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URBAN RAIL NOISE ABATEMENT SOURCE BOOK

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LETTER REPORT

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RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
Transportation Systems Center
Cambridge MA 02142

PREFACE

This source book is designed to provide information valuable to those individuals involved in planning and implementing noise and vibration control projects on urban rail transit systems. It was prepared as part of the Urban Rail Noise Abatement Program, sponsored by the Office of Technology Development and Deployment, Office of Rail and Construction Technology of the U.S. Department of Transportation's Urban Mass Transportation Administration.

Substantial contributions were made to the source book by A. Richardson Goodlatte of Energy and Environmental Engineering, Inc., Elizabeth Ivey of Smith College, Leonard Kurzweil of Bolt Beranek and Newman, and Nancy Cooney of Raytheon Service Company.

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1. INTRODUCTION

Noise abatement is a complex technical and operational problem confronting urban rail transit authorities. Progress has been made, however, by transit authorities and government agencies in solving the noise and vibration problem. This source book provides references, contacts, and resources that have proved valuable in actual experience in controlling noise and vibration on urban rail systems.

The Urban Mass Transportation Administration (UMTA) has been sponsoring research and development in the field of urban rail noise abatement since 1972. During this time, much has been learned about the source, propagation and control of noise in the urban rail transit system environment. Basic research and development have produced an understanding of the mechanisms generating noise and vibration, while various in-service tests have produced valuable information about the performance of noise control treatments in the "real world." Reports, seminars, workshops, and other forms of communication have been used to disseminate information to those who can use it.

UMTA-sponsored research in the area is summarized in the Urban Rail Noise Abatement Program Digest (52).* Another publication, the Handbook of Urban Rail Noise and Vibration Control (34), presents a comprehensive report on current practices in noise and vibration control technology. Accompanying the Handbook is an Executive Digest (35), which represents the same material in a more condensed form. Currently being prepared is a Compendium of Acoustical Materials, which will describe the range of materials available for acoustically treating transit systems. These sources should provide a wealth of technical information of those who need it.

* Note: Numbers in parenthesis refer to references in Appendix B (Bibliography).

Still, the problem of assimilating information and translating it into a specific program for noise and vibration control on a transit property is a real one. Transit authority personnel face questions concerning the nature of the noise problem on a particular system, the most cost-effective way to solve the problem, the best ways to integrate noise and vibration control with overall transit planning and management functions, and ways to fund noise control treatments. This guide addresses many of the major questions which arise in implementing urban rail noise abatement technology and provides references and sources where the answers to specific questions may be found.

This source book is divided into four sections and two appendices; each deals with a different aspect of noise and vibration control and implementation. The four sections consist of (1) an introduction to and a summary of the source book, (2) a description of the steps involved in planning and implementing a noise control program, (3) an enumeration of available noise control treatments, including an effectiveness ranking and information on where these measures have been used, and (4) a discussion of funding sources available for noise control testing and implementation. Appendix A lists organizations to contact for more information and includes individuals who are responsible for noise and vibration control at various transit authorities. A bibliography of urban rail noise and vibration control documents is included as Appendix B.

This publication has been produced in a format which lends itself to updates and corrections. Readers are encouraged to contribute additional information and make corrections where needed. Additions and changes should be brought to the attention of the Urban Rail Noise Abatement Program staff at the Transportation Systems Center.

