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Evaluation of a Prototype Lighted Ball Marker for Powerline Obstructions

Eric S. Katz

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16. Abstract

The purpose of this project was to evaluate a prototype lighted ball marker. The lighted ball marker is a powerline obstruction marker that is designed to illuminate when it is placed directly on a high voltage powerline. Three of these ball markers were installed on a powerline near the Federal Aviation Administration (FAA) Technical Center and were tested for conspicuity during nighttime, Visual Flight Rules (VFR) conditions. Results of the evaluation indicate that the lighted ball markers provide a pilot with adequate advance warning that a powerline obstruction is being approached. Complete and partial failures of the prototype markers under evaluation indicated that reliability problems may be anticipated unless design corrections are made to production units.

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EXECUTIVE SUMMARY

The purpose of this project was to evaluate a prototype lighted ball marker. The lighted ball marker's function is to provide nighttime conspicuity to high voltage powerline obstructions.

Three of these ball markers were installed on a powerline near the Federal Aviation Administration (FAA) Technical Center. A flight evaluation was then conducted to determine the effectiveness of the ball markers as a nighttime, VFR powerline obstruction marker. After each flight test session, subject pilots were asked to comment on the adequacy of the ball markers.

Results of the evaluation indicate that the lighted ball markers provide a pilot with adequate advance warning that a powerline obstruction is being approached.

Complete and partial failures of the prototype markers under evaluation indicated that reliability problems may be anticipated unless design corrections are made to production units.

INTRODUCTION

PURPOSE.

The purpose of this project was to evaluate a prototype lighted ball marker. The evaluation was undertaken in response to a request from the Engineering and Specifications Division, AAS-200, submitted through the System Technology Division, ARD-200. The work was accomplished under Technical Center project number T19-03N, "Airport and Heliport Lighting and Marking." The Technical Project Manager is Eric S. Katz.

BACKGROUND.

The Federal Aviation Administration Advisory Circular 70/7460-1G, Obstruction Marking and Lighting, describes the standard spherical marker that is presently used to enhance the conspicuity of a powerline or catenary wire. Although these markers perform effectively during daytime, Visual Flight Rules (VFR) conditions, they are not designed for nighttime operations.

As a possible solution to this problem, a prototype lighted ball marker was developed. The prototype unit, constructed using a standard spherical marker, incorporates a number of neon tubes to provide a red nighttime identification. Power for the illumination is obtained from the electromagnetic field generated by the current flow through the high voltage powerline itself. Therefore, no additional power source is required to illuminate the marker (figure 1). It should be noted that the prototype device evaluated was originally designed for use on transmission powerlines of at least 69,000-volt potential and is not intended for use on distribution powerlines of lesser voltage. Use of this device on higher potential powerlines (135 KV, 345 KV, etc.) will result in improved performance with significantly greater neon light intensities. For the purposes of this evaluation, the lighted markers were installed on a powerline having the minimum 69,000-volt design potential.

The performance criterion specified in Advisory Circular 70/7460-1G for the development of the lighted ball marker was as follows: The ball marker should be visible in nighttime, VFR conditions from a distance of at least 4,000 feet.

INSTALLATION

Three prototype lighted ball markers were acquired and installed on a 69,000-volt transmission line near the FAA Technical Center (see figure 2). The distance between each of the 36-inch-diameter marker balls was approximately 75 feet, and the height of the transmission line on which the markers were installed was approximately 50 feet above the ground. Markers were installed on the transmission line using a conventional truck mounted, two-person capacity "Bucket" device and hand tools of the type normally carried on electric utility maintenance vehicles.

