157

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

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MAINTENANCE MANAGEMENT OF STREET AND HIGHWAY SIGNS

TRANSPORTATION RESEARCH BOARD
National Research Council

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TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NOTE: The Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of interest to traffic engineers, maintenance managers, sign shop supervisors, and others interested in the maintenance of street and highway signs. Detailed information is presented on the current practices of state and local governments in managing the maintenance of street and highway signs within their jurisdictions.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

The maintenance of street and highway signs is viewed as a means for improving the effectiveness of a signing system. This report of the Transportation Research Board describes the maintenance practices of several state and local highway agencies along with the rationale for these practices. It covers inspection, refurbishing, and replacement practices, along with information on equipment and personnel requirements.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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The Transportation Research Board would like to acknowledge and thank the Michigan Section of the International Municipal Signal Association and the Michigan Office of Highway Safety Planning for the use of many of the photographs contained in this synthesis.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

MAINTENANCE MANAGEMENT OF STREET AND HIGHWAY SIGNS

SUMMARY

The ability of public agencies to adequately maintain the estimated 58 million traffic signs that line the 3.8 million miles of streets and highways within the United States is dependent on a systematic approach to maintenance.

A sign maintenance program includes those activities related to the manufacture, procurement, installation, inventory, field inspection, and repair and replacement of traffic signs.

As reported in the 1988 Federal Highway Administration Annual Report to Congress on Highway Safety Improvement Programs, traffic signing improvements have the highest benefit-cost ratio of any highway safety improvement.

The problem of inadequate funding for sign maintenance is all too evident. For example, a 1988 field survey of traffic signs in a major metropolitan area found that 60 percent of the locations surveyed needed to have some form of sign maintenance—either replacement of a sign, re-erection of a sign that was missing, removal of a sign that was unnecessary, or installation of a sign that was needed. Comparable results are reported from other agencies that have conducted similar studies.

Deficiencies in sign maintenance can have serious impacts on the highway system and on public agencies. Maintenance deficiencies result primarily in a reduction in safety for the motorist and increased liability exposure for the agency.

Tort liability losses to state departments of highway and transportation have increased 1900 percent in the 10-year period between 1975 and 1985. A large proportion of those liability losses can be attributed to traffic signing. One survey found that for states, 29 percent of the tort claims against highway departments were related to traffic control devices. For county and city road departments, the percentages of tort claims related to traffic control devices were 25 percent and 37 percent respectively. A study of tort claims considering only highway accidents in which a fatality or serious injury occurred found that signing deficiencies were cited as the primary factor in 41 percent of the claims.

Experts in transportation and law are recommending that agencies adopt a risk management program to minimize tort liability losses. Risk management is a process by which an agency attempts to identify, quantify, and control exposure to tort liability actions. Generally these risk management programs are made up of two separate activities:

- Activities directed at managing risk by reducing traffic accidents and the potential for incurring liability claims through the improvement of the safety of the road system.
- A litigation management program that, by providing a better defense, minimizes the amount of loss to the agency once a liability claim has been filed.

An important element of a street and highway sign maintenance management system is the timely detection of maintenance needs. This detection requires the cooperation of many different agencies and groups. These could include other maintenance departments, police, postal carriers, and citizens. However, this reporting process must be formalized to ensure that the lines of communication do not break down from the informant to the sign crew. This includes the establishment of a policy for the dispatch

of off-shift workers for emergency repairs of traffic signs based on the degree of hazard caused by the failure.

In addition, it is essential that inspections of traffic signs be made at night to determine the adequacy of retro-reflection and specific visibility or signing needs that may be more obvious at night.

When, because of long distances or congested roadways, travel time from a maintenance facility to a work site is longer than approximately 1 hr, consideration should be given to the decentralization of the maintenance organization. (This, however, is just one of many elements that should be considered when determining the location of a maintenance facility.) This decentralization generally includes the establishment of a district sign shop, but the majority of the sign fabrication is done at a central location. (Many agencies that have such a decentralized organization still have a limited production capability at the district shop for the manufacture of unique signs and emergency replacements.)

An increasing number of states and municipalities are relying on private contractors to do routine maintenance. This trend is a result of staffing problems caused by budget constraints or lack of specialized equipment or skills. Few agencies, however, contract out sign maintenance extensively. Those agencies that are using contractors for sign maintenance are generally reporting good results.

A key element in the management of street and highway signs is the availability of accurate information about the type of sign, its condition, and its location on the road. Such a sign inventory provides the basis for decisions relative to developing scheduling priorities and for the defense of tort liability claims. Sign inventory methods can take many forms. Agencies use manual file cards, strip maps, aerial photographs, notch cards, microcomputers, and mainframe computers. The important element is that the process should be continuous, with constant updating as signs are added, removed, or replaced.

Some agencies are also automating their sign shop to reduce personnel requirements by using robotics and computer-aided drafting (CAD) systems for sign legend layout and fabrication. A major advantage of a CAD system is the easy and rapid adjustment of spacing and letter size. In addition, some agencies are using CAD systems to reduce the quantity of silk screens on hand by storing the sign layouts in computer files and calling them up when needed.

Because of the high cost of testing materials, many agencies see a future trend toward the regionalization of materials testing procedures. The 12 states that compose the Southeastern Association of State Highway and Transportation Officials have completed a study of the feasibility and costs of regional testing. Their analysis indicated that the implementation of a regional test facility could provide an annual savings of approximately $400,000.

With rapidly increasing aluminum prices, many agencies have found it financially advantageous to either purchase a mechanical sign stripping machine or contract out sign stripping for purposes of reclaiming sign substrate.

A number of methods are being used to better manage maintenance costs for street and highway signs. These include: better management of sign vandalism problems to reduce occurrences; improvements in worker productivity; better control of overtime work; selection of materials that provide better performance and benefits versus cost; improved procurement specifications and determination of manufacturer compliance with specifications; obtaining of quantity discounts through joint purchase with other agencies or projection of material needs to allow the purchase of larger quantities; use of sign installation techniques to reduce and expedite maintenance.

Further research needs to be completed on a number of issues before the implementation of retro-reflectivity guidelines or standards. For instance, the economic impact of retro-reflectivity standards on sign maintenance budgets is still undetermined; a low-cost, rapid process must be developed to evaluate the retro-reflectivity of signs.

CHAPTER ONE

INTRODUCTION

PURPOSE AND SCOPE OF SYNTHESIS

For the 157 million U.S. motorists, who spend an average of two years of their lives on some part of the 3,853,000 miles of public roads, traffic signs are a major form of governance. The Federal Highway Administration (FHWA) estimates that there are more than 58 million traffic signs worth $6 billion on the nation's roadsides, or an average of 15 signs per highway mile. On an annual basis, one estimate claims that more than $250 million is spent on the fabrication and erection of street and highway signs (*1*). With this large nationwide inventory, effective public-agency management of street and highway signs to maintain high levels of safety and service is dependent on a systematic approach to sign maintenance.

Sign maintenance can be defined as those activities related to the manufacture, procurement, installation, inventory, field inspection, repair, and replacement of traffic control signs. There are a wide variety of techniques used by public agencies throughout the United States and Canada in the maintenance management of their traffic signs. This report is a synthesis of these techniques and is intended for use by management personnel in the review of their agencies' maintenance activities. When available, specific costs, personnel needs, productivity, etc., are provided for assistance in evaluating an agency's staffing, budgeting, and equipment requirements.

HISTORY OF SIGNS

Possibly the earliest roadway sign was the milestone. Thousands were erected by the Romans as early as 250 B.C. to show the distances from Rome. In addition to milestones, the Romans used some type of directional signing on their roads. They also instituted a one-way street system (*2*).

In the United States, the first organized roadway signing has been attributed to the Buffalo Automobile Club of Buffalo, New York. As early as 1905, it erected guide signs to provide directions to touring "horseless carriages" (*2*). In 1918, Wisconsin was the first state to assume the responsibility for the erection of route signs as a regular maintenance activity (*2*).

In 1925, the Joint Board on Interstate Highways held its first meetings to develop a uniform scheme for signing, including distinctive shapes and colors and wording that made the intent of the signs clear to the motorists. Its recommendations were accepted by the Secretary of Agriculture, and the nation had its first system of uniform signs and markings to be used by state highway departments to guide and protect motorists.

Using the guidelines developed by the Joint Board, the American Association of State Highway Officials (AASHO) published in January 1927 its *Manual and Specifications for the Manufacture, Display, and Erection of U.S. Standard Road Markers and Signs* (*3*). This was the first manual on uniform traffic control devices. In April 1929, AASHO published a second edition of the manual with a supplement on the "Use of Luminous or Reflecting Elements with Standard Signs and Markers" included in the appendix.

Other developments in traffic signing included:

1930—First manual for urban streets.

1935—First *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) (*4*).

1939—Retro-reflection required for certain types of signs.

1955—STOP sign changed from black on yellow to white on red, and YIELD sign added to the MUTCD.

1966—Passage of Highway Safety Act, which emphasized uniform traffic control devices as a safety measure.

Highway Safety Act of 1966

The Highway Safety Act of 1966 was the catalyst for many of the safety improvements in signing that are found today. Seventeen highway safety program standards were developed to assure the orderly implementation of the act (*5*).

What was then known as Highway Safety Standard 4.4.13, "Traffic Engineering Services," was one of these standards. The purpose of "Standard 13" was: "to assure the full and proper application of modern traffic engineering principles and uniform standards for traffic control to reduce the likelihood and severity of traffic accidents" (*5*). One of the goals of the standard was an orderly analysis of all traffic control devices.

Highway Safety Standard 4.4.10, "Traffic Records," also related directly to traffic signs. The purpose of "Standard 10" was to promote the implementation of record-keeping systems that would include data on drivers, vehicles, accidents, and highways. The highway data had to include records pertaining to traffic control devices.

Although the "Highway Safety Standards" have been revised extensively (being changed to Highway Safety Guides) with the passage of subsequent Surface Transportation Acts, the mandate for properly installed and maintained traffic control devices has not been lessened.

COST-EFFECTIVENESS OF TRAFFIC SIGN IMPROVEMENTS

In *The 1988 Annual Report on Highway Safety Improvement Programs* (*6*), a report on the highway environment as it relates

TABLE 1
TOP 20 HIGHWAY SAFETY IMPROVEMENTS (*6*)

Rank	Improvement Type	B/C Ratio
1	Traffic Signs	20.9
2	Illumination	10.3
3	Upgraded Guardrail	8.1
4	Upgraded Median Barrier	7.0
5	Upgraded Bridge Rail	6.5
6	Obstacle Removal	6.4
7	Bridge-Guardrail Transition	6.3
8	New Median Barrier	5.4
9	New Traffic Signals	5.1
10	Minor Structure Improvements	4.5
11	Impact Attenuators	4.0
12	Upgrade Traffic Signals	4.0
13	Pavement Grooving	3.8
14	Sight Distance Improvements	3.6
15	Median Strip	3.3
16	RR Crossing New Gates	2.8
17	Channelization	2.8
18	Shoulder Widening/Improvements	2.6
19	RR Crossing New Lights	2.2
20	RR Crossing New Lights and Gates	2.1

to safety, improvements in traffic signing are reported as having the highest benefit-cost ratio of any highway safety improvement. As described in the executive summary of this report, these results are based on data submitted by the 50 states, the District of Columbia, and other U.S. territories. The report contains current, detailed information on accident data and trends, and the analysis examines the effectiveness of completed highway safety improvement projects in reducing the number and severity of highway accidents. Table 1 lists the top 20 highway safety improvements and their associated benefit-cost ratios as listed in this FHWA report to Congress.

MAGNITUDE OF THE SIGN MAINTENANCE PROBLEM

With more than 58 million traffic signs on our nation's highways, the periodic review and maintenance of these safety devices is a monumental task.

In 1980, the Maryland Department of Transportation conducted a night field inspection to evaluate the sign retro-reflection of regulatory and warning signs on its 10,000 miles of state highways. Out of a total of approximately 50,000 signs surveyed, it found that approximately 6,000 signs (12 percent), were deficient in terms of retro-reflection and another 2,400 signs (4.8 percent) were missing from the roadway (F. Gottemoeller from T. Hicks, personal communication, May 27, 1980; D. Wolfe, personal communication, 1988).

Table 2 shows the results of a 1988 field inventory of 37,211 traffic signs on 1,626 miles of roadway in the Pennsylvania Department of Transportation's (PennDOT'S) urban district surrounding Pittsburgh (*7*). Sixty percent of the signs examined had problems that were in need of some type of action.

A study of approximately 45,200 signs on 3,075 roadway miles by consultants for the state of Tennessee found that routine maintenance was needed at 36 percent of the locations (16,270 signs), signs needed to be removed at 18 percent of the locations (8,130 signs), and new signs needed to be installed at 11 percent of the existing sign locations (4,970 signs) (Joe Holt, personal communication, March 3, 1989).

PRINCIPLES OF RETRO-REFLECTIVITY

As they navigate streets and highways in varying levels of light and changing weather conditions, motorists depend on traffic control devices that are easy to see and recognize. For that purpose, many traffic signs use retro-reflective materials for backgrounds or legends.

Reflection of light occurs when the light illuminating an object is reflected from the object. The brightness of the reflected light is directly related to the intensity of the light source and the type of material from which the object is made. There are three types of reflection: diffuse, mirror, and retro-reflection (*8*).

Diffuse reflection results when light strikes an object that has a microscopically rough surface, such as pavement, vehicles, painted signs, etc. The light scatters in all directions, and only a small amount of light is reflected back to the light source (Figure 1). Because only a very small amount of light is returned along the path of the incident (incoming) light beam, diffuse reflecting materials have very poor nighttime visibility to drivers.

Mirror (specular) reflection results when light strikes a microscopically smooth surface. The light is reflected from the surface at an equal, but opposite, angle from that of the incident light beam. Light is returned directly to the source only when the light beam is exactly perpendicular to the surface.

Retro-reflection takes place when light strikes an object and is reflected directly back to the light source. Because a relatively large amount of light is returned, retro-reflective materials appear brightest to an observer located near the light source. It is

TABLE 2
RESULTS OF A PENNDOT FIELD INVENTORY OF TRAFFIC SIGNS IN THE PITTSBURGH DISTRICT (1988)

Sign Status	Number of Signs	Percentage of Total
Signs to be left unchanged	14,889	40
Signs requiring a new sign face of the same type	6,016	16
Locations where signs were missing or required a new sign installation	11,461	31
Signs to be permanently removed	4,445	12
Signs to be relocated	400	1

this type of reflection that is used in traffic signs and other traffic control devices.

Traffic Sign Retro-reflectivity

Although there are a number of variations, there are two common types of retro-reflectors: a spherical lens and a cube-corner reflector (Figure 2).

A spherical lens reflector uses a spherical lens element (a glass bead) and a reflecting surface placed at the focal point to return light to its source. An incident light beam is refracted (bent) as it passes through the surface and is directed inside toward the back of the bead. The light beam is reflected from the reflector coat at the back surface of the bead and rebounds back through the bead. The light beam is refracted again as it leaves the bead and returns to the light source.

The back surface of a cube-corner reflector looks like a series of cubes that have been positioned point first. Light enters through the front surface, is reflected successively from the three back faces of the cube at the plastic/air interface, and is returned through the face to the source. It is not necessary that the faces of the cube have a reflective coating, because light striking a surface at less than a certain angle (called the critical angle) is reflected.

Figure 3 shows the physical makeup of enclosed lens sign sheet material (or "sheeting") (Type II-engineering-grade), encapsulated lens sheeting (Type III-high-performance), and cube-corner sheeting (Type III and IV-high-performance).

The enclosed lens sheeting consists of a layer of transparent plastic of the appropriate color in which microscopic glass beads are embedded, with a metallic retro-reflector coat behind the bead layer.

The encapsulated lens sheeting consists of exposed glass lenses embedded in a plastic resin and protected by a transparent film supported above the beads by walls constructed in a hexagonal or similar pattern. .

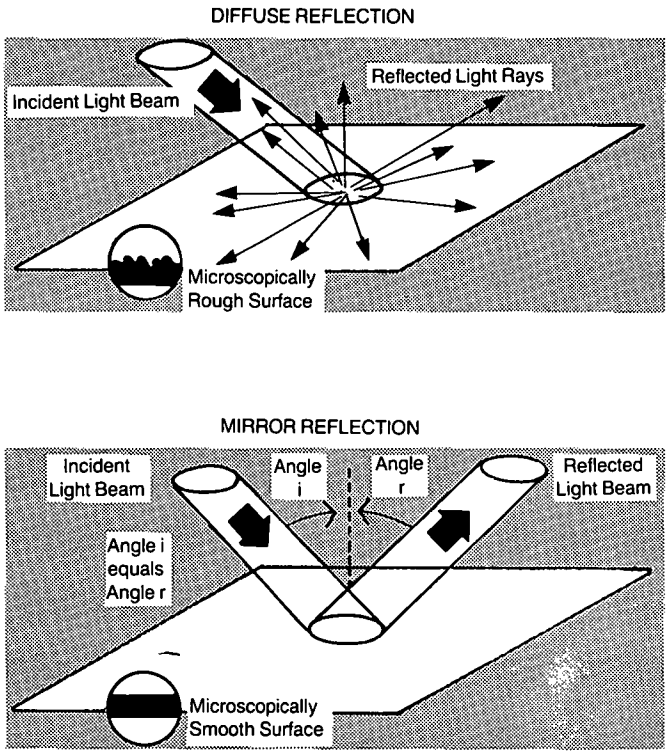
The cube-corner retro-reflective sheeting consists of micro-cube-corners enclosed in a transparent plastic film with an air cushion behind the cubes.

Several ongoing research projects should provide better guides and methods for measuring sign retro-reflectivity. These include:

- "Measuring Retroreflectivity of Pavement Markings," Advanced Retrotechnology, Inc., Small Business Innovative Research Contract, Final Report (June 1990).
- "Service Life of Retroreflective Traffic Signs," Bellomo-McGee, Inc., FHWA Contract, Final Report (August 1990).
- "A Mobile System for Measuring Retroreflectance of Traffic Signs," Ektron, Inc., NCHRP Contract, Final Report (August 1990).
- "Data Presentation and Format Requirements for the Pavement Laser Retroreflectometer," N.N. Associates, FHWA Contract, Final Report (November 1990).
- Minimum Visibility Requirements for Traffic Control Devices," Ketron, Inc., FHWA Contract, Final Report (December 1990).
- "Implementation Strategies for Sign Retroreflectivity Standards," Bellomo-McGee, Inc., NCHRP Contract, Final Report (June 1991).

SIGN DURABILITY

An important consideration in the selection of the sign material used for traffic signs is the service life of the sign sheeting. For instance, a sign manufacturer may guarantee that the retro-reflectivity of an engineering-grade material will not deteriorate more than 50 percent for a period of 7 years, whereas a more expensive high-performance-grade product may have a similar guarantee but for a period of 10 years. Thus, although the engineering-grade sign may have a lower initial cost, this may be offset by the longer service life of the high-performance material, which has a higher level of retro-reflectivity. Of course, in some instances a sign may be knocked down, stolen, or vandalized before it deteriorates at all, and in these situations, a lower-initial-cost material may be a better choice. Life-cycle cost analysis, which is discussed in Chapter 8, could identify all of the associated costs and benefits.



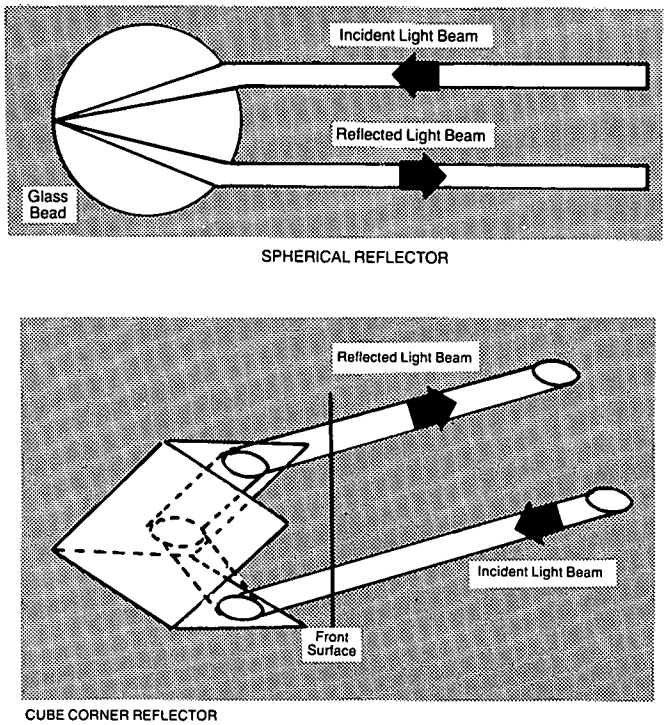


FIGURE 2 Types of retro-reflectors.

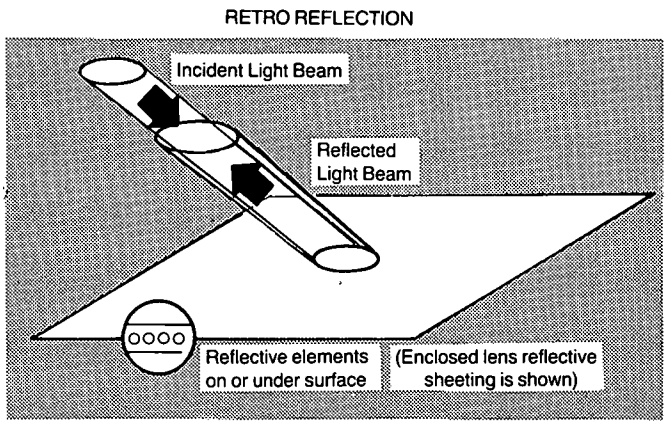


FIGURE 1 Types of reflection.

Sign Deterioration

Traffic signs are meant to supply information to the motorist. To accomplish this task they must be visible and legible under both day and night conditions. Signs deteriorate from a variety of causes, and eventually must be either rehabilitated or replaced (Figure 4). As they age, traffic signs experience deterioration of the retro-reflective sheeting from the effects of sunlight, weather, airborne abrasive particles, and air pollution. The sheeting may also experience a buildup of dirt from road spray and airborne pollution. This progressive deterioration gradually reduces a sign's visibility and legibility to the point at which a driver may no longer perceive the intended message in time to complete the required response, resulting in a reduction in traffic control and safety. Maintenance practices that retard the deterioration or keep the signs clean can provide both economic and safety benefits. On the other hand, ineffective procedures not only are a waste of time but also divert resources away from activities that may provide other benefits.

To better understand the need for proper maintenance, it is important to have an understanding of the deterioration modes experienced by sign sheeting. The five types of sheeting deterioration normally encountered in retro-reflective traffic signs have been described by Kenyon et al. (*9*) as follows:

- Clouding and Color Fading—Exposure to the ultraviolet rays in sunlight and atmospheric pollutants may cause a gradual clouding and deterioration of the transparent plastic, the metallic reflective layer may gradually disappear, and/or the transparent colorants used in the sheeting or in the screening process color coats may fade and thus diminish the color contrast between legend and background. This may also result in loss of retro-reflectivity.
- Cracking—Differences in thermal expansion between the sheeting and backing substrate may cause cracking. Nighttime retro-reflectivity may not be directly affected, but daytime appearance may suffer.
- Abrasion—Windborne particles or chemical corrosion may cause microscopic surface deterioration, producing a roughness on the originally smooth sign face surface. As a result, the sign brightness may be adversely affected because of diffuse reflection, and daytime appearance may be dull because the plastic layer is less transparent.
- Delamination and Peeling—Full-depth separation of the sign sheeting from the substrate may result from poor adhesion,

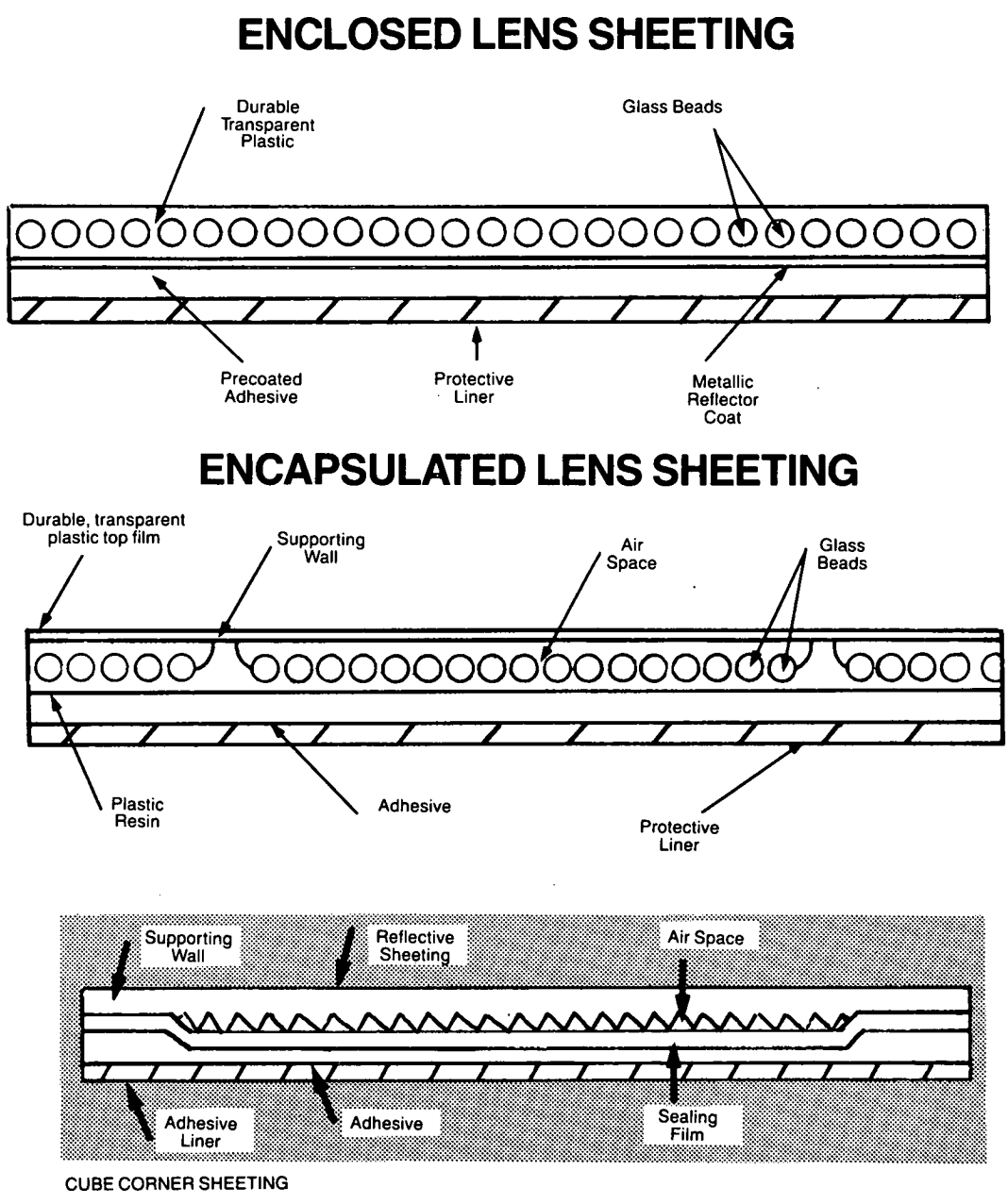


FIGURE 3 Physical composition of retro-reflective sheeting.

caused by either manufacturing or fabricating problems. Internal layer separation within the sheeting may result from manufacturing problems. Either distress mode diminishes both brightness and daytime appearance.

- Dirt Accumulation—This is the most common type of deterioration. Dirt accumulation affects most signs at various periods during their service life. Unless the dirt becomes deeply embedded in the sign face, it can be removed by washing—either through natural rainfall or as a maintenance activity—and the brightness and appearance of the sign can be restored.

Most older highway signs are found to exhibit the first four distress modes in varying degrees of severity, and all signs, to some extent, exhibit dirt accumulation. Frequently, other distress modes that are not immediately recognizable can be explained by a combination of these general types. For example, a deeply cracked or abraded surface may permit the dirt and corrosion to spread from the scar, resulting in the appearance of corrosion on the surface of the sheeting.

Signs may also deteriorate as a result of damage to the sign resulting from vandalism or knockdowns.

TYPES OF MAINTENANCE

Prompt maintenance is important, because vandalized, damaged, obscured, or missing signs constitute a traffic hazard and may contribute to vehicle accidents.

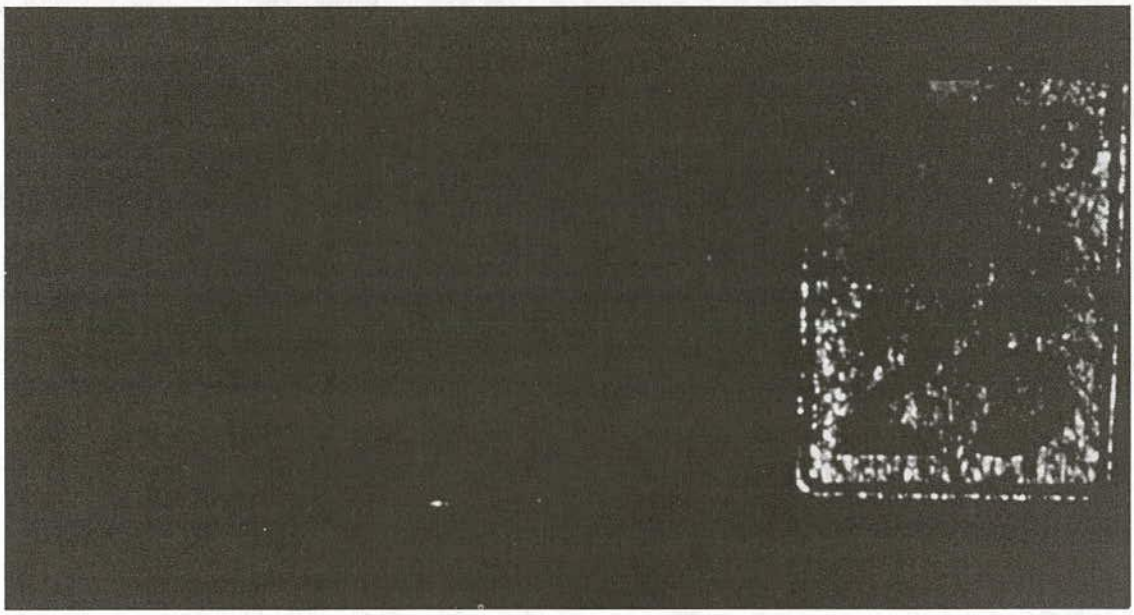


FIGURE 4 Deteriorated speed limit sign.

Sign maintenance can be grouped into three broad categories:

- Routine
- Emergency
- Vandalism

Routine

Routine maintenance consists of work activities that are done on a regular basis to ensure that the traffic signs are effective in conveying their message to the motorist. These include: replacing sign faces because of weathering or damage; straightening posts or signs; cleaning signs; removing weeds and tree limbs where signs are obscured; and replacing lamps for illuminated signs.

Emergency

Emergency maintenance consists of unscheduled work activities that are done to correct sign deficiencies. This work may occur during normal hours or it may require that personnel be called in during off-hour periods.

Vandalism

Vandalism maintenance consists of sign maintenance activities that result from the malicious destruction of the sign (Figure 5) or the theft of the sign face or post. Maintenance of vandalized signs may be a part of routine maintenance or require an emergency response.

FACTORS AFFECTING MAINTENANCE

Proliferation of Signs

There are many signs installed on streets and highways that may no longer be necessary, because they are outdated by changing conditions or they were erected as a "political sign" to pacify a special interest and serve no useful purpose. Other signs may be unnecessary because they only supplement or reinforce existing

FIGURE 5 Vandalized signs.

adequate traffic control devices. In addition, there are many unauthorized signs on streets and highways that have not been approved or installed by an official government agency.

The 1988 field inventory by PennDOT for the urban district surrounding Pittsburgh found that 4,445 out of 37,211 signs (12 percent) were not needed and could be permanently removed (*7*). The study by consultants for the state of Tennessee found that of the sign locations reviewed, approximately 18 percent of the signs were unnecessary or no longer needed and could be removed (Joe Holt, personal communication, March 3, 1989).

The city of Phoenix, Arizona, in the late 1970s canvassed its entire arterial and collector street system to try to minimize the number of signposts in place. The idea was not only to salvage the existing posts but also to eliminate roadside obstacles, reduce maintenance costs, and improve the appearance of the city streets. This was accomplished by removing signs no longer needed, mounting needed signs on existing posts with other signs, and maximizing the use of utility poles as sign supports (Figure 6). As a result of this program, more than 3000 signposts were removed at a savings of approximately $35,000 (*10*).

By reducing the number of signs on the roadway, an agency will decrease the sign maintenance work load, improve roadway aesthetics, and improve highway safety. Additionally, the reduction may increase the effectiveness of more important signs installed to meet a specific need on the street and highway system.

Productivity

The issue of worker productivity is probably one of the most sensitive issues in sign maintenance management. Because of the nature of the work, sign maintenance workers need to be self-motivated and understand the importance of traffic signing in the total highway safety picture. Many agencies do not have any system for monitoring the productivity of sign crews when they are out in the field. Many agencies have met strong worker resistance when work order procedures were implemented. However, worker productivity is a key element in an agency's sign maintenance management program.

FIGURE 6 Sign mounted on a utility pole.

IMPACTS OF MAINTENANCE DEFICIENCIES

Deficiencies in sign maintenance have serious effects on the highway system and on public agencies. Two primary issues are the reduction in safety and operational efficiency for the motorist and the liability exposure for the agency.

Highway Safety and Operational Implications

Deficient sign maintenance has a number of effects on safety and operational efficiency. The most direct effect is the potential for accidents. A missing or poorly maintained sign can be a direct cause of a serious traffic accident. The missing or illegible sign can also cause a breakdown in the operation of the traffic system. In addition, it is believed that when vandalized signs are not repaired or replaced in a timely manner, "copycat" vandalizing of other signs in the immediate area will frequently occur (*11*).

Liability Implications

Tort liability judgments attributed to inadequate maintenance of street and highway signs cost public agencies large sums of money each year. In almost every state, the shield of sovereign immunity has eroded as legislators have modified governmental immunity or has been abolished by judicial decisions.

Tort Liability

A tort is a civil wrong or injury. The purpose of a tort action is to seek repayment for damages to property and injuries to individuals. The following elements must exist for a valid tort action:

- The defendant must owe a legal duty to the plaintiff.
- There must be a breach of duty; that is, the defendant must have failed to perform or to properly perform that duty.
- The breach of duty must be a proximate cause to the accident that resulted.
- The plaintiff must have suffered damages as a result.

A tort liability survey by *The Transafety Reporter* (*12*) in 1983 found that the vast majority of state and local governments expect the growing number of tort suits filed against their agencies to continue to increase at an accelerated rate. Since 1978, states have experienced a 50 percent increase in tort suits and counties and cities have experienced increases averaging around 25 percent.

Alleged maintenance defects were the cause most often cited in tort lawsuits. For states, 29 percent of the claims against them

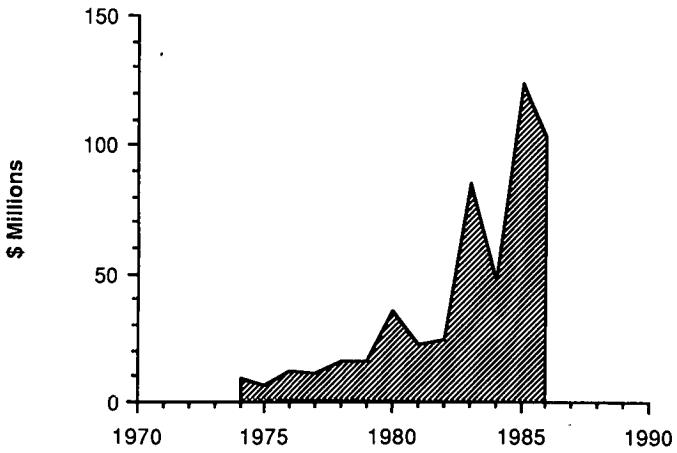


FIGURE 7 Settlements and judgments against transportation agencies.

related to traffic control devices. For counties and cities, the percentage of tort claims related to traffic control were 25 percent and 37 percent respectively.

Figure 7 shows the settlements and judgments against state transportation agencies between 1974 and 1986 (*13*). Losses went from a low of approximately $6.2 million in 1975 to a high of approximately $117.6 million in 1985. That is a 19-fold increase in losses in that 10-year period.

Carstens (*14*) in a 1981 study of highway-related tort claims involving Iowa counties found that the claims filed against these counties amounted to about $52 million during the period from 1973 to 1978 (Table 3). Of that $52 million in claims, more than $30 million were still pending at the end of 1978. Settlement and judgments were made at a cost of 12.2 percent of the amount claimed for those claims that had been disposed of, not including the costs for handling the claims, attorney fees, or court costs.

TABLE 3
ANNUAL AMOUNT OF TORT CLAIMS FOR 85 COUNTIES IN IOWA (*14*)

Year	Total Amount
1973	$6,342,008
1974	3,910,961
1975	8,338,906
1976	7,934,128
1977	4,973,057
1978	13,153,668

A study of highway tort liability in Pennsylvania showed that signing deficiencies were cited as the primary factor in 20 percent of the sampled tort actions, second only to pavement deformities (*15*). When considering only those highway accidents in which a fatality or serious injury occurred, signing deficiencies ranked as the primary factor most often cited (41 percent).

Between July 1, 1979 and June 30, 1988, the state of Pennsylvania paid nearly $100 million in settlement costs for tort liability actions. Had this money been available for maintenance, approximately 1 million signs could have been replaced (*16*).

Risk Management

Given the litigious environment in which public agencies are operating today, experts in transportation and law are recommending that agencies adopt a risk management program to minimize tort liability losses. Risk management is a process by which an agency attempts to identify, quantify, and control exposure to tort liability actions. For a traffic agency a complete risk management program contains many activities (*17, 18*). Reed (*19*) briefly summarizes activities in a risk management program to include:

- Recognizing and anticipating the degree of legal risk inherent in all of an agency's system responsibilities and programs, procedures, or actions.
- Ensuring that available resources are used in a manner to achieve maximum reduction of risk and prevention of loss while accomplishing the mission of the agency.
- Preparing a timely, defensive response for actual or threatened legal actions.
- Managing claims to result in proper resolution while achieving economy and fairness to the agency and therefore the public.

Synthesis 106 (*18*) provides the overall loss-mitigation program depicted in Figure 8.

The Oakland County Road Commission (OCRC) in Oakland County, Michigan, initiated a Highway Risk Management Program in September 1977 (*20*). At that time, the Board of Road Commissioners, responding to increasing exposure to liability losses, adopted a policy endorsing greater highway safety and instructed the managing director to "develop a Risk Management Plan and implement a meaningful traffic/safety and Loss Control Program to prevent or reduce the incidence and severity of accidents and losses" (*20*).

The OCRC Highway Risk Management Program is made up of two programs, a Risk Management Program and a Litigation Management Program.

The Risk Management Program is directed at reducing traffic accidents and the risk of incurring liability claims against the agency, principally through the improvement of the safety of the road system.

The Litigation Management Program was developed to provide better defense for the agency once a liability claim has been filed to minimize the amount of loss from such claims.

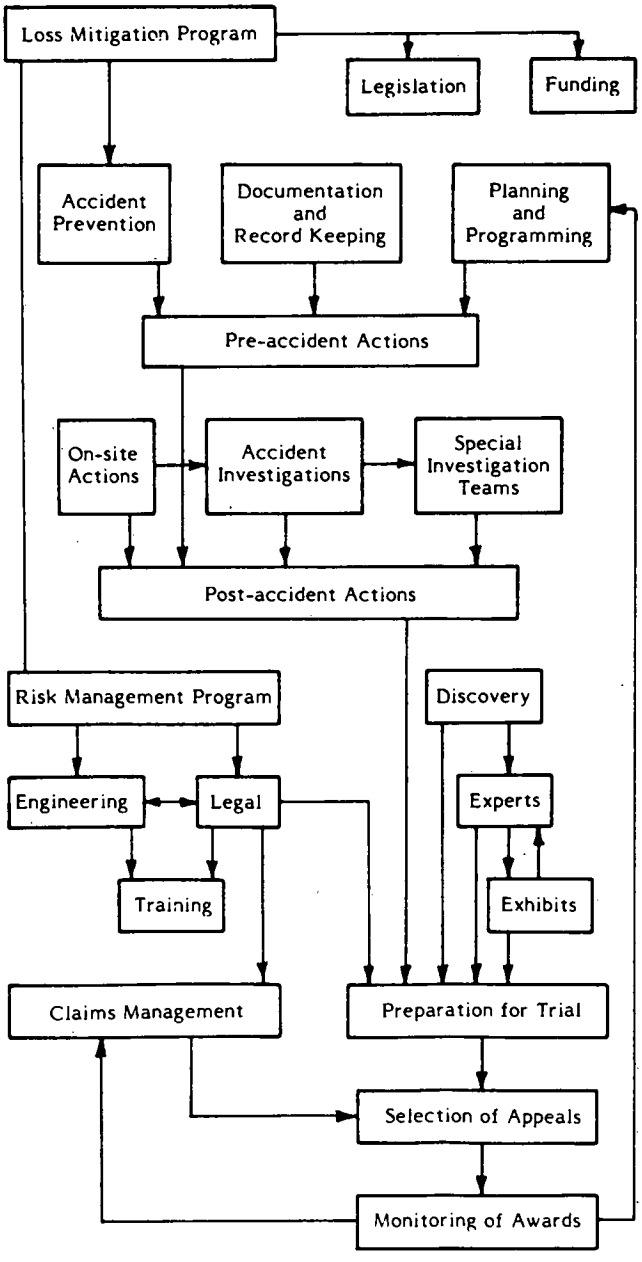


FIGURE 8 Elements of an overall loss-mitigation program.

In Michigan, many local agencies that do not have the resources on their own to establish a risk management program have established joint-liability pools. These pools have been effective in establishing post-loss strategies for managing road agency risks.

Bryer (*21*), in a risk management analysis of highway maintenance operations for PennDOT, developed a set of practices to reduce exposure to tort liability. Those related to signing are as follows:

Emergencies (working and nonworking hours)

- Develop a communication system that allows police departments to contact individuals with authority so that the emergency can be reacted to in a timely manner.
- Establish a process for crews to quickly assemble and respond to emergencies.

Notification of Hazard

- Document all complaints of a hazard on a standard notification form.

Signing

- Develop a methodology to identify and correct sign deficiencies.
- Treat missing or knocked down STOP signs as an emergency condition and replace or reinstall in a very short period of time.
- Develop a process to identify sites where foliage can reduce the visibility of a sign.

From his research on highway-related tort claims in Iowa (*14*), Carstens developed eight recommendations for reducing exposure to tort liability. Two of the eight recommendations related directly to sign maintenance management:

- Establish a continuing sign inventory process. A sign inventory is essential to provide evidence of the existence of a particular sign in a particular location at a specific time. It also provides a convenient mechanism for evaluating sign usage for conformance with standards. The inventory process should be continuous, with constant updating as signs are added, removed, or replaced.
- Establish a road and sign inspection program. Many claims result from temporary conditions, such as sign vandalism. A systematic method of notification of such conditions should be established using assistance from the general public as well as highway department workers and other public employees who travel regularly within the jurisdiction.

In 1986, the Secretary of Transportation for PennDOT formed a high-level Risk Management Task Force and charged it with the responsibility for developing a risk management action plan to deal with the most critical liability issues. The task force concluded that there is no "quick fix" to tort liability problems; a long-term perspective is necessary for achieving the most effective solutions (*16*).

Two long-term goals were recommended:

- Foster an awareness by all employees of the risk potential associated with their actions.
- Establish an environment that encourages a balance between productivity goals and risk management objectives.

CHAPTER TWO

DESCRIPTION OF THE MAINTENANCE EFFORT

Proper maintenance of street and highway signs is essential to assure that the devices are visible and legible (both day and night). Clean, legible, properly mounted signs command the respect of drivers and pedestrians. In addition to the physical maintenance of the signs, functional maintenance of the signing system is also required to adjust traffic control devices to the current operating conditions or remove unnecessary traffic control devices, when necessary. If a different sign is determined to be needed at a location, the fact that the existing sign is in good condition should not enter in to the decision process.

WORK ITEMS

Sign maintenance generally involves the repair and replacement of devices, but as a practical matter it also includes many other activities, such as developing procedures to recognize maintenance needs, to respond to those needs, and to correct deficiencies. The maintenance effort can also include the manufacture or procurement of the signs, posts, and other hardware. It also includes the clearing of brush that may be obscuring the signs.

Signs

Work activities related to signing fall into six categories:

- Installation
- Repair
- Replacement
- Overlaying
- Refurbishment
- Vegetation Control

Installation

Installation activities includes those activities related to the placement of a new sign and post at a location that previously contained no signs of that type. During installation the field crew must locate the sign at the proper longitudinal distance to allow the proper response by the driver, at the proper lateral offset, and at the proper mounting height. The crew must place the sign so that it is not obscured by any other roadside features and does not create an unnecessary roadside hazard.

Repair

Sign repair activities are those activities performed in the field that bring the sign back to its original condition or as close as possible to its original condition until a replacement can be fabricated and placed.

Replacement

Replacement is the removal of the sign and/or support and installation of another sign or support in its place.

Overlaying

Overlaying is the placement of a new sign face over the existing face while the sign remains on the post in the field.

Refurbishment

Refurbishment is removal of the sign from the field to the sign shop, the stripping of the old sign face by a chemical or grinding process, and the addition of a new face to the sign blank. Sign overlaying done at the sign shop rather than in the field is also considered refurbishment.

Vegetation Control

Vegetation control is the clearing of brush or tree limbs that block a driver's view of the sign (Figure 9).

Sign Supports

Any sign installation is only as good as the support system that holds it in place. Using the wrong type of support system creates maintenance problems and could endanger motorists or pedestrians.

Sign support maintenance activities are similar to those for sign faces. They include:

- Installation
- Repair
- Replacement

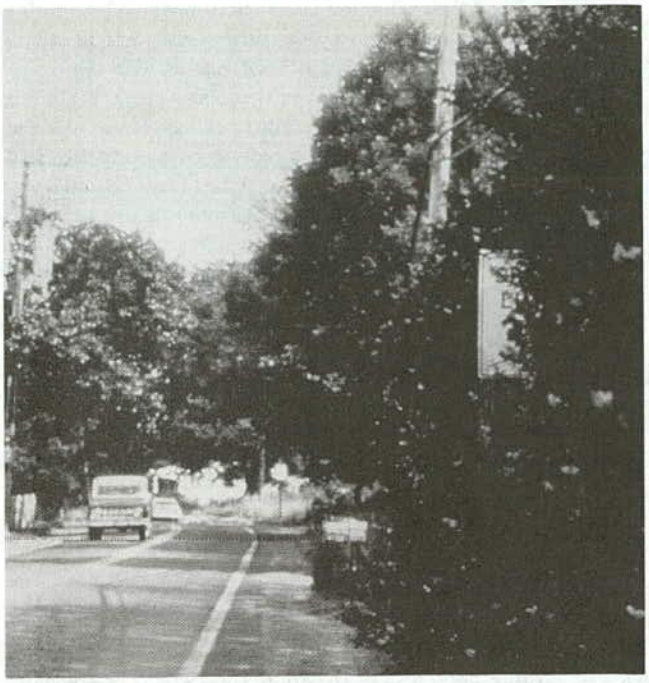


FIGURE 9 Sign hidden in vegetation.

FIGURE 10 Signpost being straightened.

Installation

Post installation, as with sign installation, requires that the sign crew consider many factors in the placement of an individual sign and post. In addition to the proper location of the sign, the crew must decide the proper post for the installation. This could entail determining the wind loading on the sign to determine the number and types of post required to attain proper torsional resistance, examining the ground and surrounding conditions to determine what type of post should be used, and determining if the sign is large enough and in a location to require a slip base.

Repair

Repair includes the straightening of the post (Figure 10) and the determination of whether the post, if straightened, would be able to support the wind loading on the sign. Painting of the post would also fall into this category, as does replacement of missing bolts, removal of stickers, etc.

Replacement

Replacement includes the removal of the old post and the placement of a new post in its place. This includes the upgrading of the support to provide necessary yielding or breakaway features.

DETECTION OF SIGN MAINTENANCE NEEDS

An important element of a good street and highway sign maintenance management system is the timely detection of maintenance needs. This detection requires the cooperation of many different agencies and personnel. The sign crew and its supervisor could detect the maintenance needs through a procedure of regularly varying the path to and from the maintenance garage. The police department in their travels pass most of the signs on the major road system, particularly at night. Garbage collectors, other maintenance workers, and postal carriers are also good sources of information on maintenance needs. Citizens, especially those who drive the same routes on a daily basis, are extremely sensitive to any change in traffic control, and they represent a potential patrolling force with complete and continuous coverage. Efforts should be made to collect information from these groups.

Inspection

The MUTCD currently requires that all warning, regulatory, or overhead guide signs show the same shape and color both by day and by night. This may be accomplished through retro-reflection (Figure 11) or external illumination. The question of whether signs are adequately visible at night can most easily be determined through nighttime inspection. The inspector or inspection crew should determine the adequacy of the illumination (external or retro-reflection) and check to see if any signs are visually obstructed. These inspections should be made using low-beam headlights. It should also be determined if signs, delineators, or markings are missing or should be added. Often such omissions are more obvious at night than in daytime. It is essential to inspect retro-reflective devices under nighttime conditions similar to those experienced by the average driver.

The Texas State Department of Highways and Public Transportation in its *Safety and Maintenance Division Manual* (*22*) has the following policy for the inspection of sign installations:

> 6-306 Inspection
>
> All signs including supports should be inspected twice a year for position, damage, legibility, obvious indications of structural

FIGURE 11 A sign with retro-reflectorized border and copy.

distress or failure, and general condition. Only trained maintenance or traffic engineering personnel should make such inspections, especially the night inspections of retroreflectivity. Desirably, inspections should be made by two persons so notes can be taken without interfering with the driving task. All personnel who frequently travel the highways should be instructed to report any obscured or damaged sign. Maintenance personnel should be alert at all times to observe signs for legibility, position and such minor damage for which immediate remedial action can be taken. The inspection of signs should include the checking of legibility and retroreflectivity of all signs at night, due to the high ratio of nighttime accidents.

Establishing a Sound Inspection Program

The establishment of a sound inspection program requires the thorough training of the inspectors and a systematic data collection and analysis procedure.

In 1979–80, the Maryland Department of Transportation performed a study of the retro-reflectivity of all regulatory and warning signs on approximately 5,250 miles (10,500 one-way miles) of state highway. The project, which cost $50,000 and was funded by the federal government, was completed in a concentrated effort over the winter of 1979–80. (F. Gottemoeller from T. Hicks, personal communication, May 27, 1980; D. Wolfe, personal communication, 1988).

The project was kicked off on February 11, 1980, when the 20 construction inspectors who were used for the actual field survey were given a training session in the inspection and rating of sign retro-reflectivity. This training session involved the actual inspection of signs that had been removed from the field and placed on a driving course. As a first activity, the group reviewed nine signs of varying material composition, age, and levels of retro-reflectivity. It was thought important to first rate them as a group to get a uniform analysis of the condition. After the group rating was completed, the inspectors broke up into groups of two and drove the evaluation course accompanied by a traffic engineer. On the course, they evaluated a different group of nine signs and discussed the reasons for ratings with the traffic engineer. After this preliminary run was completed, they made the run again without the traffic engineer. This run was made at speeds approximating the actual speeds to be used in the field survey. It was determined beforehand that if more than 20 percent of the sign face was deteriorated the sign was to be rated as unsatisfactory. The inspectors gave each sign a rating of "S" for satisfactory or "U" for unsatisfactory retro-reflectivity based on this "20 percent rule." After all of the inspection teams had completed the final run, they again reviewed the results as a group and discussed any discrepancies in the ratings. By using this group training technique, Maryland was able to obtain consistent results between inspectors while accomplishing the training task in a short time frame.

The actual field inspection was then begun using the following procedures:

Office Preparation

Every afternoon, before going into the field, each team reviewed existing photologs of the route they would be traveling that evening. From the photologs, they recorded all existing warning and regulatory signs on the form shown in Figure 12. To separate data recorded in the office from data collected in the field, entries on the form made in the office were in one color and those entries made in the field were recorded in another color.

Night Field Inspection

Field runs were then made after dark using teams of two inspectors working from a moving vehicle traveling between 20 and 40 mph on U.S. and state routes and the minimum speed on Interstates. The vehicles used were pickup trucks with headlights that had been cleaned and properly adjusted.

The field inspection consisted of evaluating all the warning and regulatory signs and noting those signs that did not meet the retro-reflectivity levels established during the training session. Any signs found in the field that were not on the photolog were placed on the form in the correct sequence. Any sign that was on the photolog but not located in the field was crossed out. While the inspectors were checking for retro-reflectivity, they were also requested to note within a "remarks" column any defects, damage, or anything else that they felt should be brought to the traffic engineer's attention. After the completion of each night's activity, the completed forms were submitted to the district traffic engineer for follow-up action.

Daytime Follow-Up

The district traffic engineer reviewed each case in which a sign was found to have unsatisfactory retro-reflective properties to determine if the sign was appropriate for the intended use; if it was located correctly; if it was the correct size, shape, and color; and if it had the correct message before the replacement was ordered. Each sign that was on the photolog but missing from

SIGN INSPECTION EVALUATION

ROUTE ______ COUNTY ______ DATE OF INSPECTION ______ DISTRICT ______

STARTING POINT & LOCATION ______ INSPECTOR ______ TIME ______

END ODOMETER & LOCATION ______ DIRECTION OF TRAVEL ______

		REFLECTIVITY		ACTION TO BE TAKEN							
ODOMETER OR PHOTOLOG MILE	LOCATION	SIGN CODE OR DESCRIPTION	COND.	REMOVE EXISTING SIGN	REPLACE EXISTING SIGN	RELOCATE EXISTING SIGN	STRAIGHTEN EXISTING SIGN	INSTALL NEW POST	REMOVE OBSTRUCTION	REMARKS	DATE WORK COMPLETED

FIGURE 12 Sign inspection form.

the field was also reviewed to determine if the sign had been correctly removed as part of a signing update or was actually missing.

COMMUNICATION OF SIGNING PROBLEMS

The communication of signing problems to the traffic engineers within an agency takes many forms, and most agencies use a combination of methods for obtaining information on signing problems. As discussed previously, there are many people on the roadway who may make a report of a deficient sign. The most critical aspect of the response procedures is to ensure that the lines of communication are properly established and do not break down from the informant to the sign crew.

