CHAPTER **8**

ASSISTIVE LISTENING SYSTEMS, CUE SIGNS, ELECTRONIC VISUAL INFORMATION DISPLAYS, AND AUDIBLE SIGNS

INTRODUCTION

Travelers using large, multimodal transit systems often find them complicated and forbiddingly complex. For individuals with visual or hearing impairments, transit systems that may be legally accessible from the ADA perspective often can be too complicated for these individuals to confidently and safely ride. In recent years, the transit industry, in partnership with the disability community, has begun to adopt technologies that provide increased confidence, safety, and ease of use by individuals with disabilities. The following discussion of assistive listening systems (ALS), dialog systems, cue signs, electronic visual information displays, and audible signs describes technologies that have great promise in increasing ridership among the hearing and visually impaired.

The technologies described in this chapter are evolving rapidly. During the course of the development of these guidelines, the Federal Transit Administration (FTA), Transportation Research Board (TRB), U.S. Architectural and Transportation Barriers Compliance Board, and Transport Canada's Transportation Development Centre were conducting numerous research projects to better define effective signage using these technologies. Research was also being conducted by numerous disability organizations to better develop and define technological aids that would provide greater access for individuals with disabilities. Because these technologies are evolving so rapidly, it is important for graphics designers to stay abreast of them in order to ensure that the techniques and materials selected are current and represent the best solutions for their riders. Contacts with one or more of the organizations mentioned above can provide up-to-date guidance on the state of the art for the signing technologies that follow. Further, local and national disability organizations are excellent resources and are eager to provide information and technical assistance in the use of current technology to increase access for their constituents.

ASSISTIVE LISTENING SYSTEMS

There are several types of ALS that signage designers may consider in providing information to individuals with hearing impairments. These systems accept input from existing public address systems, thereby reducing cost. However, the type of microphone and its placement at the sound source is crucial for the ALS to be effective. A variety of listening attachments (inductive telecoil couplers called neckloops, and the typical earbud or headphone type accessories) permit users of telecoil-equipped hearing aids to join others in understanding more with the use of ALS.

FM Systems—Sound, via a microphone or public address system, is fed into an FM transmitter. It sends sound to small, individual FM receivers. Hearing-aid users with hearing aids that are equipped with telecoils set the aid on the "T" setting and use a neckloop listening attachment; earphones are used by everyone else. The FM systems produce an excellent sound quality. The systems are not subject to electrical interference and are highly portable, simple, and inexpensive to install. Maintenance and operating costs are low because the systems are highly reliable.

The major disadvantages of an FM system are its initial equipments costs, which are greater than those for the AM system or the audio loop system, and restricted access (service is limited to the number of receivers). FM systems transmit through walls so adjacent facilities should be equipped with other frequencies to avoid interference.

Induction Loops—A loop of wire circling the room (or part of the room) near a ceiling or floor, receives input from a PA or microphone through an amplifier and transmits the sound by creating a magnetic field with the loop. This field can be picked up by listeners with hearing aids on the "T" setting or with telecoil-equipped receivers and an earpiece. The receiver is equipped with an amplifier so that the sound level can be controlled by the user.

No special receivers are needed by people whose hearing aids are equipped with telecoils. Prepackaged systems can be easily installed in small- and medium-sized spaces and are inexpensive. The disadvantages of this device are that users a) must be within the loop to receive information and b) must have telecoil-equipped hearing-aids or must be provided with loop receivers. Sound quality is often uneven throughout the looped area and fluorescent lighting can interfere with transmission. The electromagnetic field signal can "spill over" into adjacent areas. Temporary or portable loops are available but cannot be moved without difficulty. Systems for large areas are complex to install and a high-powered amplifier is required.

Infrared—Infrared systems use invisible light beams in the infrared range of the spectrum that carry information from a transmitter connected to a PA system or microphone to a special portable receiver worn by the listener and fitted with neckloops, earbuds or headphones to meet the user's needs. For persons with mild to moderate losses of hearing, the sound quality is good. The system is easy to operate and is not subject to electrical interference. It is contained within the walls of the area and it's the only system appropriate for confidential transmission. However, infrared light is present in sunlight, incandescent light and fluorescent light, so a large amount of light in the room may produce interference. Receivers must be within the line of sight of the transmitter.

AM Systems—AM systems are similar to FM systems in that receivers, which may be AM radios, pick up the signal broadcasted from an AM radio transmitter coupled to a microphone or PA system. The technology is both simple and inexpensive. Patrons can use their own personal AM radio and attachments and fine-tune to the broadcast. Unfortunately, AM systems have relatively poor sound quality, and they do not perform well in buildings with substantial amounts of structural steel.

DIALOG SYSTEMS

Though in its embryonic stages, true dialog systems are under development, which provide wayfinding information via a telephone handset. The user may interact with the system using a home telephone, a cellular telephone, or through a microphone-speaker device in an information kiosk. The system is speaker independent and works through continuous speech recognition software. Thus, the system is able to learn and recognize continuous speech of any speaker asking questions. The technology was developed in 1994 and successfully demonstrated in a transit study by the Massachusetts Bay Transportation Authority and the National Eye Institute.

The system contains two major components of a fully specified spoken language system: a discourse system and a dialog system. The discourse system remembers elements such as the origin and destination for a trip segment until they are redefined by a user during a dialog with the system. The dialog system makes use of aspects of the discourse where appropriate (for example, to interpret incompletely specified follow-up questions presented by the user).

The system also has the capability of taking charge of a dialog and asking questions where it is deemed necessary. For example, the system is able to understand that a question is not correctly specified when it occurs at a particular point in the session where there is no discourse history for it to build on. When this occurs, the system prompts the user for the missing information and proceeds with the dialog.

CUE SIGNS FOR VISUALLY IMPAIRED TRAVELERS

Cue signs are raised letter and Braille directional signs that are placed at logical decision points along major trip segments in a transit facility. The signs provide users who are visually impaired directions from one cue sign to the next until they reach their final destination. Cue signs have not been used in a facility, but limited testing indicates that cue signs do provide assistance to patrons who have visual impairments.

Each cue sign should be located at a landmark, a processing point, or at a point where the person must change direction. All direction changes are right angles (90 deg). Cue sign messages are very brief and use a very limited vocabulary so that the same words are used over and over again. The repetition enables those who do not read raised letters or Braille well to adapt and become proficient in their use within a short time.

Cue signs within a facility should are always be the same size. The recommended size is 8 in. × 8 in. (203 mm × 203 mm) with rounded corners. They should be mounted at the same height above the floor (recommended 48 in. [1,219 mm] from the floor to the horizontal centerline of the sign). They can be mounted on a wall or on a post. Mounting angles can vary from flat on a wall (perpendicular to the floor) to flat on the top of a pedestal post (parallel to the floor). The raised letters and Braille can be read more easily if the sign is mounted at a 45-deg angle from the floor on the top of a pedestal post or on a wall bracket.

The raised letters on the cue sign should be both tactile and visual, permitting those who have limited vision to see and feel the text, which increases reading speeds. The signs should be placed adjacent to and out of the way of the normal patron flows so that the users do not have to stand in the flow of traffic as they read the sign.

Cue signs should be consistently placed to the right of the flow of traffic. This standard placement helps users find the sign because they know in advance that signs will always be to the right and out of the flow of traffic. Consistent placement of cue signs is critical for success. General rules for placement should be developed and coordinated with local disability organizations. Suggested general guidelines for placement are as follows:

Station Entrance—Within 10 ft and to the right of the main entrance escalators, entrance stairways, or entrance gates.

Level Changes—Within 10 ft and to the right at the top of the escalators or stairs, and within 10 ft and to the right at the bottom of the escalators or stairs.

Fare Processing Area—On the first fare machine as one enters the fare processing area.

Fare Gates or Turnstiles—10 ft beyond the gates or turnstiles and to the right.

Platform—Within 10 ft and to the right at each entry point onto the platform.

Each sign message should provide the user directions to the next cue sign until the desired destination is reached. The directions must describe how the patron is to get from the current cue sign to next cue sign. Thus, directions should be based on the assumption that the user is facing the cue sign straight-on as it is being read and that the user's intent is to proceed to the next cue sign.

Messages on cue signs can be formulated using the following limited vocabulary.

GO, TO, TURN, THRU, FEET
RIGHT, LEFT, STRAIGHT, UP, DOWN
ENTRANCE, EXIT, PAY FARE, GATES, PLATFORM

Table 4 shows how cue signs should be designed and where they should be placed. A sketch showing locations for these cue signs is presented in Figure 39.

ELECTRONIC VISUAL INFORMATION DISPLAYS

The primary purpose of an electronic visual information display system is to automate the display of real-time schedule information to transit passengers. In addition, the systems are used to

- Assist in passenger traffic flow,
- Provide accurate and current operations information,
- Provide up-to-date information to passengers for exceptions to the normal schedule, and
- Provide passenger information in abnormal or emergency conditions.

General types of transit customer information systems in use include video display units (VDUs) and light-emitting diode (LED) readerboards using single or multiple colors. The LED is a "pea-sized" electronic device that emits light when a current is applied. LED readerboards use a two-dimensional array of LEDs to display letters, numbers, or symbols and can also provide some animation, depending on system capabilities. Customer information systems may also include audible-only systems (which automatically produce digitized voice information at appropriate times, or emit an infrared signal to be received by a pocket-sized unit) and full audio/visual systems.

TABLE 4 Cue sign message and placement

Sign #	Sign Message	Sign Placement
1	ENTRANCE TO METRO CENTER	On pedestal post 10 feet before the station entrance gates and off to the right
2	TURN LEFT GO 5 FEET TURN RIGHT GO 30 FEET PAY FARE	On same pedestal post as sign #1
3	TURN LEFT GO 15 FEET THRU GATES	On fare machine
4	STRAIGHT 15 FEET TURN RIGHT DOWN TO PLATFORM	On pedestal post 10 feet beyond fare gate and off to the right
5	RIGHT TO CENTER CITY LEFT TO END OF LINE	On pedestal post 10 feet beyond stairs and off to the right

Current Technology in Customer Information Systems

Both the FTA and Canada's Transportation Development Centre have funded projects to develop guidelines for the electronic components of customer information systems. A FTA report published in December 1994, *The Development of Ergonomic Guidelines for Electronic Customer Information Systems*, presents guidelines for character representation, scroll rates for displays, and use of color and contrast for a variety of electronic devices used in customer information systems.

The following sections summarize the above guidelines developed by Oregon State University's Transportation Research Institute for the FTA's Office of Technical Assistance. The discussion provides a description of each device, guidelines for effective use in the transit environment, and advantages and disadvantages to its use.

Video Display Units

A video display unit (VDU) is a glass tube, from which all air has been evacuated. It has an electronic gun at one end and a screen surface at the other end, which has a phosphor coating on the inside. The electron beam is first focused into a narrow beam by an electronic lens and then directed to the desired screen position by an electromagnetic deflection mechanism. When the electron beam strikes the phosphor on the inside of the screen the grains of phosphor glow. For one point of electron impact the viewer would see one very small bright spot of light. To present an image on the screen for the viewer, the electromagnetic deflection of the beam is performed in such a way that the beam is steered into the proper positions while the electron gun is switched on and off as needed to draw the desired image. This process is called beam scanning.

