U.S. Department
of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Frangible Connections

Date: 4/13/2021
Initiated By: AAS-100

AC No: 150/5220-23A
Change:

1 **Purpose.**

This advisory circular (AC) contains standards and guidelines for the frangible connections used to support objects located in airfield safety areas and object free areas.

2 **Cancellation.**

This AC cancels AC 150/5220-23, *Frangible Connections*, dated 4/27/2009.

3 **Applicability.**

The Federal Aviation Administration (FAA) recommends the guidance in this publication for the design and installation of frangible connections. This AC does not constitute a regulation and is not legally binding in its own right. It will not be relied upon as a separate basis by the FAA for affirmative enforcement action or other administrative penalty. Conformity with this AC is voluntary, and nonconformity will not affect rights and obligations under existing statutes and regulations, except for the projects described in subparagraphs 2 and 3 below:

1. The standards and guidelines contained in this AC are practices the FAA considers essential for the reliability of components to maintain acceptable level of safety, performance and operation of frangible connections.
2. Use of these standards and guidelines is mandatory for projects funded under Federal grant assistance programs, including the Airport Improvement Program (AIP). See Grant Assurance #34.
3. This AC is mandatory, as required by regulation, for projects funded by the Passenger Facility Charge (PFC) program. See PFC Assurance #9.
4. This AC provides one, but not the only, acceptable means of meeting the requirements of 14 CFR part 139, *Certification of Airports*.

The guidance in this AC does not apply to any equipment governed by the Airport Lighting Equipment Certification Program (ALECP) (as described in AC 150/5345-53, *Airport Lighting Equipment Certification Program*). The ALECP provides specific testing, certification, and frangibility standards for a variety of equipment and many of those standards are different from those contained in this AC.

These frangibility requirements cover the minimum levels of safety for airfield safety areas. In order to further the overall goal of safety on the airport, it is highly encouraged that these frangibility provisions be incorporated in the areas adjacent to safety areas whenever possible.

4 Scope.

This AC covers the following types of frangible connections:

1. Fuse bolts (including frangible or neck-down bolts),
2. Special material bolts (including alloy bolts),
3. Frangible couplings,
4. Tear-through fasteners (including countersunk rivets), and
5. Tear-out sections (including gusset plates).

This AC contains frangibility design information found in two documents:

1. International Civil Aviation Organization (ICAO), Document 9157-AN/901, *Aerodrome Design Manual*, Part 6, *Frangibility*.
2. Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design*.

5 Principal Changes.

The AC incorporates the following principal changes:

1. Deleted all references to FAA Drawing C-6046.
2. Added subparagraphs 2.1.1 and 2.1.1.1.
3. Added Figure 3-1 and Figure 3-2.
4. Added Table 4-1 to Chapter 4.
5. Added Figure 5-1 to paragraph 5.1.2.
6. Added Figure 5-2.
7. Updated paragraph 5.2.2 to reference the latest Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO) testing procedures.
8. Changed Appendix A to reference an approved frangible connection addendum.
9. Added Appendix B containing four figures.
10. Incorporated information from Engineering Brief No. 79A, *Determining RSA NAVAID Frangibility and Object and Fixed-By-Function Requirements*.
11. Updated the format of the document and made minor editorial changes throughout.

Hyperlinks (allowing the reader to access documents located on the internet and to maneuver within this document) are provided throughout this document and are identified with underlined text. When navigating within this document, return to the previously viewed page by pressing the “ALT” and “ ←” (left arrow) keys simultaneously.

6 **Use of Metrics.**

Throughout this AC, U.S. customary units are used followed with “soft” (rounded) conversion to metric units. The U.S. customary units govern.

7 **Where to Find this AC.**

You can view a list of all ACs at http://www.faa.gov/regulations_policies/advisory_circulars/. You can view the Federal Aviation Regulations at http://www.faa.gov/regulations_policies/faa_regulations/.

8 **Feedback on this AC.**

If you have suggestions for improving this AC, you may use the Advisory Circular Feedback form at the end of this AC.

John R. Dermody
Director of Airport Safety and Standards

CONTENTS

Paragraph **Page**

CHAPTER 1. TERMINOLOGY AND REFERENCES 1-1
1.1 Definitions 1-1
1.2 Acronyms and Terms. 1-2
1.3 Applicable Documents. 1-3

CHAPTER 2. INTRODUCTION 2-1
2.1 General. 2-1
2.2 Frangibility Concepts. 2-1

CHAPTER 3. PERFORMANCE STANDARDS 3-1
3.1 General. 3-1
3.2 Requirements. 3-1

CHAPTER 4. TYPES OF FRANGIBLE CONNECTIONS 4-1
4.1 General. 4-1
4.2 Fuse Bolts (Including Frangible or Neck-Down Bolts). 4-1
4.3 Special Material Bolts (also Alloy Bolts). 4-1
4.4 Frangible Couplings. 4-2
4.5 Tear-Through Fasteners (also Countersunk Rivets). 4-2
4.6 Tear-Out Sections (also Gusset Plates). 4-2
4.7 Frangible Mechanisms. 4-2

CHAPTER 5. QUALIFICATION REQUIREMENTS 5-1
5.1 Selection, Installation, Inspection, and Maintenance. 5-1
5.2 Testing, Certification, and Approval. 5-4

Appendix A. FAA APPROVED FRANGIBLE CONNECTIONS A-1

Appendix B. NON-STANDARD AND UNACCEPTABLE CONDITIONS AND EQUIPMENT NOT FIXED-BY-FUNCTION B-1

CONTENTS

Page

FIGURES

Figure 3-1. Typical Frangible Connections 3-2
Figure 3-2. Field Measurability of Frangibility 3-3
Figure 5-1. Typical Concrete Pad and Grading Detail 5-2
Figure 5-2. Typical Standard ALS Installations 5-3
Figure B-1. Non-Standard ALS Installations B-1
Figure B-2. Unacceptable Grading Surrounding NAVAIDs B-2
Figure B-3. Non-Standard RSA B-3
Figure B-4. Equipment Not Fixed-By-Function B-4

TABLES

Table 4-1. Types of Frangible Connections 4-3

Page Intentionally Blank

CHAPTER 1. TERMINOLOGY AND REFERENCES

1.1 Definitions.

1.1.1 Airfield Obstacles.

For the purpose of this AC, all fixed objects located within an airfield's runway or taxiway safety area that are not mounted on frangible connections (or any other type of frangible support). These include obstructions to air navigation, which are objects that extend above any of the imaginary elevated surfaces of the airfield (as defined in Title 14 of the Code of Federal Regulations Part 77). Airfield obstacles may be of either standard or nonstandard design.

1.1.2 Break-away or Failure Mechanism.

A device which has been designed, configured, and fabricated in a manner that it is very sensitive to one type of loading, usually resulting from a time-dependent dynamic impact, but immune to the normal environmental and operational loads imposed on the mechanism during the lifetime of the structure. The "break-away mechanism" can be designed in conjunction with the joints of the structure and/or designed independent of the joints of the structure.

1.1.3 Frangibility.

The ability of an object to break, distort, or yield when impacted by another object.

1.1.4 Frangible Object.

An object designed to have minimal mass and absorb a minimal amount of energy during an impact event. In the airport environment, the goal of these objects is to not impede the motion of, or radically alter the path of, an aircraft while minimizing the overall potential for damage during an incident.

1.1.5 Impact Energy.

The amount of energy a moving object imparts to a stationary obstacle.

