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Final Report

Examination of the Feasibility for Demonstration and Use of Radioluminescent Lights for Alaskan Remote Runway Lighting

January 1984

Prepared for the U.S. Department of Energy under Contract DE-SC06-83RL 10312 with the State of Alaska, Department of Transportation and Public Facilities, Division of Planning, Research Section, and Contract DE-AC06-76RLO 1830 with Pacific Northwest Laboratory

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EXAMINATION OF THE FEASIBILITY FOR DEMONSTRATION AND USE OF RADIOLUMINESCENT LIGHTS FOR ALASKAN REMOTE RUNWAY LIGHTING

FINAL REPORT

by

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NOTICE

ACKNOWLEDGMENTS

This report was written to address the development of radioluminescent (RL) airfield lighting at civilian airports in Alaska. For this reason, much of the development concurrently taking place for the military sector is not discussed or is only briefly treated. The authors wish to point out, however, that the overall development of the RL airfield lights has been and continues to be a cooperative effort of several agencies, both civilian and military. This cooperative effort is directed by the U.S. Department of Energy (DOE) Defense Byproducts Production and Utilization Program with the advice of a Technical Working Group. We wish to thank the individuals which have contributed so much to this team effort and specifically acknowledge the contribution of each:

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1.0 INTRODUCTION

In March 1983, the State of Alaska, Department of Transportation and Public Facilities (Alaska DOT&PF) authorized and funded a study by the Pacific Northwest Laboratory (PNL)[a] to examine the feasibility for demonstration and use of radioluminescent lights (RL lights) for remote Alaskan runway lighting applications. Radioluminescent lights have been under development by the U.S. Department of Energy (DOE) and the Department of Defense (DOD) for a variety of purposes. Previously, the lights have used the beta energy emission from tritium, krypton-85, and promethium decay to excite a phosphor to produce light for emergency and instrument lighting. Recent developments using the isotopes tritium and krypton-85 at Oak Ridge National Laboratory (ORNL)[b] and advanced phosphor technology have produced lights suitable for applications where more intense light is required, such as runway marking. This report examines the feasibility of such applications for rural Alaskan airports.

1.1 SCOPE OF WORK

The scope of the work is to investigate the feasibility of using RL lights for marking runways at remote Alaskan airfields. The following were the work objectives for the effort.

- Acquire and evaluate all available information on RL lights for use in runway lighting and marking
- Identify availability of RL lights, estimate the capital, operating, and maintenance costs. Anticipate near-term development which will affect future use of these lights in Alaska. Assess human factors including effect on pilot night vision, public acceptance, etc.

(a) The Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy.
(b) Oak Ridge National Laboratory is operated by Union Carbide Corporation for the U.S. Department of Energy.

- Estimate equipment and airfield lighting costs, and develop the benefits-costs relationships for using these lights in place of conventional lighting systems.
- Identify sites and siting needs for demonstration and use of the lights in Alaska.
- Develop a preliminary plan, and lights and lighting design requirements, including estimated costs for demonstrating the lights at a remote Alaskan runway site.
- Identify and evaluate the radiological, legal, and institutional (including regulatory) issues affecting the use of RL lights in Alaska.
- Evaluate environmental factors that affect the adaptation of this technology in the Arctic.

The work needed from PNL for the Alaska DOT&PF was to be completed in two phases, each with several tasks. The work presented in this report covers the Phase I effort and was comprised of four tasks. These four tasks encompass Task I - State of the Art Evaluation of RL Lights, Task II - Environmental, Radiological, and Regulatory Evaluations, Task III - Engineering Evaluations, and Task IV - Demonstration Plan Development and meet the scope and objectives advanced in the previous section.

The Phase II effort of this work is to implement a demonstration and installation of RL lights at an appropriate location in Alaska. The portion defining the approximate limits for the future scope of the effort is found in Section 6, Implementation. Until all factors are defined, the specific sites and siting needs for demonstration and use of the lights in Alaska cannot be completed.

1.2 REPORT ORGANIZATION

The various sections of this report cover the effort provided by the study's statement of work. The study methodology is briefly discussed including objectives and guidelines, information sources assessed and related project activities. This is followed by a discussion of the state-of-the-art for radioluminescent light development including discussions of the environmental, radiological, regulatory, institutional, and behavioral- and human-factors issues related to the use of radioluminescent lighting for aircraft marking, runway lighting, and other purposes. Other possible uses include highway marking and marine navigational aids in Alaska but are not specifically addressed in this report. The engineering evaluations and design considerations are found in the next section, followed by a cost analysis for deploying these lights at a remote Alaskan runway to demonstrate their applicability in the Arctic and/or sub-Arctic environments. Finally, the study's conclusions are presented followed by a brief section dealing with issues related to implementation of a program for lighting Alaskan village and other remote airports.

1.3 STUDY METHODOLOGY

The methodology, objectives and milestones for this study were identified during proposal preparation and contract negotiations with the Alaska DOT&PF. The objectives and limitations and methodology for the effort are discussed in the following paragraphs.

1.3.1. Objectives and Limitations

The objectives for the Phase I effort reported here are as follows:

- Acquire information to identify the state-of-the-art for application of RL lights for lighting systems for remote Alaskan airfields.
- Address the environmental, radiological, licensing and related educational needs and issues for using these devices in Alaska.
- Develop preliminary system designs and costs estimates for using RL lighting to meet remote Alaskan runway lighting and working needs.
- Assist in the development of a preliminary program plan for demonstrating the lights in Arctic and sub-Arctic Alaska.
- Assess the behavioral and human factors, institutional, and educational aspects of using RL lights for lighting and marking Alaskan bush runways.

The Alaska DOT&PF is a participant in a much larger development effort sponsored by DOE and DOD to use RL lighting to meet remote and austere lighting needs. Other contributors to the effort thus include DOE, DOE's laboratories ORNL and PNL, and various organizations within the Department of Defense. Department of Defense organizations include the North Carolina Army National Guard, the Alaskan Air Command, the Alaska Air National Guard, the U.S. Air Force Engineering and Services Center and others. Funding for the larger effort is provided by the DOE and DOD. Thus, the Alaskan effort is benefited by a large national program. Overall planning for the work is handled by a technical working group (TWG), which has membership from all organizations participating in the program. This structure imposes limitations in planning, research, development, demonstration, and implementation on the individual user, that is, the Alaska DOT&PF but allows the Alaska DOT&PF access to a much larger body of technical input and expertise than they could obtain by a unilateral research program.

1.3.2 Program Activities and Information Sources

The project plan is shown in Figure 1.1. The plan was used in the proposal to inform the sponsor how PNL and Alaska DOT&PF personnel expected to approach the effort and served as a guide for completing the work.

A brief explanation of Figure 1.1 is useful to clarify the various activities and how they were performed. In addition, because of the ongoing nature of the larger effort, some changes in direction and milestones were necessary and will be discussed where appropriate. Information for the background and state-of-the-art assessment was drawn from literature sources, information supplied by ORNL and others conducting research on tritium lights, and manufacturer's information. All of these resources were assessed and the results are presented in Sections 2.1 and 2.2. A discussion of basic information on the chemical, physical, radiological properties of tritium, and its licensing needs were prepared and are presented in Sections 2.3 and 2.4. The environmental, radiological, and regulatory evaluations and the state-of-the-art evaluation proceeded essentially in parallel. The information for environmental, radiological, and regulatory evaluation was obtained from Title 10, Code of Federal Regulations, other Nuclear Regulatory Commission

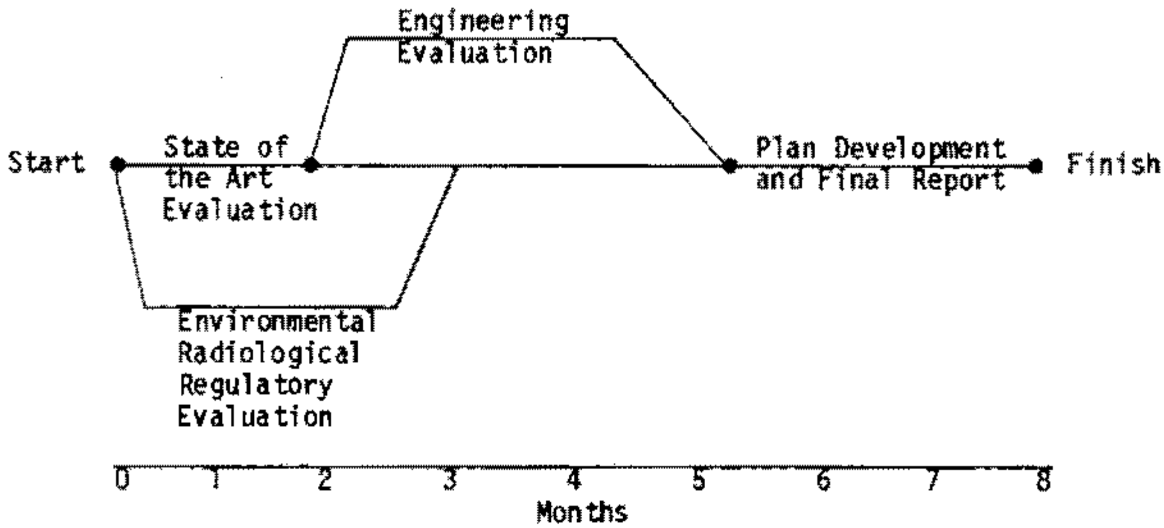

FIGURE 1.1. Work Path Diagram

(NRC) publications, accident data, and the general literature. In addition, an evaluation of the potential exposure to tritium was completed assuming worst-case scenarios. Institutional issues, educational needs, and needed behavioral- and human-factors data were addressed using inputs similar to those identified earlier and are presented in Section 2.5. Engineering evaluations and the design considerations discussed in Section 3 were completed in several iterations. This was necessary because of the continuing nature of the larger effort where major modifications to the lights, lighting fixtures, and runway-light configurations were being completed and tested. The design shown in Section 3 is based on the latest technology available as applied to a 3000-foot-long rural Alaskan runway. This design will be tested and modified as required at Central, Alaska, during the winter of 1983-84. A cost analysis is developed in Section 4. A demonstration plan which summarizes the work to be done at Central, Alaska, and Alaska DOT&PF participation in the overall program sponsored by DOE and DOD is found in the overall DOD, DOE test plan containing the DOT&PF test plan, Appendix A.

2.0 BACKGROUND AND STATE-OF-THE-ART

The work covered in this section includes the Task I and Task II effort. Included are a brief background discussion, the state-of-the-art for radio-luminescent light development, environmental issues, licensing requirements, and radiological protection needs and assessments.

2.1 BACKGROUND

The Alaska Department of Transportation and Public Facilities (DOT&PF) is working to provide airport lighting and marking systems to rural communities throughout Alaska.[1,2,3] The application of radioluminescent lights as an alternative to conventional lighting systems at these remote locations may offer reliable, safe, low-cost options which need to be examined. In addition, the use of radioluminescent lights to improve flight safety by permanent replacement of flarepots or lanterns when used by air taxi operations under Part 135 of the FAA regulations for night operations at remote airfields, could reduce insurance and other operating costs by extending operating time, reducing accident rates, and promoting more efficient use of aircraft. These reductions in costs, improved service, and flight safety, when passed on to the local level, can enhance the quality of life in the bush communities.

2.2 STATE-OF-THE-ART ASSESSMENT

The use of radiation from radioisotopes to excite phosphors that, in turn, emit visible light has been known for many years.[4-15] An example of this was the use of radium mixed with a binder and zinc sulfide phosphor painted on watch dials for self illumination. Since radium is high in cost and represents a serious health hazard to persons exposed to it, its use is now prohibited. Another isotope, tritium, has replaced radium to produce the required radiation source for self illumination of the phosphor in the commercial sector.

In principle, beta particles (electrons) are produced by the selected isotope during its decay to form another element. These electrons strike a phosphorescent material, such as zinc sulfide, which contains a small quantity of impurity, such as copper, silver, or cadmium, and are absorbed. Light is produced when the energy from this absorption is released, Figure 2.1. Other forms of radiation can also be produced during the decay process. These include alpha particles and gamma rays. Alpha particles are helium nuclei, which are emitted at high velocity. Gamma rays are a form of electromagnetic radiation similar to x-rays, but have a higher frequency, greater penetrating power, and increased damage to living tissue. Thus, if an isotope is to have a practical value as an energy source for self-powered lights, it should have the following characteristics:

- a relatively long half-life,
- not emit alpha particles or gamma rays, or be easily shielded,
- produce a stable daughter, e.g., nonradioactive isotope,
- be non-toxic chemically or radiologically, and
- have a modest or low cost.

Possible isotopes that could meet these requirements are listed in Table 2.1. Existing or experimental applications of radioactive isotopes for lighting purposes are shown in Table 2.2. Krypton-85 and promethium-147 have only been

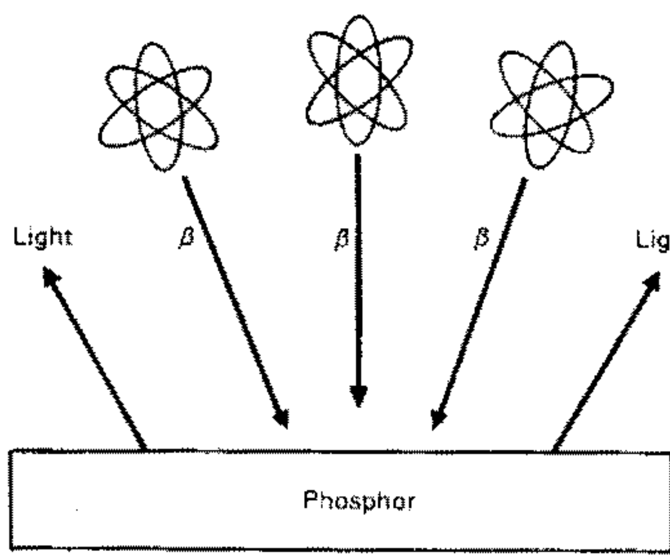

FIGURE 2.1. Technical Principle (Gas-Tritium or Krypton-85, Solid - Promethium)

TABLE 2.1. Possible Isotopes for Self-Powered Illuminators and Their Relevant Properties[16,17]

Isotope	Half life (years)	Maximum beta energy (meV)	Gamma-ray (percent)	Chemical toxicity	Radiological toxicity	Remarks
Tritium (H^3)	12.4	0.018	nil	nil	very low	Low energy. Ideal for luminous paint. Low cost. Easy to handle. No shielding required.
Promethium-147	2.6	0.23	nil	nil	medium	Expensive. Short half life.
Krypton-85	10.7	0.67	0.5 percent of 0.5 meV	nil	low	Inert gas. Some shielding required. Expensive. Encapsulation can discolor because of radiation.

TABLE 2.2. Existing or Experimental Uses for Isotopes in Self-Powered Lights[4-15]

Isotope	Uses
Tritium (H^3)	EXIT signs; public buildings and aircraft, self-luminous watch dials in aircraft and instrument dials, markers
Promethium-147	Apollo, Moon Orbiter and land-docking lights
Krypton-85	Experimental lights built and evaluated; A research area

used in special applications and in test situations. Tritium meets all of the above requirements and is, therefore, widely used in a variety of commercially-available products in various applications.

Tritium can be used in two ways. First, it can be chemically incorporated into styrene and other organic binders to produce luminescent paints. These paints have been used for watch and aircraft dial illumination, mine field marking, gunsight illumination, and other purposes. Second, tritium gas can be encapsulated in a glass tube or container coated on the inside with a zinc sulfide phosphor. Uses for this type of light source include EXIT and other self-powered warning signs for buildings, aircraft, and light standards in the photographic industry. For example, tritium lights containing from 4 to 30 curies of tritium have been used on commercial aircraft and in emergency lights (EXIT signs, etc.) since the mid-1960s.[6,7,8] Primary advantages of radioluminescent lights in existing applications are:

- They require no external source of power, thus are not subject to power failure or interruption.
- They do not burn out or require wiring; thus, are self-contained and maintenance is minimal.
- Supply problems from short shelf life component replacement, such as batteries, are reduced where temporary or emergency lighting is required.
- They can function under many severe environmental conditions such as temperatures lower than -70°F.

Thus, the technology is well developed for a variety of purposes. At least seven commercial companies are producing a variety of products commercially in the United States and Europe, Appendix B. These companies were surveyed concerning the possibilities of using RL lighting for runway lighting and marking purposes and the responses received are included in this appendix.

Strong interest exists to expand this technology to military uses in remote, austere, and tactical applications where utility or portable electrical power is unavailable or difficult to obtain. Research and development incentives for this expansion have been identified and development work to provide lights meeting the needs is underway, sponsored by the Department of Defense and Department of Energy.[18-22] Both have had specific objectives in mind; however, the products of this testing to meet these objectives have shown that radioluminescent lighting could meet many Alaskan needs including remote Alaskan airfield lighting and marking.

Primary restrictions to the further development and use of the lights are the licensing requirements imposed by the Nuclear Regulatory Commission or foreign governments; obtaining Federal Aviation Administration waivers and acceptance; tritium availability; technical restrictions imposed by the physical limitations of the phosphor, beta-particle penetration, quality assurance and quality control; and manufacturing and production needs. The licensing issues and other federal requirements are discussed later and will not be further reviewed here. Because of the above mentioned limitations of phosphor, tritium loading requirements, and beta particle penetration distance, the lights will produce only a finite light output for a given area of phosphor surface. Although this limit is not reached in existing designs, it is doubtful that the intensity per unit area can be increased more than a factor of two over present technology.[a] Future developments should thus relate to better configurations where loss of light due to interference is reduced, or use of mirrors or reflecting materials to direct the light for more efficient use. In addition, human factors research is needed to establish how the light output is perceived by the user, that is the pilots. Minimal work has been done in this area and it has largely been limited to visibility of self-luminous EXIT signs.[23,24] Another area that needs to be carefully addressed is the quality control and quality assurance requirements which should be imposed by a user when purchasing these lights from a manufacturer. On several occasions, lights have failed prematurely because leakage has occurred, phosphor quality was poor, or the phosphor was contaminated.[b] In general, this has occurred when the quality control, or quality assurance criteria, have been relaxed by a purchaser. Specific needs in this area are tests to ensure tritium has not leaked out of the tubes, the phosphor is not contaminated, and that quality is maintained. A preliminary evaluation of the lights for airfield and runway use was conducted in early 1983 for military purposes and for civilian use in Alaska. Results are encouraging. At the present time, most of the research and development is being conducted by the government, that is DOE and DOD, but at least one manufacturer[c] is also developing light sources and designing their own manufacturing facilities. Nearly all of the manufacturers are small, having sales totalling less than 10 to 15 million dollars per year; the market incentives need to be significant to justify a relatively large financial commitment for research by industry.

(a) Telephone discussions with D. John Watts, Safety Light Corp., 4/7/83 and 6/30/83; Neil Case and J. A. Tompkins, ORNL, 6/21/83, 8/17/83 and 9/7/83; and Larry Keating, NRD Corporation, 1/27/84.

(b) Telephone discussions with Carl Haff and Andy Tompkins, ORNL, several occasions; W. C. Remini, DOE-HQ, several occasions.

(c) Telephone discussions with D. John Watts, Safety Light Corp., 4/7/83 and 6/30/83, and Neil Case and J. A. Tompkins, ORNL, 6/21/83, 8/17/83 and 9/7/83.

In summary:

1. All of the technology required is available to produce a radioluminescent light potentially suitable for runway lighting and for marking a remote Alaskan runway.

2. Many advances in design of fixtures, which will enhance the way in which the light is presented to and received by the pilot are possible. The range of these designs is just now being explored; thus, many improvements can be expected as innovations in these designs appear.

3. It is doubtful that the unit light intensity, that is light output from a unit surface area, can be increased beyond a factor of two. Use of mirrors, and other reflective systems, and more efficient designs that eliminate interferences will enhance the human acquisition of the light. Thus, a pilot could acquire the light from a distance of 6 or more miles rather than 2 miles acquisition identified during the 1982-83 test in Alaska.

4. Designs of large-scale systems that use these lights are still in early development for runway lighting and marking; thus, as we better understand the human factors affecting the lights and their use under varying weather conditions, substantial improvements in this area can be expected.

5. The lights should be simple to install and use, require minimal maintenance, and because they can produce light without external power at low temperatures, should be viable for Arctic and sub-Arctic use.

6. Manufacturers could produce a radioluminescent light suitable for use in Alaska. They may not be capable of completing the development and demonstrations needed in 2 and 3 above to advance the technology to maturity because of internal financial limitations without additional help from the user, e.g., state or federal support.

7. A better definition of the quality control and quality assurance needs for purchase of the lights is needed. Tests or evaluations needed to ensure that failure after purchase is minimized need to be better defined.

2.3 ENVIRONMENTAL EVALUATIONS

Discussion in this section centers on the release of tritium and its effect on the environment. Within the discussion, various terms used in the analysis are defined along with important chemical and physical characteristics of the tritium isotope. Finally, two possible worst-case accidents are analyzed and discussed: (1) a worker exposed while handling a fixture and (2) a large number of threshold and edge lights destroyed during an accident.

2.3.1 Physical Characteristics of Tritium and Definitions of Terms

The radioactive agent in RL lights, as has been discussed, is tritium. Tritium is a commonly used name for ^3H, a radioactive form (isotope) of the element hydrogen. The important radiological characteristics of tritium include its half-life, the type of radiation emitted, and the energy of the emitted radiation.

The half-life of a radioactive agent is the time required for one-half of the radioactive material present to undergo radioactive decay. During the second half-life period, one-half of the remainder will decay, and so on. Each radioactive nuclide has its own characteristic half-life. The half-life of tritium is 12.3 years.[16,17,25]

The type of radiation emitted will influence the shielding requirements for the device. Tritium emits a beta particle. A beta particle is a high speed electron, which has been emitted from the nucleus of an atom. The beta particle will eventually lose most of its energy of motion and become just another electron. Beta particles (electrons) are relatively easy to shield against. Commonly employed shielding materials include plastics, glass, and aluminum; the thickness of shielding material required depends upon the energy of the beta particle.

The energy of a beta particle, such as those emitted by tritium, is in the form of kinetic energy, energy of motion. The energy unit used most commonly to describe radiation energy is the million electron volt (MeV). The energy level will influence the ability of the radiation to penetrate through matter; the greater the energy, the further the radiation will travel. A particular beta particle emitted by tritium can have a wide range of energies; however, the maximum energy that any particular beta particle will have is 0.018 MeV.[16,17,25] A beta particle, such as that from tritium, having an energy of 0.018 MeV will penetrate no more than 3/10,000 of an inch through water[26] and about 1/2 inch through air.[27] The glass and plastic used to contain the tritium gas in these markers have beta shielding capabilities similar to water. The walls of the glass and plastic cylinders surrounding the tritium have thicknesses which vary between 1/32 and 1/16 inch; much greater than the distance a beta particle emitted by tritium can penetrate. The consequence of this is that any radiation emitted by tritium has insufficient energy to penetrate the walls of any confinement system, which may conceivably be used in an airfield lighting unit.

Ionizing radiation, such as the beta particle emitted by tritium, can interact with tissues of the body by depositing energy in the cells of the body and may disrupt the normal functioning of the cell. Radiation dose is a measure of the extent to which radiation energy has been deposited in a tissue. The most commonly used unit of radiation dose is the rem, a subunit of a rem is a millirem, a millirem is one one-thousandth of a rem.

Radiation dosimetry refers to the measurement and calculation of radiation dose. Calculations of radiation doses are often used to predict the radiation dose to radiation workers in the nuclear industry or the general population, which may occur under various circumstances. Radiation dosimetry is divided into two distinct categories: external dosimetry and internal dosimetry.

External dosimetry refers to the calculation of a radiation dose from sources of radiation, which are outside of the body. There are three organs or groups of organs, for which an external dose is calculated: skin, lens of the eye, and the whole body. For purpose of calculation these organs are assumed to lie at a depth of 0.07 mm, 3.0 mm, and 10.0 mm, respectively, beneath the surface of the skin. Separate acceptable dose limits have been established for these three organ systems which are 30 rem, 5 rem, and 5 rem per year, respectively. These dose limits are for individuals who work with radiation as part of their job. The acceptable annual dose limits for members of the general population are about 1/10 those given above.

The depths given above represent the location of the radiation sensitive tissues; radiation which does not penetrate to the depth specified is considered to not provide a meaningful dose. For example, the skin consists of two major layers: the dermis and the epidermis,[27-29] the dermis being the outermost layer. The epidermis is likewise composed of three layers. The cells of the lowest layer (stratum basal) are the source of new skin in that they are continually dividing and supply new cells to make up for the continual loss of surface layers from abrasion. The lowest (basal) layer lies at a depth between 0.07 and 0.12 mm below the outer surface of the skin. The dose to the skin is significant only if the basal layer is irradiated because the basal layer is the source of new skin cells.

Beta particles from tritium generally penetrate only a short distance, about 0.0064 mm, in tissue but do not penetrate to the basal layer in skin. For this reason, the radiation dose to the skin from elemental tritium outside of the body is essentially zero irrespective of the amount of tritium present. For the same reason, the radiation dose to the lens of the eye and the whole body from elemental tritium outside body is essentially zero.

Internal dosimetry refers to the calculation of a radiation dose to the organs of the body from radioactive material contained within the body. The internal radiation dose is a function of the energy of the emitted radiation, the amount of radioactive material in an organ, and the mass of the organ.

Internal doses can be calculated on an organ-by-organ basis and then the organ doses can be summed to give a "whole body" dose. The calculations assume that the radioactivity is uniformly distributed throughout an organ, although the various organs may have different concentrations.

The time that the radionuclide will remain in the body is a function of its solubility in body fluids, and whether it is incorporated into tissues, for example, bone. Collectively, the distribution of the material within the body and its eventual excretion is referred to as the metabolism of the radionuclide.

All of the energy of a beta particle will contribute to the computed radiation dose because the radionuclide is surrounded by living cells, that is in contrast to external dosimetry in which the beta particle must traverse non-living skin before irradiating living tissue. Therefore, the radiation hazard from tritium is that which results from the internalization of tritium. The internalization may result from inhalation of air contaminated with tritium containing materials, ingestion of contaminated materials, or absorption of tritiated water through the intact skin. The radiation dose to an individual consequent to inhalation of tritium is dependent upon the chemical form of the tritium; the major chemical forms are elemental hydrogen and tritiated water.

The International Committee on Radiation Protection (ICRP)[31] estimates that the radiation dose from elemental tritium is primarily that to the lung from inhaled tritium gas and that the dose to the lung will be 60 to 150 times that in any other tissue. Thus the dose calculation methods described by the ICRP for elemental tritium, estimate radiation doses to the lung only. The biological model for tritiated water assumes that ingested or inhaled tritiated water is completely and instantaneously absorbed from the GI tract and the lungs respectively. Further, the rate of intake through intact skin is fully one-half the rate due to inhalation.[32] The ICRP computed that 6.3×10^{-2} millirem per microcurie of tritiated water ingested or inhaled would be the radiation dose following an intake of tritiated water.

2.3.2 Estimation of Radiation Doses

Owing to the radioactive nature of the tritium activated runway markers, it is important to estimate the radiation doses, which may be received by individuals who work with the devices, and by the general population from the tritium in the markers as a result of both normal and accident conditions.

Under normal conditions, the tritium gas in a RL light is contained within a sealed glass ampule, which is itself placed within two plastic tubes the ends of which have been stoppered and sealed with a potting compound. The external radiation dose from tritium in this configuration is zero. As discussed in the previous section, the radiation emitted by tritium does not have sufficient energy to penetrate through the glass or plastic enclosures.

The internal dose potential from the use of tritiated runway markers is also expected to be negligible. Experiments with tritium activated aircraft EXIT lights, containing nominal activity of 4 Ci[a] were found to leak tritium gas at an average rate of about 74×10^{-12} Ci per hour through intact glass tubes;[15] an equivalent leakage rate from an individual light source in a runway marker is about 5.9×10^{-10} Ci per hour. The ANSI N-540 Standard for Radioluminescent Light Sources states that commercially produced light sources shall not have leakage rates greater than 50×10^{-9} Ci per 24-hour period. Such a low leakage rate is insignificant for either out-of-doors or inside well-ventilated buildings.

2.3.3 Evaluation of Possible Accidents

Owing to the large number of conceivable accident scenarios, which could be considered, it is not practical to estimate the potential for exposure or the radiation-dose potential for each. For this report, two accidents are modeled, which may be considered worst case situations. The first assumes that a light fixture is shattered during handling by a worker, immediately releasing its entire contents. The second assumes that the threshold lights plus eight edge markers are destroyed at a runway accident, immediately releasing their contents.

Radiation doses from airborne materials, such as tritium are dependent upon the concentrations of the radioactive material. The equations, which are used to estimate air concentrations, are not valid for distances less than

(a) Activity is determined quantitatively by how many atoms are disintegrating or emitting particles (for tritium beta particles) per second. Thus, if the activity is 3.7×10^{10} disintegrations per second, the amount of radioactive material is 1 curie (1 Ci).

about 100 meters from the point of release. For this reason, it is often necessary to rely upon data developed from routine handling of accidents which are a rare consequence of laboratory procedures and the research and development process.

Perhaps the most relevant examples are incidents of this type, which occurred at Oak Ridge National Laboratory[a] and Pacific Northwest Laboratory during the preparation of tritium light tubes or other work related to the Alaskan tests held during the winter of 1983-84. Individuals working in the area when the tubes were broken have been exposed to released tritium. These individuals had been standing at distances from 0.7 meters to several meters from the tubes when they were broken. In all but one case, the rooms were well ventilated, experiencing 6 to 10 air changes per hour. In one case, a glass tube was broken in a storage area and ventilation was minimal. The glass tube was encased in a Lexan® container, but the Lexan® container was not sealed. Urine samples were obtained from all individuals within 48 hours after exposure. Maximum dose received by any individual was 30 millirem. By way of comparison, the maximum acceptable radiation dose to a radiation worker is 5 rem per year or 3 rem per calendar quarter; thus, in the incident described above, only a small fraction of the allowable dose was incurred. To further put these dose levels into perspective, consider the following: flying in a commercial aircraft from Alaska to the "Lower 48" at altitudes above 33,000 ft exposes the passenger to radiation from solar and cosmic sources, which are not present at the earth's surface. Such radiation is primarily gamma or x-ray and can contribute to radiation dose rates of 3.0 millirem per trip, and this exposure increases with increasing altitude and latitude. It is interesting to note that 10 trips are required to produce the same maximum exposure as the tritium tube breakage.

Laboratory experiments have been conducted using swine as the exposed animal[33] where larger dose rates have been observed. An analysis of a scenario using these data was performed and is summarized in Appendix C. However, the long durations of exposure and other variables do not permit

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(a) Letter from Karl W. Haff, ORNL, to G. A. Jensen, PNL, dated April 24, 1984.
® Tradename of General Electric Company Plastics Division.

direct comparison to the above incidents. It is, of course, possible to conceive of an infinite number of accident scenarios which could then be analyzed for risk. At this point, it is not clear what type of scenarios the licensing process will be required to consider; however, the above examples suggest that the probable risk to humans for an RL airfield lighting system is generally minimal.

The second accident situation considered involves the destruction of 22 markers at the end of a runway as may occur consequent to an aircraft crash. The air concentrations of tritium were estimated at distances of 300 feet, 1/2, 1, and 1-1/2 miles from the end of the runway. The air concentrations were estimated using the methods described in Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments of Nuclear Power Plants."[34] The assumptions used in the calculations were that 9,096 Ci of tritium were released and wind was blowing directly from the accident site to the point of calculation with a velocity of 4.5 miles per hour. Calculations were made for points along the centerline of the runway, as well as 30°, 45°, 60°, and 90° from the centerline of the runway. The results of the calculations are shown on Figures 2.2 to 2.6, and Table 2.3. The figures show the integral air concentrations, Table 2.3 shows the radiation dose commitment. All of the doses are less than the maximum values given in 10 CFR 32.24 for a low probability failure condition and, except for the distances less than 300 feet from the end of a runway, all are below the maximum values given in 10 CFR 32.24 for normal use and operation.

These calculations do not estimate the air concentrations and resultant radiation dose commitment to individuals at the point of the accident, such as to a pilot of an aircraft involved in the assumed crash. As mentioned previously, the calculational methods are not valid at very close distances. It can be assumed that the dose commitment to a pilot involved in such a crash, and to bystanders in the plume, will be larger than that to individuals down wind from the accident.

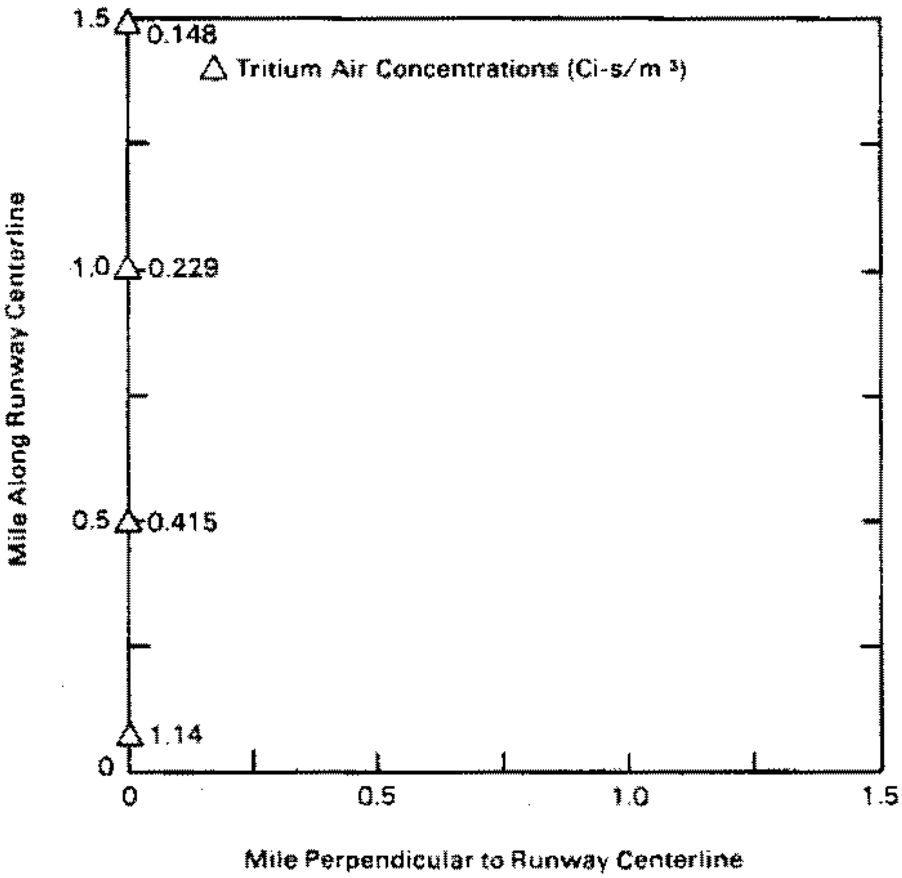


FIGURE 2.2. Integral Air Concentrations on Centerline of Runway

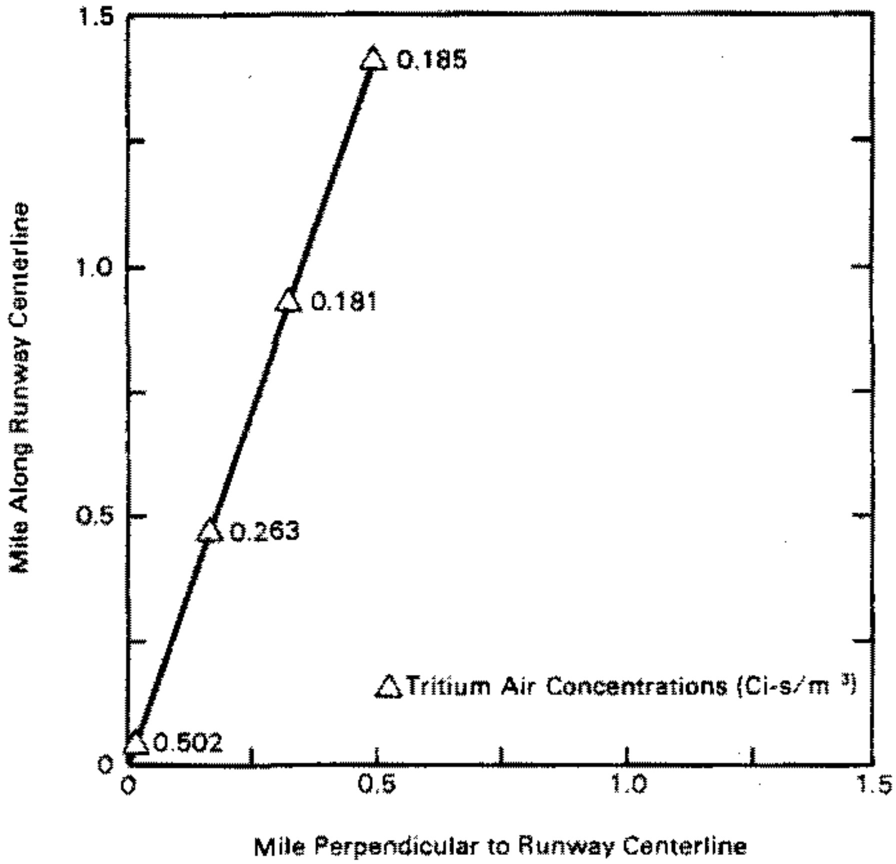


FIGURE 2.3. Integral Air Concentrations 20° Off Centerline of Runway

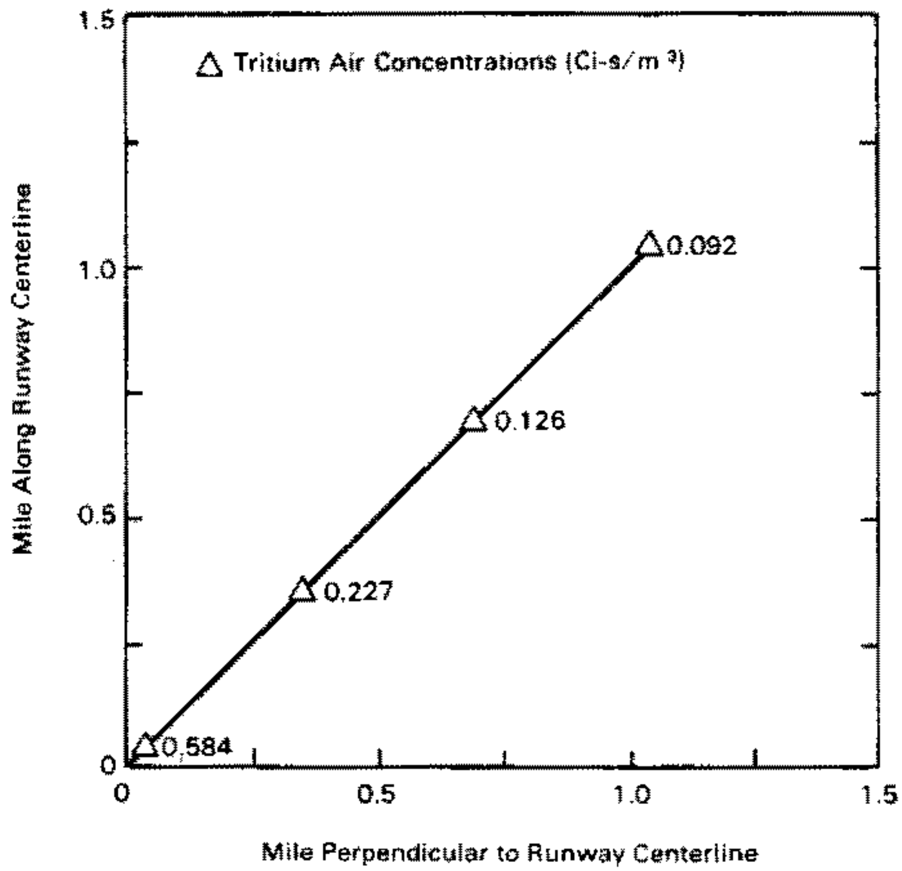


FIGURE 2.4. Integral Air Concentrations 45° Off Centerline of Runway

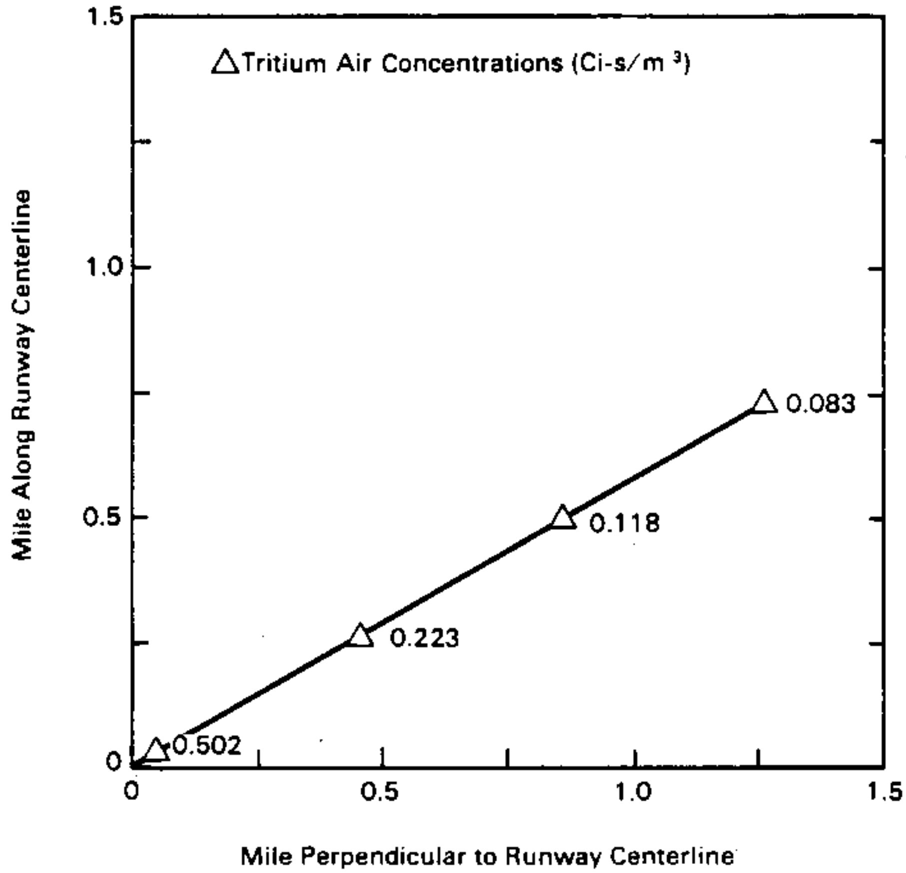


FIGURE 2.5. Integral Air Concentrations 60° Off Centerline of Runway

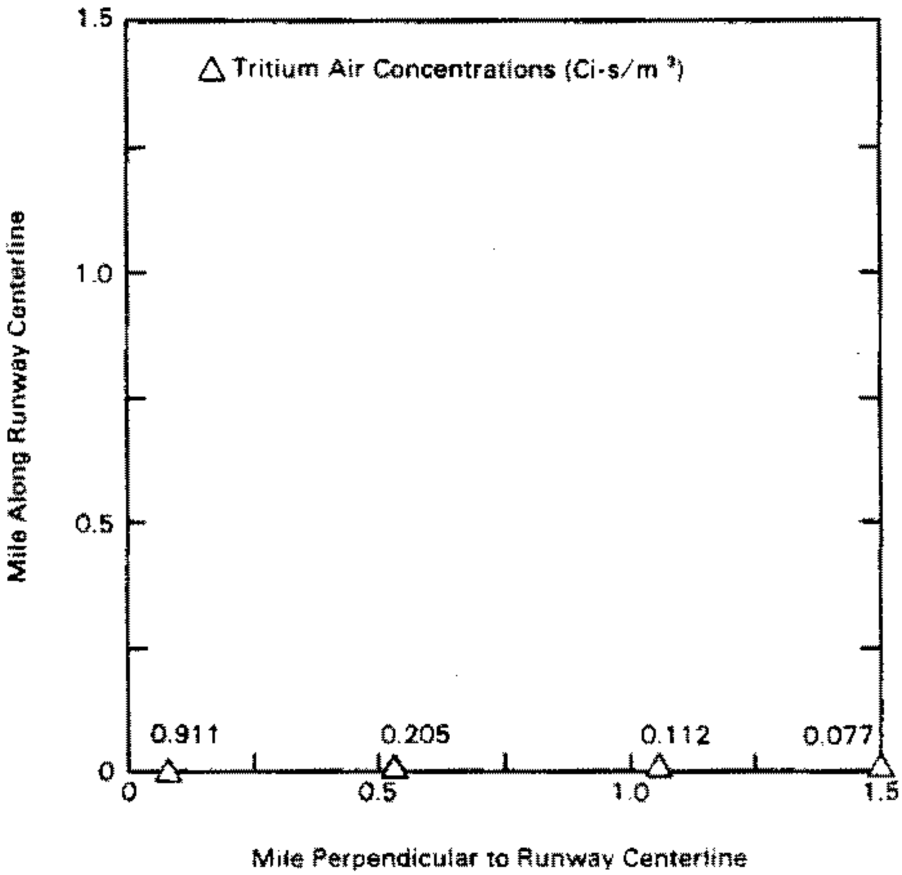


FIGURE 2.6. Integral Air Concentrations 90° Off Centerline of Runway

In summary, the radiation dose from tritium activated runway markers under normal conditions is negligible. The radiation dose commitment to individuals consequent to an accident is due to inhalation of the tritium. Accidental breakage of tubes either in the laboratory or in containers holding glass tubes has produced no significant exposure. Experiments should be performed to measure the actual rate of dispersal of, and exposure to tritium following accidental destruction of a typical fixture.

