



## **Backup Alarms: the noise scourge of construction projects**

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### **ABSTRACT**

*Vehicle backup alarms are ubiquitous on all construction sites, mines, and quarries. And for good reason; they are intended to warn people standing behind the equipment that the vehicle is moving backwards and that the operator might not see them well. Backup alarms have saved countless tradesmen on countless construction sites from great harm or worse (including the author). But backup alarms are typically quite loud and annoying on purpose in order to achieve that goal; as loud as 115 dBA at 4 feet behind a vehicle with a pure tone of about 1,250 Hz. Unfortunately, that makes them the number one source of community noise complaints for any given project. This paper will examine the regulatory (OSHA) requirements for backup alarms in the United States; review historical noise complaint data from major construction sites; review a comparison demonstration test done on different quieter alarm options; provide a real-world interview with a mining company on the subject; and include the author's recommendation for the best practice available today in order to balance the needs for both worker safety and community peace and quiet.*

### **1. INTRODUCTION**

Backup alarms have been available for construction equipment for about 60 years now. Since then, they have become ubiquitous on all construction sites, mines, and quarries with millions of them in operation across the country. They are intended to warn people standing behind equipment that the vehicle is moving backwards and that the operator might not see them well. Backup alarms have saved countless tradesmen on countless construction sites from great harm or worse. In fact, the author believes that the backup alarm on a contractor's utility truck once helped save him from grave injury one night while he was working on top of the I-93 elevated highway in Boston. Yet, in contrast, another example of the worst negative outcome if the backup alarm is not sufficient can be the author's experience supporting a forensic reconstruction examiner in early-1990s where the task was to try to determine if the backup alarm was "sufficiently audible" in the unfortunate death of a pavement worker in Baltimore, Maryland.

Backup alarms are typically quite loud and annoying on purpose in order to achieve the intended safety goal; ranging from 105 dBA to 115 dBA at 4 feet behind a vehicle with a pure tone of about 1,250 Hz. Unfortunately, that makes them the number one source of community noise complaints for any given project, as exemplified with the news article shown in **Figure 1**. Fortunately, there are readily available modern-day options that are quieter and less annoying for the community while still being effectively safe for workers behind the vehicle.

**Figure 1. Example News Article Citing Loud Backup Alarms**



## 2. REGULATORY REQUIREMENTS

The Occupational Safety and Health Administration (OSHA) sets the regulatory requirements for backup alarms in the United States<sup>(1)</sup>. The requirements can be found in 29 CFR Part 1926.601(b)(4), to wit:

*"(4) No employer shall use any motor vehicle equipment having an obstructed view to the rear unless: (i) The vehicle has a reverse signal alarm **audible** above surrounding noise level **or**; (ii) The vehicle is backed up only when an **observer** signals that it is safe to do so."*

The key points in the regulation above have been highlighted in **red** and include, (1) there are no quantitative decibel requirements in the regulation; backup alarms simply must be “audible”, and (2) in fact there is no requirement to use a backup alarm at all so long as the vehicle is directed by an observer (i.e. flagman). Thus, keeping in mind that safety is always the paramount issue, the OSHA regulation does allow for some flexibility in the use of backup alarms that could allow for attempts to minimize disturbance and annoyance for the surrounding community.

## 3. NOISE COMPLAINTS

Backup alarms have traditionally been the number one source of **all** types of community complaints near construction sites. Complaints could include roadway hazards, confusing detours, splashing debris, signage obstructions, building crack damages, utility interruptions, etc., yet the use of loud backup alarms remains the majority of all types of complaints. An ideal case study involved the I-93 Central Artery/I-90 Tunnel Project (i.e. the Big Dig) in Boston, Massachusetts<sup>(2)</sup> with construction activities that lasted 20 years from about 1990 to 2010.

In response to numerous noise complaints citing loud backup alarms, the project performed a comparison demonstration study, shown in **Photo 1**, of various backup alarm options to evaluate the balance between worker safety and community noise intrusion. Candidate methods included manually-adjustable alarms, automatically-adjustable alarms, radar-triggered alarms, sirens, and flashing lights. The results of the study favored the manually and automatically adjustable backup alarms. The flashing lights proved to be not nearly sufficient for worker safety; thus, confirming that an audible warning device works best.

