NATIONAL BUREAU OF STANDARDS REPORT

8303

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period October 1 to December 31, 1963

By
Photometry and Colorimetry Section
Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Development, Testing, and Evaluation of
Visual Landing Aids

Consolidated Progress Report
to
Ship Aeronautics Division
and
Meteorological Management Division
Bureau of Naval Weapons
Department of the Navy

and to
Federal Aviation Agency
Washington, D. C.

For the Period
October 1 to December 31, 1963

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I. REPORTS ISSUED

Report No.	Title
8106	Field Tests of Airfield Lighting Cable Connections
8146	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period July 1 to September 30, 1963
21P-67/63	Photometric and Environmental Tests of Two 45-Watt Inset Lights and Replacement Components Manufactured by Structural Electric Products Corporation
21P-82/63	Photometric Tests of a Type I, Battery Operated, Portable, Emergency Airfield Marker Light Manufactured by Multi Electric Manufacturing, Inc.
21P-109/63	Six Perforated Metal Screens for Reducing the Intensity of an Optical Landing System Cell
21P-120/63	Electrical Tests of Two 200-Watt, 20/6.6-Ampere, Series/Series Transformers Manufactured by Elastimold Division of the Elastic Stop Nut Corporation of America
Memorandum Report	Effective Intensity Distributions at Various Turntable Speeds of Type 20A/PAR56Q/1 and 20A/PAR56Q/3 Lamps

II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter. The computations and analysis of the ratios of observed slant visibility for targets or threshold lights at 20, 55, and 90 feet above the horizontal have continued. The average observed visual range ratios as a function of visual range for daytime and nighttime are given in table I.

TABLE I

Average Observed Slant Visual Range Ratios - Daytime

Horizontal Visual Range →	300'- 500'	501'- 800'	801'- 1200'	1201'- 1700'	1701'- 2300'	2301'- 3000'	Over 3000'
h_{90}/h_{20}	0.89	0.84	0.78	0.71	0.76	0.84	0.82
h_{90}/h_{55}	0.95	0.93	0.89	0.85	0.88	0.93	0.90
h_{55}/h_{20}	0.93	0.91	0.88	0.82	0.86	0.89	0.93
No. observations averaged	36	212	124	67	32	6	10

Average Observed Slant Visual Range Ratios- Nighttime

Horizontal Visual Range →	400'- 599'	600'- 799'	800'- 1099'	1100'- 1499'	1500'- 1999'	2000' 2699'	Over 2700'
h_{90}/h_{20}	0.87	0.91	0.90	0.85	0.83	0.80	0.75
h_{90}/h_{55}	0.94	0.95	0.95	0.93	0.89	0.90	0.88
h_{55}/h_{20}	0.93	0.96	0.94	0.91	0.90	0.89	0.89
No. observations averaged	11	132	255	210	69	38	23

The values of h_{20}, h_{55}, and h_{90} are the observed visual ranges of the target at heights of 20, 55, and 90 feet, respectively. The horizontal visual ranges are the observed visual ranges of the target which is 20 feet above the horizontal.

Note that the ratios tend to decrease as the visual range increases. For the daytime observations at ranges greater than 1700 feet, the fog was frequently markedly nonuniform horizontally.

From the equation $\sigma = \sigma_o (1 + ah)$ the value of a was determined for approximately 200 scans of the slant visibility meter, recorded at various times during the 1962 fog season. These values of a were computed for the fog layer nearest the ground. Values of a were also computed for each of these scans by a visual approximation of the average recorder indication, assuming that the first fog layer extended from the ground up to at least 200 feet. This approximation appeared to agree very well with the recorded reading in over 80 percent of the scans. The values of a varied from 0.089 to -0.084, but 95 percent of the values were between 0.01 and -0.01 and 75 percent of the values were between 0.001 and -0.001.

Shipboard Visibility Meter. Development and testing of circuitry to perform the several functions described in NBS Report 8059 (Progress Report for April - June 1963) has continued. The circuit difficulties reported last quarter have been corrected. A log adaptor and a gating adaptor have been obtained for the operational amplifier used in the output circuit of the instrument.

Transmissometer.

Expanded-Scale Indicator. During the extended service test of the expanded-scale transmissometer indicator operation has been very satisfactory. However, the time constant of the indicator must be very long at low pulse rates in order to smooth the output current satisfactorily. This long time constant has made adjustment of the indicator zero tedious since considerable time was required for the indicator to stabilize after each change in the zero adjustment. It also has made the hourly cutoff reading unreliable since the recorder would not always reach a stable reading during the one minute the light was off. These difficulties have been remedied by the following modifications.