The major accident involving 22 markers at one end of the runway is anticipated to be a low probability accident. The dose commitments consequent to such an accident are within the range of the maximum allowable dose commitments to members of the population under normal use conditions and are less than the maximum dose commitment for a low probability accident beyond 300 feet from the accident. For the quantities of radioactive material released when 22 markers are destroyed, the radiation dose commitments to persons in close proximity to the accident (within 300 ft) are expected to be large (5.0 rem). However, the exact doses are not known at this time.

The design criteria for items containing generally licensed quantities of radioactive material, as stated in 10 CFR 32.5 (a)(2)(iii), is that the radiation doses resulting from an accident should not exceed the doses listed in column IV of the table contained in 10 CFR 32.24. These doses are 15 rem to the whole body, 200 rem to the extremities and localized areas of the skin, and 50 rem to other organs. An enclosed area accident involving releases to give a dose of these magnitudes requires that the Nuclear Regulatory Commission be notified immediately.

2.4 LICENSING REQUIREMENTS

The Nuclear Regulatory Commission (NRC) is the principal federal agency responsible for licensing uses of nuclear energy. Included in this reponsibility are matters dealing with design, manufacture, distribution and use of most devices containing radioactive materials. Primary legislation for this reponsibility is found in the Atomic Energy Act of 1954. This act assigned primary responsibilities for the promotion and development of peaceful uses of atomic energy to the Atomic Energy Commission (AEC).

TABLE 2.3. Computer Dose Commitments Due to Inhalation of Tritium Following a Major Accident (Dose in rem)

Angle from Centerline of Runway	Distance 300 Ft	1/2 Mile	1 Mile	1-1/2 Mile
On centerline	2.4×10^{-2}	8.7×10^{-3}	4.8×10^{-3}	3.1×10^{-3}
20° off centerline	1.1×10^{-2}	5.5×10^{-3}	3.8×10^{-3}	2.8×10^{-3}
45° off centerline	1.2×10^{-2}	4.8×10^{-3}	2.3×10^{-3}	1.9×10^{-3}
60° off centerline	1.1×10^{-2}	4.7×10^{-3}	2.5×10^{-3}	1.7×10^{-3}
90° off centerline	1.9×10^{-2}	4.3×10^{-3}	2.3×10^{-3}	1.6×10^{-3}

Legislation since this original act, notably the Energy Reorganization Act of 1974, separated the promotional functions from the regulatory functions and created the NRC. By this act, the NRC was delegated authority for handling licensing and regulation of all facilities and materials licensed under the Atomic Energy Act of 1954, as ammended, including such matters as safeguards, transportation, byproduct and special nuclear materials and confirmatory research.

Other federal legislative actions which affect the use of radioluminescent lights in Alaska include the National Environmental Policy Act of 1969 (NEPA) and Executive Order 11514 which sets forth a policy to encourage harmony between man and his environment and the Federal Water Pollution Control Act (FWPCA). The AEC in January 1973 (38 CFR 2679 January 29, 1973) developed a policy statement regarding the effect of ammendments to FWPCA and the AEC's responsibilities in implementing NEPA and FWPCA. This interim policy statement and a memorandum of understanding is still in effect under NRC. It is the provisions of these acts which have allowed DOE and its National Laboratories to bring the lights to Alaska for testing in the winters of 1982-83 and for planned testing in 1983-84. Further licensing of these lights by the State of Alaska for use in Alaska for lighting and marking will be handled under the provisions of this legislation and the rules of Title 10, Code of Federal Regulations, Parts 30 through 35 (10 CFR 30-35).[35] Most of these regulations are directed at use of millicurie quantities of radioisotopes rather than the larger multicurie quantities of tritium, krypton-85, etc., to be used in radioluminescent lights for runway lighting and marking purposes.

The NRC issues either a general or a specific license for use of byproduct[a] materials. A specific license is issued to a named person upon application filed pursuant to the regulations in 10 CFR 30-35. General licenses are effective without the filing of applications with the NRC or the issuance of licensing documents to particular persons. Under Section 31.5, the NRC issues a general license permitting anyone to receive, possess, use, or transfer byproduct material contained in, among other things, "devices designed and manufactured for . . . producing light," provided the devices have been manufactured and initially transferred in accordance with a specific license issued pursuant to Section 32.51, or the equivalent requirements of an Agreement State.[b] For example, commercial aircraft such as Boeing 727's carry about 200 curies of tritium in several EXIT signs and hospitals and buildings using these devices may have up to a total of 1500 curies in various safety lighting items. All of these devices have been manufactured and transferred in accordance with the provisions of 10 CFR 32.51. Alaska is not an agreement state at present and so Alaska DOT&PF would be subject to the provisions of these regulations and guidelines[35,36,37] when using radioluminescent lights. Section 32.51 defines the requirements for NRC issuance of a specific license to manufacture or initially transfer devices containing byproduct materials for use under Section 31.5. The state could insist that each light used be manufactured in a fashion that it could be a licensed item and that the needed quality control and assurance testing are completed. Since each light is expected to contain more than 30 curies of

(a) Title 10 Code of Federal Regulations, Part 150.4 (10 CFR 150.4), "Byproduct material" means: (1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material; or (2) the tailings or wastes produced by the extraction or concentration of uranium, thorium or thorium from any ore primarily for its source material concent, including discrete surface wastes resulting from solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within the definition Ref. 10 CFR 150.4.

(b) Title 10 Code of Federal Regulations, Part 150.4 (10 CFR 150.4), defines an agreement state as follows: an agreement state means any State which the Commission or the Atomic Energy Commission has entered into an effective agreement under subsection 274b of the Act. (Atomic Energy Act of 1954) "Nonagreement State" means any other State.

tritium, the major burden for licensing would be placed on manufacturers, who would be required as a minimum to complete and meet the testing and certification requirements identified in U.S. Department of Commerce/National Bureau of Standards, American National Standard N-540.[37] Specific documentation to meet 32.51 (a)(2)(ii and iii) and 32.51 (b) would be provided by the manufacturer. Other requirements would be met by identifying specific individuals or organizations who had the appropriate qualifications.

In the case of the radioluminescent lights and their use, the required documentation for the State having a license should be minimal. Specific reasons for this are identified in the section on environmental evaluations. The manufacturer's general license for the light itself should suffice providing the state has appropriate storage and handling facilities for use in installation and replacement purposes. At the present time, it is difficult to establish the specific requirements because no precedent exists for use of as large a quantity of tritium (50 to 100,000 curies) as would be required to light a runway. Additional tests may be required by NRC for issuance of a general license. Here again, the manufacturer would have the major responsibility.

Among the specific requirements, which could be imposed under 10 CFR that would pertain to the State of Alaska's use of these devices are the following:

- 30.33(a)(2) (by reference) — The applicant's proposed equipment and facilities are adequate to protect health and minimize danger to life or property.
- 30.33(a)(3) (by reference) — The applicant is qualified by training and experience to use the material for the purpose requested in such a manner as to protect health and minimize danger to life or property.
- 32.51(a)(2) (by reference) — The applicant submits sufficient information relating to the design, manufacture, prototype testing, quality controls, labels, proposed uses, installation, servicing, leak testing, operating and safety instructions, and potential

hazards of the device to provide reasonable assurance that:

(i) The device can be safely operated by persons not having training in radiological protection.

(ii) Under ordinary conditions of handling, storage, and use of the device, the byproduct material contained in the device will not be released or inadvertently removed from the device, and it is unlikely that any person will receive in any calendar quarter a dose exceeding 10 percent of the limits specified in Section 20.101 (i.e., 10 percent of 1.25 rem/quarter for whole body; head and trunk; active blood forming organs; lens of eyes; or gonads; 18.75 rem/quarter for extremities, 7.5 rem/quarter for skin).

(iii) Under accident conditions (such as fire and explosion) associated with handling, storage, and use of the device, it is unlikely that any person would receive an external radiation dose or dose commitment in excess of that specified in column IV of the table in Section 32.24 (i.e., 15 rem whole body, 200 rem to the extremities and skin, and 50 rem to other organs).

• 32.51(b) (by reference) — If the applicant desires that the device be required to be tested for proper operation and for leakage at intervals longer than six months, he must submit additional information for the Commission's consideration on:

1. Primary containment (source capsule)
2. Protection of primary containment
3. Method of sealing containment
4. Containment construction materials
5. Form, quantity, and radiotoxicity of contained radioactive materials
6. Maximum temperature and pressure withstood during prototype test
7. Operating experience with similar devices

The shipment of radioactive material between states by rail, air, road, or water is regulated by the U.S. Department of Transportation as specified in Title 49, "Transportation" of the Code of Federal Regulations, Parts 100-199 (49 CFR 100-199).[38] In special cases, the NRC also regulates the packaging of radioactive material for transport and transportation of radioactive material under certain conditions as specified in 10 CFR 71. In addition, state laws and local ordinances will have to be complied with during shipping of the lights. The details of these requirements are so varied that they will not be summarized here but no difficulties are foreseen in transporting the devices to Alaska if properly packaged and handled. Current state laws and regulations are identified and compiled in NUREG/CR-1263(5.2).[39] Applicable regulatory guides are attached in Appendix D.

In summary, either a general or specific license can be applied to the use or possession of tritium activated runway markers. The license category most appropriate for these devices will be dependent upon the extent to which these markers have been tested and the results of the tests. The tests to which these devices should be subjected are similar to those described in 10 CFR 32.101 Schedule B - Prototype Tests for Luminous Safety Devices for Use in Aircraft, and American National Standard N-540-1975, "American National Standard N-540; Classification of Radioactive Self-Luminous Light Sources." The types of tests required include drop tests, vibration tests, puncture tests, and shock tests. A single marker must be able to pass all tests without breaking or leaking radioactive material. These tests should be performed by the manufacturer.[35,36]

The least burdensome license, from the standpoint of the user, for which tritium activated runway markers would be eligible appears to be as a generally licensed quantity; the quantity of radioactive material is too great to be considered an exempt quantity. However, this general licensed quantity status has not been achieved. Thus, a specific license of broad scope may be necessary. Owing to the fact that these devices are relatively new, the exact restriction that may be imposed upon the licensee are unknown. Discussions with NRC staff have indicated that the restrictions will be dependent upon the tests to which these devices have been subjected and the results of the tests. Specifically, if the lights have not been registered with the NRC, they may be treated as experimental devices and many restrictions may be placed upon the licensee including a requirement for a radiation safety officer, and a radiation safety committee; also the unattended use of these devices may not be allowed. At the same time that a license application is made to possess the sources, a request for a custom review should be made. The request for a custom review is generally made by the user; however, the supporting data requested by the NRC should be provided by the manufacturer. The effect of a successful custom review of these runway markers is that the license restrictions may be no greater than those restrictions placed on generally licensed quantities of byproduct material.

2.5 INSTITUTIONAL ISSUES AND EDUCATION

Public acceptance of the radioluminescent lighting technology at the community level is critical to the overall success of the program. During the demonstration phase, it will be important to understand public concerns with RL lights and to be able to communicate effectively to the public. The main factors that impact public acceptance include: concerns with radioactive substances; perceived costs and benefits of the technology; local economic impacts; direct prior experience with new technology and related developments; role of activist organizations; and characteristics and level of organization of candidate site communities.

Because of the radioactive properties of RL lights, public concern can be expected. Social scientists working in Alaska and individuals involved in public and privately supported environmental organizations vary in their estimates of the degree and character of public concern. However, there is concensus that some public response could be expected regardless of the remoteness of the community. The view was expressed that people would readily see the benefits that would accrue to their village or borough as a result of the installation of the RL lights for airstrips; the benefits of the technology, when clearly understood, should assure rapid acceptance.[a] Another perspective was that some resistance and negative response could be expected with the introduction of these lights, regardless of where they are sited. However, it is also anticipated that once issues are sorted through, the major concern of most groups (in particular, native groups) would be the effect of RL lighting on residents' livelihood.[b]

Public perception of nuclear issues, which is relevant to the acceptance of RL lights, has been found to vary greatly.[40,41] This preliminary investigation suggests that public acceptance of RL lights will vary by the locations of the site communities in the state. Several factors were mentioned in recent discussions with experts in Alaska as potential aspects of geographic differences. For example, it could be expected that to the extent that various population groups have been exposed to the impacts of other development activities, like oil development, they would hold a more cautious view of the benefits of other efforts. Coastal groups were seen as those population areas that could be expected to have the greatest number of formally or informally organized opposition groups that are ready to mobilize and carefully question any new development efforts.[b] Others felt that smaller towns may not be able to mount a response. Also voiced was the view that some villages may oppose most any development simply because of the nature of the residents. One case was cited where villagers living next to a DEW line became concerned regarding the effects of the microwaves on the local

(a) Conversation between Chris Cluett, Human Affairs Research Centers (HARC), PNL, and Dan Rogness of Alaska Public Health Service, Environmental Health Branch, August 2, 1983.

(b) Conversation between Chris Cluett, HARC, PNL, and Patty McMillan, anthropologist with the Arctic Environmental Information and Data Center, Anchorage, Alaska, August 3, 1983.

population.[a] The controversy apparently died down after a government expert was sent in to evaluate the situation.

A public education and information program should be carefully designed to be sensitive to the characteristics of the area where RL lights will likely be introduced and to the particular concerns of the local residents. Thus, the program is being designed not to force a technology on an unwilling public but rather to understand and be responsible to public concerns; that is, the program is designed to create a level of acceptance that will help ensure the success of the program. Some of the issues of public concern that can be effectively dealt with through a program of public education and information include: health and safety issues; RL lights disposal problems; impacts of vandalism and preventative measures; and public participation in siting decisions.

Health and safety concerns with technology development are typically felt by small communities and should be addressed by this program. Concerns, such as whether or not radiation can enter the food chain and arrangements for eventual disposal of the lights are topics that have already been raised[b] and are addressed elsewhere. Other questions that might arise focus on the likelihood that radiation could escape from the lights due to events, such as vandalism. This latter issue is more likely to be a concern in communities where similar events have occurred in the past; preparatory research into the frequency of similar events in candidate communities needs to be evaluated during the demonstration planned at Central, Alaska, this year.

Public information programs or messages are also influenced by the way in which they are delivered: the media (e.g., TV, radio, or newspapers); the source (community opinion leader, public figure, or national political figure); and even the language of such messages influence whether or not people listen to or accept this information.[42,43] Sensitivity to these

(a) Conversation between Chris Cluett, HARC, PNL, and Dan Rogness, Alaska Public Health Service, Environmental Health Branch, August 2, 1983.
(b) Conversation between Chris Cluett, HARC, PNL, and Mary Core, Executive Director of Issues, Alaska Center for the Environment, August 5, 1983.

variables and their application in the candidate communities should be planned for in undertaking a public information program for the demonstration phase.

The objective of these public information programs should be to educate the concerned public regarding both the benefits and the costs of RL lights. In some instances, public information can be adequately distributed in print or electronic media. Because of the likelihood that use of RL light will arouse public concern, provision should be made for a forum for public participation, such as town meeting or other public meeting). Careful preparation is vital regarding issues that are most likely to be of greatest concern to the candidate communities. Analyses of public responses to other nuclear-related technologies and concerns expressed by scientists and environmental groups indicate that health and safety issues will be foremost among public concerns. There is also a recognition that the residents of Alaska are concerned about their traditional way of life; developments that benefit or hinder their capability to sustain themselves in an accustomed manner will be viewed with distrust and opposition. Clearly a public information program prior to the introduction of these lights should be undertaken with careful and thorough consideration of how to present the issues of greatest concern to the candidate communities.

2.5.1 Human Factors Needs

The design of a radioluminescent lighting system for remote Alaskan runways and the demonstration of that system in its design environment presents a number of human factors issues that should be addressed. The following are the major human factors issues that should be investigated in planning for and conducting the demonstration phase of this project.

2.5.1.1 Pilot Acceptance and Performance

The use of RL lighting will present the pilot with unfamiliar visual cues that may affect spacial orientation and depth perception and perhaps other perceptual areas. These factors will, in turn, affect pilot acceptance. There have been a number of studies by the Office of Naval Research, the Air Force Aerospace Medical Division and the FAA in the general area of night approaches and landings using various lighting systems. In addition, the Air

Force is continuing its research in the area of electroluminescence and its effects on aircrew vision. The data from these sources should be reviewed and evaluated as an on-going part of this project.

Of particular importance will be the preflight briefings. These are needed to acquaint the flight crews of the purpose of the evaluation prior to evaluations of lights and the specific data to be collected. If possible, visual aids such as still photography or video tapes of approaches to RL-lighted runways need to be included. In addition, the post-flight debriefing/data acquisition protocols are being developed. These should be sharply focused, asking such questions as: "At what altitude and attitude did you first detect the runway?" rather than: "When did you first see the lights?" The DOT&PF questionnaire used in the 1983 testing at Malamute Airfield could be used as a starting point.

2.5.1.2 Personnel Training

The use of RL lighting may require special training for the people who handle, store, install, maintain, and dispose of system components. These requirements should be defined as an integral part of the effort and evaluated during the demonstration phase.

In formulating specific training requirements, a scenario should first be developed for the demonstration. The scenario should then serve as the basis for determining the tasks required of people who will handle, store, maintain and dispose of the system. This, in turn, will lead to a list of training requirements and a training plan. In addition, a plan for data collection and analysis should be developed.

2.5.1.3 Operating and Maintenance Procedures

Concurrent with the identification of training requirements, it is essential to begin development of procedures for all phases of the project. This includes the identification, handling, and disposal of damaged components that might pose a hazard to people. The task analysis mentioned above will yield information on those tasks that require written procedures and also provide a basis for selecting procedure formats. Procedures should be ready, at least in preliminary form, for the demonstration phase so that they can be evaluated for their technical accuracy, acceptance, and usability.

2.5.1.4 Human Factors Engineering Assessment of System Design

The human factors engineering aspects of design should be considered during the design phase and evaluated during the demonstration phase. Factors to be considered are: (1) ease of handling and storage both in transit and on-site, (2) maintenance and test equipment; and (3) component containers especially those designed for shipping of damaged components containing radioactive material.

3.0 ENGINEERING EVALUATIONS AND DESIGN CONSIDERATIONS

3.1 AIRFIELD LIGHTING RESPONSIBILITY

Radioluminescent lighting systems are mainly being developed to serve rural Alaskan airfields up to 4000 feet in length. Single- and twin-engine, light intermediate speed aircraft are the primary traffic at these airfields. The supply, installation, and maintenance of any runway lighting system is normally the responsibility of the airport owner/operator. Of specific concern are the airports owned and operated by the Alaska DOT&PF. However, any airport lighting system is subject to Federal Aviation Administration (FAA) approval before it can be used by commercial pilots for night operation while carrying passengers. Under current FAA regulations, the minimum airfield lighting system acceptable for use at State-owned and/or operated airports would be a Medium Intensity Runway Lighting System (MIRL) as described in FAA advisory circular No. AC 150/5340-24. Since federal regulations permit no modification to lighting specifications at the Regional level of FAA (in this case the Alaska Region) at the present time, the RL system clearly cannot be considered as substitute to a MIRL. However, FAA does recognize that special circumstances may necessitate night operation of an aircraft in and out of an airfield that is not equipped with a MIRL system. For this reason, the FAA regional authority may permit a specific air carrier to conduct night operations at an unlighted airfield if illuminated by flare pots or lanterns. This process is administratively addressed by FAA through modification to the operator's specification, which is issued to licensed air carriers under Part 135.229 FAR.

Since the RL system is not expected in the near term to be a completely acceptable alternative to an MIRL system until operational experience is gained, it must be treated administratively as a flare pot or lantern alternative for an administratively acceptable definition. With this distinction in mind, the development of a RL system will continue toward eventual implementation into routine use in Alaska with the following authorities and points of cooperation required:

ENTITY	ACTION	EFFECT
United States Department of Energy	Must transfer technology to private sector and make enough tritium available to industry.	Commercial and competitive interest is aroused.
Commercial manufacturer	Apply for and receive NRC general license to manufacture and sell RL airport lighting system components.	Equipment becomes commercially available.
State of Alaska Department of Transportation and Public Facilities	Procure and install a standardized RL lighting system, which FAA has received acceptable, at an airport.	A runway marking system is installed.
A commercial air carrier that desires to utilize the system for night operations.	Apply to FAA for a modification in their operating specification and negotiate with FAA the specific details of operation granted under the modification.	Night operation is permitted under a prearranged set of criteria.
Alaskan Region Federal Aviation Administration	Develop a policy to deal with improved flare pot systems for commercial carriers under Part 135 FAR and general aviation.	A routine procedure is established that will permit improvements in safety and air service to the consumer.

3.2 DESIGN DEVELOPMENT

A RL system suitable for use in Alaska at rural runways has begun to evolve. At a demonstration of tritium wands (see Figure 3.1) used for airfield marking at Bouge Field, North Carolina, in August of 1982, DOT&PF personnel first observed the lights. PNL personnel had observed earlier versions of the RL lights but not the wand. This demonstration was sponsored by DOE and was conducted by Oak Ridge National Laboratory. From this point an iterative process of design modification and evaluation has continued and is still in progress.

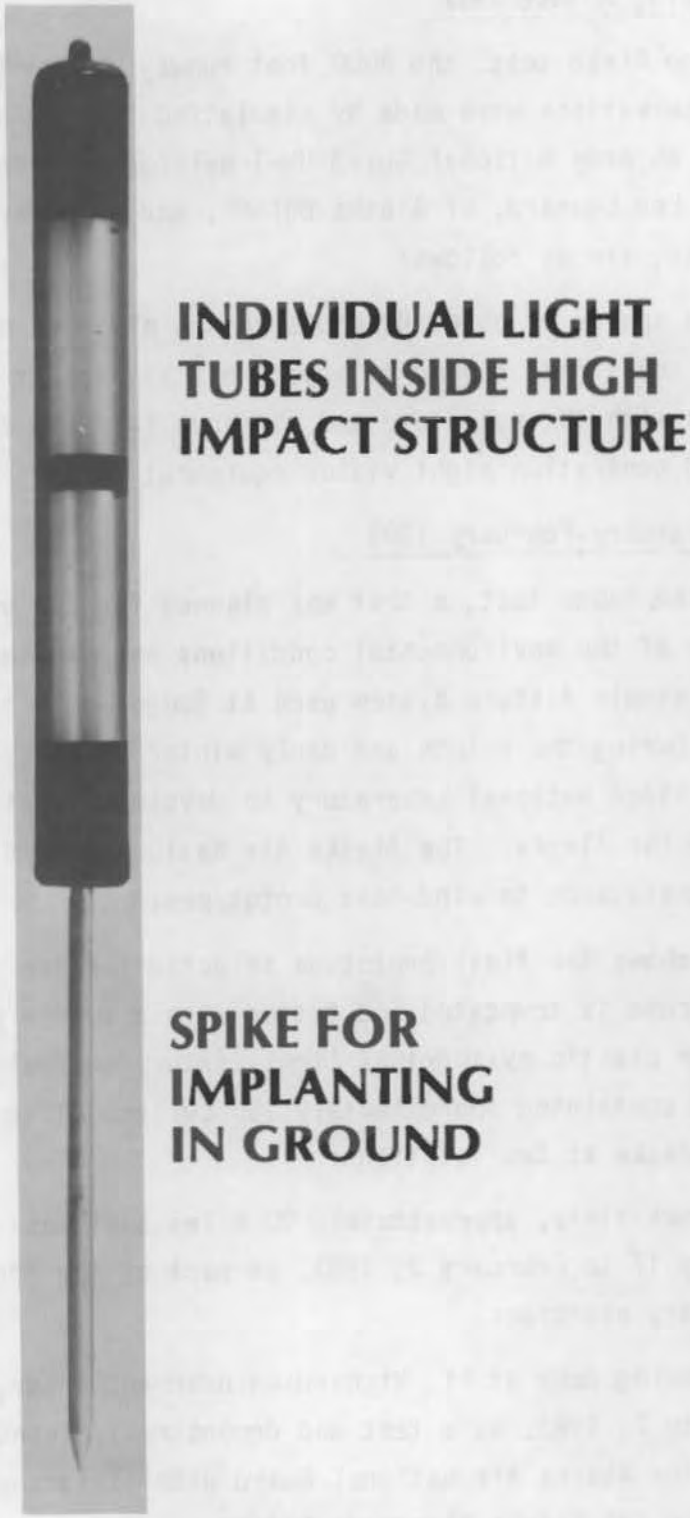


FIGURE 3.1. RL Wand

3.2.1 Bouge Field, August 1982

At the Bouge Field test, the 4000 foot runway was configured as shown in Figure 3.2. Observations were made by simulating fixed wing aircraft approaches with an Army National Guard UH-1 helicopter. The results of these observations by Lee Leonard, of Alaska DOT&PF, and Lyle Perrigo, of Battelle Alaska Operations, are as follows:

> At approach speeds of about 80 knots and an altitude of about 1000 feet, the lights seemed to appear all at once at about 1 to 1-1/2 miles with the naked eye and at about 1-1/2 to 2-1/2 miles with second generation night vision equipment.

3.2.2 Alaska, January-February 1983

Following the Bouge test, a test was planned for the winter of 1982-83 in Alaska. Because of the environmental conditions anticipated in Alaska, it was agreed that the simple fixture system used at Bouge would not be adequate for use in Alaska. During the autumn and early winter of 1982, DOT&PF and PNL worked with Oak Ridge National Laboratory to develop a portable fixture element suitable for Alaska. The Alaska Air National Guard provided logistic support by and assistance to wind-test prototypes.

Figure 3.3 shows the final prototype selected for use. A break-away plastic traffic cone is truncated and fitted with a wooden plate to receive a six-inch diameter plastic cylindrical light fixture enclosing four tritium wands, each wand containing approximately 100 curies. This basic fixture was then tested in Alaska at two locations:

1. At Clear Creek strip, approximately 20 miles southeast of Fairbanks, from January 17 to February 2, 1983, as part of the "Brimfrost-83" joint military exercises.
2. Malamute Landing Zone at Ft. Richardson near Anchorage, Alaska, on February 4 to 7, 1983, as a test and demonstration conducted by the DOT&PF and the Alaska Air National Guard with assistance from the Alaska Region FAA Flight Standards Office.

Field support for both the Clear Creek and Malamute tests was provided by DOT&PF, ORNL and PNL.

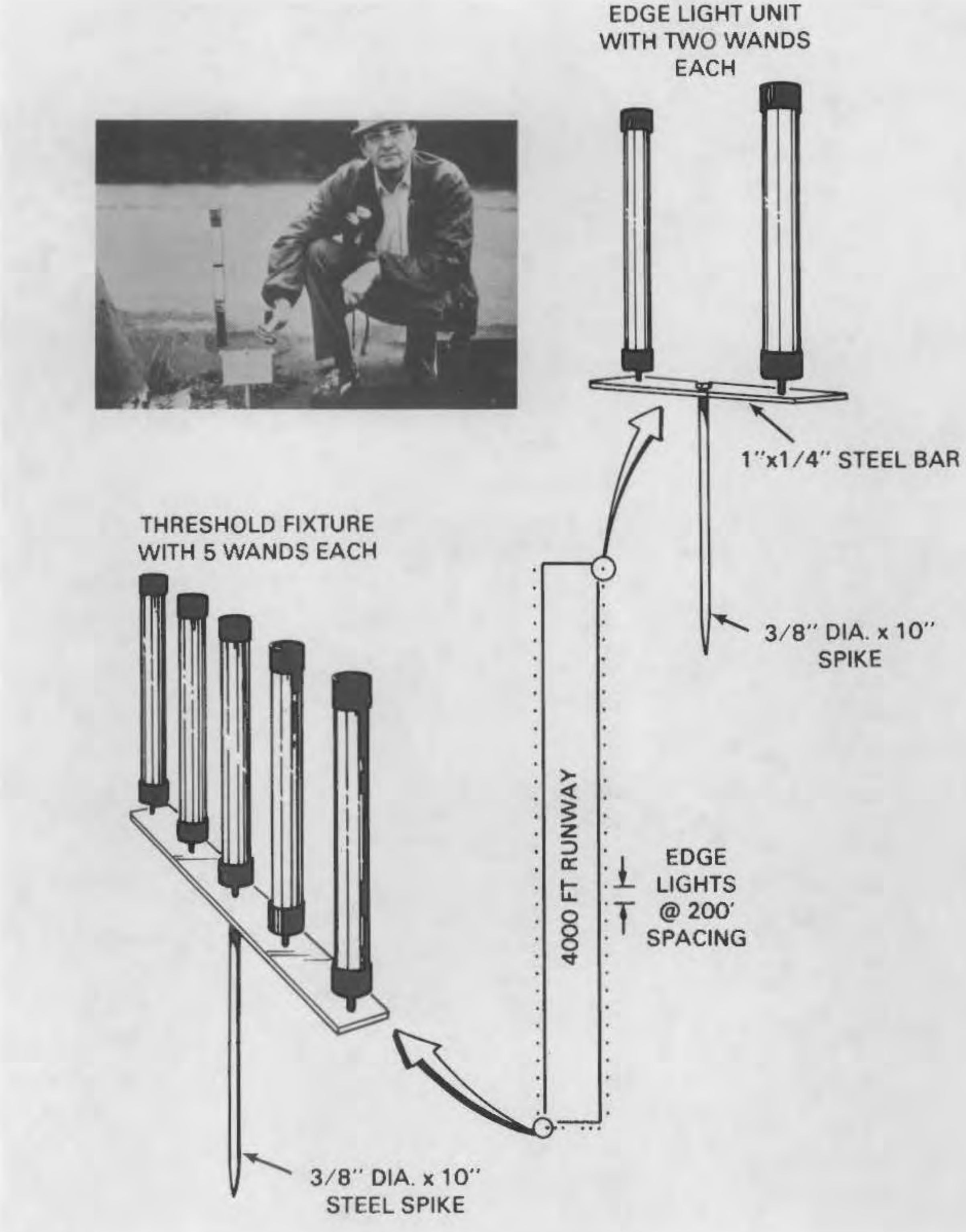


FIGURE 3.2. Bogue Field RL Lights and Fixture

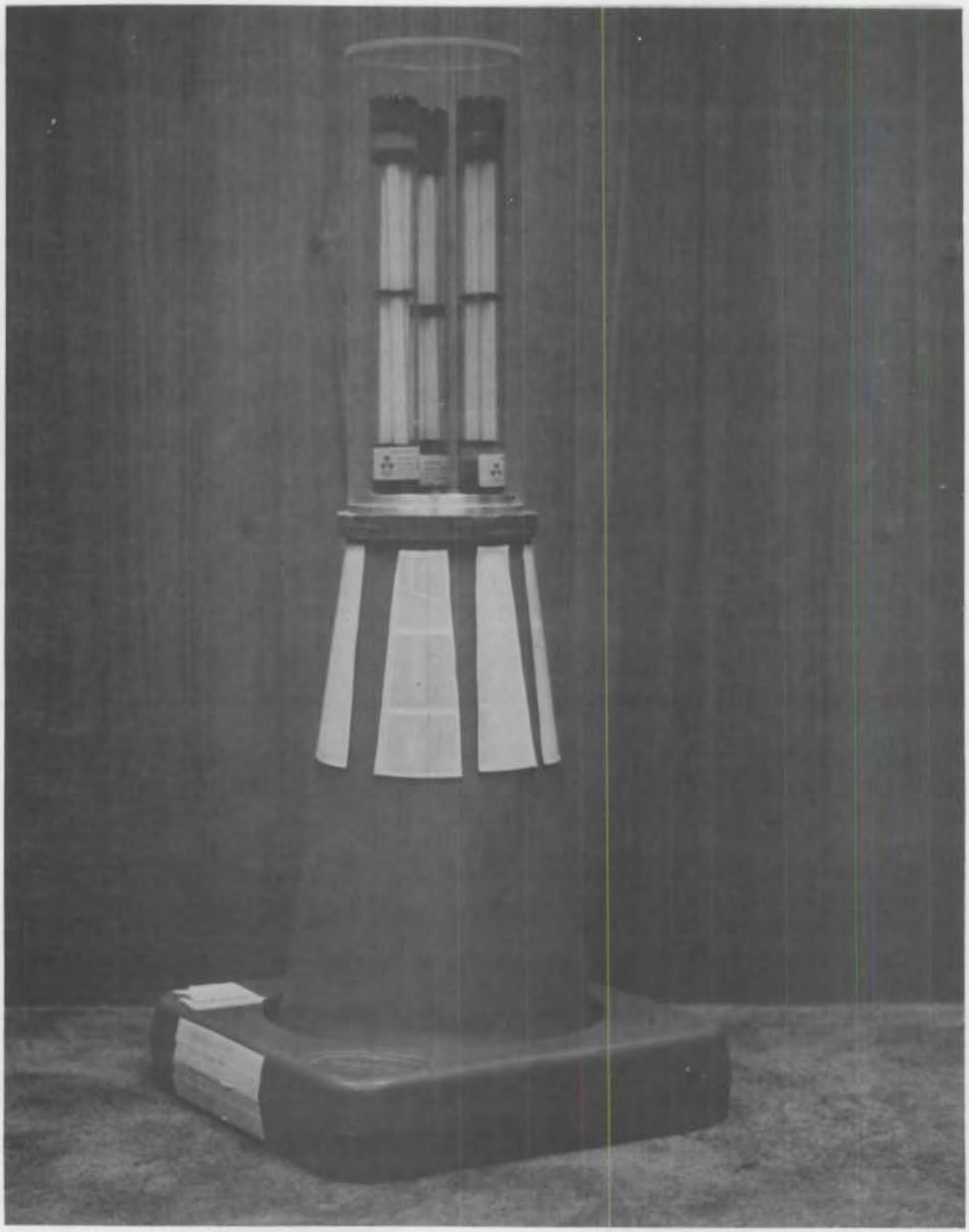


FIGURE 3.3. Prototype Light Fixture

The Brimfrost test provided little information to the DOT&PF as far as gathering data on light aircraft operation to the RL system because flight operations were largely limited to C-130 or UH-1 aircraft. However, the test was a good shakedown for both the U.S. Air Force and DOT&PF. Pilot observations were gathered and considered for eventual system improvements.

3.2.2.1 "Brimfrost 83" Tests

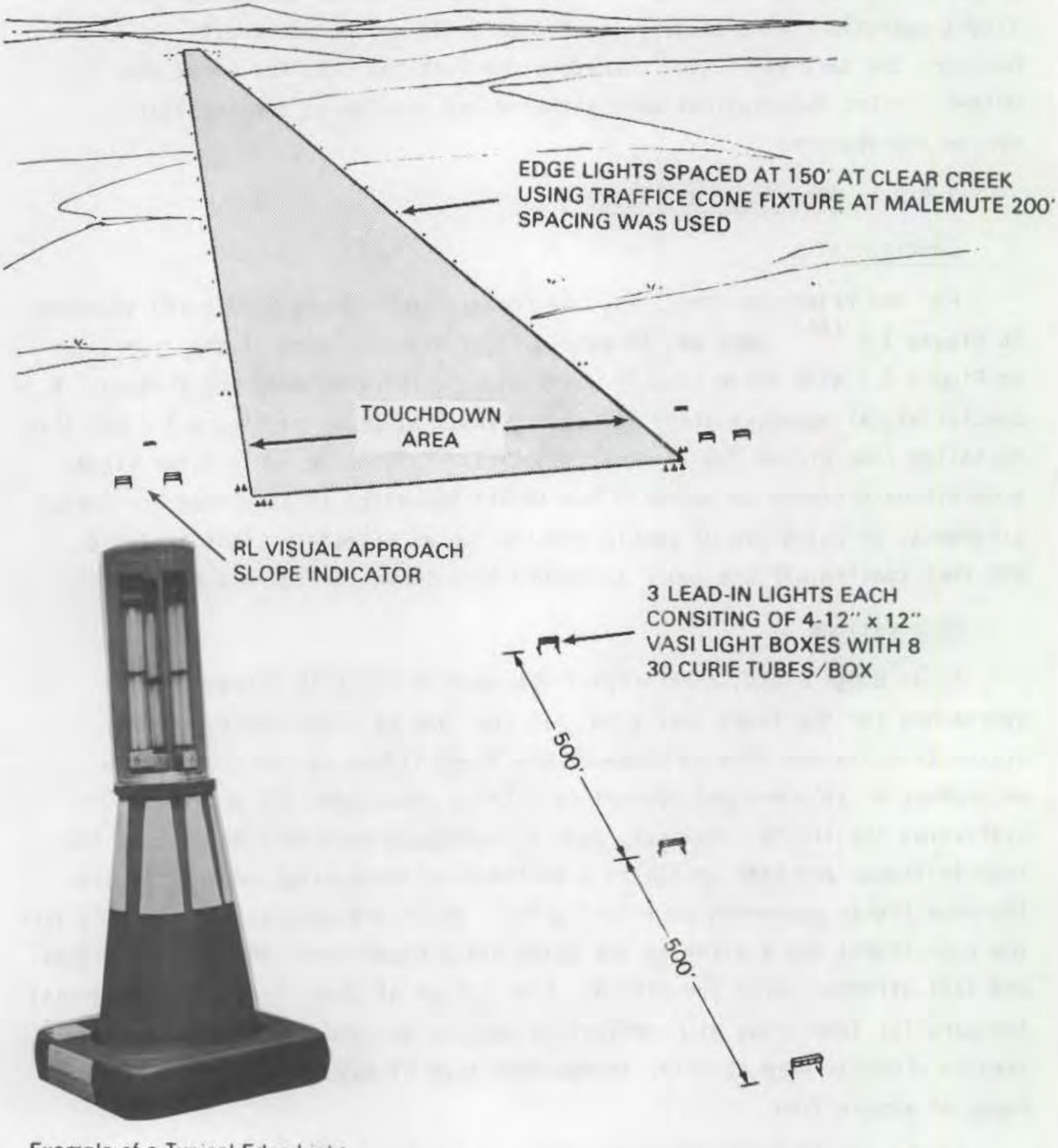
Configuration

For the Brimfrost exercises, the runway lighting was configured as shown in Figure 3.4.[44] Edge and threshold light fixtures were of the type shown in Figure 3.3 with three visible wands and one infrared wand per fixture. A special visual approach slope indicator (VASI) as shown in Figure 3.4 was also installed (see Figure 3.5 for the geometry). To provide for greater visual acquisition distance on approach and to aid the pilot in acquiring horizontal alignment, an extra set of panels were set up as a lead-in light array at 500 feet spacing off the south threshold also shown in Figure 3.4.

Observations

As at Bouge Field, a helicopter was used to simulate fixed-wing approaches for the field test crew. In the case of Clear Creek, several distractions in the form of incandescent flood lights in the area of the encampment of soldiers and support facilities compounded the problem of evaluating the lights. However, several observers were able to pick up the lead-in lights and VASI system at a distance of three miles or greater with the edge lights appearing at 1 to 2 miles. While the acquisition distance for the edge lights was similar to the Bouge Field experience, the lead-in lights and VASI affected pilot perception. Evaluations at Clear Creek indicated that the parallel tube array with reflective backing as used in the VASI and lead-in elements were superior to the wand-type of edge lights for absolute range of acquisition.