In-House Reporting

Field employees are frequently a key to the identification of signing problems. Because they are exposed to road conditions at all seasons of the year, they are generally aware of what is going on and where the problems are.

Within any agency, there are many types of employees out on the streets during the day and night. Traffic engineers or traffic technicians are conducting field investigations of problem locations; signal maintenance workers are repairing signals; pavement marking crews are applying markings to the roads; sanitation workers are collecting refuse, etc. All of these workers are out on the street seeing signs as they do their jobs. However, they are also busy doing their work, and often, by the time they return to the shop, they may have forgotten to report the signing problem. Therefore, a formalized procedure is needed to have the signing problem recorded as soon as it is seen on the street.

To meet the need for this formalization, the OCRC in Michigan, as part of its Risk Management Program, instituted an ongoing potential road hazard identification program for employees. This program, which quickly became known as the "pink slip" program because of the pink color of the report form, involved an intensive employee-training program.

In this program, *all* of the more than 500 road commission employees, including all clerical, secretarial, field, and supervisory personnel, were trained concerning what to report and how and where to report it. After the training session, each employee was given a supply of the forms, which they were requested to fill out whenever a hazard was detected. If a problem was noted, the employee filled out the form and sent it through interdepartmental mail to the appropriate department.

The department receiving the notice was then required to record the action taken on the report form, send a copy of the completed form to the originating employee, keep a copy in its files, and forward the completed original form to risk management for review. By requiring that a written response be given to the employee who submitted the pink slip, the road commission ensured that the potential hazard was examined and also reinforced the employee perception that he or she had made a contribution. Many of the pink slips submitted by the employees were related to signing problems or new sign installation needs.

In addition to an agency's own forces, the cooperation of police officers should be obtained to identify signing problems. Police officers trained to identify substandard signing could provide valuable assistance to the sign maintenance effort because they are on the street during the night when most signing deficiencies are readily apparent. Making them an integral part of the identification process provides valuable and inexpensive input to the maintenance system.

In the mid-1970s, the Traffic Improvement Association of Oakland County, Michigan, created the Traffic Engineering and Safety Coordinating Committee to address traffic safety issues in Oakland County. This committee has a membership of approximately 150 engineering, police, and public-works personnel from the 63 agencies in the county. These traffic workers meet on a periodic basis to discuss the traffic problems of the county and their own agency. During a meeting of the committee the Oakland County Road Commission presented its "pink slip" program to the other agencies and requested their participation in the identification of the safety deficiencies on county roads. The commission stressed the importance of and need for the various police agencies patrolling in the county to contact it regarding sign maintenance needs. By obtaining the support of the other agencies in the county, the road commission effectively doubled the size of its workforce in obtaining input on where sign maintenance was needed.

Citizen input will be received by the agency whether it asks for it or not. However, it is good practice to actively seek this input, because, again, it increases the size of the workforce for identification purposes. However, little effort has been made to formalize the citizen reporting concept.

Some cities and counties publish a newsletter on a periodic basis. Within it, they provide a listing of frequently called phone numbers, including a special business-hour and non-business-hour listings for sign and signal problems.

To maximize the public as a reporting source, the OCRC created a Department of Citizen Services. The purpose of this department is to receive all citizen complaints about county roads and inform the correct governmental agency of the problem. The employees receiving the calls were specially trained in the proper method of receiving, recording, and relaying the information. A copy of the reporting form used by the department is shown in Figure 13. During 1986, 19,326 complaints related to some road problem or other road-related issue were received from citizens. Of these, 1,965, or approximately 10 percent, were related to either a sign being damaged or requests for installation of a sign (*23*).

All agencies should train employees who are in frequent contact with the public in the correct procedures for receiving calls. The use of a checklist, such as that shown in Figure 13, can be very helpful in obtaining the correct information quickly and accurately.

RESPONSE PROCEDURES

The management of the response procedures includes provision of a dispatching routine, the setting of response priorities, the assurance of adequate off-hours emergency response, and the enforcement of written policies and procedures for the actual sign repair. An agency should place particular emphasis on good record-keeping and follow-up inspection to ensure the quality of the work. Syntheses 22 and 114 (*24, 25*) contain a discussion of the maintenance effort for traffic signals that is also relevant to traffic signs.

OCRC 259. REV. 10:81

OAKLAND COUNTY ROAD COMMISSION

COMPLAINT REPORT

No. 96283

T. _____

Please Print Legibly

ROAD/STREET: _____ CITY/TOWNSHIP: _____

LOCATION: _____ TIME: _____ DATE: _____

COMPLAINANT: _____

ADDRESS: _____ TELEPHONE: _____

COMPLAINT TAKEN BY: _____

CLASS OF ROAD: ☐ PRIMARY ☐ LOCAL ☐ SUBDIVISION STREET ☐ STATE TRUNKLINE

SURFACE TYPE: ☐ PAVED ☐ UNPAVED

REPORTED COMPLAINT (CHECK APPROPRIATE ITEMS)

1. SURFACE

GRAVEL
- ☐ ROUGH
- ☐ WASH-OUT
- ☐ DUST
- ☐ ICE/SNOW

PAVEMENT
- ☐ HOLE(S)
- ☐ SETTLEMENT
- ☐ EDGE HOLE
- ☐ SWEEPING
- ☐ ICE/SNOW

2. SHOULDER
- ☐ HOLES
- ☐ WASH-OUT
- ☐ DROP (EDGE OF PAV.)

3. TREES/BRUSH
- ☐ BLOCKING ROAD
- ☐ HANGING LIMBS
- ☐ REQ. REMOVAL/TRIMMING
- ☐ VISION OBSTRUCTION
- ☐ BLOCKING SIGN

4. DRAINAGE
- ☐ WATER OVER ROAD
- ☐ FLOODING PRIV. PRO.
- ☐ STANDING IN DITCH
- ☐ CULV/C. BASIN/MANHOLE
- ☐ DITCHING REQUEST

5.TRAFFIC CONTROL DEVICES

SIGNS	☐ Damage	☐ Worn	☐ Miss.	☐ Req.
GUARDRAIL	☐ Damage	☐ Req.		
SIGNALS	☐ Damage	☐ Malfc.	☐ Req.	
PAVEMENT MARKINGS	☐ Worn	☐ Req.		

6. MISCELLANEOUS
- ☐ PROPERTY DAMAGE
- ☐ LITTER PICK-UP
- ☐ WORK QUALITY
- ☐ ROADSIDE MOWING
- ☐ ROADSIDE HAZARDS
- ☐ CONSTRUCTION RELATED
- ☐ OVERWEIGHT VEHICLES

REMARKS/OTHER: _____

DISPOSITION:

DATE: _____ TIME: _____

DEPARTMENT: _____

PERSONNEL CALLED: _____

REPAIR OR CORRECTIVE ACTION TAKEN: _____

SIGNED: _____

DATE: _____

DCS RESPONSE: _____

CLOSED: _____

INITIAL: _____

ORIGINAL

FIGURE 13 Complaint record.

Bryer, in his risk management analysis of the highway maintenance operations of PennDOT (*21*), identified key steps to reduce the incidence of liability exposure as the result of emergency maintenance needs.

These steps to reduce exposure are:

- Have a communication system established so that police agencies can immediately contact responsible individuals having sufficient authority to react to the emergency.
- Have a mechanism or process established so that crews or individuals can quickly assemble and respond to emergency situations during normal weekday hours, weekday off-hours, and weekends.
- Delegate sufficient authority to the individual or individuals responsible for accepting notification during nonworking hours to determine if the condition constitutes an emergency or can be corrected during normal work hours. Although many types of conditions can easily be defined as emergencies (e.g., knocked down STOP signs), other situations may require a dialogue with the police agency or individual notifying the maintenance organization to assess the magnitude and severity of the condition specified. The decision to respond during nonworking hours should be based solely on the degree of hazard and potential for severe accident occurrence within a short period of time.
- Request the police agency, if necessary, to control traffic at the site until work crews arrive. The name of the responsible individual in the police to whom the request is made should be documented along with the time of the request.

Notification of Potential Hazard

All complaints and notification of potential hazard, whether written or by telephone, should be documented, preferably on a standard notification form. The form should identify the name, address, and phone number of the complainant and list the time the complaint was received, the person receiving the complaint, and the time that the complaint was acted on, along with the action taken.

Quality control should be performed by management to ensure that all complaints are being recorded, that the complaint forms are completed properly, and that the forms are filed using a logical, easily retrievable system.

In some instances, complaints cannot be corrected for an unusually long period of time because of higher-priority work. When this occurs, the higher-priority work that needed to be accomplished before the complaint could be corrected should be specified on the form that records the notification of the complaint.

Complaints or notification of hazards for which the responsibility for correction is with another agency should be documented in the same manner as any other complaint, along with the time that the responsible agency was notified and the name of the individual receiving the notification at the responsible agency.

Response Priorities

Various agencies have established a policy for how quickly repair personnel need to be dispatched to the scene of a device failure based on the degree of hazard created by the failure. For instance, the OCRC in Michigan has a policy under which the following signs require an immediate response:

- STOP
- YIELD
- DO NOT ENTER
- WRONG WAY
- KEEP RIGHT
- Railroad Crossing (Crossbuck)
- Turn Sign
- Curve Sign
- Reverse Turn
- Reverse Curve
- Winding Road
- Large Arrow
- Railroad Advance Warning

Other factors used in determining the response priorities include minimizing travel time, expected time required to complete the repair, and known traffic patterns.

Off-Hour Emergency Repairs

Emergency repairs that need to be made during off-hours are a major concern to management because of the expense of overtime pay. Administrators give considerable weight to cost in determining the procedures to be followed in handling off-hours trouble calls. The costs are affected by overtime pay practices, which may be controlled by the rules of the civil service or trade unions. For instance, some contracts require pay for a minimum number of hours (as high as three or four) for every callout after normal working hours, regardless of the time actually taken.

In localities where there are high crime rates during nighttime hours, the safety of the crew is a factor in the decision of whether to dispatch repair personnel.

Different methods are used to cover emergency repairs occurring outside of regular working hours. A few agencies maintain full operation on a 24-hr basis. These are usually state highway departments or large cities or counties. Others reduce their level of operation during off-hours, keeping a small staff to respond to an emergency. Most agencies keep maintenance personnel on a rotating duty roster to be called at home for emergency repairs. Some of these agencies may keep a traffic maintenance dispatcher on 24-hr duty. However, a more common practice in cities is to transfer the dispatching duties during off-hours to a police dispatcher, who either calls the designated repair crew or the duty foreman.

Many small agencies have no planned response procedures for off-duty hours. In those jurisdictions, police are usually provided with STOP signs for use where necessary, and all other repairs are handled during normal work hours. The decision of which procedure is to be followed is usually made on the administrative level, based on cost considerations.

IN-FIELD CORRECTIVE MEASURES

The in-field maintenance of traffic signs in response to identified maintenance needs takes a number of different forms. How-

ever, the importance of good documentation (e.g., work orders) on exactly what was done, when it was done, and who did it cannot be overemphasized. Chapter 4 will deal with sign inventory systems. A maintenance system that uses work order forms is of principal importance in the development of an inventory system. Even without a field inventory of signs, an agency needs a record of maintenance activities. This documentation could prove invaluable in defense of a liability lawsuit or aid in obtaining reimbursement for sign maintenance costs that were incurred in repairing damage that was the result of an accident.

Repair

Maintenance policies with relation to in-field response maintenance of traffic signs vary from agency to agency. Some agencies' policy is to spend as little time as possible at the site, replacing the sign and bringing the damaged sign and post back to the shop for repair or refurbishing. Other agencies prefer to complete the sign replacement in the field, replacing damaged sign faces with overlay material, straightening posts, and remounting signs. Other agencies use a combination of both procedures, depending on the time the maintenance is taking place or the backlog of work for both the field crew and the shop crew.

The in-field repair of the sign relates to any work done at the site to the sign to bring it as closely as possible to its original condition. This could include straightening the sign after it has been run over, resetting the sign face after it has been twisted out of position, or replacing mounting hardware that may have broken off. Most agencies do not have a formal policy for determining when a sign should be replaced instead of repaired. Most agencies leave this determination up to the sign crew based on the experience and judgment of the members.

Cleaning

Cleaning a sign with soft brush and a nonabrasive detergent, as shown in Figure 14, can restore a sign's retro-reflective properties. However, a study of maintenance practices in New York State (*9*) examined the effects of washing on sign retro-reflective performance. It was determined that although some individual signs do benefit, most signs receive little benefit from washing because natural cleansing from rainfall achieves nearly the same effect. Therefore, sign cleaning may only be necessary during winter months, in tunnels and under structures, in industrial areas where there is heavy truck traffic, in geographic areas where there is little rainfall, or in places where signs are located particularly close to the traffic, as they are in work zones.

FIGURE 14 Traffic sign cleaning.

Replacement and Overlay

Signs can be replaced in two ways. In the first, new signs are fabricated in the shop with applied copy, taken to the field, and erected in place of the old sign. The second procedure overlays new material over the existing sign substrate. The overlay material is usually a high-performance-grade, retro-reflective sheeting with a thin, semirigid backing coated with a pressure-sensitive adhesive. This material can be applied over the existing sign in the field.

Shepard (*26*) in a 1985 review of sign overlay procedures in Virginia compared the cost, manpower, time, and quality of the finished product for large ground-mounted and overhead guide signs refurbished in the shop versus those overlayed in the field. He concluded that the procedure of overlaying substrate with new sheeting in the shop with directly applied copy and attaching the panels in the field with rivets is the fastest and most economical method.

Temporary Corrections and Emergency Corrections

Frequently, a sign is knocked down by a vehicle in an accident, stolen by a vandal, or knocked down by a snow plow during inclement weather. If a sign crew comes upon one of these situations or if it is informed of the problem, it may have to make corrections without having a similar sign with it on the truck. When this happens the crew will generally repair the sign as best it can and report the problem for follow-up correction.

When any of these situations occurs to a critical sign during off-hours, an agency must have procedures for emergency corrections. Some agencies have provided police vehicles or maintenance foremen with temporary STOP signs mounted on folding pedestals that can be placed on the side of the road until a sign crew is able to make permanent repairs.

Follow-Up

Follow-up includes all work scheduled at locations where temporary repairs did not resolve a problem. Maintenance work is generally considered as follow-up only if it does not occur in the same shift as the temporary repairs or if it is done by a different maintenance crew. Unlike emergency repairs, follow-up work can be scheduled. Then the resources necessary to complete the work are known, there is a good indication of how long the work will take, and the time pressure to commence and complete the work may be somewhat decreased.

Scheduling of follow-up may be driven by a formal work order issued by a foreman or superintendent or an informal knowledge on the part of a specific crew that it must return to a given location as soon as possible to complete the repair.

In addition, a sign crew may come upon a sign that needs to be replaced but be unable to complete repairs at the time because it is on a more important work assignment or because it does not have the proper equipment or material. Some agencies prefer that the maintenance personnel report the missing or damaged sign to the foreman before taking corrective action. This notification may be made by radio communication or by the completion of a work order or "trouble" report. This way, the agency is able to maintain control of the scheduling of the sign crew work activities.

CHAPTER THREE

ORGANIZATION OF A SIGN MAINTENANCE OPERATION

A successful street and highway sign maintenance management program requires a well-structured organization in which the maintenance activities are systematically delineated and responsibilities are clearly defined. Some agencies place sign maintenance activities within the traffic division, others place it within the maintenance division, and a few contract out their sign maintenance work. This chapter will discuss the physical and operational characteristics that determine the structure of the management organization, where the sign maintenance activities are placed in the organizational structure, and contract management.

PHYSICAL AND OPERATIONAL CHARACTERISTICS

The determination of how to structure sign maintenance activities and where to place an activity in the organizational structure is dependent on a number of physical and operational considerations. The physical considerations include the size of the agency's geographic responsibility, the road mileage, and the number of signs to be maintained. The operational characteristics include the location of the sign shop in terms of either a district or centralized system, level of expertise available in the organization, and how much, if any, of the maintenance activity is contracted out.

Size of the Agency's Geographic Responsibility

The decision to centralize the sign maintenance operation or to establish maintenance districts to perform all or some of the maintenance activities should be related to the size of the area or the amount of road mileage to be covered. The American Public Works Association (APWA) indicates that when, because of long distances or congested roadways, travel time from a maintenance facility to a work site is longer than one-eighth of the available workday, consideration should be given to decentralizing the maintenance organization (*27*). However, this is just one of many elements that should be considered when the location of a maintenance facility is determined.

In the case of traffic sign maintenance, this decentralization could take one of two distinct forms or a combination of two schemes. The first alternative is to have all signs made at a central sign fabrication shop and shipped to district shops as needed. The second alternative is to have sign fabrication equipment at each district shop so that it can operate independently of the central shop. Many agencies use a combination of these two strategies. The central shop makes large quantities of the most frequently used signs and the district shops manufacture unique and emergency replacement signs.

Road Mileage and Number of Signs on Roadway System

The mileage of the street and highway system and the extent of the signing system in terms of total numbers of signs along the roadway is a good measure of the magnitude of the work required on an annual basis. Urban agencies may have relatively low road mileage but a high density of signing per mile. Therefore, an urban agency can generally maintain more signs per unit of time because the travel time between signs is shorter. However, on-street parking, traffic congestion, delivery trucks, etc. can frequently impede the operation of a sign crew and reduce its overall efficiency.

Rural agencies, on the other hand, may have many road miles to cover but relatively few signs per mile. In rural areas, however, the roadways tend to have higher speed limits and the signs are generally larger. Therefore, the operation may be less efficient because of the longer travel times between signs or because the sign installation may be more complicated because of the addition of breakaway supports for the larger signs. Again, this may be offset by easier access to the signs.

The number of signs can offer a starting point for estimating the amount of maintenance that has to be done. In general, the greater the number of signs on the road system, the greater the amount of sign maintenance activity, necessitating a larger sign maintenance staff.

CONTRACT MAINTENANCE

An increasing number of states and municipalities are relying on private contractors to do routine highway maintenance, including sign fabrication and maintenance. A number of reasons have been cited for this trend including: staffing problems caused by budget constraints, lack of specialized equipment or skills, and taxpayer perception that government has grown too large. For Synthesis 125 (*28*) a survey was distributed to agencies at all levels of government responsible for road and street maintenance. Of the 68 responses, all but four agencies reported having had some experience with contract maintenance activities. However, few had contracted sign maintenance.

Some agencies may contract out only a portion of their sign maintenance activities, such as overhead freeway sign replacement or the installation of signs on new roads or major reconstruction projects. Other agencies have contracted out sign main-

TABLE 4
PERCENTAGE OF SIGNS INSTALLED OR MAINTAINED BY CONTRACTORS

Portion of the Sign System Installed/Maintained by a Contractor (Percent)	Percentage of Respondents Using Contracted Maintenance	
	For Existing Roads	For New Roads
Less than 20	99	52
20 to 40	1	5
40 to 60	0	3
60 to 80	0	4
80 or More	0	30
No Response	0	6
Total	100	100

tenance activities to such an extent that the contractor is performing all sign maintenance—from fabrication of the sign in the contractor's sign shop to the installation, repair, and replacement of signs on the roadway.

Ross et al. (*29*) in a survey of federal agencies, state highway agencies, state turnpike authorities, cities, counties, sign suppliers, and contractors on signpost usage found that very few agencies contract out the maintenance of signs on existing roads. The survey also discovered that many agencies contracted out sign installations on major construction projects, with many of these signs being installed as part of a larger construction contract. Table 4 summarizes the results of this survey related to contract sign maintenance.

The amount of contract maintenance that an agency uses may affect the divisions of labor within an organization. Frequently, maintenance staff within an agency may be reduced if enough sign maintenance can be contracted with private companies. However, this reduction in maintenance staff may be offset by the additional staff needed to draft, bid, execute, and monitor the contracted work activities. Therefore, decisions about contracted maintenance determine the operational characteristics of the maintenance organization.

Contract Maintenance in Toronto, Ontario

The Metropolitan Toronto Roads and Traffic Department, Ontario, Canada, has used contract maintenance for traffic control devices since the early 1960s. Here, the contractor replaces every aspect of a normal municipal traffic operations unit, including the production, installation, and repair of all traffic control devices including signs (*30*) (personal communication, May 1988).

Contract

The contract between the Traffic Operations Division of the Roads and Traffic Department and the contractor is for five-year periods. The 1987 expenditure for sign maintenance, within the total traffic control device contract, was approximately $2.5 million (Canadian), and 1988 expenditure was estimated to be approximately $3.0 million (Canadian). Toronto is currently midway through a major replacement program for overhead freeway signing and street-mounted traffic signs. The contractor is also responsible for this program.

Since the beginning of contractual services, there have been only three contractors who have won the signing contract. However, there are normally 5 to 10 bidders each time the contract is up for bid.

Special Contract Provisions The general provisions of the traffic services contract are similar to most contractual agreements. Because of the specialized nature of the work and the liability exposure, however, special provisions are included in the contract. Some of the financial provisions include:

- A $3,000,000 (Canadian) performance bond to secure the obligations of the contractor,
- A $3,000,000 (Canadian) payment bond to ensure payment to employees, suppliers, and subcontractors, and
- A $10,000,000 (Canadian) liability insurance policy to protect the contractor, subcontractors, and the metropolitan Toronto government.

The size of the bonds is such that contractors with insufficient capital to adequately complete the contract are dissuaded from bidding.

Contract Management

To monitor and control compliance to contract terms, Toronto established an organizational structure in which the contractor is monitored by a supervisor and assistant supervisor of traffic signs. The people in these two positions are the only government employees in the sign maintenance organization. They are responsible for ensuring that the work quantity, quality, and cost are in fulfillment of the contract terms.

Facilities

Toronto requires that the contractor must have a sign and paint shop for the manufacture, repair, and refinishing of traffic

signs. To minimize emergency response time, the traffic operations division requires that these facilities be within the metropolitan Toronto area and be readily accessible to the expressway system.

Staffing

To ensure that there is adequate staffing to meet the needs of the signing program, the contractor is required to provide:

- a superintendent,
- a foreman,
- 10 two-person sign crews on two shifts, and
- sufficient personnel to provide 24-hr radio dispatching.

As mentioned earlier, there is an ongoing four-year effort to replace all overhead and post-mounted signs. Accordingly, the contractor has increased the sign maintenance workforce from the normal 10 sign crews to 15 and from one foreman to two. With the completion of the replacement program, however, the contractor will be able to reduce staffing levels back to the normal levels.

In addition, during the winter months, the contractor is able to reduce sign maintenance staffing levels by up to 50 percent because of decreased sign maintenance activity.

Method of Payment

Payments to the contractor for sign maintenance are cost reimbursements for the labor, materials, and consulting services plus an additional 1 percent on materials and 2 percent on labor for profit. The government does not pay for downtime or mistakes. If the contractor does not perform a job according to specifications, it is done again at no additional charge.

Work is scheduled and reported through a work order system. For each project or preplanned maintenance activity, a cost estimate is provided by the contractor, and if approved, a work order is issued by the department. For emergency sign maintenance, the city issues a blanket work order to cover this type of unscheduled sign maintenance activity.

For each completed job, a maintenance report is filled out and submitted to the city for a weekly aggregated payment.

Finance/Budget

The metropolitan Toronto government feels that the privatization of sign maintenance has resulted in a number of financial and budgetary benefits, including:

- *Reducing capital costs for the agency*—By contracting out the sign maintenance function, large capital outlays for facilities, equipment, and training of personnel are not needed.
- *Providing easier budget control*—Sign maintenance programs can be accurately estimated because the contractor is paid a fixed price for the maintenance activity.
- *Eliminating the variable costs associated with maintaining a maintenance staff*—The contractor is responsible for sick time, vacation time, and worker's compensation.
- *Varying the size of the workforce to meet the demand for sign maintenance activity*—During the winter months, when sign maintenance activity is low, the contractor is able to reduce the staffing levels by up to 50 percent. During special sign-replacement programs or during peak maintenance periods, the contractor is able to add personnel to gear up for the larger maintenance effort. Making this type of adjustment would be very difficult for the government.

Disadvantages

The implementation of contract maintenance in Toronto in the early 1960s was facilitated by the absence of one of the primary barriers to privatization, union opposition. The Metropolitan Toronto Roads and Traffic Department had just assumed maintenance responsibility for the road system. After an examination of the personnel and capital cost requirements, it was decided that the most effective way to provide this service was through the use of contract services. In the union environment that exists today in many agencies, this total contractual services concept might not be feasible.

Contract Maintenance in Montgomery County, Maryland

Montgomery County, Maryland, in March 1988 entered into a sign maintenance agreement with a contractor to supplement the existing sign crews. Because of political constraints, the county was unable to expand the size of its maintenance staff to accommodate the rapid population growth that was occurring in the county. As a result, the backlog of signing work orders became unacceptable.

As an initial test, the contractor has provided one two-man sign crew, which is assigned all of the street-name sign installation and repair work. In assessing the quality of the work of the contractor, if the county finds the work to be satisfactory, it may assign other types of sign maintenance to the contractor.

The contractual agreement in Montgomery County differs from the Toronto agreement in that the contractor is providing only the labor and equipment; the county is providing all of the signs, posts, and related hardware.

Montgomery County staff attribute the good results they have obtained to the very detailed specifications that were developed. They have also been aided by the fact that the contractor's foreman is a retired county sign crew foreman who is familiar with county policies and guidelines. Excerpts from the county's sign installation and repair contract are included in Appendix A.

WHERE STREET AND HIGHWAY SIGN MAINTENANCE ACTIVITIES ARE LOCATED IN THE ORGANIZATIONAL STRUCTURE

The type of organizational structure and the location within that structure for sign maintenance management varies from agency to agency, depending on a number of factors, including:

- Level of government

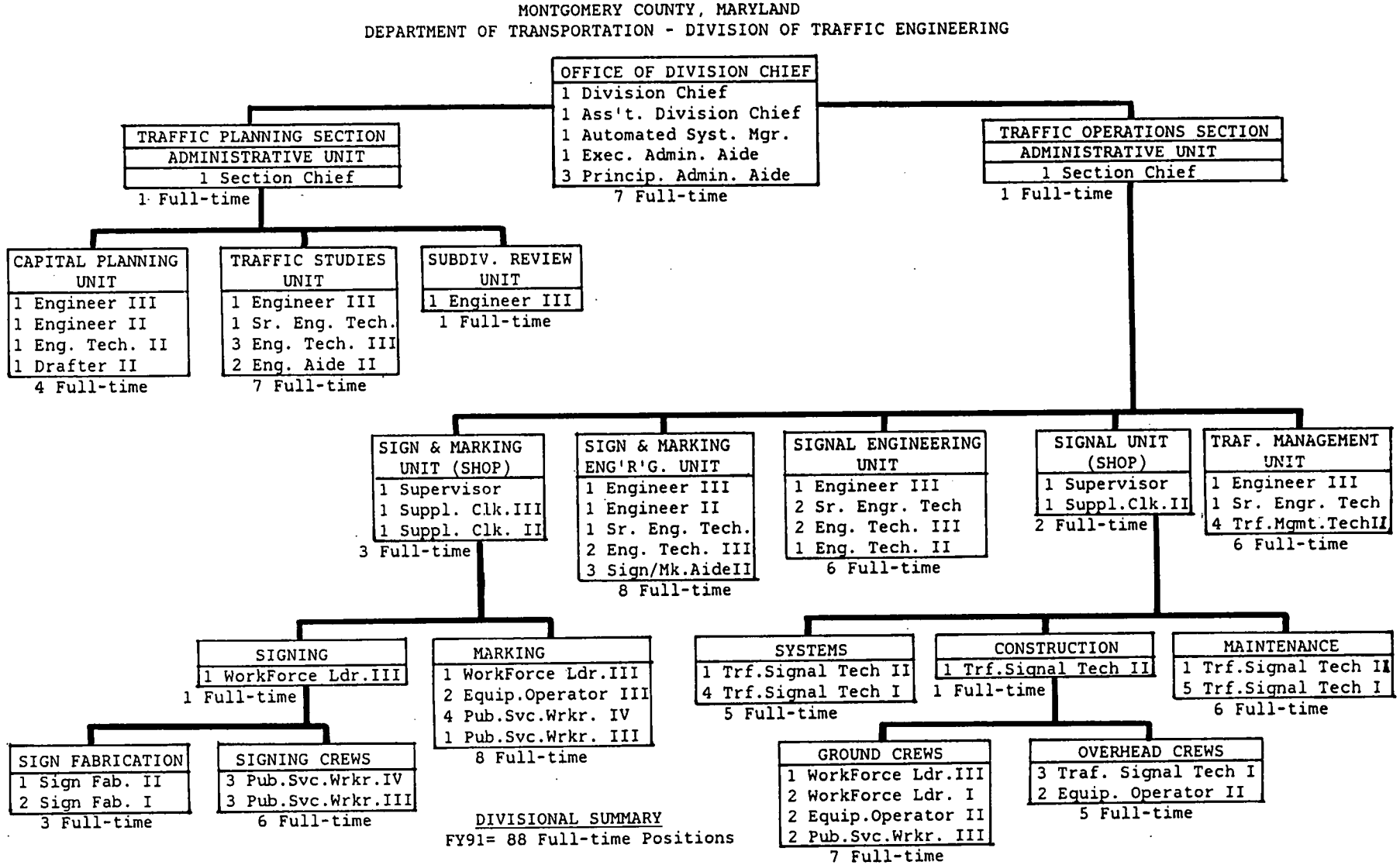


FIGURE 15 Montgomery County DOT.

- Geographic size of the agency's responsibilities
- Road mileage for which the agency is responsible
- Number and type of signs maintained by the agency

Many agencies have found that placing the sign maintenance management in the traffic engineering area allows the personnel who are best trained in the determination of the appropriate signing under various conditions to be directly responsible for the sign maintenance function. That is, the group that has the responsibility to ensure that the signing on the road system is appropriate is given the authority to carry out that responsibility. Figure 15 is an organizational chart of the Montgomery County Department of Transportation showing the placement of the sign maintenance function within it.

In other agencies, sign maintenance is part of the maintenance division. In general, sign maintenance activities are not all that different from other maintenance functions. Therefore, sign crews are managed by personnel familiar with maintenance operations.

In small municipalities, the amount of sign maintenance is generally not great enough to justify the formation of a designated sign crew. Therefore, sign maintenance, when needed, is performed by general maintenance work crews. Also, smaller agencies usually do not have a traffic engineer employed by the community. They may have a consultant, who is on retainer, but generally the traffic engineering function is performed by the police department.

All agencies have found that, independent of where the sign maintenance function is located, a good working relationship must exist between the sign maintenance workforce and the agency person responsible for the determination of the placement of signs. Without this working relationship, important sign maintenance activities may be delayed because of differing opinions, communication problems, etc. related to the sign maintenance activity.

Frequently overlooked in agencies in which the sign maintenance function is a part of the normal maintenance operation is that sign installation requires some specialized knowledge on the part of the maintenance crews. General maintenance workers frequently are not trained to select the proper mounting locations for signs, the proper sign for the hazards or conditions on the road, or the appropriate material for fabricating or installing a sign. Frequently, the crews are randomly assigned to the sign maintenance activity based on availability.

CHAPTER FOUR

FIELD INVENTORY OF TRAFFIC SIGNS

NEED FOR AN INVENTORY

To effectively manage a sign system and maintain a high level of safety for the motorists, a public agency must have complete information about the sign installations and the roadway conditions that were the basis for their installation and continued presence. This information provides the basic data for the identification of problems, system maintenance, planning and budgeting, and other agency responsibilities. To provide this information, most agencies maintain some form of traffic sign inventory, ranging from paper files, maps, and computerized data bases to a combination of these systems.

Many agencies maintain sign inventory data as part of their overall management efforts. Although these inventories vary greatly in the methods of data acquisition and the data base management system used to catalog the inventory, the basic elements are the same.

A key element in the management of street and highway sign maintenance activities is the availability of accurate details about the type of sign, its location, and other information. A field inventory provides the basis for decisions relative to:

- Identification of deficient signs
- Development of priorities for maintenance needs
- Scheduling of maintenance efforts
- Continued surveillance of maintenance activities

Carstens (*14*), in his analysis of tort claims in Iowa counties and methods for reducing liability exposure, recommended the establishment of a continuing sign inventory process. Carstens indicated that:

> A sign inventory is essential to provide evidence of the existence of a particular sign in a particular location at a specific time. It also provides a convenient mechanism for evaluating sign usage for conformance with standards. *The inventory process should be continuous with constant updating as signs are added, removed, or replaced* (emphasis added).

What was known as Highway Safety Standard 13, "Traffic Engineering Services" in the Highway Safety Act of 1966 (*5*), required each state and its political subdivisions to have a traffic control device program. The safety standard stated that a traffic control devices plan shall include:

- An inventory of all traffic control devices.
- A periodic review of existing traffic control devices, including a systematic upgrading of substandard devices to conform with standards issued or endorsed by the FHWA.

As was discussed earlier, the Highway Safety Standards have been revised extensively (to Highway Safety Guides) with the passage of subsequent Surface Transportation Acts. The mandate for properly installed and maintained traffic control devices, however, has not been lessened.

The objectives of a field inventory of traffic signs are, at a minimum:

- The classification of all traffic signs by location, type, size, and condition.
- The identification of sign conditions requiring maintenance related to: changes to the sign design or placement to bring it into conformance with the MUTCD, or the repair or replacement of the sign face or post to allow the sign to adequately do the job it was intended to do.
- Establishment of a management information system to determine the existing and future sign needs, which allows the development of a plan to systematically maintain street and highway signs.

DEVELOPING AN INVENTORY OF STREET AND HIGHWAY SIGNS

To be workable, an inventory of street and highway signs should:

- Contain all of the traffic signs in the highway right-of-way.
- Use a standard location reference system so that accident data can be merged with the sign inventory data to allow analysis of accidents by consideration of the effect of nearby traffic signs.
- Have the flexibility to allow addition of new entries, deletion of old ones, and sorting of entries by location.
- Record the completed maintenance work.
- Provide multilevel historical records of earlier sign work.
- Be accessible by sign location.
- When possible, use English descriptors instead of numerical or letter codes.
- Update the sign inventory to reflect work activity in an efficient and easy-to-use and understandable process.

The development of a sign inventory can follow a number of different approaches. An agency can develop an inventory through manual or automated means and maintain the data through manual card files, maps, or computer techniques. Therefore, before the collection of any data, an agency is required to make a number of decisions regarding the current technological expertise and the technological needs of the agency.

In general, the development of a good sign inventory program should include:

- A comprehensive study of the sign maintenance management system to identify the goals and objectives of the system, ascertain the required investment in dollars, and determine the necessary personnel skills required to implement and maintain a sign inventory.
- An analysis of data-collection and storage techniques to determine the most cost-effective procedure for the size of the system, the desired level of system sophistication, and the available resources in terms of personnel and budget.
- The development of staff acceptance through a program that motivates personnel and explains to them the advantages of a sign inventory to their work activities.

A Needs Study for a Sign Inventory System

A comprehensive study of the sign maintenance program is necessary to determine the performance expectations and resource requirements of the system. The needs study should assess the costs of data collection and implementation; estimate the length of time necessary to complete the project; develop procedures to keep the inventory system current; and evaluate personnel requirements for each level of the inventory system, including: sign installation and maintenance, filing or data entry, and computer programming and operation.

DATA COLLECTION FOR SIGN INVENTORY DATA BASE DEVELOPMENT

The data base for an inventory system can be developed through a variety of methods. These methods include:

- Manual data-collection methods
- Photologging
- Videologging
- Automated or semiautomated data-collection devices
- Aerial photography
- A combination of the above methods

The selection of the appropriate method of data collection depends on a variety of factors, including:

- Size of the signing system and composition of the road network
- Purpose of the inventory
- Required level of sophistication
- Cost, personnel, and equipment considerations
- Availability of existing records (e.g., photologs or videologs)

Manual Data Collection and Inventory

Manual methods of data collection continue to be used by a variety of agencies because they offer an opportunity to visually inspect the sign condition and placement in the field. The development of a sign inventory through manual data-collection methods is generally the easiest and most straightforward to implement. The data-collection process is relatively simple, and transfer to a computer system can be accomplished with minimum effort if this data transfer was anticipated in the system design. Manual inventories have been done by numerous agencies throughout the United States with satisfactory results (*31*).

Manual data acquisition involves the use of one or more persons equipped with data-collection forms and some type of distance-measuring device. This method has limited equipment requirements, but it is extremely labor intensive. Equipment costs can range from approximately $150 for a minimum data-collection system consisting of a measuring wheel, data-collection forms, and pencils, to approximately $5000 for a sophisticated system consisting of a vehicle equipped with a distance-measuring device and a battery-operated "notebook" computer and computer software, which allows the data to be entered by the field crew for later downloading into a microcomputer. A typical manual data-collection form for the less sophisticated system is shown in Figure 16 and a form for direct entry into a computer system is shown in Figure 17.

The 3M Company has developed a combination data collection-data storage form for manual inventories (Figure 18). This form can be notched along the edges to reflect the characteristics of signs along the roadway. The notches can be cut in the field or in the office. Once all of the notched cards are assembled, a needle sorter can be used to extract all forms with similar characteristics. This system offers the convenience of a basic field data form that can be readily used as part of a low-cost information management system.

Despite their simplicity and low equipment costs, manual procedures are labor intensive and relatively expensive to use for large highway networks, particularly in densely populated areas. The personnel cost to complete the inventory is dependent on the size of the system (i.e., miles of roadway or number of signs to be inventoried), the amount of information to be collected, population density of the area under study, frequency of data-collection elements to be recorded, and the complexity of the inventory tasks. Datta et al. (*31*) determined the costs of manual inventories completed for various sizes of city and county agencies in the state of Minnesota (Table 5). Datta's analysis indicated that the cost of collecting and analyzing sign inventory data manually ranged from $10/mile for a rural county inventory to $50/mile for a 600-mile township system.

The advantages of manual data collection for sign inventory development include:

- Low startup costs for data base development,
- Ability to use existing employees during slow work periods,
- Evaluation of the sign's condition on location, and
- Ease of data-collection implementation into an existing management system.

The disadvantages of manual methods include:

- Greater personnel requirements relative to other methods.
- No backup record of the signs at the time of inspection,
- Difficulties in quick data entry verification and data problem resolution,
- Necessity of close supervision of data-collection crews, and
- Conflicting demands for staff time, frequently prolonging the data-collection effort far beyond the anticipated completion date.

City ☐
County ☐ of_____Quadrant_____
Military Base ☐
City, Street or County Road_____
Direction_____

SIGN INVENTORY SHEET

SHEET_____OF_____
DATE_____
INVENTORY CHIEF_____
HELPER_____

A	B	C	D		E	F	G	H	I	J	K	L	M	N	O	P
ODOMETER READING, OR INTERSECTING ROAD/STREET	TYPE OF SIGN	SIGN CODE NUMBER (UNIFORM MANUAL OR STATE MANUAL)	SIZE		TYPE OF FACE	TYPE OF BACKING	CONDITION—DAY	CONDITION—NIGHT	VISIBILITY	NO. IN ASSEMBLY	POST			NON-UNIFORM	ADDITION NEEDED	REMARKS AND DESCRIPTION
			HOR. (IN.)	VERT. (IN.)							NO.	TYPE	CONDITION/ PLACEMENT			

FIGURE 16 Manual-data-collection form.

SIGN INVENTORY CODING FORM

Sioux City, Iowa

Sheet _____ of _____

Coded by: _____

Checked by: _____

Card Number	Sector	Inv. Dir.	Sign Number	Inventory Route	Sign Location			Lateral Position			MUTCD Number	Sign								Backing Mat.	Post		Remarks/Special Sign Message	Sign Change	Reason for Change	Date:		
					Distance	Reference Cross Street	Direction Facing	Distance	Side of Roadway	Number in Assembly		Shape	Color	Size: Horizontal	Size: Vertical	Condition	Reflectivity	Visibility	Height		Type	Condition				Month	Day	Year
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	30 31 32 33 34 35 36 37 38 39 40 41 42 43	44	45	46	47	48	49	50	51	52	53 54	55	56	57	58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73	74	75 76	77 78	79 80

FIGURE 17 Data entry form.

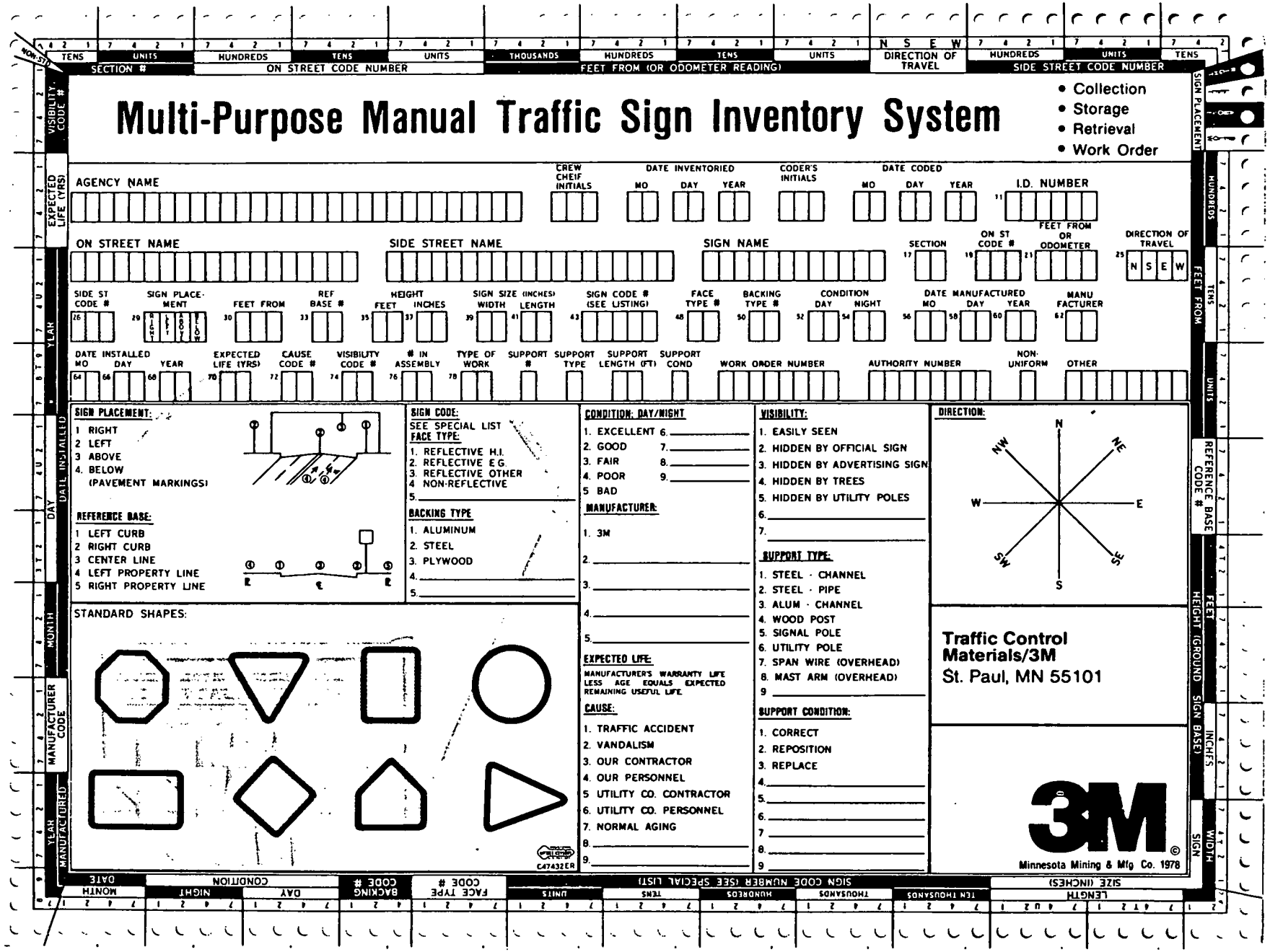


FIGURE 18 Notched data form.

TABLE 5
SUMMARY OF TYPICAL MANUAL SIGN INVENTORY DATA COLLECTION COSTS--MINNESOTA

Agency Type	Cost	Comments
City	$27/mile	
Townships	$50/mile	619 mile road system
Rural County	$10/mile	
Urban County	$15/mile	
Mixed County	$12/mile	632 mile road system (Rural & Urban)
Small City	$15/mile	50 to 100 road miles

Photologging

Photologging is a data-collection method in which sequential photographs of a highway and its environment are taken from an instrumented vehicle to record specific data about the highway (*32*). The backbone of the photolog system is an instrumented vehicle that is equipped with a 35 mm motion picture camera that has been modified to take individual frames of film at a predetermined distance increment. Additional equipment needed in the vehicle includes: a distance-measuring device, an event marker to actuate the camera, a central control unit, and an image generator, which superimposes programmed information on each frame of the photolog. Both 35 mm and 16 mm film formats have been used for photologging, but because of the higher image resolution, 35 mm film is used in most current applications. Filming rates can be 200 or 400 frames/mile (one picture for every 26.4 ft or one picture for every 13.2 ft) in very dense urban areas or 100 frames/mile (one picture every 52.8 ft) in a low-density urban, suburban, or rural area.

Photologs can be a source for any inventory that requires information on location and condition of the data element. Therefore, photologs are a good source of sign inventory information for larger agencies that might already have photologs available; for agencies desiring to inventory more than just signs (e.g., roadway features, pavement markings, or fixed obstacles); or for agencies desiring to have a film record for historical and tort liability defense purposes.

The photologging of highway and roadside features has been done since the early 1970s. Numerous state, county, and local agencies have either purchased the equipment and developed inventories or have contracted out the photolog and data-collection effort to consultants.

The advantages of using photologging to assemble a sign inventory data base are that (*31*):

- Thirty-five mm photographs provide a high-quality, detailed record of the roadway, including the existing signing.
- Photologs may already be available within the agency or through other agencies.
- An indexed photolog file provides an easily accessible source of information on signing or roadside features.
- Through the use of overlay grids, distances and the dimensions of signs can be obtained.
- Data collection can be done in an office environment that provides better quality and personnel control.
- The actual photologging can be accomplished with a one-person field crew if necessary.

The disadvantages of using photologging to develop a sign inventory data base are:

- Project startup costs are high if photologging equipment needs to be purchased.
- Film and film processing are expensive.
- Sign data collection and condition evaluation is done from a picture instead of a field survey.
- Distances and sign dimensions obtained from a photolog overlay grid may not be as accurate as field measurements.
- Equipment malfunctions, personnel errors, or weather or lighting conditions may require that some streets (several feet of film) or even major subareas (an entire roll of film) be rephotologged.
- Photologging may only be done during good weather conditions.

Videologging

Videologging has evolved as an alternative to photologging because of continued increases in the cost of the film and processing, together with the technological improvements in color video cameras and players. Although videologging applications have been more limited than those of photologging, current advances in the state of the art of roadway logging have been primarily in the area of videologging.

As in photologging, videologging is done from a moving vehicle as it travels on the road. However, videologging is accomplished by taking a continuous visual image of the roadway on

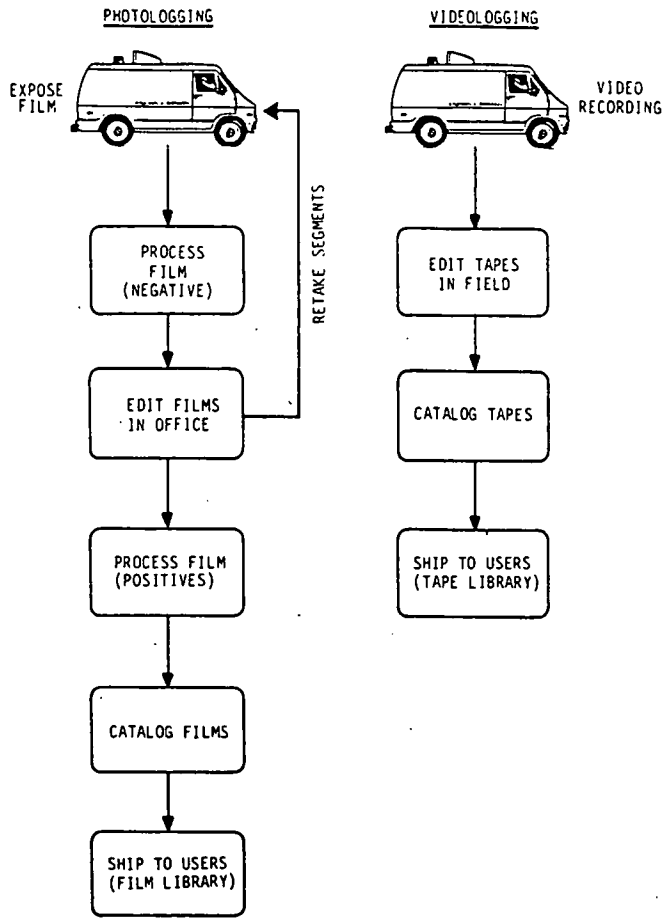


FIGURE 19 Comparison of photolog and videolog processes.

videotape instead of taking individual pictures sequentially at preset distances, as is done in photologging. Because the videolog pictures are taken continuously, however, there is no benchmark from which distances and dimensions can accurately be taken directly from the videolog. Nonetheless, because voice recording can be added to the videotape at the time of the videologging, these data could be added as supplemental information to help fix distances and dimensions.

Videologging generally requires a vehicle with similar instrumentation to that of the photologging vehicle but with the addition of a video camera, video recorder, distance-measuring instrument (DMI), information display, and monitor. In addition, videologging systems can include audio recording capabilities to allow the operator to input verbal information to supplement the video images.

One advantage with videologging is that with a monitor in the vehicle the visual images that are being recorded can be displayed immediately for an in-field review of image quality. This real-time monitoring of the picture quality reduces the likelihood of sections of road or entire roadways having to be refilmed because of poor picture quality. Videologging has also been found to be attractive because fewer steps are required to obtain a visual record of the roadway. Figure 19 shows a comparison of the steps involved in the photolog and videolog processes (*31*).

Although videologging experience has been more limited than photologging experience, recent practice with this method has determined the following advantages (*32*):

- Videotape does not have to be developed.
- Video cassettes are easy to handle.
- The finished product is available immediately, permitting real-time monitoring of picture quality.
- Voice recording can be added to the videotape either in the field or at a later date.
- Videotape can be reused.
- Video recording equipment and maintenance services are more universally available, allowing short turnaround time for servicing.

Disadvantages of the videologging procedure include:

- Image quality of typical video systems is inferior compared with the quality of 35 mm photography, particularly in the pause or single-frame mode.
- Videotaping equipment (including a high-quality color camera) is expensive compared with second-generation photologging equipment.
- Project startup costs are high if videologging equipment needs to be purchased.
- Two people are necessary to collect the field data.
- Paused video image for the sign data collection and the evaluation of the sign condition is inferior compared with that of 35 mm film frame or an actual field visit unless the audio portion provides additional information.
- Distances and sign dimensions are not obtainable directly from the videolog.
- Any data element requiring the accurate measurement of distances and dimensions is not obtainable unless the audio portion provides the information. Therefore, any data element requiring supplemental audio information not identified before the actual videologging will not be collectible when the videotapes are viewed later.

Semiautomated Methods

A number of semiautomated methods have been developed to collect, process, and record sign inventory data. These methods use electronic and microprocessor technology to record and store operator-selected input onto a computer-readable medium. This technology is called second-generation photologging and videologging.

These semiautomated systems typically consist of a microcomputer with a specially designed keyboard to allow the operator to record field data using a minimal number of keystrokes (Figure 20). As the survey vehicle travels a section of roadway, the operator presses a single key or makes a series of simple keystrokes that record the sign type, size, condition, or other data elements. The data are then automatically arrayed in a data base, along with information on the sign's location and the date of the survey. In some systems, the location of the device is automatically recorded from a distance-measuring instrument; in other systems, the operator must key in the distance from a DMI reading.

Another type of microcomputer-based recording system uses a notebook-size microcomputer with special software that allows the preprocessing of collected data for automatic loading into the main data base and with appropriate checks for data suitability. This software redefines the computer keyboard keys to allow for quick data input. These battery-operated devices are programmed to prompt the operator for specific information about the sign and can be used as a stand-alone data-collection system or in conjunction with photolog or videolog systems.

DEVELOPMENT OF SIGN INVENTORY INFORMATION MANAGEMENT SYSTEM

After the sign inventory data base has been established, an information management system must be used to organize the data and keep the inventory current. Inventory management includes all activities related to the data input, processing, report generation, and updating. Different levels of technology provide varying levels of system capability. The expertise and needs of the agency should dictate what data management process is used.

As with the data-collection process, the data management system can be either manual or computerized (*31*).

Manual Data Management

A manual sign inventory can be managed by a system that uses:

- Index cards
- Strip maps or aerial photographs
- Notched cards

Index Card System

In an index card system, individual inventory cards are kept for each sign in the system. The cards are filed by location and kept in file drawers. As signs are maintained, the date, work activity, and other relevant data elements are recorded on the card. This provides a historical record of all signs in the system. Depending on the amount of information needed, the record for each sign could range from a single index card to a series of cards the size of a sheet of legal paper.

The advantage of a card file system is that it can quickly and inexpensively be implemented with negligible update costs. The disadvantages are that it is impossible to obtain systemwide listings of signs or general update reports and that the development of a comprehensive maintenance management program would require extensive manual searching of the card file to obtain maintenance record listings.

Strip Maps or Aerial Photographs

Strip maps or aerial photographs are similar in that each sign on the road system is placed onto a map, drawing, or aerial photo to identify its position relative to the features of the roadway. As signs are maintained, the maps, drawings, or photos are updated to reflect current status. Some agencies keep sign maintenance records on the drawing, whereas others keep maintenance information in a separate card file or computer inventory that is keyed to a map or photo number (*33*). Some agencies have tied the strip maps, drawings, or photo-overlays to a CAD system so that the drawings can be updated more easily (Figure 21).

There are some advantages in using strip maps and aerial photographs for sign maintenance files. For example:

- An agency can see how the signing relates to the roadway geometry.
- An agency can relate traffic signing to accident experience by overlaying the strip map or aerial photograph with accident location maps.

There are also some disadvantages in using strip maps or aerial photographs. For example:

- The strip maps or aerial photoraphs must be updated to reflect changes in roadway configuration or geometry.
- Although a scale of 1:2400 is sufficient for low-density areas, experience has shown that the scale of the maps or photos in urban areas needs to be 1:1200 or 1:600 to provide an adequate display of the traffic signs in areas where many signs are in place (*34*).
- In most cases, a separate card or computer file must be maintained to record sign maintenance history. The development and updating of this part of the system is very labor intensive, and therefore the costs are high.
- The cost of a CAD system, if used, is very high.