1.1.6 Impact Load.

A sudden application of a load or force by an object moving with high velocity.

1.1.7 Low Impact Resistant Supports (LIRS).

Supports designed to resist operational and environmental static loads and fail when subjected to a shock load such as that from a moving aircraft.

1.1.8 Material Toughness.

The ability of a metal to deform plastically and to absorb energy prior to failure or fracture.

1.1.9 Modulus of Toughness.

The ultimate amount of energy by volume that a material will absorb. This value may be calculated as the entire area under the stress-strain curve from the origin to failure.

1.1.10 Object Free Area (OFA).

An area centered on the surface of a runway or taxiway provided to enhance the safety of aircraft operations by remaining clear of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes.

1.1.11 Runway Safety Area (RSA).

A defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway (as defined in AC 150/5300-13, *Airport Design*).

1.1.12 Taxiway Safety Area (TSA).

A defined surface alongside the taxiway prepared or suitable for reducing the risk of damage to an airplane unintentionally departing the taxiway (as defined in AC 150/5300-13).

1.2 **Acronyms and Terms.**

AASHTO	American Association of State Highway and Transportation Officials
AC	Advisory Circular
ALECP	Airport Lighting Equipment Certification Program
AIP	Airport Improvement Program
ALS	Approach Lighting System
CFR	Code of Federal Regulations
EMT	Electrical Metallic Tubing
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
ICAO	International Civil Aviation Organization
LIR	Low Impact Resistant
LIRS	Low Impact Resistant Supports
MASH	Manual for Assessing Safety Hardware
NAVAID	Navigational Aid
NCHRP	National Cooperative Highway Research Program
PAPI	Precision Approach Path Indicator
PCU	Power/Control Unit
PFC	Passenger Facility Charge

PVC	Polyvinyl Chloride
REIL	Runway End Identification Light
ROFA	Runway Object Free Area
RSA	Runway Safety Area
TRB	Transportation Research Board
TSA	Taxiway Safety Area
UFC	Unified Facilities Criteria
USAF	United States Air Force
VASI	Visual Approach Slope Indicator

1.3 Applicable Documents.

The following documents form part of this specification and are applicable to the extent specified.

1.3.1 FAA Orders, Specifications, Guidebooks, and Advisory Circulars (ACs):

AC 150/5300-13	*Airport Design*
AC 150/5340-26	*Maintenance of Airport Visual Aid Facilities*
AC 150/5345-44	*Specification for Taxiway and Runway Signs*
AC 150/5345-45	*Low-impact Resistant (LIR) Structures*
AC 150/5345-46	*Specification for Runway and Taxiway Light Fixtures*
AC 150/5345-53	*Airport Lighting Equipment Certification Program*
DOT/FAA/TC-LC19/38	*Federal Aviation Administration Frangibility Guidebook*

1.3.2 Military Publications:

Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design*, 4 February 2019.

1.3.3 International Civil Aviation Organization (ICAO):

Aerodrome Design Manual, Document 9157-AN/901, Part 6, *Frangibility*, 2006.

1.3.4 American Society of State Highway and Transportation Officials (AASHTO):

Manual for Assessing Safety Hardware (MASH).

1.3.5 Transportation Research Board (TRB) - National Cooperative Highway Research Program (NCHRP):

Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features.*

1.3.6 U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA): *Maintenance of Signs and Sign Supports.*

1.3.7 Sources:

1. FAA ACs may be obtained from: www.faa.gov/regulations_policies/advisory_circulars/.
2. FAA Orders and Specifications may be obtained from: www.faa.gov/regulations_policies/orders_notices/.
3. Military publications may be obtained from: https://www.wbdg.org/.
4. ICAO publications may be obtained from: https://store.icao.int/.
5. AASHTO publications may be obtained from: https://store.transportation.org/.
6. NCHRP publications may be obtained from: www.trb.org/NCHRP/.
7. U.S. DOT FHWA publications may be obtained from: https://safety.fhwa.dot.gov/.

CHAPTER 2. INTRODUCTION

2.1 General.

A goal of the FAA is to improve safety at airports. Specific "safety areas" have therefore been established on airfields that prohibit the placement of objects that could present a hazard to operating aircraft. Current technological limitations or operational requirements require certain objects, such as navigational or visual aids, to be placed within safety areas. Those objects are required to be of minimal mass and height, mounted as low as possible to the ground, and mounted on frangible connections.

2.1.1 Location of Objects on Airports.

Many navigational and visual aids, objects, and fixed-by-function facilities are fixed by their function and are precisely located on an airport with respect to the runways and taxiways. An example is the location of an Approach Lighting System (ALS) and its associated maintenance road. The same can be said of a Precision Approach Path Indicator (PAPI) and taxiway signs. Much of the support equipment for these aids, objects, and facilities can usually be located apart from the actual installation and therefore is not fixed-by-function. Typical support equipment, not fixed-by-function, located outside the safety areas and object free areas include junction boxes, splice boxes, power/control units, etc. If relocation to areas outside the safety area is not practicable, other options, such as underground burial, need to be considered. If the final support equipment location is still inside a safety area, comply with paragraph 3.2. See AC 150/5300-13 for the fixed-by-function designation of typical communications, navigation, surveillance, and weather equipment.

2.1.1.1 Jet Blast Deflectors.

Jet blast deflectors generally are not fixed-by-function. However, there may be situations, due to safety and equipment operational needs, that require a jet blast deflector be located within a safety area. For example, a metal blast deflector that is too close to a localizer may interfere with localizer's navigation signal to aircraft and the only practicable safety option is to place the deflector within an RSA. In this individual set of circumstances, the location of the jet blast deflector is fixed by the safety requirement it performs. Design any jet blast deflector located within a safety area with minimal mass material, such as fiberglass or plastic polymers, and mount on frangible connections that comply with the standards of this AC.

2.2 Frangibility Concepts.

2.2.1 Flight Safety Impact.

An aircraft in flight (or maneuvering on the ground) that impacts an object located on an airfield may be susceptible to the following flight safety risks (reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.1.1):

- The aircraft may lose momentum;
- The aircraft may change direction; and
- The aircraft may suffer structural damage.

2.2.2 Momentum Loss.

The amount of momentum lost is calculated by the integral of force over time. Therefore, to minimize loss of momentum, minimize both the magnitude of the impact load and the duration of its contact with a frangible structure. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.1.2)

2.2.3 Energy Components.

The structural damage to the aircraft is related to the amount of energy required to move an obstacle. This energy, minimized as low as possible, can be broken down into the following components: (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.1.3)

1. Energy to activate obstacle failure or break-away mechanisms (dependent on the efficiency of the mechanism and the number of mechanisms to be activated);
2. Energy required for deformation of the obstacle, or part of it (dependent on the choice of material: the amount will be higher for ductile materials with high-yield strengths); and
3. Energy required to accelerate the obstacle, or part of it, up to at least the aircraft's speed (dependent on the aircraft speed, which is not a design variable, and on the mass to be accelerated).

