the case may not be tried until several years after the accident. Some of the perishable conditions such as the specific pavement, shoulder, and sign conditions may be quite different at the time the claim is filed or tried compared with when the accident occurred. In such cases the plaintiff's attorney may have considerably more knowledge of the highway conditions than the agency's attorney. In those accidents in which there is likelihood that a claim may be filed against the agency, it may be beneficial to obtain highway condition information, usually photographs, shortly after the accident occurs.

Manuals and regulations should be reassessed periodically to determine whether the criteria and requirements specified reflect the actual capabilities and priorities of the agency in addition to the latest acceptable standards and techniques available. Violating a nonpriority requirement specified in an out-of-date manual may put the agency's attorney at a disadvantage.

SUMMARY

In summary, it is important that maintenance functions and tort liability relations undergo close scrutiny. Generated from these analyses are means by which future tort claims may be reduced. It is imperative, however, that an agency not lose sight of its primary maintenance goals. As such the measures implemented to reduce tort liability should complement the agency's ability to obtain established maintenance goals rather than force the agency to make a choice between goals and tort liability.

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Abridgment

Sign Maintenance Management

H. L. WOLTMAN

ABSTRACT

Sign maintenance management requires a systematic approach beginning with an inventory of traffic control devices that is updated with work orders. The initial inventory procedure can be accomplished either manually or by photologging followed by data entry in a computer file. The data base is required for management of maintenance procedures, materials purchase, inventory control, forecasting, and budget planning. A benefit of an ongoing inventory is the accurate identification of such problems as theft, vandalism, installation deficiency, and durability. Suggestions for correcting such chronic sign maintenance problems as weathering failure, accident damage, vandalism, theft, defacement, and gunshot damage are made. Refurbishment of sign faces in the field may be possible in a number of such situations. A maintenance system is required for cost justification and control and is a useful adjunct in the defense of tort liability.

The essential needs of route guidance, intersection control, vehicle guidance, and safety are most economically met by conventional traffic control signs. Maintenance of such essential traffic control devices reliably and in satisfactory condition is aided by a systematic approach that includes record keeping and such field activities as inspection, evaluation, and replacement.

INVENTORY

With proper records, the age of sign installations can be traced, and exact numbers of signs by type are known; information is available that is helpful in planning and budgeting as well as in tort liability. In their review of tort liability case law, Eck and Malaeb (1) found a pattern that claims for deficient construction signs and traffic control devices had the highest dollar award per claim. They recommended inspection, record keeping, and warning systems. This review will address these activities.

Proper planning requires the collection of information from the field, and this invariably involves an inventory of devices. Field data can be collected either manually or with photologging equipment. Automated pictorial logging is often more economical than the manual process and offers numerous other advantages. Videotaping is a relatively new method used to collect data and is also satisfactory.

Each technique has its advantages and disadvantages. Manual techniques (Table 1, Figure 1) are most appropriate for low-volume roads and where labor may be readily available for such work. The multipurpose form in Figure 1 employs a keysort needle for sorting and collating. The Utah form is designed for field use with later data entry in a computer file. The advantages of the manual method of collecting data are that it requires no special equipment or skills. The disadvantage is that it is expensive and time consuming for routes with a normal amount of traffic. In addition, it is difficult to check the accuracy of the information once it has been collected. Other field trips may be required for verification.

The objective is to be able to reconstruct in some detail a description and location of devices

TABLE 1 Sign Maintenance Materials

Material	Vendor
Multi-Purpose Manual Traffic Sign Inventory System: LM-INVGUIDE-R1	Traffic Control Materials, Division/ 3M, 3M Center 223-3N, St. Paul, Minn. 55144
Computerized sign inventory system: The Sign Manager	Bather, Belrose Boje, Inc., 7101 York Avenue South, Minneapolis, Minn. 55435
Retroreflectometer: model 910	Retro-Tech, P.O. Box 3101, LaMesa, Calif. 92041
Field weathering test deck program: Plans GIF 13 (4.5.0)	Traffic Control Materials, Division/ 3M, 3M Center 223-3N, St. Paul, Minn. 55144
Graffiti defense: No. 1100 graphic overlay film	Sign Materials Project, 3M Center 220-6W, St. Paul, Minn. 55144
Vandal-resistant fasteners:	
Vandlegard VCN 15-5 Green	Voi-Shan, division of VSI Corporation, 8463 Higuera Street, P.O. Box 512, Culver City, Calif. 90230
Tufnut	The Tufnut Works, division of Santa Fe Systems, Inc., 236 Monteguma Street, Santa Fe, N. Mex. 87501
Sign-cleaning equipment: Highway Handyman Sign Cleaner, TM-60 12V electric or gasoline	Highway Handyman Products, 2447 University Avenue, St. Paul, Minn. 55114
Field-applied overlay faces: System 5	Traffic Control Materials, Division/ 3M, 3M Center, St. Paul, Minn. 55144

