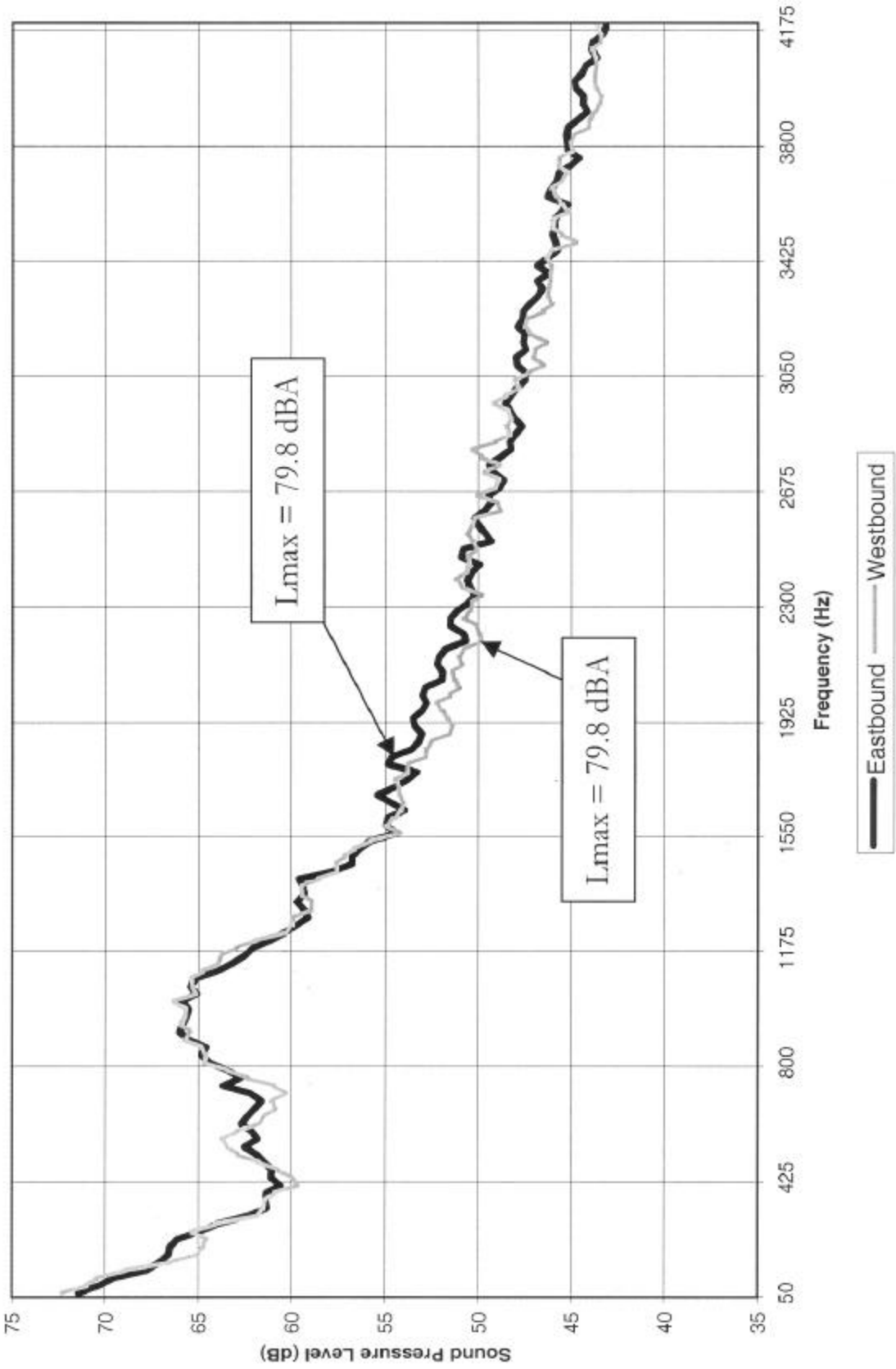


Figure 7 - 3-mm 4-mm Italgrip Comparison – STH 16, 65 mph (104 km/h)

