# I. ENVIRONMENTAL PROTECTION AGENCY AIRCRAFT EMISSIONS STANDARDS

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In late 1970 the Clean Air Act was amended (ref. 1) to require the Administrator of the Environmental Protection Agency (EPA) to "establish standards applicable to aircraft of any air pollutant from any class or classes of aircraft or aircraft engines which in his judgment cause or contribute to or are likely to cause or contribute to air pollution which endangers the public health or welfare." As a prerequisite to the establishment of aircraft emissions standards, the EPA was further required to conduct ". . . a study and investigation of emissions of air pollutants from aircraft in order to determine:

A. the extent to which such emissions affect air quality in air quality control regions throughout the United States, and

B. the technological feasibility of controlling such emissions. . ."

The study was conducted and a report was published in December 1972 (ref. 2) that summarizes the basic information supporting the need for aircraft emissions standards.

The background against which this study was conducted includes the EPA Ambient Air Quality Standards (ref. 3), which are summarized in table I-1. For the purposes of this paper, only the "primary" (health related) standards are shown. Of the six pollutants, only the first three, carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides ($NO_x$), are influenced significantly by aircraft.

With the publication of these ambient air standards on January 30, 1971, each of the 50 states was given 9 months to develop plans for implementing programs to achieve these air quality levels. These implementation plans have all been submitted, reviewed, and in many cases rewritten by EPA. The states have established emissions standards for most categories of existing stationary pollutant sources, as measures to reduce emissions from sources other than surface vehicles and aircraft. In addition, some states are establishing programs of mandatory emissions inspections and repairs for motor vehicles to help ensure that vehicles manufactured to meet Federal emissions standards maintain their low emissions in actual use.

At the Federal level, emissions standards have been established for newly manufactured passenger cars, motorcycles, engines that power commercial vehicles, and aircraft engines. Further, the Federal government has also established emissions standards for certain categories of newly constructed stationary pollution sources, large power-generation plants, for example, to make certain that the best available technology is employed in their initial design.

In spite of all these measures, it is apparent that many cities in this country will not achieve the Ambient Air Quality Standards for many years. Therefore, many sources of the pollutant species covered by the Ambient Air Quality Standards, which by themselves may appear small, must be brought under control. Aircraft are an example of such a source.

The purpose of reviewing this background is to show that, while the aircraft emissions regulations may seem stringent and may cause complications to aircraft manufacturers and users, they are a necessary part of the overall program for achieving and maintaining the level of air quality that is required in the United States.

## IMPACT OF AIRCRAFT OPERATION ON AIR QUALITY

To evaluate the influence of aircraft on air quality, it was first necessary to develop reliable emissions data on all aircraft powerplants commonly encountered in the United States. This was accomplished through a series of studies involving over 390 engine tests at 10 different test sites. Although problems were encountered in the durability and integrity of the sampling and measuring systems, extensive data were obtained, summarized, and analyzed statistically in a report prepared by Cornell Aeronautical Laboratory (ref. 4) that provided the basic information on emissions factors for engine types in service in the United States in 1971. These emissions factors were used in subsequent EPA studies to document the influence of aircraft operations at individual airports. They are currently being updated, however, using new data developed by the manufacturers.

These emissions factors, adjusted for typical times in each engine operating mode for specific metropolitan airports in the United States, were combined with the necessary supporting data on aircraft flight statistics to develop airport emissions levels for use in evaluating community air quality impact. Reference 1 describes the use of mathematical modeling as a tool for projecting the impact of aircraft operations on air quality. The present discussion covers only the information summarized in table I-2, which shows emissions densities for two United States airports located in large metropolitan areas that have serious air pollution problems.

