U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

NOV 2 3 2010

The Honorable Daniel Inouye
Chairman, Committee on Appropriations
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

I am pleased to provide you the report to Congress on Specifications and Standards for Airfield Pavement Markings. The report was requested by the House and Senate reports accompanying the Consolidated Appropriations Act, 2010, Public Law 111-117.

The report documents the research the Federal Aviation Administration undertook to evaluate the use of glass beads in airport markings. Specifically, the research was to determine whether there was any benefit to safety by having airports use the more expensive but higher reflective Type III glass beads.

This testing concluded that the conspicuity of both low-index Type I and high-index Type III retro-reflective beads is adequate to conduct aircraft operations safely.

We have sent identical letters to Chairman Obey, Senator Cochran, and Congressman Lewis.

Sincerely,

J. Randolph Babbitt
Administrator

Enclosure

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NOV 2 3 2010

The Honorable Thad Cochran
Ranking Member, Committee on Appropriations
United States Senate
Washington, DC 20510

Dear Senator Cochran:

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We have sent identical letters to Chairmen Inouye and Obey and Congressman Lewis.

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The Honorable David Obey
Chairman, Committee on Appropriations
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

I am pleased to provide you the report to Congress on Specifications and Standards for Airfield Pavement Markings. The report was requested by the House and Senate reports accompanying the Consolidated Appropriations Act, 2010, Public Law 111-117.

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Washington, D.C. 20591

NOV 23 2010

The Honorable Jerry Lewis
Ranking Member, Committee on Appropriations
House of Representatives
Washington, DC 20515

Dear Congressman Lewis:

I am pleased to provide you the report to Congress on Specifications and Standards for Airfield Pavement Markings. The report was requested by the House and Senate reports accompanying the Consolidated Appropriations Act, 2010, Public Law 111-117.

The report documents the research the Federal Aviation Administration undertook to evaluate the use of glass beads in airport markings. Specifically, the research was to determine whether there was any benefit to safety by having airports use the more expensive but higher reflective Type III glass beads.

This testing concluded that the conspicuity of both low-index Type I and high-index Type III retro-reflective beads is adequate to conduct aircraft operations safely.

We have sent identical letters to Chairmen Inouye and Obey and Senator Cochran.

Sincerely,

J. Randolph Babbitt
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Enclosure

# U.S. Department of Transportation
# Federal Aviation Administration

# Report to Congress

# on

# Specifications and Standards for Airfield Pavement Markings

# 2010

## EXECUTIVE SUMMARY

- Senate Report 111-69 and House Report 111-366, accompanying H.R. 3288, included a request for the Federal Aviation Administration to submit a report on Specifications and Standards for Airfield Pavement Markings to both the Senate and House Committees on Appropriations. The report explains what actions would be taken to clarify an issue concerning revised Federal Specification TT-B-1325D (August 6, 2007) Beads (Glass Spheres) Retro-Reflective.

- Senate Report 111-69, accompanying Public Law (P.L.) 111-117, states the Committee on Appropriations is concerned that information in the current Federal specification for high-index Type III retro-reflective glass beads, and thus adopted within our airport construction and airport marking standards, relies on outdated test data.

- In addition, several technical evaluations of such high-index, retro-reflective glass beads since 2003, including tests conducted by us, show conflicting data when compared to tests conducted prior to 1996.

- The Committee on Appropriations encouraged us to serve as the primary Federal agency to issue a revised specification and update any standards referencing high-index, retro-reflective glass beads. The Committee on Appropriations wants the FAA to do this by incorporating data and findings of federally funded research conducted in this subject area, including any research completed within Fiscal Year (FY) 2010.

- The FAA initiated a study at two airports in FY 2009 to determine if the visual cues provided to pilots on approach to a runway by painted markings with either low-index Type I or high-index Type III retro-reflective beads were adequate to safely perform the intended operation. The study compared the conspicuity of low-index Type I and high-index Type III retro-reflective beads to determine if different beads offer pilots greater visibility of surface markings. A copy of the study is attached.

- The study included measurements using standard scientific testing equipment at both airports that showed high-index Type III beads provided more retro-reflectivity upon initial installation and at two months after installation. At eight months after installation, high-index Type III beads were minimally more reflective than low-index Type I beads.

- The study included human factor evaluations by pilots landing at both airports. Pilots reported observing no differences between low-index Type I and high-index Type III bead installations at either airport.

