NATIONAL BUREAU OF STANDARDS REPORT

4820

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report For the Period April 1 to June 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

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WASHINGTON, D. C.

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

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

Heat and Power. Temperature Measurements. Thermodynamics. Cryogenic Physics. Engines and Lubrication. Engine Fuels.

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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.

Mineral Products. Ceramic Engineering. Porcelain and Pottery. 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. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Applications 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.

Radio Propagation Engineering. Frequency Utilization Research. Tropospheric Propagation Research.

Radio Standards. High Frequency Standards Branch: High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Microwave Standards Branch: Extreme High Frequency and Noise. Microwave Frequency and Spectroscopy. Microwave Circuit Standards.

NATIONAL BUREAU OF STANDARDS REPORT

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Development, Testing, and Evaluation of Visual Landing Aids

Consolidated Progress Report
to the
Airborne Equipment Division
Bureau of Aeronautics
Department of the Navy

For the Period
April 1 to June 30, 1956

For
Bureau of Aeronautics Projects

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

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids

April 1 to June 30, 1956

I. REPORTS ISSUED

Report No.	Title
4669	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period January 1 to March 31, 1956.
21P-5/56	Photometric Tests of the Proposed Optical System of a Light for Night Field Carrier Landing Practice.
Letter Report	Cable Connectors.

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.

Transmissometers. In the past phototubes and trigger tubes for the pulse-amplifier unit of the receiver have been selected by operating the tubes in a simulated transmissometer receiver and comparing their performance with that of a "standard" tube. With the increase in the number of transmissometers in service, this method has become too cumbersome. Quantitative descriptions of the characteristics suitable for use in specifications are now required. Quantitative descriptions of most of the characteristics (sensitivity, leakage, dark current, etc.) were obtained by direct measurement of these quantities using tubes which were just acceptable under operating conditions. Description of the stability of the pulse rate of the trigger tube was entirely qualitative and based upon the variations in the reading of the meter of a portable indicator. To obtain a quantitative measure of this stability, a study was made of the correlation of the ratio of the maximum to minimum intervals between pulses and the qualitative rating. A satisfactory correlation was found. The following are the recommended requirements for phototubes and trigger tubes.

Phototube (Continental Electric Type XR-711-1 or Equivalent)

Type Surface: S1
Dimensions of Photosensitive Surface:
Projected width: 5/8 inch, min.
Projected height: 3/4 inch, min.
Shadowless Anode Structure
Sensitivity: 30 μa per lumen, min.
Dark Current: 1×10^{-4} μa, max.
(Preferably 5×10^{-5} μa max.)

"Trigger Tube" (Westinghouse Type WL-759)

Sensitivity: 0.003 μ coulomb per pulse when a 22 μμfd charging capacitor is used, min.
Leakage Current: 5×10^{-5} μa, max.
Plate Voltage Plateau: 220 v to 280 v min.
Stability Ratio: 1.4, max. at a pulse rate of 1.5 pulses per second.

The phototube is a replacement for the currently used Type 919 phototube. The maximum permissible dark current is sufficiently low and the minimum permissible sensitivity is sufficiently high that no selection of tubes should be required. The U-shaped anode structure does not intercept any of the light from the projector, thus increasing the effective sensitivity of the tube about 10%.

b. Airfield Lighting and Marking.

Constant-Current Regulator. A type C-1, 4-kilowatt, 6.6-ampere regulator manufactured by Hevi Duty Electric Company was received late in the quarter and has been installed for use in tests of airfield lighting equipment.

Materials for Marking Runways. Plans for a comprehensive investigation on the performance of several materials that may prove satisfactory for runway markers have been completed and preliminary tests have been started. Two plastic materials and three types of paints are being considered in the study. All the materials are constituted with retroreflective beads. The plastic materials are "Crystalex" and "Nefslabs". The paints being used are: S. K. Laboratories, Inc. "Heat Resistant Traffic Paint"; traffic paint conforming to Federal Specification TTP115 requirements; and National Lead Company masonry paint "Nalcrete".

