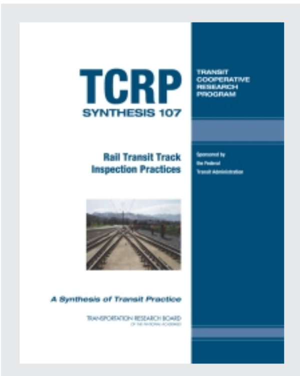

Rail Transit Track Inspection Practices

DETAILS

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TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP SYNTHESIS 107

Rail Transit Track Inspection Practices

A Synthesis of Transit Practice

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TRANSPORTATION RESEARCH BOARD
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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

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FOREWORD

Transit administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the transit industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire transit community, the Transit Cooperative Research Program Oversight and Project Selection (TOPS) Committee authorized the Transportation Research Board to undertake a continuing study. This study, TCRP Project J-7, "Synthesis of Information Related to Transit Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute a TCRP report series, *Synthesis of Transit Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Donna L. Vlasak
Senior Program Officer
Transportation Research Board

As there are no actual rail track safety or maintenance standards promulgated for transit, this synthesis offers state-of-the-practice information across a range of older and newer U.S. rail transit agencies on track inspection practices and policies. The goal is to provide rail transit agencies with a knowledge base of information that might help them to develop their own set of track safety and maintenance standards. Basic information gathered here includes agency staffing, agency organization and characteristics, track inspection program criteria, training and certification, procurement, and track safety practices.

A review of the relevant literature yielded limited results. Organizations affiliated with the rail transit industry in the track inspection area are identified, along with their recommended practices issued as guidance to the rail industry in establishing individual policies and practice relative to each agency. A selected survey of 29 respondents out of 34 rail transit agencies, across a range of rail operations, yielded an 85% response rate. Four rail transit providers highlighted more in-depth and additional details on successful practices, challenges, and lessons learned. All agency information is anonymous, as requested.

John F. Zuspan, Track Guy Consultants, Canonsburg, Pennsylvania, collected and synthesized the information and wrote the report, under the guidance of a panel of experts in the subject area. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

RAIL TRANSIT TRACK INSPECTION PRACTICES

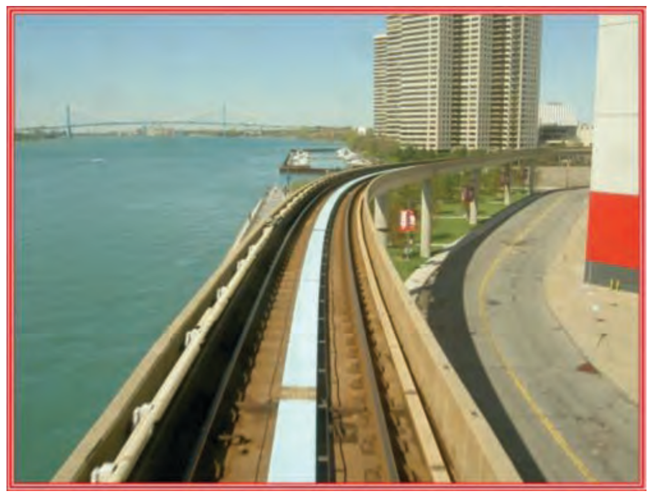
SUMMARY

In 2012, the number of transit rider trips in the United States reached a record 10.5 billion; according to APTA, almost half of those trips, 4.7 billion, were on transit-rail systems. Each one of those trips presents inherent risks because of the nature of the activity—large vehicles in motion. In order to minimize these risks, each agency must develop and adhere to inspection criteria or standards. Generally, a select few individuals in each transit agency develop and implement safety standards for the inspection and maintenance of track, vehicles, stations, signals, bridges, etc. Both FRA and APTA have developed track and vehicle inspection standards which may or may not be applicable to the various transit agencies because of significant differences in systems' specifications and equipment.

The purpose of this synthesis was to document for the rail transportation industry common safety and inspection standards and maintenance practices, based on the various rail system types. There are several modes of rail transit, including light rail, street car/trolley, heavy rail, and commuter rail; and each requires different specific safety, inspection, and maintenance standards. Track and gage differences among 19th century freight and passenger railroads in Canada and various regions of the United States caused increasing difficulties as long-distance transportation and shipping increased; so by the 1880s, the North American freight rail industry had standardized track design to permit the interchange of rail equipment. Consequently, there is one set of Track Safety Standards for freight railroads, as published and enforced by the FRA; but no "one size fits all" set of standards is possible for passenger rail transit agencies.

This synthesis summarizes state-of-the-practice information on track inspection and maintenance standards and recommended safety practices, in an effort to assist all transit agencies in the development of their own set of track safety standards and, more importantly, maintenance standards. Since many transit agencies are not part of the national railroad system, and therefore not governed by federal inspection or maintenance practices, each agency must establish its own maintenance program to ensure that passengers are transported in a safe and reliable manner.

Each transit agency has unique operating characteristics, such as vehicle loading, wheel and axle configuration, capacity, suspension system, types of track, right-of-way clearance, and gage; and a variety of propulsion methods (self-propelled, locomotive-hauled, diesel, electric, etc.). All share the same basic principle of flanged steel wheels running on fixed steel rails, and the geometry of the tracks is generally similar; however, minimum horizontal and vertical curve radii vary significantly, and many systems employ unique special track work designs, such as flange-bearing frogs, tongue and mate switches, and restraining rails. Each rail transit authority must develop its own criteria based upon these components. For this synthesis, a sample of rail transit properties across the United States was asked to complete a detailed questionnaire concerning track inspection and maintenance practices. Despite the differences in some responses, one tenet learned through survey response ran throughout: that the primary responsibility of each agency or transit authority is passenger safety.



The questionnaire and additional interviews revealed significant differences in track inspection and maintenance policies among the transit agencies surveyed. Some differences are the result of variations in wheel diameter and profile, back-to-back dimensions, flange width and depth, etc.; or differences among types of rail, methods of rail attachment (cut spikes, direct fixation, etc.), and track gage and geometry. For example, the distance between axles and wheel sets determines the minimum radius of the curves that the vehicle can negotiate. The amount of super elevation unbalance assigned to the curves and adjoining spiral lengths affects passenger ride comfort and limits the maximum permissible operating speed. The frequency of safety inspections and the standards for track maintenance that each agency uses must be tailored to these characteristics. As a result, personnel training varies significantly as well. However, all respondents reported that proper track maintenance is essential to passenger safety.

To obtain information on current practices, a questionnaire was developed regarding the maintenance and inspection of the track structure. Of the 35 agencies surveyed, 29 agencies responded for an 83% response rate.

As the agencies' standards are confidential and therefore something of a sensitive topic, many agencies requested anonymity, and this report is respectful of their requests. Survey information has been limited to those involved in the preparation of this synthesis.

According to the survey responses, the average age of the 29 agencies is 45 years. Agencies using electric traction power systems are evenly split between third-rail and overhead line (catenary). There is also an even split in the application of Track Safety Standards, FRA, or APTA. The majority of the agencies (69%) responded that they are not regulated by the FRA; a few stated that a portion of their system is regulated by the FRA. A third of the respondents (34%) stated they do not have a CWR (continuous welded rail) plan. The results of the survey are summarized in the matrix and bar graphs.

In addition, seven transit supervisors provided answers to more specific and intuitive questions about their philosophies pertaining to track maintenance. Case examples of three heavy rail agencies and one light rail agency offer more detailed information. Based on information collected for this synthesis, issues of training and certification, geometry testing standards, the wheel-to-rail interface, and procurement practices are suggested for future study.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Rail transportation systems in the United States have been around since 1830, when the first steam engine appeared. As the loads on the rails increased, engineers and maintenance workers recognized the need for harder rails and stiffer track structures, which had to be kept in a good state of repair to prevent derailments and potential loss of life. The rail itself has evolved from pig iron rail to the continuous casters of today, but the philosophy—that maintenance is essential to passenger safety—has not changed. The improvements in materials and rolling stock that help in the maintenance process are also inspired by that tenet.

Every major city in the United States relied on passenger rail systems during the last decades of the 19th century and into the first part of the 20th century, but with the inventions of the automobile and airplane, which allowed more Americans greater freedom of travel, much of the urban railway systems disappeared. After President Dwight D. Eisenhower created the Interstate Highway System, the railroads were even further reduced. However, since 1980, when the first light rail (LR) system opened in San Diego, state and local governments all over the country have rediscovered the importance of urban transportation, and have begun building light rail systems.

The freight railroads were regulated until 1980, when the Staggers Rail Act turned railroads into private (and very profitable) businesses. The metropolitan railways that do not carry freight commodities have never been regulated, and therefore have created their own sets of maintenance standards in order to prevent derailments and protect passengers. When a freight railroad violates a track safety standard, it is subject to heavy fines. This is not the case with transit agencies; if they violate their own safety standards, their only penalty is customer dissatisfaction.

Transporting people safely is the primary objective of any transit agency. To perform this task, the track should be built and maintained to a certain standard. Tolerance for construction (i.e., the acceptable amount of deviation from design dimensions) is well-defined and in most cases observed; however, although a number of organizations have defined absolute minimum maintenance requirements, none has provided maintenance tolerances, leaving them to the individual transit agency.

By law (see Appendix C), transit agencies cannot be regulated or told how to run their system. This leaves the issue of track safety to each individual agency. Though the NTSB was established in 1967 to conduct independent investigations of serious transit accidents and offer recommendations to prevent reoccurrences, it has no regulatory or enforcement powers.

This synthesis documents how transit agencies evaluate track defects and their severity, and how the number and seriousness of these defects affect train operations with respect to allowable speed and safety. To that end, information has been collected on these topics in the scope of work:

1. Staffing
2. Agency organization
3. Physical characteristics and age
4. Track inspection program criteria
5. Training/certification
6. Operating practices/defect response policy/regulatory requirements
7. Procurement practices
8. Track safety practices.

The intent of this report is to provide information to the rail transit industry, general managers, transit staff, and other stakeholders so transit agencies can work together to fulfill the primary objective: safely moving people.

ISSUES

Transit agencies vary greatly in their policies, as highlighted throughout this report. Following is a listing of problem statement issues generated by the topic panel:

- FRA requirements: Do transit agencies apply the federal requirements for freight railroads to their property in the transit arena? Throughout this report, reference is made to the FRA and its criteria as they apply to the general railway system in the United States.
- Agency policy: What are the policies, regulations, and guidelines that each transit agency uses to maintain its track structure?
- Defects affecting operations (speed restriction/operations policy): Which safety defects trigger speed restrictions, if any? This issue was addressed in the questionnaire

and the follow-up interviews with seven transit maintenance supervisors. As a safety issue, this is highlighted throughout this report.

- Wheel/rail interface: This issue is addressed in the questionnaire. The diversity is shown and problems with this issue are addressed within the railroad industry. Specific issues with wheel/rail interface are not addressed in this report, but volumes of papers and studies are available.
- Safety issues: How do agencies view safety? Safety is the first priority, emphasized by the seven respondents who were asked more specific questions about their philosophy.
- Employee qualifications: Are employees trained before they are given the responsibility of protecting the riding public by ensuring a safe track system? This issue was addressed in the questionnaire, responses to which showed that not all personnel are trained.
- Agency practice dealing with challenges: How do transit agencies define and respond to problems? A problem might be interpreted differently by a track maintenance worker than by a person responsible for keeping to a schedule. Finding the right balance between both departments can be challenging, as expressed by the seven maintenance supervisors.
- Management practice/implementation upon notice: Whose responsibility is it to prioritize and effectively implement a plan to correct a defect in the track structure? The questionnaire shows how different agencies deal with this important task.
- Track inspection policy specifics (types, timing, staffing, training etc.): The survey offers specifics about different types of defects and how personnel are trained to identify these defects. Agency managers were asked whether their system uses a priority system, as recommended by APTA, to prioritize remedial actions. It could be the responsibility of the supervisor to assign manpower and determine the severity in order to determine when the task must be completed.
- Who does what? The survey suggests that agencies differ in their assignment of responsibilities, and that responsibility may either roll up the chain of command or stay within the lower echelon.
- Agency profile/physical characteristics (age): What is the general overview of each agency? This issue was addressed in the questionnaire.
- Track inspection program: How frequently is track inspected and reported? This was addressed in the questionnaire.
- Procurement policy: Do the agencies purchase only American products or consider price? Transit agencies differ on their procurement policies, as shown in the responses.
- ADA issues: Has the agency faced any problems involving the ADA? This issue was not specifically addressed in the questionnaire, but because all transit agencies receive federal financing, they must abide by the Americans with Disabilities Act enacted in 1991 and revised in 2011.

DEFINITIONS

The following common industry terms used in this report will help the reader gain a better understanding of track-related items.

- Gage (gauge): Normally the distance measured between each rail ⅝ in. below the head. Some transit agencies with a ¾-in. wheel flange will measure ¼ in. to ⅝ in. below the top of rail. “Gage” is the U.S. spelling and “gauge” is the European spelling.
- Cant (rail inclination): Cant is the term related to the tilting of either rail with respect to a plane parallel to the wheel axle. In the United States, the typical rail cant is 40:1 and in Europe it is 20:1. Cant determines the wheel and rail relationship and helps with hunting (the abrupt side-to-side movement caused by a wheel’s moving back and forth within the free play of the gage). This is also important for wheel and rail wear. In Europe this is typically referred to as rail inclination (see Figure 1).
- Super-elevation (cant deficiency) (cant): This is the relationship between each rail irrespective of the wheel axle. Super-elevation is typically required on curves with speeds greater than 15 mph (see Figure 2). This relationship for standard gage track is calculated by

  $$E_t = 0.0007 \times D \times V^2$$

  where

  E_t is the total super-elevation,
  D is the degree of curve, and
  V is the velocity in miles per hour.

  When using the radius of the curve, the formula is $E_t = 3.78 \times V \times (V \div R)$, where R is the radius of the curve in feet. Once the full super-elevation is determined, then an unbalance is applied, typically to a maximum of 3 inches. In Europe they use the term cant deficiency or simply cant (which can become confusing when international discussions occur).
- Alignment: This is the horizontal path along which the track is designed.

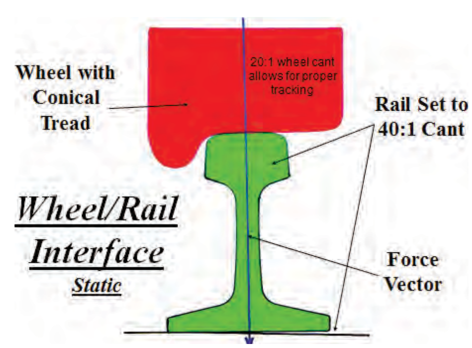


FIGURE 1 Wheel/rail interface: static.

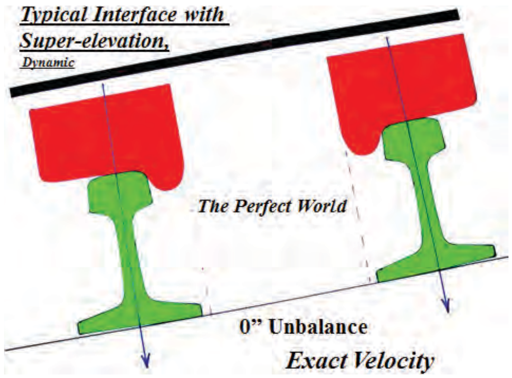


FIGURE 2 Typical interface with super-elevation: dynamic.

- Unbalance (underbalance) (imbalance): Once the full super-elevation is calculated, the unbalance is subtracted from E_t to achieve the actual elevation applied E_a. The amount of centripetal force must typically not exceed 0.1 g to 0.15 g (see Figure 3).
- Twist (cross slack): the difference between several cross level measurements.
- Tangent track: This is simply the term given for straight track.
- Flange (wheel flange): This is the amount of metal that extends down beyond the wheel tread which guides the train along the track.
- Flangeway: The distance between the gage face of the running rail and the guard face of the guard rail or restraining rail (see Figure 4).
- Tread: The surface of the wheel that rides on top of the rail.
- Rail flaw: An internal or external defect in the rail (see Figure 5).
- Direct Fixation Fastener (DFF): This type of rail fastener is used when constructing direct fixation (DF) track. It is made up of two steel plates surrounded in rubber that do not touch, allowing for noise and vibration protection to protect the concrete plinth from impact forces. These fasteners also allow for stray current protection.

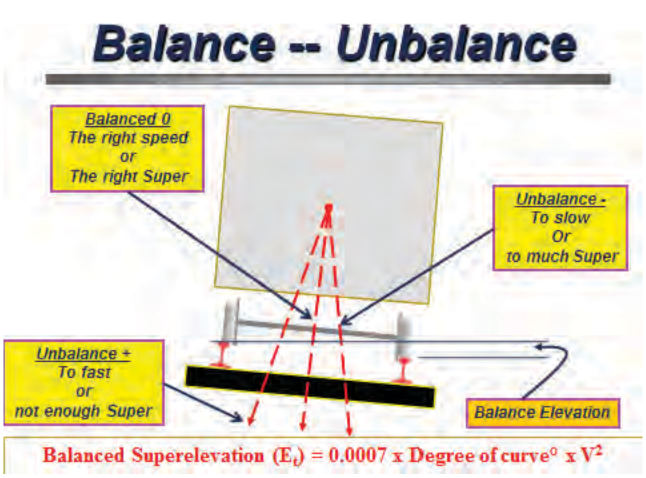


FIGURE 3 Balance–unbalance.

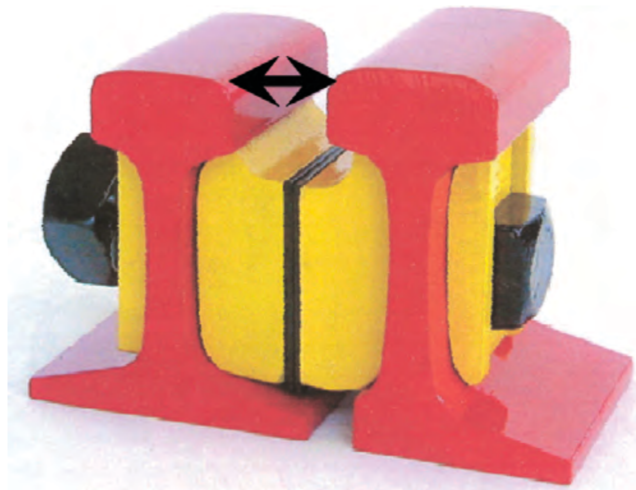


FIGURE 4 Flangeway.

The following nonstandard acronyms, common in the rail transit industry, are used in this report:

- CPUC: California Public Utilities Commission
- AREMA: American Railroad Engineering and Maintenance Association
- CS: Canadian Standards
- GRMS: Gage Restraint Measuring System
- CWR: Continuous welded rail (any rail longer than 400 feet)
- TMS: Track Maintenance Standards
- TSS: Track Safety Standards.

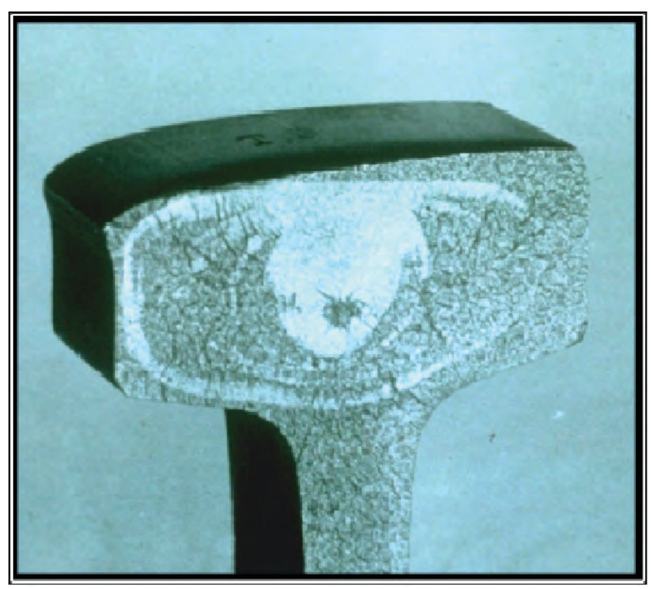


FIGURE 5 Internal flaw.

REPORT ORGANIZATION

Information in this synthesis is presented as follows:

Chapter one—Introduction offers general historical background of the passenger transportation system as well as the problem statements that guided this synthesis report. This chapter also contains specific definitions that are common to the industry as well as acronyms and issues related to the transit industry.

C**hapter two—Major Associations and Agencies Affiliated with the Rail Transit Industry** identifies those entities active in the rail transit industry.

Chapter three—Case Examples contains agency details from three heavy rail systems and one light rail system. Each agency was visited and observations documented.

Chapter four—Survey Results presents rail agency responses in tabular form, showing percentages of agency responses to each question. Detailed text responses, as they were received, are also provided in this chapter. Further details are given in the matrix as well as in bar graphs for certain questions. At the end of this chapter are the responses of seven transit supervisors who were asked more specific questions regarding their philosophy pertaining to track maintenance.

Chapter five—Conclusions summarizes the report findings and suggest further research.

Appendix A is the survey questionnaire. Appendix B is the list of agencies that received the questionnaire. (Agencies are not identified by name and only listed as A, B, C, etc., within the report to protect their anonymity, as requested.)

Appendix C is a Congressional hearing testimony concerning transit oversight. Appendix D contains FTA Track Safety Standards. Appendices E and F show the specific criteria of track safety standards presented by APTA, FRA, and nine transit agencies that allowed their maintenance criteria to be included in this report. Appendix F contains a discussion that applies to the criteria in Appendix E.