At the time of the study, 1970, the Los Angeles airport was already a more dense emitter per unit area of the three pollutants than the rest of the Los Angeles area. The contribution of aircraft operations alone was slightly above the contribution of other sources in other parts of Los Angeles. Projected to 1980 with no aircraft controls, the total emissions for the metropolitan area declined because of the automobile emissions standards and other control measures that are being taken. However, the emissions from aircraft increased because of the growth in flight activity projected for this airport, so that aircraft alone showed much higher emissions densities than those for other parts of the Los Angeles metropolitan area.

For Washington, D.C., in 1970, the emissions from aircraft alone amounted to somewhat lower densities than for the metropolitan area, although the total airport emissions were about the same as those for the metropolitan area. For 1980, however, total airport emissions densities were above those for the rest of the area, again reflecting the influence of the automobile regulatory program. This trend persisted even when aircraft operations alone were considered.

In summary, the study showed that the local influence on air quality of aircraft operations appears to be comparable to the influence of other sources in large cities, and it will get worse if aircraft (and other sources in and around the airport) are not controlled. Thus, in air quality terms, the justification for aircraft emissions standards is based on the need to protect against future degradation in the environment, particularly in areas where airport activities are growing and where other sources are being brought under control.

A paper presented to the Air Pollution Control Association in 1973 (ref. 5) goes more deeply into the development of the air quality justification for aircraft emissions standards.

## AIRCRAFT ENGINE EMISSIONS STANDARDS

With the foregoing background, and with the decision made to develop emissions standards applicable to aircraft powerplants, the next consideration was the basic elements of such standards.

### Engine Classification

First, aircraft and aircraft engines had to be classified in a manner consistent with their design, performance, and functions, with due consideration to the relative potential for reducing their emissions and the relative need to do so. It was decided that the standards should apply to engines and not to aircraft, since in the aerospace industry the two are in all cases built by different manufacturers and the technology for reducing emissions is largely under the control of the engine builder.

Table I-3 shows the complete engine classification system developed for the EPA standards. The distinction between class T1 (small engines) and class T2 (large engines) is necessary because of differences (1) in the ability to reduce emissions in small as opposed to large combustors, (2) in other engine design considerations such as pressure ratio, and (3) in the different markets the two classes serve. The standards can then take into consideration the lesser impact of the smaller engines on community air pollution problems, since they are used mostly for irregular business travel as opposed to scheduled airline service. A special class (T3) was set aside for the Pratt & Whitney JT3D engine, basic powerplant for the B 707 and DC 8 aircraft, to facilitate establishing a special smoke standard and retrofit schedule. The same applies to class T4, the Pratt & Whitney JT8D engine, basic powerplant for the B 727/737 and DC 9 aircraft. Class T5, applicable only to engines designed for supersonic commercial aircraft, is necessary because the thermodynamic cycles that are practicable for SST engines are not as low in fuel consumption as other large engines (T2), which means that for the same combustor design technology they cannot be expected to achieve as low mass emissions over a reference operating cycle. Class P1, consisting of opposed piston engines only, is necessary because of the distinctly different types of emissions and technological problems applicable to these types of engines, as well as their smaller impact on community air pollution. Class P2, consisting of turboprop engines only, is necessary because of uncertainties over the equivalency between propeller thrust and jet thrust, the small sizes of some of these engines, and the types of market that they serve. It is recognized of course that, in some cases, the same "core" engine and combustor may find itself in both class T1 and P2 applications. Class APU covers auxiliary power units used for onboard power generation in some aircraft.

## Engine Operating Conditions

Next, it was necessary to specify the engine operating conditions to be used for measuring and expressing pollutant emissions. For this purpose it was decided to use a landing/takeoff (LTO) cycle including all operations below 3000-foot altitude, which was selected as a limiting altitude above which the pollutants emitted would not be expected to diffuse downward and contribute to community air quality problems. The times at each aircraft operating mode were chosen to be typical of high-activity periods at major United States metropolitan airports. With this approach, the times in the basic engine operating modes came out as listed in table I-4 for the various engine classes.

