NATIONAL BUREAU OF STANDARDS REPORT

8059

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period April 1 to June 30, 1963

By
Photometry and Colorimetry Section
Metrology Division

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE 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
Federal Aviation Agency
Washington 25, D. C.

For the Period
April 1 to June 30, 1963

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

Development, Testing, and Evaluation of Visual Landing Aids
April 1 to June 30, 1963

I. REPORTS ISSUED

Report No.	Title
8003	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period January 1 to March 31, 1963
8019	Horizon-Sky Brightnesses Produced by Airfield Lighting
21P-33/63	Electrical and Photometric Tests of Twelve Type S-471 Flashtubes Manufactured by Kemlite Laboratories
21P-48/63	Photometric Tests of a Metal "Blinder" for a Type CD-100 Condenser-Discharge Approach Light
Letter Report	Relation of the Visual Range of Airfield Lights to the Visibility Reported by the Weather Observer.
Letter Report	Review of Transmissometer Technical Manuals NAVWEPS 50-30GMQ10-2, -3, and -4.

II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter. Work on the reduction of data from the slant visibility meter and on analysis of these results has continued. For most of the periods during the 1962 fog season when visual observations were made, scans which appeared to be representative of the atmospheric conditions or of changes in conditions were selected at frequent intervals for detailed analysis. For these selected scans, the recorder readings corresponding to the height above the horizontal at the point of the projector beam viewed by the receiver were tabulated at 20- or 50-foot intervals. These readings were converted to the equivalent signal voltage input to the receiver to correct for variations in sensitivity of the receiver and recorder and in intensity of the projector. These data have been plotted with the logarithm of the equivalent input signal in microvolts against the height in feet of the spot of the beam being viewed.

A study of the plots indicates how the signal strength varies with height of the spot within a given scan and how changes in conditions as a function of time during a test period affect the signal strength.

By comparing the plots from different test periods, conditions which provide similar signal strengths or interesting differences can be determined. To aid in evaluating the data and plots, the horizontal transmissions for the time of the scan and the corresponding attenuation constants have been tabulated.

These plots indicate that fogs at Arcata may consist of several layers within the first 433 feet above ground level. The input signal strength may remain constant within a given layer but usually it tends to increase or decrease in some manner. For conditions not obviously nonuniform horizontally, the logarithm of the input signal changes approximately in proportion to changes in height within a layer. This proportionality indicates that within a given layer the attenuation constant varies as $1 + a h^n$ where $\underline{a}$ is a constant, $\underline{h}$ is the height, and $\underline{n}$ is a numerical exponent. Values of $\underline{n}$ were determined for a few scans. They varied from 0.95 to 1.05, which indicates that $\underline{n}$ may be considered as unity. This analysis will continue during the next quarter.

Shipboard Visibility Meter. Instruments for testing and demonstrating the suitability of a number of methods of displaying the output signal of the shipboard visibility meter have been assembled and are now being tried. The methods and some of the advantages and disadvantages of each, as determined to date, are as follows.

1. Direct presentation on a calibrated oscilloscope of the pulse generated by the photomultiplier in response to the light from the flashtube.

> This method is the most direct and requires the least instrumentation. It is also the least affected by the noise generated by light from the sky background during daylight. Operation of the flashtube for only a few flashes is sufficient for a measurement. This would be advantageous during night operation of a carrier. The primary disadvantage of this method is the requirement for an operator to obtain and report the measurement. A secondary disadvantage is the need for using more than one sensitivity on the oscilloscope in order to cover the desired range of visibilities. This latter deficiency may be overcome by the use of an oscilloscope in which the signal deflection is proportional to the logarithm of the input signal instead of being directly proportional to the signal. However, this change reduces the signal-to-noise ratio and makes more difficult the measurement of the low signals obtained in clearer weather.

2. Presentation on an oscilloscope of a pulse, the duration of which is proportional to the logarithm of the amplitude of the pulse generated by the photomultiplier.