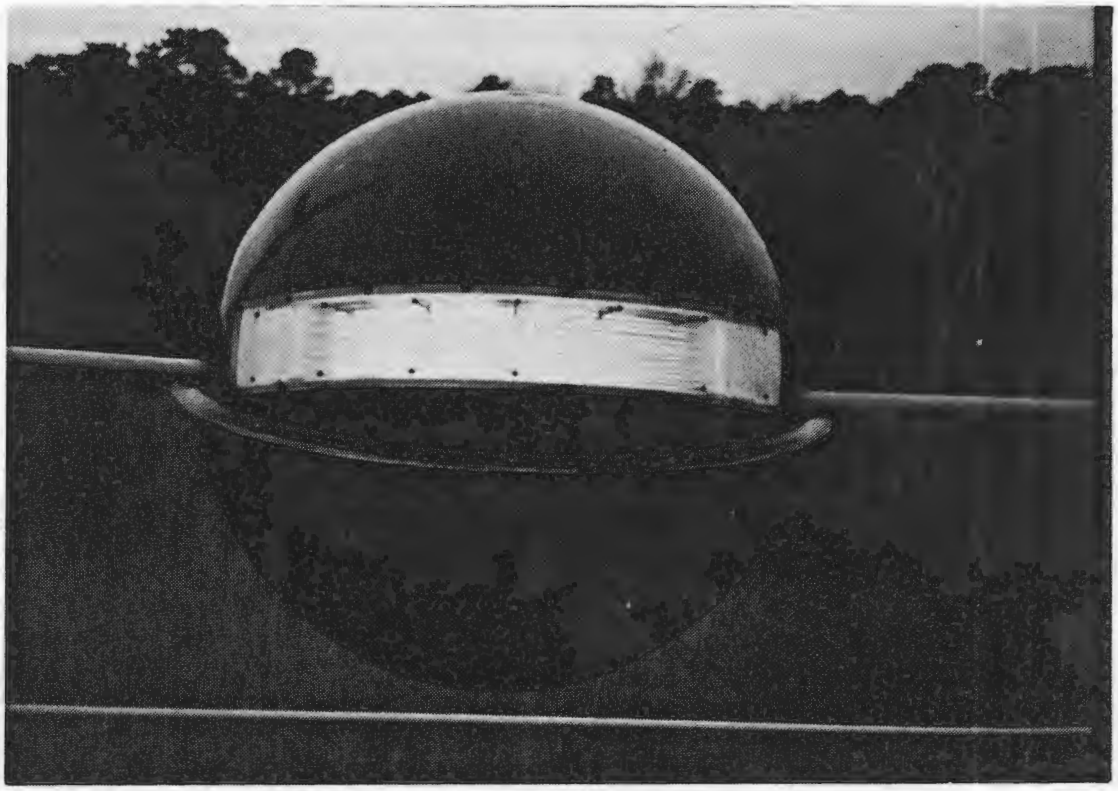

FIGURE 1. LIGHTED BALL MARKER - DETAIL

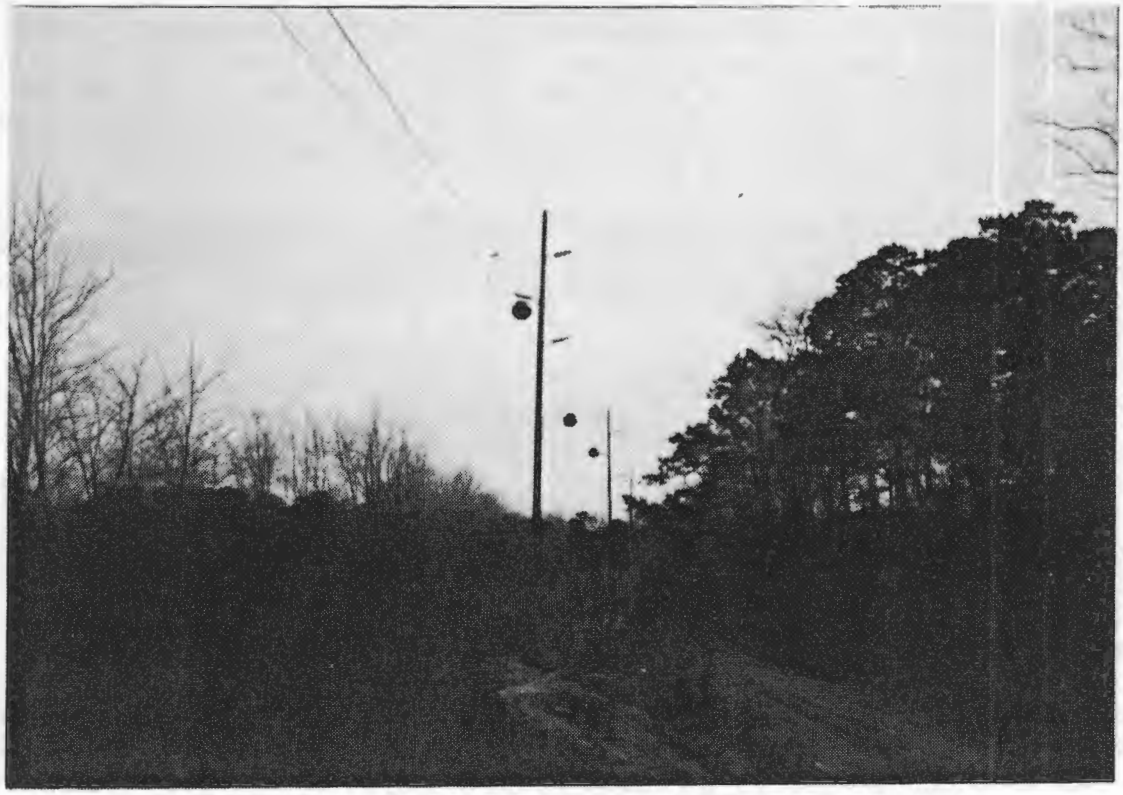

FIGURE 2. LIGHTED BALL MARKER INSTALLATION

TEST PROCEDURES

FLIGHT TEST EVALUATION.

Flight tests were conducted during nighttime VFR 3- to 5-mile visibility conditions. All of the evaluation subjects chosen were either Technical Center flight test pilots or local general aviation pilots. Prior to each flight, the subject pilot was briefed on the purpose of the evaluation, and the procedures to be followed.

During each test session, three approaches were made to the lighted ball markers from various angles. Using Long Range Navigation (LORAN-C), the subject pilot was given a series of headings that would direct the aircraft towards the ball markers. The subject pilot was asked to indicate when he first saw the markers and how many he saw. This information was immediately recorded by the observer. In each case, the aircraft was flown approximately 200 feet above the markers to insure adequate vertical clearance. Three types of aircraft were used: a Convair 580, an Aero-Commander 680, and a Cessna 172.

Upon completion of each evaluation session, the pilots were required to complete a post-flight questionnaire. A summary of pilot responses is shown in figure 3. Pilot comments are summarized in the appendix.

MEASUREMENT OF MARKER INTENSITY.

Intensity measurements with a portable intensity measuring device were to be accomplished subsequent to the completion of the flight tests. These measurements were intended to provide a minimum recommended intensity level for this type of device.

RESULTS

FLIGHT TEST EVALUATION.

Eight post-flight questionnaires were collected from the participating pilots. The lighted ball markers were first acquired at an overall average distance of 1.23 nautical miles for all of the test runs. The actual range of acquisition distance was 0.3 to 2.05 nautical miles; however, only 2 of the 24 total sightings were recorded at distances less than 4,000 feet from the ball markers.

Although three lighted ball markers were installed for evaluation, pilots identified all three markers in only 1 of 24 test runs, and identified only one marker in 14 of 24 test runs. In the remaining 9 test runs, two of the three markers were sighted. Throughout the entire test period, one of the three ball markers appeared brighter than the other two. The most probable reason for this is that the ball markers were not fully weatherized before they were sent to the Technical Center, and moisture may have diminished the light output of the two dimmer ball markers. It must be assumed that the production units, being completely weatherized and not susceptible to deterioration, will perform at least as effectively as the one prototype unit that retained its original design intensity level.

