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Guidance on Aircraft Emissions Charges Related to Local Air Quality

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AMENDMENTS

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RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

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Chapter 1

SCOPE OF GUIDANCE AND APPLICATION OF EXISTING ICAO POLICIES ON AIRCRAFT EMISSIONS CHARGES RELATED TO LOCAL AIR QUALITY

1.1 INTRODUCTION AND BACKGROUND

1.1.1 In the context of emissions-related levies, the 35th Assembly of ICAO recognized the continued validity of the Council's Resolution of 9 December 1996 on Environmental Charges and Taxes which applies to emissions in general. It also requested that the ICAO Council develop further guidance on emissions levies related to local air quality.

1.1.2 This guidance was developed to respond to this Assembly request. It is intended to assist those States that have decided to levy emissions charges on aircraft with respect to aircraft emissions that have local air quality effects. Specifically, this guidance addresses how to implement such charges consistent with ICAO policy. It should be noted that the guidance is not of a regulatory nature. Rather, it provides States with advice and information that they may need or find helpful. This guidance cannot, and does not purport to, cover every conceivable issue that might arise; indeed ICAO recognizes that States have their own legal obligations, existing agreements, current laws and established polices. States should therefore exercise discretion in applying this guidance to their specific circumstances.

1.2 SCOPE OF THE GUIDANCE AND KEY TERMS

1.2.1 Consistent with the remit to develop guidance on implementing local emissions charges, this guidance addresses only such charges. ICAO has an environmental goal to limit or reduce the impact of aviation emissions on local air quality. Charges are but one potential means for addressing aircraft emission issues. The Assembly requested the Council "to continue to study policy options to limit and reduce the environmental impact of aircraft engine emissions placing special emphasis on the use of technical solutions while continuing its consideration of market-based measures" (Assembly Resolution A35-5, Appendix H, Action Clause 2b)). Further, when market-based measures such as emissions charges are adopted, States are encouraged "to evaluate the costs and benefits of the various measures, including existing measures, with the goal of addressing aircraft engine emissions in the most cost-effective manner" (Assembly Resolution A35-5, Appendix I, Action Clause 2). Thus, for purposes of this guidance, it is assumed that a State (or its delegate) that has chosen to proceed with a local emissions charge on aircraft already has considered a range of options and has carried out a cost-effectiveness analysis and that the State is in the implementation stage for such a measure. By providing this guidance, ICAO does not mean to promote the use of emissions charges. However, it provides this guidance to promote consistency in approaches among those States that have decided to employ such charges.

1.2.2 While this guidance focuses on implementation of a local emissions charge, it may also be of assistance to those States (or their delegates) that are in the earlier stage of considering whether to proceed with a local emissions charge, as compared to other options. In such a case, the State (or its delegate) could use the guidance to assist in its consideration of a potential charges measure.

1.2.3 The following terms are defined in the context of this guidance.

a) *Aircraft emissions with local air quality effects.* For the purposes of this guidance, aircraft emissions with local air quality effects are defined as those aircraft emissions generated in the vicinity of an airport by aircraft either arriving or departing from that airport. The aircraft emissions include those generated from aircraft main engines either on the ground or in the air up to a level deemed to have local effect, as defined by the jurisdiction where the emissions are released. The aircraft pollutants of concern for these purposes are those gaseous emissions currently controlled for certification of aircraft engines under Annex 16, Volume II, including oxides of nitrogen (NO_x), carbon monoxide (CO), and hydrocarbons (HC). It is also recognized that secondary pollutants and particulate matter (PM) emissions from aircraft may have local effect and are a source of continuing research and evolving scientific understanding. To the extent that this research and understanding develops so as to allow ICAO to conclude that: 1) a new standard for direct emissions from aircraft engines is warranted or 2) a causal relationship can be demonstrated from direct emissions of precursors, then the directly emitted pollutant(s) may also be identified as an aircraft emission of concern for purposes of this emissions charging guidance.

b) ICAO recognizes that different States may have different standards or thresholds for designating whether a pollutant as emitted has local effect. In many cases, this is expressed in terms of a maximum altitude up to which a particular pollutant is emitted. Some States may specify a specific altitude for such purposes. Others may direct that modelling be undertaken to identify the altitude at which pollutants may have local effect in a particular area, often referred to as the "mixing height" within the atmospheric "boundary layer". In basic terms, the "mixing height" is the height of the vertical mixing of the air and suspended particles above the ground within the atmospheric boundary layer. Also in basic terms, the "boundary layer" is that part of the troposphere that is directly influenced by the presence of the earth's surface. States that specify a mixing height be determined for purposes of local air quality assessment typically have accepted models for such analyses and/or specify a default height for the mixing height, such as 3 000 feet.

c) *Local emissions charge for aircraft.* ICAO defines a charge as "a levy that is designed and applied specifically to recover the costs of providing facilities and services for civil aviation" (Doc 9082/7 and Assembly Resolution A35-5, Appendix I). In the context of aircraft emissions with local air quality effects, a local emissions charge for aircraft is a levy (or fee) that is designed and applied specifically to prevent or mitigate environmental impact to local air quality caused by and directly attributable to civil aircraft operations.

d) *Tax.* ICAO defines a tax as "a levy that is designed to raise national or local government revenues which are generally not applied to civil aviation in their entirety or on a cost-specific basis" (Assembly Resolution A35-5, Appendix I).

1.3 EXISTING ICAO POLICIES ON CHARGES

1.3.1 To the extent that local emissions charges are to be levied on international flights, those charges should be consistent with ICAO policies on charges. The policies that are particularly relevant to emissions charges are enumerated in this section of the guidance. These policies have been culled from the ICAO Council Resolution on Environmental Charges and Taxes (adopted 9 December 1996) (referred to in this guidance as "Council Resolution"), Assembly Resolution A35-5, Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection (referred to in this guidance as "A35-5"), and *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082/7) (referred to in this guidance as "ICAO's Policies"). Before implementing an aircraft emissions local emissions charging scheme, a State (or its delegate) should confirm that the scheme is consistent with these policies.