To remedy the first difficulty, a variable resistor has been added in series with R213 in the bridge. Changing the value of this resistor produces an immediate change in the zero setting of the indicator, without requiring the change in voltage across C203 which is needed when the present zero adjustment is used. The second difficulty has been remedied by adding circuitry which momentarily shorts capacitor C203 when the background or zero switches are first actuated. This change reduces the time for the indicator to drop from a full-scale reading to a stable background or zero reading to less than the time required for the conventional, linear, indicators.

Transmissometer Modifications to Adapt the Instrument for Use in Very Dense Fogs. An analysis is being made of the relation between the length of the transmissometer baseline, transmissometer pulse rate, and runway visual range and of methods of increasing the pulse rate of the receiver. The analysis will be completed and reported next quarter.

Study of Systematic Variations of Fog with Location. No significant variations were noted in the visual ranges of targets, looking either to the north or to the south over a 2000-foot range. Observations on the 2000-foot range were discontinued. The nighttime observations agreed very well with the visibility indicated by the transmissometers, but the daytime observed visibilities did not agree as closely as expected. Targets were moved to a 1000-foot range where the line of observations more nearly coincided with the baselines of the two transmissometers located end to end, to check for correlation of observed visibility to indicated visibility in daytime. Suitable conditions for observations on this short range did not occur during this period.

To aid in the study of variations in fog, a third transmissometer was installed with a 500-foot baseline approximately perpendicular to the baseline and near the adjoining points of the other two transmissometers. The indicated transmissions from these units are being tabulated and ratios are being computed at regular time intervals when the transmission is less than 0.70. No conclusions can be reported at this time because of the limited occurrence of low visibility conditions.

III. AIRFIELD LIGHTING AND MARKING

Stub Approach Beacon System. Some pilot comments have been obtained on the stub approach beacon. The present arrangement of the beacon uses five lamps on a turntable rotating a 12 revolutions per minute to provide 60 flashes per minute. The first lamps used were the type 20A/PAR56Q/3, 500-watt lamps. Pilot comments indicated that these lamps had adequate intensity to be detected at more than eight miles in bright sunlight (which is farther than the VASI can be detected); the intensity is higher than desired on final approach in bright daylight; the flash rate is too slow and the beacon may be confused with the airport beacon; and it is not easy to hold the beacon identification. The low intensity setting is too bright for nighttime approaches in good visibility. The intensity of these lamps may be suitable for use in noise abatement routing of jets, but a greater number of lamps per beacon may be needed to compensate for the narrow beam.

Later the type 20A/PAR56Q/1, 500-watt lamps were used. A limited number of comments indicate that the wider beamspread of these lamps makes the flash rate more suitable than that of the 20APAR56Q/3 lamps. The low intensity setting is slightly too high on final approach at nighttime during clearer visibility.

To better determine the proper low intensity setting, a 5-kilowatt continuously variable autotransformer has been obtained so that continuous dimming will be possible. The autotransformer will be installed soon and additional comments will be obtained. Control of this beacon from the tower is needed, but control lines are not available. The FAA plans to install a new control cable to the localizer. This may make control cables available for our use.

Hoskins Condenser-Discharge Light. Effective intensity distribution measurements have been made of a condenser-discharge light (type P/N 85-003-1) manufactured by Don Hoskins, Inc., and intended for use in small-airfield approach-light systems. A report is being drafted.

Experimental Condenser-Discharge Light. Tests are being made of an experimental condenser-discharge light (type EL-ASN-500M) manufactured by Electronic Lights, Inc. and intended for use as a heliport identification light.

45-Watt Inset Lights. NBS Report 21P-67/63, giving the results of photometric and environmental tests of two Structural Electric Products Corporation type 18240 45-watt inset lights, has been issued.

Experimental Deck Guide Lights. Tests have been made on two experimental deck guide lights for use on aircraft carrier decks, manufactured by Sylvania Electric Products, Inc. A 100-watt and a 160-watt experimental quartzline lamp, rated at 6.6 amperes, were used. A coherent fiber optic was used to channel and vertically align the light beam. The lights failed in the fiber optic in a very short time. The cause of failure was not determined. A memorandum report is being prepared.

Test Method For Semiflush Prismatic Lights. Some further work was done to develop a test method for semiflush prismatic lights which is independent (with regard to beam placement) of the lamp characteristics. A jig that partially collimated the light from the lamp was made, but it is not the final solution of the problem.

