# Update of ICAO's Airport Air Quality Manual (Doc 9889)

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## Introduction

The International Civil Aviation Organization (ICAO)'s Airport Air Quality Manual (Doc 9889)[2], provides guidance and essential information for ICAO Member States to implement best practices with respect to airport-related air quality. This information is related to ICAO Member State requirements, emissions from airport sources, emissions inventories, and emissions allocations (up to 3,000ft above ground).

Since this guidance material was developed to potentially assist all ICAO Member States in implementing best practices in relation to airport-related local air quality, it is necessarily broad and extensive. Accordingly, some States may already have some, or many, of the processes and measures in place that are addressed in this guidance material. In such cases, this guidance material may be used to supplement those processes and measures or used as an additional reference.

During the 12th cycle of Committee on Aviation Protection (CAEP/12), a complete and full review of ICAO Doc 9889 was performed. All the chapters of the document were revised. This revision included updates to ambient air quality pollutant limits worldwide, changes to the emissions modeling methodologies, recommendations to account for engine deterioration more accurately, estimation of emissions at low speeds below the 7% thrust level, and updates to dispersion modelling methods.

The updates were completed using the latest information from a number of stakeholders, including engine manufacturers, aircraft manufacturers, the Airports Council International (ACI), and governmental agencies. The guidance material was streamlined to remove obsolete information and to provide up to date guidance.

## ICAO Doc 9889 Structure

The opening chapters of ICAO Doc 9889 provide introductory material and information on local air quality (Figure 1). Chapter 2 describes the regulatory framework and drivers in detail. The complexity of the airport environment is outlined in the context of the various emissions sources including aircraft, ground support equipment (GSE), terminal buildings, and ground vehicular traffic. Despite the complexity involved, airports are subject to the same regulations and standards that are established to define acceptable levels of local air quality. The chapter concludes summarizing local air quality regulations in different countries. The evolving nature of the local air quality regulations is also noted.

Chapter 3 focuses on the airport emissions inventory to develop baselines and emissions mitigation programs. Guidance is provided on a number of key subjects including: emission inventory construction, emissions parameters and species, airport-related sources, local and regional sources, forecasting, and quality assurance procedures. An emissions inventory can be conducted at various levels of complexity, depending on the required fidelity of the results as well as the availability of the supporting knowledge, data, and other resources. The guidance in Chapter 3 is intended to be a framework for conducting studies at

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2 ICAO's Airport Air Quality Manual (Doc 9889): https://www.icao.int/publications/Documents/9889_cons_en.pdf

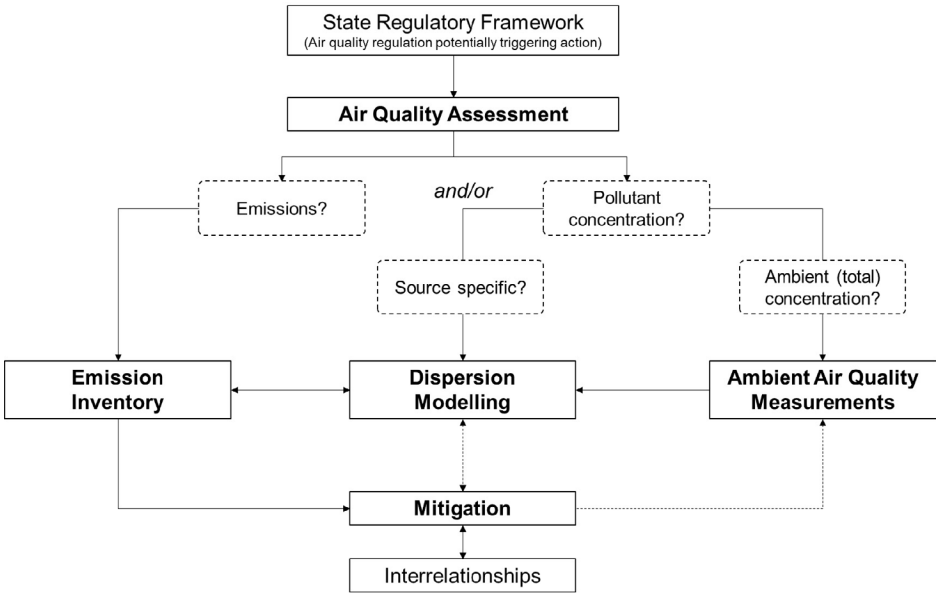


**FIGURE 1:** Local Air Quality Elements and their Interactions

various levels of complexity and guidance is given for three different levels of complexity (e.g. simple, advanced, and sophisticated). New information and methodologies were added to Appendix 1 to Chapter 3 during CAEP/12 and these updates are described in detail in a following section.

The spatial and temporal allocation of emissions provides information on locations and times with high emissions, and the relevance of different emission groups. As the pollutant concentration is proportional to the emission, such an allocation provides a first estimate of pollutant hot spots and source apportionment with respect to pollutant concentration. Transport effects due to exhaust dynamics, wind flow, atmospheric diffusion, deposition and physical or chemical conversion processes can be accounted for in a dispersion calculation which requires a detailed spatial and temporal allocation of the emissions from the various emission sources at and around the airport. Based on the calculation of emissions described in Chapter 3, guidance on spatial and temporal allocation of the calculated emissions is provided in Chapter 4.

Atmospheric dispersion models are an important complement to pollutant measurements. They provide comprehensive three-dimensional concentration distributions, insight into relevant transport mechanisms, and a clear source apportionment. In addition, they allow studies of future or other scenarios for which measurements are not available or not possible. Chapter 5 describes the general dispersion modelling approaches, input parameters and outputs. CAEP (Committee on Aviation Environmental Protection) approved dispersion models are listed in Appendix 1 to Chapter 5.

Chapter 6 describes ambient air quality monitoring for airports. Guidance is provided on the design process of a measurement plan, airport local and external factors affecting the measurements, measurement locations, measurement methods, data management, analysis of data and data quality assurance.

The document concludes with Chapters 7 and 8. Chapter 7 provides guidance on mitigation methods of environmental impacts and Chapter 8 on interrelationships associated with methods for mitigating environmental impacts.

## Rationale for ICAO Doc 9889 Updates

The technical emissions work undertaken by ICAO CAEP in support of the standard setting process involves state-of-the-art data analyses and the development of emissions quantification methodologies. This technical work enables ICAO to conduct global assessments of the incremental effects of aviation-related emissions. In addition, Member

States would also benefit from the use of already developed emissions methodologies to quantify aviation-related emissions for their domestic regulatory and planning purposes. ICAO Doc 9889 is the guidance document that allows ICAO to provide Member States with state-of-the-art emissions quantification methodologies to assess air quality in the vicinity of airports. To this end, ICAO continues updating ICAO Doc 9889 periodically to reflect the evolutionary nature of technology in the civil aviation industry.

Driven by potential adverse health effects of ultrafine particulate matter concentrations in the ambient air, there is an increasing need to estimate gaseous and particle emissions more accurately from aviation activities, as part of the broader set of emissions sources. In general, airports have a reasonable understanding of gaseous emissions from airport related sources and their impacts on local and regional concentrations, and based on this understanding, they have developed and implemented mitigation plans that have successfully yielded benefits to local air quality. The non-volatile particulate matter (nvPM) emissions standards adopted by ICAO and implemented by Member States have resulted in the reporting of certified nvPM mass and number emissions indices (EIs). Appropriate guidance in ICAO Doc 9889 on using the reported EIs will aid in a more accurate estimation of nvPM mass and number concentrations. Improving the quantification of the relative contribution of engine emissions and other airport sources in the context of wider transport sources will aid in understanding the potential reductions necessary. Ultimately, these methodologies may also be used to quantify the impacts of policy measures aimed at reducing PM emissions.

ICAO Doc 9889 provides worldwide harmonization of methods, which allows proper comparison between airport inventories and other sources.

## ICAO Doc 9889 Updates

The first two chapters of ICAO Doc 9889 were revised to remove out of date information and to include latest changes to local air quality standards worldwide. The overall regulatory framework and drivers were updated to reflect latest regulatory landscape around the world.

## Use of Measured nvPM EIs:

Comprehensive updates were made to Chapter 3. In particular, Appendix 1 to Chapter 3 was updated to provide guidance on the use of measured nvPM EIs. It was noted that the issue 28 and later, the ICAO EEDB contain information on the nvPM mass and number emissions, together with the associated fuel flow rates at the four specified LTO reference points, both as individual engine data sheets and as a spreadsheet containing the data for all certified engines. A sample ICAO Engine Emissions Data Sheet containing nvPM EIs was added to the document. Use of these newly reported nvPM mass and number EIs using inventory generation methods of varying complexities was also described in detail. The description of the methodology to estimate nvPM emissions using Smoke Number (SN) measurements for older engines was revised for clarity (Figure 2).

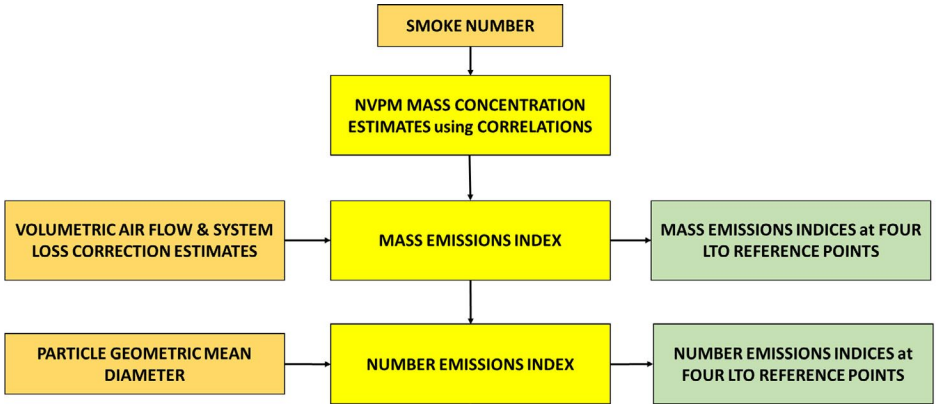


**FIGURE 2:** Estimation of nvPM mass and number EIs from Smoke Number

## Effects of Engine Deterioration on Airport Emissions:

In-service airframe and engine deterioration has a small but real effect on fuel burn and $NO_x$ emissions. There is no evidence that indicates deterioration effects on CO, HC. While there is measurement evidence of deterioration effects for some of the tested engines for smoke, quantification of this effect for fleet wide application needs more information. For nvPM mass and number, there is a modest increase in emissions due to engine deterioration that can be considered for airport inventories. Based on analyses of theoretical and actual airline data, the magnitude of engine deterioration effects for fleet-wide application for nvPM mass and number emissions were included in the update.

## Actual Idle Emissions:

In some cases, actual idle conditions have been observed as being below the ICAO LTO reference thrust point of 7% and provisions may be taken to estimate fuel flow and emissions below 7% thrust. In particular, there may be an increase in the idle nvPM emissions below 7% thrust. The document was updated to provide guidance on estimating actual idle nvPM mass and number emissions for airport inventories.

## Emissions Distribution and Dispersion Modelling:

Chapters 4 and 5 were revised to remove out of date sections and update other sections of these chapters with the latest technical information. The guidance for spatial emissions allocations was revised comprehensively to include aircraft induced emissions sources at aprons and other related locations and sources. The temporal allocation section now includes a clearer focus on aircraft and emissions sources connected to their operations. Guidance on dispersion modelling was updated to include general concepts of dispersion modelling. Elements updated include emissions models, plume models that capture exhaust dynamics more accurately, airport setup models, meteorological models, deposition models and the core dispersion model.

## Ambient Air Quality Measurements:

Guidance for ambient air quality measurements is provided in Chapter 6. With the advent of low cost air quality monitors, ad hoc measurements are being made and emissions attributed to aircraft and airports. In this context, guidance provided in ICAO Doc 9889 is of great importance for systematic measurements of pollutants in and around the airports. Updates made to this chapter include revisions to the measurement plan, location of the instruments and description of new instrument types. Information in this chapter will assist airports in considering ambient air quality measurements for demonstrating compliance to local air quality regulations and evaluating the performance of dispersion models.

## Air Quality Mitigation Options and Interrelationships:

Significant updates were made to Chapters 7 and 8 to remove out of date material and to include latest mitigation approaches. Interrelationships of different factors in mitigating environmental impacts were described in detail. Both Chapters 7 and 8 were streamlined and focused to be more useful for the airport community.

## Summary

The ICAO Doc 9889 provides guidance on two main areas to enable airport local air quality assessments: a) emissions inventories; and b) dispersion modelling of pollutant concentrations. The revised Doc 9889 contains the following updates:

- Inclusion of up to date material and removal of outdated information throughout the document.
- Guidance on the use of reported non-volatile particulate matter emission indices in airport nvPM mass and number emissions inventory generation.
- Recommendation to account for engine deterioration effects for nvPM emissions fleet wide.
- Estimation of nvPM emissions for actual idle below the 7% idle LTO mode.
- Dispersion modelling, ambient air quality measurements, air quality mitigation options and interrelationships.

## The Next Three Years

ICAO Doc 9889 will be continually updated as civil aviation technology evolves and modelling methodologies improve. The nvPM mass and number EIs are starting to become available, and this will lead to improvements in the modelling methodologies for more accurate modelling of emissions inventories. More information is expected to be available on the effect of ambient atmospheric conditions on nvPM mass and number emissions in the near future.

Further work planned on ICAO Doc 9889 includes an assessment of the current volatile PM (vPM) estimation method. A more sophisticated methodology under development during the CAEP/12 cycle is currently being evaluated for inclusion into ICAO Doc 9889.