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

Advisory Circular

Subject: Frangible Connections

Date: Draft
Initiated By: AAS-100

AC No: 150/5220-23A
Change:

1 Purpose.

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

2 Cancellation.

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

3 Application:

The Federal Aviation Administration (FAA) recommends use of the guidance and specifications in this advisory circular for applications requiring frangible connections at civil airports. Use of this AC is mandatory for all projects funded with federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, *Policies, Standards, and Specifications*, and PFC Assurance No.9, *Standards and Specifications*.

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. The standards contained in this AC must be used at certificated airports to satisfy specific requirements of Title 14 Code of Federal Regulations (CFR) Part 139, *Certification of Airports,* subparts C (Airport Certification Manual) and D (Operations).

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 is based on the performance standards and recommendations contained in two primary documents: the International Civil Aviation Organization (ICAO), *Aerodrome Design Manual*, Part 6, Frangibility, and the US Air Force (USAF) Engineering Technical Letter (ETL) 01-20: *Guidelines for Airfield Frangibility Zones*.

5 Principal Changes.

The AC incorporates the following principal changes:

1. All references to FAA Drawing C-6046 have been deleted.
2. Added subparagraphs 2.1.1 and 2.1.2.
3. Figure 3-1 added to paragraph 3.2.3.
4. Added Figure 3-2 and Figure 3-3.
5. Table 4-1 added to Chapter 4.
6. Figure 5-1 added to paragraph 5.1.2.
7. Added Figure 5-2.
8. Appendix A is changed to reference an approved frangible connection addendum.
9. Added Appendix B containing four figures.
10. Incorporates information from Engineering Brief No. 79A, *Determining RSA NAVAID Frangibility and Object and Fixed-By-Function Requirements.*
11. The format of the document has been updated in this version, and minor editorial changes have been made 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 " ←" 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

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CHAPTER 1. TERMINOLOGY AND REFERENCES

1.1 Definitions.

1.1.1 Airfield Obstacles.

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 of 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 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*).

1.1.11 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
ALECP	Airport Lighting Equipment Certification Program
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
NCHRP	National Cooperative Highway Research Program
PVC	Polyvinyl Chloride
USAF	United States Air Force
LIR	Low-impact Resistant

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-xx/xx	*FAA Frangibility Guidebook (available from the FAA's William J. Hughes Technical Center.)*

1.3.2 Military Publications:

U.S. Air Force (USAF) Engineering Technical Letter (ETL) 01-20: *Guidelines for Airfield Frangibility Zones*, November 2001.

1.3.3 International Civil Aviation Organization (ICAO):

Aerodrome Design Manual, Part 6, “Frangibility”, 2006.

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

LTS-4-M, *Structural Supports for Highway Signs, Luminaires and Traffic Signals*, 4th Edition, with 2002, 2003, and 2006 Interims

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*
Report 494	*Structural Supports for Highway Signs, Luminaires, and Traffic Signals*

1.3.6 Sources:

1. FAA ACs may be obtained from: www.faa.gov.
2. FAA Orders, Specifications, and Drawings may be obtained from: www.faa.gov/regulations_policies/orders_notices/.
3. USAF publications may be obtained from: HQ AFCESA, 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32403-5319, Telephone: (888) 232-3721, www.e-publishing.af.mil/.
4. ICAO publications may be obtained from: https://store.icao.int/.
5. AASHTO publications may be obtained from: bookstore.transportation.org/.
6. NCHRP publications may be obtained from: www.trb.org/NCHRP/.

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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 to be mounted on frangible connections.

2.1.1 Location of Objects on Airports.

The location of many navigational and visual aids, objects, and facilities are fixed by its function and must be 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 its function. Junction boxes, splice cans, power/control units and the like are typical support equipment not fixed by its function that should be located outside of the safety areas and object free areas. 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, the frangibility of the support equipment must be in accordance with this Advisory Circular.

2.1.2 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 requires a jet blast deflector to be located within 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 a Runway Safety Area (RSA). In this individual set of circumstances, the location of the jet blast deflector is fixed by the safety requirement it must perform. Any jet blast deflector located within a safety area must be made of minimal mass material, such as fiberglass or plastic polymers, and be mounted on frangible connections that comply with the standards of this Advisory Circular.

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*, 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, both the magnitude of the impact load and the duration of its contact with a frangible structure should be minimal. (Reference *ICAO Aerodrome Design Manual*, 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, which should be as low as possible, can be broken down into the following components: (Reference *ICAO Aerodrome Design Manual*, Part 6, Section 4.1.3)

- Energy to activate obstacle failure or break-away mechanisms (dependant on the efficiency of the mechanism and on the number of mechanisms to be activated);
- Energy required for deformation of the obstacle, or part of it (dependant on the choice of material: the amount will be higher for ductile materials with high-yield strengths); and
- 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*, 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*, 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*, Part 6, Section 4.2.1)

2.2.6.2 In the case of a modular design, the structure should contain 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*, 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, which 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 and the tendency to "wrap around" the aircraft should be considered an additional hazard. (Reference *ICAO Aerodrome Design Manual*, Part 6, Section 4.2.3)

2.2.7 Impact load.

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*, Part 6, Section 4.3)