CHAPTER TWO

MAJOR ASSOCIATIONS AND AGENCIES AFFILIATED WITH THE RAIL TRANSIT INDUSTRY

Over the years many organizations have assisted or overseen the rail transportation industry. Some regulate and some may simply observe, whereas others may recommend. They all play a vital role in achieving the primary objective: to move people safely.

FEDERAL RAILROAD ADMINISTRATION

The FRA was established under the U.S.DOT in 1966, and was operational by April 1, 1967. Its function is to issue and enforce railroad safety regulations, including its Track Safety Standards (*1*); to administer railroad financial assistance programs and grants; and to conduct research. The FRA employs approximately 500 certified inspectors, has eight regional offices, and inspects freight railroads within the general railroad system. It has the authority to impose fines that can be very expensive to a rail agency.

AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

APTA, which includes public transportation organizations as well as those that design, construct, and supply them, was formed in 1974 as the American Public Transit Association and in 2000 changed its name to American Public Transportation Association. In 2004, APTA published a manual on track safety standards and asked all transit agencies not under FRA jurisdiction to comply by 2006. This was on a volunteer basis and not enforceable, because APTA is a membership association without a regulatory function.

The manual is comprised of six volumes covering, respectively, Background and Process, Vehicles, Grade Crossings, Operating Practices, Fixed Structures (which includes track), and Signals and Communications (*2*).

The manual was written by 241 volunteers, representing 25 transit authorities as well as the FTA and Wabtec Corporation (a merger of Westinghouse Air Brake and MotivePower locomotive). It does not apply to commuter rail, and APTA will not accept any liability. The manual follows FRA Track Safety Standards with additional guidance with respect to high water criteria, storage of materials along the right-of-way, lift rails, switch heaters, slip joints, concrete ties, DF track, embedded track, restraining rail, rail wear criteria, slow order restrictions, new construction, power rail, and stray current. None of these conditions is addressed in FRA 213 Track Safety Standards with the exception of concrete ties, which the FRA has recently added to its Track Safety Standards.

CALIFORNIA PUBLIC UTILITIES COMMISSION

CPUC regulates privately owned railroad, rail transit, and passenger transportation companies. It was created in 1911 as the Railroad Commission, and in 1912 its regulatory authority was expanded to include natural gas, electric, telecommunications, and water utilities as well as railroads and marine transportation companies. In 1946, it was renamed the California Public Utilities Commission. This commission supersedes the FRA only in California, but does not impose fines. It does not have Track Safety Standards as the FRA does; however, it oversees and comments on an owner's means and methods when performing track maintenance (*3*).

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION

AREMA, formed in 1997 by a merger of railway and bridge engineering support associations all dating to the late 19th century, is a non-profit organization whose members range from chief engineers, CEOs, and owners of railroads to laborers, contractors, and vendors. Its website describes its mission as "the development and advancement of both technical and practical knowledge and recommended practices pertaining to the design, construction, and maintenance of railway infrastructure." AREMA does not inspect or maintain track and has no enforcement power. However, it publishes a four-volume manual of "recommended practices" involving track, infrastructure, systems management, etc., with the "aim of assisting [railways] to engineer and construct a railway plant which will have inherent qualities of safe and economical operations as well as low maintenance cost" (*4*).

FEDERAL TRANSIT ADMINISTRATION

The FTA is primarily responsible for funding of transit projects and historically has had no regulatory authority to enforce compliance with any FTA Track Safety. "The Federal Transit Administration's (FTA) role in the safety oversight of these systems is extremely limited as a matter of Federal law. We are statutorily prohibited from establishing national safety standards for a large segment of the nation's rail transit system" (as testified by FTA administrator Peter M. Rogoff in a Congressional hearing on August 4, 2009; see Appendix C for text of the full hearing). However, the FTA has been compiling a "Pocket Guide" to rail transit best inspection and maintenance practices that, along with legislative changes, may give it regulatory authority in the future.

U.S. DEPARTMENT OF TRANSPORTATION

The U.S.DOT is the umbrella organization of which the FRA has been a sub-section since 1966. Each state has a DOT that in some cases oversees transit agencies and confirms that each agency is abiding by its own maintenance standards. States do not have the authority to impose fines.

CANADIAN STANDARDS ASSOCIATION

The format of the Canadian Standards (CSA) guidelines is identical to the FRA Track Safety Standards, with very minor differences in some criteria. The CSA guidelines are written in U.S. customary measurements, not the International System of Units (SI).

CHAPTER THREE

CASE EXAMPLES

This chapter presents detailed information from three heavy and one light rail transit agencies in the United States. Proactive maintenance appears to be the key factor in extending the life of any system, while deferred maintenance and lack of maintenance standards universally affect the longevity of the transits assets. Regular documentation, as shown in Case Example #1, has also proved beneficial in preserving the life of the system. Training and understanding of the criteria are also important components. Most effective is the development of a set of maintenance standards that are stricter than the published safety standards.

CASE EXAMPLE #1

This transit agency is in the average-sized category, meaning it has between 11 and 50 miles of track. The propulsion system is third-rail and speeds exceed 60 mph. This system is close to 30 years old, and most of its track is DF. It employs more than 100 maintenance workers. This system uses APTA standards as its minimum requirements and has a written maintenance manual whose regulations are even more stringent; the agency plans to update its maintenance standards again. The agency inspects its track twice a week; runs a geometry car three times a year; and tests for internal rail defects twice a year. This transit agency also requires periodic training on APTA standards and CWR for their inspectors, supervisors, and key maintenance personnel.

In discussions with personnel involved in maintaining this system, it was immediately apparent that they care about their system and have a sense of protecting the passengers. The maintenance supervisor was involved in the original construction, so he has intimate knowledge of the system and how it was built. Inspection personnel are well-trained and knowledgeable in all aspects of the track structure, and are constantly walking track and reporting any defects, whether violations or not. One inspector walking track was seen to write down all observations, no matter how apparently insignificant. As the system nears the 30-year mark, unusual wear patterns have been observed on the rail, which may be the result of flaws in the original design and/or not enough super-elevation; as well as what appears to be premature decay of wood timbers encased in concrete. The track supervisor is quick to react and has taken advantage of new technology to make the repairs.

The supervisor tracks inspection information to determine if a pattern of damage is forming, so he can stop it before it becomes a defect. As an example: Inspection reports repeatedly showed clips missing in the station platform areas. The inspector or other maintenance worker would simply install another clip in place of the one that was missing. However, as the supervisor noticed this same issue on the reports regularly, he wanted to know why the clips were breaking in that area. During his investigation, it was found that the people cleaning the stations were washing the water into the track. The cleaning agent being used was highly corrosive, and when it came into contact with the negative return from the third rail, it caused the clips to corrode and snap. The cleaning personnel now use a non-corrosive cleaning agent and try not to wash the water into the track way; but had each broken clip not been recorded, this problem might not had been solved.

The maintenance standards of this agency are very strict, as can be seen in the Maintenance Criteria table in Appendix E, Agency A. The gage tolerances are unforgiving: a minimum of ⅛-inch tight and ¾-inch wide gage throughout the classes of track. The same tolerance applies to a 10 mph train as to a 60 mph train. Only ½ inch is permitted on alignment in any 62 feet of tangent track. These tight tolerances are relatively easy to maintain on DF track, but very difficult to maintain on tangent ballasted track. There are no criteria for high water levels because there are no tunnels in this third-rail powered system. Cross level tolerances are one-third that of APTA Safety Standards. This agency requires many more (20%–40%) good ties or fasteners than the APTA standard, mandating a good tie within 12 inches of a rail joint while APTA and FRA only require 24 inches. The only maintenance criterion that is the same as APTA and FRA is tread mismatch. Guard check and guard face gages are the same in all classes of track. The wear criteria are very strict also. The agency inspects its third-rail system annually and specifies a maximum wear permitted on the third rail before it must be replaced.

CASE EXAMPLE #2

This heavy rail transit system is in the very large category. It is more than 100 years old, and is also a third-rail system. The maximum speed is 55 mph. Fifty percent of the track is wood tie block encased in concrete, 30% is ballasted track, and 20% is elevated track. Approximately half the track is above ground and the other half below. The agency employs more than 100 maintenance workers, and follows its own maintenance standards. It has a safety priority system that restricts train speed. Track inspectors only file reports if there is a defect. A walking inspection is performed twice weekly. The agency runs a geometry car three times a year and performs rail integrity testing six times a year in the subway and three times a year on track outside. It has a formal track inspection training program with a written proficiency test. The maintenance workers are represented by a trade union.

In the 1980s this agency was suffering at least one derailment per month and the track structure was rapidly crumbling. In the early 1980s there was a derailment. There were no fatalities but there were significant injuries, and the NTSB was called in to investigate. This event spurred a massive reconstruction effort that lasted into the 1990s. This system is now in a state of good repair and the track is well maintained.

In general, the agency's maintenance criteria appear to be one-third stricter than APTA or FRA minimum standards. It has a speed-based system that allows it to apply a slow speed order if a defect is observed, assuming it is not more than the slowest speed. The runoff criteria (Appendix F, item 5) are at the limit applied by APTA/FRA, which could be the result of its long cars. Item 8 (deviation from zero cross level) is the same as APTA/FRA minimum safety requirements. The required minimum number of non-defective ties in 39 feet is the same as APTA; however, the criteria for number of ties in a row are stricter. (FRA does not address ties in a row.) In reference to item 23, this agency does not permit the use of a torch, no matter what class track. Tread mismatch and gage face wear standards are basically the same as APTA/FRA. Restraining rail flangeways (item 27) have minimum and maximum specifications, not just a minimum. This is important for prevention of rail wear and derailments. This agency identifies rail and third-rail wear limits.

Minor defects are repaired immediately and inspectors carry a tool with them when walking track, as well as a small backpack with miscellaneous small parts and a couple of mechanics' tools. Many carry a small tool bag. This supervisor says the transit agency has come a long way with hard work and the dedication of employees who remember the debacle of the 1980s; the challenge is to pass this philosophy onto the next generation.

CASE EXAMPLE #3

This is a large heavy rail system (101–200 miles). It is just over 30 years old and reaches speeds greater than 60 mph. The propulsion system is third-rail. The majority of track is DF (70%) and the rest is ballasted track (30%). The agency uses both APTA and FRA maintenance standards and employs between 51 and 100 maintenance workers who inspect their track once a week and run a geometry car twice a year. None of its track is governed by the FRA. The agency reviews and revises its standards annually. Most of its system is below ground.

This system and many others built 30 or more years ago suffer from stray current, which was not understood as it is today. Stray current occurs when there is an interruption of the return path to the sub-station. When the return path (negative return) is interrupted or when the rail is grounded, stray current is produced and becomes very corrosive. The older fasteners were not constructed as they are today; therefore, if stray current is not addressed, it accelerates the corrosion of the reinforcing steel, bolts, and even the rail. This transit agency's maintenance activities are intensely focused on keeping stray current at bay.

In most cases the agency follows APTA Safety Standards. Its maintenance criteria for surface deviation are the same as APTA. Cross level is also the same as APTA. Tie restrictions, with respect to number in a row, match those in APTA. Maintenance criteria for ties at a joint, torch cutting, tread and gage mismatch, rail end batter, flangeways, and frog tread wear all match the minimum track safety standards outlined by both APTA and FRA. The only requirements that are stricter are guard check and guard face gages, which are within 15% of APTA.

CASE EXAMPLE #4

This light rail system is above average in size and uses catenary as a propulsion method. It is approaching the 30-year mark in age. Maximum speed is 45 mph. It has embedded track (18%), DF track (22%), and ballasted track (60%). It employs between 51 and 100 maintenance workers, uses APTA minimum track safety standards, and, in most cases, APTA maintenance standards. It inspects its track twice a month and its turnouts once a month. Geometry and rail flaw detector cars run once a year. None of its track is governed by the FRA. It does not have a CWR plan. It does not have a formal training program for signal maintainers or track inspectors; the only required training is for equipment operators.

Gage requirements (item 1) are slightly stricter than APTA. It has no criteria for variation in alignment in tangent track. Its criterion for surface deviation in 31 feet (item 7) is much stricter (70% more) than the APTA Track Safety Standards. All criteria for warp, ties, torch, tread and gage mismatch, restraining rail, flangeways, and frog wear are consistent with APTA. Guard check and guard face are twice and three times as strict as APTA, respectively.

CHAPTER FOUR

SURVEY RESULTS

Thirty-five questionnaires were mailed to transit agencies, 34 in the United States and one in Canada (see Appendix B). Twenty-nine agencies responded with completed questionnaires, an 83% response rate. The primary objective was to survey transit agencies that were not under FRA jurisdiction, and this narrowed the field to light rail and heavy rail transit agencies. The questionnaire results are tallied in Tables 1–19. Table 1 shows the survey responses.

Tables 2–19 are graphs of specific questions highlighting some questionnaire responses. Each one indicates the number of agencies responding to each answer.

Answers to questions 1–35 follow. Agency responses to each question are provided here, offering some observations, based on either percentage or number of transit agencies responding. In some cases, percentages do not add up to 100% because not all agencies responded to all questions.

Question 1: About how many total miles of track are incorporated in your system (not route miles)? Do not include storage yards.

- Eleven of the agencies (38%) reported having between 11 and 50 miles of track, which will be considered average with respect to this report. Four agencies (14%) reported having less than 10 miles of track, which will be considered small; seven (24%) reported having 51–100 miles, which will be categorized as above average; two (7%) reported having 101–200 miles, considered large; and five (17%) reported having more than 200 miles, considered very large.

Question 2: What year was the first segment of track opened within your system?

- The oldest system in the United States began operation in 1888, and the newest in 2008.

Question 3: What is your top speed on mainline track?

- Eleven agencies (38%) reported a top speed of 5 mph; 10 (34%) reported speeds in excess of 60 mph; four (14%) had a top speed of 45 mph; three (10%) had a top speed of 60 mph; and one system stayed under 35 mph.

Question 4: What is your vehicle power system?

- Seventeen (59%) are operated by catenary and 11 (38%) by third-rail (see Figure 6). Only one agency is operated by diesel power.

Question 5: About how many miles of embedded track are in your system?

- Thirteen (45%) reported having no embedded track and nine (31%) have 4 to 10 miles of embedded track. One agency reported that it has more than 50 miles of embedded track (see Figure 7).

Question 6: About how many miles of direct fixation track do you have?

- Ten (34%) of the transit agencies reported having between 10 and 50 miles of DF track, four (14%) have no DF track, three reported more than 50 miles of DF track, and the remaining agencies reported between 1 and 50 miles of DF track (see Figure 8).

Question 7: About how many miles of ballasted track?

- Eleven (38%) reported having 10 to 50 miles and six (21%) reported more than 50 miles of ballasted track (see Figure 9), while the remainder reported less than 50 miles.

Question 8: How many track maintenance workers do you employ?

- Seven (24%) of the 29 respondents said they have fewer than 10 maintenance workers, another seven (24%) said they have between 10 and 30, and the same number (24%) said they have more than 100.

Question 9: Is your system standard gage 56½”?

- Twenty-four (83%) of the 29 agencies surveyed have standard gage; the other five (17%) reported a different gage.

Question 10: Do your vehicles have tapered (conical) wheels?

- One respondent did not know if his agency has tapered wheels, and one system has a combination of tapered

(text continued on page 18)

TABLE 1
SURVEY RESPONSES

? No.	Question	Totals	Transit Agency																													%
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
1	Total Track Miles																															
	< 10	4										1							1	1								1				14%
	11-50	11			1	1			1	1	1			1			1	1				1	1				1					38%
	51-100	7						1							1	1									1	1			1		1	24%
	101-200	2		1																										1		7%
	>200	5	1				1						1								1			1								17%
2	Year Opened	1964	1904	1979	2004	1989	1888	1985	1913	1955	1907	2007	1976	1984	1930	1900	1989	2003	1990	1990	1972	2000	1985	1889	1992	1898	2008	1993	2004	1996	1912	1964
3	Top Speed																															
	< 35 mph	1																										1				3%
	45 mph	4			1			1	1																	1						14%
	55 mph	11	1				1				1	1					1					1	1	1	1		1				1	38%
	60 mph	3				1				1								1														10%
	> 60 mph	10		1									1	1	1	1			1	1	1								1	1		34%
4	Power System																															
	Catenary	17			1			1	1	1		1				1	1			1		1	1	1	1	1	1	1		1	1	59%
	3rd Rail	12	1	1		1	1				1		1	1	1			1	1		1			1								41%
	4th Rail	0																														0%
	Linear Induction	0																														0%
	Diesel	1																											1			3%
	Other	0																														0%
5	Miles Embbedded Track																															
	Zero	13	1	1					1	1	1	1	1	1	1			1	1		1			1								45%
	1-3	4					1															1	1							1		14%
	4-10	9			1	1		1									1								1	1	1	1	1			31%
	10-50	2																		1											1	7%
	> 50	1														1																3%
6	Miles DF Track																															
	Zero	4			1				1	1		1																				14%
	1-3	5														1						1				1		1	1			17%
	4-10	7									1						1		1	1			1		1					1		24%
	10-50	10	1			1	1	1						1	1			1						1			1				1	34%
	> 50	3		1									1								1											10%
7	Miles Ballasted																															
	Zero	1																					1									3%
	1-3	6			1						1				1			1									1	1				21%
	4-10	5										1		1					1	1											1	17%
	10-50	11		1		1		1	1	1						1	1					1			1	1			1			38%
	> 50	6	1				1						1								1			1						1		21%
8	Number Maint. Workers																															
	< 10	7			1	1						1										1	1				1	1				24%
	10-30	7								1							1	1	1	1					1				1			24%
	31-50	3							1																					1	1	10%
	51-100	5		1				1							1	1										1						17%
	> 100	7	1				1				1		1	1							1			1								24%
9	Standard Gage?																															
	Yes	24	1	1	1	1	1		1	1	1	1	1				1	1	1	1		1	1	1	1	1	1	1	1	1	1	83%
	No	5						1						1	1	1					1											17%
10	Tapered Wheels?																															
	Yes	22	1	1	1	1	1	1		1		1	1	1	1			1	1	1			1	1	1	1	1	1	1		1	76%
	No	5							1		1						1				1	1										17%
	Some do, some don't	1														1																3%
	Don't know	1																												1		3%
11	Wheel Flanges																															
	3/4"	7				1		1						1								1				1	1			1		24%
	1"	11			1				1	1							1	1	1	1	1		1	1							1	38%
	AAR 1B	4									1	1	1																1			14%
	Other	3	1																						1			1				10%
	Don't know	4		1			1								1	1																14%
12	Wheel Tread																															
	3"	2	1		1																											7%
	3-1/2"	2																					1			1						7%
	4"	10				1		1				1		1			1				1				1		1	1	1			34%
	4-1/2"	5																1	1	1				1						1		17%
	5"	1									1																					3%
	Other	1																													1	3%
	Don't know	8		1			1		1	1			1		1	1						1										28%

TABLE 1
(*continued*)

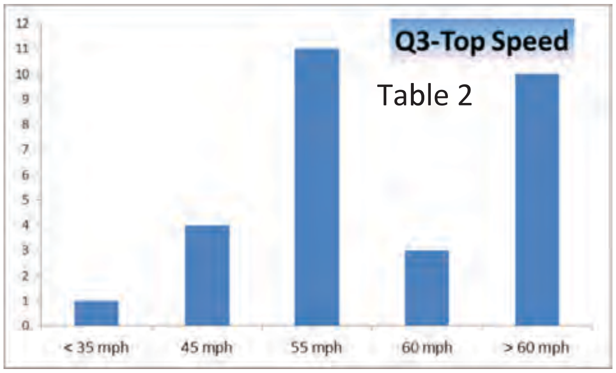
? No.	Question	Totals	Transit Agency																													%
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
13	Minimum Maint. Standards Used																															
	FRA	13		1	1	1					1		1				1	1	1	1		1			1				1		1	45%
	APTA	14		1	1		1	1	1	1		1		1	1	1							1				1	1		1		48%
	CA Utilities	2																	1	1												7%
	FTA	1																										1				3%
	Canadian	0																														0%
	None	0																														0%
	Other/Our Own	5	1																		1			1		1	1					17%
14	Have Maint. Standards																															
	Yes	24	1	1	1	1		1			1		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	83%
	No	4							1	1		1											1									14%
	More Strict? Yes	10	1	1	1									1				1			1	1			1				1	1		34%
	More Strict? No	5				1		1																		1	1	1				17%
15	Use a Priority System?																															
	Yes	21	1	1	1	1	1	1	1	1	1	1	1	1				1			1		1	1	1	1	1			1	1	72%
	No	8													1	1	1		1	1		1						1	1			28%
	If Yes, speed restriction?	20	1	1	1	1	1	1	1	1	1	1	1	1				1					1	1	1	1	1			1	1	69%
16	Can Inspector shutdown Track?																															
	Yes	19		1	1	1	1	1		1	1	1	1	1	1	1	1	1			1	1			1	1			1			66%
	No	3																					1				1	1				10%
	Depends	7	1						1										1	1				1						1	1	24%
17	Inspectors file reports?																															
	Yes	28		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	97%
	No	0																														0%
	Only if a defect	1	1																													3%
18	Supervisor make Maint. Schedule?																															
	Yes	26	1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	90%
	No	3						1							1								1									10%
	If No, who?	0																														0%
19	How often Walk Mainline																															
	Twice Weekly	15	1	1	1	1	1				1		1	1					1	1		1		1	1		1			1		52%
	Once Weekly	2													1	1																7%
	Once per Month	5										1					1	1			1		1									17%
	Twice per year	1																											1			3%
	Once per year	0																														0%
	Other	6						1	1	1																1		1			1	21%
	NO Walking	0																														0%
20	How often Walk Mainline Turnouts																															
	Twice Weekly	8		1	1		1							1								1			1		1			1		28%
	Once Weekly	2													1	1																7%
	Once per Month	16	1			1		1	1	1	1	1	1				1	1	1	1	1		1	1					1			55%
	Twice per year	0																														0%
	Once per year	0																														0%
	Other	3																								1		1			1	10%
	NO Walking	0																														0%
21	How often Geometry Car																															
	Once per month	0																														0%
	Twice per year	4		1		1															1								1			14%
	Once per year	15			1		1	1	1	1	1	1			1	1						1	1	1	1		1			1		52%
	Every 2 Years	2															1	1														7%
	Never	4																	1	1								1			1	14%
	Other	4	1										1	1												1						14%
22	Rail Flaw Detector																															
	Once per month	0																														0%
	Twice per year	5		1		1								1							1					1						17%
	Once per year	16			1		1	1				1			1	1		1	1	1		1	1	1	1		1		1	1		55%
	Every 2 Years	1															1															3%
	Never	1																										1				3%
	Other	6	1						1	1	1		1																		1	21%
23	Are you governed by FRA																															
	All Track	5									1								1	1									1		1	17%
	Half and half	0																														0%
	Most is NOT	4				1						1					1								1							14%
	None is	20	1	1	1		1	1	1	1			1	1	1	1		1			1	1	1	1		1	1	1		1		69%