Air Force pilots flying C-130 aircraft and landing at Clear Creek Airfield were asked to evaluate the lights as an operational system. The



Example of a Typical Edge Light

FIGURE 3.4. RL Runway Lighting Configuration as Used at "Brimfrost 83" and "Malamute Landing Zone 83"

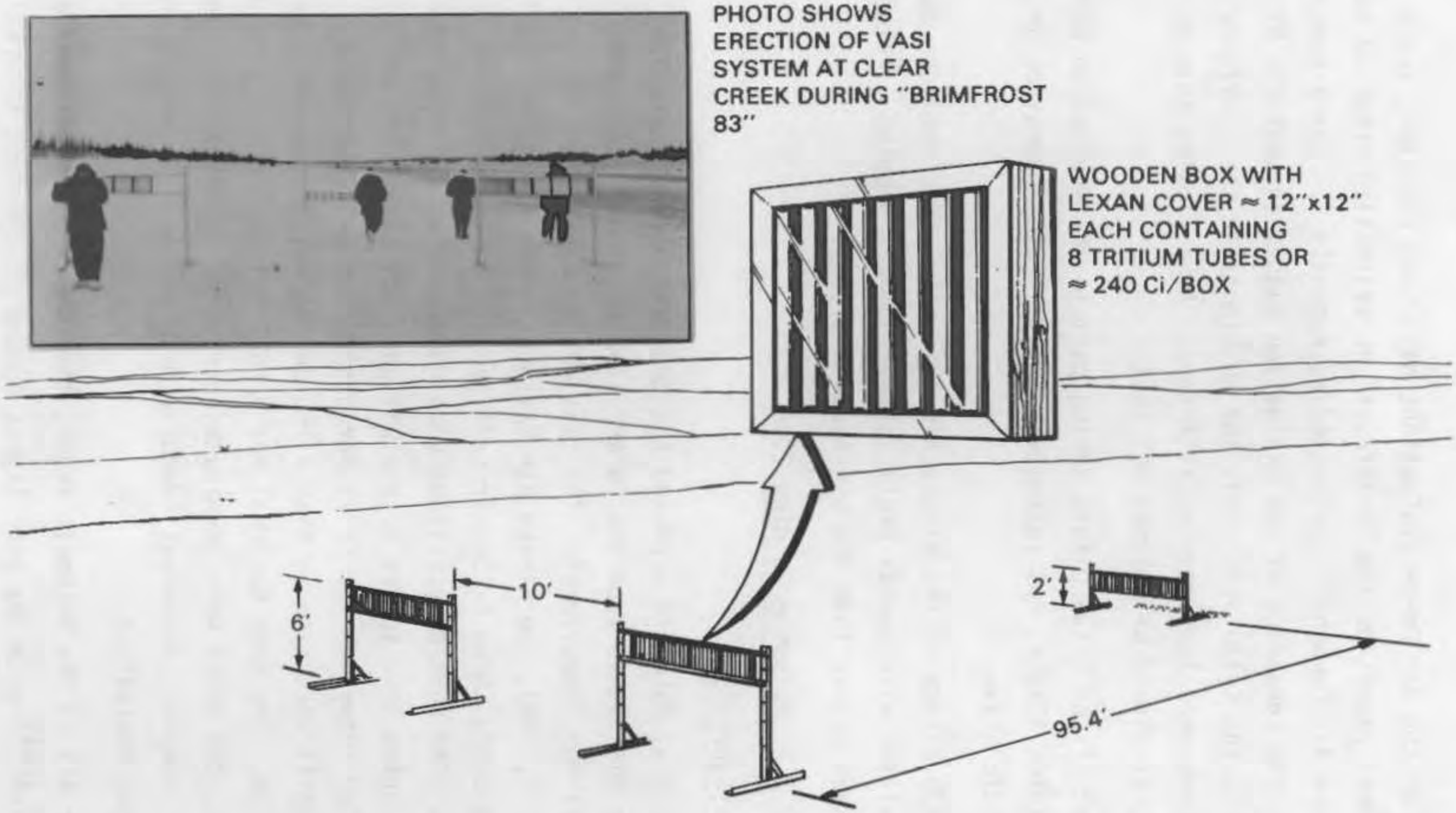


FIGURE 3.5. RL Visual Approach Slope Indicator (VASI)

results of the Air Force evaluations have been reported, and a copy of the operational report on the "Brimfrost" RL evaluation prepared by Major Hult of the Alaska Air Command is presented as Appendix E. For a number of possible reasons, the consensus of the evaluation suggested that for Military Airlift Command (using C-130 aircraft), the RL lights in the configuration used at Clear Creek were less than satisfactory. As a closing note to this test, however, it should be pointed out that:

1. Most of the C-130 pilots taking part in the evaluation were from outside Alaska, not intimately familiar with operation in remote Arctic areas.
2. C-130 pilots of the Alaska Air National Guard, who were more familiar with remote Arctic operations and problems, rated the system higher than the non-Alaskan pilots.

3.2.2.2 Malamute Landing Zone

Configuration

Tests at Malamute produced the greatest body of data from which to evaluate the lights from the DOT&PF standpoint and their effectiveness and the potential for improvement. The test period was short. On the evening of February 5, 1983, the Alaska Air National Guard flew about 23 landings and takeoffs using three C-130 aircraft as part of their routine training program. The next observations were conducted on the evening of February 7, 1983. During this series of evaluations, low approaches were flown over the RL lighted runway by Air Force personnel in a C-12 (Beech King Air). Landings and takeoffs were made by Alaska region FAA Flight Standards personnel in a Cessna 206. The Army National Guard UH-1 helicopter was also used. On this occasion, the tests were terminated early due to onset of a heavy snow shower. However, there was adequate data acquired to result in a most meaningful evaluation.

For all of the Malamute tests, the runway was configured as shown in Figure 3.4[44] with the edge lights spaced at 200-foot intervals. The lighting configuration was fundamentally that of the Brimfrost tests with the addition of a wind direction indicator as shown in Figure 3.6. Each of

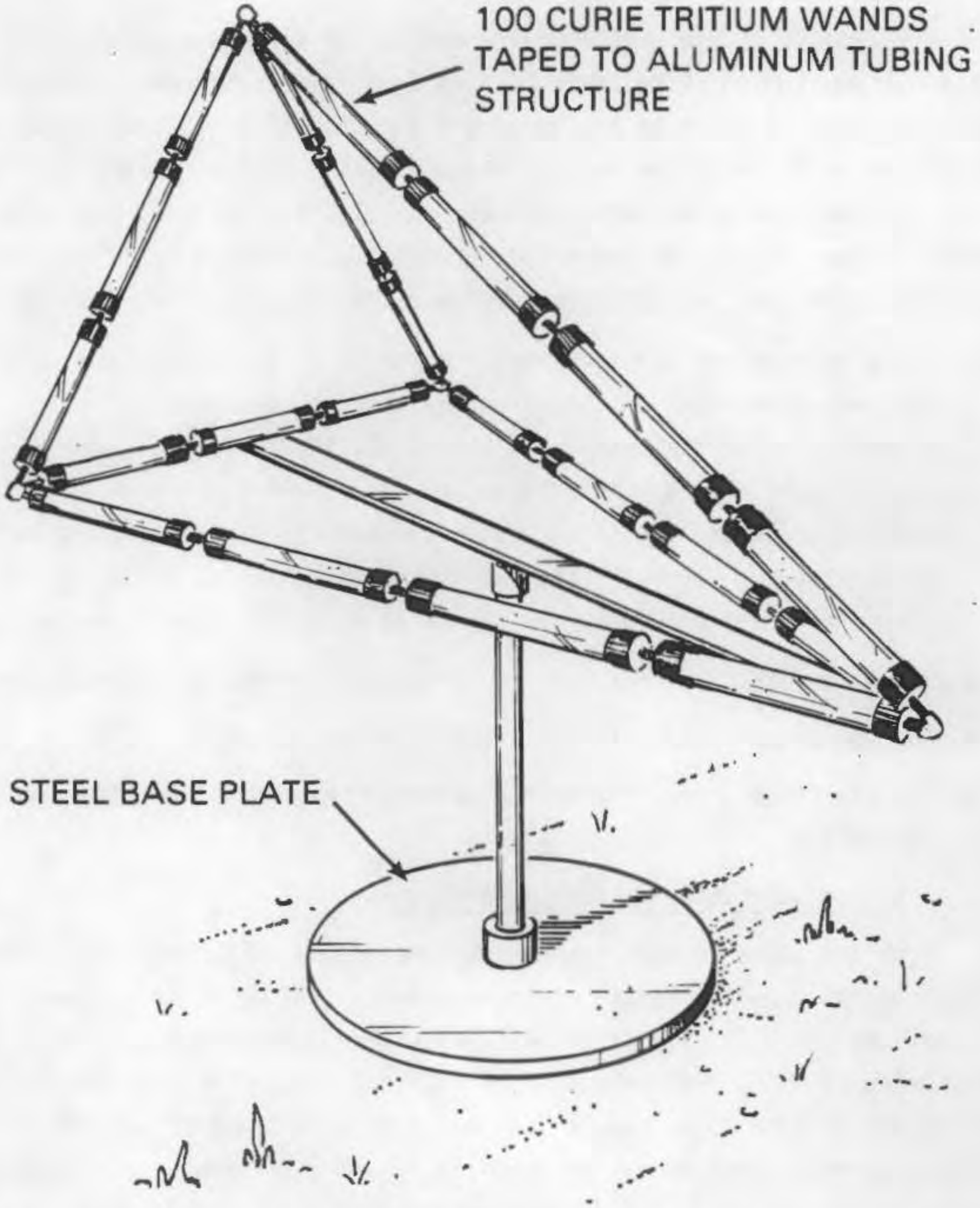


FIGURE 3.6. Wind Direction Indicator Used at "Malamute 83" Tests

the observers who took part in the Malamute tests were asked to complete a questionnaire. A sample questionnaire and the summary of the evaluation are presented as Appendix F.

Observations

The results of the questionnaire evaluation clearly suggested that the RL system as configured at Malamute Landing Zone held considerable potential for rural airports of the type now owned and operated by the State of Alaska. The evaluation also identified several areas in which design changes were needed in the system. After a debriefing held at Kulis Air National Guard Base by DOT&PF on February 8, 1983, general agreement was reached by DOT&PF and PNL/ORNL staff that the following system design changes were required.

- Since tritium was the most costly material in the system and since the amount of light emitted from the fixture was roughly proportional to the tritium it contained, the threshold fixtures should contain more tritium than the edge light fixtures. This would concentrate the light around the ends of the runway, enhancing visibility and improving the ability of the pilot to align the aircraft with the runway. This idea is illustrated in Figure 3.7.
- The wind direction indicator would need to be completely redesigned.
- The use of reflectors in the light fixtures should be tested.
- The FAA filed a report with the regional Chief of Flight Standards, Appendix G.

3.2.3 Second Generation Prototype Development

From the above fundamental design conclusions, ORNL began a concentrated effort to redesign the system with the primary goal being to increase the distance at which the lights could be seen from approaching aircraft. During the spring of 1983, ORNL experimented with polished metal reflectors. A redesigned tritium tube, Figure 3.8, was placed in front of parabolic reflectors in a panel array, as shown in Figure 3.9; or were configured as single units. Based on the assumption that reflector panels would be used in the threshold regions of the runway, Alaska DOT&PF research staff suggested a

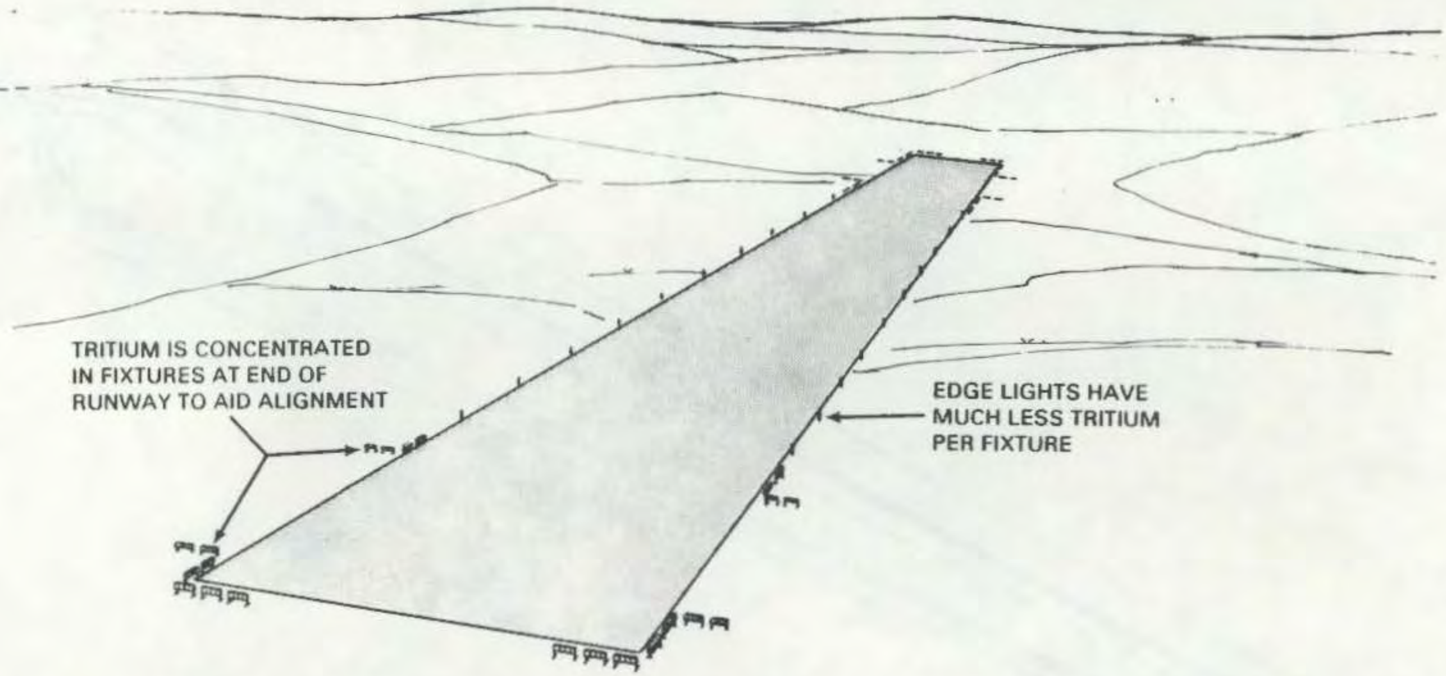


FIGURE 3.7. Conceptual RL Runway Lighting Configuration Based on MAC 55-130. Edge lights use 1 panel, 483 curies of tritium, while threshold areas use 4 or 5 panels per fixture, 1932 to 2415 curies of tritium.

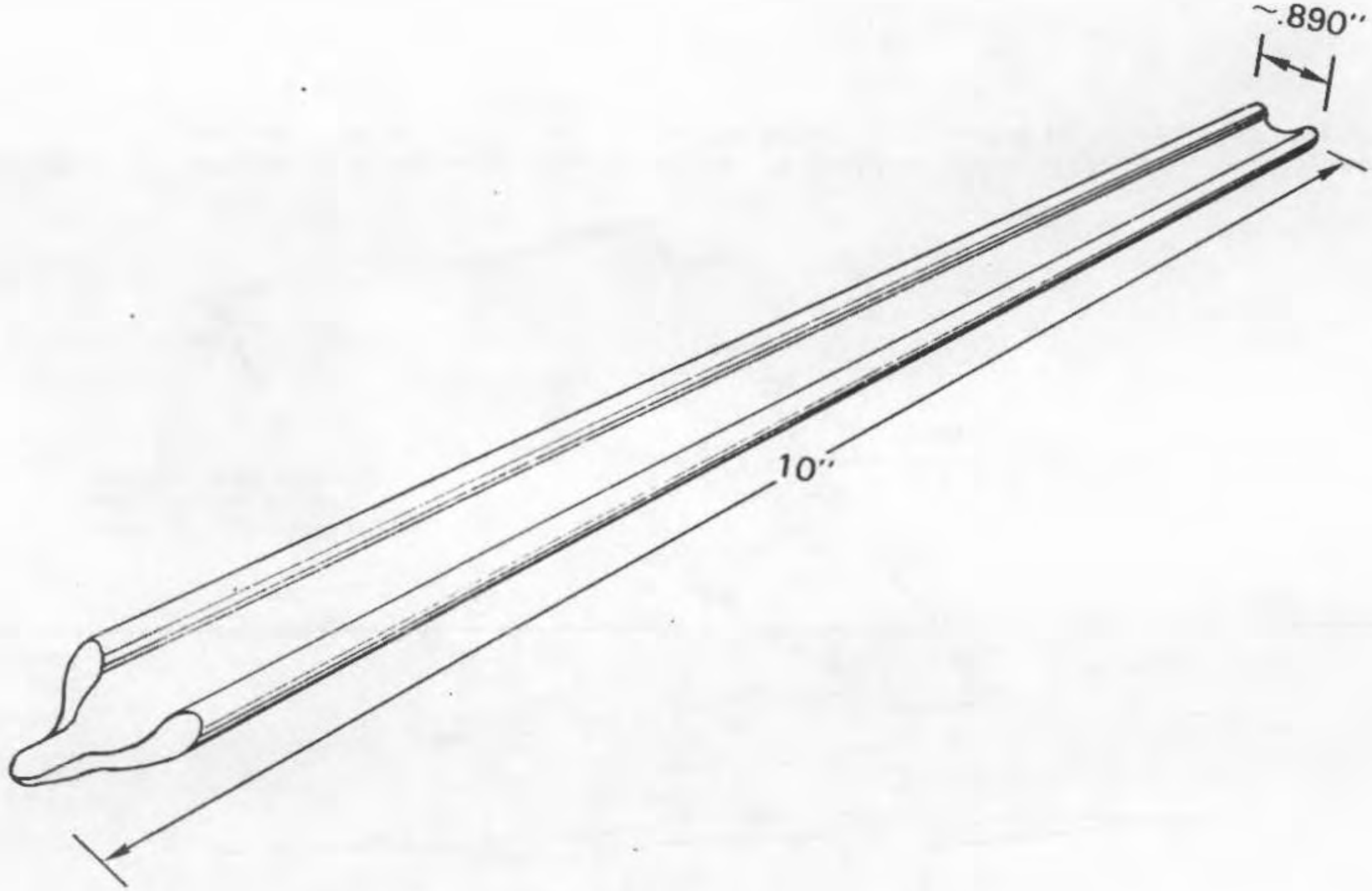


FIGURE 3.8. Tritium Tube for Second Generation Units

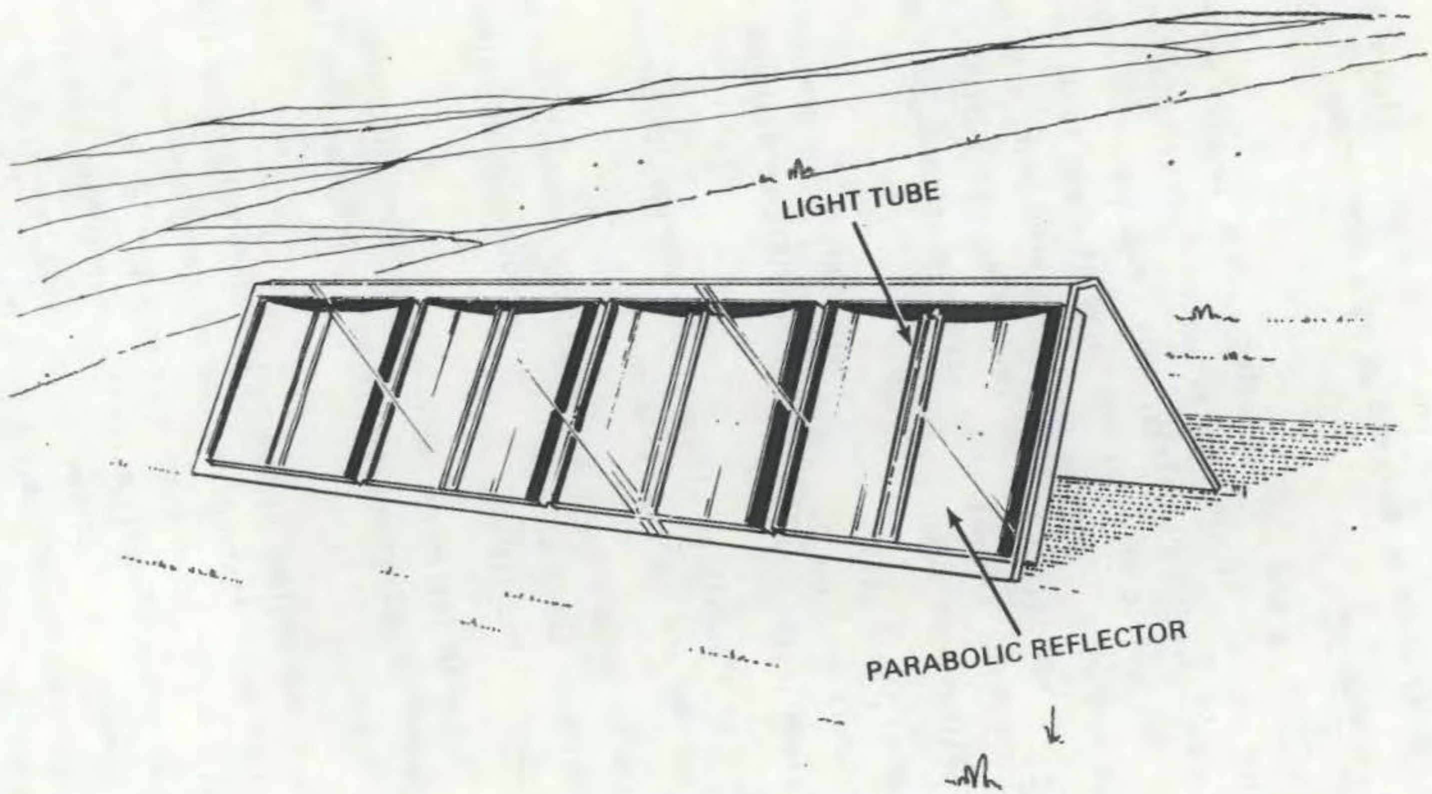


FIGURE 3.9. Redesigned Panels in Panel Array

design scheme conforming to the lighting layout shown in Figure 3.7 in which the ends of the runway would be enhanced using a panel array.

Preliminary Evaluation

On August 19, 1983, a test was conducted at ORNL to evaluate the parabolic reflector panels. It had been estimated from calculations that 4 to 6 miles could be expected. Unfortunately, this range was not achieved. For the tests, several threshold configurations based on those shown in Figures 3.2 and 3.4 were used. Weather conditions were poor, with haze, broken cloud cover, and visibility limited to 3 miles. In addition, moonlight illumination was 75 percent. Ambient light was variable throughout the test. The following observations were made:

- Acquisition of the lights was not significantly improved using the reflector panels over the 2- to 3-mile acquisition distance found in earlier Alaskan tests.
- No difference in acquisition distance was observed for panels used in Alaskan testing and the new reflector panels.
- The use of the reflectors makes alignment very critical, and the lights fade whenever exact alignment is not obtained regardless of viewed distance from the lights.
- The improved tube with its increased tritium content, improved phosphor and geometric design was significantly brighter than the earlier tubes tested.

Following this test, it was decided by the Technical Working Group (TWG) that ORNL needed to construct panel fixtures using a modular element, as shown in Figure 3.10, as the basic unit. Seven tubes were used per 12" x 12" module with each tube containing 69 curies of tritium. White polystyrene insulation was used as the reflector element. A prototype system using this type of basic element was evaluated at Camp Mackall, North Carolina, on September 7, 1983. At that test, observers were able to acquire the lighting system at a distance of 4 to 6 miles. A summary of these observations was prepared by Lieutenant Colonel Everett and is presented as Appendix H.

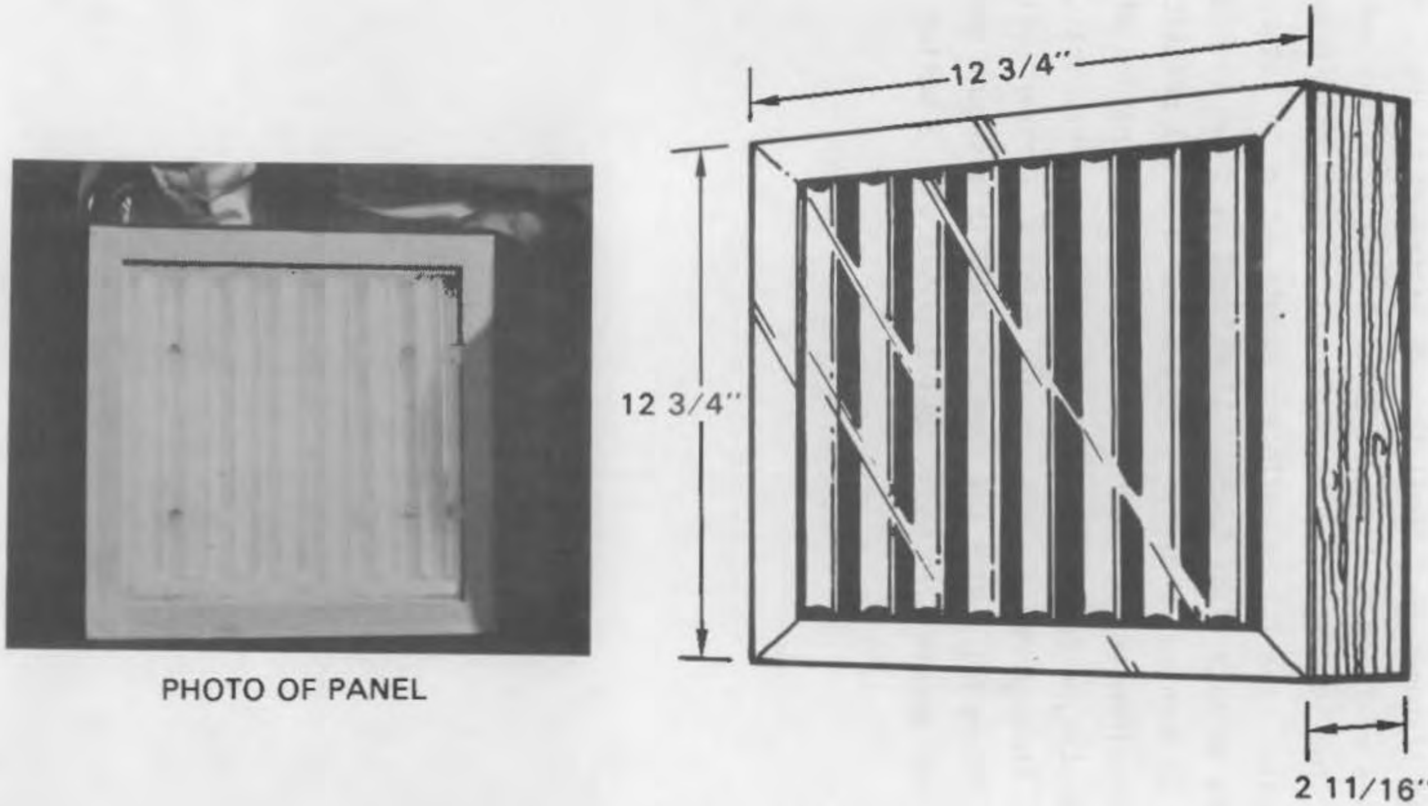


FIGURE 3.10. Second Generation Panel

Based on the results of the developments of various fixtures and the evaluations of these fixtures from April through September of 1983, it was decided that a series of field tests would be conducted in Alaska during the winter of 1983-84. The systems to be tested would be configured from two basic fixture elements: the 7-tube reflector module, shown in Figure 3.10, for panel arrays and an edge light-taxiway light unit as shown in Figure 3.11. Panel arrays would be mounted, shown in Figure 3.12. For all practical purposes then, these elements would effectively be the culmination of the second generation prototype development. Tests and evaluations anticipated for December, 1983, through March, 1984, should point to further refinements in fixture design, if needed. With the completion of this second generation development, it is now possible to begin cost analysis with a better degree of confidence.

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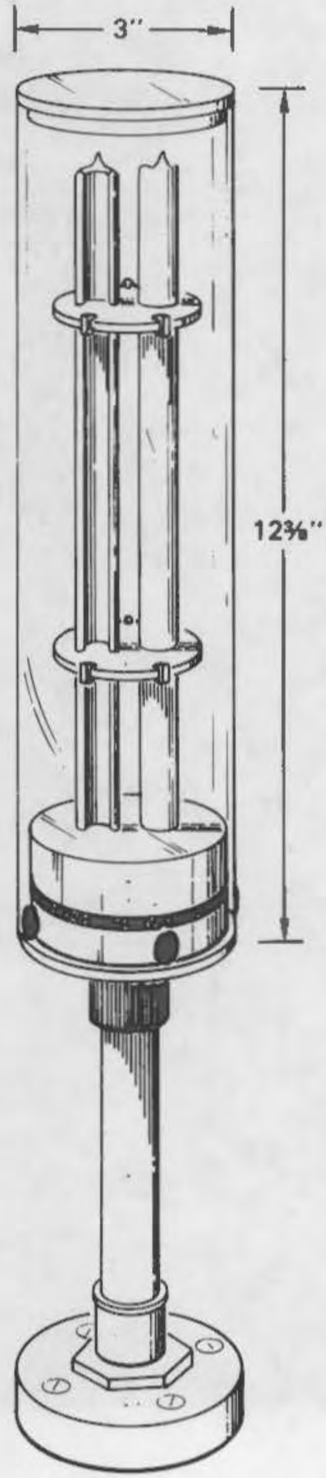

FIGURE 3.11. Edge Light - Taxiway Light

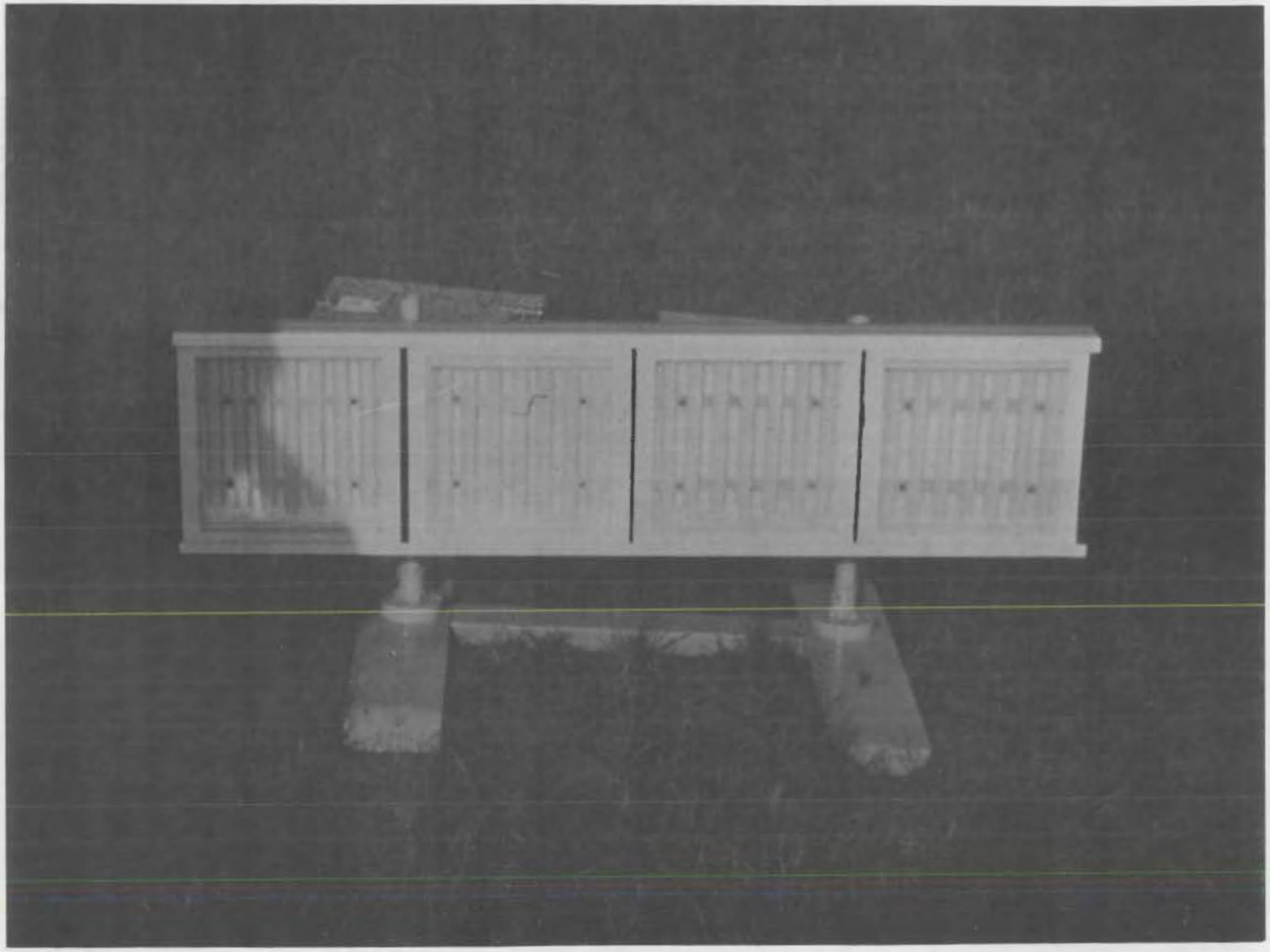

FIGURE 3.12. Panel Arrays

4.0 COST ANALYSIS

4.1 COST OF MANUFACTURE

Manufacture of tritium lights for airfield lighting applications has been confined to ORNL as part of a research and development project. Therefore, all costs discussed in this section will be based on real costs incurred at ORNL for the manufacture of the lighting element of the type to be used for the 1983-84 demonstrations and shown in Figures 3.11 and 3.12. It is anticipated, however, that the lighting elements for operational systems would be manufactured by private industry. At this writing, it is not known how the costs incurred at ORNL would relate to those of a commercial manufacturer. Discussions with potential manufacturers and ORNL staff have suggested certain variations in costs might exist. These speculations will be mentioned in this section, but only the costs obtained from ORNL are included.

4.1.1 Tritium

The most expensive single material contained in any set of RL runway lights is the tritium, and it is expected to remain that way for the foreseeable future. At this time, the only source of tritium within the United States is the Isotopes Distribution Center at ORNL. The current cost to the existing tritium light industry is approximately $1.10 per curie.

4.1.2 Light Elements

The fundamental component of all RL runway light fixtures which make up the second generation system is the tritium tube, shown in Figure 3.8. This item is the only nonconventional portion of the system. Ancillary nardware to support, contain, mount, and house these tubes in various configurations are fabricated from commercial materials. The cost of these fixturing materials are not expected to comprise the biggest expense of the airfield lighting package. At this point, it is anticipated that the cost of a single tritium tube would be as follows:

•	Tritium Tube Cost*
• Tritium 66 curies/tube ($1.10/Ci)	$72.60
• Pyrex glass specially formed (as per Figure 4.1)	15.00
• Phosphor	1.00
• Labor to prepare and load phosphor and tritium	15.00
• Quality Assurance, Testing	20.00
• TOTAL COST	$123.60

* Personal communication from ORNL personnel on several occasions.

4.1.3 Edge and Threshold Lights

Some manufacturers have indicated that the costs for materials, fabrication, overhead, etc., would typically be 25 to 30 percent of the costs of handling and filling the tubes. This does not strictly agree with the ORNL estimate above, but either way it is clear that the cost of tritium is the critical factor in the price of the tube. The cost of the materials, fabrication, and assembly of the fixtures that hold the tubes is estimated to be 2 to 12 percent of the cost of a completed tritium tube. This cost would vary since the cost of a fixture with fewer tubes per unit probably would cost a higher percentage than a fixture with several tubes. Therefore, an edge light fixture like the one shown in Figure 3.11 might cost:

2 x $123.60 = $247.20 for two tritium tubes
+ 12%
$276.86 Total

or, a 12" x 12" panel module, as shown in Figure 3.12, with 7 tubes might cost:

7 x $123.60 = $865.20 for 7 tritium tubes
+ 2%
$882.50 Total

This cost is assumed to be FOB at the factory at an unspecified location in the "Lower 48" states.

Besides the light units themselves, the following costs are associated with lighting a rural airport.

- Transportation of lights from factory to Alaska.
- Purchase of support hardware (panels, stanchions, frangible couplings, etc.).
- Transportation within Alaska.
- Installation contract.

Shipping to Alaska will be via conventional motor freight, which at this time is approximately $90 per 100 lb. Support hardware is conventional steel fabrication, which is typically $3 per lb. Frangible couplings are about $4 each. Transportation within Alaska would most likely be via air freight, which in the most expensive case would require a charter of a light aircraft. Based on communications with air freight carriers in Fairbanks, the maximum transportation costs would be under $3,500 for a set of RL lights with shipping containers. Installation could vary considerably based on specific location and the final design of the mounting hardware. Weather contingencies are always a problem, but the following estimate could be typical for installation:

*Labor - 4 men for 6 days (including travel time)	$ 7,200
Travel and per diem	4,600
Equipment rental	300
Overhead	5,000
Contingency	3,000
Profit 10%	2,000
Total	$22,100

* Assuming a remote location as much as 500 miles from Fairbanks or Anchorage.

Based on the above costs, let us consider three different light configurations which will be evaluated during the winter of 1983-84. The configurations are shown in Figures 4.1, 4.2, 4.3, and represent different amounts of tritium or

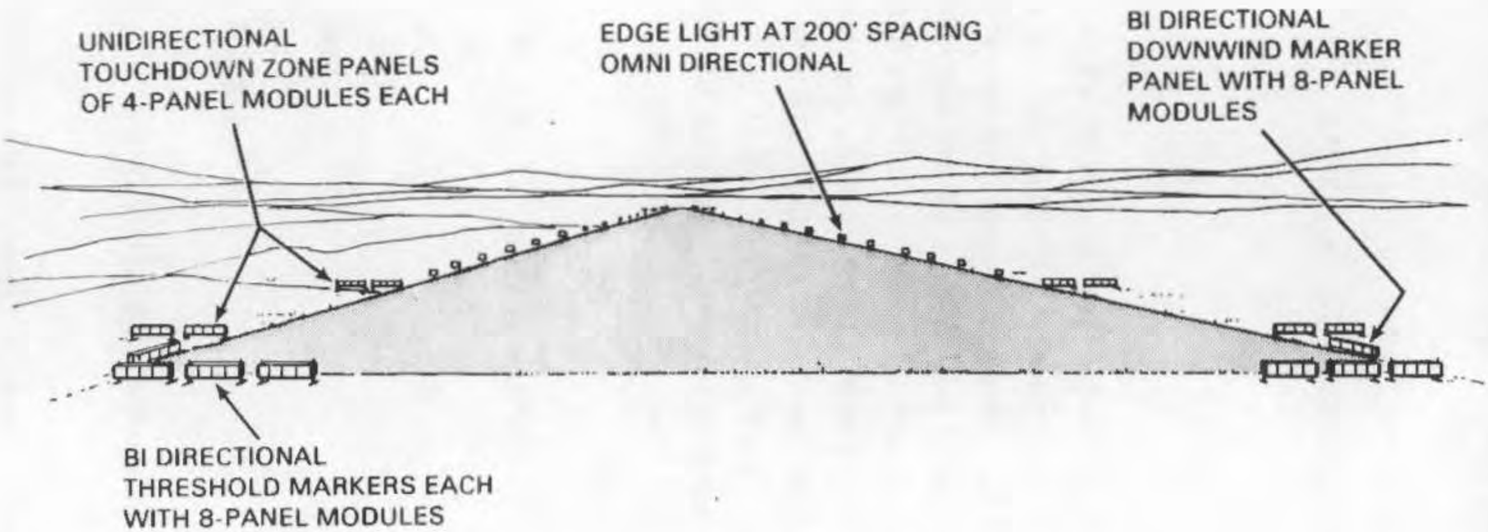

FIGURE 4.1. Military MAC 55-130 Configuration

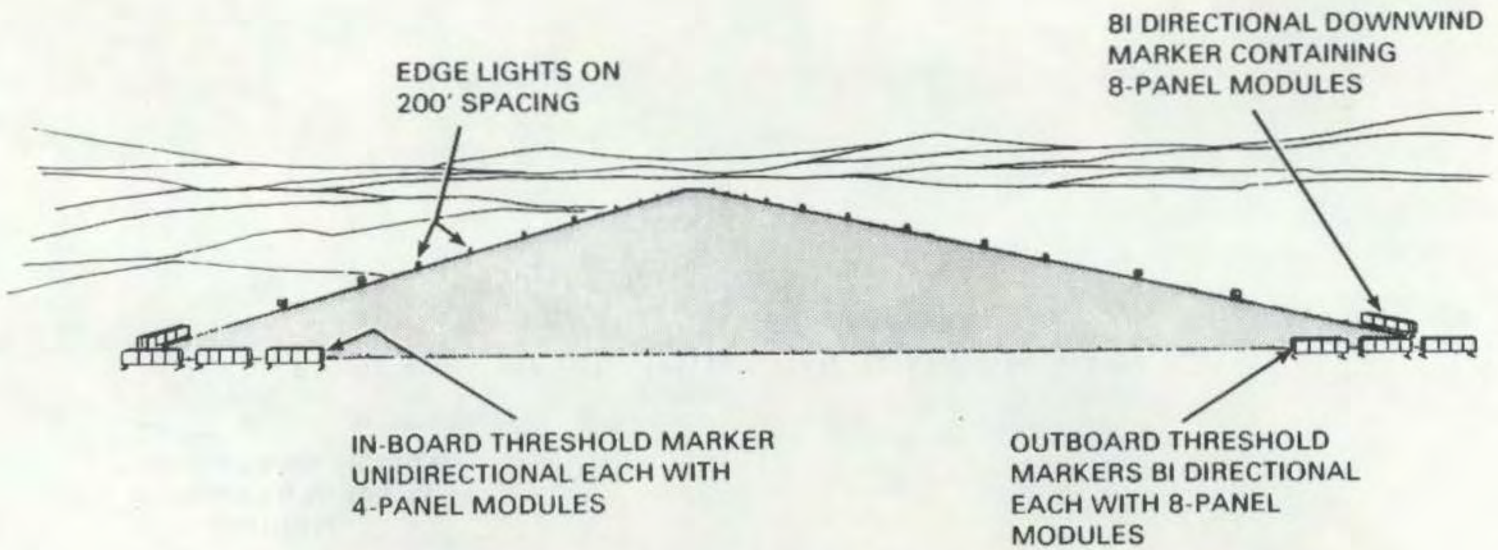

FIGURE 4.2. Civilian-Style RL Lighting System

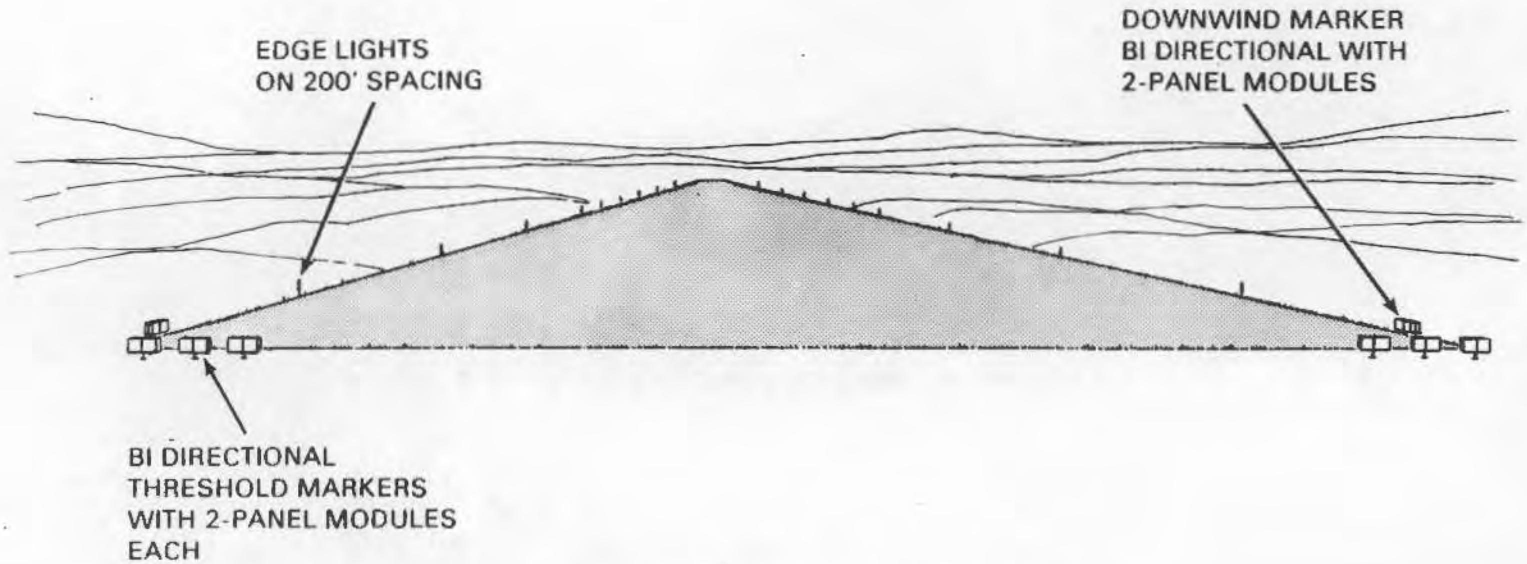

FIGURE 4.3. Minimal Civilian-Style RL Lighting System

number of tritium tubes. The estimated cost for each and the range of costs for lighting remote Alaskan runways is shown in Table 4.1.