In a color VDU, a phosphor coating that glows in different colors for different electron beam energy levels is used. There are three electron guns in a color VDU. They produce electron beams with energy levels that correspond to red, green, and blue, respectively. The beams are directed such that they go through holes in a very finely perforated metal mask before they fall upon the screen next to each other,

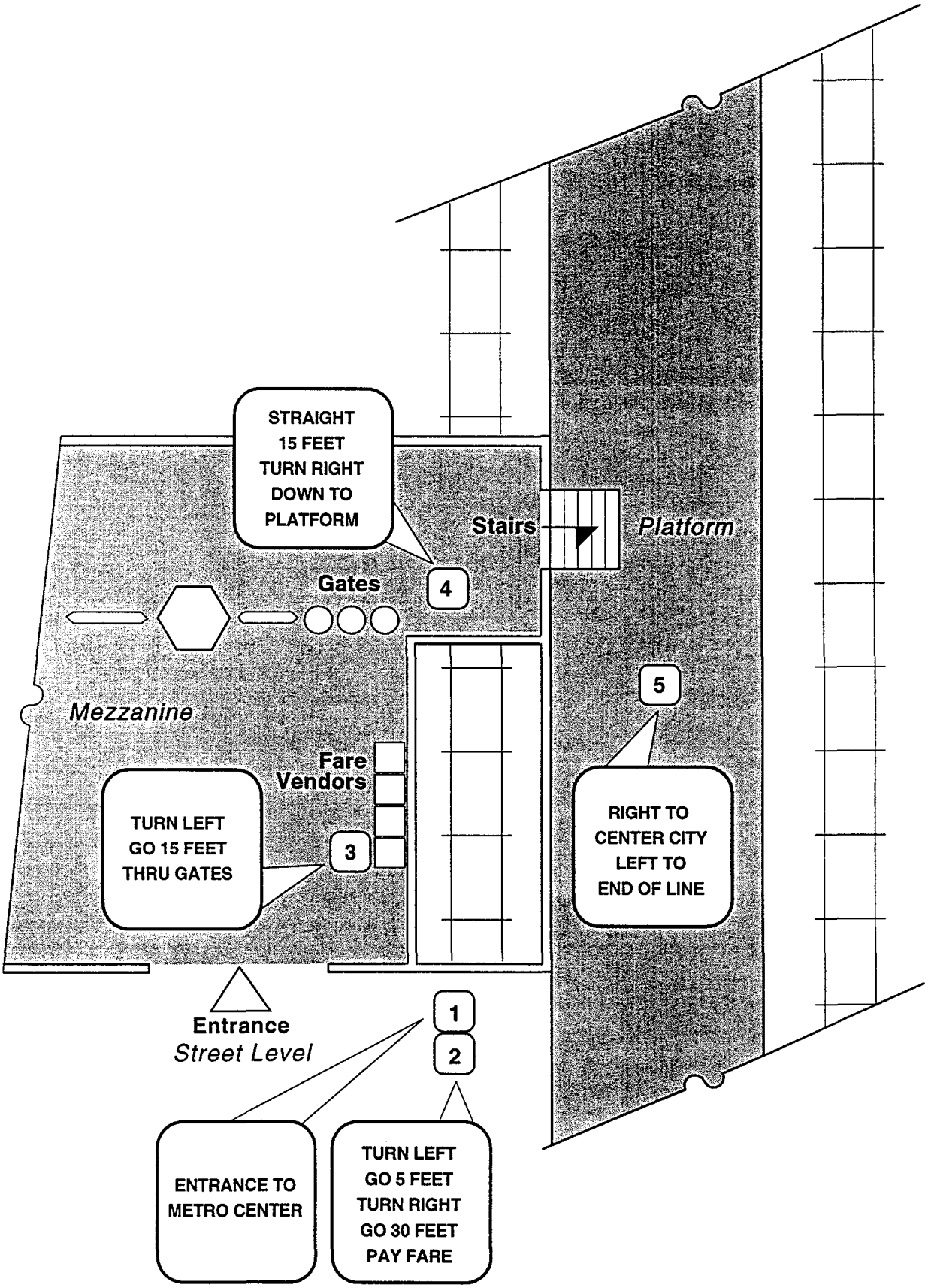

Figure 39. Location of tactile cue signs.

forming a pattern that makes a dot that is composed of a red, blue, and green dot. The intensity of the red, blue, and green dot elements are varied by the electron guns to produce the color desired for that element of the picture. This colored dot is called a "pixel," for "picture element." Pixels make up the image on a VDU screen whether it is color or monochrome. A monochrome pixel is made up of the bright glow from one electron beam. The arrangement of the red, green, and blue element dots of a color pixel varies with different designs. Characteristics of VDUs that affect their performance are as follows:

Screen Size—Screen size determination is driven by space considerations and costs. The size should be sufficient to use the desired display format while satisfying character height guidelines.

Resolution—Resolution is the number of pixels displayed per a unit of distance. Units are dots per inch or dots per centimeter. As resolution gets higher there are more pixels in a given area with which to represent a symbol or character. Higher resolution yields a more refined and more easily read display. Very good VDUs have a resolution of 30 dots per cm (80 dots per in.).

Pitch (or Dot Pitch)—Pitch is the distance between two pixels. The smaller a display's pitch the more easily it is read. Very high resolution VDUs use a dot pitch of 0.28 mm (0.011 in.).

Scan Rate—The scan rate of a display (sometimes termed refresh rate) is the number of times per second that the screen is rewritten, or refreshed, regardless of whether the displayed image is changing. If scan rate is too low, then flicker will be visible to the user. There is now a Video Electronics Standards Association standard for scan rate (which is 70 Hz).

Advantages and Disadvantages of VDUs

Advantages of VDUs, compared to other transit system usable displays, include

- Low cost,
- Better resolution (thus better legibility),
- Animation capability (thus more suitable for advertising), and
- Virtually unlimited range of variable color capability (again more suitable for advertising).

Disadvantages of VDUs, compared to other transit system usable displays, include

- Greater depth of housing (thus difficult to use as an onvehicle display),
- More subject to glare than some types of LCD displays (thus not as suitable as an outdoor display), and
- Limited screen size (which limits feasible character size, and thus limits effective viewing distance).

In summary, VDU displays are more suitable for indoor displays where better control of lighting and more space exist, than at vehicle stops, or onboard vehicles.

Light Emitting Diodes

A light emitting diode (LED) is a semiconductor device. A small current is passed through the semiconductor material. The current causes electrons in the material to be temporarily excited (raised in energy) such that they move to a higher level energy band than their normal position. When the electrons return to their normal energy band, photons (specific quantities of light energy) are emitted. The type of semiconductor material in the LED determines the color of the light emitted.

The liquid crystal display uses the property of certain crystals to change their orientation and their effect on light when an electric current is applied. Liquid crystals can be used to make dot matrices or mosaic tiles. When current is applied to the dots or tiles, alphanumeric characters are produced.

Advancements in LED technology include the development of brighter devices that emit green, orange, and yellow. Currently, only red LEDs are bright enough for outdoor use. With two of the three primary colors (red and green) currently available, the development of a blue LED is a high priority. That addition would bring increased color capability for LED displays.

Modern LED displays do not use separate LEDs placed into holes to make the display matrix. Instead the display is made up of component blocks. Each block is a square matrix with flat top cavities for each individual dot of semiconductor material. The result is that the luminous elements are right on the display surface, providing the widest possible viewing angle. The viewing angle referred to here, which is the angle between a line that is perpendicular to the display surface and a line drawn from the display to the viewer is relative to the display. Characteristics of LED displays that affect their performance are:

LED Size—The diameter (or width if the display is a matrix of square LED elements) of one LED is referred to as the "dot size" of the display. The prevalent dot size for transit system displays is currently 5 mm (0.197 in.).

Dot Pitch—The dot pitch, or distance between dot centers, which is currently prevalent in transit system displays is 6 mm (.236 in.). Greater spacing between dots produces a reduction in readability. This is due to the loss of a cumulative effect whereby adjacent LEDs act together to form an image, rather than as individual dots. At a dot pitch of 6 mm. (0.236 in.), this effect enhances display readability down to 1.8 m (6 ft.). Dot pitch is related to dot size because there is a minimum spacing required between LED adjacent elements. To make a display more readable at very close viewing distances the dot size could be reduced, which would allow a reduction in dot pitch, but the cost of the display

would be greater. The current prevalent use of a 6-mm dot pitch is due to the fact that it produces good readability at an acceptable minimum viewing distance of 6 ft (1.8 m) within reasonable cost.

Character Formation—To form a character, a minimum dot matrix of 7 x 9 is preferred. Characters must be double stroke (made up of two adjacent rows of dots).

Display Luminance—The display must be capable of enough brightness to be visible in the intended environment. If lighting conditions are variable, this would make the display too bright for the lower illumination levels. Therefore, dimming controls or sensors should be used for displays with varied ambient conditions.

Current indoor, semi-outdoor, and ultra bright versions of LED blocks for different illumination levels are available. Their ratings are given in Table 5.

Advantages and Disadvantages of LED Displays

Advantages of LED displays, compared to other transit system usable displays include

- LED display panels display text in ADA-compliant character heights,
- Lower cost than LCDs,
- Solid state design resists vibration (making LEDs suitable for on-vehicle use),
- Flat configuration suitable for use in limited space situations.
- Animation capability (thus more suitable for advertising).

Disadvantages of LED displays, compared to other transit system usable displays include the following:

- They are more subject to glare than some types of LCD displays (thus they are not as suitable as an outdoor display).
- Their readability is distorted when viewed at an angle,.

In summary, LED displays are most suitable for onvehicle or vehicle stop displays where space limitations, vibration, and the desire for advertising revenue exist.

TABLE 5 LED ratings for different illumination levels

Use	Color	Display Luminance (cd/m^2)
Indoor (V&P)	red-green-amber	100
Outdoor (V)	red-green-amber	500
Outdoor (P)	gradient control red (ultra bright)	1000

V = Vehicles P = Platforms

Liquid Crystal Display

Liquid crystal displays (LCDs) take advantage of the light transmission properties of certain materials termed "liquid crystals." There are three types of liquid crystal substances: Nematic, Smectic and Cholesteric. All three have properties associated with crystalline solids, except they are in a liquid form. Nematic liquid crystal materials have a structure that is useful in visual displays. The temperature change caused by a small amount of electrical current abruptly changes the light transmission properties. When a nematic liquid crystal element is not activated, light does not pass through. When it is activated, light does pass through. A reflective element, illumination device, or an element that is both reflective and transmissive ("transflective") with an illumination device is placed behind the liquid crystal element to give the activated element the desired appearance. A LCD display is formed by shaping the liquid crystal elements to form characters or symbols when the display is manufactured and then electrically activating proper elements to form the desired image.

There are several types of LCDs. The two most common are the active matrix displays (AMLCD), which are used in lap-top computers, and the twisted nematic displays (TNLCD), which are used for watch faces, calculators, and in transit system applications. The AMLCD has many very small elements called pixels. The pixels are used to form an image just like on a VDU. Each pixel site has a solid state, electrical switching device to determine the light transmission of that pixel. This technology is currently suitable only for lap top computers because of size and cost limitations, narrow viewing angle, and lack of sunlight compatibility. The TNLCD is available in three types, depending on the characteristics of the materials behind the liquid crystal elements: reflective, transmissive, and transflective.

The reflective display is very clear when the surrounding illumination level is high, but it must be illuminated from the front of the display in low lighting conditions. The transmissive display must be back lighted, usually by a fluorescent element. It is very clear in low lighting conditions, but it is not suitable for daytime outdoor use because of poor visibility in high levels of illumination. The transflective display is suitable for high and low illumination levels because it has both reflective and transmissive properties with back lighting. A twisted nematic liquid crystal display that is transflective is the best LCD type for transit system use where illumination levels vary.

