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A SunCam online continuing education course

Airport Engineering

Part VII: Deicing Facility Design

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Introduction

Anyone who's flown commercially in the winter has likely experienced deicing. Anxious passengers watch out the windows while the ground crew in boom trucks sprays down the wings and a peculiar smell permeates the cabin. The chance of a flight delay and missed connection makes the experience all the more trying, especially when the ordeal has to be repeated before takeoff. The consolation is that before deicing and anti-icing chemicals, flying in winter weather would have been a no-go. And for good reason: studies show that even very thin coatings of ice on wing surfaces can seriously reduce lift, which is a non-negotiable aspect of safe flight. Thus, the FAA mandates that aircraft with ice contamination may not fly. So nervous passengers can sit back and relax; it's going to be OK.

Among the many aspects of airport engineering, deicing facilities is one that deserves special attention. Deicing is critical for flight safety during winter-like conditions, and doing so in a safe and efficient way is of utmost importance; it is essential that icing conditions are properly managed to ensure aircraft and passenger safety. A **deicing facility** is where frost, ice, slush, or snow is removed from the aircraft to provide clean surfaces and/or a place to prevent clean surfaces from forming ice of frost for a limited period of time. An **aircraft deicing pad** consists of a place for an aircraft to park, and deicing vehicles to maneuver. The predominant method for deicing airplanes is the application of **freezing point depressant** (FPD) fluids, which are glycol-based products. All deicing and anti-icing products must meet AMS/SAE 1424 (Type I) or 1428 (Type II, III, and IV) specifications. Note: Type II and Type IV anti-icing fluids have more specialized requirements for storage and handling than Type I deicing fluid. **Holdover time** is the length of time the applied anti-icing fluid will prevent the formation of ice on the aircraft.

This course introduces the attributes of deicing facilities, the required equipment, and design considerations. By taking this course, you will understand the terminology involved in deicing, as well as the methodology of planning and locating a functional, practical facility. This course is based on FAA Advisory Circular 150/5300-14D *Design of Aircraft Deicing Facilities* (v. 3/17/2020).

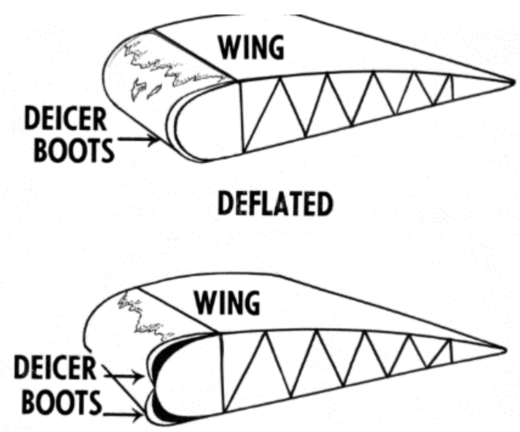
Disclaimer: this document should not be used on a direct design basis; for the most accurate content, refer to the AC.

The Danger of Ice

While most of us are familiar with the danger of ice on roads, sidewalks, and bridges, slipping on the ice is an effect of a significantly reduced coefficient of friction. We aren't expecting a slippery surface, our feet or wheels can't get traction, and we fall down or slide off the road in our car. While ice can be a problem on the ground at an airport (i.e. sliding off the runway), this isn't the concern when discussing deicing aircraft. While it does add weight, the major issue with ice building up on an aircraft is that it changes flight aerodynamics and reduces lift. When this happens, the flight characteristics of the aircraft change, and safety may be compromised. In severe cases, the aircraft can be affected to the extent that it can't fly any longer, and can lead to a crash.

Good news: deicing and anti-icing fluids can mitigate this problem, allowing aircraft to safely takeoff and fly out of dangerous weather conditions. Aircraft deicing fluids (ADF) are generally either propylene glycol (more common and preferred) or ethylene glycol (less common and expensive). These fluids reduce the freezing point of water and are sometimes heated up to 180° F before application. Deicing fluid is designed to remove ice after it accumulates on the aircraft. Anti-icing fluids are applied after deicing and before new ice forms, and are more viscous so it sticks to the aircraft skin. It's good for about 70 minutes, and naturally flies off the skin when the airplane takes off.