2. DEVELOPMENT OF A NOISE CONTROL PROGRAM

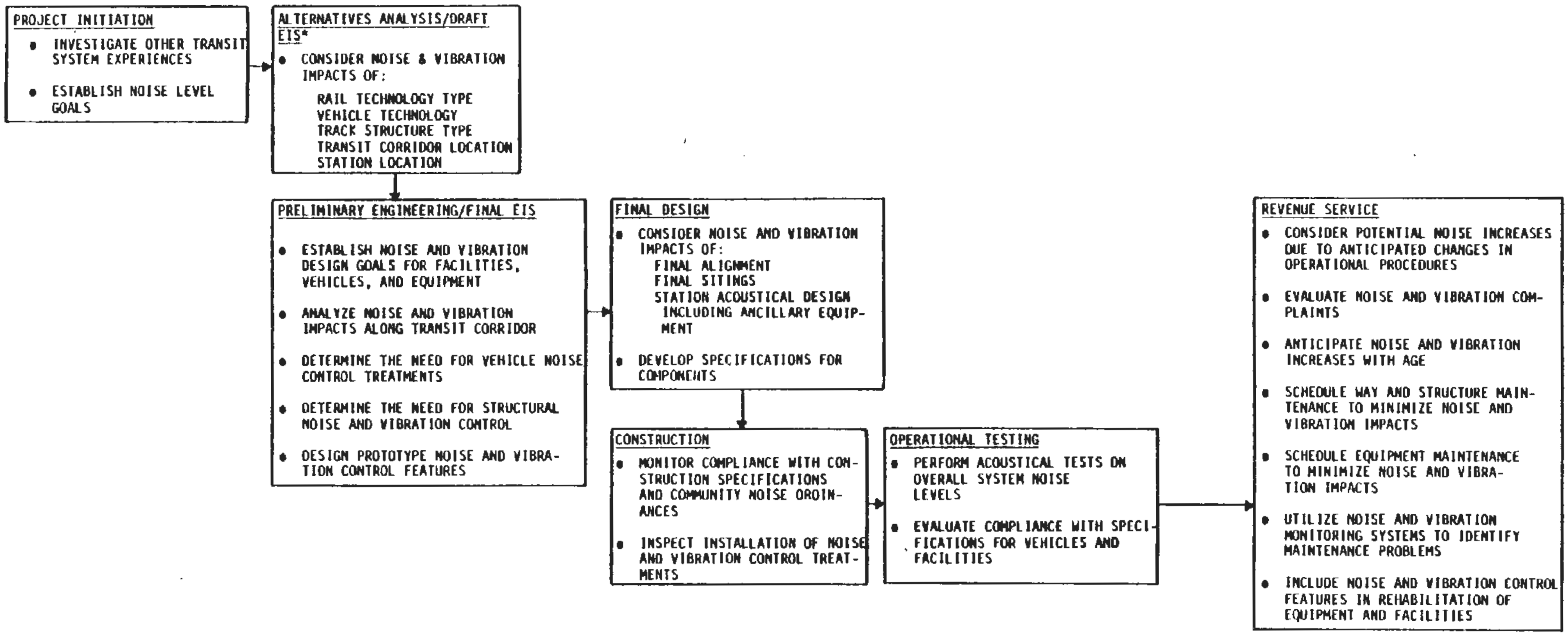
Although public concern with transit system noise and vibration is growing, transit authorities may find it difficult to devote increasing amounts of money to this problem when they are simultaneously facing tighter budgets and the pressing problems of day-to-day system operations.

On the other hand, it is more efficient and cost-effective to anticipate noise and vibration problems and to develop a coherent plan for dealing with them. The most effective approach is to incorporate proven noise and vibration control technology into the design of new transit systems or transit system extensions. The cost of including treatments in the original design is considerably less than the cost of retrofitting the same treatments.

Existing systems are faced with a more difficult problem since there is less opportunity to plan for systematic noise and vibration control. These systems, however, often face significant noise problems. It is possible to develop a realistic plan for noise and vibration control and integrate it into on-going transit property functions. When major rehabilitation projects are planned for vehicles or track, noise and vibration control measures can be incorporated as part of the project. When new vehicles and other equipment are purchased for the system, noise and vibration-related specifications can be included in the procurement process.

Routine maintenance is another area where noise and vibration control can be incorporated. Well-maintained vehicles and track are considerably quieter than those which are poorly maintained. Conversely, noisy equipment signals the need for maintenance. For example, a noisy wheel may indicate the presence of a wheel flat. Wheel truing will eliminate the noise problem, and at the same time prevent further damage to the vehicle and the track.

Figure 2-1 outlines the points at which noise and vibration control should be considered in the construction of a new system or in the operation of an existing transit system. The remainder of this section is primarily oriented



*Rehabilitation projects do not require the Alternatives Analysis/Draft Environmental Impact Statement stage.