The following characteristics of LCD displays:

Character Formation—Characters may be formed on a TNLCD by either a segmented or mosaic tile liquid crystal element layout. Watch faces and calculators are examples of a segmented display. A more complex approach, which is necessary for a more readable display, is the use of specially developed elements of varying shapes to form clearer char-

acters. The elements are called mosaic tiles. Mosaic tile displays provide the clarity needed by people with visual impairments. The associated disadvantage is higher cost than segmented displays.

Control Circuitry—The latest TNLCDs use a design termed "chip-on-glass," in which microelectric circuitry is bonded to a glass plate that is part of the display. This places the elaborate circuitry which must control each individual element of the TNLCD in unit construction with the display, rather than having need for many separate electrical connections between the display and separate control circuitry. Older TNLCD designs suffer reduced reliability because of the potential failure of any of the multitude or connections.

Advantages and Disadvantages of LCD Displays

Advantages of TNLCD display, compared to other transit system usable displays include the following:

- Reflective TNLCDs perform equally well in bright, outdoor conditions as well as in indoor conditions.
- Transflective TNLCDs perform very well in bright, outdoor conditions, and with low illumination.
- Solid state design resists vibration (making TNLCDs suitable for on-vehicle use).
- Flat configuration is suitable for use in limited space situations.
- Viewing from an angle is much better than with LEDs, which distort at even a slight angle.
- Good performance in displaying schedule information in transit facilities.
- Mosaic tile TNLCDs present a very readable character, even for those with visual impairments.

Disadvantages of TNLCD displays, compared to other transit system usable displays, are as follows:

- They are more expensive.
- They have no animation capability (making them less suitable than LEDs for advertising).
- TNLCDs cannot be used for time varying colors, although they are capable of displaying images in various fixed colors.

In summary, TNLCD displays are most suitable for onvehicle or vehicle stop displays where space limitations, vibration, and the desire for advertising revenue exist.

Flip-Dot Displays

Flip-dot displays are electromechanical devices. Electrical switching is used to rotate individual dots on the display so that either the black side is visible, for a dot that is "off," or the colored side (which is usually bright yellow) is visible, for a dot that is "on." The dots can be either round or square. Once an image is set, the flip-dot display presents a fixed message with characters made up of a dot matrix. Flip-dot displays are predominantly used for destination signs on buses.

The following characteristics of flip-dot displays affect their performance:

Dot Pitch and Dot Size—The dot pitch is the distance between dot centers on the flip-dot display. As with LED displays, dot pitch is related to the size of the dot. Dot pitch is equal to the dot size plus the dot spacing. Greater spacing between dots produces a reduction in readability. Reduced spacing between dots produces an improvement in readability.

Character Formation—To form a character, a minimum dot matrix of 7 x 9 is preferred. Characters must be double stroke (made up of two adjacent rows of dots).

Advantages and Disadvantages of Flip-Dot Displays

Advantages of flip-dot displays, compared to other transit system usable displays, are as follows:

- They are lower in cost than LCDs and LED displays while still a "flat" design, which is suitable for use in limited space situations.

Disadvantages of flip-dot displays, compared to other transit system usable displays, are as follows:

- They are more subject to partial failure than purely electronic displays because of the mechanical element of physically rotating the dots.
- They are limited to a dot matrix character, thus resolution and readability are not as good as those displays that form characters appearing more like fixed print.

In summary, flip-dot displays are most suitable for onvehicle displays where space limitations and cost limitations exist.

Split-Flap Displays

Split-flap displays like flip-dot displays are considered electromagnetic devices. The display's image is made up of two flaps, each with half the image. This type of display has been commonly found in clock radios for many years. Advantages and disadvantages of split-flap displays are listed below.

Advantages and Disadvantages of Split-Flap Displays

Advantages of split-flap displays, compared to other transit system usable displays, are as follows:

- They cost less than LCDs and LED displays.

Disadvantages of split-flap displays, compared to other transit system usable displays, are as follows:

- They are more subject to partial failure than purely electronic displays because of the mechanical element of the physical flaps.
- They are less flexible in what can be displayed. If the character is not preloaded into the installed flaps, it can not be displayed.

AUDIBLE SIGNS

Audible sign systems are comprised of small infrared transmitters that can be installed above or beside entrances, elevators, escalators, telephones, and other significant landmarks along a trip segment. The technology has been used successfully to provide limited "Walk/Don't Walk" guidance at street intersections for the visually impaired and is now being adapted for much wider use in transit facilities. Audible messages such as "Elevator to Main Street" or "Fare Vending Machine" can be transmitted to handheld receivers that are pointed in the general direction of the infrared transmitter.

Because the infrared signal transmitted from the devices marking an entrance or landmark is directional, the user is able to proceed directly to that spot indicated by the transmitter by proceeding in the direction that provides the clearest and loudest signal. Transmitters may stand alone with their own microphones for recording messages and individual power sources or they may be configured in a central system that permits programming of the devices from a central location.

The devices have undergone testing in transit environments by the Rehabilitation Engineering Research Center of the Smith-Kettlewell Eye Research Institute in San Francisco with positive results.

CHAPTER **9**

MATERIAL SELECTION AND PREPARATION, FABRICATION METHODS, AND MAINTENANCE AND REPAIR PROCEDURES

OVERVIEW

Three major requirements must be satisfied in the design and fabrication of a successful sign system. First and foremost, the system must be functional. Elaborate graphics, cabinets, and fancy backgrounds are useless unless the information is presented to the transit user in an attractive manner to promote a smooth flow through the facility.

The other two requirements are closely related—flexibility and economy. In a constantly changing transit environment, it is important that changes or modifications to the sign system be made at minimum expense. A sign system may appear to be economical when installed, but it may become costly because of the difficulty and expense of making required changes. Conversely, a flexible sign system that may have a somewhat higher initial cost may prove to be a more economical investment over time.

Fabrication cost—the largest cost factor in any sign system—is determined by the individual sign units, rather than the surface graphics. A sign system based upon a standardized system is usually less expensive over its life than individually fabricated units. The cost of signing a new facility, or resigning an old one, can be minimized by using standard sign units.

Unnecessary illumination of signs is another avoidable expense. The illumination of many signs may be eliminated when ambient lighting is at appropriate levels. Significant savings will result from reduced initial costs as well as from the elimination of continuing electrical consumption, lamp and ballast replacement, cleaning and maintenance costs.

With new computer-driven sign-making equipment and flexible screen printing techniques, the use of customlettering styles and logos is no longer an important factor in the cost of a sign system. Custom die-cut lettering adds little cost to a sign package, a factor that should be considered by the designer. With a carefully planned program of standard type sizes and styles, cost effective communication can be achieved.

Protection of the sign system from vandalism is a serious design, fabrication, and location concern in all transit facilities. Some compromise regarding design and cost may be necessary where potential vandalism is a major consideration.

This chapter addresses the areas that signing and graphics sponsors need to understand in order to implement the most economical and flexible sign system. These areas are sign material selection and preparation, fabrication methods, and sign maintenance and repair procedures. The primary purpose in addressing these topics is to help those involved in the signing process to establish a basis for good communication between themselves and the sign fabricator. This information is not intended to dictate actions, but rather to assist those designing sign systems in determining the materials and fabrication methods to use from the many choices available.

Sign materials are described using generic terminology, and examples are provided to further enhance the descriptions. Sign materials display the message or provide the structural support for the message. No discussion of materials can be complete without reference to the type and amount of preparation needed to make those materials usable for their specific purposes. Therefore, general information regarding material preparation is presented. Individuals selecting a sign system should use this information as a basis for more detailed discussion with sign designers and fabricators. Note: This discussion is not intended to endorse specific products or manufacturers.

Fabrication methods and processes commonly used in the sign industry are presented here, as well as some discussion of different message materials. In addition, suggestions are presented for an organized program to ensure that the sign system continues to function in the manner for which it is designed, which includes general rules for cleaning, repairing, and replacing signage elements.

SIGN MATERIAL SELECTION AND PREPARATION

Metal

Metal is a universal base material for sign systems and is known for its durability. The two most commonly used metals are steel and aluminum.

Steel—Steel is generally considered to be the most versatile base material for sign systems. Although it is well known for its durability, steel must be specially treated by using processes such as galvanizing, primers, and other coatings to prevent rust. The best type of steel for signs is mill galvanized, phosphate-coated. Mounting steel signs requires special consideration because rolled-steel weighs approximately 495 lb per cubic foot.

Steel is a satisfactory material for sign faces that do not need internal illumination. It welds easily and is relatively inexpensive. Sign messages are typically applied by screen printing or by the application of pressure-sensitive die-cut vinyl letters.

Sheet steel is available in thicknesses of less than $\frac{3}{16}$ in.; the minimum thickness for plate steel is $\frac{3}{16}$ in. Sheet steel is normally galvanized before painting, and requires care in specifying the proper primer or undercoat. Galvanizing is the process of applying a zinc coating to a steel sheet or core. There are two basic types of galvanizing: hot-dip and electro. Galvanizing is measured in ounces of zinc per square foot, coated on both sides of the sign panel. A 1½-oz class coating will have a 7- to 14-year life before it begins to rust.

The hot-dip galvanizing process involves dipping steel into a hot bath of zinc. This process coats the steel but leaves the entire structure vulnerable to rust once the seal has been broken. Unfortunately, hot-dipping distorts the material somewhat, and when it is straightened the seal can be broken.

Electro galvanizing is a true plating process using zinc. If the seal is broken, rust will occur only at the break. It costs about the same as hot-dip and it does not require enough heat to distort the material. If galvanized steel is used, care should be taken to select a paint that is recommended for application over a galvanized surface.

It is good practice to have any nongalvanized steel surface sandblasted prior to priming and paint application. Sandblasting removes rust, grease film, and other surface properties from the surface of the steel. After sandblasting, it should be primed with a zinc-rich epoxy. The zinc causes the primer to adhere to the steel, and the epoxy in the primer produces the desired surface hardness. Cure time of the primer is dictated by temperature and humidity. There are three types of finish coats: co-polymer, epoxy, and urethane. The primer manufacturer should be consulted for the best finish coat to be applied, and consideration should be given to the area in the country where the steel product will be installed.

Aluminum—Because of its anti-rust properties, aluminum is one of the most preferred metals for sign fabrication. It is much lighter in weight, 165 lb per cubic foot or one-third the weight of steel. Another advantage is that colors can be dyed into the surface with a bonding process that provides better durability than painted surfaces. Preparation includes a thorough degreasing, etching and rinsing, or preparation with amorphous chromate-type coating. Alodine is a chemical process that prepares aluminum for painting. It is a dip process and normally leaves a yellowish coating. Brite-Dip is a chemical coating that imparts a bright, mirror-like, reflective surface to aluminum. Mechanical buffing is another method of polishing aluminum. Buffing leaves a cloudy surface that is more polished than reflective. Prepainted sheets are also available in thin aluminum (0.020 and 0.063 or $\frac{1}{16}$ in.) for laminating to stronger sign face panels. Sheet sizes are available up to 4 ft by 10 ft.

Aluminum sign panels are first formed to the appropriate profile and then receive a protective coating which is effected by a chemical conversion of the metal surface. This method is described in military specification MIL-C-5441 and is summarized below.

- Remove grease and dirt by submerging in a solution of nonsilicated and nonchromated cleaner for 5 to 10 min at 160°F.
- Rinse in clean running water at room temperature.
- Etch 5 to 10 min in a solution of alkaline etchant at 140°F to remove oxide film.
- Rinse in clean running water at room temperature.
- Immerse in the appropriate chemical solution for 5 to 7 min at room temperature. This conversion coating converts the surface metal into a chromate layer which protects the aluminum against corrosion and assures paint adhesion.
- Rinse in clean running water at room temperature, then dry and begin fabrication.