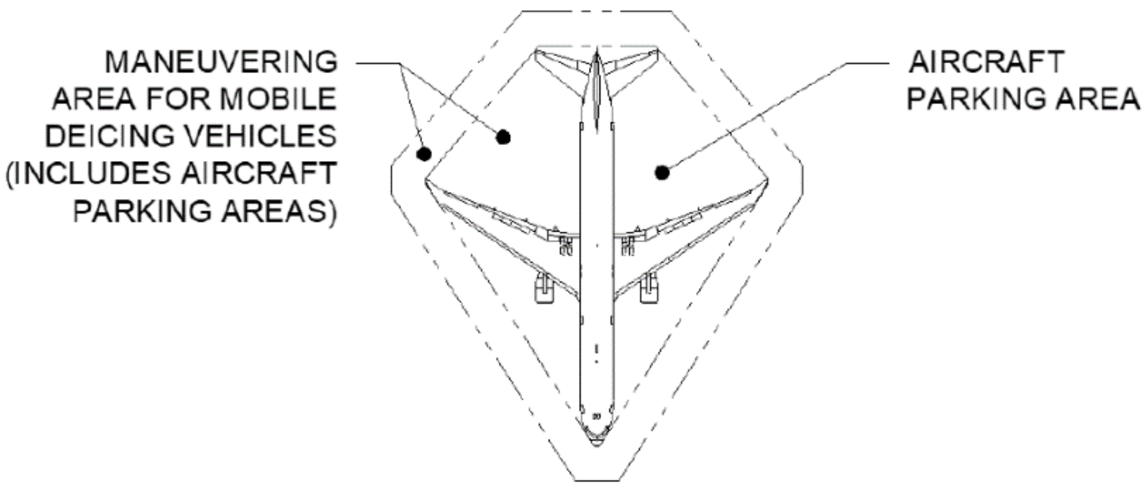
There are ways of removing ice in-flight. For example, an inflatable rubber boot inside the leading edge of the wings can be expanded, causing the ice to break free. However, it's better to prevent ice from forming than it is to remove it afterward (i.e. proactive anti-icing). Other methods of ice removal in flight include heated windshields, heated propellers, weeping wing systems that disperse antifreeze liquid during flight, and a newer method called electroexpulsive system which removes ice with vibrations.



Locating & Sizing a Deicing Facility

Not all airports require deicing facilities. If icing conditions are expected to occur during normal weather patterns, then the airport should have deicing facilities. Note: this includes airports that may develop frost or ice on aircraft even though the airport doesn't get ice on the ground. Frost can sometimes appear after landing in warm weather when the aircraft has been flying at high altitude and the wings are super-cooled.

General compliance with airport clearance and separation standards is necessary per FAA AC 150/5300-13, *Airport Design.* Deicing facilities must be located in a way that does not interfere with ATC visual view and other technical operations (NAVAIDs, radar, lighting, etc.). The width and length of the parking area (see below) should be equal to the largest airplane design group (ADG). The maneuvering area around the aircraft must be 12.5 feet wide and accessible around the pad.