Beam-Spreading Techniques for Semiflush-Prismatic Type Airport Marker Lights. Several techniques were tried in an effort to increase the vertical beam spread of a semiflush prismatic type airport marker light from the present 4 degrees to 5 degrees. A cylindrical plano-convex lens placed between the PAR-type lamp and the prism increased the vertical spread of the beam up to 16.2° from 4.6° measured without the lens. Lamps other than the type recommended for use in the units also gave an increased beam spread. The effect of lamp tilt on the elevation angle of the beam was investigated. A lamp tilt of slightly less than 2° elevated the beam axis 1.25°. NBS Report 8169 was drafted giving the results of the investigation.

Navy Taxiway Lighting Standard. Work on the draft of this Standard has been nearly completed. This work should be completed next quarter.

Lighting for SATS Airfields. Technical assistance has been given personnel of the Bureau of Naval Weapons in the development of specifications for the lighting system for SATS airfields and in the development of parts lists. Operation of the obstruction lights, and other miscellaneous lights, from the series circuits was recommended. In order that the intensity of these lights be maintained when the runway lights are operated at a low intensity setting, the transformer supplying the obstruction and miscellaneous lights must be operated in a saturated condition. The data given in NBS Report 6337 indicate that a 90-volt, 100-watt lamp would be the most suitable lamp for the 200-watt, 6.6/6.6-ampere transformers designed for SATS service. Arrangements have been made with the General Electric Company to obtain sample lamps of this rating in the A21 obstruction light lamp configuration.

200-Watt, 20/6.6-Ampere, Series/Series Transformers. Electrical tests were performed on two 200-watt, 20/6.6-ampere, series/series transformers, manufactured by the Elastimold Division of the Elastic Stop Nut Corporation of America. These transformers were designed

primarily for "SATS" airfield lighting service. They are similar to those used in general airfield lighting service except that they are more compact and lighter; the primary leads extend from opposite sides of the case; and the connectors on the primary leads are of a locking type instead of the type described in Specification L-823.

All of the electrical tests of Specification MIL-T-4950A(ASG) were performed except those listed in Paragraph 4.5.6 of the specification, Insulation Resistance. The transformers met all of the requirements of the specification for which they were tested. NBS Report 21P-120/63, giving the results of the tests, was issued.

Semiflush-Mount Omnidirectional Airport-Marker Light. Photometric tests were made of a semiflush-mount omnidirectional airport marker light (type B-3) manufactured by Multi Electric Mfg. Inc. A shield was provided by the manufacturer to be installed in the unit. The shield is intended to keep stray white light from being emitted when a blue filter is used in the light unit. The test showed that the stray white light would be objectionable above 12° vertical. The shield was effective in blocking the stray light and the effect on the main beam of the light was negligible.

700-Watt, C-5, 6000-Hour Lamps for Code Beacons. Initial luminous output tests were made of seven 700-watt, 6000-hour lamps, with C-5 filaments, for code beacons. Four of the lamps have been placed on the life-test rack. Intensity distribution measurements will be made of a code beacon light with the remaining three lamps.

Type I, Battery Operated, Portable, Emergency Airfield Marker Light. A marker light manufactured by Multi Electric Mfg. Inc. was tested for conformance to photometric requirements of Military Specification MIL-L-19661A. Three lamps were used in the light, one from NBS Test 21P-31/58, one furnished as the operating lamp with the unit, and one furnished as a spare with the unit. The light did not meet the intensity distribution specification requirements with the first two lamps. Tests with the third lamp indicated that the light would meet the requirements with this lamp. NBS Report 21P-82/63 has been issued.

Effective Intensity of Flashing PAR399 Lamps. The study of the intensity-time curves of the flashing PAR399 lamp is continuing.

Effective Intensities of Type 20A/PAR56Q/1 (500-Watt, Prismatic Cover) and Type 20A/PAR56Q/3 (500-Watt, Stippled Cover) Lamps. A Memorandum Report giving effective intensities of types 20A/PAR56Q/1 and 20A/PAR56Q/3 lamps rotating at turntable speeds of 2, 10, 20, and 40, has been issued.

Effective Intensity of PAR-Type Lamps Used in Rotating Beacons. Earlier studies, reported in previous quarters, have shown that for type 20A/PAR56Q/1 and type 20A/PAR56Q/3 lamps, the effective intensity at any vertical angle can be estimated by multiplying the maximum steady-burning intensity at that vertical angle by an effective intensity factor appropriate to the turntable speed at which the lamp is rotating. For engineering purposes, the error of estimation is small enough to be neglected.