2.2.4 Failure (or Break-Away) Mechanism.

The manner in which an object fails. Considering the energy components previously described, an efficient failure mechanism would be designed to have a limited number of components, be made of brittle materials, and have minimal mass. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.1.4)

2.2.5 Impact Area.

The structural damage to the aircraft is also related to the contact area between the aircraft and obstacle through which the energy transfer takes place. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.1.5)

2.2.6 Failure Mode:

2.2.6.1 To meet the frangibility requirements, different failure mechanisms are applied. For example, structures can be of modular design, which on impact "open a window" for the aircraft to pass through, or of a one-piece design which on impact does not disintegrate but is deflected away by the aircraft. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.2.1)

2.2.6.2 In the case of a modular design, the structure contains break-away or failure mechanisms which, apart and together, require only a minimum amount of energy for their activation. This concept permits moving the least amount of mass out of the way of a moving aircraft. The sequence of events is easier to predict as the structure behaves in a brittle way, disintegrating preferably at small deflections. The design would be unsuccessful if it allowed a structure to wrap around or entangle an aircraft rather than disintegrating or falling to the ground. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.2.2)

2.2.6.3 In the case of a one-piece design, the frangibility is guaranteed by a complete failure of the structure. This is achieved by the failure of the structural member and not the predetermined break-away or failure mechanism. The entire structure will be involved in the impact, resulting in a high kinetic energy required to move the structure. This type of failure mechanism seems suitable only for lightly loaded structures, i.e. those meant to carry low-mass equipment. Due to the continuous nature of the structure, the sequence of failure events is difficult to predict. Consider the tendency to “wrap around” the aircraft to be an additional hazard. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.2.3)

2.2.7 <u>Impact Load.</u>

The impact load is a rapidly changing dynamic load of short duration. Typical loading and response times are in milliseconds. The impact load influences the frangibility performance in two ways. First, the maximum impact load may adversely affect the structural integrity of the aircraft. Second, the integral of the impact load over the duration of the impact may lead to a change of momentum (including direction) of the aircraft. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.3)

2.2.8 <u>Energy Transfer.</u>

2.2.8.1 During an impact, energy will be transferred from the aircraft to the obstacle, resulting in aircraft damage proportional to the amount of energy transferred. The energy transfer is estimated as follows (reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.4.1):

1. The energy required to cause a break-away mechanism to fracture is determined in a laboratory on a component scale; multiply this amount of energy by the number of mechanisms to be broken;
2. The energy required for plastic and/or elastic deformation is calculated or determined by simple tests; this energy is often negligible when stiff and brittle materials are applied in a modular design; and

3. The kinetic energy required for acceleration of the fragments, or the total structure in the case of a one-piece design, is calculated using the known mass and the representative aircraft velocity.

2.2.8.2 Calculate the estimations for all different scenarios of an aircraft impacting the structure. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.4.2)

CHAPTER 3. PERFORMANCE STANDARDS

3.1 General.

The performance standards listed in this section focus on the frangible connections used to support equipment located in airfield safety areas and object free areas. General frangibility requirements are provided, while the specific requirements for different classes of airfield structures (such as elevated lights, signs, and navigational aids, etc.) are specified when applicable.

3.2 Requirements.

3.2.1 Equipment located in airfield safety areas (such as RSAs or TSAs, as described in AC 150/5300-13), is mounted on frangible supports to ensure the structure will break, distort, or yield in the event of an impact by an aircraft. Select materials that preclude any tendency for the components, including the electrical conductors, etc., to "wrap around" the aircraft. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 3.3.1)

3.2.2 Frangible structures include effective failure or breakaway mechanisms, such as those containing a limited number of parts, brittle or low-toughness members and connections, and/or low-mass members. Various design concepts exist, each with its own advantages and disadvantages. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.1)

3.2.3 Structural Integrity.

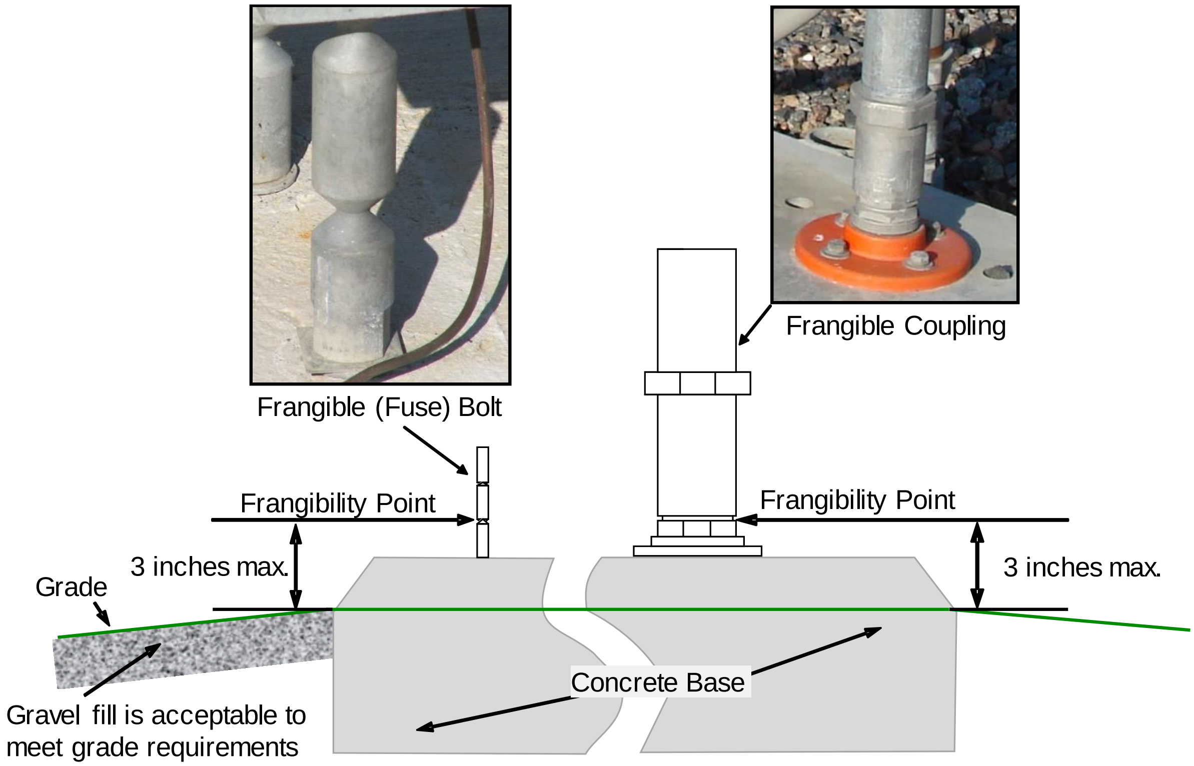
3.2.3.1 General Requirements.

Unless otherwise specified, design frangible connections as follows:

1. to withstand wind or jet blast loads with a suitable factor of safety but break, distort, or yield when subjected to the sudden collision forces of a 6,600 pound (lb) (3,000 kg) aircraft moving on the ground at 31 mph (50. km/h or 27 kt) or airborne and traveling at 87 mph (140 km/h or 75 kt);
2. to not impose a force on the aircraft in excess of 13,000 pounds force (lbf) (58.0 kN). The maximum energy imparted to the aircraft as a result of the collision is 40,500 foot pounds (ft lbs) (55.0 kJ) over an approximate 100 millisecond contact period between the aircraft and the structure. To allow the aircraft to pass, the structure mechanically fails by fracturing or buckling. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.9.20); and
3. to provide for a frangibility point no greater than 3.0 inches (76 mm) above the surrounding grade. Make structural foundations (e.g. concrete blocks) flush with the surrounding grade (or as close as

possible if there is a need to mitigate water accumulation/ponding). (See Figure 3-1 and Figure 3-2, and reference AC 150/5300-13.)