**Photo 1. Backup Alarm Demonstration Study at the Big Dig in 1996**



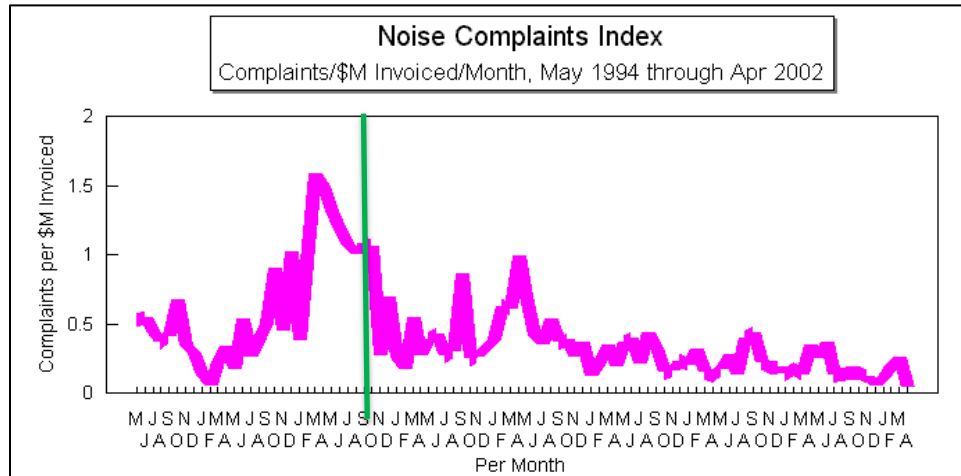
**Figure 2** shows historical noise complaint data from the Big Dig project during the years of heavy construction from about 1994 to 2002. The metric shown (i.e. Noise Complaints Index) was the author’s attempt to normalize the number of noise complaints on a monthly basis with the ever-expanding extent of construction work that was occurring throughout the city. Again, the majority of these noise complaints were due to loud backup alarms, especially at night if the backup alarms awakened people or prevented them from sleeping well.

In October of 1996, as indicated with the **green** line, the project started to apply significant efforts and resources to address the excessive noise complaints. To that end, the most internally-debated new noise policy was the idea to prohibit contractors from using audible backup alarms at night. After deciding yes, the project’s construction noise specification (721.560) was amended to read:

*“Between the hours of 11 PM to 6 AM, the Contractor shall use in lieu of audible backup alarms an appropriate alternative safety method in accordance with OSHA regulations (29 CFR Part 1926, Subpart “O”, 1926.601.b.4 and 1926.602.a.9.”*

Note that this clause is worded to be a performance-based specification, meaning that it is up to the contractor to solve the problem to comply with the specification. It was intentionally not written as a prescriptive-based specification where the project would mandate the solution. This was done for legal liability reasons in case an accident/incident occurred in the field. In this manner, the only solution for the contractor, other than to avoid working at night, was the use of observers at night. Thus, the decision and responsibility for safety was that of the contractor and not the project. As can be seen in the figure, the noise complaints index dropped precipitously after implementing the project’s new noise control policies, and to the author’s knowledge, there were no reported injuries due to rearward moving vehicles.

**Figure 2. Noise Complaints from the Big Dig (May 1994 - April 2002)**

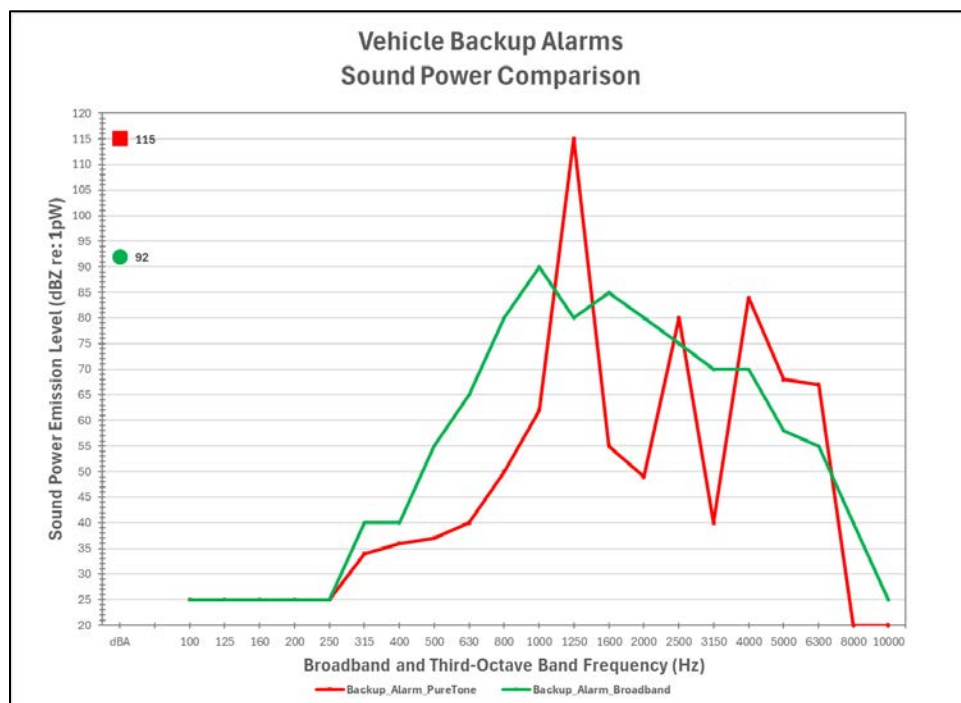


#### 4. MODERN-DAY ALTERNATIVES

Since the mid-2000s, a new type of backup alarm has been available. Rather than emit a loud pure tone, the new alarms produce a broadband “white noise”. To the author’s understanding, Brigade in the UK was the first company to promote such alarms.