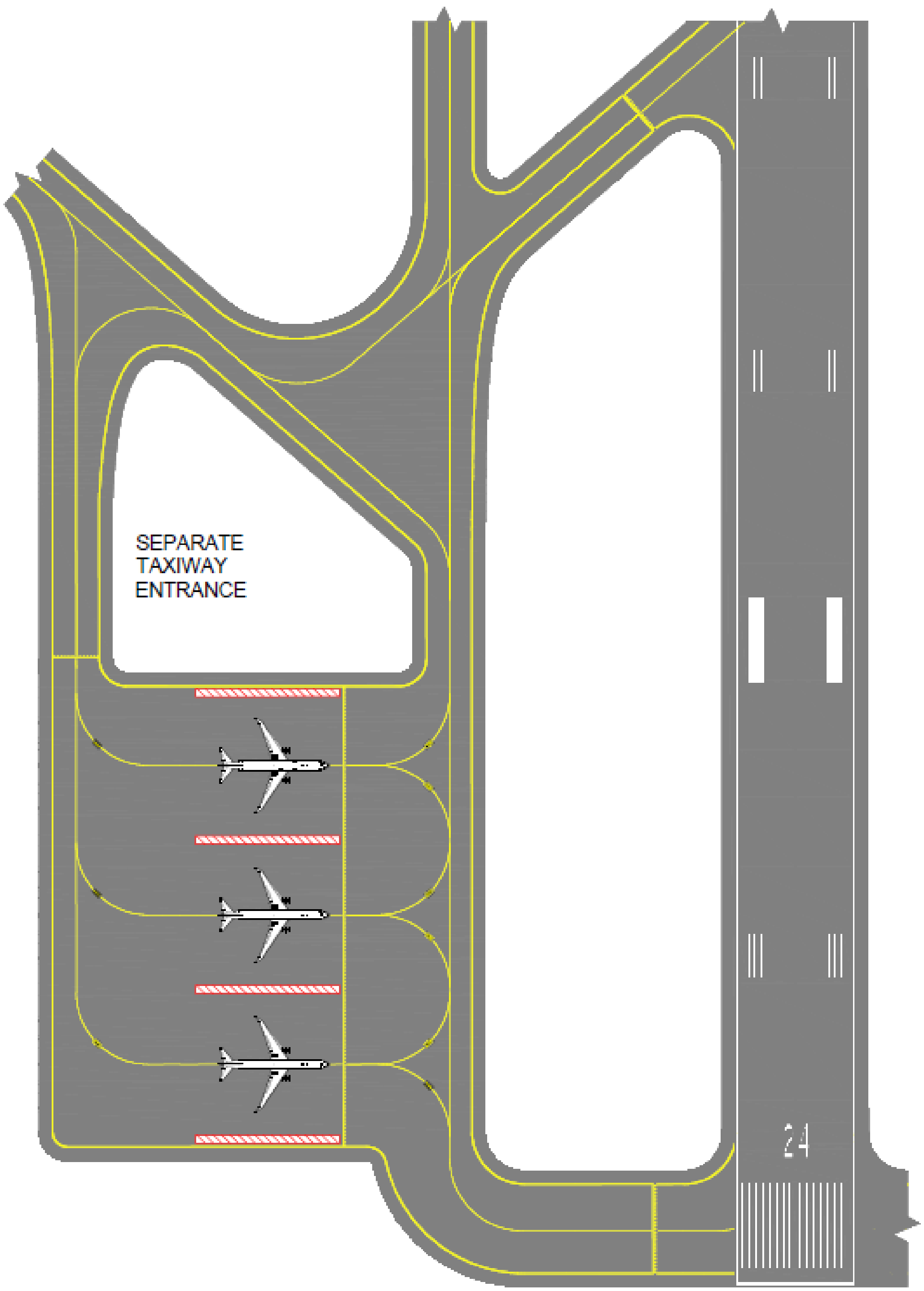
Some airports may require several deicing pads, while others only require one. For example, airports that frequently experience wet snow or freezing rain should have more deicing pads to prevent delays. Ideally, the number of deicing facilities should balance with aircraft use and acceptable holdover times. Type, size, and fleet mix must also be considered. Note that smaller, single engine aircraft are processed faster than large, wide-body jets with center fuselage mounted engines. Quantity of deicing facilities should be determined on the airport master plan level of decision. The airport ALP should help locate a deicing facility.

The most common deicing sites are **terminal gates**. Since they exist already and the aircraft is there when not flying or taxiing, it's a logical option. As long as the taxiing times from the gate to the runway are acceptable, using a gate is fine. A major point to consider, however, is the runoff and disposal of deicing fluids (more on this later).

If gates don't work, a **centralized facility** can be used along a taxi route or apron leading to the departure runways. The benefit of a central location includes shorter time to taxi to the runway after deicing, and less chance the weather will change between deicing and takeoff. This locale prevents gate delays (or lack of gates) and may be more cost effective than collecting runoff at terminal gates. The primary factor for siting a central facility is the holdover time, which begins with the last step of deicing and ends with takeoff clearance. The types of deicing fluids and their varying holdover times will be discussed in an upcoming section.

Deicing facilities need nighttime lighting so crews can see at night or in low-visibility conditions. Facilities also must have enough space to allow taxiing aircraft to bypass the site and continue without being impeded.

The figure below shows a separate taxiing entrance to a centralized deicing facility.



Deicing Pad Design

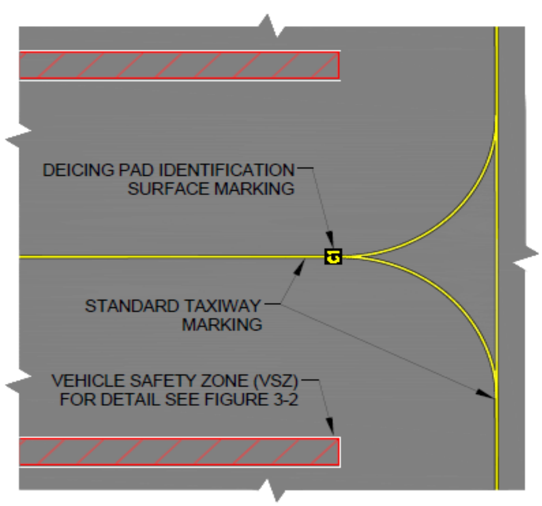
Common pad layout has a single centerline through the deicing pad to guide all aircraft. Airports with frequent high winds should orient the centerlines with the prevailing wind direction for maximum deicing effect. If winds are high, heated fluid can cool and also be wasted. Jet blast from exiting aircraft should be considered to prevent compromising the deicing effect on other airplanes. Deicing operations too clos e to other aircraft can cause snow, ice, or moisture to blow onto adjacent aircraft or service equipment.

