NATIONAL BUREAU OF STANDARDS REPORT

7104

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period October 1 to December 31, 1960

By
Photometry and Colorimetry Section
Metrology Division

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers. These 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 periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

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 ($1.50), available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

NATIONAL BUREAU OF STANDARDS REPORT

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Development, Testing, and Evaluation of
Visual Landing Aids

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

and to
Federal Aviation Agency
Washington 25, D. C.

For the Period
October 1 to December 31, 1960

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids
October 1 to December 31, 1960

I. REPORTS ISSUED

Report No.	Title
7027	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period July 1 to September 30, 1960
7046	Static Tests of Model L-809 (Modified) Airport Marker Light Base and Multi-Electric Class BB Light
21P-45/60	Photometric Measurements of a 600-Watt, 28-Volt, Type 4559, PAR-64 Airplane Landing Lamp
21P-46/60	Photometric Measurements of Four 500-Watt, PAR-64 General-Service Lamps
21P-47/60	Physical and Electrical Tests of Five Tee Receptacle Connectors for Airfield Lighting Cable

II. VISIBILITY METERS AND THEIR APPLICATION

Shipboard Visibility Meter. Construction of a feasibility model of the shipboard visibility instrument is now nearly complete except for the electronic recording circuitry.

Slant Visibility Meter. The installation of the slant visibility meter equipment at the new site was completed. The projector and receiver are installed on a baseline of 250 feet and the transmissometer on a 500-foot baseline. This transmissometer also serves to measure transmission for one site of Operation Pea Soup of the Air Force. Near the intersection of the beam of the projector and the line of site of the receiver a telescoping tower has been installed. This tower may be extended to a height of 110 feet and carries three threshold lamps and three 3-foot-square black targets for use in making slant visibility observations at night or in daylight. This tower is lowered when it is not being used for observations, to avoid its being an obstruction to aircraft. An observation range from this tower has been measured and marked providing a maximum range of 3700 feet. The indicator-recorder for the slant visibility meter is located in an instrument shelter near the receiver and the transmissometer indicator and recorder are located at the site in a walk-in type instrument shelter belonging to the Air Force. Since completion of the installation, observations of slant visibility have been obtained on only one occasion because the fog season ended early. On this occasion the difference in visual range of the lights at the different heights was easily observed.

Transmissometer.

Expanded-Scale Indicator. Calbration curves were run on the two NBS transmissometer indicators which were modified to the expanded-scale type last spring. One of these indicators had been in continuous operation since modification and the other had been unused. No measurable drifts in calibration were observed. At the request of the Aviation Weather Project, Atlantic City, the calibration of their modified indicator was checked to determine if the discrepancies in transmission indications between the modified and an unmodified indicator were caused by calibration drift of the modified indicator. No drift in calibration of the modified indicator was observed.

The Effect of High Intensity Airfield Lighting on Background Luminance and Horizontal Illumination. Review of the preliminary draft of the report on the effect of high intensity airfield lighting on background luminance indicated that the obtaining of additional data was justified. Additional data have been obtained on several occasions from a position 50 feet from each side of the runway threshold. The effect of the high intensity edge-marker runway lights and of the centerrow approach lights in the direction of landing and toward the approach was measured. Additional data are needed for visibilities between one-fourth mile and three miles. The data should be obtained during the next quarter.

III. DEVELOPMENT OF AIRFIELD LIGHTING AND MARKING COMPONENTS

Airfield Lighting Maintenance Manual. Work on Section II, "Preventive Maintenance and Repair," has been resumed. A list of items which are presently standard equipment or which, though obsolescent may still be in use at some stations, and of available technical information has been prepared. This list will be used primarily in the preparation of Section I on theory and description of airfield lighting. It also served as a basis for the preparation of Section II. An outline for Section II has been prepared and part of the preliminary draft has been completed. The draft of Section II should be completed during the next quarter.

Temperature Rise of Prismatic Head Lights. Parts have been received to expand the scale of the Brown Recording Potentiometer to 800°F. A new Jefferson transformer (6.6-amp. to 20-amp, 500-watt), and a new lamp were placed in the base for the second test. Thermocouples were placed in the same positions as for the first test.