Wood

The durability of wood varies according to geographic location. In humid climates, wood requires special preservation treatment. With the addition of special treatments, the useful life of wood can be extended. Exterior wood grades should be used in practically all sign applications. There are three woods that can be used successfully without special treatments: redwood, tidewater red cypress, and red cedar. However, because of the high cost of these woods, the most common wood used for general purposes is plywood, particularly AC exterior fir. High or medium density overlaid sign grade (HDO or MDO) are the most common grades used for signs. The following section describes woods that can be used as sign materials.

Redwood—available in two grades: all-heartwood (which is highly resistant to termites and decay) and sapwood-containing. Redwood is a superior wood for exterior sign construction. Its tendency to weather check is inconspicuous; it has minimal tendency to cup and pull nails loose; it has high dimensional stability, and it accepts the widest range of paints and coatings while giving good service. The best grades for signing are clear, all-heart, vertical grain, and a regular grain without knots.

Cypress—a closed-grain wood with a slightly red to yellowish-brown natural color. Cypress has medium hardness and medium to high dimensional stability. It is very popular in the construction industry. It weathers well and will develop a pleasing gray patina over time when used for exterior signs.

Red Cedar or Western Cedar—a soft, closed-grain wood of light to dark red color. It is economical compared to pine and has very high natural decay resistance. Cedar is one of the top three woods suitable for signs. It has good finishing characteristics and dimensional stability.

AC Exterior Plywood—made from any of the woods that are described in this section, but AC exterior U.S. Product Standard, PSI 66 is most commonly used. Care must be taken to prepare plywood for sign face use by filling and sealing all flaws and edges before applying the finish coats. Exposed edges, especially the upper edge, should be weather protected to prevent the wood from warping and de-laminating.

High or Medium Density Overlay (HDO or MDO) differs from standard plywood in that a layer of phenolic resin impregnated fiber sheet is bonded to both sides. This covering minimizes the grain of the wood and effectively seals both surfaces of the panel. Edges are still unprotected and must be filled and sealed. The most typical use for MDO is in highway signing where its durability has been amply proven.

Other woods that can be used for signs, provided they are treated with special weather treatment, are as follows:

Douglas Fir—also a closed-grain wood with a reddish-tan color. Fir is available in two grains: flat and vertical. The vertical grain is more expensive, but has better stability than the flat grain which tends to splinter. It is a soft wood with fair to good finishing characteristics and dimensional stability. Fir is an excellent choice for use where structural strength is important.

Mahogany—few types are suitable for exterior use. Lauan or light Philippine softwood mahogany is light to reddish brown in color. It is open grained and more expensive than pine, cypress, or fir, and has fair finishing characteristics and stability. Matching plywood is generally available. Lauan is an excellent wall or sign cladding material.

Oak (white oak, plain-sawn)—a grayish-tan, opengrained hardwood available in a wide range of grain patterns and colors. It has excellent finishing characteristics for transparent rather than opaque coatings and is generally available in matching plywood. It has poor dimensional stability and large sections may require expansion joints.

Pine—a soft closed-grain wood that, like Douglas Fir, is inexpensive and readily available. Pine also shares good to excellent finishing characteristics and medium dimensional stability. Pine plywood is generally not available, except for Ponderosa, the most widely used pine.

The cleaning process for these woods requires light abrasion with sandpaper or steel wool either soaked with xylol or naphtha, and then air dried. One test to check if the sign surface is ready to accept a paint coating is to sprinkle water on the surface. If the water beads on the prepared wood, then it is not ready to paint.

It is not the purpose of this section to deal with the complicated chemical technologies of wood preservation materials such as copper napthenates and zinc napthenates. Generally speaking, wood is preserved by a chemical fluid that is forced into the fibers under pressure to protect them from decay, insects, fungi, and marine organisms. Fire-retardant chemicals are also available. Some chemicals will overkill the wood, rendering it so full of preservative that it is impossible to apply an acceptable sign surface.

In summary, without benefit of special coatings, the two best woods for sign making are redwood and tidewater red cypress. They are the only two woods in the United States available in commercial quantities that are high in decay and termite resistance. However, if it is economically feasible, red cedar is also an excellent wood.

Plastics

The terminology for plastics is categorized either by "base polymer" or brand names. The types of plastics will be addressed in their most familiar terms. These materials are popular and common to the signing industry. One disadvantage of plastic sheeting is temperature change susceptibility. Depending on the type of plastic, an expansion and contraction allowance of up to $\frac{3}{16}$ in. for every 4 ft is required to allow this material to expand and contract without restraint. Bolting or other inflexible fastening will not provide for this expansion and may result in sign breakage. Because of different expansion coefficients, plastic sheeting, if not properly bonded to other materials such as metals, may release in extreme change in temperatures. Nevertheless, there are some excellent plastics suitable for signing and sign finishes. A discussion of the major types of plastic suitable for signing follows.

Acrylics—Ranging from fully transparent to opaque, acrylics are available in a broad selection of colors. Opaque plastic used in conjunction with clear areas on backlit applications provide consistent and good block-out qualities. Acrylics hold up well under outdoor exposure and little fading occurs from exposure to direct sunlight. They can be heated to conform to almost any shape, and they can be sawed, drilled and machined like a soft metal. Acrylics shatter relatively easily, have a generally low impact strength, and have a fragile surface that can be easily defaced. They also tend to build up static electricity that attracts dust and dirt particles to their surface, although they can be easily cleaned. Some manufacturers of acrylic sheeting provide special hard coatings that eliminate this static electricity. Paints, when properly applied, will fuse with the surface and become an integral part of the plastic. Surfaces can be ordered in gloss or matte finishes. There is a higher impact acrylic called "DR," which is modified to produce a tempered hardness that falls between acrylics and polycarbonates. Acrylic sheeting is the most commonly used material for internally illuminated signs. It also can be used in nonilluminated signs, in which case it is better to specify the matte surface to reduce halide reflection from the illuminated copy of the background.

Polycarbonate Film and Sheet—tough and virtually shatter-proof, making it desirable in areas of potential vandalism. Although the color selection is limited to clear, clear matte, and white, this material can be subsurface screen printed for brilliant and colorful communication. Films are available in thicknesses from 0.005 in. to 0.040 in., and

sheets are available in thicknesses of from 0.125 in. to 0.50 in. The films are used to produce end graphics to be applied to other surfaces, and the sheet is used for applications where the sign may be free standing or supported by a perimeter frame. Polycarbonate can be backlighted like acrylic sheet but is much more shatter-resistant. Thicker gauges tend to have a milky appearance. Polycarbonate can be specified with a marresistant finish to provide additional protection against scratching and ultraviolet light degradation. The polyvinyl fluoride/polycarbonate (PVF/PC) composite now offers excellent UV, chemical and graffiti resistance.

Butyrate—oan optically clear, impact-resistant plastic that exhibits many good qualities, especially in the area of formability. It is available in a limited range of translucent and transparent colors.

High-Impact Polystyrene (HIPS)—another limited use plastic, used primarily for interior applications. It is very conformable and can be cut easily and shaped with common hand tools. This plastic is too brittle for outside use and yellows rapidly from its natural opaque white appearance when exposed to direct sunlight. It is readily available and inexpensive. Different levels of opacity are offered as are custom colors. Clear Polystyrene (OPS) is printable, but only in thinner gauges below 0.025 in.

Fiber-Reinforced Polyester-Nylon—normally manufactured as a very thin and flexible plastic. This material must be supported by another substrate because it is too flexible for freestanding applications and requires special handling during fabrication. Other fiber-reinforced polyester materials, excluding nylon, are sufficiently rigid. This material will also yellow over time when exposed to direct sunlight.

Polypropylene and Polyethylene—classified as limiteduse products, primarily for short term temporary or interior use signage. Color selection is quite extensive. Standard sheets are available in 4 ft by 8 ft panels. However, care must be taken because the material is flexible and may separate from other materials that are not fused to the surface.

Following are some selected brand names of plastics (many of these brand names are registered):

Acrylic—Plexiglas, Lucite, Acrylite
Acrylic—Polyvinyl Chlorides - Kydex 100
Butyrate—Uvex
Coatings—Reflectorized, Mirror, Abcite AC, Abcite PC, Lucite AR
Fiber-Reinforced Polyester—Fiberglass, Fiberlite, Alsynite/Structoglas
Hi-Impact Polystyrene—PAEX, Prime Impax
Oriented Clear Polystyrene—Polyflex
Fiber-Reinforced Polyester-Nylon—Filon, Tuflite, Filoclad
Polycarbonates—Lexan, Rowlex, Tuffak, Makrofol
Spun Polyolefin—Tyvek
PVF/PC Composite—EPC

Paper

As a sign material, paper typically is used only in temporary sign systems. Several types are available for signage applications.

Treated Paper—made from any combination of wood and rag fibers and impregnated with other substances. For signing purposes, papers impregnated with plastic are the most durable. Moisture-resistant and yellow-resistant paper also is available. The exterior life span of paper is approximately 3 to 6 months before fading occurs.

Laminated Paper—offers limited opportunities for signs. Metal foils can be laminated to papers and boards with wrapped edges to prevent delamination from moisture. Papers can also be laminated in plastic using adhesives or heat and pressure to protect them from weather and handling.

Synthetic Papers—typically solid sheets of polyethylene-based plastics that are treated to receive printing inks. There are no fibers, no impregnations, and no coatings; they are completely waterproof and non-yellowing. Printing and subsequent lamination to a substrate offer valuable applications in signing. They are also suitable for maps, directories, and design manuals because they will not tear. Common brand names include Tyvek^{t}, Kimdurd^{t}, Teslin^{t} and Printflex^{t}.

There are two basic finishes for paper, coated and uncoated. Coated stocks are categorized as glossy, enamel, cast-coated, or dull-coated. Uncoated stocks are categorized as vellum, natural, or regular, and absorb ink printed upon them.

Glass/Mirror

Glass—Can pose special signing problems because of reflections and the possible show-through of the backgrounds behind the glass. Subtle signs on glass are generally lost to the viewer. Sign colors should be chosen after reflection and background considerations have been researched. This material is best suited for use with controlled backgrounds. Contra Vision^{t} window markings offer special solutions to signing on glass windows and partitions effectively.

An important consideration in using glass is that different materials have different expansion characteristics. Signs that are screen printed on glass can crack if improperly applied because the glass expands at a greater rate than the screen printing inks, causing the letters to split. Plastic cutout letters with adhesive backs will not adhere permanently because of the expansion of the glass (which weakens the adhesive bond) and the deterioration of the adhesive caused by the sun. For individual letters, pressure-sensitive die-cut vinyl letters, which stretch with the expansion of the glass, are most effective. Decals are also very effective, but poor quality materials or workmanship can cause cracks or premature yellowing with age. If glass panels are to be completely coated with a dark, heat-absorbing color, a clear 2-in. border must be left around the edges to allow for expansion or the glass may break.

Glass Mirror—Can be used as a communications medium (aside from surface application of messages) by removing the silvering from the back by a sandblasting or chemical etching process. The resulting depression can then be filled with the desired color. After mounting the mirror, the message is vandal-proof because of its subsurface application.

Care should be taken with color selection. Tints, even clear tints, may change the color value of the paint seen through the glass. Therefore, messages should be reverse etched.

SIGN FINISHES

There are more sign finishes and coatings than there are sign materials. Thus, information provided here is only a brief summary of the basic finishes and coatings presently in use in the sign industry. Although this section does not cover all finishes and coatings, descriptions of the most popular ones are presented.