- Pilots reported at distances ranging from 0.9 to 6.0 miles from the runway threshold no visual differences between low-index Type I and high-index Type III installations. For nine out of ten pilots, there was no difference in seeing tested markings with low-index Type I or high-index Type III beads.

- The study validates our previous studies indicating that the human eye is not as sensitive to differences in light intensity as compared to measurements by standard scientific instruments.

## INTRODUCTION

Our guidance to improve the visual cues offered to pilots by airport pavement markings has evolved over the years as we continue to research new materials and technologies. By most measures, this has been a very successful effort. In response to suggestions from the National Transportation Safety Board (NTSB), we undertook a study in 1994 that resulted in allowing retro-reflective glass beads to be applied to runway markings. Up to that point, glass beads were not recommended for runway markings due to concern about their potential impact on frictional characteristics of markings. The study indicated that both low-index Type I glass beads typically specified for highway use and high-index Type III glass beads specified for airport pavement markings were found to provide acceptable and adequate enhancements to markings during nighttime operations. The study also indicates that beads do not have a detrimental effect on pavement friction.

Based on this information, in 1996, we revised Advisory Circular (AC) 150/5370-10, Standards for Specifying Construction of Airports, to allow glass beads in airport markings. We revised AC 150/5340-1, Standards for Airport Markings, to recommend the high-index Type III glass beads for use on holding position markings to improve conspicuity. Either type bead could be used on other markings.

The high-index Type III glass beads are approximately five times more expensive because they are made from virgin glass and not recycled glass. As a result, airports for the most part were using the less costly type glass beads for markings other than at holding positions.

The high-index Type III glass bead manufacturers claimed that their higher reflectivity would increase the conspicuity of all markings, increase pilot situational awareness, and improve safety. They met with us in late 2008 and urged that the FAA conduct a new research effort to determine if there was a safety benefit from requiring the use of the more expensive high-index Type III glass beads on all markings.

We agreed that research to revisit the use of glass beads was warranted and initiated a research study in 2009. Subsequently, the language in the Senate Report 111-69, accompanying P.L. 111-117, requested us to provide a report on the results of its glass beads research that was under way.

## BACKGROUND

Airport markings must meet requirements found in the current revision of AC 150/5340-1. The guidance in this AC includes a recommendation to use high-index Type III glass beads to increase conspicuity at runway holding position markings and allows either high-index Type III or low-index Type I glass beads for all markings.

Airport marking materials must meet requirements found in the current revision of AC 150/5370-10, Standards for Specifying Construction of Airports. The guidance in this AC allows the airport owner to choose paint type and glass bead type for markings. References to Federal specifications for paint and glass beads are included in the guidance. Specifically, Item P-620, Runway and Taxiway Painting, of the AC requires the use of glass beads in painted

markings that meet the requirements of the latest revision of Federal Specification TT-B-1325D Beads (Glass Spheres) Retro-Reflective.

When TT-B-1325D was revised in August 2007, it included the following language:

> Information for Guidance Only. (This section contains information of a general or explanatory nature that is helpful, but is not mandatory.)
>
> Intended use:
>
> Type I, Gradation A, coarse - low-index recycled glass beads for drop-on applications are intended for marking highways and all airfield markings.
>
> Type I, Gradation B, fine - low-index glass beads for premixed paint are intended for marking highways, or for use in applying temporary airport or airfield markings.
>
> Type III, high-index glass beads for drop-on applications are intended for applications where increased retro-reflectivity is needed.
>
> Note: The increased retro-reflective values obtained from use of high index of refraction glass beads are only apparent to the observer in cases where the observer's line of sight is in close proximity to the path of the light source used to illuminate the markings. Studies by the United States Air Force and the FAA have shown that in cases where the light source is not in close proximity to the viewer's eye position, the added benefit from the use of the higher index of refraction beads is negligible.
>
> Type IV, Gradation A – large coarse, direct-melt, low-index glass beads for drop-on applications are intended for highways and all airfield markings.
>
> Type IV, Gradation B – medium coarse, direct-melt, low-index glass beads for drop-on applications are intended for highways and all airfield markings.

The Committee on Appropriations is concerned that portions of the above statements could have a negative impact on the use of high-index glass beads, which could impact aviation safety.