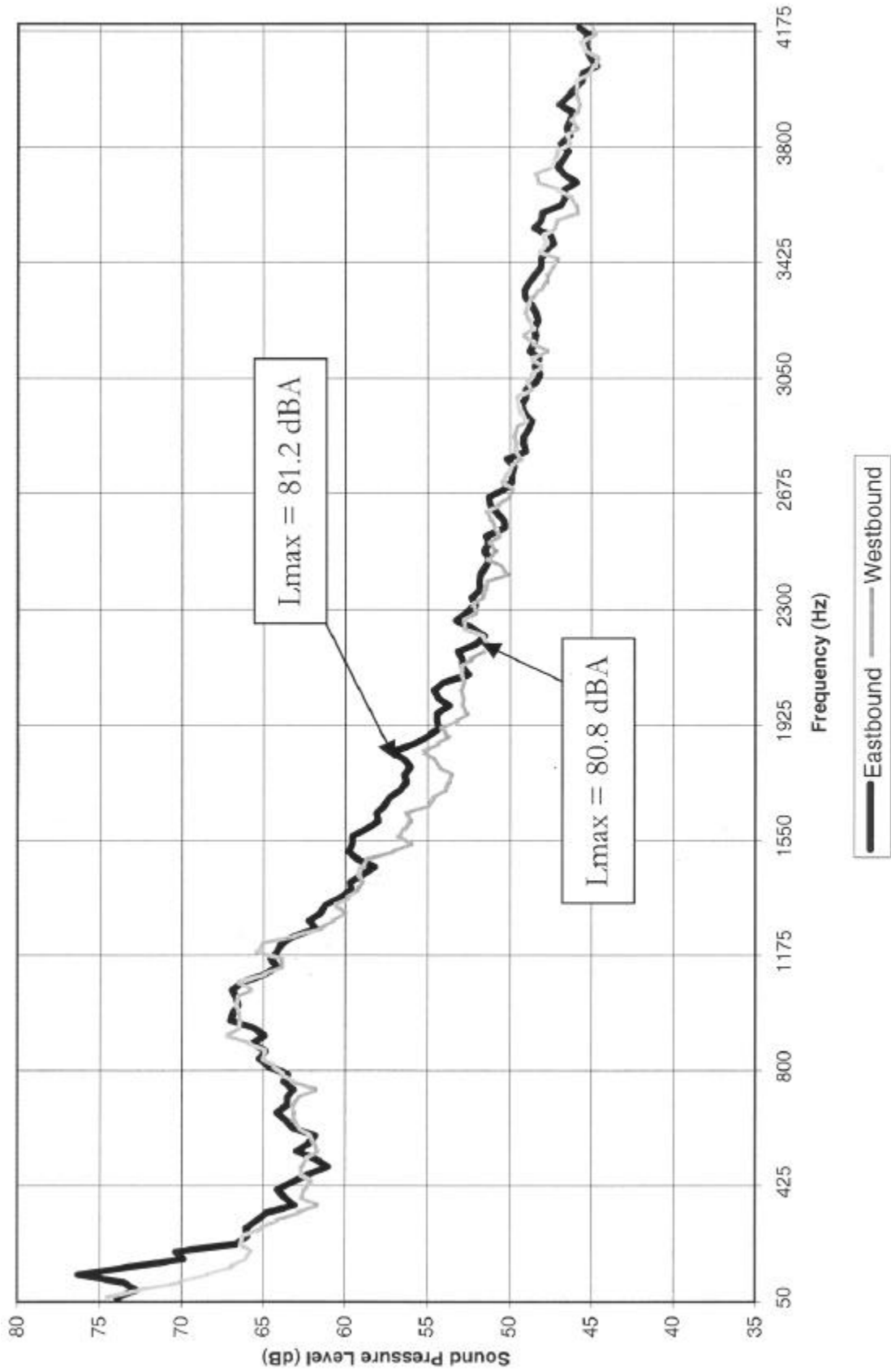


Figure 8 - 3-mm 4-mm Italgrip Comparison – STH 16, 70 mph (112 km/h)

CONCLUSIONS

1. Grinding the pavement resulted in a 3-decibel decrease in the noise level.
2. The Italgrip System reduced noise levels an additional one-decibel when compared to the ground PCC pavement at 60 mph and 65 mph (96 km/h and 104 km/h).
3. Italgrip produces a two (2) to three (3) decibel decrease when compared to the ground pavement between 1,550 and 2,000 Hz, at speeds of 60 mph and 65 mph (96 km/h and 104 km/h), a noticeable change in sound to the ear.
4. The reduction in noise levels for both operations (grinding, Italgrip) across all three speeds was approximately 4 decibels.
5. The change in noise level at 70 mph (112 km/h) between Italgrip and the ground pavement is insignificant.
6. The noise level difference between the 3 mm and 4 mm aggregate is insignificant.
7. The acoustical benefit of Italgrip cannot be separated from the known and expected acoustical benefit of diamond grinding the PCC pavement (known from prior studies) except in the 1500-2000 Hz frequency range.
8. No major shift in frequency spectrum occurred when comparing the tined, ground and Italgrip pavement conditions.

RECOMMENDATIONS

Italgrip literature mentions “an apparent noise reduction effect is achieved by an advantageous shift in frequency” and that the effect on “tyre” noise could be a “3.0/4.0 db” reduction. The frequency shift was not observed in the measurements. However, a two (2) to three (3) decibel reduction was observed in some frequencies when compared to ground pavement or the tined surface. Should further studies be considered, measuring Italgrip placed on standard PCC pavement would result in a better assessment of the acoustical benefits of Italgrip as compared to placing Italgrip on ground PCC pavement.

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