Computerized Sign Inventory Data Management

A fast and efficient method of data management is necessary to handle the record-keeping for a large number of signs, especially when work on the signing system is done by multiple crews. A computer-based sign inventory can provide the data management necessary for the system to be useful. Work order forms can be processed quickly and the inventory updated instantly to reflect completed sign work. Depending on the capabilities of the system, listings of traffic control devices can be printed for a given road or a section of a road, or for a given type of sign and size. Sign totals can be summarized by size and age, and work order forms can be generated for distribution to the workforce. Sign repair totals can be compiled for a given time frame to analyze worker use. High knockdown locations can also easily be identified. This allows the signs at these locations to be relocated or protected in some other way. Areas with frequent vandalism can also be identified. This assists the staff in deciding possible countermeasures for this type of problem, such as requesting the assistance of the police department or deciding to use special antivandalism techniques or hardware.

As with manual methods for managing sign inventory data, a computerized sign inventory can take many different forms. In a computerized system, the differences between the various forms are related to the size of the computer storing the data, whether the system operates in an on-line mode or an off-line batch system, and the extent of the system's software capabilities.

For any configuration more elaborate than a simple listing of sign type and location, the selection of what other data elements to include in the sign inventory can be important. Historically,

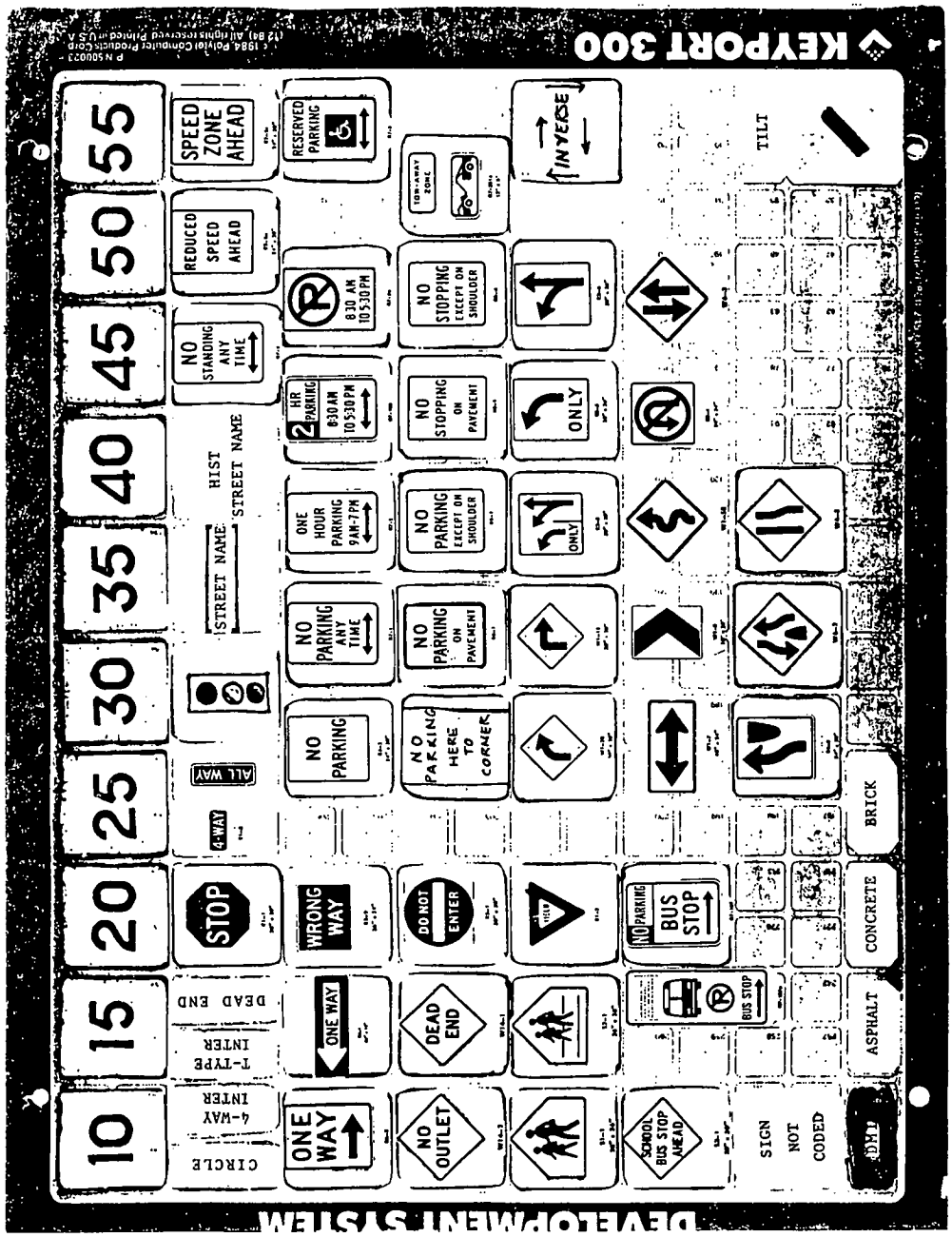


FIGURE 20 Semiautomated keyboard.

sign inventories have been developed and then abandoned after a period of two to three years because the updating procedures were too complicated or time consuming, or the cooperation of the field crews was lacking because of the time and effort needed to keep the inventory up to date. A sign inventory that does not reflect the current status of the signing on the street is useless.

Rapidly changing computer technology has dramatically changed the way business is conducted. The first computerized sign inventory systems, which were developed in the early 1970s, had to be implemented using a mainframe computer system with customized computer software. However, with microprocessor-based computer systems, the inventories of all but the largest sign systems can be more easily developed, implemented, and maintained on a microcomputer that uses off-the-shelf software.

Microcomputer-Based Inventory Systems

With microcomputer-based systems, because of the relative lost cost of computer hardware, agencies have found it is advisable to find computer software that can perform the inventory and then purchase the computer hardware required to run the software.

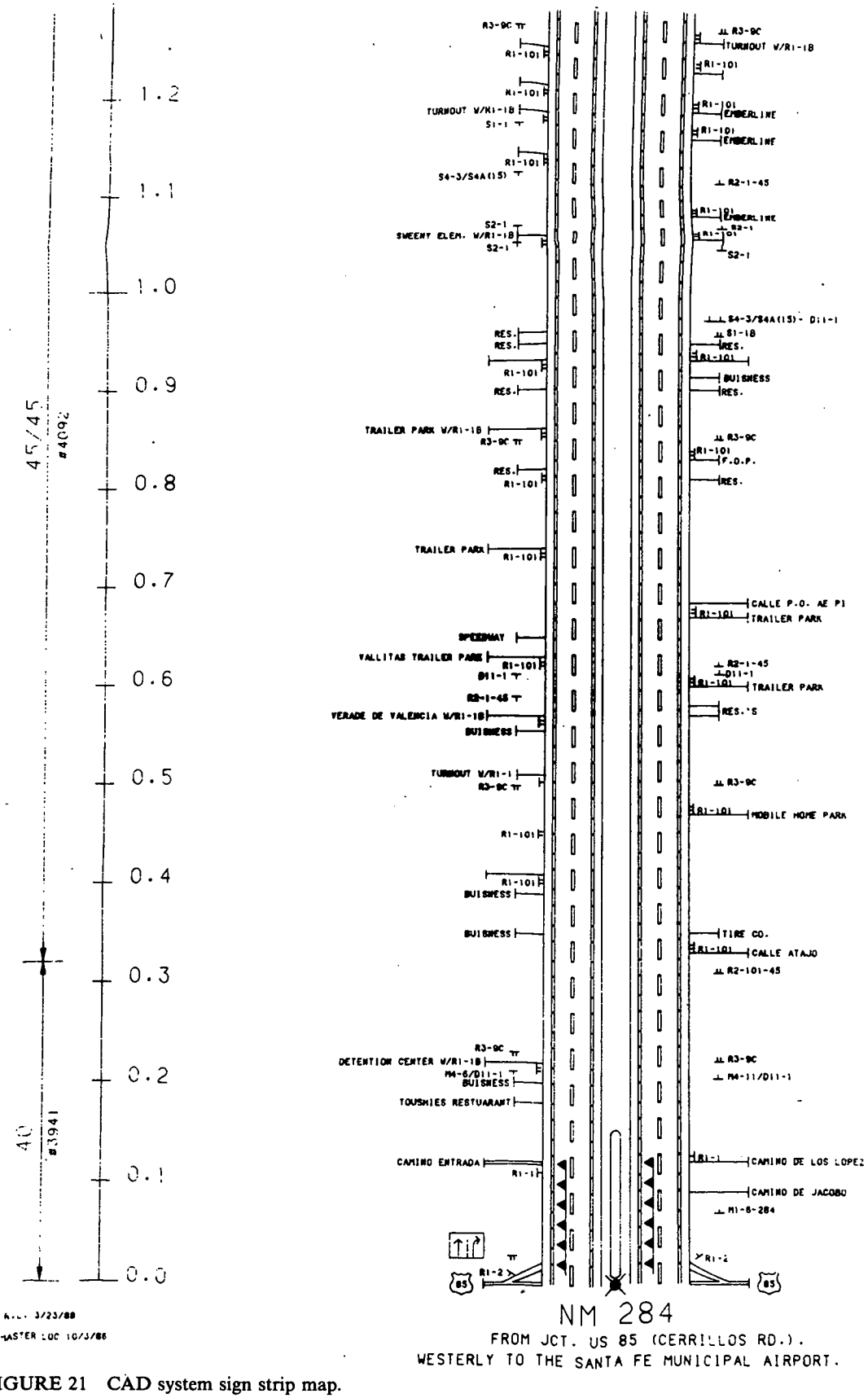


FIGURE 21 CAD system sign strip map.

Software There are a number of off-the-shelf microcomputer programs designed to provide an efficient inventory system for traffic signs (*35*). Most of the programs are built around a data base management software (DBMS) package. In addition, with the increasing ease of use of data base software, and the increasing sophistication of "program generators" within DBMS packages, many agencies are developing their own inventory system without the assistance of a computer programmer. Some agencies are even using the data base capabilities of modern spreadsheet software, such as Lotus 1-2-3, to develop a simple sign inventory that is adequate for a small community (*36*). Others are using public-domain software that can be obtained from users' groups, such as the McTrans Center at the University of Florida.

Public-domain software consists of computer programs developed for use by an agency and put into the public domain for use by others at no cost or very low cost. The advantage is the low cost of the software; the disadvantage is that the inventory must be tailored to the software.

Data base management software has become increasingly popular because it provides a simplified means to meet the data processing, analysis, and reporting needs of an agency through the use of "user friendly" macro routines. Through a menu-driven system, these macro routines control processing functions, such as sorting, merging, report generation, and data updating. Therefore, users need not be computer programmers or operators to use the system. The user can give the appropriate command from the menu selection to enter into the desired process. Then, simply by filling in a form displayed on the screen and responding to prompts from the software, the user can manipulate the inventory without knowing the processing technology or the relationships between the data elements and the program.

The advantages of the data base management systems for sign file maintenance include:

- Improvement of the organization, control, and security of the sign inventory data base.
- Reduction of data redundancy and inconsistency.
- The sharing and intergration of data.
- Elimination of the need for extensive computer programming knowledge.

Hardware The hardware requirements for a microcomputer-based sign inventory system depend on the size of the sign system and the software or data base management system used.

A system that uses DBMS software will generally require the use of at least a 20-megabyte hard disk for storage of programs and data. A system that is built around a spreadsheet or custom programming may or may not require the hard disk, depending on the size of the sign system.

In general, the computer hardware needed includes:

- a central processing unit (CPU),
- a video display screen,
- one floppy disk drive and a hard disk drive or two hard disk drives, and
- a printer.

The cost of such a system could range from $1,000 for a low-speed CPU with two disk drives, a monochrome monitor, and a low-speed dot-matrix printer to $15,000 for a high-speed CPU with a 300-megabyte hard disk, a color monitor, and a laser printer.

Mini or Mainframe Computer-Based Inventory Systems

For larger agencies, because of the size of the signing system that they deal with and considering the current speed of printers and processors, the only practical computer system is a mainframe. (For this discussion, mainframe computers include anything larger than a microcomputer, i.e., traditional mainframes, midis, minis, etc.) For mainframe systems, the cost of the computer hardware is the primary consideration and the cost of the software is secondary.

Hardware The primary features of these larger computer systems are the amount of data-storage capability, the speed of the processors, the capability for computer tape utilization, and the speed of producing hard-copy output, which is a very important feature. A sign system that has 100,000 signs with eight work crews and three sign technicians needs to produce hard-copy sign lists in a timely fashion. Mainframe computer systems, with their high-speed page printers, can provide this capability.

A moderate-sized state or a large county or city could easily have more than 100,000 signs installed on the road system. Most agencies have found it necessary to have a printed list of the sign inventory for each maintenance crew, as well as a list for the technical support staff back at the office. Depending on the number of signs listed on a page, a sign listing of 100,000 signs could require as many as 2,500 to 5,000 pages of output. Couple that with 8 to 10 copies of the sign listing for the various work crews or other support staff, and the printing time becomes unmanageable for a microcomputer-based system.

In addition, a file of 100,000 signs stored on a microcomputer's hard disk drive that is accessed only infrequently during the day is considered by some data processing departments to be a waste of computer resources. In these agencies, a tape drive is used to store the sign inventory data when it is not necessary to have them resident in the computer memory. However, as the price of disk memory becomes less expensive and labor to mount tapes becomes more expensive, this argument is becoming less supportable.

Software As with microcomputers, commercial data base management systems are popular on mainframe computers. However, unlike that of the microcomputer, the mainframe DBMS requires that a computer programmer be involved in the inventory software development process. Therefore, the costs for the development of the sign inventory software are much higher for the mainframe computer system. However, the mainframe DBMS software is much more sophisticated than microcomputer software in terms of organization of data, error trapping, speed of operation, advanced report generation capabilities, data integration, security of data base, etc. Although development costs are higher, the potential performance of the system is greater.

Many of the sign inventories developed during the mid to late 1970s and early 1980s were implemented on mainframe computers using custom software written in COBOL and sold as part of an entire sign inventory package by consultants. This software was tailored to the needs of the individual agency and implemented on its computer system.

Most large agencies already have computer facilities that may be available to them for purposes of implementing a sign inventory. However, in assessing the suitability of the computer system, consideration should be given to:

- the accessibility of the computer,
- the availability in terms of run time, or times of access to the system,
- the turnaround time for production of output,
- the possibility of on-line updating and inquiries, and
- the costs for software development and implementation.

A computer system that is only available during off-hours or requires long lead times for the production of nonstandard types of reports will have limited use in the sign inventory process.

DATA TO BE COLLECTED

Careful selection of data items to be included in a sign inventory is an important element in determining the success of a system. Experience has shown that trying to collect data that are in the "nice to have" category in addition to the "must have" data will overburden the field crews and result in worker resistance. By restricting the data to essential items, the inventory stands a far better chance of success. Considering how the data will be used and what the desired end products are has proved to be a good way to determine what relevant data items are.

The data elements collected as part of sign inventories have evolved over the years. Sign inventory data elements were defined in the early 1970s for urban agencies (*37*) and further defined in the mid-1970s for nonurban agencies (*38*). Figure 22 is an example of an early sign inventory. The data elements included are:

- Sign number (a unique number assigned to each sign to allow for computer filing and updating),
- Street name of the street on which the sign is located (could also be block number or route number),
- Sign location distance (distance and compass direction from nearest intersection or control point),
- Name of reference cross street or control point,
- Side of street or roadway (north, south, east, west, island, overhead, etc.),
- Direction sign is facing (compass direction),
- Sign code (MUTCD coding scheme or other agency coding),
- Sign size (horizontal and vertical dimensions generally in inches),
- Date (date of last work or date of inventory, whichever is more recent),
- Remaining life of sign (based on sign face material, date of sign face installation or last replacement, and manufacturer's warranty for that material),
- Sign condition (good, fair, damaged, rusty, etc.),
- Visibility factor (good, rotated, obstructed, etc.),
- Support type (U-post, square post, utility pole, etc.),
- Support condition (good, fair, bent, etc.), and
- Conformance to the MUTCD in terms of color, legend, shape, and vertical and lateral clearance.

In addition, some inventories provide for:

- Listing of traffic control devices quantities by type,
- Traffic control device maintenance totals by sign or road section to identify high-knockdown-frequency locations, and
- Traffic control device quantities used during the year to manage the sign shop inventory of materials.

Over the years, the sign inventories have matured and some of the original data elements were found to be no longer relevant. The sign inventory data that were collected were then modified to meet current needs. Second-generation inventories now include the following additional data elements (Figure 23):

- Reason for work (new installation, general maintenance, relocation, vandalism, accident, etc.),
- Work to sign (install, replace, repair, clear brush, etc.),
- Work to post (install, replace, repair, etc.),
- Date sign placed in field (month, year),
- Years face at site (difference between current date of inventory listing and date sign placed in field; this has replaced expected life to provide a more accurate estimate of the condition of the sign's retro-reflective material),
- Sign face material (Type III, engineering-grade, nonreflective), and
- Knockdown and vandalism tally for the current year and to date.

In addition to different data elements, many second-generation inventories used an on-line system to update the data elements immediately as opposed to batch processing. This allowed the addition of sign and post quantities on hand, used to date, and determination of when to order new material.

Currently, research is under way at FHWA to develop a microcomputer-based sign management system (*39*). This third-generation sign inventory will go beyond being just a listing of sign type and location. The system will use predictive computer models for sign deterioration to estimate when a sign is likely to need replacement. In this way, an agency's limited resources can be used to replace those signs that are in the most serious need of maintenance (Figures 24–26).

Data elements that are unique to this system include:

- Most recent inspection date (mm/dd/yy),
- Sign retro-reflectivity reading [in specific intensity per unit area (SIA)] measured with a commercially available retro-reflectometer,
- Sign condition,
- Complexity—subjective assessment of the visual complexity of surrounding area (e.g., high—very urbanized area with a lot of competing information, low—rural area with little competing information),
- Speed limit,
- Road alignment (curve, straight),

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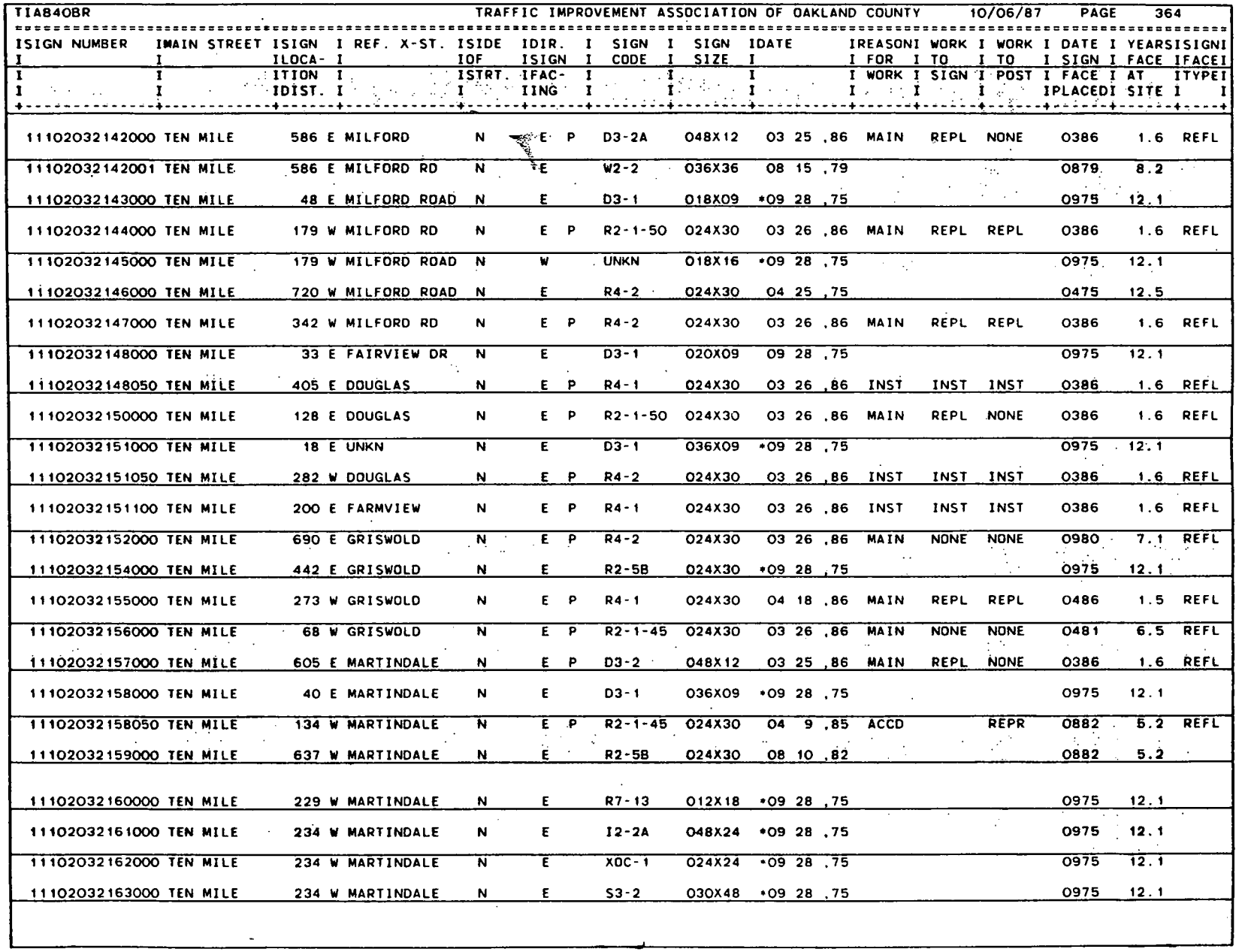
SIGN NUMBER	MAIN STREET	SIGN LOCATION DIST.	REF. X-ST.	SIDE OF STRT.	DIR. SIGN FACING	SIGN CODE	SIGN SIZE	DATE	EXPCT LIFE	SIGN CONDITION	VISIBILITY	SUPPORT TYPE	POST CONDITION	STD/INSTD
1000000377230	AMY	39 E	IORTONVILLE	N	E	R1-1	030X30	*04 19 /76	5 YR	FAIR	GOOD	UPST	GOOD	NSHD
1000000385410	ANDOVER	80 N	IEXETER	E	S	R7-1	012X18	*05 9 /76	5 YR	FAIR	ROTD	UPST	GOOD	NSHD
1000000385420	ANDOVER	80 N	IEXETER	E	S	R7-2	012X18	*05 9 /76	5 YR	FAIR	ROTD	UPST	GOOD	NSHD
1000000385490	ANDOVER	30 S	ILONG LK	E	S	R1-1	030X30	*05 9 /76	0 YR	REPL	GOOD	UPST	GOOD	NSHD
1000000385500	ANDOVER	131 S	ILONG LK	W	N	R7-2	012X18	*05 9 /76	5 YR	FAIR	GOOD	UPST	GOOD	NSHD
0500000390040	ANDREWS	29 E	IBOGIE LK RD	N	E	R1-1	024X24	*04 22 /76	5 YR	FAIR	GOOD	UPST	GOOD	NSD
2100000344460	ANGELENE	37 E	ICLINTONVILLE	N	E	R1-1	030X30	*04 9 /76	0 YR	REPL	GOOD	UPST	GOOD	NSD
1000000385910	APPLE	20 N	IKIRKLAND	W	N	R1-1	024X24	*05 9 /76	5 YR	FAIR	POBS	UPST	GOOD	NSHD
2100000113980	AQUARINA	29 N	IWALTON	W	N	R1-1	030X30	*04 5 /76	5 YR	FAIR	GOOD	UPST	GOOD	NSD
0300000338710	ARDMOOR	1278 N	IBURNINGBUSH	E	S	R2-1-25	024X30	*03 19 /76	0 YR	REPL	GOOD	UPST	GOOD	STD
1460000034830	ARDMORE	35 S	ILASHER	E	S	R1-1	030X30	*03 22 /76	0 YR	REPL	GOOD	UPST	REPL	NSH
0200000108570	ARIZONA CT	43 W	IARIZONA	S	W	R1-2	030X30	*03 30 /76	0 YR	REPL	GOOD	UPST	GOOD	NSD
1500000301940	ARMSTRONG	71 S	ISATURN	ISLD	N	R4-7A	024X30	*04 8 /76	0 YR	REPL	GOOD	UPST	GOOD	NSH
1500000301950	ARMSTRONG	29 N	IWALDON	W	N	R1-1	030X30	*04 8 /76	0 YR	REPL	GOOD	UPST	REPL	NSD
1500000367690	ARMSTRONG	71 S	ISATURN	ISLD	N	R4-7A	024X30	*04 8 /76	0 YR	REPL	GOOD	UPST	GOOD	NSH
1500000367700	ARMSTRONG	29 N	IWALDON	W	N	R1-1	030X30	*04 8 /76	0 YR	REPL	GOOD	UPST	REPL	NSD
1010000037410	ARMY	455 W	IDEVONSHIRE	S	W	R7-1	012X18	*05 20 /76	0 YR	REPL	GOOD	UPST	GOOD	NSD
1010000037411	ARMY	164 W	IDEVONSHIRE	S	W	R7-1	012X18	*05 20 /76	5 YR	FAIR	GOOD	UPST	REPL	NSD
1010000037414	ARMY	129 E	IKINGSTON	S	W	R7-1	012X18	*05 20 /76	5 YR	FAIR	GOOD	UPST	GOOD	NSD
1010000037416	ARMY	1021 E	IKINGSTON	S	W	R7-1	012X18	*05 20 /76	5 YR	FAIR	GOOD	UPST	GOOD	STD
1010000037417	ARMY	795 W	IROCHESTER	S	W	R7-1	012X18	*05 20 /76	5 YR	FAIR	GOOD	UPST	GOOD	NSD
1010000037430	ARMY	133 W	IDEVONSHIRE	N	E	R7-1	012X18	*05 20 /76	0 YR	REPL	GOOD	UPST	GOOD	NSD
2220000029845	ARROWHEAD	1410 N	IDEERFOOT	E	S	R1-1-RR	030X30	*03 19 /76	0 YR	REPL	GOOD	UPST	REPL	NSHD
1230000031989	ARTDALE	28 S	IBISCAYNE	E	S	R1-2	030X30	*04 28 /76	5 YR	FAIR	GOOD	UPST	GOOD	NSH

FIGURE 22 First-generation sign inventory.



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ISIGN NUMBER	MAIN STREET	SIGN LOCATION DIST.		REF. X-ST.	SIDE OF STRT.	DIR. SIGN FACING		SIGN CODE	SIGN SIZE	DATE	REASON FOR WORK	WORK TO SIGN	WORK TO POST	DATE SIGN FACE PLACED	YEARS AT SITE	SIGN FACE TYPE
11102032142000	TEN MILE	586	E	MILFORD	N	E	P	D3-2A	048X12	03 25 ,86	MAIN	REPL	NONE	0386	1.6	REFL
11102032142001	TEN MILE	586	E	MILFORD RD	N	E		W2-2	036X36	08 15 ,79				0879	8.2	
11102032143000	TEN MILE	48	E	MILFORD ROAD	N	E		D3-1	018X09	*09 28 ,75				0975	12.1	
11102032144000	TEN MILE	179	W	MILFORD RD	N	E	P	R2-1-50	024X30	03 26 ,86	MAIN	REPL	REPL	0386	1.6	REFL
11102032145000	TEN MILE	179	W	MILFORD ROAD	N	W		UNKN	018X16	*09 28 ,75				0975	12.1	
11102032146000	TEN MILE	720	W	MILFORD ROAD	N	E		R4-2	024X30	04 25 ,75				0475	12.5	
11102032147000	TEN MILE	342	W	MILFORD RD	N	E	P	R4-2	024X30	03 26 ,86	MAIN	REPL	REPL	0386	1.6	REFL
11102032148000	TEN MILE	33	E	FAIRVIEW DR	N	E		D3-1	020X09	09 28 ,75				0975	12.1	
11102032148050	TEN MILE	405	E	DOUGLAS	N	E	P	R4-1	024X30	03 26 ,86	INST	INST	INST	0386	1.6	REFL
11102032150000	TEN MILE	128	E	DOUGLAS	N	E	P	R2-1-50	024X30	03 26 ,86	MAIN	REPL	NONE	0386	1.6	REFL
11102032151000	TEN MILE	18	E	UNKN	N	E		D3-1	036X09	*09 28 ,75				0975	12.1	
11102032151050	TEN MILE	282	W	DOUGLAS	N	E	P	R4-2	024X30	03 26 ,86	INST	INST	INST	0386	1.6	REFL
11102032151100	TEN MILE	200	E	FARMVIEW	N	E	P	R4-1	024X30	03 26 ,86	INST	INST	INST	0386	1.6	REFL
11102032152000	TEN MILE	690	E	GRISWOLD	N	E	P	R4-2	024X30	03 26 ,86	MAIN	NONE	NONE	0980	7.1	REFL
11102032154000	TEN MILE	442	E	GRISWOLD	N	E		R2-5B	024X30	*09 28 ,75				0975	12.1	
11102032155000	TEN MILE	273	W	GRISWOLD	N	E	P	R4-1	024X30	04 18 ,86	MAIN	REPL	REPL	0486	1.5	REFL
11102032156000	TEN MILE	68	W	GRISWOLD	N	E	P	R2-1-45	024X30	03 26 ,86	MAIN	NONE	NONE	0481	6.5	REFL
11102032157000	TEN MILE	605	E	MARTINDALE	N	E	P	D3-2	048X12	03 25 ,86	MAIN	REPL	NONE	0386	1.6	REFL
11102032158000	TEN MILE	40	E	MARTINDALE	N	E		D3-1	036X09	*09 28 ,75				0975	12.1	
11102032158050	TEN MILE	134	W	MARTINDALE	N	E	P	R2-1-45	024X30	04 9 ,85	ACCD		REPR	0882	5.2	REFL
11102032159000	TEN MILE	637	W	MARTINDALE	N	E		R2-5B	024X30	08 10 ,82				0882	5.2	
11102032160000	TEN MILE	229	W	MARTINDALE	N	E		R7-13	012X18	*09 28 ,75				0975	12.1	
11102032161000	TEN MILE	234	W	MARTINDALE	N	E		I2-2A	048X24	*09 28 ,75				0975	12.1	
11102032162000	TEN MILE	234	W	MARTINDALE	N	E		XOC-1	024X24	*09 28 ,75				0975	12.1	
11102032163000	TEN MILE	234	W	MARTINDALE	N	E		S3-2	030X48	*09 28 ,75				0975	12.1	

FIGURE 23 Second-generation inventory.

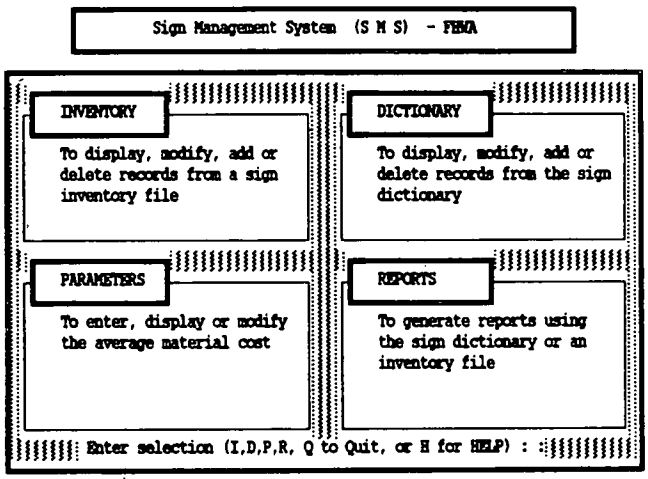


FIGURE 24 SMS main menu.

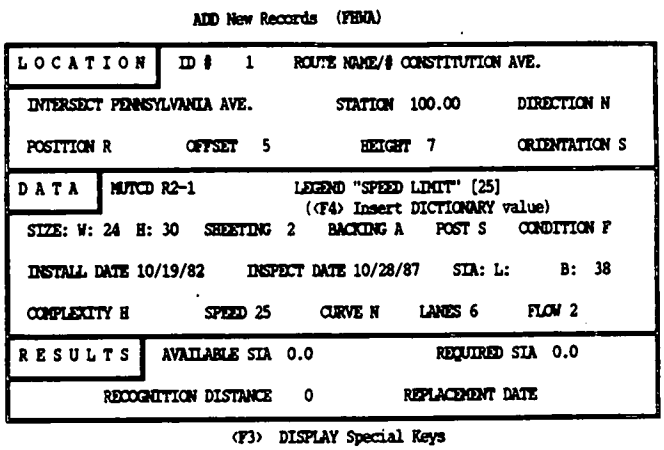


FIGURE 25 Add screen.

- Number of lanes, and
- Flow (divided highway, one-way street, or two-way road).

The following data elements would be calculated by the computer models:

- Available SIA—estimate of retro-reflection available,
- Required SIA—estimate of retro-reflection required,
- Recognition Distance—estimate of recognition distance available, and
- Replacement Date—estimate of the date when the sign should be inspected for possible replacement.

Upon completion, the sign management system will operate as a stand-alone microcomputer-based sign inventory, or the predictive models can be transported into mainframe programs for those agencies that use mainframe systems.

COSTS OF INVENTORY DEVELOPMENT

The selection of an appropriate inventory development process is dependent on many factors. However, the primary consideration is generally the cost-effectiveness of the inventory procedure.

Datta and Herf (*40*) evaluated the various alternative inventory procedures related to sign density and determined estimated costs for the alternative inventory procedures shown in Table 6.

The estimated cost of the photologging includes the cost of film at $125/400-ft roll and the cost of processing at $95/roll. Based on the estimate that 27.5 roadway miles can be recorded per roll, this equates to a film cost of $8.00/roadway mile (1987 dollars).

WORK ORDER FORMS

Street and highway signs are worked on by maintenance crews on a daily basis, and the success of the inventory system is dependent on the quality of the information obtained from the field personnel. The changes made by the work crews to the

ID#	ROUTE NAME	DIR	INTERSECTION	STATION	MUTCD CODE	INSTALL DATE	INSPECT DATE	SIA L	SIA B	RPL COST
1	CONSTITUTION AVE.	W	PENNSYLVANIA AVE.	100.00	R2-1	10/19/82	10/28/87	0	38	16.00
2	CONSTITUTION AVE.	W	CONNECTICUT AVE.	100.00	R1-1	10/30/81	11/13/87	50	10	20.00
3	CONSTITUTION AVE.	W	VERMONT AVE.	20.00	R5-1	03/12/86	10/02/87	45	12	20.00
4	CONSTITUTION AVE.	W	VERMONT AVE.	50.00	R6-1	05/08/86	11/01/87	0	58	9.60
5	CONSTITUTION AVE.	W	MAINE AVE.	10.00	R3-2	10/30/85	10/10/87	0	53	12.80
TOTAL RECORDS	5						TOTAL COST $			78.40

FIGURE 26 Sign inventory report.

signing system must be entered into the inventory files. All agencies that have an inventory use some type of work order form to record their maintenance activities, regardless of whether the inventory is manual or computerized.

The purpose of a work order form is two-fold: (a) it enables an agency to have a planned maintenance program and (b) it enables an agency to keep the inventory files current, ensuring that new installations and maintenance changes are entered to update the files.

Work order forms are generally divided into two areas. The top half of the form, which is generally filled out in the office, is the information on the location of the sign, the work to be done, and any other instructions to the field crews. The bottom half of the form relates to when the work was completed, what materials were used, what equipment was required, who completed the work and when, utility clearance, and sign placement as recorded in the field by the maintenance crews.

The completed work order is returned to the sign superintendent, so that the overall progress of the sign maintenance program can be monitored, and then to the sign inventory staff, to update the card files, strip maps, or the computer files to keep the inventory current.

Most of the forms used in computer-based inventory systems are set up so that the separate hand-coding of information is not required. That is, the data fields on the work order form are marked by the field or office staff so that the data entry personnel can read the form directly and input the information into the computer. For most systems, this requires that each sign be placed on a separate form.

Those agencies that are using a manual sign inventory system generally record the total day's maintenance activity on one form to reduce the paperwork and ease the record-keeping process.

Samples of various work order forms used by agencies are included in Appendix B for reference.

TABLE 6
ESTIMATED COSTS FOR ALTERNATIVE INVENTORY PROCEDURES IN COST PER ROADWAY MILE

Roadway Category	Manual	Second Generation Photolog	Videolog
Urban (High Sign Density)	$134.41	$69.62	$68.88
Urban/Suburban (Moderate Sign Density)	82.61	46.98	31.29
Rural/Small Urban (Low Sign Density)	43.84	29.07	22.11
Rural (Very Low Sign Density)	15.27	23.74	16.05

CHAPTER FIVE

MAINTENANCE FACILITIES, EQUIPMENT, AND MATERIALS

To maintain the highway signing system, specialized operations, equipment, and materials must be available to the responsible jurisdiction from public or private sources. These resources can include: a fully staffed sign shop, sign manufacturing equipment, sign materials, posts and other mounting materials, field equipment to install signs, and other hardware.

MAINTENANCE FACILITIES AND EQUIPMENT

Sign Shop

The size and scope of sign shop operations vary from state to state and agency to agency as dictated by local economics and policy decisions.

Some smaller agencies may decide not to set up a sign manufacturing facility but instead buy completed signs from other agencies, such as the state, county, or other communities, or from private sign manufacturing companies.

Some medium-size agencies fabricate only a few types of signs, such as street name or other limited-production signs, and rely almost entirely on signs purchased from outside sources. For instance, Montgomery County, Maryland, purchases signs that are used frequently (STOP sign, speed limit, etc.) from a private sign fabrication company and only manufactures in-house the little-used or unique signs. It feels that it is able to significantly reduce its maintenance costs through this purchasing process.

Because of the relatively large investment required for equipment, only the largest agencies have more than one sign shop. Because more than one sign shop would require expensive duplication of equipment, most agencies have found it more economical to consolidate the sign manufacturing into a central shop and ship the completed signs to smaller district shops. However, some agencies do maintain a limited amount of sign fabrication equipment at their district sign shops to meet the fabrication needs for emergency sign maintenance. The central sign shop usually supplies the signs required for general maintenance activities.

In some states, prison labor may cut and furnish sign blanks, whereas in other states the prison labor may furnish the completed sign. A number of agencies use the federal Prison Industries for the purchase of traffic signs. Signs purchased from Prison Industries are prequalified for federally funded projects without having to go to bid.

Central versus District Sign Shops

When agencies decide to manufacture their own signs, they may manufacture them all at one central facility or they may manufacture all or part of them at the district level.

An FHWA Federally Coordinated Program of Research Category 7 study of sign maintenance in Arkansas, Florida, and Kentucky ". . .recommended that the States develop a centralized sign shop as the most economical method of fabricating and refurbishing signs" (*41*). The major economies of centralized sign shops are that:

- Materials purchasing is more effective because the materials can be delivered to one location.
- Sign fabrication crews become more efficient because they are able to gain more experience in a centralized sign shop.
- The quality and quantity of the signs in the shop inventory increase.
- Better control of the sign inventory is maintained and the production of signs that are not needed is reduced or eliminated.

Size of Sign Shop

The determination of what size and how extensive the operations of a sign shop should be depend on:

- The number of signs maintained by the agency,
- The cost of labor and materials for agency employees to fabricate the signs versus the cost of prefabricated signs,
- The need and ability to reassign sign maintenance workers and sign fabricators to other work activities during inclement weather or slow periods,
- The availability of storage facilities to keep an inventory of important signs for emergency replacements,
- Local policies on the response time for emergency replacement, and
- Local policies on purchasing.

Sign Shop Equipment

When using only prescreened, manufactured sign faces an agency needs the following fabrication equipment:

- Heat vacuum applicator
- Squeeze roller

When fabricating the sign completely in-house, the following fabrication equipment is needed:

- Heat vacuum applicator
- Squeeze roller

- Screen table
- Exposure frame
- Light source
- Layout equipment
  Computer
  Photo
  Hand-cut film
- Fabric stretchers
- Screen wash area
- Squeegee sharpener
- Fans
- Die-cut letter press
- Screen frames
- Drying racks
- Metal shear

Sign Shop Layout

The sign shop should be designed to create a smooth flow from the entrance of the raw materials to the exit of the fabricated sign. Interference between work areas and traffic patterns should be minimized.

Figure 27 (*42*) shows typical small sign shop functions and illustrates general locations that have been found to produce efficient operation. Locations of storage areas, fire walls, sanitary facilities, exits, etc. must be considered, depending on local building codes and health and safety requirements.

Figure 28 (*42*) shows typical medium to large sign shop functions and illustrates general locations that have been found to produce efficient operation. As with the small shop layout, locations of storage areas, fire walls, sanitary facilities, exits, etc. should be provided to meet local building codes and health and safety requirements.

Sign Storage

Many agencies have found it useful to establish a sign storage area for keeping an inventory of frequently used signs. This provides the agency with signs for emergency replacements and gives it the opportunity to reduce costs by making large production runs of common signs and then storing them for later use. Agencies with sufficient storage space have found that storing the signs vertically in racks reduces sign damage during storage, preserving the retro-reflective qualities of the sign faces. Such sign racks are fairly simple to make and relatively inexpensive. Material costs run about $500 (*43*). Many agencies have also found that rack storage requires less floor area than simply stacking the faces on top of each other. The racks also provide a quick and efficient means of inventory control. Figure 29 shows some typical storage arrangements for signs.

Field Equipment

The efficiency of sign crews is dependent on the availability of the proper equipment to quickly and safely complete the task at hand. Depending on the sign maintenance activity, a sign crew's needs may range from a wrench to tighten a loose bolt to an aerial lift for the replacement of overhead signing. Field equipment, as used in the context of this synthesis, includes: vehicles, tools, and safety equipment for the workers and equipment operators.

Sign Truck and Related Equipment

The International Municipal Signal Association (IMSA) *Traffic Signal Manual of Installation and Maintenance Procedures* (*44*) provides a general guide to assist in the selection of truck type, bodies, aerial lifts, and related equipment used in the maintenance of traffic signals (Figures 30 and 31). Most of the discussion in the IMSA manual that relates to the selection of signal maintenance equipment is also appropriate for the selection of equipment used for the maintenance of traffic signs.

The IMSA manual suggests that three areas should be considered before the purchase of any truck or aerial equipment for field maintenance work:

- Does the equipment provide adequate work performance?
  Sufficient gross vehicle weight rating
  Aerial lift capacity
  Platform work area
- Is it a proven product?
  Certified number of units in service
  Reliability of design
  Safety features
- Is service available?
  Service contract
  Replacement parts
  Warranty

The truck and related equipment section of the manual also provides:

- Specifications for various types of aerial equipment,
- Occupational Health and Safety Administration rules and regulations for aerial lifts,
- Components of pickup bodies, utility service bodies, maintenance bodies, and crew compartment bodies, and
- A listing of accessory equipment for bodies and other related equipment.

Other Equipment for Sign Maintenance

Other sign maintenance equipment found on a typical sign truck would include:

- Earth auger
- Pavement breaker and drill
- Portable generator
- Impact wrench
- Chain saw
- Post driver
- Post puller
- Aerial bucket or platform
- Sign racks
- Toolboxes and hand tools
- Acetylene torch
- Floodlights

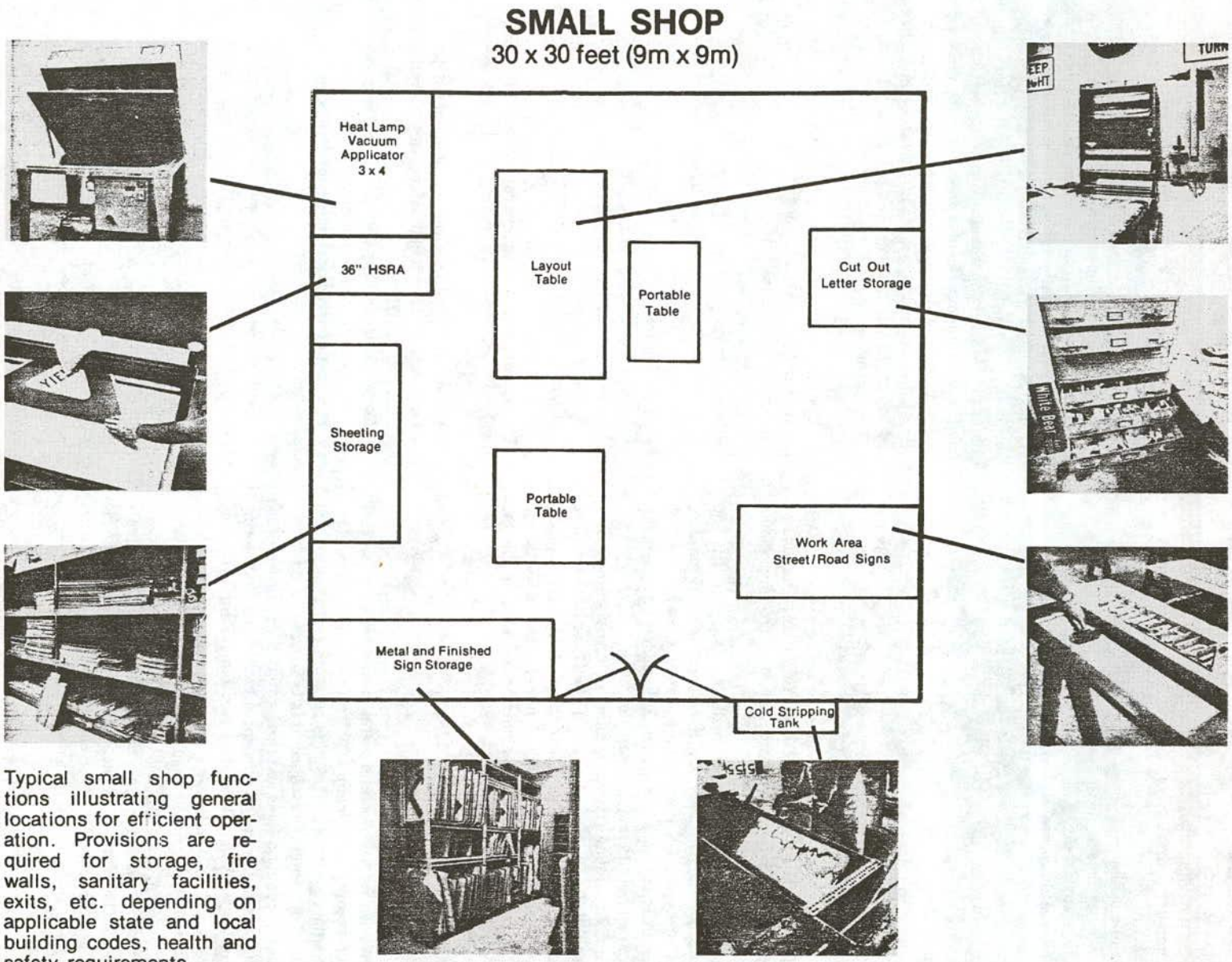


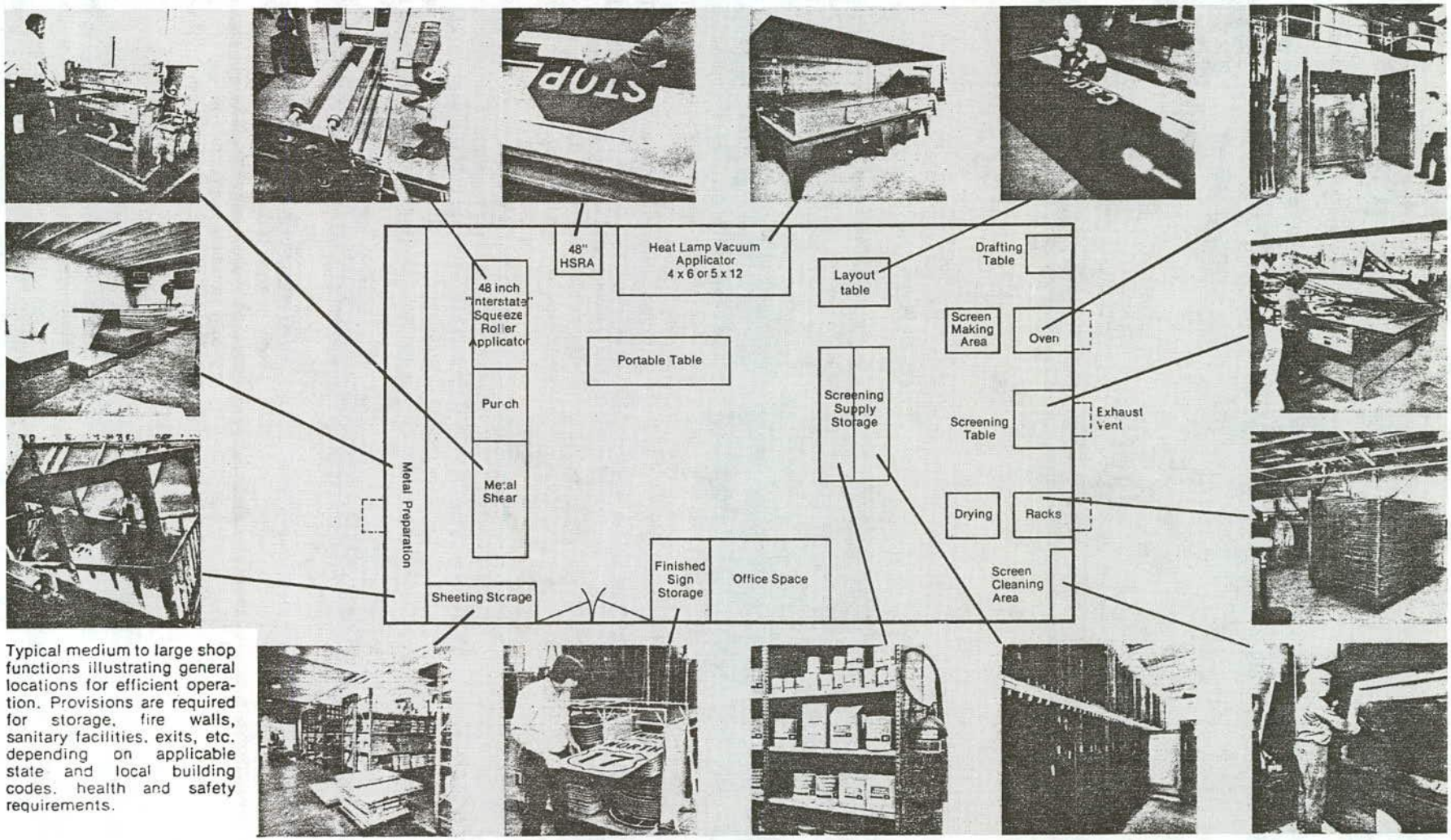
FIGURE 27 Small sign shop.

Typical small shop functions illustrating general locations for efficient operation. Provisions are required for storage, fire walls, sanitary facilities, exits, etc. depending on applicable state and local building codes, health and safety requirements.

FIGURE 28 Medium to large shop.

MEDIUM TO LARGE SHOP

40 x 70 feet (12m x 21m)



Typical medium to large shop functions illustrating general locations for efficient operation. Provisions are required for storage, fire walls, sanitary facilities, exits, etc. depending on applicable state and local building codes, health and safety requirements.

FIGURE 29 Sign storage system.

FIGURE 30 A sign truck.

- Arrow board
- Worker safety equipment (hard hats, safety vests, goggles, etc.)
- Warning flashers

MATERIALS

A typical sign installation is made up of the following elements:

- Sign blanks
- Sign faces
- Signposts

FIGURE 31 Sign storage on truck.

Sign Blanks

The most widely used sign blank materials are wood (usually plywood) and aluminum. Recently, there has been some use of plastic and reinforced fiberglass as sign blank materials.

Large agencies, because of their need for large quantities of signs, have obtained considerable cost savings in buying large sheets of aluminum and cutting them to size. In addition, the large shears used to cut the sheet aluminum into sign blanks may also be used to salvage damaged signs by cutting them into smaller blanks.

However, almost all smaller agencies find it more economical to purchase from manufacturers sign blanks already cut to size rather than purchase large sheets of aluminum and cut their own sign blanks. This reduces the need for large sheet-storage areas and expensive metal-cutting equipment. Some smaller agencies have found it more economical to use only metal sign blanks rather than both metal and wood. This standardizes their sign face application process and eliminates the need for two different storage areas for the different materials. However, with the increasing cost of aluminum, many agencies are finding that the purchase of a sign stripper should be investigated.

Sign Faces

An agency can purchase prescreened sign faces for application onto the sign blanks or it can fabricate its own. There are four basic methods of sign face fabrication. They are: silk screening, overlay, stenciling, and hand painting.

Silk Screening

When an agency manufactures large quantities of the same sign, silk screen printing can be a low-cost alternative for creating sign faces. However, many small agencies do not create the volume of signs or have the expertise to justify the purchase of the equipment required for this process. These smaller agencies

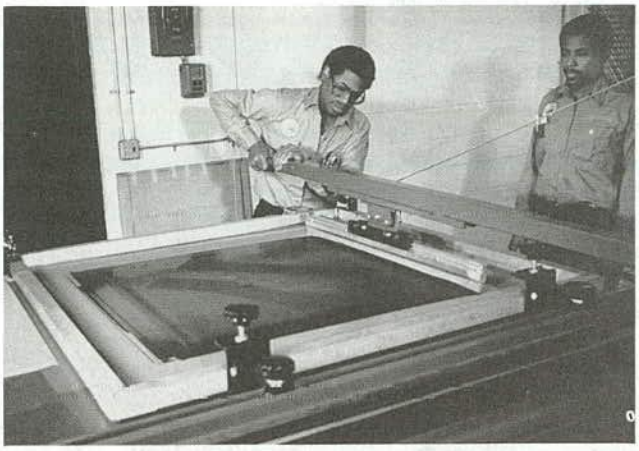


FIGURE 32 Sign silk screening.

have found it more economical to purchase prescreened faces from suppliers. Figure 32 shows the silk screening of sign faces.

Overlay

Overlay fabrication is a process in which retro-reflective cut-out letters or shapes are applied to retro-reflective sheeting (Figure 33). The letters or shapes may be purchased precut from suppliers, cut with a die-cut press, hand cut with stencils and scissors, or cut using a computerized letter-cutting system.

The state of Washington estimates that a die cutter saves it more than 25 percent in the cost of materials every year. The die-cutter allows the state to use almost all of the scrap material that had previously been discarded. In addition, by cutting letters or shapes as needed, the state does not have to stock a large supply of precut letters or shapes from suppliers (*45*).