The latter two paints and the plastic materials are "white"; the other paint is "yellow".

Several mechanical and thermal tests are planned for this investigation: adhesion, tear resistance, impact, plasticity, temperature cycling, weathering, abrasion, oil and dirt resistance and wetting. As the latter five tests influence the optical properties of the materials without completely destroying the materials, the optical characteristics will be determined before and after the mechanical and thermal tests are performed. The optical tests are: the luminance factor for 75° incidence angle and 0.5°, 1.0° and 3.0° divergence; the directional reflectance and color (45° incidence, 0° view). So that a reasonable statistical average is obtained, three specimens of each material for each mechanical and thermal test have been prepared for this investigation.

Runway Lights for Non-Instrument Runways. Analysis of the runway-light intensity distribution distribution required for circling approaches indicates that the intensity should be relatively constant over the range of azimuth angles from 80° to 280° where 0° is the direction toward and perpendicular to the runway centerline. Type M-1 lights with the asymmetric distribution are generally used for this purpose. However, the main beams of these lights are only a few degrees wide. Hence when the lights are operated at a low brightness setting to reduce the glare to aircraft on final approach, there is little guidance to aircraft circling the field. In order to obtain operational tests of the feasibility of using lights with a uniform intensity over the desired range of azimuth, clear and green symmetric-type lenses for the type M-1 fixtures have been obtained and sent to NAS Atlantic City for test. Shields will be installed so that the intensity in the directions toward the runway will not be excessive. The intensity of runway lights using these lenses will be too low for use in weather which requires GCA or ILAS approaches, but when the lights are operated at a suitable brightness setting, they should meet the requirements for non-instrument runways.

Contracts have been let for twenty runway circling-guidance lights, eight runway identification lights, and twenty 6.6/20 ampere isolating transformers for use in field tests.

Heliport Lighting. A report from the naval station which was flight testing units for lighting landing areas for helicopters showed that the lamps in the test lights were not giving adequate life. It was found that the lamp being used was one which had been tested at this Bureau in the unit under test and that our report pointed out that this lamp could not be expected to give satisfactory life. The selection of a lamp for this unit was discussed with representatives of the General Electric Co. at Nela Park and a lamp was recommended by their engineers. This lamp and also lamps suggested by engineers in the Bureau of Aeronautics were studied. The lamp recommended by Nela Park was found to be the most promising and its prospective life in this use was determined both by calculation and life tests. In both cases the results indicated it would be a satisfactory lamp.

c. Seadrome Lighting.

Two seadrome light units for field tests at the Naval Air Test Center at Patuxent were assembled. Unexpected difficulties arose as these units did not start reliably. The difficulty proved to be evasive and considerable testing was required to locate it. It was, however, finally eliminated by the addition of a capacitor and the units were completed. Some preliminary investigation was started on the design of floats for cable-fed buoy lights.

d. Carrier Lighting.

Lights for Night Field Carrier Landing Practice. Engineering assistance in the design of these lights has continued. Tests have been made of the optical system proposed by the manufacturer to determine if the beam pattern meets the intensity distribution requirements of specification XAE-120. Although the maximum and minimum intensities exceeded the specified limits, these deviations are considered unlikely to have a significant effect on the performance of the light. Results of this test are reported in NBS Test Report 21P-5/56. After the manufacturer had completed the mold for the case of these lights, additional intensity distribution measurements were made with the lenses mounted in molded cases. No significant changes in the intensity distribution were observed.

Mirror Landing System. An analysis was made of the horizontal intensity distribution and beam spread of the image of the source lights formed by the mirror of a mirror landing aids system. The effect of the following parameters was considered: width and radius of curvature of the mirror; distance between source lights and

mirror; length and average brightness of source-light configuration; and, if the mirror is rotating about a horizontal axis, the spread of rotation of the mirror. The results indicate that when the desired beam spread is 60° or less, for mirrors of the same width, no increase in effective intensity is obtained by using a rotating mirror unless a multisided mirror is used and the spread of rotation is low - so low that individual flashes can be seen. There would be, of course, an increase in the horizontal beam spread of the system when a rotating mirror is used. This analysis was presented to the Ad Hoc Group monitoring this project.

e. Lighted Suit for Landing Signal Officers.

