
14 CFR Ch. I (1–1–12 Edition)
ullage is flammable for a fleet of an airplane type operating over the range of flight lengths in a world-wide range of environmental conditions and fuel properties as defined in this appendix.

(f) **Gaussian Distribution** is another name for the normal distribution, a symmetrical frequency distribution having a precise mathematical formula relating the mean and standard deviation of the samples. Gaussian distributions yield bell-shaped frequency curves having a preponderance of values around the mean with progressively fewer observations as the curve extends outward.

(g) **Hazardous atmosphere.** An atmosphere that may expose maintenance personnel, passengers or flight crew to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a confined space), injury, or acute illness.

(h) **Inert.** For the purpose of this appendix, the tank is considered inert when the bulk average oxygen concentration within each compartment of the tank is 12 percent or less from sea level up to 10,000 feet altitude, then linearly increasing from 12 percent at 10,000 feet to 14.5 percent at 40,000 feet altitude, and extrapolated linearly above that altitude.

(i) **Inerting.** A process where a noncombustible gas is introduced into the ullage of a fuel tank so that the ullage becomes nonflammable.

(j) **Monte Carlo Analysis.** The analytical method that is specified in this appendix as the compliance means for assessing the fleet average flammability exposure time for a fuel tank.

(k) **Oxygen evolution** occurs when oxygen dissolved in the fuel is released into the ullage as the pressure and temperature in the fuel tank are reduced.

(l) **Standard deviation** is a statistical measure of the dispersion or variation in a distribution, equal to the square root of the arithmetic mean of the squares of the deviations from the arithmetic means.

(m) **Transport Effects.** For purposes of this appendix, transport effects are the change in fuel vapor concentration in a fuel tank caused by low fuel conditions and fuel condensation and vaporization.

(n) **Ullage.** The volume within the fuel tank not occupied by liquid fuel.

N25.3 Fuel tank flammability exposure analysis.

(a) A flammability exposure analysis must be conducted for the fuel tank under evaluation to determine fleet average flammability exposure for the airplane and fuel types under evaluation. For fuel tanks that are subdivided by baffles or compartments, an analysis must be performed either for each section of the tank, or for the section of the tank having the highest flammability exposure. Consideration of transport effects is not allowed in the analysis. The analysis must be done in accordance with the methods and procedures set forth in the Fuel Tank Flammability Assessment Method User’s Manual, dated May 2008, document number DOT/FAA/AR–05/8 (incorporated by reference, see §25.5). The parameters specified in sections N25.3(b) and (c) of this appendix must be used in the fuel tank flammability exposure “Monte Carlo” analysis.

(b) The following parameters are defined in the Monte Carlo analysis and provided in paragraph N25.4 of this appendix:

1. **Cruise Ambient Temperature, as defined in this appendix.**
2. **Ground Ambient Temperature, as defined in this appendix.**
3. **Fuel Flash Point, as defined in this appendix.**
4. **Flight Length Distribution, as defined in Table 2 of this appendix.**

(c) Parameters that are specific to the particular airplane model under evaluation that must be provided as inputs to the Monte Carlo analysis are:

1. **Airplane cruise altitude.**
2. **Fuel tank quantities. If fuel quantity affects fuel tank flammability, inputs to the Monte Carlo analysis must be provided that represent the actual fuel quantity within the fuel tank or compartment of the fuel tank throughout each of the flights being evaluated. Input values for this data must be obtained from ground and flight test data or the approved FAA fuel management procedures.**
3. **Airplane cruise mach number.**
4. **Airplane maximum range.**
5. **Fuel tank thermal characteristics. If fuel temperature affects fuel tank flammability, inputs to the Monte Carlo analysis must be provided that represent the actual bulk average fuel temperature within the fuel tank at each point in time throughout each of the flights being evaluated. For fuel tanks that are subdivided by baffles or compartments, bulk average fuel temperature inputs must be provided for each section of the tank. Input values for these data must be obtained from ground and flight test data or a thermal model of the tank that has been validated by ground and flight test data.**
6. **Maximum airplane operating temperature limit, as defined by any limitations in the airplane flight manual.**
7. **Airplane Utilization. The applicant must provide data supporting the number of flights per day and the number of hours per flight for the specific airplane model under evaluation. If there is no existing airplane...**
fleets of the three parameters (ground ambient temperature, cruise ambient temperature, and flight length) must be used when conducting a flammability exposure analysis to determine the fleet average flammability exposure. Variables used to calculate fleet flammability exposure must include atmospheric ambient temperatures, flight length, flammability exposure evaluation time, fuel flash point, thermal characteristics of the fuel tank, overnight temperature drop, and oxygen evolution from the fuel into the ullage.