2.2.8 Energy Transfer.

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*, Part 6, Section 4.4.1)

- The energy required to cause a break-away mechanism to fracture is determined in a laboratory on a component scale; this amount of energy must be multiplied by the number of mechanisms to be broken;
- 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
- 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 The estimation should be done for all different scenarios of an aircraft impacting the structure. (Reference *ICAO Aerodrome Design Manual*, Part 6, Section 4.4.2)

CHAPTER 3. PERFORMANCE STANDARDS

3.1 General.

The performance standards listed in this section are focused on the frangible connections used to support equipment located in airfield safety 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), must be mounted on frangible supports to ensure the structure will break, distort, or yield in the event of an impact by an aircraft or moving object. The materials selected must preclude any tendency for the components, including the electrical conductors, etc., to "wrap around" the aircraft. (Reference *ICAO Aerodrome Design Manual*, Part 6, Section 3.3.1)

3.2.2 The frangible structure must include effective failure or break away 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*, Part 6, Section 4.5.1)

3.2.3 Structural Integrity:

3.2.3.1 **General Requirements.**

Unless otherwise specified, frangible connections located in the RSA or TSA must be designed 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 must not exceed 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 should mechanically fail by fracturing or buckling. (Reference *ICAO Aerodrome Design Manual*, 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. Structural foundations (e.g. concrete blocks) must be made flush with the surrounding grade (or as close as

possible if there is a need to mitigate water accumulation/ponding). (Reference AC 150/5300-13).

Figure 3-1. Measuring Frangibility of NAVAIDs in the RSA

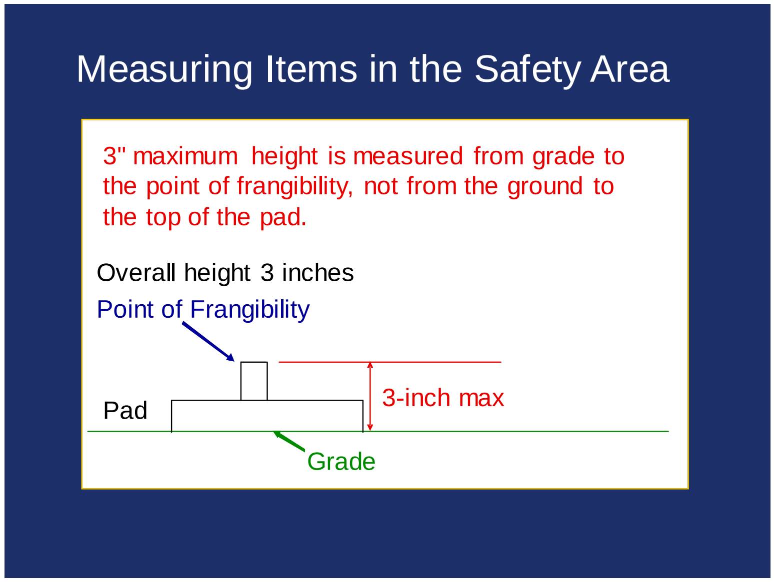
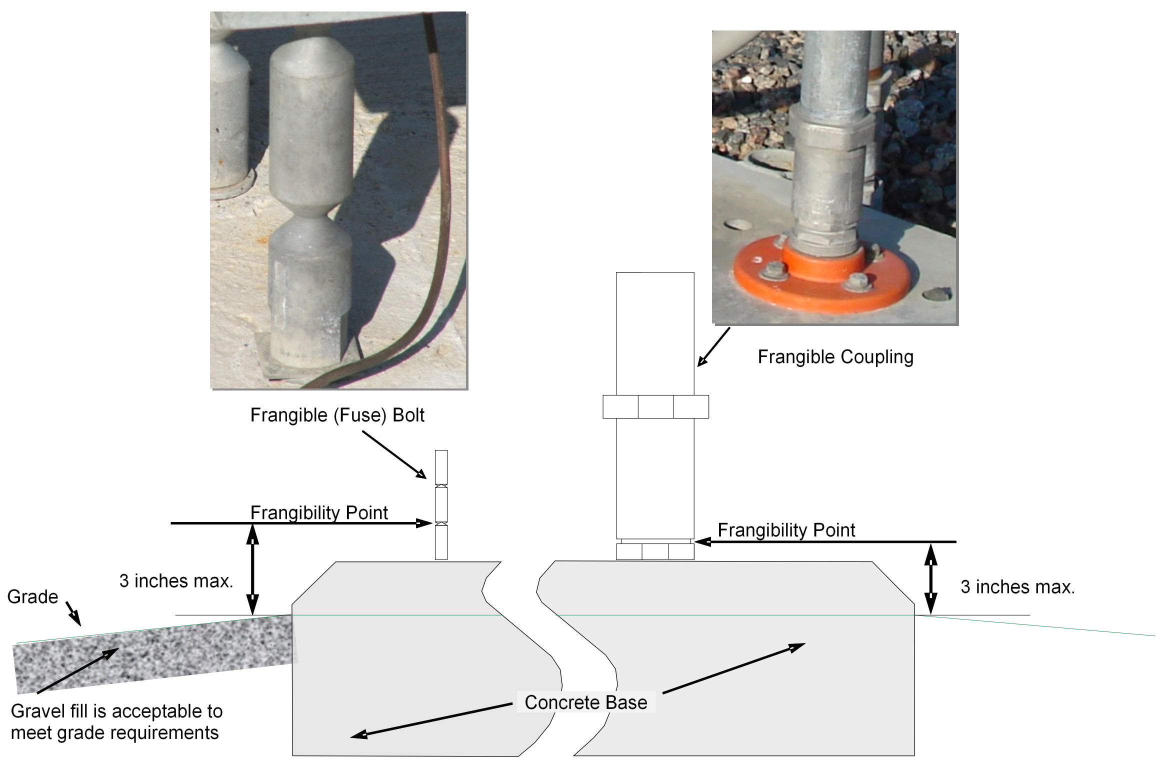


