CONCLUSIONS

Considerable reduction of sound can be expected when this device is used on existing sound barriers, without a big modification of the barriers. If new sound barriers are constructed, then the use of this device can contribute to the economical design of the sound barrier system by lowering the height and reducing the weight of the installation. This device, when combined with the back sound barrier panel that intercepts the refracted propagated noise, can effectively reduce the noise from sources such as railroads or highways.

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Review of Federal Noise Emission Standards for Interstate Rail Carriers

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ABSTRACT

The federal noise emission standards for interstate rail carriers, the most recent portion of which took effect on January 15, 1984, are reviewed. Some potential problems in carrying out various elements of these standards are described, and possible solutions to these problems are discussed.

The Noise Control Act of 1972 identified noise as a growing danger and declared that the policy of the United States was "to promote an environment for all Americans free from noise that jeopardizes their health and welfare." Included in the Act was the authorization to establish federal noise emission standards for products distributed in commerce, and the mandate for the U.S. Environmental Protection Agency (EPA) to coordinate federal activities in noise control. Section 17 of the Act specifically required EPA to promulgate standards and the U.S. Department of Transportation (DOT) to promulgate compliance regulations setting limits on "noise emission resulting from operation of the equipment and facilities of surface carriers engaged in interstate commerce by railroad." It further required that such regulations include noise emission standards that "reflect the degree of noise reduction achievable through the application of the best available technology, taking into account the cost of compliance."

In accordance with Section 17 of the Act, EPA issued final railroad noise emission standards on December 31, 1975. These standards applied to all railroad cars and all locomotives, except steam locomotives. On August 23, 1977, FRA published Railroad Noise Emission Compliance Regulations setting forth procedures for enforcing the EPA standards.

In June 1977 the Association of American Railroads (AAR), along with several railroad companies, challenged the EPA regulation in the U.S. Court of Appeals on the basis that it did not include standards for all railroad equipment and facilities as required by the Noise Control Act. The concern of the railroad industry was that, lacking federal preemption of all railroad noise source regulations, there could develop a great variety of differing and inconsistent standards in every jurisdiction along the railroad's routes. In addition, local communities would not necessarily be bound by the protective, requirement in the Noise Control Act for use of the "best available technology, taking into account the cost of compliance."

The judgment of the court was in favor of the railroad industry. As a result EPA published proposed noise regulations for additional railroad equipment and facilities in April 1979. These proposed regulations would have established federal standards for overall railroad facility and equipment noise, as well as specific standards for retarders, refrigerator cars, and car-coupling operations.

After an extended public comment period, EPA published final rules on January 4, 1980, establishing standards for noise from four specific sources, namely, switcher locomotives, retarders, car couplings, and locomotive load cell test stands. These new standards took effect on January 15, 1984.

Although at the time of preparation of this paper DOT had not yet promulgated compliance regulations for these new standards, draft regulations were in the process of being prepared.

LOCOMOTIVE STANDARDS

The data in Table 1 summarize the standards for noise emission from all locomotives, except steam locomotives, operated or controlled by railroads within the continental United States.

The original standards, issued in 1975, differentiated among three different operating conditions:

1. Stationary at idle throttle setting,

TABLE 1 Locomotive Noise Emission Standards

Operating Condition	Noise Metric	Meter Response	Meas't Location	Locomotive Type: Non-Switchers Built On or Before 31 Dec 79	Locomotive Type: All Switchers;* Non-Switchers Built After 31 Dec 79
Stationary, Idle	L_{max}	Slow	100 Feet	73 dB(A)	70 dB(A)
Stationary, Non-Idle	L_{max}	Slow	100 Feet	93 dB(A)	87 dB(A)
Moving	L_{max}	Fast	100 Feet	96 dB(A)	90 dB(A)

* Switchers are in compliance if L_{90}(Fast) ≤ 65 dB(A) on receiving property. L_{90} measurement must be validated by showing that L_{10}(Fast) – L_{99}(Fast) ≤ 4 dB(A).

2. Stationary at a throttle setting other than idle, and
3. Moving at any throttle setting.

The standards also differentiated between two classes of locomotive:

1. Those built on or before December 31, 1979, and
2. Those built after December 31, 1979.

The standards for locomotives built after December 31, 1979, were from 3 to 6 dB lower than those for the older locomotives, depending on the mode of operation. All standards specified the maximum A-weighted sound level that could occur at a distance of 100 ft from the source. Instrumentation, test site clearance, weather condition, and background noise criteria for these measurements were also defined in the standards.

The new addition to these standards, which took effect on January 15, requires that all switcher locomotives meet the lower, more stringent standards, regardless of their year of manufacture. Switcher locomotives are those locomotive models that are designated as a switcher by the builder or reported to the Interstate Commerce Commission (ICC) as a switcher by the operating or owning railroad. Appendix A of Subpart A of the standard lists those locomotive models that are considered to be switchers.