Figure 3-1. Typical Frangible Connections



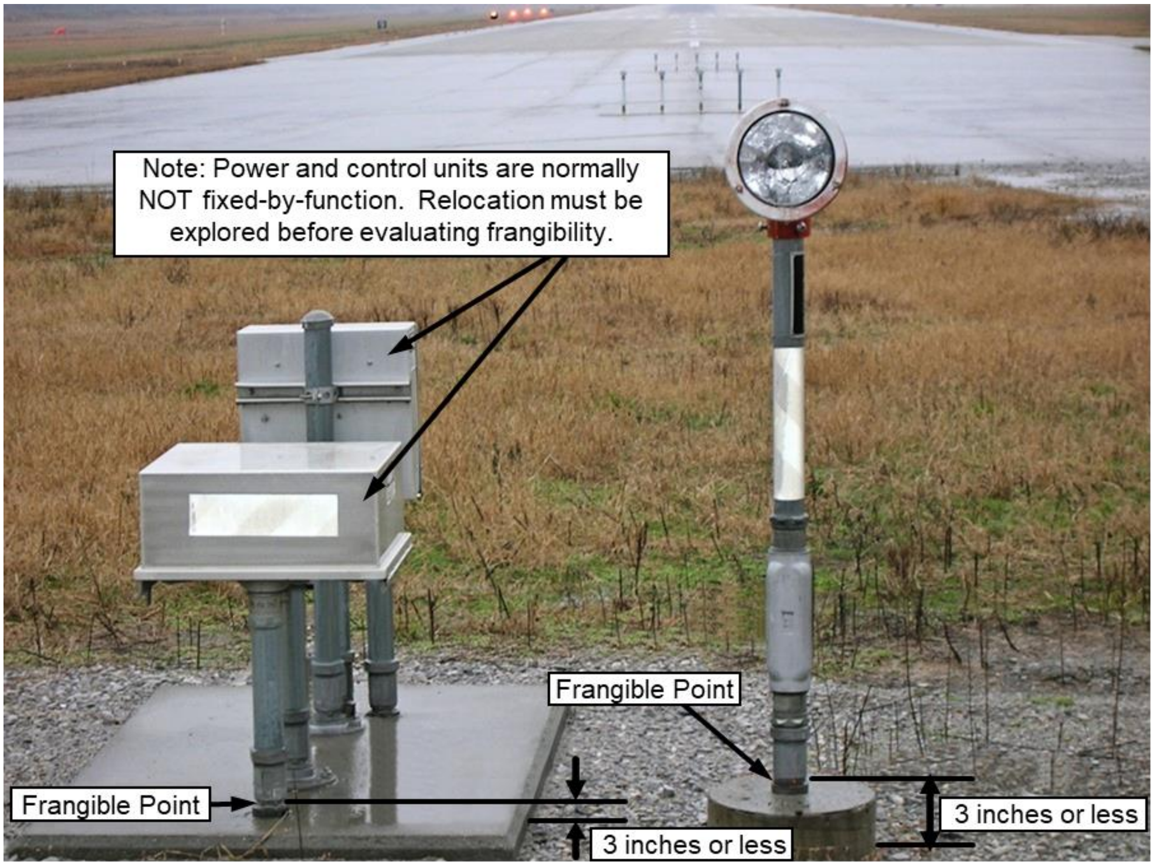
Notes for Figure 3-1:

Note 1: Frangible bolts or fuse bolts are typically installed on:
a. ALS that use Low Impact Resistant (LIR) structures
b. Localizers

Note 2: Frangible couplings are used with electrical metallic tubing (EMT) and are installed on:
a. ALS light station that is less than 6 feet high (refer to Figure 5-2)
b. PAPI
c. VASI
d. REIL
e. ALS maintenance stands

Note 3: This figure is to be used for evaluating existing installations for frangibility. New installations provide grading that is flush with the top of the concrete base. See Figure 5-1.

Figure 3-2. Field Measurability of Frangibility



Note 1: Refer to Appendix B, Figure B-4. .

3.2.3.2 **Specific Requirements.**

Design standards for the following equipment can be found in the corresponding ACs:

Signs, Runway and Taxiway	AC 150/5345-44
Low Impact Resistant (LIR) Structures	AC 150/5345-45
Light Fixtures, Runway and Taxiway	AC 150/5345-46

3.2.4 Any design using frangible mechanisms has to ensure that no slippage or change in shape occurs from cyclic loading. For example, in a design using interconnecting tubes, aeroelastic flutter on a tube caused by a jet blast or wind could loosen or separate it from its counterpart. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.8)

3.2.5 Break-away or Failure Mechanisms.

Locate the break-away or failure mechanism in an area where the resulting damaged components do not present a greater hazard than they present as part of the undamaged structure. It is desirable that break-away or failure mechanisms are independent of the strength required for withstanding wind loads, ice loads, and other environmental loads. In addition, select a mechanism that is not prone to premature fatigue failure. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.6)

3.2.6 Environmental.

The environmental requirements for specific types of equipment are in the ACs listed in paragraph 1.3.1. The environmental requirements for frangible connections supporting such equipment are equal to those required for the entire structure/system.

3.2.7 Material Selection.

3.2.7.1 Ensure materials and configurations for frangible structures suitable for the intended use and result in the lightest structure practicable. Structures may be fabricated from materials that are not adversely affected by outdoor environmental conditions. Select materials to meet frangibility requirements that are strong, lightweight, and have a low modulus of toughness. Minimum weight is important to ensure that the least amount of energy is expended to accelerate the mass to the speed of the impacting aircraft. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.7.1)

3.2.7.2 Standard, commercially available materials often provide cost-effective designs. Ensure all materials are capable of withstanding or are protected against environmental effects including: temperature fluctuations; solar radiation; vibration; weathering (salt spray, wind, relative humidity); and corrosion (due to rain, snow, ice, sand, grit, or deicing materials) typically encountered in the airfield environment.

3.2.8 Electrical Components.

Consider the strength of electrical conductors incorporated in the design of frangible structures as well as the fire hazard presented by the arcing of disrupted conductors in the overall design. Design conductors such that they do not rupture but disconnect at predetermined points within the limits for frangibility of the structure. This is accomplished by the providing connectors that require a lower tensile force to separate than that required to rupture the conductor. In addition, protect the connectors with a break-away boot of a size commensurate with the voltage employed in order to contain any possible arcing at disconnection. Break-away connector assemblies are commercially available. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.8.2, and AC 150/5345-45, *Low-Impact Resistant Structures*.)

3.2.9 Maintenance Equipment Design.

3.2.9.1 A frangible structure no longer meets requirements if the structure itself is used as a climbing frame or by the addition of a fixed ladder. Maintain the total structure either by using equipment that can be easily moved into position or by lowering the structure to the ground. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 7.2.2)

3.2.9.2 Portable maintenance stands are recommended to maintain airfield lighting structures. (It may be possible to convert a permanent stand into a portable stand by installing a threaded can into the foundation, which allows for the stand to be temporarily screwed into place whenever needed.)