Electronic message boards assist in efficiency and communication between flight crews and ground personnel. Deicing pad pavement should be designed in accordance with FAA design requirements. Grooves in the pavement assist with fluid collection and traction. Aprons should direct flow away from pad centerlines and vehicle zones.

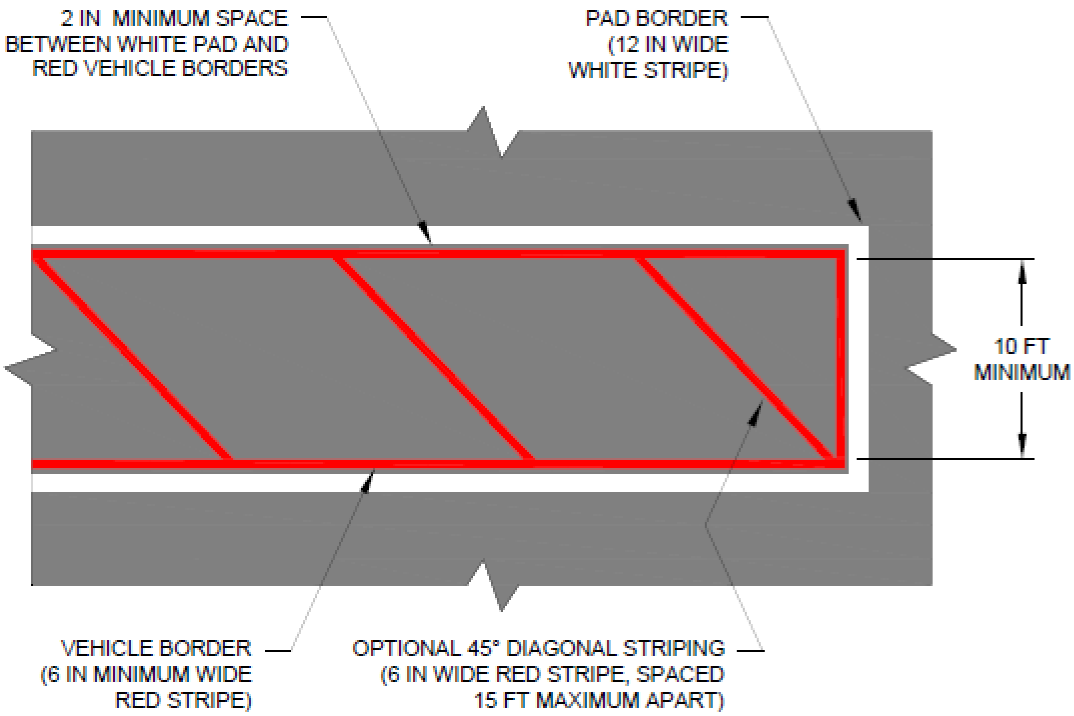
Centralized deicing pads must also have a form of bypass taxiing measures so aircraft being deiced don't restrict runway access.

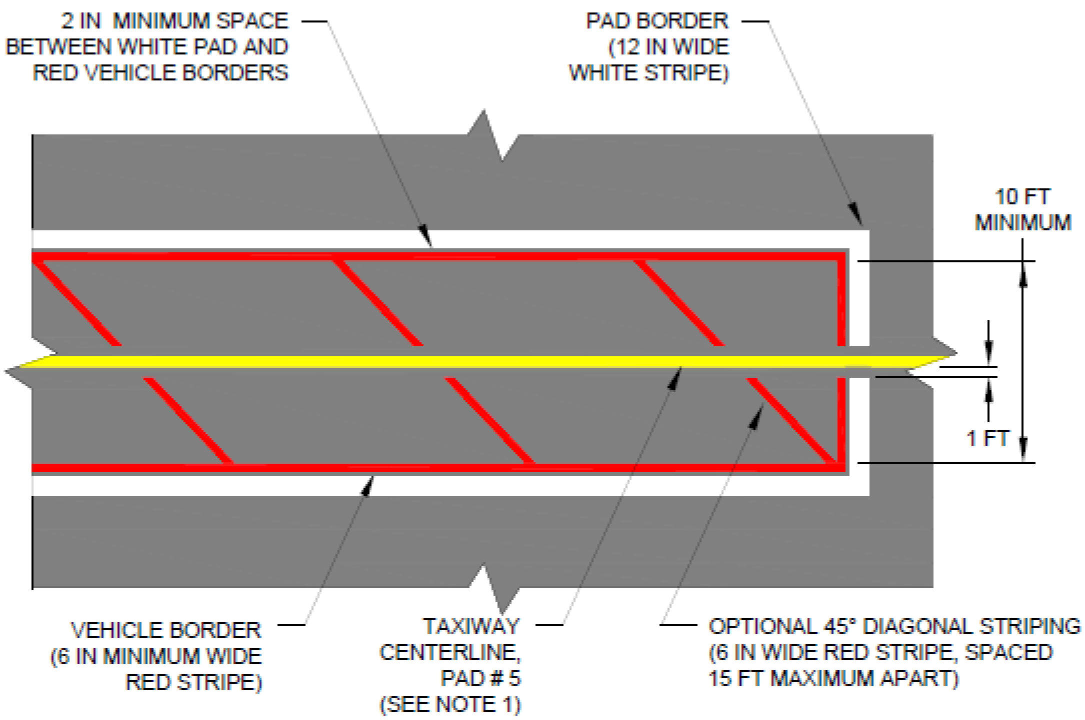
Spacing criteria for centralized deicing pads is determined by the following chart, which identifies separation based on ADG. It's important to understand that a vehicle safety zone (VSZ) must be marked on each side of the centerline. VMA stands for vehicle maneuvering area.