The study of the feasibility of using this method of estimation has now been extended to type 20A/PAR56, 20A/PAR56/2, 200PAR Locomotive (with CC-8 and C-13 filaments), 500PAR64/NSP, 500PAR64/MFL, 4519, and 20A/PAR36/1 lamps and compared with effective intensity calucations for several vertical angles. The particular vertical angles used in the studies varied from lamp type to lamp type. Estimation errors have been found to vary with the vertical angle, the turntable speed, and with the lamp type. The estimation error usually rises with the absolute magnitude of the vertical angle, and is a maximum with respect to turntable speed in the region of 40 to 80 rpm. For all but one of the lamp types tested, the estimation error, at 40 rpm (turntable speed) and at a vertical angle corresponding to a maximum instantaneous intensity of 20% of the peak instantaneous intensity of the lamp, is less than 18%. The one exception was a type 200PAR Locomotive lamp with a CC-8 filament. Here the estimation error is about 37%. This large error is presumed to be a result of the circular shape of the beam of the lamp, but other lamp types with beam shapes close to circular have not exhibited large estimation errors.

Effective intensity factors for the above enumerated lamp types and for type 20A/PAR56Q/1 and 20A/PAR56Q/3 lamps at turntable speeds of 1 to 200 rpm have been plotted and will be included in a report that is being drafted.

Airfield Lighting Cable Connectors Field Test. A report giving the results of connector tests to June 1963 has been issued as NBS Report 8106, Field Tests of Airfield Lighting Cable Connections. An additional test in October indicated very little change in the insulation resistance of these test units. However, three or four test units have developed cracks in the insulation in sections of the cable to which connectors are attached. These sections had been previously buried, but are now exposed to the atmosphere.

Last quarter the buried connections were uncovered for a visual check and to bring the ends of the cables that had been buried into the instrument shelter for additional tests. About 30 days after the cables had been re-arranged, they were inspected. One of the cables that had 2400 volts continuously applied to it had cracked open where it entered the shelter and was arcing to the shelter wall. Closer

inspection of the other cable ends that had been buried during previous tests showed slight cracks and checks where these cables entered the shelter. Airfield lighting cable connectors were ordered so that the ends of the cables which had been buried could be cut off above ground level and new cable could be extended from that point to the test measuring instruments. It appears that the part of the cable which has been buried over a period of more than three years may have a tendency to crack and check when it is brought out above ground. The new connectors have been received and will be installed. Further checks and tests will be made periodically. A guard circuit will eliminate the effects of the new connectors on the measurements of the insulation resistance of the connections under test.

Field Tests of Cable Test-Detecting Set AN/TSM-11. The flush-light circuit on Arcata Runway 13-31 was checked with the TSM-11 to obtain additional data for preparing a report on the use of this cable test equipment. The lights in the circuit were operable, although they had not been used for two or three years and had not been maintained for several years. The circuit was expected to provide a good test of the feasibility of using the TSM-11 on circuits with multiple high-resistance faults to ground.

Checks were made with the signal generator connected to one feeder and then to the other. Careful analysis of the readings indicated a number of areas in which faults were probable. Cleaning the bases of the lights and making further checks showed that many of the indicated areas did have high resistance faults to ground. Some places that had indicated possible faults showed no evidence of any faults. Some bases had water well above the sockets but the TSM-11 gave no indication of a fault.

The results of this test show that for ground conditions at the Arcata Airport (which has high ground resistance), if effects of marked changes in depth, of magnetic shielding, and of alternating current power interference can be eliminated, the TSM-11 indications can be interpreted as follows:

A decrease in reading of 25 percent or more definitely indicates a fault.

A decrease of 10 percent is likely to indicate a fault.

Some faults can not be detected.

A high series-resistance fault, unless associated with a ground fault, can not be detected.

Since this testing with the TSM-11 may require two complete checks around the circuit, one with the signal generator connected to each feeder and additional testing as the faults are cleared, the normal good maintenance procedure of first clearing the more easily detected faults and then using the TSM-11 to try to locate any remaining grounds appears to be the most expedient method of cleaning up circuits that have not had proper maintenance.

Radioactivated Taxiway Lights. Radioactivated light sources are being studied to determine their suitability for use as taxiway lights. One of each of three different types of radioactivated lights has been ordered from the United States Radium Corporation.

IV. SEADROME LIGHTING

No work was conducted in this field during the quarter.