In addition to extending the more stringent 100-ft sound levels to switcher locomotives of all manufacture dates, the new standard introduces the concept of a "trigger" level. Recognizing that noise from switcher locomotives operating in a railroad yard is a community problem only if the sound level at the boundary of the yard is excessive, these standards deem all switcher locomotives in a yard to be in compliance if the L_{90} sound level on neighboring receiving property due to stationary switcher locomotives does not exceed 65 dB(A) when measured for a period of at least 15 min. If this 65-dB(A) trigger level is exceeded on any receiving property, then 100-ft maximum sound level measurements must be made to determine the compliance of locomotives within the yard.

To ensure that any L_{90} measurement on receiving property is restricted to essentially steady-state noise sources (presumably stationary switcher locomotives in the yard), the new standard defines a validation procedure for the L_{90} measurement, which requires that the difference between L_{10} and L_{99} be 4 dB or less. Meeting this requirement indicates that the sound being measured changes only slightly with time and thus emanates from steady-state sources.

RAIL CAR STANDARDS

The pre-1980 noise emission standards on rail cars have not been changed by the promulgation of the new standards. As noted by the data in Table 2, these standards differentiate between two operating conditions:

1. Speeds less than or equal to 45 mph, and
2. Speeds exceeding 45 mph.

TABLE 2 Noise Emission Standards for Railroad Equipment Other than Locomotives

Noise Source	Operating Condition	Noise Metric	Meter Response	Meas't Location	Standard dB(A)
Railroad Cars	Speed ≤ 45 mph	L_{max}	Fast	100 Feet	88
	Speed > 45 mph	L_{max}	Fast	100 Feet	93
Active Retarders	Any	$L_{adj.ave.max.}$	Fast	Rec.Prop.	83
Car-Coupling	Any	$L_{adj.ave.max.}$	Fast	Rec.Prop.	92
Locomotive Load Cell Test Stands	Any	L_{90}*	Fast	Rec.Prop.	65
	or (a) Primary Standard	L_{max}	Slow	100 Feet	78
	or (b) If (a) Is Not Feasible	L_{90}*	Fast	Rec.Prop. >400 Feet	65

* L_{90} measurement must be validated by showing that L_{10}(Fast) – L_{99}(Fast) ≤ 4 dB(A).

The standards specify the maximum fast-response A-weighted sound level that can occur 100 ft from the centerline of the track as the rail car passes by. Instrumentation, track construction and curvature, test site clearance, weather condition, and background noise criteria for these measurements are also defined in the standard.

RETARDER AND CAR-COUPLING STANDARDS

Standards on two new railroad noise sources--active retarders and rail car couplings--went into effect on January 15. The data in Table 2 indicate that the metric used to measure sound from these two intermittent sources is the adjusted average sound level measured on neighboring receiving property. The adjusted average sound level is the energy-average of the maximum fast-response A-weighted sound levels measured for a sequence of events (either retarder sounds or car-coupling impacts, but not both), adjusted by a factor that takes into account the rate at which these events occur. At a rate of one event per minute, the adjustment factor is zero; at a rate of two events per minute, 3 dB is added to the computed energy-average level; at a rate of four events per minute, 6 dB is added; and so on. At a rate of one event every 2 min, 3 dB is subtracted from the calculated energy-average level; at a rate of one event every 4 min, 6 dB is subtracted; and so on.

In measuring the sequence of retarder or car-coupling sound levels, at least 30 consecutive events must be included and the measurement period must be at least 60 min and not more than 240 min. An event is defined as the occurrence of a sound in which the maximum fast-response A-weighted sound level during the occurrence exceeds the level immediately before the occurrence by at least 10 dB. Instrumentation, test site clearance, and weather condition criteria for the measurements are defined in the standard. Correction factors for the use of type 2 sound level measurement instrumentation are also specified.

LOCOMOTIVE LOAD CELL TEST STAND STANDARDS

Also taking effect on January 15 were standards on the noise emissions from locomotive load cell test stands. These test stands are large, fixed banks of resistors (usually fan cooled) that are connected to the electric generator of a stationary diesel-electric locomotive to provide an electrical load for testing the operation of the diesel engine and the electrical system.

Typically, these tests involve operating the locomotive for several minutes at each of a series of throttle settings. The noise emissions during such tests originate from locomotives under test, the test stand cooling fans, and possibly the resistor bank. Maximum noise levels usually occur when the locomotive is operating at the maximum throttle setting.

The data in Table 2 indicate that the standard defines the maximum slow-response A-weighted sound level as measured at 100 ft from the geometric center of the locomotive being load tested. As in the case of the new switcher locomotive standard, an L_{90} trigger level, as measured on neighboring receiver property, is defined. If this level is not exceeded, all locomotive load cell test stands in the railroad facility are deemed to be in compliance with the standard. This L_{90} measurement must be validated by showing that L_{99} minus L_{10} does not exceed 4 dB.

Instrumentation, test site clearance, and weather condition criteria are also defined in the standard. Because the test site clearance requirements are not often satisfied around existing load cell test stands, the standard defines an alternate measurement in terms of the maximum L_{90} sound level on receiving property at least 400 ft away from the test stand. This alternate standard may only be applied when the clearance requirements for the 100-ft measurement cannot be met.

