Abridgment

Maintenance Management of Traffic-Signal Equipment and Systems

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ABSTRACT

A description is given of the 1984 update of Synthesis of Highway Practice 22, which was published by the Transportation Research Board in 1974. This abridgment summarizes the portions of the update that may be of most interest to road maintenance personnel. Evidence abounds from U.S. sources and those abroad that signal malfunctions are widespread and serious in their consequences. The problem is with the frequency of failure and the excessive time before a failure may be reported. Hardware malfunctions are estimated to cost Los Angeles drivers $3.6 million annually and to increase gasoline consumption by 2.8 million gallons per year. Specific problem areas include nonstandardization of equipment, overuse of sophisticated controller and detector configurations, inadequate inspection during installation, the use of low-grade components not suitable to the environment, insufficient quality control, inadequate maintenance capability, damage from power surges including lightning transients, and lack of funds for equipment replacement programs. The basics of legal responsibility and liability, including the elements of negligence suits, are also summarized and suggestions are given for reducing risk.

The author was retained by the TRB to update NCHRP Synthesis of Highway Practice 22 published in 1974 (1). The purpose of this abridgment paper is to call attention to the availability of the updated report to be published in 1984 and highlight those portions of interest to road maintenance personnel attending the 1984 Maintenance Management Workshop.

The report is a synthesis of current information, particularly published material, available from U.S. and foreign sources on the management aspects of traffic signal maintenance. It is intended for use by management personnel responsible for staffing, budgeting, and so forth, rather than as a manual for the field troubleshooter or the repairman working at a bench in a signal shop. Specific data are presented on the estimated costs and manpower requirements for maintaining traffic signals at intersections and for other signal systems of various complexities. Readers will find support for their recommendations for increases in staff, funds for equipment replacement programs, and so forth.

The introductory chapter illustrates the importance of proper maintenance, points out some particular problem areas, and defines several types of maintenance. Subsequent chapters are entitled

- Description of the Maintenance Effort,
- Maintenance Personnel,
- Maintenance Facilities and Equipment,
- Types of Maintenance Organizations,
- Maintenance Costs and Funding, and
- Administrative Control.

The final chapter contains the conclusions, which are discussed briefly here.

1. The need to reduce equipment sophistication and enforce standardization is stressed. Other ways to reduce maintenance needs, or make required maintenance easier to perform, are to specify components with higher reliability and to demand modularity of components.
2. The emphasis is on inspection patrols and self-detection methods to discover malfunctions and on subsequent checking to be certain the faults have been corrected rather than on routine, scheduled maintenance to prevent malfunctions.
3. The number of signalized intersections (including school flashers and flashing beacons) that can be maintained by one technician varies widely but appears to be in the range of 25 to 35.
4. Maintenance contracts are cost-effective and are necessary for computers and much of the peripheral equipment.

The appendices furnish details useful to the manager in setting staffing levels, hiring qualified personnel, stocking maintenance equipment and replacement parts, contracting maintenance, keeping adequate records, and testing competing brands of lamps. One appendix lists documents for further reading that were not referenced in the report.

The remainder of this abridgment paper emphasizes those portions of the updated report that may be of interest to road maintenance personnel.

PROBLEMS ASSOCIATED WITH INADEQUATE MAINTENANCE

Evidence abounds from U.S. sources and those abroad that signal malfunctions are widespread. The problem includes both the frequency of failure and the excessive time before a failure may be reported.

Startling results were obtained from a recent field survey in Atlanta (2). Fifty-nine intersections were inspected by a three-man team from the traffic engineering staff. They found that equipment malfunctions at nearly 50 percent of the intersections significantly restricted the smooth flow of traffic. In several instances the deficiency was so severe that the signal stopped operating.

Consequences of Maintenance Deficiencies

Maintenance deficiencies that cause equipment malfunctions tend to reduce equipment life and to result in serious consequences to the road user and society. Tillotson reported in 1975 (3) that a simple failure (such as a broken detector loop) can induce significant delay. By locking in a call to the controller phase, it will cause the green signal to extend to its maximum limit irrespective of traffic demands. If the signal is caused to operate as a fixed-time controller with a cycle length of the order of 120 seconds, then the extra delay amounts to about one-half the normal daily delay.

Faults in signal equipment in central London have been estimated to cause delays costing the community about 4,000 pounds sterling per year per stopline (4). In 1984 the dollar equivalent was over $6,000 per stopline. There are safety implications as well. Hulscher (5) inferred from New South Wales data that the overall accident rate at blacked out or faulty signal locations is about eight times higher than at signal sites functioning normally.

A signal that is malfunctioning may be placed on flashing yellow or red by the maintenance crew or by a digital master that has recognized a problem. Nighttime data gathered in San Francisco (6) showed that crashes almost tripled when their signals were converted to flashing operation after midnight.

A 1981 Los Angeles report (7) concluded that, in spite of a rigorous maintenance program, almost 24 percent of their signals had malfunctions that would affect the efficiency of traffic flow. Rowe of the Los Angeles Department of Transportation used the TRANSYT computer program to estimate that hardware malfunctions increase the fuel consumption on surface streets by 0.5 percent. This amounts to 2.8 million extra gallons of gasoline per year and about a $3.6-million annual loss to Los Angeles drivers.

The cost-effectiveness of good maintenance is beyond question. Even if signal malfunctions were to increase stops and delay by just a small percentage (a second or two) the cost to motorists would far exceed the cost to maintain the signals properly.

Specific Problems

Specific problems include nonstandardization of equipment, overuse of sophisticated controller and detector configurations, inadequate inspection during installation, the use of low-grade components not suitable to the environment, insufficient quality control, inadequate maintenance capability, damage from power surges including lightning transients, and lack of funds for equipment replacement programs.