3.2.9.3 If permanent fixed maintenance stands are to be used, ensure they meet the structural integrity requirements in paragraph 3.2.3, or mount the stands on frangible supports. If pressure treated wood posts are used, ensure they are no larger than 4 × 4 inches (0.1 × 0.1 m) in size. Additionally, drill 1-inch (25 mm) diameter holes completely through the center of each face of the post, at a hole centerline height no greater than 3 inches (76 mm) above the surrounding grade. (U.S. DOT FHWA, *Maintenance of Signs and Sign Supports*)

3.2.10 Vehicular Signs.

Signs may be necessary to protect vehicular drivers from entering safety areas. If signs are to be used, ensure the post meets the structural integrity requirements in paragraph 3.2.3, or mount on frangible supports. If pressure treated wood posts are used, ensure they are no larger than 4 × 4 inches (0.1 × 0.1m) in size. Additionally, drill 1-inch (25 mm) diameter holes completely through the center of each face of the post, at a hole centerline height no greater than 3 inches (76 mm) above the surrounding grade. (U.S. DOT FHWA, *Maintenance of Signs and Sign Supports*)

Page Intentionally Blank

CHAPTER 4. TYPES OF FRANGIBLE CONNECTIONS

4.1 General.

Frangibility is incorporated in the connection, which carries the design load but fractures at impact. The structural member is not designed to break but rather to transfer the impact force to the connection. A stiff, lightweight member provides efficient load transfer to the connection and minimizes the energy absorbed from bending and mass acceleration. Use connections that break at low energy levels, as determined by impact tests. Types of frangible connections include neck-down or fuse bolts, special material or alloy bolts, countersunk rivets or tear-through fasteners, and gusset plates with tear-out sections. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.2) (See Table 4-1, Types of Frangible Connections.)

4.2 Fuse Bolts (Including Frangible or Neck-Down Bolts).

4.2.1 Failure of this type of connection is induced by providing a “stress raiser,” due to removal of material from the bolt shank. One method used to achieve this is to machine a groove to reduce the bolt diameter or to machine flats in the sides of the bolts, making it weaker in a specific direction. Shear strength is maintained and tensile strength is reduced by machining a hole through the bolt diameter and locating it out of the shear plane. Carefully install fuse bolts to ensure they are not damaged or overstressed when tightened. One disadvantage of fuse bolts is that the stress raiser may shorten the fatigue life of the bolt or may propagate under service loads and fail prematurely. Fuse bolts with machine grooves are commercially available. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.2.a)

4.2.2 Common applications of fuse bolts include use as the frangible connections for localizers (typically five-eighth or 0.625-inch (15.88 mm) diameter bolts) and for approach light towers (typically three-quarter or 0.75-inch (19.1 mm) diameter bolts).

4.3 Special Material Bolts (also Alloy Bolts).

Use of fasteners manufactured from special materials eliminates the need for extensive machining or fabricating and allows the basic design to consist of conventional cost-effective techniques. The fasteners are sized to carry the design loads but are made from material with low-impact resistance. Select materials such as steel, aluminum, and plastic based on strength and minimum elongation to failure. Because frangibility is based on material selection, it is extremely important to purchase hardware with guaranteed compliance of physical properties. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.2.b)

4.4 Frangible Couplings.

4.4.1 A frangible connection for cylindrical or tubular objects is often obtained through the use of frangible couplings. Frangibility is achieved in these devices by modifications that reduce the circumference of the coupling at a given point or through the machining of holes or other elements that reduce the effective strength of the coupling at a given point.

4.4.2 Common applications of frangible couplings are found in light posts, masts, and EMT supports for runway and taxiway lights (See AC 150/5345-44 and AC 150/5345-46 for frangibility requirements). It is important to recognize that many types of frangible couplings are available. Use only those types approved for the purpose or application originally intended.

4.5 Tear-Through Fasteners (also Countersunk Rivets).

Fasteners such as countersunk rivets can be used to sustain shear loads but tear through the base material if the impact force creates a tension load. The hole in the base material is accurately machined to grip a minimum amount of the area under the head of the fastener. The taper of the countersunk head also helps initiate the pull-through. This technique relies heavily on the manufacturing process and requires extensive quality inspection. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.2.c)

4.6 Tear-Out Sections (also Gusset Plates).

Connecting gusset plates can be designed with notches that will tear out with the member. In this type of connection, the fastener does not break but instead is used to pull out a section of the gusset plate. Fatigue life and manufacturing quality are the primary design considerations. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.2.d)

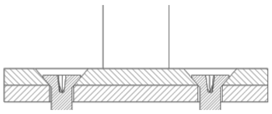
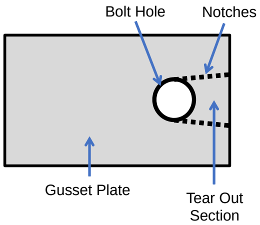
4.7 Frangible Mechanisms.

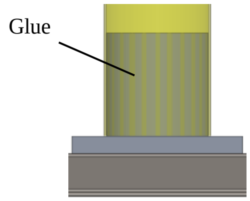
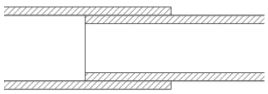
4.7.1 Frangibility can be incorporated into the support structure by means of a mechanism that slips (e.g. slip-bases), breaks, or folds away on impact and removes the structural integrity of the support. A frangible mechanism can be designed to withstand high wind loads but remain very sensitive to impact loads. Frangible mechanisms tend to be directional in strength, i.e. they carry high tension and bending moments but very low shear strength. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.5)

4.7.2 Friction joints used as frangible mechanisms can supply high strength normal to the sliding surface but slip when the force is applied parallel to the sliding surface. In a support structure, impact forces are predominantly horizontal. Design friction joints so that the slip plane is horizontal and complete failure occurs if impacted in any direction in that plane. This is achieved by using flange-type couplings on the ends of tower legs or interconnected tubes that slide apart on impact. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.6)

4.7.3 "Swing-away" support members can also be used as frangible mechanisms. These are incorporated into the structure to provide stability but if broken away on impact, leave the structure unstable and allow it to fracture. This type of design, however, may require large amounts of mass to be moved out of the way before failure. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 4.5.7)

Table 4-1. Types of Frangible Connections

Frangible Connection	Illustration	Description
Fuse Bolt / Neck-Down Bolts		Bolts designed to break at a specific tensile load by reducing the diameter at a point on the bolt shank. These connections are typically located between the structure and the foundation.
Special Material Bolts		Bolts engineered with specific materials to fail at a given load. Must have a certificate to guarantee compliance of physical properties.
Frangible Couplings		Cylindrical couplings with a reduced circumference or cross-sectional area in a specific area to reduce strength at that point. Typically located between structure and foundation.
Tear Through Fasteners		Fasteners, such as countersunk rivets, designed to tear through the base material when dynamically loaded. Can be used with slip joints.
Tear-Out Sections		Gusset plates designed with notches that will tear out during a dynamic impact. Fasteners do not fail but are used to pull out a section of the gusset plate.

Frangible Connection	Illustration	Description
Glued Joints		Type of slip joint where adhesive is added to provide extra strength during normal use. Can be used at base of structure or throughout the structure.
Friction Joints		Friction joints can supply high strength normal to sliding surface but slip when force is applied parallel to surface.
Swing-away or Frangible Support Members		Support members incorporated into a structure providing stability. During an impact, these members will break or swing free, leaving it unstable.

Source: *FAA Frangibility Guidebook*

CHAPTER 5. QUALIFICATION REQUIREMENTS

5.1 Selection, Installation, Inspection, and Maintenance.

5.1.1 Selection

There are two primary factors used in selecting frangible connections for supporting equipment in airfield safety areas:

1. All devices are approved by the FAA through the testing, certification, and approval process as detailed in paragraph 3.2 of this AC.
2. Ensure that the total rated shear strength of all the frangible connections does not exceed the frangibility design requirements listed in the relevant equipment ACs.