POTENTIAL PROBLEMS

Several problems may potentially exist in carrying out some of the measurements required by the new standard. For example, it is required that the measurement of the L_{90} trigger level associated with the switcher locomotive standards and the locomotive load cell test stand standards be validated by demonstrating that L_{99} minus L_{10} does not exceed 4 dB. The purpose of this requirement is to ensure that the noise at the receiving property measurement site primarily consists of nearly steady-state railroad noise, presumably from nearby stationary locomotives or load cell testing. The data on which these statistical sound levels are based must be measured over a period of at least 15 min or, if manual sampling techniques are being used, until 100 measurements at intervals of 10 sec are made.

If the measured value of L_{90} so obtained is not validated (i.e., if $L_{99} - L_{10} > 4$ dB), then the standard states that "measurements may be taken over a longer period to attempt to improve the certainty of the measurement and to validate L_{90}." No guidance is provided as to when to terminate attempts to validate the L_{90} measurement. Because many railroad yards are located in or near large cities with heavy automobile, truck, and aircraft traffic nearby, it may often be the case that the measured noise field is not nearly steady-state and validation of L_{90} is impossible.

The intent, of course, is to eliminate sites in such heavily trafficked areas from this part of the standard, because the switcher locomotives and load cell test stands are probably not major sources of environmental noise. Without guidance, however, the potential exists for many hours of wasted effort as inexperienced personnel attempt to validate the measurement.

A second problem may occur in the case in which the L_{90} measurement is validated. In such a case, to determine the applicability of the standard the observer is required to determine "the principal direction of nearly steady-state sound at the measurement location...by listening to the sound and localizing its apparent sources(s)." In the envisioned situation in which nearby stationary locomotives or load test stands or both are the only major noise sources, there should be no real problem in identifying the source.

In the more common case, however, in which road vehicle and aircraft passbys contribute to the measurement, it is impossible even for the experienced professional to determine the major contributor(s) to L_{90} without a detailed study of a strip chart of the continuous sound level on which has been annotated the identification of the principal noise source at each instant of time. No existing automatic equipment can determine the contribution to the L_{90} measurement of only the railroad noise.

Thus, without some detailed guidelines in this area, the potential exists for gross errors in the identification of the major source of receiving property noise. A need exists for better procedures to identify major contributors to statistical sound level measurements where there are several noise sources present.

A third potential problem relates to the way in which the trigger level portion of the regulation may be applied to switcher locomotives. The standard states that all switcher locomotives that operate in a particular railroad facility are deemed to be in compliance with this standard if the L_{90} trigger level on nearby receiving property does not exceed 65 dB. If this trigger level is exceeded, then presumably an inspector may require a 100-ft sound level measurement for each switcher locomotive in the railroad yard.

It is not too difficult to envision a situation in which one or more locomotives that meet the 100-ft sound level standard (70 dB at idle throttle setting) cause the trigger level of 65 dB to be exceeded because they are normally parked close to the receiving property measurement site. The obvious solution to any community noise problem caused by these locomotives is to move them further from the edge of the railroad yard, even though they meet the 100-ft standard. Yet the standard can be interpreted to require that all other switcher locomotives in the yard be tested at 100 ft and any exceeding the specified maximum be modified, even though those locomotives are not contributing to the trigger level at the receiving property measurement site.

Clearly, some discretionary judgment should be allowed both enforcement officials and railroad personnel in solving a noise problem such as this. A solution that reduces the L_{90} at the receiving property below the trigger level should be acceptable, even if it does not involve making 100-ft measurements of all other switcher locomotives in the yard.

CONCLUSIONS

Because elements of the new railroad noise emission regulations attempt to cover many complex situations, they can be implemented in a manner that is counterproductive to cost-efficient noise control. Proper training of both enforcement and railroad personnel will be required, along with the use of reasonable judgment on the part of these persons, in order that the intents of the noise act be carried out in an effective manner.

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Use of Microcomputers in Highway Noise Data Acquisition and Analysis

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ABSTRACT

A microcomputer-based noise data acquisition and analysis system has been designed that expands the capabilities currently available for monitoring highway traffic noise. The system was designed for research activities investigating the effects of pavement and tire design on highway noise levels, and it incorporates the state of the art in microcomputer interfacing equipment design. The system is designed to allow the high-speed collection and analysis of both A-weighted and 1/3 octave noise data for multiple microphone configurations. The components of the system are described, and a discussion of the hardware and software development, as well as the specific application the system is used for, is included. It is suggested that there are other applications that the system could be easily adapted to, and some insight into the effect that continued advancements in microelectronics may have on such a system is provided.

Conventional methods of acquiring highway noise data have made use of systems consisting of a series of microphones, sound level meters, and tape recorders. Collected data are then generally brought back to the laboratory for playback and analysis [see Figure 1 (1)]. This analysis is usually accomplished by using various types of filter systems coupled together with a computer. Although this method provides the necessary capabilities to carry out a detailed analysis of data, it requires large capital outlays for equipment and tends to be a time-consuming, labor-intensive, and thus costly activity.

With the advancements in the field of microelectronics in the past 5 to 10 years, the prospects of more compact and even portable equipment have been greatly improved. The evolution of the computer from vacuum tubes to transistors to integrated circuits