25.4 Variables and data tables.

The following data must be used when conducting a flammability exposure analysis:

(A) Atmospheric Ambient Temperatures and Fuel Properties.

(1) In order to predict flammability exposure during a given flight, the variation of ground ambient temperatures, cruise ambient temperatures, and a method to compute the transition from ground to cruise and back again must be used. The variation of the ground and cruise ambient temperatures and the flight length for the flight is defined by a Gaussian curve, given by the 50 percent value and a ±1-standard deviation value.

(2) Ambient Temperature: Under the program, the ground and cruise ambient temperatures are linked by a set of assumptions on the atmosphere. The temperature varies with altitude following the International Standard Atmosphere (ISA) rate of change of the fuel temperature for the flight. For cold days, an inversion is applied up to 10,000 feet, and then the ISA rate of change is used.

(3) Fuel properties:

(a) For Jet A fuel, the variation of flash point of the fuel is defined by a Gaussian curve, given by the 50 percent value and a ±1-standard deviation, as shown in Table 1 of this appendix.

(b) The flammability envelope of the fuel that must be used for the flammability exposure analysis is a function of the flash point of the fuel selected by the Monte Carlo for a given flight. The flammability envelope for the fuel is defined by the upper flammability limit (UFL) and lower flammability limit (LFL) as follows:

(1) LFL at sea level = flash point temperature of the fuel at sea level minus 10 °F. LFL decreases from sea level value with increasing altitude at a rate of 1 °F per 800 feet.

(2) UFL at sea level = flash point temperature of the fuel at sea level plus 3.5 °F. UFL decreases from the sea level value with increasing altitude at a rate of 1 °F per 40 feet.

(4) For each flight analyzed, a separate random number must be generated for each of the three parameters (ground ambient
temperature, cruise ambient temperature, and fuel flash point) using the Gaussian distribution defined in Table 1 of this appendix.

### Table 1.—Gaussian Distribution for Ground Ambient Temperature, Cruise Ambient Temperature, and Fuel Flash Point

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature in deg F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ground ambient temp</td>
</tr>
<tr>
<td></td>
<td>Cruise ambient temp</td>
</tr>
<tr>
<td>Mean Temp</td>
<td>59.95</td>
</tr>
<tr>
<td>Neg 1 std dev</td>
<td>20.14</td>
</tr>
<tr>
<td>Pos 1 std dev</td>
<td>17.28</td>
</tr>
<tr>
<td>(FP)</td>
<td>8.0</td>
</tr>
</tbody>
</table>

(b) The Flight Length Distribution defined in Table 2 must be used in the Monte Carlo analysis.