Airplane Design Group[2]	Off-Gate Aircraft Deicing Facilities				
(ADG)	Non-Movement Area[1]		Movement Area[1]		
	Column #1[3] Outer Deicing Pad Taxi Centerline (CL) to Edge of Vehicle Safety Zone (VSZ)	Column #2[3] Interior Deicing Pads Taxi CL to Taxi CL	Column #3[3] Outer Deicing Pad Taxi CL to Edge of VSZ	Column #4[3] Interior Deicing Pads Taxi CL to Taxi CL	Column #5[4] Temporary Deicing Pads Taxi CL to Taxi CL
	Includes 1 Vehicle Maneuvering Area (VMA)	Includes 2 VMAs + 1 VSZ Includes 1 VMA	Includes 2 VMAs + 1 VSZ	Includes VMAs and no VSZ	
ADG VI	167 ft (51 m)	344 ft (105 m)	193 ft (59 m)	396 ft (120.5 m)	324 ft (99 m)
ADG V	138 ft (42 m)	286 ft (87 m)	160 ft (48.5 m)	330 ft (100.5)	267 ft (81 m)
ADG IV	112.5 ft (34 m)	235 ft (71.5 m)	129.5 ft (39.5 m)	269 ft (82 m)	215 ft (65.5 m)
ADG III	81 ft (24.5 m)	172 ft (52.5 m)	93 ft (28.5 m)	196 ft (59.5 m)	152 ft (46.5 m)
ADG II	57.5 ft (17.5 m)	125 ft (38 m)	65.5 ft (20 m)	141 ft (43 m)	105 ft (32 m)
ADG I	39.5 ft (12 m)	89 ft (27 m)	44.5 ft (13.5 m)	99 ft (30 m)	74 ft (22.5 m)