Baked Enamel—One Part Paint

Baked enamel (B/E) paints are melamine-base finishes that are most commonly sprayed onto a metal material (aluminum or steel). For application to steel, a base primer that inhibits rust must be applied prior to the application of the B/E. Though not the best finish for steel, a B/E finish can be applied to all gauges of aluminum and all alloys. It can be sprayed using the air fluid method or airless spray method.

After B/E is applied, it is baked in an oven at 250°F for a time cycle of one and a half to two hours. The baking process starts at room temperature, is increased to the maximum temperature, and then reduced to room temperature at the end of the baking cycle. B/E paints must have all solvents cured out to ensure nonfailure of the finish.

Color Matching of B/E—Can be successfully accomplished with most paint matching systems; PANTONE[t] is one of the most effective paint-matching systems.

Durability—Good for 5 to 15 years, if the paint manufacturer's specifications for preparation of the metal and paint application are strictly followed.

Fade—Depends on the color and pigment of the paint as well as gloss of the paint. The higher the gloss level specified, the greater the fade. A full matte finish is not recommended. The best finish is semigloss.

Hardness—Very good, better than air dry enamel but not as good as polyurethane.

Air Dry Enamel—One Part Paint

Air dry enamel paint (A/E) has the same spraying capabilities and metal application procedures as B/E. The metal to be painted must be cleaned using the same procedures used for B/E.

A/E enamel is used where the material to be painted cannot be baked in an oven because of oven size or size of the product to be painted. Air dry paints cure in normal air environments. The drying process is dictated by temperature and humidity. A/E can be baked but it must be done in a manner that does not vaporize the solvent in the paint too quickly and cause early paint failure. A/E can be baked by ambient heat around 100°F for 1 to 2 hours to speed up drying.

Color Matching—Same as for B/E paints.

Durability—Depends on color/pigments used in the paint. Darker colors do not last as long as lighter colors. Specification adherence for metal preparation and paint application is critical to achieve a finish durability of 5 to 12 years.

Fade—Same as B/E paints.

Hardness—Less than B/E paints or polyurethane.

Polyurethane Paint—Two Part Paint

Most two-part paints are one part base with pigments and one-part catalyst to speed up hardening. The more catalyst mixed with base, the faster the paint will cure. A catalyst only affects curing time, not final durability or hardness.

Several relatively new polyester paints are available. Some are "precatalyzed," having a shelf life up to 8 months. No mixing with hardener is required prior to application. A "no catalyst" type is also available, which requires no preapplication additions and dries for use in 8 days. Still another polyester product is a "water borne" variety for use in areas where evaporation of solvents presents a problem.

Color Matching—Good, may have problems with some colors. Consult with the sign fabricator before specifying color.

Durability—Excellent, same as B/E and A/E.

Fade—Better than B/E or A/E, and the gloss level can be better controlled.

Hardness—Excellent, better than B/E and A/E, but not as good as porcelain enamel.

Porcelain Enamel on Aluminum/Steel

The most durable of all man-made finishes, porcelain is an applied surface material that becomes integral to the structure of the material to which it is applied.

Porcelain is a mixture of inorganic material called frits/glass and water. These materials are ground into a fluid state and then sprayed onto the aluminum or steel structure. This structure is placed in an oven at 1000°F and fired at this temperature until it becomes very porous. At that point, the porcelain flows into the porous parts of the metal. As a result, the porcelain is not a surface film as B/E, A/E, or polyurethane, but becomes an integral part of the sheet or structure.

Because the porcelain on aluminum sheet or structure must be fired at 1000°F and the melting point of aluminum is 1200°F, aluminum may lose its shape. Therefore, there are many restrictions on using this finish in sign design. Consultation with a known porcelain enamel fabricator prior to specifying this material is recommended.

The principal disadvantage of this finish is its vulnerability to breakage, which is similar to glass. A hard blow from a stone or metal object can fracture the surface finish causing deterioration of the subsurface, which cannot be satisfactorily repaired.

Color Matching—Restrictive, but possible for most colors.

Durability—Depends on color. Because of fading, reds, oranges, and yellows are not good colors for outdoor use; however, they should last for 20 to 30 years.

Fade—Depends on color.

Hardness—Excellent, best of all man-made paints.

Coatings

Alkyds—Oil modified resin bases, they are fast drying and reasonably priced. Medium duration of life and color retention.

Asphalts—Natural or petroleum-based products that have poor resistance to ultraviolet exposure and very short life spans.

Chlorinated Rubber—Very fast-drying and not feasible for brushing. It will "chalk" (i.e., oxidize) fairly fast but has fair resistance to many common chemicals.

Epoxy (catalyzed)—A two-part paint that has a very hard coating and good chemical resistance. It also has a fair resistance to chalking under outdoor exposure but is more expensive than enamels.

Epoxy (air-dry)—Modified with oils, it is inferior to catalyzed epoxy. It is a one-part type and has a very long and durable life span.

Latex—Uses synthetic latex binders in the base. It is easy to apply, relatively inexpensive and safe to clean up. Fast-drying.

Oleoresinous—Oil-based and modified with resins, it is more durable than the standard oil base.

Phenolics—Resins with oils that have poor chemical resistance and poor color retention. They can be softened by strong solvents. They discolor with age and are difficult to re-coat because of poor adhesion.

Silicone Alkyds—Superior to standard alkyds, they have good heat resistance and color retention.

Urethanes—Contain polymers which work like epoxies; have good abrasion resistance and work well on wood and masonry.

Vinyls—Composed of liquefied vinyl base, they are very fast-drying and have excellent durability for outdoor applications. Temperatures must not exceed 130°F because of their thermoplastic characteristics.

Zinc Coating (limited to primers)—Zinc dust primers are used to cathodically protect steel. Zinc-rich primers are also used to cathodically protect steel but poorly cleaned steel may result in early failure of the coating.

Acrylic Enamels (thermosetting)—With a 12- to 15- year life span, they are best used with metals. Special application procedures are required. A variety of colors are available, including metallics in high, medium, or low gloss finishes. They can be applied by spray or by using coilcoat methods on aluminum or hot dip galvanized onto steel.

Polyurethanes—Because of their excellent durability and flexibility, they have very high life-expectancy with proper application. These coatings work well on wood, masonry or fiberglass. It is not uncommon for this product to last 20 years without chalking or loss of color.

Oils—Primarily used in the manufacture of alkyds. Following are the most common types of oils:

- Linseed oil—slow drying, good weather resistance;
- Tung oil—faster drying and has greater water and weather resistance than similar products, reacts well with varnish resins;
- Octicia oil—similar to tung oil;
- Soybean oil—good flexibility and non-yellowing properties, but dries slower than tung oil; and
- Safflower oil—one of the best nonyellowing oils.

MESSAGE MATERIALS AND IMAGING TECHNIQUES

Magnetic Material

Magnetic materials are limited to use on ferrous metal surfaces. They are advantageous when numerous message changes are required. The same material from which magnetic tapes are made ($\frac{1}{16}$-in. and $\frac{1}{32}$-in. thicknesses and ½-in., ¾-in., 1-in., and 2-in. widths) is also available in sheets and rolls. These are available in 11-in. and 12-in. widths that can be cut to any length, usually 14-in., 24-in., 36-in., and 96-in. Magnetic tape (a dark brown color in its natural state) is available in white or uncoated. It can be screen printed, handpainted, and die cut, and is most often used for magnetic signs on the sides of vehicles and for changeable signage.

Pressure-Sensitive Materials and Decals

Adhesive films are manufactured from thin vinyl and other plastic films and coated with adhesive backings. Types of precoated adhesives that are available include permanent, removable, and repositionable. Most films are available in numerous degrees of gloss and matte finishes. Vinyls are available in a wide array of colors and can be screen printed to match any color selection.

Decals, or self-adhesive markings, are a common method of applying printing to various surfaces that would otherwise

not be receptive to a printing process. They are simple, onestep applications and avoid extraneous operations such as painting, riveting, or stenciling.

Decals are used for varied sign requirements ranging from small-scale signs to identification of vehicles. The several major plastic substrate categories of decals include

- Calendared vinyl,
- Cast vinyl,
- One-way clear film,
- Static cling,
- PVF/PC composite,
- Reflective, and
- Polyester.

Sign surfaces should be degreased and free of any oil, dirt, chemicals (including cleansers), or foreign matter prior to the application of pressure-sensitive materials. Premium grades of various quality films can provide a 5- to 7-year life expectancy in normal outdoor exposure conditions. One of the economic advantages of removable pressure-sensitive films is the flexibility for changing messages on static signing systems. These materials do not require special substrate surfaces for immediate application; consequently, permanent or temporary applications can be installed quickly on glass windows, walls and other structures.

Permanent Film

Permanent film requires a minimum curing time after which the film can only be removed by strong solvents such as methyl ethyl ketone, a product that will damage many painted or vinyl surfaces. Bonded metal finishes and anodized sheet metal are the best substrate sign surfaces for permanent film because they remain the most impervious to solvents.

Removable Film

Removable films, usually vinyl, are typically less expensive than permanent films. These films are normally easy to remove for up to 1 year after application, under normal weather conditions. Because they are removable, vinyls are most commonly used for temporary die cut copy and symbols. Like most other films, removable vinyls will also withstand severe weather and handling conditions.

Reflective Film

This film is characterized by its retroreflective properties. It reflects light back to the source, becoming highly illuminated. If contrasting values of colors are used for copy/background combinations, maximum visibility of a sign will be obtained during varying light and weather conditions. Another common combination is a contrasting nonreflective darker background color with a reflective copy. This combination provides effective reflection at severe angles and performs well under the heaviest rain conditions. Reflective material is recommended for use on signing that is located in low-lighting conditions or for vehicular traffic. Because its effectiveness is best used in situations where strong light sources are beamed directly at it, care should be taken to place these signs locations where their special characteristics can be best used. Reflective film can withstand years of severe weather and less than ideal handling conditions.

Subsurface Markings with Applied Adhesives

Some of the most colorful, permanent, and practical markings and sign faces are constructed by screen printing subsurface graphics onto extremely stable, durable PVF/PC clear composite films and subsequently laminating ultra permanent adhesives to the back (ink) side before mounting onto a rigid sign substrate. PVF/PC composite is available in a variety of finishes and thicknesses and has high resistance to graffiti and general vandalism. The surface may be cleaned with very strong chemicals without affecting the plastic or printing. The PVF/PC sign face can be applied to any clean, relatively nonporous surface with specialized adhesives. High-performance acrylic adhesive or very high bond (VHB) adhesive produce excellent results.

Screen Printing

Printing highly detailed designs using a variety of colors is normally achieved by the screen printing process (formerly known as "silkscreen"). Screen printing deposits a thicker, more pigmented durable coating of color and creates a more lasting impression than any other form of printing. Use of a universal color matching reference system like the Pantone Matching System[t] is invaluable in maintaining color consistency. Screen printing can be done on the face surface of the sign on opaque substrates, or subsurface printed on a clear substrate for increased durability. Inks on the surface (face printing) sometimes present a problem in areas where extreme weather or vandalism are a concern. Without extra protection, the letters or image may deteriorate with age. One partial solution for face-side deterioration is to use the screen of the original message application to screen a protective clear varnish or plastic coating directly over the message and in exact registration. This approach will protect the letters and render them less vulnerable to the elements. Subsurface printing offers superior durability. Screen printing is very versatile for printing on a wide variety of substrates and can ensure consistency of faces in numerous quantities. An experienced fabricator normally makes screens by photographic or computerized methods, depending upon demand and available equipment.