FIGURE 2-1. TRANSIT SYSTEM NOISE AND VIBRATION CONSIDERATIONS toward the planning and implementation of a comprehensive noise control program for new systems and system extensions. Although existing systems can also benefit from such a program, they may be more interested in solving noise problems on a case-by-case basis due to financial, economic and operational constraints.

Criteria

A first step in any noise control program or project is to establish noise level goals. In doing so, it is necessary to weigh acceptable levels of human exposure against the practicality of achieving a specific noise level, given economic and technological limitations. Acceptable levels vary with the audience exposed. Residential areas, for example, would require lower levels than commercial districts. The noise levels imposed on surrounding neighborhoods can vary considerably in loudness, duration, frequency, and character and, thus, it is important to adopt goals which are relevant to the surroundings.

The Handbook, referred to earlier, contains a chapter on acceptability criteria, including various noise level descriptors and a list of references. Two particularly useful sources of information on acceptability criteria are the Environmental Protection Agency's "Levels" document (3), and the American Public Transit Association's (APTA) Noise and Vibrations Guidelines (4). The "Levels" document discusses noise levels considered safe for the average individual in a variety of environments, while the APTA report recommends noise level goals specifically for rail transit systems. Local noise ordinances must also be considered when setting noise level goals.

Once these goals have been established, noise levels must be measured or predicted to determine the level of compliance. Two options for determining noise levels are to develop an in-house capability or to hire an acoustical consultant. Since predictions are somewhat more complex than measurements, they usually require the expertise of a consultant.

Several sources of information discuss instrumentation, requirements and procedures for measuring and predicting noise and vibration. Noise and vibration workshops are held around the country throughout the year by various professional organizations. Information about these workshops is available through APTA, local chapters of the Acoustical Society of America, and in acoustical trade journals. Several of the references included in this source book, especially (1), (2), (5), and (6), contain useful and comprehensive information on noise and vibration measurement. The Handbook also describes appropriate measuring systems and approaches, as well as additional references.

Source Identification

Once the need for noise and vibration control has been established, the next step is to identify the specific sources of the problem. Information on how to diagnose the sources of the noise and vibration is becoming more available as transit properties become involved in this area.

Identifying the dominant noise sources which make up overall noise levels is not an easy task. Sometimes specific sources can be determined from overall measurements based on characteristic patterns which show up in the data. Chapter 3 of the Handbook describes different sources of noise and vibration and can aid in identifying specific sources of noise. Persons involved in diagnosing and treating noise problems within their own transit systems are another resource. A list of such individuals appears in Appendix A of this source book. Often, however, more detailed investigation will be required, such as frequency analyses or the systematic identification of one source at a time.

Chapter 3 of the Handbook provides information for evaluating the noise and vibration effects of proposed features of transit systems still in the planning and design stages. Evaluations of potential impacts can be made based on the operating experiences of existing transit systems, although care must be taken that comparable operating environments are being considered.

Noise Control Treatments

Noise control should be considered in all aspects of a capital program. It is often more economical to design noise reduction into a new or rebuilt car or facility than to retrofit later. For example, the Metro Dade Rapid Transit System in Miami is purchasing its new cars with grooves cut in the wheels at a cost which is only slightly more than solid steel wheels. If these cars screech loudly on curves then ring dampers can be added later at a very modest cost.

Other issues to consider in deciding about noise control treatments include:

- o Is it more cost effective to treat noise at its source or to block its path from the source to the listener (e.g., the use of sound barriers)?
- o Is it more cost-effective to apply a treatment on a system-wide or site-specific basis?
- o Will a treatment enhance or detract from the proper maintenance of the system?

The Handbook and its associated Executive Digest are two useful references on noise control treatments. The Handbook discusses the various noise and vibration control treatments under the following categories of noise sources: vehicles (Chapter 5), surface track (Chapter 6), aerial structure (Chapter 7), groundborne (Chapter 8), station (Chapter 9), auxiliary equipment (Chapter 10), yards and shops (Chapter 11). The Executive Digest has an exhaustive table of sources and treatments with comments on their effectiveness.