The transformer was placed upright in the base. All wires were pressed to the bottom of the tank as far as possible except for the lead to the lamp terminals. Two pieces of "Alcoa Wrap Aluminum Foil" approximately 12" square were placed between the transformer and lamp assembly. Rated power was applied to the lamp for 72 hours and then turned off. There was some bulging and sagging of the transformer case and one seam at the bottom opened slightly but not enough for the compound to run out. Comparison of temperature ranges of the two transformers has not been completed but it appears that the aluminum foil helps considerably. A third test is in progress without the foil but with the transformer on its side.

It was noticed that a black, oily substance appeared around the glass prism on the outside of the fixture after the first test. This may have come from the paint or the prism-mounting compound. No additional indication of this material was noticed after the second test.

"Wheels-Up" Warning Lights. The "Wheels-Up" warning system consists of a bank of lights located 1000 feet downwind of the threshold which are used at night to illuminate the underside of the aircraft and lights at three stations located at 500-foot intervals on each side of the runway which are flashed by day and by night to indicate a wheels-up condition. Type 500 PAR64 MFL and type 500 PAR64 NSP lamps appear to be the most suitable for the flood and the flashing lights respectively. Field tests at the Naval Air Test Center indicated that obtaining adequate conspicuity of the flashing lights would be a problem. Therefore, use of three lamps at each position along the runway was recommended. Consideration was also given to operating these lamps at overvoltage. It was found that the life of these lamps exceeded 100 hours when the lamps were flashed on a duty cycle of 50% on - 50% off with an applied voltage of 180 volts. At this voltage the effective intensity is 90% of the intensity of the lamps burned steadily at rated voltage. Intensity distribution measurements were made of both type lamps. The results of this study are reported in NBS Test Report 21P-46/60.

Output Maintenance of Sealed-Reflector Approach and Runway Light Lamps. A comprehensive study of the output maintenance characteristics of sealed-reflector approach and runway lamps is in progress. Lamps with 6.6- and 20-ampere filaments are being burned in both vertical and horizontal positions. Measurements of the relative output are being made periodically both of the complete lamps and of selected zones of the lamps. Photometric tests have been completed on the 20-ampere lamps burned horizontally and vertically and evaluation of the data has been started.

Static Tests of a Type MS24526 Airport Marker Light Base and a Class BB Light. Data were needed to determine whether the airport marker light base is structurally adequate for use with runway marker lights when installed in a runway. Also, data were needed on the load deflection relations of aircraft tires on the class BB runway light and on the behavior of the light base assembled with this light or a cover plate. Static load tests were made on an assembled light and light base with 20x4.4 and 32x8.8 tires. Tests were made on light bases assembled with cast iron or with steel cover plates, applying the loads through the aircraft tires or through a steel strut.

An examination of the components after the tests revealed no visible damage. However, strain measurements on the base after loading with the 32x8.8 tire indicated a small amount of inelastic action. Strains measured on the base loaded with the 20x4.4 tire did not exceed 340×10^{-6} and indicated no permanent set. A base covered with a steel plate was subjected to load in 20,000 pound increments through the 5-1/4 inch diameter steel strut to 200,000 pounds. During the loading of this base assembly, the flange of the base yielded until it became conical in shape. Further increase in the load caused the steel plate to yield and become hemispherical in shape. Details of this study are given in NBS Report 7046.

IV. DEVELOPMENT OF SEADROME LIGHTING COMPONENTS

Static Inverters for Battery Operated Lights. Four transistorized inverters manufactured by Walter Kidde, Inc. which provide power for operating 6-watt fluorescent lamps from 12-volt batteries have been obtained from NAEF(SI) for study. A comparison is being made of the performance of the static inverter and a mechanical vibrator.

Photoelectric Switch for Seadrome Lights. After tests on the static inverters had been completed, one of the inverters and the previously assembled photoelectric control were packaged into a working model of a seadrome light. The completed model, consisting of the photoelectric control, the inverter and the lamp, is packaged into a methymethacrylate cylinder twenty-one inches long and four and one-half inches in diameter. Because of the relatively slow starting time of fluorescent lamps, it is difficult to tell immediately that the light has been switched on. To give the operator a more immediate indication a small neon lamp was placed on top of the unit. This lamp is wired in parallel with the fluorescent lamp and lights immediately after switching and stays on until the fluorescent tube lights. The completed assembly is available for demonstration purposes.