> This method is very similar to method 1. The effects of noise on the readability of the signal are reduced and the accuracy is increased.

3. Continuous recording of a current proportional to pulse signal.

A continuous record is, of course, desirable. However, obtaining the record requires that the light be operated continuously. This may be undesirable during night operations. This method requires rather elaborate instrumentation. The amplitude of the peak of the pulse signal may be only one ten-thousandth of the amplitude of the signal from daylight, and the energy in a pulse signal may be only one hundred-millionth of the energy in the signal received from daylight between two signal pulses. Thus, very careful gating is required in order that the desired signal will not be masked by the signal from daylight. (This has been the primary problem in the development. It appears that a satisfactory solution has been obtained.) Range changing would be required.

4. Continuous recording of an output proportional to the logarithm of the pulse signal.

This method is similar to method 3 except that there would be a better scale relating visibility to the output of the visibility meter and no range changing would be required.

5. Continuous recording of an output proportional to the ratio of the signal received from the back scatter from the atmosphere to the signal received directly from the flashtube.

The accuracy obtained using methods 1 through 4 is dependent upon the stability of the output of the flashtube and of the voltage applied to it and upon the stability of the sensitivity of the photomultiplier which is dependent upon the background light, the temperature, and is very dependent upon the applied voltage. Consequently long term stability of the system can not be expected. Instead, frequent adjustments based upon readings obtained directly from the flashtube will be required. The need for adjustments is eliminated with method 5, but the complexity of the instrument is increased.

6. Continuous recording of an output proportional to the difference between the logarithm of the signal produced by the back scatter and the logarithm of the signal produced by direct light from the flashtube.

This method has the same advantages over method 5 as does method 4 over method 3. In addition, the circuitry required for method 6 would be somewhat simpler than that required for method 5.

It should be noted that it would be possible to use a combination system combining method 1 or 2 with one of the other methods. This would permit continuous recording whenever the flashing would not be objectionable and spot readings requiring only two or three flashes during critical times.

A demonstration and a conference to discuss the problem and future work is planned for the following quarter.

Transmissometer.

Review of Transmissometer Manuals. Copies of Technical Manuals for Tranmissometer Sets AN/GMQ-10B and AN/GMQ-10C on which corrections and suggested editorial changes had been marked have been forwarded to the Meteorological Management Division for consideration. The review of the Manual and the problems encountered therein have been discussed with personnel of the Air Force Cambridge Research Laboratories.

Effect of Airfield Lights on Brightness. The report on this task has been issued as NBS report number 8109, "Horizon-Sky Brightnesses Produced by Airfield Lighting." This completes work on this task.

Visual Range of Airfield Lights. A letter report has been prepared listing representative intensities of airfield lights. Curves relating visual range to intensity for both night and day and meteorological visibilities of 1/4, 1/2, 1, 1-1/2, and 2 miles are included.

III. AIRFIELD LIGHTING AND MARKING

Stub Approach Beacon System. The lamps on the stub approach beacon for runway 13 were changed from six 300-watt lamps to five 500-watt type 20A/PAR56Q/3 (stippled cover) lamps. This change reduces the flash rate from 72 to 60 flashes per minute and increases the effective intensity. Because of the higher effective intensity, this beacon is no longer operated continuously but is operated only when it is to be observed for comment. (Remote control to the tower would be very helpful. However, control lines are unavailable.) The beacon with the new lamps can be seen easily in daytime at distances of five to six miles, but it is not conspicuous until the distance is reduced to about four miles. The beacon appears to have an effective intensity nearly equal to that of the red lights from the visual approach slope indicator (VASI) installation, but the VASI installation is more conspicuous than the stub beacon.