4.2 MAINTENANCE

It is still premature to discuss potential maintenance costs with any degree of certainty. The fixtures are still in a prototype stage of development, and maintenance costs can only be based on a final design. We can, however, discuss the parameters of an RL lighting system that are expected to effect maintenance costs.

4.2.1 Energy Cost

Since RL lights are self powered, the energy costs are included in the first cost and replacement cost. However, since the tritium continually decays, reducing the light emitted, the useful life of an RL light is finite. What this life cycle may be in practice is not known. The half-life of tritium is approximately 12 years, but depending on the gas pressure, phosphor, tube shape, etc., it is not easy to say whether or not the diminishing rate of useful light output will be directly proportional to the rate of decay in beta energy of the tritium. At this point, we can use 8 to 10 years as a life cycle for estimating purposes, but it is definitely only a rough estimate.

4.2.2 Quality Assurance

Since each light is a unit, it is reasonable to expect some defective units would find their way into use. The most critical factor would be a tritium leak in a light tube, which might not show up until the fixture had left the factory. Thus, quality control and quality assurance requirements need better definition. Another area of possible defect would be the phosphor and the binder with which it is attached to tube surface. Other potential defects would be related to the materials and assembly. The frequency of such defects is related to the manufacturing process and to a large degree relates to size of the market and, thus, the rate of production. These factors will effect maintenance costs, but cannot be estimated at this time.

TABLE 4.1. Cost Table

Configurations	Tritium Curies	Cost of Light Units	Cost of Transportation to Alaska	Installation Hardware	Cost of Transportation to Site in Alaska	Cost of Installation	Totals
1. As shown in Figure 4.1 uses MAC 55130 lighting pattern with touch-down zones delineated. Probably would not be used for civilian application	1176 tubes at 69 curies/tube for 3000 ft 1316 tubes at 69 curies/tube for 4000 ft	168 panel modules 188 panel modules	motor freight	FAA approved stakes and coupling panel	Charter of Skyvan or equivalent and $500 in conventional air freight		
3000 foot runway	$89,258	$148,260	$1,100	$4,100	$3,500	$21,800	$178,760
4000 foot runway	$99,884	$165,910	$1,200	$4,260	$3,500	$22,100	$196,970
2. As shown in Figure 4.2 similar configuration to #1 above, however, no touch-down zone delineation as included	728 tubes at 69 curies/tube for 3000 ft 868 tubes at 69 curies/tube for 4000 ft	104 panel modules and panel edge lights 124 panel modules and panel edge lights	motor freight	FAA approved stakes and coupling panel racks at $60 each	Charter of Skyvan		
3000 foot runway	$55,355	$ 91,780	$ 900	$2,910	$3,000	$20,800	$119,390
4000 foot runway	$65,881	$109,430	$1,000	$3,060	$3,000	$21,100	$137,690
3. As shown in Figure 4.3 75% of the threshold illumination has been removed. Edge lighting is the same as #2 above	468 tubes at 69 curies/tube for 3000 ft 508 tubes at 69 curies/tube for 4000 ft	64 panel modules and 20 edge lights 64 panel modules and 30 edge lights	motor freight	FAA approved stakes and coupling panel racks at $20 each	Charter of Piper Navajo Chieftain		
3000 foot runway	$35,521	$ 62,017	$ 400	$1,070	$2,200	$19,800	$85,577
4000 foot runway	$38,557	$ 64,785	$ 500	$1,220	$2,200	$20,000	$88,705

4.2.3 Breakage

It is anticipated that the single greatest factor influencing the maintenance cost of an RL system would be the cost of replacement of units that are broken as a result of accident, vandalism and/or theft. Again, it is not possible at this time to estimate these factors before we have gained some field experience in a user environment.

4.3 PRELIMINARY LCC ANALYSIS AND COST-BENEFIT CALCULATIONS COMPARING CONVENTIONAL SYSTEMS

4.3.1 Summary of Cost Factors

Based on the above, it would appear that an RL system could be developed that would be competitive with conventional lighting systems in first cost and should result in considerable operating (total) cost savings over conventional systems. Installation costs for a medium intensity lighting system for a 2520 ft runway at Birch Creek, Alaska, are estimated at $265,000. Typical costs for conventional medium intensity lighting systems in Alaska range from a low of $100,000 to a high near $300,000. Thus, cost when compared to the cost of configuration number 2, Table 4.1, which is expected to be a typical configuration, is expected to be nearly twice the cost of the RL light system. While maintenance costs cannot be estimated with a satisfactory level of accuracy at this time, there is every reason to expect that continuing cost for both maintenance and operations would not exceed those for conventional systems.

4.3.2 Visual Approach Slope Indicator (VASI)

An RL visual approach slope indicator (VASI) can be considered as an option to the basic system. Since a typical VASI would require a minimum of 9 panel modules, the greatest portion of the cost would be the light panels at $7942. It is reasonable, therefore, to assume that mounting hardware and installation (if included as part of the edge and threshold light installation) might add an additional $600 to this. Therefore, assume the cost of a VASI would be approximately $8500.

4.3.3 Wind Direction Indicator

At this time there are not enough test data or design information on a wind direction indicator to develop a realistic cost estimate.

5.0 CONCLUSIONS

Radioluminescent (RL) lights have been used with some success as illuminators to assist night landings of aircraft. This application has been identified as a potentially valuable alternative to firepots or similar nonconventional lighting at many rural airports throughout Alaska.

RL airport illuminators are experimental at this time and are not available commercially; however, successful demonstrations have been made suggesting that a prototype design has been refined to a point where technology transfer to industry may be made in the near future.

Preliminary cost estimates suggest that significant cost advantages could be possible for applications in rural Alaska compared to conventional lighting systems.

Since the RL lights contain radioactive materials, there is some potential risk that their use will result in exposure to radiation doses to humans who come into contact with them. Under normal usage, this risk is shown to be insignificant. Under worst-case accident scenarios, however, it is possible that a significant dose greater than 5.0 rem could be received by a limited number of people. Generally speaking, the radiological hazard, however, is expected to be minimal for this application.

Development of the RL airfield lighting system is expected to continue in the 1983-84 period with some permanent installations possible in late 1984. However, implementation of such systems are not expected to be possible on a routine basis prior to 1985.

6.0 IMPLEMENTATION

Radioluminescent systems that could be used for airport lighting applications and would be useful to the Alaska DOT&PF are, at this time, in the process of research and development. They are not now available from any source other than the U.S. Department of Energy, and this availability is limited to special experiments. This condition is not expected to change in FY 1984. However, if the present rate of progress continues in the development of these systems, it is possible that implementation of this technology into the routine operations of the DOT&PF could begin in FY 1985.

This report describes in detail the RL system and suggests that its successful development could be very beneficial to the DOT&PF, the State of Alaska, and its people. If this is to happen, however, several factors must be resolved. The following is a list of factors that, while probably incomplete, should serve to define approximate limits for the future scope of this development effort:

1. Funding from DOT&PF to the U.S. DOE must continue in FY 1984 and DOT&PF research staff must maintain an active level of involvement with the DOE Program through the Technical Working Group.
2. DOE allocations from the federal budget for this program must continue.
3. The limited demonstration planned for Central, Alaska, during December 1983, and January 1984, must prove satisfactory to:
   a. Community residents
   b. Pilots and commercial air carriers
   c. FAA Division of Flight Standards
   d. DOT&PF personnel.
4. Based on evaluations and testing during the winter of 1983-84, a final design for an operational RL system must be developed with detailed specifications.
5. DOE must begin the process of transferring the RL technology to commercial manufacturers.

6. DOT&PF must encourage commercial manufacturing firms to produce lights as part of their product line and to apply for a general license on those products from the NRC.

7. If potential markets for RL airport lighting appear to be too small to interest the existing tritium light industry, then the State of Alaska may consider applying for the license and arrange for manufacture within the State.

8. The Alaska Region of the FAA must develop adequate policies and procedures to permit the incorporation of RL airport lights into routine use in Alaska for air taxi operations under Part 135 FAR.

If, by the summer of 1984, items 1 through 4 above are found to have been favorably resolved, then we recommend for consideration a demonstration installation at an appropriate location in Alaska. This location would serve as a permanent field test in a user environment from which data could continually be gathered to support the resolution of items 5 through 8. Although this installation would not be a truly routine operational system, it would be a permanent prototype and could become the final stepping stone toward full implementation.

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APPENDIX A

IMPROVED TRITIUM RADIOLUMINESCENT (RL) AIRFIELD LIGHTING

DEVELOPMENT TEST PLAN

PROJECT FIREFLY II

TABLE OF CONTENTS

FOREWORD

PROJECT FIREFLY is a joint Department of Energy (DOE) and Department of Defense (DOD) program established by the DOD/DOE RL Technical Working Group (RL-TWG) to develop unique airfield night lighting devices powered by radioluminescent (RL) phosphors. This Arctic Test Plan (ATP) has been prepared by the RL-TWG to respond to the AAC mission requirement for a self-sustaining airfield lighting system suitable for Arctic deployment. The RL-TWG shall test several RL airfield lighting applications during Fall/Winter 83/84, Alaskan Air Command (AAC) exercise. AAC and other users shall evaluate the operational success during an Evaluation Review Board (ERB) following the exercise. Air Force Engineering and Services Center's (HQ AFESC) Engineering and Services Laboratory (ESL) has overall responsibility for the test. The success of this Arctic Developmental Test will depend largely upon the cooperative efforts of the DOE, the National Guard Bureau (NGB), and State of Alaska operating under the auspices the RL-TWG.

AIR FORCE ENGINEERING AND SERVICES CENTER
Tyndall Air Force Base, Florida 32403

IMPROVED TRITIUM RADIOLUMINESCENT (RL)

AIRFIELD LIGHTING

DEVELOPMENT TEST PLAN

PROJECT FIREFLY II

ACRTIC TEST PLAN (ATP)

This test plan has been reviewed and approved by:

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"PROJECT FIREFLY II"

ARCTIC TEST PLAN

1.0 OBJECTIVE: The objective of this developmental test and evaluation (DT&E) is to evaluate the operational suitability and effectiveness of the improved tritium runway lighting to support military aircraft operations, and also to allow further design refinement prior to a full scale initial operational test and evaluation (OT&E).

2.0 SCOPE: This work unit (JON 2673-0034) shall be conducted over a period of approximately six months. (Reference: SCHEDULE, Section 7.0.) The contractor, Oak Ridge National Laboratory (ORNL), shall deploy a second generation set of tritium airfield lights and fixtures to be deployed consecutively at two locations in Alaska, test flown, and evaluated by aircrews of various aircraft. Ground support crews will also evaluate the ease of deployment, installation, reconfiguration, maintenance, and redeployment of the lights. Lights will be provided by Department of Energy, Oak Ridge National Laboratory (ORNL), and will include a combination of runway and taxiway lights, visual approach slope indicator (VASI), and helipad lighting systems. Several organizations shall provide radiological protection and test consultation services at the ATS during executing of the ATP. The Engineering and Services Laboratory (ESL) shall orchestrate the ATP to insure all test objectives are tested and evaluated. HQ AAC shall provide the ATS, make its resources available to the test team, coordinate the ATP with the Fall/ Winter 83/84 exercise participants, and direct the Evaluation Review Board (ERB) to assess the results of the Arctic Test. ORNL and ESL shall observe the ERB to document the test results in interim and final technical reports.

3.0 BACKGROUND: A joint DOD/DOE study group was formed to develop applications for Defense nuclear waste radioisotopes as "alternate energy" lighting systems. This group, now known as DOD/DOE RL Technical Working Group (TWG), has identified and demonstrated many military applications.

The military, and specifically the Air Force, is investigating alternate airfield lighting systems which provide improved portability, maintainability, and operational support. Radioluminescent (RL) lighting uses radiation from radioisotopes in combination with phosphors to produce visible and infrared (IR) light. Oak Ridge National Laboratories (ORNL), under contract to the Department of Energy (DOE), applied earlier technology and developed RL lighting utilizing tritium as the energizing isotope, and initially demonstrated this lighting in 1980. The tritium lighting is completely portable and does not require any wiring, external power, or fuel. These characteristics offer potential for worldwide application, but the need is especially evident for use at tactical operating locations (TOLs) during the long and dark arctic winters.

Subsequently, joint DOE/ESL sponsored research at ORNL produced a report entitled, Tritium-Powered Runway Distance and

Taxiway Markers, ESL-TR-81-45, Aug 81. ORNL performed the initial evaluation tests on these RL signs, which included the evaluation of illumination intensity, discoloration, temperature, thermal shock, pressure, impact, vibration, immersion, rough handling, blowing sand, and service life tests.

The program became known as PROJECT FIREFLY when tests of an improved RL fixture were conducted by ORNL at Bogue MCALF, NC on 14-18 Sep 81. These test evaluated the product of joint DOE/ESL sponsored RL developments (ESL-TR-80-55, and ESL-TR-82-12), and showed that the new fixture was at least twice (228%) as bright as the original prototypes. During 9-12 Aug 82 tests at Rogue MCALF, ORNL conducted a developmental test and evaluation (DT&E) of a new tritium light fixture geometry redesigned to provide a significantly greater area of light emission.

In 1982, Air Force Engineering and Services Center (AFESC), Alaskan Air Command (AAC), and the State of Alaska Department of Transportation and Public Facilities (AKDOTPF) incorporated a tritium light test into the joint service exercise, BRIM FROST 83. The results of this test showed the lights had potential for runway application, but design improvements were required primarily to improve the acquisition range by airborne pilots.

In July 1983, a newly designed tritium light was shown at a conference hosted jointly by AAC and AKDOTPF. Planning was initiated to operationally test the new lights during 1983-84.

A final report concerning this military test shall be approved by HQ AFESC, HQ AAC and coordinate with HQ MAC. AFESC will published results for distribution to all participating agencies.

The program priority and direction to develop an airfield lighting system that would fulfill Air Force needs for air base survivability and mobility are established in the following documents:

1. Program Management Directive (PMD) Draft for Portable Airfield Lighting Systems (Program Elements: 27596, 28031, 28032-TAC, 41115, 41896-MAC and 62601).

2. HQ USAF Statement of Need (SON) Draft SON-1-82 for Improved Energy Self-Sufficient Airfield Lighting (Format B).

ORNL installed (RL) runway and threshold airfield lighting system for the pre-Artic test at Mackall Army Airfield, N.C. on 2-3 Nov 83. The unofficial test results indicated the Airlift Center (ALCENT) C-130 aircrews were able to acquire the RL lights within 4-6 nautical miles (NW) from the touchdown zone as required by MAC. ALCENT provided more than 20 C-130 low approaches over Mackall AA. Feedback from the ALCENT's test director indicated the aircrew members' ability to acquire the RL lights improved with each approach. Some C-130 aircrew members were acquiring the lights 6.2 NW from the touchdown zone.

4.0 PARTICIPATING ORGANIZATIONS: Key Project Personnel

4.1 Air Force Engineering and Services Center: HQ AFESC RDCS: USAF Test Manager, Mr Thomas Hardy, (904) 283-6275, AUTOVON: 970-6275, Associate Test Manager, Mr Wade Grimm, (904) 283-6284, AUTOVON: 970-6284.

4.2 Alaskan Air Command: HQ AAC

DOOS: Staff Executive Officer, Test Director, Maj Lee Hult, AUTOVON: 317-552-5346.

DE: DCS/Engineering & Services, Col Hodge, AUTOVON: 317-552-5222.

DEM: Director of Operations and Maintenance, Maj Syta, AUTOVON: 317-552-4142.

SGB: Command Bioenvironmental Engineer (BFE), Lt Col Richard Nuss, AUTOVON: 317-552-4282.

616 MAG/DO: Director of Operations, Col Snider, AUTOVON: 317-552-5517.

4.3 Military Airlift Command: HQ MAC

XPQT: MAC Test Coordinator, Maj Bob Oertel, AUTOVON: 638-3903/4.

USAFALCENT/RA: MAC Test Advisor, Maj Ron Jones, AUTOVON: 486-2449.

4.4 Headquarters United States Air Force: HQ USAF

LEEVX: USAF Project Coordinator, Maj Harold W. Olson, (202) 697-4173, AUTOVON; 297-4173.

4.5 Radioluminescent Technical Working Group: RL-TWG DEPARTMENT OF ENERGY

HQ DOE: Program Manager, Office of Defense Waste and By-Product Management (DP-123)/Chairman, RL-TWG, Mr William C. Remini; or Mr Tom Anderson, (301) 353-4265, FTS: 233-4265.

ORNL: Program Manager, Mr Karl Haff (615) 574-7096 FTS 624-7096. Principal Investigator(s), Mr Neil Case; or Mr Andy Tompkins, (615) 574-7105/7095, FTS: 624-7105/7095.

DOE/ORO: Contract Manager, Mr Doyle Brown, (615) 576-4876, FTS: 626-4876.

HQ NGB/PO: Chief, Office of Policy & Liaison, Lt Col William Florence, (202) 695-6998, AUTOVON; 225-6998.

North Carolina ARNG: Air Operations Officer, Lt Col Les Everett, (919) 733-2555, AUTOVON: 582-9181.

STATE OF ALASKA

Alaska-DOT: Chief, Energy & Building R&D (DOT/RF), Mr Lee Leonard, (907) 479-3003/2241/4650.

Alaska-ANG (176 TAG/CAG): MAC/ANG Liaison Officer, Maj Erv Hobbs, (907) 243-1145 x 200, AUTOVON; 317-626-1200/1444.

Battelle-Alaska: Alaskan Operations Manager, Mr Lyle D. Perrigo, (907) 274-8811 or;

Battelle-PNL: Senior Research Engineer, Mr George A. Jensen, (509) 375-2602.

4.6 United States Air Force Radiological Protection Committee: USAF-RPC.

HQ AFMSC/SGPZ: Radiosotope Committee Recorder, Capt Bollinger, AUTOVON: 240-3331.

5.0 TEST REQUIREMENTS:

5.1 HQ AFESC/RDC will perform a developmental test on the second generation of tritium RL-lights.

5.1.1 The tritium threshold lights should be visually acquired at a minimum distance of four nautical miles by A-10/ C-130 pilots flying in total darkness, when the atmospheric visability is seven nautical miles or greater.

5.1.2 The tritium lights should allow accurate runway alignment guidance at a minimum of two nautical miles.

5.1.3 The tritium VASI system should provide glide path information at a minimum of two nautical miles.

5.2 The ground support people shall evaluate tritium light fixture assemblies to determine whether or not they present a hazard to ground personnel, aircraft or surrounding environment.

5.2.1 The tritium fixtures should be designed for temporary installation at remote airfields.

5.2.2 The tritium fixture design should contain a simple built-in security system to help minimize theft of the lights.

5.2.3 The tritium fixtures should be durable, light weight and easy to assemble and disassemble in the arctic and subarctic environment.

5.2.4 The tritium lights should be capable of providing a continuous and reliable light source under severe arctic temperatures and weather conditions.

5.3 The airfield lighting waiver required by AFM 88-14, Para 1-9, shall be arranged by HQ AAC/DOOS and coordinated with HQ AAC/DO, HQ USAF/LEEEU/LEEVX/XOORF/RDRQ, HQ AFESC/RDCS AND FAA/ACT-350. ORNL shall provide working drawings of prototype fixtures as they are required to satisfy the waiver.

5.4 ORNL shall work with the TWG Test Director to arrange for transport of the test fixtures and test team to an Arctic Test Site (ATS) in Alaska to be determined by HQ AAC.

5.4.1 The fixtures shall be installed to illuminate a 150 ft x 5000 ft runway.

5.5 ORNL/PNL shall provide on-site technical support in Alaska during the deployment to maintain the lighting system and observe the evaluation.

5.6 An approved tritium light questionnaire shall be distributed by AAC to participating flying organizations following a briefing by HQ AAC/DOOS.

5.7 The test team evaluation shall be completed in two parts to follow the approved test plan. ORNL shall perform all data reduction and analysis and fully document the test results in the interim and final technical reports.

5.7.1 Part I - Visual Evaluation: Results of the questionnaire survey will be summarized by an evaluation review board directed by HQ AAC/ADO who will make a written assessment of the overall operational acceptability of the tritium lights.

5.7.2 Part II - Physical Evaluation: Observations, photographs, and interviews recorded while the test team witnesses the evaluation shall be condensed by ORNL and presented in the final reports.

5.8 Upon completion of the evaluation, ORNL shall recover and return the complete tritium lighting system to Oak Ridge, TN. ORNL/PNL shall remain in custody of the lighting system until further testing or disposal at the discretion of the DOE Program Manager.

5.9 Reporting: ORNL shall prepare interim and final technical reports which shall include all data, calculations and analyses required in this technical effort. In addition, ORNL shall include detailed descriptions, photographs, and drawings of the final fixture design; fabrication & installation techniques; installation & flight training plans; final erection problems; shipment limitations; and detailed project costs. The final technical report shall cover complete system performance limited to the actual field observations during this test to include disposal method and cost. Conclusions and recommendations concerning further use, further R&D, and projected economic analysis (i.e., cost of 1st...10th...100th runway) of RL airfield lighting shall be delineated as an overall assessment of the project.

5.10 Responsibilities: The participating organizations are assigned the following responsibilities:

5.10.1 Engineering and Services Laboratory: (ESL) Prepare necessary documents for internal coordination.

5.10.1.1 Assign a USAF Test Manager who will orchestrate the test activities and prepare all special actions for TWG coordination:

5.10.1.1.1 Test plan

5.10.1.1.2 Liaison with USAF Radiological Protection Committee

5.10.1.1.3 Coordinate all test activities with HQ AAC.

5.10.1.2 Coordinate transportation of USAF personnel with Test Director.

5.10.1.3 Provide input to ORNL concerning pre-test evaluation.

5.10.1.4 Review preliminary development evaluation draft report.

5.10.1.5 Publish and distribute final system development report.

5.10.1.6 Prepare, distribute, collect and analyze aircrew and ground support personnel questionnaire.

5.10.1.7 Act as DOD test manager. Will coordinate with DOE on TWG matters.

5.10.2 <u>Alaskan Air Command</u>: (HQ AAC)

5.10.2.1 Assign a Test Director who will orchestrate test flights and required test support.

5.10.2.2 Provide Arctic Test Site (ATS).

5.10.2.3 Coordinate ATP with winter exercise authorities to determine availability of ATS and time of ATP execution.

5.10.2.4 Provide photographic documentation.

5.10.2.5 Provide ground support for light deployment.

5.10.2.6 Coordinate and direct pilot evaluation board.

5.10.2.7 Make at least one vehicle available for transportation at ATS.

5.10.2.8 Provide schedule of day-to-day operation involving field test (coordinate with test director).

5.10.2.9 Provide adequate security for deployed lights.

5.10.2.10 Provide weather information and documentation.

5.10.2.11 Coordinate the use of non-AAC test airfields and facilities.

5.10.2.12 Arrange for distribution of pilot questionnaires and provide preliminary results.

5.10.2.13 Arrange participation by different type aircraft.

5.10.2.14 Obtain/provide authorization for test team personnel to have access to tritium lighting storage, deployment and test locations.

5.10.2.15 Obtain/provide authorization for test team personnel for emergency medical aid; issue of arctic clothing and vehicles for transportation.

5.10.2.16 AAC Test Director:

5.10.2.16.1 Act as Point of Contact with DOE Test Advisor in concert with DOD Test Manager, DOE Program Managers and TWG Test Director.

5.10.2.16.2 Assist in preparation and review of test plan.

5.10.2.16.3 Coordinate ANG/ARNG activities throughout test.

5.10.2.16.4 Coordinate and provide Arctic clothing for team members not stationed in Alaska.

5.10.2.16.5 Perform as communications frequency manager for test team by coordinating communications call signs and FM frequencies for communications between team members and aircraft as required.

5.10.2.16.6 AAC/DO representative will function as AAC test director; direct flying test program; interface with participating aircrews; and assist in evaluating tritium lights based on objectives and criteria in this plan.

5.10.2.16.7 AAC/DE representative will ensure layout and setup is accomplished per Air Operations Officer's recommendation; ensure modification and maintenance of tritium lights as required; and assist in evaluation of the lights per this plan use of Allen Army Airfield, AK.

5.10.2.16.8 Obtain written approval to AR 385-11, paragraph 2-3.

5.10.2.17 <u>343 COMPW</u>:

5.10.2.17.1 Appoint an A-10 qualified project officer to coordinate A-10 flight operations, brief/debrief pilots, and coordinate with local agencies participating in the evaluation.

5.10.2.17.2 Ensure the base RPO monitors and approves arrangements for delivery, transportation, storage, and deployment/redeployment of the tritium lights until transferred to the 21 TFW for deployment to Donnelly L2.

5.10.2.17.3 Provide A-10 and O-2 aircraft to participate in evaluation.

5.10.2.17.4 Provide at least four personnel for receipt and transport of tritium lights upon arrival in Alaska. Since Battelle/Pacific National Laboratory is custodian of the RL light fixtures, their representative will be present to count and make suitable checks on the receipt of these fixtures.

5.10.2.17.5 Provide an enclosed bed cargo truck and cargo van for transporting the lights. The vehicles should be large enough to hold containers taking up about two 463L pallets, be weatherproof, and be capable of being secured.

5.10.2.17.6 Provide a secure location for temporary storage of the tritium lighting and shipping packages, as necessary.

5.10.2..17.7 Provide four personnel for transportation and installation of lights at Allen AAF, including assistance in varying test configurations, performing fixture maintenance and removing the lights and fixtures. These should be the same four personnel in 5.10.17.4.

5.10.2.17.8 Provide vehicle and runway condition reading RCR measurement equipment and operator to conduct RCS/RCR measurement IAW T.O. 33-1-23, if required by the AAC test director.

5.10.2.17.9 Provide ground to air communications (UHF/VHF).

5.10.2.17.10 Provide personnel and equipment, as necessary, to support A-10 turnarounds at the designated test airfield, if required.

5.10.2.18 21 TFW:

5.10.2.18.1 Provide a contingency storage location for the tritium lights at Elmendorf AFB.

5.10.2.18.2 Appoint a rated project officer to coordinate operational aircraft support for the test at Allen AAF.

5.10.2.18.3 Provide C-12 aircraft support for evaluation of the lighting system.

5.10.2.18.4 Provide four personnel to deploy the lighting package from Eielson AFB to Donnelly LZ: and install, maintain and remove the lights and fixtures.

5.10.2.18.5 Deploy, install, maintain and redeploy an electroluminescent (EL) or conventional incandescent lighting set from Eielson or Elmendorf to Donnelly LZ which will provide backup lighting for C-130 support.

5.10.3 <u>Military Airlift Command</u>: (HQ MAC)

5.10.3.1 Provide MAC aircrews and aircraft to evaluate the RL lighting at the ATS.

5.10.3.2 Extend a MAC Airfield Lighting Waiver to the RL lighting system for the period of the ATS deployment.

5.10.3.3 Assist in preparing, distributing, collecting and analyzing aircrew and ground support personnel questionnaires.

5.10.3.4 Ensure aircrews and ground support personnel are briefed and debriefed.

5.10.3.5 Provide a Radiological Protection Officer (RPO) to approve and monitor handling, storage, transportation and use of the tritium lights while involved in AAC testing. (Custodial responsibility will be maintained by the DOE or its designated contractor representative.)

5.10.4 Headquarters, United States Air Force: (HQ USAF)

5.10.4.1 Provide timely Air Staff coordination of the ATP.

5.10.4.2 Provide a USAF Project Coordinator/ Action Officer as a focal point for executive coordination and management briefings.

5.10.5 Headquarters Department of Energy: (HQ DOE)

5.10.5.1 Serve as Chairman, RL-TWG.

5.10.5.2 Provide program management direction for all DOE test activities.

5.10.5.3 Coordinate test plans with responsible DOD personnel.

5.10.5.4 Coordinate test preparation and DOE requirements with ORNL.

5.10.5.5 Provide executive management briefings as required.

5.10.6 Oak Ridge Operations Office: (DOE/ORO)

5.10.6.1 Coordinate test plan with DOD.

5.10.6.2 Coordinate HQ DOE requirements for contract documentation between ORO and ORNL.

5.10.6.3 Provide test and assistance personnel during test.

5.10.6.4 Approve and assist in RL light system and equipment security planning and execution.

5.10.6.5 Provide reimbursement authorization letter to non-DOE support personnel for travel, and subsistence.

5.10.7 Oak Ridge National Laboratory: (ORNL)

5.10.7.1 Prepare prototype fixure.

5.10.7.2 Fabricate adequate quantity of RL light fixtures for a 5000 ft runway.

5.10.7.3 Provide planning for pre-test evaluation (full scale).

5.10.7.4 Prepare shipping documents and accountability documents.

5.10.7.5 Arrange transportation for pre-test evaluation.

5.10.7.6 Deploy lights for pre-test evaluation.

5.10.7.7 Make required modifications.

5.10.7.8 Prepare check lists and inventory lists.

5.10.7.9 Package lights and equipment for transport to Alaska.

5.10.7.10 Obtain final concurrences for shipment from ORO/DOE.

5.10.7.11 Provide technical guidance in assembly of lights at destination.

5.10.7.12 Provide briefing to HQ AAC Radiological Protection Officer (RPO) and ground support installation team on light handling and safety assessment.

5.10.7.13 Train and brief ground support installation test personnel on test objectives.

5.10.7.14 Supervise and assist packaging of lights for return to ORNL.

5.10.7.15 Make final inventory and transfer documents.

5.10.7.16 Prepare draft test evaluation document and distribute for comments.

5.10.7.17 Prepare draft technical report and distribute for comments.

5.10.7.18 Prepare final technical report for distribution.

5.10.7.19 Initiate fund reimbursement letter for travel of non-ORNL personnel as required.

5.10.7.20 Assist in preparation of test plan.

5.10.8 Pacific Northwest Laboratory (PNL) will perform cold climate engineering and human factors work required for field testing. Provide required support to and or in lieu of ORNL responsibilities (above).

5.10.9 176th Tactical Airlift Group:

5.10.9.1 Provide transportation support for transfer of lights from ORNL to and from Alaska.

5.10.9.2 Effect physical transfer to AAC.

5.10.9.3 Notify HQ AAC/DOOSS of exact delivery time as early as possible.

5.10.9.4 Provide a C-130 aircraft for evaluation purposes at Allen AAF.

5.10.10 National Guard:

5.10.10.1 North Carolina Army Air National Guard (NC-ARNG) will provide training in Alaska same as TWG Test Director and will provide logistical support for the ATS. Will coordinate test procedures with AK-ARNG, AK-ANG.

5.10.10.1.1 Provide aircrew briefings on best method to acquisition tritium RL-lights during test.

5.10.10.2 Alaska Army National Guard (AK-ARNG)

5.10.10.2.1 Provide helicopter transportation for personnel and equipment within local vicinity of ATS.

5.10.12.2.2 Provide helicopter support for test.

5.10.11 State of Alaska: (AK-DOT) (See Appendix F)

5.10.11.1 Fabricate and install light base units at test site.

5.10.11.2 Provide liaison between State of Alaska and the RL-TWG.

5.10.11.3 AKDOTPF, Battelle AK, and other test team members, as applicable, will advise test director on configuration, modification and evaluation of tritium lights in conjunction with FAA evaluation state of ATS.

5.10.11.4 Provide a secure storage area upon transfer of equipment in Alaska prior to AK-DOT deployment.

5.10.12 <u>United States Air Force Radiological Protection Committee:</u> (USAF-RPC)

5.10.12.1 ORNL/PNL will perform Radiological Protection function as outline in Appendix C.

5.10.12.2 Advise HQ AAC/SGB of their responsibilities.

5.11 Safety: See Appendix C.

5.12 Security: See Appendix D.

6.0 SPECIAL ACTIONS:

6.1 Security Classification: It is anticipated that the security classification for this project will remain unclassified.

6.2 Release of Information: All information concerning developments under this contract shall be reported to other agencies through HQ AFESC/RD. Until public release of the final technical report by the USAF, there shall be no briefings, presentations, publications, or information relative to this technical effort transmitted by ORNL without prior approval of HQ AFESC/RD and the DOE Program Manager.

6.3 Official Photography: ORNL shall cooperate with the official Air Force photographic support arranged by HQ AAC/DOOS for the Air Force Project Officer and the DOE Program Manager.

6.4 Radiological Protection Officer (RPO): ORNL/PNL will assist the RPO during the entire contract period. Coordination for handling the RL markers will also be accomplished by ORNL with AFMSC/SGPZ, Brooks AFB, TX 78235.

7.0 SCHEDULE: The following schedule applies:

7.1 TRITIUM LIGHTING TEST SCHEDULE

Phase	Date	Event
Deployment	18 Nov 83	Lighting package delivered by 176 TAG C-130 to Allen AAF
	19 Nov 83	Light fixtures/bases secured/lights installed
Preliminary Test	19-22 Nov 83	Configuration and visual acquisition range evaluations by: AAC, ADOTPF, FFA, AK ANG, and AK ARNG
	23 Nov 83	Light fixtures/bases packed up and transported to secure storage at Eielson AFB.
Deployment	27-28 Nov 83	Lighting package picked up from Eielson AFB and transported by 21 TFW personnel to Donnelly LZ and installed
C-130 Test (Annex IV)	28 Nov - 11 Dec 83	Operational evaluation during this period
	11 Dec or Earlier	Lighting package return to Eielson by 21 TFW (as directed by AAC test director)
Weather Backup	11-15 Dec	Weather backup for Allen and/or A-10s as needed
End of AAC Test	15 Dec 83	Transfer to State of Alaska for AKDOTPF testing

Phase	Date	Event
End of Alaska Test	Mar 84	Lighting package returned to Lower 48 by 176 TAG C-130

7.2 Scheduled events.

7.2.1 18 Nov 83 - The tritium lighting package will be delivered to Allen AAF, AK, by 176 TAG via C-130. The package will be accompanied by and/or met by member(s) of the test team and custodial representative (PNL). 343d personnel will receipt and transport the lighting to the secure storage location. The 343d RPO and Battelle PNL representative will inspect the lights and packaging. If weather conditions do not permit the C-130 landing at Allen AAF, Eielson AFB will be the alternate delivery location. In the event of a divert to Eielson AFB, 343d personnel will be notified as soon as possible so all support can be repositioned.

7.2.2 19 Nov 83 - The fixtures will be installed on the airfield per instructions of Test Director (Annex VI). The runway will be determined by the AAC test director.

7.2.3 19-23 Nov 83 - Preliminary Test Period. This period will be used to evaluate installation methods, alternate lighting configurations, and visual acquisition range. Contingent on other airfield operations, the tritium lighting test will begin approximately 1600L and end at 2000L daily.

7.2.3.1 During each test period, aircraft will fly multiple low approaches, with full stops and takeoffs, using the tritium lighting. The pilots will receive a briefing (Annex

III, IV) prior to the first flight, complete the questionnaire (Annex V), and be debriefed by test personnel as appropriate.

7.2.3.2 After each test sequence the lighting configuration may be altered in an attempt to improve performance. Each change will be fully coordinated with the pilot(s) flying during that period. Their questionnaire comments must be keyed to the specific test.

7.2.3.3 At the completion of each test period, the test team may remove the lights and place them in secure storage. The lights may remain installed if no participant, including the Allen AAF manager, has any objections.

7.2.4. A-10 Operational Evaluation. Not less than four 343 COMPW A-10 aircraft will participate in a the test. If weather conditions and runway condition reading (RCR) permit, the site will be Allen AAF. If Allen AAF is unacceptable, another test will be completed at a suitable A-10 location, with Eielson AFB as a last selection. Each A-10 will make at least one low approach to the lighting system prior to a full stop. After the full stop the pilot will be debriefed. After takeoff, the pilot may make additional low approaches, fuel permitting, prior to returning to Eielson AFB. Each pilot will complete the aircrew questionnaire.

7.2.5 27-28 Nov 83 - C-130 Operational Test Deployment. 21 TFW personnel will transport and install the tritium lighting at Donnelly LZ. Test team members will be present to provide supervision and assistance. Lighting will be installed IAW MACR 55-130.

7.2.6 28 Nov - 11 Dec 83 - C-130 Operational Test. C-130 aircraft supporting the 172 Infantry Brigade Field Training Exercise will land, using the tritium lighting. A conventional backup lighting system will be available, and turned on if the pilot requests.

7.2.7 11 Dec 83 - Tritium and conventional lighting removed from Donnelly LZ by 21 TFW and test team personnel and returned to Eielson AFB and temporarily stored.

7.2.8 15 Dec 83 - Tritium lighting package transferred to AKDOTPF for civilian testing.

APPENDIX I

PROCEDURES FOR PRELIMINARY TESTING OF RL RUNWAY LIGHTING

1. Each organizaiton or agency participating in the tritium runway lighting test will appoint a project officer or point of contact for scheduling briefing and coordination.

2. Organizations and aircraft which will be directed or invited to participate are as follows:

   a. 21 TFW/C-12

   b. 343 COMPW/O-2, A-10

   c. 616 MAG/C-130

   d. 176 TAG/C-130

   e. 222 Av Bn/C-12, UH-1

   f. USCG/C-130

   g. State of Alaska/Unknown

   h. Federal Aviation Administration/Unknown

   i. Other civilian agencies/aircraft

3. To gain maximum participation from each organization, flexibility in scheduling each test period will be maintained.

4. Aircraft will be scheduled to fly during a specific time block during each test period on the days of 19-22 Nov 83.

5. Pilots using IFR flight plans may execute an instrument approach or may cancel the clearance and proceed VFR.

6. Pilots will thoroughly familiarize themselves with the terrain surrounding Allen AAF and the layout of the airfield and runway.

7. The primary runway for testing the lighting at Allen AAF is anticipated to be Runway 18. Runway 18 is 7499' long and 150' wide. Depending upon tritium lights available, only 5,000 feet will be lighted. Runways 36, 06, 24, 09 and 27 may be used if conditions warrant.

8. Prior to their flights, pilots will receive a thorough briefing on the runway in use, lighting configuration, radio frequencies, and other pertinent information.

9. The pilot will contact the test team on the specified radio frequency as soon as possible. At that time, he will receive an additional briefing on current status of lights, weather conditions, and runway condition reading (RCR) or latest reported braking action.

10. Pilots will align the aircraft on the extended runway centerline, at least five miles from the threshold. This may be accomplished visually or by use of TACAN DME information.

11. Pilots will, as accurately as possible, document the maximum distance at which the lights are acquired and the distance the lights become usable for runway alignment and/or glide path information. TACAN DME will be noted if used for measurement.

12. If weather conditions permit, the pilot will execute a low approach and return to the final approach for a second view of

the test lighting. Pilots may subsequently land or execute additional low approaches. At least one full stop landing is requested. Pilots will provide comments to the test team while on the ground.

13. Civilian pilots may make low approaches. Full stop landings are authorized if US Army civilian use requirements are met.

14. Pilots will complete the handout questionnaire and submit to the unit project officer or mail to HQ AAC/DOOSS, Elmendorf AFB, AK 99506.

15. Engineers and/or ground support crews will also complete questionnaires and submit to the project officer or mail to HQ AAC/DEM, Elmendorf AFB, AK 99506.

16. The AAC test director will establish operating procedures/ methods depending on site environmental conditions during the test.

APPENDIX II

BASIC EVALUATION PLAN

Introduction

Subjective analysis of ground observations and aircrew questionnaires shall be the primary methods of data collection. The approved tritium light questionnaire (ANNEX VI) shall be briefed and distributed to participating flying organizations by HQ AAC/DOOSS. Members of the team shall interview Prime BEEF and other ATS support personnel to determine the success of ground operations. At the conclusion of the exercise, HQ AAC/ADO shall direct an Evaluation Review Board (ERB) to make a written assessment of the overall operational acceptability of the RL lighting system under Arctic operations. ESL and ORNL/PNL shall observe the ERB critique to document the results and recommendations in the final technical reports.

Method

The test team evaluation shall be completed in two parts to follow the ATP. ORNL shall perform all data reduction and analysis to document test results in the interim and final technical reports.

Part I - Visual Evaluation: Questionnaires shall be distributed to aircrew and ground observers as they in-process the exercise and during daily preflight briefings. The observers will receive an explanation of the purpose of the test. The questionnaires can be returned by self-addressed mail to HQ AAC/DOOSS. Those received by the end of the exercise shall be reviewed by ERB.