The following section contains an overview of various noise control treatments currently used on U.S. transit properties. In planning a noise control program, transit authorities should take advantage of the experiences of other properties as these experiences can be very useful when purchasing new equipment. Most new transit vehicles being purchased today are much quieter than older models. A transit property purchasing new vehicles can collect examples of recent vehicle procurement specifications from other properties to see what noise and vibration criteria they contain. Although the options may be somewhat more limited in a vehicle retrofit program, it is still useful to investigate specific improvements made by other properties.

3. OVERVIEW OF NOISE CONTROL TREATMENTS

This section contains an overview of noise and vibration control treatments in tabular form. Table 3-1 lists treatments applicable to transit cars while Table 3-2 lists treatments for tracks and wayside areas. The tables indicate the degree of effectiveness of each treatment in reducing various types of urban rail noise: wheel/rail, propulsion system, elevated structure, and groundborne. Wheel/rail noise is created by the interaction of wheels and rails. Propulsion system noise includes that produced by the train's motor, gearboxes, and its motor cooling fan. Elevated structure noise is radiated by the structure or from the train when a train travels along an elevated section of track. Groundborne noise and vibration result from the transmissions of vibrations from the trackbed to adjacent buildings.

Included in the tables are transit systems which have used or tested the treatment in question along with references reporting test results. More information on acoustical and operational effectiveness can be obtained by contacting the transit system involved with the treatment (see Appendix A for individuals to contact).

TABLE 3-1. CAR NOISE AND VIBRATION CONTROL TREATMENTS

KEY: ■ MAJOR OR PRIMARY EFFECT
▲ SMALLER OR SECONDARY EFFECT
○ LITTLE OR NO EFFECT

CAR TREATMENTS (WHEELS, TRUCK, CAR BODY)	TYPE OF NOISE/VIBRATION										
	WHEEL/RAIL			PROPULSION EQUIPMENT	ELEVATED STRUCTURE	GROUND-BORNE	OTHER	LOCATION QUIETED			SOURCE OF INFORMATION
	SQUEAL	IMPACT	ROAR					CAR INTERIOR	WAYSIDE	STATION	
RESILIENT WHEELS	■	○	○	○	○	▲	○	✓	✓	✓	TESTED AT SEPTA (25). IN USE OF THE LRV'S ON THE MBTA AND SFMUNI
DAMPED WHEELS	■	○	○	○	○	○	○	✓	✓	✓	RING-DAMPED WHEELS TESTED AT SEPTA (25). FOUR TYPES WILL BE TESTED BY NYCTA. IN USE AT CTA AND PATCO. CONTRAINED-LAYER DAMPERS IN USE IN PARIS.
WHEEL TRUING	▲	■	■	○	■	■	○	✓	✓	✓	IN GENERAL USED TO ELIMINATE WHEEL FLATS. IN ADDITION TO UNDERFLOOR TRUING MACHINES, BELT GRINDERS USED ON BART AND TTC.
SLIP/SLIDE PREVENTION	○	■	○	○	■	■	○	✓	✓	✓	USED ON NEW CARS IN NYCTA, WMATA, BART, AND MBTA. BEING TESTED FOR RETROFIT ON CTA.
STEERABLE TRUCKS	■	○	○	○	○	○	○	✓	✓	✓	BEING TESTED ON PATCO
SOFT PRIMARY SUSPENSION	○	▲	▲	○	○	■	○	✓	✓	✓	MANY NEW CARS HAVE SOFT PRIMARY SUSPENSIONS. TESTED AS A RETROFIT ON CTA.
VEHICLE SIDE SKIRTS	▲	▲	▲	■	○	○	○		✓		EXPERIMENTALLY EVALUATED FOR POSSIBLE USE ON PATCO AND MIAMI (36).
UNDERCAR ABSORPTION	▲	▲	▲	■	○	○	○	✓	✓	✓	EXPERIMENTALLY EVALUATED FOR POSSIBLE USE ON PATCO AND MIAMI (36).
SEALING CAR BODY (DOORS, WINDOWS)	■	■	■	■	■	○	○	✓			ALL NEW CAR PURCHASES HAVE SPECIFICATIONS ON CAR BODY TRANSMISSION LOSS. RETROFIT FIXES WERE DEVELOPED FOR NYCTA (47).
QUIET MOTOR COOLING FAN	○	○	○	■	○	○	○	✓	✓	✓	NEW, QUIETER DESIGNS USED ON NYCTA, MARTA, AND WMATA.
FORCED VENTILATION MOTOR COOLING	○	○	○	■	○	○	○	✓	✓		USED ON MARTA AND CTA.
REDUCED TRAIN SPEED	▲	■	■	■	■	▲	○	✓	✓	✓	USED IN NOISE-SENSITIVE AREAS ON NYCTA, MARTA, BART.
REDUCED TRAIN LENGTH	■	■	■	■	■	■	○	✓	✓	✓	
AIR BRAKE VENT MUFFLERS	○	○	○	○	○	○	BRAKE SYSTEM	✓		✓	TESTED ON NYCTA.
WHEEL FLAT OR ROUGHNESS MONITOR	○	■	■	○	▲	▲	○	✓	✓	✓	USED ON TTC.