This approach required additionally that a uniform manner for specifying engine power settings be selected that corresponds to the operating modes identified in table I-4. Based on advice from airlines, other aircraft operators and the FAA, the engine power settings to be used on test stands for simulation of each aircraft operating mode were specified as shown in table I-5.

## Expression of Emissions Performance

The next item to be considered was the form of expressing the emissions data for the purposes of setting standards. Four possible ways in which this might be done, using the emissions measurements at each power setting in the LTO cycle, are

(1) Concentration, ppm by volume

(2) Ratio of mass pollutant to mass of fuel consumed

(3) Mass pollutant over LTO cycle

(4) Ratio of mass pollutant to thrust-hours, both over LTO cycle

Item 1, pollutant concentration, has the advantage of being easy to use, but it provides no guide to the mass pollutant emissions levels for the engine. Item 2, mass pollutants emitted divided by mass fuel consumed (or emissions index), provides a reliable guide to the cleanliness of the combustion system in a given engine, but not to the emissions impact of the complete engine, since different engines have different fuel consumption characteristics. Therefore, while this approach is extremely useful to combustion system designers, it is not the most suitable for regulatory purposes. Item 3, total mass emissions over the LTO cycle, is of course the most useful form of expression if one is interested in estimating airport emissions from operations data on different aircraft and engines. However, for regulatory purposes, this would be somewhat cumbersome, because each engine would have to be assigned a different emissions standard in proportion to its rated thrust or power level.

It was decided that the form of emissions parameter shown as item 4 would be adopted for the purposes of the EPA aircraft engine emissions standards. By normalizing the emissions over the LTO cycle with a thrust or horsepower term, a "figure of merit" is obtained that relates the emissions behavior of the complete engine to its ability to do useful work for society. This is similar to the emissions parameter used by the EPA for standards applicable to truck and bus engines.

### Emissions Measurement

Some mention should be made of the status of the technology for accurate sampling and measurement of pollutants in the exhaust emitted by aircraft gas turbine engines. The tests undertaken in 1971 to develop the data cited earlier disclosed a number of detailed problems relating to the adequacy of the sampling system for collecting and delivering a representative sample of gases to the measurement instruments, plus other problems, lesser in magnitude, with the instruments themselves. Therefore, studies have continued since that time to resolve these problems and to improve test variability. One such study, which was conducted under EPA sponsorship, is described in references 6 and 7. The work of the Society of Automotive Engineers, Technical Committee E-31, "Aircraft Exhaust Emissions Measurements," has from the start been an important source of basic information and advice from knowledgeable engineers in industry and government on the establishment of standardized sampling and measurement procedures.

Other work to improve the precision of the emissions data has been carried out by government and industry laboratories on the development of correction factors for ambient temperature, humidity, and (less important) pressure. The Environmental Protection Agency has sponsored several investigations by qualified private laboratories on such environmental effects. These data are presently undergoing analysis and will be reported in the near future. Since most engine laboratories that routinely do emissions testing have independently developed their own correction factors for ambient conditions, the EPA has recently solicited information from these organizations for review prior to taking any action to amend the Aircraft Engine Emission Standards to specify correction procedures for ambient conditions.

### Emissions Control Technology

Next, it was necessary to consider the technology that could be applied to reduce aircraft engine emissions in response to the Clean Air Act requirement quoted on page 1. The report prepared in response to this requirement (ref. 2) concluded that for engines of existing design the most promising approaches for reducing emissions involve (1) combustor design changes, (2) use of divided fuel supply so as to permit operating only part of the engine combustors at low power settings (sector burning), (3) increased air bleed rates, and (4) water injection for nitrogen oxides control. The emissions reductions achievable by these techniques were estimated to range from 50 to 70 percent for the different pollutant species.