1.3.2 *Take into account the interests of all parties concerned.* When market-based emissions measures, such as charges, are adopted, Contracting States are encouraged "to take into account the interests of all parties concerned…" *Source:* A35-5, Appendix I, 2nd Action Clause.

1.3.3 *Non-discrimination.* The ICAO Council urges "States that are considering the introduction of emissions-related charges to take into account the non-discrimination principle in Article 15 of the Convention on International Civil Aviation..." *Source:* Council Resolution, 5th Action Clause. "Charges must be non-discriminatory both between foreign users and those having the nationality of the State in which the airport is located and engaged in similar international operations, and between two or more foreign users." *Source:* ICAO's Policies, Paragraph 23(iv).

1.3.4 *Take into account the potential impacts on the developing world.* When market-based measures, such as emissions charges, are adopted, Contracting States are encouraged "to take into account the potential impacts on the developing world…" *Source:* A35-5, Appendix I, 2nd Action Clause. In light of the non-discrimination provision in Article 15 of the Chicago Convention, the way in which the potential impacts on the developing world are taken into account must not discriminate on the basis of State of Registry. This may or may not preclude the possibility of exemptions or waivers based on technical criteria, a transitional approach or a phased implementation. An example of a technical approach for taking into account the potential impacts on the developing world without running afoul of the non-discrimination requirement might be to exempt *de minimis* operations into an airport from the charging scheme. Operators from developing States may be able to benefit from *de minimis* exemptions, to the extent they may have fewer operations into a particular airport than operators from developed States. Nonetheless, because any operator from any State could take advantage of a *de minimis* exemption if its operations were below the threshold, such a scheme would not be discriminatory based on State of Registry.

1.3.5 *Transparency.* Charging authorities are urged to "Ensure transparency as well as the availability and presentation of all financial data required to determine the basis for charges." *Source:* Doc 9082/7, Paragraph 15(iii).

1.3.6 *Cost-basis.* "States that are considering the introduction of emissions-related charges" are urged to take into account the principle that "the charges should be related to costs". *Source:* Council Resolution, 5th Action Clause. Further, "charges should be based on the costs of mitigating the environmental impact of aircraft engine emissions to the extent that such costs can be properly identified and directly attributed to air transport". *Source:* A35-5, 10th "Whereas" Clause.

1.3.7 *Cost-effective measures.* When market-based measures, such as emissions charges, are adopted, States are encouraged "to evaluate the costs and benefits of the various measures, including existing measures, with the goal of addressing aircraft engine emissions in the most cost-effective manner..." *Source:* A35-5, Appendix I, 2nd Action Clause.

1.3.8 *Minimize competitive distortion.* "States that are considering the introduction of emissions-related charges" are urged to take into account the principle that "the charges should not discriminate against air transport compared with other modes of transport". *Source:* Council Resolution, 5th Action Clause. In addition, authorities are urged to "Ensure there is no overcharging or other anti-competitive practice or abuse of dominant position." *Source:* Doc 9082/7, Paragraph 15(ii).

1.3.9 *No fiscal aims.* "States that are considering the introduction of emissions-related charges" are urged to take into account the principle that "there should be no fiscal aims behind the charges". *Source:* Council Resolution, 5th Action Clause.

1.3.10 *Charges, rather than taxes.* The ICAO Council "Strongly recommends that any environmental levies on air transport which States may introduce should be in the form of charges rather than taxes..." *Source:* Council Resolution, 4th Action Clause.

1.3.11 *Funds collected should be used to mitigate environmental impact.* The ICAO Council "Strongly recommends that any environmental levies on air transport which States may introduce should be in the form of charges rather than taxes and that the funds collected should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions, for example to: (a) addressing the specific damage caused by these emissions, if that can be identified; (b) funding scientific research into their environmental impact; or (c) funding research aimed at reducing their environmental impact, through developments in technology and new approaches to aircraft operations." *Source:* Council Resolution, 4th Action Clause.

1.4 OTHER EXISTING ICAO GUIDANCE

1.4.1 In addition to the policies outlined in 1.3, States may also wish to note that Appendix A of Assembly Resolution A35-5 states that "ICAO is conscious of and will continue to take into account the adverse environmental impacts that may be related to civil aviation activity and its responsibility and that of its Contracting States to achieve maximum compatibility between the safe and orderly development of civil aviation and the quality of the environment." Specifically in relation to local air quality, the Resolution states that ICAO will strive to "limit or reduce the impact of aviation emissions on local air quality".

1.4.2 States may also wish to note that Appendix I of A35-5 states that there has been increasing recognition by Governments of the need for each economic sector to pay the full cost of the environmental damage it causes. Appendix I also states that market-based measures are policy tools that are designed to achieve environmental goals at lower cost and in a more flexible manner than traditional regulatory measures.

1.4.3 Appendix I also recalls Principle 16 of the Rio Declaration on Environment and Development (1992) which states that "national authorities should endeavor to promote the internalization of external costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment".

Chapter 2

PROCESS FOR IMPLEMENTING LOCAL EMISSIONS CHARGES

This chapter further identifies how States wishing to implement local emissions charges on aircraft might do so, specifically identifying the steps that are involved in the process.

2.1 RESPONSIBILITY OF CONTRACTING STATES

It is ultimately the responsibility of individual Contracting States to develop appropriate solutions to environmental problems at their airports, with due regard to ICAO rules and policies. Appendix I of Assembly Resolution A35-5 recognizes in the context of market-based measures that Contracting States have legal obligations, existing agreements, current laws and established policies. During the different phases of the introduction of any measure, Contracting States may chose to delegate their powers to any competent authority. Thus, while this guidance is specifically provided for States, it may also be applied by their delegates.

2.2 AN AIRPORT-BY-AIRPORT APPROACH

This guidance is intended to apply to any airport being served by international air traffic that has an identified local air quality (LAQ) problem and at which emissions charges have been identified as an appropriate instrument for mitigation. ICAO recognizes that a local emissions charging scheme needs to be tailored to the specific characteristics of the airport concerned by means of an airport-by-airport approach. Nonetheless, a general framework may be implemented at a State level in order to set up a common methodology for the implementation of the scheme on an airport level for airports meeting the above criteria.