Another type of 500-watt lamp, a type 20A/PAR56Q/1 (prismatic cover) lamp, has been obtained recently and will be tried in this beacon also. Further observations and comments will be obtained. Note: The peak effective intensity of the 500-watt stippled cover lamp at 12 rpm is approximately 100,000 candles and the peak intensity of the 500-watt prismatic-cover lamp at 12 rpm is approximately 30,000 candles. The peak effective intensity of the red sector of a unit of the VASI system is about 30,000 candles when the unit is observed from a distance of several miles. However, there are 12 units in the VASI system. Although the intensities of the several units are not additive, conspicuity is increased by the number of units. The red color also increases the conspicuity.

Blinder for Type CD-100 Condenser-Discharge Approach Light. Photometric tests were made of a Type CD-100 condenser-discharge approach light with a metal blinder attached. The blinder was a metal scoop-shaped device supplied by the FAA. It was intended to cut off the lower part of the beam and thereby eliminate to some extent the cause of complaints of property owners near the approach zones of airports. The blinder was "set" (an arbitrary angle designation was used) at 8.5° above the horizontal and the reflector was then adjusted by increments. The blinder cut the peak intensities of the light unit; the four intensity distributions included with the report issued (NBS Test Report 21P-48/63) show 63%, 74%, 83.5%, and 85% peaks with the blinder when compared to the peaks without the blinder. The blinder cut off all light from the light below a chosen angle. However, it did not produce a sharp cutoff of the lower edge of the beam. Thus, if the cutoff was set at the horizontal, the intensity at 3° elevation was only 400 candles and at 5° elevation the intensity was 4000 candles. The results of the test were reported in NBS Test Report 21P-48/63.

Photometric Tests of Flashtubes. Six flashtubes (type S-471) were submitted by Kemlite Laboratories, Chicago, Illinois, for evaluation, having been selected from a production run by a GSA inspector. They were individually seasoned for 6 to 8 hours, during which times two flashtubes failed. Six additional lamps were requested and received. These lamps were seasoned and the luminous output of the 10 lamps was determined. The test showed a 10% increase over the output obtained when six similar lamps were tested and reported on in 1959. After a 500-hour field test the flashtubes will be retested.

Runway Identification Lights. The two synchronized runway identification lights are being prepared for installation on an outdoor range at NBS for visual observations.

Effective Intensity of Lights Using Rotating PAR-56 Lamps. Calculations have been made of vertical effective intensity distributions at various turntable speeds of type 20A/PAR56Q/1 (500-watt, prismatic cover) and type 20A/PAR56Q/3 (500-watt, stippled cover) lamps. The instantaneous intensity data were obtained from NBS Test 21P-44/62. Lamps A3 and B4 of that test were chosen as most representative of their respective groups. Calculations were made at turntable speeds of 2, 10, 20, and 40 rpm for several selected vertical angles. Vertical effective intensity distributions were drawn from the data so obtained.

It was found that with both lamp types for most engineering purposes the ratio of the effective intensity at any vertical angle to the steady-burning intensity at that angle can be considered to be determined by the turntable speed only and is not dependent upon the elevation of the line of sight. Hence the effective intensity at any vertical angle can be obtained by multiplying the steady-burning intensity at that vertical angle by a factor appropriate to the turntable speed.

Effective Intensity of Flashing PAR399 Lamps. The study of the intensity-time curves of the flashing PAR399 lamps which were reported last quarter is continuing.

Intensity Maintenance of 500-Watt, PAR-56 Quartzline Lamps. Both the prismatic and stippled-cover lamps have been burned for 600 hours. Of the three remaining stippled-cover lamps, the intact lamp has a peak intensity approximately 30% of its initial peak. The lamp with the apparently shorted turns has a peak intensity approximately 25% of its initial peak, and the lamp with the shattered quartz envelope has a peak intensity of approximately 13% of its initial peak.

Photometric measurements of the prismatic lamps have not yet been made after the 600-hour burning period.