Contra Vision®

This special imaging product can be applied to almost any glass or transparent glazing surface and it allows for strong, bright, opaque-appearing messages to be viewed on one side of a window while providing full viewing transparency (through the glass) from the second side. This one-way clear film consists of a patented printing technique, which places copy or logo upon a clear, continuous polyester pressure sensitive material. Contra Vision XR™ should be considered for signage in areas where there may be privacy or security issues, or where a conventional opaque sign would block the view of transit passengers or security personnel. Contra Vision® is very practical in both large and small quantities.

Stenciling

Stenciling is a very fast, inexpensive method of printing where only coarse detail is required. Its major drawback is the "bridge" connector bar that holds together certain characters. This gives a primitive look to the end product. The most common type is the military-style block letter stencil, although other alphabets may be adapted for transit signage. The same stencil can be used to increase durability with an overprint clear coat (in the same manner as the screen printed procedure mentioned above) but it still does not overcome the crude stencil appearance.

Die-Cutting

This process, which is performed on a special stamping press, is another form of stenciling, but has other advantages. Virtually any type of thin sign material can be die-cut, including many plastics. This technique is much more precise than sawing but can be more expensive for short runs and should be used when larger quantities of signs are required. Letters can be mass-produced as well as custom-made, and any type font may be used. Sizes are available from ½ in. to 12 in. Letters larger than 12 in. are, for the most part, hand cut. Die-cut letters can be applied to any suitable smooth, clean surface.

Computer Cutting

Essentially a computer-driven form of die-cutting, this process is used to cut thin vinyl pressure-sensitive materials for use as cut-out letters or symbols to be applied to rigid background materials. The process is inexpensive, accurate and fast. Sometimes referred to as SpaceGrafix®, the independent "floating" pieces are held together by a temporary support carrier or application tape enabling the installer to transfer the entire image set to the sign application surface.

Vacuum Forming

This process consists basically of pulling heated plastic over a raised template, thereby stretching the plastic to a shape. An added benefit to this process is that it strengthens the sign face. A vacuum-formed letter cut with a lip can be inserted in a metal or plastic frame, or it can be mounted on canvas, metal, or plastic backgrounds. Large sawed letters can be glued (though not totally weatherproofed) or fused with ethylene dichloride to another plastic. This fusing process is the only available application between acrylic plastics or polyester. Both vacuum-formed and sawed letters can be mounted using pressure-sensitive adhesive. They adhere best to smooth, hard, nonporous surfaces. They are not intended for use where a permanent bond is necessary, such as outdoors.

Molding

This is similar to vacuum forming, except that the heated plastic is pressed between a male and female die template set, usually by machine. This method is expensive, but it does provide good detail because two dies are used. Molding is generally used for applications having a large number of units.

Engraving

Engraving is not usually applied to acrylic plastics or glass, although acrylic plastic and glass carving is possible. Machine engraving can be done in a variety of materials but it usually involves a two-color laminated plastic sandwich called engraving stock plastic. The laminate consists of colored exterior layers over a white inner core. The image is cut through the colored layer to expose the contrasting white core. This process is more permanent than painting or filling in an engraved area. Engraving in plastic is more frequently used for small signs, and the corners of the letters are only as sharp as the engraving master and the size of the cutting router will permit.

Photoetching

Photoetching is a process by which an image is engraved through removal of metal by means of a photo-resistant chemical. Unfortunately plastic engraved signs are easily soiled and vandalized, and are difficult or nearly impossible to clean or repair. Deep-etched metal signs are extremely durable and attractive but expensive in quantity.

Embossing—ADA Compliant

This process is an effective way to create Braille and raised-letter graphics to comply with ADA tactile signage

requirements. In this process, graphics of almost any type and useful dimension can be produced using dies and high pressure in the molding process. This process is most practical in medium and large quantities. Excellent ADA signage is produced using this process on PVF/PC composite plastics.

Embedding

This process involves the encapsulation of raised copy on a surface by flooding it with a clear resin, resulting in a more vandal-proof sign than normal unprotected surface screen printing. Polyurethane-coated panels are superior to polyester-coated panels in abrasion resistance, flexural strength, and impact resistance. Polyurethane also has a greater resistance to moisture and stains. Graphics tend to appear less vivid and crisp after they have been "embedded."

Routing

This process is normally used on wooden signs, but it can be used on metal panels. It is similar to engraving, but cutouts are deeper. Wood routing cuts partially through the thickness, and the cut is filled with paint for coloring or is left in its natural color. Metal panels are usually cut all the way through, to be used for backlighting applications. Modifications to signs made by using this process are usually expensive.

Casting

Cast products are usually made by pouring molten metal or plastic in a three-dimensional mold to produce solid copy pieces. The cast material produces solid signs. One-piece signs or individual letterforms are relatively heavy. They are often used when durability or prestige identification is required. Cast metal signs are mounted with metal-rod wall fasteners, or by welding or brazing onto a metal surface. It is a relatively inexpensive and fast process when used to produce small letters in mass quantities.

Sandblasting

This may be done on wood, plastic, or glass signs by covering the surface with a rubber masking material, cutting out the characters, and blasting with a fine sand. The depth of the letters is determined by the length of time the sand can be sprayed before it eats through the rubber and destroys the surface. Woods used should have a very even grain, like redwood, or the surface will splinter and edges will be uneven. Size is not a limitation with sandblasting. Care should be taken when sandblasting glass. Only a thin layer of glass needs to be removed to get the desired opaqueness and spraying too long will decrease the strength of the glass.

Enameling

This is a conventional system involving the painting of background and copy with enamel paint on a substrate. A similar process is porcelain enameling, which involves painted-on copy also, but the paint used is a special heat activated type, which, when heated, liquefies and bonds to give an extremely long lasting sign. Its main drawback is that, when hit by a hard projectile, it will shatter at the point of impact like glass. The fracture will expose the substrate underneath and, in the case of steel, will be prone to rust deterioration. If the substrate is made of aluminum, there will be no rust problems.

Hot Stamping

Somewhat like a typewriter, this process uses heated metal type that imprints on metal foil or film, transferring the film's coloring to a substrate. A wide range of colors, including metallic, are available. The product is a hard and durable sign, but expensive. It is highly vandal-resistant under exterior or interior conditions, and it can be further protected by over-laminating with a clear film.

Electronic Digital Imaging

This new technique is most useful in reproducing color photographs and complicated color logos from computer digitized artwork. Most methods result in materials that have limited durability. Electronic digital imaging is usually unable to produce the rich solids or accurate color matches that are achievable through screen printing and is used primarily for smaller quantities. Electrostatically produced digital images offer the most durability for large format signs.

ILLUMINATION

Types of Illumination

There are five basic types of illumination used for signs: incandescent, fluorescent, high-intensity discharge, reflective, and luminescent.

Incandescent

Incandescent illumination uses common incandescent bulbs or quartz-iodine lamps. They light small areas with high intensity. Their output ranges from low to medium. Their rendition of colors emphasizes reds and yellows and they require no ballasts.

Incandescent lighting is practical only for very small signs. It may be used for such special effects as flashing signs. The bulbs themselves may form the letter, or they may

be arranged in a grid, with any combination of light bulbs flashing to form simple letters or numbers. The frame for this type of sign is usually a metal box with a sun shield glass front, mounted to a wall. Within the box, each bulb is placed in its own black tubular frame to direct the light and prevent glare from adjacent bulbs.

Fluorescent

Fluorescent illumination uses common fluorescent tubes in cool to warm colors. They light large areas with low intensity, their light output is fair to good (best with "daylight" type lamp), their rendition of colors varies according to the color of the bulb, and they require ballasts. Care should be exercised in the selection of ballasts that are made for varying temperatures. Bulbs are generally available in lengths of 24, 48, 60, 72, 84, 96, 108 and 120 in.

Fluorescent lighting is the most practical for internally illuminated signs. It requires a minimal electrical installation and comes in a wide variety of sizes. The tubes should be placed at least 4 in. away from the face of the sign, but not more than 1 ft apart to achieve even illumination. To eliminate "hotlines," the face of the sign should not be closer to the tubes than one-half the distance between the tubes. This spacing may not be critical if sign copy consists of narrow (3 to 4 in.) strips of trans-illuminated copy on an opaque background.

If the light source is excessively bright, irradication or halation will cause the individual letters (if they are translucent against an opaque background) to merge with their neighbors, and the message will disappear as a blur of light.

High-Intensity Discharge

High-intensity discharge illumination uses mercury vapor lamps in cool to warm colors. Light is produced by an electric arc in mercury vapor. These types light small areas with very high intensity; their light output is high; their rendition of colors is fair, with normal tones taking on bluish and greenish casts, and they require ballasts.

Reflective

Reflective illumination (or more precisely retroreflective) depends upon an independent, exterior light source usually provided by or near the viewer. One of the most common uses of retroreflective lighting is for highway signs and vehicle license plates where headlights provide the light source and the message is brilliantly "reflected" back to the reader. Reflectivity can also be used on windows and doors as well. Reflective signage can appear more than 100 times brighter than white paint.

Luminescent

Luminescent (phosphorescent or glow-in-the-dark) illumination can provide effective and inexpensive back-up communication in the event of a sudden power interruption. During normal power operation the luminescent signage can also be practical and effective. Subsurface PVF/PC signage is a particularly effective surface signage medium to deliver the advantages of luminescent communication.

There are two common methods used to provide lighting on a sign—internal sign lightings and external sign lightings.

Internal Sign Lighting

The most common form is backlighting. Incandescent light is limited to small signs, and can be used for the flashing mode. Fluorescent lights are the most practical because they give better light spread, use less power, and have longer life per unit. Sign faces are generally fabricated out of a plastic material. Sign face and light source are installed in a metal frame or housing. The signs should be adequately sealed against weather and insects. Attention should be given to the rating of all components, wires, switchings, and fixtures to ensure that each is designed to handle the desired electrical current. Lighting units that develop high temperatures must be adequately ventilated and spaced from materials that may be damaged by heat.

Exterior Sign Lighting

An exterior light source provides the simplest and most economical way to light a sign, both in terms of installation and maintenance. It is used to light large painted signs, such as billboards, or signs made of various opaque materials such as metal, stone, or wood. Lighting techniques include spotlights, flood lights, backlighting, and ambient systems. The most common types are mercury vapor, quartz iodine, or fluorescent. Mercury vapor casts a slight blue tint, while quartz iodine emits a light similar to daylight, is easier to maintain than fluorescent, and has a longer life span. Fluorescent lamps set in rows can illuminate large areas. A common exterior system is the "show case"-type luminaire with fluorescents. This system is very versatile because light intensities can be altered by changing ballasts.

Spotlights—the simplest kind of outside light source. They are strong, focused lights and can be used to light small areas from above, below, or to one side. Spotlights must be carefully placed to avoid glare. Mercury, fluorescent, or incandescent lights may be used. In certain controlled situations retroreflective sign surfaces illuminated with spotlights can be very effective and low in cost.

Floodlights—used for uniform illumination of a large area. Light types include mercury, quartz iodine, halogen

reflector floodlights, fluorescent lights, and incandescent lights. Both floodlights and spotlights must be adequately shielded from the eyes of the viewer, and must be protected from vandalism. Floodlighting may also be placed in ground trenches covered with a vandal-proof wire cage, but special care must be taken to properly shield the lamps from weather and provide adequate drainage. This method generally deteriorates within a few years.

Ambient Light—spill from existing light sources may offer sufficient illumination to make a sign legible. If so, there will be no need to provide additional lighting, thus considerably reducing the initial and long-term costs of the sign system. Designers who plan to rely on this method for illuminating their signs should carefully study the matter of color contrast. Floodlights may also be used to boost the ambient light.