**Figure 2** shows a comparison of sound power level emission spectra for a typical pure tone backup alarm and a broadband backup alarm. The pure tone alarm emits a sound power level of 115 dBA PWL which would equate to about 105 dBA SPL at 4 feet behind the vehicle, while the broadband alarm emits a sound power level of 92 dBA PWL which would equate to only about 82 dBA SPL at 4 feet behind the vehicle. The broadband backup alarm spreads the noise over several octave bands rather than in a single pure tone. Thus, it is not only quieter for the public, but it is also a much less annoying type of sound to be heard.

**Figure 3. Backup Alarms Sound Power Level Comparison**



More recently, the New York City Construction Noise Regulation<sup>(3)</sup> went into effect in 2007. The new regulation, developed by the Department of Environmental Protection (NYC DEP), was codified in New York City Local Law 113, Administrative Code Rules, Section 24-219, Chapter 28, Title 15. By that point in time, the option of using broadband backup alarms had not only started to become available, but as shown in **Figure 4**, the use of broadband alarms had actually started to be mandated<sup>(4)</sup>.

**Figure 4. Excerpt from NYC DEP Construction Noise Regulation**

**New York City, Local Law #113**

The only back-up alarm for use at sites near "sensitive" areas is listed as "BBS-TEK Brigade Model BBS-92". SA-BBS-97, an automatically adjustable version has been confirmed as an acceptable equivalent. BBS-TEK models wide frequency spectrum broadband sound rather than the more familiar strident tonal alarm.

"Sensitive" areas are defined in §28-101 (i) as properties and buildings including schools, hospitals, places of worship and homes for the aging.

Excerpts from Brigade News Release: New York Local Law #113—Citywide Construction Noise Mitigation

## 5. INDUSTRY REACTION

One of the author's clients, Wake Stone Corporation in North Carolina, recently made the switch on all their quarry mining heavy equipment from pure tone backup alarms over to broadband backup alarms. The following are responses from Mr. Cole Atkins, Wake Stone's Head Geologist & Environmental Supervisor, to a series of related interview questions.

1. *Which of Wake Stone's mining facilities switched their pure tone backup alarms over to broadband backup alarms?*

Wake Stone has switched backup alarms at **all five of our locations**: Triangle Quarry, Knightdale Quarry, Moncure Quarry, Nash County Quarry, and North Myrtle Beach Quarry. Triangle Quarry and Knightdale Quarry have been completely converted to the broadband alarms, and the other quarries are mostly converted, with only some of the less frequently used machines still carrying the pure tone alarms.

2. *Approximately when did Wake Stone switch over the backup alarms?*

We started switching to the white noise alarms, or "quackers" as we tend to call them, in **2020**. We continue to convert equipment as new machines are purchased or older machines are repurposed.

3. *What were the brand names/models of the older pure tone alarms and the newer broadband alarms?*

I don't know what brand of pure tone alarms were removed. They were whatever reversing alarms came standard on the equipment. Likely it depended on the manufacturer, as we do operate machines from a variety of makes and models. I believe we have purchased a couple of different models of broadband alarms, including different sizes for different sized machines and applications. For small machines like a Deere 317G skid steer for example, we are using **Yuesonic** 100 dB adjustable white noise reversing alarms. Larger machines are mostly using **Brigade BBS** 107 dB white noise heavy duty reversing alarms. Most of our equipment is large, like our CAT 980M loaders, and require the heavy duty alarms.

4. *What motivated or pressured Wake Stone to make this switch in backup alarms (e.g. regulatory, political, lawsuit, safety, good public relations, etc.)?*

To some extent, all of the above, but primarily it was for **public relations**. We became aware of and familiar with the broadband alarms through our consultant, Erich Thalheimer with WSP. We were asked to provide a noise study by North Carolina mining regulators as part of the permitting process to expand our existing quarry to a second one on our own property. Normally, quarry expansion permit modifications are pretty simple and don't meet a lot of resistance (at least compared to new quarry operations), but this existing quarry happens to be adjacent to a large state park who raised objections based on additional traffic, visual impact, and primarily, noise intrusion<sup>(5)</sup>.