Airfield Lighting Cable Connectors Field Test. A draft for this report has been completed and is being reviewed and edited. Several specimens of three types of cable connectors and splices have been directly buried in the ground for up to 50 months, and current leakage tests were made periodically. These units were then uncovered and inspected for signs of damage or deterioration. During this test period, the insulation resistance of each of the connectors and splices had remained well above the values required in Specification MIL-C-7192. Of the three types of connections, the vulcanized splices had the greatest insulation resistance, the connector kits were next, and the epoxy splices were lowest. However, the differences in value may not be of major importance. The insulation resistance of the connector kits and the included sections of cables at the end of this period was approximately one-half the original values of the newly prepared connectors. The deterioration of the insulation of the cable itself may account for part, or all, of this decrease. The inspection of the connections did not show any definite indication of damage or deterioration except at the taped end of some of the cables. These test units have been reburied and the measurements will continue.

IV. SEADROME LIGHTING

FMF-6 Seadrome Light. Information received to date indicates that a battery pack can be designed which will fit into the present battery container and which will deliver approximately 350 ampere-hours at 6 volts or 180 ampere-hours at 12 volts. On a duty cycle of 8 hours daily, either of these packs will give approximately 30 days of operation as compared to 18 days for the present 90-volt pack. It is estimated that the pack will weigh about 50 pounds.

Portable Spot-Pad Lights. Seven portable spot-pad lights were designed, constructed, and forwarded to the Air Officer, USS Iwo Jima, for shipboard evaluation. These units are intended to be placed on the deck to mark the landing spot for helicopters.

The design requirements stated by the Bureau of Naval Weapons were:

1. Maximum diameter: 10 inches
2. Maximum height: 3 inches
3. Maximum weight: 10 pounds
4. The light must be capable of withstanding a direct hit by the landing wheel of a helicopter.
5. The light must be capable of being handled and carried easily by deck personnel.
6. The intensity of the lights should approximate that of a flashlight.
7. Six lights were requested, four with a 360° horizontal beam spread and two with a narrow horizontal beam spread.

Six feasibility models were constructed to meet the requirements. They were 2-5/8 inches high including the rubber skid-resistant pad and 10 inches in diameter with a handle extending approximately 1-1/8 inches from the side. The weight of a complete unit was approximately 8-3/4 pounds.

Accompanying each unit was a box of parts, including a spare lamp, a spare sponge rubber light shield, a 10-32 thumb screw with ring attached for ease in removal of the bottom plate, and a red, a yellow, and a green filter.

Included in the shipment was a seventh unit for use as a spare. It was an intermediate developmental design.

V. CARRIER LANDING AIDS

A meeting of the Night Carrier Lighting Working Group of the Vision Committee was attended. The work of the three contractors studying the problems of night carrier lighting under contract to the Office of Naval Research was reviewed.

The NBS laboratories were visited by personnel of the Naval Air Test Center to discuss development of carrier visual landing aids. Subsequent to the conference, the Fresnel lens assembly and associated hardware which had been used at NBS in tests of High-Low cells were shipped to NATC.

Doane Night Vision Floodlights. A photometric study of Doane Night Vision Floodlights, models 325-A, 326-A, 328-A, and 329-A was undertaken. Models 325-A and 328-A have 14-inch, double-visor hoods; models 326-A and 329-A have 24-inch, double-visor hoods. Models 325-A and 326-A are one- lamp units using a type 200 PAR46/6.6 (200-watt, 6.6-ampere) lamp; models 328-A and 329-A are two-lamp units using two type 6.6/PAR56/4 (250-watt, 6.6-ampere) lamps. Each model was tested with both a corrugated, polished aluminum reflector and a spread lens window and with a specular aluminum reflector and clear window. The units with 14-inch hoods are adjusted for peak intensity at -4.5° vertical, and the units with 24-inch hoods at -3.0° vertical. The beam characteristics of each unit are summarized in table 1. A report is now being drafted.