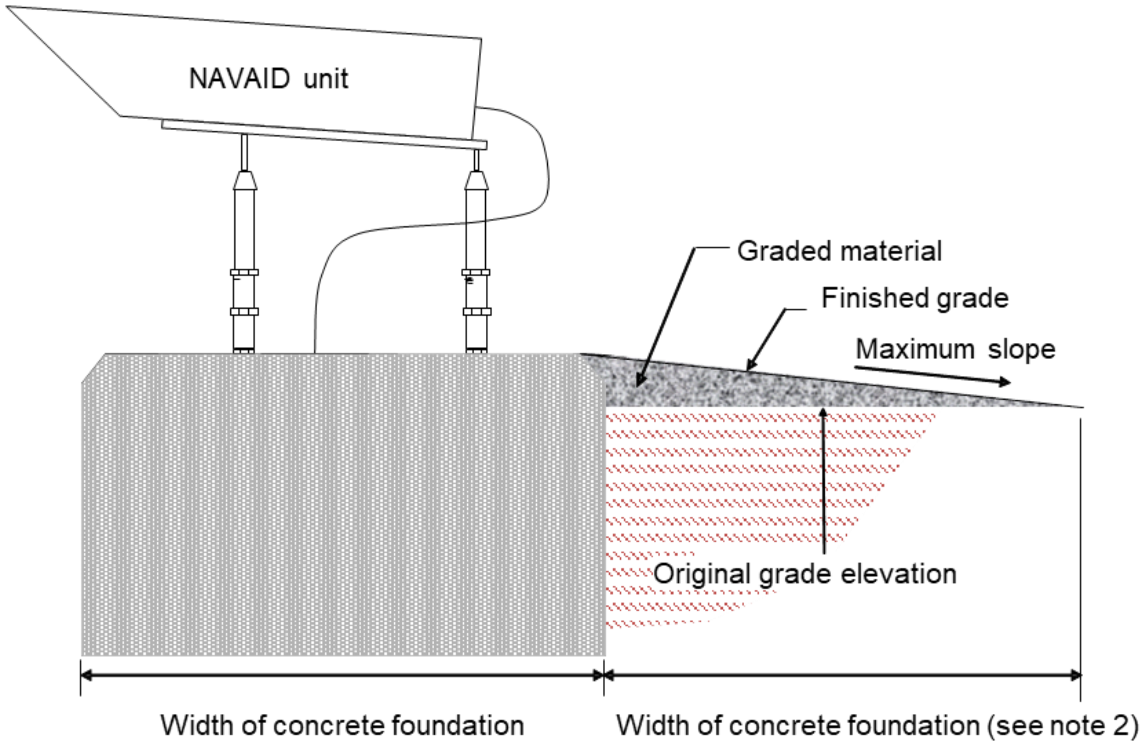
For example, in order to meet the impact force limits to an aircraft defined in the general structural integrity requirements (paragraph 3.2.3.1, item 2) of this AC, ensure the rated shear strength of all the frangible connections is less than or equal to 58 kN (13 kip). Consider all supports for a particular piece of equipment when determining the proper amount and type of frangible connections to be used: one support requires one frangible connection rated at 58 kN (13 kip); two supports require two frangible connections at 29 kN (6.5 kip) each; and so on.

5.1.2 Installation.

Refer to Figure 5-1 and Figure 5-2 for typical airport new installations. Install frangible structures according to the recommendations of the manufacturer and the requirements of the applicable AC. This refers to the structure, any cabling and connectors, and the base on which the structure is fitted. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 7.2.1)

5.1.2.1 Firm bases are essential for any precision visual or non-visual navigational aid. Design the base to provide maximum stability. Navigational aids are commonly supported on a concrete base, which is not an obstacle to an aircraft overrunning an installation. This objective is achieved either by depressing the base below or at ground level or by sloping its sides so that the aircraft comfortably rides over the base (see paragraph 3.2.3.1, item 3, for detailed requirements). Where the base is depressed, backfill the cavity above the base with the appropriate material. This, together with the frangible construction of the navigational aid and its supports, ensures that no substantial damage is sustained if an airplane runs over the aid. (Reference *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 7.2.3, and UFC 3-260-01, Section B13-2.2)

Figure 5-1. Typical Concrete Pad and Grading Detail



Notes for Figure 5-1:

Note 1: Typical detail for finishing and grading around concrete pad foundations. Grading to be consistent on all sides of the foundation.

Note 2: If the concrete foundation is not constructed flush with the top of the surrounding grade, place and compact additional graded material at maximum allowable grade for the width of the foundation as shown. Refer to AC 150/5300-13 for allowable RSA and ROFA grades.

Note 3: Provide for adequate drainage around the concrete foundation. The grading away from the foundation to be consistent with AC 150/5300-13.

Note 4: Crushed rock, or equivalent material, is to be treated with a binder or contained with wire mesh in areas exposed to jet blast.

Note 5: Refer to Figure 3-1 for frangibility point measurement.

Figure 5-2. Typical Standard ALS Installations

Standard Low Impact Resistant (LIR) structure installation with frangible bolts and flush gravel maintenance plot.

Standard ALS installation. Note electrical metallic tubing (EMT) with frangible couplings installed on light stations that are less than 6 feet high.

5.1.3 Inspection and Maintenance.

Ensure the inspection and maintenance of frangible structures meets the manufacturer's or purchaser's requirements, whichever is more stringent. Recommendation for an inspection and maintenance program can be found in AC 150/5340-26, *Maintenance of Airport Visual Aid Facilities*, and the *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Section 7.3.

5.2 Testing, Certification, and Approval.

5.2.1 General.

Test all frangible connections and devices for conformance to frangibility standards by an independent, third-party certification body. For specific equipment addressed by existing FAA ACs, or those listed in the ALECP, ensure the provisions of AC 150/5345-53 are met. Detailed testing and certification requirements are found below.

5.2.2 Testing.

5.2.2.1 There are two primary categories of frangibility testing considered in this AC. The first category is that which is undertaken to determine the frangibility performance of an entire airfield structure. Within this category, a number of frangibility testing requirements apply, including:

1. Signs, Runway and Taxiway — AC 150/5345-44
2. Low Impact Resistant (LIR) Structures — AC 150/5345-45
3. Light Fixtures, Runway and Taxiway — AC 150/5345-46
4. Other Airfield Equipment — *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Chapter 5, *Testing for Frangibility*

5.2.2.1.1 The second category applies to all other airfield structures requiring frangible connections. The testing procedures used by the Federal Highway Administration (FHWA) to determine the performance of frangible connections for the highway infrastructure provide a reasonable indication of how these same objects may perform in the airfield environment. The laboratory testing procedures identified in the AASHTO *Manual for Assessing Safety Hardware (MASH)* determine the acceptable performance of the breakaway connections/hardware. Individuals may use FHWA testing data to supplement their request to use their frangible device on airports. The frangible device can be approved for airport use provided it meets all the performance standards listed in Chapter 3.

5.2.2.1.2 As a service, the FHWA provides Federal-aid eligibility letters to the State(s) for connections that satisfy the AASHTO *Manual for Assessing Safety Hardware (MASH)* requirements. These FHWA Federal aid eligibility letters are posted online at: https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/breakaway/.

