FOG

A REVIEW OF THE LITERATURE PERTAINING TO HIGHWAY PROBLEMS AND POSSIBLE SOLUTIONS

by

Marion F. Creech
Highway Research Analyst

Virginia Highway Research Council
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SUMMARY

1. Fogs are significant contributors to multiple car accidents that often result in fatalities.

2. Systems that adequately abate fogs or lighting systems that provide minimum visibility requirements have not evolved.

3. Most abatement techniques stem directly from methods used at airports. It is well to use methods already developed but the roadway requirements are different from runway requirements. For airports, a clear swath is needed from the surface up to several hundred feet while highway needs are for a vertical distance of approximately 3 feet.

4. It is very improbable that a lighting system can be designed that will produce a visibility level equal to the before fog condition.

5. Lighting manufacturers are interested in mass producing their products and have done little research in fog lighting. Consequently, any lighting system for fog will have to be designed by the organization requiring it with very little information for guidance.

6. Fog abatement techniques have not progressed to the point that they are feasible for highway usage. Some of the fog seeding methods appear to hold promise for the future, especially the ground seeding techniques; however, more sophisticated equipment will have to be developed than is available at this time.

7. A combination low level lighting system and lineal guidance system will improve visibility and, potentially, driver control.

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INTRODUCTION

Fog is usually defined as a state of atmospheric obscurity in which visibility is less than 1,100 yards, irrespective of whether the obscurity is produced by water droplets or solid particles.[1] Atmospheric obscurity produced by water droplets but resulting in visibility not less than 1,100 yards is described as mist. If the visibility is less than 200 yards, the fog is defined as being thick. All the information in this literature review pertains to thick fog.

Warm fogs, those forming above 32°F, make up 95% of the fogs that close airports and highways. They form whenever the temperature of the air is colder than its dew point and moisture forms on tiny particles in the atmosphere.[2]

That fog impairs the safe and efficient operation of motor vehicles, there is little doubt. The literature reveals that fog effects: (1) A slight reduction in accident frequency, (2) an increase in the likelihood that an accident will result in a fatality, and (3) an increase in the likelihood that the accident will be a multiple vehicle accident.[3]

In terms of research, the effect of fog on accidents has received only minor attention and is not well understood, primarily because of the difficulties associated with the collection of valid data on traffic exposure to fog and non-fog conditions. In an investigation in metropolitan Melbourne, fog was shown to significantly reduce the probability of casuality accidents; on the other hand in a sample of accidents on California freeways, the fatality rate in fog was essentially twice as high as in non-fog conditions. Throughout the literature these opposite effects occur. Perhaps the only explanation for this is the difference in driver attitude in this and other countries.

The study of traffic accident data and fog suggests two mechanisms which operate in fog: (1) The delay in responding due to the inability to see ahead appears to affect the severity of accidents, and (2) the care exhibited by drivers in fog is related directly to their estimate of the likelihood of interactions with other vehicles. Drivers appear to be aware of fog as a hazard but they seem either not to know how to, or to be willing to, respond in ways other than modest speed reductions. Data show that the speed reductions are insufficient to preclude excessive overdriving.[4]

Some of the accidents that occur in fog become holocausts, as witnessed in an accident on the New Jersey Turnpike.

> In November 1969, a car traveling at 45 mph entered sudden dense fog on the Turnpike. The driver slowed to 30 mph, and was overrun by a tractor and a tank-semitrailer that overturned and blocked both lanes and the shoulder. When other vehicles entered the area, multiple collisions occurred, resulting in 6 fatalities and 3 serious and 15 minor injuries. Some of the vehicles involved were trucks carrying gasoline or propane, so explosions and fires resulted. Five of the 6 fatalities resulted from burns, and the pavement was so damaged it had to be resurfaced. Twenty-nine vehicles were involved in this multiple vehicle accident; 20 cars were demolished and six trucks were destroyed or damaged. The safety board determined the cause of the accident to be vehicle penetration into a dense fog area with a visibility of from 20 to 50 feet, coupled with varying rates of speed that prevented appropriate evasive action.[5]

To dispel any idea that such accidents occur only in other states or foreign countries, attention is called to the following excerpts from the Virginian Pilot of July 24, 1971, referring to traffic accidents that had occurred in a heavy fog the previous day in the Norfolk area.

