U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: FLOOR PROXIMITY EMERGENCY ESCAPE PATH MARKING SYSTEMS INCORPORATING PHOTOLUMINESCENT ELEMENTS

Date: 7/24/97 **Initiated by:** ANM-114

AC No: 25.812-2 **Change:**

1. PURPOSE. This advisory circular (AC) provides guidance material for use in demonstrating compliance with the provisions of part 25 of the Federal Aviation Regulations (FAR) regarding floor proximity emergency escape path marking systems (FPEEPMS) which incorporate photoluminescent elements. Like all ACs, it is not regulatory but is to provide guidance for applicants in demonstrating compliance with the objective safety standards set forth in the rule. Although mandatory terms such as "shall" or "must" are used in this AC, because the AC method of compliance is not itself mandatory, these terms apply only to applicants who seek to demonstrate compliance by use of the specific method described by this AC.

2. RELATED DOCUMENTS.

a. Federal Aviation Regulations (FAR).

Section 25.812, Emergency lighting (Amendment 25-58)

Section 121.310, Additional emergency equipment (Amendment 121-183).

b. Advisory Circulars (AC).

Advisory Circular 25.812-1A, Floor Proximity Emergency Escape Path Marking.

3. BACKGROUND.

a. The Federal Aviation Administration (FAA) issued Amendments 25-58 and 121-183 (49 FR 43182; October 26, 1984) establishing requirements for the FPEEPMS which will provide visual guidance for emergency evacuation of passenger cabins when all sources of cabin lighting more than four feet above the aisle floor are totally obscured by smoke.

b. The FAA also issued AC 25.812-1, Floor Proximity Emergency Escape Path Marking, dated September 30, 1985, to provide guidance in the finding of compliance to the FPEEPM requirements of part 25. That AC was replaced by AC 25.812-1A on May 22, 1989. Appendix 1 of AC 25.812-1A, lists the various types of systems which have been found acceptable for different areas of the FPEEPMS. All of these systems are powered by electricity provided by batteries.

c. Recently, manufacturers of photoluminescent materials have begun marketing FPEEPMS utilizing such material. These systems do not require electrical power, which has been an integral part of all previous FPEEPMS. Instead, the elements of these new systems are "charged" by incident light provided by the normal airplane passenger cabin lighting, including sunlight which enters the cabin when the cabin window shades are open during daylight hours. When the cabin darkens, the elements "discharge" the stored energy in the form of a luminescent glow.

d. Because these systems are dependent upon incident light in order to perform their intended function, a determination must be made that sufficient incident light to charge the system will be available prior to the time the FPEEPMS may be called upon to perform its intended function. This "conditioning" of the system is important in determining the adequacy of the system. It should be noted that different airplane models have different schemes for providing cabin lighting and the levels of maximum intensity vary significantly. This must be accounted for in the certification program.

e. Because any incident light will recharge the photoluminescent elements to some extent, paragraph 7 (Conduct of Evaluations) of AC 25.812-1A is insufficient in providing adequate guidance for conducting naive human subject testing with this type of system. Special precautions must be taken to ensure that the conditioned photoluminescent elements are not subjected to incidental extraneous lighting. See paragraph 8.

f. Demonstrations of photoluminescent systems were conducted at the FAA's Civil Aeromedical Institute (CAMI) using volunteers. These demonstrations were held in the CAMI airplane cabin evacuation facility and were limited in scope to the marking of a single, straight aisle using the two currently offered photoluminescent materials, zinc sulfide and strontium aluminate. Trials were run with the photoluminescent elements conditioned under the two scenarios discussed in paragraph 6.

g. In AC 25.812-1A, paragraph 6.a.(1) states "This requirement would not be met by a system which merely provides a distant light at the exit or outlines the escape path, where the escape path remains essentially dark." It further states "Outlining the escape path, but not providing for visual recognition of the cabin aisle floor along the escape path, is also not in compliance with the requirement." At the time this guidance was included in that AC, the FAA was concerned with systems proposing to use tiny electrically-powered micro-bulbs or self-illuminated elements installed in short strips, which appeared to be points of light floating in space. These proposals were not capable

of providing test subjects with sufficient guidance to result in satisfactory test subject performance. While photoluminescent elements may not totally illuminate the cabin floor, the technology has progressed to the point that, with appropriate limitations, some illumination of adjoining cabin furnishings is provided, and, more importantly, visual guidance to allow test subjects to identify the width and vertical location of the escape path can be provided.