Montgomery County, Maryland, uses a CAD system for sign legend layout and fabrication. The sign legend is laid out onto pin-fed retro-reflective sheeting and automatically cut by a computer-driven plotter equipped with a cutting edge (Figure 34). Montgomery County has found that the main advantage of the computer-aided system is the quick and easy adjustment of letter and word spacing and letter size and the speed at which a large number of identical legends, such as specific street name, can be cut out.

The city of Grand Rapids, Michigan, also uses such a computer-aided system. It estimates that it can lay out and cut a sign in 20 min, compared with the 120 min that it took to do it manually. In addition, it has reduced the number of silk screens that it has kept on hand because it is able to store sign layouts in computer files and call them up when needed. It currently maintains only 20 silk screens of standard signs. The rest of the sign layouts that it needs are stored in files on the computer.

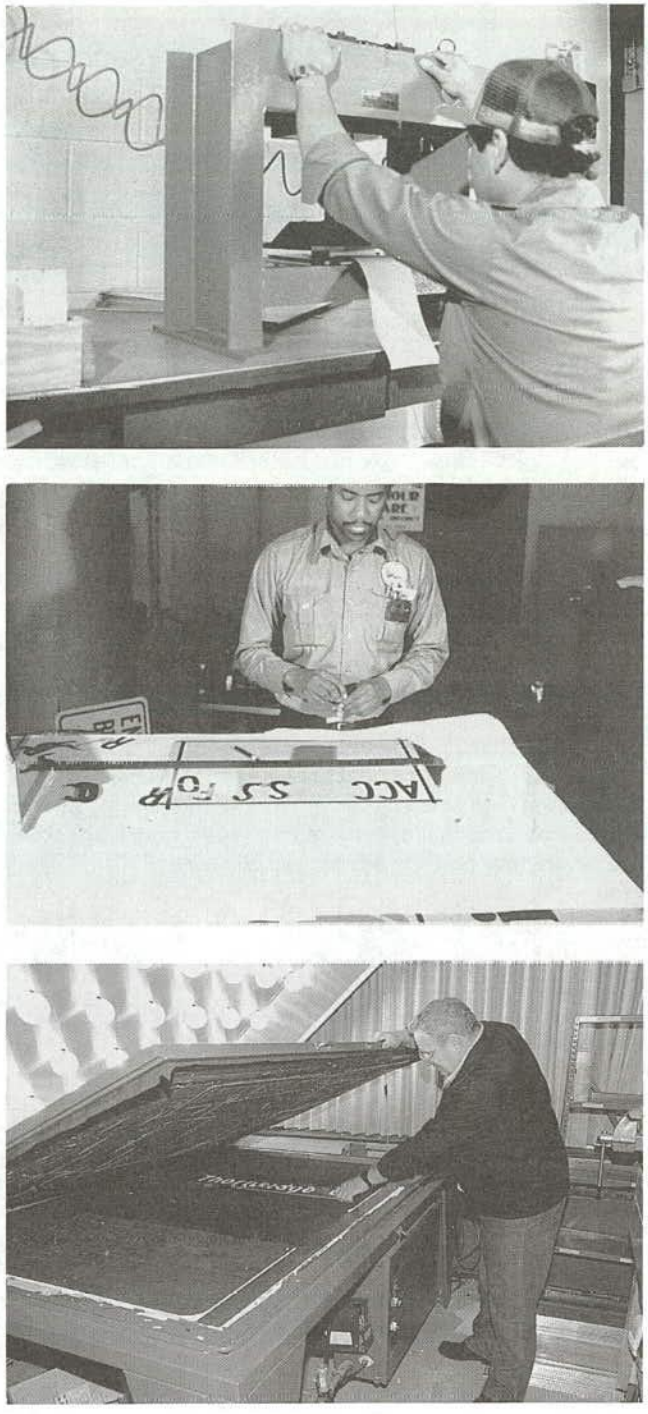


FIGURE 33 Overlay fabrication process.

Signposts

Highway signs are positioned and mounted in a variety of ways, using a variety of materials. Agencies place signs on steel, aluminum, or wooden posts or on existing utility poles. Posts may be round, square, U-shaped, or other shapes. In order to meet American Association of State Highway and Transportation Officials (AASHTO) standards, the post must be rigid enough to resist twisting in the wind or collapsing under the weight of snow and ice, and the post must be designed to break away or bend over when hit by an errant vehicle. A good sign support system will not create a collision hazard for motorists. It is also made from readily available low-cost materials and is inexpensive to install and maintain.

FIGURE 34 CAD sign system.

Ross et al. (*29*) in a 1979 survey of federal agencies, state highway agencies, state turnpike authorities, cities, counties, sign suppliers, and contractors on signpost usage found that for single- and multiple-post installations, the U-post was the most widely used sign support. Approximately 34 percent of single-post sign installations and 30 percent of multiple-post sign installations were placed using a U-post. Table 7 summarizes the Ross survey. The results of the survey also showed that there is considerable variation in the use of wood posts, round tube posts, and square tube posts by different jurisdictions.

Signpost Bases

To be effective in providing needed information to the motorist, and because of limited right-of-way availability on many roadways, most sign installations are placed within the clear zone of the traveled way. Therefore, the sign and its support system must be designed to break away or yield so that the installation does not become a fixed-object hazard. A yielding support is an embedded sign support the base of which bends over when struck by a vehicle. Most sign foundations simply consist of a signpost driven into the ground.

For single-post installations, Ross found that many of the U-posts are simply driven into the ground without any breakaway mechanism (Table 8). For wood posts, approximately 30 percent are weakened at their base by drilled holes, notches, or some other means (Figure 35). For round steel pipe signposts, approximately 28 percent use a slip base, a weakened section, or a threaded coupling. About 43 percent of the steel square tubing posts have a slip base (Figure 36) or other type of breakaway mechanism. All agencies that use beam-type posts use a coupling or slip base design.

For multiple-post installations, the U-post design is again the most widely used sign support, being used with approximately 30 percent of all multiple-post installations. As with single-post installations, almost all of the multiple-post installations are simply driven into the ground (Table 8). For wood posts, approximately 35 percent are weakened at their base by drilled holes or notches. For round pipe signposts, approximately 23 percent use a slip base and 15 percent have some other form of foundation such as a threaded coupling. About 31 percent of the steel square

TABLE 7
TYPE OF POST USED IN SINGLE AND MULTIPLE POST SIGN INSTALLATIONS (PERCENT USEAGE BY JURISDICTION) (*29*)

Type and Shape of Material	Single Post					Multiple Post				
	State	Cities	Counties	Other	Total	State	Cities	Counties	Other	Total
Steel or Aluminum										
"U" Single	29.8	48.6	48.3	36.6	34.0	32.4	1.8	97.8	4.5	29.7
"U" Back to Back	1.2	0.0	0.0	0.0	0.9	3.4	0.0	NR	0.0	3.0
Square Tube	13.6	10.1	13.4	2.9	12.7	7.0	11.1	NR	NR	7.2
Round Pipe	25.8	33.3	5.8	12.2	25.6	5.6	83.6	2.2	0.3	13.3
Beam (I,S,W or H)	0.2	0.0	0.0	NR	0.3	23.3	0.0	0.0	3.8	20.4
Angle (Z)	NR	1.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Wood										
Square	28.9	6.3	32.5	38.0	25.6	27.4	3.5	0.0	53.6	25.1
Round	0.5	0.0	0.0	4.2	0.5	0.9	0.0	0.0	15.5	1.0
Combination	0.0	0.0	0.0	6.1	0.1	NR	0.0	0.0	20.1	0.3
Plastic										
Round Pipe	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 8
BREAKAWAY MECHANISMS OF THE MOST WIDELY USED SINGLE- AND MULTIPLE-POST SIGN INSTALLATIONS (PERCENT USEAGE BY JURISDICTION) (*29*)

	Single Post						Multiple Post					
Type and Shape of Material	Slip Base	Drilled Hole	Weakened Section	Other	Not Given	None	Slip Base	Drilled Holes	Weakened Section	Other	Not Given	None
Steel												
"U" Single	2.3	0.0	0.0	1.1	6.9	89.7	4.8	0.0	0.0	0.0	7.1	88.1
"U" Back to Back	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Square Tube	20.0	2.9	2.9	17.1	14.3	42.8	0.0	0.0	6.2	25.0	12.5	56.3
Round Pipe	17.9	0.0	2.6	7.7	7.7	64.1	23.1	0.0	0.0	15.4	7.7	53.8
Beam (I,S,W or H)	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Aluminum												
"U" Single	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Square Tube	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Round Pipe	18.2	0.0	0.0	18.2	9.1	54.5	0.0	0.0	0.0	22.2	11.1	66.7
Beam (I,S,W or H)	0.0	0.0	0.0	0.0	0.0	100.0	75.	00.0	0.0	0.0	0.0	25.0
Wood												
Square	1.7	20.0	8.3	0.0	20.0	50.0	1.8	25.5	7.3	0.0	14.5	50.9
Round	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	33.3	0.0	0.0	66.7

FIGURE 35 Wood signpost with weakened section.

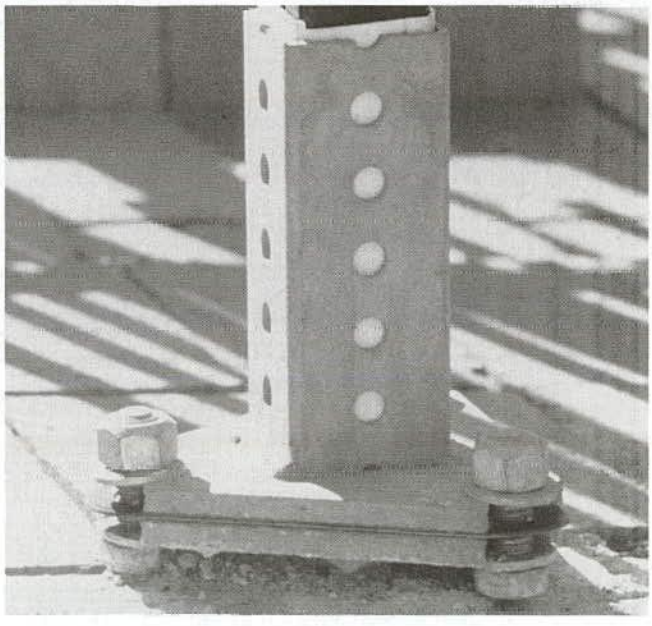


FIGURE 36 Slip base.

tubing posts have a slip base or other type of breakaway mechanism.

Other base systems for signs include:

- Frangible coupling
- Break-safe coupling
- Wedge-lock base
- Bolted base

Selection Criteria for Signposts

Ross found that for most agencies the impact performance or crashworthiness of the system is the most important factor in selecting the type of support system for a sign installation (Table 9). Other factors include:

- Installation cost
- Maintenance cost
- Amount of maintenance required
- Availability of replacement materials

Purchasing Procedures for Sign Maintenance Materials

The procedures used to purchase sign maintenance materials can have a significant effect on the prices obtained in the bidding process. Factors that can affect the bid prices on material include:

- Availability of raw material,
- Quantities of material purchased,
- Number of suppliers bidding,
- Number of places and locations to which the material is to be delivered,
- Time of the year the bid is let, and
- Special-contract purchasing.

An FHWA study of sign maintenance in Arkansas, Florida, and Kentucky (*41*) compared bids received on comparable items and found a large cost difference for many items. It was concluded that a significant savings in materials costs could be realized by purchasing materials on a yearly basis. In cases in which an agency has insufficient storage space for large quantities of material or in which the material has to be delivered to district shops, the bidding could be done with a requirement in the request for bid for the delivery of partial quantities at different locations on different dates.

Agencies should consider a comprehensive review of their purchasing procedures, because significant savings in materials costs can be obtained in a very short time with practically no implementation cost.

Suppliers

Many agencies have realized significant savings in the cost of maintenance materials and equipment by actively promoting competition among suppliers. They do this by maintaining up-to-date lists of suppliers, widely circulating written notices of upcoming requests for bids, and even placing telephone calls to potential bidders to broaden the competition.

For agencies without lists of approved suppliers, sources of material and equipment can be obtained from:

- neighboring agencies,
- state departments of transportation,
- trade associations, and
- professional journals.

The Public Works Journal Corporation publishes an annual *Public Works Manual* (*46*) that includes listings for street and highway suppliers.

DURABILITY

With constrained budgets, the durability of sign materials is a critical issue for public agencies. Signs that provide a longer useful life not only reduce materials costs but also save labor and equipment costs. However, there is a trade-off between materials life expectancy and cost. Most agencies rely on product warranties to develop durability specifications for sign materials.

TABLE 9
RANKING OF SIGN SUPPORT SELECTION FACTORS (BY AGENCY TYPE) (*29*)

Sign Support Selection Factors	State Agencies	Cities	Counties	Other	Total
Availability of Materials for Replacement	3	3	4	3	4
Amount of Maintenance Required	3	1	2	2	3
Initial and Maintenance Costs	2	2	2	4	2
Collision Hazard to Motorists	1	4	1	1	1
Total Number of Respondents	(46)	(35)	(15)	(9)	(105)

To ensure adequate traffic control device material durability many states have established committees to test new materials before they are used in the field.

For example, the Michigan Department of Transportation (MDOT) has established a New Materials Committee. Before any product is used in sign fabrication or placement on state projects, the material must be approved for use by the New Materials Committee. This committee is made up of representatives from the following divisions within MDOT:

- Construction
- Maintenance (this division includes the sign shop)
- Traffic
- Right-of-Way
- Materials and Technology

Any new material proposed for use on state projects is sent to this committee for investigation. If the committee decides to consider the material, it is forwarded to the appropriate division for testing.

In the case of sign materials, the Materials and Technology Division conducts the physical testing of the material to ascertain the material's conformance to state specifications. For sign face material this testing includes:

- Preweathering retro-reflectivity and color conformance testing
- Physical testing
  Liner removal and adhesive bond
  Impact
  Peel
  Solvent resistance
  Water immersion
  Flexibility
  Accelerated weathering
  Shrinkage

The Michigan Department of Transportation specifies in the "Michigan Standard Specifications for Construction" (*47*) the minimum level of retro-reflection that a sign must maintain after a set amount of time in a weatherometer (Figure 37). The level of retro-reflectivity and the time exposure in the weatherometer vary depending on the type of sheeting. The exposure and retro-reflective values for different types of sheeting are as follows:

- *Type II - Enclosed Lens*
  1000 hours of exposure
  50 percent of initial specification retro-reflectivity
- *Type IIa - Enclosed Lens - Extended Life*
  2200 hours of exposure
  50 percent of initial specification retro-reflectivity
- *Type III - Encapsulated Lens*
  2200 hours of exposure
  80 percent of initial specification retro-reflectivity

If the material survives the weatherometer testing, a minimum of 10 signs are placed in the field to determine performance under actual traffic conditions. Periodically throughout the year retro-reflective measurements of the sign faces are taken. After the specified exposure period, if the signs are still within the requirements shown above, the sign face material is recommended to the New Materials Committee for approval. The New Materials Committee reviews the test data, the track record of the company, and comments from the various other departments related to the material. The committee then decides if the new material should be added to the state's approved-product list.

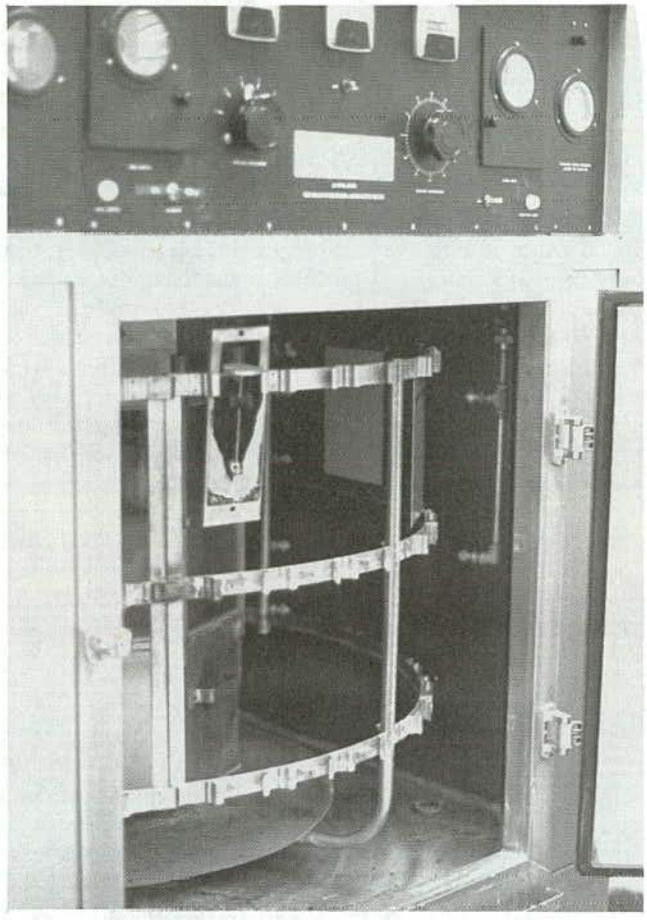


FIGURE 37 Weatherometer.

Continued Testing of Approved Materials

To ensure that a manufacturer maintains the quality of an approved material in production, MDOT conducts tests on the delivered production material on a continuing basis.

This testing is as follows:

- For every production run number, a roll of material is selected at random and the retro-reflectivity and color of the material is tested.
- For every 10 to 15 production run numbers, a roll of material is selected at random and all of the physical tests, except the weatherometer, are conducted.
- Every five years, all tests, including the weatherometer, are conducted on random samples of production material.

In addition, signs in the field that are more than seven years old are randomly sampled to determine the appearance and retro-reflectivity of the sign face material.

By following this testing and approval procedure, MDOT feels it can ensure that all materials placed in the field will meet a prescribed level of durability.

Future Directions in Materials Testing

Because of the high cost for testing materials, a strategy by which materials testing becomes regionalized is developing. It is believed that regional test facilities would minimize costs by reducing the overlap in field and laboratory testing of materials done by the states. A regional, rather than national, approach is favored because not all states experience the same type of road and weather conditions, but states in the same region usually experience similar environmental conditions. A regional approach also allows the states to exercise a greater amount of local control.

The 12 states that make up the Southeastern Association of State Highway and Transportation Officials (SASHTO) have completed a feasibility study of such a regional test facility and have determined that a savings of approximately $400,000 per year (1988) could be realized by the states in the SASHTO region through the implementation of regional testing (*48*).

SPECIFICATIONS

Specifications are precise written descriptions of materials, products, or services that are being purchased. In maintenance-related activities, there are two common types of specifications, general specifications and product specifications.

General specifications relate to contract requirements such as bidding procedures, bond requirements, legal responsibilities, prequalification of bidders, and other factors relating to the contracting process.

Product specifications establish requirements that must be met by the material, product, or service being purchased.

Specifications can have a significant impact on cost over the service life of a material. For example, many agencies are specifying Type III sign face material because of the longer useful life of the material, even though the initial cost is higher.

Sources for obtaining information about various specifications related to sign material are:

- "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," FP-85, Federal Highway Administration (*49*),
- American Association of State Highway and Transportation Officials (AASHTO),
- American Society for Testing and Materials (ASTM),
- Federal Specification LS - 300 C, General Services Administration (*50*), and
- Manufacturers of signing materials.

Types of Specifications

Bid specifications may take different forms, depending on the item purchased. The specification can be a:

- Conventional specification—A specification in which the agency describes the item in detail or by product name.
- Technical specification—A specification in which the agency defines the technical attributes of the material or equipment.
- Performance specification—A specification in which the agency sets forth minimum standards of performance that the material or equipment must provide to perform the task for which it is used.

Most agencies bid sign material based on some form of technical specification. However, considering the ramifications of the FHWA proposal to include minimum retro-reflectivity standards in the MUTCD, some agencies envision that the specifications in the future will become more performance oriented; that is, they will require a minimum level of retro-reflection after a fixed period of field exposure.

Federal and State Specifications

On road and bridge projects using funds from the direct federal-aid program, FHWA requires that the FP-85 specifications (*49*) be used for sign materials. State-administered projects, even those funded with federal funds, are usually governed by state specifications, and many state specifications refer to the FP-85, LS - 300 C (*50*), AASHTO, or ASTM standards for sign materials or restate one of these standards with slight modifications.

Local Specifications

On projects or purchases that do not involve state or federal funds, a local agency may use its own specifications. Because writing detailed specifications is a time-consuming effort, many local agencies simply refer to an applicable state specification in their specifications and require the material to meet or exceed this specification. The phrase "all material shall be in accordance with the state's standard specifications except as noted in the special provisions" is frequently found in local agency specifications. However, most local agencies do not have the equipment or expertise to verify that the material does indeed comply with the specifications. Therefore, they may require the supplier to certify conformance to the specification.

Sources for sign material specifications include:

- Neighboring agencies,
- State departments of transportation,
- Trade associations, manufacturers, and suppliers,
- AASHTO,
- Local chapters of the APWA, Institute of Transportation Engineers (ITE), or IMSA, and
- Other professional organizations.

The AASHTO guide "Specifications for Highway Construction" (*51*) encourages uniformity among state highway agencies by providing standard formats and language for specifications. Agencies that wish to prepare their own standard specifications might find this document helpful.

REFURBISHING

Because of declining financial resources, many agencies refurbish sign faces and posts to reduce materials costs. In the past, most sign faces were chemically stripped from the aluminum back in a cold-soak stripping tank. The stripping solution was an advanced formula paint stripper designed to remove retro-reflective coatings without damaging metal. However, this process is no longer used because of the hazards associated with the handling of the chemicals and the problems in the disposal of the used solutions. Currently, most refurbishing is accomplished by using a mechanical stripper (Figure 38) or by overlaying a new sign face on the old face and blank (Figure 39).

As part of the previously discussed FHWA study of sign maintenance for Arkansas, Florida, and Kentucky (*41*), Arkansas's sign scrap piles were analyzed to determine the amount of material that could be salvaged by stripping or using an overlay technique. Of 614 scrap signs studied, 61 percent (376 signs) could be salvaged by stripping techniques. If an overlay technique was used for salvaging signs, 77 percent (475 signs) of the scrap signs could be reused. The study found that only 22 percent of the signs were unsalvageable and would have to be sold for scrap.

Stripping

The Missouri Highway and Transportation Department (MHTD) estimates that it has saved $3 for every dollar invested in a sign reclamation effort that is able to salvage approximately 75 percent of Missouri's used signs (*52*). The MHTD reclamation process uses a sign blank straightener, a mechanical stripper that uses a sanding procedure, and shearing and punching equipment for resizing the blanks. The costs (in 1977 dollars) for their reclamation system included:

Sign sander with dust collector	$38,000
Straightening machine	27,900
Mechanical shear	26,900
Two drill presses	2,800
Air compressor	2,800
Total Cost	$98,400

FIGURE 38 Mechanical sign face stripper.

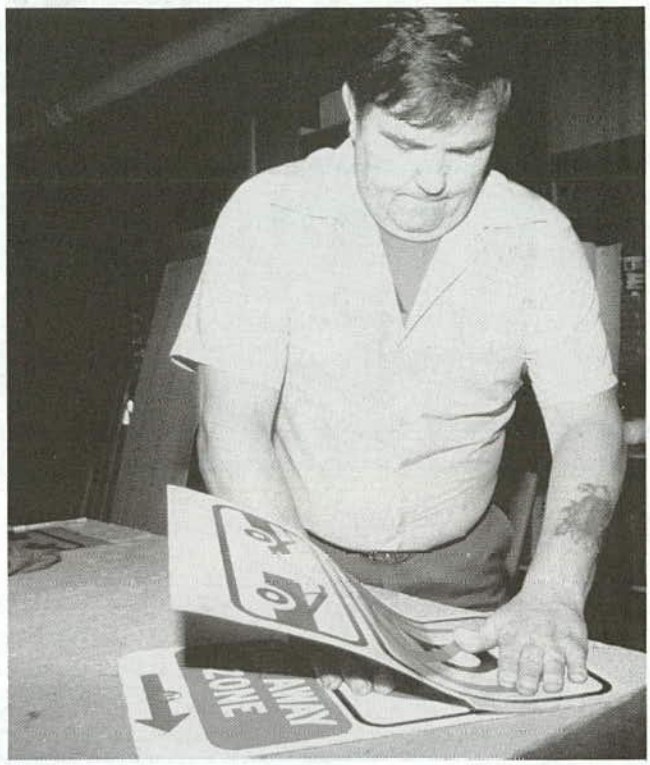


FIGURE 39 New sign face being overlayed over old.

During the first year of operation, it was estimated by MHTD that 139,000 ft^2 of metal signs had been reclaimed by this process. At 1978 prices, the savings amounted to $176,000.

Other agencies, such as the Minnesota Department of Transportation, use a grinding process for removing the retro-reflective material in reclaiming used signs. For those agencies that do not handle the volume of signs to justify the initial cost of a sign reclamation system, there are private contractors that can do the job.

The Pennsylvania Department of Transportation also salvages its damaged aluminum signs. The actual recovery of the sign blanks is done by a contractor, but sign shop labor is used to handle and sort the used signs. In fiscal year 1986–87, 33,770 sign blanks, representing 37 percent of PennDOT's annual sign usage, were salvaged (*53*). An analysis of the PennDOT cost savings per square foot of aluminum salvaged is as follows:

Cost Element	Cost per Square Foot
Salvage	
Sign Shop Labor	$0.07
Vendor Stripping	0.40
Scrap Value of Used Signs	0.37
Total	$0.84
New Sign Blanks	$1.07
Cost Savings	$0.23

Overlay

Another way to refurbish signs is to overlay a new sign face onto a damaged or faded sign face in the field or in the sign shop. This process uses retro-reflective sheeting with a thin, semirigid aluminum backing that has a pressure-sensitive adhesive. The sheeting can be overlaid on old signs by wiping the old sign with a solvent, then positioning and applying the new sheeting onto the old sign. The retro-reflective sheeting material is then pressed into place with a hard rubber roller applicator. In this process, no stripping chemicals are used. Whether the overlay is done on-site or in the sign shop, restoring signs by overlaying retro-reflective sheeting eliminates the cost of purchasing new sign blanks.

Some agencies are using pressure-sensitive overlay material to upgrade large guide signs that are still mounted in place in the field (*54*). Other agencies using the overlay process to reclaim sign blanks are applying the material in the controlled conditions of the sign shop instead of in the field to have better control of the quality of the overlay.

CHAPTER SIX

MAINTENANCE PERSONNEL

Street and highway sign maintenance is more exposed to public scrutiny than almost any other government activity. The millions of signs that have been erected along our highways are viewed by hundreds of millions of motorists on a daily basis. The maintenance workers installing, replacing, or repairing these signs are also observed in their activities. Thus the public has a front-row seat for viewing the performance of maintenance personnel.

Sign maintenance workers are also entrusted with tens of thousands of dollars in equipment. In addition, if they fail to do their jobs properly they may open their agency to the potential for millions of dollars in liability judgments. Therefore, it is important that the agency's workforce be made up of qualified, conscientious employees.

CREW SIZE

The size of the workforce needed to perform sign maintenance is usually related to the number of signs and size of the road system. However, a Transportation Research Board (TRB) survey of maintenance and operation personnel in state agencies found that a trend toward a reduction in permanent staff levels is occurring in many states (*55*).

The TRB survey also found that 38 of the 50 states have special crews devoted strictly to sign maintenance. An additional six states have special crews that both maintain and refurbish the signs. The survey also found from those states reporting that the average sign crew had to maintain signs along 1888 lane miles of road. The range of values for this variable ran from a low of 280 lane miles to a high of 4826 lane miles. The survey defined a lane mile as a 1-mile length of a single driving lane.

At lower levels of government, the maintenance of the 60,000 signs under the jurisdiction of Michigan's OCRC are maintained by eight sign crews. The 8000 signs in the city of Dearborn, Michigan, are maintained by one part-time sign maintenance crew. The 36,000 signs in the city of Grand Rapids, Michigan, are maintained by four one-person sign crews. The 75,000 signs in Toronto, Ontario, are normally maintained by 10 crews. In addition, each agency has additional supervisory and support staff, including superintendents, foremen, sign fabricators, etc.

Most agencies use a two-person crew for sign maintenance activities, although some agencies have one-person crews and other agencies may use three or more people per crew.

For special projects, such as replacing overhead signs that are in high-traffic areas, multiple crews may be used for the replacement of a sign or crews may specialize in only the replacement of overhead mounted signs. For example, the Louisiana Department of Transportation and Development has three special crews for the maintenance of large signs on breakaway posts and trusses and other large signs. The three crews travel statewide, making frequent trips on the Interstate.

WORK FUNCTIONS

Several different skills are required for the maintenance of street and highway signs. Although the job titles and job descriptions may vary from agency to agency, the general work activities and responsibilities remain the same. These general work activities include supervision, sign fabrication, and sign installation.

Typical job functions in a sign maintenance work activity as determined by the TRB survey (*55*) include:

- Sign Supervisor is responsible for the fabrication, installation, and maintenance of traffic signing and for the activities of the maintenance personnel under his or her direction.
- Sign Shop Foreman directs a crew fabricating traffic signs.
- Sign Erection Foreman directs a crew in the activities related to the erection and maintenance of all traffic signs.
- Sign Fabricator specializes in the fabrication of traffic signs.
- Sign Technician operates equipment and supervises laborers for all activities associated with signing for both fabrication and erection.
- Sign Laborer performs a variety of sign maintenance functions such as the installation of new signs, in-field repair of signs that are damaged, and the removal of signs that are no longer needed.

SHIFT WORK

Most agencies perform all scheduled sign work during the day shift. However, in some urban areas a second shift is used to maintain signs in the downtown area. Sign maintenance in the central business district would disrupt traffic flow during daytime hours. All of the overhead signing in a jurisdiction is frequently maintained on an evening shift, when traffic volumes are lower and thus easier to control. For similar reasons, some agencies maintain a second shift to perform maintenance on all signs on urban freeways. A few agencies keep a 24-hr, full-time operation, and others keep a skeleton staff on duty to respond to emergencies. In addition, field inspection of traffic signs to check retro-reflectivity requirements must also be done at night.

Overtime and Staffing Policies

Because overtime maintenance activities are a drain on a maintenance budget, most agencies restrict overtime as much as possi-

ble. Depending on union contracts, civil service rules, day of week, holidays, etc., the compensation for overtime could include straight pay, time-and-a-half, double time, or compensatory time off.

With the intent of providing as safe a road system as possible but still keeping control of overtime, some agencies have developed policies related to the after-hours call-in of sign workers for emergency sign maintenance (Chapter 2). For example, the OCRC in Michigan, in order to reduce unnecessary overtime and eliminate confusion regarding which signs require emergency call-in, has a policy that only the following signs will be replaced during off-hours:

- STOP
- YIELD
- DO NOT ENTER
- WRONG WAY
- KEEP RIGHT
- Railroad Crossing (Crossbuck)
- Turn Sign
- Curve Sign
- Reverse Turn
- Reverse Curve
- Winding Road
- Large Arrow
- Railroad Advance Warning

Some agencies indicate that any red regulatory signs (except parking) or "W1- " yellow warning signs require overtime call-in when reported during off-hours. Other agencies leave it up to the discretion of the foreman or dispatcher to analyze the type of sign and the specific sign's importance based on location and traffic flow to determine if a work crew should be called in. Still others indicate that overtime is not used and all sign maintenance takes place during the day shift.

When overtime is necessary, some agencies maintain an on-call duty roster. They generally rotate the on-call responsibility between staff, either on a daily or weekly basis. Other agencies use a call-in procedure, based on seniority, by which the highest-seniority worker is called first and then workers down the seniority list are called until a complete work crew is found.

The responsibility for obtaining the necessary off-hours staffing varies from agency to agency. Some agencies have an on-call foreman who is responsible for obtaining the necessary staff. In other agencies, a dispatcher is responsible for calling the workers to inform them to report to work. No matter what procedure is used, the workers must be aware of their responsibilities so that the emergency work is completed in a timely fashion.

CATEGORIES OF MAINTENANCE PERSONNEL

Within the sign maintenance function, there are a number of different activities, both in the office/shop or in the field.

One agency's sign department has the following positions:

- Superintendent
- Accounting Clerk
- Foreman
- Skilled Laborer I
- Skilled Laborer II
- Semiskilled Laborer
- Equipment Operator
- Sign Fabricator
- Assistant Sign Fabricator
- Carpenter

Depending on the work rules in the labor contract and the size of the maintenance operation, many agencies have consolidated these positions into fewer job classifications. A small municipal organization may have the following sign maintenance positions:

- Foreman/Sign Fabricator
- Skilled Laborer
- Semiskilled or Unskilled Laborer

Office/Shop Personnel

The need for office/sign shop personnel is dependent on the type of the maintenance organization. When district shops are used, more supervisory and office personnel are generally needed throughout the organization. When the sign maintenance function is consolidated at one location, fewer supervisory and office personnel are necessary.

In most agencies, one person is in overall control of the sign maintenance function. Levels of intermediate supervision may be provided, depending on the size and complexity of the organization.

In larger agencies, an engineer, sometimes called the superintendent or engineer of maintenance, is in overall control. If the agency has a particularly large sign inventory, a clerk is frequently used to manage the paperwork and keep track of and process the work order forms to keep the inventory current. In addition, engineering aides may be employed to investigate complaints, including missing or knocked-down signs, and issue work orders.

The actual sign maintenance is under the direct control of the sign foreman. The foreman will oversee the sign crews' work activities. Depending on union contracts, local policies, and civil service requirements, the foreman may just supervise the work activities but may also become involved in the actual work. Often, the foreman has risen in the organization and is generally familiar with all of the sign maintenance work activities. In some agencies, particularly the smaller agencies, the foreman may also do the sign fabrication. In other agencies, the sign fabricator is a separate shop position.

Field Personnel

In general, a sign crew is composed of two workers, one skilled laborer, sometimes called a sign technician, who is the crew chief, and one semiskilled or unskilled laborer who provides assistance to the crew chief and is under the crew chief's direct supervision. Advancement in the laborer job classification is generally based on union or civil service requirements and promotion is generally from within.

RECRUITMENT AND RETENTION

In many agencies, the recruitment of employees to the sign maintenance department follows the procedures for any public-

employment position. There may be open civil service exams or the direct hiring of employees based on an interview process. Advancement within the organization may be dependent on contract provisions or civil service policies.

Because most sign maintenance activities do not require a high level of technical knowledge, agencies did not indicate any problems in finding workers to fill the sign maintenance positions. However, agencies that used a general laborer job classification system, as opposed to a distinct sign worker job classification, did report higher employee turnover because employees were able to transfer between the sign department and other maintenance departments quite freely. This rapid changeover in personnel frequently results in the need for a continuing training program for sign installation and maintenance for new employees. The agencies that had a specific job classification for sign maintenance worker reported a higher level of retention within the department. Here, the workers became knowledgeable in sign maintenance activities, and there was less need for introductory sign maintenance training sessions and more time for training in other areas and refining job skills.

TRAINING

There are many aspects of training related to traffic sign maintenance. There is the training that establishes the basic knowledge of good sign maintenance procedures, the training related to making the worker operate more safely and efficiently, and the advanced training for sign fabrication, establishment of advisory speeds, etc.

Personnel responsible for sign maintenance will work more efficiently if adequately trained about correct sign installation procedures. In addition, sign maintenance personnel may take more pride in their work if they are aware of the purpose of the sign and what effect it has on driver safety. Also, time and labor cost savings may result if incorrectly fabricated, placed, or installed signs do not have to be redone.

The level of training provided to the sign maintenance workers should broaden as their experience increases.

Entry Level

At a minimum, each new employee should be provided introductory training related to the standards set forth in the MUTCD and the *Traffic Control Devices Handbook* for the placement of traffic control devices. For this purpose, the ITE has developed a Traffic Technician Curriculum on Signs and Markings. The three-part slide/tape series gives an introduction to the various aspects of good signing and provides training related to the proper field placement of signs.

Additionally, training related to the operation of equipment such as post drivers, post pullers, etc. should be provided to ensure that workers use the equipment safely and the signs are properly installed. Also, training should be provided related to driving, using heavy equipment, and working in and around moving traffic. Liability issues should also be addressed so that the sign worker is aware of the implications for the agency that might arise from failure to do the job properly.

TABLE 10
SIGN MAINTENANCE COURSE OUTLINE (*41*)

- I. Evolution of Signing
- II. Signing Process
  - A. Identifying Needs
  - B. Sign Manufacturing
  - C. Sign Placement
    - 1. Locating
    - 2. Erection
- III. Equipment
- IV. Materials
- V. Job Management
  - A. Planning (need)
  - B. Organize
  - C. Direct
  - D. Control
    - 1. Observation
    - 2. Reporting
- VI. Safety
  - A. Equipment
  - B. Personal
- VII. Review
- VIII. Exam

Table 10 provides a suggested training course outline.

The Pennsylvania Department of Transportation has developed a *Sign Foreman's Manual* (*56*) that is used as a basis for training new employees and as a supplement to its traffic standards manual. Appendix C contains a copy of the *Sign Foreman's Manual.*

Continuing Education

As sign maintenance workers gain experience, continuing educational opportunities should be provided to expand their knowledge of good sign maintenance and other work needs. Because of union contract requirements related to overtime, travel time, and costs, however, many agencies find that in-service training is the most practical method of upgrading job skills. Some agencies provide in-service continuing-education training through the purchase of videotapes that are related to the broad aspects of maintenance but that have implications for the sign maintenance worker. These include tapes on the use of acetylene torches, welding, carpentry, lifting and carrying, etc.

Short courses have been developed by IMSA, APWA, sign material manufacturers, and other groups to provide training material related to signing. Seminars and short courses are presented by IMSA sections in conjunction with their section meetings, and the international organization puts on sessions related to signing at its annual convention.

The Michigan section of IMSA in cooperation with the Michigan Office of Highway Safety Planning has developed a three-day training program including a slide/tape and lecture related to signs and pavement markings. This program is designed to give participants information on materials; equipment; and the general techniques and practices of making, installing, and maintaining street and highway signs. The first part of the four-part program begins with an introduction to traffic signs and

pavement markings. The second part covers pavement markings, the third part covers sign fabrication, and the fourth part covers sign installation and maintenance.

A fundamental point in the training process is to keep the material attractive and easy to read. Some state agencies have reprinted portions of the MUTCD to be used as a quick reference by the workers. When possible, pocket-sized summaries could be provided to the maintenance workers for use in the field. The American Traffic Safety Services Association (ATSSA) has developed a pocket-sized *Work Area Traffic Control* guide that sets forth the principles and guidelines for the movement of traffic and the protection of workers in work areas. The city of Milwaukee, Wisconsin, has developed a pocket-sized booklet entitled *Traffic Control for Construction and Maintenance Work.* This booklet contains a summary of traffic control for construction and maintenance work zones oriented toward urban street applications. It contains schematic diagrams of proper signing in work zones on city streets. The Traffic and Safety Division of the New York State Department of Transportation has developed the *Traffic Sign Handbook for Low Volume Rural Roads.* This handbook was developed to cover the majority of traffic situations encountered by agencies responsible for operating and maintaining low-volume rural roads. The APWA has developed the *Tailgate Safety Training Guides,* which help supervisors plan and organize 10-to-15-min safety talks to work crews. The ATSSA has also developed a 15-min videotape with the title "New Directions in Traffic Sign Management," which is aimed at helping local jurisdictions improve their sign maintenance programs through inventory, evaluation, and scheduled replacement.

CERTIFICATION

At the present time, most agencies do not require sign maintenance workers to possess a certification in sign maintenance. An exception is the state of Florida, which requires that any sign maintenance worker be certified by the IMSA certification program.

The IMSA program certifies sign maintenance workers at two levels:

- Traffic Technician I—General knowledge of the maintenance of existing signing and basic sign installation techniques.
- Traffic Technician II—More advanced knowledge of signing, including the warrants for different signs, establishing speed zones, sign manufacturing and fabrication, etc.

CHAPTER SEVEN

MAINTENANCE COSTS AND FUNDING

As discussed in Chapter 1, it is estimated that there are more than 58 million signs along U.S. highways, with an approximate value of more than $6 billion. On an annual basis, it is estimated that more than $250 million is spent on sign maintenance.

The cost to an agency for street and highway sign maintenance depends on a number of factors, including:

- Size of signing system,
- Policies on sign replacement for maintaining minimum retro-reflectorization,
- Type of material used,
- Level of vandalism,
- Severity of weather and other environmental conditions, and
- Personnel costs

NUMBER OF SIGNS IN PLACE

Ross et al. (*29*), in a survey of federal agencies, state highway agencies, turnpike authorities, cities, counties, sign suppliers, and contractors regarding their signpost usage, determined the number of signs placed by various levels of government (Table 11).

Table 12 provides a summary of the causes for sign maintenance work based on an analysis of 36,800 sign replacements in the state of Idaho for the period from January 1981 through June 1988 (unpublished analysis, James Pline, engineering consultant).

SIGN VANDALISM

Sign vandalism costs taxpayers millions of dollars each year and has been reported as a contributing cause in a number of serious traffic accidents (Figure 40). Surveys of state and local agencies indicate that up to 30 percent of all sign repair and replacement is caused by vandalism and an average of 30 percent of a typical sign maintenance budget is used to repair or replace vandalized signs (*57*).

The number of signs replaced as a result of vandalism is difficult to determine because the record-keeping relating to sign vandalism is not comprehensive. Few agencies are able to provide anything but estimates of the vandalism rate. Some agencies report sign knockdowns as sign vandalism; others report only signs that are defaced or stolen.

Another problem in determining accurate replacement numbers for vandalized signs is the type of sign maintenance an agency is doing. Some agencies replace only signs that are knocked down or vandalized. Therefore, the percentage of their work related to sign vandalism is high. Other agencies are in extensive sign-upgrading programs or have a program of regular sign replacement. Therefore, their vandalism-related maintenance rate is much lower.

Another difficulty in comparing vandalism rates involves how the rate is determined. The number of vandalized signs replaced expressed as a percentage of the total number of signs on the roadway can be vastly different when compared with the number of vandalized signs replaced expressed as a percentage of the total number of signs that get some maintenance attention. Some agencies estimate that 10 to 30 percent of their sign maintenance activity is replacing vandalized signs. However, when looking at the total number of signs on the roadway, only 2 to 5 percent of their total system is replaced as a result of vandalism.

Many agencies indicated that some of their vandalism problems are related to a specific type of sign (i.e., street name, STOP, etc.) and, in many cases the same sign is repeatedly vandalized. If this is the case, there are some countermeasures that can reduce this type of vandalism.

Excessive maintenance costs and the potential for serious traffic accidents because of vandalized signs have resulted in the development of a wide range of remedial measures and programs. Most sign vandalism countermeasures fall into one or more of the following categories (*58*):

- Physical Countermeasures include using property identification seals and agency decals on the back of signs (Figure 41), using vandal-resistant sign face material and fasteners, raising the mounting heights of signs, improving the anchoring of posts in the ground, and using a different type of substrate material, such as Lexan or plywood.
- Legal Countermeasures include enacting different types of sign-vandalism laws.
- Educational Programs include education programs targeted at specific age groups that detail the adverse effects of sign vandalism on traffic safety and costs to society.
- Public-Information Campaigns include public-service announcements and sign "amnesty" weeks.

In 1975, the Wisconsin Department of Transportation reported that more than 8,500 highway signs were vandalized on its 11,400 miles of state highway. In addition, at least two fatal accidents were reported to have occurred as a result of vandalized signs (*11*).

In 1976, Wisconsin enacted a law dealing with sign vandalism. The law made possession of a traffic sign illegal and provided for penalties of up to $10,000 and/or imprisonment for up to

TABLE 11
NUMBER OF IN-PLACE SIGNS

Question and Type of Response	All Government Agency Respondents		State Agency Respondents		City and County Agency Respondents	
	Number	Percent	Number	Percent	Number	Percent
Number of All Signs in Place						
Less than 20,000	19	17	0	0	16	30
20,000 to 49,999	16	15	6	12	9	17
50,000 to 99,999	17	15	9	19	6	11
100,000 to 199,000	14	13	7	15	7	13
200,000 or more	21	19	16	33	3	6
No response	24	21	10	21	12	23
Percentage of All Signs of Small Type[a]						
Less than 20%	1	1	0	0	1	2
20% to 40%	0	0	0	0	0	0
40% to 60%	2	2	0	0	0	0
60% to 80%	11	10	10	21	0	0
80% or more	90	81	34	71	50	94
No response	7	5	4	8	2	4
Percentage of Small-Type Signs with Single-Post Support System						
Less than 20%	5	4	1	2	3	5
20% to 40%	0	0	0	0	0	0
40% to 60%	5	5	2	4	1	2
60% to 80%	21	19	17	36	2	4
80% or more	73	66	23	48	45	85
No response	7	6	5	10	2	4
Total Respondents	111	100	48	100	53	100

[a]Signs having panel areas of 50 ft² (4.65 m²) or less are designated as small.

TABLE 12
REASON FOR SIGN MAINTENANCE ACTIVITY

Problem	Percentage
Reflectivity/Delamination	30
Size, Legend or MUTCD Changes	31
Vandalism	26
Accident/Weather	13
Total	100

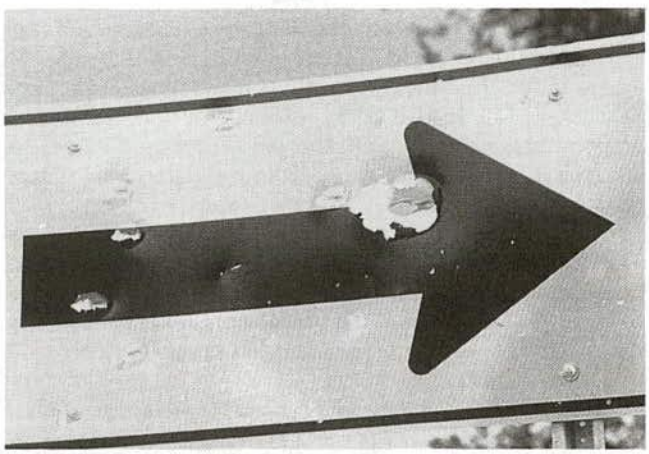


FIGURE 40 Vandalized sign.

FIGURE 41 Property identification and warning stickers.

two years if an act of sign vandalism resulted in death. In conjunction with the passage of the law, Wisconsin conducted a statewide public-information and education program illustrating the costs and consequences of sign vandalism.

Since the 1976 program began, the sign-vandalism problem in Wisconsin has shown significant improvement. An analysis of vandalism incidents for the period from 1977 to 1982 indicates that vandalism incidents have been reduced by 68 percent from the 1975 levels.

ESTIMATES OF SIGN MAINTENANCE CREW PRODUCTIVITY

It is estimated that the annual productive time for a maintenance worker amounts to approximately 1630 hours. This is based on a 40-hr workweek, subtracting three weeks for vacation, two weeks for sick leave, one week for training, 13 holidays, and 30 min/day for breaks. At varying levels of productivity, one sign crew could maintain the following number of signs:

Productivity (Minutes per sign)	Signs Maintained Annually
20	4890
30	3260
45	2168
60	1630

It is important to note that the travel time between sign maintenance locations needs to be included in determining the length of service time per sign. Also, this estimate does not account for startup time at the beginning of the day or shutdown time at the end of the day or for lower productivity during inclement weather.

By determining the percentage of the total signing system maintained each year, however, an agency could estimate the number of signs crews required to adequately perform the sign maintenance activity.

Example

100,000 signs in total system.
Proposed annual sign replacement program of 15,000 signs.
Average time to replace a sign is 60 min including travel time.

Thus:

For 15,000 signs/year, with 1,630 signs replaced/year/crew (at 60 min/sign), 9.2 crews would be required (i.e., 15,000 signs/year ÷ 1,630 signs/year/crew = 9.2 crews).

Therefore, either 9 or 10 sign crews would be required to maintain 15,000 signs/year.

This process could also be used to determine the number of signs that could be maintained with a given number of sign crews.

ESTIMATES OF MAINTENANCE EXPENDITURES

Ross et al. (*29*) collected data summarized in Table 13 on the total annual maintenance expenditure and the percentage of annual maintenance expenditure devoted to signing. Approximately 75 percent of city and county respondents (24 of 32) indicated that they spent more than 20 percent of their annual maintenance budget for traffic signing, whereas approximately the same percentage of state agencies indicated that they spent less than 20 percent of their maintenance budget for signing.

Maintenance Costs

Table 14 provides a sign maintenance budget for a typical suburban community with a population of approximately 74,000, road milage of approximately 250 miles, and a sign system of approximately 9,500 signs maintained by three employees.

Table 15 provides a sign maintenance budget for a small central city with a population of approximately 80,000, road milage of approximately 300 miles, and a sign system of approximately 15,000 signs that is maintained by nine employees.

Table 16 provides a sign maintenance budget for a county road commission in a suburban area with a population of approximately 1,000,000, road milage of approximately 2,700 miles, and a sign system of 65,000 signs maintained by 45 employees.

As can be expected, because of the varying labor rates, the cost of sign repair varies from agency to agency. In 1985, Montgomery County, Maryland, commissioned a consultant study (*59*) to determine fabrication and installation costs for traffic signs. The sign fabrication costs, as defined by the consultant, include the cost of labor and materials to fabricate. The sign installation costs include expenditures for sign crew personnel,

TABLE 13
MAINTENANCE EXPENDITURES

Question and Type of Response	All Government Agency Respondents		State Agency Respondents		City and County Agency Respondents	
	No.	%	No.	%	No.	%
Total Annual Maintenance Expenditure[a]						
Less than $1,000,000	33	30	3	6	28	53
$1,000,000 to $9,999,999	20	18	9	19	8	15
$10,000,000 to $49,000,000	19	17	17	35	0	0
$50,000,000 or more	11	10	10	21	0	0
No response	28	25	9	19	17	32
Percentage of Annual Maintenance Expenditure Devoted to Signs						
Less than 20%	44	40	29	60	8	16
20% to 40%	22	20	7	15	15	28
40% to 60%	6	5	1	2	5	9
60% to 80%	3	3	1	2	2	4
80% or more	3	3	0	0	2	4
No response	33	30	10	21	21	39
Percentage of Annual Maintenance Expenditure Devoted to Small Signs[b]						
Less than 20%	42	38	27	57	9	17
20% to 40%	17	15	3	6	14	26
40% to 60%	2	2	1	2	6	11
60% to 80%	2	2	0	0	1	2
80% or more	15	14	3	6	11	21
No response	33	30	14	29	12	23
Total Respondents	111	100	48	100	53	100

[a]Expenditures for the immediate past fiscal year.
[b]Signs having panel areas of 50 ft² (4.65 m²) or less.

vehicles, posts, and miscellaneous material. The repair or replacement of signs also includes the cost of post removal and replacement. It excludes overhead and transportation costs. Table 17 summarizes the sign fabrication costs and Table 18 summarizes the sign installation costs.

Funding

The major sources of funding for governmental agencies include income taxes, property taxes, sales taxes, and use taxes. For all practical purposes, these revenue sources are largely fixed. Agencies must try to balance increasing needs with these fixed revenue sources. Therefore, whenever possible, alternative methods of financing should be used to expand the sign maintenance funding base.

For example, the state of Minnesota recently funded sign upgrade projects for local agencies in Minnesota using 90 percent federal Hazard Elimination Safety (HES) monies (*60*). The program consisted of three parts:

- Each county inventoried the non-federal-aid roads to determine the signing needs.
- A bid for materials was obtained.
- The signs were installed.

As part of the agreement, the counties were also required to bring the federal-aid roads into compliance as a program contribution. This ensured that both federal-aid and non-federal-aid roads would have the same quality of signing.

The actual costs of the projects indicated that the total cost per mile was approximately $140.

Table 19 shows how the project costs have been spent and Table 20 shows the breakdown by type of signing.

TABLE 14
SUBURBAN CITY SIGN MAINTENANCE BUDGET (1987)[a]

Item	Amount
Salaries and Wages	$44,000
Social Security	3,000
Workman Compensation & Unemployment	1,000
Sick Pay	2,000
Hospitalization & Life Insurance	4,000
Vacation	4,000
Retirement	6,000
Material & Supplies	35,000
Contracting Services	1,000
Other Insurance	1,000
Equipment Rental	25,000
Total	$101,000

[a]Some foreman time included but not superintendent time.

TABLE 15
SMALL CENTRAL CITY SIGN MAINTENANCE BUDGET (1987)[a]

Item	Amount
Salaries and Wages	$116,000
Materials and Supplies	76,000
Contractua	I2,000
Vehicle Expenses	190,000
Shop Renta	I20,000
Equipment Rental	1,000
Total	$405,000

[a]Includes signing, pavement markings, and guardrail installation. Includes full-time foreman/sign fabricator but not superintendent.

TABLE 16
COUNTY ROAD COMMISSION SIGN MAINTENANCE BUDGET (1987)[a]

Item	Amount
Salaries and Wages	$1,500,000
Materials	320,000
Contractual	35,000
Total	$1,855,000

[a]Includes superintendent, clerk, and three foremen.

TABLE 17
SIGN FABRICATION COSTS (1985) MONTGOMERY COUNTY, MARYLAND

Work Item	Workload	Costs ($) Direct	Overhead	Total	Unit
SIGN FABRICATION	No. of Signs				
Stop/Yield Series	570	10,815	399	11,614	20.37
Speed Series	94	2,847	230	3,077	32.74
Movement Series	447	23,733	1,095	24,828	55.54
Parking Series	1,675	20,664	2,390	23,594	14.09
Miscellaneous	1,799	36,954	4,406	41,360	22.99
Bus Stop	3,435	73,417	12,018	85,435	24.87
Warning	511	27,130	1,251	28,381	55.54
Reflectors/Object Markers	542	4,862	569	5,431	10.02
Metro Street Name	142	7,101	497	7,598	53.51
Extruded Street Name	1,665	36,685	5,825	42,510	25.53

TABLE 18
SIGN INSTALLATION COSTS (1985) MONTGOMERY COUNTY MARYLAND

Work Item	Workload	Costs ($) Direct	Overhead	Total	Unit
SIGN INSTALLATION	No. of Signs				
Install Traffic Signs	5,118	86,923	10,261	97,184	18.99
Install Street Signs	211	2,600	317	2,917	13.83
Repair/Replace Traffic Signs	3,520	71,156	8,821	91,977	22.72
Repair/Replace Street Signs	1,867	27,531	3,509	31,040	16.63

TABLE 19
ANALYSIS OF HES PROJECT COSTS

Expense	Percent of Total Expense
Signs	32.1
Posts	26.3
Installation	27.3
Removal	4.4
Inventory	9.9

TABLE 20
TYPE OF SIGNING IN HES PROJECT

Sign Type	Percent of Total System
Warning	54.0
Regulatory	27.0
Delineator/ Object Markers	19.0

CHAPTER EIGHT

MANAGEMENT CONTROL

Good management is needed to plan, control, and evaluate the signing program. With typical sign systems involving hundreds of miles of roadway, thousands of signs, numerous employees, and expenditures of hundreds of thousands of dollars, control of the entire process is necessary to ensure the success of the program.