> A series of fiery chain-reaction collisions on fog-bound interstate 64 atop and near the high level draw span at Gilmerton early Friday left at least 53 vehicles damaged and 22 people injured. Traffic backed up for miles from both ends of the I-64 bridge over the southern branch of the Elizabeth River. Eight cars and a mail truck in the first pile up "burned totally", State Police said. Wrecked vehicles were strewn for miles along the high-speed highway as oncoming cars and trucks plunged into those already stopped or slowed by the major collisions.

METHODS OF INCREASING VISIBILITY IN THICK FOGS

This review turned up two approaches to increasing visibility in thick fogs: (1) Fog abatement systems, and (2) guidance systems designed to reduce fog hazards. These will be discussed in the following two sections.

Fog Abatement Systems

Several fog abatement systems used at airports may be modified for highway usage. The major problems involved when trying to apply airport techniques to highways are the greater areas involved, the cost, and the specialized equipment necessary. In mountainous areas such as Afton, the fog covers a limited area and recurs in approximately the same location. This is not the case in flat areas such as Norfolk, where the fog may occur over wide areas or in patches. The most promising fog abatement systems appear to be the following:

1. Fog Seeding. The seeding concept involves the redistribution of drop sizes in natural fog with the necessity of altering liquid water content. It can be easily demonstrated that whenever the drop size distribution in a fog is modified to cause the liquid water to be concentrated in a few large droplets, rather than the normal large number of small droplets, visibility will be improved. Seeding natural fog with a relatively few giant hygroscopic nuclei can effect such a redistribution in drop size. Calculations and experiments suggest that for highway application NaCl particles of about 4 microns radius are best, although larger particles are necessary if rapid clearing is desired. [3]

   Two types of seeding may be employed — ground seeding and aerial seeding. Ground seeding is accomplished using a vehicle that shoots the hygroscopic particles into the air. The main drawback of the ground technique is that only a relatively small area of fog can be treated at a time using a single seeding unit. This suggests that a series of smaller seeding units would be preferable for highway applications.

   The most successful aerial seeding procedure involves flying perpendicular to the prevailing wind and disseminating the hygroscopic material in evenly spaced rows over the fog. The results of aerial seeding trials have been encouraging. Within a few minutes after seeding, narrow paths can be detected in the fog; they increase in size until, after about 15 minutes, large areas of fog are completely dissipated. In experiments in which quantitative data were collected, the clearing persisted for about 20 minutes before unmodified fog began to reduce visibility in the seeded area. [3]

2. Air Mixing with Helicoptors. This technique involves the use of very large helicoptors to mix the saturated air with drier air from aloft. The system requires that the humidity of the drier air be no more than 90% because mixing nearly saturated air with the fog can cause the cloud to become more dense.

3. Forest Stands and Vegetation Barriers. These barriers theoretically could be used to block the movement of shallow fog from higher elevations to low-lying surrounding areas. The literature doesn't suggest configurations of planting to accomplish this; in addition, most of Virginia's fog could hardly be classified as shallow.

Visual Guidance Systems

Visual systems can be classified into three types: active, passive, and signaling, depending on the illumination system involved. The active system has the source of light moving with the vehicle (headlights) to illuminate the target or scene. In the passive system, the road is lighted by fixed light sources independent of the vehicle. Signaling systems include brake lights, turn signals, taillights, traffic lights, and lane marking lights.

1. Active System. In highway applications, the active system presents difficulties. The reflectance of light, referred to as backscatter, from fog particles does not allow the light to reach the target; in addition, the light is reflected into the driver's eyes as glare and further reduces the visibility.(3) Several studies on the use of polarized light to reduce the amount of light reflected into the driver's eyes did not produce any positive results. One of the problems involved with polarized light is the very high powered lamps necessary. In one experiment a 300 watt high intensity aircraft light was used in conjunction with a polarized light and no significant improvement in visibility was noted.

   The very best results are obtained with headlights in fog when the lights are mounted as far as possible from the driver's line of sight and aimed so as not to illuminate the fog directly in front of the vehicle. Fog lights on large trucks employ this principle.