4. OBJECTIVE OF THE RULE. Floor proximity escape path marking is intended to allow passengers who have become familiar with the cabin layout during the period of general overhead illumination prior to an accident to find their way to exits unassisted, should the general overhead illumination become obscured by smoke. This objective is stated in the rule as two separate requirements. The first is that the emergency escape path marking will enable each passenger to visually identify the emergency escape along the cabin aisle floor after leaving the cabin seat, and the second is that the marking will enable each passenger to readily identify each exit from the emergency escape path by reference only to marking and visual features not more than four feet above the cabin floor. In both cases it is assumed that all sources of illumination more than four feet above the cabin aisle floor are totally obscured and that it is dark.

5. LIMITATIONS IN PHOTOLUMINESCENT SUBSYSTEM DESIGN AND OPERATION.

a. As noted in paragraph 3.f, the demonstrations conducted at CAMI were limited in scope to the performance of photoluminescent elements within a narrowly defined area, i.e., the marking of the main aisle in a single aisle cabin. Because of these limitations, approval of photoluminescent elements, when determined to be appropriate, should be limited as follows:

(1) Continuous photoluminescent marking strips must be installed at floor level along both sides of the main passenger aisle(s). Continuous in this instance means without significant breaks, e.g., for the basic installation, several inches of marking strip need not be luminescent where photoluminescent strips meet or are joined together. Care should be exercised in the location of these breaks so that they do not occur in areas where evacuees may interpret the break as indicating the location of an exit. An example of such a location would be the space between a galley or lavatory and the first row of seats aft of it. For the MMEL configuration, some of the photoluminescent elements may be allowed to be non-operable if the adequacy of the remaining elements can be demonstrated in the naive subject tests.

(2) The photoluminescent aisle marking elements must be combined with the more typical battery powered exit markers and cross-aisle markers (applicable only on multi-aisle airplanes) in making up the total FPEEPMS, creating a so-called hybrid system. The photoluminescent elements may be considered to be a subsystem of the FPEEPMS.

(3) Of the current materials used to achieve the photoluminescent effect, only the strontium aluminate should be used. As compared to the zinc sulfide, the strontium aluminate takes a little longer to charge, but maintains a brighter level of discharge for a significantly longer period. New materials may be considered, if they provide equivalent or superior performance to the strontium aluminate.

b. As additional research or advances in photoluminescent technology occur, revisions to the limitations above or to conditioning and naive human subject test protocols of paragraphs 6 and 8, respectively, may be considered by the FAA.

6. CONDITIONING OF THE TOTAL FPEEPM SYSTEM.

a. The photoluminescent subsystem.

(1) This subsystem should be evaluated under at least two separate conditioning scenarios.

(i) The first scenario may be referred to as the "first flight of the day" scenario. In this scenario the airplane is assumed to have been without power overnight thereby discharging the photoluminescent elements beyond the point at which they are useful. For purposes of evaluation trials the elements should first be discharged for at least 16 hours in total darkness. The elements should then be charged using the lowest level of cabin lighting allowed by the normal cabin lighting system controls. The charging time should be conservatively limited to the minimum time consistent with preparing an airplane for the first flight of the day. In the CAMI demonstrations noted above, 30 minutes was used as a reasonable minimum time for cabin preparation for the first flight of the day. After the charging time has been reached, normal cabin lighting should be extinguished and the naive subject testing discussed in paragraph 8.h should commence.