Figure 3-2. Typical Frangible Connections



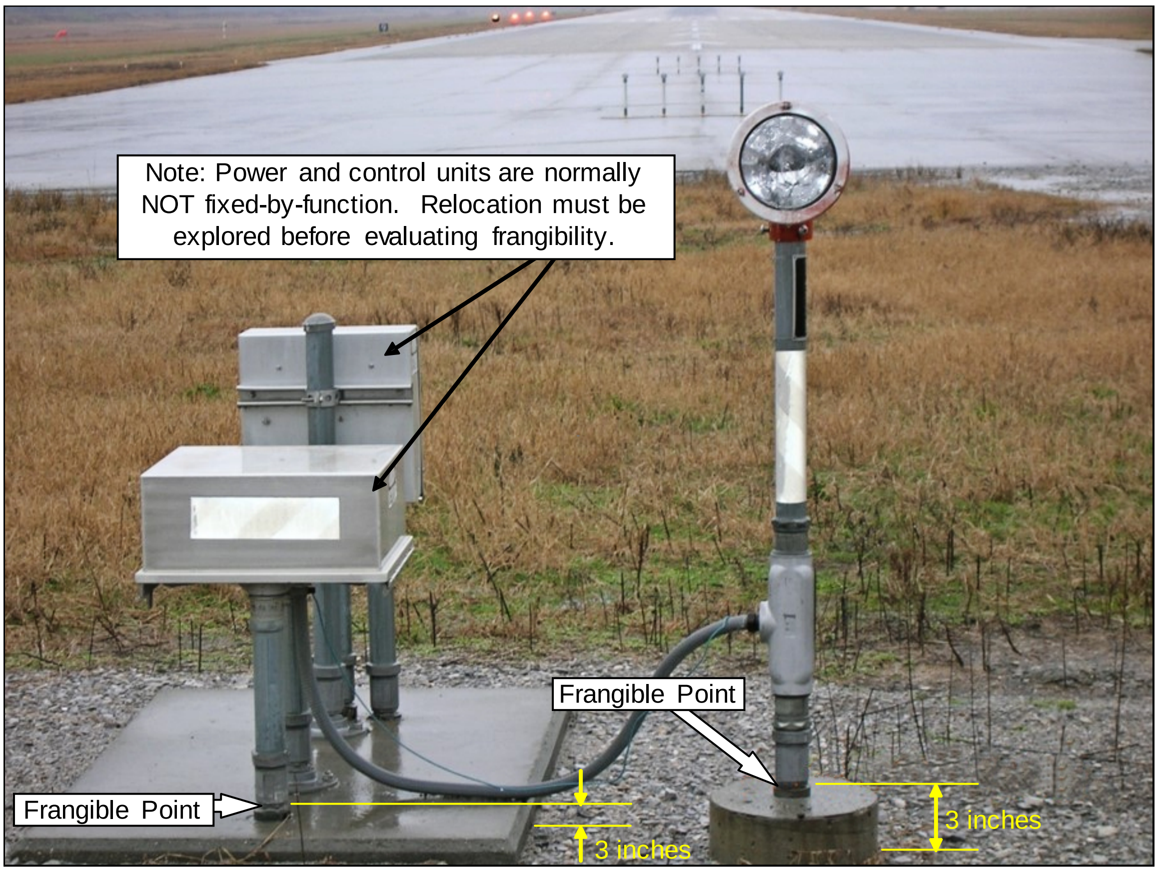
Note 1: Frangible bolts or fuse bolts are typically installed on:

a. Approach Light Systems (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. Approach Light Systems that are less than 6 feet high
b. PAPI
c. VASI
d. REIL
e. ALS maintenance stands

Note 3: Objects that are not fixed-by-function must be removed from the RSA to the best extent practicable, regardless of the lowest point of frangibility. These include above ground junction boxes, power control units and appurtenances that are otherwise practicable to relocate outside the RSA/ROFA.

Figure 3-3. Field Measurability of Frangibility



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

3.2.3.2 Specific Requirements.

Design standards for the following types of equipment are provided in the following 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*, Part 6, Section 4.5.8)

3.2.5 Break-away or Failure Mechanisms.

The location of the break-away or failure mechanism should be 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, the mechanism must not be prone to premature fatigue failure. (Reference *ICAO Aerodrome Design Manual*, Part 6, Section 4.6)

3.2.6 Environmental.

The environmental requirements for specific types of equipment can also be found 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 Materials and configurations for frangible structures must be suitable for the intended use and should result in the lightest structure practicable. Structures may be fabricated from materials that are not adversely affected by outdoor environmental conditions. Materials selected to meet frangibility requirements must be 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*, Part 6, Section 4.7.1)

3.2.7.2 Standard, commercially available materials provide the most cost-effective design. All materials must withstand or be 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.