2.3 AN INCLUSIVE AND TRANSPARENT PROCESS

ICAO urges States to institute or oversee an inclusive and transparent process when adopting and implementing local emissions charges. The steps in this could include, but may not necessarily be limited to, the following:

a) local air quality assessment, including

   1) identification of relevant local air quality standards and regulations;

   2) determination of airport air quality;

   3) compliance and impact assessment; and

   4) quantification of aircraft relative contribution;

b) designing a local emissions charges scheme, including

   1) aircraft engine emissions classification;

   2) establishing a cost-basis; and

   3) ways of levying the charge; and

c) administration, including

   1) provision for consultation;

   2) dissemination of the evaluation results;

   3) notification of decisions;

   4) dispute resolution; and

   5) reporting and record-keeping.

Chapter 3

LOCAL AIR QUALITY ASSESSMENT

3.1 OVERVIEW

States (or their delegates) that intend to introduce local emission charges on aircraft should make an assessment of the existing and forecast future airport local air quality by comparing pollutant concentrations in the air in the vicinity of the airport against the relevant local air quality (LAQ) standard(s) and goals to determine if any exceedences exist or are predicted. This will identify whether a local air quality issue exists (or will exist in future) and to what extent. Accordingly, this chapter provides guidance on assessing LAQ at airports, determining compliance or otherwise with local air quality standards and goals, and quantifying the aircraft contribution to any non-compliance and its impact.

The recommended process involves four steps:

Step 1: Identification of relevant local air quality standards and regulations;

Step 2: Determination of airport air quality;

Step 3: Compliance and impact assessment; and

Step 4: Quantification of aircraft relative contribution.

More detail on these steps is provided below.

3.2 STEP 1 — IDENTIFICATION OF RELEVANT LOCAL AIR QUALITY STANDARDS AND REGULATIONS

3.2.1 Responsibility for defining and achieving acceptable air quality in and around airports rests with the State. States have historically developed their own air quality regulations and guidelines and, therefore, a number of national air quality standards exist. Some airports or regions may also establish criteria or goals that are more stringent than State standards (e.g. due to regional concerns).

3.2.2 In assessing local air quality in the vicinity of airports, it is important to identify any relevant local air quality standards and goals established by the State (or its delegate) to protect public health and welfare and the environment in general. These standards usually identify the levels or concentrations of pollutants that the State deems acceptable or unacceptable within a specified volume of air. Generally, local air quality standards or regulations will indicate the emissions species to be assessed, acceptable concentrations of each species over a specific period of time, the location or locations where the assessment is to be made and the period over which the assessment should be made. Other requirements such as measurement, modelling and reporting may also be specified. For more information on standards, regulatory drivers, and other background information related to State requirements, consult the *Airport Air Quality Guidance Manual* (Doc 9889, in preparation).

3.3 STEP 2 — DETERMINATION OF AIRPORT AIR QUALITY

3.3.1 Airports and their associated activities are sources of different gaseous and particulate emissions. There are many air pollutants present in gaseous emissions from aviation-related activities that impact the environment. However, not all pollutants are relevant or regulated, and State requirements should be considered. Common emissions species considered in airport air quality assessments, which are relevant to this guidance, are oxides of nitrogen (NO_x), hydrocarbons (HC), and carbon monoxide (CO), though other pollutants such as sulfur oxides (SO_x) are often assessed as well.

3.3.2 Local air quality in and around an airport is quantified in terms of pollutant concentrations, as identified in Step 1 above. These concentrations can be calculated from airport activity data and numerical models of the emissions of each source and their interaction with the physical environment. Alternatively or additionally, existing pollutant levels can be measured using automated air sampling and analysing equipment.

3.3.3 *Numerical modelling.* Existing and/or predicted future concentration levels can be calculated utilizing software tools (numerical models). Local air quality modelling consists of the following two basic steps.

3.3.3.1 *Emissions inventory.* An airport emissions inventory identifies the total amount of emissions of each species under consideration (e.g. pollutant kilograms over a specified period) generated by airport sources, either currently or at some future time. There are many emissions sources at airports and they typically are grouped into four categories:

a) aircraft;

b) aircraft handling;

c) stationary or infrastructure-related sources; and

d) landside vehicle traffic sources.

The total airport emissions inventory is quantified by totalling all airport source emissions. For aircraft this should cover emissions generated during the landing and take-off (LTO) cycle, calculated using inputs including aircraft and engine types, performance data, engine emissions data, number of aircraft movements, engine emissions factors (e.g. an emissions rate expressed as g/kg of fuel), and the respective operational parameters over a determined period. For the other sources including aircraft handling, stationary and infrastructure-related sources and landside traffic sources, individual emission source data for each source and species is required, as well as equipment and activity/operating data. The inventory should take into account the quantity of each species and the periods over which species of pollutants are emitted. In some cases, e.g. when subsequent dispersion modelling is to be performed based upon these data, inventories also take other parameters into account, such as location, time and temperature of the emissions.

The emissions inventory is a necessary input to dispersion modelling and determination of pollutant concentrations as outlined below. For more information on emissions inventorying and temporal and spatial distribution (e.g. steps, inventory parameters, emission species, airport emissions sources, and other considerations or factors), consult the *Airport Air Quality Guidance Manual* (Doc 9889, in preparation).

3.3.3.2 *Dispersion modelling.* Dispersion is the process by which atmospheric pollutants disseminate due to atmospheric conditions, terrain, buildings, chemical reactions and other factors. Dispersion modelling is a calculation procedure that takes parameters (including, among others, airport source emissions calculated in the emissions inventory, the timing and location of the emissions, meteorological conditions, and topography) and estimates the expected pollutant concentration levels at receptor locations, such as positions on an airport or at neighboring residential areas. These pollutant concentrations are calculated to determine whether emissions from the airport result in unacceptably high air pollution levels, and exceed State standards or goals (by comparison to relevant regulations).