(ii) The second scenario may be referred to as the "maximum overnight flight" scenario. In this scenario the airplane is assumed to fly at night for the maximum time allowed by the performance characteristics of the airplane. During that flight duration, it is assumed that the passenger cabin will be either dark or in a subdued lighting environment for a significant portion of the flight to allow passengers to sleep. During this darkened cabin period, the photoluminescent elements will be discharging. Then prior to landing, an inflight emergency is assumed, which will prevent normal cabin lighting from illuminating, thus preventing any recharging of the photoluminescent elements. The emergency is also assumed to include dense smoke in the upper areas of the cabin thereby preventing the overhead emergency lighting from partially recharging the floor level photoluminescent elements. In the CAMI demonstrations, the system was charged at a low intensity of 25 lux for 30 minutes and then left in the dark for 150 minutes prior to the start of the testing. The 150 minutes was used as a reasonable approximation of the length of time a short/medium range airplane may have a darkened cabin. The length of time for a darkened cabin for a long range airplane, i.e., over six

hours flying time, was not considered during the CAMI demonstrations. For long range airplanes, a suitable period of darkness, beyond the 150 minutes used at the trials, would need to be agreed to by the FAA.

(2) In the evaluation of any specific photoluminescent subsystem of the FPEEPMS, the intensity of the charging cabin lights and the length of required discharge prior to the initiation of naive subject testing must be thoroughly discussed and then agreed to by the FAA.

(3) As noted earlier, the maximum interior lighting levels vary significantly among different airplane models. In addition, there is usually a great deal of flexibility in providing different levels of lighting by utilizing only parts of the overall normal lighting system for any given model. Additionally, operator procedures may vary as to the lighting intensity that should be used in the airplane, e.g., one airline procedure may be for the flight attendant to closely match the airplane interior lighting level to the outside ambient light level.

(4) Unless conservative values are used for the minimum cabin lighting intensity and duration of the exposure of the photoluminescent elements to the ambient cabin light, it would be necessary to establish a limitation on how intense and how long cabin lighting must be on prior to pushback from the boarding gate. Such limitations could be difficult to monitor in service and are, therefore, not recommended. If, however, such limitations are deemed necessary, appropriate limitations should be placed in the airplane flight manual and airline operational procedures should be developed and implemented.

b. The powered exit and cross-aisle subsystem. Sections 25.812(i) and 121.310(d)(3) require that the energy supply to each emergency lighting unit provide the required level of illumination for at least 10 minutes at the critical ambient conditions after emergency landing. For compliance with these sections for the powered subsystem of the FPEEPMS, the appropriate test conditions of Radio Technical Commission for Aeronautics Document No. DO-160C, Section 4, may be used to determine the output level for any emergency power supplies which are used. An alternate method of compliance would be to use any combination of analysis, lab tests, or actual airplane tests to show that the energy supply to each powered FPEEPMS element provides the required level of illumination for at least 10 minutes. The conditions listed in Appendix 1 have been found to be an acceptable alternative.

7. OBJECTIVE OF THE NAIVE HUMAN SUBJECT TEST.

a. While the regulation does not require a test of the system using naive human test subjects, such a test should be conducted in order to identify deficiencies in any particular proposal which may not be apparent to FAA certification personnel.

b. A naive human test subject, for purposes of this AC, is someone who has not participated in a previous evaluation of emergency lighting systems or in airplane evacuation testing, is not familiar with airplane emergency lighting systems or emergency evacuation systems or procedures, and is not a crewmember, mechanic, or trainer who operates, maintains or teaches about airplanes in the normal course of their duties.

c. Each test subject acting alone and without assistance should be able to:

(1) Leave the passenger seat or seat row and enter the escape path immediately adjacent to the seat or seat row. The FPEEPMS need not provide a visual reference to assist the test subject in entering the escape path adjacent to the test subject's seat row, i.e., moving from his/her seated position to the adjacent aisle.