MAINTENANCE POLICIES

It is important that management establish policies that set levels of service for signing; establish policies related to response times for emergency maintenance for various types of signs; and establish personnel practices and work procedures for carrying out the maintenance program. It is through the setting of policies and procedures that management is able to establish control and organize priorities for maintenance activities.

Policies and procedures are needed in a typical public agency's sign maintenance program because funding is generally inadequate to meet the signing needs. In addition, during times of economic decline it is easy for policy makers, however false the economy may be, to reduce sign maintenance funding levels. Through the establishment of suitable policies and procedures, an agency can respond to the changing economic climate in planning and performing sign maintenance activities.

The major factor that should be considered in establishing policies and setting priorities is the safety of the motoring public. Street and highway signs should be maintained to a point at which the motoring public is not endangered while traveling on streets and highways.

Level of Service for Maintenance

An important policy consideration that affects sign maintenance program budgets and procedures is maintenance level of service. A maintenance level of service defines a threshold deficiency level at which maintenance should take place. That is, when should a sign be replaced because it is no longer serving its intended function? The level of service that an agency selects affects decisions on where, when, and how much maintenance is required. For example, if the agency policy is that all signs must be legible to the motorist by day or night, then the procedures for obtaining this level of service might be:

- Program daytime and nighttime inspection of signs,
- Clean or replace illegible signs as soon as possible,
- Replace damaged regulatory and certain warning signs immediately, and
- Replace other damaged signs as soon as possible.

COMPONENTS OF A MAINTENANCE MANAGEMENT SYSTEM

The APWA outlined the basic components of a maintenance management system as follows (*27*):

> The development of performance standards which for principal maintenance activities, describe the procedures to be followed, the [personnel], equipment and materials to be used and the rate of production to be achieved.
> - The determination of workloads through the measurement of quantities of [signing] on the street. . .and the evaluation of the external influences (weather, [vandalism], etc.) acting upon [the signing] which create a need for maintenance.
> - The budgeting. . .of resources. . .to meet the predicted workload in terms of specific programs (activities, quantities,. . .) to be achieved.
> - The scheduling of activities within the budgeted program to utilize resources in the most efficient manner, to reduce fluctuations in [personnel] and equipment requirements to a minimum, and to keep the street system operating in a safe, convenient manner.
> - The establishment of a management information system which provides the basic knowledge required by [management] for routine decisions and the. . .reports required by management for control and improvement of the program.

Other aspects of management control in a sign maintenance program relate to the control of the components of the maintenance process, that is, administrative, technical, material, and fiscal.

Administrative Control

Administrative control relates to the management of the sign maintenance activity through productivity standards, work program computation, and record-keeping.

Productivity Standards

Productivity standards (*25*) are "a formally established criterion for a specific activity which: (a) outlines the work involved; (b) describes work methods and composition of efficient crews; and (c) lists the expected accomplishments or productivity rate."

The establishment of realistic productivity standards for sign maintenance is one of the more controversial and difficult aspects of establishing a maintenance program. However, any management system should include procedures to determine if work crews are meeting planned work targets. With productivity standards, management is better able to allocate resources and isolate nonproductive activities for corrections. The corrective action does not necessarily mean punitive action; it may be work reassignments, adjustment of performance standards, or provision of special equipment or training for the crews.

The APWA has developed the framework for performance evaluation through the publication *Highway Maintenance Performance Specifications.* The performance specification for sign maintenance is shown in Figure 42. These performance specifications are used to describe each identifiable activity in the maintenance program. They are designed to show the work needed (activity), what is done (description), why (purpose), what is used (labor, equipment, and materials), how work is done (procedure), and the rate at which the work is done (productivity).

Jackson County, Oregon, has developed and implemented a performance standard for its sign maintenance activities. Figure 43 is a copy of the sign installation/replacement standard and Figure 44 is a copy of the sign fabrication standard. In conjunction with the adoption of the performance standards, Jackson County developed a computerized maintenance management system. This system allows it to project work activities and costs and compare them to actual output and expenditures.

Work Program Computation

One of the important elements in the management control of the sign maintenance function is the development of a realistic annual work program. This work program should be based on the level of service that the agency determined is appropriate for its maintenance activity. From this level of service the quantity of work for each activity can be determined, based on the sign inventory or historical records. All work activities combined together represent the workload.

The APWA describes a method in which the annual work program is determined by multiplying the quantity of individual work activities by the corresponding "planning value" for that activitiy. Sample planning values for sign maintenance are shown in Table 21.

To see how the values in Table 21 are used, as an example assume that 3000 signs need to be cleaned annually within a jurisdiction. For sign cleaning, the planning value is 2 times per year $\times$ 3000 signs = 6000 signs per year. This 6000 signs cleaned per year represents the annual work units for this activity.

From this, the personnel requirements and materials needed to perform the work can be determined. The number of work units for each activity, together with the productivity standards, provide the basis for computing the labor, equipment, and materials.

Continuing with the sign cleaning example, the 6000 work units $\div$ the daily production of 30 signs cleaned per day per crew = 200 crew days of work.

Assuming two two-person crews with one pickup truck and one power cleaner for each crew to perform the work, the resource requirements would be:

200 crew days of work per year $\div$ 2 crews = 100 crew days of work per year

100 crew days of work per year $\times$ 2 people per crew $\times$ 2 crews = 400 person days of work per year

100 crew days of work per year $\times$ 1 pickup truck per crew $\times$ 2 crews = 200 days of pickup truck usage per year

100 crew days of work per year $\times$ 1 power cleaner per crew $\times$ 2 crews = 200 days of power cleaner usage per year
No materials are needed except cleaning solution

Using labor rates, equipment rates, material unit costs, etc., the total maintenance costs for this activity can be determined for the budget.

Figure 45 is a copy of a monthly work progress report from Jackson County, Oregon, generated from its computerized maintenance management system that details actual versus projected work activities.

Record-Keeping

Through a comprehensive record-keeping system, an agency can document:

- The work accomplished by the work crews.
- Compliance with specifications.
- Historical record of work at a location in order to settle disputes with a contractor or in a liability case.

The record-keeping system can include a work order form for recording sign maintenance activities and equipment use and a daily field diary kept by the foreman or inspector detailing the inspections.

Technical Control

On a daily basis, management makes technical decisions that have a direct impact on the cost of the maintenance activities.

Service Life of Material and Equipment Considerations

Characteristics that should be considered when selecting a product for signal systems were described by Cimento (*61*) in 1980.

Three of these characteristics can be adapted for sign maintenance as follows:

- Reliability is a function of the performance of the material. It describes the ability of the equipment or material to maintain its functional integrity and continue to perform without failure or degradation.
- Maintainability refers to equipment or materials that require only simple maintenance procedures.
- Damage Resistance is the material's or equipment's ability to avoid breakdown from causes not related to design; examples

Highway Maintenance Performance Standard

Activity	Date	No.
SIGN MAINTENANCE	Approved	

Description

The cleaning, repairing and replacement of traffic signs.

Purpose

The purpose of this maintenance activity is to provide the traveling public with clearly visible traffic signs during daylight and night time hours.

Work Unit	Productivity
Each	

Personnel	Equipment	Materials
1–Traffic Tech 1–Qualified Operator 2–Laborers	1–Pickup - (Sign body) 1–Sign-Washer Truck*	Household Detergent* Kerosene* Sign Paint* Signs* Posts* Hardware*
		Hand Tools
		Wrenches Brush Post Driver

*Include as Required

Procedure

1. Initiate proper traffic control safety procedures at jobsite.
2. Spray sign, back and front, with cleaning solution, scrub with soft bristle brush, and rinse with clear water. If bituminous material is on sign that does not have acrylic reflectors, wipe sign with cloth saturated with kerosene, then wash.
3. Any obstructions to a clear view of signs by motorist, such as brush or tree limbs, should be removed.
4. Repair minor damage such as small deformations or stone marks which do not impair legibility. Where needed, spot paint with matching color.
5. Straighten bent posts where possible.
6. Where damage to sign and/or post is extensive, replace and take damaged sign/post back to sign shop for repair or disposal.
7. Where sign support is of the breakaway type, check torque on all bolts as described in Paragraph 8.02G of PART 5.
8. Load all equipment and work area traffic control devices and move to next jobsite.

Traffic Control

Washing

Repairing

Clearing

Move

FIGURE 42 Sign maintenance performance standard.

PERFORMANCE STANDARD

JACKSON COUNTY
DEPARTMENT OF PUBLIC WORKS
WORK MANAGEMENT SYSTEM

ACTIVITY Sign Installation/Replacement **NO.** LR4300

DESCRIPTION & PURPOSE
Repairing and installing signs to restore adequate traffic control.

PERFORMANCE CRITERIA By service request as prioritized, "STOP" signs within 4 hours, warning and regulatory signs within 12 hours, all other replaced within 4 days. Location, installation, and types to be placed are regulated by MUTCD. All roads should be scheduled for inspection with deficient signs noted and scheduled for maintenance.

SCHEDULING AUTHORITY Traffic Control Supervisor or above

TYPICAL DAILY CREW NEEDS

LABOR
1-3 - Persons (2 persons at 1/3 time)

EQUIPMENT
2 - Pickups (equipped with sign, post rack, and winch) (1 pickup at 1/3 time)
Hand Tools as Required

MATERIALS
Signs
Posts
Miscellaneous Attaching Hardware

STANDARD WORK METHOD

1. Place safety devices.
2. Dig hole using suitable tools.
3. Assemble sign and post using appropriate hardware.
4. Install sign according to standards as provided in MUTCD; height, distance from centerline, distance from hazard.
5. Log addition or change to CH2M Hill sign inventory; type, location, by Federal MUTCD code.
6. Pick up safety devices and move to next service location.

STANDARD ACCOMPLISHMENT AND RESULTS

8 signs installed per 10 hour day.
6-7 signs installed per 8 hour day.

NOTES
Follow the assigned route for scheduled replacement subject to service calls or priority calls. Vandalism accounts for approximately 70% of this required activity.

APPROVED BY Douglas L. Crandall **DATE** May 19, 1982

FIGURE 43 Sign installation/replacement performance standard.

PERFORMANCE STANDARD

JACKSON COUNTY
DEPARTMENT OF PUBLIC WORKS
WORK MANAGEMENT SYSTEM

ACTIVITY Sign Fabrication **NO.** LR4400

DESCRIPTION & PURPOSE
Fabricating various types of roadway signs to provide directions, warnings and regulatory information to motorists and pedestrians.

PERFORMANCE CRITERIA Maintain adequate sign stocks to handle scheduled maintenance and service request. Fabricate signs and devices conforming to MUTCD as well as signs for other entities. Fabricate signs only when required due to special conditions regarding type, hazard situation, or fabrication being the most economical means to acquire necessary signs.

SCHEDULING AUTHORITY Traffic Control Supervisor or above

TYPICAL DAILY CREW NEEDS

LABOR
1 - Sign Maker
1-2 - Helpers (1/8 time)

EQUIPMENT
Misc. Sign Maker Tools
1 - Vacuum Heat Applicator
1 - Table Saw
1 - Sander
1 - Router
1 - Paint Equipment
1 - Silk Screen Equipment

MATERIALS
Sign Blanks, Metal or Wood
Paint
Ink
Sheeting Material; Faces, Letters, Borders

STANDARD WORK METHOD

1. Determine from inventories and needs type of MUTCD sign that is required.
2. Accumulate work needs as much as possible to batch type operation for efficient use ob labor and equipment.
3. Secure necessary materials.
4. Lay out sign using appropriate sign fabrication techniques; silk screening, painting, sheeting, lettering, etc.
5. Complete fabrication process and store sign in labeled rack.
6. Clean tools and work area.

STANDARD ACCOMPLISHMENT AND RESULTS

Report total labor hours of sign fabrication.

NOTES
Help required generally when vandalism depletes sign stocks rapidly or fabricating of large or unwieldly signs is required.

Rev. 12-3-85

APPROVED BY [signature] **DATE** May 19, 1986

FIGURE 44 Sign fabrication performance standard.

TABLE 21
PLANNING VALUES FOR SIGN MAINTENANCE

Activity	Planning Value	Unit of Measurement
Sign Cleaning	2 times/year	Each
Straightening	As directed	Each
Legend Repairs	As directed	Each
Sign Face Replace	As directed	Sq Yd
Sign Post Replace	As directed	Each

are resistance to extreme weather, vandalism, or mishandling by workers.

When making decisions related to the purchase of material or equipment, an agency should consider the service life of the product. In many cases, a slightly larger initial investment can be more than offset in reduced operating and maintenance expenses. In addition, the low-bid item may not be as reliable or may require frequent maintenance or special equipment.

An example of this in the sign maintenance process is the decision to purchase higher-cost material rather than a lower-priced product. Many agencies decide to purchase higher-cost sign sheeting because they feel the reliability and maintainability of the product are better than for a lower-priced product. A study by the city of Milwaukee, Wisconsin (*62*), showed that high-performance sheeting resulted in annual savings of 9 percent for a STOP sign, based on materials costs and average total product costs (labor, fabrication, installation, etc.). Savings for other types of signs ranged from 8 to 16 percent.

Procurement Specifications

Proper procurement specifications can significantly reduce costs over the service life of the material or equipment. Given the tight budgets under which agencies are required to operate, the durability of equipment and material is a critical issue. An agency can reduce its maintenance activities and thus its costs by developing specifications that require products to be reliable, easy to maintain, and damage resistant.

To ensure compliance, the agency should also have stringent acceptance testing of the product before purchasing large quantities. Chapter 5 provides an example of such acceptance testing. The Michigan Department of Transportation's New Materials Committee conducts extensive physical testing before a sign material is accepted for installation on the state road system.

The city of Milwaukee, Wisconsin, as a result of past experience with a material that lost its retro-reflection within a year, has established a policy of prequalifying material from companies that want to sell sheeting to the city (*63*). The city places samples of the product on a south-facing weathering deck for a period of one year to test the material's ability to withstand weathering (Figure 46).

Also important is the ongoing testing of equipment and material to ensure that the manufacturer maintains the quality of the approved product in production.

Cost-Saving Strategies

There are many cost-saving strategies that can be used in a sign maintenance program:

- Purchasing jointly or tying in to the bids of larger agencies to obtain lower prices as a result of the larger bid quantities.
- Increasing the circulation of bid notices and aggressively widening competition for materials and equipment.
- Projecting materials and equipment needs so that the purchasing can be done on a yearly basis.
- Using overlay material to upgrade the sign face.
- Refurbishing sign blanks, thereby reducing the quantity of sign blank material purchased.
- Removing unnecessary signs and mounting needed signs on nearby signposts or utility poles.
- Consolidating the sign fabrication process into a central shop instead of district shops.
- Contracting certain maintenance activities, such as the installation of new signing on construction projects.
- Using specifications and accepted product listings developed by the state to reduce the likelihood of obtaining material or equipment that does not comply with specifications.

To improve the efficiency and cost of the state sign shop, PennDOT in 1986 commissioned a study of the management practices of the sign shop (*53*). As a result of this study, the state was able to institute a number of recommendations that it expects will substantially improve the cost, capacity, and service effectiveness of the sign shop.

The study took two approaches to improving the sign shop operation: Management techniques were used to better manage the sign manufacture, distribution, and inventory; and specialized sign manufacturing equipment was used to increase productivity through computerization, robotics, and other techniques. Some of the recommendations include:

- On-line computer entry of sign orders to the sign shop.

PWWM620R

1986-87 WORK PROGRESS REPORT-SUMMARY
JACKSON COUNTY PUBLIC WORKS DEPARTMENT
JUNE

7/10/87
14:57:37

ACTIVITY NO	DESCRIPTION	UNIT	OUTPUT PLAN	OUTPUT ACTUAL	COST PLAN	COST ACTUAL	LABOR DAYS PLAN	LABOR DAYS ACTUAL	HRS/UNITS PLAN	HRS/UNITS ACT	ADP PLAN	ADP ACTUAL	20-DIFF O	C	L	H
LR0100	GRADING	-MILES GRADED	1112	761	245272	226609	888	693	7.2	8.2	2.4	1.6	*		*	
LR0200	GRAVELLING	-CU/YD PLACED	21766	29559	331036	390981	511	778	.2	.2	110.6	82.4	*		*	
LR0300	CRACK SEALING	-POUNDS PLACED	30240	13935	30164	24807	116	126		.1	1700.0	733.4	*			*
LR0400	SHOULDERING	-SHOULDER MI	556	809	378759	394684	673	1077	11.1	12.0	4.1	3.2	*		*	
LR0500	SWEEPING	-LANE MILES	886	1874	131980	55066	194	142	2.0	.7	1.8	11.1	*	*	*	*
LR0600	COLD MIX PATCHI	-CU/YD PLACED	296	121	150753	61178	657	253	19.5	18.8	.9	.9	*	*	*	
LR0700	ROCK AND OIL PA	-CU/YD PLACED	1367	1029	300815	177431	820	691	5.4	6.0	15.0	11.8	*	*		
LR0800	BLADE PATCHING	-TONS ASPHALT	10124	7893	450706	380592	777	666	.8	.8	112.0	89.7	*			
LR0900	DIGOUT REPAIRS	-CUBIC YARDS	650	253	22338	8400	61	25	.9	.9	24.0	15.8	*	*		
LR1000	CHIP SEALING	-M/SQ.YARDS	857	742	641382	438096	794	711	9.0	8.6	15.5	13.5		*		
LR1100	OTHER ROAD SURF	-LABOR HOURS	2218	2507	50907	85835	258	280	1.0	1.0	19.8	6.8		*		
LR1200	HOT MIX PAVING	-TONS - MIX		2069		75982		120		.5		188.1	*	*	*	*
LR1300	MECHANICAL PATC	-TONS - MIX	177	2351	13842	166526	30	371	1.7	1.4	30.0	31.3	*	*	*	
LR1400	MINOR IMPROVEME	-LABOR HOURS	606	3987	72171	205277	76	443	1.1	1.0	28.0	22.1	*	*	*	
LR2000	GRADER DITCHING	-DITCH MILES	28	58	43153	65840	118	186	38.2	29.0	.7	.5	*	*	*	*
LR2100	GRADALL DITCHIN	-DITCH MILES	203	95	334174	180763	1232	653	54.6	61.8	.7	.4	*	*	*	
LR2200	MECHANICAL CULV	-NO. CLEANED	1601	2157	66815	72832	293	246	1.6	1.0	9.0	20.8	*			*
LR2300	MANUAL CULVERT	-NO. CLEANED	4079	7313	36527	22706	229	136	.5	.2	28.1	39.8	*	*	*	*
LR2400	CLEAN STORM DRA	-LABOR HOURS	124	394	9122	35269	16	48	1.0	1.1	16.0	9.9	*	*	*	
LR2500	INSTALLING CULV	-LABOR HOURS	950	1673	40709	66671	123	185	1.2	1.0	36.0	17.2	*	*	*	
LR2600	PLACING RIPRAP	-CUBIC YARDS	855	944	23375	30810	95	96	1.0	.9	40.5	16.8		*		
LR2700	OTHER DRAINAGE	-LABOR HOURS	672	353	15335	11614	80	38	1.1	1.0	14.4	10.1	*	*	*	
LR2800	MAJOR CHANNEL W	-LABOR HOURS		5		4044		10		18.4		.7	*	*	*	*
LR3000	MANUAL BRUSH CU	-LABOR HOURS	3641	9286	81253	222140	424	1073	1.0	1.0	25.2	16.4	*	*	*	
LR3100	MECHANICAL BRUS	-LABOR HOURS	1080	566	29489	17402	123	63	1.0	1.0	8.8	7.6	*	*	*	
LR3200	ROADSIDE HERBIC	-ACRE/TREATED			96743	128483	197	343	1.1	2.0	8.6	7.8		*	*	*
LR3300	NOXIOUS WEED CO	-ACRE/TREAT			[illegible]	11602	134	53	6.7	[illegible]					*	*
[illegible]	OTHER VEGETATIO	-LAB				[illegible]		50								

FIGURE 45 Monthly work progress report.

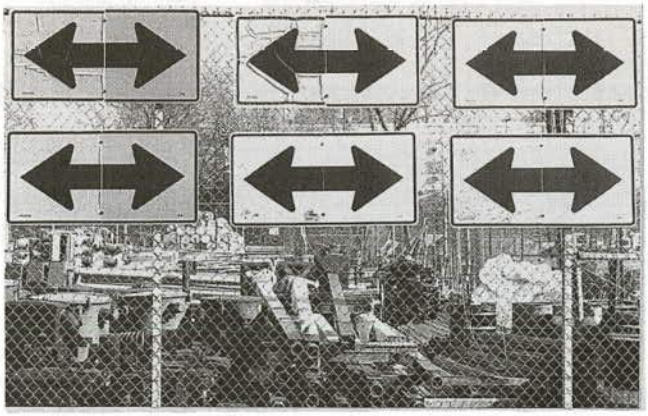


FIGURE 46 Weathering tests of sign material.

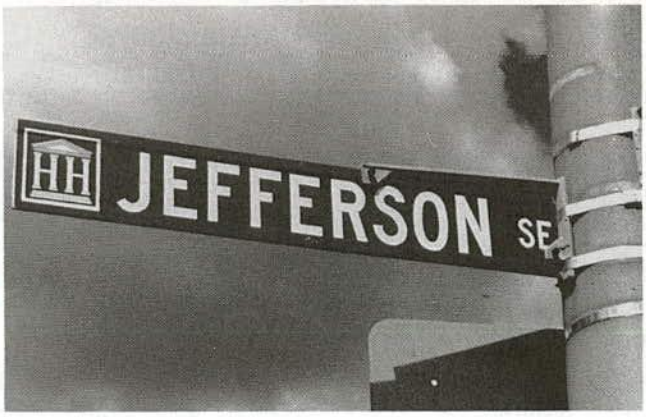


FIGURE 47 Sign mounted on utility pole with SIGNFIX.

- A uniform method of reporting sign withdrawals from sign inventories.
- More accurate reporting of sign shop costs and better monitoring of productivity.
- Use of robotics in the sign manufacturing process to align and palletize signs.
- Use of pressure-sensitive legends to replace cut legend signs.
- Use of extruded panels instead of flat sheet aluminum for large signs.
- New sign shop layout to provide more efficient sign production.

It is estimated that the implementation of the proposed changes will cost approximately $600,000 for capital items. There will be 23 percent less staff making 21 percent more signs in 31 percent less space. In addition, the productivity of sign crews will increase by 7.5 percent. At 1987 labor rates, the estimated savings would amount to $122,500 per year. Thus, the overall payback time is estimated to be approximately five years.

Installation Techniques to Reduce and Expedite Maintenance

The county of Du Page, Illinois, decreased by 30 percent the number of knocked down signs by relocating signs further away from the edge of pavement or in front of utility poles whenever possible (*64*).

Monroe County, New York, developed a new method of manufacturing street name signs (*65*). Its process uses paper letters placed on sign blanks that have white retro-reflective material applied to both sides. These letters become the dropout for the silk screen, which prints the green background with transparent ink, leaving the letters and border showing through in white. This technique has increased productivity from 50 signs per day to 250 signs per day and reduced costs from $3.20 per side to $0.22 per side. The county also estimates that the reverse-screening process has added five more years to the life of the sign. The county also developed a vandalproof bracket for mounting the street name signs that has saved the county approximately $36,000.

The Owens-Corning Corporation conducted a finite-element analysis (FEA) to determine the proper number and location of attachments to signs to minimize stresses within the sign (*66*). Through laboratory testing, FEA, and field evaluation, the research resulted in the publication in a mounting manual of a series of performance-related recommendations aimed at increasing the life spans of all signs.

The city of Grand Rapids, Michigan, uses a product called "SIGNFIX" to mount signs on utility poles when possible. The city has found that this mounting location reduces installation costs, knockdowns, and vandalism (Figure 47).

Other techniques to reduce maintenance costs through a reduction in vandalism include:

- Use vandal-resistant hardware to prevent the sign from being easily loosened and carried away (Figure 48).
- Peen the bolt threads and nut to eliminate the ability to remove it with normal hand tools.
- Brand or attach a sticker to the sign to identify the agency that owns the sign (Figure 49).
- Place warning labels on the back, warning of a penalty for theft, vandalism, etc. (Figure 50).

FIGURE 48 Vandal-resistant fasteners.

FIGURE 49 Property identification.

- Place signs that must be close to the roadway at the maximum practical mounting height.
- Use extruded aluminum sign blanks for street name signs to increase the resistance to bending.
- Use materials that continue to perform the sign function, even though marred. Plywood substrate, for instance, reduces the effect of bullet damage.

Service Histories to Identify High-Maintenance Locations

Many agencies that have computerized sign inventories are using the inventory to maintain a service history of the signs. This helps to identify locations where there is an inordinate amount of sign maintenance activity. This maintenance activity could be related to vandalism, knockdowns, etc. By identifying locations of high-frequency maintenance, countermeasures can be developed to ameliorate the problem. For instance, if a sign is frequently stolen, antivandal nuts could be used. If a sign is frequently knocked down, it may be an indication that there may be something wrong with the placement of the sign at the location and it should be checked.

Even those agencies that have a card file inventory system can use the file to identify service histories. The identification process, however, would have to be done at the time the data are entered on the card. A systemwide search of the card file would probably be too time-consuming to be practical.

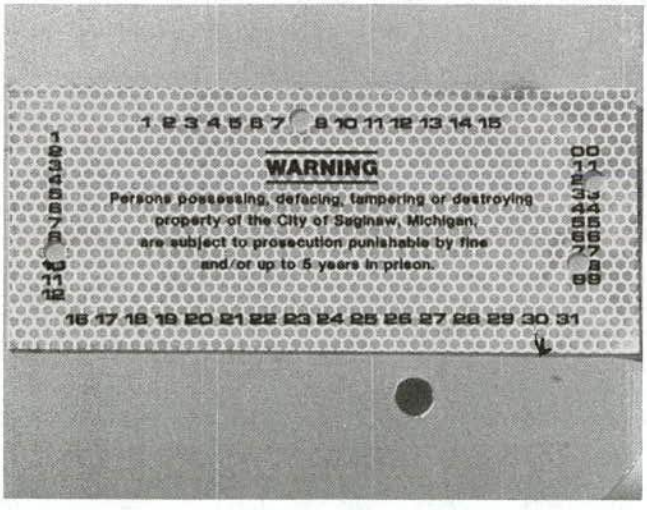


FIGURE 50 Warning decal with installation date.

Material Control

Effective management control requires that close attention be paid to the purchase, storage, and distribution of the many items used for street and highway sign maintenance. Chapter 4 presented a discussion on the value of a computerized sign inventory system for keeping a record of the signs in the field. In addition to the sign inventory aspects, many agencies are using the sign inventory and work order process to manage the material control aspects of sign maintenance. As signs are installed or replaced, the computer updates sign shop materials inventories. With this system, the agency is able to monitor sign or materials inventories. This information enables the computer to trigger an order to fabricate new signs when the stock is depleted below a certain threshold value. Figures 51–53 from the city of Norfolk, Virginia, Traffic Control Device Information System illustrate this process (*67*).

Fiscal Control

The failure of revenue for government activities to keep up with growing demands for service, and the concomitant competition for limited funds between public agencies, point out the need for fiscal control of the street and highway sign maintenance process. Fiscal controls include: cost accounting, budgeting, payroll, and sign and equipment replacement programs.

The city of Sioux City, Iowa, has implemented a sign inventory system that assists in the development of spending priorities, budget requirements, and materials purchases. This is accomplished through an algorithm that calculates the quantity of each sign type requiring maintenance and its size, the cost of the sign blanks and reflective sheeting, the post requirements and costs, and an estimate of any additional material costs for the maintenance activity. With this system, the city can produce a report detailing the quantity and cost of sign maintenance for budgeting. If the costs exceed available funding, the parameters can be refined and a new priority listing and costs can be developed.

Another item to consider in exercising fiscal control is the impact that deficient signing can have on an agency's budget. Because of financial and personnel limitations, it would be impossible for most agencies to gear up to replace all of their deficient signs in a one-year period. A more realistic approach to the problem is to establish a systematic program for replacement of a certain percentage of signs each year. That way, an agency is able to program the replacements on a continuing basis.

The city of St. Paul, Minnesota, has been divided into seven maintenance districts. Each year the sign department replaces all of the signs in one district. In the eighth year the sign department goes back to district one and starts again. Using this procedure, the city is able to ensure that all signs are no older than seven years. In addition, the replacement program can be accomplished with a reasonable budget and no increase in staffing.

The city of Rochester Hills, Michigan, has begun a four-year

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Sample Signs In-Place Summary

Sign Code	Description	Age(years) 0-1	2-3	4-5	5+	Total signs	Maintenance Actions Inst	Repair	Clean	Other	Total Transactions
R1-1	STOP SIGN	6	3	9	1	19	0	0	0	1	1
R1-2	YIELD SIGN	2	4	3	3	12	2	0	0	0	2
R2-1(25)	SPEED LIMIT 25 MPH	2	3	5	8	18	2	0	0	0	2
R2-1(30)	SPEED LIMIT 30 MPH	2	7	0	8	17	1	1	0	0	2
R2-1(35)	SPEED LIMIT 35 MPH	1	6	2	23	32	0	1	0	0	1
R2-1(40)	SPEED LIMIT 40 MPH	3	4	7	6	20	1	0	0	2	3
R2-1(45)	SPEED LIMIT 45 MPH	1	0	7	0	8	1	0	0	0	1
R2-2(40)	TRUCK LIMIT 40 MPH	1	2	7	4	14	1	0	0	0	1
R3-1	NO RIGHT TURN (SYMBOL)	1	0	0	9	10	1	0	0	0	1
R3-2	NO LEFT TURN (SYMBOL)	1	3	6	0	10	1	0	0	0	1
R3-4	NO U-TURN (SYMBOLIC)	3	1	5	11	20	0	0	0	3	3
R3-8	DUAL LEFT TURN (SYMBOL & WORDS)	1	0	3	5	9	1	0	0	0	1
R4-1	DO NOT PASS	1	1	12	7	21	1	0	0	0	1
R4-7	KEEP RIGHT (SYMBOL)	2	0	0	8	10	2	0	0	0	2
R5-1	DO NOT ENTER	0	1	6	3	10	0	0	0	1	1
R6-1L	ONE WAY (ARROW LEFT)	2	0	5	6	13	2	0	0	0	2
R6-1R	ONE WAY (ARROW RIGHT)	2	1	0	2	5	2	0	0	0	2
R7-11	NO PARKING HERE TO CORNER	2	3	3	0	8	1	1	0	0	2
R7-11AL	NO PARKING HERE TO CORNER (ARROW L)	1	0	5	4	10	0	1	0	0	1
R7-11AR	NO PARKING HERE TO CORNER (ARROW R)	3	6	3	4	16	1	0	0	2	3
R7-13	NO PARKING THIS SIDE OF STREET	1	0	7	0	8	1	0	0	0	1
R7-201	TOW-AWAY ZONE	1	6	3	8	18	1	0	0	0	1
R8-3	NO PARKING	1	2	1	0	4	1	0	0	0	1
R8-3AD	NO PARKING (ARROW BOTH DIRECTIONS)	1	4	0	5	10	1	0	0	0	1
R8-3AL	NO PARKING (ARROW LEFT)	3	7	6	0	16	0	0	0	3	3
R8-3AR	NO PARKING (ARROW RIGHT)	1	3	4	2	10	1	0	0	0	1
W11A-2	PEDESTRIAN CROSSING (SYMBOL)	1	9	0	2	12	1	0	0	0	1
NG-1	WATERFRONT X BLOCKS	2	12	3	7	24	2	0	0	0	2
NG-19	TUNNEL TO PORTSMOUTH	0	9	0	8	17	0	0	0	1	1
NG-2	WATERFRONT PARKING	2	14	8	0	24	2	0	0	0	2
NG-24	NORFOLK TOUR	2	4	6	3	15	2	0	0	0	2
NG-3	GRANBY MALL	2	5	7	4	18	1	1	0	0	2
NG-57	STREET NAME SIGN	1	6	5	1	13	0	1	0	0	1
NG-58	STREET NAME SIGN (OVERHEAD)	3	9	0	1	13	1	0	0	2	3
NG-8	EASTERN VIRGINA MEDICAL CENTER	1	1	3	1	6	1	0	0	0	1
NG-9	SCOPE TRAILBLAZER	1	2	5	9	17	1	0	0	0	1
NP-45	NO PARKING LOADING ZONE	1	4	2	11	18	1	0	0	0	1
NP-49	NO PARKING HERE TO DRIVEWAY	1	0	0	3	4	1	0	0	0	1
NP-47	NO STANDING	3	0	0	4	7	0	0	0	3	3

FIGURE 51 Typical signs in-place summary output.

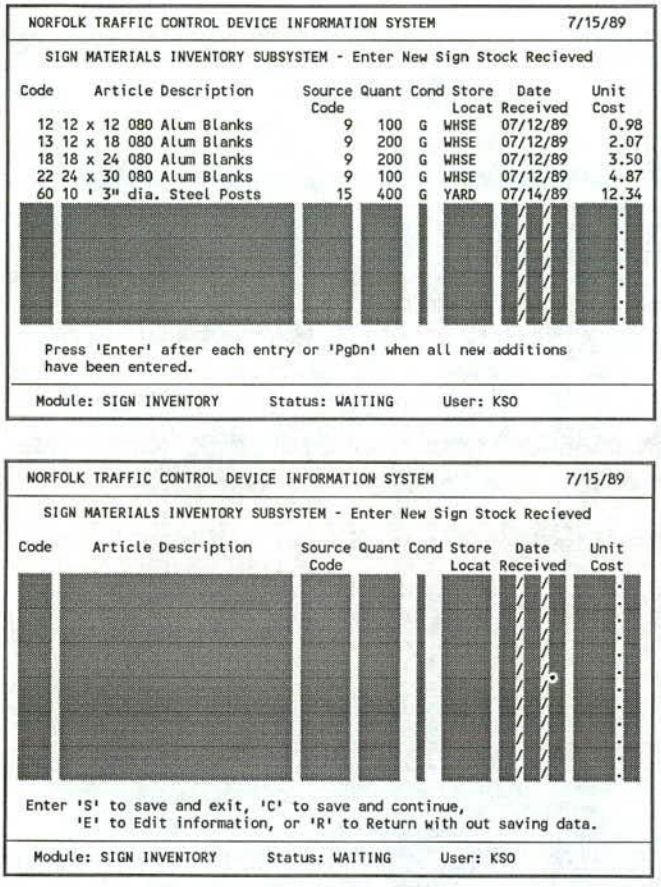

FIGURE 52 Typical sign shop material inventory input screen.

program of sign replacement to upgrade the quality of signing on the city streets. The program is as follows:

- Year One
  Begin and complete red series signs.
  Begin yellow series.
  Begin green series on major roads.
- Year Two
  Complete yellow series.
  Continue green series on secondary roads.
- Year Three
  Continue and complete green series on residential streets.
- Year Four
  Replace any other sign series not yet replaced.

Life-Cycle Cost Analysis

An important element in the fiscal control of street and highway sign maintenance is the selection of the sign sheeting as it relates to the durability and life of the material. In making a life-cycle cost analysis, several factors need to be determined (*8*):

- Cost of sign fabrication, including substrate material and sheeting,
- Cost of sign installation, including post, hardware, and labor,
- Service life of the sheeting material, and
- Benefits.

A simple procedure for making a life-cycle cost analysis, as described by McGee and Mace (*8*), is to divide the cost of the sign by the performance life of the material. That is:

$$C = TC/PL$$

Where:

C = Cost per year of useful life;
TC = Total costs of material during the life of the sign;
PL = Performance life, which can be the service life of the sheeting or the manufacturer's warranty life.

Some agencies believe that the total cost of the sign installation is more appropriate than just the fabrication costs, and therefore they use the total sign fabrication and installation costs rather than just the sheeting cost.

As minimum levels of retro-reflectivity become a reality, the modification of this life-cycle cost analysis is possible to reflect the benefits of using a sheeting that maintains a higher level of retro-reflectivity over its useful life. This could be done by multiplying the performance life by the average luminance of the material over its useful life. That is:

$$C = TC/(((L_n + L_o)/2) \times PL)$$

Where:

C, TC, and PL are as defined above;
L_n = Luminance (SIA) of new material;
L_o = Luminance (SIA) of worn material at end of useful life.

This procedure, however, requires the collection of sign retro-reflectivity data on signs that have exceeded their useful life for the establishment of a data base to provide meaningful data for this life-cycle cost analysis.

In instances in which a sign may be knocked down, stolen, or vandalized before it exceeds its useful life, a lower-initial-cost material may be a better choice.

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Page : 1 Sample Sign Shop Materials Inventory

MATERIALS INVENTORY

Article Code	Description	Condition	Storage Location	Unit Cost	Quantity	Reorder Quantity
1	EXT ST NAME BRACKETS (CROSS)	G	WHSE	2.61	593	100
2	EXT ST NAME BRACKETS (45 DEG	G	WHSE	3.10	357	100
3	EXT ST NAME BRACKET (CAP)	G	WHSE	2.72	600	100
4	4"X18" 080 ALUM BLANKS	G	WHSE	0.49	647	100
5	6"X12" 080 ALUM BLANKS	G	WHSE	0.98	22	50
6	6"X18" 080 ALUM BLANKS	G	WHSE	0.70	46	50
7	9"X21" 080 ALUM BLANKS	G	WHSE	1.65	44	50
8	9"X24" 080 ALUM SIGN BLANKS	G	WHSE	1.84	244	100
9	9"X30" 080 ALUM BLANKS	G	WHSE	2.30	51	50
10	9"X36" 080 ALUM BLANKS	G	WHSE	2.75	65	50
11	9"X42" 080 ALUM BLANKS	G	WHSE	3.21	0	50
12	12"X12" 080 ALUM BLANKS	G	WHSE	1.12	107	100
13	12"X18" 080 ALUM BLANKS	G	WHSE	2.07	316	100
14	12"X30" 080 ALUM BLANKS	G	WHSE	2.70	194	100
15	12"X42" 080 ALUM BLANKS	G	WHSE	3.79	193	100
16	15"X21" 080 ALUM BLANKS	G	WHSE	2.13	876	100
17	18"X18" 080 ALUM BLANKS	G	WHSE	2.44	93	100
18	18"X24" 080 ALUM BLANKS	G	WHSE	3.24	215	100
19	18"X30" 080 ALUM BLANKS	G	WHSE	4.06	151	100
20	24"X12" 080 ALUM BLANKS	G	WHSE	1.95	1296	200
21	24"X24" 080 ALUM BLANKS	G	WHSE	4.32	1174	200
22	24"X30" 080 ALUM BLANKS	G	WHSE	5.40	893	200
23	24"X36" 080 ALUM BLANKS	G	WHSE	5.84	63	50
24	24"X64" 125 ALUM BLANKS	G	WHSE	15.30	1	0
25	30"X30" 080 ALUM BLANKS	G	WHSE	6.77	224	100
26	36"X12" 080 ALUM BLANKS	G	WHSE	3.24	91	50
27	36"X12" 125 ALUM BLANKS	G	WHSE	5.07	315	100
28	36"X18" 080 ALUM BLANKS	G	WHSE	7.62	119	50
29	36"X36" 080 ALUM BLANKS	G	WHSE	9.73	113	50
30	36"X48" 080 ALUM BLANKS	G	WHSE	12.97	259	50
31	48"X18" 080 ALUM BLANKS	G	WHSE	12.50	4	0
32	30"X36" 080 ALUM BLANKS	G	WHSE	8.06	83	50
33	48"X24" ALUM SIGN BLANKS	G	WHSE	15.32	143	50
34	48"X48" ALUM SIGN BLANKS	G	WHSE	28.22	22	10
35	60"X18" ALUM SIGN BLANKS	G	WHSE	13.76	2	0
36	60"X30" ALUM SIGN BLANKS	G	WHSE	21.17	11	0
37	78"X18" ALUM "METRO" BLANKS	G	WHSE	10.56	14	0
38	78"X30" ALUM "METRO" BLANKS	G	WHSE	17.62	15	0
39	90"X18" ALUM "METRO" BLANKS	G	WHSE	12.19	9	0
40	90"X30" 080 ALUM BLANKS	G	WHSE	20.32	10	0
41	120"X60" ALUM "METRO" BLANKS	G	WHSE	95.37	0	0
42	108"X48" ALUM BLANKS	G	WHSE	77.68	8	0
43	24" 080 STOP BLANKS	G	WHSE	3.53	417	0
44	30" 125 STOP BLANKS	G	WHSE	4.95	49	0

FIGURE 53 Typical sign materials supply report.

CHAPTER NINE

CONCLUSIONS

Although an estimated $250 million is annually spent on maintaining the 58 million signs along the nation's highways, the problem of inadequate funding for sign maintenance is all too evident. Although support does exist amongst governmental agencies for the implementation of minimum retro-reflectivity guidelines or standards, the impact of retro-reflectivity standards on sign maintenance budgets is still undetermined. However, an increase in the level of maintenance by public agencies is unlikely. Therefore, a systematic approach to maintenance management will be required.

The key conclusions to be drawn from this synthesis are as follows:

- Improvements in traffic signing have the highest benefit-cost ratio of any highway safety improvement.
- Field studies of traffic sign conditions indicate that a large proportion of agencies' signing systems are in need of some form of maintenance.
- Tort liability losses to state transportation agencies have increased by more than 1900 percent between 1975 and 1985.
- Studies have shown that approximately 29 percent of tort liability lawsuits against highway departments are related to traffic signing.
- The implementation of a risk management program is recommended by transportation and law experts to minimize tort liability losses.
- The establishment of a sign inventory is one of the most beneficial actions an agency can take to reduce liability exposure. Advancements in computer hardware and software have provided the capability for all levels of government to develop a sign inventory system. However, constant updating of the inventory is needed as signs are added, removed, or replaced.
- One of the foundations for a street and highway sign maintenance management program is the timely detection of maintenance needs. This requires the implementation of procedures to facilitate the reporting of maintenance needs from a number of different sources, both from within and outside of the agency, and to ensure that the communication of the maintenance need is reported to sign crews in a timely fashion.
- With increasing awareness of the important role that retro-reflectivity of traffic signs plays in nighttime traffic safety, the development of a systematic nighttime inspection program is becoming an integral part of a maintenance management program.
- When travel time from a maintenance facility to the work site is in excess of an hour, consideration should be given to the establishment of a district sign maintenance operation. Although the decentralization of the field work is beneficial, analysis has indicated that a central sign shop is more economical than numerous district sign shops.
- As a result of the staffing problems caused by declining budgets, an increasing number of states and municipalities are relying on contractors to do routine maintenance on the U.S. road system, though contractual sign maintenance is still rather limited. However, those agencies that have reported experience with contractual sign maintenance have generally reported good results.
- Technological enhancements are coming to the sign shop as agencies use robotics and computer-aided drafting to improve productivity.
- Agencies have found that by projecting materials needs so that the purchase of signs and materials can be made on a yearly basis or by combining purchases with other agencies, significant cost savings can be obtained.
- With the rapidly increasing prices of aluminum, sign substrate reclamation can result in a significant savings in materials costs.
- There are many additional cost-saving strategies used by agencies for sign maintenance activities, including: better management of sign vandalism problems to reduce occurrences, better management of the scheduling of field workers to improve productivity, better control of overtime through the implementation of call-in procedures, selection of sign materials that provide better benefits and performance versus costs, improved specifications, and determination of compliance to specifications by the manufacturer.

Further research needs include:

- Determination of the economic impacts of minimum retro-reflectivity standards.
- Determination of what level of retro-reflectivity is necessary.
- Development of a low-cost, rapid procedure for the measurement of in-field sign retro-reflectivity.
- Development of sign deterioration models.

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Montgomery County Government

Purchasing Division
101 Monroe Street
Rockville, Maryland 20850
301/217-7315

CONTRACT

_____

_____

_____
Contractor

_____
Address

_____
Telephone Number

_____
Contact Person

MONTGOMERY COUNTY, MARYLAND

CONTRACT _____

THIS CONTRACT, made this _____ day of _____ in the year _____, is by and between

_____
(CONTRACTOR'S NAME)

_____
(CONTRACTOR'S ADDRESS)

hereinafter called the CONTRACTOR, and Montgomery County, Maryland, hereinafter called the COUNTY.

WHEREAS, this Contract for Street Names Signs & Traffic Sign Assemblies

_____

_____

is subject to all the terms and conditions contained in IFB 80168 **(hereinafter referred to as the solicitation) and; deliveries shall be** As Scheduled by Contract Administrator **and; payment terms are** Net 30 Days and;

WHEREAS this contract has been awarded pursuant to the Contractor's bid in response to the solicitation (as modified to specify the items awarded) and;

WHEREAS, it was one of the conditions of the solicitation that a formal contract evidencing the terms of the contract should be executed.

NOW, THEREFORE, it is agreed as follows:

1. The contractor will perform the requirements of the contract, in accordance with the solicitation and the bid (as modified to specify the items awarded), both of which are hereby incorporated by reference and made a part hereof. The contractor will comply with each obligation set forth in the contract.

2. The County will pay for satisfactory performance of the requirements of the contract, when due and payable, and will comply with each obligation set forth in the contract.

IN WITNESS WHEREOF, the parties have caused this contract to be executed by their duly authorized officers as of the date indicated above.

FOR THE CONTRACTOR

by: _____
(Signature)

_____
(Printed or Typed Name)

_____
(Title)

_____
(WITNESS)

FOR THE COUNTY

by: _____
Montgomery County
Contracting Officer

_____
Approved as to Form and Legality
County Attorney

Rev. 12/18/85

APPENDIX A

EXCERPTS FROM MONTGOMERY COUNTY, MARYLAND, SIGN INSTALLATION AND REPAIR CONTRACT

SECTION III - SPECIAL TERMS AND CONDITIONS

MANDATORY INSURANCE REQUIREMENT

Prior to the Commencement of the Agreement, the Contractor shall obtain at its own cost and expense and keep in force and effect until the termination of this agreement, the following Insurance with the Insurance Company/Companies licensed and qualified to do business in the State of Maryland evidenced by a Certificate of Insurance.

Worker's Compensation
Statute limits and the following limits:

Bodily Injury by Accident $100,000 each accident
Bodily Injury by Disaster $500,000 policy limits
Bodily Injury by Disaster $100,000 each employee

Commercial General Liability
Minimum $300,000 combined single limit of Bodily Injury and Property damage per occurrence including the following coverages:

Contractual Liability
Premises and Operations
Independent Contractors

Automobile Liability
Bodily Injury
$100,000 each person
$300,000 each occurrence

Property Damage
$300,000 each occurrence

Including the following:
Owned automobiles
Hired automobiles
Non-owned automobiles

Additional Insured
Montgomery County Government shall be named as an additional Insured on all liability policies.

Policy Cancellation
Sixty (60) days written notice of Cancellation or Change in any materials on the policies is required.

Certificate Holder
Montgomery County Government
Purchasing and Materiel Management Division
101 Monroe Street - 13th Floor
Rockville, Maryland 20850

CONTRACT TERM

The contract term shall be for a period of one (1) year from date of award. Upon mutual concurrence of the contractor and the County, and contingent upon appropriate fiscal funding, as approved by the Montgomery County Council, the contract may be extended for an additional two one year periods, with all terms and conditions of the original contract applying to any such extension.

ANNUAL PRICE ADJUSTMENT

Prices quoted are to be firm for one (1) year after award of a contract. A contractor may submit a request for a price adjustment to be effective for a renewal period in writing, no later than sixty (60) days prior to the expiration of the contract. A request for a price adjustment is subject to approval or rejection by the Chief, Division of Purchasing & Materiel Management. A request for price adjustment may not be approved, which exceeds the amount of the annual percentage change of the Consumer Price Index (CPI) for all urban consumers issued for the Washington, D.C. Metropolitan Area (all items) published by the United States Department of Labor, Bureau of Labor Statistics for the twelve month period immediately prior to the date of request. A price adjustment may only be approved prospectively by a written contract amendment. If the price adjustment is rejected in whole or in part, the contractor need not agree to renew the contract.

BID GUARANTEE

A Bid Guarantee (Bid Bond, Certified or Treasurer's Check, or Irrevocable Letter of Credit), must be enclosed and accompany each Bid and be duly executed by the Bidder as a principle and having security thereon the amount of five percent (5%) of the Bid made payable to Montgomery County. Bid Guarantees, other than Bid Bonds, will be returned to all except the three (3) lowest bidders within 15 days after the formal opening of Bids, and the remaining Guarantees will be returned to the three lowest bidders within 5 days after the County and the accepted Bidder(s) have executed the contract(s). If no contract has been executed within the time specified herein, the Bidder may request the return of the Bid Guarantee. The County reserves the right of approval of any instrument offered as Bid Guarantee.

PERFORMANCE BOND

No contract shall exist until the County receives a duly executed Performance Bond prepared on an approved form in the amount of $10,000.- made payable to Montgomery County, as security for the faithful performance of the contract and having as surety thereon such surety company or companies as are acceptable to the County and as are authorized to transact business in the State of Maryland. In the event the Performance Bond is not delivered within ten (10) days of Notice of Award then the offer may be ruled null and void and the award shall be made to the next lowest responsive bidder.

The Performance Security will provide assurance of faithful performance and discharge of all duties and responsibilities attendant thereto required by law or as provided herein by the contractor of all ASPECTS, TERMS AND CONDITIONS of the contract and shall be maintained in full force and effect until the termination of this agreement.

QUANTITIES

It is estimated that the yearly expenditure under this contract will approximate the quantities listed on the Quotation Sheet. Under the terms of this Invitation, however, the resultant contract shall be considered a "Requirements-type" contract only. The quantities are approximate only and will be used for comparing bids. In addition, the quantities are contingent on appropriate fiscal funding. The County reserves the right to increase or decrease the quantities and such action by the County shall not be cause for any increase or decrease of contract unit prices bid.

REFERENCES OF PREVIOUS SUCCESSFUL EXPERIENCE

Each bidder shall list on the form included in this Invitation one or more references of clients for whom the bidder has successfully completed a contract for installing traffic signs. For each reference, the bidder shall list the name of the client, address, and phone number of client's contact person, types and quantities of signs installed, and annual dollar value of contract. The County intends to contact and verify references. Failure to submit acceptable references that demonstrate the ability to successfully pursue and complete work of the type and scope of this contract may cause the bid to be deemed non-responsive.

EQUIPMENT

Each bidder shall list on the form included herewith the details of the equipment currently owned or rented by the bidder, or to be obtained by the bidder, and that will be available to pursue the work in this contract. Failure to submit information on equipment in sufficient detail for the County to determine whether the equipment meets the specifications may cause the bid to be deemed non-responsive.

PERSONNEL QUALIFICATIONS

Each bidder shall identify, on the form included herewith, the numbers, sources, and experience of the personnel proposed to be used to pursue the work in this contract.

CONTRACT ADMINISTRATOR/ENGINEER

The Contract Administrator shall be responsible for:

A. Instructing the contractor of the details of work required including the labor and the material/equipment to be used.
B. Inspect all work performed and authorize payment upon acceptance.
C. Other responsibilities as outlined in the contract documents.

Where used elsewhere in the Contract documents, the term "Engineer" shall be defined to mean "Contract Administrator". The Contract Administrator for this contract will be Mr. Ronald C. Welke, Chief, Division of Traffic Engineering (301-251-2190) or his duly authorized representative.

IMPLIED WORK

All incidental work required by the drawings or specifications, for which no payment is specifically provided, any work or materials not therein specified which are required to complete the work and which may fairly be implied as included, shall be done or furnished by the Contractor without extra compensation.

INJURY TO PROPERTY

In case any direct or indirect damage is done to public or private property by or because of the work, or in consequence of any act or omission on the part of the Contractor, his employees or agents, the Contractor shall, at his own cost, restore such property to a condition similar or equal to that existing before such damage was done, by repairing, rebuilding, or otherwise restoring, as may be required by the Engineer, or shall make good such damage in a satisfactory manner; and in case of failure on the part of the Contractor to promptly so restore or make good such damage, the Engineer may, upon 48 hours written notice, proceed to repair, rebuild, or otherwise restore such property as may be necessary, and the cost thereof will be deducted from any monies due to become due the Contractor under the Contract; or the Engineer may deduct from any monies due the Contractor a sum sufficient, in the judgement of the Engineer, to reimburse the owners of the property so damaged.

DECISIONS AND EXPLANATIONS BY ENGINEER

The Engineer shall decide any and all questions which may arise as to the quality and acceptability of materials furnished and work performed and as to the manner of performance and rate of progress of the work and shall decide all questions which may arise as to the interpretations of any or all plans relating to the work and of the specifications, and all questions, as to the acceptable fulfillment of the Contract on the part of the Contractor; and the Engineer shall determine the amount and quantity of the several kinds of work performed and materials which are to be paid for under the contract, and such decision and estimate shall be final and conclusive, and such estimate, in case any questions shall arise, shall be a condition precedent to the right of the Contractor to receive any money due under the Contract. Any doubt as to the meaning of or any obscurity as to the wording of the specifications and contract or the intent of the plans, and all directions and explanations requisite or necessary to complete, explain or make definite any of the provisions of the specifications, Contract or plans and to give them due effect, will be interpreted by the Engineer. The decision of the Engineer will be final.

LOCATION OF WORK AND METHOD OF ASSIGNMENT

Upon award of contract, a notice to proceed will be issued by the Contract Administrator, accompanied by an initial 50 work orders to be completed by the Contractor. The Contractor shall commence work as soon as possible but not later than 7 calendar days thereafter. After commencement of work by the Contractor, work orders will be generally issued daily to the Contractor (Monday through Friday except County holidays) at a rate that will not exceed 100 work orders per week. The order in which the work orders are pursued by the Contractor is at the discretion of the Contractor, so long as the schedules specified elsewhere in this contract are met.

The County reserves the right to delete work orders as necessary and to revise details of any work order at any time prior to the completion of any work order.

RATE OF PURSUING THE WORK

The County desires each work order to be completed by the Contractor as soon as possible. The Contractor must complete each work order within 14 calendar days of receiving the work order. At the sole discretion of the Engineer, the COUNTY may grant exceptions to this 14 days requirement in extreme circumstances such as an unusually heavy snowfall that makes signing work impossible for an extended period. If the Contractor finds at any time he cannot complete the work orders within 14 calendar days (at the rate assigned by the County), the Contractor shall hire and train additional crews and obtain additional equipment, so as to be able to complete the work within the required 14 calendar day time frame, or Liquidated Damages shall apply. Each day a work order is not completed after the 14 days allowed shall be considered 1/10 of a calendar day for each work order not completed during which failure to pursue the work at an adequate rate occurred. See "Liquidated Damages" and "Default of Contract".