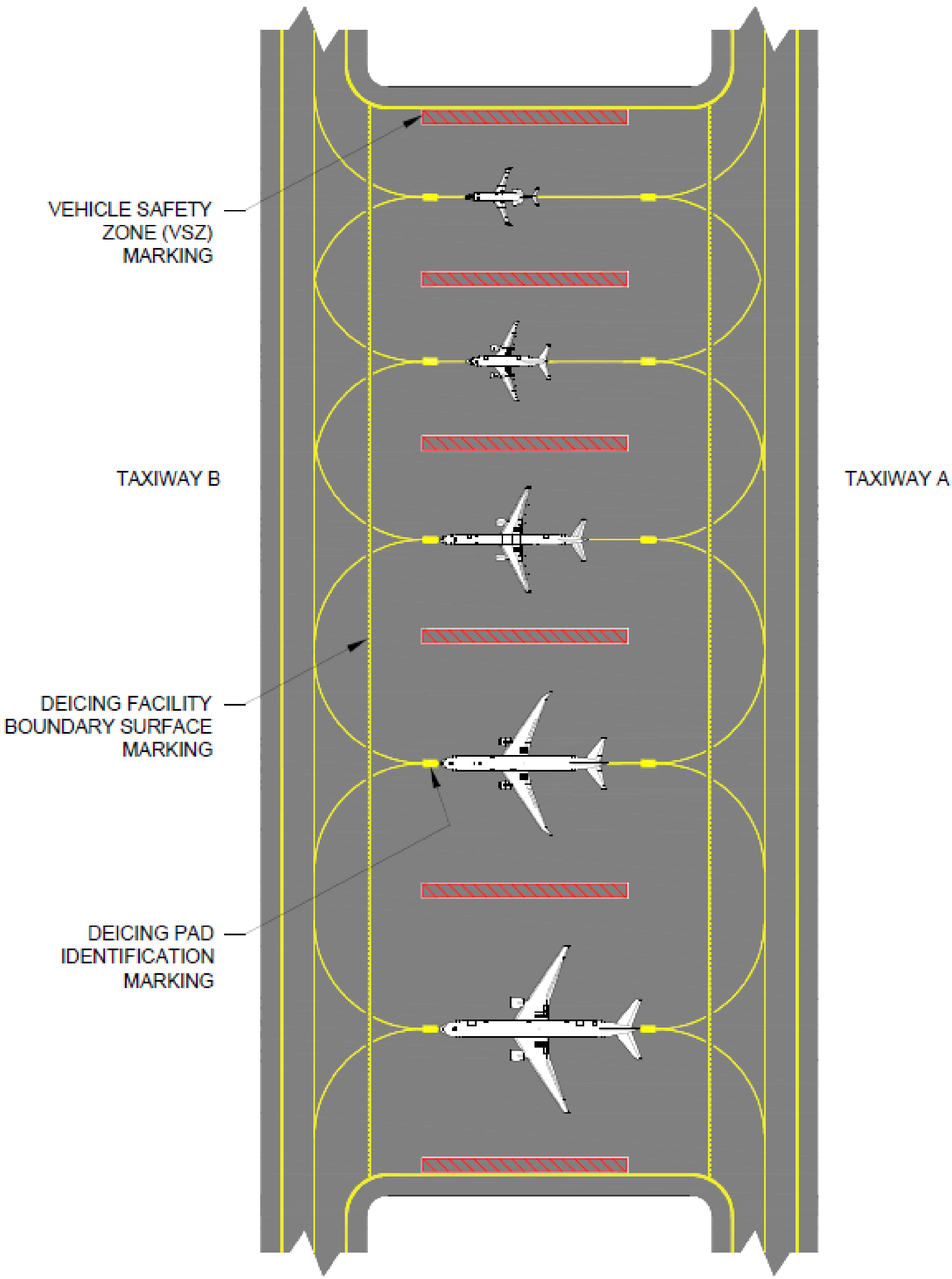


Marking standards for vehicle safety zones are shown here:

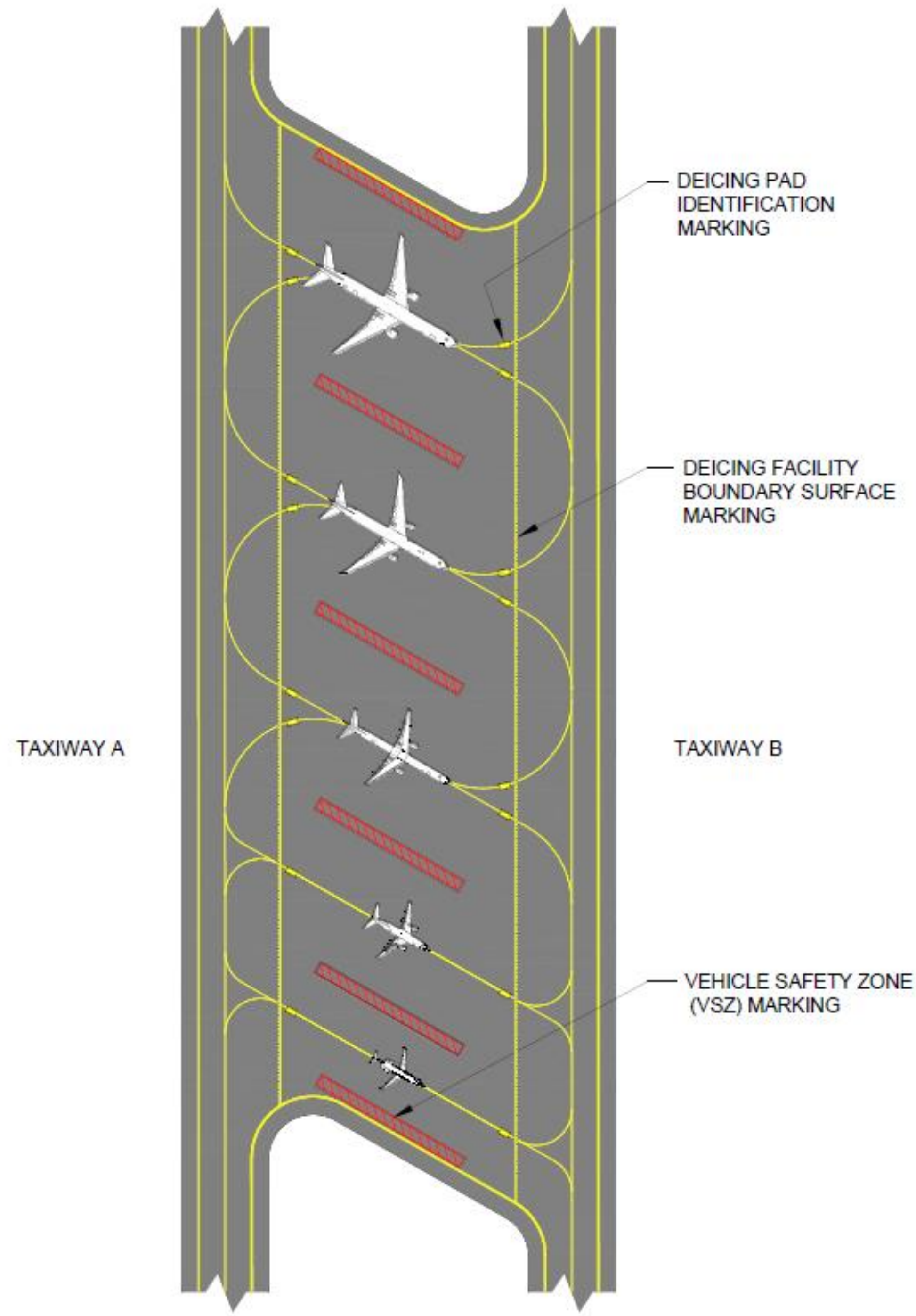




This layout shows a common deicing pad with parallel aircraft:



Deicing pads with 60 degree orientation between two taxiways:



Alternative Deicing Method: Infrared

Another way to remove ice on an aircraft is the use of infrared heat. An FAA-approved method, infrared eliminates the need for fluid containment and environmental mitigation. It's just a huge heater the airplane taxis under and waits until the ice is melted. However, this is only a deicing process, not anti-icing prevention. So application of anti-icing fluid may still be necessary. Infrared deicing facilities require the following features:

- Entrance taxiway
- Deicing structure with 10' height clearance minimum
- Nighttime lighting
- Computerized infrared system
- Operations shelter
- Anti-icing capability
- Exit taxiway
- Ice detection cameras (optional)

Table 5-1. Protective Cover Lengths

Airplane Design Group (ADG)	Protective Cover Length[1]
ADG II and Smaller	20 feet (6.1 m)
ADG III and Larger	30 feet (9.1 m)

Note 1: PC is equally divided front and back of the fuselage.

Table 5-2. Horizontal Clearances

Airplane Design Group (ADG)	Clearance Distance
ADG II and Smaller	10 feet (3.0 m)
ADG III	15 feet (4.6 m)
ADG IV and Larger	20 feet (6.1 m)

Runoff: Environmental Impact & Mitigation

Deicing and anti-icing fluids are chemicals that can adversely affect water quality. Therefore, deicing facilities must have runoff mitigation measures in place (consistent with the airport's stormwater pollution prevention plan, or SWPPP). Controlling the source permits airports to comply with BMP's in two ways: 1) it isolates runoff from storm sewers and airfield water runoff and 2) it promotes recycling glycols in concentration rather than dilution with other runoff.

The FAA strongly recommends the federal, state, or local authority review the proposed runoff alternative in meeting water quality requirements. Some examples of alternatives are:

Off-airport biochemical treatment
On-airport detention basin with pump station
On-airport anaerobic biochemical reactor for pre-treatment of runoff
On-airport underground storage tanks for runoff detention
On-airport recycling system