PILOT QUESTIONNAIRE

NAME: 8 Total DATE: DUSK: OR NIGHT: X

Observed Visibility (MI): 3-5 Aircraft Type:

1. At what distance did you first identify the Lighted Ball Markers?

   Run 1: 1.03 Miles (average all subjects)

   Run 2: 1.25 Miles (average all subjects)

   Run 3: 1.41 Miles (average all subjects)

2. How many Lighted Ball Markers did you see during each run?

   Run 1: 1 to 3 Run 2: 1 & 2 Run 3: 1 & 2

3. Do the Lighted Ball Markers give adequate advance warning that a powerline obstruction is being approached?

   Yes: 8 (100%) No: 0 (0%)

Comments: (see appendix)

Thank you

FIGURE 3. SUMMARY OF QUESTIONNAIRE RESPONSES

When asked to rate the effectiveness of the lighted ball markers, all eight subject pilots stated that the markers provided adequate advance warning that a powerline obstruction was being approached.

MEASUREMENT OF MARKER INTENSITY.

The intensity measurements to provide a minimum recommended intensity level for the device were not taken. Shortly after the completion of flight testing, the one prototype ball marker that appeared to have retained its original design intensity level failed completely, producing no discernable light output. Therefore, no relevant light measurement of desired intensity or output level was possible. The ball marker was in continuous operation for approximately 12 months before the failure occurred.

CONCLUSIONS

From the results of the evaluation, it is concluded that:

1. The performance criterion specifying visibility at a distance of 4,000 feet under nighttime minimum Visual Flight Rules (VFR) conditions has been successfully met by the lighted ball markers.

2. The complete or partial failure of all three prototype ball markers indicates that the reliability of these markers is questionable, and that design corrections will have to be made to production units.

RECOMMENDATION

If the use of lighted catenary warning devices of this type is to be included in the Obstruction Marking and Lighting Advisory Circular, AC 70/7460-1, it is recommended that the following paragraph be added to the contents of Chapter 6, "High and Medium Intensity White Obstruction Lighting Standards":

j.(6) Supplementary Catenary Wire Illumination. To provide enhanced nighttime visual identification of high-voltage (69 KV and higher) transmission line catenary wires, lighted spherical ball markers having a minimum intensity of at least 30 candelas may be installed along the wire at intervals of 200 feet (61m), or fraction thereof. The lighted spheres should be displayed on the highest energized wire. Where there is more than one energized wire at the highest level, the spheres may be installed alternately along each wire if the distance between adjacent spheres meets the spacing standard. This method will allow the weight and wind loading factors to be distributed.

ADDITIONAL COMMENTARY

If it is intended that the lighted ball markers will serve only as a catenary warning supplement to the presently required high intensity condenser discharge lights on support towers, an intensity level approximately equal to that of conventional L-810 steady burning red obstruction lights will suffice. Such an intensity level would fall in the range of 30-70 candelas for a class 1 device.

If it is intended that the lighted ball markers are to serve as the primary catenary wire warning device, acceptable in lieu of high intensity condenser discharge supporting tower lights, an intensity level approximately equal to that of the supporting tower lights will be required. Such an intensity level would be 20,000 candelas during twilight and 2,000 candelas during periods of darkness.

APPENDIX

SUMMARY OF PILOT COMMENTS

Subject pilot comments, as recorded by the pilots on their post-flight questionnaire forms, are shown below. The excerpts, while not necessarily direct quotes of individual pilots, reflect the general nature of the comments. Noted prior to each comment are the visibility conditions during the flight periods.

(4-5 miles) 1. The lighted ball markers satisfactorily perform their intended function. (3 pilots)

(3-5 miles) 2. The lighted ball markers denote an approaching obstruction, however, the obstruction is not necessarily recognized as a powerline. (2 pilots)

(3 miles) 3. The markers are excellent and distinctive features for a strand of powerline. Recognition was good. (1 pilot)

(3 miles) 4. The marker's color is distinctive and the brightness is sufficient to give warning. Overall, the system is adequate. (1 pilot)

(5 miles) 5. The markers will be of great value. (1 pilot)