LIQUIDATED DAMAGES

Liquidated damages at the rate of $500.00 per calendar day may be assessed by the County in the event any of the following occurs:

a. Failure of the Contractor to start work within seven calendar days of notice to proceed.
b. Failure of the Contractor to pursue the work at an adequate rate (see "Rate of Pursuing Work").
c. Failure to correct defective work within three calendar days (Saturday, Sunday, holidays excepted).
d. Repeated failure to keep the Engineer advised of work schedules.

Should it become necessary for the County to halt the work because of incorrectly located or un-satisfactory installation of signs or posts under the terms of this contract, liquidated damages may also be assessed at the rate noted above.

DEFAULT OF CONTRACT

In the event of any of the following conditions, the County will consider the Contractor to have defaulted on the contract:

a. Failure of the Contractor to start work within fourteen calendar days of the notice to proceed.
b. Failure of the Contractor to have pursued the work at an adequate rate such that Liquidated Damages are eligible to be assessed in excess of fourteen calendar days total.

Default on the contract will result in termination of the contract and forfeiture of the performance bond for any and all uncompleted work.

WORKMANSHIP

The work shall be under the general direction of the Contractor but subject to the inspection of the Contract Administrator or the authorized representative, who may require the Contractor to correct defective workmanship without cost to the County.

Except for County-supplied materials, all material and practices which are necessary, or which normally provided and performed in order to accomplish the desired results, shall be furnished by the Contractor at the bid price and shall conform in strength, quality of material, appearance, and workmanship to that usually provided by the trade.

DEFECTIVE WORK

If, in the judgement of the Engineer, repairs, renewals, or replacements become necessary, due to incorrectly applied or improperly located materials said actions shall be promptly made by the Contractor, with any inferior or defective work replaced by good and acceptable materials, and all necessary work done to put the improvement in first class condition. If available, the County will supply the materials for the necessary repairs, renewals, or replacements, and the cost of said County-supplied materials shall be deducted form any monies due to the Contractor. If the County does not have available a sufficient quantity of additional materials for this purpose, the Contractor shall provide at his own cost the necessary quantity of materials meeting the County's specifications. Such materials shall not be used before they are specifically approved by the County.

If the Contractor does not, within three (3) working days after notification from the Engineer, complete such necessary work as stipulated above, then the Engineer may proceed with the work and assess one full day of Liquidated Damages.

INVOICES

At the end of each month the Engineer will prepare an estimate of the quantities of the various work items that the Contractor has completed during the month and that have been accepted by the County. The Engineer will include a deduction, if necessary, for County-supplied materials that have been wasted by the Contractor. The Engineer's estimate will be furnished to the Contractor for his use in preparing monthly invoices.

Any work order that has not been fully completed or that contains defective work that has not been corrected by the Contractor will not be accepted for payment by the County, even if only a portion of the work included in that work order is incomplete or defective.

Invoices shall be submitted monthly reflecting quantities of work completed by the Contractor and accepted by the County. All true and corrected invoices are to be sent to:

Montgomery County Division of Traffic Engineering
101 Monroe Street, 11th Floor
Rockville, Maryland 20850

Invoices for completed work shall reflect deduction of wastage of County-supplied materials, if any, and any other deductions the County is authorized to take under the terms of this contract.

End of Section III - SPECIAL TERMS AND CONDITIONS

SECTION IV - SPECIFICATIONS AND SPECIAL PROVISIONS
INSTALLATION AND REPAIR OF STREET NAME SIGNS AND TRAFFIC SIGN ASSEMBLIES

GENERAL DESCRIPTION AND SCOPE

Work under this contract consists of providing the services to install new and repair existing street name signs, and traffic signs, using Montgomery County-supplied signs, posts and related sign installation hardware. The signs, posts and sign installation hardware will be supplied to the Contractor at no charge.

The new sign assemblies to be installed will consist generally of 1) extruded aluminum street name sign panels on a single post; 2) extruded aluminum street name sign panels to be affixed to existing street light poles or traffic signal poles; 3) flat aluminum traffic sign panels on either one or two posts as directed; and 4) combination street name sign/traffic sign assemblies on either one or two posts as directed. Repairs to existing sign assemblies will consist generally of 1) repairing sign panels; 2) replacing missing sign panels or assemblies; 3) removing existing sign panels and replacing with new sign panels; 4) removing and replacing existing posts; and 5) adding supplemental sign panels, as directed by work orders.

Initially, work orders are expected to involve only 6 3/4" or 9" street name signs, 24" or 30" stop signs, and 30" or 36" yeild signs. The drawings included in these specifications govern placement of these types of signs. The County reserves the right to issue work orders under this contract to the Contractor for installation or repair of other types of signs as the County's needs dictate, and will supply drawings governing placement of such other types of signs as necessary. The installation or repair of such other types of signs that the County may call for will not require the Contractor to expend a level of work effort that is substantially greater than the level of work effort required to install or repair street name signs, stop signs, or yield signs, although the locational standards may differ. The bid unit prices established in the contract shall govern compensation for all work orders.

GENERAL REQUIREMENTS

All signs and assemblies shall be installed in accordance with the following:

a. Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), published by the Federal Highway Administration, latest edition;
b. These specifications and special provisions;
c. Work orders and attachments to work orders that will be issued as the work proceeds.

In the event of conflict between the above standards, the work orders and attachments shall take precedence.

DEFINITION OF TERMS

Sign Panel: An individual sign, such as a Stop sign, or a Street name sign. Traffic sign panels will normally be intended for viewing from only one direction. Street name sign panels will normally be two-sided, with a single street name on each side of the panel.

Sign Assembly: Composed of one or more sign panels mounted individually or as a group on one or more supports.

MATERIALS

The County will supply to the Contractor all prepunched fabricated sign panels, posts (2" round pipe or 2 pounds per foot U-channel post), post caps, sign crosses, post anchors, brackets, clamps, nuts, bolts, washers, set screws, banding material, and other sign hardware. The hardware to be supplied by the County will generally conform to the attached drawings (#5 through #12 and #22 and #23), which are included herein for bidders information only.

The materials will be made available at the Montgomery County Sign and Marking Shop, 1283 Seven Locks Road, Rockville, Maryland. The Contractor may pick up the County supplied materials between the hours of 6:30 AM and 2:30 PM, Monday - Friday except County holidays, providing arrangements have been at least 48 hours in advance by contacting Mr. Robert Poole, Supervisor (279-1391).

No more material will be supplied in any one week than is necessary to complete one week's work. Fabricated sign panels will be made available to the Contractor as the work orders requiring use of those signs are assigned to the Contractor. Any excess material shall be returned to the Sign and Marking Shop at no expense to the County. A deduction shall be made from any monies due the Contractor for any excess material not returned, at the rate of the cost of the material to the County, plus $35 or 15% handling charge, whichever is higher.

No substitutions of Contractor-supplied materials will be permitted for use in place of County supplied materials even if such materials are supplied at no cost the the County.

The County reserves the right to make minor changes in the specifications of the materials and hardware supplied to the Contractor at any time. Such changes may include the use of a heavier weight standard U-post. Any such changes shall not be cause for the Contractor to make any claim to the County based on those changes in materials supplied.

DAMAGE TO COUNTY-SUPPLIED MATERIALS

The Contractor shall inspect all signs and other materials furnished to him by the County for any damage or discrepancies with the work orders. Any damage to the signs must be noted by the Contractor at the time of receipt from the County. The Contractor shall be held responsible for any transporting, handling and installation. Signs shall be transported on the Contractor's vehicles upright, on edge, suitably protected to prevent rubbing or scraping of the sign faces. The cost of the sign to the County, plus 15% or $35 handling charge (whichever is higher), shall be withheld from monies due the Contractor if, in the opinion of the Engineer, any damage is caused to the sign by the Contractor that will affect the performance of the sign for the intended life of the sign. The opinion of the Engineer shall be final.

CONTRACTOR QUALIFICATIONS

The Contractor must be experienced in the installation and repair of traffic signs. Bidders that cannot demonstrate successful previous experience in work of the type in this contract will be considered not responsible and will not be considered for award of this contract.

The Contractor must possess (own or rent) and/or assure the availability of sufficient vehicles, equipment and special tools to successfully pursue the installation, removal and repair of the signs, posts, and sign hardware as presented in this contract.

Personnel employed by the Contractor for work on this contract shall be experienced in this type of work requiring little or no training necessary to expeditiously commence the work and pursue its completion.

COMMUNICATIONS

The Contractor shall designate a working leader ("foreman") in charge of each signing crew. No crew shall operate without one person being in charge and responsible for work done in the field. The County will provide to the foreman, for the duration of the contract, a portable radio and charger to provide for voice communications between the County Sign Shop and the Contractor's work crews during signing operations. The Contractor shall cooperate with the County by maintaining effective voice communications. The radio and charger shall be returned to the County at the end of the contract work period. If the voice equipment is lost or damaged, the County will deduct the cost of replacement or repair from monies otherwise due the Contractor.

CONTRACTOR'S BASE OF OPERATIONS

The Contractor may, with the approval of the County, store the materials, vehicles, equipment and supplies necessary for this project at the County Sign Shop at 1283 Seven Locks Road in Rockville, Maryland. However, the County will bear no responsibility for the safety of the equipment and/or supplies. The Contractor is responsible for handling and proper storage and protection of al materials after release of materials to the Contractor by the County.

WORK ORDERS

Two types of work orders will be issued to the Contractor, one for street name signs, and one for traffic signs. In the case of an assembly involving both street name signs and traffic signs, two work orders will be issued, cross-referenced to each other. The Contractor is expected to properly coordinate performance of the two work orders.

The work orders will specify the signs to be installed or repaired, the type and quantity of posts to be used, and other pertinent instructions which must be followed.

Examples of the blank work order forms and a list of some of the standard abbreviations used on work orders are included in the attachments to these specifications. The County may make minor changes in the work order forms at any time.

SCHEDULING AND RECORD-KEEPING

At the start of each working day, the Contractor shall submit all work orders that were completed the previous working day to the Engineer. New work orders (if any) will be issued to the Contractor each working day at the time the previous day's completed work is submitted. The Contractor's schedule shall be verbally updated each working day (i.e., progress report on accomplishments and scheduling changes). If the Contractor will not be working on any given day, the Contractor must advise the Engineer no later than 7 AM of that day. Repeated failure to do so will result in assessment of one day of liquidated damages for each occurrence.

All work orders must be properly filled in by the Contractor before the work order will be considered completed and be considered for payment. All appropriate items including date of installation, time of day work was completed, and all materials accounted for must be completed.

The sequence of executing the work orders is at the discretion of the Contractor. However, once the installation or repair of any given sign assembly is started, that sign assembly installation or repair must be completed in its entirety before the Contractor may leave that work location or take any work break. Also, once a work order is started, all sign work included in that work order must be completed before the Contractor may start another work order unless permission otherwise is granted by the Engineer. The Contractor is reminded of Liquidated Damages that may be applied if a work order is not completed within 14 calendar days.

The Contractor shall notify the Engineer at least two working days in advance of any proposed scheduled work on weekends or holidays, or during other than normal working hours (7 AM - 5 PM), and shall obtain prior permission of the Engineer before undertaking such work.

INSTALLATION AND REPAIR OF SIGNS

Installation and repair of signs shall be as required by the work orders, the drawings attached to these specifications, other drawings that may be issued by the County during the course of the contract, the manufacturer's recommendations where applicable, and other requirements of these specifications. The following specifications and procedures shall be followed:

LOCATION OF SIGN ASSEMBLIES

1. General

   a. Sign assemblies shall be installed in the locations directed by work orders, drawings, and these specifications, providing adequate visibility of the signs as presented in the following table is maintained.

Posted Speed Limit	Minimum Distance Signs Must be Visible to Approaching Traffic
25 MPH	175 feet
30 MPH	225 feet
35 MPH	275 feet
40 MPH	325 feet
45 MPH	400 feet
50 MPH	475 feet

b. If it is apparent that adequate sign visibility cannot be accomplished within the instructions of these specifications relating to tree trimming and the instructions on the work order, the Contractor or his foreman shall contact the Engineer by radio to receive further instructions prior to installing the sign assembly. If the Engineer cannot be contacted by radio, the Contractor shall hold the work order until such time that the Engineer is contacted. No additional compensation will be allowed. No additional time will be allowed for the completion of a work order unless stated in writing by the Engineer.

c. Traffic signs shall be properly aligned facing approaching traffic. Existing posts shall be straightened as necessary.

d. Street name signs shall be properly aligned so as to be approximately parrallel to the street they name, unless otherwise directed by the work order or by the Engineer.

2. Lateral Clearance

a. Roadways with curb: the standard lateral clearance shall be two feet from near edge of sign to back of curb (see drawing), except as follows:
   1. Where utility poles are adjacent to the curb or more than two feet from the back face of the curb, or where parking meters are present, the near edge of the sign may be placed as close as one foot from the back face of the curb or in line with the existing poles or parking meters.
   2. Where the sidewalk abuts the back face of curb, the near edge of sign should be mounted six inches from the edge of the sidewalk farthest from the travelled roadway, if conditions (1) and (3) do not apply.
   3. The maximum lateral clearance shall be 12 feet from near edge of sign to back face of curb.

b. Roadways with paved shoulders: The standard lateral clearance to the near edge of the sign shall be two feet from the outside edge of the usable paved shoulder or six feet from the near edge of the paved travel lane, whichever is the greater distance.

c. Roadways without shoulders or curbs: The standard lateral clearance shall be six feet from the near edge of sign to the near edge of pavement, provided adequate sight distance can be accomplished. Where it is impractical to maintain the standard lateral clearance, a lesser lateral clearance may be used, but in no case shall it be less than one foot.

3. Longitudinal Position of STOP or YIELD sign and/or Street Name sign Assemblies:

The sign assembly shall be erected at a longitudinal position along the roadway that is as close as practicable to the point where it is intended that vehicles are to stop. It shall not be less than six feet nor more than 50 feet in advance of the extended curb line or edge of pavement of the intersecting roadway. Where there is a sidewalk or a marked crosswalk, the STOP or YIELD sign should be placed at least four feet in advance of the edge of the sidewalk or crosswalk line nearest to approaching traffic. Distances less than this minimum may be allowed when the STOP or YIELD sign is combined with a street name sign (see attached drawings).

4. Sight Distance Obstructions (vegetation):

The Contractor shall be required to trim any vegetation obstructing or otherwise restricting the sight distance of the sign, up to 1/2 inch in diameter. No additional compensation will be allowed for this work.

5. Cleaning of Existing Signs:

Whenever repairs or modifications are being made to an existing sign assembly, the Contractor shall clean the existing sign panels that are to be retained in the assembly by wiping off the surface with a damp cloth. No solvents or other cleaners shall be used that would, in the opinion of the Engineer, damage the sign face. If, in the process of carrying out a work order for repairs or modifications to an assembly, a sign panel on the assembly is found to be damaged by spray paint or other vandalism, the Contractor shall contact the Engineer by radio and obtain verbal instructions as to what actions, if any, are to be taken.

6. Underground Utilities:

It is the Contractor's responsibility to contact "Miss Utility" if the Contractor wishes to verify the location of an undergound utility, and to conduct the work so as to avoid all damage to utilities, structures, and properties. It is the sole responsibility of the Contractor for any damage that he may cause to any utility, drainage structures, or other property as a result of his actions. No additional time will be allowed for the completion of a work order because of the location of any utility or structure.

SIGN, POST AND HARDWARE INSTALLATION

1. General: Signs shall be installed or repaired as directed with the signs, post and hardware provided by the County. All installations and repairs shall be accomplished with good workmanship in accordance with these specifications and drawings attached. The Contractor shall familiarize himself with these requirements and the hardware supplied so that there shall be no question as to the intent of the County. The Contractor shall furnish all vehicles, post drivers, post pullers, banding tools, and any other specific or incidental tools or equipment necessary for the successful installation and repair of traffic signs and their supports at no cost to the County. In cases of dispute concerning the manner in which the hardware is to be installed, the Engineer shall be the final authority on the intent of the County.

2. Vandal Resistant Hardware: County-supplied vandal resistant hardware shall be installed in accordance with the attached drawings and the instructions of the Engineer. The Contractor is required to furnish the special tools required to install this hardware at no cost to the County.

3. Post Installation:

   a. Driving of Posts: The type and quantity of posts to be installed shall be as designated on the work order. Posts shall be driven into the ground, to the depth specified and/or to achieve the specified mounting height of signs, with proper post-driving equipment that will minimize damage to the top end of the post. Except in sidewalks, the excavation or drilling of a hole and subsequent backfilling around the post will not be allowed. The County retains the right to pull any post that is suspected of having been driven to an insufficient depth. If the post is found to have been driven to an insufficient depth, the Contractor shall re-install the post and sign assembly at no expense to the County.

   b. Plumbing: All posts shall be plumbed using a carpenter's level. Any existing post that is not to be replaced shall be plumbed and, if necessary, straightened by the Contractor to obtain a final assembly that is plumb. Any newly installed posts or existing posts that are not replaced that are not plumb upon completion of the work order will not be accepted.

   c. Levelling: For assemblies using two posts, the tops of the posts shall be levelled with a carpenter's level. Signs installed on posts shall be level as determined by a carpenter's level. Signs that are not level will not be accepted.

   d. Hole Drilling in Concrete: For sign posts that are required to be installed in concrete sidewalks (portland cement type or asphalt type), work orders will be marked "COMPRESSOR". For such post installation in sidewalks, the Contractor shall use a suitable rotary drill or similar equipment to drill a 3" to 3 1/2" diameter hole in the concrete prior to driving the post the remainder of the required depth. After the post is driven and plumbed, the hole shall be filled with "Epoxyment" (Rotanium Products) or approved equal patch compound suitable for quick-dry all-weather use. Additional compensation will be allowed for the drilling of a post hole in concrete sidewalk area when required, as per the appropriate bid item in these specifications.

   e. Lock-Set Post Anchors: Each 2" pipe post (round tube) shall be secured in the ground after driving of the post, by use of a County-supplied "Lok-Set" post anchoring system. The anchors shall be installed by the method and procedures prescribed by the manufacturer. Additional compensation will be allowed for the installation of a Lok-Set anchor system for each 2" pipe post, as per the appropriate bid item in these specifications.

4. Post Removal:

   When it is required by the work order or other directions to remove a post, the Contractor shall remove the post using tools and equipment specifically intended for that purpose. The post shall be completely removed, transported to the County's Sign Shop, and deposited as directed elsewhere in these specifications. All holes left from the removal of the posts shall be backfilled with a suitable material, tamped, and levelled to match the surrounding area.

5. Banding of Wing Brackets for Street Name Signs on Street Light, Utility, or Signal Pole:

   When street name sign panels are required to be installed on an existing street light pole, utility pole, or traffic signal pole, County-supplied wing brackets shall be used to affix the sign panels to the pole. The Contractor shall insert and secure each street name sign panel into the wing bracket supplied, taking extra care to assure that the set screws are torqued sufficiently to "bite" deeply into the sign panel. Each wing bracket shall be banded to the pole with two banding straps (top and bottom). The banding shall be installed sufficiently tight to prevent rotation or sliding of the sign panel assembly on the pole.

WORKMANSHIP

1. General: A professional quality of work is required. All hardware that is required shall be installed including all proper length and type bolts, nuts, lock washers, nylon washers, set screws, etc. Signs shall not overlap nor shall signs be obstructed in any manner. If signs cannot be installed or repaired as required on the work order without violating other requirements of this contract, the Engineer shall be contacted by the Contractor by radio or the work order shall be held until the next working day and returned to the Engineer. No compensation will be allowed for work orders that are returned to the County because they cannot be properly installed. No monies will be paid to the Contractor for work that does not meet the intent of these specifications.

2. Defective Work: Any work found to be defective due to the inability of the Contractor to meet any of the requirements of these specifications or because of less than professional workmanship shall be considered incomplete, and shall not be acceptable. Any such work must be completed or corrected by the Contractor to the satisfaction of the Engineer within three calendar days (not including Saturdays, Sundays, and County holidays). If the Contractor cannot correct the incomplete installation within these three days, the County may, at it's option, complete or repair the incomplete installation using County forces and charge one day's Liquidated Damages to the Contractor.

3. Field Personnel: Field personnel shall be knowledgeable of the proper installation of traffic signs. A copy of these specifications and attached drawings as well as an up-to-date Alexandria Drafting Co. Montgomery County Street Map Book shall be with the field personnel at all work sites. Failure to have a copy of these specifications and drawings and the required street map book with the field personnel will be considered sufficient reason for the Engineer to suspend the work of the Contractor until copies of specifications and drawings and map book are placed with the field personnel.

INCIDENTAL FIELD CHANGES

The possibility of damage to a sign assembly and/or its supports due to a vehicle accident, the commencement of construction activity, other incidental acts, or acts of nature that may have occurred after the work order was written may affect the ability of the Contractor to execute a work order as written. If a work order cannot be implemented as written, the Contractor shall return the work order to the Engineer the following working day. This shall not be cause for the Contractor to make any claims for additional compensation from the County. The Contractor or his foreman may, at his option, contact the Engineer by radio to request additional instructions. The Engineer may, at his sole discretion, modify the work order verbally to include any additional work necessary to complete the work order. Any and all verbal changes shall be confirmed in writing the following working day in order to be eligible for compensation for work done. Only work included in the bid items will be compensated.

REIMBURSEMENT FROM THIRD PARTY FOR REPAIRS OR DAMAGES

The County reserves the right to make recovery from a third party or parties for damage to any part of existing sign assemblies and no part of such recovery shall inure to the benefit of the Contractor.

CONTRACTOR TO BE ALERT FOR MISSING OR DAMAGED SIGNS

While the Contractor is at an intersection or other location and is engaged in doing the work contained in a work order for that location, the Contractor is expected to be alert for missing or damaged signs at that location that are not included in the work order. An example would be a stop sign on the opposite side of the intersection that is apparently missing or that is damaged. Whenever such situations are encountered, the Contractor shall contact the Engineer by radio to report the situation and request additional instructions. The Engineer may, at his sole discretion, modify the work order verbally to include any additional work deemed necessary. No such additional work shall be undertaken by the Contractor without the verbal permission of the Engineer. Any and all verbal changes shall be confirmed in writing the following working day in order to be eligible for compensation for the additional work. Only work included in the bid items shall be compensated.

DISPOSAL OF DAMAGED OR REMOVED SIGN MATERIALS

The Contractor shall transport all damaged, bent, obsolete or otherwise unusable sign materials removed from the field to 1283 Seven Locks Road, Rockville, Maryland and deposit them as directed by the Engineer. The Contractor shall remove all reusable materials to 1283 Seven Locks Road, Rockville, Maryland, clean the signs to the satisfaction of the Engineer, and store these materials at a location designated by the Engineer. All re-usable materials shall be handled with reasonable care. All materials removed from the field shall remain the property of the County.

MAINTENANCE OF TRAFFIC

The purpose of this portion of the contract is to provide for the safe and continuous maintenance of traffic through the area where traffic signs are being installed or repaired and to minimize accidents and accident severity while at the same time minimizing inconvenience to the traveling public and the Contractor.

All work shall be performed in accordance with applicable parts of Maryland State Highway Administration's "Standard Specifications" (Section 814) (copy attached), and Part VI of the United States Department of Transportation's Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD).

The Contractor shall furnish and place all warning devices, flagpersons, and flashing arrow boards and other traffic control devices required to direct, control and protect the traveling public while signing operations are in progress. Traffic shall have minimal, if any interruption. If, in the sole judgement of the Engineer, the signing operation is causing an excessive amount of traffic backup or congestion, he may order the Contractor to cease signing operations at that location until a period of lighter traffic or to take other actions a may be appropriate.

Each vehicle used by the Contractor on this Contract shall be equipped with, as a minimum, a vehicle-mounted flashing arrow board and one or more yellow strobe lights. Also, each vehicle shall carry an adequate number of orange traffic cones. Each of the Contractor's personnel shall wear reflective orange vests at all times. The County reserves the right to change or modify these requirements as it sees fit, at no additional cost to the County. The Contractor must have his vehicles inspected and approved by the Engineer prior to starting work on this contract. Lack of approval of vehicles will not be a valid reason for waiving Liquidated Damages.

The Contractor shall be solely responsible for all accidents and/or damage to persons and/or property that may result from the Contractor's operation. This shall include sodding that is necessary due to installation of lock-set post anchors or driving of vehicles off of the pavement.

There will be no separate payment for Maintenance of Traffic. All such work shall be incidental to the sign installation or repair work.

RESTRICTIONS ON WORK OPERATIONS BLOCKING TRAVEL LANES

Except on minor residential streets as allowed by the Engineer, the Contractor's work operations shall not result in the blockage or obstruction (partial or full) of any moving lane of traffic during the periods of 6:30 AM to 9:00 AM and 3:30 PM to 6:30 PM, Monday - Friday.

BID ITEMS - DESCRIPTIONS

1. Install Street Name Sign Assembly With Single Post - This item shall cover the installation of an assembly consisting of a single post (either U-post or 2" pipe tube), and either one, two (normal) or possibly three street name sign panels on the top of that post (but no traffic signs) as required by the work order and as covered by these specifications and attached drawings.

2. Install Traffic Sign Assembly With Single Post - This item shall cover the installation of an assembly consisting of a single post (either U-post or 2" pipe tube) and either one (normal) or possibly two or three traffic sign panels (some of which may be back-to-back) on the post, as required by the work order and as covered by these specifications and attached drawings.

3. Install Combined Street Name Sign/Traffic Sign Assembly With Single Post - This item shall cover the installation of an assembly consisting of: a single post (either U-post or 2" pipe tube); either one, two (normal) or possibly three street name sign panels on the top of that post; and either one (normal) or possibly two or three traffic sign panels (some of which may be back-to-back) on the post below the street name signs; all as required by the work order(s) and as covered by these specifications and attached drawings.

4. Install Traffic Sign Assembly With Two Posts: This item shall cover the installation of an assembly consisting of two U channel posts and either one (normal) or possibly two or three traffic signs (some of which may be back-to-back) on the posts, as required by the work order and as covered by these specifications and attached drawings.

5. Install Combined Street Name Sign/Traffic Sign Assembly With Two Posts - This item shall cover the repair consisting of: two U-channel posts; either one, two (normal) or possibly three street name sign panels on top of those posts; and either one (normal) or possibly two or three traffic sign panels (some of which may be back-to-back) below the street name signs; all as required by the work order(s) and as covered by these specifications and attached drawings.

6. Install Street Name Sign Assembly on Existing Street Light Pole, Utility Pole, or Signal Pole: This item shall cover the installation of an assembly consisting of either one, two (normal), or possibly three street name sign panels, using wing brackets banded to an existing street light pole, utility pole, or traffic signal pole as required by the work order and as covered by these specifications and attached drawings.

7. Repair, Replace, or Modify Existing Sign Assembly on Existing Post or Posts - This item shall cover the repair and/or the removal and/or the replacement of an existing assembly, and/or the addition of an auxiliary sign panel, the addition of a new street name sign panel or any other miscellaneous sign modification(s) work to an existing sign assembly as required by the work order that does not require any new or additional posts. Such work shall be as covered by these specifications and attached drawings.

8. Repair, Replace, Remove, or Modify Existing Sign Assembly and Add, Remove, or Replace Posts - This item shall cover the repair and/or the removal and/or the replacement of an existing assembly, and/or the addition of an auxiliary sign panel, the addition of a new street name sign panel, or any other miscellaneous sign modification(s) work to an existing sign assembly as required by the work order that does require modifications to the existing posts. Modifications to the existing posts may include the removal and/or replacement of one or more posts or the addition of another post to the existing sign assembly. Such work shall be as covered by these specifications and attached drawings. In the case of relocation of an assembly from one location to another location, such work shall consist of two separate pay items - removal (item #8) and installation (item # 1, 2, 3, 4, 5, or 6).

9. Drill Hole for Post in Concrete - This item shall cover the drilling of holes and subsequent patching for posts that must be installed in concrete sidewalks. The drilling of holes is normally accomplished by the use of a rotary drill with the appropriate drilling bit. The need for the drilling of hole in concrete is noted on the work order by the checking of the box titled "COMPRESSOR". The driving of a sign post is considered incidental to the sign assembly installation and is not covered under this bid item.

10. Install Lock-Set Post Anchoring System - This item shall cover the installation of lock-set post anchoring systems to secure 2" pipe posts (round tubes) in the ground, in accordance with manufacturer's recommended methods and procedures. Any sodding or other cleanup work that may be required following installation of the post anchoring system shall be incidental to this item.

BID ITEMS - INCIDENTALS

For all bid items, the installation of all nuts, bolts, clamps, post caps, crosses, and all other items necessary to successfully complete the work shall be considered incidental . Also, all straightening of existing posts that may be necessary to properly align the sign assembly with approaching traffic shall be considered incidental.

BID ITEMS - METHOD OF MEASUREMENT

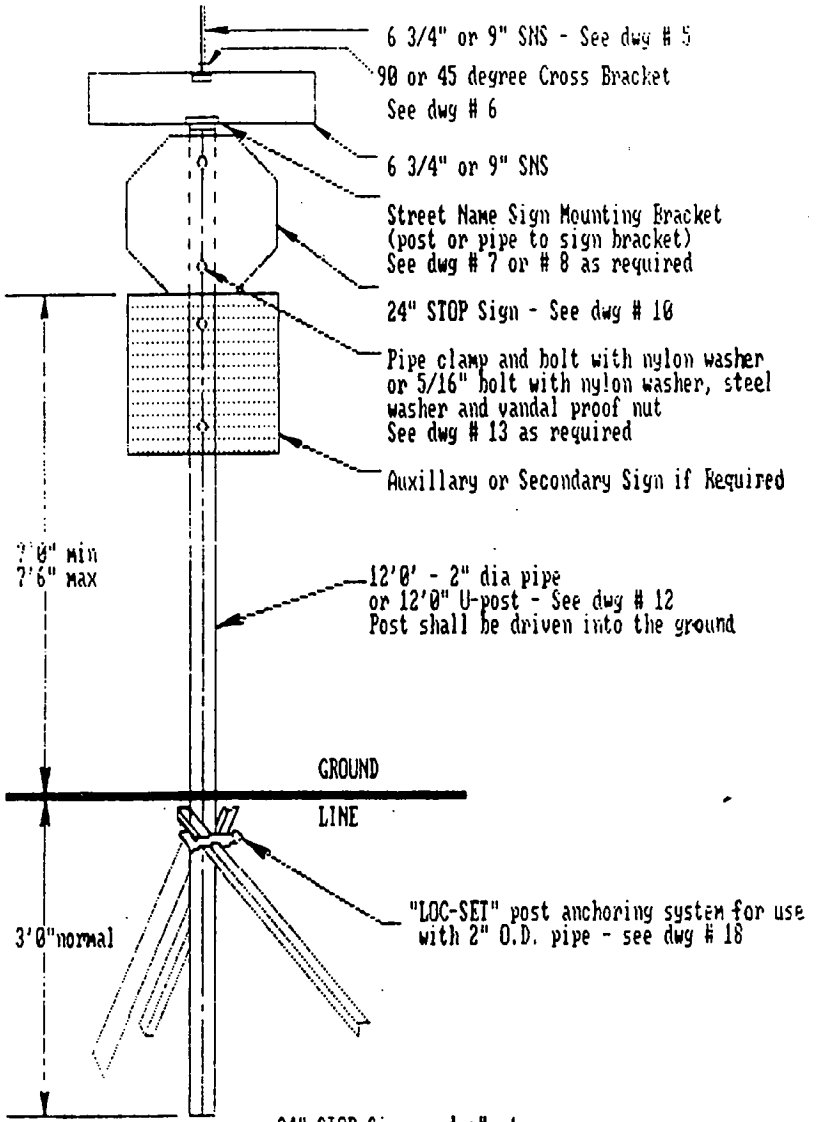
For bid items #1 through #8, these items shall be measured each per completed assembly, regardless of the number of sign panels that may be included in that assembly. In the case of more than one sign assembly included in a single work order, each assembly shall be counted separately.

For bid items #9 and #10, these items shall be measured each per completed hole drilled or post anchoring system installed, as appropriate.

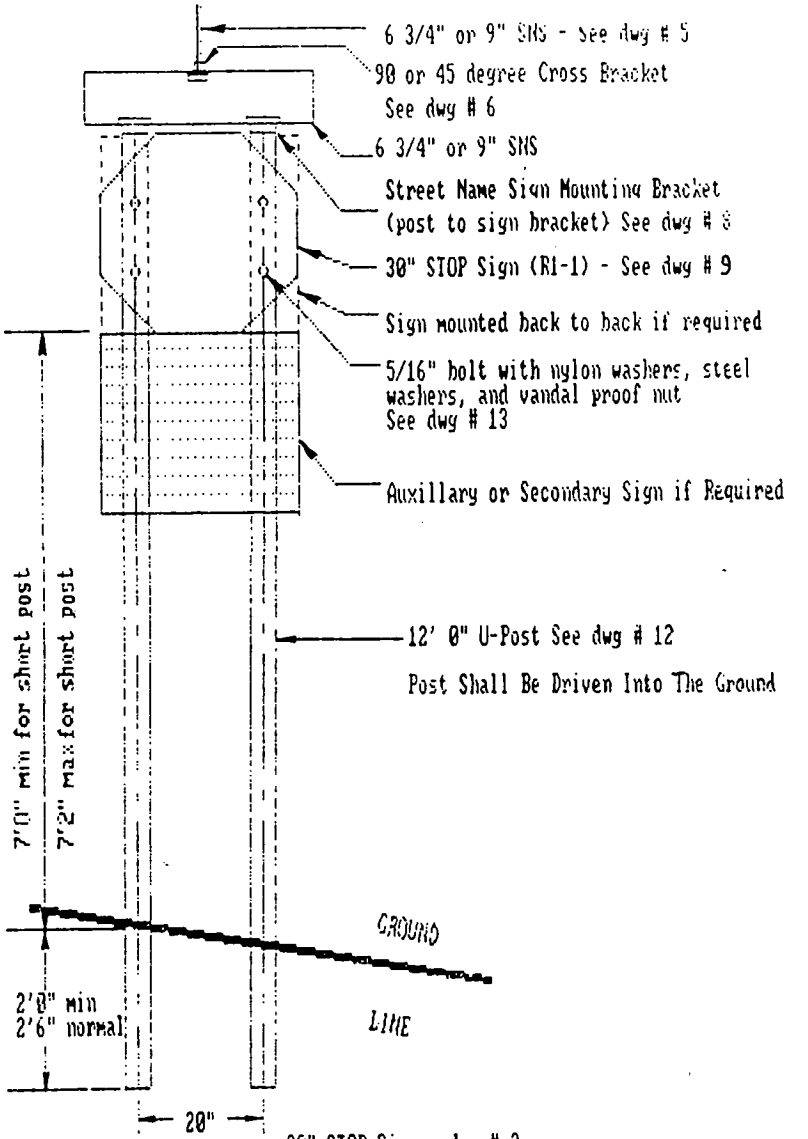
BID ITEMS - BASIS OF PAYMENT

Work completed and accepted by the Engineer will be paid for at the contract unit price of each item, which price shall be full compensation for all labor, tools, equipment, maintenance of traffic, and incidentals necessary to complete the work.

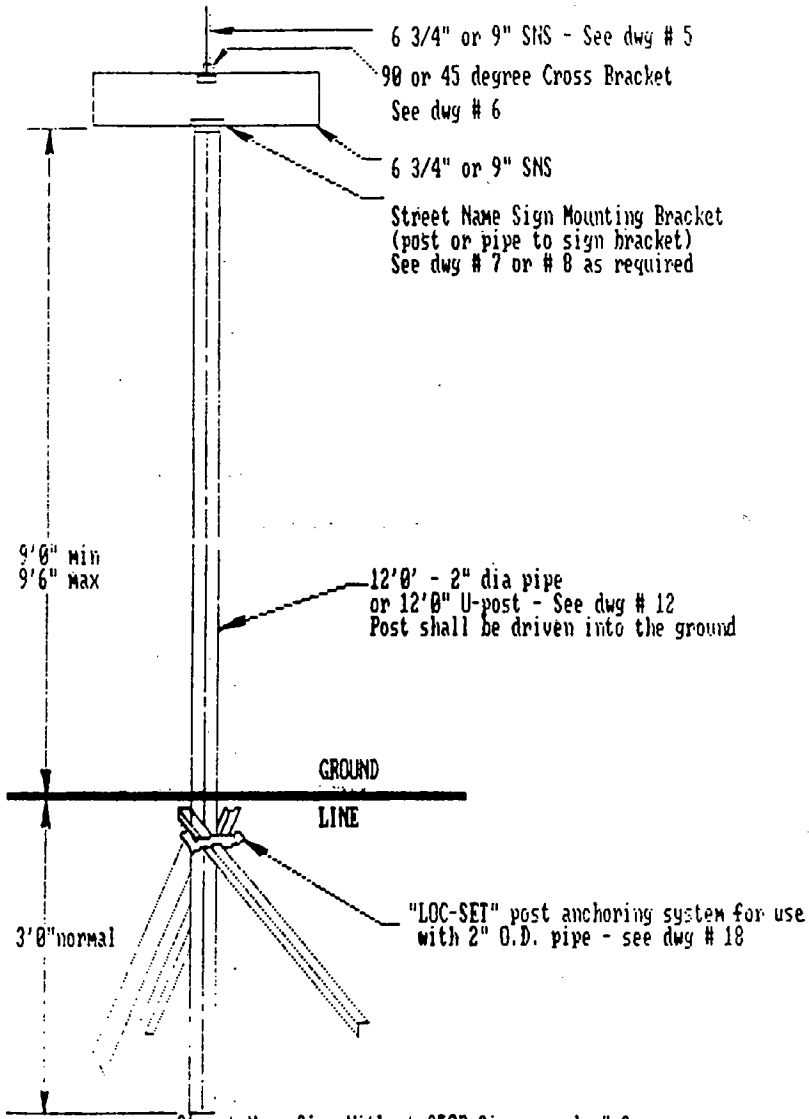
LIST OF DRAWINGS



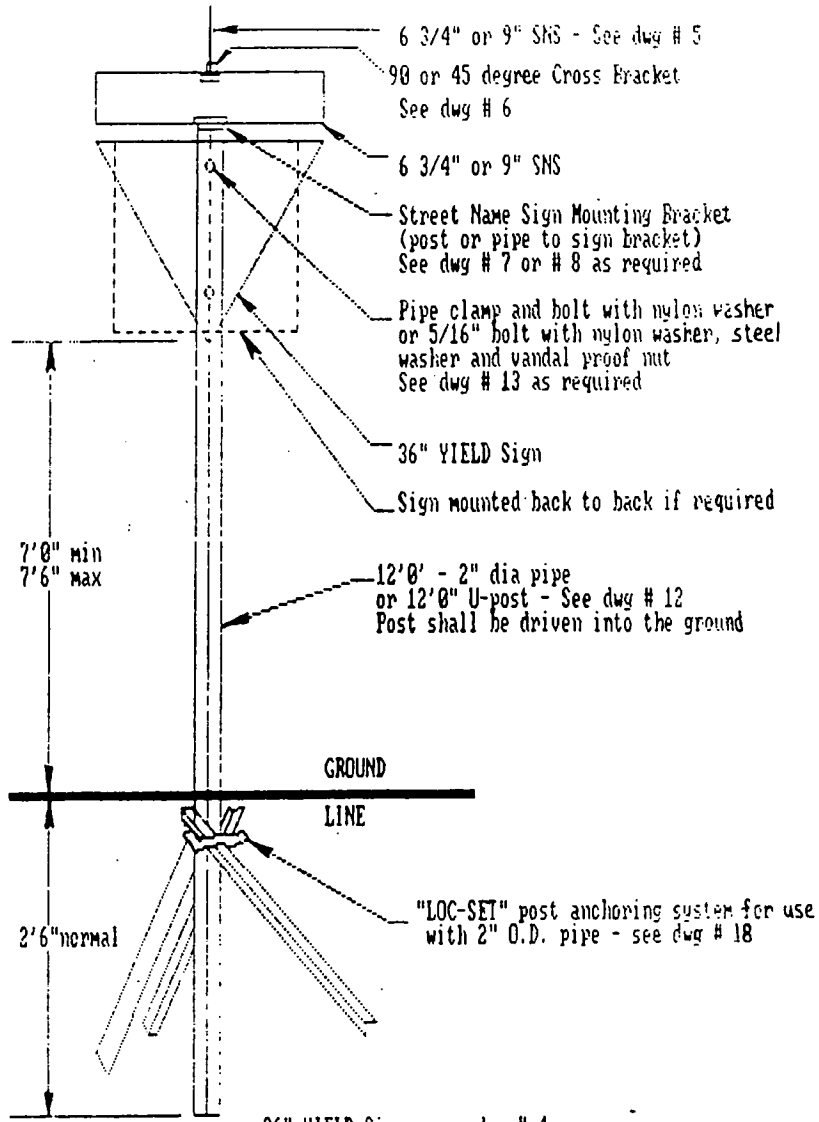
24" STOP Sign dwg# 1



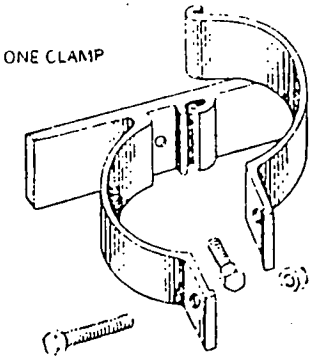
30" STOP Sign dwg # 2

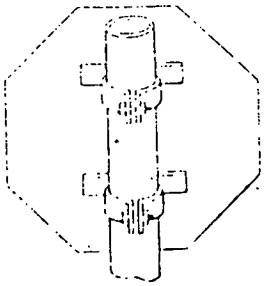


Street Name Sign Without STOP Sign dwg# 3

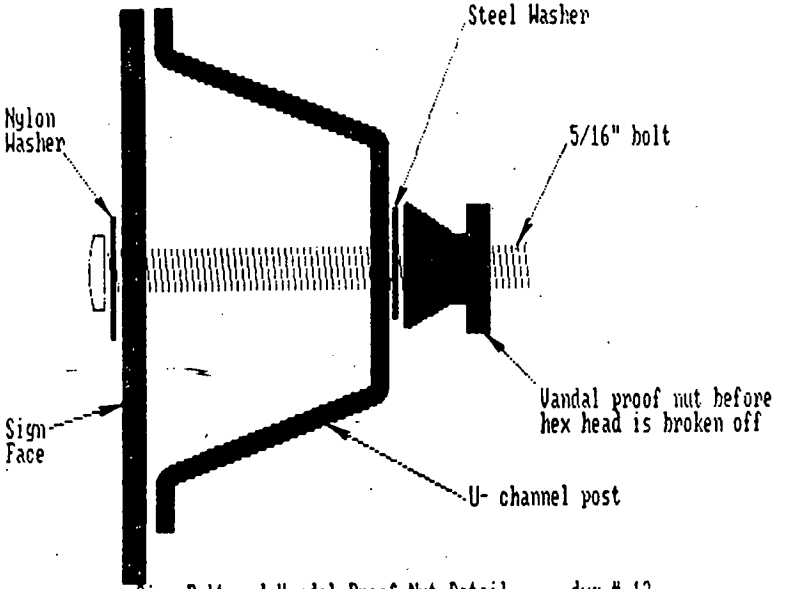


36" YIELD Sign dwg # 4



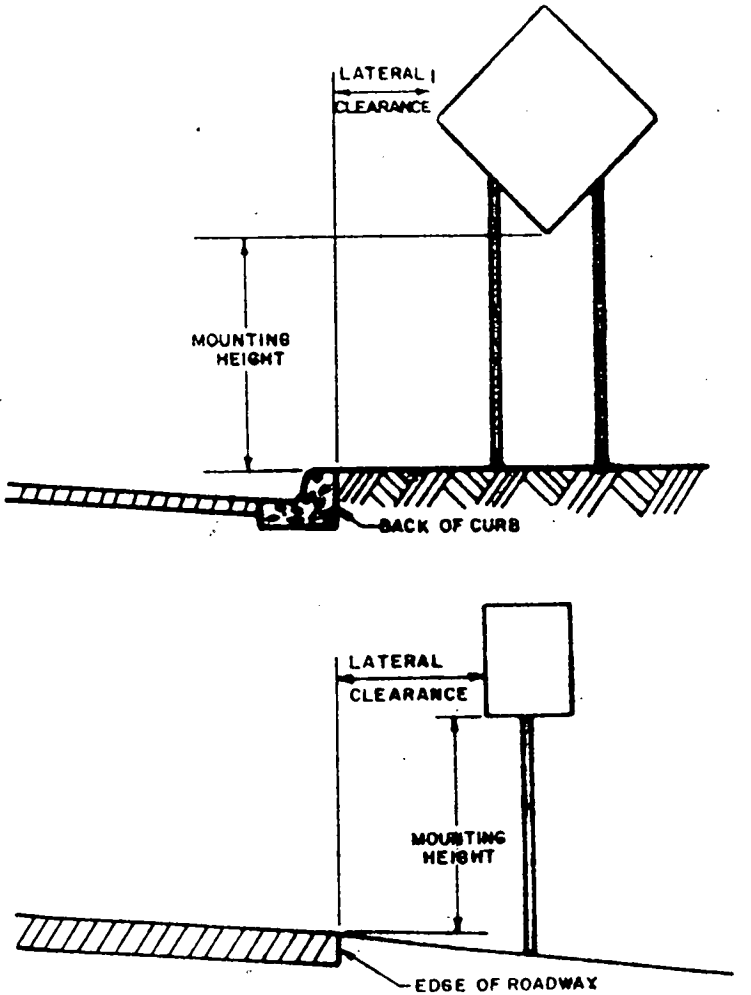


ONE SET: TWO CLAMPS

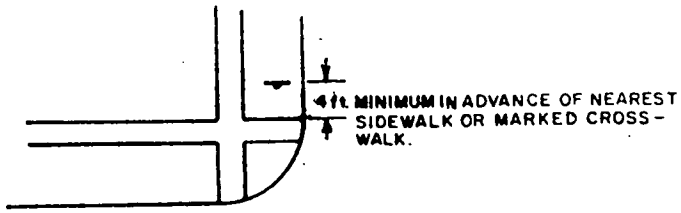


Sign Bolt and Vandal Proof Nut Detail dwg # 13

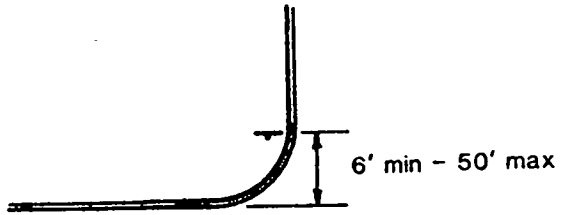
LATERAL CLEARANCE AND MOUNTING HEIGHTS DEFINED GRAPHICALLY



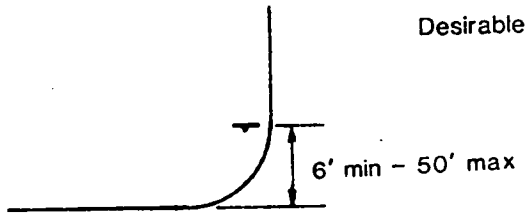
TYPICAL STOP SIGN INSTALLATIONS



WITH SIDEWALK(S) AND WITH OR WITHOUT CURB AND GUTTER



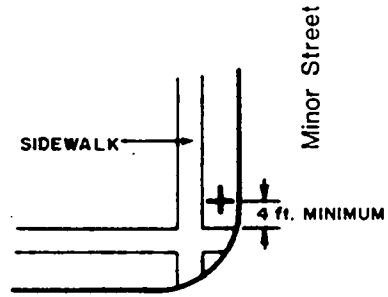
WITH CURB AND GUTTER ONLY



WITHOUT SIDEWALK(S) AND CURB AND GUTTER

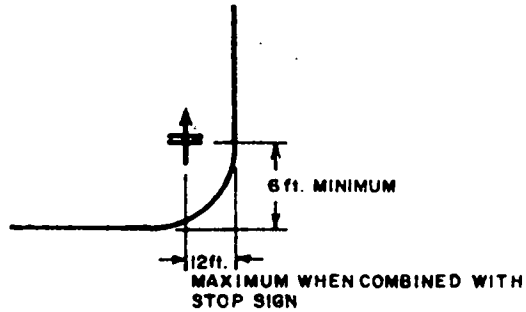
dwg # 15

TYPICAL STREET NAME SIGN INSTALLATIONS



Major Street

Desirable 20' - 30' from extended curb



dwg # 16

COMMON ABBREVIATIONS FOR SIGN AND SNS WORK ORDERS

Item	Abbreviation
Back to Back	B/B or b/b
Combine With	C/W
Do Not Enter	DNE
Fabricate	Fab
Install (New)	N
Minimum	MIN or min
Relocate	REL
Remove	REM
Repair	REP
Replace	R
Standard	STD or std
Street Name Sign	SNS
Traffic Order	TO (#)
Truck Traffic Order	TTO (#)
Work Order	WO

dwg # 17

STREET NAME SIGN WORK ORDER

Issued By:_____ Traffic Operations Section Division of Traffic Engineering Work Order ☐-☐

Requested By:_____ Date:__/__/__

Area _____ Computer Logged ☐

Bill Required ☐ PRIORITY: ☐ By ☐ On Date:__/__/__ Approved By:_____

Bill TO:_____ _____ Date:__/__/__

Intersection/Location:_____

(And/At/Between)_____

(And)_____ Map Ref:_____

Sketch attached ☐ reversed ☐ Coordinate w/ W.O. sign ☐ signal ☐ ☐-☐ SNS marking ☐ Field Checked By:_____ Date:__/__/__ Time:_____

CODES: Project location or C.I.P._____ Material_____ Labor_____

QTY	Length	6"	9"	18"	(For Fab. ONLY) STREET NAME (Caps OR u.c./l.c. as required)	SUFFIX

max. letters for 9" SNS

Function		Support	OK	N or R	Comb w/STOP	OK	N or R
New		Pipe			Pipe		
R		SPM			1 Upost		
Rep		LPM			2 Upost		
Rel		T-Post					
Rem							

Compressor ☐ COMMENTS:_____

STREET NAME SIGNS

QTY	6"	9"	18"	Length

VEHICLES: Step Van ☐ Other_____

Fab By:_____ Date:__/__/__

COMMENTS:_____

HARDWARE

12' Upost	_____	Sign Bolts	_____
2" pipe	_____	Lag Bolts	_____
Cups	_____	Clamps	_____
Crosses	_____	Banding 18"	_____
Trisets	_____	Banding 26"	_____
Upost Cap	_____	Banding 44"	_____
Wing Bracket	_____	Other	_____

COMPLETED BY:_____

Date: __/__/__ TIME:__:__ a.m. p.m.

HOURS WORKED REG_____hrs OTP_____hrs

REMOVED BY:_____

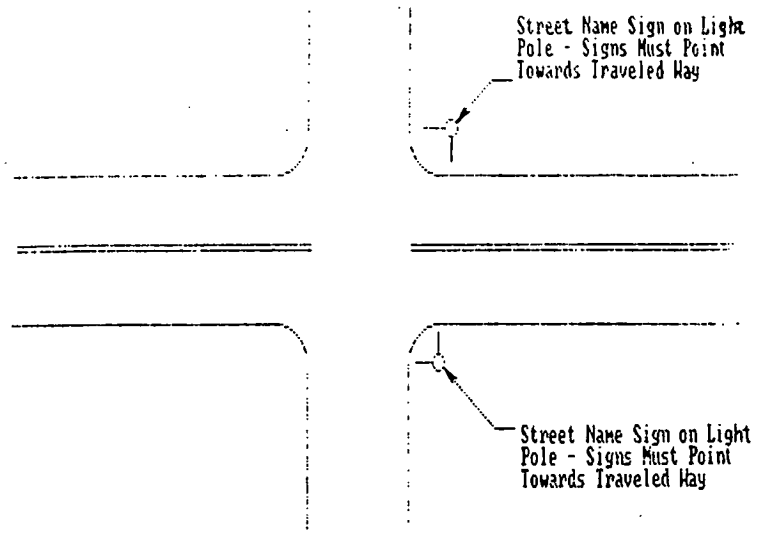
Date: __/__/__ TIME:__:__ a.m. p.m.

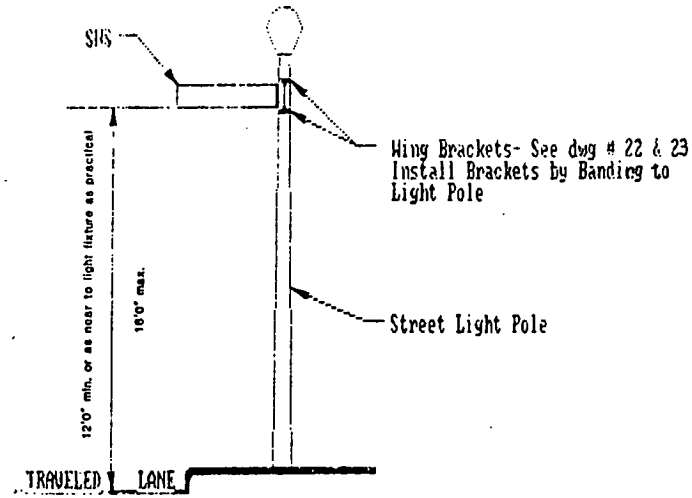
Checked By:_____

Date: __/__/__ TIME:__:__ a.m. p.m.