NOTE: NUMBERS IN PARENTHESIS REFER TO REFERENCES IN APPENDIX B.

TABLE 3-2. TRACK AND WAYSIDE NOISE AND VIBRATION CONTROL TREATMENTS

KEY: ■ MAJOR OR PRIMARY EFFECT
▲ SMALLER OR SECONDARY EFFECT
○ LITTLE OR NO EFFECT

TRACK AND WAYSIDE TREATMENTS	TYPE OF NOISE/VIBRATION: WHEEL/RAIL			PROPULSION EQUIPMENT	ELEVATED STRUCTURE	GROUND-BORNE	OTHER	LOCATION QUIETED			SOURCES OF INFORMATION
	SQUEAL	IMPACT	ROAR					CAR	WAYSIDE	STATION	
RAIL WELDING	○	■	○	○	■	■	○	✓	✓	✓	ALL NEW SYSTEMS BEING BUILT WITH CONTINUOUS WELDED RAIL. NYCTA IS WELDING IN-PLACE RAIL (25).
RAIL GRINDING	○	▲	■	○	■	■	○	✓	✓	✓	DONE ON SYSTEMS WITH RAIL CORRUGATION: NYCTA, CTA, SEPTA (25)
LUBRICATING RAIL ON CURVES	■	○	○	○	○	○	○	✓	✓	✓	STUDIED AT PATH (48) AND OTHER U.S. AND EUROPEAN SYSTEMS (59) BEING USED FOR CONTROL OF WEAR ON MOST SYSTEMS (NYCTA, PATH).
HARDFACING RAIL ON CURVES	■	○	○	○	○	○	○	✓	✓	✓	IN LIMITED USE IN EUROPE (59).
RESILENT RAIL FASTENERS	○	▲	▲	○	▲	■	○		✓		USED ON MARTA, WMATA, TTC, BART. TESTED ON STEEL ELEVATED STRUCTURES IN NYCTA (54)
NOISE BARRIERS	■	■	■	■	▲	○	UNDERCAR, YARDS, SHOPS		✓	✓	USED ON ELEVATED STRUCTURES IN MARTA AND BART (54).
PARTIAL OR FULL ENCLOSURE	○	○	○	○	■	○	YARDS + SHOPS		✓		USED ON ONE ELEVATED STRUCTURE ON TTC. TESTED EXTENSIVELY ON ELEVATED STRUCTURES ON THE JAPANESE NATIONAL RAILWAY (JNR) (39).
STRUCTURAL DAMPING	○	○	○	○	■	○	CAR BODY COMPONENTS	✓	✓		TESTED ON STEEL RAILWAY BRIDGES ON THE DB (GERMAN FEDERAL RAILWAYS) (54) AND ON THE JNR AND MARTA (39,54)
ACOUSTICAL MATERIAL IN STATIONS/TUNNELS	■	■	■	■	○	○	UNDERCAR	✓		✓	DESIGNED INTO STATIONS ON NEW SYSTEMS (MARTA, WMATA, BART). RETROFITTED IN SOME STATIONS ON NYCTA.
BALLAST MATS	○	○	○	○	▲	■	○		✓		EVALUATED IN EUROPE, CANADA, AND JAPAN (39,50)
FLOATING SLAB TRACK	○	○	○	○	▲	■	○		✓		USED ON WMATA, MARTA. TESTED ON NYCTA (39).
FLOATING TIES OR MINI-SLABS	○	○	○	○	○	■	○		✓		USED ON TTC (50) AND IN EUROPE (39).
TRENCHES OR IN-GROUND BARRIERS	○	○	○	○	○	■	○		✓		TESTED ON TTC AND IN JAPAN (35).
GENERAL TRACK MAINTENANCE	○	■	○	○	■	■	○	✓	✓	✓	EFFECT OF RAIL JOINT MAINTENANCE ON IMPACT NOISE EVALUATED ON SEPTA (25).