with respect to mileage, specific intersections, and road features. Such information must be available for each direction of travel and include approaches to intersections where cross traffic is controlled by signs. The specific details include sign size, type, color, mounting (i.e., one or two posts, offset, and height), and installation date. A most important activity is continual updating by the recording of any changes or improvements. This is accomplished with the work order form, which is employed for updating the file.

Computer data processing is a practical way to handle the inventory. Furthermore, collation, cross reference, and inventory control can be accomplished with accuracy. Programs exist in most of the common computer languages to segment information in virtually any manner desired. Most software programs have search routines that can select one or more identifiable criteria. For example, the criterion determining the replacement of signs might be for low reflectivity of a group of signs by year of installation or by manufacturer.

MAINTENANCE

Sign maintenance generally involves replacement of devices but as a practical matter also includes many

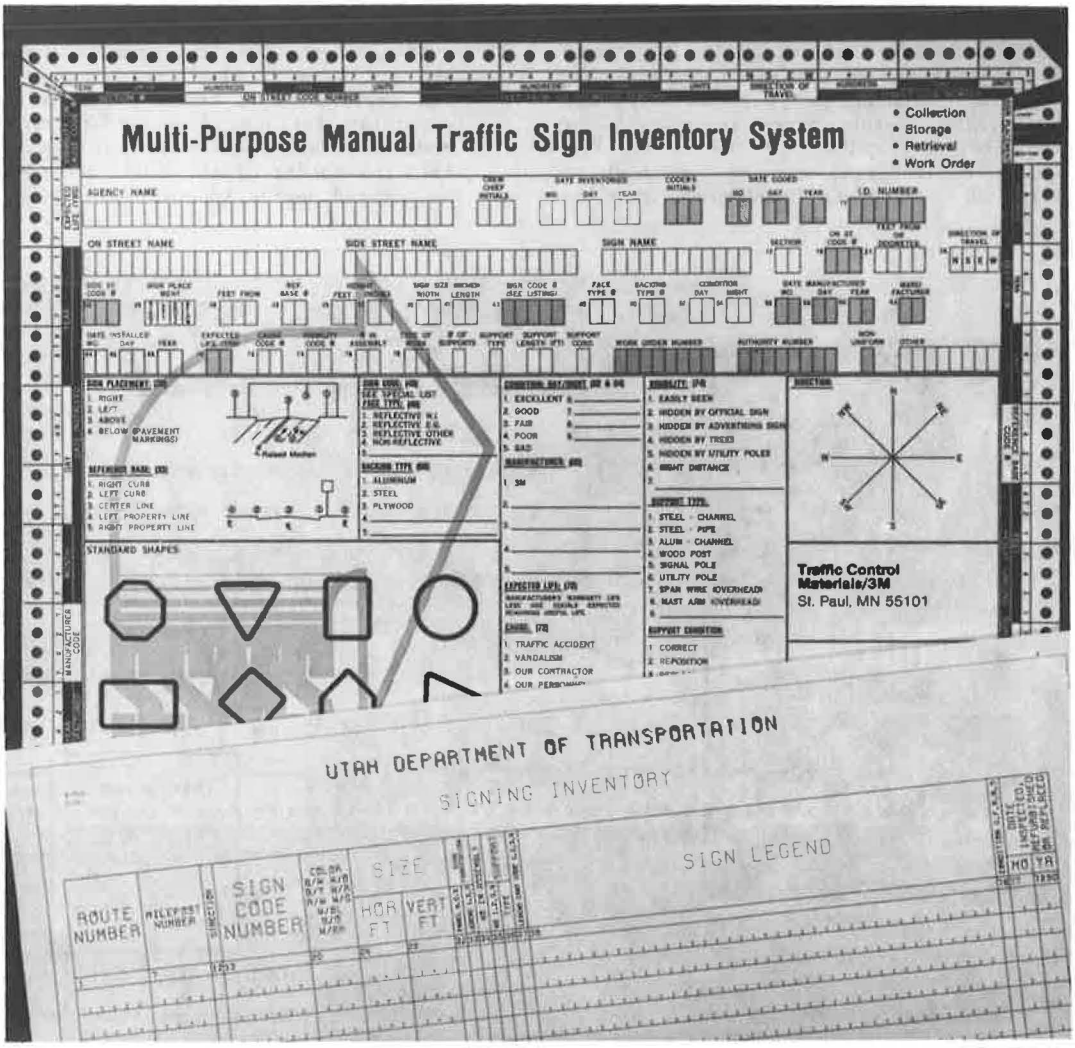

FIGURE 1 Examples of manual inventory forms.

other activities such as manufacture, procurement, inventory, and field inspection. Replacement of signs may be required for the reasons discussed in the following.

Weathering

Over time, the effects of weathering will reduce the night reflectivity of most reflective materials used for traffic signs and delineators. There is a serious lack of understanding of the impact of this gradual degradation of performance.

In the Manual on Uniform Traffic Control Devices (2) it is stated that signs having significance during hours of darkness should be reflectorized or illuminated. The question of whether signs are adequately visible at night can be most easily determined in a night inspection. It is essential to inspect such roadways with low-beam headlamps to determine the adequacy of reflection, visual obstructions to the device, and specific visibility needs if signs, delineators, or markings are missing or should be added. Often such omissions are more obvious at night than in the day. The extensive use of low beams even on low-volume rural roads has been well documented. It is essential to inspect night