Table 1. Beam Characteristics of Several Doane Night Vision Floodlights

Unit	Vertical Peak Adjusted For: (Degrees)	Horizontal Peak Intensity (Kilocandles)			"Average" Horizontal Peak Intensity[1] (Kilocandles)	Beam Width At 50% of Peak (Degrees)		Beam Width At 10% of Peak (Degrees)	
		Peak	Dip	Peak		Horizontal[2]	Vertical[3,4]	Horizontal[2]	Vertical[3,4]
Type 325-A, 14" hood									
Corrugated Reflector and Spread Lens Window	-4.5	7.7	5.3	7.4	6.8	44.5	3.8	54.0	6.6
Specular Reflector and Clear Window	-4.5			35.5		6.7	3.1	13.2	6.1
Type 326-A, 24" hood									
Corrugated Reflector and Spread Lens Window	-3.0	7.9	5.4	7.9	7.1	44.0	3.2	53.5	5.8
Specular Reflector and Clear Window	-3.0			38.0		6.9	2.8	13.3	4.7
Type 328-A, 14" hood									
Corrugated Reflector and Spread Lens Window	-4.5	13.8	12.7	14.0	13.5	43.5	3.9	53.5	7.2
Specular Reflector and Clear Window	-4.5			83.8		7.3	3.4	15.2	7.3
Type 329-A, 24" Hood									
Corrugated Reflector and Spread Lens Window	-3.0	15.2	13.0	14.8	14.3	43.5	3.3	55.0	7.8
Specular Reflector and Clear Window	-3.0			83.0		7.5	3.3	14.2	6.9

1 The average of the two peaks and the dip.

2 Measured at specified fraction of "average" peak intensity for corrugated reflectors.

3 All vertical measurements taken on the vertical traverse through 0.0° horizontal.

4 Measured at specified fraction of "dip" peak intensity for corrugated reflectors.

VI. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Manuals, Specifications, and Drawings.

The Naval Technical Manual NAVWEPS 51-50AAA-1, Visual Landing Aids Design Standards, was reviewed and comments have been forwarded.

The technical sections of the following specifications have been reviewed and comments forwarded.

MIL-L-26202D	Light, Marker, Airport, Approach, Runway and Taxiway, Flush
MIL-R-26627B	Regulator-Control, Airport Lighting. RGU-3/F, RGU-4/F, and RGU-5/F

VII. MISCELLANEOUS

Weather Bureau. A rotating beam ceilometer has been installed in the approach zone to runway 31 at Arcata by the Weather Bureau. The installation is complete except for final alignment and adjustments. This ceilometer should be put into official operation early next quarter.

Fog Chamber at University of California. Instructions for calibrating and installing the remote-indicating sky brightness equipment have been prepared and furnished to the University of California Illumination Laboratory. They are installing this equipment in their fog chamber. They plan to measure the ambient brightnesses in their fog chamber for the daytime tests.

Guide for Operation of Airfield Lights. Assistance was given the AGA Section of ICAO in the preparation of a guide for the operation of airfield lights for inclusion in a Working Paper for the recent RAC/OPS meeting. The desirability of operating high intensity lights during periods of poor visibility by day was emphasized.

FAA Program. A briefing on the FAA program for the development of an improved approach lighting system, held at NAFEC, was attended.

NBS Report 8059
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US COMM NBS DC

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
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THE NATIONAL BUREAU OF STANDARDS

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Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage. Absolute Electrical Measurements.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Volume.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

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

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

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

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Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

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

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING LABORATORY

Cryogenic Processes. Cryogenic Properties of Solids. Cryogenic Technical Services. Properties of Cryogenic Fluids.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Troposphere and Space Telecommunications. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Spectrum Utilization Research. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Standards Physics. Frequency and Time Disseminations. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Microwave Physics.

Radio Standards Engineering. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

Joint Institute for Laboratory Astrophysics-NBS Group (Univ. of Colo.).

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