5.2.2.2 The third-party certification body will determine if any software simulations are acceptable to supplement frangible device performance. General guidance on these methods can be found in the *ICAO Aerodrome Design Manual*, Document 9157-AN/901, Part 6, Chapter 6.

5.2.3 Certification and Approval.

5.2.3.1 For individuals wishing to obtain certification and/or approval for frangible devices used on equipment listed in the ALECP or in paragraph 5.2.2.1, follow the procedures of AC 150/5345-53.

5.2.3.2 For devices or equipment not applicable to the preceding paragraph, such as commonly available frangible connection devices, items that have Federal-aid eligibility letters from the FHWA for use in highway applications (as described in paragraph 5.2.2) may be similarly approved for use on airports, provided that they can meet all of the performance standards listed in Chapter 3 of this AC. When a FHWA compliant frangible device does not exist or does not address the owner's need, frangible devices compliant with NCHRP 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, may be similarly approved for use on airports provided they meet all the performance standards listed in Chapter 3 of this AC.

5.2.3.3 A link to a list of frangible connections approved for use on airports is found in Appendix A. For approval of new devices, send a copy of the following items to an FAA-approved third-party certification body for consideration: the FHWA Federal-aid eligibility letter, static and/or full-scale testing reports, copy of the manufacturer's quality assurance program, and product technical drawings. AC 150/5345-53 contains a list of the FAA's approved third party certification bodies and information on the third-party certification program and procedures.

Page Intentionally Blank

APPENDIX A. FAA APPROVED FRANGIBLE CONNECTIONS

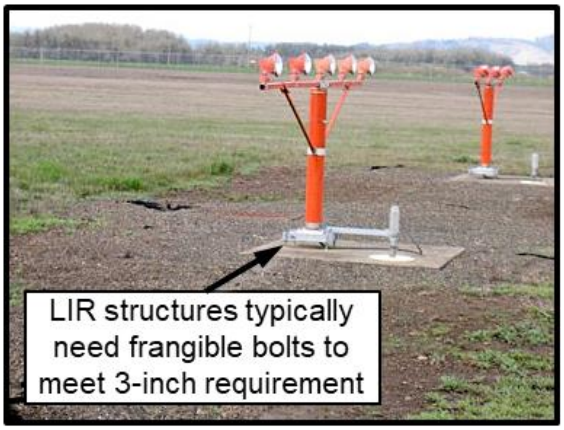
An addendum to this appendix, listing FAA approved frangible connections and the equipment manufacturer's addresses, is updated on an as-needed basis. The addendum is available on the internet at www.faa.gov/airports/ under "Advisory Circulars" with the file titled "150/5220-23A."

Page Intentionally Blank

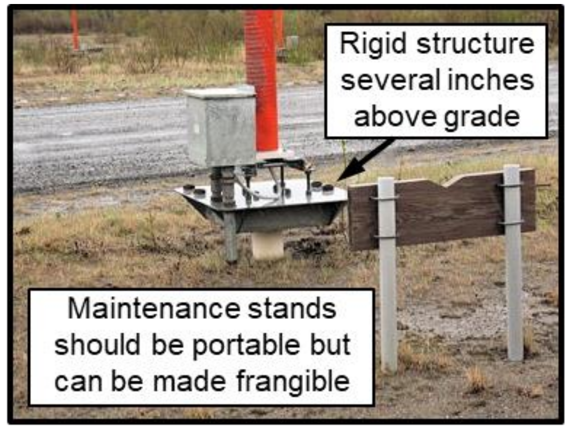
APPENDIX B. NON-STANDARD AND UNACCEPTABLE CONDITIONS AND EQUIPMENT NOT FIXED-BY-FUNCTION

Note: The figures in this Appendix are provided for informational purposes only.

Figure B-1. Non-Standard ALS Installations

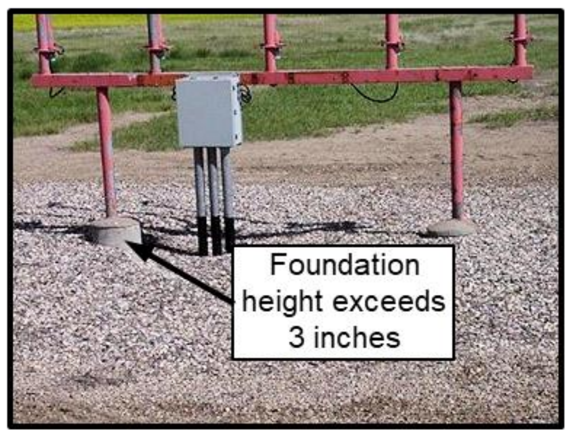


LIR structure - needs frangible bolts; should use EMT if less than 6 feet



LIR structure installed on a rigid structure - frangible bolts alone are not enough