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 must be considered in the overall design. It is recommended that conductors be designed such that they do not rupture but disconnect at predetermined points within the limits for frangibility of the structure. This is accomplished by the provision of connectors that require a lower tensile force to separate than that required to rupture the conductor. In addition, the connectors should be protected by 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*, Part 6, Section 4.8.2; USAF ETL 01-20: *Guidelines for Airfield Frangibility Zones*, Section 5.8; and AC 150/5345-45, *Low-Impact Resistant Structures*, Section 3.9.d.)

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. The total structure should be maintained either by equipment that can be easily moved into position or by lowering the structure to the ground. (Reference *ICAO Aerodrome Design Manual*, 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 permanently fixed maintenance stands are to be used, they should be made of material no stronger than Schedule 40, 2.0-inch (51 mm) diameter PVC piping or pressure treated wood posts (preferably Southern Pine or Douglas Fir) no larger than 4 x 4 inches (0.1 x 0.1 m) in size. Additionally, if wood is used, 1.0-inch (25 mm) diameter holes must be drilled completely through the center of each face of the post, at a hole centerline height no greater than 3.0 inches (76 mm) above the surrounding grade. Certain environmental conditions may require permanent maintenance stands to be made of other materials, in which case the stands must be mounted on frangible supports.

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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. The connection should 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*, 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. Fuse bolts must be carefully installed 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*, 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. Materials such as steel, aluminum, and plastic should be selected 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*, 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 electrical metallic tubing (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, and only those types approved for the purpose or application originally intended should be used.

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*, 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*, Part 6, Section 4.5.2.d)

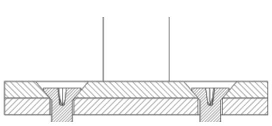
4.7 Frangible Mechanisms.

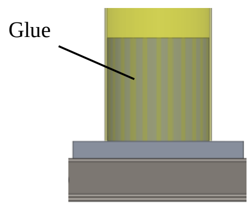
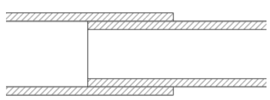
4.7.1 Frangibility can be incorporated into the support structure by means of a mechanism that slips (e.g. slip-bases), breaks, or folds away on impact and removes the structural integrity of the support. A frangible mechanism can be designed to withstand high wind loads but remain very sensitive to impact loads. Frangible mechanisms tend to be directional in strength, i.e. they carry high tension and bending but very low shear. (Reference *ICAO Aerodrome Design Manual*, 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. Friction joints should be designed 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*, 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*, Part 6, Section 4.5.7)

Table 4-1. Types of Frangible Connections

Frangible Connection	Illustration	Description	Advantages	Disadvantages
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.	• Shear strength maintained • Predictable/repeatabl e • Variety of different sizes available • Two products currently FAA approved	• Susceptible to fatigue failure and corrosion • Due to location, may not reach failure loads if impact occurs too far from connection
Special Material Bolts		Bolts engineered with specific materials to fail at a given load. Must have a certificate to guarantee compliance of physical properties.	• Eliminates the need for machining to reduce diameter	• Difficult to periodically inspect for corrosion or fatigue
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.	• Eliminates the need for heavy base plates on small posts, masts, and tubing • Variety of different sizes and types available	• Susceptible to fatigue failure and corrosion • Due to location, may not reach failure loads if impact occurs too far from connection
Tear Through Fasteners		Fasteners, such as countersunk rivets, designed to tear through the base material when dynamically loaded. Can be used with slip joints.	• Decrease mass being pushed by impactor • Good for tension or bending failure	• High tolerance machining process • Extensive quality inspection

Frangible Connection	**Illustration**	**Description**	**Advantages**	**Disadvantages**
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.	• Decrease mass being pushed by impactor • Minimize deflection in the structure	• Susceptible to fatigue failure • High tolerance machining process
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.	• Variety of adhesives available with different strengths • Not susceptible to corrosion • Low maintenance	• Inconsistent failure based on application of adhesive and environmental conditions
Friction Joints		Friction joints can supply high strength normal to sliding surface, but slip when force is applied parallel to surface.	• Designs can be simple and easy to install • Low maintenance	• Inconsistent failure based on impact scenario • Separation force may change over time with cyclic loading
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.	• Provides high stability to structures requiring low amounts of deflection	• May require large amounts of mass to be moved by the impactor

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. First, all devices must be approved by the FAA through the testing, certification, and approval process as detailed in paragraph 5.2 of this AC.
2. Second, it must be ensured that the total rated shear strength of all the frangible connections do not exceed the frangibility design requirements listed in the relevant equipment ACs.