reflective devices under conditions generally similar to those employed by the average motorist. Clusters of signs, such as assemblies of route shields, should be examined. Occasionally the contrast of one or two signs of low brightness makes the entire assembly appear to be confusing and poorly maintained. Daytime inspection is important, but unless instruments are available to measure retroreflectivity, the inexperienced observer will not be able to determine whether signs are capable of performing adequately at night.

The effective reflectivity can be measured in daytime in terms of candlepower (candlepower per incident footcandle per square foot of signing material at 0.2 degree observation and -4 degrees entrance angles, the terms and angles commonly employed in photometric specification requirements) and a decision made to replace the sign at some minimum level.

The measurement may also be gauged at night by using a comparison panel of sheeting having the chosen minimum level of reflectivity. The comparison panel is held on the surface of the sign while an observer 100 or 200 ft away matches the reflectivity of the sign to the comparison panel using the headlamps of his vehicle. Should the sign be judged of equal or lower brightness, it is recorded for replacement.

If an inventory record indicates the age of signs, inspection of a sample of signs by age may reveal those signs where reflectivity may be suspect. Replacement can then be made. Several methods can be employed to identify sign age:

- Inventory record: An obvious benefit of data processing is the capability of itemizing all signs by installation date, type, manufacturer of reflective sheeting, size, direction facing, and location so that replacements and work orders (3) may be ordered appropriately.
- Sign stickers: A less sophisticated but quite functional method is to apply a sticker on which the installation date is coded. Sticker color can be varied each year to aid rapid identification from a vehicle, or the date code can be punched in the appropriate part of the sticker at the time the sign is installed (Figure 2). This permits field crews to identify and replace signs known to be of an age approaching failure. One jurisdiction plans to code the signs with a logo to be screen printed into the border of the sign. The position would be rotated yearly to correspond with hours on a