The Bureau of Aeronautics contract for lighted LSO suits has been let. This contract is being monitored by the National Bureau of Standards.

f. General Laboratory and Consultive Services.

Specifications. Technical assistance has been given in the preparation of a coordinated MIL specification for the TSM-11 Cable Test-Detecting Set (replacing specification MIL-T-18934(Aer)) and in preparing comments on the proposed revision of specification MIL-L-7082.

Specification for Aviation Surface-Marking Orange. Chips were obtained representing a commercial paint marketed by the Sherwin Williams Company. The Company claimed this paint would be satisfactory for aviation surface-marking orange. Spectrophotometric curves were made for these chips and the chromaticities were computed. It was found that the color of the paint represented by these chips was within the limits adopted by I.C.A.O., but presumably did not match that of the standard chip adopted by the General Services Administration for this color. It was, therefore, proposed that a distinction should be made between paints that are within the basic definitions and those which may be properly called U.S. aviation marking orange. When large quantities are to be purchased, or paint is needed to complete work already started with U.S. standard aviation orange, only paints meeting the General Services Administration specifications should be acceptable. For small purchases to be used on isolated objects, paint conforming to the international basic limits should be satisfactory and arrangements could be made to allow manufacturers to use a suitable phrase on their cans to indicate that the contents have been tested and found to be within the I.C.A.O. limits; but this paint should not be called aviation surface-marking orange.

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 threshold lights and the approach beacon for the stub approach beacon system on runway 31 have been completed. The approach beacon is located 500 feet from the runway threshold. A tower from the old center-line approach light system was used for mounting. The threshold lights are so wired that either the new system or the standard configuration can be used with the approach beacon. The control lines of the old slope-line system were used for this purpose.

The CAA INSAC station has reported another instance in which an aircraft was unable to locate the runway by means of the high intensity runway lights and the slope-line approach light system but located it easily when the approach beacons were turned on.

Runway Distance Markers. In order to obtain a quantitative measure of the legibility distance of runway distance markers and the effects of changing the illumination on the markers, two temporary marks have been installed. These marks were constructed in accordance with the proposed design: a 48-by 48-inch mark with a 33-inch numeral; the background is aviation orange; the numeral is white outlined with a black strip. A 75-watt, PAR 38 floodlight is used to illuminate each side of the mark. The voltage applied to the lamps is adjustable and independent of the brightness setting of the runway lights. The marks are located 20 feet outboard of the runway lights. In clear weather a legibility distance of from 1100 to 1200 feet was obtained for both a stationary observer and one traveling at 40 miles per hour. When the runway lights were on step 1 (0.2% intensity) the maximum legibility distance was obtained with the lamps illuminating the distance marker operating at about 15% intensity. When the runway lights were on step 3 (5% intensity), an intensity of 40% was optimum for the marker lights. Observations are being continued. Performance data under foggy conditions will be obtained.

Airfield Lighting Maintenance Manual. The Section of the Maintenance Manual covering Troubleshooting of Series Circuits has been completed. The editing of the Step-by-Step Troubleshooting Procedure, the troubleshooting charts which outline the procedure in chart form, and the text accompanying these, has been completed and the material is being prepared for reproduction. It is expected that this material

will be released next quarter. The General Troubleshooting Section is being reorganized and redrafted and is expected to be completed next quarter.

b. Electrical Engineering.

Survey Trip. Plans have been completed for a survey of airfield lighting installations and maintenance practices at Naval and Marine Corps Air Stations on the West Coast. A survey questionnaire, which will be used as a guide in conducting interviews and analyzing the data, has been completed and edited. As requested, the scope of the survey has been expanded to include interviews with pilots and operational personnel.