Part II - Physical Evaluation: ORNL/PNL shall collect, analyze, and condense the test teams observations, photographs, and witness interviews at the ATS. Preliminary findings shall be briefed at the ERB and presented in the final reports.

Evaluation Objectives (See Annex VII)

Data Collection

The evaluation objectives shall be evaluated from the following sources collected by AAC, and the RL-TWG test team:

1. Aircrew Questionnaires
2. Ground and Airborne Observations
3. Individual Interviews
4. Mission Debriefings
5. Exercise Critique
6. Evaluation Board
7. Photographic Aids

Analysis

The final reports shall contain the RL airfield lighting's actual system performance under Arctic conditions as determined by expert observers (i.e., ERB), and other data collection techniques. A discussion shall explain the final fixture designs, fabrication techniques, expedient installation methods, project costs, shipment limitations, and final erection problems.

Conclusions/Recommendations

Proposed future applications, further R&D, and project economic and operational benefits shall be delineated as an overall assessment of the Arctic Development Test. All conclusions and recommendations shall be substantiated by this analysis and approved by the PROJECT FIREFLY test committee before publication.

Documentation

ORNL shall prepare a draft technical report. The final technical report shall be written in accordance with DID S-3591A. Submit two copies of draft final report within 30 days after completion of SOW, Section 5.2. Submit reproducible original within 60 days after receipt of sponsor's comments on the approval of drafts. Approving authority will be AFESC/RDCS. Reproducible original will be a "camera ready" copy, reference MIL-STD-847A. Report shall be published as a joint AFESC/DOE technical report.

APPENDIX III

SAFETY PLAN

1. Purpose. The purpose of the safety plan is to anticipate both general and radiological accidents to reduce, control, and eliminate hazardous conditions. Before ground installation and air operations can begin at the ATS, official approval must be granted from the Test Director and the ATS Airfield Manager. The following safety documents are applicable to this test:

AFR 127-4	AFR 800-16
AFR 127-12	AFOSH STD 127-66
AFR 160-132	T.O. 00-110-A-12
AFR 161-8	T.O. 00-110-N-2
AFR 161-16	T.O. 00-110-N-3
AFR 161-28	T.O. 00-110-N-5

2. Overall Safety Responsibility. The Test Manager is responsible for enforcing the overall safety program for the test. The Alaskan Air Command Chief of Safety (HQ AAC/IG) or his designated representative is the safety officer during all air operations. The Test Manager is the safety officer for all other ATP events at the ATS. The Test Manager will maintain close coordination with AAC/IG on all safety matters.

3. Safety Areas. The safety requirements of the ATP have been divided into two separate areas to establish the specific requirements for different operational areas:

a. General Safety.

b. Radiological Safety.

4. <u>General Safety</u>. The responsibility for general site safety resides with AFESC. The authority to execute specific safety directives is delegated to the Test Manager. The Director of Information (HQ AAC/PA) is responsible for public notification of the test.

a. Safety Briefing. The Test Manager will brief all RL-TWG personnel on the safety hazards at the ATS.

b. Visitors. Visitors shall not be allowed at the ATS without approval of the Test Manager or the ATS Airfield Manager. Visitors shall be instructed on applicable area safety regulations.

c. Individual Safety Responsibilities. Careful attention to the hazards at the ATS must be stressed at each level of supervision. The purpose of the safety rules is to outline the most important precautions to be taken with the ATS. These rules do not cover all the possibilities, but as new problems arise, new safety measures will be established to cope with the circumstances. In the interim, common sense must be applied to insure that safety prevails. This entire Safety Plan must be closely followed by all personnel and enforced by all supervisors. These procedures shall be accepted as minimum standards until the Test Manager, with the concurrence of HQ AAC/IG/SGP authorizes deviation.

d. Vehicles. Speeds shall not exceed 30 mph when driving on unpaved roads. Seat belts will be used at all times while vehicles are in motion. Speed within the immediate area of the ATS shall not exceed 10 mph. When a vehicle is parked, the hand brake will be set and the transmission placed in reverse or park for automatic transmissions.

e. Hypothermia. Extremely cold weather is expected during the test period. This has the potential for hypothermia, frost bite and accidents caused by impaired physical ability. Arctic clothing will be issued. Arctic orientation training will be required for each test team member as they arrive in Alaska. Procedures set by the military for emergency supplies required during air travel and field operations will be imposed on non-military personnel involved in the test.

f. Accident Reporting (Emergency):

(1) Scope. This standard procedure is intended to serve as a guide to expedite medical care as a result of an accident. All "post emergency" reporting and accident investigation will be performed by current Air Force Regulations and is not within the scope of this procedure.

(2) Responsibility. It is the responsibility of every person involved in this program to be completely familiar with the emergency reporting procedures established by this plan and to immediately implement these procedures after an accident. It is the responsibility of the Test Director to familiarize all supervisors with this procedure, and in turn, the supervisors will explain these procedures to their subordinates.

(3) Emergency Reporting Procedures. After an accident at the ATS the following procedure will be followed:

(a) The senior supervisor at the scene of an accident will direct appropriate first aid. Caution will prevent aggravation of an accident-related injury.

(b) The ATS Dispensary will be immediately notified of the nature of the accident, including apparent condition of the injured person, and the location of the accident. The Test Manager or the senior supervisor at the scene shall determine whether to attempt transfer of the injured to a hospital, or to request emergency ambulance support.

(c) The Test Manager or the senior supervisor shall determine the seriousness of the accident. If it is determined that the accident is not serious enough to require emergency hospitalization, disregard para 4f(3)(b) and administer first aid at the site. If further medical attention appears necessary, the injured person will be taken to a doctor by normal transportation.

g. First Aid. An adequate supply of first aid items will be maintained at the ATS. These items will be properly stored and periodically inspected to insure adequacy for an emergency.

5. Radiological Safety. ORNL will perform the responsibilities of the RPO. The Alaskan Air Command BEE (HQ AAC/SGP) will have the complete authority for the enforcement of all NRC requirements and procedures while on USAF real property at the ATS. The

safety procedures for handling, transporting, storing, and installing the RL fixtures at the ATS are specified below:

a. Hazard. These tritium-filled tubes do not emit any beta radiation outside their sealed glass containers. But in the event of tube breakage, Type-2R containers will be on-hand to package the broken tube for safe transport to ORNL for disposal. Personnel exposure calculations have been made for a maximum credible accident involving 1000 ci H-3 (one shipping container of wands). A single light fixture breakage would result in an exposure equal to 10% of the value shown in the 1000 ci release calculation. (See attached ORNL calculation of dose in runway lighting accident.)

b. Responsibility. ORNL representative will be acting as Radiological Protection Officer (RPO) to advise and act in radiation incidents. The HQ AAC RPO will be in charge of radiation related problems and will advise and act in an overall position of authority should a radiation incident occur during the exercise.

c. Training. The RL-TWG test team will brief individuals who will install and dismantle lights prior to any assignment. The installation briefing (Annex III) will cover the following areas:

(1) Safe handling.

(2) Proper installation.

(3) Breakage hazards.

(4) Physical security.

APPENDIX IV

SECURITY PLAN

1. Transportation. Lights will be transported from ORNL to McGhee-Tyson ANGR TN packaged to meet DOT regulations. Transfer of lights to an ANG aircraft (C-130) will be under the guidance of ORNL personnel. A package count will be made to confirm transfer inventory at each transfer point, e.g., loading at ORNL onto transfer vehicle, unloading truck and loading aircraft at McGhee-Tyson, unloading aircraft at Fairbanks, Alaska, for transport to the ATS. When loads are divided for transter in more than one vehicle, an inventory record will be maintained.

Light fixtures will be attached to base units previously installed in the field. In the event the test site becomes inactive relative to light use, the lights will be removed from the base unit and placed in a secure area.

Lights will be transported to a secured location following the Arctic testing. Then an inventory of lights will be conducted. Lights will be placed in a secure area during non-test periods.

2. Storage. Following the test, lights will be dismantled, placed in "DOT Type A" shipping containers for delivery of lights to ORNL. Arrangements will be made with ORNL Traffic Department for meeting the aircraft and delivery of the lights to ORNL. A final inventory of the lights will be made upon receipt of the lights at ORNL.

A notification list will be maintained by ORNL/PNL personnel to provide information to appropriate ORNL/PNL and DOE personnel in the event that a reportable incident occurs during the test. HQ AAC/DOOS/SGP/IG/DE/PA and HQ AFESC/RD/PA will be expeditiously notified of any incidents. (See attached notification list.)

Lights are labeled with a notification statement, radiation symbol, identification of radioisotope (tritium) and quantity of isotopes present. These labels are attached to the base of each light unit (wand) and a serial number is engraved into the base of each wand. The lights are shown to be the property of the USDOE and in case of an emergency the ORNL plant shift supervisor must be notified.

3. Notification. The following agencies will be notified within eight hours of any reportable incident:

a. Alaskan Air Command:

DOOSS: Maj Hult, AUTOVON: 317-552-5346

SPO: Capt Knall, AUTOVON: ____________

SGB: Maj Carmichael, AUTOVON: 317-552-4282

IG: Col Brandt, AUTOVON: ____________

DE: Col Hodge, AUTOVON: 317-552-5222

PA: Lt Col Sanford, AUTOVON: ____________

b. Air Force Engineering and Services Center:

CC: Col Callahan, AUTOVON: 970-6101

RD: Col Boyer, AUTOVON: 970-6309

PA: Maj Geary, AUTOVON: 970-6476

c. Department of Energy:

DP-123: Mr Remini, (615) 353-4265

DOE/ORO: Mr Brown (615) 574-4876

ORNL: Plant Shift Supervisor, (615) 574-6606

PNL: Mr Jensen, (509) 375-2602

d. State of Alaska:

Alaskan-DOT: Mr Leonard, (907) 479-3003/2241/4640

4. News Release. Any press releases will be coordinated by DOE, AFESC and Alaskan Air Command. Any press releases for incidents that occur during transport of lights in the State of Alaska will be coordinated by DOE, AFESC, AAC and Alaskan DOT. Any press releases required while lights are transported in the lower 48 states will be coordinated with all the above.

APPENDIX V

DISTRIBUTION LIST

ACTION

HQ NGB/PO
ATTN: LT COL FLORENCE
PENTAGON, RM 2E383
WASHINGTON DC 20331

HQ MAC/DEE
ATTN: LT COL EDDINGS
SCOTT AFB IL 62225

HQ AAC/DE
ATTN: COL HODGE
ELMENDORF AFB AK 99506

HQ AAC/DEM
ATTN: MAJ SYTA
ELMENDORF AFB AK 99506

HQ AAC/DEMG
ATTN: MAJ TULL
ELMENDORF AFB AK 99506

HQ AAC/DOOS
ATTN: MAJ HULT
ELMENDORF AFB AK 99506

AK-ARNG (OLF-62 MAW)
176 TAG/CAG
ATTN: MAJ HOBBS
KULIS ANGB AK 99502

HQ USAF/XOORF
ATTN: COL STRICKLAND
PENTAGON, RM BF935B
WASHINGTON DC 20331

HQ USAF/LEEVN
ATTN: MAJ OLSON
BOLLING AFB DC 20332

HQ USAF/LEEEU
ATTN: MR WORDEN
BOLLING AFB DC 20332

HQ DOE (DP-123)
ATTN: MR REMINI
GAITERSBURG DC 20545

ACTION

ERADCOM (NV & EOL-DELNV-SE)
ATTN: MR NOWAK
FT BELVOIR VA 22060

NC-ARNG
ATTN: LT COL EVERETT
P O BOX B
MORRISVILLE NC 27560

HQ AFESC/RD
TYNDALL AFB FL 32403

HQ AFESC/RDC
TYNDALL AFB FL 32403

HQ AFESC/RDV
TYNDALL AFB FL 32403

HQ AFESC/DEO
TYNDALL AFB FL 32403

HQ AFESC/DEB
TYNDALL AFB FL 32403

HQ AFESC/DEM
TYNDALL AFB FL 32403

HQ AFESC/DEV
TYNDALL AFB FL 32403

1 SOW/DOX
ATTN: LT COL GAMBLE
HURLBURT AFB FL 32544

ORNL
ATTN: MR CASE
P O BOX X
OAK RIDGE TN 37830

HQ AFMXC/SGPZ
ATTN: CAPT BOLLINGER
BROOKS AFB TX 78235

ORNL
ATTN: MR K. W. HAFF
P O BOX X
OAK RIDGE, TN 37830

DISTRIBUTION LIST (CON'T)

ACTION

DOE/LANL
ATTN: MR ANDERSON (MS:C348)
P O. BOX 1663
LOS ALAMOS NM 87545

NASA/JPL
ATTN: MR ROSCHKE (MS:507-228)
PASADENA CA 91109

DOE/PNL-BATTELLE, NW
BATTELLE BLVD
ATTN: MR JENSEN
RICHLAND WA 99353

DOE/PNL-BATTELLE OF ALASKA
101 W BENSON, SUITE 305
ATTN: MR PERRIGO
ANCHORAGE AK 99503

STATE OF ALASKA
DOT/PF (ATTN: MR LEONARD)
2301 PEGER RD
FAIRBANKS AK 99701

HQ MAC/XPQT
ATTN: MAJ OERTEL
SCOTT AFB IL 62225

HQ MAC/XPQS
ATTN: MAJ HASTINGS
SCOTT AFB IL 62225

USAFALCENT/RA
ATTN: MAJ JONES
POPE AFB NC 28308

HQ MAC/DOXT
ATTN: CAPT NELLIS
SCOTT AFB IL 62225

HQ MAC/DOXS
ATTN: MAJ GOLLEY
SCOTT AFB IL 62225

HQ ARRS/DORQ
ATTN: MAJ FARAGE
SCOTT AFB IL 62225

ACTION

DOE/ORO
ATTN: MR BROWN
P O BOX E
OAK RIDGE TN 37830

USAF-OEHL/RZI
ATTN: SMSGT HARVEY
BROOKS AFB TX 78235

INFORMATION

ESC/SCU-5
ATTN: CAPT TUSTIN
HANSCOM AFB MA 01731

USA-NATICK LABS
ATTN: DR R S SMITH
KANSAS ST
NATICK MA 01760

USA-CRREL-EE
ATTN: MR WOURI
72 LYME RD
HANOVER NH 03755

HQDA (MA-WSA)
ATTN: MAJ BELL
PENTAGON, RM 3B454
WASHINGTON DC 20310

SAF/MII
ATTN: MAJ KROOP
PENTAGON, RM 4C940
WASHINGTON DC 20330

HQ USAF/LEYSF
WASHINGTON DC 20330

HQ AFSC/DLWM
ATTN: CAPT REED
ANDREWS AFB MD 20334

HQ AFSC/SDN
ATTN: MR MILLER
ANDREWS AFB MD 20334

DISTRIBUTION LIST (CON'T)

INFORMATION

USA-FESA-T
ATTN: DR HOLLIS
FT BELVOIR VA 22060

9 AF/LED-RDJTF
ATTN: CAPT STARASLER
SHAW AFB SC 29512

WR-ALC/MMTMH
ROBINS AFB GA 31098

AD/YQ
ATTN: COL BITTLE
EGLIN AFB FL 32541

AFIT/DET
ATTN: CAPT SCHULTZ
WRIGHT-PATTERSON AFB OH 45433

ASD/RADE
ATTN: MAJ PIEROWAY
WRIGHT-PATTERSON AFB OH 45433

AFAMRL/HEA
ATTN: DR TASK
WRIGHT-PATTERSON AFB OH 45433

USA-CERL-ES
ATTN: MR WINDINGLAND
P O BOX 4005
CHAMPAIGN IL 61820

HQ AFCC/DEMU
SCOTT AFB IL 62225

AIR FORCE ENERGY LIAISON OFFICE
DOE/ALO
P O BOX 5400
ALBUQUERQUE NM 87115

COMMANDING OFFICER
NCEL (ATTN: CODE L03AE)
PORT HUENEME CA 93040

HQ AFTEC/XPP
KIRTLAND AFB NM 87117

APPENDIX VI

STATE OF ALASKA

TEST PLAN

Evaluation of:

Radioluminescent (RL) Airfield Marking System

Location and time:

Field test at Central, Alaska. Period from December 13, 1983, to February 15, 1984.

Equipment to be evaluated:

1. Radioluminescent airfield edge and threshold second generation lights with prototype fixtures and semi-permanent base mount systems. Some of the first generation lights may also be used if deemed necessary.

2. Radioluminescent portable glide slope landing aide contingent on availability.

3. Radioluminescent airfield wind direction indicator.

Objectives:

To evaluate, in an operational environment, a usable, self powered lighting system designed for remote airfields. The system must be operationally simple wtih low maintenance requirements and realistic cost potential.

SCHEDULE AND DESCRIPTION OF EVENTS

Upon selection of a bush airfield:

1. Alaska Department of Transportation and Public Facilities (DOTPF) personnel will notify appropriate airport maintenance

personnel on selection of runway for RL light test. Maintenance personnel (either contract personnel or direct state employees) will be instructed as to necessary inspection checks we will require for lights. They will have easy access to DOTPF/DOE Laboratory personnel if any problems arise with the system in the absence of DOTPF/DOE Laboratory personnel. (Completed as of October 1, 1983)

Weather data will be compiled daily by DOTPF/DOE Laboratory personnel. Data to be collected will include:

a. Outdoor temperature.

b. Wind direction and speed.

c. Ambient light conditions.

d. Precipitation.

e. Cloud cover.

2. Village concil and mayors will be informed of test program and briefed on the lighting system. If the village is receptive to the light test in their location, a "Public Relations" program will go into effect in which all village citizens, young and old, will be informed of the importance of the runway lights to their community and what level of risk the RL light system presents. Items to be covered in the briefing will include:

a. RL light safety features.

b. Effects of breakage of RL lights (health-physics).

c. No external power source, therefore, low maintenance.

d. Importance of scheduled air travel to bush in winter.

(Completed September 8, 1983)

3. DOTPF personnel will coordinate with FAA on notification of air carriers and private pilots of the test lighting system. (Completed September 22, 1983)

4. Letters will be sent to the following groups of people to inform them of the test location and duration. Their participation to view/evaluate the light system will be encouraged.

a. Alaska Department of Transportation and Public Facilities personnel.

b. FAA personnel.

c. State legislators.

d. Canadian Department of Transportation.

e. Air Carriers Association representatives.

f. Civil Air Patrol (CAP) personnel.

g. U. S. Navy.

h. Coast Guard.

i. Army Guard.

j. Air Guard.

5. Scheduled bush air carriers and airlines for the village will be briefed on the lighting system -- a special briefing will be given to interested pilots (private and commercial) on how the lighting system works and how the lighting system would be perceived by a pilot (slides and other video aides will be used). Newspaper ads and radio shorts will be used to notify pilots of the briefing location and time.

6. Pilots will be informed that we would appreciate all comments, either positive or negative, or phone or mail, on the lighting system after they have flown to it. Evaluation sheets will be provided for pilots prior to system installation. A system of evaluation form distribution and retrieval of completed forms will be organized.

September 1983

Base mounts for light fixtures will be installed at selected brush airfield location by DOTPF personnel. (See figures 1 and 2 for fixture and base mount design as suitable alternatives).

November 1983

On November 1-4 DOTPF/DOE Laboratory personnel will brief the Technical Working Group (TGC) on the State of Alaska's tests. Identifying all details and points of coordination necessary.

November 18-22

At Allen Army Airfield DOTPF/DOE Laboratory personnel will offer assistance where needed to the DOE/Air Force personnel. Also during this period DOTPF/DOE Laboratory personnel will make adjustments to the lighting configuration to allow FAA Flight Standards inspectors to fly against the lights in a light aircraft. FAA will evaluate three separate configurations as shown in figures 3, 4, and 5. This operation should be accomplished during one evening of testing. Exact schedule will be developed during the November 1-4 meetings at Camp McKall.

November 22 - December 13

During this period FAA will be requested by state of Alaska to adopt a procedure to allow commercial and/or private pilots to utilize the lighting system once it has been installed and accepted at Central, Alaska.

December 1983

Alaska Air National Guard (AKANG) C-130 Transport will arrive at Central with cargo of RL lights, fixtures, and ancillary equipment.

NOTE: If preassembly of light fixtures is required before lights arrive at final bush airfield demonstration location, the above will occur along with the following steps.

1. DOTPF/DOE Laboratory personnel will meet C-130 and offload equipment to ground transportation. Equipment will be taken to secure warm storage and assembly area at DOTPF facility, 2301 Peger Road, Fairbanks, AK, or other approved location.

2. Assembly of RL lights and fixtures will commence.

NOTE: If preassembly is not required the following will take place.

December 1983

1. Lights will be transported to bush airfield location at Central, Alaska, via AKANG C-130 aircraft.

2. Light system will be mounted on preset base mounts.

3. Test landings and takeoffs will be made to the newly installed light system. Deficiencies will be corrected at this time. FAA will cooperate here.

NOTE: All shipping containers for the lights will be stored at a secure DOTPF or other approved facility at Central throughout the duration of the DOTPF test.

At least one DOTPF/DOE laboratory personnel will remain at the runway location for up to one week upon deployment of the lights. Travel inspection/evaluation trips to the village will be made weekly or as needed after initial acceptance of the lights. Any changes in light configuration throughout the duration of the test will be agreed upon by both DOTPF and FAA personnel. The USAF, AAC, AKARNG, AKANG, and CAP aircraft and personnel will be encouraged to fly to Central to view and evaluate the lights throughout the duration of the State's test. A questionnaire will provide a data base for this aspect of the test. Also a cost analysis by the commercial carriers will be requested to determine the impact of the lighting system on their respective operations.

January 16 - 20, 1983

One or more days during this week will be set aside for a presentation on the RL lighting system for USDOE and Alaska DOTPF personnel. A field trip to Central to view the lights will also be scheduled during this time for others primarily interested in civilian uses of RL airfield lighting systems.

February 1984

Upon completion of DOTPF's portion of the test, the AKARNG and/or AKANG will be called upon for air support to return the lights to secure storage in Anchorage or Fairbanks pending instructions from DOE.

Any adnormalities in the light system which can be easily remedied will be corrected at this time. The lens covers will be cleaned as needed.

February 15, 1984

The lights will be made available to the AAC for their continued testing.

A pilot debriefing and critique will be held following the removal of the lighting system. Newspaper ads and radio shorts will be used to notify pilots of briefing location and time.

Upon completion of the test, a meeting will be held in Central to get feedback from the DOTPF maintenance personnel and residents of Central on their perceptions of the RL runway lighting system.

During the spring of 1984 all data will be compiled and a report written.

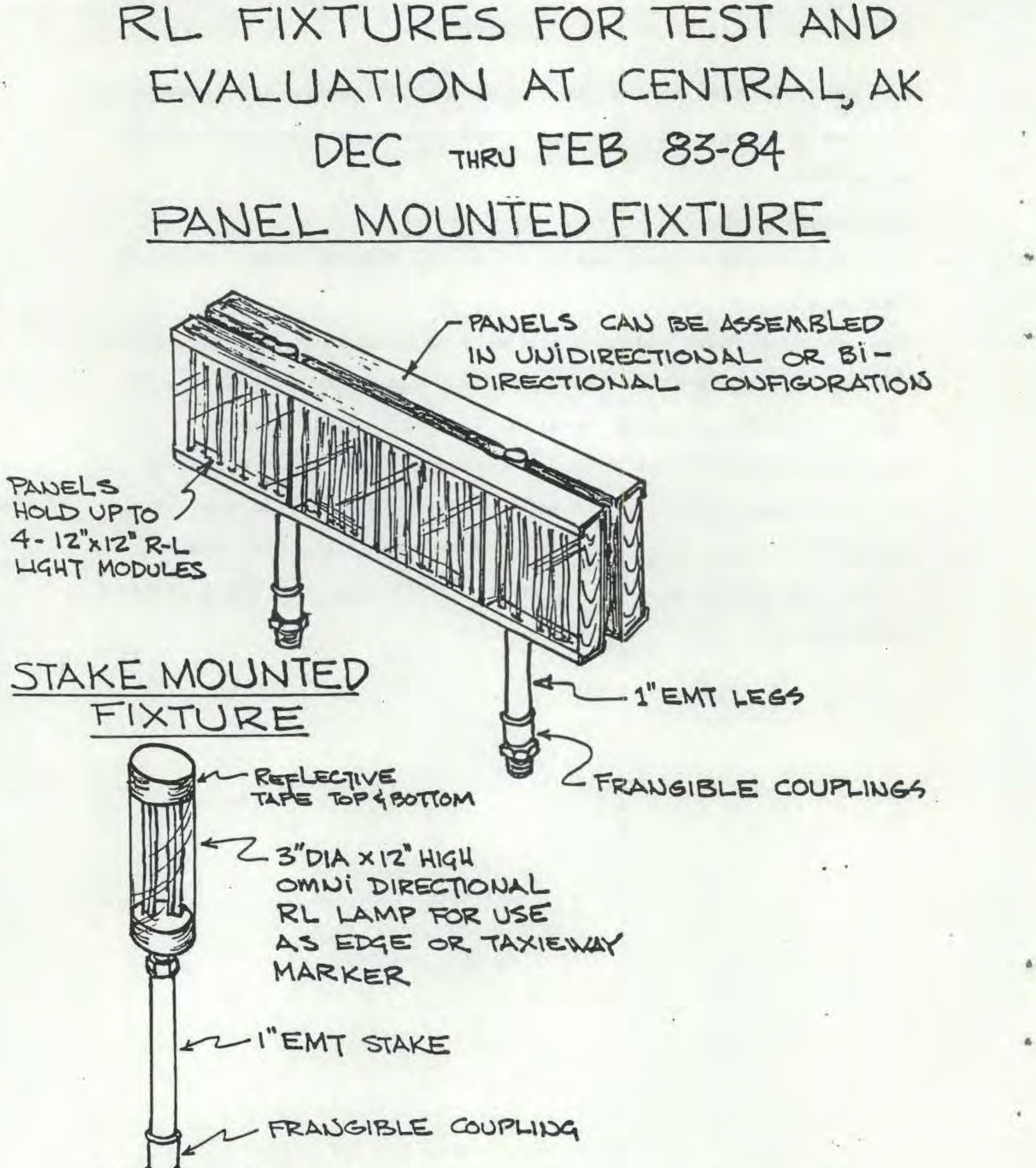
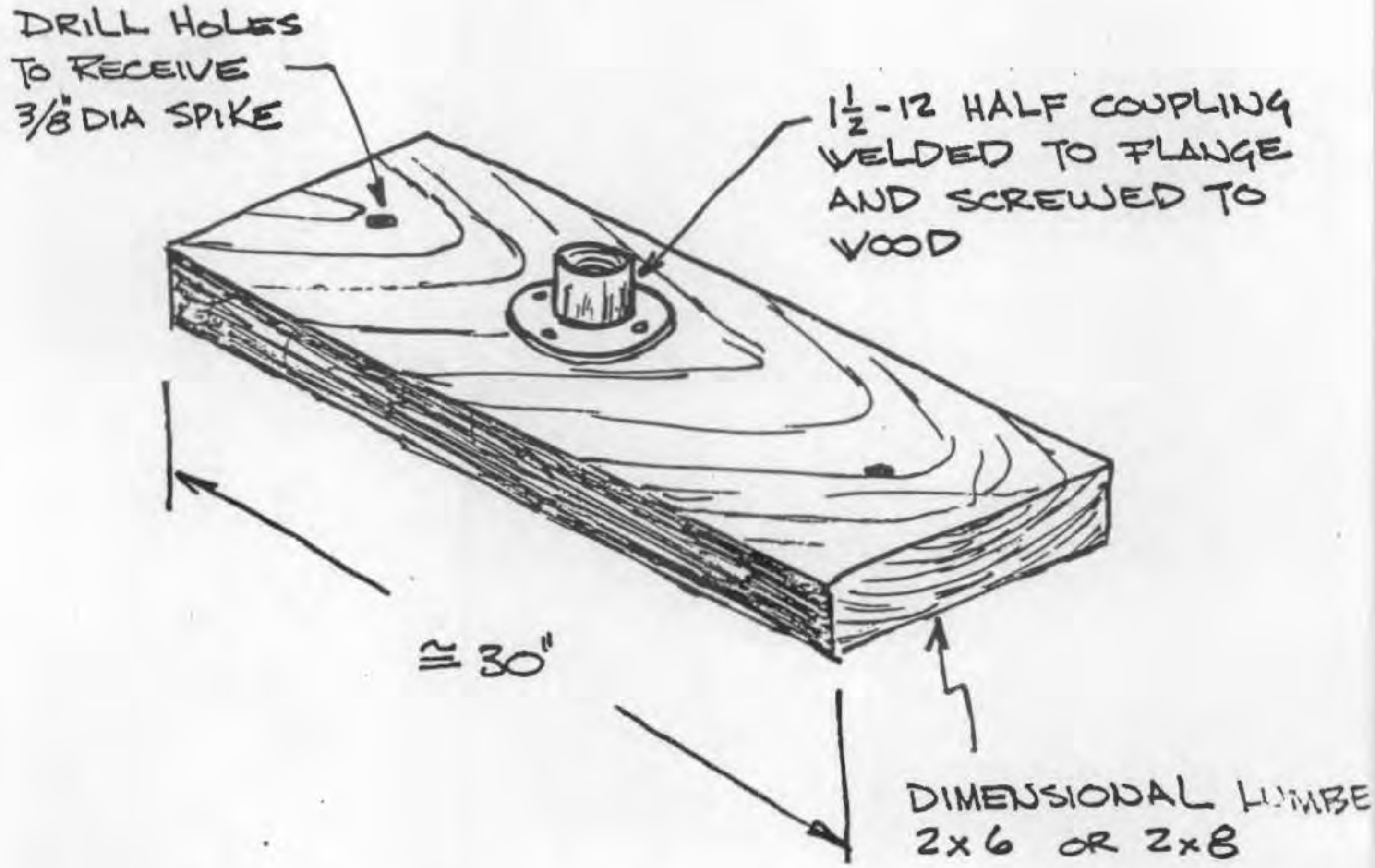


Figure 1. RL Fixtures for Test and Evaluation at Central, AK Dec thru Feb 83-84

RL LIGHT BASE MOUNT



1-PIECE REQUIRED FOR EACH STAKE MOUNTED R-L LIGHT UNIT

2-PIECES REQUIRED FOR EACH PANEL MOUNTED R-L LIGHT UNIT

Figure 2. RL Light Base Mount

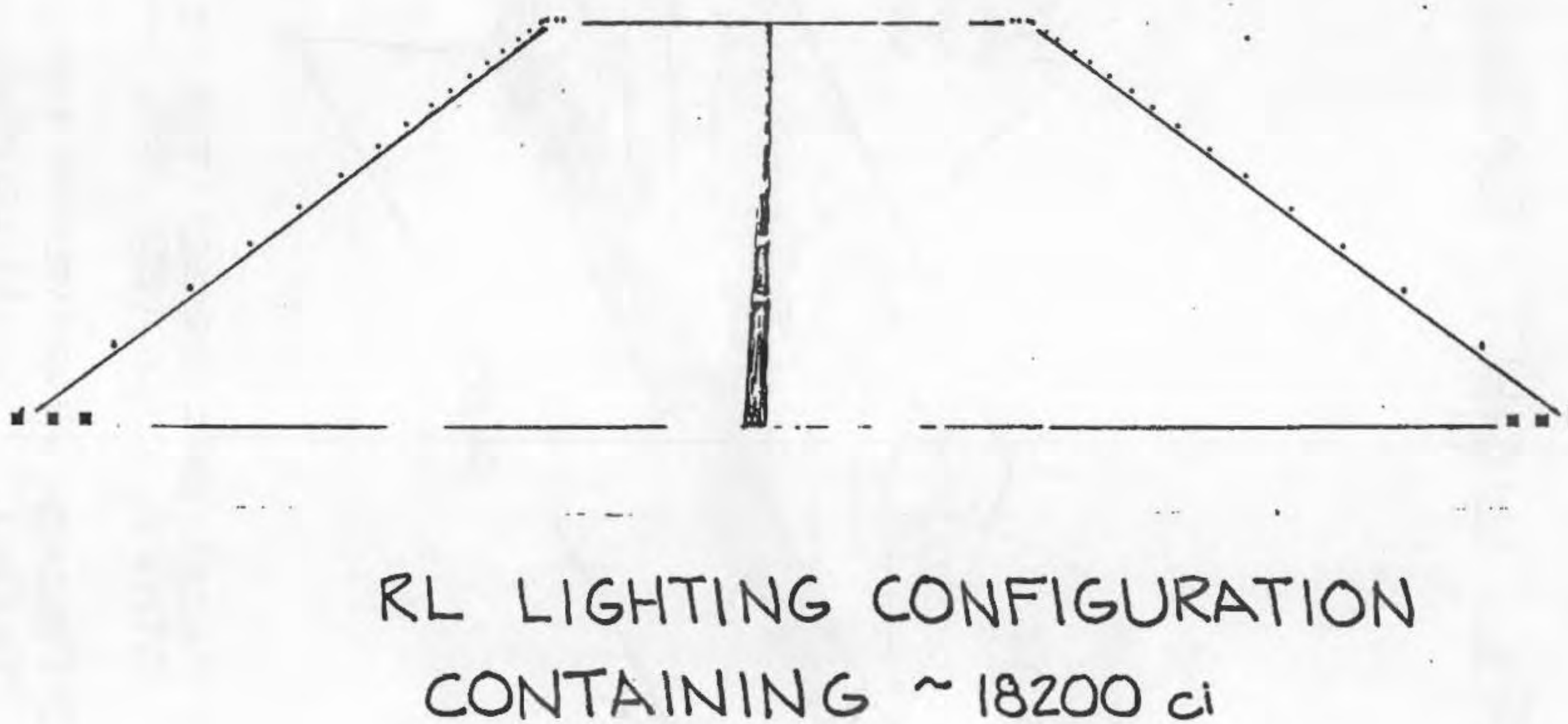


Figure 3. RL Lighting Configuration Containing 18200 ci

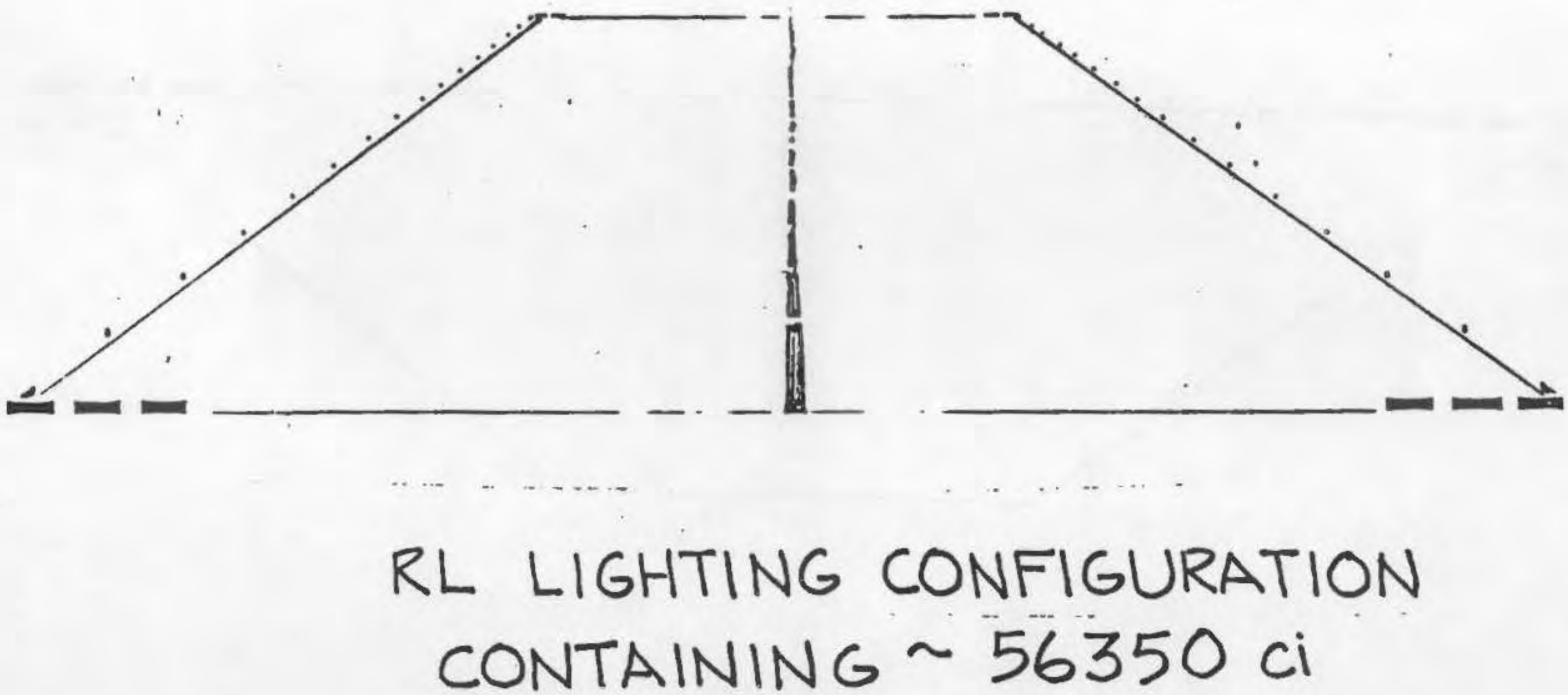


Figure 4. RL Lighting Configuration Containing 56350 ci

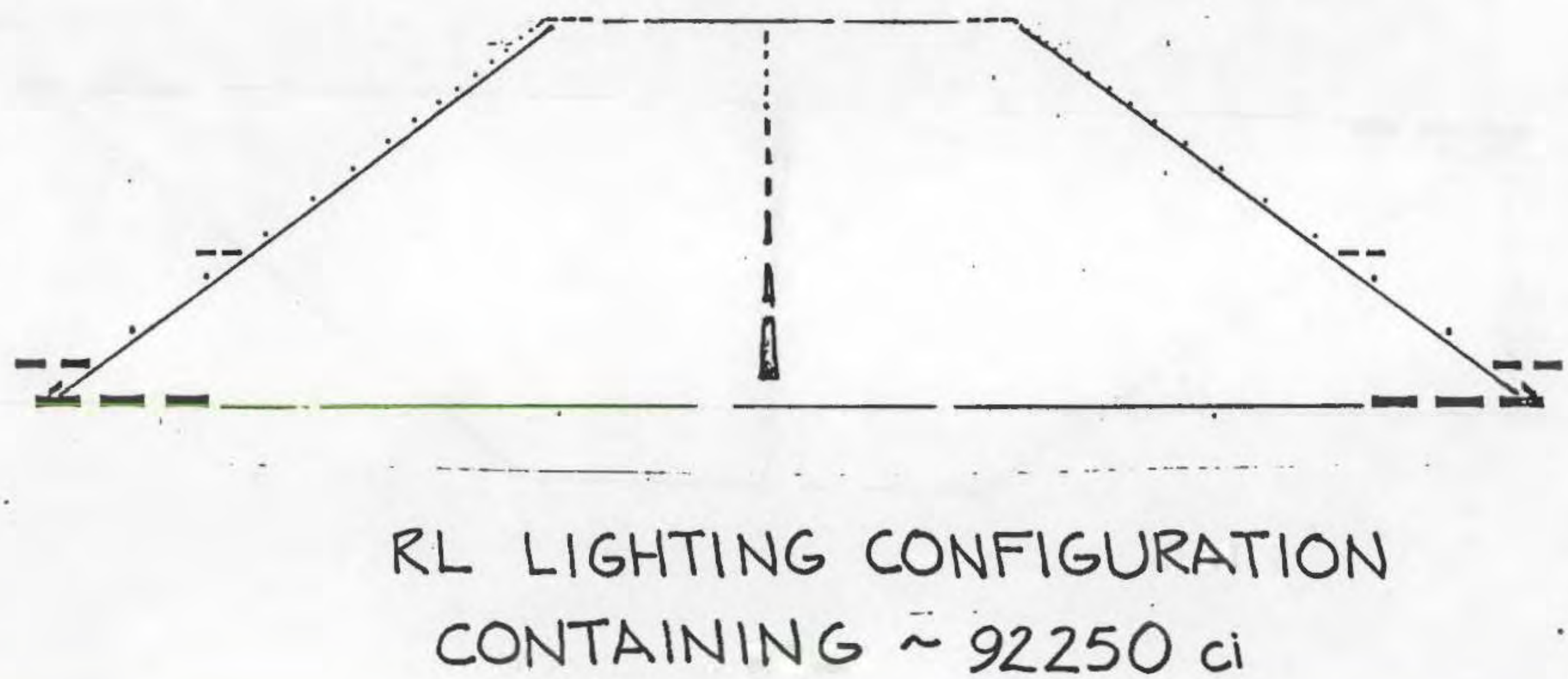


Figure 5. RL Lighting Configuration Containing 92250 ci

ANNEX I

EVALUATION OBJECTIVES

1. Identify and evaluate human factors and cold climate engineering variables affecting the deployment, operation and maintenance, and redeployment of tritium lights and fixtures for different arctic and subarctic applications, including:

a. Ease and safety of storing and transporting the lights and fixtures.

b. Ease and safety of fixture handling while encumbered with arctic clothing for extreme cold, wind and snow conditions.

c. Suitability and adaptability of fixture supports for temporary installation (freezing and/or staking to ground) and effectiveness of fixture bases.

d. Installation and removal time requirements.

e. Maintainability, to include cleaning the lights and fixtures.

f. Ability to stand up to weather, propeller and jet blast effects.

2. Evaluate the physical and environmental safety and security of RL lighting applicable in remote arctic operations.

3. Evaluate security precautions to preclude theft and/or destruction of the lights.

4. Identify and evaluate visual slant range at which pilots acquire the tritium lights. The improved RL airfield lighting system should have a 4-6 mile acquisition range. This is to be verified by each aircrew.

5. Evaluate pilot views of tritium lighting as aid for approach, landing, rollout and takeoff.

6. Evaluate capability of a VASI system to provide glide slope information to pilots.

7. Assess overall adequacy of tritium lighting to support a variety of aircraft and operations in an arctic and subarctic environment.

8. Provide individual and/or group recommendations to enhance any aspect of light utilization.

9. Ground support briefing to be conducted by responsibility of AAC/DEMG.

ANNEX II

BRIEFING HANDOUT ON

TRITIUM RADIOLUMINESCENT (RL) PORTABLE LIGHTING

BACKGROUND

Radioluminescent (RL) lighting is defined as the use of radiation from radioisotopes in combination with phosphors to produce visible light. Radioluminescent lighting has been used in industry for clock dials, exit signs and light standards in the photographic industry. The military has used light-emitting paints for aircraft dial illumination, mine field markers, and gunsight illumination.

