

thrust engines would also be dependent on an engine's thrust or rated output.⁷⁹ (See section IV.A.1(a)(ii) and IV.A.1(b)(ii) for a description of these different standards.) For example, at a rated pressure ratio of 30 and a thrust of 58 kN (thrust level in the middle of 26.7 kN and 89 kN), these proposed standards are an 8 percent reduction (or increase in stringency) from the existing standard compared to a 16 percent reduction for the proposed standards for mid- and high-thrust engines.⁸⁰

The existing standards were not set at a stringency level that created a need for low-thrust engines to have different requirements, but at the level of NO_x stringency proposed today different requirements are considered necessary for such engines. Due to their physical size, it is difficult to apply the best NO_x reduction technology to low thrust or small engines. The difficulty increases progressively as size is reduced (from around 89 kN).⁸¹ For example, the relatively small combustor space and section height of these engines creates constraints on the use of low NO_x fuel staged combustor concepts which inherently require the availability of greater flow path cross-sectional area than conventional combustors.⁸² Also, fuel staged combustors need more fuel injectors, and this need is not compatible with the relatively lower total fuel flows of lower thrust engines. (Reductions in fuel flow per nozzle are difficult to attain without having clogging problems due to the small sizes of the fuel metering ports.) In addition, lower thrust engine combustors have an inherently greater liner surface-to-

combustion volume ratio, and this requires increased wall cooling air flow. Thus, less air would be available to obtain acceptable turbine inlet temperature distribution and for emissions control.⁸³ Since the difficulties increase progressively as engine thrust size is reduced, EPA believes it would be appropriate to make a graded change in stringency of the proposed NO_x standards for low-thrust engines.

4. Rationale of Proposed NO_x Standards for Newly Certified Low-, Mid-, and High-Thrust Engines

The proposed standards for low-, mid-, and high-thrust engines, which are equivalent to the CAEP/4 standards, ensure that new engine designs would incorporate the existing combustor technology and would not perform worse than today's current engines. EPA intends to promulgate these standards by January 2004 in order to be consistent with U.S. obligations under ICAO. (See section II.B for a discussion of the obligation of ICAO's participating nations). At this time, there is not sufficient lead time to require more stringent emission standards than the CAEP/4 NO_x emission standards by January 2004. As discussed later in section IV.A.5 for future standards, we are deferring action on more stringent NO_x standards because pursuant to section 231(b) of the CAA we need more time to better understand the cost of compliance with such standards, and additional cost data is expected to be available from CAEP/6 in February 2004 (see section IV.A.5 for further discussion regarding lead time).

EPA believes that the proposed standards would not impose any additional burden on manufacturers, because manufacturers are already designing new engines to meet the ICAO international consensus standards by 2004 (see section VII of today's action for further discussion of regulatory impact). Even though the U.S. did not immediately adopt the ICAO NO_x standards after 1999, engine manufacturers have continued to make progress in reducing these emissions. Today's proposed standards are aimed at assuring that this progress is not reversed in the future.

5. Future NO_x Standards for Newly Certified Low-, Mid-, and High-Thrust Engines

More stringent standards for low-, mid-, and high-thrust engines will be necessary in the future. As discussed earlier in section III, the growth in aircraft emissions is projected to occur at a time when other mobile source categories are reducing emissions.⁸⁴ The 1999 EPA study of commercial aircraft activity in ten cities projected that the aircraft NO_x emissions would double in some of these cities by 2010, and the aircraft component of the regional mobile source NO_x emissions in the ten cities would grow from a range of 1 to 4 percent that existed in 1990 to a range of 2 to 10 percent in 2010.⁸⁵ (As indicated earlier, the above projections were made prior to the tragic events of September 11, 2001, and the subsequent economic downturn. A January 2003 report by the Department of Transportation indicated that the combination of the September 11, 2001 terrorist attacks and a cut-back in business travel had a significant and perhaps long-lasting effect on air traffic demand. However, the FAA expects the demand for air travel to recover, and then continue a long-term trend of annual growth in the United States.) More recently, as discussed earlier FAA reports that flights (or activity) of commercial air carriers will increase by 18 percent by 2010 and 45 percent by 2020.⁸⁶ Thus, based on these trends

⁸⁴ The projected growth in aircraft emissions is not simply from the number of operations, but it could also be attributed to the change in the types of aircraft being operated. For example, regional aircraft activity is growing (regional aircraft are generally referred to as those aircraft with more than 19 but fewer than 100 seats—regional jets and turboprops). In the U.S., traffic flown by regional airlines increased about 20 percent in 1999 and is expected to grow approximately 7 percent annually during the next ten years, compared to 4 to 6 percent for the major airlines. In addition, regional jets comprised about 25 percent of the regional aircraft fleet in 2000, up from only 4.2 percent in 1996, and their fraction of the fleet is expected to increase to nearly 50 percent by 2011. Regional aircraft are 40 to 60 percent less fuel efficient compared to larger narrow- and wide-body aircraft, and regional jets are 10 to 60 percent less fuel efficient than turboprop aircraft. However, fuel costs have less of an effect on the operating costs of regional aircraft compared to large aircraft. In addition, regional jets have historically operated at higher load factors than turboprops due to their popularity with travelers. (R. Babikian, S. P. Lukachko and I. A. Waitz, "Historical Fuel Efficiency Characteristics of Regional Aircraft from Technological, Operational, and Cost Perspectives," *Journal of Air Transport Management*, Volume 8, No. 6, pp. 389–400, Nov. 2002).

⁸⁵ U.S. EPA, "Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft," April 1999, EPA420-R-99-013. This study is available at <http://www.epa.gov/otaq/aviation.htm>. It can also be found in Docket No. OAR-2002-0030.

⁸⁶ The flight forecast data is based on FAA's Terminal Area Forecast System (TAFS). TAFs is the

⁷⁹ The proposed standards for mid- and high-thrust engines are dependent only on an engine's rated pressure ratio.

⁸⁰ Additional examples of the proposed standards for low-thrust engines in comparison to the proposed standards for mid- and high-thrust engines are provided below. At rated pressure ratios of 10 and 20 with a thrust of 58 kN, the proposed low-thrust engine standards are a 14 and 10 percent reduction from the existing standard, respectively. Whereas, at these same rated pressure ratios, the proposed standards for mid- and high-thrust engines are 27 and 20 percent reductions.

In addition, at rated pressure ratios of 40 and 50 with a thrust of 58 kN, these low-thrust engine standards signify a 5 and 2 percent reduction from the existing standard, respectively. In comparison, at these same rated pressure ratios, the proposed standards for mid- and high-thrust engines are 9 and 4 percent reductions.

⁸¹ ICAO/CAEP, Report of Third Meeting, Montreal, Quebec, December 5–15, 1995, Document 9675, CAEP/3.

⁸² "The burner section of an aircraft engine, which contains the combustion chamber, burns a mixture of fuel and air, and delivers the resulting gases to the turbine at a temperature which will not exceed the allowable limit at the turbine inlet." (United Technologies Pratt and Whitney, "The Aircraft Gas Turbine Engine and Its Operation," August 1998.)

⁸³ ICAO/CAEP Working Group 3 (Emissions), "Combined Report of the Certification and Technology Subgroups," section 2.3.6.1, Presented by the Chairman of the Technology Subgroup, Third Meeting, Bonn, Germany, June 1995. A copy of this paper can be found in Docket OAR-2002-0030.