NATIONAL BUREAU OF STANDARDS REPORT

9904

DEVELOPMENT, TESTING, AND EVALUATION OF VISUAL LANDING AIDS

Consolidated Progress Report

For the Period

April 1 to June 30, 1968

By
Photometry Section
Optics Metrology Branch
Metrology Division
Institute for Basic Standards



U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS

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The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, and the Center for Radiation Research.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement, coordinates that system with the measurement systems of other nations, and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Standard Reference Data and a group of divisions organized by the following areas of science and engineering:

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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NBS PROJECT		NBS REPORT
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DEVELOPMENT, TESTING, AND EVALUATION OF VISUAL LANDING AIDS

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Ship Installations Division
and
Meteorological Division
Naval Air Systems Command
Department of the Navy
and to
Federal Aviation Administration

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Standards and Technology (NIST)
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U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

II. VISIBILITY METERS AND THEIR APPLICATION

Shipboard Visibility Meter.

The instruction manual for the shipboard backscatter visibility meter developed by NBS has been completed and released as NBS Report 9825. The instrument has been shipped to the NBS Visual Landing Aids Laboratory, Arcata, California, for field testing. Details of the field testing will be reported under the heading "Field Tests of Fog Detectors and Visibility Meters" below.

Transmissometers.

A visit was made to the plant of Solid State Radiation, Inc., Los Angeles, California, to assist the FAA Project Engineer in first-article acceptance tests of a transmissometer/RVR system.

Fog Variability Studies.

The report of the "Summary of Low Visibility Conditions at the Arcata Airport" is being revised to include additional data concerning the number of occurrences of runway visual range (RVR) below 1000 feet. The analysis is complicated because these occurrences frequently lasted for only a very few minutes, but often, after a short period of higher RVR, the low RVR conditions re-occurred one or more times. These data were analyzed by treating each period as an individual occurrence and also by considering low RVR periods which are separated by 30 minutes or less as a single occurrence, with the duration of the period extending from the time the RVR first dropped below the limiting value to the end of the last period of low RVR. The data for 1965 and 1966 are summarized below.

Summary of Low Visibility Conditions
Arcata Airport 1965 and 1966

RVR below 1000 feet

Individual Occurrences	Night	Day
Total time (hours)	35.61	87.87
Number of occurrences	118	311
Maximum duration (hours)	2.92	3.10
Mean duration (hours)	0.30	0.28

Combined Periods

Total time (hours)	44.44	113.39
Number of occurrences	65	93
Maximum duration (hours)	5.07	8.32
Mean duration (hours)	0.68	1.22

RVR Below 800 feet

Individual Occurrences	Night	Day
Total time (hours)	0.17	25.90
Number of occurrences	1	102
Maximum duration (hours)	-	1.92
Mean duration (hours)	-	0.25

Combined Periods

Total time (hours)	0.17	32.16
Number of periods	1	49
Maximum duration (hours)	-	2.37
Mean duration (hours)	-	0.70

During this quarter the elapsed time meters recorded 476 hours of instrument flight rules (IFR) conditions and the runway lights were operated at 100 percent intensity for 53 hours.

Field Tests of Fog Detectors and Visibility Meters.

Operation of the previously installed fog detectors and visibility meters has continued except for interruptions by malfunctions of the detectors. There were very few dense fog conditions during this period. Tests will continue during the next quarter when dense fogs and more frequent occurrences of fog are expected.

The Edison Fog Detector.

The Edison fog detector has been operating on field test since August 1967. Previously the major malfunction was the loss of sensitivity of the detector element, which was replaced in December. During this quarter the ultraviolet lamp in the light source became intermittent in operation and was replaced. After the lamp replacement, performance was much improved but the response to a given fog density was less than that obtained in December after replacement of the detector element. This may indicate a decrease in sensitivity of this detector element. Soon after the new lamp was installed the unit was removed from service temporarily but it will be put back into operation for the fog season. The surface of the reflector in the light source is showing considerable deterioration.

The Hoffman VMS-508A Fog Detectors.

The operation of the Hoffman VMS-508A fog detectors had been discontinued at the beginning of the period because of lack of sensitivity. Factory technicians have since repaired both units at Arcata. They found that in both units the gallium-arsenide diode had failed or was emitting poorly. This is the infrared source for the projector. After the emitting diodes were replaced and the amplifier circuits peaked, both units were calibrated and adjusted to work satisfactorily. The units will be reinstalled for field tests during the next quarter.