Within the last several years a joint DOD/DOE effort has been underway to develop tritium RL lighting for airfield application. A first generation of tritium lighting was evaluated at Clear Creek,LZ during BRIM FROST 83. These lights proved to have a visual acquisition range of one to two miles which was suitable only for slow moving aircraft.

Since then, comprehensive engineering efforts have produced a significantly improved runway light. It is anticipated this light can be acquired by aircrews between four to six miles, which is suitable to support C-130/A-10 type aircraft operations.

Certain known techniques may be used by participating pilots to improve acquisition of the lights, such as keeping cockpit/cabin lighting to an absolute minimum, and not staring at the tritium lights; viewing slightly to the side may improve acquisition. Also helpful is not turning landing lights on until short final, as they tend to wash out the test lights.

One final reminder - Tritium lights are not incandescent. They give off a smooth glow rather than a bright point light.

Attached are specific procedures to follow during the test and a questionnaire to be completed.

ANNEX III

PROCEDURES FOR A-10 EVALUATION

OF TRITIUM RL RUNWAY LIGHTS

1. A primary motive behind tritium lighting development is the enhancement of tactical operations at bare bases, especially in the arctic environment.

2. It is extremely important that A-10 pilots have the opportunity to evaluate the tritium runway lighting and its capability to support their mission.

3. Pilots will receive a briefing prior to their first flight.

4. A maximum number of pilots is desired, but an individual pilot may fly more than one test sortie.

5. At least two sorties are desired daily (1600L-2000L).

6. Aircraft will depart Eielson AFB to arrive at Allen AAF between 1600 and 1900 local with sufficient intervals to allow time for low approaches and landings.

7. Pilots may execute an instrument approach to Runway 18 at Allen AAF, AK.

8. Pilots may execute visual approaches if weather conditions allow VFR operations.

9. Pilots will execute at least one missed approach/low approach prior to a full stop landing.

10. Prior to a full stop landing the pilot will receive the current weather conditions including an acceptable runway condition reading (RCR) from the test teams.

11. Final decision to land will remain with the pilot - SAFETY WILL NOT BE COMPROMISED.

12. After landing, the aircraft will be taxied to the specified parking area and shut down for mandatory brake cool period.

13. If possible, pilots will be verbally debriefed by the test team.

14. A-10 aircraft will then take off, make one additional low approach, and return to Eielson AFB.

15. Pilots and ground support crews will complete questionnaires and return them to the project officer.

ANNEX IV

PROCEDURES FOR C-130 DEVELOPMENT TEST

OF TRITIUM RUNWAY LIGHTING AT DONNELLY LZ

1. Portable, dependable airfield lighting is a necessary asset in the successful accomplishment of the tactical airlift mission.

2. It is extremely important the C-130 pilots have the opportunity to evaluate the improved tritium runway second generation tritium lighting and its capability to support their mission.

3. The 616 MAG will appoint a project officer to coordinate all test requirements and ensure participating C-130 aircrews are briefed and debriefed.

4. C-130 aircrews will receive a thorough brief prior to their first flight and receive a questionnaire handout package.

5. Pilots will file a flight plan and fly their aircraft to Donnelly, LZ IAW normal MAC and ATC operating requirements and procedures.

6. Pilots will align the aircraft on the extended runway centerline, at least five nautical miles from the runway threshold to begin a straight-in approach.

7. Pilots will, as accurately as possible, document the maximum distance at which the lights are acquired, usable distance, glide path information, and other data required by the aircrew questionnaire.

8. Low approaches/missed approaches will not be planned in support of the tritium test.

9. Pilots may request that conventional runway lighting be turned on anytime they feel safety may be compromised.

10. Pilots will complete the questionnaire and return it to the unit project officer.

ANNEX V

TRITIUM RUNWAY LIGHTING

AIRCREW QUESTIONNAIRE

Instructions: This questionnaire shall be completed as soon as possible after viewing the test lights. Please identify acquisition distance for each approach made. Return to your project officer or return to: HQ AAC/DOOS, Elmendorf AFB AK 99506. When evaluating the RL lighting system (RLS), use "outstanding" as if you were evaluating an excellent incandescent system. A satisfactory system will be your opinion on an acceptable airfield lighting system.

I. General

A. Approach flown: VOR ___ NDB ___ TACAN ____ Visual____

B. Maneuvers: Low Approaches _____ Landings _____

C. Have you flown approaches and/or landed at this airfield before? Yes_____ No_____

II. Weather Conditions

A. Cloud Cover: Scattered _____ Broken _____ Overcast _____

B. Ceiling/Visibility: Height _____ AGL; Distance _____nm

C. Precipitation: Snow ____ Fog ____ Haze ____ None ____

III. VASI Landing System

A. Maximum Acquisition Distance (each approach)

___ ___ ___ ___ ___ ___ nm
1 2 3 4 5 6

B. At what distance did the VASI provide usable "glide path" information? (each approach) ___ ___ ___ ___ ___ ___ nm
1 2 3 4 5 6

C. How was this distance measured? (each approach)

Estimated	___	___	___	___	___	___
Radar	___	___	___	___	___	___
DME	___	___	___	___	___	___
Chart	___	___	___	___	___	___
	1	2	3	4	5	6

D. Rate the VASI for overall performance in providing runway end acquisition and glide path information: Outstanding ___ Excellent ___ Satisfactory ___ Marginal ___ Unsatisfactory ___

IV. Threshold Runway Markers

A. Maximum Acquisition Distance (each approach)

___ ___ ___ ___ ___ ___ nm
1 2 3 4 5 6

B. At what distance did the lights aid in runway alignment? (each approach) ___ ___ ___ ___ ___ ___ nm
1 2 3 4 5 6

C. How was this distance measured? (each approach)

Estimated	___	___	___	___	___	___
Radar	___	___	___	___	___	___
DME	___	___	___	___	___	___
Chart	___	___	___	___	___	___
	1	2	3	4	5	6

D. Rate the threshold and edge lights for overall performance: Outstanding ___ Satisfactory ___ Marginal ___ Unsatisfactory ___

V. Edgelights Runway Marker Lights

A. Maximum Acquisition Distance (each approach)

___ ___ ___ ___ ___ ___ nm
1 2 3 4 5 6

B. At what distance did the lights aid in runway alignment? (each approach) ___ ___ ___ ___ ___ ___ nm
1 2 3 4 5 6

C. How was this distance measured? (each approach)

Estimated	___	___	___	___	___	___
Radar	___	___	___	___	___	___
DME	___	___	___	___	___	___
Chart	___	___	___	___	___	___
	1	2	3	4	5	6

VI. Landing/Takeoff

A. Could you identify the entire landing/rollout/takeoff area using the test lights? Yes ___ No ___

B. Did the test lights provide similar visual cues (i.e., peripheral vision, depth perception, etc.) as conventional lighting? Similar ___ Different ___ Better than ___ As good as ___ Not as good as ___

Comments: ______________________________

____

____

VII. Conclusion:

A. Does the RL lighting system (RLS) meet your requirements as a landing, rollout, and takeoff aid? What recommendations would you make to improve upon this system? Please write your answers to the above questions and any additional comments appropriate regarding the RLS. ____________________________________

____

____

____

____

____

____

____

B. Name: ______________________________ Rank: ____________

Organization: ____________________ Location: __________

C. Telephone (Autovon and commercial): ____________________

D. Type aircraft flown: __________________________

E. Aircrew duty status: P _____ CP _____ Other _____

F. Aircrew aviation experience years ____ flight hours _____

G. If observer: Type aircraft: ______________

Have you evaluated RLS before? Yes _____ No _____

VIII. Your cooperation and support is appreciated. Please turn in questionnaire as requested in the coordinating instructions. Your input is essential!!

ANNEX IV

INSTALLATION BRIEFING PLAN

(30 minutes)

TITLE: "Radioluminescent (RL) Light Handling"

AUDIENCE: Prime BEEF installation team, and HQ AAC Radiological Protection Officer's (RPO) staff.

LOCATION: Arctic Test Site (ATS).

- PURPOSE. Explain and demonstrate safe installation of RL lighting fixtures.
- OVERVIEW
- INTRODUCTION: "Test and evaluation of new technology..."
- DESCRIPTION
  - -- What are RL lights?
  - -- How do they work?
  - -- Are they hazardous?
- GROUND OPERATIONS
  - -- Why use in Arctic?
  - -- Method(s) of deployment
  - - Physical security
- SAFETY
  - -- In case of breakage: Reporting & Controlling
  - -- Function of RPO
- DEMONSTRATION
  - -- Site preparation
  - -- Installation
  - -- Alignment
- SUMMARY: Q & A

ANNEX VII

TRITIUM RUNWAY LIGHTING

GROUND SUPPORT CREW QUESTIONNAIRE

The RL lights to be used for USAF field tests in Alaska during the fall and winter of 1983-84 are experimental devices. Of importance to these fall and winter tests are the ease and efficiency with which they can be deployed, redeployed, used and stored. Key factors affecting these four operations are handleability, materials performance, attachment, removal, assembly, disassembly, dusting, condensation, icing and maintenance under the field conditions in which they will be tested.

Instructions: Please complete this questionnaire as soon as possible after conducting one or more of the following operations: (1) storing, (2) deploying, (3) redeploying, and/or (4) observing operation of the tritium RL lights. Limit your comments to those questions that address the activities in which you were personally involved.

I. Type of Operation

A. Storing __________

B. Deployment __________

C. Redeployment __________

D. Operations/maintenance __________

II. Weather Conditions

A. Surface temperature ______________

B. Surface wind speed __________ Direction ___________

C. Surface Visibility: Distance ________________

D. Precipitation: Snow _____ Rain _____ Fog _____

Ice fog _____ Haze _____ None _____

E. Date _____________ Time _____________

III. VASI Landing System

	Outstanding	Excellent	Satisfactory	Marginal	Unsatisfactory
A. Handleability					
1. Time					
B. Assembly					
C. Disassembly					
D. Attachment					
E. Removal					
F. Weight					
G. Materials Performance					
H. Frosting					
I. Dusting					
J. Condensation					
K. Cleanability					
L. Personnel Req'd					
M. Storage					

When evaluating H, I, & J consider equipment designs ability to limit each characteristic. For L it is Outstanding when system requires less than conventional system, and more would be unsatisfactory.

IV. Threshold Lights

	Outstanding	Excellent	Satisfactory	Marginal	Unsatisfactory
A. Handleability					
B. Assembly					
C. Disassembly					
D. Attachment					
E. Removal					
F. Weight					
G. Materials Performance					
H. Frosting					
I. Dusting					
J. Condensation					
K. Cleanability					
L. Personnel Req'd					
M. Storage					

When evaluating H, I, & J consider equipment designs ability to limit each characteristic. For L it is Outstanding when system requires less than conventional system, and more would be unsatisfactory.

V. Edge Lights

	Outstanding	Excellent	Satisfactory	Marginal	Unsatisfactory
A. Handleability					
1. Time					
B. Assembly					
C. Disassembly					
D. Attachment					
E. Removal					
F. Weight					
G. Materials Performance					
H. Frosting					
I. Dusting					
J. Condensation					
K. Cleanability					
L. Personnel Req'd					
M. Storage					

When evaluating H, I, & J consider equipment designs ability to limit each characteristic. For L it is Outstanding when system requires less than conventional system, and more would be unsatisfactory.

VI. Conclusions and Recommendations

A. Give your overall evaluation of the ease of storage/deployment/redeployment/use of the tritium RL lights.

____

____

____

____

B. List any suggestions you may have for improving the design and use of the RL lights (handling, storage, etc.).

____

____

____

____

____

____

____

____

VII. Responder

Name ______________________________ Rank/Rating ____________

Organization ___________________________ Location ____________

Telephone Number ___________________________

ANNEX VIII

TERMS, DEFINITIONS, ACRONYMS

AAC	Alaskan Air Command
AFESC	Air Force Engineering and Services Center
AKDOTPF	State of Alaska Department of Transportation and Public Facilities
ATC	Air Traning Command
ATP	Arctic Test Plan
ATS	Alaskan Test Site
AvBn	Aviation Battalion
COMPW	Composite Wing
DOD	Department of Defense
DOE/OR	Department of Energy/Oak Ridge Operations
EL	Electroluminescent
FAA	Federal Aviation Administration
IFR	Instrument Flight Rules
IR	Infrared
MAC	Military Airlift Command
MAG	Military Airlift Group
NCARNG	North Carolina Army National Guard
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratories
OT&E	Operational Test and Evaluation
PNL	Pacific Northwest Laboratory
RCR	Runway Condition Reading
RL	Radioluminescent
RPO	Radiological Protection Officer

RSC	Runway Surface Conditions
TACAN	Tactical Aid to Navigation
TAG	Tactical Airlift Group
TFW	Tactical Fighter Wing
TOLs	Tactical Operating Locations
UHF	Ultra High Frequency
USAF	United States Air Force
USCG	United States Coast Guard
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency

APPENDIX B

COMMERCIAL PRODUCERS OF TRITIUM LIGHTS IN THE UNITED STATES AND EUROPE

NRD CORPORATION
2937 ALT BOULEVARD
GRAND ISLAND NY 14072

SAFETY LIGHT CORPORATION
4150-A OLD BERWICK ROAD
BLOOMSBURG PA 17815

SELF POWERED LIGHTING
8 WESTCHESTER PLAZA
ELMSFORD NY 10523

BRANDHURST COMPANY, LTD.
WELLINGTON ROAD
P.O. BOX 70
HIGH WYCOMBE, BUCKS
ENGLAND HP12 3PS

SAUNDERS-ROE DEVELOPMENTS, LTD.
MILLINGTON ROAD, HAYES
MIDDLESEX
ENGLAND UB 3 4NB

MB-MICROTEC AG
FREIBURGSTRASSE 624
CH-3172 NIEDERWANGEN/BERN
SWITZERLAND

RADIUM-CHEMIE, LTD.
CH-9053
TEUFEN
SWITZERLAND

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509) 375-2602
Telex 15-2874

June 28, 1983

SAMPLE LETTER REQUESTING INFORMATION
SENT TO FIRMS LISTED ON PREVIOUS PAGE

Gentlemen:

We are currently working with several organizations to evaluate and further develop self-contained lighting for a variety of purposes. As a part of this effort, we have a commitment to assess the state-of-the-art for the use of radioluminescent lighting for airfield lighting and working purposes such as runway edge, threshold and taxiway lighting. Use of this lighting would be in remote and rural areas where commercial electric power is unavailable, unreliable or extremely expensive.

Prototype systems as they exist now require further development or modification before operational designs for routine use are available; however, to evaluate the state-of-the-art, specific information such as the following would be useful:

* Could industry provide a light of sufficient intensity to be useful in this application?
* What would be required to produce such a light and what would be its cost?
* Would the light be directional, bidirectional or omnidirectional?
* Is there something in existing product lines which would be suitable?
* What are the foreseen institutional problems such as licensing, public acceptance, etc.?

Battelle

While these are not all the questions that should be addressed, they are representative; and any information you could provide, including catalogs and published information, would be useful. Since we are conducting the evaluation for a public organization, the report on the work can be made available on request, and appropriate arrangements could be made to ensure that you receive a copy.

With best regards,

George A. Jensen
Senior Research Engineer
Ceramics and Polymers Development Section
Materials Department

GAJ/tf

mb-microtec
mb-microtec ag
CH-3172 Niederwangen/Bern
Freiburgstrasse 624
Telefon National 031 34 11 25
International + 4131 34 11 25
Telex 32 829 merbe

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington 99352 USA

Attn. Mr. George A. Jensen
Ceramics & Polymers Dev. Sect

Ihr Zeichen Your ref	Ihre Nachricht vom Your message of	Unser Zeichen Our ref.	Datum Date
		OWT/ss	July 12, 1983

Gaseous Tritium Light Sources (GTLS)

Dear Mr. Jensen

Thank you for your letter of June 28, 1983. Your interest is very much appreciated. GTLSs and some devices with them are our only products, so that we are naturally interested in new applications.

We sketch answers to your questions as follows:

1. "Could industry provide a light of sufficient intensity to be useful in this application?"

   To be more specific, we would need to know from you what "sufficient intensity" useful in this application quantitatively means.

   The prototype systems you have looked at must have given you at least a good idea of what is necessary.
   The further general comment refers to self-contained sources with tritium gas. Using a source configuration which gives a good energy conversion efficiency, any light intensity can be produced at established, known costs. The question of the hardware cost is much more open and depends on the optical parameters required for the application and the applicable safety criteria.

./.

mb-microtec
mb-microtec ag
CH-3172 Niederwangen/Bern
Freiburgstrasse 624
Telefon National 031 34 11 25
International + 4131 34 11 25
Telex 32 829 merbe

2. "What would be required to produce such a light and what would be its cost?".
   Clearly, some answers to the questions raised in 1. are necessary to give a meaningful answer to this question.

3. "Would the light be directional, bidirectional or omnidirectional?"
   If the application requires, either one of these directional proporties answers in the form of economical practical designs can be found.

4. "Is there something in existing product lines which would be suitable ? "

   Definitely not. Closest comes a prototype panel (usual EXIT sign size e.g. 7,5 x 16,5 inches) with an array of parabolic reflectors loaded with 5 mm dia green GTLSs. It is quite directional, quite rugged, weight about 5,5 lbs and its activity is some 140 Curies T_2. Order of magnitute emitted light intensity is 0.25 Lumen.

5. "What are the foreseen institutional problems such as licensing, public acceptance, etc?"

   In our opinion, none of the private companies handling tritium at the present time would easily increase its tritium throughput by one or two orders of magnitude, as may be necessary to support the wide scale program which you envision.
   On the other hand, given the proper location, expertise and capital, tritium gas in the required quantities can be handled safely.
   Public acceptance may always be a problem. Here, the circumstances for acceptance should be favorable: low "physical" risk, and few exposed persons who tend to benefit rather directly.

Please, let us know, if that is the preliminary type of information you look for. Receipt of the information requested from you would permit us to become more specific.

We certainly are interested in an exchange of information and we request the report on your work when it becomes available.

I enclose a brief description on our company and some of its products.

Sincerely yours

mb-microtec ag

O.W. Thüler

RADIUM-CHEMIE LTD. TEUFEN

Telephone 071 / 33 14 15
Telex: 77 231

Manufacturers of Luminous Products
and Luminising Equipment

Mr. George A. Jensen
Pacific Northwest Laboratories
P.O. Box 999
RICHLAND, Washington 99352.
U.S.A.

Your Ref.: GAJ/tf Our Ref.: EH/h CH - 9053 Teufen. October 14, 1983.

Gentleman:

We acknowledge receipt of your letter dated June 28, 1983 describing briefly your commitment to assess the state-of-the-art for the use of radioluminescent lighting for airfield lighting and others.

Since we are not manufacturing suitable gaseous tritium light sources for the application in mind, we feel sorry to give you a negative answer. We assume that you have also approached the existing specialists, such as N.R.D., Brandhurst Co.Ltd. and MB Microtec for assistance and proposals.

We have been specialising in the manufacture of tritium, promethium-147 and C14 activated luminous products, as described in the attached leaflets.

We apologize for the unusual delay in replying.

Sincerely yours,

RADIUM-CHEMIE LTD.

E. Huber

E. Huber

Encl.

BRANDHURST COMPANY LIMITED

INDUSTRIAL DIVISION

P.O. Box 70, Wellington Road, High Wycombe, Buckinghamshire HP12 3PS
Telephone: High Wycombe (0494) 33411 Telex: 837138

DAT/RAB

6th July, 1983

Mr. G.A. Jensen,
Senior Research Engineer,
Ceramics & Polymers Development Section,
Materials Department,
Battelle,
Pacific Northwest Laboratories,
P.O. Box 999,
Richland,
Washington 99352.

Dear Mr. Jensen,

Thank you for your letter of 28th June regarding the use of radioluminescent lighting for airfield marking purposes.

You are quite correct in your assumption that there is a great deal of interest in this application for our product and Brandhurst have, in fact, manufactured several prototypes which are already undergoing trials. To answer your questions:-

1. We most certainly can provide a light of sufficient intensity to be useful in many of the applications mentioned.

2. The cost would depend upon the particular application and could vary between $50 and $500 per unit according to size and brightness.

3. For a given tritium content a unidirectional light would be the brightest, however, we have produced prototypes which are unidirectional, omnidirectional and variable.

4. To my knowledge, there is nothing in existing product lines which would be suitable.

2/ ...

Mr. G.A. Jensen 6th July, 1983

5. In mainland U.S.A. it would be necessary to licence such an object and, as it has a high tritium content, it is more likely to be granted a licence for military purposes.

We do not have any published information at this date but once our trials are concluded we may be in a position to forward it to you.

With best regards.

Yours sincerely,

D. A. Tonks
Managing Director

APPENDIX C

ANALYSIS OF AN ACCIDENT USING DATA DEVELOPED IN REFERENCE 33

Radiation doses from tritium are dependent upon the concentration of radioactive material released to the atmosphere, in this case tritium, and the relative amounts of tritium, as elemental tritium or water, taken up by man or animals under the same conditions of exposure. The equations used to estimate the air concentrations are not valid for distances less than about 100 meters from the point of release. For this reason, it is often necessary to rely upon data developed from animal experiments or routine handling of accidents which are a rare consequence of laboratory procedures and the research and development process. The latter case was addressed in the text. To ensure that a possible accident was not overlooked, an analysis of an accident was made using data obtained from several experiments performed using swine as an experimental animal.[33]

The swine were contained in pens situated 0.5 meters above the location where tritium activated light sources were broken. Water content of the released tritium was high, approximately 1.5 percent, much higher than that contained in any lights produced today, which is less than 0.1 percent. The experiments were conducted under two sets of conditions: first, the pens were in open air; and second, the pens were enclosed in a plastic tent-like structure to model the out-of-doors and a closed room, respectively. Tritium uptake was determined from blood samples taken prior to and 24 hours after the experiment.

The extrapolation to humans from swine depends upon the relative amount of tritium taken up by the human compared to the swine under the same conditions of exposure. Using the exposure data from these experiments as a basis for calculation, the radiation dose to an individual in close proximity to a tritium activated runway marker (368 Ci of tritium) that was destroyed was 0.7 rem if the accident occured out-of-doors and 50 rem if the accident occured in an enclosed area such as a nonventilated room. The long durations of exposure and other variables in the above experiments do not permit direct comparison to the expected accidents described in the text but could define the outer limit of doses that could result from the destruction of a light. It is, of course, possible to conceive an infinite number of accident scenarios which could then be analyzed for risk. At this point, it is not clear what type of scenarios the licensing process will be required to consider; however, the above example shows that the probable risk to humans for an accident involving an RL lighting fixture is minimal.

APPENDIX D

APPLICABLE REGULATORY GUIDES

Revision 1
August 1979

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 10.7

GUIDE FOR THE PREPARATION OF APPLICATIONS FOR LICENSES FOR LABORATORY AND INDUSTRIAL USE OF SMALL QUANTITIES OF BYPRODUCT MATERIAL

1. INTRODUCTION

This guide describes the type of information needed by the NRC staff to evaluate an application for a specific license for laboratories and industries using millicurie quantities of byproduct material (reactor-produced radionuclides). This type of license is provided for under Title 10, Code of Federal Regulations, Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material."

Paragraph 20.1(c) of 10 CFR Part 20, "Standards for Protection Against Radiation," states that "...persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable" (ALARA). Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable," provides the NRC staff position on this important subject. License applicants should give consideration to the ALARA philosophy, as described in Regulatory Guide 8.10, in the development of plans for work with licensed radioactive materials.

2. LICENSE FEES

An application fee is required for most types of licenses. The applicant should refer to §170.31, "Schedule of Fees for Materials Licenses and Other Regulatory Services," of 10 CFR Part 170 to determine the amount of fee that must accompany the application. Review of the application will not begin until the proper fee is received by the NRC.

3. FILING AN APPLICATION

An applicant for a byproduct material (radioisotopes) license should complete Form NRC-313I (see the appendix to this guide).[1] All items on the application form should be completed in sufficient detail for the NRC to determine that the applicant's equipment, facilities, and radiation protection program are adequate to protect health and minimize danger to life and property.

Since the space provided on Form NRC-313I is limited, the applicant should append additional sheets to provide complete information. Each separate sheet or document submitted with the application should be identified by a heading indicating the appropriate item number (on Form NRC-313I) and its purpose (e.g., radiation safety instructions).

The application should be completed in triplicate. The original and one copy should be mailed to the Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. One copy of the application, with all attachments, should be retained by the applicant since the license will require, as a condition, that the institution follow the statements and representations set forth in the application and any supplement to it.

*Lines indicate substantive changes from previous issue

[1]Applications for medical uses should be submitted on Form NRC-313M, and applications for use of sealed sources in radiography should be submitted on Form NRC-313R.

4. CONTENTS OF AN APPLICATION

Most items of Form NRC-313I are self-explanatory (see instructions with the form). The following comments apply to the indicated numbered items of the form.

Items 2 and 4. Specify the applicant corporation or other legal entity by name and address of principal office. Individuals should be designated as the applicant only if the use of the byproduct material is not connected with the individual's employment with a corporation or other entity. If the applicant is an individual, the individual should be specified by full name and address, including state and zip code.

Item 5. Specify the street address of the location of use if the address differs from the one given in Item 4. If use is to be at more than one location, the specific address of each should be given. Describe the extent of use and the facilities and equipment at each location. A post office box address is not acceptable.

Item 6. Specify the names of the persons who will directly supervise the use of radioactive material or who will use radioactive material without supervision.

Item 7. Specify the name of the person who will be designated as the radiation protection officer.[2] This person should be responsible for implementing the radiation safety program and therefore readily available to the users in case of difficulty and should be trained and experienced in radiation protection and in the use and handling of radioactive materials. In a small program not requiring a full-time radiation protection officer, the duties of the radiation protection officer may be assigned to one of the persons named under Item 6 of Form NRC-313I. Note, however, that it must be established that the person acting as radiation protection officer will have the opportunity to devote sufficient time to the radiation safety aspects of the program for the use of radioactive materials.

Items 8A, B, C, and D. Describe the byproduct material by isotope, chemical and/or physical form, and activity, in millicuries or microcuries. A separate possession limit for each nuclide should be specified. Possession limits requested should cover the total anticipated inventory, including stored materials and waste, and should be commensurate with the applicant's needs and facilities for safe handling.

If the use of sealed or plated sources is contemplated, the isotope, manufacturer, and model number of each sealed or plated source should be specified. If a source will be used in a gas chromatograph, gauge, or other device, the manufacturer and model number of the device should be specified.

Item 8E and Item 9. The use to be made of the radioactive materials should be clearly described. Sufficient detail should be given to allow a determination of the potential for exposure to radiation and radioactive materials both of those working with the materials and of the public.

Items 10 and 11. Specify for each radiation detection instrument the manufacturer's name and model number, the number of each type of instrument available, the type of radiation detected (alpha, beta, gamma, or neutron), the sensitivity range (milliroentgens per hour or counts per minute), the window thickness in mg/cm^2, and the type of use. The type of use would normally be monitoring, surveying, assaying, or measuring.

Describe the instrument calibration procedure. State the frequency, and describe the methods and procedures for the calibration of survey and monitoring instruments, as well as any other instruments and systems used in the radiation protection program, such as measuring instruments used to assay sealed-source leak-test samples (see Item 15), contamination samples (e.g., air samples, surface "wipe" samples), and bioassay samples (see Item 12).

An adequate calibration of survey instruments usually cannot be performed with built-in check sources. Electronic calibrations that do not involve a source of radiation are also not adequate to determine the proper functioning and response of all components of an instrument.

Daily or other frequent checks of survey instruments should be supplemented every 6 months with a two-point calibration on each scale of each instrument with the two points separated by at least 50% of the scale. Survey instruments should also be calibrated following repair. A survey instrument may be considered properly calibrated when the instrument readings are within ±10 percent of the calculated or known values for each point checked. Readings within ±20 percent are considered acceptable if a calibration chart or graph is prepared and attached to the instrument.

If the applicant proposes to calibrate his survey instruments, a detailed description of planned calibration procedures should be submitted. The description of calibration procedures should include, as a minimum:

a. The manufacturer and model number of each radiation source to be used,

[2] The terms "radiation protection officer" and "radiological safety officer" are synonymous.

b. The nuclide and quantity of radioactive material contained in each source,

c. The accuracy of the source(s). The traceability of the source to a primary standard should be provided.

d. The step-by-step procedures, including associated radiation safety procedures, and

e. The name and pertinent experience of each person who will perform the calibrations.

If the applicant intends to contract out the calibration of instruments, the name, address, and license number of the firm should be specified together with the frequency of calibration. The applicant should contact the firm that will perform the calibrations to determine if information concerning calibration procedures has been filed with the Commission. If information concerning calibration procedures has not been filed, it should be obtained and submitted.

Quantitative measuring instruments used to monitor the adequacy of containment and contamination control such as those used for measuring leak test, air, effluent, bioassay, work area, and equipment contamination samples should usually be calibrated prior to each use. The procedures and frequency for calibration of such instruments should be submitted and should include:

a. The name of the manufacturer and model number of each of the standards to be used,

b. The nuclide and quantity of radioactive material contained in each of the standard sources,

c. A statement of the accuracy of each of the standard sources. The source accuracy should be, as a minimum, ±5 percent of the stated value and traceable to a primary standard, such as that maintained by the National Bureau of Standards.

d. Step-by-step calibration procedures and, if appropriate, associated radiation safety procedures, and

e. The name and pertinent experience of each person who will perform the instrument calibrations.

Item 12. Personnel monitoring is required to ensure compliance with §§20.101 and 20.202 of 10 CFR Part 20. Personnel monitoring is also required if a person enters a high radiation area (greater than 100 millirems per hour). If personnel monitoring equipment will be used, the name of the organization furnishing film badge or thermoluminescent dosimeter (TLD) service and the frequency for changing badges, dosimeters, etc., should be specified. If pocket chambers or pocket dosimeters will be used, the useful range of the device, in milliroentgens, the frequency of reading, and the procedures for maintaining and calibrating the devices should be specified.

If personnel monitoring will not be used, the applicant should submit calculations or documentation from radiation surveys demonstrating that it is unlikely that any individual will receive a dose equal to or greater than that indicated in 10 CFR Part 20.

The applicant should show that the need for bioassays has been thoroughly considered and should establish the adequacy of the proposed bioassay program in relation to the proposed program of use of radioactive material. Bioassays are normally required when individuals work with millicurie quantities of hydrogen-3, iodine-125, or iodine-131 depending on the type of work, equipment, and procedures followed. Regulatory Guide 8.20, "Applications of Bioassay for I-125 and I-131," and a document entitled "Guidelines for Bioassay Requirements for Tritium"[3] may be consulted. Other materials may also be used in physical or chemical forms and under conditions that present an opportunity for uptake by the body through ingestion, inhalation, or absorption. A bioassay program to determine and control the uptake of radioactive material should be considered and discussed in relation to each such material, procedure, etc. Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," may be consulted.

The criteria to be used in determining the need for bioassays, the type and frequency of bioassays that will be performed, and the bioassay procedures should be specified and described in detail. If a commercial bioassay service is to be used, the name and address of the firm should be provided.

Bioassays may not be substituted for other elements of a safety program such as air monitoring and dispersion control (hoods, glove boxes, etc.) and for well-thought-out and well-executed handling procedures.

Item 13. The facilities and equipment for each site of use should be described in detail. The proposed facilities and equipment for each operation to be conducted should be adequate to protect health and minimize danger to life and property. In describing available facilities and equipment, the following should be included, as appropriate:

a. Physical plant, laboratory, or working area facilities. Fume hoods, glove boxes, waste receptacles, special sinks, ventilation and containment systems, effluent filter systems, and

[3]A copy may be obtained by a written request to the U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle and Material Safety, Washington, D.C. 20555, Attention: Director, Office of Nuclear Material Safety and Safeguards.

all processing, work, and protective clothing change areas should be described.

A drawing or sketch should be submitted showing the location of all such equipment and the relationship of areas where radioactive materials will be handled to unrestricted areas where radioactive materials will not be handled. In those programs where radioactive material may become airborne or may be included in airborne effluents, the drawing or sketch should also include a schematic description of the ventilation system annotated to show airflow rates, differential pressures, filtration and other effluent treatment equipment, and air and effluent monitoring instruments. Drawings or sketches should be drawn to a specified scale, or dimensions should be included on each drawing or sketch. Each drawing or sketch should be labeled to specify the location of the facilities and equipment depicted with respect to the address(es) given in Item 5 of Form NRC-313I.

b. Containers, devices, protective clothing, auxiliary shielding, general laboratory equipment, air sampling equipment, etc., actually employed in the daily use of material. Special provisions for shielding and containment to minimize personnel exposure should be described. Storage containers and facilities should provide both shielding and security for materials.

c. The number, type, and length of remote handling devices.

d. If respiratory protective equipment will be used to limit the inhalation of airborne radioactive material, the provisions of §20.103 of 10 CFR Part 20 should be followed and appropriate information should be submitted.

Item 14. The procedures for disposing of byproduct material waste should be described. Under NRC regulations, a licensee may dispose of waste in the following ways:

a. Transfer to a person properly licensed to receive such waste in conformance with paragraph 20.301(a) of 10 CFR Part 20. The name of the firm (which should be contacted in advance to determine any limitations that the firm may have on acceptance of waste) should be given.

b. Release into a sanitary sewer in conformance with §20.303 of 10 CFR Part 20. Depending on water usage, releases of up to 1 curie per year are permitted.

c. Burial in soil in conformance with §20.304 of 10 CFR Part 20. Up to 12 burials per year are permissible. The allowable quantity depends upon the radionuclide.*

d. Release into air or water in concentrations in conformance with §20.106 of 10 CFR Part 20. Possible exposure to persons offsite limits the amount that may be released.

e. Treatment or disposal by incineration in conformance with §20.305 of 10 CFR Part 20. This must be specifically approved by the Commission.

f. Other methods specifically approved by the Commission pursuant to §20.302 of 10 CFR Part 20.

Item 15

a. Survey Program. Commission regulations require that surveys be made to determine if radiation hazards exist in a facility in which radioactive materials are used or stored (see §20.201 of 10 CFR Part 20). A survey should include the evaluation of external exposure to personnel, concentrations of airborne radioactive material in the facility, and radioactive effluents from the facility. Although a theoretical calculation is often used to demonstrate compliance with regulations regarding airborne or external radiation, it cannot always be used in lieu of a physical survey.

Except for those cases where sources of radiation and radioactive material are well known and accurately and precisely controlled, it will usually be necessary that a physical survey be made with appropriate detection and measurement instruments to determine the nature and extent of radiation and radioactive material or, as a minimum, confirm the results of a theoretical determination.

A radiation protection program should include the following surveys for radioactive contamination and radiation:

(1) In laboratory or plant areas (e.g., checking for contamination on bench tops, handling and storage equipment, clothing, hands).

(2) While work is being done with radiation or radioactive materials (e.g., breathing zone air surveys, general air surveys; personnel exposure measurements, including eyes and extremities; checking shutters and containment).

(3) In areas associated with disposal or release of radioactive materials (e.g., checking

*The NRC has proposed an amendment that would delete §20.304 of 10 CFR Part 20 (43 FR 56677, December 4, 1978). If this amendment is adopted, all burials of radionuclides in accordance with §20.304 of 10 CFR Part 20 will require NRC approval.

disposal containers and disposal sites; liquid, gas, and solid effluents; filters and filter-duct systems).

The frequency of surveys will depend on the nature of the radioactive materials and their use. However, surveys should be performed prior to the use of radioactive materials in order to establish a baseline. The surveys should be repeated when radioactive materials are present, when the quantity or type of material present changes, or when changes occur in their containment systems or methods of use. Repetitive surveys may also be necessary to control the location of radioactive materials in the handling system and in the case of the use of sealed sources outside a shielded container.

For operations involving materials in gas, liquid, or finely divided forms, the survey program should be designed to monitor the adequacy of containment and control of the materials involved. The program should include air sampling, monitoring of effluents, and surveys to evaluate contamination of personnel, facilities, and equipment. Physical effluent measurements are essential to determine compliance with Appendix B to 10 CFR Part 20.

The description of an air sampling program should include the area where samples will be taken, the frequency of sampling, and the location of the sampler with respect to workers' breathing zones. Assays performed to evaluate air samples and the methods used to relate results to actual personnel exposures should also be described.

The effluent monitoring program for releases to unrestricted areas should encompass all airborne and liquid radioactive material releases. Theoretical evaluations should be supplemented by stack monitoring, water sampling, and other environmental monitoring appropriate for the planned and potential releases.

For operations involving only sealed sources, a survey program should include evaluation and/or measurement of radiation levels for storage and use configurations. When sources are used in devices having "on" and "off" positions, both positions should be evaluated at the time of installation. Supplemental surveys should be performed following any changes in operation, shielding, or use.

The types, methods, and frequency of surveys should be described in the application. Guidance may be obtained from the National Council on Radiation Protection Report No. 10, "Radiological Monitoring Methods and Instruments,"[5] and the International Atomic Energy Agency's Technical Report Series No. 120, "Monitoring of Radioactive Contamination on Surfaces."[6]

b. Records Management Program. Provision for keeping and reviewing records of surveys; materials inventories; personnel exposures; receipt, use, and disposal of materials, etc., should be described. Persons responsible for keeping and reviewing records should be identified.

c. Sealed-Source Leak-Test Procedures. Sealed sources containing more than 100 microcuries of a beta or gamma emitter or more than 10 microcuries of an alpha emitter must be leak tested at 6-month intervals. Leak testing of alpha-particle-emitting sources containing more than 10 microcuries of an alpha emitter is required at 3-month intervals. If a commercial firm is to perform the leak tests, the name, address, and license number of the firm should be submitted. If the tests are to be performed using a commercial "kit," the name of the kit manufacturer or distributor and the kit model designation should be given. If the applicant intends to perform his own leak tests without the use of a commercial kit, the following information should be submitted:

(1) Qualifications of personnel who will perform the leak test,

(2) Procedures and materials to be used in taking test samples,

(3) The type, manufacturer's name, model number, and radiation detection and measurement characteristics of the instrument to be used for assay of test samples,

(4) Instrument calibration procedures, including calibration source characteristics, make, and model number, and

(5) The method, including a sample calculation, to be used to convert instrument readings to units of activity, e.g., microcuries.

d. Instructions to Personnel. If a number of individuals will use radioactive materials under the supervision of one or more of those persons named in Item 6 of Form NRC-313I, written instructions should be prepared and submitted with the license application in the form in which they will be distributed to those working with radioactive materials. These instructions should cover, but not necessarily be limited to:

(1) The availability, selection, and use of laboratory apparel and safety-related equipment and devices (e.g., laboratory coats, gloves, and remote pipetting devices).

[5] Copies may be obtained from NCRP Publications, P.O. Box 4867, Washington, D.C. 20008.

[6] Copies may be obtained from UNIPUB, Inc., P.O. Box 433, New York, N.Y. 10016.

(2) Limitations and conditions to be met in handling liquid or uncontained (unencapsulated, dispersible, or volatile) radioactive materials and special laboratory equipment to be used in working with these types of materials. For example, the instructions should explain when operations with materials should be confined to a radiochemical fume hood or glove box and should specify the use of appropriate shielding and remote handling equipment when energetic beta- or gamma-emitting materials are to be used.

(3) The performance of radiation survey and monitoring procedures for each area in which radioactive materials are to be used.

(4) Safety precautions to be observed in the movement of radioactive materials between buildings, rooms, and areas within rooms.

(5) Safety requirements for storage of radioactive materials, including labeling of containers of radioactive materials and posting and securing areas where radioactive materials are to be stored. This should include the storage of contaminated laboratory equipment such as glassware.

(6) Requirements for posting of areas in which radioactive materials are used.

(7) The availability and use of personnel monitoring devices, including the recording of radiation exposures and the procedures to be followed for the processing of personnel monitoring devices such as thermoluminescent dosimeters and film badges in order to obtain personnel monitoring results.

(8) Waste disposal procedures to be followed, including limitations on the disposal of liquid or other dispersible waste to the sanitary sewer and procedures for the collection, storage, and disposal of other wastes.

(9) The maintenance of appropriate records as required by 10 CFR Part 20 and 10 CFR Part 30.

(10) The requirements for and the method of performing or having appropriate sealed-source leak tests performed.

(11) Good radiation safety practices, including the control of contamination, specification of acceptable removable and fixed contamination levels for both restricted and unrestricted areas, prohibition of smoking and the consumption of food or beverages in areas where radioactive materials may be used, and prohibition of the frequent transfer of potentially contaminated equipment between potentially contaminated areas and unrestricted areas.

(12) The use of radioactive materials in animals. If radioactive materials will be used in animals, instructions concerning such use should be prepared and submitted with the license application. Such instructions should include (a) specification of the facilities to be used to house the animals, (b) instructions to be provided to animal caretakers for handling animals, animal wastes, and carcasses, (c) instructions to appropriate personnel for cleaning and decontaminating animal cages, and (d) methods to be used to ensure that animal rooms will be locked or otherwise secured unless attended by authorized users of radioactive materials. A description of animal handling and housing facilities should be included under Item 13 of Form NRC-313I.

(13) Emergency procedures. These instructions should be addressed to all persons in all laboratory or facility areas where radioactive materials will be used and should cover actions to be taken in case of such accidents involving radioactive materials as spills, fires, release or loss of material, or accidental contamination of personnel. Specifically, these instructions should (a) specify immediate actions to be taken in order to prevent or limit the contamination of personnel and areas, e.g., the shutting down of ventilation equipment, evacuation of contaminated and potentially contaminated areas, containment of any spills of radioactive material, (b) give the telephone numbers of individuals to be notified in case of emergency, and (c) instruct personnel in proper entry, decontamination, and recovery operations for contaminated facilities. (Note: Only properly trained individuals should attempt decontamination and recovery operations.)

(14) Requirements and procedures for picking up, receiving, and opening packages (see §20.205 of 10 CFR Part 20).

Items 16 and 17. A resumé of the training and experience of each person who will directly supervise the use of material, who will use material without supervision, or who will have responsibilities for radiological safety should be submitted. The resumé should include the type (on-the-job or formal course work), location, and duration of the training. Training should cover (a) principles and practices of radiation protection, (b) radioactivity measurements, standardization, and monitoring techniques and instruments, (c) mathematics and calculations basic to the use and measurement of radioactivity, and (d) biological effects of radiation. The description of the use of radioactive materials should include the specific isotopes handled, the maximum quantities of materials handled, where the experience was gained, the duration of experience, and the type of use. The qualifications, training, and experience of each person should be commensurate with the material and its use as proposed in the application. The amount and type of training and experience with radiation and radioactive materials required to support a determination of adequacy by the Commission will vary markedly with certain factors.

If other persons such as technical assistants and laboratory workers will use radioactive materials in the absence of persons specified above, the specification of the training of such personnel should include (a) instruction in radiation safety, including topics covered and by whom taught, (b) on-the-job training in use of radioactive materials, and (c) determination of competency to work without the presence of supervisory personnel.

The use of microcurie quantities of a few nonvolatile radioactive materials by a person with a minimum of training and experience under precisely specified and carefully controlled conditions subject to the surveillance of a competent and adequately trained radiation protection officer may be justified. Such minimum training and experience may consist of a few hours of training and experience in the use of one or more radioactive materials similar to the use proposed in the application under the supervision and tutorship of a licensed user.

Persons using millicurie quantities of a number of radionuclides for general laboratory tracer work under unspecified conditions should have more extensive training and experience and, depending on the exact nature of the proposed program of use of radionuclides, may need to have completed formal course work at the college or university level covering the areas listed under Item 16 of Form NRC-3131.

The use of larger quantities of material (approaching a curie) under conditions where a potential exists for significant loss and ingestion, inhalation, or absorption of the radioactive material by those working with the material is normally done under carefully controlled conditions using specialized equipment. A person who is to use radioactive materials independently under these conditions should not only have a background of formal training in all areas described in Item 16 of Form NRC-3131 but should also have extensive experience working with radioactive material and a thorough working knowledge of the equipment required to handle the material safely.

5. AMENDMENTS TO LICENSES

Licensees are required to conduct their programs in accordance with statements, representations, and procedures contained in the license application and supportive documents. The license must therefore be amended if the licensee plans to make any changes in facilities, equipment (including monitoring and survey instruments), procedures, personnel, or byproduct material to be used.

Applications for license amendments may be filed either on the application form or in letter form. The application should identify the license by number and should clearly describe the exact nature of the changes, additions, or deletions. References to previously submitted information and documents should be clear and specific and should identify the pertinent information by date, page, and paragraph.

6. RENEWAL OF A LICENSE

An application for renewal of a license should be filed at least 30 days prior to the expiration date. This will ensure that the license does not expire until final action on the application has been taken by the NRC as provided for in paragraph 30.37(b) of 10 CFR Part 30.

Renewal applications should be filed on Form NRC-3131, appropriately supplemented, and should contain complete and up-to-date information about the applicant's current program.

In order to facilitate the review process, the application for renewal should be submitted without reference to previously submitted documents and information. If such references cannot be avoided, they should be clear and specific and should identify the pertinent information by date, page, and paragraph.

APPENDIX A

Form NRC-313 (I)
(1/79)
10 CFR 30

U.S. NUCLEAR REGULATORY COMMISSION

Form Approved by GAO
B 180225(R0579)

INSTRUCTIONS FOR PREPARATION OF APPLICATION FOR BYPRODUCT MATERIAL LICENSE

FORM NRC-313 (I)

GENERAL INFORMATION

An applicant for a "Byproduct Material (Radioisotopes) License," should complete Form NRC-313 (I) in detail and submit in duplicate to the U.S. Nuclear Regulatory Commission. The applicant should endeavor to cover his entire radioisotope program with one application, if possible. However, separate applications should be submitted for gamma irradiators. Applications for medical uses should be submitted on Form NRC-313 (M) and applications for use of sealed sources in radiography should be submitted on Form NRC-313R. Supplemental sheets may be appended when necessary to provide complete information. *Item 15 must be completed on all applications. Submission of an incomplete application will often result in a delay in issuance of the license because of the correspondence necessary to obtain information requested on the application.*

NOTE: When the application includes one of the special uses listed below, the applicant should request the appropriate pamphlet which provides additional instructions.

1. Industrial Radiography: "Licensing Requirements for Industrial Radiography" (use application Form NRC-313R for Radiography);

2. Laboratory and Industrial Uses of Small Quantities-"Guide for Preparation of Applications for Laboratory and Industrial Uses of Small Quantities of Byproduct Material."

3. Broad License (research and development): "Licensing Guide for Type A Licenses of Broad Scope for Research and Development;"

4. Licensing Guides for the performance of well logging operations.

5. Licensing guide for the use of sealed sources in portable and semi-portable gauging devices.

The Commission charges fees for filing of applications for licenses as specified in Section 170.12, Title 10, Code of Federal Regulations, Part 170. The applicant should refer to Section 170.31, *Schedule of fees for materials licenses*, to determine what fee should accompany the application. No action can be taken on applications until fees are paid. Checks or money orders should be made payable to the U.S. Nuclear Regulatory Commission.

Two copies of the completed Form NRC-313 (I) and two copies of each attachment thereto, should be sent to the Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. One copy should be retained for the applicant's file. Applications may also be filed in person at the Commission's office at 1717 H Street N.W., Washington, D.C. or at 7915 Eastern Avenue, Silver Spring, Maryland.

EXPLANATION OF FORM NRC-313 (I)

Form NRC-313 (I) is designed for use in supplying information on programs of varying complexity. The applicant should provide complete information on his proposed program for the possession and use of licensed material. For those items that do not apply, indicate as N.A. (not applicable).

Item No.

1. Self-explanatory.

2. The "applicant" is the organization or persons legally responsible for possession and use of the licensed materials specified in the application.

3. Self-explanatory.

4. Self-explanatory.

5. The actual sites of use should be listed as indicated. Permanent facilities such as field offices for portable gauges or devices should be identified in Item 5 by Street, Address, City and State. Temporary field locations of use should be specified as "temporary job sites of the applicant" and list the States throughout which the temporary job sites will be located. Attach additional properly keyed sheet if more space is needed.

6. Self-explanatory.

7. The "Radiation Protection Officer" is the named individual who is expected to coordinate the safe use of the licensed material specified in the application and who will ensure compliance with the applicable parts of Title 10, Code of Federal Regulations.

8 List by name each radioisotope to be possessed and used under the license. Example:

A	B
(1) Iodine-131	(1) Iodide
(2) Iodine-131	(2) Iodinated Human Serum Albumin
(3) Krypton-85	(3) Gas
(4) Cesium-137	(4) Sealed Source

C	D
(1) Not Applicable	(1) 150 millicuries
(2) N/A	(2) 1 millicurie
(3) N/A	(3) 1 millicurie
(4) Iso Corp Model Z-78	(4) 2 sources of 150 millicuries each

Attach additional properly keyed sheets if more space is needed.

8.1 State the use of each licensed material listed in 8.A, B, C, and D.

9 Description of containers and/or devices in which sealed sources listed in Item 8 will be stored or used. Example:

A	B
(1) Ni Source housing	Iso Corp

C
Model Z-278

10-18 Self-explanatory. If on these items that do not apply, so state as N/A (not applicable).

PRIVACY ACT STATEMENT

Pursuant to 5 U.S.C. 552a(e)(3), enacted into law by section 3 of the Privacy Act of 1974 (Public Law 93-579), the following statement is furnished to individuals who supply information to the Nuclear Regulatory Commission on Forms NRC-313M, NRC-313a, NRC-313I, or NRC-313R. This information is maintained in a system of records designated as NRC-3 and described at 40 Federal Register 45334 (October 1, 1975).

1. AUTHORITY: Sections 81 and 161(b) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2111 and 2201(b)).

2. PRINCIPAL PURPOSE(S): The information is evaluated by the NRC staff pursuant to the criteria set forth in 10 CFR Parts 30-35 to determine whether the application meets the requirements of the Atomic Energy Act of 1954, as amended, and the Commission's regulations, for the issuance of a byproduct material license or amendment thereof.

3. ROUTINE USES: The information may be used: (a) to provide records to State health departments for their information and use; and (b) to provide information to Federal, State, and local health officials and other persons in the event of incident or exposure, for their information, investigation, and protection of the public health and safety. The information may also be disclosed to appropriate Federal, State and local agencies in the event that the information indicates a violation or potential violation of law and in the course of an administrative or judicial proceeding. In addition, this information may be transferred to an appropriate Federal, State, or local agency to the extent relevant and necessary for a NRC decision or to an appropriate Federal agency to the extent relevant and necessary for that agency's decision about you. A copy of the license issued will routinely be placed in the NRC's Public Document Room, 1717 H Street, N.W., Washington, D.C.

4. WHETHER DISCLOSURE IS MANDATORY OR VOLUNTARY AND EFFECT ON INDIVIDUAL OF NOT PROVIDING INFORMATION: Disclosure of the requested information is voluntary. If the requested information is not furnished, however, the application for byproduct material license, or amendment thereof, will not be processed.

5. SYSTEM MANAGER(S) AND ADDRESS: Director, Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

FORM NRC-313 I
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10 CFR 30

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR BYPRODUCT MATERIAL LICENSE
INDUSTRIAL

See attached instructions for details

Completed applications are filed in duplicate with the Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555 or applications may be filed in person at the Commission's office at 1717 H Street, NW, Washington, D.C. or 7915 Eastern Avenue, Silver Spring, Maryland

1. APPLICATION FOR: *(Check and/or complete as appropriate)*

- a. NEW LICENSE
- b. AMENDMENT TO LICENSE NUMBER
- c. RENEWAL OF LICENSE NUMBER

2. APPLICANT'S NAME *(Institution, firm, person, etc.)*	3. NAME OF PERSON TO BE CONTACTED REGARDING THIS APPLICATION
TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION	TELEPHONE NUMBER: AREA CODE – NUMBER EXTENSION
4. APPLICANT'S MAILING ADDRESS *(Include Zip Code)*	5. STREET ADDRESS WHERE LICENSED MATERIAL WILL BE USED *(Include Zip Code)*

(IF MORE SPACE IS NEEDED FOR ANY ITEM, USE ADDITIONAL PROPERLY KEYED PAGES.)

6. INDIVIDUAL(S) WHO WILL USE OR DIRECTLY SUPERVISE THE USE OF LICENSED MATERIAL
(See Items 16 and 17 for required training and experience of each individual named below)

	FULL NAME	TITLE
a.		
b.		
c.		

7. RADIATION PROTECTION OFFICER	*Attach a resume of person's training and experience as outlined in Items 16 and 17 and describe his responsibilities under Item 15.*

8. LICENSED MATERIAL

LINE NO.	ELEMENT AND MASS NUMBER A	CHEMICAL AND/OR PHYSICAL FORM B	NAME OF MANUFACTURER AND MODEL NUMBER *(If Sealed Source)* C	MAXIMUM NUMBER OF MILLICURIES AND/OR SEALED SOURCES AND MAXIMUM ACTIVITY PER SOURCE WHICH WILL BE POSSESSED AT ANY ONE TIME D
(1)				
(2)				
(3)				
(4)				

	DESCRIBE USE OF LICENSED MATERIAL E
(1)	
(2)	
(3)	
(4)	

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9. STORAGE OF SEALED SOURCES

LINE NO.	CONTAINER AND/OR DEVICE IN WHICH EACH SEALED SOURCE WILL BE STORED OR USED. A.	NAME OF MANUFACTURER B	MODEL NUMBER C.
(1)			
(2)			
(3)			
(4)			

10. RADIATION DETECTION INSTRUMENTS

LINE NO.	TYPE OF INSTRUMENT A	MANUFACTURER'S NAME B	MODEL NUMBER C	NUMBER AVAILABLE D	RADIATION DETECTED *(alpha, beta, gamma, neutron)* E	SENSITIVITY RANGE *(milliroentgens/hour or counts/minute)* F
(1)						
(2)						
(3)						
(4)						

11. CALIBRATION OF INSTRUMENTS LISTED IN ITEM 10

☐ a. CALIBRATED BY SERVICE COMPANY

NAME, ADDRESS, AND FREQUENCY

☐ b. CALIBRATED BY APPLICANT

Attach a separate sheet describing method, frequency and standards used for calibrating instruments

12. PERSONNEL MONITORING DEVICES

TYPE *(Check and/or complete as appropriate.)* A	SUPPLIER *(Service Company)* B	EXCHANGE FREQUENCY C
☐ (1) FILM BADGE		☐ MONTHLY
☐ (2) THERMOLUMINESCENCE DOSIMETER *(TLD)*		☐ QUARTERLY
☐ (3) OTHER *(Specify)* ______		☐ OTHER *(Specify)* ______

13. FACILITIES AND EQUIPMENT (Check were appropriate and attach annotated sketch(es) and description(s).

☐ a. LABORATORY FACILITIES, PLANT FACILITIES, FUME HOODS *(Include filtration, if any)*, ETC

☐ b. STORAGE FACILITIES, CONTAINERS, SPECIAL SHIELDING *(fixed and/or temporary)*, ETC

☐ c. REMOTE HANDLING TOOLS OR EQUIPMENT, ETC.

☐ d. RESPIRATORY PROTECTIVE EQUIPMENT, ETC

14. WASTE DISPOSAL

a. NAME OF COMMERCIAL WASTE DISPOSAL SERVICE EMPLOYED

b. IF COMMERCIAL WASTE DISPOSAL SERVICE IS NOT EMPLOYED, SUBMIT A DETAILED DESCRIPTION OF METHODS WHICH WILL BE USED FOR DISPOSING OF RADIOACTIVE WASTES AND ESTIMATES OF THE TYPE AND AMOUNT OF ACTIVITY INVOLVED. IF THE APPLICATION IS FOR SEALED SOURCES AND DEVICES AND THEY WILL BE RETURNED TO THE MANUFACTURER, SO STATE

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INFORMATION REQUIRED FOR ITEMS 15, 16 AND 17

Describe in detail the information required for Items 15, 16 and 17. Begin each item on a separate page and key to the application as follows:

15. RADIATION PROTECTION PROGRAM. Describe the radiation protection program as appropriate for the material to be used including the duties and responsibilities of the Radiation Protection Officer, control measures, bioassay procedures *(if needed)*, day-to-day general safety instruction to be followed, etc. If the application is for sealed source's also submit leak testing procedures, or if leak testing will be performed using a leak test kit, specify manufacturer and model number of the leak test kit.

16. FORMAL TRAINING IN RADIATION SAFETY. Attach a resume for each individual named in Items 6 and 7. Describe individual's formal training in the following areas where applicable. Include the name of person or institution providing the training, duration of training, when training was received, etc.

    a. Principles and practices of radiation protection.

    b. Radioactivity measurement standardization and monitoring techniques and instruments.

    c. Mathematics and calculations basic to the use and measurement of radioactivity.

    d. Biological effects of radiation.

17. EXPERIENCE. Attach a resume for each individual named in Items 6 and 7. Describe individual's work experience with radiation, including where experience was obtained. Work experience or on-the-job training should be commensurate with the proposed use. Include list of radioisotopes and maximum activity of each used.

18. CERTIFICATE

(This item must be completed by applicant)

The applicant and any official executing this certificate on behalf of the applicant named in Item 2, certify that this application is prepared in conformity with Title 10, Code of Federal Regulations, Part 30, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.

WARNING.—18 U.S.C., Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

a. LICENSE FEE REQUIRED *(See Section 170.31, 10 CFR 170)*	b. CERTIFYING OFFICIAL *(Signature)*
	c. NAME *(Type or print)*
(1) LICENSE FEE CATEGORY:	d. TITLE
(2) LICENSE FEE ENCLOSED: $	e. DATE

FORM NRC-313 I (1-79)

CUSTOM MADE SEALED SOURCES AND DEVICES

GUIDE FOR STANDARD FORMAT AND CONTENT OF APPLICATIONS FOR HEALTH AND SAFETY REVIEWS OF CUSTOM MADE SEALED SOURCES AND DEVICES CONTAINING LICENSED RADIOACTIVE MATERIAL

I PURPOSE AND SCOPE

This guide provides a description of the content and format of an application for the possession and use of custom made sealed sources and/or devices by an applicant specifically licensed pursuant to §30.32, Title 10 Code of Federal Regulations, Part 30. Use of this format will ensure the completeness of the information needed for the custom review and will aid in shortening the time required for the review process.

II CONTENT OF APPLICATION FOR CUSTOM REVIEW AND LICENSING OF SEALED SOURCES AND DEVICES

The applicant shall submit sufficient information regarding each model of sealed source and/or device to enable the NRC to make a safety analysis of the sealed source and/or device including safety and efficacy of the proposed use. Such information shall include:

1. Identification

A. Sealed, plated or foil radioactive source(s).

(1) If the radioactive source design is registered with the NRC or an Agreement State, specify the manufacturer, model number, isotope and maximum activity for each source to be incorporated into the device.

(2) If the sealed source design has not been registered with the NRC or an Agreement State, provide the information as outlined in Appendix A for the custom source(s).

B. Device

(1) Specify the name and address of the manufacturer.

(2) Identify the device by type or descriptive name and model number or other specific model designation.

2. Proposed Use

   A. Describe the proposed use of the device and identify the environments and operating conditions expected during normal conditions of use. Include descriptions of the types of users, locations of use and the circumstances of normal use.

   B. Describe the probable effects of severe conditions on the device, including accidents and fires, and possible diversion from intended use.

3. Construction

   A. Submit engineering drawings of the source housing, identifying all materials of construction, dimensions, methods of fabrication and means of incorporating the radioactive material into the source housing and device.

   B. Include a detailed description of all special design features (for example, shutters, fail safe on-off mechanism, interlocks, etc.) which protect the radioactive material from abuse and minimize the radiation hazards. Describe in sufficient detail so that the nature, function and method of operation are clearly defined.

   NOTE: If device is foreign made, all drawings, notes, descriptions etc. shall be in English.

4. Human Access

   Describe the degree of access of human beings to the radioactive material contained in the device and to the radiation emitted from the device during normal conditions of use.

5. Radiation Profiles

   Provide calculations, estimates or measurements where available of the radiation profiles, e.g., expected dose rates at 5 cm, 30 cm and 100 cm, from the most and least accessable surface of the custom device with the shutter(s), on-off mechanism(s), etc. in (1) the open or "on" and (2) closed or "off" positions. These radiation profiles should be provided for each kind of radioactive material and maximum activity expected to be used in the device.

6. Labeling and Instructions for Use

Submit facsimilies of the labeling or marking to be placed on the device. Include a description of where the device will be labeled. The label or marking shall consist of the name, trademark, or symbol of the manufacturer, assembler, or the licensee who will possess the custom device, the type and amount of radioactive material, the date of measurment, the standard radiation symbol and the words, "CAUTION RADIOACTIVE MATERIAL." The label or marking must be of the standard radiation caution colors as specified in §20.203, 10 CFR 20.

7. Availability of Services

Submit information stating who will perform the following services on the custom device. (If any of the listed services will be performed by someone other than the specifically licensed device manufacturer, provide a description of training and experience of the individual(s) who will perform the services and include a description of the procedures to be used in the performance of the services.)

A. Installation and relocation within the applicants' facilities, if applicable.

B. Initial radiation survey upon receipt, installation, etc. at the applicant's facility.

C. Leak Testing: (Required for all sealed sources other than gaseous, e.g., krypton-85, or sources with half-lives of less than 30 days.) A certificate showing that each radiation source contained in the device has been tested for leakage or contamination within six (6) months of the date of transfer to the recipient of the device must be provided to the recipient. Results of the leak testing shall be in units of microcuries and should be maintained by the licensed recipient for inspection by the Commission. State if the device manufacturer will furnish the leak test certificate on the finished device or, otherwise, fully explain the means of obtaining the initial leak test certificate.

D. Repair, periodic maintenance, shutter or beam control operations checks.

E. Source exchange.

F. Disposal in the event the custom device is no longer needed.

8. Test Results on the Finished Custom Device Prior to Use

The applicant shall specify that the tests listed below will be performed on the finished custom device to verify that the device meets specifications furnished to the NRC. If the test results are to be supplied to the recipient by the licensed device manufacturer, it should be so stated. If the specified tests are not to be conducted by the specifically licensed device manufacturer, the applicant shall specify the name(s), training and experience of the person(s) who will perform the tests; and a description of the procedures and equipment to be used for performing the tests shall be included. Copies of the test results on the custom device shall be maintained for inspection by the Commission.

A. Radiation profiles (isodose curves, for example, dose rates at 5 cm, 30 cm, and 100 cm.) of the custom device with shutter(s) and/or beam control mechanism(s) in both the (1) open ("on") and (2) closed ("off") positions. Radiation levels should be measured using the maximum activity of each kind of radioactive material to be used in the device.

B. Visual or other quality control inspections to determine if cracks, voids, or other manufacturing defects exist.

C. Shutter or other "ON"-"OFF" beam control operations.

D. Leak tests for radiation leakage or contamination prior to use.

E. Other Tests: Specify any additional tests to be done on the finished custom device to verify that the device can be operated safety with minimum radiation hazard.

9. Safety Analysis Summary

Submit a brief safety anlaysis summary on the evaluation of the ability of the custom design to withstand the normal conditions of handling, use, and storage; including corrosion, vibration, impact, and the probable effects on radiation containment and shielding of abnormally severe conditions, such as explosion and fire. Any additional information including results of experimental studies and tests which will facilitate the final determination of the safety of the custom device should also be included in the safety analysis summary.

APPENDIX A

CUSTOM MADE RADIATION SOURCE(S)

A. Custom Source Supplier

Identify by name and address the supplier of the custom made source to be used in the custom made device.

B. Identification

Identify the source by type or model number or other specific model or part number designation.

C. Radioactive Material

(1) Specify the radioisotope.

(2) Maximum activity per source in millicuries or microcuries.

(3) Chemical and physical form of the radioactive material.

(4) Descriptive details of the method of incorporating and binding the radioactive material in the source.

D. Construction

(1) Submit engineering drawings of the source capsule (both inner and outer capsule, if applicable) identifying all materials of construction, dimensions and methods of sealing the source.

(2) Submit drawings of the source holder, for example, the mechanical support for the source, if any, identifying materials of construction, dimensions and methods for mounting the source in the holder.

NOTE: If sealed source is foreign made all drawings, notes, descriptions, etc. shall be in English.

E. Labeling

Provide a description of the information to be engraved, etched or imprinted on the radiation source or a facsimile of the label containing this information to be attached to the source. Ideally the source labeling should include the words: "CAUTION - RADIOACTIVE MATERIAL," manufacturer's trademark or unique serial number, radionuclide activity, assay date, and the radiation symbol. Where labeling the source is impractical, a tag containing the above information should be attached to the source, unless the attachment of such a tag is also impractical. NOTE: When a sealed source is permanently mounted in a device, source labeling is not required provided the device is labeled as specified above.

F. Source Assay

Describe the assay method used to determine the radioactive content of the finished source. The assay method shall be traceable to a National Standard.

G. Quality Control Inspections of Finished Source

Describe the tests to be performed on the finished source to ensure that the final product meets the design specifications. Where applicable provide information on the following minimal tests.

(1) Visual or other inspections to be performed on source seals or welds to ensure integrity of the finished product.

(2) Leak tests.

(3) Tests for determination of radiation levels at, for example, 5 and 30 centimeters from the external surface of the finished source averaged over an area not to exceed 100 square centimeters.

H. Additional Information

Submit any additional information, including experimental studies and tests that may have been performed on similar source designs, which will facilitate a determination of the safety of the source and efficacy of its use in the custom device.

DRAFT

A GUIDE FOR PREPARATION OF APPLICATIONS FOR LICENSES TO USE SEALED SOURCES CONTAINING BYPRODUCT MATERIAL IN NONPORTABLE GAUGING DEVICES

Nuclear Regulatory Commission
Division of Fuel Cycle and Material Safety
Material Licensing Branch
Washington, DC 20555

Paul Guinn
March 1980

TABLE OF CONTENTS

I. INTRODUCTION

This guide describes the information needed to evaluate applications for specific licenses for receipt, possession, and use of sealed sources containing byproduct material in nonportable gauging devices, i.e., gauges mounted in "fixed" locations, for measurement and/or control of material density, flow, level, thickness, weight, etc. In addition to the contents of this guide, applicants should refer to the requirements in the Commission's regulations listed below. The applicant should carefully read the regulations. This guide is not a substitute for an understanding of the regulations.

1. 10 CFR Part 19, "Notices, Instructions and Reports to Workers; Inspections."

2. 10 CFR Part 20, "Standards for Protection Against Radiation."

3. 10 CFR Part 30, "Rules of General Applicability to Licensing of Byproduct Material."

4. 10 CFR Part 170, "Fees For Facilities and Materials Licenses, and Other Regulatory Services Under The Atomic Energy Act of 1954, As Amended."

II. FEES

The applicant should refer to 10 CFR Part 170, Section 170.31 "Schedule of Fees for Materials Licenses and Other Regulatory Services," to determine the amount of the fees which must accompany the application. No action will be taken on applications filed without the proper fee. Checks should be made payable to the U.S. Nuclear Regulatory Commission.

III. FILING AN APPLICATION

Two copies of the Form NRC-313 should be submitted in accordance with the instructions on the form and should provide, as a minimum, the information described in this guide. Since licensees are required to comply with Commission rules and regulations, license conditions, and the content of the submitted application, we suggest that the applicant prepare and retain one copy for reference. Space on the form is limited, additional information should be provided on attachments to each copy of the form. Attachments should clearly reference the applicable items on the form for which additional information is being provided.

Applications should contain sufficient information to enable the Commission to have a clear understanding of the activities to be performed by the applicant. Submittal of insufficient information will result in delays in issuance of the license. Applications should be mailed to:

Nuclear Regulatory Commission
Division of Fuel Cycle and Material Safety
Material Licensing Branch
Washington, DC 20555

Except for Item 1 which is self-explanatory, the following provides a discussion of the minimum information needed for each item on the Form NRC-313.

Items 2, 3, 4, and 5 - Applicant, Mailing Address, and Locations of Use: The applicant, corporation, or other legal entity should be specified by name in Item 2 and mailing address in Item 4. The name and telephone number of the individual who should be contacted concerning the application should be provided in Item 3. Individuals should be designated as the applicant only if they are acting in a private capacity and the use of byproduct material is not connected with their employment with a corporation or other legal entity.

The actual location(s) where the byproduct material in sealed sources, source holders, gauges, etc., will be possessed, stored, and/or used should be specified in Item 5. Such location(s) should be clearly identified by road or street name, number, city and state. A Post Office Box number should not appear in Item 5.

Item 6 - Individual Users: The name of the individual(s) who will use (operate) and/or supervise the use of the devices listed in the application must be listed in Item 6. An adequate number of trained users should be listed to provide for continuity of operations. Normally, an individual user should be physically present when the devices are in use.

Item 7 - Radiation Protection Officer: Normally, it is not necessary for users of nonportable gauging devices to designate a radiation protection officer unless there are multiple users and gauges within the plant or facility. However, the applicant should list the name in Item 7 of an individual user, supervisor, foreman, or other designated individual who has been assigned responsibilities for determining that:

(a) All byproduct materials, sealed sources, and devices in use and/or in the possession of the applicant are limited to those listed in the license and are being used for the purposes specified in the license.

(b) Only those individuals authorized by the license use or supervise use of the devices.

(c) Periodic leak tests of the sealed sources are conducted as required by the license.

(d) The established "lock-out" procedures are followed during maintenance or repairs on or around the pipes, tanks, vessels, conveyors, etc., to prevent individuals from entering the radiation beams. (As shown in Item 15 of this guide, "lock-out" procedures must be described in the application for certain types of devices.)

Item 8 - Byproduct Material, Forms and Uses - Each radioisotope to be used should be specified in Item 8.A. and Item 8.B. should show that the byproduct material is to be possessed and used is in the form of sealed source(s). The name of the manufacturer and model number of the sealed source should be shown in Item 8.C. and the total activity, in millicuries, in the sealed source should be provided in Item 8.D. Item 8.E. should specify the manufacturer and model number of each gauge, source holder or device in which the byproduct material and sealed source described in Items 8.A. through 8.D. will be used. In addition, Item 8.E. should describe the purpose for which the device will be used. Some examples of the kinds of information to be provided in Item 8 are as follows:

8.A	8.B	8.C	8.D	8.E.
Cesium-137	Sealed sources	XYZ, Inc. Model XYZ-1	Not to exceed 100 millicuries per source	For use in an ABC Company Model 22 source holders to control level of coke in hoppers.
Cobalt-60	Sealed sources	Mesa Verde, Inc. Model A-34	Not to exceed 1500 milli-curies per source	For use in Grand Mesa, Inc., Model 3201 source holders to control level of molten glass in furnaces.
Cobalt-60	Sealed sources	Rio Grande, Inc. Model RG-1	Not to exceed 500 millicuries per source	For use in an Ojeto. Inc., Model X-12 holders for density control of concrete-sand mixture in mixers.

Item 9 - Storage of Sealed Sources: Since sealed sources are normally removed from gauging devices by the manufacturer or supplier of the devices, it is only necessary to reference Item 8 in Item 9.A. of the application for information regarding storage devices, i.e., storage in the gauging devices only. Applicants who will remove or relocate gauging devices (refer to Section VII in this guide) should describe storage devices (if any) and storage areas (refer to Item 13 in this guide).

Items 10 and 11 - Radiation Detection Instruments: For routine use of devices, radiation survey and measuring instruments are not normally required. Applicants who will perform other activities which require the use of radiation detection instruments should provide the applicable information described in Section VII of this guide.

Item 12 - Personnel Monitoring: For routine use of devices, the use of personnel monitoring devices (film badges or thermoluminescent dosimeters) are not normally required. Applicants who want to perform nonroutine activities which will require the use of personnel monitoring devices should provide the name of the supplier of the monitoring devices should provide the name of the supplier of the monitoring devices and the frequency of exchange for processing by the supplier. For guidance concerning personnel monitoring requirements, the applicant should refer to Section 20.202, 10 CFR Part 20.

Item 13 - Facilities and Equipment: The applicant should provide a description of the equipment and facilities to utilize the devices containing the byproduct material. A simple annotated sketch or drawing showing where each device is installed and the location of adjacent ladders, aisles, or work areas employees will occupy should be provided.

Item 14 - Waste Disposal: The applicant should describe the disposal method for sealed sources containing byproduct material when use of the devices containing the byproduct material is discontinued. If the supplier will remove the devices and sealed sources from the applicant's facility for disposal, this should be so stated in the application. If persons or company other than the supplier will remove the devices and sealed sources from the applicant's facility for return to the supplier or transfer to an authorized recipient, the number of the NRC or Agreement State license which authorizes removal and disposal of the applicant's sealed sources and devices should be provided.

If the applicant will remove devices containing sealed sources for return to the manufacturer or for transfer to another authorized person for disposal, this should be stated in the application. Section VII.1 of this guide specifies the additional information which should be provided in the application for authorization to perform this operation.

Item 15 - Radiation Protection Program: For routine use of devices, the applicant should provide the following information:

(a) The name of the company or person who will conduct servicing operations involving installations, relocations, removals, initial radiation surveys, maintenance, repairs, and removal of the devices containing licensed material and installation, replacement, and disposal of sealed sources containing licensed material used in the devices. If any of these operations will be performed by someone other than the supplier of the device, the applicant should provide the name and the number of the NRC or Agreement State license which authorizes performance of these operations. Applicants who request authorization to perform any of the above servicing operations should provide the information described in Section VII.I of this guide.

(b) A description of how access to the devices containing byproduct material will be controlled. (Barriers, warning signs, remote or inaccessible locations, control by individual users, etc.)

(c) For use of a device where it is possible for a major portion of an individual's body to receive exposure to the radiation beam from the device, a description of "lock-out" procedures, (i.e., procedures for preventing employees from entering the radiation beam during maintenance, repairs, or other work on or around the bin, tank, hopper, pipe, etc., on which the device is mounted) should be submitted. If the device shutter or switch is locked, bolted, "tagged-off", etc., until the work is completed, the applicant should describe this and provide the name of the individual(s) responsible for enforcing this procedure.

(d) The procedures for leak testing of the sealed sources. If the supplier of the devices containing the sealed sources will perform leak tests of the sealed source in the applicant's facility, it is only necessary for the applicant to state this and to specify the frequency of the leak tests. If the applicant plans to use a leak test kit, the name of the supplier and the model number of the leak test kit should be specified. Applicants who will perform their own leak tests, i.e., collect the leak test wipes and analyze the wipes, should provide the information described in Section VII.2. of this guide.

The required frequencies for leak testing of sealed sources in nonportable devices range from three months for alpha emitting byproduct material to six months for beta-gamma emitters. Some sealed source/device combinations containing beta-gamma emitters have leak test frequencies not to exceed three years. Information concerning sealed sources and devices which have three year leak test frequencies may be obtained from suppliers and/or manufacturers. Unless a specific request for the three year leak test frequency is included in the application, a six-month frequency will be specified in licenses.

Items 16 and 17 - Qualifications of Individual Users: The training and/or experience of each individual named in Item 6 of the application must be commensurate with the requested use and should be described in attachments for Items 16 and 17. For routine use of devices containing sealed sources, the training provided by the manufacturers at the time of installation is sufficient to qualify individual users. Training for nonroutine operations (e.g., installation, relocation, removal from service, etc.) or training provided by someone other than the device manufacturer must be described in detail and submitted as an attachment to the application. As a minimum, the following information should be submitted:

(a) The names and qualifications of the instructors.

(b) An outline of the training program.

(c) The duration of the training program.

(d) The method for determining trainee competency.

Item 13 - Certification: The application should be signed and dated by an official representative of the applicant, e.g., the Plant Manager, Department or Division Head, Safety Supervisor, etc., to certify that the application contains information which is true and correct to the best of the applicant's knowledge and belief. Applications which are unsigned will be returned for proper signature.

V. AMENDMENT OF LICENSES

Applications for amendment of existing licenses may be filed in the same manner as initial applications or may be filed in letter form. The application should clearly identify the license to be amended by license number and specify the exact nature of the requested changes to the license. Additional supporting information, as necessary, should be provided.

VI. RENEWAL OF LICENSES

Applications for renewal of licenses filed at least thirty (30) days prior to the expiration date shown in the license remain in effect until final action has been completed on the application. Applications filed after the expiration date are considered to be new applications. Applicants needing additional time to prepare renewal applications should submit written requests for extension of the license expiration date.

Renewal applications should contain complete and up-to-date information concerning the applicant's activities to be conducted under the license. General references to previously submitted information (e.g., see previous applications, see previous amendment, etc.) or submittal of copies of the current license are not acceptable. The Form NRC-313 should be completed in its entirety and documents submitted with the application should describe the applicant's current program.

Applicants may reference previous applications and/or documents in renewal applications provided these are clearly identified by date. Where portions of previously submitted applications and/or documents will be referenced in the renewal application, these should be clearly identified by date, attachment number, section number, and page number.

VII. SPECIFIC AUTHORIZATIONS

This section describes the information applicants must provide in applications to the Commission for specific authorizations to perform any of the following operations:

1. Servicing operations on devices containing byproduct materials.

2. Leak testing of sealed sources except by means of leak test kits.

3. Calibration of radiation survey and measuring instruments.

Each of the above are discussed, in order, in the following.

1. Servicing Operations. Applicants who want to perform operations on devices involving installation, relocation, maintenance, repair, removal for disposal, performance of radiation surveys following installation, etc., should provide the following information:

   (a) The specific device(s) on which the operations are to be performed.

   (b) A description of each specific operation to be performed.

   (c) The step-by-step procedures to be followed in performing each operation including a description of the radiation safety procedures which will be followed.

   (d) The name of each individual who will perform the services.

   (e) An outline of the training received by each individual who will perform the operation. This training should include instructions in the performance of each specific operation; the step-by-step procedures to be followed; radiation safety and the use of radiation survey instruments, "lock-out" procedures, i.e., procedures for securing the device shutters and/or switches in the closed or shielded position; and, if applicable, personnel monitoring requirements.

(f) A description of the qualifications of the individual(s) who provided the training in servicing of devices.

(g) If operations are performed which require radiation surveys, (e.g., installations or removals) a description should be provided to show the locations of the radiation measurements and the kinds of records to be maintained of the results.

2. Leak testing of sealed sources. Applicants who want to perform leak tests of sealed sources, i.e., collect the wipe tests and analyze the results, should provide the following information:

(a) The name and qualifications of each individual who will perform the leak tests.

(b) Procedures and materials to be used in collecting test samples.

(c) The type, manufacturer's name, model number, and radiation detection and measurement characteristics of the instrument to be used for assay of test samples.

(d) Instrument calibration procedures, including the name of the manufacturer and model number of each standard source to be used; the nuclide and quantity of radioactive material in each standard source; the step-by-step calibration procedures to be followed; and the name and the experience and training of each individual who will perform the calibrations. In providing information concerning the standard sources used in the calibrations, applicants should provide information concerning the accuracy of each source used. Each source should be, as a minimum, ± 5 percent of the stated value and traceable to a primary standard, such as that maintained by the National Bureau of Standards.

(e) The method, including a sample calculation, used to convert instrument readings to units of activity, e.g., microcuries.

3. Radiation survey instruments. If the applicant will perform activities requiring the use of radiation survey instruments, each instrument should be described. The manufacturer's name, model number and the range of each instrument should be provided. If the applicant will perform calibrations of the radiation survey instruments, the following information should be provided:

(a) The manufacturer and model number of each radiation source to be used.

(b) The nuclide and quantity of radioactive material contained in each source.

(c) The accuracy of the source(s). The traceability of the source to a primary standard should be provided.

(d) The step-by-step procedures, including associated radiation safety procedures.

(e) The name and the experience and training in instrument calibrations for each person who will perform the calibrations.

If the applicant intends to contract out the calibration of instruments, the name, address, and license number of the firm should be specified together with the frequency of calibration for each type of instrument.

An adequate calibration of survey instruments usually cannot be performed with the built-in check sources. Electronic calibrations that do not involve a source of radiation are also not adequate to determine the proper functioning and response of all components of an instrument. Daily or other frequent checks of survey instruments should be supplemented every 6 months with a two-point calibration on each scale of each instrument with the two-points separated by at least 50% of the scale. Survey instruments should also be calibrated following repair. A survey instrument may be considered properly calibrated when the instrument readings are within ± 10 percent of the calculated or known values for each point checked. Readings within ± 20 percent are acceptable if a calibration chart or graph is prepared and attached to the instrument.

APPENDIX E

ALASKAN AIR COMMAND TRITIUM LIGHT EVALUATION

"BRIMFROST 83"

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS ALASKAN AIR COMMAND
ELMENDORF AIR FORCE BASE, ALASKA 99506

8 MAR 1983

REPLY TO ATTN OF: DOOS (Major Hult, 552-5346)

SUBJECT: Tritium Runway Lighting Test

TO: See Distribution List

1. Tritium runway lighting was evaluated by the Alaskan Air Command during BRIM FROST 83. The test demonstrated that the lights can be deployed, operated, and maintained in austere arctic conditions. Aircrew comments reflected that the lights were not as operationally effective as anticipated. However, we are optimistic that with engineering modifications or the addition of extra lighting, operational capability can be greatly improved.

2. Attachment 2 is a report on the tritium lighting evaluation. Additional questions may be addressed to our POC, Major Hult, Av 317-552-5346.

John Bordeaux Sr

JOHN C. BORDEAUX, SR.
Colonel, USAF
DCS/Operations

2 Atch
1. Distribution List
2. Operational Report on the Tritium Runway Lighting Test Conducted During BRIM FROST 83

RECEIVED
MAR 11 1983
DOTFP RESEARCH SECTION

Operational Report
on The Tritium Runway
Lighting Test Conducted
During BRIM FROST 83

PROBLEM

1. Alaskan Air Command has unique requirements for portable runway lighting. First, the arctic environment makes installation and maintenance of lighting equipment difficult and hazardous. Also, during winter periods the hours of useable daylight are few, making it mandatory to have lighting to support air operations. Finally, the commitment to support joint AF-USA exercises requires dependable runway lighting.

2. The purpose of the tritium runway light test was to evaluate its capability to support Alaskan Air Command operations in the arctic environment. This included the following objectives extracted from the AFESC/RD test plan:

a. Storing, shipping, handling, installing and maintaining the lights.

b. Physical and environmental safety and security aspects.

c. Acquisition range of the lights under varying conditions and for different aircraft.

BACKGROUND

1. A package of tritium powered lights was developed for the test project. These included runway edge, VASI, lead in, and wind tee.

2. The lights and test personnel were transported to Alaska and Clear Creek LZ by ANG aircraft.

3. The lights were installed and operational approximately 20 Jan 83 and remained in position until 2 Feb 83.

4. C-130 and helicopter crews operated into Clear Creek and completed test questionnaires.

5. Limited A-10, O-2 and C-12 sorties (low approach) were also flown against the tritium lights.

6. The light system was setup at Malamute DZ, Fort Richardson, 5-7 Feb 83 for State of Alaska Testing. One 21 TFW C-12 sortie was flown during this test.

7. On 8 Feb 83 Battelle Alaska was given custodial responsibility for the lights.

8. On 9 Feb 83 the tritium lights were stored in the 21 CSG Prime Beef Readiness Equipment building.

DISCUSSION.

1. Maintenance and Safety.

There were no problems identified with storing, shipping, handling, installing, or maintaining the tritium lights during the test. The lights were deployed from Fort Wainwright to Clear Creek via helicopter and subsequently installed on plastic bases. These fixtures were secured at designated positions along the runway by freezing in place. Several fixtures were overturned by C-130 prop blast but sustained no damage and were returned to service.

2. Security.

Prior to the BRIM FROST 83 test, much concern was raised about the tritium lights being removed, stolen, or vandalized. Because of the physical conditions at Clear Creek and limited security personnel available, it was decided that risk was within limits and this would be an undefined evaluation factor. Results in this area were totally satisfactory. Throughout the test period only one light was removed, retrieved immediately, and returned to service. This one isolated case is insignificant when considering the large number of USAF and USA personnel involved at Clear Creek, the length of deployment, and lack of active security measures.

3. Aircrew Evaluation.

a. Acquisition Range.

(1) Range at which pilots could visually acquire the tritium lights was considered a critical evaluation factor. Throughout the test it was shown that acquisition range was highly dependent upon the level of light from external sources. Range decreased greatly with dawn and dusk or with a full moon and clear skies. Under ideal dark conditions, range varied from one to two miles and was dependent again on several factors. First, pilots of slower aircraft such as helicopters acquired the lights sooner than faster/larger aircraft such as the C-130. Also, range seemed to increase with increasing pilot familiarization with the tritium lights. Also, the lead in and VASI panels were acquired sooner than the smaller runway edge lights, which was expected, considering the differences in light fixture frontal area.

(2) The USA UH-60 pilots considered the tritium lights entirely satisfactory for their mission. They evaluated both visible and infrared (IR) lighting and rated both excellent.

(3) O-2 pilot participation in the test was minimal. Consensus was that the tritium lights, in the present configuration, would be as acceptable as the alternative method of runway identification, coleman type fuel laterns. Acquisition range, under ideal conditions, was one to two miles and tended to improve slightly with familiarity.

(4) A-10 pilots participation in the test was minimal. Questionnaires received showed erratic aircrew responses which did not provide any meaningful information. A primary reason was undoubtedly due to pilot unfamiliarity with the tritium lights.

(5) C-12 pilots acquired the tritium lights at one to two miles under ideal conditions. Range again improved with the familiarity.

(6) C-130 pilots tended not to acquire the lights as quickly as pilots of smaller, slower moving aircraft. Even under best conditions they felt range was between one-half and one and one-half miles. This, again, is probably due to aircraft size and approach speed.

b. Runway Alignment. Most pilots felt the tritium lights provided useable alignment information from about one mile. This was considered satisfactory for slow moving aircraft which would be afforded additional time for correction. Pilots of higher speed aircraft felt the tritium lights provided minimal time for alignment and forced go arounds were a definite possibility.

c. VASI Lights. The tritium VASI system was a simple three bar system. Acquisition range for most pilots was one to one and one-half miles. However, useable range (able to discern glideslope deviation) was generally put at about one half the acquisition range. Most pilots considered the VASI system, as configured for this test, a limited cross-check system rather than a total glideslope guidance system.

d. Runway landing zone/Edge lights. Only UH-60 and C-130 aircraft landed using the tritium light system and nearly all pilots considered them adequate for safe landing. O-2, A-10, and C-12 aircraft flew low approaches only, but these pilots felt a safe landing could have been made.

CONCLUSION

The test completed during BRIM FROST 83 showed the durability and dependability of the tritium lights. It also showed the system, as now designed, can probably support the operations of small, slow moving type aircraft. For larger, faster moving aircraft the lights offer only marginal performance and would have to be supported with other lighting aids to be totally acceptable.

RECOMMENDATIONS

1. The use of tritium runway lights, as presently designed, should be limited to supporting operations of small, slow moving aircraft like O-2s and helicopters.

2. Aircrews must have the opportunity to fly approaches to the tritium lights, in a controlled training environment, prior to any operational deployment.

3. Visual acquisition range must be improved by redesigning the lights and/or providing an additional location aid.

4. Further testing and evaluation is required to determine the feasibility of tritium lights to support A-10 or C-130 operations.

APPENDIX F

SAMPLE QUESTIONNAIRE AND EVALUATION SUMMARY

MALAMUTE LANDING ZONE, ALASKA, FEBRUARY 1983

RADIO-LUMINESCENT AIRFIELD LIGHTING DEMONSTRATION

QUESTIONNAIRE

To be completed by all observers:

This questionnaire is intended to act as a semi-formal data gathering method which will help determine the overall effectiveness of the R-L system as well as identify areas where further testing, development, or improvements are needed.

Name of Observer ______________________________

Affiliation ______________________________

Address ______________________________

Telephone ______________________________

OBSERVATION DATE: ______________ TIME: ______________

LOCATION: ______________________________

1) Are you a licensed pilot? ☐ Yes ☐ No

2) During the observation what would you estimate was the maximum distance which you were able to see any of the R-L lights.

☐ 1/4 mile ☐ 1/2 mile ☐ 3/4 mile ☐ 1 mile

☐ 1.5 mile ☐ 2 mile ☐ 2.5 mile ☐ 3 mile

3) The first R-L Lights which you saw were:

☐ Lead-in markers ☐ VASI

☐ Wind Tee ☐ Runway Edge Lights

4) While in the traffic pattern were you able to maintain reference of the runway by use of the R-L Lights?

☐ Yes ☐ No Comments: ______________________________

____

5) While on final approach did the R-L lead-in markers help you align with the runway?

☐ Helped very much ☐ Helped somewhat

☐ Did not help Comments: ______________________________

____

6) Did the R-L VASI assist in maintaining glide slope?

☐ Helped very much ☐ Helped somewhat

☐ Did not help Comments: ____________________

____

7) Did the R-L VASI assist in horizontal runway alignment?

☐ Helped very much ☐ Helped somewhat

☐ Did not help Comments: ____________________

____

8) In your opinion, is the R-L VASI a practical landing aid for runways 4000 feet and under?

☐ Yes ☐ No Comments: ____________________

____

9) Was the R-L Wind Tee clearly visible? ☐ Yes ☐ No

10) Was the R-L Wind Tee easily interpreted?

☐ Yes ☐ NO Comments: ____________________

____

11) In your opinion, is the R-L Wind Tee a practical landing aid?

☐ Yes ☐ No Comments: ____________________

____

12) Were you able to see the R-L Runway Edge Lights from a distance which would permit adequate time for final approach corrections?

☐ Yes ☐ No Comments: ____________________

____

13) Did the R-L Edge Lights give adequate definition to landing zone?

☐ Yes ☐ No Comments: ____________________

____

14) Were the reflectors on the R-L light fixture bases of assistance during landing?

☐ Yes ☐ No Comments: ______________________________

____

15) What is your opinion of the color of the R-L phosphor?

____

____

____

16) Were the R-L taxi-way lights adequate to define ground control?

____

____

17) In your opinion, is the R-L lighting system which you have observed suited for application in Alaska in its present form?

☐ Yes ☐ No ☐ Yes with improvements and modifications

18) What improvements and modifications would you like to see? __________

____

____

19) General Comments: ______________________________________

____

____

____

____

____

Thank you for your cooperation. Please return to:

Lee Leonard
Research Section
Alaska Department of Transportation
and Public Facilities
2301 Peger Road
Fairbanks, AK 99701

R-L QUESTIONNAIRE

SUMMARY OF RESULTS

FROM: Malemute Field Test
Fort Richardson, Alaska
February 5 & 7, 1983

TOTAL NUMBER OF QUESTIONNAIRE RESPONSES: 23 Responses

NOTE: Questionnaire attached for reference.

QUESTION #1

22 respondents were licensed pilots
1 was not a licensed pilot.

9 people observed from C-130.
5 people observed from C-12 (Beech King Air Light Twin)
6 people observed from Cessna 206
8 people observed from Huey helicopter

Note: Some individuals observed lights from two or more aircraft during the test period.

Conclusions:

Essentially all of the queried observers were licensed pilots.

QUESTION #2

½ mile - 1	1½ mile - 3
3/4 Mile - 7	2 mile - 4
1 Mile - 6	3 Mile - 2

Conclusions:

Fifty-six percent of the observers acquired the lights in the 3/4 to 1 mile range while 39% acquired them at a greater distance which would indicate that 1 mile would be a nominal acquisition distance to report under the weather conditions experienced during tests.

QUESTION #3

Lead in lights - 18
VASI - 3
Edge lights - 2

Conclusions:

Seventy-eight percent acquired the lead-in lights first and many felt that some form of the lead in system was necessary to any R-L System.

QUESTION #4

Yes - 8
No - 15

Conclusion:

Downwind reference of edge lights was not good--65% not able to keep track of lights while 35% did. However, C-130 crews were using 1½ to 2 mile from runway downwinds while Cessna 206 was blocked from seeing lights on downwind because of low ceiling and the interference of the tree line.

QUESTION #5.

Helped very much - 17
Helped somewhat - 6

Conclusions:

One hundred percent of observers felt that the lead-in lights were helpful.

QUESTION #6:

Helped very much - 5
Helped somewhat - 10
Did not help - 5
No comment - 3

Conclusions:

Sixty-five percent of observers felt the R-L VASI was useful for approach slope.

QUESTION #7

Helped very much - 4
Helped somewhat - 11
Did not help - 6
No comment - 2

Conclusions:

Sixty-five percent of observers felt the R-L VASI was useful for horizontal alignment, although later in the debriefing the concensus seemed to be that this use of the VASI was insignificant.

QUESTION #8:

Yes - 13
No - 6
No choice - 4

Conclusion:

Fifty-seven percent of observers seemed to think that the R-L VASI was a significant landing aid. The difference between this percentage and that shown in question 6 & 7 seems to reflect the feeling of some that for light aircraft a VASI is not normally required.

QUESTION #9:

Yes - 9
No - 12
No choice - 2

Conclusions:

The reaction of observers to the wind tee was not very favorable. However, the concensus seems to be that the wind tee which was used was too small to permit adequate definition. Redesign should improve this problem.

QUESTION #10

Yes - 4
No - 14
No choice - 5

Conclusion:

Same as #9.

QUESTION #11

Yes - 7
No - 10
No choice - 6

Conclusion:

Same as #9.

QUESTION #12

Yes - 16
No - 5
No choice - 2

Conclusion:

Seventy percent of the observers felt that the R-L System permitted adequate time for final approach corrections while 28% did not. This would indicate that 70% would be comfortable landing to the system while 22% would be hesitant.

QUESTION #13

Yes - 18
No - 3
No choice - 2

Conclusions:

Seventy-eight percent of observers felt the landing zone was adequately defined by the system while only 13% did not. We interpret this to mean that 13% were dissatisfied with the distance at which they could acquire runway definition.

QUESTION #14:

Yes - 11
No - 8
No choice - 4

Conclusions:

Forty-eight percent of observers felt the reflectors were helpful while 35% did not. This result is highly dependent on the aircraft from which the observation was made and the power of the landing lights. The reflectors were considered important by the C-130 observers and not very helpful to the light aircraft.

QUESTION #15:

Adequate - 20
Inadequate - 2
No comment - 1

Conclusions:

Only two observers or 9% objected to the color of R-L lights.

QUESTION #16:

Adequate - 19
Inadequate - 1
No comment - 3

Conclusions:

Only 1 observer or 4% did not feel the taxiway lights were adequate for ground control.

QUESTION #17

Yes - 2
No - 3
Yes w/improvements - 18
No comment - 0

Conclusions:

Eighty-seven percent of the observers felt that the system would be suitable for application in bush Alaska at runways 4,000 feet and less. However, the majority of these (78% of all observers) felt improvements were needed to the system which they observed.

GENERAL:

Of a total of 368 possible qualitative answers from the 23 observers the following results were obtained:

Sixty-five percent were positive answers showing confidence in the system as a whole.

Twenty-six percent were negative answers suggesting that the system was not yet adequate for the use intended.

Nine percent were neutral.

APPENDIX G

FAA RESPONSE TO RL LIGHT TESTING DURING FEBRUARY 1983

February 10, 1983

AL-FSDO-61

Radioluminescent Light (RL) System

Albert J. Crook
Manager, AL-FSDO-61

Jerome P. Bushnell
Manager, AAL-200

The Alaska Department of Transportation Research Section, working with the Alaska Air National Guard, FAA Flight Standards and the Army National Guard, conducted a demonstration of a radioluminescent light (R-L) system at Malemute Field, located three miles from Ft. Richardson's Bryant Airfield. To test the lighting system's effectiveness for aircraft in different performance categories, Lockheed Hercules C-130's, a Cessna 206, and a Huey Helicopter were used. The C-130 demonstration was conducted on February 5, 1983. A Cessna 206 flight, scheduled for Febrruary 6th, had to be cancelled for weather. This flight and the Huey Helicopter flight were accomplished the following evening.

The lighting system consisted of lead in lights, VASI panels, a lighted wind cone, and runway edge lights. During our observatóons, participants unanamously agreed, lighting system usefulness and runway acquisitóon weee enhanced with experience. The R-L system does not have the light intensity or color of a standard incandesent lighting system, thus reducing the useful range and changing the runway characteristic appearance.

With lead innlights, the airfield was vibible from 2-3 miles. This provided pilots sufficient time to achieve proper alignment in all aircraft performance categories. Without the lead in lights, runway acquisition wasates difficult and left insufficient time for the C-130's to make final approach alignment corrections. Light aircraft flown by pilots familiar with the system were able to operate with only threshold and edge lights. The helicopter did not have difficulty with either lighting configuration, having the advantage of reducing ground speed to meet visibility conditóons.

The VASI light provides valuable assistance in maintaining glide slope and horizontal alignment. With light intensity affecting depth perception, particularly with blowing snow, this was a practical länding aid. Instead of the oormal red over white VASI presentation, the R-L system used three light panels that, when aligned in a hat shape fashion, gave an on glide slope indication. After several approaches, the new VASI system was comfortable to use.

CONCURRENCE
RTG. SYMBOL
INITIALS/SIG.
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RTG. SYMBOL
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DATE

Runway Edge Lights gave adequate definition of the landing zone and were excellant for taxiing. When used without lead in lights, runway acquisition was difficult but the range could be extended by concentrating more lights in the threshold touchdown area. Again, operating with only runway edge lights requires experience with the light system to help locate the runway. Runway edge lights should not be considered adequate for a sole means of locating an airfield. Navigational aid intersections, terrain features, and pilotage would enhance airfield acquisition.

The R-L Lighting System combinations are well suited for rural Alaska locations without electrical power. With the availability of lead in lights, VASI systems, and runway edge lights, combinations may be developing to satisfy operator requirements. The R-L system, unlike flare pots, provides light continuously, requires no maintenance, and operates effectively in all weather conditions. By using the lead in lights for timely runway acquisition, VASI lights for horizontal guidance, and the runway edge lights for runway identification, it appears operations would be limited only by runway length and surrounding terrain.

CONCURRENCE
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APPENDIX H

TECHNICAL WORKING GROUP TEST AND EVALUATION

SEPTEMBER 7 AND 8, 1983

DEPARTMENT OF THE ARMY
ARMY AVIATION SUPPORT FACILITY NO. 1
NORTH CAROLINA ARMY NATIONAL GUARD
MORRISVILLE, NORTH CAROLINA 27560

AASF #1 15 September 1983

MEMORANDUM FOR RECORD

SUBJECT: Test and Evaluation Project Firefly 7-8 Sep 83 at Camp Mackall

1. As per discussion, Mr. Remini requested the undersigned to release this report as the official minutes of the TWG conference held and test and evaluation conducted at Raleigh and Camp Mackall, NC on 7-8 Sep 83 in order to expedite program information to all recipients.

2. Members of the TWG met on the afternoon of 7 Sep for the purpose of reviewing and finalizing the test program for that night. During the afternoon the runway at Mackall to be used (RW 04) was set up for the night's testing (see Incl #1 for Camp Mackall Airfield layout).

3. The primary purpose of this test was to determine if increasing the number of tubes per fixture would provide the required acquisition distance of 4-6 miles for USAF Military Airlift Command (MAC) use. The fixtures used for threshold landing and touchdown zone lights were non-reflectorized and contained multiple tubes. The runway edge lights were reflectorized and contained one tube for each fixture. The lights were deployed as depicted on page 5-10 MACR 55-130 (Incl #4) minus the red lights to mark the end of the runway.

4. Testing at Mackall confirmed that increasing the number of tubes does increase the acquisition distance of the lights. Distances in excess of 6 miles were identified for acquiring the lights and in excess of 4 miles for identifying "breaks" in the lights (see Incls #2,5,6,&7 for test results). The runway edge marker lights (reflectorized one tube) were not adequate to provide the desired "definition" for runway identification. The four tube round oblong container used in Alaska tests for the RW edge markers is more suitable for this purpose than the one tube reflectorized light.

5. Pertinent weather for this test was 20,000' scattered visibility of 7 miles, no moon, and relative humidity of 65%.

6. The following conclusions were determined regarding the nights testing:

a. By increasing the number of tubes, acquisition and identification distances can be obtained well within the stated needs of MAC of 4-6 miles.

b. The parabolic reflector containing one tube provides insufficient runway edge lighting to provide early runway definition.

c. The round oblong lighting fixture containing 4 tubes per fixture used in Alaska is believed to be sufficient for RW edge markers to provide early RW definition.

d. Additional work is required regarding engineering and hardware (human factor considerations) in constructing the fixtures, mounting apparatus, and shipping containers.

e. More technicians from Oak Ridge must be dedicated to field testing for required support.

f. In that the purpose of the tritium lights was not intended as a navigational aid but a landing aid, the committee should evaluate the use of a "beacon" or other light to be used as an aid to provide early acquisition of the airport environment.

7. A meeting was held on 8 Sep 83 with the TWG committee and other participating personnel in which the above conclusions were reached and generally agreed upon. (See Incl #3 for list of attendees and participating personnel.) The following items were discussed and evaluated/agreed upon:

a. Mr. Remini, DOE, directed the following:

(1) ORNL is to obtain two TEG's for powering strobe lights (beacon) and have both fully operational prior to the next field test.

(2) ORNL is to evaluate number needed and provide ORNL technicians in sufficient numbers to support future field tests.

(3) ORNL is to inspect and inventory all hardware, supplies, fixtures, etc., prior to shipment to verify contents and condition.

(4) Make coordination with Alaskan personnel to bring RW edge marker lights from Alaska to Mackall for next field test. George Jensen, BATTLLE volunteered to initiate coordination for same.

(5) LTC Everett, test director, to publish official minutes of test and meetings.

(6) ORNL is to coordinate/initiate time motion study to determine number manhours to establish and have operational the airfield lighting system. Also to determine time required to "tear down" and prepare for movement/shipment. Study to include the optimum number of personnel to accomplish these actions.

(7) ORNL is to maximize efforts to improve and simplify all hardware, shipping containers, fixtures, mounting apparatus, etc., associated and needed with the lighting system.

(8) ORNL, time and resources permitting, is to engineer and construct red tritium lights for marking end of RW use. Committee needs were identified to be four red fixtures (two for each side of runway) with 10 tubes per fixture (total of forty (40) red tubes).

b. Visual Approach Slope Indicator (VASI) lights are to be included and evaluated at the next field test. VASI lights presently in Alaska are to be used in the event ORNL does not have time to construct the new tubes.

c. USAF Europe in Twix Message #R301445Z Aug 83 to AFESC Tyndall AFB expressed interest in the tritium lighting system specifically for edge, threshold, and approach slope indicator lighting.

d. Mr. G. Grandy, an employee of Dupont with the Savannah Nuclear plant under government contract with DOE, attended briefings and testing of the lights at Mackall. His interest was seeking a reliable, no external power supply lighting solution for marking obstructions to low level flight; i.e., putting lights on top of poles, wires, towers, etc.

e. Mr. Remini and Mr. Hardy noted that AFESC, TAFB, had transmitted to DOE a military interdepartmental purchase request (MIPR) in the amount of $400,000.00 to support continued development of the design prototype fabrication and the deployment/evaluation of the radioluminescent airfield lights. A statement of work (SOW) spelling out testing in Alaska was included.

8. In summary the test at Mackall validated the 4-6 mile acquisition distance needed by the USAF. The reflectorized one tube fixture is insufficient to provide early runway definition. The first generation RW edge lights used in Alaska will be used in the next test at Mackall. Target date for the pre-Alaska test is still tentatively scheduled for 2-3 Nov 83 at Mackall. A test plan for 2-3 Nov will be developed and distributed on or about 6 Oct 83. A VASI system will be incorporated into the next test.

Leslie T. Everett Jr.
LESLIE T. EVERETT, JR.
LTC, AR, NCARNG
Commander, AASF #1

7 Incls
1. Camp Mackall Airfield Layout
2. Test Results Recap
3. List of Attendees/Participants
4. MACR 55-130 Extract
5. Tests 1-7
6. Test 8
7. Test 9

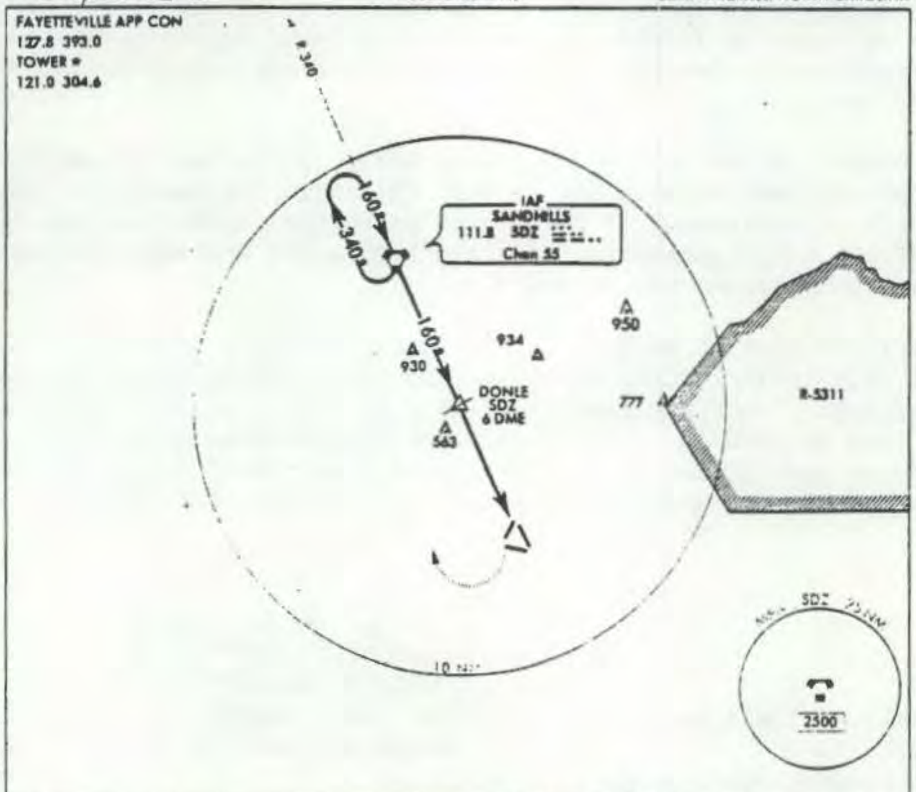
DISTRIBUTION:
Mr. Remini
Mr. Case (2)
Mr. Nelson
MAJ Bell
Mr. Hardy
COL West
Mr. Jensen
MAJ Hobbs
MAJ Hult (2)
MAJ Olson
COL Guard
Mr. Gale

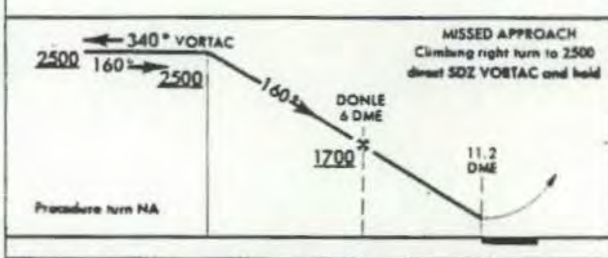
Amdt 1

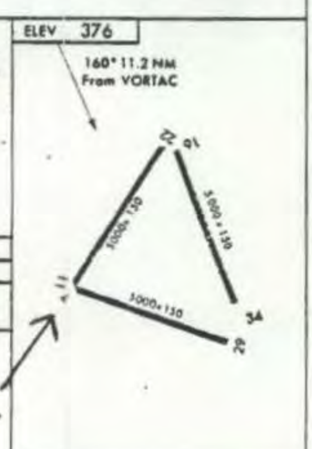
VOR/DME-B

AL-6315 US Army

MACKALL AFF (HFF)
CAMP MACKALL, NORTH CAROLINA







CATEGORY	A	B	C	D
CIRCLING*	840-1 464 (500-1)		840-1½ 464 (500-1½)	940-2 564 (600-2)

* Procedure not authorized at night.
When local altimeter not available, use SIMMONS AAF altimeter setting and increase all MDA's 120 feet.

△ NA

*

* Lighting system set up on RW 4 and all approaches made to that RW.

INCL #1

TEST DATA FOR ALL TESTS

TEST #1: (Altitude 1800'; lights 18" above ground)

Trained eye acquired lights at 4.5 miles.

TEST #2: (Altitude 2000')

Trained eye acquired lights at 6.0 miles; identified at 4.5 miles.

Untrained eye acquired 3.5 miles; identified 3.5.

TEST #3: (Altitude 2500')

Trained eye acquired 6.0 miles; identified 4.0.

Untrained eye acquired 5.25 miles; identified 4.0.

Untrained eye acquired 5.0 miles; identified 4.0.

* No significant improvement on raised lights.

TEST #4: (Altitude 3000')

Trained eye acquired lights at 5.5 miles; identified 3.5.

Untrained eye acquired lights at 5.5 miles; identified 3.5.

Untrained eye acquired lights at 5.5 miles; identified 3.5.

All acquired runway edge lights at 2.5 miles.

TEST #5: (Altitude 2700')

Trained eye acquired lights at 5.5 miles; identified 3.5.

Untrained eye acquired lights at 5.0 miles; identified 3.5.

Untrained eye acquired lights at 5.0 miles; identified 3.5.

TEST #6: (Altitude 3000')

Trained eye acquired lights at 5.5 miles; identified 4.5.

Untmined eye acquired lights at 5.5 miles, identified 4.5.

Untrained eye acquired lights at 5.5 miles, identified 4.5

* 1st row of lights appeared dimmer.
  2nd & 3rd rows of lights appeared brighter.

Heights of lights were 18", 36", and 60". Overall acquisition appeared to slightly increase. Lights appeared to be stacked optically at 4.5 miles.

Incl #2

TEST #7: (Altitude 3000')

Trained eye acquired lights at 5.5 miles; identified 3.5.

Trained eye acquired lights at 5.5 miles; identified 3.5.

Untrained eye acquired lights at 4.5 miles; identified 3.0.

Untrained eye acquired lights at 5.0 miles; identified 3.0

trained eyes acquired runway edge lights at 2.5 miles.

untrained eyes acquired runway edge lights at 1.5 miles.

TEST #8: (Plan E) (Altitude 2500')

trained eyes acquired lights at 6 miles; identified at 4.5.

untrained eyes acquired lights at 4.5 miles; identified at 3.5.

TEST #9: (Plan F) (Altitude 2500')

trained eye acquired lights at 6 miles.

untrained eye acquired lights at 5.5 miles.

untrained eye acquired lights at 5.0 miles.

All eyes identified at 3.5 miles at 2100'.

At 3.5 miles 3rd set of lights were noted visually as being raised.

LIST OF ATTENDEES/PARTICIPANTS

7-8 SEPTEMBER 1983

Mr. Bill Remini

Mr. Neil Case

Mr. Tom Hardy

LTC Les Everett

CPT James B. Stokes

CPT L.A. Mauro

CW3 Bob Wehrenberg

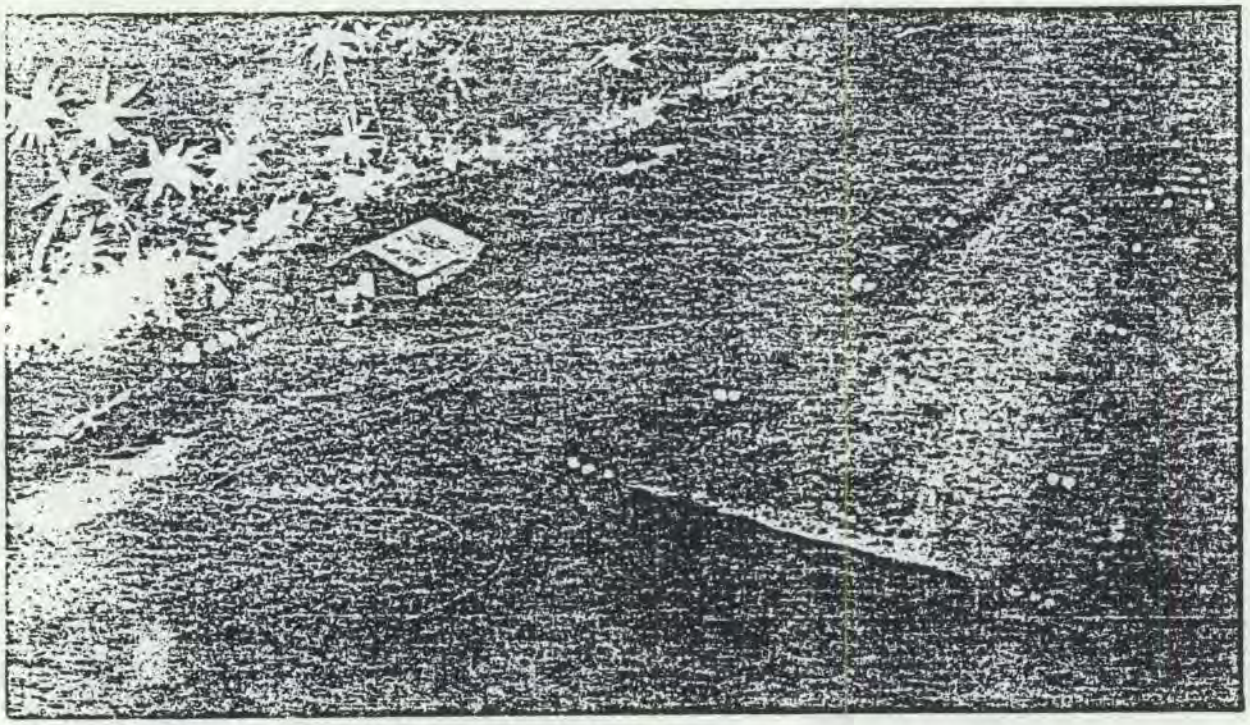
Mr. George Jensen

Mr. Andy Thompkins

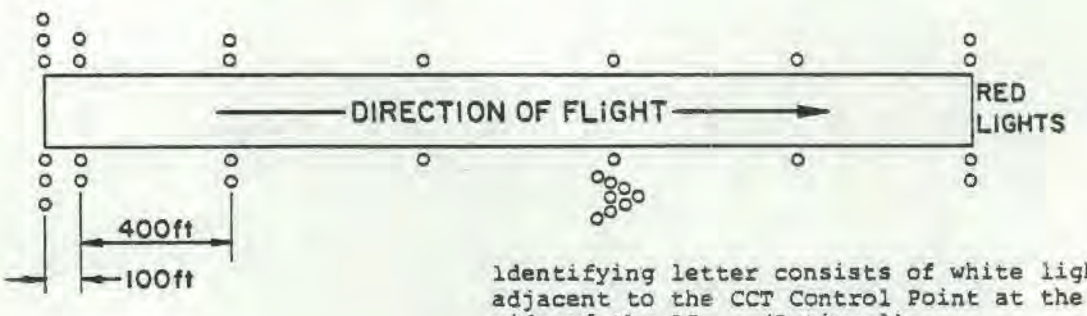
Mr. Tom Anderson

Mr. G. Grandy

Incl #3



Six green lights define the end of the usable runway. The lights are placed at each corner and are spaced six feet apart.



Identifying letter consists of white lights adjacent to the CCT Control Point at the side of the LZ. (Optional)

First white lights are dual and 100 feet down from the approach end of usable runway. The second white lights are dual and 400 feet down from the first. All subsequent white lights are single and 500 feet apart.

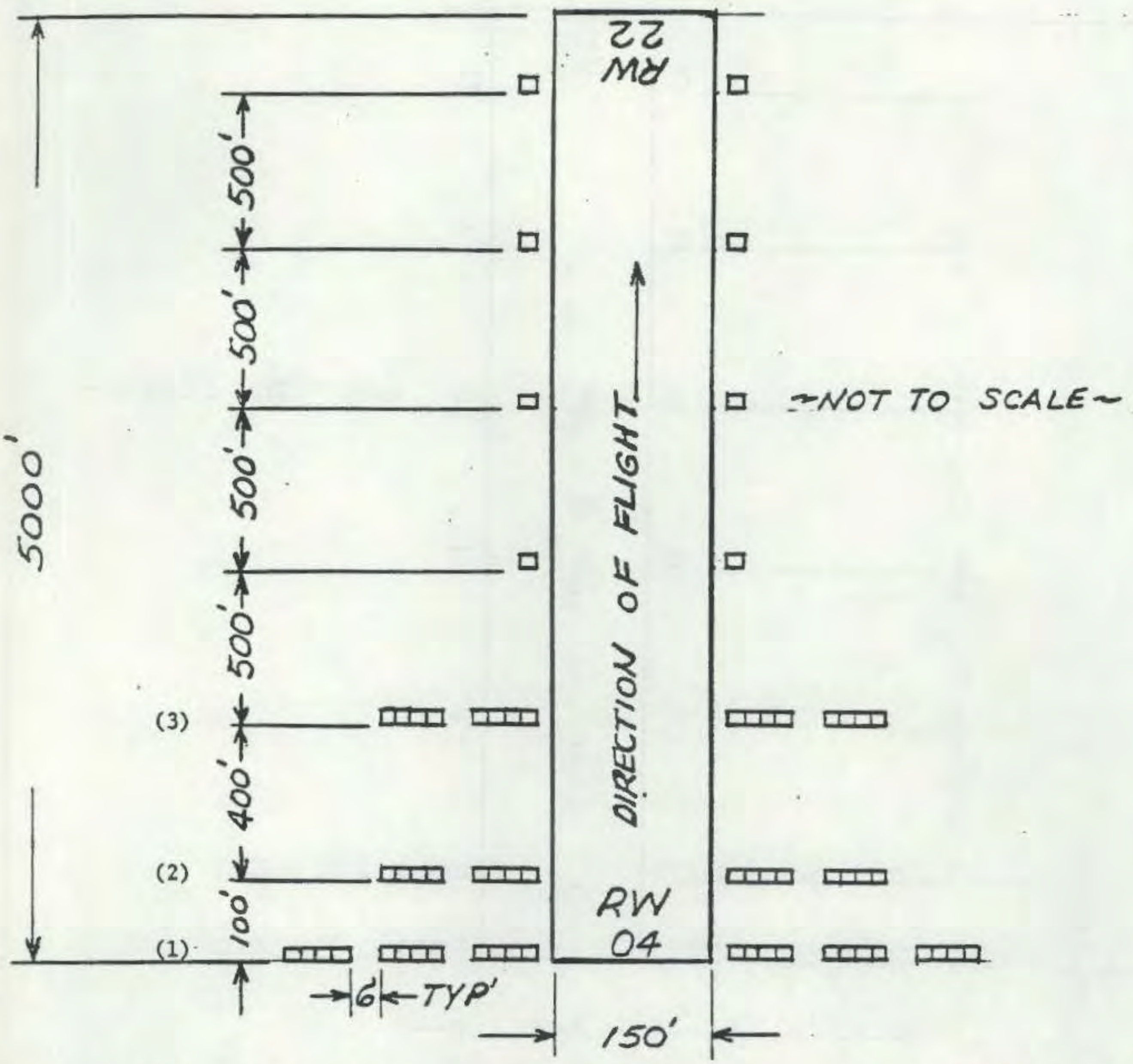
NOTE

All obstructions are marked with red lights. All taxiways and loading areas are marked with blue lights.

Figure 5-5. Landing Zone Markings (Night).

INCL 4

TESTS #1 thru #7:



Each set of lights in the threshold and landing zone system contains 4 each 12" x 12" fixtures containing 7 tritium lights each fixture = 28 tubes per set of lights. Tubes were mounted vertically for all tests.

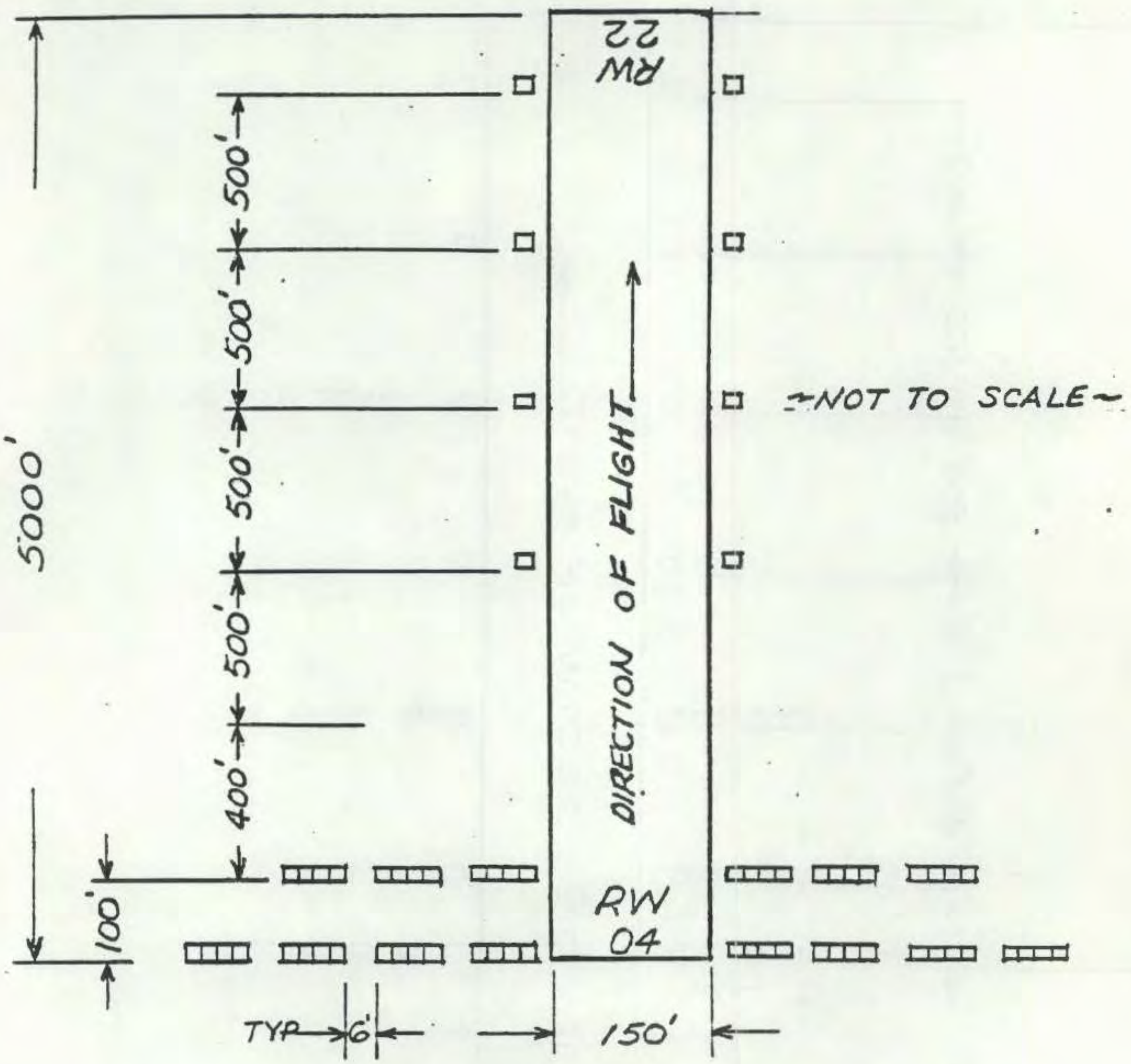
TEST #2: Edge lights were added every 250' with no significant improvement.

TEST #3: Lights in Row #3 were raised 2' with no significant improvement.

TEST #6: Lights in Row #2 & #3 raised. Changes noted in configuration and overall acquisition appeared to slightly increase. Height of 3 sets 18", 36", 60". Lights appeared to be stacked optically.

Incl #5

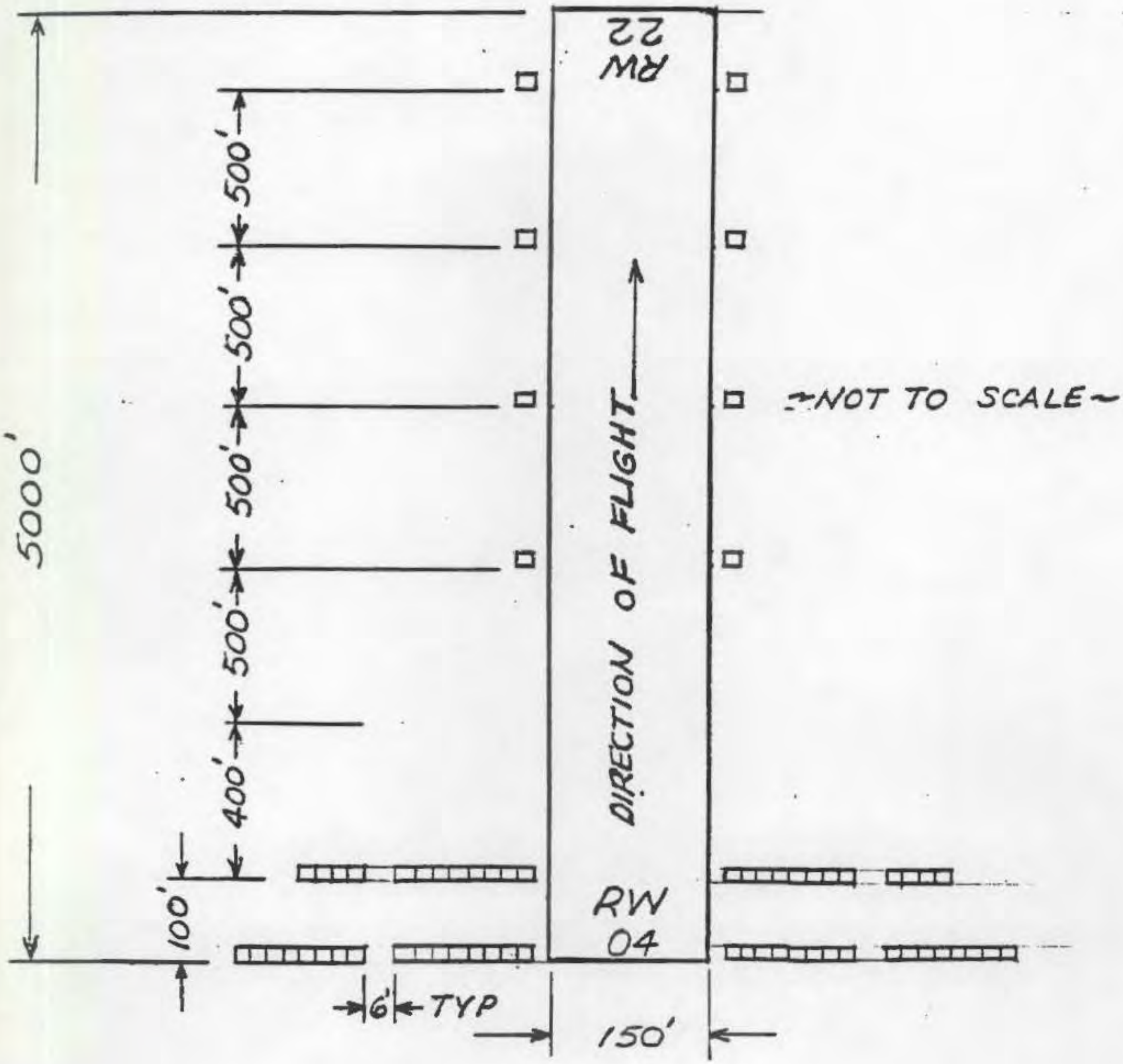
TEST #8:



Light sets (4 fixtures each set) were moved from the far end of the landing zone and divided between the bottom end of the landing zone and the threshold lights. See Incl #2 for results.

Incl #6

TEST #9:



Light sets were moved closer together as depicted to "mass" more lights - see Test #9 results on Incl #2.

Incl #7

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