USING ISO 1996-3 TO EVALUATE TIRE CHANGE IMPULSES

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1 Introduction

Facilities that change tires on cars and trucks are sources of impulsive sound that is emitted to the outdoor environment when the doors are open. Where this sound influences noise-sensitive locations, the characteristics can be important to its description.

Individual jurisdictions address impulsive sound characteristics differently. For example, in the province of Ontario stand-alone impulses are evaluated separately from continuous sound. However, a sequence of them with a time interval of less than 0.5 seconds is evaluated together with continuous sound and is called quasi-steady impulsive sound. The definition of an impulse in Ontario is no longer clear. This paper considers the value of the ISO 1996-3 impulse identification method to find a consistent modern evaluation method for impulse characteristics in Ontario.

2 Sources

In North American climates where precipitation varies seasonally between rain and snow, tire constructions are targeted to either summer weather or winter weather. Government and insurance companies require or encourage owners of cars and light trucks to use tires targeted to the seasonal weather conditions. Consequently, many vehicle owners change tire types bi-annually. Facilities that change tires are therefore busiest twice per year.

There are two methods for managing the change between tire types. In the first method, a vehicle owner purchases a second set of rims to accompany the second set of tires. The tire stays on the rim so that the complete wheel is changed at the change of season. In the second method, a vehicle owner has two sets of tires but only one set of rims. This requires that twice per year the tires are dismounted from the rims and the other set of tires are mounted on the rims.

The process of changing tires involves lifting the vehicle and removing the nuts that hold the wheels in place. An air impact wrench, similar to what is shown in Figure 1, is used to remove the nuts. If necessary, the tire is removed from the rim and a different one installed using a separate machine. The air impact wrench is once again used to install the wheel.

Among the sources of impulse sound occurring during tire changes, the air impact wrench is the most dynamic. It has a pulse or chatter noise as it operates. The chatter speed varies with the applied torque. The chatter slows when the nut tightens at the end of installation. Similarly, nuts that are installed with higher torque result in a slower start to the nut removal.

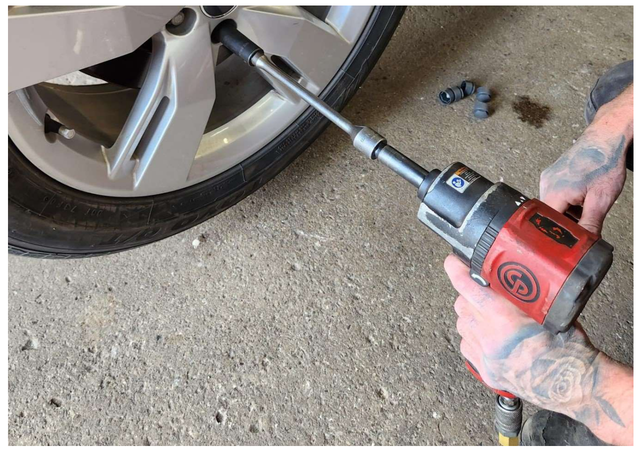

Figure 1. Air impact wrench tightening a wheel bolt

Another consideration is the number of sound events. Each vehicle has from four to eight nuts per wheel. Facilities using floor jacks to lift the vehicle are known to process up to six cars or light trucks per hour per bay if the tires are already on rims. Fewer vehicles can be done if tires need to be dismounted and replaced on the rims.

3 Method

Measurements were conducted with Larson Davis 831C and Brüel & Kjær 2270 sound level meters. The meters were at a height of 1.5 m above the ground, at a distance of 6 m from the open doorway. The sampling interval of 10 ms is within the specification of the ISO 1996-3 standard. Following the procedures in the standard, the resulting data was processed using modern mathematical software programming methods to identify each of the impulses.

4 Results

Time histories of the data were plotted. A green dot marks where the slope first exceeds 10 dB/s. A red dot marks the end of that 10 dB/s slope. When there is a small gap, the slopes are joined as long as the overall slope remains at least 10 dB/s. Stars instead of dots mark the start and end points of the joined sections. The joined sections are considered a single impulse.

The example data in Figure 2 shows the sound levels during wheel tightening, with each of the four wheels having five bolts. High sound levels between the groups are the result of an item dropping on the floor or loud talking.

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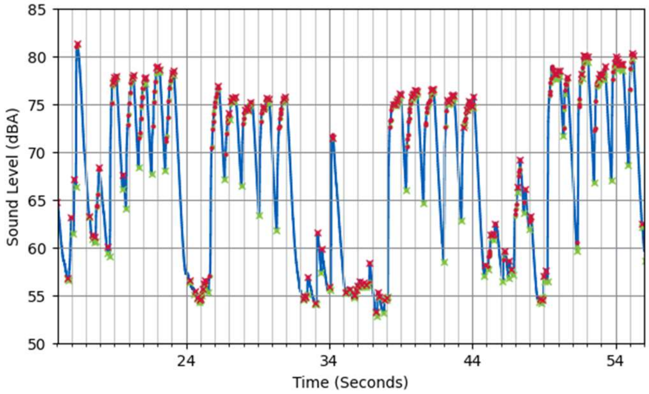

Figure 2: Time history of nut tightening on four wheels

The bolts being tightened on a light truck are shown in greater detail in Figure 3. Each tightening begins with an extremely rapid rise in sound level, which flattens during tightening. Because the bolts on this vehicle were tightened to a higher torque specification, the air impact wrench was applied for longer duration at the end of each tightening. Where a lower torque specification applies, there is almost no hold, as shown for the small car in Figure 4.