NOTE: NUMBERS IN PARENTHESIS REFER TO REFERENCES IN APPENDIX B.

4. FEDERAL GRANTS

The federal government supports progams which promote cost-effective noise control technology through grants for research, development, and demonstrations, as well as assistance in capital funding for new and rehabilitated vehicles and facilities. Noise abatement projects are funded by UMTA under two sections of the Urban Mass Transportation Act. Section 3 of the Act authorizes grants for captial improvements, including new and rehabilitated vehicles and facilities. Section 6 authorizes grants for research, development and demonstration projects in relation to new facilities, equipment, techniques, and methods.

The following material describes how these UMTA grant programs can be used to assist transit authoritites in solving critical noise and vibration problems.

Capital Assistance Program-UMTA Section 3 Grants

Section 3 of the UMTA Act authorizes grants for capital improvements including new and rehabilitated vehicles and facilities. Under this funding category, transit authorities have the opportunity to include noise abatement as part of their capital improvements. For example UMTA has approved and encouraged the following types of noise abatement products as part of new equipment, new construction, and system rehabilitation:

- Product and system design assistance from acoustical consultants

- Quiet components and acoustical insulation in new and rehabilitated rail cars and equipment.

- Welded rail, resilient rail fasteners, and noise barriers for track and stations as part of new construction and rehabilitation programs.

It is recommended that transit authorities attempt to incorporate the latest noise and vibration control technology in their capital improvement programs.

The previous section presented an overview of treatments currently in use on various U.S. properties. More detailed information can be obtained from the TSC Urban Rail Noise Abatement Program Office.

Research, Development and Demonstration Program - UMTA Section 6 Grants

Section 6 of the Act authorizes research, development and demonstration projects in relation to new facilities, equipment, techniques, and methods. The following is a brief description of the different types of projects that UMTA classifies as research, development and demonstration (RD&D):

Research Projects - Projects intended to investigate possible improvements in urban mass transportation with regard to equipment, facilities, systems, or methods.

Development Projects - Projects involving the fabrication, testing, and evaluation of new equipment, facilities, systems, or methods resulting in prototype hardware, test results, and reports.

Demonstration Projects - Projects in the final stage in the RD&D process, prior to large-scale transit system implementation. In this stage, technical and procedural innovations in urban mass transportation are subjected to limited in-service operation. The main purpose of demonstrations is to develop information for national application at other candidate sites by demonstrating the project's economic and technical feasibility. A factual basis can thus be provided for decisions regarding subsequent transportation investment.

Many noise abatement projects have been funded under the UMTA RD&D Program. Typically these RD&D efforts concentrate on the demonstration phase of a project and are performed under revenue service conditions. Working through the Transportation Systems Center (TSC), UMTA will often fund a project which is jointly managed by TSC and a public transit agency. In some cases, TSC will hire a contractor to perform the work, and UMTA will issue a grant to the agency to cover their part of the costs. In other cases transit authorities may manage the entire process and perform the work with in-house personnel and/or contractors.

An example of the first type of arrangement is the NYCTA damped wheel testing. The purpose of this test is to evaluate the acoustic, economic, and operational effectiveness of four types of wheel dampers (ring dampers, constrained layer dampers, and tuned dampers) in revenue service operations. These treatments are potential cost-effective solutions to the problem of wheel squeal from transit cars on short-radius curves. The test program is being planned by TSC and will be conducted by a contractor to TSC. The New York City Transit Authority will be compensate through a Section 6 grant for materials and services provided during the test, including: furnishing and maintaining wheels and damping mechanisms, providing trains and appropriate test sites, and assisting in the technical evaluation of test results.