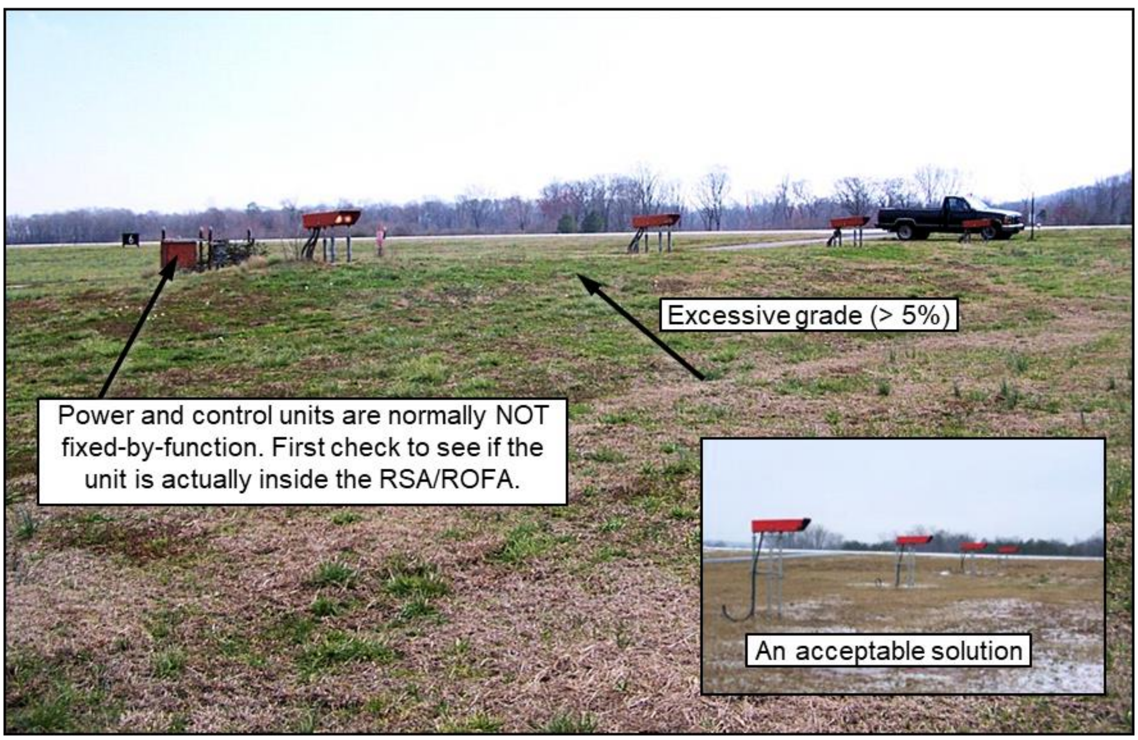
LIR structure - needs frangible bolts



Foundation exceeds 3 inches above grade

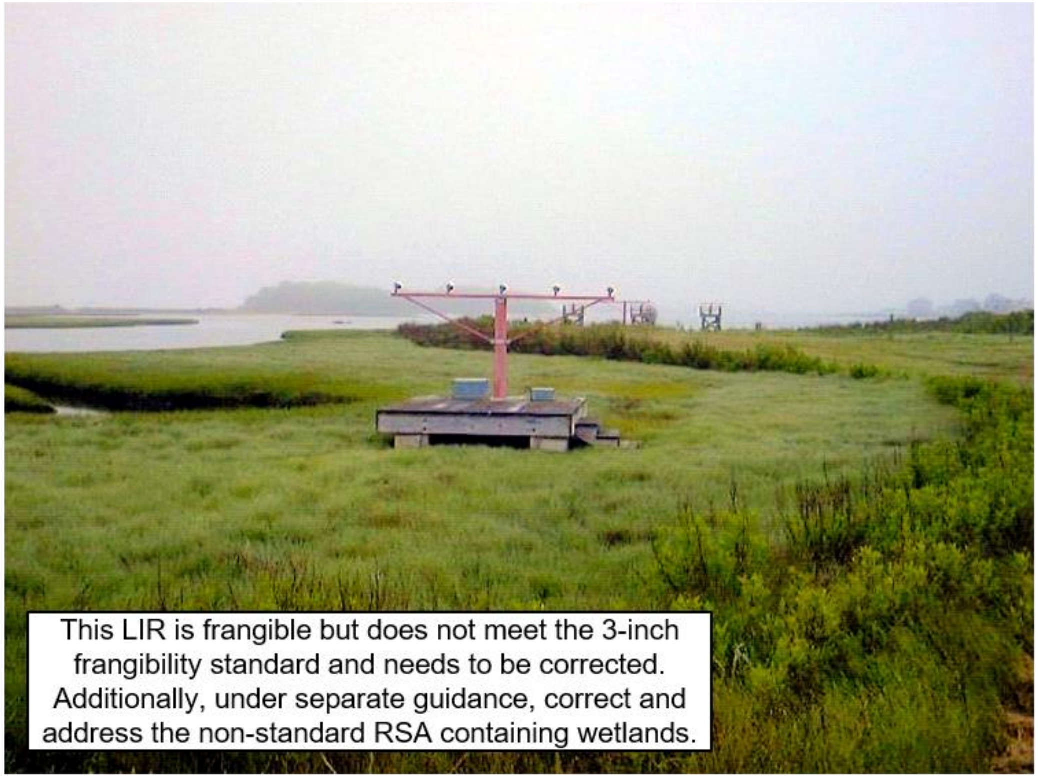
Figure B-2. Unacceptable Grading Surrounding NAVAIDs

Excessive gravel fill creates a hazard



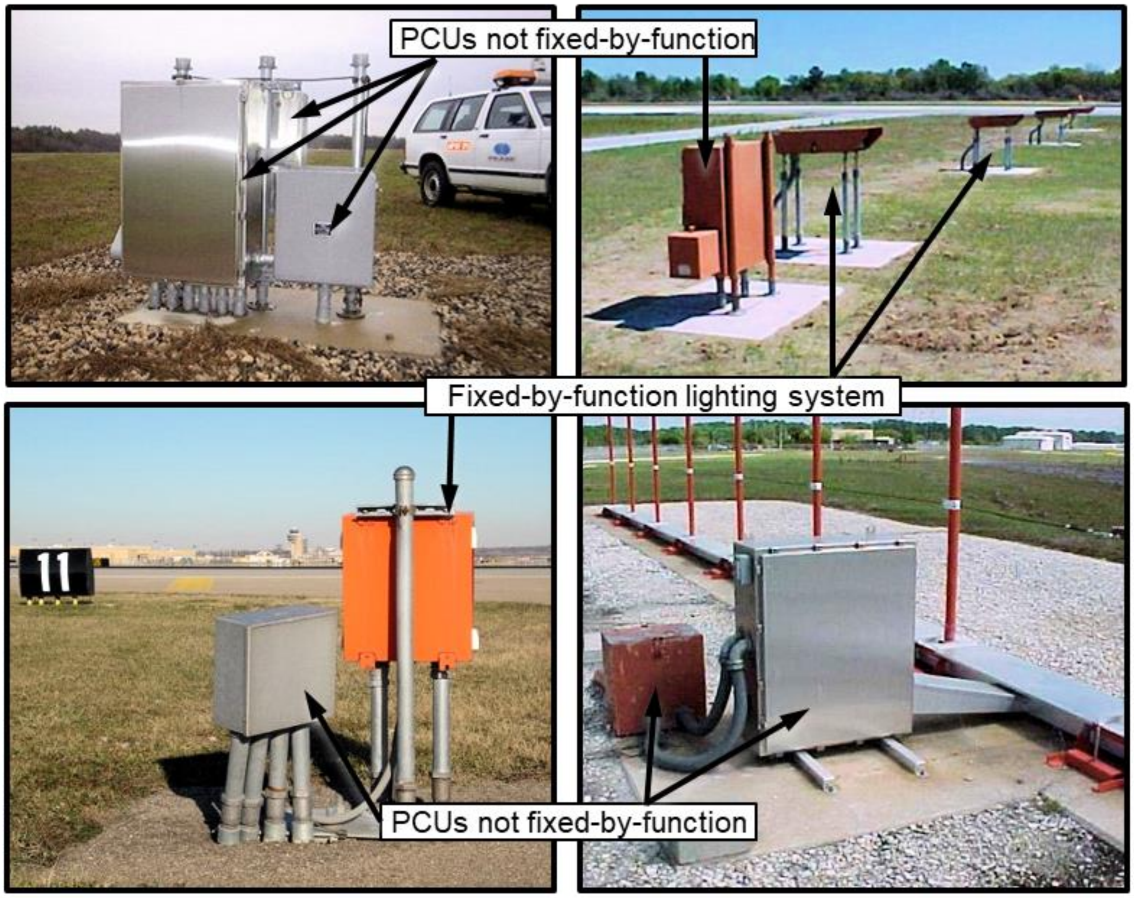
PAPI installation with excessive grade

Figure B-3. Non-Standard RSA



Non-Frangible NAVAID installed in an RSA that does not meet standards.

Figure B-4. Equipment Not Fixed-By-Function



Notes for Figure B-4:

Note 1: Power/control units (PCUs) and junction boxes are fixed-by-function if they meet the standards of AC 150/5300-13.

Note 2: Refer to AC 150/5300-13 for the fixed-by-function designation of typical communications, navigation, surveillance, and weather equipment.

Advisory Circular Feedback

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) mailing this form to Manager, Airport Engineering Division, Federal Aviation Administration ATTN: AAS-100, 800 Independence Avenue SW, Washington DC 20591 or (2) faxing it to the attention of the Office of Airport Safety and Standards at (202) 267-5383.

Subject: AC 150/5220-23A   Date: ____________________

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph __________ on page _____________.

☐ Recommend paragraph ______________ on page ______________ be changed as follows:

____
____
____

☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

____
____
____

☐ Other comments:

____
____
____

☐ I would like to discuss the above. Please contact me at (phone number, email address).

____
____
____

Submitted by: ___________________________   Date: ____________________________