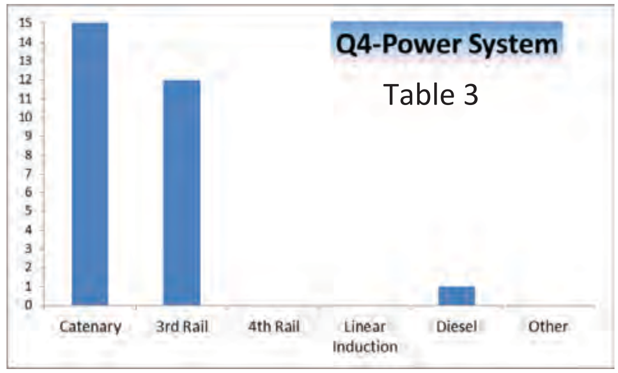
(*continued on next page*)

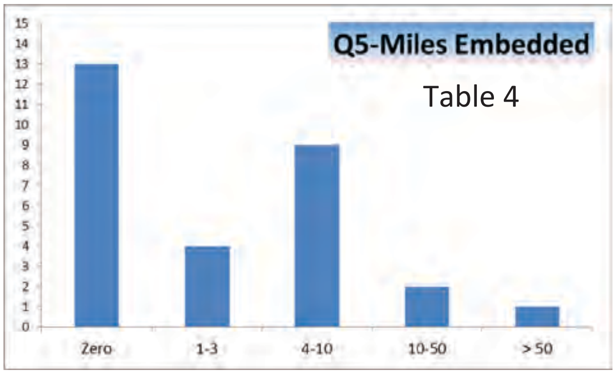
TABLE 1
(*continued*)

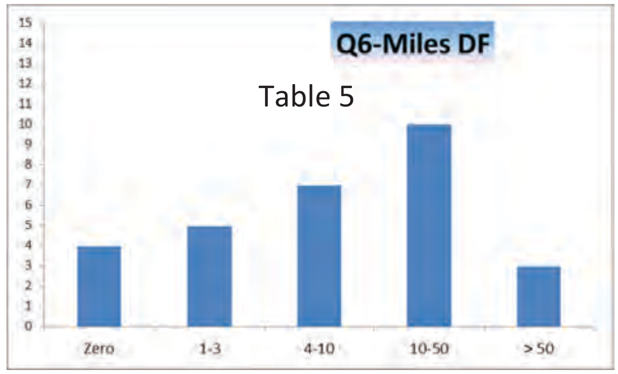
? No.	Question	Totals	Transit Agency																													%
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
24	Do you sub-contract Track Maint.																															
	Yes	15			1	1		1	1	1	1		1				1	1				1	1		1	1	1	1				52%
	No	14	1	1			1					1		1	1	1			1	1	1			1					1	1	1	48%
	If Yes																															
	< 10%	12			1			1	1	1	1						1	1				1			1	1	1	1				41%
	10% - 50%	3				1							1										1									10%
	> 50%	0																														0%
25	Sub out Inspections?																															
	Track	3							1	1																		1				10%
	GRMS	2				1																			1							7%
	Geometry Car	22		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1	1	1	1			1	1		76%
	Rail Flaw Detector	29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
	Bridge Inspection	8		1		1						1					1	1				1			1					1		28%
	We sub-nothing	0																														0%
26	Procurement Buy America?																															
	Yes	19		1	1	1	1	1	1	1			1		1	1			1	1		1	1	1	1			1		1	1	66%
	No	9	1								1			1			1	1			1					1	1		1			31%
27	Only Low Bid																															
	Yes	17	1		1	1	1	1	1	1	1	1			1	1			1	1				1		1	1				1	59%
	No	12		1									1	1			1	1			1	1	1		1			1	1	1		41%
28	Do you have a CWR Plan																															
	Yes	19	1	1	1	1					1		1	1	1	1	1		1	1	1				1	1	1		1	1	1	66%
	No	10					1	1	1	1		1						1				1	1	1				1				34%
	Don't have CWR	0																														0%
29	Inspector Qualification Process?																															
	Yes	22	1	1	1		1		1	1	1	1	1		1	1		1			1	1		1	1	1	1	1	1	1	1	76%
	No	6						1						1			1		1	1			1									21%
	If Yes, Written Exam?																															
	Yes	17	1	1			1		1	1	1	1	1			1		1			1	1		1	1	1			1	1		59%
	No	4			1																						1	1			1	14%
30	Maint. Worker Training																															
	RWP 1/per year	14							1	1	1	1	1		1	1	1				1	1			1		1		1		1	48%
	RWP 1 Only	6	1			1								1				1						1		1						21%
	RWP Never	3			1														1	1												10%
	TSS 1/year	8					1		1	1	1		1					1									1			1		28%
	TSS 1 only	3	1		1												1															10%
	TSS Never	2																	1	1												7%
	TSS 2/Year	2		1																	1											7%
	Equipment	17	1	1	1	1	1	1	1	1				1			1	1			1		1	1	1		1			1		59%
	Other	6	1	1			1											1							1			1				21%
31	Predominant Type Tie																															
	Wood	16	1		1		1	1	1	1	1		1		1	1							1	1		1		1	1		1	55%
	Concrete	13		1	1	1						1					1	1	1	1	1	1			1		1			1		45%
	Steel	0																														0%
	Rubber	0																														0%
	Tropical Hardwoods	1												1																		3%
	Other	1			1																											3%
32	Type Rail	113.1	100	115	115	115	115	115	100	115	100	115	115	115	100	115	115	115	115	115	119	115	115	115	115	115	115	115	115	115	115	113.1
33	Trade Union?																															
	Yes	23	1	1		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1		1	1	1	1				1	79%
	No	6			1							1											1					1	1	1		21%
34	Hand Held Device for Defects?																															
	Yes	2		1			1																									7%
	No	27	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	93%
35	Future Plans																															
	Update Standards	17	1	1	1	1	1	1			1	1		1	1	1	1	1			1				1		1			1		59%
	Write a Maint. Manual	4				1					1							1									1					14%
	Write a CWR Plan	3				1																				1	1					10%
	Nothing, we are good	11							1	1			1						1	1		1	1	1				1	1		1	38%

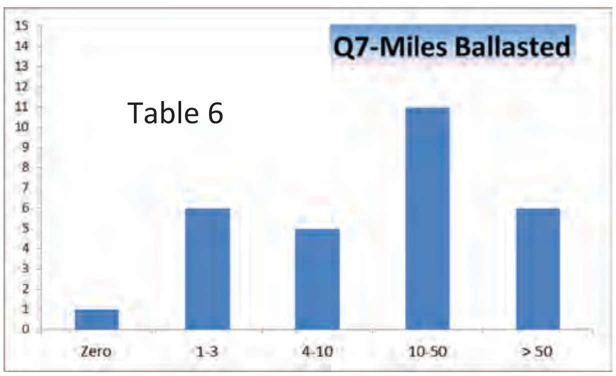
TABLES 2–19
GRAPHS OF SPECIFIC QUESTIONS HIGHLIGHTING SOME QUESTIONNAIRE RESPONSES

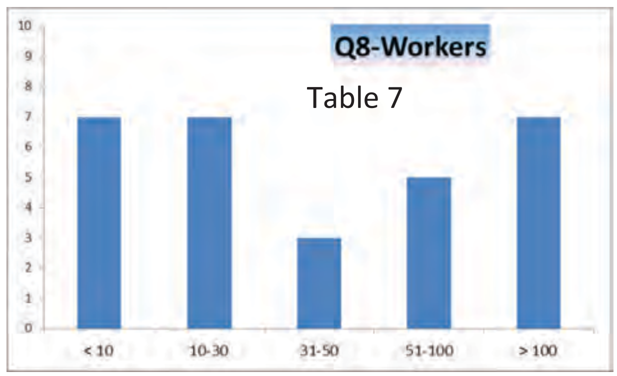


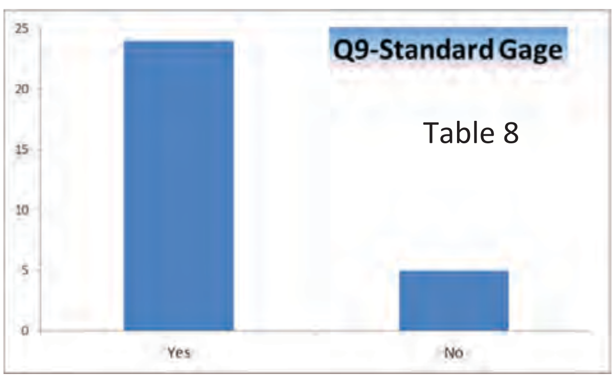


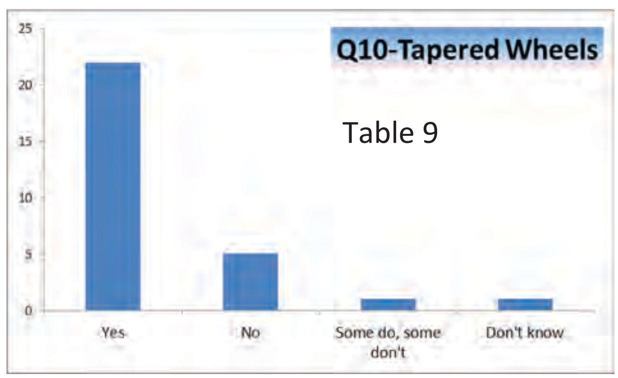












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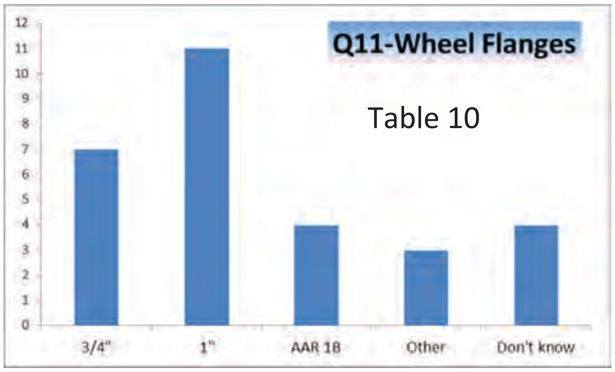

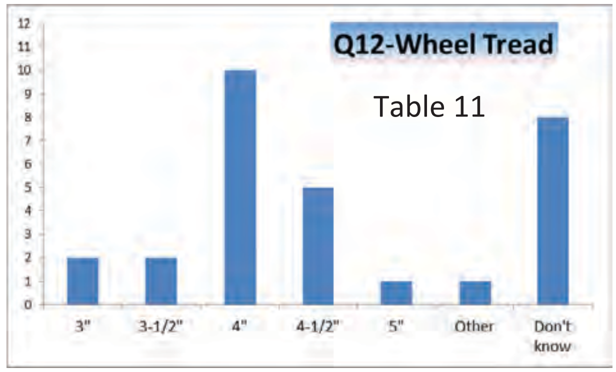

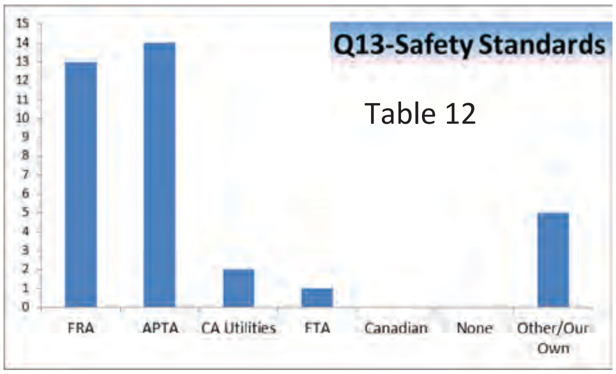

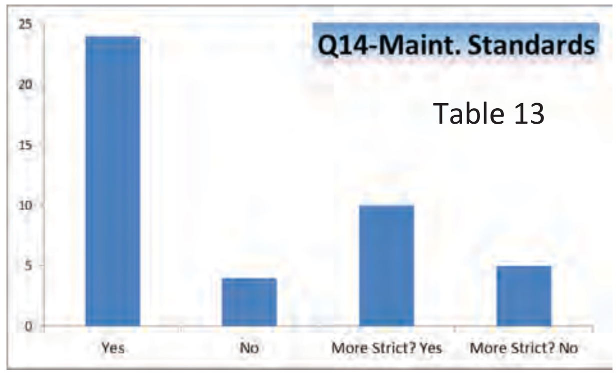

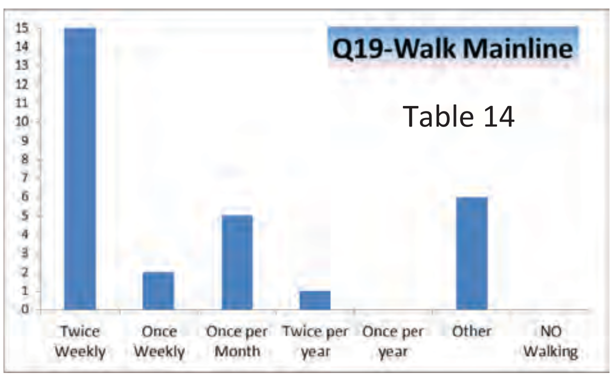

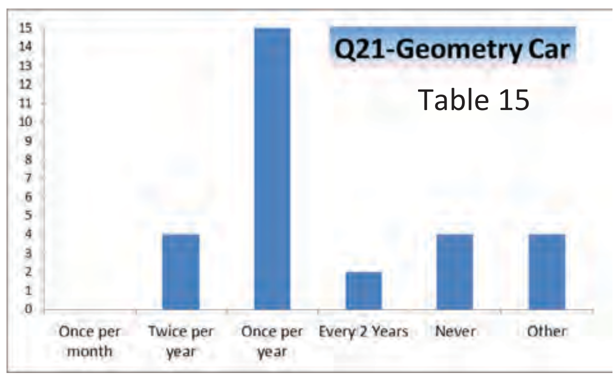

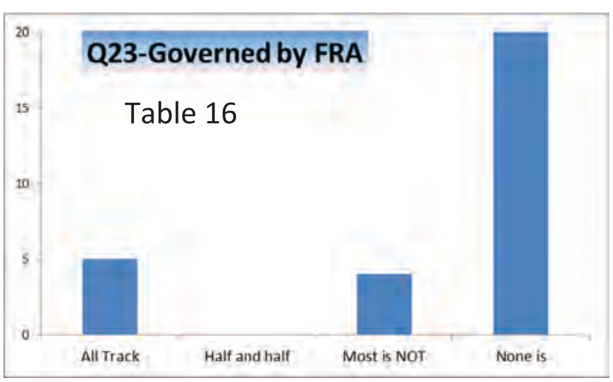

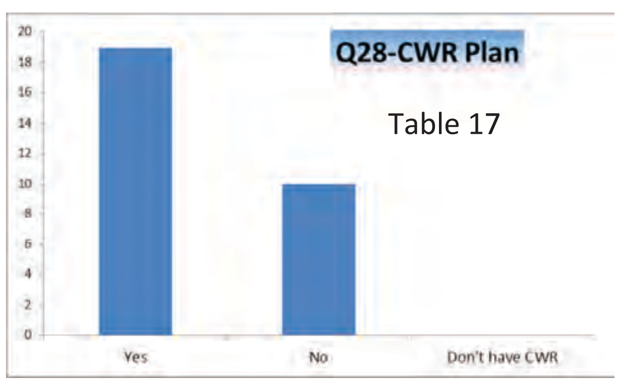

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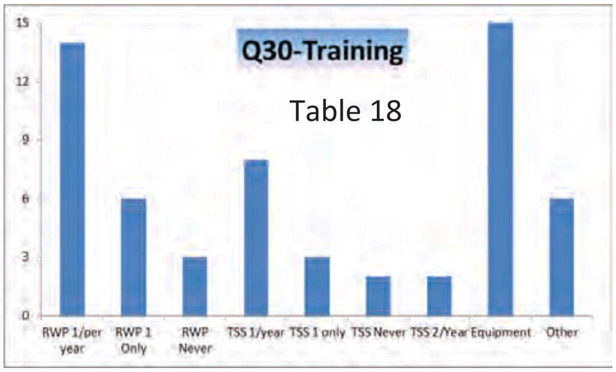

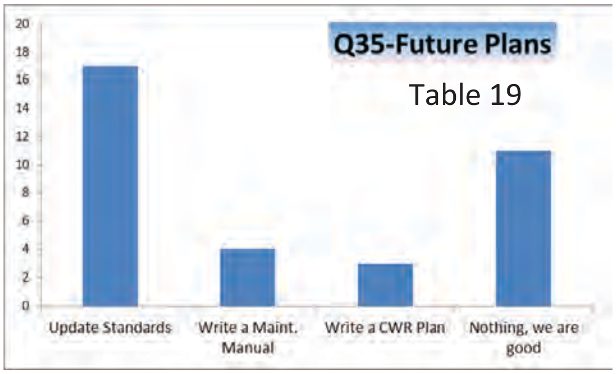

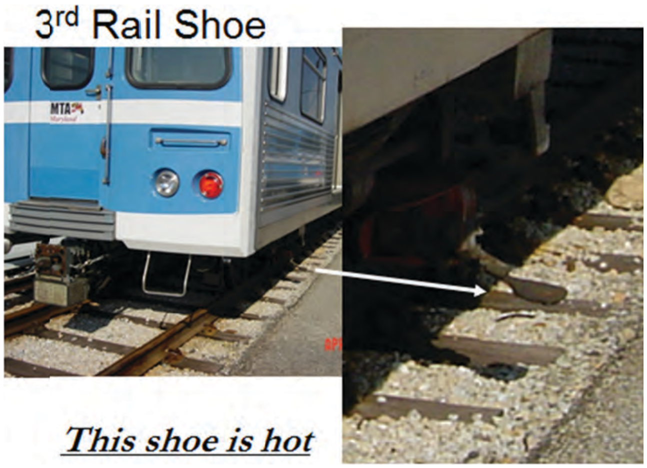

FIGURE 6 Third-rail shoe.

FIGURE 7 Embedded track.

FIGURE 8 Direct fixation (DF) track.

FIGURE 9 Ballasted track. Concrete ties, 115 rail, CWR, e-clip, with #3 ballast and overhead catenary.

and flat wheels. The majority of properties (22, or 76%) have tapered wheels and five (17%) agencies have flat wheels.

Question 11: Are your wheel flanges . . . [¾”, 1”, AAR 1B, Other, Don’t know]?

- Eleven systems (38%) have 1-inch flanges, whereas seven (24%) have ¾-inch flanges. Four (14%) agencies did not know and three (10%) responded something other than the options listed.

Question 12: Is your wheel tread . . . [3”, 3½”, 4”, 4½”, 5”, Other, Don’t know]?

- Maintenance professionals at eight agencies (28%) did not know the wheel tread measures. Ten (34%) have 4-inch tread, five (17%) have 4½-inch, one (3%) agency has a 5-inch tread, two (7%) have 3-inch tread, and two have 3½-inch tread. One agency has something other than the options listed.

Question 13: What minimum Track Safety Standard (TSS) is used for track maintenance?

- Thirteen agencies (45%) reported using FRA, 14 (48%) use APTA. Two (7%) agencies use the California Utilities Commission, and one (3%) agency uses FTA. Five (17%) agencies either use their own standards or something other than the options listed (see Figure 10).

Question 14: Do you have your own Track Maintenance Standards?

- Twenty-four agencies (83%) said yes. Four (14%) agencies said no. Five agencies (17%) said their maintenance standards are not stricter than the Track Safety Standards and 10 (34%) said they are stricter.