V. DEVELOPMENT OF CARRIER-LIGHTING AIDS. (TED NBS RSSH-32001)

Consideration has been given to the effects of the compensation of carrier visual glide path systems for the true heave of the carrier. If there is complete compensation for true heave, then the point of intersection of the indicated glide slope and the carrier deck will be displaced by a distance equal to $h/\tan\theta$ where h is the heave and θ is the indicated glide slope. This displacement will at times be unacceptably large. However, if there is no compensation for true heave and if the pilot can follow the vertical movement of the glide path, which is caused by true heave only, there will be no displacement of the touchdown point. Hence compensation for true heave appears to be undesirable.

Technical assistance has been provided at conferences of contractors and Bureau of Weapons personnel.

VI. PHOTOMETRIC AND ELECTRICAL TESTS OF AIRFIELD AND SEADROME LIGHTING COMPONENTS. (TED NBS SI-5003)

Tests of Airfield Lighting Connectors.

Field Tests. Measurements were made on these connectors before any winter rains occurred and no noticeable changes have taken place since the last measurement.

Tee Receptacle Connectors. Tests have been completed of five tee receptacle connectors manufactured by the Clark Cable Corporation and a report giving the results of the tests has been issued (NBS Test Report 21P-47/60). The connectors failed to meet the requirements of several of the paragraphs of Specification MIL-C-7192B (Aer) including those covering dimensions, insulation resistance, millivolt drop, and separating force.

VII. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Test of Light Developed by Fog-Master Corporation. At the request of the Bureau of Ships, the peak intensity-voltage characteristic of the 600-watt, 28-volt, type 4559, PAR-64 airplane landing lamp manufactured by the Westinghouse Electric Corporation has been obtained. The lamp was used in the field tests of the Fog-Master light which were conducted at the NBS Visual Aids Field Laboratory, Arcata, California. At 28 volts input the peak intensity of the lamp was about 500 kilocandles. Details of this test are reported in NBS Test Report 21P-45/60.

Intensity Distribution of PAR-38 Lamps. Intensity distribution data were obtained for a group of PAR-38 lamps. The group contained lamps of various wattages, voltages, and beam patterns. These distributions were taken for information only and will be kept on file to be used when required.

Methods of Altitude Measurement. An analysis was made of a proposed system of determination of the altitude of landing aircraft by a member of the crew by triangulation with beams from lights mounted on the aircraft. While theoretically possible, the method appears to be of little practical value.

VIII. MISCELLANEOUS

Air Force Operation Pea Soup. The personnel for the project left Arcata for the season about December 1 and expect to have some members return about April 1. Some discussions on how to interpret and use the transmissometer data for evaluation of results were participated in by our group. Cooperation with this group has been very good throughout the past fog season with a minimum of our time involved.

Summary of NBS Reports on Visual Landing Aids. Work was begun on a bibliography of the NBS reports prepared by the Ground Lighting group during the past ten years. Test reports are not being included. A summary of each report is being prepared for inclusion in the bibliography.

Visual Aids Panel. Mr. Douglas attended, as the representative of the C.I.E., the First Meeting of the Visual Aids Panel of the International Civil Aviation Organization, held in Montreal November 16 to December 6, 1960. A brief summary of this meeting is given in Appendix A.

Personnel. Mr. Andrew C. Wall, Physicist, reported for duty on November 28, 1960.

NBS Report #7104
March 1961

US COMM NBS DC

First Meeting of Visual Aids Panel (VAP) of International Civil Aviation Organization (ICAO)

The Visual Aids Panel met at I.C.A.O. Headquarters, Montreal, Canada, from 16 November to 6 December 1960 to consider the question of visual aids to assist in the solution of the undershoot and overshoot problem of the landing of aircraft and to exchange views on complete lighting and marking systems for aerodromes. The meeting was attended by delegates from seven countries and three international organizations. The C.I.E. was represented by Mr. C. A. Douglas (United States) attending as Liaison Officer between C.I.E. and I.C.A.O. and as a member of Committee E 3.3.2.1 (Aviation Ground Lighting). Two other members of E 3.3.2.1 attended, Mr. A. N. Baldino, as the delegate from France and Mr. J. B. deBoer, as a member of the delegation from the Netherlands.

The Panel spent approximately two weeks on problems concerning visual glide slope indicators. A statement of ten operational requirements was drafted. The several visual glide slope indicators which have been developed were then evaluated, using these operational requirements as a guide. Following the evaluation the Panel recommended as a matter of urgency the adoption of the two-color visual glide indicators developed by the Royal Aircraft Establishment and recommended that urgent steps be taken to foster the installation of these indicators.