Both gallium-arsenide diodes failed within two months after the units had been thoroughly checked out at the factory. At least one diode was replaced at the factory check. This indicates that the life of these diodes may be inadequate. On one unit the cover glass on the projector has broken on three different occasions. The cover glass on the projector of the other unit cracked while the unit was stored in the laboratory and the heaters unenergized.

AGA Fog Detector.

The AGA fog detector has continued to operate and to energize the alarm circuit at approximately the same level of transmittance. On a few occasions the alarm circuit on the recorder did not function during fog. The cause of these failures has not been determined but may be in the signal lines. The fog detector still functions over a wide range of transmittance conditions. The tests will continue.

AGA Visibility Meter.

Operation of the AGA visibility meter has been continued although some maintenance has been required and performance is less than optimum. AGA representatives suggested that the opening through the reflectorized coating on the side of the lamp for the pilot beam should be enlarged to correct the unsatisfactory performance found after the lamp replacement. After this opening was enlarged, the performance was much improved. The new calibration is not in good agreement with the original calibration. The response seems to approach a minimum value when visibility is approximately one-fourth mile in daytime or one-half mile at night and remains constant for lower visibilities. Since useful data are again being obtained, a request for an extension of the loan period for another two months has been made to AGA.

Videograph Fog Detector.

The Videograph B fog detector manufactured by F. Frungel Impulsphysics and Automatic Power, Inc. has been installed in the field for operational testing. The unit was mounted on the platform of transmissometer T-L2 light source tower and faces north approximately parallel to the transmissometer baseline. Initially the recorder was installed in the laboratory but the noise on the signal lines was objectionable and the recorder was moved to an instrument shelter near the unit. Some adjustment of the calibration has been required. The instructions state that a setting of 4.44 on the Sensitivity resistor should give a reading of 0.8 kilometer visibility on the automatic calibration. The calibration samples a portion of the light directly from the light source into the receiver by using fiber optics. The Sensitivity resistor had to be set at 1.50 to obtain the 0.8 km reading. Neither the 1.50 nor the 4.44 setting gives good correlation of the indication on the Visibility meter with observed conditions. A setting of 3.75 is presently being used because with this setting the response on the recorder is distributed across the middle of the chart for atmospheric conditions in the one-fourth to two mile visibility range. The automatic internal interrogator functioning at approximately 20-minute intervals is more frequent than desired for field testing as a visibility meter. Once per hour would be adequate. The unit has been

operating very satisfactorily without appreciable change in calibration after installation in the field.

NBS Atmospheric Backscatter Meter.

An atmospheric backscatter meter prototype designed and constructed by NBS was received for field testing. Basically, this equipment consists of a pulsed light source, a photomultiplier detector, a reference sample from light source to detector, a logarithm ratio amplifier to compare the ratio of the reference signal to the backscatter signal, and the related amplifier, switching and power supply circuits. (A complete description of equipment and theory of operation is given in NBS Report No. 9825 "Instruction Manual--Atmospheric Backscatter Meter"). The equipment consists of three parts; a lamp-photocell box unit, a power supply unit, and an electronics unit. The lamp-photocell box contains a xenon-gas type FT-34/HP discharge lamp for a light source, a type 6467 photomultiplier receiver, and the associated shutter drive, optics, filters, timing discs, and switches. The power supply unit contains the flash lamp, photomultiplier, power supplies; operating controls, and circuit breakers and operating time delay circuits. The electronics unit contains the seven circuit boards for switching, log-ratio, etc; a monitor meter and switch; a null test meter circuit; heater circuits; and the output terminals. The instrument is designed for a Day and Night mode of operation.

The flash lamp is operated at approximately 2000 volts. The nominal energy per flash is 116 joules in the Day mode and 16 joules in Night mode. The Day mode may be used at night if the intensity of the light flash is not objectionable. The signal flash is at 1.5-second intervals. The lamp flashes for a reference signal at the midpoint between the signal flashes with the light to the outside blocked by a shutter. The reference signal light comes from an opening in the wall between the lamp compartment and the photomultiplier compartment and is reflected into the optical path. Both the backscatter signal and the reference signal are routed to separate peak detector circuits and then fed into the log-ratio circuit for comparison. The log-ratio is averaged in another circuit and the results are presented to the output terminals. The output signal, E_o, is proportional to the logarithm of the ratio of the peak amplitudes of the reference signal, V_{REF}, to the backscattered signal, V_{SIG},

$$E_o = 3.33 \log \frac{V_{REF}}{V_{SIG}}.$$

Thus for a ratio of 1:1 the output is 0 and for a ratio of 1000:1 the output is 10 volts.