We contracted with WSP to perform this study, and that began a continuing professional relationship with Mr. Thalheimer to this day. He had mentioned during conversations regarding the quarry expansion project that the typical pure tone backup alarm is often the most recognized nuisance sound from construction and industrial activities. When we looked into the cost and determined it to be relatively affordable, Wake Stone leadership decided to replace all of the alarms at Triangle Quarry even before the study and resulting report were completed. We were not required by any regulation to do so, but it would eventually be one of the recommendations in the final report provided by WSP. We did not initially have any intention of making this transition at our other quarry locations. A couple of years later, we received a complaint from a neighbor near our Knightdale Quarry regarding nighttime noise. Although no local noise ordinance required us to respond (noise levels from the quarry were below limits and safety alarms were exempt), Wake Stone management again decided to swap out all of our backup alarms for good public relations. And at this point, we decided to be more proactive and began to replace the alarms at all our locations.

5. *What has been the reaction by Wake Stone's employees to the new broadband alarms?*

Employees have **not really had any reaction**, positive or negative. It is just a different sound, and everyone has adjusted. In talking to our safety director who has some experience with the psychology of noise, there is a general feeling that the removal of the pure tone alarms may have had a positive impact on employee mood. But when you have worked around heavy equipment all your life, I suspect it was something that just becomes part of the normal working sound environment.

6. *What has been the reaction by surrounding communities to the new broadband alarms?*

I think it may be a little early for us to know how much the surrounding communities might benefit from the new broadband alarms. However, **people seem to appreciate** that we are taking active measures to be good neighbors, whether they have experienced nuisance noises from our operations or not.

7. *Has anyone been hurt by a reversing vehicle equipped with a new broadband alarm?*

Most reversing incidents involve hitting stationary objects rather than another vehicle or person, which suggests that backup alarms of any sort are effective to warn people. We have had **no reversing incidents** where the new broadband alarms would have played a role. They appear to be just as safe as the pure tone alarms.

8. *Any overall comments or recommendations for other mining or construction companies?*

Although not necessarily cheap (at about **\$300 per alarm** not including installation cost), we have been **very happy** with the broadband backup alarms. They are typically very easy to install. Some equipment does require additional wiring harnesses because of the way the standard pure tone alarms are mounted, but most installations are a very quick and simple swap. I would **highly recommend** that any mining



operating in quiet or noise sensitive areas or are

operating at night, use broadband backup alarms. My experience with our mining operations before we switched from the pure tone alarms is that often the only noise that was clearly identifiable at some distance from the operation were the backup alarms. Removing the pure tone alarms allows most of the other construction and industrial noises to simply blend in with other ambient sources such as public vehicle roadway noise and distant air traffic noise.



## 5. CONCLUSIONS

Vehicle backup alarm technology has come a long way since the earliest alarms were introduced some 60 years ago. While the alarm's purpose as a worker safety device is still the most important aspect, manufacturers have focused much more attention on trying to minimize the associated disturbance for nearby neighborhoods. Quieter backup alarm options that have been introduced over the decades include manually-adjustable alarms, ambient-sensitive alarms, and more recently, broadband "white noise" alarms.

Real-world experience using the broadband backup alarms has shown them to be much less annoying for the public while still being effectively safe to warn people standing behind a rearward moving vehicle. Broadband backup alarms appear to have solved the ever-present necessity for balance between the contractors need to safely perform the given work with the communities need for peace and quiet.

## 6. REFERENCES

- (1) U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), Title *Safety and Health Regulations for Construction*, Subpart O, 29 CFR Part 1926, Section 601(b)(4).
- (2) Thalheimer, E., *Construction Noise Control Program and Mitigation Strategy at the Central Artery/Tunnel Project*, Proceedings of InterNoise 1999 Conference, Ft. Lauderdale, Florida, December 1999, and published in *Noise Control Engineering Journal* (NCEJ, 48 (5), Sep-Oct 2000).
- (3) New York City Department of Environmental Protection, Local Law 113, Administrative Code Rules, Section 24-219, Chapter 28, Title 15, *New York City Construction Noise Regulation*, July 2007.
- (4) Thalheimer, E. & Shamon, C., Opening Plenary Speech, *Understanding and Complying with the New York City Construction Noise Regulation*, Proceedings of InterNoise 2012 Conference, New York City, New York, August 2012.
- (5) Thalheimer, E. & Poling, J., *Wake Stone Quarry Expansion: An acoustical and legal saga win*, Proceedings of NoiseCon 2024 Conference, New Orleans, Louisiana, June 2024.