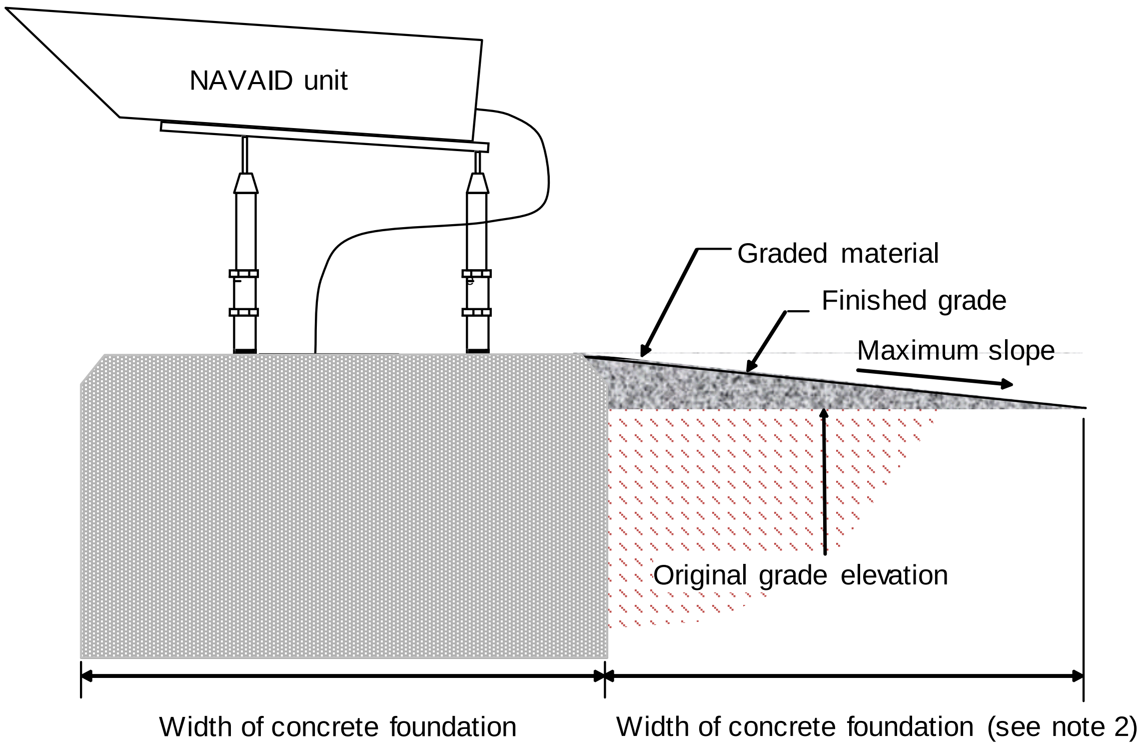
As a general example, in order to meet the impact force limits to an aircraft defined in the general structural integrity requirements (paragraph 3.2.3.1, item 2) of this AC, the rated shear strength of all the frangible connections must be less than or equal to 58 kN (13 kip). It must be emphasized that the all of the supports for a particular piece of equipment must be considered in order to determine the proper amount and type of frangible connections that are to be used: 1 support requires 1 frangible connection rated at 58 kN (13 kip); 2 supports require 2 frangible connections at 29 kN (6.5 kip) each; and so on.

5.1.2 Installation.

Frangible structures should be installed in accordance with the recommendations of the manufacturer and the requirements of the applicable advisory circular. This refers to the structure, any cabling and connectors, and the base on which the structure is fitted. (Reference *ICAO Aerodrome Design Manual*, Part 6, Section 7.2.1)

5.1.2.1 Firm bases are essential for any precision visual or non-visual navigational aid. The design of the base should therefore provide maximum stability. Navigational aids are commonly supported on a concrete base, which should not be 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, the cavity above the base should be back-filled with appropriate material. This, together with the frangible construction of the navigational aid and its supports, ensures that no substantial damage is sustained should an airplane run over the aid. (Reference *ICAO Aerodrome Design Manual*, Part 6, Section 7.2.3 and USAF ETL 01-20: *Guidelines for Airfield Frangibility Zones*, Section 5.9)

Figure 5-1. Typical Concrete Pad and Grading Detail



Note 1: Typical detail for finishing and grading around concrete pad foundations.

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 minimum grade away from the foundation should not be less than 3%.

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

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.

The inspection and maintenance of frangible structures should meet 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*, Part 6, Section 7.3.

5.2 **Testing, Certification, And Approval.**

5.2.1 General.

All frangible connections and devices must be tested 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, the provisions of AC 150/5345-53 must be 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:

- 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
- Other Airfield Equipment *ICAO Aerodrome Design Manual*, Part 6, Chapter 5, “Testing for Frangibility”

5.2.2.2 The second category of frangibility testing 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 used in highway infrastructure provide a reasonable indication of how those same objects might perform in the airfield environment. It is the intent of this AC to build upon and adopt the substantial testing program of the FHWA regarding frangible connections.