Completion Logged on Computer ☐

dwg # 19





SNS on Light Pole dwg # 21

INSTALLATION AND REPAIR OF STREET NAME SIGN AND TRAFFIC SIGN ASSEMBLIES

QUOTATION SHEET

Item #	Estimated Annual Quantity	Description	Unit Price	Amount
1	150 Each	Install Street Name Sign Assembly With Single Post	35.00	5,250.00
2	100 Each	Install Traffic Sign Assembly With Single Post	35.00	3,500.00
3	100 Each	Install Combined Street Name Sign/Traffic Sign Assembly With Single Post	38.00	3,800.00
4	300 Each	Install Traffic Sign Assembly With Two Posts	45.00	13,500.00
5	500 Each	Install Combined Street Name Sign/Traffic Sign Assembly With Two Posts	48.00	24,000.00
6	200 Each	Install Street Name Sign Assembly on Existing Streetlight Pole, Utility Pole, or Signal Pole	18.00	3,600.00
7	200 Each	Repair, Replace, or Modify Existing Sign Assembly on Existing Post or Posts	15.00	3,000.00
8	100 Each	Repair, Replace, Remove, or Modify Existing Sign Assembly and Add, Remove, or Replace Post or Posts	37.00	3,700.00
9	75 Each	Drill Hole for Post in Concrete	70.00	5,250.00
10	100 Each	Install Lock-Set Post Anchoring System	50.00	5,000.00
		TOTAL AMOUNT:		70,600.00

APPENDIX B

SAMPLE WORK ORDER FORMS

CITY OF GRAND RAPIDS — SIGN WORK ORDER — TRANSPORTATION DEPARTMENT

SIGN LOCATION
Road Name _____
From Street _____
To Street _____
Street Address _____

SIGN IDENTIFICATION
Sign Type _____
Sign Type ID Number _____ – _____

REFLECTIVITY TYPE: New ____ Used ____
(1) Eng. Grade ____ (2) Paint ____ (3) High Intens. ____
(4) Illuminated ____ (5) Other _____

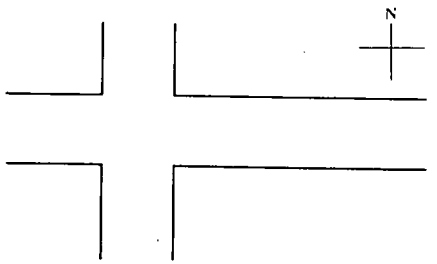
SUPPORT TYPE: New ____ Used ____
(1) Post ____ (2) Telspar ____ (3) Light Pole ____
(4) Utility Post ____ (5) Other _____

ACTION:
(1) Install sign ____ (2) Install sign/and support ____
(3) Replace sign ____ (4) Repair sign ____
(5) Replace support ____ (6) Repair support ____
(7) Replace sign/support ____ (8) Repair sign/support ____
(9) Remove sign/support ____ (10) Remove sign ____
(11) Remove support ____ (12) Other _____

REASON:
(1) Authorized ____ (2) Petition ____ (3) Accident ____
(4) Deterioration ____ (5) Missing ____ (6) Vandalism ____
(7) Other _____

Work Order Number _____
Approved By _____
Date _____

Special Instructions
_____
_____
_____
_____
_____
_____



Completion Date _____ Time _____
By Crew _____

CITY OF SAGINAW
TRAFFIC ENG. DIVISION
WORK ORDER

ISSUED BY _____ W.O. NO. _____
DIST ____ BLK. CD ____ FACE ____ STREET TYPE ____
DATE _____ TIME _____ EXISTING SIGN NO. _____

REPAIR ( ) REPLACE ( ) INSTALL ( ) CODE NO.
LOCATION AND MISC. INFORMATION
DISTANCE

ELIMINATED ( ) MOVED ( ) REMAINED ( ) NEW ( )
NEW SIGN NO. _____ UNIFORM, YES ( ) , NO ( )
NEW SIGN SIZE ___ X ___ FACE TYPE ___ BACK TYPE ___
ASSEMBLY , YES( ) NO( ), NO. OF SIGNS IN ASSEMBLY _____
POST TYPE _____ NO. OF POSTS _____
SIZE OF SIGN REPLACED ___ X ____ BTM HEIGHT _____
BOTTOM HEIGHT OF NEW SIGN ASSEMBLY _____
NEW POLE DISTANCE IN FROM CURB _____

XXXXXXXXXX COMPLETION DATA XXXXXXXXXX
DATE __ / __ / ____ TIME _____ BY _____
EQUIPMENT USED _____
MATERIAL _____
TOTAL MAN HOURS _____

102

Nº 85 2946

WORK ORDER

FOR SIGNAL CONSTRUCTION AND SIGN MAINTENANCE

DIVISION OF TRAFFIC ENGINEERING

DEPARTMENT OF TRANSPORTATION

CITY OF INDIANAPOLIS

LOCATION:

ITEM	CHECK	No.	DESCRIPTION
ERECT			
REPAIR			
REMOVE			
REPLACE			
RELOCATE			
OTHER			

REMARKS

WORK AUTHORIZED DATE

WORK ORDER BY:

WORK COMPLETED BY:

DEPARTMENT OF TRANSPORTATION

TRAFFIC ENGINEERING DIVISION

WORK SHEET

DATE

LOCATION

CODE	STOP NEW	STOP USED	YIELD NEW	YIELD USED	ALL WARNING SIGNS NEW	ALL WARNING SIGNS USED	PARKING SIGNS NEW	PARKING SIGNS USED	ALL OTHERS NEW	ALL OTHERS USED	U-IRON NEW	U-IRON USED	STREET NAME NEW	STREET NAME USED
REPAIRED														
ERECTED														
REPLACED														
RELOCATED														
REMOVED														
TEMPORARY INSTALLATION														

REMARKS

WORK ORDER

OWN INITIATIVE

FROM SIGN CREW FOREMAN

FROM DISPATCHER

TRUCK FOREMAN

SIGN INSTALLATION & REPAIR LOG

TRUCK _____ DATE _____

FOREMAN _____ MILEAGE _____ OUT _____ IN _____

HELPER _____ GASOLINE GAL. _____ OIL QT. _____

TIME OUT SERVICE	TIME IN SERVICE	LOCATION	WORK PERFORMED	ORDERED

DuPage County Highway Department

SIGN WORKSHEET

County Highway _____ Time _____ Date _____ BY _____

Location _____

Sign _____

Work Needed

- ☐ KNOCKDOWN (RE-ERECT)
- ☐ STRAIGHTEN (SIGN/POST)
- ☐ REPLACE (SIGN/POST)
- ☐ REMOVE (SIGN/POST)
- ☐ NEW INSTALLATION
- ☐ CUT BRUSH
- ☐ CLEAN SIGN FACE
- ☐ MOVE SIGN
- ☐ BOLTS REPLACED
- ☐ BAND
- ☐ OTHER _____
- ☐ DETOUR (TURN PLATES AROUND)

WORK CREW

TRUCK NUMBER _____ DRIVER _____

TIME _____ HELPERS _____

DATE REPAIRED _____ WEATHER _____

REPAIR ACTION _____ SIDE OF STREET N S E W M
(NORTH, SOUTH, EAST, WEST, MEDIAN)

TYPE OF AREA R U
(RURAL OR URBAN)

SIGN FACING N S E W
(NORTH, SOUTH, EAST, WEST)

SIGN _____

COLOR B/W B/Y W/G
(RED, WHITE, BLUE, GREEN, YELLOW, BLACK, BROWN)

SIZE OF SIGN _____
(WIDTH X LENGTH)

BACKING MATERIAL A S
(ALUMINUM, STEEL)

SURFACE MATERIAL E H
(ENGR., H.I.)

TYPE OF POST GC PC TE GP TS LP W4
(GALV. CHANNEL, PAINTED CHANNEL, TELESPAR, GALV. PIPE, TRAFFIC SIGNAL, LIGHT POLE, WOOD 4x4)

NUMBER OF SIGN IN ASSEMBLY 1/1 1/2 2/2

NUMBER OF POSTS 1 2

UTILITY CLEARANCE

GAS _____

TELEPHONE _____

ELECTRIC _____

OTHER _____

MATERIALS USED

NEW SIGN FACE ( )

NEW POST (S) ( ) - 10' 11' 12' 13' 14'

CITY OF DEARBORN — ENGINEERING DIVISION
TRAFFIC SIGN WORK ORDER

ZONE:

STREET CLASS:

REQUEST DESC:

BY:

DATE:

PRIORITY:

MAIN STREET:

SIGN NUMBER:

N, E, S, W, O (OVERHEAD), C (CENTER), I (ISLAND)

DISTANCE (FT.) FROM CROSS ST.:	DIRECTION FROM CROSS ST.:	CROSS STREET	SIDE OF STREET	DIRECTION OF TRAFFIC	SIGN TYPE / CODE:

SIGN SIZE	FACE TYPE	SUPPORT TYPE			DATE OF WORK
WIDTH HT	(1) PAINTED (2) ENGINEER (3) HI-INTENS.	(1) CHANNEL (2) SQ.POST (8) OTHER (3) PIPE (9) UNKNOWN (4) UTILITY	(1) INSTALL (4) REMOVE (2) REPLACE (5) NONE (3) REPAIR (6) UNKNOWN SIGN WORK POST WORK		

2 LB. CHANNEL	3 LB. CHANNEL	1¾ IN. SQ. POST	2 INCH SQ. POST	BACK PLATES	SIGN BRACKETS	REASON:	(1) ROUTINE MAINT. (2) NEW INSTALLATION (3) MISSING/STOLEN (4) ACCIDENT (5) VANDALISM

COMMENTS:

DONE BY:

Section No. _____

District No. _____

ROCHESTER HILLS TRAFFIC-SAFETY DEPARTMENT SIGN INSTALLATION AND REPAIR

CITY/TWP: _____ CHARGE: _____

Sign Number [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14]

Road Type: State Trunkline (1), Primary (2), Local (3), Sublocal (4), City (5) _____ [15] [16] [17] [18]

On _____ [19] [20] [21] [22] [23] [24] [25] [26] [27] Feet N(1), E(2), S(3), W(4) [28] [29] [30] [31] [32] [33]

Of _____ [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45]

On The N(1), E(2), S(3), W(4), Overhead (5), Centerline (6), Island (7) Side [46] [47]

Facing N(1), E(2), S(3), W(4) _____

WORK SCHEDULED: _____

REASON FOR WORK: New Installation (1), General Maintenance (2), Relocation (3), Vandalism (4), Accident Damage (5), Contractor/Construction Damage (6) _____ [48]

SIGN TYPE: _____ Code: [49] [50] [51] [52] [53] [54] Size [55] [56] [57] [58] [59] [60] X

FACE TYPE: Reflectorized (2), High Intensity (3) _____ [61]

SIGN BLANK: Aluminum (1), Plywood (2), Plastic (3)

POST TYPE: U-Channel (Painted) (1), U-Channel (Galv.) (2), Breakaway (3), Span Wire (4), Pipe (5), Utility Pole (6), Telespar (7), Wood (8), Other (9) _____ [62]

SIGN WORK: Install (1), Replace (2), Repair (3), Remove (4), Clear Brush (6)

POST WORK: Install (1), Replace (2), Repair (3), Remove (4)

Order Approved By _____ Date ___/___/___

WORK PERFORMED:

ASSIGNED TO: Crew Leader _____ Class _____

Helper _____ Class _____

Date Work Completed [63] [64] : [65] [66] : [67] [68] Time: _____ AM/PM

Equip. # _____ [69] [70]

SIGN WORK: Installed(1), Replaced(2), Repaired(3), Removed(4), No Work Required(5), Cleared Brush(6) _____

POST WORK: Installed(1), Replaced(2), Repaired(3), Removed(4), No Work Required(5) _____

Number of Posts _____ and length of each _____

Bottom Height of Sign _____ Number of Signs in Assembly: _____

Lateral Placement _____

Comments _____

White—Engineering Pink—Operations Gold—Miss Dig FORM #592-16

CITY OF SOUTHFIELD TRAFFIC ENGINEERING DEPT.

SIGN WORK ORDER

ENGINEERING OFFICE

WORK ORDER NUMBER _____ ASSIGNMENT DATE _____

SIGN NUMBER ☐☐☐☐☐☐☐☐ ASSIGNED TO _____

LOCATION: _____ , ☐☐☐☐ FEET N___, E___, S___, W___ ☐

OF _____. NUM. ☐☐☐☐ ON THE N___, E___, S___, W___SIDE ☐

FACING N___, E___, S___, W___ ☐

WORK TYPE: _____

_____

_____

SIGN TYPE _____ POST TYPE _____

SIGN CODE ☐☐☐☐☐

INSTALL (1)_____ INSTALL (1)_____
REPLACE (2)_____ REPLACE (2)_____
REPAIR (3)_____ ☐ REPAIR (3)_____ ☐
REMOVE (4)_____ REMOVE (4)_____

WORK ORDER APPROVED_____
DISAPPROVED_____ BY _____ DATE _____

SIGN CREW

DATE WORK COMPLETED ☐☐-☐☐-☐☐

MATERIAL USED:
SIGN SIZE_____
FACE TYPE. REFLECTORIZED (1)_____ HIGH INTENSITY (2)_____ ☐

POST TYPE, U-CHANNEL (1)_____ PIPE (2)_____
UTILITY POLE (3)_____ TELESPAR (4)_____ ☐
POST LENGTH_____

BOTTOM HEIGHT OF SIGN_____ EQUIPMENT USED _____

LATERAL PLACEMENT_____ TIME TO COMPLETE _____

NUMBER OF SIGNS THIS ASSEMBLY ☐☐ NO. OF MEN IN CREW _____

LOCATION AND DIRECTION IF DIFFERENT FROM ABOVE _____

_____

COMMENTS _____

CREW LEADER _____

TRAFFIC SIGN WORK ORDER

Traffic Operations Section
Division of Traffic Engineering

Issued By: _____
Requested By: _____
T.O. # _____
Bill Required ☐
Bill TO: _____

Area _____
PRIORITY: ☐ By ☐ On ☐ Remove Date: ___/___/___

Work Order ☐-☐☐☐☐
Date: ___/___/___
Computer Logged ☐
Checked By: _____
Date: ___/___/___
Approved By: _____
Date: ___/___/___

Intersection/Location: _____
(And/At/Between) _____
(And) _____ Map Ref: _____
Sketch attached ☐ reverse ☐ Coordinate w/ W.O. ☐☐☐☐ sign ☐ SNS signal ☐ marking ☐ Field Checked By: _____ Date: ___/___/___ Time: _____

CODES: Project location or C.I.P._____
Material_____
Labor_____

FUNCTION	QTY.	SIGNS - (type - message - etc)	SIZE	POSTS QTY.	POSTS TYPE	FAB NO.

Hilti Gun ☐
Compressor ☐
COMMENTS: _____

SIGNS

QTY	FAB	TYPE	SIZE

FAB BY_____ Date: ___/___/___

HARDWARE

12' Upost	_____	Sign Bolts	_____
11' Upost	_____	Lag Bolts	_____
10' Upost	_____	Clamps	_____
8' Upost	_____	Banding	_____
2" pipe	_____	Rivets	_____
Break-away	_____	Nylon Washers	_____
Trisets	_____	Chevron Bracket	_____
Flex Posts	_____	Other	_____

COMMENTS: _____
_____
_____

CHECKED BY: _____ Date: ___/___/___
TIME: ____:____ a.m. p.m.

COMPLETED BY: _____
Date: ___/___/___ TIME: ____:____ a.m. p.m.
HOURS WORKED REG_____hrs OTP_____hrs
REMOVED BY: _____
Date: ___/___/___ TIME: ____:____ a.m. p.m.
Completion Logged on Computer ☐

STREET NAME SIGN WORK ORDER

Issued By:_____ Work Order ☐-☐

Requested By:_____ Traffic Operations Section
Division of Traffic Engineering Date:___/___/___

Area _____ Computer Logged ☐

Bill Required ☐ PRIORITY: ☐ By Approved By:_____

Bill TO:_____ ☐ On Date:___/___/___ Date:___/___/___

Intersection/Location:_____

(And/At/Between)_____

(And)_____ Map Ref:_____

Sketch attached ☐ reversed ☐ Coordinate w/ W.O. ☐-☐ Field Checked By:_____

sign ☐ SNS ☐ signal ☐ marking ☐ Date:___/___/___ Time:_____

CODES: Project location or C.I.P._____
Material_____
Labor_____

QTY	Length	6"	9"	18"	(For Fab. ONLY) STREET NAME (Caps OR u.c./l.c. as required)	SUFFIX

max. letters for 9" SNS

Function		Support	OK	N or R	Comb w/STOP	OK	N or R
New		Pipe			Pipe		
R		SPM			1 Upost		
Rep		LPM			2 Upost		
Rel		T-Pole					
Rem							

Compressor ☐ COMMENTS:_____

_____

_____

STREET NAME SIGNS

QTY	6"	9"	18"	Length

VEHICLES

Step Van ☐

Other_____

HARDWARE

12' Upost	_____	Sign Bolts	_____
2" pipe	_____	Lag Bolts	_____
Cups	_____	Clamps	_____
Crosses	_____	Banding 18"	_____
Trisets	_____	Banding 26"	_____
Upost Cap	_____	Banding 44"	_____
Wing Bracket	_____	Other	_____

Fab By:_____ Date:___/___/___

COMMENTS:_____

_____

_____

_____

_____

_____

_____

_____

COMPLETED BY:_____

Date: ___/___/___ TIME:___:___ a.m. p.m.

HOURS WORKED REG_____hrs OTP_____hrs

REMOVED BY:_____

Date: ___/___/___ TIME:___:___ a.m. p.m.

Checked By:_____

Date: ___/___/___ TIME:___:___ a.m. p.m.

Completion Logged on Computer ☐

TRUCK NO. #	RT HI	LT ENG.	TECH II	RT HI	LT ENG.
REVERSE TURN			SPEED LIMIT 30		
REVERSE CREVE			SPEED LIMIT 35		
TURN			SPEED LIMIT 40		
CREVE			SPEED LIMIT 45		
TRANSITION			WEIGHT LIMIT 5		
LANE END			WEIGHT LIMIT 10		
BRIDGE MARKER			WEIGHT LIMIT 11,000		
ONE WAY			R 1		
NO TURN			YIELD		
DEAD END			OTHERS		
NO OUTLET					
STOP AHEAD					
DO NOT ENTER					
ONE LANE BRIDGE					
NARROW BRIDGE					
(P)					
NPAT					
NPTS					
NPHTC					
NSOS					

APPENDIX C

SIGN FOREMAN'S MANUAL

Chapter I

INTRODUCTION

1.1 TORT LIABILITY

The Commonwealth lost sovereign immunity in 1978. One effect of this action is that it allows individuals to seek retribution through the legal system for personal injury damages associated with conditions along our highways. As a result, the Department spent $25 million on tort claims during 1985.

Signing deficiencies are one of the most predominate type of conditions cited in legal actions against the Commonwealth. The most common types of sign deficiencies are the absence of a necessary sign, especially a regulatory or warning sign, or a sign placement that can not be readily seen because of foliage or another obstruction. Both of these conditions can be corrected by an efficient sign crew. Therefore, the efficiency of a sign crew has an effect on the number of legal actions taken against the Department.

Signs are essential when special regulations apply at specific places or at specific times, or when hazards are not self-evident. They also give information as to highway routes, directions, destinations and points of interest. Signs are especially helpful for the unfamiliar driver who is unacquainted with the highway and the area, and as such, they convey a message to the driver that should result in the orderly and predictable movement of traffic.

The sign foreman should insure that correct signs are properly placed and visible both day and night and are located to give the driver ample time to respond to the sign message. When properly installed signs make a significant safety contribution to the highway system and should be maintained or replaced as required.

1.2 PURPOSE

The mission of the Department's signing program is "to erect and maintain the appropriate regulatory, warning and guide signs for the safe and efficient operation of the highway transportation system".

This manual has been prepared as a tool to be used by the sign foreman and sign crew to obtain, install and maintain traffic signs in order to fulfill the mission of the Department's signing program. It should be used as a supplement to and in conjunction with Publication 111 (Traffic Standards).

Current policies applicable to sign functions have been incorporated into this manual. It is the responsibility of the District Traffic unit and the holder of this manual to keep it current and up-to-date as future changes are issued.

1.3 DEFINITIONS

The following terms shall have the meanings when used in this manual:

- Accessories -- Posts, bolts, nuts, washers, rivets, brackets, straps, shims, stiffeners and miscellaneous hardware used to install signs.
- Breakaway sign post -- A post designed to separate or break from its base when impacted in order to reduce the damage to the impacting vehicle.
- Delineators -- Delineators are reflectors used to indicate the alignment of the roadway or to highlight a roadside obstacle.
- Foundation -- A base for anchoring a sign support.
- May -- Indicates an action that is permissible but not required.
- Reflective sheeting -- A material applied to a sign blank capable of reflecting light back to a light source.
- Roadway -- The portion of the highway designed or ordinarily used for vehicular travel. The shoulder is not part of the roadway.
- Shall -- Indicates that an action is required or prohibited.
- Should -- Indicates that an action is advisable but not required.
- Sign -- As used herein, an official traffic control device used to convey a message to motorists.
- Sign assembly -- A complete sign installation which includes the foundation, support, sign and accessories.
- Support -- Any device used to support a sign. Examples include a post, bridge, span wire or an overhead sign structure.

Chapter 2

DEPARTMENT AGENCIES AND THEIR RESPONSIBILITIES

2.1 GENERAL

Various organizations within the Department are involved in signing and each have their necessary function and area of responsibility. The flow line of information starts with Department regulations and policies and end with the actual installation and maintenance of the signs.

The various organizations and their relationship are identified in Sections 2.2 through 2.4.

2.2 TRAFFIC ENGINEERING AND OPERATIONS DIVISION

2.2.1 Central Office

The Traffic Engineering and Operations Division is responsible for establishing signing policies and guidelines; developing standards, specifications, and regulations related to signing; developing annual contracts for the purchase of raw materials, sign accessories and work zone traffic-control devices; developing statewide safety programs; monitoring the statewide use and inventory of signs and accessories; and performing quality assurance reviews of sign installations.

2.2.2 Central Sign Shop

The Sign Shop manufactures signs and stocks select sign accessories for distribution to the county maintenance districts. The Sign Shop also calculates sign costs and transfers the materials to the appropriate county by the AIMS terminal. The Sign Shop will attempt to have most signs and sign accessories available within 2 weeks with the balance of all other items, including major guide signs, available within 3 months.

2.3.1 District Traffic Engineering Unit

The Traffic Unit determines the need for sign installations and issues work orders to install new signs and to relocate or remove existing signs. The Traffic Unit also maintains a permanent file of work orders. They prepare maintenance complaint records related to signing and when required, assign priorities or due dates for signing work. The Traffic Unit also provides technical assistance and guidance to the Maintenance Districts in matters related to signing, and may order signs and accessories for the counties.

2.3.2 District Aims Coordinator

The AIMS coordinator is responsible for training and directing county personnel to use the computer to maintain inventory control and sign orders; establishing reorder points and reorder quantities; validating county input data to insure accurate records; and supervising and reporting on all physical inventories.

2.3.3 District Maintenance Unit

The District Maintenance Unit contracts for and has lease arrangements for equipment now owned by the Department. Some of this equipment, such as bucket trucks and auger trucks, may be useful for signing projects.

2.4 COUNTY MAINTENANCE DISTRICT

2.4.1 Administrative Staff

The administrative staff is responsible for the following functions:

- Identifying traffic-control devices that are damaged or in need of repair.
- Preparing complaint records for the routine maintenance of existing signs.
- Maintaining a record of all signs ordered from the Sign Shop.
- Establishing a work schedule for the sign foreman.
- Insuring that the issued work orders are completed in a timely and satisfactory fashion.
- Transporting signing materials from the Sign Shop.
- Providing direction to the sign foreman and to other maintenance foremen for handling minor items on signing such as replacement of missing bolts on signs.
- Inspecting work performed by the sign crew.

2.4.2 Storekeeper

The storekeeper is responsible for:

- Preparing and submitting signing material orders to the Sign Shop.
- Issuing signs and accessories to foremen on an as needed basis.
- Maintaining a functional sign inventory with slip sheeting or foam between all signs. All signs made with Class II reflective sheeting (No Passing Zone Pennants, Hazard Markers, Bridge Clearance Markers and Chevrons) should be stored in a vertical position to prevent the cells from being crushed.

2.4.3 Sign Foreman

The sign foreman is responsible for:

- Removing, relocating, replacing, installing and repairing traffic-control devices.
- Trimming trees and bushes to improve visibility to the traffic-control devices.
- Reporting sign materials and accessories used from inventory to storekeeper.
- Informing the storekeeper or other responsible persons of existing and anticipated material needs.

Chapter 3

TYPES AND PRIORITIZATION OF SIGNS AND MARKERS

3.1 TYPES OF SIGNS

There are three basic types of signs which are identified below:

- Regulatory signs inform the driver of traffic laws or regulations and normally are placed where the regulations apply.
- Warning signs direct the driver's attention to potentially hazardous conditions on or adjacent to the roadway that otherwise would not be readily apparent. Warning signs are normally placed an adequate distance in advance of the condition. The actual advance warning distance should be determined by the normal approach speed and other roadway conditions as well as the availability of space for the sign (see Section 5.2). These factors must be considered so the normal driver has time to comprehend and react to the sign message and take any action necessary to safely pass through or avoid the potential hazard.
- Guide signs provide direction to the driver, including traffic routes, destinations, available services, points of interest, and other geographic, recreational or cultural sites. Guide signs are placed in advance of or at the point where a decision must be made regarding a change in direction of travel.

3.2 MANDATORY TRAFFIC-CONTROL DEVICES

Some traffic-control devices are basically mandated by the Manual on Uniform Traffic Control Devices (MUTCD) published as a national standard by the FHWA, the Department's Regulations for Official Traffic Control Devices (Publication 68), or by Department standards and policies.

Some of the required devices are:

- Center Lane Left Turn Only Signs
- Delineators along the right side of expressways and freeways where fixed-source highway lighting does not exist and along at least one side of interchange ramps.
- Railroad Advance Warning Sign (W10-1) in advance of all at-grade railroad crossings, except: (1) on low-volume, low-speed roadways crossing minor spurs or other tracks which are infrequently used and which are flagged by train crews; (2) in the business districts of large cities where active grade crossing traffic control devices are in use; or (3) where physical conditions do not permit even a partially effective display of the sign.
- Mile Post Markers on Interstate Highways.

3.3 PRIORITIZATION

The prioritization of signing activities by sign types are as follows, beginning with the most important signs:

- Stop, Yield and Do Not Enter signs
- The regulatory signs which protect the integrity of the system, e.g., Weight Limit, Road Closed, Bridge Out, No Trucks, etc.
- Warning signs
- Balance of regulatory signs
- Guide signs
- Motorist service signs, i.e., general motorist service signs, logo signs, hospital signs, State police signs, etc., and tourist-oriented directional signs (signs for colleges, universities, parks, historic sites, etc.)

Chapter 4

SIGN MATERIALS

4.1 TYPES OF SIGN BLANKS AND FACES

4.1.1 Flat Sheet Aluminum Signs

Flat sheet aluminum is the most common type sign blank material and is generally covered with reflective sheeting. Approximately 90 percent of all signs made at the Sign Shop are made from flat sheet aluminum and 90 percent of these have silk-screened messages. Signs larger than 96"x48" are typically made with stiffeners in accordance with Section 4.1.2.

4.1.2 Flat Sheet Aluminum Signs with Stiffeners

Flat sheet aluminum signs with stiffeners are covered with reflective sheeting on the front side and have extruded aluminum stiffeners riveted to the back side. The legend and border is generally demountable button copy or direct applied white Class II reflective sheeting.

This type of sign is illustrated in Figure 4-1 and is normally used only for large guide signs on expressways and freeways. These sign panels should be attached to W-beam steel posts by stainless steel post clips or attached to wood posts by stainless steel buckle straps in accordance with Traffic Standard TC7701S.

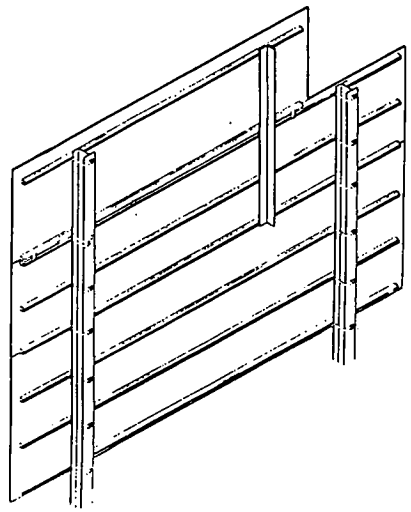


Figure 4-1. FLAT SHEET ALUMINUM SIGN WITH STIFFENERS

4.1.3 Extruded Aluminum Channel Signs

Extruded aluminum channel signs are typically made from 12-inch wide channels (up to two 6-inch wide channels may also be used) placed one on top of the other to form a single sign of the desired height. In the past, the sign face of the panels were coated with nonreflective material, but new signs are now supplied with reflective sheeting. This type of sign is currently not manufactured by the Sign Shop and is therefore not normally installed by Department sign crews. These signs may, however, require routine maintenance. (Traffic Standard TC7701E provides guidance on this type of sign.)

4.1.4 Laminated Panel Signs

Laminated panel signs are composed of a cardboard honeycomb core with thin flat sheet aluminum panels attached to each side. The flat sheet aluminum on the face side is finished with nonreflective porcelain enamel. This type of sign was frequently used for large guide signs prior to 1980, but is being phased out by reflective background signs. Sign crews may, however, be requested to perform routine maintenance on these signs while they are still in service.

4.1.5 Plywood Signs

Small distance and directional signs generally are made of plywood covered with reflective sheeting. The legend and border is generally made of cutout letters and characters from Class II reflective sheeting materials. These signs are supplied by the Sign Shop.

4.1.6 Plastic Signs

Folding plastic signs generally are used by Department personnel for maintenance and protection of traffic. These signs are purchased from a sign manufacturer and made available through the Sign Shop.

4.1.7 Fiberglass Signs

The Department is currently experimenting with fiberglass signs as a potential replacement for aluminum signs. They can be used with or without stiffeners.

4.2 IDENTIFICATION OF SHEETING MATERIALS AND TIME OF MANUFACTURE

Each sign manufactured at the Sign Shop has codes to identify the manufacturer and class of reflective sheeting, and the year and quarter of the year that the sign was made. For silk-screened signs, this information is typically screened on the lower part of the signs. These symbols are small and inconspicuous, and may even look like dirt.

The code for the year is the last two digits of the year, e.g., 85, 86, 87, etc., (prior to 1980, only the last digit was used) and the letter A, B, C or D is used for the 1st, 2nd, 3rd or 4th quarter of the year. The type and class of reflective sheeting is identified by the following symbols:

Manufacturer	Class I	Class I-A	Class II
Seibulite	■	■ +	■ II
3M	●	● +	● II
Avery	◆	◆ +	◆ II
Kiwalite	▲	▲ +	▲ II
Morgan	★	★ +	★ II

On signs made with cut-out legend, two pressure-sensitive stickers are applied -- one in the lower left corner for the background material and one in the lower right corner for the legend material. However, unlike the silk-screened signs the symbols that are missing or punched out identify the material and time of manufacture. For your information, an unpunched sticker is illustrated in Figure 4-2. Also, please note that for the stickers, the double-digit year code was first used in 1986.

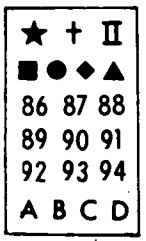


Figure 4-2. IDENTIFICATION STICKER

Chapter 5

GENERAL SIGN INSTALLATION REQUIREMENTS

5.1 SIGN GROUPING

Signs are normally individually erected on separate supports. However, when one sign supplements another and where the installation of two or more signs on the same post or structure will not tend to confuse the drivers, signs should be grouped. Some examples of sign grouping include:

- o Stop and Except Right Turn signs.
- o Stop or Yield signs and One-Way or Turn Restriction signs.
- o Yield and To Oncoming Traffic signs.
- o Stop or Yield signs with Divided Highway Crossing or Divided Highway Sideroad Crossing signs.
- o Intersection warning signs and street or highway name signs.
- o Route marker assemblies and distance directional signs, especially where stop or yield conditions exist.
- o SR or Segment Markers with all types of signs, except markers should not be installed on the same side of the post as a Stop or Yield sign. In addition, when placed on the same side of a post as another sign, the marker should be placed at least 12 inches below the other sign.

Signs that do not fit into the above paragraph (signs requiring different decisions by the driver) should be spaced far enough apart in travel time along the roadway that the driver may respond and make any required decisions safely. Generally a minimum of 200 feet should be maintained between all signs.

5.2 LONGITUDINAL PLACEMENT

The longitudinal location of signs depends on the type of sign, the nature of the message and the desired motorist response. Therefore, the placement should be such that the sign is at the proper location, is within the cone of vision of the intended drivers, and does not block motorist's vision of the road or other signs.

When possible, adequate space should be provided between sign installations to allow the driver time to comprehend the message of one sign before being confronted with another. This spacing requirement is subject to the limitations prescribed for the location of the specific sign, and should normally be taken care of by the District Traffic Unit in the development of the signing plan or sign work order. Slight adjustments in the longitudinal placement may often be made to provide the driver with an unobstructed view without sacraficing the intent of the sign.

Other miscellaneous warning signs that advise of potential hazards but are not related to a specific spot (e.g., Deer Crossing and Soft Shoulder signs) may be installed in the most appropriate locations since they are not covered in Table 5-1.

The effectiveness of the placement of any sign should be tested under both day and night conditions whenever possible.

The longitudinal placement of guide signs is similar to the placement of warning signs. The best location may be found by making the necessary adjustments to provide an unobstructed view of the sign.

5.3 ORIENTATION OF SIGNS

The majority of signs should be installed at approximate right angles to the intended traffic stream. On straight sections of highway it is desirable to angle most signs about 3 degrees toward traffic (20:1 angle from perpendicular). On curves, the sign should be at right angles when the driver is about 250 feet from the sign.

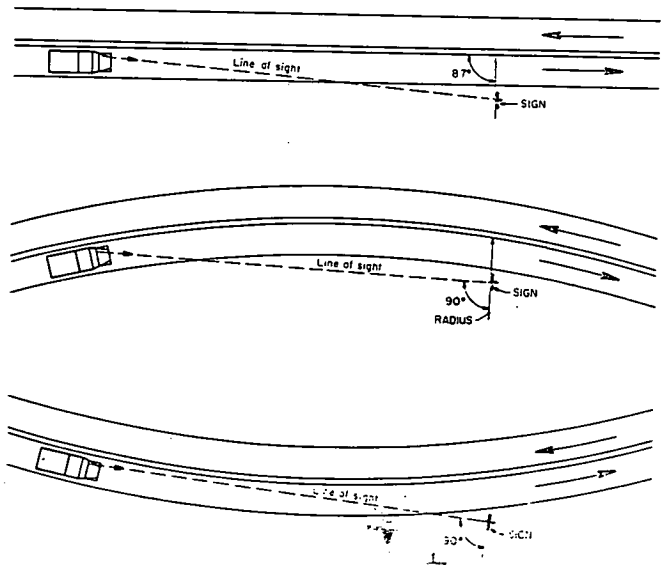


Figure 5-1. NORMAL ORIENTATION OF SIGNS

Large guide signs are fabricated from Class II reflective material and should be oriented at a slight angle away from traffic in order to avoid specular glare which could reduce sign legibility. The suggested orientation is depicted in Figure 5-2. However, on curved sections of highway, specular glare is almost inevitable; therefore, the signs should be perpendicular to the drivers in the right lane when the vehicle is a distance in feet equal to 50 times the height of the smallest legend in inches. (For example, 50 x 12 inch letters equal 600 feet.)

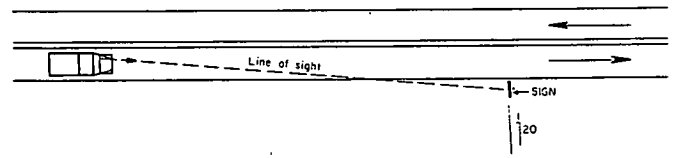


Figure 5-2. ORIENTATION OF LARGE GUIDE SIGNS

5.4 LATERAL CLEARANCE

Signs should be placed as far as practical from the edge of the roadway to reduce the possibility of vehicles hitting the signs.

When guide rail is present, signs should be placed behind the guide rail if possible. The sign crew should discuss sign relocations with the District Traffic Unit if moving a sign is questionable.

An effort should be made to place signs with the following lateral clearances:

- 6 feet from edge of shoulder where possible
- 12 feet from edge of the roadway if no shoulder exists and right-of-way allows
- 2 feet behind guide rail or concrete barrier
- 2 feet behind a curb, except in urban areas a clearance of 1 foot will be permitted when sidewalk width is limited or when existing poles are close to the curb
- 30 feet from the edge of roadway for large major guide signs

Regulatory signs should be located where the regulation applies, thus limiting the adjustment of their location. (See Pub. 68)

Since warning signs are primarily for the protection of the driver who is unacquainted with the road, it is very important that care be given to their placement. Warning signs should provide adequate time for the driver to perceive, identify, and decide, and perform any necessary maneuver -- this total time is typically referred to as PIEV time and can vary from about 3 seconds for general warning signs to 10 seconds for warning signs requiring high-driver judgment.

Table 5-1 lists minimum recommended sign placement distances for three conditions:

- Condition A -- A high-driver judgment condition which requires the driver to use extra time in making and executing a decision because of a complex driving situation; examples include Merge, and Right Lane Ends signs.
- Condition B -- A condition in which the driver will likely be required to stop; examples include Cross Road, Stop Ahead, Signal Ahead, and Pedestrian Crossing signs.
- Condition C -- A condition in which the driver will likely be required to decelerate to a specific speed; examples include Turn, Curve, Divided Road, Hill, and Dip signs.

Table 5-1. ADVANCE WARNING SIGN PLACEMENT

POSTED OR 85TH PERCENTILE SPEED(MPH)	RECOMMENDED MINIMUM WARNING SIGN PLACEMENT DISTANCE (FT.)*						
	CONDITION A HIGH JUDGMENT NEEDED**	CONDITION B STOP CONDITION	CONDITION C DECELERATION CONDITION TO LISTED ADVISORY OR DESIRED SPEED (MPH) AT CONDITION				
			10	20	30	40	50
25	250	--	100				
30	325	100	150	100			
35	400	150	200	175			
40	475	225	275	250	175		
45	550	300	350	300	250		
50	625	375	425	400	325	225	
55	700	450	500	475	400	300	
60	775	550	575	550	500	400	300

* Distances are for level roadways, and should be increased on downgrades. If 48 x 48 inch signs are used, the distance may be reduced by 75 feet.

** Distance provides for 10-second PIEV. In urban areas a supplementary plaque underneath the warning sign should be used specifying the distance to the condition if there is an in-between intersection which might confuse the the driver.

5.5 HEIGHT

Signs on posts should be placed at the minimum height indicated in Figures 5-3 and 5-4. The minimum height is measured from the nearest edge of roadway to the bottom of the sign, except in urban areas the height is measured as indicated. Although a minimum height is specified, the signs may be placed at a greater height to provide better visibility and to eliminate the need to cut posts to the exact height of the sign. A greater height also helps to reduce the amount of vandalism by helping to put the sign out of reach.

5.6 SPECIAL CONSIDERATIONS

5.6.1 Cooperation With Property Owners

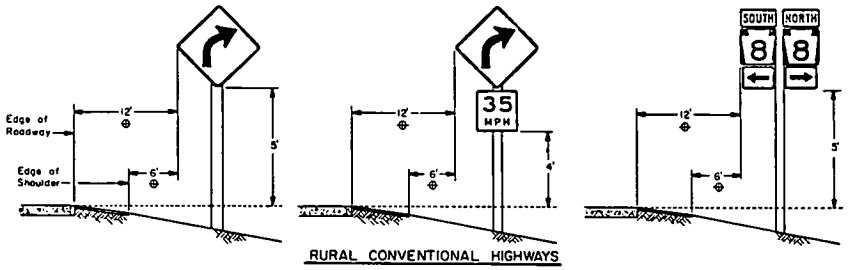
Property owners adjacent to our highways often maintain the right-of-way with the same care as they do their own land. Placement of signs often conflict with the property owners' desires. If a sign can be moved a few feet either way without losing its intended function, every effort should be made to honor the property owner's request. Many times the District Traffic Unit will have already faced and solved this problem; however, the sign crew may be approached with a request from the property owner to relocate a sign. Since the exact placement of some signs is critical, it may be necessary to contact the District Traffic Unit to determine if the sign location can be moved. However, as noted in Section 5.2, in most instances a sign can be moved as much as 20 feet in either direction without effecting the usefulness of the sign.

5.6.2 Underground Utilities

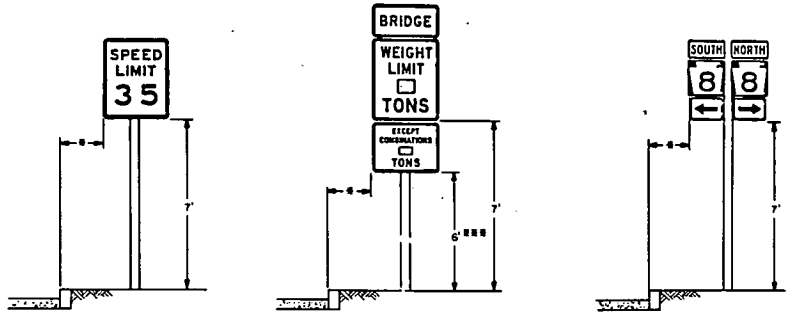
Gas, water, sewer, electric and telephone lines are frequently located underground. Their locations should be marked, but the plaques or markers may have deteriorated or may have been removed by accidents or vandalism. When markings are not present, other clues such as service valves or sub-sided trenchs could indicate the presence of an underground utility. When underground utilities are anticipated, care and consideration should be practiced before deciding to drive a post into the ground. These areas should be avoided for sign installations if at all possible. If a sign must be erected in the vicinity of an underground utility, the utility company should be contacted for the exact location of the utility.

Act 287 was adopted to prevent accidents involving underground utilities. Basically, Act 287 and related Department policy requires the following:

- The County Recorder is required to keep a list of the names and telephone numbers of a contact person for each utility in each municipality.
- Three days before beginning non-emergency work involving the use of powered equipment or explosives for augering, backfilling, blasting, digging, drilling, etc., the Assistant County Maintenance Manager should notify the appropriate utility company by use of the County Recorder's list. As an added convenience, a number of utilities throughout the Commonwealth have developed the "Pennsylvania One Call System". This one toll-free number may be used by Department personnel once it is determined which utilities are located in the scheduled area (see Figure 5-5).



6' & 12' Horizontal where conditions permit

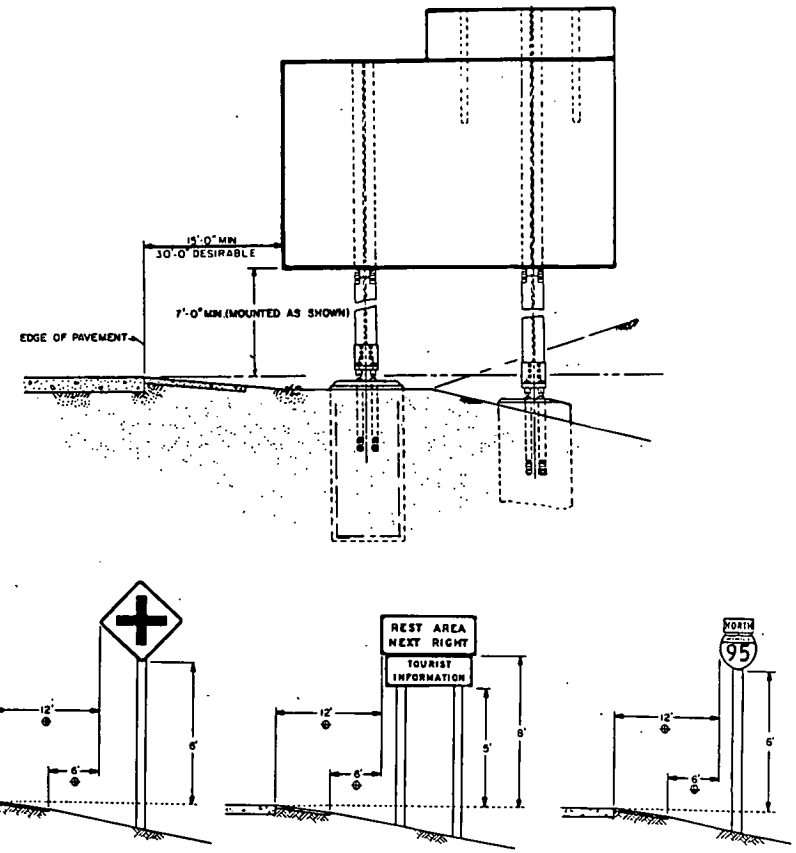


* 2', except 1' is permitted when sidewalk width is limited or when existing post are close to the curb.

*** 7' where pedestrians or walkway exist

⊕ Ideal, However, install within limits of available space

Figure 5-3. HEIGHT AND LATERAL OFFSET OF SIGNS ON CONVENTIONAL HIGHWAYS



⊕ Ideal, however, install within limits of available space

Figure 5-4. HEIGHT AND LATERAL OFFSET OF SIGNS ON EXPRESSWAYS AND FREEWAYS

- Within 2 days, each utility provides the following information: (1) approximate location of the line; (2) what the utility will do to assist; (3) what can be done to prevent damage; and (4) the serial number assigned to the request (the County shall keep a permanent record of requests).

- The Assistant County Maintenance Manager informs the foreman and equipment operator of the necessary information.

- Any leaks, dents, etc., should be reported to the utility company by the person closest to the work. Alert nearby residents in case of an emergency.

Figure 5-5. PENNSYLVANIA ONE CALL SYSTEM

5.6.3 Care in Handling Signs

Signs covered with reflective sheeting are easily damaged by rough handling. In order to protect the sign faces, slip sheeting (a heavy wax paper), thin foam or cardboard is provided to separate signs and to protect the sign face. These separators should be kept against the sign face until the sign is installed.

5.6.4 Dating of Signs as Installed

The back of each sign should be marked with the month, day and year of installation with a permanent type marker. It is recommended that the date be marked prior to attaching to the post, but care should be taken to insure that the marking will not be behind the post when erected. A suggested code system that could be used is as follows:

Initial sign location .....I (I - 1-31-86)

Replacement in kind.....R (R - 1-31-86)

Relocation of sign.....M (M - 1-31-86)

Temporary signs such as No Guide Rail, Low Shoulder, etc., should also be dated and the dates marked off when taken down.

5.7 WORK AREA PROTECTION

Work area protection shall be in accordance with Publication 203, "Work Zone Traffic Control", for the type of roadway and operation involved. Table 5 of Publication 203 (first page in Appendix A), should be especially helpful in determining what traffic control is required.

5.8 DO'S AND DON'TS

- Do install signs plumb and level.

- Do install signs in accordance with the required vertical clearance.

- Do install signs in accordance with the ideal horizontal clearance whenever possible.

- Do remove branches and foliage or other obstacles from blocking the view of all signs.

- Don't place a conflicting regulatory speed limit sign in the near vicinity of a warning sign with an advisory speed plaque.

- Don't install a sign where the view will be blocked by trees, utility poles, or other signs.

- Don't install a sign where it will block the driver's view of other signs or oncoming traffic.

Chapter 6

SIGN SUPPORTS

6.1 BREAKAWAY CRITERIA

The American Association of State Highway and Transportation Officials (AASHTO) developed criteria to insure that sign supports yield when struck by a vehicle, thereby minimizing injury to occupants and damage to vehicles. Posts that are crash tested and satisfy the AASHTO criteria are considered breakaway posts and are acceptable for use adjacent to a highway. Popular FHWA-approved breakaway posts are identified in Table 6-1. Post systems currently used by the Department are included in Sections 6.2 through 6.5.

Because the average weight of automobiles is decreasing, AASHTO has recently made some changes to their criteria and new full-scale crash testing is currently underway using 1800-pound vehicles traveling at speeds of 20 to 60 mph. Upon impact, the maximum acceptable change in speed will be limited to 15 feet per second (4.57 mph). When the testing is complete, Table 6-1 may have to be revised.

6.2 STEEL CHANNEL BAR POSTS

6.2.1 General

The steel channel bar post is the most widely used sign support in the United States. Although some states use single-piece posts, all channel bar sign posts installed by or for the Department have a separate anchor to allow the post to be driven from ground level.

The steel channel bar post should be used to erect most regulatory, warning and small guide signs. They may also be used to erect exit gore signs along the freeways.

6.2.2 Channel Bar Post Sizes

Channel bar posts are available in two different weights, 2.5-pound/foot and 4-pound/foot. The standard anchors for both posts are 3.5-feet long and the same weight as the post. The most common post is the 2.5-pound post in the 8.5-foot length, but the 2.5-pound post also is available on contract in 4-foot, 7-foot and 10-foot lengths. The 4-pound post is only available in the 10-foot length.

The required size and number of posts for a sign installation can be determined by using Tables 6-2 and 6-3 and the graphs in Figures 6-1, 6-2 and 6-3. An example of the use of the figures in determining the required size and number of posts is included as Figure 6-4.

6.2.3 Proper Installation of "Eze-Erect" Posts

It is important that the strap and star washers be installed on all "Eze-Erect" sign post installations since they insure a strong connection and prevent the bolts from vibrating loose.

Figure 6-5 shows the proper installation method. Please note that the maximum anchor height for all new posts is now 4 inches.

Table 6-1. POPULAR BREAKAWAY POSTS

One Post in 8-Foot Path

- Any one-piece high-carbon steel channel bar posts through 4-pound/foot
- Franklin Steel's "Eze-Erect" channel bar posts through 4-pound/foot
- Unistrut's Telespar steel square post through 2.5"x2.5"x10-gage
- Wood posts through 4"x6" w/o holes, 6"x6" with 1.5" diameter holes, and 6"x8" with 2.5" diameter holes
- Standard steel pipe through 2" ID w/o breakaway coupling, or through 2.5" ID with standard pipe coupling at ground level
- Any channel or square post with Foresight Industries' "V-Loc Socket System"
- Transpo Safety's "Break-Safe" couplings per Traffic Standard TC7702A
- "New Jersey" breakaway coupling (Type II on old TC7702A Std.)
- "Texas Slip-Base" coupling

Two Posts in 8-Foot Path

- Any one-piece high-carbon steel channel bar posts through 4-pound foot
- Franklin Steel's "Eze-Erect" channel bar posts through 4-pound/foot
- Unistrut's steel square posts through 2"x2"x12-gage
- Wood posts through 4"x4" w/o holes, or through 6"x6" with 1.5" diameter holes
- Transpo Safety's "Break-Safe" couplings per Traffic Standard TC7702A
- Foresight Industry's "V-Loc Socket System" with 1.90" diameter, 12-gage channel adapter and up to 3-pound/foot channel bar posts

Three Posts in 8-Foot Path

- Franklin Steel's "Eze Erect" channel bar posts through 4-pound/foot
- Foresight Industries' "V-Loc Socket System" with 1.90" diameter, 12-gage channel adapter and up to 3-pound/foot channel bar posts

Table 6-2. ODD-SHAPED SIGNS

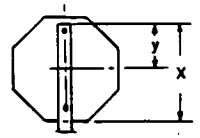
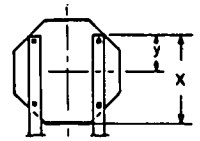
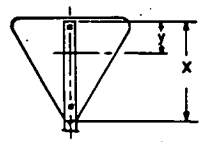
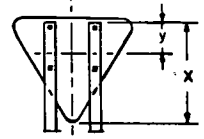
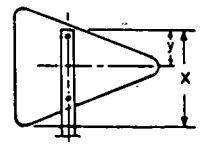
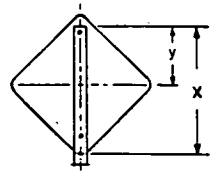
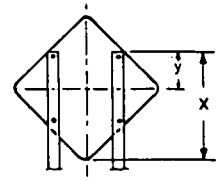
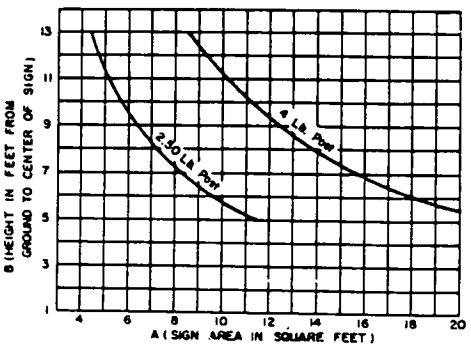
	Sign Size	"X" Dimension	"Y" Dimension
	24"x24"	22"	10"
	30"x30"	28"	13"
	36"x36"	34"	16"
	48"x48"	40"	16"
	36"x36"	28"	8"
	48"x48"	34"	9"
	60"x60"	46"	15"
	48"x36"	27"	10"
	18"x18"	22"	10"
	30"x30"	36"	16"
	36"x36"	44"	19"
	48"x48"	49"	16"
	60"x60"	62"	19"

Table 6-3. SIGN AREA

Square or Rectangular Signs						Irregular Shape Signs	
Sign Size	Area (Sq.Ft.)	Sign Size	Area (Sq. Ft.)	Sign Size	Area (Sq.Ft.)	Sign	Area (Sq. Ft.)
8" x 36"	2.0	24" x 24"	4.0	48" x 60"	20.0	YIELD(RI-2) 36" x 36"	4.C
8" x 48"	2.5	24" x 36"	6.0	60" x 60"	25.0	YIELD(RI-2) 48" x 48"	7.0
12" x 18"	1.5	24" x 48"	8.0	120" x 12"	10.0	YIELD(RI-2)60" x 60"	10.5
12" x 24"	2.0	30" x 15"	3.0	120" x 15"	15.0	NO PASSING PENNANT(W3-10)48" x 36"	6.0
12" x 30"	2.5	30" x 24"	5.0	120" x 24"	20.0	RAILROAD WARNING(W10-1) 36" Dia.	7.0
12" x 36"	3.0	30" x 30"	6.5	120" x 30"	25.0	SCHOOL(S1-1) 36" x 36"	7.0
12" x 48"	4.0	30" x 36"	7.5	120" x 60"	50.0	SCHOOL CROSSING(S2-1)36" x 36"	7.0
18" x 18"	2.5	30" x 48"	10.0	144" x 12"	12.0	STOP (R1-1)30" x 30"	5.5
18" x 24"	3.0	30" x 60"	12.5	144" x 18"	18.0	STOP (R1-1)36" x 36"	7.5
18" x 36"	4.5	36" x 36"	9.0	144" x 24"	24.0	STOP (R1-1)48" x 48"	13.5
18" x 48"	6.0	36" x 48"	12.0	144" x 30"	30.0	Interstate Route Marker (M1-1) 24" x 24"	3.5
21" x 15"	2.0	48" x 48"	16.0	144" x 60"	60.0	Interstate Route Marker (M1-1)30" x 24"	4.5
						Interstate Route Marker (M1-1)36" x 36"	7.5
						Interstate Route Marker (M1-1)45" x 36"	9.5



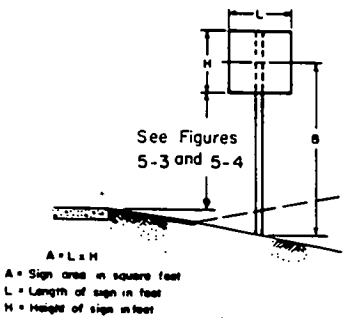


Figure 6-1. "EZE-ERECT" SINGLE-POST INSTALLATIONS

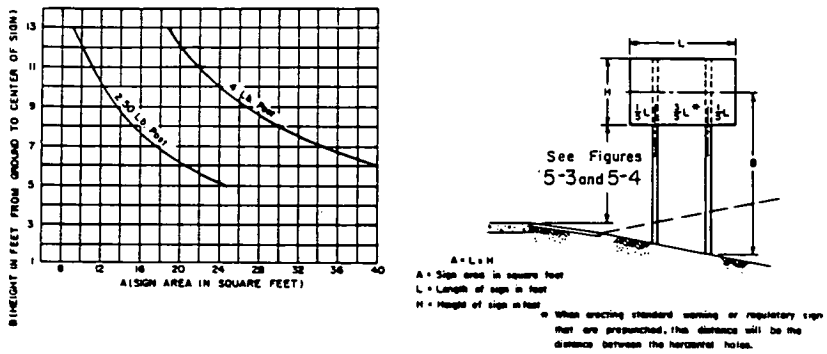


Figure 6-2. "EZE-ERECT" 2-POST INSTALLATIONS

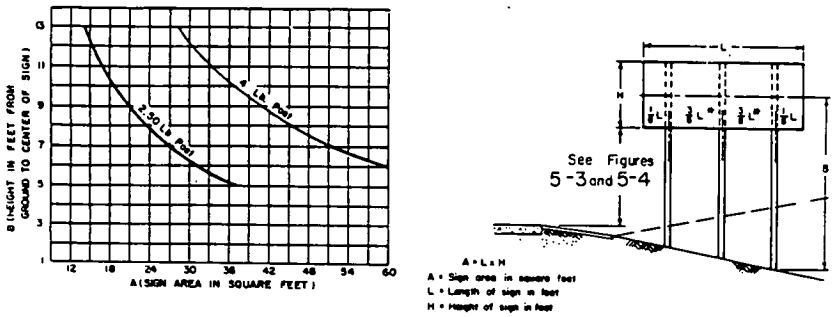
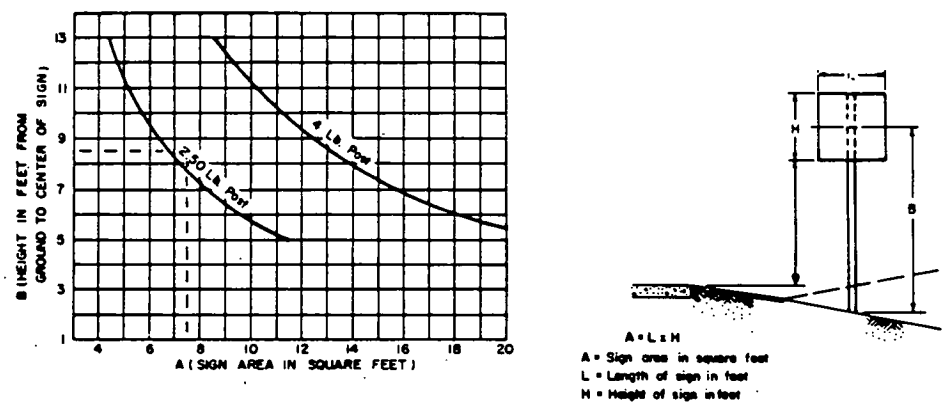


Figure 6-3. "EZE-ERECT" 3-POST INSTALLATIONS



Problem: Install a 30"x36" sign along a rural conventional highway.