(2) While standing or stooping in the aisle, identify from visual reference to the FPEEPMS the direction(s) in which exits are located. The test subject should be able to indicate to a test observer the means by which identification of the direction(s) to the exits(s) was made, and may be asked to do so during an interview after the test.

(3) Traverse the escape path in the direction of an exit without significant hesitation, delay, or apparent confusion. If the test subject takes more than four or five seconds before proceeding along the escape path in an appropriate direction, the reason for the delay should be determined during an interview conducted after the test. If there are exits available in two directions, a test observer may direct the test subject in one specific direction. This may be done to ensure that guidance to a non-end of cabin exit is acceptable from both directions.

(4) Make positive identification of the exit by visual reference to features not more than four feet above the cabin floor. The means for making the identification should be stated to a test observer. Identification should be made with the exit either opened or closed.

NOTE: Per the limitations noted in paragraph 5, the features used in the vicinity of the exits should be based on the more typical battery powered systems.

8. CONDUCT OF THE EVALUATIONS.

a. The total group of test subjects, in addition to meeting the requirements of paragraph 7.b, should be a mix of males and females and should include some subjects over 50 years of age.

b. A minimum of ten test subjects should be used to evaluate each unique exit, main aisle, and cross-aisle marking configuration in the airplane. Situations which may warrant the use of additional test subject groups include, but are not limited to,

airplanes with floor level and non-floor level exits or passenger cabin zones with exits available at only one end of the zone.

c. Prior to conducting the test, an explanation should be given to all test subjects, individually or as a group, that they are participating in an evaluation of airplane escape systems. The explanation should also include the following:

(1) The test will be conducted in a simulation of dark of night conditions.

(2) Each test subject will be expected to move from his/her seat to the nearest exit, and to identify the exit itself.

(3) Each test subject should move as quickly as possible but only to the extent the subject feels safe while doing so.

(4) Because the test conditions are meant to simulate a cabin with smoke four feet above the floor, the subject should bend over to approximately the top of the seat backs upon entering the aisle and maintain that position during the rest of the test. In order to prevent subjects from getting too close to the elements, and thereby giving an advantage to a dim system, the subjects should be advised to keep their heads at or above the top of the seat backs. Additionally, there should be no penalties if test subjects remain in an upright posture during the evaluation.

(5) Test observers will be stationed in the airplane or mockup and the test subject should follow all instructions given by an observer and provide answers to all questions asked by an observer.

d. Testing should be conducted in an airplane or a mockup of sufficient size that will adequately simulate a complete system installation.

e. All lighting, signs, markings, etc., four feet above the floor should be obscured in a manner which would simulate the area four feet above the floor being completely obscured by smoke. This can typically be accomplished by conducting the test in a darkened hanger or during the dark of night with all such items deactivated or completely covered.

f. The output of the emergency power supplies used to power the battery-powered elements of the hybrid system should be determined using the guidance contained in paragraph 6.b.

g. Because of the dark conditions in the cabin during the testing, it may be necessary to provide vision enhancing equipment (infrared or night vision goggles) for some of the test observers so that they will be able to more clearly see the actions of the test subjects. It may also be desirable to record the actions of the test subjects using

infrared camera or video equipment. If infrared lamps are used to improve the visibility using infrared devices, it must be verified that the lamps do not recharge the photoluminescent elements or aid test subject vision.

h. Acceptable test protocol for the "first flight of the day" scenario:

(1) One test observer should be designated as the test focal point who will lead the test subjects, one at a time, into the cabin area of the airplane or mockup in which the testing will take place. (Only one test subject at a time should be allowed in the vicinity of the aisle, cross-aisle, or exit being evaluated to preclude learning effects.) The proposed minimum level of cabin lighting should be on when each test subject is led into the cabin. The focal point should lead the test subject to the selected seat row and direct the subject to sit in the position furthest from the aisle, e.g., against the fuselage in a single aisle airplane, and to fasten the seat belt.