2. Passive Systems. The passive systems involve roadway lighting. Several studies have been done and no method has been found that will produce the visibility of non-fog conditions; however, visibility can be greatly improved by a specially designed light system in which the lights are mounted at low elevations alongside the roadway. A lighting system for use in fog should have the following attributes:

   (a) The volume of illuminated fog between the driver and the road should be small,

   (b) the light which must traverse this volume of fog should do it at angles to the driver's vision that produce the minimum light scattering, and

   (c) direct glare sources should be minimized.

Specially designed luminares mounted with their bases 2.5 feet in height project almost no glare into the driver's eyes. The cutoff plane is rotated 4.15° below horizontal to keep the blanket of illuminated fog as thin as possible, and by rotating the cone of illumination 110° to the center line of the road in the direction of travel satisfactory visibility may be obtained under unfavorable fog conditions. Sharp cutoff and accurate construction of the reflectors are of great importance, as is accurate adjustment of the tilt of the cutoff plane.(6) The lighting system can be enhanced by using pavement edge striping, reflectorized paints, and beaded lane delineators.

3. Signal System. Signaling systems are composed of self-illuminating lights. These systems may be separated into, (a) the lights contained on the vehicle such as brake or signal lights, or (b) lights located on the road. Because of the one-way light transmission involved a high degree of contrast is obtainable.

The versatility and utility of lineal guidance systems have been proven for airports and they are now in generally accepted use. Lineal guidance is obtained from light sources inset into pavement surfaces. At least two highway departments have made trial installations. This means of providing added visual information by lighted lane lines under poor visibility conditions is highly desirable and the extra visual information provided under good conditions is also beneficial. Under poor visibility conditions, the range of visibility of the lighted lane lines is far greater than with any of the present paint markings or border materials. In general, the visual range is approximately doubled that available from reflective marking materials. The low wattage units placed on close spacing have been found to be preferable to higher wattage units placed on wider spacings. One reason is that the continuity of the lineal pattern is improved and the glare per individual unit is greatly reduced.(7)

PROMISING METHODS OF IMPROVING VISIBILITY

No single method covered in the literature will produce adequate visibility during heavy fogs and no combinations of methods will restore visibility to the non-fog condition. The combination of methods given below will increase visibility, will tend to keep vehicles from running off the road (a major cause of accidents during fog) and will keep drivers from getting lost in fog.

1. Button lights installed into pavement edges at 20 foot spacings. This technique employs lineal guidance obtained from light sources inset into pavement surfaces. Low intensity light sources closely spaced have been found to be preferable to higher wattage units placed on wider spacings. A reason for this is that the continuity of the lineal pattern is improved and the glare per individual unit is greatly reduced. A quartz, iodine cycle, tungsten bulb of from 5 to 8 watts appears to be suitable because it can be operated in the open without damage by moisture, rain, snow, or other weather conditions. The quartz bulb is free from thermal shock, and the general construction of the unit is reported to be rugged.

   It should be pointed out that cuts will have to be made in the pavement for the installation of the lights and resealed with epoxy around the installations, and that the electrical wiring will be buried beneath the pavement edges. One other potential problem is the possibility of damage to the lights during snow plowing.

2. Low level lighting, mounted with the base of the luminare 2.5 feet in height. The cutoff plane is to be rotated 4.15° below horizontal and the cone of illumination rotated 110° to the center line in the direction of travel. Sharp cutoff and accurate construction of the reflectors are of great importance, as is accurate adjustment of the tilt of the cutoff plane. The lighting should be mounted at the edge of the paved shoulder in accordance with interstate road edge delineators as indicated on page 848 of the Virginia Manual of Uniform Traffic Control Devices for Streets and Highways, Note 1A. This publication states that the installation will be erected 2 feet beyond the outer edge of the shoulder or the face of unmountable curb or in the line of guardrail. An experimental spacing of 20 feet is suggested with enough elasticity in the system to allow for increasing or decreasing the spacing if necessary. Special attention should be paid in design to guard against vandalism and to ensure that the aesthetic features of the road are not destroyed.

3. Pavement edge lines using reflectorized paints and a width of 6 inches. The Highway Department might wish to consider three test sections. One for the lineal guidance system, one for the low level lighting system, and one for a combination of the two systems. All three test sections would employ a 6 inch edge line.

   The cost of the test sections is not known at this time, except the literature does advise that the button lights would cost about $1.50/lin. ft. The writer will discuss with the Maintenance Division the feasibility of installing test sections.

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