The Panel then developed specifications and guidance material for the installation of these indicators.

The Panel also recognized that there were other promising systems under development, and because of the possible advantages of symbolic representation, recommended further development and evaluation of systems such as the Australian "T-Bar" system as soon as possible.

The Panel then turned its attention to complete airfield lighting and marking systems. In view of the development toward automatic approach and landing it was suggested that efforts should be concentrated on runway lighting and the inner part of the approach lighting system rather than on costly and extensive modifications to the outer portion of existing approach light systems. It was suggested that the C.I.E. could assist the Panel on the matter of determining the optimum intensity distribution of approach lights, and that, since nowhere in the present guidance material was there any statement of the desirable intensity distributions for approach light systems installed on the approaches to non-instrument runways, the C.I.E. could assist the Panel on this matter also. The Panel unanimously agreed that both controlled evaluations and operational experience to date indicate that narrow gauge lighting in the touchdown zone is a desirable visual aid for landings under conditions of restricted visibility, that centerline lighting extending the full length of the runway provides a valuable aid for takeoff and a valuable addition to the narrow gauge system for landing and rollout under conditions of low visibility, and that every effort should be made to obtain standardization of the principal details of touchdown zone lighting as soon as possible.

There was an exchange of views on the means of testing specific configurations and on the methods of evaluating test results. As an introduction to this agenda item, Mr. deBoer reported on the evaluations conducted in the Netherlands on three complete systems of approach and runway lighting. Details of the equipment used, including the "Stabilized Screen" for restricting runway visual range to any predetermined value, the configurations of the systems as seen on the Netherlands simulator, and views of the full-scale tests were presented on slides and in a color film. Methods of obtaining objective data and criteria for use in evaluating the quality of an approach and landing as the various lighting systems were used for guidance were presented by Mr. deBoer and were discussed at length by the Panel. It was generally agreed that the Netherlands' objective tests were a significant forward step and that tests of this type should be encouraged.

It was generally agreed that simulated tests constituted only a preliminary step in the whole process of evaluation of visual aids. Relatively simple and inexpensive simulators had proved satisfactory for the earlier evaluations conducted on approach lighting configurations but the stage had now been reached when far more complex and costly simulators were required for evaluating runway lighting systems where such factors as aircraft characteristics assumed a greater measure of importance.

It was generally agreed that controlled tests and evaluation could be used only up to a certain stage in the development of an aid and there came the time when ultimate proof in determining its merits and defects could be obtained only by operational evaluation.

Means of improving the coordination of research in the development of visual aids were considered. It was generally agreed that in establishing a need for improving existing aids a full exchange of ideas was most desirable and that there was a real necessity to seek international agreement when a conclusive stage of testing and evaluation had been reached. The importance of providing information on negative as well as promising results was stressed. Information and suggestions should be circulated at the earliest possible stage and time should not be lost in waiting for the completion of formal reports. Basic research should be conducted freely, as now, and not be influenced by attempts to reach agreement in the preliminary stages. However, the Panel should take an active part in attempting to identify problem areas. More emphasis should be placed on fundamental studies by joint efforts of scientists and operations specialists. It was generally agreed that I.C.A.O. and, in particular, the Visual Aids Panel should continue to isolate specialized problems which could be well defined and transmitted to scientific organizations. For example, in the field of lighting, such problems could be transmitted to the C.I.E.

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., 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 publications, appears on the inside of the front cover.

WASHINGTON, D.C.

ELECTRICITY. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

METROLOGY. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

RADIATION PHYSICS. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

CHEMISTRY. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

MECHANICS. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Combustion Controls.

ORGANIC AND FIBROUS MATERIALS. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

METALLURGY. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

MINERAL PRODUCTS. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

BUILDING RESEARCH. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

APPLIED MATHEMATICS. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

DATA PROCESSING SYSTEMS. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

ATOMIC PHYSICS. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics.

INSTRUMENTATION. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

IONOSPHERE RESEARCH AND PROPAGATION. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

RADIO PROPAGATION ENGINEERING. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

RADIO STANDARDS. High frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

RADIO SYSTEMS. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

UPPER ATMOSPHERE AND SPACE PHYSICS. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

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