5.2.2.2.1 In testing frangible connections, the FHWA requires that testing procedures are performed in accordance with the National Cooperative Highway Research Program (NCHRP) Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features. The requirements for breakaway supports used in that testing are based on the American Association of State Highway and Transportation Officials’ (AASHTO) Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

5.2.2.2.2 Results of this testing are submitted to the FHWA for approval, whereupon acceptance letters are written to manufacturers of frangible connection devices (or breakaway support systems) acknowledging that the devices tested successfully according to the required parameters and performed satisfactorily. Typically, the acceptance letters describe the device tested and include a drawing of the device, test results, and information on limitations on use of the device, such as the weight of the system tested or the soil in which it is acceptable. The acceptance letters are also posted online, and can be found at the following URL for the FHWA: http://safety.fhwa.dot.gov/roadway_dept/road_hardware/breakaway.htm

5.2.2.3 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*, Part 6, Chapter 6.

5.2.3 Certification and Approval:

5.2.3.1 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 must 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 been approved by the FHWA for use in highway applications (as described in paragraph 5.2.2.2) 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.

5.2.3.3 A list of frangible connections approved for use on airports is found in Appendix A. For FAA approval of new devices, individuals must send a copy of the following items to the address below for consideration: the FHWA approval letter; static and/or full-scale testing reports, if any; and product technical drawings.

- Manager, Airport Engineering Division (AAS-100), ATTN: FRANGIBILITY, Federal Aviation Administration, 800 Independence Avenue SW, Washington DC 20591.

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APPENDIX A. FAA APPROVED FRANGIBLE CONNECTIONS

An addendum to this appendix, listing all current certified equipment manufacturer's addresses, is updated monthly. The addendum is available on the internet at http://www.faa.gov/airports/ under "Advisory Circulars" in the file titled "150/5220-23B Addendum." The addendum can also be obtained from the Office of Airport Safety and Standards, Attention: AAS-100, Federal Aviation Administration, 800 Independence Ave., SW, Washington, DC 20591, or from FAA Regional Airports and District/Field Offices (http://www.faa.gov/airports/news_information/contact_info/regional/).

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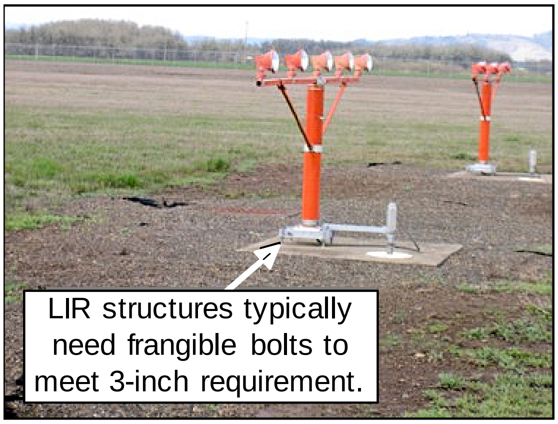
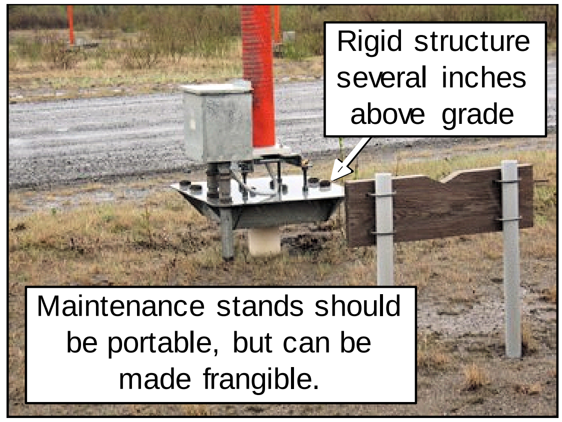
APPENDIX B. NON-STANDARD AND UNACCEPTABLE CONDITIONS AND EQUIPMENT NOT FIXED-BY-FUNCTION

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

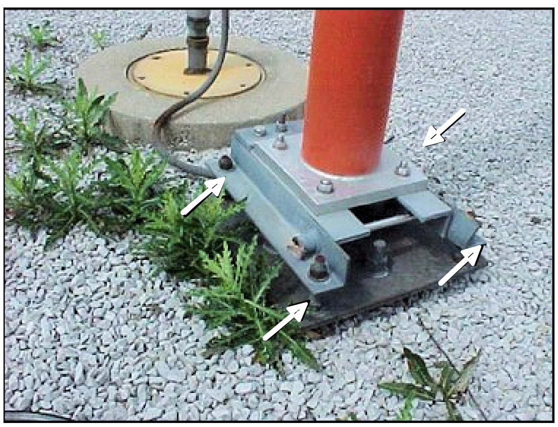
Figure B-1. Non-Standard ALS Installations



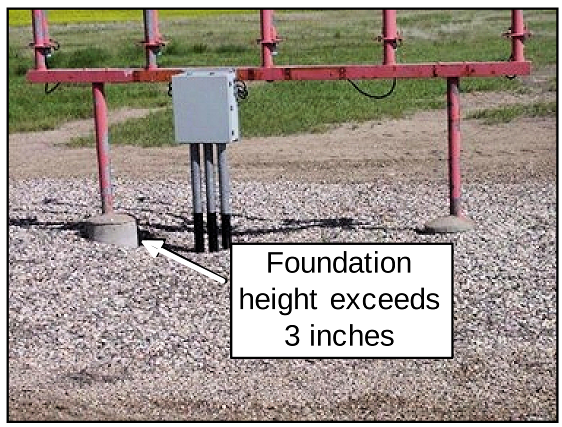
LIR structure - needs frangible bolts; should use EMT if less than 6 feet