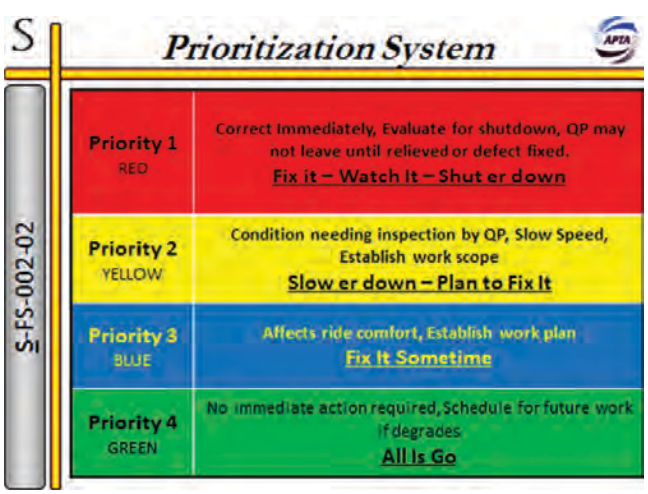

FIGURE 10 Prioritization system.

Question 15: Do you have a priority system related to track defects?

- Twenty-one agencies (72%) said yes, although one reported that no speed restriction is applied to the priority system. Eight (28%) said no. Twenty (69%) have a speed restriction associated with defects.

Question 16: Does a Track Inspector have the authority to shut down the railroad?

- Nineteen (66%) said yes, three (10%) said no, and seven (24%) reported that it depends.

Question 17: Do Track Inspectors file reports?

- Twenty-eight of the 29 surveyed (97%) said yes; the others responded that reports are only filed if there is a defect.

Question 18: Does the Track Supervisor set priorities and develop a maintenance schedule?

- Twenty-six (76%) said yes and three (10%) said no.

Question 19: How often do Inspectors perform a walking inspection of the mainline?

- Fifteen (52%) of the agencies inspect their mainline twice per week. Five (17%) reported their mainline was inspected once a month. One agency (3%) performs a walking inspection twice per year.

Question 20: How often do Inspectors perform a walking inspection of mainline turnouts?

- Eight (28%) said inspections are performed twice weekly, 16 (55%) said inspections are conducted monthly, and two (7%) agencies said once weekly.

Question 21: How often do you run a geometry car on the mainline?

- Fifteen (52%) reported running one once per year, four (14%) said twice per year, four (14%) reported they never run a geometry car.

Question 22: How often do you run a rail flaw detector car on your mainline?

- Sixteen (55%) reported doing this once per year, five (17%) said twice per year, one (3%) agency does this every two years, and one agency never runs a rail flaw detector car.

Question 23: Is your system governed by the FRA?

- Twenty (69%) said that none of their track is governed by the FRA. Five (17%) say that the FRA does govern their systems and four (14%) say that most of their track is not governed by the FRA.

Question 24: Do you sub-contract any track maintenance?

- Fifteen (52%) said yes and 14 (48%) no.

Question 25: Do you sub-contract any inspections?

- Three agencies (10%) said they subcontract track inspections. Twenty-two (76%) subcontract geometry car inspections. All 29 (100%) agencies state that they subcontract rail flaw detection.

Question 26: Are all procurements under "Buy America"?

- Nineteen (66%) said yes and 10 (34%) no.

Question 27: Does the agency ONLY accept lowest bid when procuring material and services?

- Seventeen (59%) said yes and 12 (41%) said no.

Question 28: Do you have a CWR plan?

- Although all agencies (100%) reported having CWR, 19 (66%) reported having a CWR plan and 10 (34%) reported not having a CWR plan.

Question 29: Does your agency utilize a formal track inspection/track foreman written qualification process?

- Twenty-two (76%) said yes and six (21%) said no. One (1) agency did not respond to this question.

Question 30: Do track maintenance workers have training requirements?

- Fourteen (48%) require once yearly Roadway Worker Protection (RWP) training. Three agencies (10%) do not do any RWP training. Eight (28%) perform Track Safety Standards (TSS) training once per year, while two (7%) agencies do no TSS training. Seventeen (59%) do equipment training.

Question 31: What is the predominant type of railroad ties used in your track?

- Sixteen agencies (55%) reported wood ties as the predominant type and 13 (45%) reported concrete. One (3%) agency reported something other than wood, concrete, steel, rubber, or tropical hardwood ties.

Question 32: What is the predominant type of rail used in your track?

- The overwhelming majority of agencies, 26 (90%) reported 115RE rail. Three agencies (10%) reported the predominant rail type as 100-pound.

Question 33: Are your railroad track maintenance and inspection employees represented by a trade union?

- Twenty-three agencies (79%) said yes and six (21%) said no.

Question 34: Do you use computer hand-held devices for recording track defects?

- Only two agencies (7%) reported yes, the rest said no.

Question 35: Do you have any future plans to . . . :

- Seventeen agencies (59%) reported that they intend to re-write their maintenance standards. Four (14%) stated that they intend to write a maintenance manual. Three (10%) agencies said they intend to write a CWR plan. Eleven agencies (38%) say they are satisfied and have no plans to change anything.

Additional interview questions were asked of seven transit supervisors to gain a better understanding of their philosophies pertaining to track maintenance. The responses follow:

Question 1: What is your philosophy on track maintenance?

- In a word it would be proactive! You should know the condition of your track and the areas that are approaching (or) exceeding your thresholds. These should be dealt with prior to becoming a defect.
- Improve overall system reliability through maintenance and minimize or eliminate system interruptions. We are measured against performance-based targets and therefore strive to ensure that track issues (switch failures, signaling events, track condition, and status) are minimized. We also target maintenance that helps prolong the life of the track system in order to minimize capital spending costs.
- Track maintenance is work in progress. The track is under constant rehabilitation. Following Track Safety Standards it is easy to stay ahead of track problems and slow orders. Establishing good trend analysis on the specific track and area of the county allows for repair schedules to be created, that gives Operations time to adjust train schedules allowing track time for the specified repairs.
- My philosophy is simple really. Make every effort to stay ahead of the curve. This applies to corrective

maintenance (CM) as well as preventative. For CM, my approach is to use every resource available to me at the time. Of course this includes the newest materials, my own experience, and any literature about the issue at hand, but it also has to include the experience and know-how of those around me and in the industry. It is very rare, if ever, that the corrective maintenance problem at hand is unique and has never been seen before. Pride has to take a back seat and allow you not only to ask others questions but to actually listen and apply their suggestions appropriately. Combine all available resources; correct the problem with the long-term solution in mind. The long-term solution is not always the quickest or easiest but has to be pushed in order to reach the next stage, preventative maintenance (PM). If your time is consumed, as it often is, putting out fires from the last "quick solution," PM is difficult to obtain. If you're lucky enough to be involved with PM, the philosophy is the same. Approach PM with an open mind. Status quo may or may not be the best approach. Use your resources.

- RR and transit have different practical issues. Much of transit is using it until you replace the entire track system—for example, street track—you can make minor repairs but it will deteriorate until all you can do is replace it. Conventional RR track is open to cyclical maintenance . . . tie renewal (30%) surfacing. The DFF and hybrid fixations in the subways are challenging. Basically—if the track can be maintained to keep it in good condition—reasonably—that would be the first option.
- #1 priority—Perform "must have" repairs first. These are repairs/maintenance required to meet the minimum track safety standards. #2 priority—Perform special work maintenance to keep in good state of repair. #3 priority—Perform rail maintenance such as replacement, tamping, drainage, prioritized by need.
- Ideally, track maintenance should always be performed so that the track does not degrade to the point that Priority 1 defects appear. That means keeping the track at an acceptable condition, consistent with good riding qualities. Rail and fastener plus tie and ballast maintenance should assure the longevity of those elements and assure a good riding quality. Safety should always be paramount and this is also a basic precept for Track Maintenance, along with quality. Resources should be allocated to achieve these goals.

Question 2: What challenges do you face when trying to get track time for maintenance activities?

- The largest challenge is events in town. You're not only wrestling with rail transportation but also with the marketing folk. This of course is understandable, as we are in the business of moving people.
- The operating rules for our driverless system require that all track maintenance is completed under closed track conditions. This requires traffic diversions that impact headways and frequency of train service. Some of the diversions can have a significant impact on service levels and we are therefore restricted from running these diversions at certain times of the month. Further, there is often a small window of time that we are allowed for the diversion. The restrictions on diversions combined with weather and other events severely limit our access to the track for maintenance.
- Track time is always difficult, operations needs plenty of notification. Passenger service does not react to unscheduled maintenance favorably. With new extensions being added [and] head ways increased, staying ahead of the maintenance is critical to success.
- Rapid transit and light rail (LR) system is a two-track system that operates revenue service between the approximate hours of 5 a.m. and 1:30 a.m., seven days a week. This allows track, as well as other maintenance, to be primarily handled during the hours of 1:30 a.m. and 4:30 a.m. This obviously limits the extent of work that can be done in one night. It also sometimes limits the quality of work as it's performed, specifically, proper welding time and rail expansion time. Both suffer because of the limited on-track time. This leads to more maintenance in the future that may not have been necessary if the task had the proper time frame. Other challenges include: high rail equipment is shared between lines; very few pieces are dedicated to a specific line. None of the lines physically connect, sharing track time and location with other trades and departments, restrictions placed by communities, scheduling changes owing to weather and events.
- Safety rules requiring track time to perform maintenance are making the work more difficult. It now takes two people to inspect RR track, and more in the event the line of site is obstructed owing to curves etc. Most transit systems by their very nature are intensively using their track, which means that there is little opportunity to take possession of the track to do work. We schedule work during the night owl shutdown or if the line can be bused, try that. The night owls are typically short so the expense for what is accomplished is high.
- The last several years have seen a change with the ability to obtain revenue track time. A greater emphasis has been placed on customers being delivered according to schedule. Our thought is that it might be at the expense of track maintenance. I should make clear that this does not apply to meeting safety standards. It is more directed at trying to get ahead of the maintenance curve, scheduled PMs, etc. One particular issue is the inability to get two single track operations on the same day. Another issue is obtaining a rolling single track, in other words moving from one switch section to the next.
- Competition from other departments and/or divisions for track access, trying to satisfy the needs of the cus-

tomers, assuring a decent level of on-time performance, political pressure.

Question 3: How do you determine priorities for Track Maintenance?

- We record not only defects but also observations, areas that may develop into a defect. We use a three-color priority scheme that we call severity estimators. Green is really an observation, yellow should be scheduled for maintenance, and a red would be repaired or protected immediately.
- Track maintenance is prioritized by safety, routine, and planned special work. The target is to complete routine maintenance on a repetitive cycle with special projects (grinding, overhauls, etc.) layered on top of the cycle. The repetitive cycle would be pre-empted by any emergency or safety critical work.
- The work orders are prioritized every six months and updated, then the work schedule is amended. This allows for real time evaluation of track conditions, allowing for rescheduling of work force and track time for the maximum efficiency.
- Track walking and inspection is primarily done during the day with daily reports. These reports (quality assurance and quality control) are prioritized and are the primary tool for prioritizing the after service work. Long-term issues and larger jobs that may require a service diversion and shutdown are discussed and prioritized at management level along with the transportation department primarily for logistics.
- Day to day [management] is done with the maintenance supervisors, the assistant directors and the maintenance directors. They review the inspector's reports and determine the priorities. Obviously the work is prioritized in regard to (1) safety and (2) [to] prevent or eliminate speed restrictions.
- Based on periodic and frequent quality inspections of track under load on a regular basis, assessing the condition and longevity of the major track elements on a periodic basis, comparing the conditions found against industry standards and observing trends.

Question 4: What is your number one concern when performing track maintenance?

- Safety! This has always been and probably always will be a dangerous activity. Concerns about employee and patron safety are no doubt number one.
- Safety: Safety for the passengers during service and safety for the track workers during maintenance.
- Employee safety, working long hours and tight areas, keeping the work equipment updated, and service for maximum productivity.
- Number one is always the safety of the riding public and the workforce as well. Each task has to be considered a long-term solution that will keep that piece of track safe for a[s] long as possible. An overall level of safety must not only be maintained but exceeded to the highest level possible for that parameter. Long-term solutions to maintenance may be more time consuming and usually more expensive, but they allow breathing room down the line (no pun intended). If maintenance can be done properly for each task, this allows you to perform PM work and stay ahead of the curve.
- That it is done right. It is very easy to botch up maintenance work and leave a nightmare for the next guy.
- Customer safety. Our track inspection and maintenance standards are generally tighter than APTA recommendations. This attention to safety has resulted in a marked decrease in safety-related incidents such as derailments.
- Achieving the desired results regarding the quantity and quality of the work performed in order to assure the longevity and ride quality of the track, along with the safety of the track and the passengers. Making sure that resources are properly allocated and that productivity is at its maximum.

These additional responses highlight the vital importance of maintaining a transit system, and these professionals' proactive approach to track maintenance. There are many different facets—employees and mechanisms—that make up a transit system. These elements must work together for a system to run smoothly.

CHAPTER FIVE

CONCLUSIONS

A large number of new rail transit systems have been built in the United States in the last few decades that may start to show signs of age and require more maintenance since the inaugural train ran on the track. Survey responses indicate that each agency appears to have developed its own set of maintenance standards, in some cases using FRA Track Safety Standards (TSS) as minimum criteria while reporting actually maintaining their track to a higher standard. This synthesis documents the “state of the practice,” the diversity in maintenance standards, and even some agency philosophy. Minimum track safety standards only apply to a single criterion and certain specific combinations of defects must not be ignored. Evaluating these combinations of defects which could impact system safety is one of the functions of the maintenance professional. One location of track can have gage, line, and surface measurements at the borderline of the limits, yet that track may be at a very high risk for a derailment.

Survey results indicate that there is a need for a vehicle that can measure track parameters and internal rail integrity, all while applying a load to the track. If such a specialized vehicle could be designed that would do a computer analysis by rating every curve and segment of transit track, it would be invaluable. Every 500 feet of track could be given a numerical rating, and as the track came close to operational limits, maintenance personnel could correct the defects. Survey respondents indicate that making comparisons to previous ratings is a good maintenance tool when planning activities and applying for funding.

Several agencies have experienced a 30-year cycle after which the track appears to begin deterioration. Some types of track may experience this before 30 years and some may even see these material failures occur after 10 years. Improvements in technology, and better materials, may serve the industry better.

Respondents agree that the most important role of maintaining track is to prevent derailments. When a transit system begins to fail, it could be because of two factors, lack of planning and maintenance. Proper planning of maintenance activities is the key to success.

On October 16, 2008, the Rail Safety Improvement Act 2008 was enacted. The U.S. Secretary of Transportation was ordered to determine whether mandatory track inspection intervals needed to be amended; whether track remedial action requirements needed to be amended; and whether different track inspection priorities and methods were required. A study was presented to Congress on May 2, 2011, and in August of the same year the Railroad Safety Advisory Committee (RSAC) accepted the task of addressing specific changes to the FRA 213 TSS to improve the track inspection process, including:

- Expanding the use of automated inspection,
- Developing additional training requirements for inspectors,
- Rejecting a maximum speed for inspection vehicles, and
- Influencing the safety culture through a safety reporting system.

Freight railroads are private businesses whereas transit agencies are not. Freight railroads are policed whereas transits are not. Freight railroads carry commodities whereas transits carry passengers**.** The FRA is constantly updating and improving its TSS and strengthening enforcement of these rules. For their part, freight railroads have realized the importance of maintaining track to strict levels because it will affect the bottom line if they do not.

APTA has developed minimum track safety standards but they cannot be enforced. Survey results indicate agencies are calling for a new generic maintenance standard that can be slightly modified to accommodate differences in infrastructure and vehicles. Agencies appear to have concluded that it is time to develop universal track safety standards before the newer systems get too old, and to ensure that all passengers are riding on safe track.

The survey revealed a wide variety of guidelines within the transit industry. For example, five transit agencies, all older, reported having other than standard gage track, which can shift the center of gravity causing different unbalances between the systems. The newer systems all reported standard gage with 115RE rail, except for one that chose girder rail.

Standards for wheel gage, wheel flange, and wheel tread are also mixed among the transit agencies. Even wheel diameters vary, which can dramatically change the wheel to rail interface and in turn affect the minimum maintenance standards. Many agencies reported the same maintenance requirements had varied standards with respect to the wheel and rail interface. Rail develops corrugation if the wheel and rail are not matched correctly. Noise and vibration can also develop if the match is not correct.

For responses to survey questions about minimum safety standards that are used, fewer than half (13) of the 29 agencies reported using FRA, a similar number (14) use APTA, two (2) agencies use California Public Utilities Commission, one (1) uses the FTA, and five reported having their own minimum safety standards. These standards are similar and the table shows the similarities between APTA and the FRA. When asked if they had maintenance standards, 24 (83%) said they have their own, four (14%) agencies do not have maintenance standards, and five (17%) said that their maintenance standards are the same as the track safety standards. Twenty-one agencies, or about three-quarters (72%), have a priority system requiring speed restrictions if a defect is found, whereas the rest (28%) do not.

Inspection frequencies also vary, with 15 agencies (52%) reporting twice weekly inspections and others doing an inspection once a month; one agency performs inspections only twice per year. Four of the agencies (14%) surveyed never run a geometry car and one agency never runs a rail flaw detector vehicle. Both APTA and the FRA require that a geometry car be used. The FRA has strict requirements for rail flaw detection, as does APTA for this type of testing. The frequency of inspections required by the FRA is very detailed, and APTA has suggested criteria about frequency of track inspection.

Only a little over a quarter of the agencies (eight, or 28%) train their workers about track safety standards and two (7%) do no training. The FRA has only had training requirements for continuous welded rail since 2009. Since 2012, the FRA has required training on FRA 213 TSS. Neither APTA nor the responding agencies have requirements for training.

Although transit agencies are all different, there is a common responsibility that each recognizes and strives to achieve, and that is safely transporting passengers.

Based on the information in this report, the following general topics are suggested for future study:

- Training
- Geometry testing
- Wheel-rail interface
- Procurement practices.

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APPENDIX A

Survey Questionnaire

The Transportation Research Board has chosen Track Guy Consultants (TGC) for a data collection project pertaining to Railroad Track Maintenance Practices. The purpose of this survey is to simply collect information about how Transit Authorities maintain their track. This is a very important document for the success of the project. Please give it careful consideration. Only about 30 minutes of your time is required to complete this survey and it will be greatly appreciated. This survey can be completely anonymous. Just say so and it will not go further than me. You have my personal guarantee that your agency will not be published or named to anyone else. John Zuspan, President, TGC.

COMPLETING THE SURVEY:

There are several ways to complete the survey; you can open the Word file and use the yellow highlight function to choose your response and type in any comments. You could also print the pdf or Word file and circle your answers. You could also give me a call and we can do it over the phone. As a memento for filling out the form, I will send you a slice (about ¼" thick) of a piece of pear shaped rail rolled in 1845. It was the first "T" section rolled in the USA and was made from pig iron, not steel. It also was the section used in the Trans-Continental Railroad. I found a 30 foot piece while walking track in New Jersey in 1998 and have been cutting slices ever since. I am down to 8 feet.