With all such Section 6-funded tests, UMTA requires a thorough report on the results of the project in order to make the information available to the transit industry at large.

The application process for RD&D grants is described in Circular No. UMTA C 6100.1 dated July 9, 1979 (available in UMTA Regional Offices). Prior to initiating the application process, it is advisable to discuss the RD&D project informally with the UMTA Office of Rail and Construction Technology or the TSC Urban Rail Noise Abatement Program Office.

APPENDIX A. INDIVIDUALS INVOLVED IN NOISE CONTROL APPLICATIONS

The following list contains names of transit industry personnel who are involved in the application of noise control technology. Many of these people are members of the APTA Noise and Vibration Subcommittee of the Way and Structures Committee or the APTA Noise and Vibration Liaison Board to the Transportation Systems Center.

The Subcommittee is generally responsible for reviewing and establishing APTA policy in the area of noise and vibration, while the Liaison Board is more technical in nature and works to ensure that UMTA-sponsored programs are applicable and responsive to transit industry needs. Because of their experience in noise control applications, members of these committees are particularly knowledgeable. Subcommittee members are indicated by the letters "SC" and Liaison Board members by "LB" in the following list.

Transit Systems

City/Acronym	Name and Address	Principal Contacts For Noise Programs
Atlanta (MARTA)	Metropolitan Atlanta Rapid Transit Authority 2200 Peachtree Summit 401 West Peachtree St., NE Atlanta, GA 30308 (404) 586-5000	Sahab Nooromid (LB)(SC) Mechanical Engineer (Facilities) 586-5015
Baltimore (BRRT)	Mass Transit Administration of Maryland 109 East Redwood Street Baltimore, MD 21202 (301) 383-3434	Frank A. Hoppe (LB) Director of Construction and Systems 383-6184 Robert Hampton (SC) Director of Facilities Engineering 383-4442
Boston (MBTA)	Massachusetts Bay Transportation Authority 50 High Street Boston, MA 02110 (617) 722-5000	John I. Williams (LB) Project Manager, Design and Development 722-3320

City/Acronym	Name and Address	Principal Contacts For Noise Programs
Chicago (CTA)	Chicago Transit Authority Merchandise Mart Plaza P.O. Box 3555 Chicago, IL 60654 (312) 664-7200	Walter R. Keevil (LB) (SC) Supervisor Electrical Vehicle Design Ext. 547
Cleveland (GCRTA)	Greater Cleveland Regional Transit Authority 3420 East 93rd Street Cleveland, OH 44104 (216) 781-5100	Ken Sislak (LB) Director of Technical Services Ext. 286
Los Angeles (SCRTD)	Southern California Rapid Transit District 425 S. Main Street Los Angles, CA 90013	Neil P. Richards (SC) Project Engineer (213) 972-6341 James E. Crawley Deputy Chief Engineer for Ways and Structures (213) 972-6562
Miami (METRO)	Metropolitan Dade County Transportation Administration 44 West Flagler Street Miami, FL 33130 (305) 579-5674	Robert T. Bretz (LB) Principal Vehicle and Car Equipment Engineer 579-5576
Montreal (MUCTC)	Montreal Urban Community Transit Commission Metropolitan Transit Bureau 1701 De Havre Street Montreal, Quebec H2L 4J7 (514) 877-6300	Jean Paul Senay, Chief of Equipment (LB) 872-6940
New York (NYCTA)	New York City Transit Authority 370 Jay Street Brooklyn, NY 11201 (212) 878-7000	Anthony Paolillo (LB) Staff Division Engineer, Environmental Staff Division 330-3115 William Jehle Environmental Staff Div. 330-3115
New York (PATH)	Port Authority of New York and New Jersey One PATH Plaza Jersey City, NJ 07306 (201) 963-7000	Mehemet Yontar (LB) (SC) Engineer of Research and Development 963-7201 Vincent Petrucelli 963-7213