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



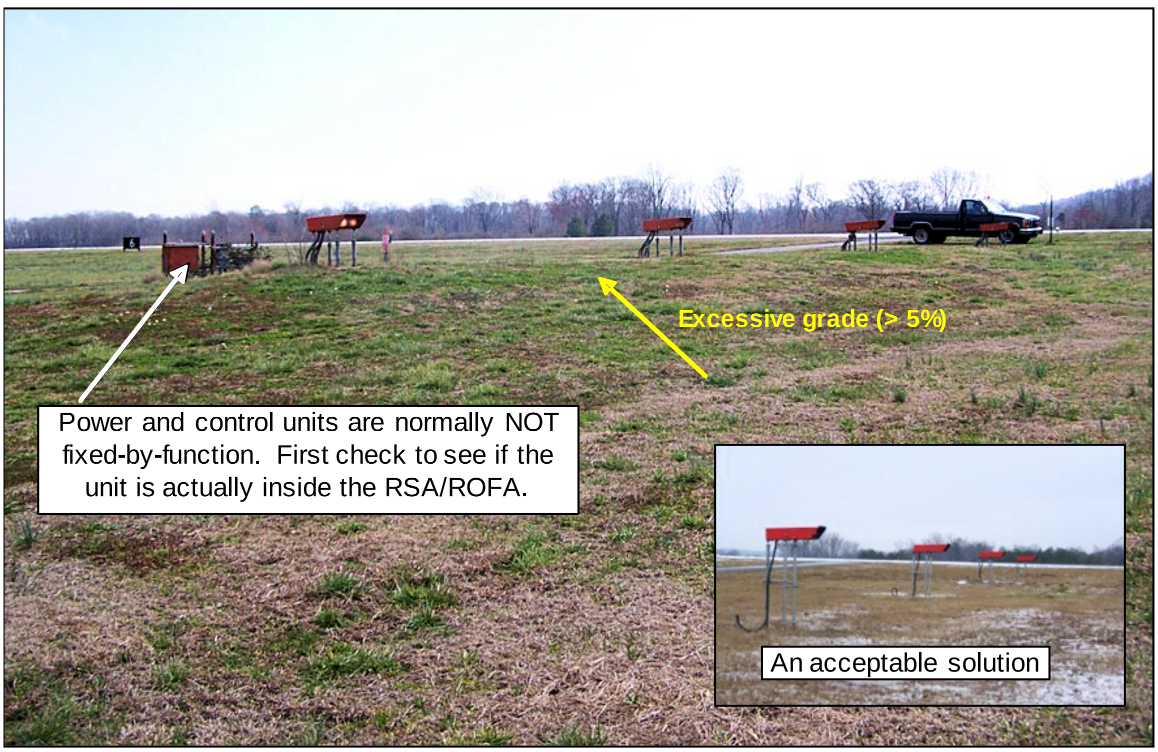
LIR structure - needs frangible bolts



Foundation exceeds 3 inches above grade

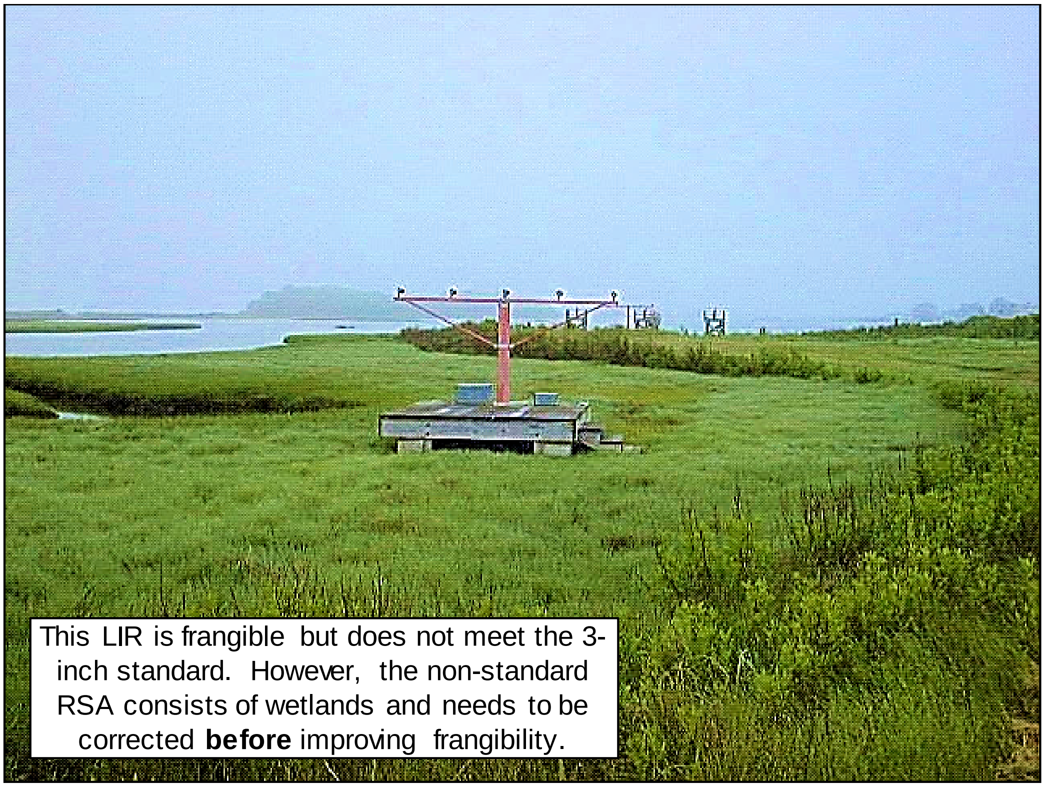
Figure B-2. Unacceptable Grading Surrounding NAVAIDs