## FAA STANDARDS AND POLICY

As mentioned previously, airport markings must meet requirements found in the current revision of AC 150/5340-1. The guidance in this AC includes a recommendation to use high-index Type III glass beads to increase conspicuity at runway holding position markings and allows either high-index Type III or low-index Type I glass beads for all markings.

Airport marking materials must meet requirements found in the current revision of AC 150/5370-10. The guidance in this AC allows the airport owner to choose paint type and glass bead type for markings. References to Federal specifications for paint and glass beads are included in the guidance.

## RESEARCH OBJECTIVES

There were three objectives of the glass bead research.

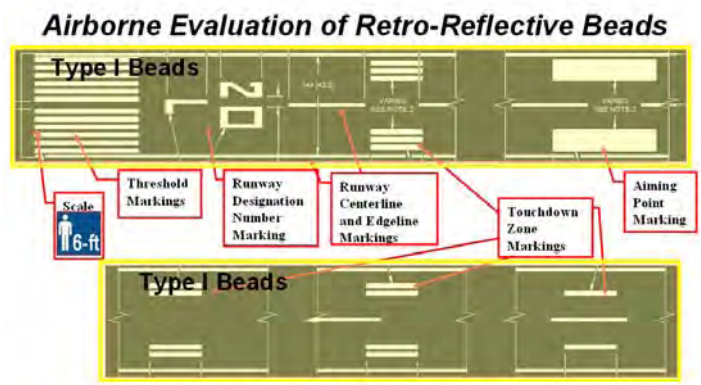
- Determine the effectiveness of retro-reflective beads over the useful life of an airfield marking.
- Determine if the visual cues provided to pilots on approach to a runway by painted markings with either low-index Type I or high-index Type III retro-reflective beads are adequate to safely perform the intended operation.
- Compare the conspicuity of low-index Type I and high-index Type III retro-reflective beads.

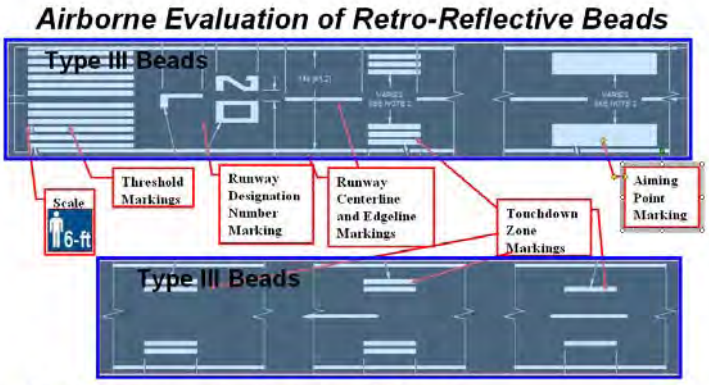
## RESEARCH PLAN

- Markings with low-index Type I and high-index Type III glass beads were installed at two airports.
- Atlantic City International Airport (ACY)
- Savannah/Hilton Head International Airport (SAV)

# *Airborne Evaluation of Retro-Reflective Beads*

ACY runway

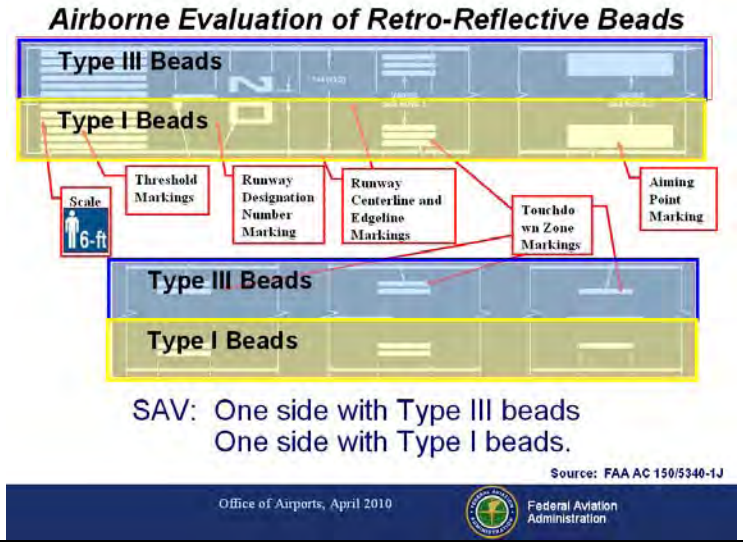



At ACY, markings with low-index Type I beads were installed on one end of the runway. The high-index Type III beads were installed on the other end. Pilots on approach at either end of the runway were asked to comment on their observation of the markings.