Cable Connectors. During the installation of the threshold lights for the stub approach beacon system it was observed that there was insufficient spring loading in the sockets of the connectors used. In some of the sockets the fit was so loose that the pins would fall out of the sockets when inverted. It is recommended that the specifications be revised to require a method of spring loading which will not be affected by the molding procedure and to include a requirement for minimum separating force between pins of minimum size and the socket. The present specification requirements of millivolt drop across the connector and pull-out force are so affected by the fit between the body of the connector and the insulation of the mating cable that insufficient spring loading of the socket may be concealed. (See National Bureau of Standards Letter Report of June 26, 1956.)

Cable Fault Finding. In using the TSM-11 test set for tracing cables or for locating faults, a knowledge of the depth of the cable is frequently desirable, particularly when there is a change in signal strength which may be caused by a high-resistance fault or a change in the depth of the cable.

The following method has been used satisfactorily to determine the approximate depth of the cable. With the magnetic-field detecting element touching the ground and oriented for maximum signal, the indicator gain is adjusted to obtain a convenient meter reading, generally full scale. Then without changing its orientation, the magnetic field detecting element is lifted until the meter reading drops to one-half its former value. Since the field surrounding a long straight conductor is inversely proportional to the distance from the conductor, the depth of the cable is approximately equal to the distance between the field detecting element and the ground.

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. During this quarter the sensitivity of the phototube of the sky brightness meter dropped to a very low value with no apparent cause. The phototube was replaced.

Slant Visibility Meter. Lamp life in this unit is still unsatisfactory. The average lamp life is about 40 hours. Despite many checks the cause of the short lamp life has not been found. The investigation is being continued.

100% Setting Calibrator. A number of field checks of the 100% Setting Calibrator for the transmissometer have been made. These tests indicate that when sufficient attention is paid to the alignment of the instrument and the transmission of the light path is uniform over the transmissometer range, the accuracy of the setting is comparable with that obtained under the best of conditions by the extrapolation method, about 1% error. It has been found that on calm nights the small amounts of dust raised in driving from the projector site to the receiver site or smoke from a car exhaust or from cigarettes will disturb the uniformity of the transmission over the transmissometer light path and produce significant errors for many minutes. A report describing the circuitry of this instrument and giving the procedures for calibration, installation, and use is being prepared.

Effective Intensities of Flashing Lights. The data obtained during the tests of the effective intensity of a "strobeacon" and an approach beacon have been reduced and the effective intensities* of these lights, corrected for the size of the lights, have been obtained. At night the effective intensity of the "strobeacon" varies from about 4000 candles when the visual range of the light is 900 feet to about 8500 candles

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*The effective intensity of a flashing light is the intensity required of a steady burning light which is a point source to produce the same visual range.

when the visual range is 5500 feet. Similarly, under daylight conditions the effective intensity varies from about 6000 candles when the visual range of the light is 700 feet to 15,000 candles when the visual range is 5800 feet. At night the effective intensity of the approach beacon operating at 12 rpm and using 300 PAR 56/SP lamps varies from 7000 candles when the visual range of the light is 900 feet to 13,000 candles when the visual range is 5500 feet. In daylight the effective intensity is 10,000 candles when the visual range is 1000 feet and 16,000 candles when the visual range is 5800 feet. The variation in intensity with visual range is not caused by a change in the Blondel-Rey relation but is caused by the variation in angular size of the light. Under conditions of low visual range, few lights can be considered as point sources. If the effective intensity is based upon the intensity of a steady burning light of the same size as the flashing light, the effective intensities obtained for the test units for all visual ranges will be slightly greater than those obtained at the maximum visual ranges used.

d. Facilities.

During the quarter considerable attention has been given to the maintenance of equipment and installtions using the services of the Humboldt County Department of Aviation as much as possible. All transmissometer and other towers have been cleaned and painted. Access roads have been smoothed. Fences have been built around the distribution transformers in the field. Temporary transmissometer signal lines which had been laid on the ground have been replaced with a buried multiconductor cable salvaged from LAES installations. A tower for the approach beacon of the stub beacon system and a baffle for the projector of transmissometer T-A have been erected.

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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