### Table 2.—Flight Length Distribution

<table>
<thead>
<tr>
<th>Flight length (NM)</th>
<th>Airplane maximum range—nautical miles (NM)</th>
<th>Distribution of flight lengths (percentage of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From  To</td>
<td>1000 2000 3000 4000 5000 6000 7000 8000 9000 10000</td>
<td></td>
</tr>
<tr>
<td>0 200</td>
<td>11.7 7.5 6.2 5.5 4.7 4.0 3.4 3.0 2.6 2.3</td>
<td></td>
</tr>
<tr>
<td>200 400</td>
<td>27.3 19.9 17.9 15.9 13.2 11.4 9.7 8.4 7.3 6.7</td>
<td></td>
</tr>
<tr>
<td>400 600</td>
<td>46.3 40.0 35.7 32.6 28.5 24.9 21.2 18.7 16.4 14.8</td>
<td></td>
</tr>
<tr>
<td>600 800</td>
<td>103.116.5 110.102.9 91.8 9.6 6.9 6.1 5.4 4.8</td>
<td></td>
</tr>
<tr>
<td>800 1000</td>
<td>4.4 8.5 8.6 8.2 7.4 6.6 5.7 5.0 4.5 4.0</td>
<td></td>
</tr>
<tr>
<td>1000 1200</td>
<td>4.5 4.8 5.3 5.3 4.8 4.3 3.8 3.3 3.0 2.7</td>
<td></td>
</tr>
<tr>
<td>1200 1400</td>
<td>3.6 4.4 4.5 4.2 3.8 3.3 3.0 2.7 2.4 2.4</td>
<td></td>
</tr>
<tr>
<td>1400 1600</td>
<td>2.2 3.3 3.5 3.3 3.1 2.7 2.4 2.2 2.0 2.0</td>
<td></td>
</tr>
<tr>
<td>1600 1800</td>
<td>1.2 2.3 2.6 2.5 2.4 2.1 1.9 1.7 1.6 1.6</td>
<td></td>
</tr>
<tr>
<td>1800 2000</td>
<td>0.7 2.2 2.6 2.6 2.5 2.4 2.2 2.0 1.8 1.7</td>
<td></td>
</tr>
<tr>
<td>2000 2200</td>
<td>0.0 1.6 2.1 2.2 2.1 1.9 1.7 1.6 1.4 1.4</td>
<td></td>
</tr>
<tr>
<td>2200 2400</td>
<td>0.0 1.1 1.6 1.7 1.6 1.4 1.3 1.2 1.2 1.2</td>
<td></td>
</tr>
<tr>
<td>2400 2600</td>
<td>0.0 0.7 1.2 1.4 1.4 1.3 1.2 1.1 1.1 1.1</td>
<td></td>
</tr>
<tr>
<td>2600 2800</td>
<td>0.0 0.4 0.9 1.0 1.1 1.0 0.9 0.9 0.8 0.8</td>
<td></td>
</tr>
<tr>
<td>2800 3000</td>
<td>0.0 0.2 0.6 0.7 0.8 0.7 0.7 0.6 0.6 0.6</td>
<td></td>
</tr>
<tr>
<td>3000 3200</td>
<td>0.0 0.0 0.6 0.8 0.8 0.8 0.8 0.7 0.7 0.7</td>
<td></td>
</tr>
<tr>
<td>3200 3400</td>
<td>0.0 0.0 0.7 1.1 1.2 1.2 1.1 1.1 1.1 1.1</td>
<td></td>
</tr>
<tr>
<td>3400 3600</td>
<td>0.0 0.0 0.7 1.3 1.6 1.6 1.5 1.5 1.4 1.4</td>
<td></td>
</tr>
<tr>
<td>3600 3800</td>
<td>0.0 0.0 0.9 2.2 2.7 2.8 2.7 2.6 2.5 2.5</td>
<td></td>
</tr>
<tr>
<td>3800 4000</td>
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<td></td>
</tr>
<tr>
<td>4000 4200</td>
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<td></td>
</tr>
<tr>
<td>4200 4400</td>
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<td></td>
</tr>
<tr>
<td>4400 4600</td>
<td>0.0 0.0 0.0 0.0 1.0 2.0 2.3 2.5 2.5 2.4</td>
<td></td>
</tr>
<tr>
<td>4600 4800</td>
<td>0.0 0.0 0.0 0.0 0.6 1.5 1.8 2.0 2.0 2.0</td>
<td></td>
</tr>
<tr>
<td>4800 5000</td>
<td>0.0 0.0 0.0 0.0 0.2 1.0 1.4 1.5 1.6 1.5</td>
<td></td>
</tr>
<tr>
<td>5000 5200</td>
<td>0.0 0.0 0.0 0.0 0.0 0.8 1.1 1.3 1.3 1.3</td>
<td></td>
</tr>
<tr>
<td>5200 5400</td>
<td>0.0 0.0 0.0 0.0 0.0 0.8 1.2 1.5 1.6 1.6</td>
<td></td>
</tr>
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<td>5400 5600</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 1.7 2.1 2.2 2.3</td>
<td></td>
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<td>5600 5800</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.6 1.6 2.2 2.4</td>
<td></td>
</tr>
<tr>
<td>5800 6000</td>
<td>0.0 0.0 0.0 0.0 0.0 0.2 1.8 2.4 2.8 2.8</td>
<td></td>
</tr>
<tr>
<td>6000 6200</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 1.7 2.6 3.1 3.3</td>
<td></td>
</tr>
<tr>
<td>6200 6400</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.4 2.4 2.9</td>
<td></td>
</tr>
<tr>
<td>6400 6600</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.9 1.8 2.2</td>
<td></td>
</tr>
<tr>
<td>6600 6800</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5 1.2 1.6</td>
<td></td>
</tr>
<tr>
<td>6800 7000</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.2 0.8 1.1 1.3</td>
<td></td>
</tr>
<tr>
<td>7000 7200</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.4 0.7 0.8</td>
<td></td>
</tr>
<tr>
<td>7200 7400</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.3 0.5</td>
<td></td>
</tr>
<tr>
<td>7400 7600</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.1 0.6</td>
<td></td>
</tr>
<tr>
<td>7600 7800</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.1 0.6</td>
<td></td>
</tr>
<tr>
<td>7800 8000</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0</td>
<td></td>
</tr>
<tr>
<td>8000 8200</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0</td>
<td></td>
</tr>
<tr>
<td>8200 8400</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0</td>
<td></td>
</tr>
<tr>
<td>8400 8600</td>
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<td></td>
</tr>
<tr>
<td>8600 8800</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0</td>
<td></td>
</tr>
<tr>
<td>8800 9000</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0</td>
<td></td>
</tr>
<tr>
<td>9000 9200</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0</td>
<td></td>
</tr>
</tbody>
</table>