City/Acronym	Name and Address	Principal Contacts For Noise Programs
Philadelphia (SEPTA)	Southeastern Pennsylvania Transportation Authority 200 West Wyoming Avenue Philadelphia, PA 19140 (215) 456-4000	Russell Jackson (LB) Transportation Systems Engineer 456-4525 John Petro Environmental Planner 574-2769
Philadelphia (PATCO)	Port Authority Transit Corporation Benjamin Franklin Bridge Plaza Camden, NJ 08102 (609) 963-8300	J. William Vigrass (LB) Superintendent of Equipment Ext. 233
San Francisco (BART)	Bay Area Rapid Transit District 800 Madison Street Oakland, CA 94607 (415) 465-4100	Joseph C. Sheehy (SC) Mechanical Engineer Ext. 848
Toronto (TTC)	Toronto Transit Commission 1900 Yonge Street Toronto, Ontario M4S 1Z2 (416) 534-9511	Alex Hunt (LB)(SC) Superintendent Environmental Assessment and Research Ext. 798
Washington, DC (WMATA)	Washington Metropolitan Area Transit Authority 600 Fifth Street N.W. Washington, DC 20001 (202) 637-1234	Homer Chen (LB)(SC) Senior Structural Engineer 637-1342

U.S. Department of Transportation (DOT)

Urban Mass Transportation Administration (UMTA)
400 Seventh Street S.W.
Washington, DC 20590

Office of Technology Development and Deployment (Code UTD-1)

Peter Benjamin, Associate Administrator - (202) 426-4052

Office of Rail and Construction Technology (Code UTD-30)

Stephen Teel, Director - (202) 426-0090
Paul Spencer, General Engineer - (202) 426-0090

Transportation Systems Center (TSC)
Kendall Square Cambridge, MA 02142
Urban Rail Noise Abatement Program (Code DTS-331)

Mr. Robert Hinckley, Program Manager - (617) 494-2185 or 2402
Mr. Michael Dinning, Assistant Program Manager - (617) 494-2119 David Knapton.
Ms. Meryl Richmond, Librarian - (617) 494-2783

American Public Transit Association (APTA)

1225 Connecticut Ave. N.W.
Suite 200
Washington, DC 20036

Mr. Ted Gordon, (LB)(SC), Senior Engineer, Technical Research - (202) 828-2886

APPENDIX B - REFERENCES

The references listed below are valuable in noise and vibration control planning and implementation. Many of these documents are available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161. NTIS orders may also be placed by calling (703) 557-4650. To order reports from NTIS, use the order numbers (PB numbers) listed after most of the references below. The lack of an order number indicates that the report is not available through NTIS.

These documents are also available through various technical and university libraries and from the Urban Rail Noise Abatement Information Center through an interlibrary loan. To use the center, contact Meryl Richmond, Librarian, DTS-930, Transporation Systems Center, Kendall Square, Cambridge, MA 02142, telephone (617) 494-2783.

General Acoustical References

1. Handbook of Noise Control. C.M. Harris, (editor), McGraw-Hill, 1979.

2. Handbook of Noise Measurement. P.G. Peterson and E. E. Gross, Jr., GenRad, Inc. 1974.

3. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. Environmental Protection Agency, EPA Report 550/9-74-004, March 1974. PB239 429.

4. 1981 Guidelines for Design of Rapid Transit Facilities. American Public Transit Association (APTA), Section 2-7, June 1981.

5. Noise and Vibration Control. L.L. Beranek, (editor), McGraw-Hill, 1971.

6. Shock and Vibration Handbook. C.M. Harris and C.E. Crede (editors), 2nd edition, McGraw-Hill, 1976.

Noise and Vibration Assessement

7. Development of an Acoustic Rating Scale for Assessing Annoyance Caused by Wheel Rail Noise in Urban Mass Transit. T.J. Schultz, Bolt Beranek and Newman Inc. February 1974. UMTA-MA-06-0025-74-2, PB-231-363.

8. National Assessment of Urban Rail Noise. G. Chisholm et al.; U.S. DOT, Transportation Systems Center. March 1979. UMTA-MA-06-0099-79-2, PB-295-752.

9. Noise Assessment and Abatement in Rapid Transit Systems - Report on the MBTA Pilot Study. L.G. Kurzweil, R. Lotz, and E.G. Apgar; U.S. DOT, Transportation Systems Center. September 1974. UMTA-MA-06-0025-74-8, PB-238-113.

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