Accordingly, emissions standards based on this type of technology were proposed on December 12, 1972 (ref. 8). Public hearings were held to entertain comments on the proposed standards early in 1973, followed by final promulgation on July 17, 1973 (ref. 9). The standards promulgated were influenced heavily by the comments received at the public hearings and by the research goals for low-emissions aircraft combustors developed independently during this period by NASA and the Air Force.

No more will be said in this paper about technology for reducing emissions, since that is the major topic addressed in the other papers. The current EPA views with respect to technology for reducing emissions have been recently summarized in reference 10, which incorporates the results of an analysis by EPA technical staff of the progress made by manufacturers of aircraft gas turbine engines in their efforts to reduce emissions to meet the EPA emissions standards. While this analysis may lead to a proposal for changes to some of the standards or their implementation dates, that subject is not addressed in the present paper.

## Regulatory Levels and Schedules

Table I-6 shows the schedule for the various emissions standards established by the EPA on July 17, 1973. The first four of these requirements are already in effect, and only minor problems have been encountered during their implementation. These have mainly been a need by some operators for extensions in time for compliance because of difficulties in obtaining parts and in scheduling the shop work for installing them.

The smoke standard applicable to class T3 engines (JT3D) was changed on December 15, 1976, to extend the date by which low-smoke combustors must be installed on in-service engines from January 1, 1973, to September 1, 1981, with 90-percent compliance required by September 1, 1980. This action was taken in response to a petition by the Air Transport Association because of developmental problems with the low-smoke replacement combustors.

The remainder of the discussion deals mostly with the gaseous emissions standards scheduled to become effective for 1979 on all newly produced engines and the 1981 standards, which will apply to advanced-design, newly certified engines after that date. These are the standards that are the most directly relevant to the scope of this conference.

Table I-7 lists the specific requirements applicable to all engine classes for engines newly manufactured after January 1, 1979. The standards apply both to the newly produced engines and to those engines throughout their service life. In addition, it was proposed at the time of promulgating these standards that they also be made applicable to class T2 engines of greater than 29 000-lb thrust that are in service by January 1, 1983. This proposal was the subject of public hearings in January 1976 and the comments are still under review by EPA technical staff.

As mentioned earlier, the requirements applicable to small turbojet engines are more lenient than those applicable to larger engines, because of less available technology, smaller markets, and lesser pollutant impact.

Further, the requirements applicable to engines designed for propulsion at supersonic flight speeds (ref. 11) are significantly less stringent than for other commercial engines, because the engine cycles practicable for supersonic flight are inherently less efficient and more highly polluting during low-altitude operations such as those specified in the EPA LTO cycle. Therefore, using equivalent emissions control technology, SST engine emissions will be 3 to 5 times those of subsonic engines of comparable performance.

Table I-8 lists the more stringent gaseous emissions standards applicable to newly certified aircraft gas turbine engines after January 1, 1981. Here, it is assumed that the engine will have been designed from its inception with emissions control in mind. Therefore, more-advanced combustor designs reflecting the most optimum emissions control approaches can be considered from the very beginning. In addition, other aspects of the basic engine design, such as pressure ratio, bypass ratio, allowable combustor volume, and pressure drop, can also be considered as they influence the capability of the engine to meet the emissions control targets.

At the time these standards were first proposed, December 1972, consideration was also given to methods for reducing the amount of time spent by commercial aircraft under engine idle and taxi situations at large metropolitan airports. It was stated earlier in this paper (p. 5) that the LTO cycle devised for expression of emissions standards corresponds to peak traffic periods with resultant long delay situations at certain United States airports. Obviously, any practical way of reducing such nonproductive engine idle time during traffic delays would not only reduce emissions of hydrocarbons and carbon monoxide very substantially but would result in very meaningful fuel savings as well. It was estimated that approximately 60 million gallons of fuel per year could be saved in the United States, with commensurate emissions reductions, through application of readily available measures, such as partial engine taxi operations. Even more could be saved with longer range approaches, such as towing or moving the aircraft in some other fashion not requiring operation of the propulsion engines or through more extensive use of buses or mobile lounges to carry passengers to the aircraft at locations close to the runway. An Advanced Notice of Proposed Rule Making was published (ref. 12) by the EPA in December 1972 that solicited comments on the feasibility of these techniques. The comments led to a cooperative demonstration program with the Air Transport Association (ATA) and FAA in 1973 to study the effectiveness of partial engine taxi operations and to NASA and FAA sponsored studies on aircraft towing, powered landing gear, etc. At the present time, however, the LTO cycle expressed in the standards is still believed to be realistic of peak traffic periods and delay situations at busy metropolitan airports.