(2) The normal pre-flight safety briefing should then be given by someone, e.g., the focal point, acting as a flight attendant.

(3) The focal point should explain to the test subject that in a short period of time the normal airplane lighting will be turned off. When this happens the test subject is to unbuckle his/her seat belt, move to the aisle, identify in which direction(s) there is an exit, move as quickly as possible down the aisle until he/she reaches the nearest exit, and indicate when he/she is at an exit by pointing at it and verbally identifying that fact. Optional - the focal point may remind the test subject to keep their head at approximately the level of the top of the seat backs.

(4) After waiting approximately 15-45 seconds, all normal cabin lighting should be extinguished and all powered elements of the FPEEPMS should be turned on or come on automatically. The photoluminescent elements of the FPEEPMS will begin to discharge. To ensure that all test subjects consider the change in cabin illumination as the start of the test, the focal point should say clearly "Begin."

(5) If there is a need for the test subject to go in one particular direction (and there is a choice of directions), the focal point can direct the test subject to go in that direction. This could be appropriate in the situation where, for example, the test subjects have been seated between the forward and mid exits on a single aisle airplane. If the first five of ten test subjects seated in that vicinity all moved forward, it may be necessary to direct at least some of the remaining test subjects to move aft in order to be able to evaluate the guidance provided by the system between the seated position and the mid exits. Alternatively, the test subject may be allowed to move forward, but upon reaching the first exits in that direction, a test observer may then direct the test subject to turn around and find the nearest exit in the aft direction.

(6) Observers can be located, typically in outboard seats, at strategic points throughout the airplane or mockup to facilitate witnessing the tests.

(7) After the test is completed, the test subject should be interviewed to record his/her perception of the FPEEPMS. This information may be used to determine if any particular positive or negative actions by the test subject were caused by features of the system or other reasons. For example, if a test subject were to hesitate for a significant time upon entering the aisle before moving either forward or aft (with exits available in both directions), the interview may establish that the test subject recognized that exits were available in both directions but just could not make up his/her mind in which direction to go.

(8) For this scenario careful preparation and execution is required to ensure that the photoluminescent elements are not overcharged as each test subject is brought into the test area and given the pre-flight briefing during which time the cabin lights are on.

i. Acceptable test protocol for the "maximum overnight flight" scenario:

(1) One test observer should be designated as the test focal point who will lead the test subjects, one at a time, into the airplane or mockup. All powered cabin lighting, normal or emergency, should be off. A blindfold or sleeping mask should be placed over the eyes of each test subject as he/she is led into the cabin. The focal point should lead each test subject to the selected seat row and request that the subject sit in the position furthest from the aisle, e.g., against the fuselage in a single aisle airplane, buckle his/her seat belt, and remove the blindfold or mask.

Note: Because the cabin is darkened prior to the test subject entering, a pre-flight briefing may be given to the entire group of subjects in a lighted holding area outside the airplane or mock-up.

(2) The focal point should explain to the test subject that in a short period of time he/she will hear the word "begin." When this happens, the test subject is to unbuckle his/her seat belt, move to the aisle, identify in which direction(s) there is an exit, move as quickly as possible down the aisle until he/she reaches the nearest exit, and indicate when he/she is at an exit by pointing at it and verbally identifying that fact. Optional - the focal point may remind the test subject to keep their head at approximately the level of the top of the seat backs.

(3) After waiting approximately 15-45 seconds the focal point should say clearly "Begin." At this time the electrically powered elements of the FPEEPMS should be turned on.

(4) If there is a need for the test subject to go in one particular direction (and there is a choice of directions), the focal point can direct the test subject to go in that direction. This could appropriate in the situation where the test subjects have been seated between the forward and mid exits on a single aisle airplane. If the first five

of ten test subjects seated in that vicinity all moved forward, it may be desirable to direct some of the remaining test subjects to move aft in order to be able to evaluate the guidance provided by the system between the seated position and the mid exits. Alternatively, the test subject may be allowed to move forward, but upon reaching the first exits in that direction, a test observer may then direct the test subject to turn around and find the nearest exit in the aft direction.