Mercury and Quartz Iodine—the most common floodlights in use. Both lights have even vertical and horizontal light distribution, and their beam angle can be changed to cover any desired spread. Installation and maintenance of these lights is easier than for fluorescent tubing. Light units are usually mounted on single poles extending from the top of a sign. Mercury and quartz iodine lights have a life span about two and one-half times longer than fluorescents. In interior applications, mercury and quartz iodine are often used as recessed top or bottom lighting.

Fluorescent Lights—can be used as floodlights, although their lighting capacity does not compare with mercury or quartz iodine. Fluorescent strip lighting (a row of bulbs mounted end-to-end) can be used to cover large areas. Encased fluorescent lights (cove lighting), mounted nearly flush to the sign, can be used when required by building codes.

FABRICATION METHODS

For the most part, designers depend on a fabricator to build and install signing and graphic systems. The skill and knowledge of a good fabricator is based on years of diverse shop and field experience.

In general, the designer's role during fabrication can be simplified if only one fabricator coordinates the entire fabrication and installation effort. In addition to previous experience, the fabricator assigned to coordinate the entire job should meet the following qualifications:

- Reads working drawings.
- Understands and follows specifications.
- Understands designer needs in terms of:
  - Ordering and enlarging typography and art work;
  - Preparing lettering guides or patterns showing exact size, spacing, and placement of copy;
  - Color matching samples;
  - Prototyping samples; and
  - Reviewing material submittals.
- Produces detailed shop drawings and understands submittal and approval processes.
- Works effectively with designers and translates their designs into practical and durable signs.
- Knows and works well with qualified subcontractors.
- Stands behind work and that of subcontractors and makes corrections when required.
- Delivers signs on time if the time frame is reasonable.
- Obtains adequate financial backing and follows good business practices.
- Offers consulting services to designers when needed.

During the early stages of work, fabricators provide certain services as they interact with designers. Basic steps for the fabrication process are as follows:

- The fabricator will review the designer's drawings and specifications to become thoroughly familiar with the sign system.
- The fabricator will submit a bid with an itemized list showing cost to provide and install all items. This bid is usually submitted to the designer for review and client approval.
- After the contract has been awarded, the fabricator will prepare full-size details and scaled shop drawings for designer approval; these are based on the designer's working drawings and specifications. Any conflicts with the drawings or specifications should be identified at that time.
- The fabricator will survey the existing site conditions of the project to identify any problems of interface with the installation and operation of the signs.
- The fabricator will inform the designer of any specific problems requiring attention.
- If requested in bid documents, the fabricator will produce prototype samples of specified items.
- After receiving approved shop drawings from the designer, fabrication of the approved items will proceed.
- The fabricator will provide all labor and material necessary to make and completely finish all signs.
- During fabrication, the designer will be informed when items are ready for inspection prior to installation.
- After obtaining the designer's approval of fabricated items, their installation will be arranged by the fabricator.
- During installation, the fabricator will call the designer periodically for inspection of installed signs.
- The fabricator will make any final corrections or adjustments based on a checklist submitted by the designer's supervisor.
- If additional items are needed to improve functioning of the system, the fabricator will provide these items for a reasonable additional cost.
- Under certain circumstances it may be desirable for the sponsor to have installation performed by a third party or their in-house sign maintenance personnel.

SUPPORTS

The most common types of sign supports are steel or wooden posts. Single posts will suffice for signs up to 4 ft wide, with no more than 10 sq ft of surface.

Wall and ceiling structures intended for sign attachment must be of sufficient strength and durability to hold the largest display likely to be needed at that location. All displays mounted overhead, or perpendicular to walls, should have a clearance of 8 ft (2.4 m) above the floor if architectural conditions allow. The minimum allowable clearance above the floor is 80 in. (2,030 mm).

In the case of signs or displays, where transit users may have physical contact, care should be taken to ensure that they do not have sharp edges or corners, which may cause injury. Materials should be used that are resistant to fire and vandalism and are unlikely to break or shatter. If the bottom of the display is higher than 27 in. (685 mm) above the floor it should not protrude over its base or from the wall more than 4 in. (100 mm) in order to be compliant with ADA.

MAINTENANCE AND REPAIR

A good signage program requires continuous inspection and documentation. Signs that are located in transit facilities must be inspected on a regular basis for graffiti or deterioration. A structured cleaning program can extend the useful life of signs and reduce repair and replacements costs.

The frequency of cleaning will vary with local conditions. For example, typical professional maintenance schedules for signs in industrial areas are

- Urban areas—Sign exterior cleaning—3-month intervals
  —Sign interior cleaning—12-month intervals
- Suburban areas—Sign exterior cleaning—6-month intervals
  —Sign interior cleaning—12-month intervals

Regular cleaning will keep the signs attractive, provide higher light output, and maintain surface brightness, all of which are sharply reduced by dirt adhering to surfaces.

General Cleaning Information

Surfaces exposed to the atmosphere collect dirt, depending on the location, environmental conditions, and surface finish. Signs in heavy industrialized areas require more frequent cleaning than in rural areas. In areas of heavy rainfall, less cleaning may be required than in more arid locations. In using a cleaner, follow the directions provided by the manufacturer. The directions usually contain specific information about concentrations, temperatures, contact times, and other pertinent data.

Different cleaners should not be mixed, because specific cleaners carry formulations for specific cleaning jobs. Mixing different cleaners can be dangerous to the user, and harmful to the finish.

Do not clean hot surfaces. Heat generally accelerates chemical reaction. Surfaces heated by the sun can become streaked or stained due to rapid evaporation of the cleaning agent. If possible, clean in the shade, or schedule cleaning on cool, cloudy days. If necessary, cool the surface with water before cleaning.

Clean a small area first. This permits a safe evaluation and demonstrates the effectiveness of the cleaning agent.

Use the recommended concentration. Do not let cleaning compounds remain on the surface any longer than necessary for satisfactory cleaning results. Unless advised by the manufacturer, do not increase the concentration in an effort to accelerate the cleaning process. Thoroughly rinse the surface after cleaning and let the surface dry.

Specific Product Cleaning

Porcelain Enamel Sign Panels

Porcelain panels can be cleaned with soft cloths, sponges, or soft bristle mops and detergent in warm water to loosen dirt film. After mopping, the surface should be rinsed with clean water using a hose with a strong fine spray to remove all traces of detergent, then wiped dry with a clean damp chamois. If a stronger cleaner is required to remove stubborn spots or stains, use products recommended for cleaning glass. Always follow manufacturer directions. For cleaning plastic or vinyl lettering on porcelain enamel panels, simply wipe with a clean damp cloth. Scouring pads or any cleaners having abrasives that will scratch porcelain surfaces should not be used.

Painted Aluminum or Steel Signs, Frames and Pylons

Painted metal signs can be cleaned using mild soaps, detergents, solvents, and emulsion cleaners. Mild soaps probably will not remove stubborn stains. Wipe with a damp cloth or wash with water containing a soap or detergent, then rinse with clean water and dry. The cleaning action of these mild aqueous solutions can be improved by scrubbing with a soft bristle brush. Oil and grease can be removed from painted metal with various cleaning agents. Residual oil and grease films can be removed with a hot solution of mild soap or detergent or with a mild solvent and emulsion cleaners. Solvents and emulsions should be used in well-ventilated areas with close attention to directions concerning contact with bare flesh, plastic faces, and painted surfaces. Scouring pads or cleaners that have abrasives that will scratch painted surfaces should not be used.

Stainless Steel

Stainless steel sign frames can be cleaned using mild soaps and detergents. After cleaning use a mild solvent to restore the natural finish. Several stainless steel cleaning products are available that effectively remove grease and dirt. Never use an abrasive cleaner on stainless steel sign cabinets.

Plastic/Fiberglass Reinforced Sign Faces

For cleaning plastic sign faces, simply wipe with a clean damp cloth. Fiberglass reinforced plastic (FRP) sign faces can be cleaned with soft cloths, sponges or a soft bristle mops and detergent in water to loosen dirt film. After mopping, the faces should be rinsed with a water and a clean sponge or mop. If practical, the outside surface of the panel may be rinsed with a hose, using a strong fine spray to remove all traces of soap, then wiped dry with a clean damp chamois. Check all the drains to make sure they are clear. Wipe the lamps with a damp cloth and wipe the inside of the sign boxes to remove any oil, grease, or water that might have collected inside them.

Cloths containing grit or abrasive particles or scouring compounds should not be used to clean plastic because they will scratch the surface. Boiling water, strong solvents such as acetone, alcohol, carbon tetrachloride, leaded or ethyl gasoline or window cleaning fluid, which may contain such solvent, should not be used because they will soften the FRP.

Cast Acrylic Sheet

Cast acrylic sheet such as Plexiglas^{t}, Lucite^{t}, or Acrylite^{t}, has a highly polished lustrous surface, and will retain its fine appearance for many years, if given proper care. Cleansing materials containing abrasives, such as scouring powders or strong solvents that are found in window cleaning solutions, should never be used to clean acrylic. Gasoline, acetone, or denatured alcohol tend to soften the surface of the plastic and often cause crazing, and they should not be used.

When first installed, glazing compound and masking paper adhesive can be removed from acrylic glazing with hexane, dry cleaning naphtha, kerosene, or isopropanol. These solvents are flammable. They may be applied with a soft absorbent cloth, followed by rinsing with clean water. Remaining drops of water should be wiped away with a soft chamois or moist cellulose sponge. Thereafter, an occasional washing with mild soap or detergent and water solution is sufficient to keep acrylic looking like new. Household ammonia in water in the concentrations recommended for general cleaning can also be used. Fine scratches may be removed or minimized by using mild automobile cleaner polish such as Dupont No. 7^{t} polish. This cleaner polish has a very mild abrasive action and its wax content tends to fill small scratches and make them less visible.

Lucite SAR (Super-Abrasion Resistant Sheet)

More conventional cleaning techniques can be used on Lucite SAR. This product is not affected by most cleaners, including ammonia and strong detergents. To remove paint or ink marks, a soft cloth saturated with isopropyl alcohol or hydrocarbon solvent such as VM&P naphtha can be used. Abrasive cleaners, razor blades or other sharp instruments should not be used.

Subsurface PVF/PC Signs

These highly durable sign surfaces are virtually impossible to harm with nonabrasive chemical cleaners. Because the message graphics are buried below a polyvinyl fluoride surface, graffiti and surface grime can be easily removed restoring the surface to its original condition and lustre. Stronger solvents and acids will not adversely affect the PVF/PC surface. Graffiti remover can be used to remove magic marker without affecting the surface of the PVF.

Contra Visiont Window Graphics

Soap and water should be used to clean this type of sign. Abrasive cleaners should be avoided. After washing, rinse with clean water and pat dry with a clean cloth. Rubbing with paper towels should be avoided.

Vinyl Letter Signs

Vinyl letter signs can be cleaned by using a damp cloth, or by washing with mild soaps and detergents, then rinsing with clean water and drying with a soft dry cloth. Use caution cleaning; the surface should not be rubbed with any abrasive material because this will scratch the surface and possibly loosen the copy.

CHAPTER **10**

CONSULTANT SELECTION AND BIDDING PROCEDURES

CONSULTANT SELECTION

Overview

Although these guidelines have been developed to assist the transit provider in the design of a signage system, there may be times when the transit authority requires consultant assistance. This chapter presents typical procedures used by most transit agencies to develop a project solicitation package and evaluate and select a consultant for the layout and design of a signage system. The process for preparing a bid package, receiving bids, and awarding a sign fabrication and installation contract is also presented.