## CONCLUDING REMARKS

The development of the U.S. Environmental Protection Agency standards for control of emissions from commercial and private aircraft has been described. It is shown that the air quality impact of aircraft will rise in future years, relative to emissions from other sources in large U.S. cities, unless their emissions are reduced. Studies of methods available for emissions reduction and emissions testing showed that the engineering state of the art is adequate to support the promulgation of standards. The form of the standards, expressed as mass emissions over a landing/takeoff cycle divided by the impulse (or power) developed by the engine, is believed to relate equitably the stringency of control to the work produced by aircraft engines during operations in proximity to airports, with due allowance for specific engine classes having special technological or economic constraints.

## REFERENCES


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9. Environmental Protection Agency. Control of Air Pollution for Aircraft Engines - Emission Standards and Test Procedures for Aircraft. Fed. Regist., vol. 38, no. 136, pt. II, July 17, 1973, pp. 19088-19103.

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11. Environmental Protection Agency. Control of Air Pollution from Aircraft and Aircraft Engines - Supersonic Aircraft. Fed. Regist., vol. 41, no. 159, pt. II, Aug. 16, 1976, pp. 34721-34725.

12. Title 40 - Protection of Environment; Part 871 - Ground Operation of Aircraft to Control Emissions, Advanced Notice of Proposed Rule Making. Fed. Regist., vol. 37, no. 239, Dec. 12, 1972, pp. 26502-26503.

UNITED STATES AMBIENT AIR QUALITY STANDARDS*

| Pollutant | Description |
| --- | --- |
| Carbon Monoxide | 10 milligrams/meter$^3$ (maximum 8-hour concentration once per year) |
| | 40 milligrams/meter$^3$ (maximum 1-hour concentration once per year) |
| Hydrocarbons (except methane) | 160 micrograms/meter$^3$ (maximum 3-hour concentration once per year) |
| Nitrogen Dioxide | 100 micrograms/meter$^3$ (annual arithmetic mean) |
| Sulfur Dioxide | 80 micrograms/meter$^3$ (annual arithmetic mean) |
| | 365 micrograms/meter$^3$ (maximum 24-hour concentration once per year) |
| Particulates | 75 micrograms/meter$^3$ (annual geometric mean) |
| | 260 micrograms/meter$^3$ (maximum 24-hour concentration once per year) |
| Oxidant | 160 micrograms/meter$^3$ (maximum 1-hour concentration once per year) |

*Primary standards only. Source, ref. 3.

Table I-1.

EMISSION DENSITIES FOR AIRPORTS VERSUS URBAN AREAS

| | | EMISSION DENSITIES, TONS/mi$^2$-day | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1970 | | | 1980 | | |
| | AREA mi$^2$ | CARBON MONOXIDE | HYDRO-CARBONS | NITROGEN OXIDES | CARBON MONOXIDE | HYDRO-CARBONS | NITROGEN OXIDES |
| LOS ANGELES METROPOLITAN AREA | 1250.0 | 7.2 | 2.0 | 1.0 | 2.8 | 0.9 | 0.8 |
| LOS ANGELES AIRPORT - ALL EMISSION SOURCES | 3.9 | 20.6 | 10.3 | 2.0 | 19.1 | 4.0 | 5.6 |
| LOS ANGELES AIRPORT - AIRCRAFT ONLY | 3.9 | 11.2 | 8.8 | 1.1 | 13.0 | 3.4 | 4.9 |
| WASHINGTON D.C. METROPOLITAN AREA | 61.0 | 12.5 | 1.7 | 1.7 | 3.3 | .4 | 1.3 |
| NATIONAL AIRPORT - ALL EMISSION SOURCES | 1.0 | 10.2 | 2.4 | 1.7 | 9.5 | 2.1 | 1.9 |
| NATIONAL AIRPORT - AIRCRAFT ONLY | 1.0 | 6.6 | 1.7 | 1.0 | 8.3 | 2.0 | 1.4 |

Table I-2

ENGINE CLASSIFICATION SYSTEM FOR EPA STANDARDS

| SYMBOL | DESCRIPTION |
|---|---|
| T1 | TURBOJET/TURBOFAN LESS THAN 8000-lb THRUST |
| T2 | TURBOJET/TURBOFAN GREATER THAN 8000-lb THRUST (EXCEPT JT8D AND JT3D) |
| T3 | P&W JT3D |
| T4 | P&W JT8D |
| T5 | TURBOJET/TURBOFAN ENGINES FOR SUPERSONIC AIRCRAFT |
| P1 | OPPOSED PISTON ENGINES |
| P2 | TURBOPROP ENGINES |
| APU | AUXILIARY POWER UNITS |

Table I-3.

LANDING/TAKEOFF CYCLE FOR EXPRESSION OF
AIRCRAFT ENGINE EMISSIONS DATA

| AIRCRAFT OPERATING MODE | ENGINE CLASS | | | |
|---|---|---|---|---|
| | T1, P2 | T2, 3, 4 | T5 | P1 |
| | TIME IN MODE, MIN | | | |
| TAXI OUT | 19 | 19 | 19 | 12 |
| TAKEOFF | .5 | .7 | 1.2 | .3 |
| CLIMBOUT | 2.5 | 2.2 | 2.0 | 5.0 |
| DESCENT | N/A | N/A | 1.2 | N/A |
| APPROACH | 4.5 | 4.0 | 2.3 | 6.0 |
| TAXI IN | 7.0 | 7.0 | 7.0 | 4.0 |

Table I-4.

ENGINE POWER SETTINGS FOR EMISSIONS MEASUREMENTS

| AIRCRAFT OPERATING MODE | ENGINE CLASS | | | |
|---|---|---|---|---|
| | T1, P2 | T2, 3, 4 | T5 | P1 |
| TAXI OUT | (1) | (1) | (1) | (1) |
| TAKEOFF | 100 | 100 | 100 | 100 |
| CLIMBOUT | 90 | 85 | 65 | (2) |
| DESCENT | N/A | N/A | 15 | N/A |
| APPROACH | 30 | 30 | 34 | 40 |
| TAXI IN | (1) | (1) | (1) | (1) |

[1]MANUFACTURER'S RECOMMENDED.
[2]MANUFACTURER'S RECOMMENDED, MUST BE BETWEEN 75 AND 100 PERCENT RATED POWER.

Table I-5.

SCHEDULE OF EMISSION STANDARDS APPLICABLE TO AIRCRAFT

| CLASS | |
|---|---|
| T4 | MAX. SMOKE NUMBER OF 30[1] AFTER JAN. 1, 1974 |
| T2, T3, T4 | PROHIBITION OF FUEL VENTING[1] AFTER JAN. 1, 1974 |
| T1, P2 | PROHIBITION OF FUEL VENTING[1] AFTER JAN. 1, 1975 |
| T2 (ABOVE 29,000 LB THRUST) | MAX. SMOKE NUMBER BASED ON THRUST[2] RATING AFTER JAN. 1, 1976 |
| T3 | MAX. SMOKE NUMBER OF 25[2] AFTER JANUARY 1, 1978 |
| T1, T2, P2 | MAX. SMOKE NUMBER BASED ON THRUST (HORSEPOWER) RATING[2] AFTER JAN. 1, 1979 |
| T1, T2, T3, T4, P2, APU | GASEOUS EMISSIONS STANDARDS FOR SUBSONIC ENGINES OF EXISTING DESIGN[2] MANUFACTURED AFTER JAN. 1, 1979 |
| P1 | GASEOUS EMISSIONS STANDARDS FOR PISTON ENGINES[2] MANUFACTURED AFTER DECEMBER 31, 1979 |
| T5 | GASEOUS EMISSIONS AND SMOKE STANDARDS FOR SUPERSONIC ENGINES OF EXISTING DESIGN[2] MANUFACTURED AFTER JAN. 1, 1980 |
| T2 | GASEOUS EMISSIONS STANDARDS FOR SUBSONIC ENGINES OF NEW DESIGN[2] CERTIFIED AND MANUFACTURED AFTER JAN. 1, 1981 |
| T3 | MAX. SMOKE NUMBER OF 25[3] AFTER SEPTEMBER 1, 1981 |
| T5 | GASEOUS EMISSIONS AND SMOKE STANDARDS FOR SUPERSONIC ENGINES OF NEW DESIGN[2] CERTIFIED AND MANUFACTURED AFTER JAN. 1, 1984 |

[1] NEW AND IN USE.
[2] NEW ONLY.
[3] IN USE ONLY.

Table I-6.

GASEOUS EMISSION STANDARDS APPLICABLE TO NEWLY MANUFACTURED AIRCRAFT GAS TURBINE ENGINES

| ENGINE CLASS | | POLLUTANT* | | |
|---|---|---|---|---|
| | HC | CO | $NO_x$ | EFFECTIVE DATE |
| T1 TURBOJET/TURBOFAN LESS THAN 8000 LB THRUST | 1.6 | 9.4 | 3.7 | JAN. 1, 1979 |
| T2 TURBOJET/TURBOFAN GREATER THAN 8000 LB THRUST (EXCEPT JT8D AND JT3D) | .8 | 4.3 | 3.0 | ↓ |
| T3 P&W JT3D | .8 | 4.3 | 3.0 | ↓ |
| T4 P&W JT8D | .8 | 4.3 | 3.0 | ↓ |
| P2 TURBOPROP ENGINES | 4.9 | 26.8 | 12.9 | ↓ |
| T5 TURBOJET/TURBOFAN ENGINES FOR SUPERSONIC AIRCRAFT | 3.9 | 30.1 | 9.0 | JAN. 1, 1980 |
| P1 PISTON ENGINES | 1.9 | 42.0 | 1.5 | DEC. 30, 1979 |
| APU AUXILIARY POWER UNITS | .4 | 5.0 | 3.0 | JAN. 1, 1979 |

*"T" STANDARDS AS LB/1000 LB THRUST-HOUR/CYCLE;
"$P_2$" STANDARDS AS LB/1000 HORSEPOWER-HOURS/CYCLE;
"$P_1$" STANDARDS AS LB/1000 RATED HORSEPOWER/CYCLE;
APU STANDARDS AS LB/1000 HORSEPOWER.

Table I-7.

GASEOUS EMISSION STANDARDS APPLICABLE TO NEWLY CERTIFIED AIRCRAFT GAS TURBINE ENGINES

| ENGINE CLASS | | POLLUTANT | | |
|---|---|---|---|---|
| | HC* | CO* | $NO_x$* | EFFECTIVE DATE |
| T2 | 0.4 | 3.0 | 3.0 | JAN. 1, 1981 |
| T5 | 1.0 | 7.8 | 5.0 | JAN. 1, 1984 |

*EXPRESSED AS LB POLLUTANT/1000 LB THRUST-HOUR/CYCLE.

Table I-8.