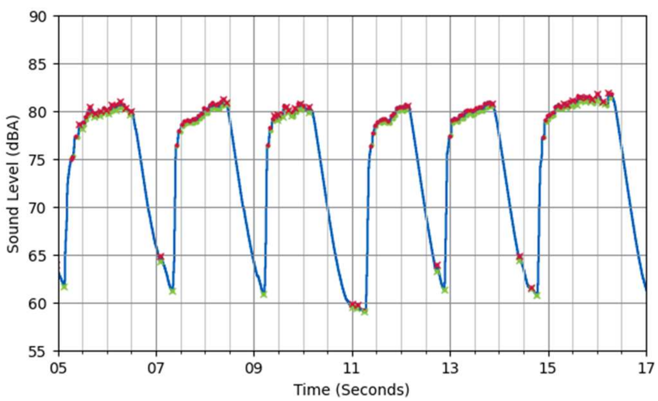

Figure 3: Bolt tightening for a light truck

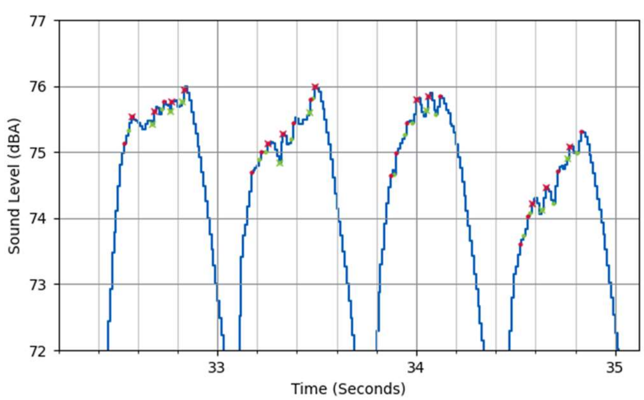

Figure 4: Bolt tightening for a small car

The chatter as a bolt is tightened is also visible in the time history. Figure 5 shows the repeated rise and fall in sound level in rapid sequence. Each of the rises is in excess of 10 dB/s.

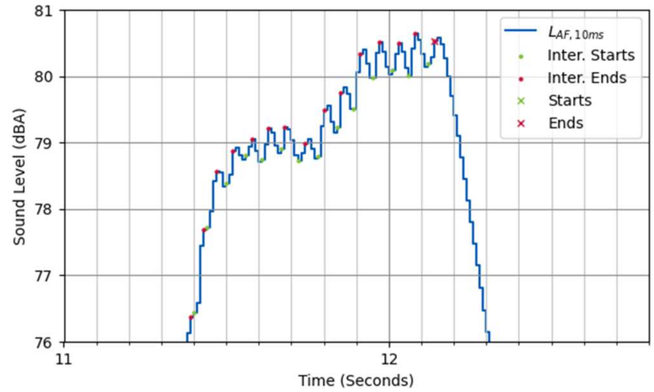

Figure 5: Chatter during bolt tightening

5 Discussion

The sound characteristics of wheel nut tightening using an air impact wrench show both large- and small-scale features. Larger-scale sound level increases occur at the beginning of each bolt tightening, as is shown in Figure 3. The level difference in these situations is in the range of 10 dB. The onset rate, or rate of increase, is also very steep. ISO 1996-3 identifies these as impulses. Similarly, this would be expected of individual impulses in the Ontario guidelines.

The impulse identification in ISO 1996-3 also gives positive indications for changes that are less obvious. These are visible as the stars after small level changes in Figure 4. However, the standard continues with an evaluation for prominence. Setting a prominence threshold, as is implicit in the standard, can be used to remove impulses of small significance. This could also be used to eliminate impulses of low significance under Ontario guidelines.

The ISO 1996-3 method provides no explicit method for identifying repeated changes that are aligned with the Ontario concept of quasi-steady. The chatter, shown in Figure 5 as the repeated rise and fall in sound level in rapid sequence, is not separately characterized in the ISO standard. Instead, the standard merges them into a one or a few individual impulses that are generally screened out by the prominence threshold. However, the smaller undulations that satisfy the quasi-steady time-series criteria could be identified with a small adaptation of the standard.

6 Conclusion

The example of an air impact gun shows that the ISO 1996-3 standard provides a modern method of identifying individual impulses in a stream of data, which is aligned with Ontario guidance. Adaptation of the standard could be used to identify the quasi-steady characteristic used in Ontario.

Reference

[1] ISO. ISO/PAS 1996-3 Acoustics – Description, measurement and assessment of environmental noise – Part 3. Objective method for the measurement of prominence of impulsive sound and for adjustment of L_{Aeq}, 2022.