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TABLE 2.—FLIGHT LENGTH DISTRIBUTION—Continued

<table>
<thead>
<tr>
<th>Flight length (NM)</th>
<th>Airplane maximum range—nautical miles (NM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From To</td>
<td>1000</td>
</tr>
<tr>
<td>9200 9400</td>
<td>0.0</td>
</tr>
<tr>
<td>9400 9600</td>
<td>0.0</td>
</tr>
<tr>
<td>9600 9800</td>
<td>0.0</td>
</tr>
<tr>
<td>9800 10000</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(c) Overnight Temperature Drop. For airplanes on which FRM is installed, the overnight temperature drop for this appendix is defined using:

1. A temperature at the beginning of the overnight period that equals the landing temperature of the previous flight that is a random value based on a Gaussian distribution; and
2. An overnight temperature drop that is a random value based on a Gaussian distribution.
3. For any flight that will end with an overnight ground period (one flight per day out of an average number of flights per day, depending on utilization of the particular airplane model being evaluated), the landing outside air temperature (OAT) is to be chosen as a random value from the following Gaussian curve:

TABLE 3.—LANDING OUTSIDE AIR TEMPERATURE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Landing outside air temperature °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Temperature</td>
<td>58.68</td>
</tr>
<tr>
<td>negative 1 std dev</td>
<td>20.55</td>
</tr>
<tr>
<td>positive 1 std dev</td>
<td>13.21</td>
</tr>
</tbody>
</table>

(d) The outside ambient air temperature (OAT) overnight temperature drop will be chosen at random value from the following Gaussian curve:

TABLE 4.—OUTSIDE AIR TEMPERATURE (OAT) DROP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OAT drop temperature °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Temp</td>
<td>12.0</td>
</tr>
<tr>
<td>1 std dev</td>
<td>6.0</td>
</tr>
</tbody>
</table>

(d) Number of Simulated Flights Required in Analysis. In order for the Monte Carlo analysis to be valid for showing compliance with the fleet average and warm day flammability exposure requirements, the applicant must run the analysis for a minimum number of flights to ensure that the fleet average and warm day flammability exposure for the fuel tank under evaluation meets the applicable flammability limits defined in Table 5 of this appendix.

TABLE 5.—FLAMMABILITY EXPOSURE LIMIT

<table>
<thead>
<tr>
<th>Minimum number of flights in Monte Carlo analysis</th>
<th>Maximum acceptable Monte Carlo average fuel tank flammability exposure (percent) to meet 3 percent requirements</th>
<th>Maximum acceptable Monte Carlo average fuel tank flammability exposure (percent) to meet 7 percent part 26 requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000</td>
<td>2.91</td>
<td>6.79</td>
</tr>
<tr>
<td>100,000</td>
<td>2.98</td>
<td>6.96</td>
</tr>
<tr>
<td>1,000,000</td>
<td>3.00</td>
<td>7.00</td>
</tr>
</tbody>
</table>