Various computer models with varying levels of sophistication are available to perform such modeling. ICAO is developing for CAEP/8 in 2010 dispersion modelling guidance to include in the *Airport Air Quality Guidance Manual* (Doc 9889, in preparation). Until such time that this guidance on dispersion modelling is available, States should follow State-specific guidelines and are encouraged to use the best available data and methodologies.

3.3.4 *Measurement.* Air quality measurements of existing conditions can be conducted using air sampling and analysing equipment that measures and records the current concentrations of a pollutant species at a specific location. Using a series of measurements, pollutant levels can be tracked over time and the average levels over a specific period (e.g. 1-hour, 8-hour, 24-hour, or 1 year) can be determined. Proprietary measurement equipment, including mobile units that can be installed temporarily, is widely available. Air quality measurements of existing pollutant levels can be used either directly or in combination with modelled results to determine the existing air quality situation at and in the vicinity of the airport (as measurements can only be taken of existing conditions, future local air quality can only be assessed using modelling). When measurements are used in combination with modelling, the measured data can be used to evaluate and refine modelled results or, conversely, modelling can be used to put the results of measurements into a proper context (e.g. when major off-site pollution sources dominate local air quality). ICAO is developing for CAEP/8 in 2010 measurement guidance to include in the *Airport Air Quality Guidance Manual* (Doc 9889, in preparation). Until such time that this guidance on measurement is available, States should follow State-specific guidelines and are encouraged to use the best available data and methodologies.

3.3.5 *Air quality forecasts.* Air quality measurements and the corresponding modelling calculations indicate only the existing situation at an airport. To predict the air quality situation at some time in the future, the inventory needs to be repeated for some future operational scenario. Factors to be taken into account include, for example, projections of the volume of air traffic movements, the fleet mix including types of aircraft and engines, changes in airport infrastructure, changes in aircraft operational procedures, the expansion and/or replacement of non-aircraft sources including ground service equipment and other vehicles, and background concentrations of the pollutant species in the area. Once the expected growth (or reduction) of each of the relevant sources has been evaluated, the new inventory can be used to model the expected future air quality concentrations.

3.4 STEP 3 — COMPLIANCE AND IMPACT ASSESSMENT

The next step is to compare the measured and/or calculated existing and forecast pollutant concentrations to the concentrations specified in applicable State regulations in order to assess existing and future compliance with the standards and requirements. As State air quality standards are generally based on the protection of health of the population and the environment in general, exceedances of these limits are indicative of an adverse impact and typically action is required to alleviate the non-compliance and its impact.

3.5 STEP 4 — QUANTIFICATION OF AIRCRAFT RELATIVE CONTRIBUTION

To determine the relative contribution of aircraft to the LAQ situation, that contribution needs to be put in context with other airport sources and all airport sources may need to be put into the larger context of whatever local area is subject to the emissions standard or requirement. The contribution of an airport source’s emissions to the airport’s total emissions and its overall impact is dependent on the amount, time, and location of the emissions. Should such detailed analysis not be practicable, simplifying assumptions might be employed to estimate the aircraft contribution.

Chapter 4

DESIGNING A LOCAL EMISSION CHARGES SCHEME

4.1 OVERVIEW

Once the local air quality situation and the aircraft contribution to adverse impact has been determined, the charging scheme itself can be designed. The relevant steps States may wish to consider for designing such a charge are addressed in this chapter.

4.2 AIRCRAFT ENGINE EMISSIONS CLASSIFICATION

4.2.1 In implementing a charging scheme, a common methodology for quantifying the amount of emissions from different aircraft engines should be identified, such that the charges applicable to specific aircraft can be determined and differentiated. Thus, a classification scheme is recommended to enhance consistency in the way aircraft engine emissions are calculated for purposes of applying a charge. The classification scheme should incorporate an accepted methodology for measuring the amount of emissions from each aircraft during a landing and take-off (LTO) cycle. The methodology within this classification scheme should be transparent, reliable, consistently applied, and generally accepted by stakeholders.

4.2.2 ICAO recommends that an emissions classification scheme with the following elements be implemented:

a) *Calculation based on absolute mass of emissions.* The basis on which the aircraft is classified should be the absolute mass of the specified emissions within a landing and take-off (LTO) cycle. As noted previously in, and for the purpose of, this guidance, the emissions of potential concern are NO_x, HC and CO. To determine the mass of emissions per aircraft, every aircraft type has to be considered individually by identifying the specific engine type and using the relevant emissions data together with the number of those engines fitted to the aircraft.

b) *LTO cycle.* Historically, ICAO has developed certification standards for aircraft engine emissions based on a standardized LTO cycle, with default assumptions for the time an aircraft will operate in each of the four LTO-modes (take-off, climb out, approach and taxi). In daily aircraft operation, however, thrust settings and time in each mode are very much dependent on specific conditions like aircraft weight, outside temperature, wind, airport altitude, runway conditions and airline procedures. It should be noted that actual emissions will also vary according to factors such as ambient conditions and the mechanical condition of the engine. The ICAO standardized LTO cycle will, therefore, not necessarily reflect actual emissions from aircraft engines at a specific airport. Therefore, within the context of emissions charges, actual times in mode or approximated actual times (e.g. average actual data or performance-based times) and performance-based thrust settings are preferred over ICAO default times whenever available. Likewise, for practicality, actual aircraft operational data for a specific aircraft may need to be averaged over a specified time period (e.g. the previous 3 months or the previous 6 months.) Absent the availability of average actual data or performance-based data, the default ICAO standard assumptions might be used.

For more information on calculating emissions during the LTO cycle, consult the *Airport Air Quality Guidance Manual* (Doc 9889, in preparation).

c) *Calculation of the emission value for an aircraft.* The following sets forth a recommended methodology for calculating an absolute amount of a specified emission (in this guidance, NO_x, CO or HC) from an aircraft's engines during an LTO cycle, using NO_x as an example. While the information is specific to NO_x, the same approach can be taken for other emissions by replacing the "NO_x index" (i.e. EI_{NO_x}) in the formula with the index for another emission (for example, by replacing the "NO_x index" with the "CO index").

Aircraft main-engine emissions are a function of four parameters: aircraft fleet, time-in-mode and fuel flow, aircraft movements, and main engine emission indices. The basic equation is a function of these four parameters, as shown below. The purpose and need for quantifying aircraft emissions drive the level of accuracy required, which in turn determines the sophistication level of the equation inputs used. For emissions charges purposes, a refined method for calculating aircraft emissions using best available and refined data (i.e. refined engine emission indices, aircraft time-in-mode including representation of mixing height, aircraft thrust level) should be utilized to most closely approximate actual aircraft LTO operations.

The absolute amount of NO_x within the LTO cycle is calculated by using the ICAO pollutant emission index (EI) values for all LTO-modes of the individual engine and multiplying those EIs by the corresponding modal fuel flow. An EI is the mass of pollutant (CO, HC or NO_x), in grams, divided by the mass of fuel used in kilograms. When ICAO engine emission indices (EIs) are used to calculate aircraft emissions, it is important to use the pollutant EI of the measured data, and not the pollutant D_p/F_{oo} characteristic level of the regulatory data, which also is reported in the ICAO databank.

Note.— The characteristic D_p/F_{oo} level is used to determine compliance of an engine type with emission standards. It is derived by correcting the measured EI values of an engine to the reference standard engine and reference atmospheric conditions and calculating an average D_p/F_{oo} level. This is then converted to a characteristic level by the application of a coefficient corresponding to the number of tests and number of engines tested. The resulting statistically corrected values are always higher than the average D_p/F_{oo} level.

The formula is as follows:

$$Aircraft - NO_{x_{LTO}} = E_N * \sum_{LTO\text{-}modes} (60 * time * fuel\ flow * EI_{NO_x} \div 1000)$$

where:

E_N: number of engines fitted to the aircraft

Time: time in mode (in minutes)

Fuel flow: fuel flow per mode (in kg/sec)

EI_{NO_x}: index per LTO-mode, NO_x emissions (in g/kg fuel)

Multi-pollutant considerations.

As noted above, the approach for calculating mass NO_x could also be used for other emissions, such as HC or CO. However, there may be instances where a State or its delegate may want to take multiple emissions into account in a single aircraft engine emissions classification scheme. Although there is no ICAO-endorsed methodology for considering multiple emissions, one example methodology is the ECAC emissions classification scheme for NO_x, as reflected in ECAC/27, Report, Strasbourg, 8–9 July 2003. NO_x is the primary emission used for this classification methodology. However, ECAC recognized that some engines, particularly older engines, may have relatively low NO_x emission values, but at the same time relatively high hydrocarbon emissions (HC). HC — applied as a factor in relation to the ICAO limit — is mainly used in this calculation to avoid any undue treatment of engine technology with higher HC. The current ICAO standard [1] requires that any regulated engine shall not exceed the characteristic HC D_p/F_{oo} of 19.6 g/kN rated output[2] during the LTO cycle test regime. For non-regulated engines (i.e. in this context engines without ICAO emissions certification) hydrocarbons are not being considered, as the term D_p/F_{oo} in g/kN is not applicable for unregulated engines.

Accordingly, under the ECAC aircraft engine emissions classification scheme, all considered aircraft are set into a linear scale with the value:

$$Emission\ Value_{Aircraft} = a * NO_{x_{Aircraft}} \qquad \text{(no dimension)}$$

where:

a = 1 if the average HC D_p/F_{oo} is less than or equal to the current ICAO standard of 19.6 g/kN rated output or for unregulated engines.

a > 1 if the average HC D_p/F_{oo} is larger than the current ICAO standard.

a = average measured HC D_p/F_{oo} / 19.6, with a maximum value for “a” of 4.0

d) *Application to aircraft with engines that are not certified under Annex 16, Volume II, Part III, Chapter 2 or Chapter 3.* It is recommended that all civil aircraft with engines that are certified (i.e. regulated) under Annex 16, Volume II, Part III, Chapter 2 or Chapter 3 be classified with the above recommended methodology. This guidance does not address how or whether States should classify aircraft with non-certified aircraft engines. However, should a State decide to cover such aircraft with a charging scheme, the State should apply a consistent methodology to those aircraft. Appendix II gives one example of how some States have addressed the application of charges to aircraft that are powered by non-certified aircraft engines.

e) *Data sources.* Emission factors for ICAO-certified turbojet and turbofan engines of rated outputs > 26.7 kN are published in the ICAO Aircraft Engine Emissions Databank and can be found on: http://www.caa.co.uk/default.aspx?catid=702&pagetype=90

1. ICAO, Annex 16, Volume II — *Aircraft Engine Emissions,* 2nd edition, July 1993.
2. D_p is the mass of any gaseous pollutant emitted during the reference emissions LTO cycle. F_{oo} is the rated output, which, for engine emissions purposes, is the maximum power/thrust available for take-off under normal operating conditions at ISA sea level static conditions without the use of water injection as approved by the certifying authority.

4.3 ESTABLISHING A COST-BASIS

4.3.1 As noted previously in this guidance, if local emissions charges are to be applied to aircraft, those charges should be based on the costs of mitigating or preventing the environmental impact of aircraft engine emissions. In determining the cost-basis, States may find it beneficial to consider the following guidelines.

4.3.2 *Types of costs.* The costs at issue are the costs that are properly identified and directly attributable to the aircraft contribution to LAQ adverse impact. These costs can be quantified in terms of damage, mitigation and/or prevention costs, as follows:

4.3.2.1 *Damage costs.* Damage costs are the costs incurred due to repercussions (effects) of direct environmental impacts (for example, from the emission of pollutants) such as the degradation of land or human-made structures or health effects. These costs are borne by a party(ies) other than the emitter or producer of a product or service. Damage costs can take many forms, such as water contamination or the adverse effects on human health, caused by the degradation of local air quality from pollutants such as NO_x, HC and CO. If aircraft emissions charges are to be based on the value of the adverse environmental impact, an environmental damage cost assessment of the aircraft's contribution to adverse impact would need to be performed. Once the effects of environmental damage are known, the next step is to try to monetize the adverse effects, to the extent possible. It is beyond the scope of this guidance to address the means by which this process might be carried out. Nonetheless, some States may have guidance available on how to monetize such effects. After the damages are valued, a charge can then be set to recover those costs, apportioned to aircraft based on their contribution to the damage.

This process may be difficult to implement, however. While the environmental impacts may be readily identified in the form of smog alert days and adverse effects on health, it can be difficult to quantify these costs in terms of a monetary value. Health care or medical costs, for example, cannot be easily apportioned to a specific pollution species or source.

4.3.2.2 *Mitigation costs.* Mitigation costs are the costs aimed at adopting corrective measures to reduce an adverse environmental impact. This corrective action is typically in response (or reactive) to a problem once it has been discovered. If the charges are to be based on the costs of measures identified to alleviate the adverse impact, an assessment of the available measures would need to be undertaken. ICAO urges that any mitigation measures that are to be funded by aircraft charges be the most cost-effective measures available.

4.3.2.3 *Prevention costs.* Prevention costs are the costs to be incurred by taking actions aimed at avoiding anticipated adverse environmental impacts. This corrective action is typically proactive in anticipation of a problem**.** If a LAQ charge on aircraft operations is to be based on prevention costs, an assessment of the available measures would need to be undertaken. ICAO urges that any prevention measures that are to be funded by aircraft charges be the most cost-effective measures available.

4.3.2.4 *Relationship between damage costs and mitigation and/or prevention measures.* To the extent that mitigation and prevention measures are intended to address the damage from aircraft emissions, ideally the costs of any mitigation or prevention measures should be no greater than estimated damage costs. However, due to the fact that full or complete information for damage valuation may not be available, for a multitude of reasons, correlating damage costs with mitigation and prevention costs can be difficult. Nonetheless, the damage assessment process based on the best information available can provide a guidepost for determining the magnitude of the mitigation or prevention measures one might take to address the problem.

4.3.3 *Avoiding over-charging.* To the extent that aircraft emissions charges are to be based on the costs of the portion of an LAQ problem that is directly attributable to the operation of aircraft, when a State (or its delegate) implements such a charge, care should be taken to avoid over-charging for the same problem. For example, if a general levy is put in place to deal with a specific NO_x impact level from all sources of local emissions (including aircraft) on or in the proximity of an airport, then an aircraft emissions charge aimed at addressing that same NO_x impact level would be inappropriate if it led to aircraft paying more than their share of the full damage, mitigation, or prevention costs.

4.3.4 *Proper calibration, review and uses of charges.* To the extent that local emissions charges are to be used, they should be calibrated on a periodic basis (e.g. annually or biennially, but typically not less than every four years) to address an identified existing or future local air quality problem. The charges will usually be levied by an airport on an aircraft operator. Local emissions charges can address the cost mentioned in 4.3.1 with the policies and principles described in Chapter 1.

A requirement to evaluate and justify an emissions charge (and its level) over a specified period of time should be made part of any emissions charging scheme adopted by States. Once an environmental problem attributed directly to aircraft has been corrected and is not projected to return, LAQ aircraft emissions charges should cease to be imposed.

4.3.5 *Use of funds to address LAQ impacts.* Existing ICAO policy (the December 1996 Council Resolution and Assembly Resolution A35-5) states that the funds collected from an emissions charge should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions. The December 1996 Resolution provides three examples:

a) addressing the specific damage caused by these emissions, if that can be identified;

b) funding scientific research into their environmental impact;

c) funding research aimed at reducing their environmental impact, through developments in technology and new approaches to aircraft operations.

4.3.5.1 As these categories are only examples, States may want to consider other categories of costs consistent with ICAO policy. For example, States may want to fund the mitigation or prevention of aircraft emissions from within the aviation sector. Such measures may also include air quality data gathering, monitoring and reporting systems for aircraft emissions, to the extent that it addresses aircraft contribution to a local air quality concern. Examples of such measures might include the following:

a) local air quality monitoring on the airport and in the vicinity to the extent it is believed aircraft may be contributing or are contributing to a local air quality problem;

b) airport-related emission inventory calculation and dispersion modelling to the extent it is believed aircraft may be contributing or are contributing to a local air quality problem;

c) installation of fixed ground power and ventilation for aircraft at piers, aimed at mitigating emissions;

d) installation of low emission fuel station (e.g. liquid natural gas or bio-fuels) for handling equipment and airside traffic, aimed at mitigating emissions;

e) improvements to aircraft ground movement systems such as taxiways designed to reduce emissions; and

f) air quality management, research and development aimed at addressing aircraft local air quality emissions.

4.3.6 *Cost-effectiveness.* Simply defined, cost-effectiveness represents achieving an environmental objective to reduce or avoid any adverse impacts on LAQ in the least costly way. States are encouraged to employ this concept in every facet of activities related to emissions charges, as a means of ensuring consistency with ICAO's policies on charges. Cost-effectiveness analysis is a technique that evaluates the variable costs or variable benefits against a prescribed objective (status quo or baseline) to determine cost-effectiveness. For a more detailed definition and discussion of cost-effectiveness analysis, please see *Guidance on the Balanced Approach to Aircraft Noise Management* (Doc 9829).

4.4 WAYS OF LEVYING THE CHARGE

4.4.1 There are different ways in which a State (or its delegate) might levy an aircraft emissions charge. This guidance describes some of the concepts and possibilities; in practice, schemes may be a hybrid of these.

4.4.2 *LTO cycle.* To the extent that the emissions classification scheme described above is employed, it would be most logical to levy the local emissions charge (LEC) based on the emissions generated on an LTO cycle basis for each aircraft. In this manner, an LEC scheme could be based on records of movements used to generate periodic (e.g. monthly) invoicing.

4.4.3 *Direct charge.* A stand-alone, direct charge would be administered as a specific fee, separate from other fees an airline operator is subject to at a particular airport. This approach is likely to be the most transparent means for levying and collecting a charge, as the charging amount and its relation to the aircraft operator's emissions could be clearly reflected on the invoice that is used and not intertwined with other fees. For example, the charge levied could be expressed as a fee for each aircraft based on a fixed amount per kilogram of a certain species of pollutant (e.g. $x/kg NO_x) emitted during the LTO cycle, which typically would be determined through application of the aircraft emissions classification methodology.

4.4.4 *Modified landing (or take-off) charge.* An alternative scheme could involve applying a modification to an already existing fee, such as a landing (or take-off) fee. For example, for a specified level of NO_x emitted in the LTO cycle (as determined through the aircraft emissions classification methodology), the landing fee is increased by x%.

4.4.5 *Surcharges and rebates*

4.4.5.1 *Surcharge.* A surcharge is a charge applied to an aircraft movement which emits more than a certain threshold of a particular pollutant species. This can take the form of a direct charge to the aircraft operator or an increased landing (or take-off) fee. The threshold could be defined on a scale set according to an aircraft's emissions as determined through the aircraft emissions classification methodology. The size of the surcharge can be linked to the extent to which the emissions are over the threshold. If the threshold is set at zero, then all aircraft would be paying a surcharge.

4.4.5.2 *Rebate.* A rebate is a refund (or discount) applied to an aircraft movement which emits less than the threshold of a particular pollutant species. A rebate on lower emissions aircraft would generally be applied in conjunction with a surcharge on the higher emissions aircraft, using the same threshold. The rebate can take the form of a direct refund to the aircraft operator or a decreased landing (or take-off) fee. The size of the rebate can be linked to the extent to which the emissions are below the threshold.

4.4.5.3 *Related to costs.* The level of the surcharges and rebates in a surcharge/rebate scheme should be based on analysis indicating that these surcharges/rebates will address the identified emissions problem. If it is intended that the total of the surcharges collected (over a certain period) is to be greater than the total of the rebates distributed, then the difference (i.e. net monies collected), should be related to costs as outlined in 4.3 of this guidance.

It is also possible to set up a surcharge and rebate scheme, where there are no net monies collected (i.e. the total surcharges are equal to the total rebates) or where the total surcharges are less than the total rebates.

Chapter 5

ADMINISTRATION

5.1 PROVISION FOR CONSULTATION

5.1.1 Opportunities for meaningful consultation with stakeholders should be provided from the point a charge is being considered, through the point such a measure is adopted, and after adoption throughout the period of implementation.

5.1.2 Consultation aims to provide a forum in which all points of view may be explored in order to provide stakeholders the opportunity to be made aware of a perceived problem and to be notified that there is an intent to pursue corrective action through the implementation of local emissions charges.

5.1.3 Consistent with a transparent process, inviting stakeholders to participate in the discussions on the development of a new charge may help to highlight any practical issues or difficulties at an early stage. An open dialogue can be vital in developing mutual trust between all participants.

5.2 DISSEMINATION OF THE EVALUATION RESULTS

Information on the local air quality situation, evaluation of impacts, determination of the aircraft contribution to those impacts, and on the cost-basis for the charge should be disseminated to stakeholders.

5.3 NOTIFICATION OF DECISIONS

Information regarding a proposed charge should be communicated as early as possible. When a revision of charges or the imposition of new local emissions charges is contemplated by a State (or its delegate), appropriate notice should be given to the airlines or their representative bodies, normally at least four months, in accordance with the regulations applicable in each State. Reasonable advance notice of the final decision should also be provided.

5.4 DISPUTE RESOLUTION

In order to avoid and/or minimize disputes it is important to have an open dialogue with the stakeholders and be transparent in the methodology and calculations of the charge. There may be a need for a “first resort” mechanism in case a dispute arises. Essentially, this entails having a neutral party at the local level available to focus on conciliation or mediation, or full arbitration if the State concerned so decides. Beyond that, there should be an appeals process consistent with the regulatory regime in the State concerned.

5.5 REPORTING AND RECORD-KEEPING

Any State (or its delegate) imposing local emissions charges on aircraft that are in international operation should annually report the existence of such charging schemes to ICAO. Furthermore, the charging authority should maintain records regarding the charges collected and the use of funds and make them available to all users.

Appendix A

GLOSSARY OF TERMS

This appendix contains a glossary of terms used in this guidance. It is not an exhaustive list of terms related to aviation environmental issues but, rather, contains those key terms needed to better explain the nature of this guidance and its use in the proper context.

CAEP. Committee on Aviation Environmental Protection.

Certificated aircraft engine. An engine that has demonstrated compliance with the requirements for emissions certification specified in Annex 16, Volume II, Part III, Chapter 2 or Chapter 3. Any aircraft engine that does not meet this compliance would be termed a non-certificated aircraft engine.

Charge. A levy that is designed and applied specifically to recover the costs of providing facilities and services for civil aviation. In the context of local emissions, a **local emissions charge for aircraft** is a levy (or fee) that is designed and applied specifically to alleviate environmental impact to local air quality caused by and directly attributable to civil aircraft operations.

Cost-effectiveness analysis (CEA). A technique that evaluates the variable costs or variable benefits against a prescribed objective (status quo or baseline). CEA differs from **cost-benefit analysis** (CBA) in that it asks a different question; namely, given a particular objective, it asks what is the least costly (or most efficient) way of achieving it. For a more detailed definition and discussion of cost-effectiveness, please see *Guidance on the Balanced Approach to Aircraft Noise Management* (Doc 9829).

Damage cost. The cost incurred due to repercussions (effects) of direct environmental impacts (for example, from the emission of pollutants) such as the degradation of land or human-made structures or health effects. These costs are borne by a party(ies) other than the emitter or producer of a product or service. Damage cost can take many forms, such as water contamination or the adverse effects on human health, caused by the degradation of local air quality from pollutants such as NO_x, HC and CO.

Mitigation cost. The cost aimed at adopting corrective measures to reduce an adverse environmental impact. This corrective action is typically in response (or reactive) to a problem once it has been discovered.

Prevention cost. The cost to be incurred by taking actions aimed at avoiding anticipated adverse environmental impacts. This corrective action is typically proactive in anticipation of a problem.

States' delegates. Those entities acting on behalf of States to address a specified environmental purpose.

Tax. ICAO defines a tax as "a levy that is designed to raise national or local government revenues which are generally not applied to civil aviation in their entirety or on a cost-specific basis". (Assembly Resolution A35-5, Appendix I).

Appendix B

ECAC APPROACH TO CHARGES FOR AIRCRAFT POWERED BY NON-CERTIFICATED AIRCRAFT ENGINES

In 2003, 42 ECAC member states agreed upon a recommendation with respect to a scheme for the classification of aircraft NO_x emissions (ECAC 27-4). Two sets of data are used, one for those engines which are regulated by ICAO and the other for those which are not. Data for regulated jet engines of greater than or equal to 26.7 kN thrust are based upon the standardized ICAO landing and take-off (LTO) cycle as set out in Annex 16, Volume II and published in Doc 9646. Data for unregulated engines have been reported by their manufacturers to the Swedish Aeronautical Institute. The Institute has been charged with producing an interim database that, with the manufacturers' consent, could be distributed to authorized parties. A proposal for an internationally recognized permanent emissions database for such engines has been put to ICAO.

To ensure non-discrimination, all civil aircraft with a maximum take-off weight (MTOW) over 8 618 kg should be classified using the recommended methodology. Member states may classify emissions from other aircraft (e.g. aircraft not exceeding 8 618 kg MTOW that are powered by small turboprops or piston engines, and helicopters) at their discretion. With respect to NO_x, the contribution of these aircraft to emissions is very small compared to those of heavier aircraft.

The Swedish Defence Research Agency (FOI) is the keeper of a database of EIs for turboprop engines supplied by the manufacturers for the purposes of developing emissions inventories. Although the database is publicly available only through FOI, the International Coordinating Council of Aerospace Industries Associations (ICCAIA) closely monitors who requests the use of the database to ensure the data is not misused. The FOI database is not endorsed by ICAO because the data are not certified and may have inaccuracies resulting primarily from the unregulated test methodologies. There is also a significant issue of an appropriate idle setting for turboprops. Therefore, ICAO has included this information in this guidance document because it recognizes that the FOI turboprop database may assist airports in conducting emission inventories. Currently, documentation of how the EIs were derived and the types of turboprop engines is unavailable. Information about turboprop engines, suggested times in mode (TIMs) and how to obtain the data from FOI can be found at the following weblinks:

www.foi.se → In English → Activities → What can FOI do for you? → Confidential database for Turboprop Engine Emissions

or http://www.foi.se/FOI/templates/Page 4618.aspx

Switzerland's Federal Office of Civil Aviation (FOCA) has developed a methodology and a measurement system to obtain emissions data from piston-powered aircraft. For these engine types, there is no requirement for emissions certification; hence the FOCA data is one of the few sources of data available for conducting emission inventories with respect to aircraft with these engines. However, the FOCA data has not been corroborated by ICAO, and is not endorsed by ICAO. Therefore, ICAO has included this information in this guidance document because it recognizes that FOCA's data may assist airports in conducting emission inventories for certain aircraft for which they otherwise might not have any data sources. The reader is referred to FOCA's website below to obtain documentation of the emissions measurement system, the consistent measurement methodology, and recommendations for the use of their data to conduct simple emission inventories using suggested TIMs. All material is openly available for download at:

http://www.aviation.admin.ch/fachleute/lufttechnik/entwicklung/00653/index.html?lang=en

— END —

ICAO PUBLICATIONS AND RELATED PRODUCTS IN THE AIR TRANSPORT FIELD

The following summarizes the various publications and related products in the air transport field issued by the International Civil Aviation Organization:

- *International Standards and Recommended Practices (SARPs)* adopted by the Council in accordance with Articles 37, 54 and 90 of the Convention on International Civil Aviation and designated, for convenience, as Annexes to the Convention. Annex 9 — *Facilitation* — contains SARPs dealing with customs, quarantine, immigration and health matters concerned with international air navigation. Annex 17 — *Security* — is composed of SARPs on all matters related to safeguarding civil aviation against acts of unlawful interference. Any differences between the national regulations and practices of a State and what is prescribed by an International Standard must be notified to the Council in accordance with Article 38 of the Convention. The Council has also invited Contracting States to notify differences from the provisions of the Recommended Practices.

- *ICAO's policies* on the regulation of international air transport, charges for airports and air navigation services, and taxation in the field of international air transport.

- *Technical specifications* on machine readable travel documents (MRTDs).

- *Tariffs* for airports and air navigation services, including charges applied towards users in more than 180 States.

- *Manuals* providing information or guidance to Contracting States on such issues as regulation of international air transport, financial management of airports and air navigation services, air traffic forecasting methods, and compliance with Annex 17 provisions.

- *Circulars* providing specialized information of interest to Contracting States. They include studies on medium- and long-term trends in the air transport industry at a global and regional level and specialized studies of a worldwide nature covering issues such as the economic and financial aspects of CNS/ATM systems implementation, regional differences in airline operating economics, economic contribution of civil aviation, privatization of airports and air navigation services, and regulatory implications of slot allocation.

- *Aviation Security Training Packages (ASTPs) and courses* on a range of subjects designed to assist security professionals, managers and staff in developing a more comprehensive understanding of SARPs, as well as to offer specialized practical expertise in the implementation and monitoring of measures and provisions in accordance with local programmes. For further information, please contact avsec@icao.int or visit the training page on the ICAO AVSEC website at www.icao.int/avsec.

- *Publications in electronic form*, in database and interactive forms, such as the world's air services agreements and the ICAO template air services agreements. *Civil aviation statistics* can be accessed by purchasing an annual subscription to one or more of the data series distributed by ICAO through its commercial website at www.icaodata.com. Questions regarding ICAO statistics or special orders for statistical data should be sent to sta@icao.int.

- *Reports of meetings in the air transport field,* including reports on the Facilitation and Statistics divisional-type meetings and those related to conferences on aviation security, regulation of international air transport, and economics of airports and air navigation services.

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