Selection Process

The selection process for a signage and graphics design consultant must be conducted in an open and fully competitive setting. A common selection process includes the following elements:

- Prepare and assemble the solicitation package.
- Advertise either a request for qualifications (RFQ) or a request for proposal (RFP) or both.
- Coordinate preproposal site visits or briefings.
- Control and distribute changes to the solicitation package.
- Appoint a selection committee.
- Develop evaluation criteria.
- Review and evaluate qualifications or technical proposals.
- Identify a short list of firms for further consideration. If RFQs were submitted, the short list of firms may be asked to submit a technical proposal. If technical proposals were submitted, the short list of firms may be invited for interviews by the selection committee.
- Review and rank the short list of firms.
- Negotiate cost with the preferred firm.
- Award the contract.

Project Definition

Before advertising for the services of a signing and graphics design consultant, it is important that the scope of work for the project be defined. Outside professional assistance may be required to assist the in-house technical staff with this task. The scope of the project should be defined in sufficient detail so that an estimate of the staff-hours and cost of the signing and graphic design work can be prepared and furnished to the contracting officer before commencing negotiations.

In addition to defining all of the tasks that will be accomplished by the consultant, the project definition should describe how the design project will be managed by the owner and contain a schedule for project implementation. The schedule should be prepared in sufficient detail to provide the design firms with sufficient information to schedule key staff time during the life of the design contract. The schedule should also show when the fabrication and installation of the signage system are to be completed.

The project definition or statement of work is incorporated into the solicitation document which is assembled, distributed, and controlled by the contracting officer.

Project Solicitation

The solicitation process needs to target firms capable of performing the required services. Targeting those firms can be simplified by issuing a request for qualifications (RFQ). This approach allows all interested firms to prepare and submit a general capabilities statement that can be reviewed by the selection committee to determine which firms will be asked to prepare technical proposals.

This RFQ solicitation document should be advertised locally and nationally. It should inform interested firms where they can obtain more information about the project and whether a briefing or site visit will be conducted during the solicitation period. It should list the specific items that are to be considered in the evaluation; for example:

- General capabilities of the firm,
- Experience on specific projects that are similar to this project,
- Resumes of key staff, and
- References from past projects.

Official points of contact for the owner should be identified for contractual matters and technical matters. It is impor-

tant that all questions received from interested firms be coordinated and controlled during the solicitation period.

Answers to questions must be provided in writing to all firms that requested a solicitation package. The contracting officer should be the control point for any changes to the solicitation package.

Selection Committee

The selection committee is generally appointed by the Contracting Officer. The composition of the committee should reflect the nature of the assignment and include skilled professionals who are knowledgeable in the technical aspects of the project, the administrative and contractual issues associated with the project, and the scheduling and review requirements. The selection committee should be responsible for all stages of the selection process, e.g., the review of the qualifications, review of technical proposals, interviews and negotiation of the contract.

Evaluation Criteria

Once appointed, the selection committee's first task is to develop evaluation criteria. If an RFQ has been issued, the committee must develop general criteria that can be used to determine which firms have sufficient capability and experience to be asked to submit technical proposals. More specific evaluation criteria must be developed to assess the technical proposals and to use during subsequent interviews with the firms included in the short list.

The evaluation criteria should address the following:

- Professional qualifications necessary for satisfactory performance of the required services.
- Specialized experience and technical competence in the work required.
- Capacity to perform the work within the time specified.
- Past record of performance on contracts with government agencies, state and local public bodies, and private industry, including such factors as control of costs, quality of work, and ability to meet schedules.
- Location in the general geographic area of the project and knowledge of the locality of the project.
- Acceptability and availability of key staff proposed for the project.
- History of performance with proposed team members.
- Understanding of the project scope, i.e., the unique and subtle features of the project from technical, administrative, and political viewpoints.
- References on past and current contracts, technical contacts. and contracting officers.

Review and Evaluate Qualifications

Using the evaluation criteria developed specifically for the project, the selection committee will be provided copies of the qualification statements or the technical proposals submitted by each firm. The committee should consider the responsiveness of the various submissions to the evaluation criteria and consider the firm's understanding of the project requirements. Every effort should be made for the selection committee to evaluate the submittals in a uniform fashion. A numerical rating system can be used.

A meeting of the selection committee is typically held to discuss and rank the submittals. During this meeting, the committee will determine which firms should be asked to submit technical proposals (if they responded to an RFQ) or which firms should be "short listed" and scheduled for presentations/interviews (if they responded to an RFP). The short list of firms should be agreed upon by the committee and formally submitted to the contracting officer.

Depending on the actions recommended by the committee, the contracting officer will proceed with the next step (either request for proposals or scheduling of interviews).

The firms on the short list will be provided the opportunity to present their capabilities to the committee. At this meeting, the committee should ask specific questions to ensure that the firms are knowledgeable in all aspects of signing and graphics. Each firm should be asked the same or similar questions. After the interviews, the committee should rank the top three firms and submit this ranking formally to the contracting officer.

The contracting officer will then request the top-ranked firm to submit a cost proposal. This cost proposal coupled with the owner's estimate of cost will form the basis for negotiations.

Negotiations

The contracting officer is the responsible official for the conduct of negotiations and for the results thereof. In discharging those responsibilities, the contracting officer will use the services of technical, legal, audit and other specialties as required. Generally a representative from the technical office or the selection committee will be present and will assist in the negotiations.

The owner's estimate will be used by the contracting officer as the basis for negotiations. Generally a cost-type contract will be used for a professional services contract; thus, the contractor will be required to develop staffing tables for each task and document actual pay rates for each of the proposed technical staff. Contractor overhead and general and administrative burden rates will generally be verified by the owner's audit staff.

During the negotiation process, it is important to consider the following factors to ensure the signing and graphics design contract will be successful.

- The statement of work should be refined and detailed. Specific deliverables should be itemized. The coordination between the owner's staff and the design consultant staff should be defined in detail.

- Once each task is defined, the time required on each task should be presented and the various disciplines assigned.
- Special studies or reports should be specifically estimated and shown on the project schedule.
- The number of meetings and presentations should be defined so that meeting preparation and subsequent follow-up actions can be estimated by the design consultant.
- Any coordination required with other consultant designers should be identified.
- The overall project schedule for design, fabrication, and installation should be refined to ensure that the duration for the design contract is appropriate.

BIDDING PROCEDURES

The primary method of procurement for fabrication and installation of a signage system is the sealed bid competitive solicitation that results in a fixed-price contract awarded to the low responsive and responsible bidder. Because fabrication and installation contractors must submit firm fixed-price bids, it is important that the design consultant develop very detailed signage requirements to include types of materials, sizes of signs, and installation details.

Invitation for Bid Solicitation Package

The contracting officer is the responsible official for soliciting formal bids. The solicitation package is generally called an invitation for bid (IFB). Each IFB should be publicly advertised, and bids should be publicly opened. Bids should be solicited from an adequate number of vendors to assure full and open competition.

The IFB solicitation package should include the following:

- Instructions and information to bidders concerning the bid submission requirements, including the time and date set for receipt of the bids and the address where bids are to be delivered.
- A statement indicating whether the award will be made on the basis of the lowest bid price or the lowest evaluated bid price, whichever is applicable.
- A description of the supplies or services required, required quantities, and the acceptability of alternate bids.
- Any additional description or specifications necessary to permit full and open competition.
- Where applicable, packaging, packing, preservation, and marking requirements.
- Inspection, acceptance, quality assurance, reliability, and warranty requirements.
- Time, place, and method of delivery or performance requirements.
- Requirements for accounting, appropriation data, and any required contract administration information.
- Special contract requirements; e.g., bid guarantee, bonds, insurance, liquidated damages, progress payments.
- Contract clauses or provisions required by law or federal/local regulations.
- A list of documents, exhibits, and other attachments.
- Representations, certifications, and other statements required of bidders.
- Instructions, conditions, and notices to bidders.
- Evaluation factors for the award, such as any pricerelated factors other than the bid price.

Notices of Invitation for Bids

Invitation for bids or notices of the availability of IFBs shall be mailed or otherwise furnished to an adequate number of bidders for the purpose of securing full and open competition.

Pre-Bid Conferences

The contracting officer may use pre-bid conferences to explain the procurement requirements. If a pre-bid conference is to be held, it should be announced to all prospective bidders in the IFB. The pre-bid conference should be held as early as possible after the IFB has been issued and before the bids are opened.

Nothing stated at the pre-bid conference should change the IFB unless a change is made by the contracting officer by written amendment to the IFB. The contracting officer should prepare a written report of the conference and make a copy available to all prospective bidders or others upon receipt of a written request.

Amendments to Invitation for Bids

Amendments to an IFB should be identified as such and should require the bidders to acknowledge receipt of all amendments issued.

If it becomes necessary to make changes in quantities, specifications, delivery schedules, opening dates, or other items, or to correct a defective or ambiguous IFB, the change should be accomplished by amendment to the IFB. Each amendment should reference the portion of the IFB it amends.

The contracting officer must send each amendment to all prospective bidders to whom an IFB has been furnished. The contracting officer should distribute each amendment within a reasonable amount of time to allow all prospective bidders time to consider the information before submitting their bids. If, because of an amendment, the time and date for receipt of bids is not sufficient to permit preparation of the bid, the con-

tracting officer should consider increasing the time for submission of the bids. This can be done in the amendment or, if necessary, by telegram or telephone and confirmed in the amendment.

Bid Requirements

Each bid should be

- Based upon specifications contained in the IFB;
- Typewritten or written legibly in ink (all erasures or alternations should be initialed in ink by the person who signs the bid);
- Submitted in a sealed envelope, which clearly indicates that it contains a bid and identifies the bid by the IFB number; and
- Submitted with acknowledgment by each bidder of the receipt of all amendments and changes issued.

Submission of Bids

To be considered for award, a bid must comply in all material respects with the IFB. Bids shall be filled out, executed, and submitted in accordance with the instructions in the IFB.

Bids shall be submitted so that they will be received in the office designated in the IFB not later than the exact time set for the opening of bids. A reasonable time should be provided for prospective bidders to prepare and submit bids. As a general rule, the bidding time should be not less than 30 calendar days from the first day of publication.

Opening of Bids

Bids should be opened publicly, at the time, date, and place designated in the IFB. The name of each bidder, the bid price, and other information that is deemed appropriate should be read aloud or otherwise made available. This information should be recorded at the time of bid opening. The bids should be tabulated, or a bid abstract should be made.

Bid Evaluation

Before awarding the contract, the contracting officer should determine whether the apparent low bidder is responsible and that the prices offered are reasonable. Bids should be evaluated without discussions with bidders.

Contract Award

Each contract should be awarded to the responsible and responsive bidder whose bid meets the requirements set forth in the IFB, and has the lowest bid price or lowest evaluated bid price, considering only price and price-related factors included in the IFB.

The contracting officer should make a contract award by furnishing a properly executed award document or a notice of award to the bidder within the time frame for acceptance specified in the bid.

IFB Documentation

A file for the IFB should be maintained. The following information should be on file:

- The name and address of each prospective bidder on the solicitation mailing list to whom the IFB was sent and any additional prospective bidders who were sent copies of the IFB upon request.
- The name of each publication in which notice of the IFB was published and the date of each publication.
- The date when the IFB was issued.
- A copy of the IFB.
- An abstract or tabulation, recording the name of the bidder(s), the bid amount, and when appropriate, whether the bidder acknowledged amendment(s) to the IFB and provided a bid guarantee.

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Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transit Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation