

## **Appendix E: Auxiliary Power Unit Emission Methodology**



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## Appendix E: Auxiliary Power Unit Emission Methodology

### E1. METHODOLOGY

A methodology was developed for calculating emissions from auxiliary power units (APUs) based on the methodology for calculating aircraft exhaust emissions, which is provided in EPA's *Procedures for Emission Inventory Preparation* (Reference 82). APU emissions are calculated for one complete LTO cycle of each aircraft type. Calculation inputs are the emission factors and fuel flow for the aircraft's specific APU model and the amount of APU usage during the course of the full aircraft LTO. Equation E-1 assumes each aircraft type has one APU. If a particular aircraft has multiple APUs, then the equation must be multiplied by the number of APUs on the aircraft in question.

$$E_{ij} = T * (FF_j / 1000) * (EI_{ij})$$

#### Equation E-1: APU Emissions from a Single LTO

Where:

- $E_{ij}$  - emissions of pollutant i, in pounds, produced by the APU model installed on aircraft type j for one LTO cycle
- T - operating time per LTO cycle, in minutes
- $FF_j$  - fuel flow, in pounds per minute, for each APU used on aircraft type j
- $EI_{ij}$  - emission index for pollutant i, in pounds of pollutant per one thousand pounds of fuel, for each APU used on aircraft type j
- i - pollutant type (HC, CO,  $NO_x$ ,  $SO_2$ )
- j - aircraft type (e.g., B-737, MD-11)

Using Equation E-1, APU emissions per LTO can be calculated for multiple aircraft types and any period of time (e.g., day, month, year). Total APU emissions can be calculated using Equation E-2. Equation E-2 multiplies the APU emissions per LTO for a given aircraft type and operating time (determined using the above equation) by the number of corresponding LTOs, then sums the emissions over all aircraft types.

$$E_{Ti} = \Sigma (EI_{ij} \times LTO_j)$$

#### Equation E-2 : Total APU Emissions

Where:

- $E_{Ti}$  - total APU emissions of pollutant i, in pounds, produced by all aircraft types in question
- $EI_{ij}$  - emission index for pollutant i, in pounds of pollutant per one thousand pounds of fuel, for each APU used on aircraft type j
- $LTO_j$  - number of landing and takeoff cycles for aircraft type j during the inventory period

## **E2. DATA SOURCES**

### **E2.1 APU Model**

The particular APU model that is installed on an aircraft must be determined to select the emission indices used in calculating the emissions. Individual aircraft operators at airports or the air base's operations department are potential sources of site-specific APU model information. If site-specific information is not available, the FAA and EPA's *Technical Data to Support FAA's Advisory Circular on Reducing Emissions from Commercial Aviation* (Reference 52) lists APU models commonly found on commercial aircraft. For military aircraft, default data is provided in the USAF's *The Engine Handbook* (Reference 44) or the latest version of EPA's *Compilation of Air Pollutant Emission Factors*, Volume II (Reference 71), which list several military aircraft and their common APU models.

### **E2.2 Emission Indices and Fuel Flow**

Emission indices and fuel flow vary by APU model. APU emission indices generally are in pounds of pollutant per 1000 pounds of fuel consumed. APU fuel flow typically is in pounds per minute of usage. Emission indices and fuel flow are provided for several APU models in the FAA and EPA's *Technical Data to Support FAA's Advisory Circular on Reducing Emissions from Commercial Aviation* (Reference 52). Potential sources of additional emission index and fuel flow data are APU engine manufacturers. Where emission indices and fuel flow are unavailable for a specific APU, data for an alternative unit of the same or similar horsepower should be used.

### **E2.3 Operating Time**

The APU operating time for the full aircraft LTO must be known to calculate emissions. This includes time the APU operates while parked at a gate or parking space, during aircraft or APU maintenance, and during aircraft taxi, approach, or climbout. APU operating time varies by LTO, aircraft, operator, and airport. Potential sources of site-specific APU operating time data are individual aircraft operators at airports or the air base's operations department. If no information is available, surveys of operators could be conducted. If site-specific information is not available, an airline, airport, or air base average APU operating time can be used.

As a last resort, if APU operating time data is not available, a conservative estimate would be to assume the APU runs the entire time the aircraft is on the ground. If the aircraft total ground time is not available, the rough estimate of a one hour turn around time at the gate can be added to aircraft taxi time. See the commercial aircraft or military aircraft inventory section for more information on aircraft taxi data.

### **E2.4 Aircraft Fleet and Activity**

See the commercial aircraft or military aircraft inventory section in Appendix D for more information on aircraft fleet and activity.