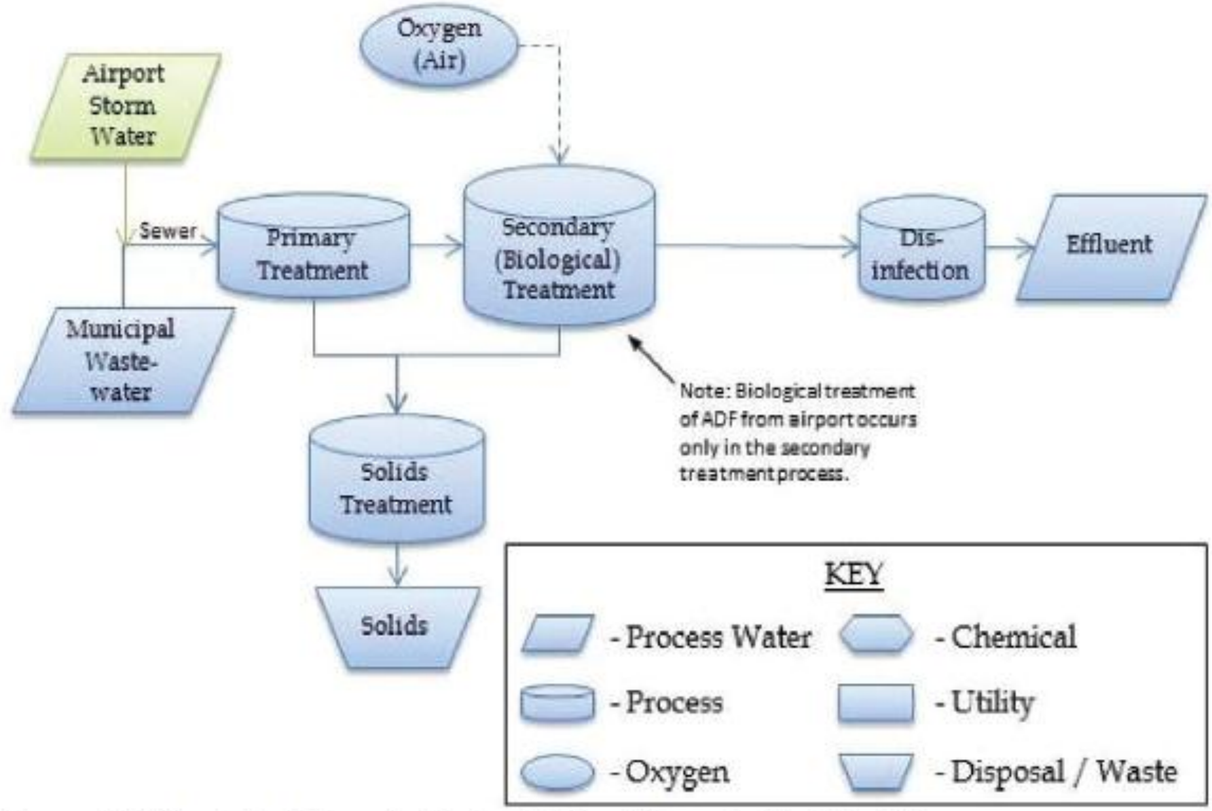
Specific details and monitoring requirements for the above options are outside the scope of this course; further information can be found in the AC.

The primary effects of glycol are biochemical oxygen demand (BOD) and toxicity. A mitigation alternative would need to monitor chemical oxygen demand (COD), total organic carbon (TOC), total suspended solids (TSS), oil/grease, pH, and flow rate limits.

Volumes of runoff vary by aircraft size and weather conditions. During wet weather, volumes of ADF can vary from 10 gallons for a light aircraft to 1000 gallons for a heavy commercial jet. Severe weather could require 1000-4000 gallons. Dry weather deicing requires much less fluid, around 20-50 gallons.

Both ethylene glycol and propylene glycol are relatively nontoxic to aquatic organisms. Ethylene glycol, however, is toxic to mammals when ingested. This is the same chemical commonly used in automotive antifreeze. Propylene glycol is not directly toxic and is found in many food and consumable products. Both compounds deplete dissolved oxygen when they break down in aquatic environments, rendering them a significant pollutant that kills fish and encourages growth of undesirable bacteria.

Publicly owned treatment works (POTW) use biological processes to break down biodegradable organic compounds in wastewater. A POTW, among the other options listed above, can provide a convenient and cost-effective offsite option for deicing runoff. This flowchart demonstrates the process:



Source: *ACRP Report 99: Guidance for Treatment of Airport Stormwater Containing Deicers*

For further example, this type of system should consider airport flow rates, BOD loads requiring disposal under a variety of weather conditions, flow resistance, fee calculations, permit requirements, etc. Storage requirements to contain large storm events under the constraints of flow and loading to the sanitary sewer must also be analyzed. If runoff is to be held for an extended period, pH adjustment may be required, as would alternative disposal options for decreased allowable discharges or larger than expected load conditions.

Deicing Photos

Reference Material

1. AC 150/5300-14D, *Design of Aircraft Deicing Facilities*
2. AOPA Safety Advisor #22, *Aircraft Deicing and Anti-Icing Equipment*
3. FAA ACRP 114, *Deicing Planning Guidelines and Practices for Stormwater Management Systems*
4. Stormwater: Journal for Surface Water Quality Professionals, *Deicing by Design, Oct. 2006*

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