Procedure:

1. Find "B" Height in feet from ground to center of sign. The minimum mounting height is 5 feet, but the minimum length post is 1 1/2' + 5' + 3' = 9 1/2'. Since a 10-foot post will be used and the excess will not be cut off, the "B" Height is one-half the sign height below the top of the post, or 10' - 1 1/2' = 8 1/2'. (The bottom of the sign will be 5 1/2 feet above the edge of roadway.)

2. Find the area of the sign in Table 6-2, or calculate the sign area by multiplying the sign width in feet by the sign height in feet. (Example: 2.5 x 3 = 7.5 square feet.)

3. Enter chart at two points. On the vertical B scale enter at 8 1/2 feet, project that point horizontally to the right. Enter the horizontal scale at 7.5 square feet and project that point vertically until it intersects the first projected line. The intersecting point falls to the right of the 2.50-lb. post; therefore, the 4-lb. post should be used for this sign.

Figure 6-4. SAMPLE INSTALLATION OF 30"x36" SIGN

In order to install the anchor at the 4-inch maximum height and still be able to tighten the anchor bolts, it is recommended that a shovel of dirt be removed at the anchor location before driving the anchor. When the anchor and post connection is tightened, the dirt should be backfilled around the anchor.

Normally signs are installed on the flanged face of these posts in order to take advantage of the maximum bearing area. However, if required, signs may be installed on both faces, and by using formed channels as illustrated in Figure 6-6, signs may be installed on the sides of the post. Aluminum sign bolts should generally be used to attach the signs and the formed channels.

6.2.4 Post Splice

If posts are not long enough, additional post lengths can be added as illustrated in Figure 6-7. Splices should be made near the top of the post. If the splice is adjacent to the sign, the 12-inch splice channel should be on the back of the other two posts as indicated; otherwise, the splice channel may be on either side of the other two posts.

6.2.5 V-Loc Socket System

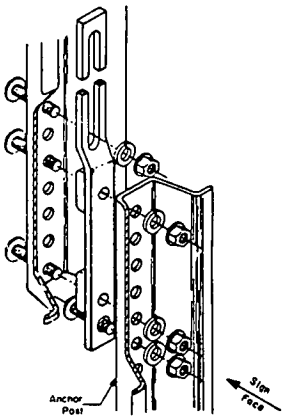
Because the maximum anchor height is now 4 inches, when 2.5-pound channel bar posts are required in concrete islands, medians or sidewalks, new installations should use the V-Loc Socket System as illustrated in Figure 6-8.

The components for the V-Loc Socket System are available on annual contract by use of the following commodity codes:

#0210-5000-2500	8" Socket, Wedge, Channel-Adapter, Bolts, Nuts & Washers for Channel Bar Posts
#0210-5030-0004	Replacement Channel-Adapter w/ Bolts, Nuts & Washers
#0210-5035-0001	Replacement Wedge
#0210-5040-0003	Wedge Puller

Installation instructions are as follows:

- Drill 6-inch diameter hole through concrete and to a minimum depth of 8 inches.
- Place socket in the hole with the top of socket flush with the original concrete elevation and place concrete around the socket.
- When the concrete is cured, insert lower portion of channel-adapter in the socket with the three pierced holes at the same height as the top of the socket and with the two upper holes in the adapter rotated toward traffic.



NOTES

1. Determine the proper size sign post and anchor from the appropriate graph.
2. Remove a shovel of dirt at the post location to allow for final attachment of the post to the anchor.
3. Drive the anchor into the ground with a drive cap until only 10" of anchor is above ground.
4. Align the hole closest to the long slot in the retainer space strap with the top hole in the anchor. Attach strap by making a bolted connection through the bottom hole in the strap and the hole it aligns with in the anchor.
5. Rotate the strap 90 degrees to the left or right and drive the anchor into the ground until only 4" remain above ground level to enhance the breakaway features of the sign.
6. Rotate the strap back to vertical position.
7. Place the sign post against the anchor and the strap. Align the bottom hole in the sign post with the lowest open hole in the strap. Insert two anchor bolts through the common holes in the sign post, strap and anchor.
8. Complete the construction by attaching the strap to the sign post with a bolt and nut at the bottom of the long slot in the strap.
9. Tighten the bolts and nuts by the turn-of-nut method, i.e., bring nut to a snug tight condition to insure that all parts are brought together into full contact with each other, then tighten an additional 1/2 turn.
10. Restore the dirt around the anchor.

Figure 6-5. INSTRUCTIONS FOR INSTALLING "EZE-ERECT" POSTS

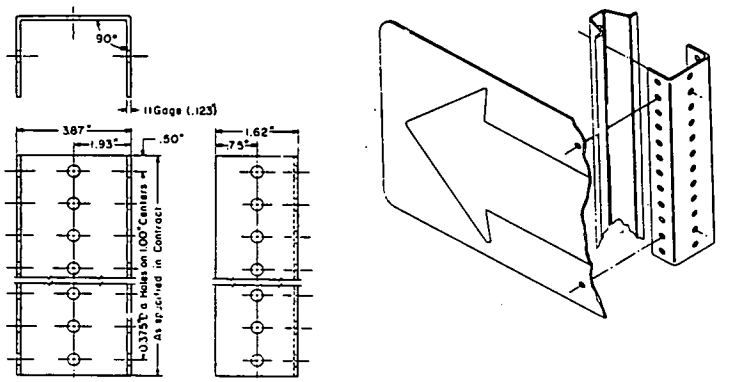


Figure 6-6. FORMED CHANNEL SIGN MOUNT

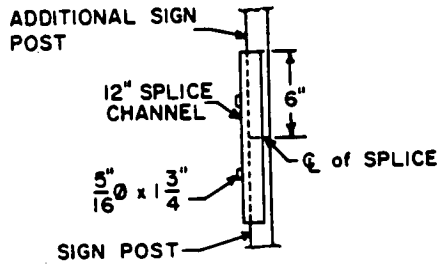


Figure 6-7. CHANNEL BAR POST SPLICE

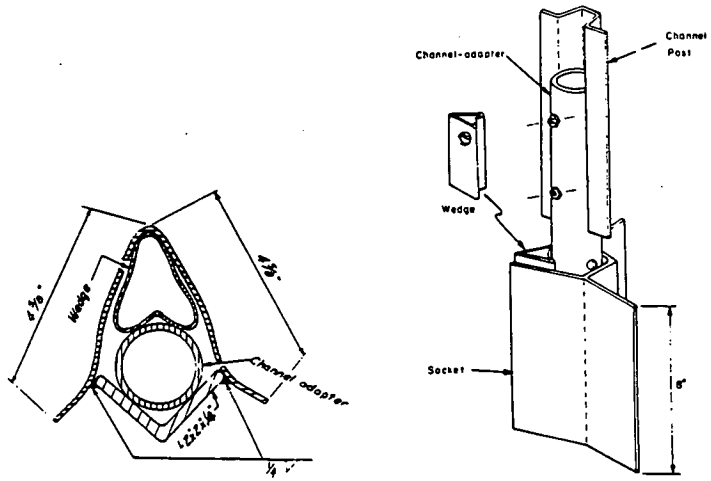


Figure 6-8. "V-LOC SOCKET" SYSTEM

- Position the wedge in the socket with its hole at the top, and drive the wedge into the socket until the top of the wedge is flush with the top of the socket.

- Attach 2.5-pound channel bar post to channel-adapter, placing one flat washer at each end of both bolts.

The V-Loc Socket System can not technically support as much sign area as the Eze-Erect anchor, but in the absence of detailed graphs, Figures 6-1, 6-2 and 6-3 should be used.

If a channel adapter needs to be removed, the wedge can be pulled by the wedge puller, which is similar to a dent puller used by auto body mechanics.

6.3 STEEL SQUARE POST SIZES

Type B steel square posts are available on contract in 2" and 2½" sizes. The anchor for all posts are 3 feet in length and typically one size larger than the sign post. The sign post lengths vary from 7' to 10'6". Within an 8-foot path, only one 2" 10 gage or two 2" or 2½" posts may be used.

The required size and number of posts for a sign installation can be determined by using the graphs shown in Figures 6-11 and 6-12.

6.4 WOOD POSTS

6.4.1 General

Wood posts are frequently used to install large guide and information signs along freeways and expressways. They are also frequently used to install some of the larger directional signs as well as route marker assemblies.

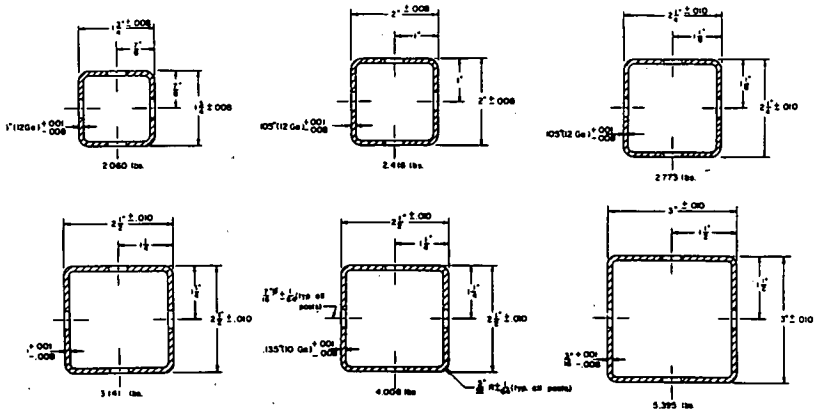
6.4.2 Breakaway Requirements

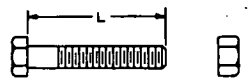
Wood posts supplied by the Sign Shop and ones conforming to Publication No. 408 are considered to be breakaway posts after the required holes are drilled perpendicular to vehicular travel. However, only one 6 x 8 inch post and/or two 6 x 6 inch posts should be used in an 8-foot path unless the sign posts are protected by guide rail. Therefore, two 6 x 8 inch posts should not be used for signs which are less than 13.5 feet wide and three 6 x 6 inch posts should not be used for signs which are less than 11 feet wide.

6.4.3 Post Size

The required cross-section and number of posts for a particular sign installation can be determined using the graph in Figure 6-13

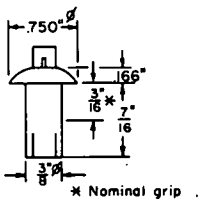
In order to determine the length of posts needed, add the height of the sign, the required vertical distance from the bottom of the sign to the near edge of the roadway, the vertical distance from the near edge





POST SIZE	DIMENSION L
2"	3"
2 1/2"	3 1/2"

3/8" BOLTS & NUTS-STEEL



DRIVE RIVET

See note * 4

Figure 6-9. STEEL SQUARE POST DETAILS

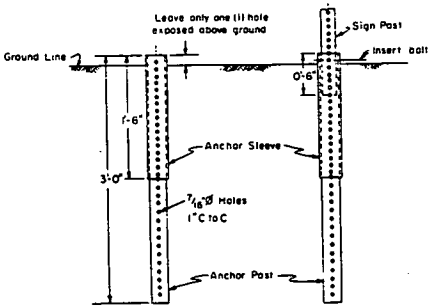


Figure 6-10. INSTALLATION OF STEEL SQUARE POSTS

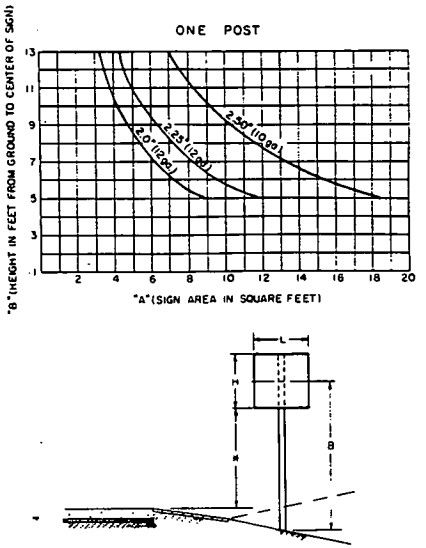
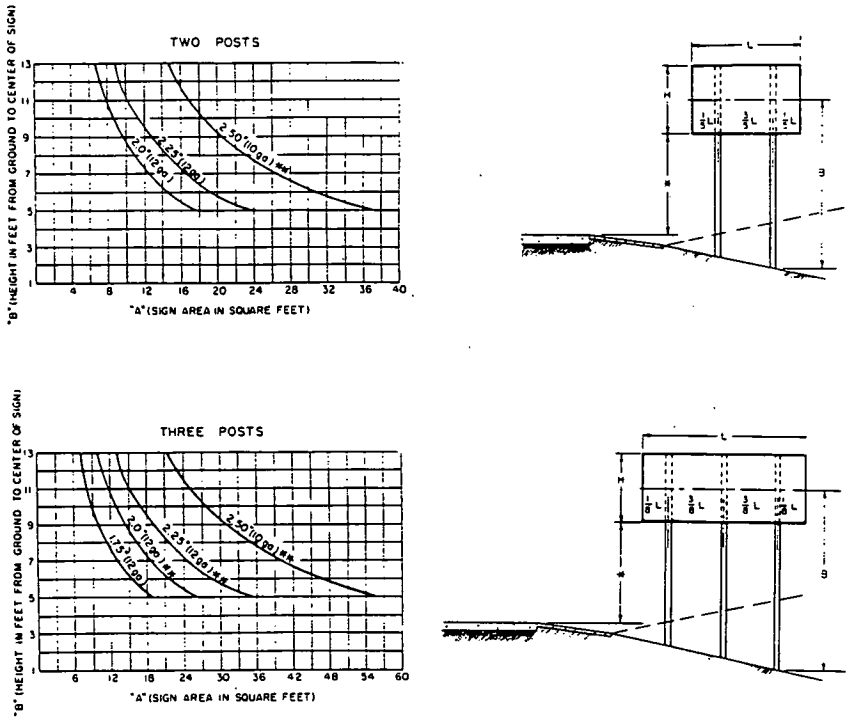


Figure 6-11. SIGN AREA FOR SINGLE, STEEL SQUARE POST INSTALLATIONS



NOTES:

* 1. Conventional Highways.

a. Rural Districts — Signs erected at the side of the road shall be mounted at a height of at least five feet, measured from the bottom of the sign to the near edge of the pavement.

b. Business, Commericol, and Residential Districts — Where parking and/or pedestrian movement is likely to occur, the clearance to the bottom of the sign shall be at least seven feet.

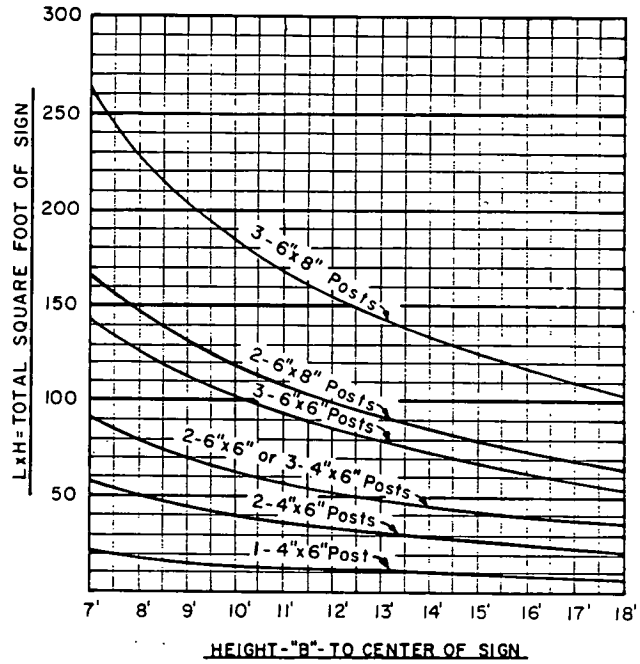
* 2 Expressways and Freeways

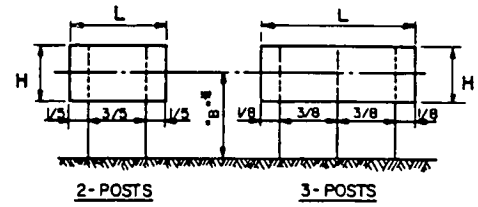
a Directional Signs — Signs shall be erected with a minimum height of seven feet from the level of the near edge of pavement.

b. Route Markers, Regulatory, and Warning Signs — All signs and markers shall be at least six feet above the level of the pavement edge.

** - Within an eight-foot path, only one 2 1/2" (10ga.) or two 2" or 2 1/4" posts may be used per sign unless within an area protected by guide rail or other physical obstructions.

Figure 6-12. SIGN AREA FOR MULTIPLE, STEEL SQUARE POST INSTALLATIONS



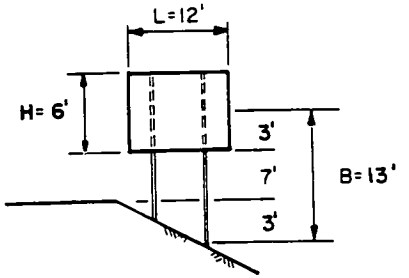


* "B" dimension used in determining the size and number of posts from the graph is always the longest "B". The same size posts (cross section) should be used on any individual sign installation.

Figure 6-13. WOOD POST SELECTION CHART

Example:

Install a 12-foot wide, 6-foot high sign on wood posts.



Procedure:

1. Find the area of the sign L x H = 12 x 6 = 72 square foot.

2. Find the B dimension. Embankment slope 3 feet, plus 7 feet to the bottom of the sign, plus half of the 6-foot sign height, or another 3 feet. Therefore the "B" dimension = 3+7+3=13 feet.

3. Enter Figure 6-13 at two points, i.e., 60 on the L x H scale projecting that line horizontally, and 13 feet on the "B" scale and project that line vertically upward. The intersection point falls below the three 6" x 6" post line and the two 6" x 8" post line. Both post combinations are suitable if the sign is located behind guide rail.

   However, if the sign is exposed to traffic, the post spacing should be reviewed to determine if only one 6" x 8" post or two 6" x 6" posts can be used in an 8-foot path. In this example, the three 6" x 6" posts would be at a 4.5-foot spacing (3/8 x 12) and the 6" x 8" posts would be at a 7.2-foot spacing (3/5 x 12). Since two 6" x 8" posts should not be used in an 8-foot path, the three 6" x 6" post combination should be used.

Figure 6-14. EXAMPLE OF WOOD POST SELECTION

of roadway to ground level of each post, and the depth the post is to be installed. An example of determining the required size and number of posts is shown in Figure 6-14.

6.4.4 Installation of Wood Posts

Wood posts are normally installed with a concrete foundation. It is not recommended to install the posts in earth except for temporary sign installations that will be removed after a short period of time. Posts installed in earth should be installed to a depth of at least 4 feet, properly set and braced, and backfilled in layers, firmly tamping the backfill to assure that the backfill is properly compacted.

Posts embedded in concrete foundations should normally be installed using post sleeves, shim bars and shim plates as shown in Figure 6-15. The concrete should be cured a minimum of 48 hours before the posts and the signs are erected.

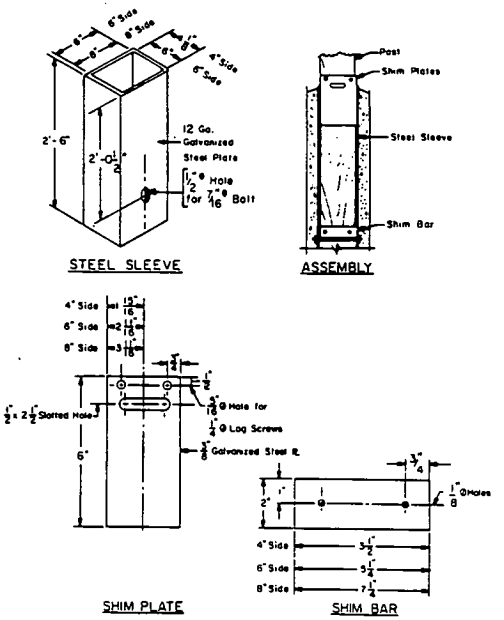


Figure 6-15. STEEL SLEEVES FOR WOOD POSTS

Posts installed in concrete foundations should be embedded 2 feet with a minimum 2.5 foot foundation as shown in Figure 6-16. For very large signs and in certain soils, it may be necessary to install the post foundations to depths of up to 4 feet. The depth to install wood posts should be discussed with the Engineering District.

If the posts are to be embedded directly in the concrete, care must also be taken to set and brace the posts before the concrete is poured to assure that the posts remain plumb.

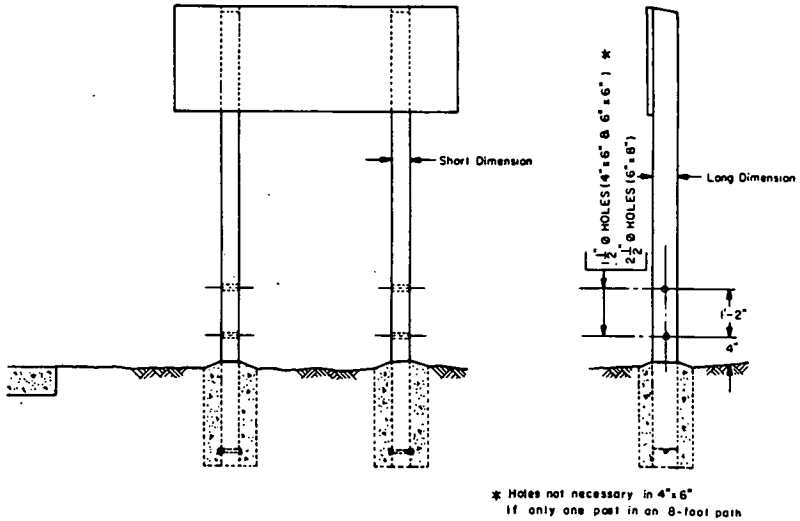


Figure 6-16. TYPICAL WOOD POST INSTALLATION

Some counties that have tried to remove wood post stubs from post sleeves have experienced difficulty and in some instances have not been able to remove the stub. As a result of this problem, the post sleeve design for Department purchases has been revised to facilitate the removal of the posts. Of prime importance, the bottom of the sleeve is now open to allow water to drain into the subbase. (If the foundation is deeper than 2.5 feet -- the length of the steel sleeve -- a greased pipe should be placed inside the steel sleeve and driven into the bottom of the foundation. When the pipe is removed, the hole will prevent water from accumulating around the wood post.)

It is also beneficial to have the top of the concrete slope away from the post and to seal the opening between the post and the sleeve to help prevent water from going into the foundation. If used, the sealing material should be beaded and pressed into the opening.

If a county has a number of wood posts to install, consideration should be given to the following procedure:

- Auger or dig all holes, but cover during nonworking hours
- Set and properly brace all sleeves or posts
- Utilize a concrete truck, if available, to place all concrete at the same time

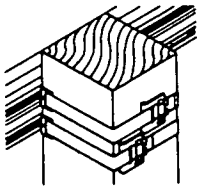
Some districts have indicated problems augering holes for wood posts with current equipment while other districts indicate they are able to auger holes up to approximately 3 or 3 1/2 feet deep. (It may be possible that the county could utilize rental equipment for augering holes for post installation. This option should be discussed with the Maintenance or Engineering District.) Some suggestions that may be helpful are:

- Periodically sharpen or replace the spiral point on the auger and the cutting teeth on the bottom of the auger. The cutting teeth become dull and replacement of the teeth usually permits the augering of deeper holes in less time.
- Keep moving the auger up and down in the hole so that the flutes will clear. The flutes are not very long and this action will help remove the material from the hole.
- If a rock is hit, remove the auger and loosen the rock with bars. The flutes will usually bring the rock up after it has been loosened.

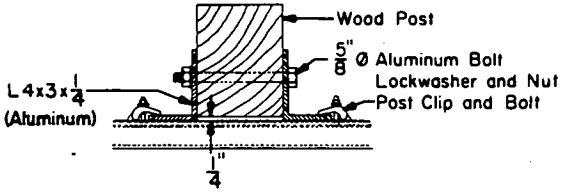
6.4.5 Sign Attachment

Flat sheet aluminum and plywood signs are usually attached to wood posts with lag screws.

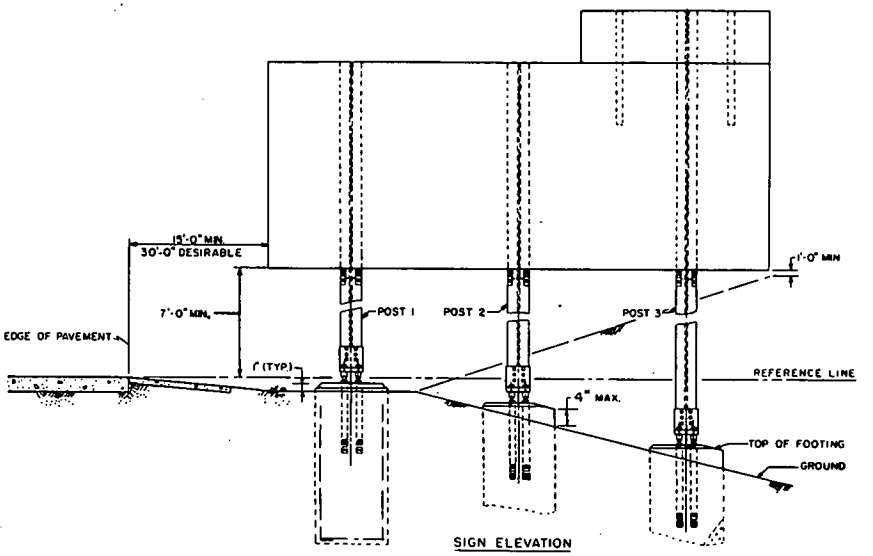
Flat sheet aluminum with stiffener signs are usually attached to the post with either stainless steel toggle and buckle straps, or aluminum angles and post clips as illustrated in Figure 6-17.



BUCKLE STRAP



POST CLIP



SIGN ELEVATION

Figure 6-17. ATTACHING LARGE SIGNS TO WOOD POSTS

6.5 STEEL W BEAM BREAKAWAY POSTS

These posts are used to install major guide signs along freeways and expressways.

Beginning in July, 1985, breakaway hardware and W-Beams were made available on annual contract for new and replacement installations. With the new low profile anchors, several sign crews have found these installations to be very easy. Further, these posts will support much larger signs than wood posts.

When placing the concrete for W-beam post foundations, it is important that the reinforcing steel be used in accordance with Traffic Standard TC7702A and that the anchor bolt template is level and oriented properly.

When used, the posts and hardware should be installed in accordance with the instructions from the hardware manufacturer. In addition, the hardware should be routinely maintained as noted in Section 8.4.3.

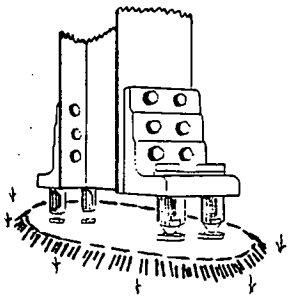


Figure 6-18. STEEL BREAKAWAY POSTS

Chapter 7

DELINEATION DEVICES

7.1 DELINEATORS

7.1.1 General

All delineators installed along two-way undivided roadways shall be white, except yellow delineators shall be used to mark obstructions and to create a funnel on the approach to narrow and one-lane bridges.

The color of delineators installed along divided highways and one-way roadways, including one-way ramps and connecting roadways, shall conform to the color of the edge line, i.e., white on the right side and yellow on the left side. Red delineators shall be used to delineate both sides of truck escape ramps and may be used facing wrong way traffic.

The color and placement of delineators at median crossovers and gores on expressways and freeways, and on islands on conventional highways, shall be as indicated in Traffic Standard TC7709.

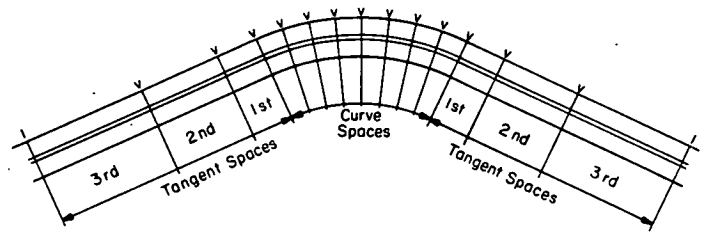
7.1.2 Spacing

The normal spacing between delineators except on curves is as follows:

- Expressways and freeways -- up to 264-foot spacings along the right side of the main roadway; and 132-foot spacings along and between the acceleration and deceleration lanes, and along one or both sides of the ramps.
- Conventional highways -- up to 528-foot spacings along the right side when installed.
- Truck Escape Ramps -- 50-foot spacing of red delineators on both sides of ramp.
- Narrow and One-lane Bridges -- Delineation may be provided on the approaches to a narrow or one-lane bridge to create a "funneling effect". The need for the additional delineation should be based on an engineering study which takes into account bridge width, approach roadway width, ADT, traffic speed, accident experience, etc. If the bridge is greater than 100 feet in length, white barrier-mounted or parapet-mounted delineators may be used on both sides of the bridge at 50-foot intervals.

Spacing of delineators on horizontal curves should normally be established by the District Traffic Engineering Unit in accordance with Figure 7-1.

Degree of Curve	Radius on Curve	Spacing on Curve	Spacing in Advance of and Beyond Curves		
			First Space	Second Space	Third Space
	Feet	Feet	Feet	Feet	Feet
1	5730	225	264	264	264
2	2865	160			
3	1910	130			
4	1433	110	225		
5	1146	100	200		
6	955	90	185		
7	819	85	165	250	
8	716	75	155	230	
9	637	75	145	220	
10	573	70	135	205	
11	521	65	130	195	
12	478	60	125	185	
—	328	50	100	150	
—	228	40	80	120	240
—	150	30	60	90	180
—	95	20	40	60	120



NOTES:

1. Spacing for specific radii not shown may be interpolated from the table. In advance of or beyond a curve, and proceeding away from the end of the curve, the spacing of the delineator is 2S, the second 3S, and the third 6S, where S refers to the delineator spacing for specific radii computed from the formula $S = 3\sqrt{R-50}$. The minimum spacing should be 20 feet.
2. It is desirable to use bi-directional delineator brackets (Type C) around the outside of the curve.

Figure 7-1. DELINEATOR SPACING ON CURVES

7.1.3 Lateral Clearance

The normal placement of roadside delineators is 6 feet beyond the edge of shoulder or immediately behind a curb. Delineators should be placed a constant distance from the edge of roadway except where a guide rail or other obstruction exists between the edge of the roadway and the line of delineators. In those cases, the delineators should be in line with or inside the innermost edge of the obstruction.

7.1.4 Height

Delineators should normally be located so that the top of the reflective unit is about 4 feet above the ground. (Substandard height will exist for barrier-mount delineators.)

7.1.5 Types of Delineators

- Centermount delineators are approximately 3 inches in diameter and are normally mounted on rigid delineator posts, e.g., 6-foot channel bar posts. The flanged face of the post should generally face toward approaching traffic. The centermount delineator should generally be attached by a two-piece rivet (commodity code 0210-1210-0000). Centermount delineators may also be attached to a Type C bracket (bi-directional bracket) or a Type F bracket (used on top of concrete median barrier).

- Flexible delineator posts are designed to withstand several high-speed impacts and return to their original position. All of the models which are currently approved (Section 900 of Pub. 35) are driveable with a 3"x12" area of Class II reflective sheeting. If the sheeting becomes damaged, new strips of white, yellow or red sheeting may be ordered from the Sign Shop or, beginning on May 1, 1986, from the delineation contract.

  Flexible delineator posts should be installed in accordance with the manufacturer's recommendations, which may include the use of a pilot hole driver. (Pilot hole drivers and post pullers should be on contract beginning on May 1, 1986.

- Barrier-mount delineators typically attach to the sides of concrete median barrier by a pressure-sensitive adhesive. Single-sided yellow and white barrier-mount delineators are available from contract by the respective commodity codes 0721-6033-1012 and 0721-6033-1023.

- Type F delineator brackets are 4-inch high brackets fabricated from Ethylene Vinyl Acetate which may be attached to the top of concrete median barrier by use of lead shields, Hilti studs or by other methods. The brackets are available from contract by commodity code 0721-6034-1014.

7.2 CHEVRONS

The Chevron emphasizes changes in roadway alignment at locations where standard delineators are inadequate. Chevrons are signs and should be mounted as such, except back-to-back mountings such as indicated in Figure 7-2 are very beneficial.

Chevron spacing should be such that the driver always has at least two chevrons in view. As a general rule, chevrons should be spaced at approximately twice the delineator spacing shown in Figure 7.1. Also as a rule of thumb, six chevrons are required on a 90-degree turn, regardless of the severity of the curve.

7.3 DELINEATION OF IMPACT ATTENUATORS

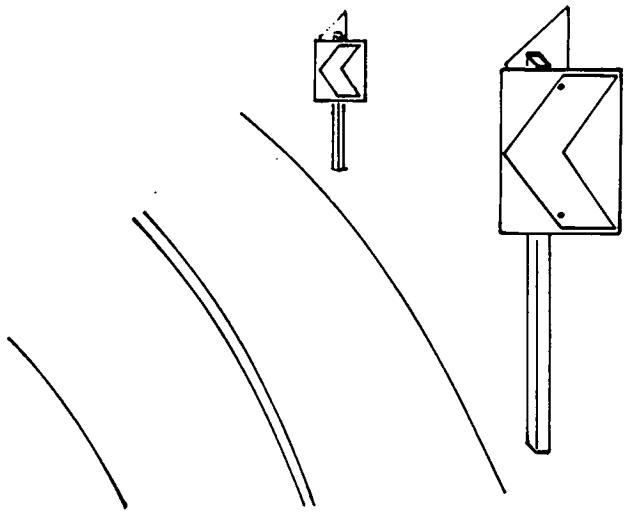
One or more clearance markers (W16-2R or W16-2L) should be attached to the front of all impact attenuators. The type of marker used should be as follows:

- Impact attenuators on the right side of all approaching traffic should have a W16-2R marker attached.

- Impact attenuators on the left side of all approaching traffic should have a W16-2L marker attached.

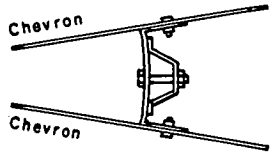
- Impact attenuators located where traffic passes on the left and right side should have a W16-2L marker to the left of a W16-2R marker.

On G.R.E.A.T. and hydro-cell attenuators, the standard aluminum markers should be attached to the leading edge. However, on sand barrels, pressure sensitive sheeting without a rigid substrate should be applied directly to the barrier. In no case should a marker be erected on a post in front of the impact attenuator.



Scheme #1

- o Install post with flanges parallel to the edge of road.
- o Attach two 2-inch long sections of formed channel to the post, attach chevrons and then tighten the bolts in the formed channels until the chevrons are properly aligned.



Scheme #2

- o Cut two 2"x6" strips of metal from old station marker and drill one 3/8" hole 1 inch from each end.
- o Install post with flanges at right angle to the edge of road.
- o Bend plates to required angle.
- o Attach chevron and bent plates to post.
- o Attach second chevron to bent plates and adjust as necessary.

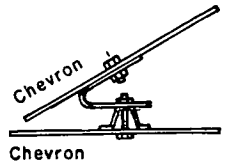


Figure 7-2. BACK-TO-BACK CHEVRON INSTALLATIONS

8.1 GENERAL

It is important that all signs be kept in proper position, clean and legible at all times. Damaged signs, especially knocked down regulatory signs shall be repaired or replaced as soon as feasible. Stop, yield and one-way signs shall have the highest priority.

Since signs are continually subjected to damage by wind, traffic accidents, and vandalism, it is important to establish a suitable schedule for inspecting, cleaning and replacement.

Inspection can be routinely performed, when traveling to and from worksites, by checking for missing signs and obvious damage to signs, supports or accessories.

Special attention and necessary action should be taken to remove signs no longer required (approval of the District Traffic Engineering Unit is required prior to the removal of an existing sign). Another item of importance is to see that weeds, trees, and shrubs do not obscure the face of any sign.

When replacing a sign or sign support, refer to the applicable requirements of this manual regarding installation. In addition, check the entire installation for other repairs that could be done to prevent an unnecessary return to the same site.

For example, check:

- o the condition of sign, especially the sign face
- o the sturdiness of the support(s) and foundation(s)
- o for loose or broken fasteners or other accessories

8.2 PRIORITIES

Routine maintenance schedules must be adjusted to give priority to damaged or missing signs that could be considered emergency. Emergency repairs should be with priorities as noted in Section 3.3.

Within the regulatory signs, priority should be given to those signs that prevent a conflict between vehicles. In the warning sign priority, preference should be given to those signs that warn of a reduction of roadway width or number of traffic lanes, curves, narrow or one-lane bridges or underpasses, or changes in traffic patterns.

8.3 DEFECTIVE, MISSING OR DAMAGED SIGNS

Determining the need to replace a missing sign is obvious, however determining when a sign is defective or should a damaged sign be repaired or replaced is not always that evident.

A sign would be determined defective when its target value was found to be undesirable due to discoloration, alligator cracks, tears, etc.

In determining whether a damaged sign should be repaired or replaced, consideration must be given to the economics involved in repair or replacement and will the repair result in a functional sign.

8.4 SUPPORTS

8.4.1 Type B Posts

Maintenance of Type B Posts will frequently be restricted to repairing the breakaway connection. Repairs or replacement shall be in accordance with the installation requirements for the particular Type B Post. (See Sections 6.2 and 6.3 and Standard Drawing TC7702B).

8.4.2 Wood Post

Due to the nature of this post, required maintenance will normally mean replacing the post. Replacement shall be in accordance with the installation requirements for Wood Post. (See Section 6.4 and Standard Drawings TC7702C and TC7702E.)

8.4.3 Steel Beam Post

Steel W-beam posts are used to support Type A Signs (Flat Sheet Aluminum with Stiffeners, Extruded Aluminum Channel, or Laminated Panel).

The current breakaway connection is the Transpo-Safety connection as defined in the TC7702A Standard. The Transpo-Safety connection uses a bolt-on aluminum angle on the front and back side of each post and a special breakaway bolt in each of the four corners of the post. Steel W-beam posts and breakaway hardware are available on a statewide annual contract.

Very little maintenance is required on the Transpo-Safety connection, except in the event of wind or accident damage.

Two other obsolete Type A post connections are still in existance and therefore may necessitate repair or maintenance. These two posts are as follows:

- Type II, commonly known as the New Jersey breakaway connection, uses a welded bracket and breakaway bolt connection. Any necessary repair or replacement of Type II base connections or hinge plates should be in accordance with recently obsolete TC7702A Traffic Standard. This standard can be made available from the Traffic Engineering and Operations Division.

- Type III, commonly known as the Texas Slip-base is in widespread use throughout the State. Because of its design, the tension in the slip-base and fuse-plate bolts is extremely critical for the proper operation of the Texas Slip-Base. Therefore, on an annual basis, the bolts should be loosened and retorqued to the following values to insure that wind vibration doesn't cause the post to "walk" off its post stub or the post to bend at the fuse plate:

Bolt Diameter (inch)	Torque (in-lb.)
5/8	450
3/4	750
7/8	1050
1	1400
1 1/8	1800

When it is necessary to replace a Texas Slip-Base, the base connection may be retained or replaced in kind as necessary. However, if all of the posts for a given sign need to be replaced and the foundation and stub base are still good, it is recommended that the stub base be retrofitted to accommodate the current breakaway connection in order to eliminate annual maintenance. Retrofit connections are available on a Statewide annual contract.

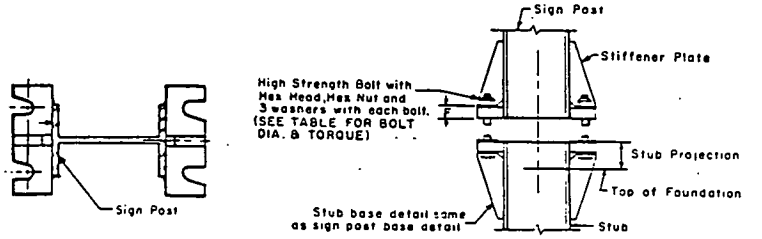


Figure 8-1. TYPE III OR TEXAS SLIP-BASE POST

8.4.4 Delineators

Maintenance of delineators consists of replacing delineators or their posts and straightening or re-installing dislodged posts.

8.4.5 Overhead Structures

Maintenance of overhead signs and supports will normally be restricted to emergency repairs. Since overhead signs, lighting fixtures, and supports are vulnerable to damage by wind and oversize vehicles, they should be periodically inspected by the sign crew or district personnel. Detected damages should be repaired, if possible. If not, report the damages to the Maintenance District.

8.5 CLEANING

Signs become dirty and the sign faces become obscured by mud, dust, diesel exhaust, fumes, windblown fungus, pollen, tree sap, bird droppings and ordinary road film. All of these dulling agents cause signs to lose

their visual effectiveness. Therefore, sign cleaning should be a scheduled sign crew activity when necessary.

Cleaning Procedures:

- Flush the sign thoroughly with water to remove the loose dirt.
- Wash the sign with a carwash type soft brush or mop, wash from the top down using a mild soap or detergent.
- Finish with a clean water rinse and allow the sign to dry.

To remove asphalt tar, oil, diesel residue, etc., use a solvent such as kerosene or mineral spirits, then rinse with soap and water.

Chapter 9

SIGNS AND MARKERS INSTALLED AND MAINTAINED BY OTHERS

9.1 GENERAL

Most signs in urban areas and some signs in rural areas are installed and maintained by local authorities or non-governmental organizations. Most of the specific types of signs in these categories are in Publication 68, Section 211.6(b), paragraphs (3) and (4).

If you are aware of maintenance problems involving signs installed by others, you should contact the responsible party. In the case of a missing or knocked down Stop sign, if the responsible party cannot be contacted in an expedient manner, it is desirable to temporarily install a Department sign until the appropriate party can install their sign.

Some specific types of signs not addressed in Publication 68 are discussed in Sections 9.2 and 9.3.

9.2 LOGO SIGNS

Logo signs are currently being installed by the Pennsylvania Logo Signing Trust on most Interstate highways and the intersecting roadways. These signs identify specific trademarks or business names and are provided for the convenience of the motorists.

Logo signs are being funded by the participating businesses but are technically Department property; however, maintenance is the responsibility of the Trust. Therefore, if logo signs are in need of repair, the Trust should be notified. The contact person is Ms. Ronni Hannaman, Administrator, Pennsylvania Logo Signing Trust, at (717) 232-8880.

9.3 HISTORICAL MARKERS

At least two types of historical markers currently exist along our roadways:

- Cast aluminum markers similar to the type illustrated in Figure 9-1 are installed and maintained by the Pennsylvania Historical and Museum Commission. The contact person for the Commission is Donald Behney at 8-447-6944.
- Cast iron markers on a keystone similar to the type illustrated in Figure 9-2 were allegedly installed by the Department about 40 years ago on cast iron posts. Because of the weight of these signs and posts, these markers are only authorized at locations where they are protected by guide rail, bridge abutments, or non-mountable curbs. Therefore, if these markers are located

at vulnerable locations, the District Traffic Unit should be contacted for advise on the removal of the markers. If a relocation is required, the District should try to obtain a sponsor for the relocation and maintenance of the marker.

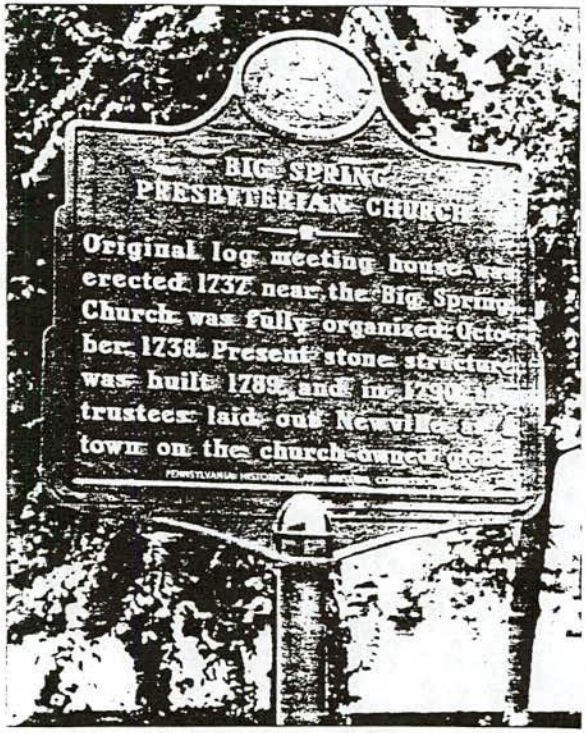
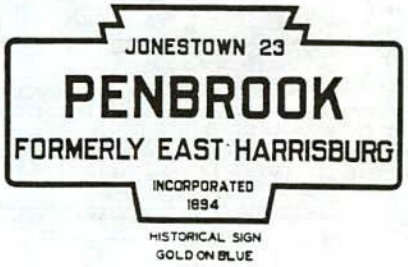


Figure 9-1. CAST ALUMINUM HISTORICAL MARKERS



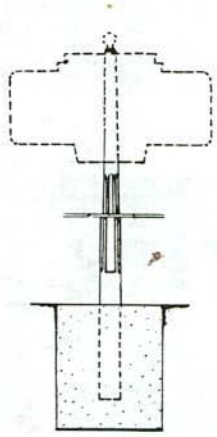


Figure 9-2. CAST IRON HISTORICAL MARKERS

Chapter 10

EQUIPMENT AND PUBLICATIONS FOR SIGN CREW

As a minimum, it is recommended that sign crews have the following equipment and publications available for their use at all times:

- Crew cab truck
- Power pack or generator
- Electric drill
- Electric or gasoline post driver
- Portable electric band saw
- Post puller
- Level (should be at least 2 feet long)
- Measuring devices
- Ladder
- Sledge hammers
- Wrecking bar
- Saws (hand and hack)
- Drift pins
- Mechanic's hammer
- Various mechanical tools
- Cold chisels
- Pioneer tools - (axe, digging iron, pick, & shovel)
- Pruning tools
- Bandit tool
- Pop rivet gun
- Pub. 68, Official Traffic Control Devices
- Pub 203, Work Zone Traffic Control
- Pub. 111, Traffic Standards
- Pub. 113, Maintenance Foreman's Manual

Chapter 11

SIGN WORK ORDERS AND COMPLAINT RECORDS

11.1 RECOMMENDED PROCEDURES

Sign work orders (Form 692) are a joint responsibility of the District Traffic Unit and the County Maintenance District. The areas of responsibility dealing with sign work orders are as follows:

11.1.1 Issuance of Sign Work Orders

Sign work orders should be issued by the District Traffic Unit and then only for the installation of new signs, the removal of an existing sign, or the replacement of an existing sign with a different type of sign. All other sign work that originates in either the Engineering District or the County should be requested on the Complaint Record (Form M-206) as discussed in Section 11.2.

11.1.2 Work Order Log

The District Traffic Unit and each County shall keep a record of sign work orders. One person in the Traffic Unit shall be responsible for keeping a detailed computerized sign work order record. The County should keep a simplified sign work order record similar to the following:

Work Order No.	Route No.	Date Issued	Date Received	Material Ordered	Work Scheduled	Priority & Notes

11.1.3 Staging Area

When the County receives the sign work order, the necessary signs should either be removed from inventory or ordered from the Sign Shop. It is recommended that the signs be: (1) issued out as soon as they are pulled or received: (2) grouped by sign work order; and (3) placed in a sign staging area. Signs placed in a sign staging area should not be removed for any other use.

11.1.4 Inspection of Work Orders

The basic responsibility for inspection of sign work rests with the sign foreman's supervisor. When inspected, the inspector should sign and date the work order in the appropriate spot on the form. A member of the District Traffic Unit should also make random field checks of the completed sign work as the need dictates. As a general rule, a minimum of 10 percent

of all orders should be checked, with a higher percentage when errors are noted.

11.1.5 Priorities

The District Traffic Unit should assign priorities to all work orders, and may include a requested completion date. Priorities may also be assigned to work requested on the Complaint Record.

11.1.6 Status Report

Each month the District Traffic Unit shall tickle the County on all uncompleted sign work orders which are over 30 days old. The sign foreman shall advise the District Traffic Unit of the status of each identified work order and, for each one over 60 days old, the reason the work has not been completed.

11.2 COMPLAINT RECORDS

The M-206 form should be used for replacing signs due to deterioration or knockdown, replacing missing bolts or signs, replumbing posts, etc. The form is illustrated below:

M-206 (7-79)	COMPLAINT RECORD	

County_____ Municipality_____ Tickle Date

LR._____ Sta. No._____ TR_____ Local Name_____

Name_____ Phone_____

Address_____

Rec'd by_____ Time_____ Date_____

Complaint_____

Asst. Maint. Mgr._____ Foreman_____

Chapter 12

EXCESS NUMBER OF SIGNS AND SIGN ACCESSORIES

12.1 ACCOUNTING

Counties are charged for all items obtained from the Sign Shop, but do not receive any credit for returned items. In light of this, counties should not obtain an excess number of signs and sign accessories. However, if a surplus does exist, it is recommended that an administrative message be sent to the other counties, advising of the availability of the item. In this case, the transferring county will receive credit for the transfer.

12.2 REUSABLE ITEMS NOT ACCEPTED AT THE SIGN SHOP

Since many signs were fabricated to meet specific needs, the Sign Shop will not accept the return of the following signs, nor any sign or sign accessory which is no longer stocked:

Nomenclature	Sign Specification
D1-1	Single Line Destination
D1-2	Double Line Destination
D1-3	Triple Line Destination
D2-1	Double Line Distance
D2-2	Confirmation Marker
D3-2	Single Line Advance Street Name
D3-3	Double Line Advance Street Name
D5	Special Directional Signs
D6	Expressway Laminated Signs
D7	Special Expressway Sign
I 10-1	City Name
I 10-2	Borough Name
I 10-3	Village Name
I 10-4	Township Name
I 10-5	County Name
I 10-6	River Name
I 13-3	Mountain Elevation
M1-1	Interstate Route Marker
M1-4	US Route Marker
M1-6	PA Route Marker

12.3 REUSABLE ITEMS RETURNED TO THE SIGN SHOP

Salvageable items not included in Section 12.2 may be returned to the Sign Shop in accordance with the following guidelines:

- Prepare a separate TE-6160 for each class (e.g., R-series, W-series, sign accessories, etc.) being returned.
- Properly package all items with slip sheeting between each sign face.
- Place signs on a skid according to sign size. Properly band the signs to the skid.

- Label each package of signs on the skid with the nomenclature of the signs in the package and indicate the maintenance district returning the signs and the quantity of each type of sign.

- Insure that the signs do not get wet since the slip sheeting may not be removable after getting wet.

- Include the TE-6160 with all returns.

12.4 RECYCLING SIGN BLANKS

The Sign Shop has a sign stripping and cleaning contract for recycling aluminum sign blanks for a fraction of the cost of new aluminum. Therefore, unless an aluminum blank has an excessive number of bends or has jagged-edge holes or tears, it will be recycled. In order to assist the Sign Shop, the blanks should be sorted and banded on the skids in order from the largest to the smallest.

If aluminum blanks are not capable of being stripped and cleaned, the blank will be sold as scrap aluminum. Aluminum blanks which obviously cannot be recycled should be banded to the skid and labelled "Damaged".

Plywood signs have no salvage value at the Sign Shop; therefore, they may be used for Department shelving, bins, etc.

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