(5) Observers can be located, typically in outboard seats, at strategic points throughout the airplane or mockup to facilitate witnessing the tests.

(6) After the test is completed, the test subject should be interviewed to record his/her perception of the FPEEPMS for the same reason as in paragraph 8.g.(7).

j. Because of the sensitivity of photoluminescent elements to incident lighting, it is necessary to ensure that the airplane or mockup is configured to prevent stray light from impinging on the photoluminescent elements when test subjects are brought into the airplane or mockup. For that reason it may be necessary to provide a holding area somewhere in the airplane or mockup for the group of test subjects to wait prior to the individual testing. That area would need to be separated from the testing area by a light barrier, such as a curtain made of opaque material firmly secured in place. If test subjects who have not yet participated could hear what is going on during the testing, ear covers or head phones should be provided to prevent them hearing what is occurring during the testing. For test scenarios in which the FPEEPMS photoluminescent subsystem is kept in the dark or dimly lit condition for a long period or time without a chance to recharge, the test subjects may have time to allow their eyes to adapt to the dark while in the holding area. They should be allowed at least 10 minutes for dark adaptation under simulated night flight conditions.

k. The Master Minimum Equipment List (MMEL) configurations should be evaluated at the time of approval (as part of the naive subject test), at the critical ambient conditions, to expedite inclusion in the MEL. These evaluations should address the minimum configurations for both the FPEEPMS elements and the normal cabin lights (which are necessary to energize the photoluminescent elements).

l. Other aspects of the design and equipment of the photoluminescent subsystem of the FPEEPMS must be considered as part of any certification project. These include, but are not limited to:

(1) Reaction to exposure to expected cabin materials, such as coffee, alcohol, soft drinks, and cleaning solvents.

(2) The effect of cabin service carts and cleaning crew carts passing over the elements of the system, as well as wear and tear from passengers in various footwear stepping on the elements.

(3) A means to assess the initial (as delivered) as well as continuing effectiveness of the system should be developed and available for implementation.

(4) An expected life of the photoluminescent elements should be projected based on research.

(5) The impact of hot and cold extremes of the cabin on the performance of the photoluminescent elements should be considered.

(6) The effect of exposure to a humid, dry, or dusty environment and to ultraviolet radiation.

(7) The ability to resist degradation of performance when exposed to fungus.

(8) Quality control of the photoluminescent base material which is typically provided by a supplier other than the supplier of the system elements.

9. DETERMINATION OF WHETHER THE SYSTEM PASSED OR FAILED. At least eighty percent of the test subjects participating in each of the test scenarios should be judged by the FAA test observers as having achieved the objectives listed in paragraphs 7.c (1) through (4) in order for the system to pass.

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APPENDIX 1. ALTERNATIVE CRITICAL AMBIENT CONDITIONS

1. Cruise Cold Soak.

a. Airplane flight at the maximum altitude for maximum cruise time.

b. Emergency descent and immediate landing at a -40° F. ambient temperature.

c. Floor proximity emergency escape path marking systems and subsystems activated.

2. Overnight Cold Soak.

a. Unconditioned airplane sitting for 8 hours in a ramp environment of -40° F.

b. Airplane interior warmed for 2 hours, using normal airplane or ground facilities.

c. Immediate aborted takeoff at a -40° F. ambient temperature.

d. Floor proximity emergency escape path marking system and subsystems activated.

3. Hot Day.

a. Unconditioned airplane sitting for 8 hours in a ramp environment of +120° F.

b. Airplane interior cooled for 2 hours, using normal airplane or ground facilities.

c. Immediate aborted takeoff at +90° F. ambient temperature.

d. Floor proximity emergency escape path marking system and subsystems activated.