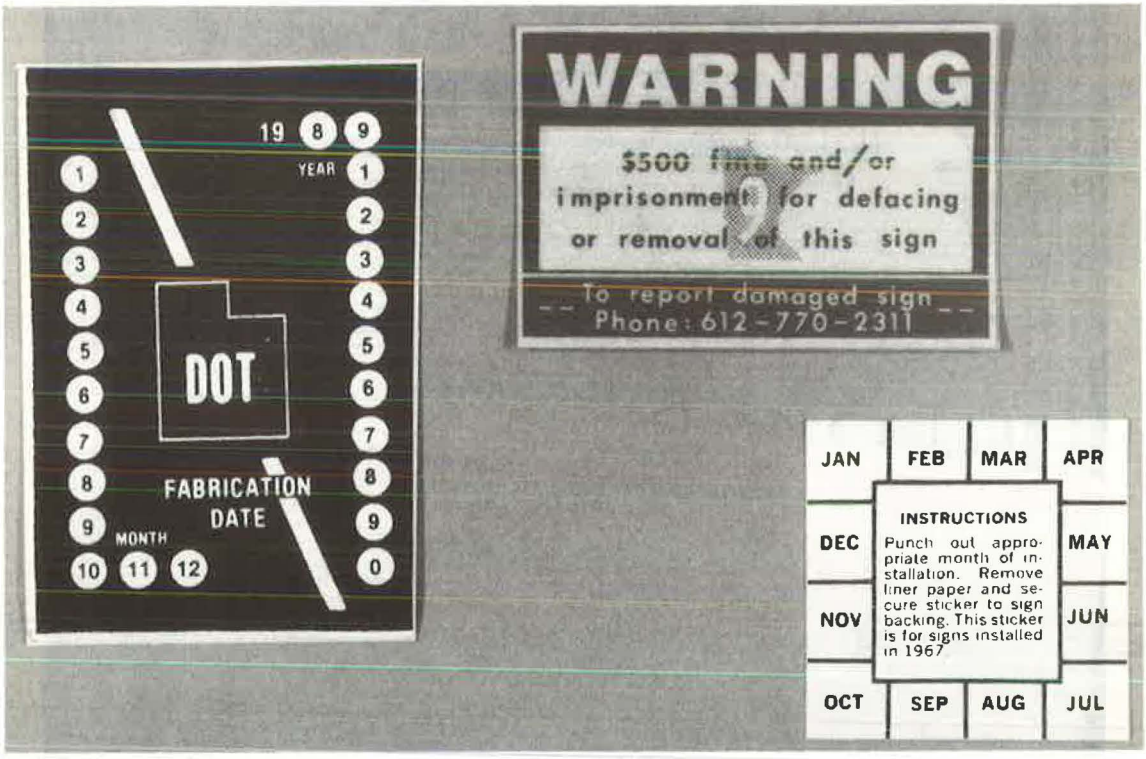

FIGURE 2 Sign identification labels combining installation date, warning, and identification information.

clock face. Thus the year 1984 would be coded by a logo in the border at 4 o'clock, 1985 at 5 o'clock, and so on. At the next decade the logo shape would change but the clock code would continue.

Mass replacement of signs at an interval of 5 years is performed by one city. Their procedure is to change all Stop and Yield signs within one-fifth of the city each summer. These are then reworked during the winter months.

Weathering progress can be monitored by reviewing a representative sampling of signs (from 3 to 5 percent by direction and age is suggested). A weathering test deck (Table 1) can be employed for monitoring samples, and additional locations in the field can be reviewed to sample weathering progress. Above all, adequate record keeping and truly representative signs are required. Such weathering test samples are best cut from production signs because metal treatment, adhesives, application techniques, process colors, and so on, are then accurately represented. The rates of natural deterioration for signs facing west, south, and east are approximately equal. North-facing signs and signs otherwise shaded will generally last 150 percent of the time for those facing south. A test deck should include both 45-degree south facing and vertical exposure racks because 45-degree exposure proceeds at a rate of approximately two times normal vertical south-facing exposure. The test deck can provide useful comparative information for sign materials.

Accidents

Records may reveal that certain locations require most sign replacements because of accidental damage. A review of roadway elements at these locations may suggest alternative mounting locations, for example, wider offset, greater height, larger or brighter signs. Posting signs on both sides of the road, particularly if signs are missed because of background clutter or visual noise, is frequently helpful.

Additional advance-warning signs on both sides of the road are often a solution to locations with a high incidence of accidents. Above all, consultation of the signing manuals (2,4) for review of warrants, appropriate signs, and roadway markings for recommended solutions should precede action for the particular situation.

Vandalism

Vandalism on traffic signs falls into three categories: defacement, theft, and gunshot. Often defacement and theft can be reduced by placing signs above reach. Such height is approximately 2.5 m (8 ft) to the bottom edge. At this height, sign visibility is generally improved by being above the height of most parked vehicles and vegetation. In addition, this height removes signs from the intense splash and spray of passing vehicles. A number of investigations have shown that dirt can reduce sign reflectivity up to 50 percent. Most of this soil accumulates only during winter freeze-thaw cycles.

Vandalism in some jurisdictions has been reported in the form of theft of metal sign posts. The most satisfactory low-cost alternative proved to be transite (asbestos cement) pipe. Other posts, such as treated wood, were higher in cost.

Defacement is often caused by paint spray and stickers of various types that are not easily removed. Limited defenses against graffiti are available. One is a coating (Table 1) of removable transparent film applied when the sign is new, which when peeled off takes the graffiti off and leaves a clean sign surface. New film must be reapplied for continued protection. Liquid graffiti removers contain solvents that are intended to remove spray paint. Such removers will generally remove screen process colors used for sign legends but may not otherwise damage reflective sign material. They must be used with care.

Sign theft and defacement are discouraged at the recommended 2.5-m mounting height and can be further discouraged with nonremovable fasteners. Such fasteners cannot be removed with common tools. Some examples are rivets that may be set with swaged sleeves or carriage bolts having specially formed nuts that require special wrenches and removal means (Table 1, Figure 3).

Gunshot damage to signs is occasionally a problem. The solution that appears to have the greatest effect rests on an educational campaign of both short- and long-range nature. The perpetrator is generally a youthful individual. The forum for educating the young hunter (in the United States) is the Hunter Safety Training Course, the completion of which is often required for issuance of a hunting license. Emphasis against such shooting damage varies from program to program but can often receive added emphasis once hunter safety training coordinators are alerted to the problem by their state departments of conservation or departments of natural resources. If action is required, costs and photographic evidence in the form of slides may be required. Key sportsmen's groups are also sensitive to the "slob hunter," as are public utilities. Sign stickers for dating the installation should carry some message such as "Warning: $500 fine and/or imprisonment for defacing or removal of this sign. To report damaged sign phone _____" (Figure 2).

The educational campaign requires a sustained commitment for long-term benefits and together with appropriate stickers or other local warnings includes both long- and short-range efforts.

The extent of vandalism and the perception of vandalism vary greatly and cannot be defined without records. Some jurisdictions report an extensive and costly problem; others (5) with accurate records report the incidence of vandalism to be 0.7 percent annually, a relatively negligible level.

SIGN CLEANING

Removal of dirt, tar, crayon, and road salt is occasionally necessary. A wet nonabrasive detergent cleaner suitable for automotive finishes is satisfactory. With equipment designed for this purpose (Table 1), the sign is flushed with clean water to remove loose dirt particles, washed with detergent and a soft brush, and rinsed with clean water. Use of a mild solvent such as mineral spirits or kerosene can remove most other materials from nonscreen-processed areas. Such localized cleaning should be followed by cleaning with detergent and flushing with water.

Replacement of sign faces due to weathering or minor surface damage where the sign backing is still intact may be accomplished in the field with overlay faces (Table 1). Such prefabricated retroreflective faces can be applied over the existing face without removal of the sign from the post. The complete procedure involves minor straightening, cleaning, and in some cases priming the existing face; punching holes in the new overlay at bolt-head locations; and applying the pressure-sensitive face. This procedure eliminates considerable transportation and handling but, more important, it reuses existing sign back-

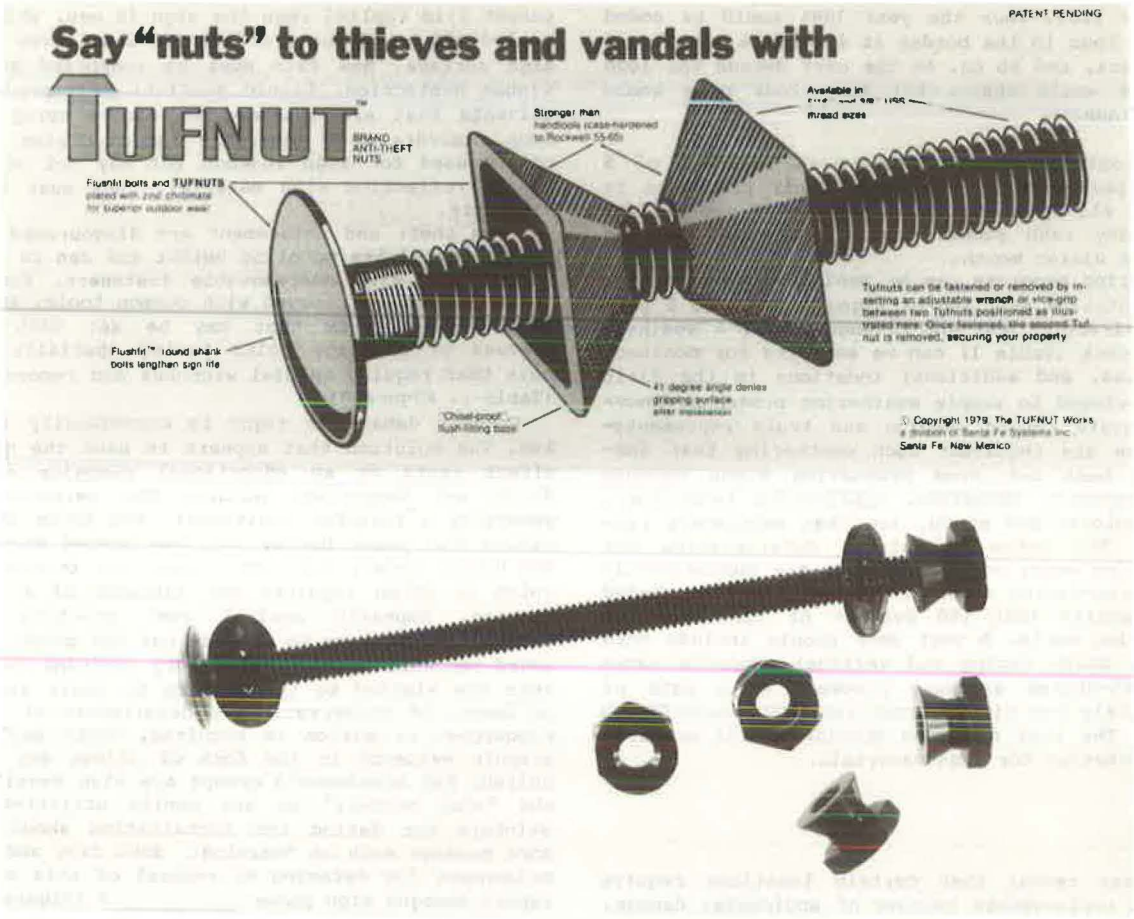

FIGURE 3 Vandal-resistant sign fasteners.

ings and frees sign shop personnel and application equipment for more specialized work.

DELINEATION

Delineation of curves can often be simplified by reducing the number of shoulder-mounted delineators. Snowplowing, mowing, and other shoulder maintenance can also be somewhat simplified.

Consideration should be given to the use of the chevron alignment signs (W1-8) (4). These should be mounted on the outside of curves and should begin at the end of the tangent section and terminate at the beginning of the tangent section following the curve. Frequently the chevrons can be placed back to back on the same post to serve traffic from both directions. The usual spacing practice is to mount chevrons so that two to three are visible throughout the curve.

For more abrupt curves, the large arrow sign (W1-6) is a single device installed on the outside of the curve that may suffice if adequate [minimum 30 m (500 ft)] sight distance is available. Both signs have the effect of reducing the number of individual devices needed, which in turn reduces installation, replacement, mowing, snowplowing, or other maintenance requirements.

CONCLUSION

Proper sign maintenance requires continued management of inventories, production, installation, and theft and vandalism, as well as day and night inspection to ensure continued satisfactory performance. Inventory techniques that offer district offices flexibility and adequate inventory control together with simple record-keeping procedures are an essential part of a total maintenance system.

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