## Airborne Evaluation of Retro-Reflective Beads

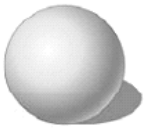
SAV runway




At SAV, the markings with low-index Type I beads were installed on one side of the runway. The high-index Type III beads were installed on the other side. Pilots on approach at either side of the runway were asked to comment on their observation of the markings.

# Airborne Evaluation of Retro-Reflective Beads

**Type III Bead****
"Airport Bead"
Virgin Glass
1.9 IOR



**Type I Bead*****
"Highway Bead"
Reclaimed Glass
1.5 IOR

****At installation, Type III should yield 600-1300 mcd/m²/lx on white markings and 350-550 mcd/m²/lx on yellow.**

*****At installation, Type I should yield 300-450 mcd/m²/lx on white markings and 175-250 mcd/m²/lx on yellow.**

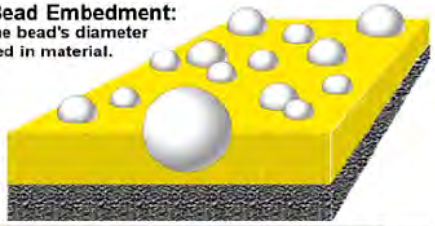
IOR = index of refraction

**Readings at Installation**

| ACY | SAV |
|---|---|
| 820* | 879* |
| 352* | 278* |

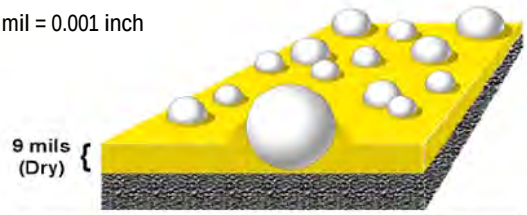
**Source: FAA Airborne Study**

**Optimal Bead Embedment:**
**50-60% of the bead's diameter is submerged in material.**




Applying less than 15 mils of binding material leads to poor retention of the glass beads, while applying more than 15 mils leads to complete submersion of the beads into the binder. In both cases, reflectivity is diminished.

1 mil = 0.001 inch




Once the coating is allowed necessary curing time, the material wicks up around glass beads as it dries, securing them in the binder. Standard waterborne paint dries to approximately 9 mils thick.

*The standard unit of measure used to report retro-reflectivity is millicandela per meter squared per lux abbreviated mcd/m²/lx.

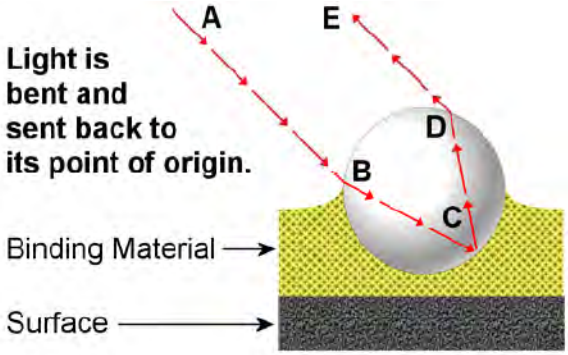
**Source: Airfield Marking Handbook, IPRF/FAA Project No. 01-G-002-05-1**

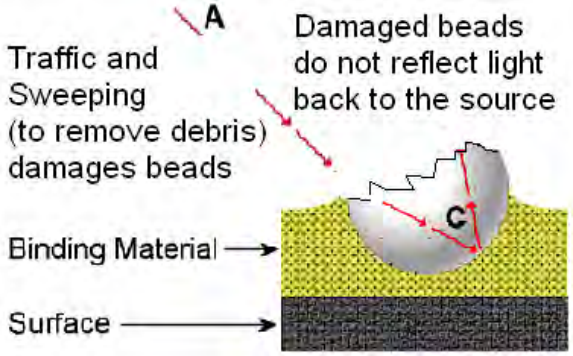
Office of Airports, April 2010 — Federal Aviation Administration