In the field installation, the lamp-photomultiplier box was mounted on a tower adjacent to the light source of transmissometer T-L2 and aimed nearly parallel to the beam of the transmissometer. The power supply and electronics units were placed in a nearby instrument shelter. The recorder is in the laboratory approximately 2700 feet distant. A malfunction in the electronic unit has occurred. This problem appears to be a poor contact in a component or terminal of the log-ratio board. One other malfunction has been encountered. After the field installation was completed the operation of the flash lamp became intermittent. This was caused by intermittent contact in the connector at the power supply box for the high voltage to the flash lamp. A temporary connection was made. Further adjustments are awaiting the arrival of the designer of the equipment. The results obtained indicate that this equipment responds well to changes in atmospheric conditions over a range of visibility from .0. 1 to 5 miles.

Effect of Height Above Ground on Transmission.

A task to determine the change in atmospheric transmission with height above the ground was started. In advection type fogs frequently visibility is better close to the ground than a few feet above the ground. In radiation type fogs the reverse may occur. To determine the effect of this variation in height on transmission, three transmissometers will be installed over the same 250-foot baseline--one at 5, one at 10, and one at 15 feet above the ground. The T-L1 and T-L3 transmissometers are being moved to the T-L2 transmissometer site. This installation will be completed early next quarter.

Transmissometers.

The length of time required for the transmissometers to stabilize when initially energized has been investigated. The projector, receiver, and indicator of two transmissometers were turned off over night and the three units were energized at the same time next morning with readings made at regular intervals, initially starting at one minute intervals. Also tests were made when only the projector or the receiver were turned off over night. The readings were compared with the transmittances from a third transmissometer which was operating continuously. Approximately four hours were required for the readings to stabilize within one percent of the final value and small differences could be detected for five to seven hours. The maximum error occurs within a few seconds after energizing the units and may be 12 to 20 percent above normal. The readings were within two percent of stability in about 2-1/2 hours. Most of the drift is in the projector and probably caused by the change in temperature of the voltage regulating transformer. The receiver produces a low reading when first energized but this is only 3 or 4 percent low and stabilizes in one or two hours.

III. AIRFIELD LIGHTING AND MARKING

Field Tests of Type L-842 Inset Runway Lights with Force Drainage Modification.

These five type L-842 inset runway lights have completed one year of test operation. Three of the lights have the forced drainage modification and two are standard. The lights are operated at rated current for three hours daily. This totals over 1000 hours of operation. Four lamps failed within the first month of tests, another in December, and one in May. Except for the light in which the lamp was replaced, there was no inspection during this period. This light was dry at this time although it contained some water drops when inspected last quarter.

SATS Runway Centerline Light with Coaxial Filament Q6.6A/T4/CL Lamps.

NBS Test Report 212.11-28/67 Supplement was issued giving the results of measurements made of a SATS runway centerline light with a coaxial filament Q6.6A/T4/CL lamp. The unit was originally tested with the regular lamp, the filament of which is displaced one-half coil diameter from the axis of the lamp. The unit was inadvertently designed for a coaxial filament lamp. (The coaxial filament lamp is distributed under the designation Q150T4/CL). Peak intensities of 1520-1660 candelas were recorded with three different lamps. The light beam tended to deviate to the left of center because the hole that provides a seat for the exit lens is about 0.06 inch off center laterally.

Field Tests of Cable-Fault Locator Developed by NBS.

Many field tests of the cable-fault locator developed by NBS have been completed. A draft of the progress report has been prepared. Further tests will be made and the progress report should be completed next quarter.

A report describing the instrument and its circuitry has been drafted and is now being edited. This report includes the results of laboratory performance tests.

Gage for Checking L-850 Light Base for Conformance to Specification.

A pair of gages ("go" and "not-go") was fabricated for checking L-850 light bases. The gages were submitted to the gage section at NBS for dimensional verification.

Dimensions of Two "Joy" Connectors.

Two "Joy" trademark cable connectors (male and female) were submitted by the Federal Aviation Administration for dimensional tests. The mating portion of the male connector tapered from 0.602 to 0.611 inch. The specifications calls for a diameter lying between 0.604 and 0.614 inch. The mating portion of the female connector measured 0.575 inch, somewhat larger than the specified maximum diameter of 0.545. There may, however, have been some "set" in the material. A memorandum report was issued.

IV. CARRIER LIGHTING AIDS

Criteria for the Inspection of Fresnel Lenses.

A meeting was attended at NAS Norfolk to discuss testing of and acceptance criteria for the Fresnel lens used in the Fresnel Lens Optical Landing System. In attendance were engineers and test personnel from the Naval Air Engineering Center (Ship Installation), a representative from COMAIRLANT, and quality control and testing facility personnel from NAS Norfolk.

Information made evident and/or agreed upon by the group includes the following:

(a) Stray light (that light observable in areas or directions outside the main informational light beam, or meat ball) is not the problem that NBS was led to believe at the beginning of the investigation.

(b) The smooth transition of the meat ball from one cell to another adjacent one is the prime problem from an operational standpoint. This problem is complicated by the fact that an array of five cells in ABCDE order might have a poor transition characteristic between one or more pair of cells, while the same array in AECDB order would have an acceptable transition characteristic between all pairs.

(c) NAS Norfolk focuses a FLOLS cell by means of a "hang-on" positive lens that covers the entire face of the cell under test. The method also evaluates the quality of the Fresnel lens. This facility reports good results by this method, often detecting "imperfect" lenses not discovered by the method in (d) below.

(d) NAEC(SI) Philadelphia focuses a FLOLS cell by a "peep-sight" method incorporating the geometry of the projected light beam. The degree of "straightness" of the light bar (the meatball is a bar at distances close to the cell) is used as a measure of the quality of the Fresnel lens.

(e) There was no agreement as to the "best" procedure delineated in (3) and (4) above.

(f) Much of the Fresnel lens testing is of necessity based on a visual examination for scratches, gouges, etc., termed "cosmetic" defects. The point at which cosmetic defects become operationally undesirable or hazardous has not been defined. A NAEC document specifies the criteria for cosmetic defects allowable on the original acceptance procedures.

(g) There was some evidence that some transition problems may be the result of the geometric center of the Fresnel lens in the cell not coinciding with the optical center of the lens. The degree of "perfection" required has not been determined.

(h) A third method of focusing the cells used by some facilities was described, based on a measurement of the projected beam on a screen at a fixed distance in front of the cell. There was no information available that this method would disclose defects of the Fresnel lens.

A visit was made to NAEC(SI) on June 18 to see the test facilities and confer further with the personnel involved in the FLOLS testing project. Some time was spent on the discussion of the egg-crate lens restrainer, the necessity to hold the Fresnel lens to a curved format and to what tolerances. The problems were left open for further study.

A 500-foot visual inspection range was constructed in the photometric range using a plane mirror. One cell was modified in the laboratory by reversing the egg-crate restraining devices and forcing the Fresnel lens into a flat configuration and then refocusing it. Neither photometric measurements at 300 feet nor visual examination at 500 feet showed any indication of a false signal.

A second cell has been requested from the Naval Air Engineering Center (SI) in Philadelphia. This will permit a stacking of two cells to possibly give some indication of the cause of the meatball transition problems which have been reported.

Lights for Marking Transmission Lines and Their Supporting Structure.

NBS Test Report 212.11-13/68 was issued giving the results of the measurements made on a catenary light and a condenser-discharge type obstruction light.

Type L-852 Wide-Angle Airport Taxiway Light.

NBS Test Report 212.11-3/68 was issued giving the results of measurements made of a type L-852 wide-angle airport taxiway light.

Measurement of Flight Deck Illumination and Luminance.

A task was established at the request of the Commander, Naval Safety Center, NAS Norfolk to the Commander, Naval Air Systems Command, to "substantiate the quantity and quality of illumination provided" by white floodlights now installed on most carriers. Envisioned is a program whereby each carrier will have an illumination survey made of the overhead white floodlighting as to uniformity, luminance ratios and glare. A portable telephotometer with a provision for converting it to a luminance meter was ordered for this program.

Fiber Optics Cable and Light Source.

A surgical type fiber optics cable and light source were received from the Naval Air Systems Command for test. Intensities above 100 candelas were recorded in a $\pm 15^{o}$ sector in one plane of measurement through the axis of the cable. The unit was submitted for test in order to determine the feasibility of fiber optics for use in an inset light in aircraft carrier flight deck lighting. A memorandum report was issued.