OPTIONAL INFORMATION

Name of Transit Agency:

Address of Agency:

Contact Person with contact Information:

Date Completed:

HOW TO GET THE SURVEY BACK TO ME:

snail mail to: John Zuspan, 934 Royal Ct., Canonsburg, PA 15317

e-mail: zuspan@trackguy.com

fax: 724-873-5733

phone: 973-222-1300

I do not tweet

1. About how many total miles of track is incorporated in your system (not route miles)? Do not include storage yards.
   a. Less than 10
   b. 11–50
   c. 51–100
   d. 101–200
   e. More than 200

   Comments: _____

2. What year was the first segment of track opened within your system? _____

   Comments: _____

3. What is your top speed on mainline track?
   a. <35 mph
   b. 45 mph
   c. 55 mph
   d. 60 mph
   e. >60 mph

   Comments: _____

4. What is your vehicle power system?
   a. Overhead Catenary
   b. Third-rail System
   c. Fourth-rail System
   d. Linear Induction
   e. Diesel Power

   Comments: ______

5. About how many miles of Embedded Track are in your system?
   a. Zero
   b. 1–3
   c. 4–10
   d. 10–50
   e. More than 50

   Comments: ______

6. About how many miles of Direct Fixation Track do you have?
   a. Zero
   b. 1–3
   c. 4–10
   d. 10–50
   e. More than 50

   Comments: ______

7. About how many miles of Ballasted Track?
   a. Zero
   b. 1–3
   c. 4–10
   d. 10–50
   e. More than 50

   Comments: ______

8. How many ***Track*** maintenance workers do you employ?
   a. <10
   b. 10–30
   c. 31–50
   d. 51–100
   e. >100

   Comments: ______

9. Is your system standard gage 56½”? Yes No
   a. If “No,” what is it? ______

   Comments: ______

10. Do your vehicles have tapered (conical) wheels?
    a. Yes
    b. No
    c. Some do, some don’t
    d. Don’t know

    Comments: ______

11. Are your wheel flanges:
    a. ¾”
    b. 1”
    c. AAR 1B Narrow Flange
    d. Other ______
    e. Don’t know

    Comments: ______

12. Is your wheel tread:
    a. 3”
    b. 3½”
    c. 4”
    d. 4½”
    e. 5”
    f. Something else _____
    g. Don’t know

    Comments: _____

13. What ***minimum*** Track Safety Standard (TSS) is used for Track Maintenance?
    a. FRA
    b. APTA
    c. CA Utilities Commission
    d. FTA
    e. Canadian
    f. We don’t use any
    g. Other _____

    Comments: _____

14. Do you have your own Track Maintenance Standards?
    a. Yes
    b. No
    c. If “Yes,” are they stricter than the Track Safety Standards? Yes No

    Comments: _____

15. Do you have a priority system related to track defects?
    a. Yes
    b. No
    c. If “Yes,” does it have a speed restriction assigned based on severity of defect?
       i. Yes
       ii. No

    Comments: _____

16. Does a Track Inspector have the authority to shut down the railroad?
    a. Yes
    b. No
    c. Depends

    Comments: _____

17. Do Track Inspectors file reports?
    a. Yes
    b. No
    c. Only if a defect

    Comments: _____

18. Does the Track Supervisor set priorities and develop a maintenance schedule?
    a. Yes
    b. No
    c. If “No,” who does _____

    Comments: _____

19. How often do Inspectors perform a walking inspection of the mainline?
    a. Twice weekly
    b. Once weekly
    c. Once per month
    d. Twice per year
    e. Once per year
    f. Something else: _____
    g. Never perform walking inspections

    Comments: _____

20. How often do Inspectors do a walking inspection of mainline turnouts?
    a. Twice weekly
    b. Once weekly
    c. Once per month
    d. Once per year
    e. Something else: _____
    f. Never perform walking inspections

    Comments: _____

21. How often do you run a geometry car on the mainline?
    a. Once per month
    b. Twice per year
    c. Once per year
    d. Every 2 years
    e. Never

    Comments: _____

22. How often do you run a rail flaw detector car on your mainline?
    a. Once per month
    b. Twice per year
    c. Once per year
    d. Every 2 years
    e. Never

    Comments: _____

23. Is your system governed by the FRA?
    a. All trackage is
    b. About half is and half is not
    c. Most of the track is not
    d. No track is governed by the FRA

    Comments: _____

24. Do you sub-contract any track maintenance?
    a. Yes
    b. No
    c. If “Yes,” <10%, 10% to 50%, >50%

    Comments: _____

25. Do you sub-contract any inspections?
    a. Track Inspection
    b. GRMS
    c. Track geometry
    d. Rail flaw detection
    e. Bridge inspection
    f. We sub-contract nothing
    g. Other: _____

    Comments: _____

26. Are all procurements under “Buy America”?
    a. Yes
    b. No

    Comments: _____

27. Does the agency ONLY accept lowest bid when procuring material and services?
    a. Yes
    b. No

    Comments: _____

28. Do you have a CWR Plan?
    a. Yes
    b. No
    c. Don’t have any CWR

    Comments: ______

29. Does your agency utilize a formal track inspection/track foreman written qualification process?
    a. Yes
    b. No
    c. If “Yes,” does it include a written exam?
        i. Yes
        ii. No

    Comments: ______

30. Do track maintenance workers have training requirements?
    a. Roadway Worker once per year
    b. Roadway Worker once only
    c. Roadway Worker never
    d. Track Maintenance Standards (TSS) once per year
    e. TSS once only
    f. TSS never
    g. TSS twice per year
    h. Equipment Training
    i. Other Training, please list: ______

    Comments: ______

31. What is the predominant type of railroad ties used in your track?
    a. Wood
    b. Concrete
    c. Steel
    d. Rubber
    e. Tropical Hardwoods
    f. Other: ______

    Comments: ______

32. What is the predominant type of rail used in your track? ______

    Comments: ______

33. Are your railroad track maintenance and inspection employees represented by a trade union?
    a. Yes
    b. No

    Comments: ______

34. Do you use computer hand-held devices for recording track defects?
    a. Yes
    b. No

    Comments: ______

35. Do you have any future plans to:
    a. Update or change existing standards
    b. Write a maintenance standard
    c. Write a CWR Plan
    d. Nothing, we are good

    Comments: ______

36. Can you share your Maintenance Standards with John Zuspan ONLY ? Yes No

If yes: Please e-mail a pdf file to zuspan@trackguy.com. All will be anonymous. Thank You.

37. Comments about anything: ____

____

____

____

____

APPENDIX B

Questionnaires Sent to the Following Agencies

State	City	Organization Name	Mode Name	Lines	Year original line opened	Miles of mainline passenger track	Maximum speed (m.p.h.)
WA	Seattle	Central Puget Sound Regional Transit Authority	LR	1	2003	2	35
NC	Charlotte	Charlotte Area Transit (CAT)	LR		2003		
IL	Chicago	Chicago Transit Authority (CTA)	HR	9	1892	222	55
TX	Dallas	Dallas Area Rapid Transit Authority (DART)	LR	2	1996	91	65
OH	Cleveland	Greater Cleveland Regional Transit Authority	HR	1	1955	38	45
OH	Cleveland	Greater Cleveland Regional Transit Authority	LR	2	1920	31	45
CA	Los Angeles	Los Angeles County Metro. Transport. Auth. (LaMetro)	HR	2	1993	33	70
CA	Los Angeles	Los Angeles County Metro. Transport. Auth. (LaMetro)	LR	3	1990	118	65
MD	Baltimore	Maryland Transit Administration	HR	1	1983	29	55
MD	Baltimore	Maryland Transit Administration	LR	2	1992	46	50
MA	Boston	Massachusetts Bay Transportation Authority (MBTA)	HR	4	1901	75	50
MA	Boston	Massachusetts Bay Transportation Authority (MBTA)	LR	5	1889	54	40
TN	Memphis	Memphis Area Transit Authority (METRA)	LR	3	1993	18	8
MN	Minneapolis	Metro Transit	LR	1	2004	24	55
GA	Atlanta	Metro. Atlanta Rapid Transit Auth. (MARTA)	HR	5	1979	99	70
TX	Houston	Metropolitan Transit Authority of Harris County	LR	1	2004	15	40
FL	Miami	Miami-Dade Transit Agency	HR	1	1984	48	58
NY	New York	MTA New York City Transit (NYCT)	HR	26	1904	659	50
NJ	Newark	New Jersey Transit Corporation (NJT)	LR	3	1935	111	60
NY	Buffalo	Niagara Frontier Transit Metro System	LR	1	1985	13	50
NJ	Jersey City	NJ Transit - Hudson Bergen	LR		1998		
PA	Pittsburgh	Port Authority of Allegheny County	LR	4	1964	47	35
NJ	Jersey City	Port Authority of NY and NJ (PATH)	HR	5	1908	29	55
NY	Jamaica	Port Authority of NY/NJ JFK AirTrain	LR-LI-AG	1	2001	27	55
CO	Denver	Regional Transportation District (RTD)	LR	1	1994	28	55
CA	Oakland	San Francisco Bay Area Rapid Transit District (BART)	HR	5	1972	208	80
CA	San Francisco	San Francisco Municipal Railway (MUNI)	LR	6	1892	73	52
CA	San Jose	Santa Clara Valley Transportation Authority	LR	3	1987	80	55
PA	Philadelphia	Southeastern PA Transport. Auth. (SEPTA)	HR	3	1907	60	70
PA	Philadelphia	Southeastern PA Transport. Auth. (SEPTA)	LR	7	1905	96	50
MO	St. Louis	St. Louis Transit	LR		1988		
ON	Toronto	Toronto Transit Commission (TTC)	LR	11	1861	108	12
UT	Salt Lake City	Utah Transit Authority (UTA)	LR	2	1999	35	55
DC	Washington	Washington Metro. Area Transit Auth. (WMATA)	HR	5	1976	212	59
NJ	Camden	South Jersey LRT - River Line	LR	1	2003		

HR=Heavy Rail - CR=Commuter Rail - LR=Light Rail - IP=Inclined Plane - AG=Automated Guideway - CC=Cable Car - IR=Intermediate Rail - LI=Linear Induction

Reference: APTA.

APPENDIX C

Congressional Hearing Statement by the Administrator of the FTA

Hearing on Rail Modernization: Getting Transit Funding Back on Track. Source—Website

08-04-09

STATEMENT OF PETER M. ROGOFF, ADMINISTRATOR

FEDERAL TRANSIT ADMINISTRATION

BEFORE THE SUBCOMMITTEE ON HOUSING, TRANSPORTATION AND COMMUNITY DEVELOPMENT

COMMITTEE ON BANKING, HOUSING AND URBAN AFFAIRS

UNITED STATES SENATE

HEARING ON RAIL MODERNIZATION: GETTING TRANSIT FUNDING BACK ON TRACK

Chairman Menendez, Ranking Member Vitter, and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the state of good repair of the nation's public transportation systems. In the interest of both the safety and the reliability of our public transportation systems, it is imperative that we aggressively address and stay on top of their aging condition. Deferred maintenance items, if deferred long enough or left undetected, can become critical safety risks. The issues of the conditions of our transit infrastructure and the safety of our transit systems are inextricably linked. The Federal Transit Administration's (FTA) role in the safety oversight of these systems is extremely limited as a matter of Federal law. We are statutorily prohibited from establishing national safety standards for a large segment of the nation's rail transit system. Still, FTA continues to regularly assess the condition of transit infrastructure and disseminate and encourage best practices by the industry.

Safety

Safety is the Department's highest priority. And, as we address safety issues as part of this hearing, it must be remembered that traveling by rail transit in the United States remains an extraordinarily safe way to travel—far safer than traveling on our highways. That makes it particularly important that our transit systems maintain their infrastructure to a standard where they can provide riders with service that is both reliable and comfortable. Conditions that prompt commuters to abandon transit and get back into their cars adversely impact highway safety performance. And, defective equipment, late trains, broken escalators, and malfunctioning air conditioners do just that.

While transit remains the safest mode of surface transportation in the United States, the National Transportation Safety Board (NTSB) has been called in to investigate several transit-related accidents in the recent past. The NTSB investigated the July 2006 Chicago Transit Authority (CTA) Blue Line derailment that resulted in 152 injuries. They concluded that "[t]he tie plates and fastener systems failed to maintain the track gauge because of the effects of corrosion, wear and tear, and degraded ties." Their report stated, "[the accident is a] wakeup call. . . .to all transit agencies. . . .with equipment and infrastructure that ages with each passing day." This lag screw served as one of thousands holding CTA rail to ties in the area of the Blue Line derailment. As you can see, it is corroded and deformed from its original design. It was so ineffective that it could be removed by hand. The NTSB report noted that most of these ties and fasteners date back to the installation of the original Blue line that opened for revenue service on February 25, 1951. It should not be a surprise to anyone that a 58-year-old track structure is prone to failure.

The NTSB statements appear prophetic today. While its investigation of the June 22, 2009, Washington Metropolitan Area Transit Authority (WMATA) subway train collision is not complete, NTSB preliminarily reports that the condition of equipment and age of the rolling stock may have resulted in the tragic loss life and injuries. Such tragedies are unacceptable. A little over a year earlier, on June 9, 2008, there was a derailment on WMATA's Orange Line outside the Court House station. The accident investigation and WMATA's subsequent public announcements indicated that an undetected track defect had contributed to the derailment. WMATA responded by initiating the purchase of a track geometry car which should be on the property by this September to better assess and evaluate track defects to find and correct problems before a derailment occurs.

We all must focus our attention and resources on this important issue of maintaining the significant public investment in transit systems, if we are to maintain public confidence. Moreover, while transit remains a safe mode of travel, data indicates that a number of accident categories have trended up in recent years.

Equipment failures at transit stations can also cause safety problems and erode customer confidence. A little over two months ago, New York's Metropolitan Transportation Authority (MTA) released a list of 23 of its worst-functioning elevators and escalators. MTA operates 158 passenger elevators and 169 escalators in five boroughs. According to the report, three escalators have not operated in over a year, another two escalators worked less than 37 percent of the time, and yet another escalator operates only 67 percent of the time. The report also showed that about 31 MTA elevators and escalators dropped from working more than 90 percent of the time in 2008 to working only 80 percent of the time or less. And, in July 2008, a "subway report card" issued by the Straphangers Campaign said that the New York City Transit subway system experienced mechanical failures every 156,624 miles in 2006 and every 149,646 miles in 2007. On July 19, 2006, the Boston Herald reported that Massachusetts Bay Transportation Authority (MBTA) received 99 complaints within 2 days about air-conditioning breakdowns. MBTA acknowledge that "roughly 14 percent of the fleet—47 cars—had air-conditioning problems" the day before.

Safety is not just about the condition and aging of equipment. The human factor is a critical element. On July 28, 2008, two MBTA trains collided, killing one of the operators and injuring three crewmembers. Of the 185 to 200 passengers on the two trains, four sustained minor injuries and one was seriously injured. In its July 23, 2009 report, the NTSB stated that the total damage was estimated at $8.6 million and found that the probable cause was the failure of the operator of the striking train to comply with the controlling signal indication. In this instance, the NTSB also found that a contributing factor was the lack of a positive train control system that would have intervened to stop the train and prevent the collision. In yet another incident involving MBTA transit system on May 9 of this year, approximately 46 people were taken to area hospitals after an operator slammed his trolley into another trolley. It has been reported that the operator admitted to texting at the time of the accident.

Similarly, on July 22, 2009, a collision between San Francisco Municipal Railway (Muni) light-rail vehicles at the West Portal station injured 47 people. While the NTSB is far from concluding its investigation into this accident, investigators reported that the operator involved in the crash appears to have switched his train to manual about 24 seconds before the light-rail vehicle plowed into another train stopped in the station. In so doing, he may have disabled the very system designed to avoid such accidents. These incidents point up the nexus between the state of good repair and the organizational safety culture at transit agencies. Employee attitudes and performance are shaped by the environment they work in. If important maintenance and renewal are deferred, it sends a message. If leadership at all levels of government allow transit infrastructure to degrade, FTA is concerned that public transit employees may become disheartened and be less confident in the functional capacity of their automated safety equipment systems.

Rail transit provides more than three billion passenger trips each year, and moves millions of people each day. At the same time, national passenger fatality rates for heavy rail transit systems are about 0.03 per million passenger miles. This accident rate is lower than most other modes of transportation and far safer than traveling by automobile. However, as evidenced by the recent accidents and incidents highlighted in my statement, in order to maintain this level of safe performance, government at all levels must address each transit system's state of repair and safety regimes more aggressively. We cannot rest on the laurels of a good safety record—we must take action to ensure that we stay on top of aging infrastructure so that we can not only maintain, but also improve that record. Otherwise safety will degrade.

It is important that we ensure that transit systems know how to develop asset management systems, and that they use them to make tough, but critical investment decisions. Asset management systems focus the attention of transit operators on undertaking the most critical repairs first, and optimizing the sequence of maintenance and repair work over the life of the asset so that the asset is maintained at a state of good repair and at the highest level of safety. This statement is not directed at only the older systems. Newer systems built with advanced technology are aging, and we are uncertain of the useful life of these technologies. So this must be a focus for the entire industry as well.

Federal Regulation

Our nation's rail transit systems operate under two very different Federal safety regimes. Some commuter rail systems are funded by FTA but regulated by the Federal Railroad Administration (FRA) safety regulations, while light, heavy, and other urban rail systems are overseen by the State safety oversight (SSO) agencies. For example, commuter rail operations on the general system of railroads—such as the Southeastern Pennsylvania Transportation Authority's (SEPTA) Philadelphia/Doylestown regional rail line (R-5) and New Jersey Transit's Northeastern Corridor Line—fall under FRA's safety regulatory system, which includes national mandatory safety standards and on-site spot inspections and audits by Federal technical specialists and inspectors, who have backgrounds in train control, track operations and other disciplines. FRA is also empowered to dictate operating practices and assess fines on those transit operators that don't comply. On the other hand, for rail systems not subject to FRA oversight—such as the SEPTA's trolley system and Market-Frankford heavy rail line, NJ Transit's Hudson-Bergen light rail system, and PATCO (which is a subsidiary of the Delaware River Port Authority of Pennsylvania and New Jersey)—the State is expected to take the lead for oversight and require those agencies to establish a safety program. The State, through a designated SSO agency, is then expected to monitor the transit system's implementation of its safety program. FTA's role is to identify elements of requisite system safety program plans and requirements regarding the timing and establishment of an SSO agency (when there is an FTA funded rail system in the State), provide training and technical assistance to the SSO agency, establish some requirements for State oversight responsibility, and monitor the State's oversight activities. FTA is prohibited by law from establishing national safety standards, requiring Federal inspections, or requiring specific operating practices.

Given this gap between the level of regulatory oversight for rail transit operations and commuter rail operations, a team of safety officials and experts under the leadership of Deputy Secretary John D. Porcari is focused on developing options for transit safety reforms, which may extend to bus operations as well. To that end, the Deputy Secretary's workgroup is collaborating with other modal administrations within the Department of Transportation (DOT) with jurisdiction in safety regulation. These include the Federal Railroad Administration, the Federal Motor Carrier Safety Administration, and the Federal Aviation Administration. We are also assisted in our analysis by the Research and Innovative Technology Administration. This team will review the many alternative models within DOT to address safety as well as review the statutory authority on safety for transit with an eye toward developing reforms.

Conditions and Performance

As suggested earlier, the state of good repair is not just about safety—it is also about the condition of the infrastructure and reliability of transit systems nationwide. The expected useful life for rail vehicles is 25 years, 10 to 12 for heavy-duty transit buses, and 40 to 50 years for facilities. However, transit assets are often called upon to work beyond their original useful life, which requires renewing capital improvement investment. According to DOT's 2006 Conditions and Performance Report (C&P report), the average age of urban light rail cars is 16.5 years and for commuter rail passenger coaches it is 17.8 years. The average age of bus vehicles in urban areas is 6.1 years. Meanwhile, nearly half of the nation's urban bus maintenance facilities are more than 21 years old. More to the point, on average nearly one-third of urban bus maintenance facilities are in marginal or poor condition, as are 51 percent of urban rail passenger stations and eight percent of rail transit track. Yet, as transit infrastructure is aging, the demand for service continues to rise. Americans took 10.3 billion trips on public transportation in 2008, the highest level ever, surpassing increases in any other mode of transportation.

Marginal or poor transit infrastructure conditions exist despite FTA's financial support of rehabilitation and replacement activities, primarily through section 5309 Fixed Guideway Modernization funds and Section 5307 Urbanized Area Formula Grant funds. In addition, preventive maintenance is an eligible capital project expense for transit agencies in both large and small urbanized areas. It includes a variety of expenditures—activities, supplies, materials, labor related to maintenance, services, and associated costs—required to preserve or extend the functionality and serviceability of a transit vehicle, facility, or other asset in a cost-effective manner.

For the most part, systems that are adequately financed are those that have a dedicated funding source. For example, WMATA does not have a dedicated source of funding, which we believe has contributed to the system's deteriorating state of repair. Secretary LaHood and I support any Congressional effort to make public transportation agencies more financially viable with dedicated local revenue funding sources, which we believe should be directed to addressing the most safety critical issues in the systems as identified by appropriate vulnerability assessments.

State of Good Repair

Clearly, funding is not enough. Public transportation agencies must make it a top priority to achieve and maintain a state of good repair to provide safe and reliable service to millions of daily riders. To foster this commitment, FTA has made transit infrastructure's state of good repair its priority and has embarked on a multi-pronged initiative, in partnership with the transit industry, to make progress on this key priority. FTA's state of good repair initiative includes sharing ideas on recapitalization and maintenance issues, asset management practices, and innovative financing strategies. FTA kicked off its state of good repair initiative in 2008, with an initial meeting of 14 transit properties to help the agency identify key issues in bringing the industry into a state of good repair. Since then, FTA has published reports on issues associated with state of good repair; set up a state of good repair website; formed an FTA-Industry working group to discuss and share issues and ideas; and, just last month, convened a "State of Good Repair Roundtable" hosted by WMATA in Washington, DC. The purpose of this roundtable meeting was to draw attention to the issue, share experiences, and identify needs to address the repair of our nation's transit infrastructure. It was attended by more than 50 transit experts representing nearly 30 large and small rail and bus transit systems.

Continuing the momentum, in April 2009 FTA presented its State of Good Repair Study, prepared in response to the conference report accompanying the fiscal year 2008 Transportation-HUD Appropriations Act and to a December 7, 2007, letter from Senator Richard Durbin and 11 other senators to FTA.

The State of Good Repair Study assessed the level of capital investment required to attain and maintain a state of good repair for the nation's seven largest rail transit operators [Chicago's CTA, Boston's MBTA, New York's MTA, New Jersey Transit, San Francisco's Bay Area Rapid Transit System (BART), Philadelphia's SEPTA, and Washington's WMATA], which carry 80 percent of the nation's rail transit ridership. Unlike the most recent C&P report, which looks at the average condition of large and small transit agencies' bus and rail fleets and facilities, the study assessed assets based on their useful life. The study also estimated the total value of the existing backlog of over-age assets at these seven agencies.

The State of Good Repair Study finds that more than one-third of the seven agencies' assets are in marginal or poor condition, compared with less than 20 percent for transit agencies in the nation as a whole. This finding indicates that these assets are near or have already exceeded their expected useful life. In addition, the study finds that there is a backlog of unmet recapitalization needs of about $50 billion at the nation's seven largest rail transit operators. Imagine the impact to the nation's economy if these seven systems could no longer provide, due to the deteriorating conditions of infrastructure, the basic mobility that so many Americans depend on daily. Estimating future transit infrastructure needs is difficult, but additional investment will be needed over the next few decades to deal with physical deterioration, congestion, and travel demand.

Transit agencies recognize the need to progress on their state of good repair. For example, SEPTA, one of the seven study agencies, will receive $190 million in funds from the American Recovery and Reinvestment Act of 2009, which the agency is dedicating to long-deferred rehabilitation of rail stations and other facilities and the purchase of 40 replacement hybrid buses. While all seven study agencies maintain asset inventories for capital planning purposes, and while the industry recognizes the need to improve conditions, the State of Good Repair Study found that other asset management practices are lacking. These include the use of decision-support tools that provide for the ranking and prioritization of re-investment needs and the conduct of comprehensive asset condition assessments on an ongoing basis. In order to assist agencies in correcting these deficiencies, FTA is developing a transit asset management training course, working with the Federal Highway Administration Office of Asset Management, to glean "lessons learned" from their bridge and pavement management systems to see how they might be applied in transit, and conducting a review of U.S. and international agency asset management practices.