Excessive gravel fill creates a hazard



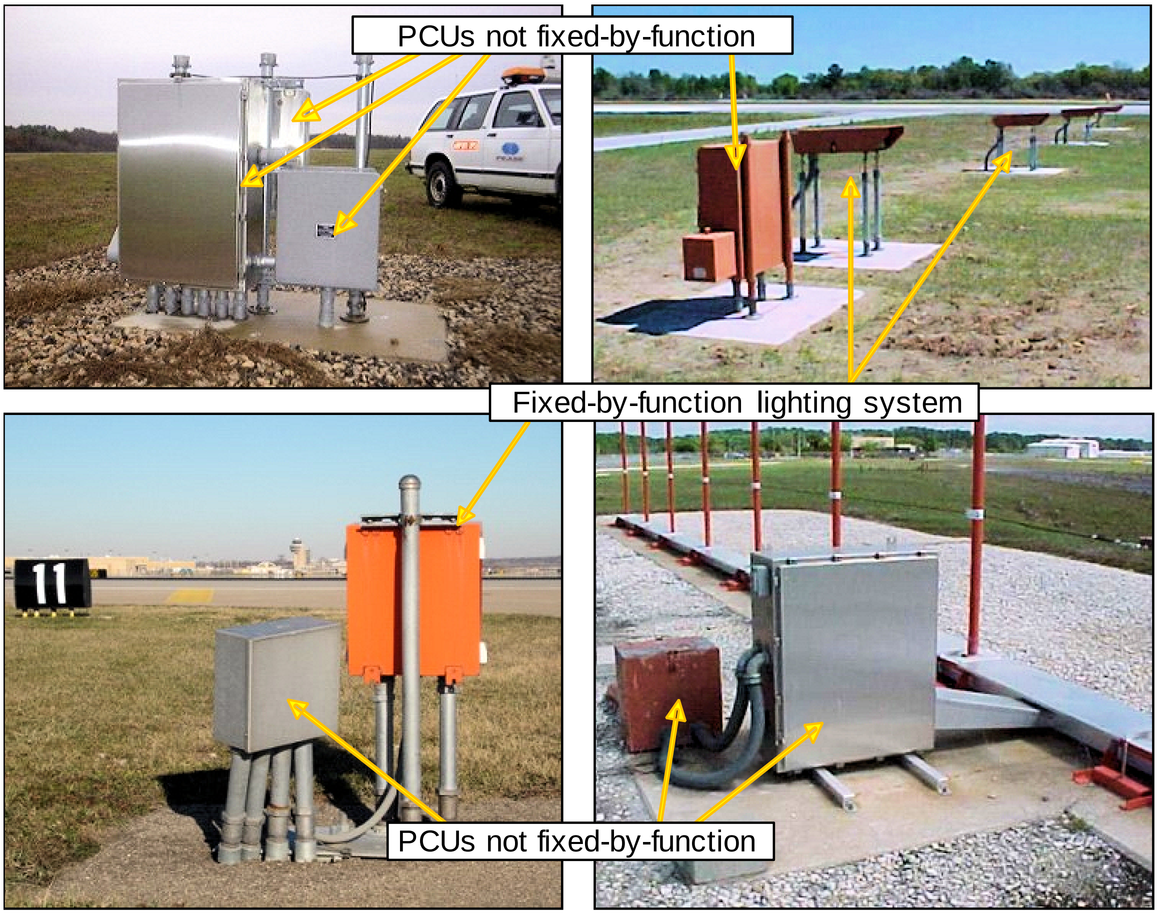
PAPI installation with excessive grade

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



Note 1: Power/control units (PCUs) and junction boxes are fixed-by-function if they meet the standards of AC 150/5300-13 or the requirements of Note 2.

Note 2: The location of equipment shelters, junction boxes, transformers, power control units, and other appurtenances that support fixed-by-function NAVAIDs are not generally fixed-by-function unless operational needs require them to be located in close proximity to the NAVAID. The support equipment should meet frangibility standards if their proximity to the NAVAID requires their placement within the safety area. The FAA April 23, 2010, memorandum, *Amendment to Engineering Clarification for Navigational Aids Runway Safety Area Improvements*, and the FAA December 8, 2011, memorandum, Precision Approach Path Indicator (PAPI) Power Control Assembly (PCA) and Power and Control Unit (PCU) Siting Clarification, provide guidance for determining whether or not specific the associated equipment are fixed-by-function. ARP and ATO jointly signed both memorandums and are available upon request.

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:

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

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☐ Other comments:

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

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Submitted by: ___________________________ Date: ___________________________

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