V. MISCELLANEOUS TECHNICAL AND CONSULTIVE SURVICES

The following proposals, draft reports and specifications have been reviewed. Comments have been forwarded by letter, marked copy of the document and/or conferences with cognizant DOD and FAA personnel.

FAA E-2325 Medium Intensity Approach Light System

FAA E-2340 Condenser Discharge Flashers and Accessories

FAA E-1328B Visual Approach Slope Indicator Lamp Housing Assembly

FAA Drawing C-5407-9 Lamp PAR 64 VASI

Draft Stanag Helipad Lighting

Beneficial Suggestion for Fault Detection of Airfield Lighting Circuits.

An employees beneficial suggestion for use of an over-current relay and of installing ground detectors to determine the presence of ground faults on series airfield lighting circuits was received from the Navy for review and comment. Since series circuits are energized from constant-current regulators, the over-current relay is not a practical means of detecting grounds on the circuit. A ground detector could detect a fault which reaches a sufficiently low resistance but periodic maintenance tests of circuit insulation should detect such faults much earlier. The use of ground detectors is questionable because this may tend to relax periodic maintenance, and, if used, ground detectors must never be connected to deenergize the equipment. Use of ground detectors would prohibit the use of midpoint grounds on the circuit which are frequently installed to reduce voltage stresses and to indicate a ground fault occurrence by partial circuit outages. On a series circuit, a single ground fault does not affect the lights but with a ground detector a single fault could result in a partial or total outage of the circuit.

Use of Helicopters in Civil Emergencies.

Information on the losses and rescue efforts from use of helicopters in the floods which occurred in Humboldt County during December 1964 was requested from the Navy Flight Safety Center. A report based on memory and data from local emergency organizations was forwarded.

Operation Foggy Cloud.

The Earth and Planetary Sciences Division of the Naval Weapons Center, China Lake, California, has selected Arcata Airport as the site for field test experiments for Operation Foggy Cloud. The object of this Operation is to determine the effects of various chemicals on warm stratus clouds and warm fog. The field operation was started on March 25 and is expected to continue through October. Fog and cloud seeding has been accomplished by burning pyrotechnics in the form of fusees mounted on aircraft and larger units at selected locations on the ground. Later seedings will also include liquid spray from a B-25 and powder spray from a C-117. The effects are evaluated by airborne meteorological instrument readings before and after seedings, visual observations from the air and from the ground, and aerial photography. Liquid and powder seeding from the air will be radar controlled. A radar site has been established atop Trinidad Head, which is six miles from the Arcata Airport.

Other groups participating in this Operation with the Navy are the Army Electronics Command, Meteorological Support Activity, Ft. Huachuca, Arizona; Army Atmospheric Sciences Laboratory, White Sands Missile Range, New Mexico; Air Force Cambridge Research Laboratories, Massachusetts; Navy Weather Research Facility, Norfolk, Virginia; and Meteorological Operations, Inc., Hollister, California. NBS personnel at Arcata have assisted in selecting sites for installations, discussion of plans for testing and installations, providing communications for ground burns when contact with the FAA Flight Service Station was required, and consultation on miscellaneous matters which arose.

Comparison of Appearance of Condenser-Discharge and Rotating Incandescent Lights.

A system to compare the appearance of a rotating incandescent light to a flashing condenser-discharge light of approximately the same effective intensity was set up and demonstrated to a group of six observers from the FAA. The setup consisted of a condenser-discharge light and a rotating incandescent light operating at a flash rate of approximately fifty flashes per minute. The two lights were operated both independently and together with different input voltages and colored filter combinations. All observations were made in daylight at approximately one-half mile distance.

In the first test alternate flashes of the two lights were presented with the lateral separation between the lights as small as feasible. Filters were used to obtain the following combinations: 1) both red; 2) both 2854K; 3) both 6500K; 4) c-d 2854K-incand. 6500K. 5) c-d 6500K incand. 2854K. Each set was presented twice. Only one observer reported that both lights were being shown. In 3 of his 10 observations (once each combinations 1, 4, and 5) he reported both lights. Three

other tests were run with the lateral separation of the lights increased so that the lights could be identified as to location and both lights were shown with alternate flashes or individually. The same color combinations were used. (Note that in a test of this type random guessing will produce about 50 percent correct answers.) These tests indicated that the observers were using color rather than flash duration to identify the lights for the number of correct answers was well above chance when the two lights were shown without filters (c-d 6500K-incand. 2854K) and were well below chance when both lights were filtered to obtain combination 4, (c-d 2854K-incand. 6500K).


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