Next Steps

The importance of bringing the transit industry into a state of good repair and addressing the industry's safety and reliability problems makes clear that further action is needed. To this end, FTA will initiate an expanded study, looking beyond the seven largest transit agencies, to better understand industry-wide state of good repair needs. As part of this follow-on study we will seek to identify what we define as safety critical infrastructure. We will also consider the relationships between a transit agency's current infrastructure conditions, its ability to maintain and improve those conditions, and its plans to implement new projects under FTA's discretionary New Starts program.

My staff and I are eager to work with this committee to identify authorization proposals that will assist agencies in achieving and maintaining a state of good repair that is so necessary to the safety and reliability of public transportation service in our nation. I will be happy to answer any questions you may have.

APPENDIX D

FTA Track Safety Standards

Source—website

Oversight of Rail Transit Agency Track Inspections

Rail transit agencies perform inspections of their track on a routine basis according to their own track standards. The main purpose of these inspections is to ensure that the track is safe for the passage of trains, to determine if any aspects of the track and roadway do not meet the defined maintenance standards of the rail transit agency, and for maintenance planning purposes. 49 CFR Part 659.17 requires that the SSO Agency require the rail transit agencies under their jurisdiction to include in their System Safety Program Plans (SSPP) "a description of the process used for facilities and equipment safety inspections," as well as "a description of the maintenance audits and inspections program." These descriptions must:

- Identify the affected facilities and equipment subject to regular safety-related inspection and testing,
- Identify the maintenance cycles and documentation required,
- Include the techniques used to conduct inspections and testing,
- Provide inspection schedules and procedures, and
- Describe how results are entered into the hazard management process.

SSO Agencies are also required by Part 659 to ensure the rail transit agencies under their jurisdiction perform track inspections according to the processes stated in their SSPPs and track standards. Many SSO Agencies however, lack the resources necessary to actually participate in track inspections, while others are unfamiliar with the track standards used by the rail transit agencies under their jurisdiction. As a result, these SSO Agencies must rely solely on the information gathered from the rail transit agencies they oversee to monitor inspection performance.

The following is intended to provide SSO Agencies with a clearer understanding of the rail transit industry's track inspection processes.

Track Inspection Standards

As track components age and degrade as a result of everyday use, exposure to the elements, or for other reasons, ride quality and system safety also degrade. The rail transit industry must therefore perform track inspections to identify and correct defects. While there is no specific regulatory requirement that mandates how rail transit agencies conduct track inspections, the following are the most frequently applied and generally accepted standards used by the industry.

- 49 CFR Part 213, Track Safety Standards—Prescribe minimum safety requirements for railroad track that is part of the general railroad system of transportation. The requirements prescribed in this part apply to specific track conditions existing in isolation. Therefore, a combination of track conditions, none of which individually amounts to a deviation from the requirements in this part, may require remedial action to provide for safe operations over that track. This part does not restrict a railroad from adopting and enforcing additional or more stringent requirements.
- The American Public Transportation Association (APTA) Standard for Rail Transit Track Inspection—Created for rail transit systems (operating agencies), original equipment manufacturers (OEMs), consultants, engineers, and general interest groups, this standard provides procedures and minimum requirements for inspecting and maintaining rail transit system tracks. It represents an industry consensus of safety practices for rail transit systems directed towards achieving a high level of safety for passengers, employees, and the general public.
- The American Railway Engineering and Maintenance-of-Way Association (AREMA) Track Work Manual, Section 2.2, Track Inspection and Maintenance—Provides a guide for track inspectors pertaining to the types of defects to look for while performing track inspections, the observations that may indicate a potential or actual problem, and the important measurements to check. This manual also provides useful checklists and recommendations for obtaining thorough and accurate inspection records.

Each of the above provides detailed requirements for performing track inspections. They define acceptable tolerance limits for track components, and detail how to best document inspection results. Because of their proven effectiveness, they often serve as the basis upon which rail transit agencies have developed their own track inspection standards. At a minimum, the rail transit agency's track inspection standards should define:

- Track Inspector Qualifications.
- Track Worker Protection Rules and related safety procedures.
- The frequency at which track inspections are performed (for both walking inspections and vehicle borne inspections).
- How inspections are to be performed (for both walking inspections and vehicle borne inspections).
- Track component tolerance limits.
- How results of track inspections are to be documented.
- How remedial action plans are to be developed and implemented.

To better understand and oversee the track inspection process it is incumbent upon the SSO Agency to become familiar with the track inspection standards used by the rail transit agencies under its jurisdiction and to determine if these standards meet the minimum requirements established by the above referenced standards and practices.

The FTA Recommended Practice for Rail Transit Track Inspection

In 2008, in response to an alarming industry trend of increased track work fatalities, FTA began development of its own recommended practices for rail transit track inspection. The purpose of this document is to ensure rail transit agencies can verify that tracks are operating safely and as designed through periodic inspection and maintenance, thereby increasing reliability and reducing risk of hazard and failures. Currently in draft form, FTA intends to issue these recommended practices as a pocket guide that can be easily carried and referred to by track inspectors during inspections. FTA anticipates publishing the pocket guides later this year.

Track Inspector Qualifications

Maintaining system safety is the primary focus of all rail transit activities. It is therefore imperative that all track inspectors and maintenance staff be fully qualified to fulfill the responsibilities of their positions. Qualified track inspectors should have at least 2 years of satisfactory related experience inspecting, constructing or maintaining track and special work. They should possess a combination of experience in track maintenance and training received from a qualified course in track inspection or from a college-level education program related to track inspections, or they should have had progressive satisfactory supervisory experience on another transit or railroad system.

Refresher training and recertification programs must also be established on at least an annual or biannual basis to ensure track inspectors remain qualified. In addition, the rail transit agency must ensure that its track inspectors know and understand the requirements of the agency's track inspection standards and requirements, can detect deviations from these standards and requirements, and can prescribe appropriate remedial action to correct or safely compensate for those deviations.

SSO Agencies should periodically review the training and certification records of track inspection personnel to ensure they are up-to-date. This can be done as part of the SSO Agency's triennial review of the rail transit agency, or as part of the SSO Agency's ongoing oversight activities.

Track Inspection Basics

Track inspections are made either by foot or by riding over the track in a vehicle at a speed that allows the track inspector to visually inspect the track structure to determine if it is within the limitations defined in the rail transit agency's track standards. If a vehicle is used, it should be prohibited from exceeding 5 miles per hour when passing over track crossings and turnouts; otherwise vehicle speeds are required to be maintained at the sole discretion of the track inspector based on track conditions and inspection requirements.

Before beginning an inspection, track inspectors should first obtain, review, and keep accessible for use during the inspection, the following items:

- Operating rules and conditions: Defines the track safety requirements that must be maintained during the inspection. As conditions change, so to must the safety precautions taken to maintain track and personnel safety.
- Current timetables: Defines the frequency at which trains will be operating. This enables track inspectors to be better prepared for oncoming train traffic so that they can take the necessary precautions to maintain system and personnel safety.
- General instructions, bulletins or special orders that may be in effect during the inspection: Defines any special operating conditions that may exist during the inspection that may affect how the track inspection is performed. Also assists track inspectors in determining the necessary precautions that must be taken to maintain system and personnel safety.
- Track car rules: Defines the operating rules that must be followed when using track cars to support track inspection efforts. This includes operating speed limits for different track types and locations, the number of personnel permitted aboard the track car, and how personnel must behave while onboard the track car.
- First aid rules: Defines who has received the necessary training and certification to administer first aid, where first aid equipment will be maintained during the track inspection, and when and how it should be used.
- Maintenance-of-way rules: Defines the on-track safety rules that must be followed by track inspectors to maintain system and personnel safety. This may include requirements for the use of watchmen/flagmen, derail devices or other systems and equipment during the track inspection.
- Maintenance standards for all areas to be inspected: Defines how each track component is to be inspected, original equipment manufacturer specifications and acceptable tolerance limits for track components, and how repairs are to be made.
- Necessary equipment and measurement tools: Defines the equipment and tools that must be used to conduct quality track inspections, including when, where, and how equipment and tools are to be used.
- Authority to slow or stop traffic: Provides track inspectors with the authority needed to maintain system and personnel safety while performing track inspections.
- Watchmen/flagmen to support inspection activities: Serve as "lookouts" for oncoming train traffic. Are used to warn track inspection crews of approaching trains and to warn train operators that track inspection crews are ahead.
- Copies of the previous track inspection reports including the previous ultra-sonic test run results and track geometry car results: Enables track inspectors to identify past and potential future defects so that track inspections can be targeted at high-risk areas. Enables track inspectors to verify that past defects have been corrected.
- Blank inspection forms: Ensure that track inspectors will be able to properly document inspection findings. Completed forms also serve as a record of the track inspection and can be reviewed to identify the depth and quality of the inspection.

In addition to the above, job briefings should be held prior to the start of any on-track activity including track inspections. Job briefings are intended to discuss the sequence of the steps that will be taken to complete the track inspection including the responsibilities of each employee involved in the inspection (this includes who will be doing what, where it will be done, how it will be done, and when it will be done). All tools, inspection equipment and safety equipment must be checked prior to use, and any potential hazards that may be encountered during the inspection must be discussed. The track inspector must also ensure protective equipment is available and is being used properly. Finally, the track inspector must review any emergency procedures that may need to be taken during the inspection and confirm that every member of the work crew understands what has been discussed in the job briefing. Each of these items is essential to maintaining track safety and to performing a quality track inspection.

Once the job briefing has been completed, permission has been obtained from the control center to enter the track, and all necessary safety precautions have been taken, the track inspection can begin. Ideally track inspections should be performed at different times of day using different inspection methods. In general, track inspections are performed to identify:

- Rail defects such as broken rails, discolored running surface, worn or flat spots, cracks, or other damage;
- Rail fastener defects (i.e., tie plates, spikes, inserts, etc.) such as missing or broken bolts and washers, or loose or freely moving fasteners;
- Turnout and crossing defects;

- Roadway and general surface defects including line misalignments, uneven track, abnormal depressions, cracks or slides on embankments;
- Rail lubricator defects;
- Tie defects such as cracking, signs of rot or deterioration;
- Ballast defects including voids, holes, or depressions;
- Culvert defects including blockages;
- Ditch and drainage channel defects including blockages and high water;
- Grade grossing defects including damage gate arms, obstructed views and clearances, obstructed flangeways, or holes in the crossing surface;
- Track signal defects;
- Clearance defects such as obstructions closer than 6 feet from the gauge side of the rail;
- Vegetation defects (i.e., vegetation is encroaching into the right-of-way or is affecting the track structure);
- Weather or environmentally caused defects; and
- Miscellaneous other defects.

SSO Agencies should periodically review the rail transit agency's track inspection procedures, track standards, and track inspection records to verify that the rail transit agency is addressing, at a minimum, each of the above items during its inspection processes.

Track Inspection Equipment:

Although various inspection methods and equipment can be used depending on the type, nature and location of the inspection being performed, much of the track inspection can be performed visually. The condition of ballast, ties, drainage, culverts, and vegetation for example, can normally be determined by visual walking or riding inspections. For those track components that require more thorough examination, track inspection equipment is used. Types of track equipment used may include:

- Rail wear gauges: Used to measure rail wear, this gauge is designed to be carried by the track inspector and manually applied to the rail to measure the degree to which the rail head and side have been worn down. This enables the track inspector to verify if the rail is still within acceptable tolerance limits.
- Straight edge and taper gauges, dial indicators and 36 inch straight edges, and dial indicators and parallel 36 inch straight edges: Used to measure surface defects including corrugations, corrosion, engine burns, surface spalling, and other conditions or anomalies that directly affect the behavior of the dynamic wheel/rail interface. The taper gauge and straight edge can be used by the track inspector to determine batter and the surface conditions of rail ends, but are of little use in measuring engine burns and other similar flaws in the rail surface. A dial indicator has a higher degree of accuracy than a taper gage, and when used with a 36 inch straight edge, allows for the measurement of corrugating and engine burns. To measure defects that extend over 36 inches, two 36 inch straight edges are bolted together. The dial indicator can then be moved anywhere along the 72 inch length of the straight edges, and can obtain continuous measurements along the length.
- Goop gauge: Used to measure the degree to which lubricant has migrated from the flange area to the top of rail. Based on the measurements taken, the track inspector or maintenance crew can identify defects pertaining to the rail lubricator and can make adjustments as necessary.
- Track gauge: Come in several different shapes and models, and are used to measure the distance between the rails of a track. Track gauge defects can be measured in various ways, including through the use of a standard track gauge, a combination gauge-level board (frequently used by track inspectors), a pocket rule or tape, or a special car equipped to measure track geometry. Unless a track geometry car is available, checking the entire railroad at regular intervals for possible gauge defects requires a great deal of labor.

All measurements gathered through the use of this equipment must be documented on the track inspection form. SSO Agencies should verify that the rail transit agencies under their jurisdiction not only have the equipment necessary to complete quality track inspections, but that they have also trained all necessary personnel in its correct use, calibration and maintenance. SSO Agencies should also periodically inspect track inspection forms and reports to identify the types of equipment used during the inspections and to verify that measurements have been recorded appropriately. This again can be done as part of the SSO Agency's triennial review of the rail transit agency or as part of the SSO Agency's ongoing oversight activities.

The Track Inspection Form

As the track inspector completes his or her inspection of the track, he or she must record all identified defects on a track inspection form. Completed track inspection forms should be maintained by the rail transit agency for a minimum of two years after the inspection and for at least one year after remedial action is taken. At a minimum, the rail transit agency's track inspection forms should:

- Identify the track inspector's name, the date of the inspection, a supervisor's signature, and the work order number (if applicable).
- Identify the area inspected including the track number and the starting and ending locations of the inspection. The track inspector may vary an inspection from one track to the other as frequently as deemed necessary for efficiency but each stretch of track should be indicated by direction.
- Include a record of all findings and defects including the track number and actual location of where the defect was identified. (If exceptions relate to switches or turnouts the unique switch identification number should be entered with a description of the location.)
- Identify the repairs or other actions taken by the track inspector to address and correct the defect. In some instances, a "slow order" may be issued until actual repairs can be made. These instances should also be documented on the inspection form.
- Acknowledgement that a Supervisor has reviewed and agrees with the track inspector's assessment of track conditions. This may be in the form of a signature or by the Supervisor initialing each entry on the inspection form.
- Additional sheets as required to fully document the inspection findings and actions taken. Additional sheets should be completed sequentially and numbered in the top right hand corner of the form. The total number of pages should also be recorded.

SSO Agencies should periodically review track inspection forms to verify that, at a minimum, the above information has been recorded on the forms. SSO Agencies should also verify that completed track inspection forms are being maintained by the rail transit agency for a minimum of two years after the inspection and for at least one year after remedial action is taken.

Remedial Action Plans

Based on the outcomes of the track inspection, the track inspector may take immediate action to correct identified deficiencies or may implement a remedial action plan if the defect is beyond the immediate capabilities of the track inspector and/or work crew. In both instances, the actions taken by the track inspector must be identified on the track inspection form. If the defect cannot be immediately corrected, it must be reported to the track maintenance department so that the required repairs can be scheduled and made. This will typically require that the rail transit agency issue a work order. The date of when the final repairs are made should be added to the track inspection form once completed.

SSO Agencies should periodically review track inspection forms and work orders generated as a result of the track inspection process to verify that corrective actions are being taken by the rail transit agency to correct identified deficiencies in a timely manner. This again can be done as part of the SSO Agency's triennial review of the rail transit agency, or as part of its ongoing oversight activities.

10 Quick Questions SSO Agencies Can Ask to Evaluate RTA Track Inspection Processes

To gain an immediate sense of a rail transit agency's track inspection processes, SSO Agency can ask the following questions:

1. Are the rail transit agency's track standards based on 49 CFR Part 213, APTA, AREMA or other equivalent standards and practices?
2. What is the date of the rail transit agency's track inspection standards and when were they last reviewed and/or revised?
3. Do all necessary track maintenance personnel have ready access to the rail transit agency's track inspection standards?
4. How does the rail transit agency ensure the safety of maintenance personnel performing track inspections?
5. Do all track inspectors have up-to-date training and certifications?
6. Does the rail transit agency have the equipment necessary to perform quality track inspections?
7. Have all applicable personnel received training on how to use, calibrate and maintain track inspection equipment?
8. Are track inspections well-documented using track inspection forms and are these forms reviewed and formally approved via Supervisors?
9. Are completed track inspection forms maintained for a minimum of two years after the inspection and for at least one year after remedial action is taken?
10. How does the rail transit agency assure identified deficiencies are corrected in a timely manner?

Effective Oversight of RTA Track Inspection Processes—A Case Study of the Chicago Transit Authority

Special thanks is given to Ms. Grace Gallucci, Mr. John Goodworth, Ms. Violet Gunka, and Ms. Amy Kovalan for their support and cooperation in developing this article.

On Tuesday, July 11, 2006 a northbound Chicago Transit Authority (CTA) Blue Line train derailed in the subway tunnel between the Clark/Lake and Grand stations. The derailment caused smoke in the subway and all eight cars of the train had to be evacuated. The National Transportation Safety Board (NTSB) investigation that followed specifically identified the CTA's "ineffective management and oversight of its track inspection and maintenance program" as a probable cause of the accident. The NTSB also identified the Regional Transportation Authority, acting as the SSO Agency for the state of Illinois, as failing "to require that action be taken by CTA to correct unsafe track conditions" as a contributing factor to the accident. Finally, NTSB noted that FTA's "ineffective oversight of the Regional Transportation Authority" had contributed to the accident. Now, nearly three years after the accident, both the CTA and the Regional Transportation Authority have come full circle to address the NTSB's recommendations and to administer and oversee an effective track inspection and maintenance program.

Based on the results of both the CTA and NTSB investigations, the CTA developed an action plan focused on infrastructure renewal and investment, work structure and staffing, and technology changes to address deteriorating track conditions. Activities that the CTA has completed under this plan have included:

- Completing a detailed track inspection of the Blue Line subway and developing a schedule to replace corroded parts;
- Installing new track marker locations, directional and emergency exit signs, evacuation maps, and telephone directories to reflect current conditions and to facilitate the identification of train locations and passenger evacuations from tunnels;
- Replacing all lighting in the Blue and Red lines, dramatically increasing visibility in the tunnels;
- Hiring a contractor to perform track strength measurements throughout the entire rail system (these tests are now conducted on an annual basis);
- Purchasing manual load testing equipment to enable track gauge measurement under 3,000 psi loads;
- Entering into on-going contracts for annual track vehicle geometry testing and ultrasonic testing;
- Using new track plates that electrically isolate the negative return in the running rails to prevent the corrosion of fasteners;
- Reorganizing its track engineering department to separate track inspectors from track maintainers and increasing the number of positions dedicated to track inspection and maintenance;
- Instituting management systems and quality control checks to ensure track inspections are more closely monitored;
- Providing all track inspectors with ongoing refresher training;
- Revising its track inspection and maintenance standards to meet, and in many cases exceed the American Public Transportation Association's (APTA) standards. The new standards now incorporate improved parts that reduce the likelihood of corrosion, and also require track inspections be conducted twice every seven days for track that is older than 10 years;
- Providing System Safety department staff with track safety, track inspection, and track standards training and they now audit the track inspection and maintenance functions;
- Using a new computerized database with handheld units for field employees that integrates the maintenance records and other information needed to effectively and economically monitor the condition and repair of all tracks; and
- Implementing a grouting program to address areas of water seepage in the subway.

The Regional Transportation Authority also took action to address the NTSB recommendations and to improve and strengthen its oversight program. This has included:

- Quadrupling its level of effort devoted to its SSO Program to provide increased oversight of CTA-related issues;
- Exploring legislative changes that would provide the RTA with additional enforcement authority regarding the CTA's implementation of Part 659 requirements;

- Receiving right-of-way safety training and certifications so that RTA personnel are now fully authorized to enter the CTA right-of-way to observe track inspections and other activities;
- Receiving training from CTA operations pertaining to the Zeta Tech handheld units now used by CTA track inspectors to enter and monitor inspections; and
- Accompanying the CTA's System Safety department and track personnel during track inspections.

In addition to each of the above, the Regional Transportation Authority, as the designated State Oversight Agency, felt it could contribute more to safety by becoming both a partner and ally to the CTA in the mutual exploration of new safety technologies. A program called "Safety Discovery" was initiated to promote this partnership between agencies. As part of this program, each agency agrees to be on the lookout for safety issues or concerns and any ideas that might improve safety in the CTA system. Both agencies meet regularly to share and compare these ideas, using each other as a sounding board, teammate and "best friend" in the quest for enhanced safety.

In one example, John Goodworth, Division Manager, Program Compliance for RTA's Research, Analysis and Policy Department, inspired by the FTA's Track Inspection Workshop and working with the CTA's System Safety department, created a prototype track inspection process to help CTA track inspectors more easily detect areas of the rail right-of-way that are out of alignment and need to be properly adjusted. The prototype device was presented to the CTA's System Safety department and Track Inspection department at the January 2009 Safety Discovery meeting and received very positive reviews from both the CTA and the Regional Transportation Authority's management. The prototype makes use of a new automatic "walk behind" device used to measure track gauge and is designed for affordability and ease of use. The device can be quickly removed from the track and safely held upright if a train is approaching and measures track deviations as small as a quarter inch, using both audible and visual alarms to notify inspectors of any problem areas. Used in tandem with the CTA's handheld GPS devices, the CTA can now use the prototype to immediately identify the exact location of any misalignment issues within the system and determine to what extent it is out of tolerance.