V. CARRIER LANDING AIDS

Photometry of the Fresnel-Lens Optical Landing System. An investigation was made into the photometry of a diverging lens system such as the one incorporated into the Fresnel-Lens Optical Landing System. The results indicated that the apparent distance of the virtual image (the "meat ball") behind the Fresnel lens must be taken into consideration when computing (1) the luminous intensity of the unit from the measured illuminance at a point, and (2) the vertical position angle and spread of the beam emitted by the unit. Brightness measurements of the Fresnel lens showed a gradual dropping off of brightness with increasing angle from the center of the meat ball, with no "hot" spots or ghosts. NBS Report 8167 has been drafted giving the results of the investigation.

Screens for Fresnel-Lens Optical Landing System. NBS Test Report 21P-109/63 was issued, giving the results of photometric tests of six perforated metal screens, single-cell size, intended for use in the intensity control of the Fresnel-Lens Optical Landing System. The tests indicated that the screens reduced the intensity approximately the same fraction at each horizontal angle measured. Thus light at large angles ("stray" light) was not reduced a greater fraction than was the light in the main beam.

Portable Spot-Pad Lights. An additional LPH spot-pad light has been constructed for use as a model by NAEL(SI) in their preparation of a specification for these lights. Engineering sketches of these lights are being prepared for use by NAEL(SI).

LPH Angle-of-Approach Light. An LPH angle-of-approach light has been constructed and is mounted on the outdoor photometric range at the National Bureau of Standards for visual observation by Bureau of Naval Weapons personnel. This unit consists of a black anodized aluminum box containing two 6.6-ampere, 100-watt lamps mounted side by side behind a baffle that restricts stray light and permits only the direct light from the filament to be seen by the observer. A three-color plastic filter is mounted in the box opposite the lamps. The filament color observed (red, green, amber) is determined by the vertical angle at which the observer is viewing the unit. The part of the beam transmitted by the lower area of the filter is red and has a five-degree vertical angular spread. The part transmitted by the center area is green and has a three-degree vertical angular spread, while that part transmitted by the upper area is amber and has a five-degree vertical angular spread. The tri-color beam has a 80-degree horizontal angular spread.

For shipboard service this unit will be mounted on a stabilized, oil-damped platform constructed by Naval Air Material Center in Philadephia. The complete unit will be mounted under a weatherproof clear plastic dome.

VI. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Specifications. The following specifications were reviewed and comments forwarded.

MIL-D-4806A Distribution Box, Runway Lighting, 5000 Volt, 20 Ampere MA-1

MIL-L-6363D Lamps, Incandescent, Aviation Service, General Specification for

MIL-L-26202D Light, Marker, Airport, Semiflush, General Requirements for, and associated MS Drawings

MIL-T-27535A Transformer, Isolation, Series Circuit, General Specification for, and associated MS Drawings

MS24348 Lamp, Incandescent, PAR56, Mogul End Prong, Airport Lighting

MS24448 Lamp, Incandescent, PAR56, Screw Terminal, Airport Lighting

MS24526(ASG) Base Airport Marker Light

MS26577(ASG) Gasket, Airport Light Marker Base

Several meetings of Defense Department and of Federal Aviation Agency Ad Hoc groups reviewing specifications have been attended and suggestions for modifications based on work performed at the National Bureau of Standards were presented.

Consultive Services to University of California Fog Chamber. Three visits were made to the Fog Chamber at Richmond, California, two by Washington personnel and one by Arcata personnel, to provide technical assistance on problems concerned with the measurement and control of the fog density and of the measurement of fog brightness. A controller which provides cyclic control of the water flow to the fog nozzles was designed, constructed, and shipped to the fog chamber. The controller provides a means of adjusting the repetition rate and the duration of pulses in the flow of water to the nozzles for each of the four sections of fog generators.

Visitors to Arcata Field Laboratory. In October C. A. Douglas, NBS, J. J. Bouvier, FAA, and R. F. Gates, FAA-NAFEC, and in November C. A. Douglas, NBS, and Paul Allee, Weather Bureau, visited the Arcata Field Laboratory. Installations were toured and operations were discussed, especially in relation to features of interest to the Federal Aviation Agency and the Weather Bureau.

Other Consultive Services. Technical assistance has been given to personnel of the Hazeltine Corporation in their study of the improvement of visual landing aids for carriers and to personnel of the Airborne Instruments Laboratory in their study of the use of infrared equipment for improved penetration of fog.

Theory of the Photometry of Projection Apparatus. Preparation of a review of the elementary theory of the photometry of projection apparatus has been started. This review is being prepared to provide a sound basis for the interpretation of the results of photometric measurements of projection systems which produce noncollimated beams.

VII. MISCELLANEOUS

A review of the book, "Introduction to the Utilization of Solar Energy," A. M. Zarem and Duane D. Erway, Editors, was prepared for publication in the Journal of the Optical Society of America.

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