NATIONAL BUREAU OF STANDARDS REPORT

4947

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report For the Period July 1 to September 30, 1956

By
Photometry and Colorimetry Section
Optics and Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS
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THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside back cover of this report.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metals Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Application Engineering.

- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
0201-20-2301 0201-20-2304 0201-20-2327	November 1956	4947

Development, Testing, and Evaluation of Visual Landing Aids

Consolidated Progress Report
to the
Ships Installations Division
Bureau of Aeronautics
Department of the Navy

For the Period
July 1 to September 30, 1956

For
Bureau of Aeronautics Projects

TED No. NBS-AE-10002
TED No. NBS-AE-10011

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids

July 1 to September 30, 1956

I. REPORTS ISSUED

Report No.	Title
4820	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period April 1 to June 30, 1956.
21A-7/56	Study of an Optical System and Battery for Portable Lights for Helicopter Landing Areas.
21A-9/56	Acceptance Tests of Approach-Angle Lights, Type II. (Letter Report)

II. RESEARCH AND DEVELOPMENT, LABORATORY TESTING, AND CONSULTATION SERVICES IN CONNECTION WITH VISIBILITY, AIRFIELD LIGHTING, AND FOG MODIFICATION PROBLEMS (TED NBS-AE-10002).

a. Visibility Meters and Their Application.

The stability of the pulse rate of the type WL-759 trigger tubes delivered on recent purchase orders has been unsatisfactory. The pulse rate of most of the tubes is so unstable that the fluctuations of reading of the meter of the receiver power supply are so great that adjustments of the 100% setting and alignment are very difficult. The manufacturer has investigated the cause of this instability and found it to be the result of too little radioactive material within the tubes. Since an excess of this material produces leakage, the control of the manufacturing process is critical. A sample group of tubes with different amounts of radioactive material was brought to the National Bureau of Standards by the manufacturer and the tubes were tested here. The stability of the tubes was considerably improved but the leakage was somewhat higher than desirable. A set of test equipment was loaned to the manufacturer so that tests of the type described in NBS Report 4436 can be made at the time of manufacture. Since the transmissometer is the principal user of these tubes, the manufacturer is revising his tests and specifications so that a tube more suitable to this instrument will be produced.

b. Airfield Lighting and Marking.

Taxiway Signs. Lights were installed in the interiors of two taxiway route and destination signs constructed by the Naval Air Development Center and the signs then shipped to the Naval Air Test Center. Four 30-watt, 6.6-ampere lamps connected in series were installed in one sign and six such lamps in the other sign. In order to obtain a satisfactorily uniform brightness of the lettering of the signs, it was necessary to finish the interior of the signs, including the backs of the lettered panels, with white paint. The brightnesses obtained were slightly below and slightly above those recommended in the survey report prepared by Dunlap and Associates, Inc.

Runway Lights. A USA Model C Elfaka flush light has been received and is being tested. Because of the size of the unit it is necessary to use the 277-meter outdoor range for the photometric measurements. This has required considerable effort to obtain a photometer system with sufficient sensitivity. Because of the effects of background illumination during daylight, all measurements are made at night. The light was adjusted by the manufacturer and intensity distributions made. The intensity at angles below one degree elevation was very low. The unit has been readjusted by the manufacturer and the measurements are being repeated.

Characteristics of Transformers. Measurements of the lamp current as a function of primary current have been made using a number of lamp-transformer combinations. The results are given in table 1 below. All measurements were made using a 4-kilowatt, type C-1 Hevi Duty regulator operating at nearly full load.

Table 1

Transformer Characteristics

Primary Current (amperes)	Secondary Current (amperes) for Lamp-Transformer Combination			
	1	2	3	4
2.8	2.8_6	2.8_5	2.8_2	2.9_0
3.4	3.4_5	3.4_1	3.3_6	3.4_9
3.8	3.8_3	3.7_9	3.7_6	3.8_7
4.1	4.1_2	4.0_9	4.0_4	4.1_7
4.2	4.2_3	4.1_9	4.1_5	4.2_7
4.8	4.8_2	4.7_7	4.7_4	4.9_0
5.2	5.2_4	5.1_6	5.1_2	5.3_2
5.5	5.5_4	5.4_7	5.4_4	5.6_5
6.6	6.6_5	6.5_6	6.4_5	6.8_0*

*For the 325-lumen and the 30-watt lamps; the current through the 45-watt lamp is 6.7_8 amperes and through the 1020-lumen lamp 6.7_6 amperes.

Lamp-Transformer Combinations

1. 325-lumen and 30-watt, 6.6-ampere lamps with 30/45 watt Jefferson transformer.
2. 45-watt, 6.6-ampere lamp with 30/45 watt Jefferson transformer.
3. 1020-lumen, 6.6-ampere lamp with 30/45 watt Jefferson transformer.
4. Any of above lamps with 200-watt Line Material transfomer.

Distance Markers. Measurements have been made of the intensity-voltage, intensity-current and voltage-current characteristics of the 75-watt, 30-volt, PAR 38 floodlight lamps proposed for use in illuminating runway distance markers. Graphs of these characteristics will be sent under separate cover.

Materials for Marking Runways. Optical tests on the plastic and paint materials being considered for runway markings have been performed previous to their subjection to mechanical and thermal tests. Investigation is under way to find mechanical tests that will be meaningful in determining how well these materials will withstand service conditions.

The optical tests performed are: the luminance factor for 75° incidence angle and 0.5°, 1.0°, and 3.0° divergence angles; the directional reflectance and color (45° incidence, 0° view). Table 2 below shows the average results of these tests for each material.

Table 2

Average Values of Optical Properties

Materials	Luminance Factor for Divergence Angle of			Directional Reflectance	Chromaticity Coordinates	
	0.5°	1.0°	3.0°	percent	x	y
Plastics						
Crystalex	0.9	0.8	0.7	65.9	.330	.338
Nefslabs	1.1	1.0	0.9	78.8	.317	.323
Paints						
Heat Resistant	7.8	6.6	4.8	34.6	.473	.447
Traffic	6.2	5.4	4.4	57.7	.332	.345
Masonry	10.4	7.8	6.1	58.5	.328	.336

These optical tests will be repeated after the optical and thermal tests have been performed.

Heliport Lighting. Three approach-angle lights were checked for compliance with specifications and found acceptable. A set of seven Big-Beam, type 440 lanterns were fitted with shields inside the lens to restrict the beam for advanced-area use. These and one of the approach-angle lights were taken to Quantico for flight tests as an advanced-base landing-area marker light system for helicopters. Assistance was given with the initial test which gave promising results. The pilots, however, desired a wider vertical angle for the satisfactory-approach indication. A new filter increasing the vertical angle of the green sector has been made and is ready for field tests. Several type 1597 lamps have been modified for use in the field tests.

Three types of amperites designated by the manufacturer as 4A-10, 4H-10, and 3H-10 have been tested with a Forway approach-angle unit. A circuit was devised using the 4A-10 amperite which makes it possible to use this light on a transformer energized by a series circuit, but more satisfactory results can be obtained if the amperite manufacturer can redesign it to provide a slightly larger current.

c. Seadrome Lighting.

Three miniature models of cable-fed buoy lights were made and tested in a tank at this Bureau. The results were encouraging but it was not possible to obtain waves of constant length and height in any tank available. Arrangements were accordingly made with the Beach Erosion Board to carry out a comparative test in one of their tanks. This was done and the motion of the models was photographed on motion picture film. Subsequent study of these films showed that one of these models was superior to the other two but all of them rocked considerably at some wave frequency. Two additional models were made and tested in the Bureau tanks with somewhat better results.

The project has been discussed with engineers of the A'G'A Division of the Elastic Stop Nut Corporation of America at their plant. They believe it will be possible to design a buoy which will be sufficiently steady to warrant restricting the vertical spread of light to 15°. The relative merits of a cylindrical fresnel lens as compared with a PAR lamp with its axis vertical combined with an inverted conical reflector were discussed. The A'G'A engineers favored the latter design. They also recommended that any green filter used in the unit be placed between the lamp and reflector in order to minimize the heating of the cover. A

plastic cover may be used to keep the center of gravity of the unit low but, if so, the lamp should not use more than 200 watts to avoid excessive heat.

Two prototype quick-starting buoys have been completed. These have been taken to the Naval Test Center at Patuxent for demonstration and field test. Consideration of the very much higher resistance to be expected in fresh water as compared with salt water indicated that the operation of the prototype buoys might not be as reliable as would be desired in fresh water. To make a light usable in either fresh or salt water, a new type of buoy antenna and wand have been developed which provide a metallic return circuit. Laboratory tests with this antenna and wand suggest that it is practical for use even in somewhat rough water. The models are being held pending an opportunity to give them a field test.

A preproduction buoy-mounted channel marker, type FMF-6B has been received from the Soderberg Manufacturing Company and is being checked for conformance to specification requirements.

d. Carrier Lighting.

Lights for Night Field Carrier Landing Practice. Several conferences with the manufacturer and representatives of the Bureau of Aeronautics have been held. A satisfactory three-position push switch has been installed in place of the rotary switch. The push switch is actuated by pushing on the flexible case so that no opening is required. This modification has eliminated most of the difficulties with the case-to-chassis seal. The light is now satisfactory for production.

Mirror Landing System. An electroformed cylinder manufactured by The Electroform Corporation for use as a form for electroforming mirrors for the mirror landing system was received and examined. Neither the surface finish nor the accuracy of the cylinder appeared to be sufficient for the purpose.

e. Lighted Suit for Landing Signal Officers.

Production on the Bureau of Aeronautics contract for these suits, which is being monitored by the National Bureau of Standards, is proceeding.

f. General Laboratory and Consultive Services.

Cable Test-Detecting Set. A TSM-11 Cable Test - Detecting Set which was found to be inoperative upon receipt from stock was delivered to the Bureau by NAS Anacostia. It was found that the cause of the trouble was failure in the 20-mfd, 6-volt electrolytic capacitors. All capacitors of this type were replaced. Subsequently, a second set was received from stock. It operated about 10 minutes before a capacitor failed. These failures plus those reported by NAS Atlantic City and the Equipment Laboratory, Wright Air Development Center, indicate that a change in this component is necessary.

Kinorama. The kinorama was demonstrated to representatives of the Civil Aeronautics Administration who requested that tapes be made to represent three types of narrow-gauge runway lighting. On the approval of the Bureau of Aeronautics, these tapes were prepared and tested by Commander Ogle of that bureau and Mr. Gates of the Civil Aeronautics Administration. The results of these tests indicated that one of the configurations was so far superior to the other two that it would not be necessary to include the latter in the field test. The kinorama has also been demonstrated to representatives of the Military Air Transport Service and the School of Aviation Medicine. Dr. Rose of the latter institution stated he would ask his school to consider requesting the transfer of the kinorama to their agency.

Color Standards. At the request of the Bureau of Aeronautics, samples representing the color of a commercially available orange paint made by the Sherwin-Williams Company were tested for conformity with the requirements of the General Services Administration for aviation surface marking orange. The paint was found to be within the I.C.A.O. definition of this color but not within a reasonable tolerance of the chromaticity represented by the General Services Administration standards. Recommendation was made that a system be established whereby manufacturers could state on their containers that the paint complied with the I.C.A.O. definition when this was true. A provision could then be made that agencies requiring small quantities of paint for use on isolated structures could buy commercial paint bearing this guarantee. Paint required to match existing paint and paint for large surfaces should be manufactured to conform to the GSA specifications. If some practical means of carrying out this program is found, it should result in substantial savings.

A meeting of the U. S. National Committee on the Colors of Signal Lights was held on September 7. The committee adopted a procedure for approving portions of the U. S. Standard and a preamble for Part I of the Standard which will make clear its status. Exhibits were prepared for the committee to illustrate the effect of lowering the saturation requirements for red signal lights and altering the boundaries of railway highway-crossing red and railway yellow in the interest of conformity with other specifications. The committee recommended some further research in these fields. The committee decided to recommend against the introduction of a pedestrian orange signal which can weaken the distinctiveness of both red and yellow signal lights. Part I of the proposed standard was again reviewed. It is now considered ready for a letter ballot.

Collaboration has been given to the Naval Vision Laboratory at New London, Connecticut, in designing a research on the visual discrimination of blue, white, and green signal lights.

III. VISIBILITY AND BRIGHTNESS TESTS, SURVEYS, EVALUATION AND ANALYSIS OF VISUAL LANDING AIDS, BASIC TESTS AND EQUIPMENT AS A FIELD SERVICE AT ARCATA, CALIFORNIA (TED NBS-AE-10011).

a. Airport Lighting and Marking.

Approach Beacons. The installation of control circuits and switches which permit the use of either the standard two-beacon system or the stub system using a single approach beacon has been completed. A new metal turntable has been installed on the outer beacon of the two-beacon system.

Runway Distance Markers. Night observations of floodlighted runway distance markers have been made in dense fog. These observations indicate that the brightness of marks illuminated with 75-watt PAR 38 lamps is lower than desired when the runway lights are on step 5. Efforts are being made to obtain more satisfactory lamps. A marker using fluorescent orange paint on the background is being prepared.

b. Electrical Engineering.

Survey Trip. A survey of visual landing aids was made at the following Naval and Marine Corps Air Stations.

NAS Alameda
NAS Moffett Field
NAS Miramar
MAS North Island
NAAS Brown Field
NAS Point Mugu
MCAS El Toro

Pilots, operational, and maintenance personnel were interviewed and the airfield lighting installations were surveyed. The following is a brief summary of major conclusions from the survey. A detailed report will be issued at a later date.

Operation. From the operational and pilots' viewpoint the major deficiencies of airfield lighting are:

1. Lack of standardization at different airfields. Standardization is probably the greatest need in visual landing aids. Most pilots feel that they would sacrifice optimum performance to obtain uniform lighting systems. This is especially true of approach lighting.

2. Lack of pilot awareness of visual aids. Pilot education is necessary to obtain the fullest degree of efficiency from any system. A surprisingly large percentage of the pilots were not aware of much of the information provided by visual aids.

3. Lack of satisfactory approach light systems. Pilots feel that approach lights are a necessary part of airport lighting and should be installed in conjunction with instrument landing aids. Additional guidance is needed for today's high performance aircraft for alignment before crossing the runway threshold.

4. Lack of a satisfactory taxiway lighting system. Pilots at all stations agreed in general that: a, taxiway lights are too bright; b, additional circuits are needed for better control of traffic and to reduce confusion; c, more taxiway lights are needed; d, the blue point-source lights cause difficulty with depth perception; and e, the intensity of lights on taxiways paralleling runways is greater than the off-axis intensity of runway lights during VFR conditions. This causes confusion.

All pilots expressed approval of the distance marker signs along the runways. Illumination of the signs is required.

Seadrome lighting is regarded by pilots as a problem needing immediate attention. No workable suggestions were offered. Pile-mounted lights are considered a major hazard especially

during taxiing, although the one seadrome using pile-mounted lights did not have a higher accident rate than seadromes using buoy-mounted lights.

Maintenance. In general, maintenance at the stations visited is good. The principal maintenance difficulties are:

1. Inadequate cable insulation resistance. Inadequate installation specification requirements are primarily responsible for this condition.

2. Water in the bases of AN-L-9 units and in lead-covered cable.

3. Lack of availability of small parts.

4. Lack of interchangeability of the same type part or unit from different manufacturers.

5. Lack of standby supplies or storage space.

6. Lack of communication to the tower.

7. Inadequate transportation.

8. Lack of emergency power.

9. Unsatisfactory battery life in the battery-operated seadrome lights.

10. Expense of servicing present seadrome lights.

11. Unavailability of theoretical and technical maintenance information including diagrams, troubleshooting procedures, etc.

Cable Test-Detecting Set. All stations visited had received their TSM-11 Cable Test-Detecting Sets but only one station had tried to use the set to locate a fault. All sets appeared to be in operating condition.

Maintenance personnel desire periodic visits by someone who can instruct them and keep their information current.

c. Research on Visibility and Visibility Measurements.

Sky Brightness. Measurements of horizon sky brightness, horizontal and vertical illumination, and ratio of direct to indirect illumination have continued. The data obtained are being tabulated and analyzed.

Slant Visibility Meter. Lamp life in the projector of the slant visibility meter continued to be short until some "prewar" lamps received from Washington were installed. The first of these lamps lasted 52 hours. The second has operated over 1000 hours to date. It appears that the cause of all of the difficulty with lamp life may have been the lamps themselves.

Effective Intensity of Flashing Lights and Composite Light Sources. The required checks of the computations of equivalent visibility during the time of observation from the transmissometer data have been completed. The equivalent visibility appears to be about 10% to 15% lower than the observed visibility. This is especially noticeable and consistent at visibilities less than 1000 feet. An analysis and check is being made of the possible causes of this discrepancy.

Lamps for the Westinghouse "krypton" light have been received. The light is now operating satisfactorily. Installation and testing of this unit will be started as soon as possible.

Back Scatter Measurements. Messrs. Joseph A. Curcio and Lloyd Knestrick of the Naval Research Laboratory were at the Arcata Laboratory for a two-week period testing a back-scattering type of extinction coefficient meter. Fortunately their visit coincided with a period of frequent fogs suitable for their work.

d. Facilities and Personnel.

With the start of the school year Messrs. Carrothers and Woodcock have reverted to WAE employment as they complete their senior years. This leaves the Laboratory short-handed. Efforts are being made to obtain additional personnel.

During the time the Laboratory has been in operation a large percentage of the time of the personnel there has been spent in installing and maintaining the necessary test equipment and instruments and in performing the necessary calibrations of the test equipment. This has been particularly true when the group has been short-handed. Sufficient data have now been obtained so that the emphasis during the next few months can be shifted from the obtaining of data to the reduction of data and the preparation of reports.

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.


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