The Regional Transportation Authority and the CTA continue to work together to explore other possible related inspection products and tools and are continuing to develop the prototype into a full production model that can be used by all CTA inspectors across the entire system. Both agencies believe this device can significantly improve the track inspection process, which can help to prevent future train derailments and ultimately help to save lives.

Indeed, significant accomplishments have been made by both the CTA and the Regional Transportation Authority since the 2006 accident. To gain deeper insight into the issues and challenges faced with implementing these vast changes and with developing an effective track inspection program, both from an SSO Agency and transit agency perspective, the FTA contacted Ms. Grace Gallucci, Deputy Executive Director, Research Analysis and Policy Development, Regional Transportation Authority; Mr. John Goodworth, Division Manager, Program Compliance, Regional Transportation Authority; Ms. Violet Gunka, Program Manager, Rail Safety Oversight, Regional Transportation Authority; and Ms. Amy Kovalan, Vice President of Safety, CTA. Outtakes from these conversations are provided below.

Regional Transportation Authority

How has the oversight agency's role changed since the 2006 derailment with regards to overseeing track inspection activities at CTA?

Grace Gallucci (GG): From an oversight perspective, we took the NTSB report very seriously and used it to address our entire oversight program, including how it was viewed internally and externally to CTA. We quadrupled our resources and changed our oversight approach from being a reactive audit function to a much more proactive approach with CTA. Before we would audit CTA's track inspection function, make recommendations, and follow-up to see if corrective actions had been implemented. Now our staff are fully trained and certified to participate in CTA's track inspection activities.

John Goodworth (JG): We've formed a very strong partnership with CTA that is now used to identify and solve problems. Our goal is to be able to look ahead and to make system improvements before accidents can occur. We no longer focus all of our energy on simply identifying what is broken, but now try to determine why problems exists, what impact they have on other system components, how they can be fixed, and what can be done to prevent them from occurring again. We now have regularly scheduled meetings with CTA focused solely on these issues and how we can work together to improve the system. Through this expanded role, we now hope to be much more than just an overseer of CTA's rail systems.

CTA's System Safety Department views the Regional Transportation Authority as a sympathetic collaborator, which has allowed us to work together as a team. We believe that because of this teamwork we've been able to realize exponential improvements to our safety programs. Two entities working together can accomplish much more than twice the amount of one. We now consider each other to be an extension of ourselves and our programs.

Violet Gunka (VG): What we've found as a result of our partnership with CTA and our increased onsite activities is that we're now able to hold an open dialogue about problems. As a result, we've been able to come up with truly positive approaches to improving the system. Our success with the track inspection program now has been extended to other areas such as the signaling system, which is currently undergoing a thorough review in much the same manner as the track inspection program.

What challenges did your agency face in making these changes and how did you overcome them?

GG: Our biggest challenge was to get CTA to view oversight in a different way. We needed to overcome issues of trust so that CTA personnel could be convinced that we were committed to helping them improve the system, and weren't just there to conducted repetitive audits that generated countless findings. This took time, but we overcame these issues by working and communicating with CTA on a regular basis. We began spending much more time on-site participating in training and actual field work, and we began communicating with all levels of CTA. This enabled our oversight staff to form strong working relationships with CTA personnel that extended from the highest levels of the organization to the lowest. As a result, we're now able to gather information much more easily and our time and resources as a team with CTA can be leveraged much more effectively.

What do you feel is the most important role or responsibility of an SSO Agency in overseeing the track inspection processes of the rail transit agencies under its jurisdiction and how have you fulfilled these roles and responsibilities?

GG: Traditional auditing is still required; however, we now place greater emphasis on identifying and ensuring the correct processes are in place to achieve goals and to solve problems. We've done this through partnership with CTA, realizing that we all have unique levels of responsibilities that must be fulfilled to identify and mitigate risks and to administer the requirements of Part 659. Through this partnership, both agencies have been able to better align their responsibilities so that we can all be more effective.

What advice can you offer to other SSO Agency's with regards to overseeing rail transit agency track inspection processes?

GG: Above all else, SSO personnel need to get out in the field. This work can't be done from behind a desk. Partnering with CTA has proven incredibly important and effective. SSO Agency's need to look first at their process to identify management's role, safety's role, their resources, and how these resources can be leveraged across both the SSO Agency and the rail agency to have the greatest impact.

Chicago Transit Authority

It is clear that the CTA has made sweeping changes to its track inspection processes over the past several years. How have these changes improved your department's oversight of the track inspection program?

Amy Kovalan (AK): From a CTA perspective, we've undergone a significant cultural change to improve the track inspection program. We conducted a full review of the program and realigned territories to make them more realistic; we underwent an extensive reorganization to separate track inspection and maintenance responsibilities and to improve accountability at all levels of the organization; and we began using more advanced tools such as hand-held technology with GPS and real-time data capabilities to improve the accuracy and oversight of inspections. The System Safety department became a separate, stand-alone department and the position of Vice President of Safety, reporting directly to the CTA's President, was created. This has helped to increase the visibility of safety and integrate the System Safety department's recommendations into the organization's broader restructuring of accountability through the use of a data-driven, performance management system.

The results of these changes have been very positive. Beginning in 2007, the System Safety department instituted monthly audits of the track inspection and maintenance functions. Because System Safety was able to verify over the course of 2007 and 2008 that the track department's improvements to the inspection and maintenance programs were working, System Safety, after discussion with our SSO team, decided to move to a quarterly audit of the track inspection and maintenance functions. This will free up our audit resources to focus on other areas such as signal maintenance, where CTA management is now applying some of the same principles and concepts that were used to improve the track inspection and maintenance program.

What has been the greatest challenge in making these changes and how have you overcome them?

AK: Changing the culture was the most difficult because the previous track inspection program had been in place for so long. Employees had to be empowered to make changes and to report problems, knowing that management would respond promptly and appropriately. They also had to know that they would be held accountable for their individual actions. Management had to take an active role in the change management process including implementing the handheld technology and managing by the data. Management also put their full support behind the FTA's new Track Inspection and Maintenance workshop which was piloted at the CTA. The workshop provided the entire track department the opportunity to learn about new tools, alternative techniques and industry best practices.

We also began collecting, analyzing and managing far more data and made significant improvements to our recordkeeping processes. With better data we've been able to realign our resources to have the greatest benefits of the program. As a result, we have a high level of confidence in our inspection program and in what is being reported.

Have the improvements made to date had any unexpected effects on CTA's safety, operations, or maintenance programs (such as improvements in employee morale, fewer employee and customer complaints, better system performance, etc.)?

AK: Overall, there seems to be a higher level of employee job satisfaction because the inspection program and employee roles and responsibilities within it are now much more clear and enforceable. We believe that improvements can't be made unless we're capable of having an open dialogue about the problems. Employees are now empowered to report safety concerns and are rewarded for doing so.

Last year, your agency participated in the FTA's Track Inspection and Maintenance workshops. How did these workshops benefit your agency?

AK: The FTA's Track Inspection and Maintenance workshops added incredible value by reinforcing the improvements made to our track inspection and maintenance program. In addition to the excellent content of the training, the mix of people that participated in the training, which included representatives from the FTA, our State Safety Oversight team, and outside consultants, added credibility and gave CTA management the opportunity to acknowledge our front line employees for their contribution to our customers' safety.

Normally transit personnel think outsiders won't understand the issues they are facing because their systems are unique. However, the Track Inspection and Maintenance workshop demonstrated that while every system is unique, there are still a number of similarities and best practices that can be shared. The workshop helped to educate CTA personnel regarding these similarities and how we can work together to continuously improve our track inspection and maintenance program. The CTA would readily volunteer to pilot any other similar programs the FTA may be developing.

APPENDIX E

APTA/FRA Track Safety Standards and Some Maintenance Standards

The following charts are based on reported maintenance standards. Each transit agency has its own maintenance standards and many use either APTA or the FRA for their safety standards. Maintenance standards and safety standards are not the same. The first column is the item number used as a reference number only. The second column is a brief description of the criteria used for maintenance. (See Appendix F for further explanation.)

The third column is the class of track. Each track class has an assigned maximum speed that trains may travel before the risk of a derailment is too great. The fourth column is the speeds assigned to the classes of track. Both APTA and FRA agree with respect to maximum passenger speed. The remainder of the columns represents minimum and maximum values of each individual transit authority.

Item	Description of Defect	Class of Track	Max passenger speed in mph APTA and FRA	APTA		FRA		Agency Maintenance Criteria																	
								A		B		C		D		E		F		G		I		J	
				Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In
1	Variation from standard gage	1	15	-½	1½	-½	1½	-⅛	¾	-¼	¾	-½	1	-⅜	1	-½	1¼	-½	1	-⅛	1¼	-½	1½	-½	1
		2	30		1¼		1¼						⅞		⅝			-⅜	¾	-⅛	1		1¼	-⅜	¾
		3	60								½		⅝			-7/16	1								
		4	80		1		1						¼			-⅜	¾	-¼	½				1	-¼	½
		5	90																						
2	Variation in alignment - 62' chord - Tangent	1	15		5		5		1	No Criteria			1		2		3		5	No Criteria			5		2¼
		2	30		3		3		¾				½		1½		2		3				3		1½
		3	60		1¾		1¾		½				¾		1¼		1½						1¾		
		4	80		1½		1½						0		1		1¼		1½				1½		1
		5	90		¾		¾								¾								¾		
3	Variation in alignment - 31', ( ) = 62' chord - Curve	1	15		3	N/A			⅝		1¼		1		(2)		2¼		(4)	1½	1½	N/A			1¼
		2	30			N/A					½		½		(1½)		1½		(2½)	¾	¾	N/A			1¼
		3	60		1¼		1¼		¼				¾		(1¼)		1						1¼		
		4	80		1		1						0		(¾)		¾		(1¼)				1		⅝
		5	90		½		½				¼				(½)								½		
4	High Water ( ) = Height above base of Rail	1	15		Head	No Criteria		No Criteria			Head		6½	No Criteria			Head	No Criteria			Head	No Criteria		No Criteria	
		2	30		Web						Web		5				Web				Web				
		3	60		Base						Base		1¼				Base				Base				
		4	80										0												
		5	90										0												
5	Runoff in 31'	1	15		3½		3½		1½		3½	No Criteria			1½		1½		3		3		3½"		2½
		2	30		3		3		1		2				1				2½		2		3		1½
		3	60		2		2		½						1								2		
		4	80		1½		1½				1				¾				1½				1½		1¼
		5	90		1		1								½								1		
6	Surface Deviation 62' Chord	1	15		3		3		1½	No Criteria		No Criteria			2		3		2¾		2¾		3		2½
		2	30		2¾		2¾		1						1½		2¾		2¼		2¼		2¾		2
		3	60		2¼		2¼		¾						1		2¼						2¼		
		4	80		2		2								¾		2		1¾				2		1⅝
		5	90		1¼		1¼								⅝								1¼		
7	Surface Deviation 31' Chord	1	15		1	No Criteria		No Criteria			¾		2	No Criteria			1	No Criteria			1¾	No Criteria		No Criteria	
		2	30		¾						9/16		1¼				¾				1¼				
		3	60		½								⅞				½								
		4	80		⅜						¼		½				⅜								
		5	90		¼																				

Item	Description of Defect	Class of Track	Max passenger speed in mph APTA and FRA	APTA		FRA		Agency Maintenance Criteria																	
								A		B		C		D		E		F		G		I		J	
				Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In
8	Deviation from 0 cross-level in 62'	1	15		3		3		1		3		1½		2		3		2½		2		3		1⅞
		2	30		2		2		¾		1¾		¾		1¾		2		1¾		1¾		2		1¼
		3	60		1¾		1¾		½				½		1¼		1¾						1¾		
		4	80		1¼		1¼				1		¼		1		1¼		1¼				1¼		1⅛
		5	90		1		1								¾								1		
9	Deviation from theoretical cross-level in 62', ( ) = 31' chord in spirals	1	15		2	No Criteria		No Criteria		No Criteria			1¼	No Criteria			2		(1¾)		1½	No Criteria			(1½)
		2	30		1¾								⅞				1¾		(1½)		1¼				(1⅛)
		3	60		1½								½				1½								
		4	80		1								¼				1		(1)						(⅞)
		5	90		¾																				
10	Warp/Twist in 62'	1	15		3		3		1¼	No Criteria		No Criteria			2		3		2½		2		3		2⅛
		2	30		2¼		2¼		1						1¾		2¼		1¾		1¾		2¼		1¾
		3	60		2		2		⅝						1¼		2						2		
		4	80		1¾		1¾								1		1¾		1¼				1¾		1⅝
		5	90		1½		1½								¾								1½		
11	Warp/Twist in 31'	1	15		2		2	No Criteria		No Criteria		No Criteria		No Criteria			2	No Criteria			2		2	No Criteria	
		2	30		1¾		1¾										1¾				1¾		1¾		
		3	60		1½		1¼										1½				1½		1¼		
		4	80		1¼		1										1¼				1¼		1		
		5	90		1		¾														1		¾		
12	Non-Defective Ties or fasteners in 39', ( ) = 62', [ ] = out of 10, { } = 100'	1	15	6		5		14		6		(16)		[4]		14		5		6		5		5	
		2	30	8		8				8		(18)		[6]		11		8		8		8		8	
		3	60					16				(20)													
		4	80	12		12				15		(22)		[7]		7		9		12		12		8	
		5	90																						
13	Non-Defective Ties in 39', ( ) = 62'for greater than 2° curves	1	15	No Criteria		6		14		6		(16)		No Criteria		13		6		No Criteria		6		6	
		2	30			9				9		(18)				10		9				9		9	
		3	60			10		16				(20)				9						10			
		4	80			14				21		(22)				5		11				14		10	
		5	90																						
14	Maximum defective ties or fasteners in a row for > 2000'R, ( ) = distance in inches	1	15		5	No Criteria			3		3		5		4		5		4		5	No Criteria			4
		2	30								2		4						3						3
		3	60		4				2				3		3		4				4				
		4	80		3								2				3		2		3				2
		5	90																						

Item	Description of Defect	Class of Track	Max passenger speed in mph APTA and FRA	APTA		FRA		Agency Maintenance Criteria																	
								A		B		C		D		E		F		G		I		J	
				Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In
15	Maximum defective ties or fasteners in a row for Radius between 1000' and 2000'. ( ) = distance in inches	1	15		4	No Criteria			3		2		4		3		4	No Criteria			4	No Criteria		No Criteria	
		2	30								1		3												
		3	60		3				2				3		2		3				3				
		4	80		2								2				2				2				
		5	90																						
16	Maximum defective ties or fasteners in a row for R < 1000'. ( ) = distance in inches	1	15		3	No Criteria			3		2		4		2		3		3		3	No Criteria			3
		2	30								1		3						2						2
		3	60		2				2				3		1		2				2				2
		4	80		1								2				1		1		1				1
		5	90																						
17	Quarter Cracked joint bars with bolts loose	1	15	N/A		N/A		Replace in 30 days		Replace		Replace		No Criteria		N/A		N/A		N/A		N/A		N/A	
		2	30																						
		3	60	Replace		Replace										Replace		Replace		Replace		Replace		Replace	
		4	80																						
		5	90																						
18	Center cracked joint bars			Replace		Replace		Replace Immediate		Replace Immediate		Replace Immediate		No Criteria		Replace		Replace		Replace		Replace		Replace	
19	Less than 2 bolts per rail, Classes 2-5 and 1 bolt per rail for Class 1			Install		Install		Install		Install		Install		Install		Install		Install		Install		Install		Install	
20	In CWR at least 2 bolts per rail			Install		Install		Install		Install		Install		Install		Install		Install		Install		Install		Install	
21	Torch cut holes or torch cut rail	1	15	N/A		N/A		No Criteria		Not Permitted		Not Permitted		Not Permitted		N/A		N/A		N/A		N/A		N/A	
		2	30	Replace Rail		Replace Rail										Replace Rail		Replace Rail		Replace Rail		Replace Rail		Replace Rail	
		3	60																						
		4	80																						
		5	90																						
22	Number of ties within 24" of the center of a joint	1	15	1		1		1 within 12"		1 within 24"		No Criteria		No Criteria		1		1		1		1		1	
		2	30																						
		3	60	2		2				1 within 18"						2		2		2		2		2	
		4	80																						
		5	90																						

Item	Description of Defect	Class of Track	Max passenger speed in mph APTA and FRA	APTA		FRA		Agency Maintenance Criteria																	
								A		B		C		D		E		F		G		I		J	
				Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In
23	Reconfigure joint bars with a torch.	1	15	OK		OK		No Criteria		Not Permitted		Not Permitted		Not Permitted		OK		OK		OK		OK		OK	
		2	30																						
		3	60	No		No										No		No		No		No		No	
		4	80																						
		5	90																						
24	Tread Mis-Match	1	15		¼		¼		¼		¼	No Criteria			3/16		¼		⅜		¼		¼		⅜
		2	30						3/16		3/16				⅛				¼						¼
		3	60		3/16		3/16										3/16				3/16		3/16		
		4	80		⅛		⅛		⅛		⅛				1/16		⅛		⅛		⅛		⅛		⅛
		5	90																						
25	Gage Face Mis-Match	1	15		¼		¼		3/16		¼	No Criteria			⅛		¼		¼		¼		¼		¼
		2	30		3/16		3/16				3/16						3/16		3/16		3/16		3/16		3/16
		3	60																						
		4	80		⅛		⅛		⅛		⅛				1/16		⅛		⅛		⅛		⅛		⅛
		5	90																						
26	Rail end batter	1	15		½		½		3/16		½	No Criteria			¼		½		⅜		½		½		⅜
		2	30		¼		¼		⅛		¼						¼		¼		¼		¼		¼
		3	60		3/16		3/16								3/16		3/16				3/16		3/16		
		4	80		⅛		⅛				⅛				⅛		⅛		⅛		⅛		⅛		⅛
		5	90		1/16		1/16								1/16						1/16		1/16		
27	Restraining Rail Flangeway ( ) = from design	1	15	1½		1½		No Criteria		1½	3	No Criteria		1½		No Criteria		(-⅜)	(⅜)	1½		1½			2⅛
		2	30							1¾	2¾							(-¼)	(¼)						1⅞
		3	60																						
		4	80															(-⅛)	(⅛)						1¾
		5	90																						
28	Double guard face gage with restraining rail on both running rails.	1	15		+½	No Criteria		No Criteria			⅜	No Criteria		No Criteria		No Criteria		No Criteria			+½	No Criteria			2
		2	30		+⅜																+7/16				1¾
		3	60																						
		4	80																						1⅝
		5	90		+¼																+¼				
29	Frog Flangeways	1	15	1½		1½		1¾	2	No Criteria		No Criteria		1½		1½		1½		1½		1½		1¼	
		2	30																						
		3	60																						
		4	80																						
		5	90																						

Item	Description of Defect	Class of Track	Max passenger speed in mph APTA and FRA	APTA		FRA		Agency Maintenance Criteria																	
								A		B		C		D		E		F		G		I		J	
				Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In
30	Minimum flangeway depth in a frog	1	15	1⅜		1⅜				1⅜						1⅜				1⅜		1⅜			
		2	30																						
		3	60	1½		1½		1½		1½		No Criteria		1½		1½		1½		1½		1½		No Criteria Flange Bearing	
		4	80																						
		5	90																						
31	Tread Wear on Frog	1	15										⅝												
		2	30										½												
		3	60		⅜		⅜	No Criteria		No Criteria			⅜		⅜		⅜		⅜		⅜		⅜		⅜
		4	80										¼												
		5	90																						
32	Guard Check Gage	1	15	-½		-½						-½		-⅞		-⅜		-½				-½		-½	
		2	30	-⅜		-⅜						-⅜		-¼		-¼		-⅜				-⅜		-⅜	
		3	60	-¼		-¼		-⅛	⅜	-¼		-¼								-⅛		-¼			
		4	80									-¼		-⅛		-⅛		-⅛						-⅛	
		5	90	-⅛		-⅛						-⅛										-⅛			
33	Guard Face Gage	1	15		½		½						½		½		½		½				½		
		2	30														⅜		⅜						
		3	60		⅜		⅜	-⅛	¼		¼		⅜								⅛		⅜	No Criteria	
		4	80												¼		¼		¼						
		5	90		¼		¼						¼										¼		
34	Frequency of Hi-Rail or walking inspection on Mainline/Siding Track	Excepted				Monthly																			
		1	15																						
		2	30	Weekly		Weekly		Weekly		Twice Weekly		Monthly		Monthly		Twice Weekly		Twice Weekly		Twice per Month		Weekly		Twice Weekly	
		3	60																						
		4	80			Twice Weekly																			
		5	90																						
35	Frequency of Gage Restraint (GRMS) Testing on Mainline	>2MGT,>30mph Pass.				Annually																			
		<2MGT,<30mph Pass.		No Criteria		24 months		No		No		No		No		No		No		No		No		No	
36	Frequency of Geometry Car Testing on Mainline			Once per year		No Criteria		3 times per Year		3 times per year		Every 2 years		Twice per year		Twice per year		4 times per year		Once per Year		Once per Year		Once per Year	

Item	Description of Defect	Class of Track	Max passenger speed in mph APTA and FRA	APTA		FRA		Agency Maintenance Criteria																	
								A		B		C		D		E		F		G		I		J	
				Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In	Min In	Max In
37	Frequency of Rail Flaw Detection Testing on Mainline	1	15			Once/30mgt Once/year, whichever longest																			
		2	30	Once per year				Twice per Year		6 times per year		Once per Year		Twice per year		Twice per year		Twice per year		Once per Year		Once per Year		Once per Year	
		3	60			Once/40mgt Once/year, whichever shortest																			
		4	80																						
		5	90																						
38	Rail Wear Limits (Gage - Top)	1	15									⅞	1			⅝	5/16	⅞	⅝						
		2	30									⅝	⅞			½	¼	¾	½						
		3	60	No Criteria		No Criteria		⅝	⅝	7/16	½	½	⅝	⅝	½					No Criteria		No Criteria		⅞	½
		4	80									⅜	½			7/16	1/16	½	⅜						
		5	90																						
39	CWR Plan (Yes or No)			Yes		Yes		Yes		Yes		No		Yes		Yes		Yes		No		Yes		No	
40	3rd Rail Inspection							1/Year																	
	Max 3rd Rail Wear							⅝		¾															
	3rd Rail Gage			No Criteria		No Criteria												-½	½						
	Max Speed in mph							>60		55		60		>60		>60		45		45		>60		50	

Min In = Minimum requirement in inches

Max In = Maximum requirement in inches

If description requirement states unit in hole number then applies

APTA is the American Public Transportation Association, FRA is the Federal Railroad Administration

Agency maintenance criteria is listed as Agency A, B, C etc to maintain aninimity

Classes of track and related speeds may vary slightly among Transit Agencies. Speeds are shown as APTA and FRA limits.