At installation, the retro-reflective readings on markings with high-index Type III glass bead were within the acceptable retro-reflective range. The retro-reflective readings on markings with low-index Type I beads installation on one side of SAV's runway was slightly below the 300 mcd/m²/lx expected

# *Airborne Evaluation of Retro-Reflective Beads*

A = light source
B = point of entry of light beam, bent by sphere
C = light reflecting from point in glass bead
D = point of exit of light beam
E = return of light to original source




| Retro-Reflective Readings ACY | Initial | After 8 months |
|---|---|---|
| Type III | 820* | 351* |
| Type I | 352* | 313* |

Source: FAA Airborne Study

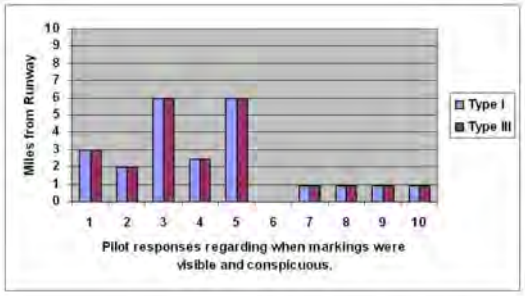
***The standard unit of measure used to report retro-reflectivity is millicandela per meter squared per lux abbreviated mcd/m2/lx.**

**Source: Airfield Marking Handbook, IPRF/FAA Project No. 01-G-002-05-1**

Office of Airports, April 2010 — Federal Aviation Administration

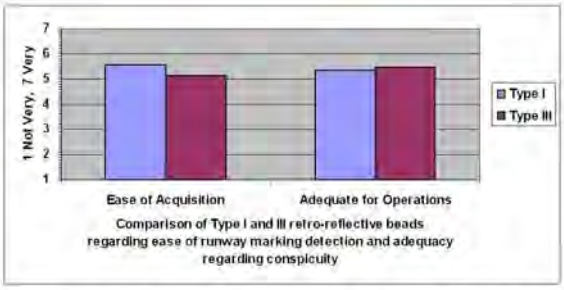
There was a substantial drop-off in retro-reflective readings on markings with high-index Type III beads after eight months of operation (from 820 mcd/$m^2$/lx to 351 mcd/$m^2$/lx) at ACY. There was a less substantial drop-off in retro-reflective readings on markings with low-index Type I beads after eight months (from 352 mcd/$m^2$/lx to 313 mcd/$m^2$/lx). Briefly, the readings fluctuate as the glass beads get contaminated with rubber deposits and other dirt and grime coatings. Precipitation can partially clean the glass beads and restore some retro-reflective properties. However, when the glass bead is damaged, as shown above, the light from the damaged bead is not reflected back to the source and there is a permanent loss of retro-reflectivity.

CONCLUSIONS




**Pilots (human eyes) reported at 0.9 to 6.0 miles from the threshold no real visual differences between Type III and Type I installations.**

**This result contradicts the result recorded by instrument measurements.**




**Pilots report no real differences between Type III and Type I bead installations**

The chart on the left shows pilots reported no visual difference between bead types. The chart on the right shows very little difference between bead types relating to ease of seeing the marking and the adequacy of the marking.

- The majority of the subjects tested at both ACY and SAV stated they do not use runway markings on approach at night. Instead, runway lighting is the predominant visual cue. They had to concentrate on looking for markings and then only saw a very slight difference between low-index Type I and high-index Type III beads.
- While not part of the evaluation, some subjects indicated that they use the markings more after touchdown and indicated that all the markings looked the same.
- This research validates the airborne research performed in 1996 and is consistent with ground-based research performed to date, including research completed in 2009, which is waiting final report preparation.

## FAA ACTIONS

We do not intend to change the guidance in AC 150/5340-1. We will continue to recommend high-index Type III glass beads to increase conspicuity at runway holding position markings.

We do not intend to change the guidance in AC 150/5370-10 to require airports to use the higher cost high-index Type III glass beads. The research showed that pilots observed little difference in either the low-index Type I or high-index Type III beads on approach at night. We will continue to allow the airport owner to choose glass bead types for markings.

Furthermore, the research documented that the initial higher reflectivity of the high-index Type III beads decreased significantly over time, while that of the low-index Type I beads did not. The reflectivity measured by instruments after eight months was almost identical for the low-index Type I and high-index Type III beads.

Attachment
Airborne Evaluation of Retro-Reflective Beads Document