TYPES OF MAINTENANCE

The report prepared for the Pennsylvania Department of Transportation (PennDOT) (8) divided maintenance into three categories that are defined as follows:

- Preventive maintenance. Periodic checks and procedures to assure reliable operation of traffic signal equipment and reduce field failures.
- Response maintenance. Repairs and returns failed equipment to normal operation.
- Design modification. Any change to the approved design or operation of a traffic signal that is justified because of a recurring problem. Usually it adds or removes a phase of a special function or changes the signal display to correct a problem in a new installation.

Preventive maintenance can be implemented at two levels, A and B, where B is the minimum for reliable operation. For example, level A calls for painting the cabinet every 2 to 5 years, oiling the hinges every year, replacing the filter once a year and cleaning it at midyear. Level B omits the painting and oiling and services the filter only by replacing it once a year.

Response maintenance can be implemented at three levels--A, B, and C. Level C requires only a signal mechanic to provide complete service for electromechanical equipment only. The signal mechanic can service solid-state equipment only by swapping units. Level B is performed by a signal technician, who is capable of level C work and troubleshooting systems and communications. A municipality desiring level A response capability would need to add a signal specialist capable of performing bench repair of all equipment.

Response maintenance performed according to the PennDOT standards begins with a trip to the intersection within 1 hour to verify and identify the reported problem. This could be performed by the police or others. Then, maintenance personnel provide either final repair or emergency repair. Final repair either repairs or replaces the failed equipment to restore the intersection to proper and safe operation, in accordance with the state permit, within 24 hours. This type of repair is required for span wires or signal heads knocked down as the result of an accident, and for equipment failures involving lamp burnout, conflict monitor, flasher, load switch, or signal cable. For other types of failures emergency repair is acceptable. Emergency repair temporarily restores safe operation within a 24-hour period. The repairs required to bring the equipment into conformance with the permit must be completed within 30 days unless prohibited by weather conditions or availability of equipment.

Selecting the time periods allowed to elapse before a signal system is restored to operation is difficult, because of the liability implications. The PennDOT time periods for repair were based partly on the fact that in Pennsylvania much of the maintenance is performed by contractors who may be some distance from the area to be serviced.

RISK MANAGEMENT

Tort liability judgments related to inadequately maintained traffic signals cost government agencies large sums annually. The shield of sovereign immunity has eroded considerably, leading many agencies to develop methods to handle and monitor their exposure to loss. This process is known as risk management.

Basics of Legal Responsibility

Many articles and reports (such as 9-13) have set forth the elements of negligence as applied to traffic signal maintenance and have explained the liability of governmental agencies and their personnel. The International Municipal Signal Association (IMSA) ran a series of articles (including 14 and 15) alerting the maintenance technician to his vulnerability to suit. Another IMSA article, by Krueper (11), emphasized that potential liability can be reduced by keeping adequate maintenance records both in the office files and in the curbside cabinet.

Lawsuits in this area are based on allegations of negligence or that a hazard was a public nuisance. These lawsuits generally have the following principal issues:

1. Did a potentially dangerous defect or hazard exist?
2. Was there injury or property damage?
3. What was the defendant's duty of care in this situation?
4. Was the defendant derelict in fulfilling his duty? For example, did this technician troubleshoot this controller according to the standard of a reasonably prudent technician working in this part of the country and under these circumstances?
5. Did the damages or injuries result directly from the dereliction of duty?
6. Was the defendant aware of the hazard for some time before the accident? Was the presence of the defect phoned in by a motorist (actual notice), or would the agency have discovered the defect in

the normal course of doing its work properly (constructive notice)?

7. Was there any contributory negligence (such as speeding) on the part of the plaintiff? In many states this can bar recovery by a plaintiff, and in others that have a "comparative negligence doctrine" the amount of the recovery would be reduced.

8. Could the defendant have warned the motorist of the hazard, or made the location safe by means such as police control, before correcting the hazard?

9. Was there reasonable time, method, and money to correct the hazard?

Failure to Comply with Maintenance Standards or Guidelines

In NCHRP Research Results Digest 129 (16) Thomas discussed the legal implications of a highway department's failure to comply with design, safety, or maintenance guidelines. The court cases discussed by Thomas are evidence that guidelines applicable to maintenance and maintenance procedures may be admissible as evidence of the standard of care the highway agency should have followed. A specified procedure may be put into evidence to establish that the department should have had notice of an unsafe condition and that the department failed to meet its own standard of care.

Suggestions for Reducing Risk

The maintenance manager should provide his technicians with up-to-date equipment and should ensure that the equipment is being used. Mere visual inspections should not be allowed nor should technicians be permitted to seek a temporary repair by removing power and then reapplying it to restart the controller. (This may allow a marginal semiconductor to cool enough to operate satisfactorily for a time, but the problem will reappear.) The manager should be sure that the maintenance technician does not neglect repairs other than those he was sent out to repair. He should seek other problems that may exist and correct them.

Adequate maintenance records should be kept so that in the event of litigation there will be no doubt what was done and when. The following should be included in a maintenance record:

1. Who made the complaint?
2. Time complaint was received by the dispatcher.
3. Time complaint was given to the repair crew.
4. Time crew responded.
5. Time repair was completed.
6. What trouble was found, including any additional problem found by maintenance person?
7. What repairs were made?
8. What materials were used?

Further suggestions for reducing risk can be found in NCHRP Synthesis of Highway Practice 106, Practical Guidelines for Minimizing Tort Liability (17).

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