See Appendix F for definitions of criteria

9 Transit Agencies are shown which represents those agencies that willingly submitted their Maintenance Criteria.

APPENDIX F

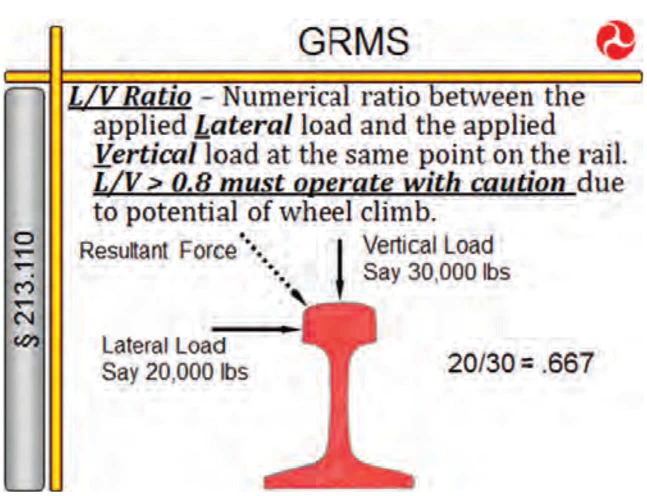
Explanation of Standards

This section offers a discussion that explains the aspects of track safety. It is based on certain parameters that can affect the safe passage of trains. The basic format was developed by the FRA and titled 213 Track Safety Standards. Freight and passenger systems have used this format and applied their own maintenance standards based on a particular maximum speed.

Item 1—Variation from standard gage: Gage is the distance between the two rails measured ? inch below the top of rail. Transits with a ¾-inch wheel flange typically measure ¼ to ⅝ inch below the top of rail. This measurement is considered to be under load, and if obvious movement is observed it must be added to the static measurement. Gage Restraint Measuring Systems (GRMS) will apply a given load based on the vehicle "crush" load and apply that to both rails, then record the gage. Typically, geometry cars are not considered to be GRMS, although some, such as the FRA geometry car, may be.

Track Class	Gage	
	Minimum (in)	Maximum (in)
1	- ½	+ 1½
2 – 3	- ½	+ 1¼
4 - 5	- ½	+ 1

Item 2—Variation in alignment for 62-foot cord on tangent (straight) track: *Any given* 62 feet of track may not have more than the middle offset measurement in the table. During manual measuring, a 62-foot piece of string is used and pulled taut with each end held against the gage face of one running rail. The measurement (offset) that is recorded in the middle of the string is the measurement that is applied to the table, giving the maximum speed that a train may operate. This measurement is also to be considered under load and any obvious movement must be added to the actual measurement. Geometry cars typically do not apply enough loads to represent the transit vehicle. GRMS can be programmed to apply to any given load.



Class	Tangent Track	Curved Track	
	Max. deviation of the mid-offset from a 62' line	Max. deviation of the mid-offset from 31' chord (same on tangent)	Max. deviation of the mid-offset from 62' chord
1	5"	3"	5"
2	3"	3"	3"
3	1¾"	1¼"	1¾"
4	1½"	1"	1½"
5	¾"	½"	⅝"

Item 3—Variation in alignment with a 31-foot cord in tangent: The same principles apply as in Item 2, but using a 31-foot cord instead of a 62-foot cord. (Note that some agencies do not use a 31-foot cord on curves; also note that the middle ordinate offset for a 62-foot cord is not one-half for a 31-foot cord but one-fourth. For example, if a middle ordinate offset of 4 inches is recorded for a 62-foot cord, then for a 31-foot cord it would be 1 inch.)

Class of Track	Priority	Speed	High Water Condition
1	1	< 15 mph	Within the head of either running rail [1]
2	2	16-30 mph	Above the base of either running rail
3-5	3	31-90mph	Up to the base of either running rail

NOTE:
1 – Only supervised operation is permitted where water is above the running surface of either rail.
2 – This table is not applicable for street running track. Rail transit systems with street running track shall develop and adhere to specific guidelines for their conditions

Item 4—High water: This item expresses that when ground water reaches a certain elevation with respect to the rail, action should be taken. Note that FRA has no criteria for this.

Item 5—Runoff in 31 feet: During maintenance activities, it may be necessary to adjust the elevation of the track to correct defects or simply to smooth out the profile. When these activities are completed, the track must be gradually transitioned back to the original elevation. This criterion expresses the maximum transition in 31 feet to accomplish that activity based on a particular speed.

Track Surface	Track Class				
	1	2	3	4	5
Max. Runoff 31' (inches)	3½	3	2	1½	1

Item 6—Surface deviation in 62 feet: The same concept applies in horizontal alignment as it does in these criteria for

Track Surface	Track Class				
	1	2	3	4	5
Max Deviation 62' (inches)	3	2¾	2¼	2	1¼
Max Deviation 31' (inches)	1	¾	½	⅜	¼

vertical alignment. Any given 62 feet of track may not experience more than the allowable "dip" or "hump" in the track. The 62-foot string line is stretched on top of the rail to obtain this measurement recorded at the 31-foot mark.

Item 7—Surface deviation in 31 feet: The same concept applies as in Item 6 but with the use of a 31-foot string. The middle measurement at 15 feet 6 inches is used to apply to the table. Note that FRA has no criteria for this.

Item 8—Deviation from zero cross level in 62 feet: This criterion applies to tangent track that should have zero cross level. (Cross level is the difference between the two rails.) This is considered to apply to any given 62 feet of track, not *each* 62 feet of track. The table expresses the maximum change from zero cross level that any given 62 feet of track may experience.

Track Surface	Track Class				
	1	2	3	4	5
Deviation from 0" X-Level in 62' (inches)	3	2	1¾	1¼	1
Deviation from theo X-Level in 62' in spirals (inches)	2	1¾	1½	1	¾

Item 9—Deviation from theoretical cross level in a 62-foot cord in spirals: This applies to the change in cross level or super elevation in a spiral. It applies to the theoretical change in elevation to achieve full super elevation prior to entering the full body of the curve. The spiral has an increasing radius, whereas the curve has a constant radius. As an example: A 2,865-foot radius curve (2°) would have a 2-inch offset for a 62-foot cord. For a 31-foot cord, it should be ½-inch offset (one-fourth of the measurement, not one-half).

Item 10—Warp (twist) in 62 feet: This is similar to item 8; however it pertains to the difference or change in cross level measurements in any given 62 feet. A track could experience a ½-inch cross level and 62 feet away it might be ½ inch the other way, which would be a combined 1-inch warp. This is an important measurement, since it is reflected in rider comfort when a train experiences side movement. At higher rates of speed, warp may cause "wheel lift off" or harmonics resulting in a possible derailment.

Track Surface	Track Class				
	1	2	3	4	5
Warp (Twist) 62' (in)	3	2¼	2	1¾	1½
Warp (Twist) 31' (in)	2	1¾	1½	1¼	1

Item 11—Warp (twist) in 31 feet: This is the same application as in item 10, however using 31 feet for the application.

Track Class	Non-Defective Ties or Fasteners in 39' Min Good
1	6
2	8
3	8
4 & 5	12

Item 12—Non-defective ties or fasteners in 39 feet: This is the number of good ties (non-defective) in a given piece of track. Agency C uses the number of good ties or fasteners in 62 feet of track.

Item 13—Non-defective ties in 39 feet for curves greater than 2°: This is the same as item 12 except this applies to curves.

Item 14—Maximum defective ties or fasteners in a row for curves with greater than a 2,000-foot radius: This is self-explanatory. Note that FRA has no criteria for this item.

Track Class	R ≤ 1,000'	1,000' < R < 2,000'	R > 2,000'
1	5	4	3
2	5	4	3
3	4	3	2
4 & 5	3	2	1

Maximum ties in a row

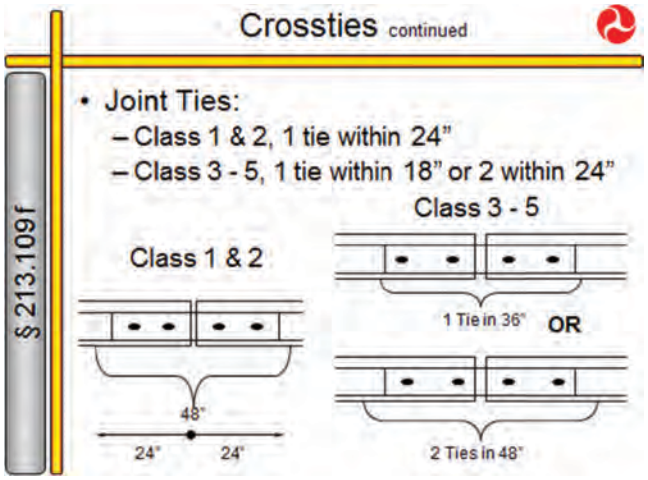
Item 15—Maximum defective ties or fasteners in a row for curves with 1,000 to 2,000-foot radii: This is self-explanatory. Note that FRA has no criteria for this item.

Rail Joints	
Defect/Condition	Action
Cracked joint bar or rail moves with bolts tight in Classes 3-5	Replace
Joint bar cracked or broken between 2 middle holes	Replace
Each RAIL shall have 2 tight bolts in Classes 2-5, 1 in Class 1	Install
In CWR at least 2 tight bolts per RAIL.	Install
NO rail shall have torched bolt holes in Classes 2-5	Replace Rail
NO torch cut joint bars in Classes 2-5	Replace Bars

Item 16—Maximum defective ties or fasteners in a row for curves with less than 1,000 foot radius: This is self-explanatory. Note that FRA has no criteria for this item.

Item 17—Quarter-cracked joint bars with loose bolts: A quarter crack is a crack in one of the joint bars between the second and third holes in a four-hole joint bar, or between the third and fourth holes on a six-hole joint bar.

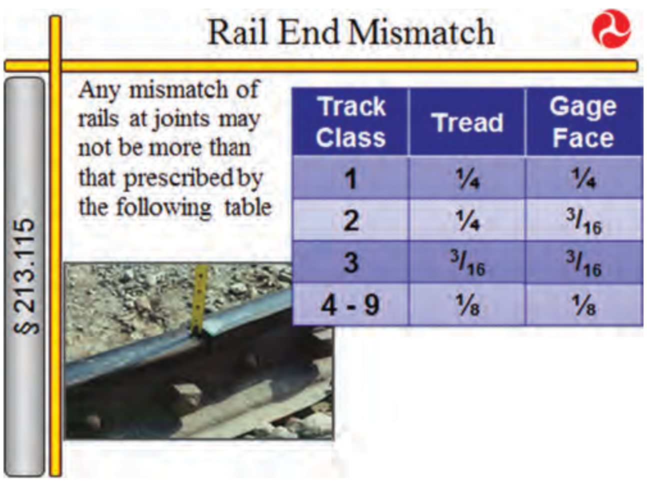
Item 18—Center-cracked joint bars: This refers to a crack in a joint bar between the middle holes where the two rail ends come together.



Item 19—Fewer than two bolts per rail for Classes 2–5 and one bolt per rail for Class 1: Each joint must be held tightly together using at least four bolts for Classes 2–5 (two per rail) or two bolts for Class 1 one per rail) in order to comply with this standard. The bolts counted must be tight and secure.

Item 20—In CWR, at least two bolts per rail: This is similar to item 19 except that there is no distinction for class of track.

Item 21—Torch-cut holes or torch-cut rail: This is self-explanatory. Note that both APTA and FRA permit torch cutting for Class 1 track (speeds 15 mph for APTA and 10 mph for FRA).



Track Class	Tread	Gage Face
1	¼	¼
2	¼	3/16
3	3/16	3/16
4 - 9	⅛	⅛

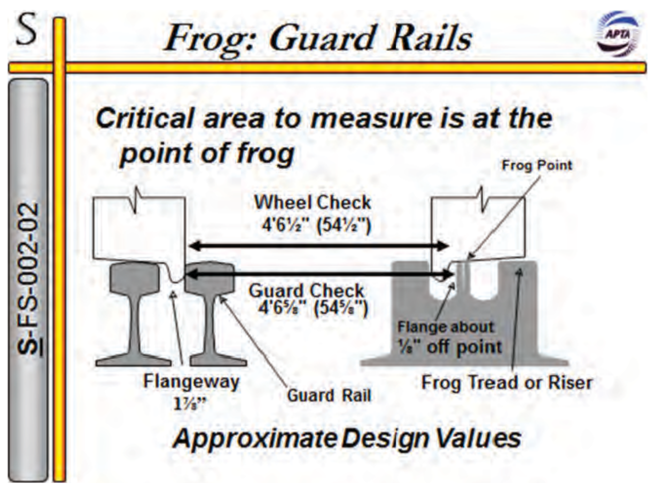
Item 22—Number of ties within 24 inches of the center of a joint: There must be at least one good tie within 2 feet of the rails coming together. This distance is measured from the center of the joint to the center of the tie.

Item 23—Reconfiguring joint bars with a torch: If a joint bar needs to be trimmed or the hole in a joint bar made larger, it is permitted for Class 1 & 2 (30 mph) by APTA and Classes 1 & 2 (25 mph) by FRA.

Item 24—Tread mismatch: When two rails are joined together, if there is a difference in elevation creating a "step," then this item applies.

Item 25—Gage face mismatch: The same principles apply as in item 24 but on the gage face of the rail, which creates a blunt end for the flange of the wheel to contact.

Item 26—Rail end batter: This is similar to item 25. The difference is how much the end of one rail is worn compared to the wear measurement 18 inches from the end of the rail. Typically, both ends where the rails are joined are worn to the same degree, creating a "speed bump" at the joint.



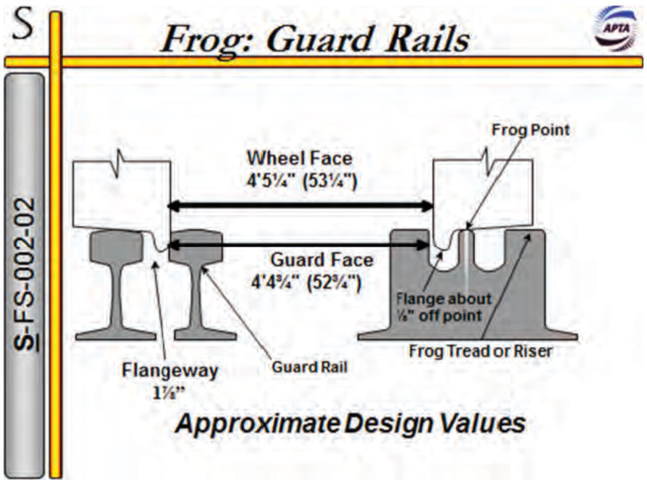
Item 27—Restraining rail flangeway: This is the minimum distance between the gage face of the running rail and the back side of the restraining rail (guard rail).

Item 28—Double guard face gage with restraining rail on both rails: This is a maximum distance measured between both guard faces (from inside to inside). This can be a major factor with different wheel gages.

Item 29—Frog flangeways: The minimum distance between gage line and guard face of the frog creates the flangeway.

Item 30—Minimum flangeway depth in a frog: This measurement is taken from the tread surface to the bottom of the flangeway in a frog.

Item 31—Tread wear on frog: This is the same as top wear on rail. The actual measurement is subtracted from the measurement as it was when new to give the wear measurement. Typically, the wing rails are not worn at the frog point and can be used as a surface to measure wear with a straight edge.



Item 32—Guard check gage: This is a measurement from the gage face of the frog to the guard face of the opposing guardrail. This is a minimum measurement. If this measurement is less than the criteria, then there is an opportunity for the wheel operating over the frog to hit the point of the frog or traverse in the wrong direction, causing a derailment.

Measurement (inches)	Class 1	Class 2	Class 3&4	Class 5
Guard Check Gage: Gage line of frog to gage face of it's guard rail. **May not be less than**	54⅛	54¼	54⅜	54½
Guard Face Gage: Distance between guard lines. **May not be more than.**	53¼	53⅛	53⅛	53

Item 33—Guard face gage: This is a measurement taken from the guarding face of the guard rail to the guarding face of the frog. In slang terms, it is called the back-to-back gage. This is a maximum dimension so that the back sides of both wheels do not come in contact with the guarding faces at the same time.

Item 34—Frequency of high rail or walking inspection on mainline and siding: This is self-explanatory. APTA has some criteria on this activity. The range reported by transit agencies varies from twice weekly to monthly. The FRA requires a minimum frequency of once per week for speeds up to 60 mph and twice per week for speeds higher than 60 mph.

Class Track	Type Track	Frequency
1, 2, 3	Main & Siding	Weekly with at least 3 days between
1, 2, 3	Other than main	Monthly with at least 20 days between
4, 5		Twice weekly with at least 1 day between

Item 35—Frequency of gage restraint testing on mainline: See definition of GRMS under Item 1. Note that the FRA (§213.110. (o). (1)) requires that a GRMS check is done annually on passenger systems traveling greater than 30 mph. APTA has no criteria for this item.

Item 36—Frequency of geometry car testing on mainline: Both APTA and FRA offer safety standards for this item.

Class Track	Type Track	Frequency
ALL	Revenue	Weekly
ALL	Non-Revenue	Monthly
UT Testing	Mainline	Once per year
Geometry Car	Revenue	Once per year
Geometry Car	Non-Revenue	Once per 2-years
Switches & Xing's	Mainline	Monthly
Switches & Xing's	Yards	Once per 3-months
Switches & Xing's	Signaled	Joint Inspect Track & Signal Dept

Item 37—Frequency of rail flaw detection testing on mainline: APTA has requirements for this and the FRA applies this criteria to freight railroads based on MGT's (million gross tons) and passenger Class 3. All (100%) of the transit agencies surveyed utilize a rail flaw detection vehicle with frequencies ranging from six times per year to every two years.

Item 38—Rail wear limits: Neither FRA or APTA have criteria for this. AREMA has recommended practices pertaining to maximum wear limits on the rail.

Suggested Rail Wear Limits			
	Rail Wear	Monitor	Change Rail
115 RE	Vertical Wear	≥ ½"	≥ ⅝"
	Side Wear	≥ ⅜"	≥ ⅝"
	Guard Rail Side	≥ ¼"	≥ $^7/_{16}$"

Item 39—Continuous Welded Rail (CWR) plan (yes) or (No): A CWR plan encompasses a wide range of standards that each railroad must adhere to. Each railroad should produce a CWR plan according to APTA, and if under FRA jurisdiction should have submitted it to the FRA by October of 2009. According to the survey, 65% of transit agencies have a CWR plan but they may not follow the requirements of FRA. When questioning different transit professionals, it was determined that each

agency's definition was different and not that of the FRA. The FRA requires that at a minimum the following be addressed:

- Installation, adjustment, maintenance, and inspection of CWR and CWR joints
- A training program for application of procedures
- Designation of a desired rail temperature (DRT) and a de-stressing procedure to obtain DRT
- Rail anchoring or fastener requirements to restrain the rail from movement, especially around bridges
- Specific procedures for maintaining the DRT during rail cutting, welding rail, and buckles and pull-aparts with existing temperature so that:
  - When rail is removed; the installed rail length is calculated using the DRT.
  - Under NO circumstances shall rail be added when rail temperature is below the DRT.
- A procedure for adjusting CWR on curves
- Procedures which control train speed when:
  - Any work disturbs the roadbed or ballast that will reduce the longitudinal or lateral restraint.
  - Establishing a range that causes buckling.
  - In formulating the procedure the owner shall determine duration of speed restriction based on sufficient stabilization.
  - Taking into consideration the type of crossties.
- Procedure for physical inspection to determine potential track buckles.
- Locations where tight or kinky rail will occur.
- Determine areas prone to buckles and pull-aparts.
- Recently performed track work
- In formulating the procedure, owner shall specify the timing of inspection and specify remedial action taken.
- Owner must have a comprehensive training program with written procedures and provisions for annual re-training. The program shall be available to FRA upon request.
- Owner shall have accurate recordkeeping requirements and a history of all track built with CWR. At a minimum, records must include:
  - Rail temperature, location, and date of CWR installation retained for at least one year
  - Records of any non-conformance with the procedures.

Abbreviations used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation