General Authority of Civil Aviation

ADVISORY CIRCULAR

Subject	Issuance Date	AC Number	Version
Guidance Material on Local Air Quality at Airports	1-September-2024	156-04	1.0

Note: This Advisory Circular is published to provide additional information and recommended actions that further elaborate on provisions or concepts prescribed in GACAR part-156.

1. Introduction

1.1 Purpose

The purpose of this advisory circular is to address local air quality at airports and discuss:

- Emissions inventory species, sources, factors, development, and quality assurance
- Mitigation measures examples and planning methodology

1.2 Applicability

This advisory circular is applicable to all aerodrome operators.

1.3 Cancellation

This is the first official version of this advisory circular, and it cancels no other advisory circular on the subject matter.

1.4 Related regulatory references

a) GACAR Part-156.

1.5 Related reading materials and references

a) ICAO Document 9889, Airport Air Quality Manual, available at: https://store.icao.int/en/airport-air-quality-manual-doc-9889

b) ICAO Air Quality Management at Airports, Eco Airport Toolkit, available at: https://www.icao.int/environmental-protection/Pages/Ecoairports.aspx

1.6 Approval

This advisory circular has been approved for publication by the Executive Vice President for Safety and Environmental Sustainability of the General Authority of Civil Aviation.

2. Background

a) In addition to climate change-and-emissions and aircraft noise, ICAO's environmental protection focuses on local air quality. With a goal to limit or reduce the impact of aviation emissions on local air quality (LAQ), it started, in the late 1970s, developing measures to address emissions from aircraft engines in the vicinity of airports and other relevant airport sources (airport vehicles, ground handling, etc.).

b) GACA has always been committed to international civil aviation environmental goals as well as the national targets for environmental sustainability. To steer the Saudi civil aviation industry toward environmental sustainability, GACA has developed the Saudi Civil Aviation Environmental Sustainability Program (CAESP). This program covers 7 environmental pillars, with LAQ having a specific pillars and dedicated programs.

Hence, this advisory circular is aimed to raise the awareness of aviation stakeholders of the environmental protections measures to reduce the aviation activities' impact on LAQ in nearby communities.

c) A number of current opportunities airports and the aviation industry can take advantage of to promote sustainable development in commercial air transportation, including optimizing airport design, layout and infrastructure, modifying operations for greater efficiency, retrofitting GSE fleets with green technologies, and promoting alternative ground transport modes.

3. Emissions inventory

Airports, along with their associated activities, produce a variety of gases and particles. A measure of airport air quality is the quantity or mass of airport emissions that meet particular characteristics with regard to their relative impacts and regulatory compliance. In order to determine this value, an emissions inventory must be completed. The objectives of an emission inventory include, but not limited to:

- Obtaining information regarding emissions and monitoring trends in order to assess future scenarios
- Evaluation of emissions against legal requirements (e.g., MEWA's executive regulation for noise thresholds).
- Calculating pollution concentrations based on input data for dispersion models.
- Developing mitigation programs and initiatives.

3.1 Emissions inventory Parameters

An emissions inventory should consider the following factors:

a) Purpose

Emissions inventory requirements primarily determine its design. The methodologies used will be simple and straightforward if the objective is only to calculate the total mass of emissions. In the event that the inventory is to be utilized as part of a dispersion model, the methodology could be different and more detailed, since dispersion models require spatial information as well as more detailed temporal information. This should be considered when designing the emissions inventory to prevent its future use from being limited.

b) System perimeter

The system perimeter defines the functional and spatial area in which emissions will be calculated. An airport perimeter fence, a designated height (e.g., mixing height) and/or access roads leading to the airport could be the spatial area. Airport functional areas are typically defined by emissions sources connected to airport operations, but outside the airport perimeter (e.g., fuel farms).

c) Updates

An inventory's frequency of updating determines its design and any related databases or data tables. For example, a single value versus many values over time determines its temporal resolution. Additionally, it is necessary to evaluate the effort and resources needed to compile the inventory on a regular basis.

d) Level of accuracy/complexity

A data input's accuracy level is determined by its fidelity and the knowledge level of the analyst.

Table 1: Emissions inventory levels of complexity

Characteristics	Simple approach	Advanced approach	Sophisticated approach
Complexity	Basic knowledge required; necessary data are easy, standardized and available; straightforward methodology	Advanced knowledge, airport specific and/or access to additional data sources are required.	In-depth knowledge, cooperation among various entities and/or access to proprietary data might be required.
Accuracy	Generally conservative	Good	Very high
Confidence	Low	Medium	High

3.2 Emissions species

Air pollution from aviation-related activities can result in a variety of gaseous and particulate emissions that may have an adverse effect on human health and the environment. This, not all of them are relevant to emissions inventories or necessary for them. MEWA's Executive Regulation for Air Quality mentioned in GACAR 156 determines emissions species that are required for the inventory in KSA.

In general, the following species may be considered primary species in emissions inventories:

- Nitrogen oxides (NOx), including nitrogen dioxide (NO2) and nitrogen oxide (NO).
- Volatile organic compounds (VOC), including non-methane hydrocarbons (NMHC).
- Carbon monoxide (CO).
- Particulate matter (PM), fractions of PM2.5 and PM10.
- Sulphur oxide (SOx).

Carbon dioxide (CO2) is sometimes included in inventories based on total fuel burn, since is more of a global concern than a local one, but local inventories can feed into global inventories.

In emissions inventories, hazardous air pollutants (HAPs) may also need to be considered as potential health and environmental concerns. Low levels of HAPs are present in aircraft and GSE exhaust as gaseous and particulate emissions. HAPs' research is still in early stages, and it is important to note that the knowledge of their emission factors is limited. Thus, the creation of an inventory of HAPs might not be possible or such an inventory might not be as accurate as other more common species. HAPs associated with airport sources of air pollution include, but not limited to, butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter, formaldehyde, lead, naphthalene, propionaldehyde, toluene, xylene.

3.3 Airport-related emissions sources

At airports, a wide variety and number of emission sources can be found. However, not all types of emissions sources present at every airport, depending on the specific activities conducted.

Airport-related emissions sources have four main categories:

a) Aircraft emissions

Aircraft main engine: from start-up to shut down, main engines of aircraft within a specified operating perimeter.

Auxiliary power unit (APU): provides electrical/pneumatic power to aircraft systems during ground operations.

b) Aircraft handling emissions

Ground support equipment (GSE): GSE is required to handle aircraft during turnaround at the stand, including ground power units, air climate units, aircraft tugs, conveyer belts, passenger stairs, forklifts, tractors, cargo loaders, etc.

Airside traffic: within the airport perimeter fence, service vehicles and machinery move around service roads such as sweepers, catering, fuel, sewage, and cars, vans, and buses.

Aircraft refueling: the evaporation of aircraft fuel tanks (vents), fuel trucks, and pipelines.

Aircraft de-icing: de-icing and anti-icing substances applied to aircraft during winter.

c) Infrastructure and stationary sources

Power/heat generating plant: heat/cooling plants, boilers, co-generators provide energy for the airport's infrastructure.

Emergency power generator: generators powered by diesel for emergency operations (e.g. for runway lights or for buildings).

Aircraft maintenance: it includes all activities and facilities associated with aircraft maintenance, such as washing, cleaning, paint shops, engine test beds, etc.

Airport maintenance: maintenance of airport facilities (e.g., cleaning agents, building maintenance, repairs, landscaping) and machinery (e.g., vehicle maintenance, painting).

Fuel: fuel farms and vehicle fuel stations store, distribute, and handle fuel.

Construction activities: construction activities associated with the operation and development of airports.

Fire training: various types of fire training activities (kerosene, butane, propane, wood).

Surface de-icing: application of de-icing and anti-icing substances to aircraft moving areas, service roads, and access routes.

d) Vehicle traffic sources.

Vehicle traffic: on-site parking lots, curbsides, drive-ups, access roads, motor bikes, vans, trucks, buses, motor coaches, and vehicle evaporative emissions (including engine start-up and fuel tank evaporation).

3.4 Local and regional emissions

An airport emissions inventory should always consider the larger environment that extends beyond the perimeter fence and property line of the airport. The development of emission inventories for a larger regional perimeter (e.g., an airshed) can be used for certain purposes, such as modelling the formation of O3. These larger inventories would typically be conducted by the relevant governmental bodies (e.g., MEWA or NCEC), in cooperation with the airport. The system boundaries must be clearly defined to avoid double counting of emissions. In some cases, the airport inventory may contribute only a relatively small portion of the overall area emissions inventory, depending on the assumptions made (e.g., the sources considered and their spatial extent or borders). Despite this, inventories in themselves do not necessarily provide a complete picture of the impact of an emission source. Dispersion modelling can be used to better define air quality impacts.

3.5 Emissions inventory development

To calculate emissions inventories, a bottom-up approach is typically used, due to its high level of accuracy. Thus, the first step is to calculate the emissions mass, based on the source, time period, and pollutant. The variables are calculated by considering individual emissions sources, their emission factors (measured in grams per kilogram of fuel, grams per hour of operation, or grams per kilowatt of power), and their respective operational parameters. Based on these two parameters, the total source-related emissions at the airport are calculated. There are several ways to express the total emissions source, such as individual sources, groups of sources, pollutants, or time periods (e.g., hour, day, week, month, year).

The following steps shall be followed to develop an emissions inventory:

- Identify the general inventory parameters, such as the purpose, the functional and spatial perimeter, and the frequency of updates.
- Choose the emissions species that should be considered.
- Identify the existing sources of emissions.
- Calculate the emissions from these sources.
- As appropriate, consider macroscale issues such as regional emission inventories.
- Incorporate quality assurance and control measures to identify uncertainties and limitations.

3.6 Quality assurance

The development of an emissions inventory can be a complex exercise that might result in some simplifications or limitations. To achieve reliable results, emissions inventories should go through a quality control process.

Quality assurance includes, but is not limited to, the discussion of missing information, assumptions, error estimations, transparency/traceability of data sources and methodologies, and validation.

a) **Missing information:** information or data may be missing due to lack of availability of certain data (i.e. operational data and/or accurate emission factors). In such cases, estimations or assumptions must be made before omissions are made, as data or information can improve inventories or methodologies. Adding sources that have not been considered before is generally more difficult.
b) **Error estimations:** error estimations are important for credibility reasons and for evaluating the accuracy of an inventory. As shown below, available data and information usually fall into three categories:
    1) **Measured:** the data are measured using calibrated and verified tools and methods, counted or otherwise assessed through other methods directly associated with the data source. Calculating CO2 mass emissions from kerosene-burning engines can be done by taking the actual measured fuel flow and using a CO2 relationship factor of 3,150 grams per kg of fuel.
    2) **Calculated:** calculations are made using algorithms and data not directly associated with data sources.
    3) **Estimated:** data are estimated using references, past experience, qualified assumptions, or interpolations.
c) **Transparency and traceability:** it is essential to outline and properly document the applied calculation methodology in order to ensure an effective quality control. In inventories, sources of information and emission factors must be identified. If an ideal data source is not feasible, then other (e.g., next best) data sources need to be considered
d) **Validation:** a proper quality control system should validate and cross-check the results. In this case, it may be necessary to compare with reference data of similar systems or recalculate specific emissions inventory elements.

3.7 Forecasting

Air quality analysts may want to consider future airport emissions when analyzing past and present conditions. Future airport emission inventories (e.g., 5, 10 or 25 years in the future) should include all airport elements, including aircraft operations and movements, passenger and cargo handling, airport infrastructure needs, and surface vehicle traffic volumes. A forecasting methodology can be very complex and requires advanced knowledge of the airport and its environs, market behaviors, airline equipment usage, and regulatory requirements.

4. Mitigation measures

Emission reduction measures primarily fall into three general categories: regulatory, technical, and operational. Table 2 provides examples of each category. Using a combination of these measures may prove to be the best way forward when applied to a particular problem based on a case-by-case evaluation. The objective of all measures is to reduce emissions at the source, directly or indirectly.

Regulatory measures are a mandatory requirement stated in the laws and regulations of the applicable jurisdiction.

Technical measures affect the emission characteristics of a particular source. Typically, these measures are aimed at reducing emissions at the source (e.g., vehicles) or in infrastructure (e.g., insulation, road layout).

Operational measures are those implemented by the operator of the equipment in question, whether it's the airline, airport authority, tenants, or anyone else.

Table 2: Emission sources reduction measures per category

Emissions source	Measures		
	Regulatory	Technical	Operational
Aircraft	• ICAO Annex 16 Volume II Aircraft Engine Emissions • APU usage restrictions	• General airport layout • High-speed runway turn-offs • Parallel taxiways • Flow management • 400Hz/PCA at aircraft gates/stands	• Engine start-up • Scheduling improvement • Single/reduced engine taxiing • Reduced engine idling time • Aircraft towing • Reduced APU use • De-rated/reduced thrust • Engine washing • Use of alternative jet fuel • Airport-specific ATM measures, including RNAV, RNP and continuous descent operations (CDOs)
Aircraft handling and support	• Motor-vehicle emissions standards for GSE (as applicable)	• Alternative-fuel GSE (CNG/LNG, LPG, electric) • Alternative-fuel fleet vehicles (CNG/LNG, LPG, electric) • Emissions reduction devices (PM filter traps, etc.) • Fuel fumes capturing systems	• Reduction of vehicle operational characteristics • Use of generators, GPUs, air starts • Reduced intensity of hot fire practices
Infrastructure and stationary sources	• Emissions standards for facilities (e.g., power plants, emergency generators)	• Low emissions energy plant, incinerator • Energy conservation measures in new construction and building maintenance • Change of fuel use • Change in stack heights and location	• Low emissions procedures for maintenance operations (painting, engine testing, cleaning)
Landside access traffic	• Motor-vehicle emissions standards • Idling restrictions	• Enhanced public transit and intermodal connections • Road structure layout Sustainable fuels • Dedicated public traffic lanes	• Off-airport check-in • Preferential parking for electric vehicles • Preferential queues for green taxis

5. Mitigation planning methodology

The following paragraphs outline a management approach (plan-do-check-act).

Identify the problem: determine the emissions that need to be reduced and the sources of those emissions. An emissions inventory with the various sources could be used to make such an analysis, and then the resulting concentration predictions could be analyzed using a dispersion model.

Analyze and define the objectives: analyze the problem and set the targets for emissions reducing. A thorough understanding of the regulatory requirements necessary to ensure local air quality compliance and/or the successful implementation of a program is required.

Develop solutions: outline the available options for reducing emissions in light of the identified problems and objectives. The most appropriate mitigation strategy needs to be evaluated thoroughly, based on previous mitigation option requirements.

Assess the cost-effectiveness of options: analyze the relative cost-effectiveness of the proposed measure or combination of measures and then identify the most cost-effective means of reducing emissions.

Stakeholder review: consult with all interested parties to ensure alignment. A successful mitigation program requires the development of a stakeholder review team and the sponsorship of public review forums.

Implement measures: the proper implementation of the strategy is essential after obtaining the alignment of relevant stakeholders. Specifically, the mitigation options should be outlined in the plan, along with expectations for all stakeholders and a timeline for achieving all objectives.

Monitor/review the program: for a mitigation plan to be successful, it is essential to establish control procedures, such as performance indicators. These will enable you to monitor progress towards the desired outcome, verify success and benefits, monitor cost performance, and identify unexpected shortfalls. This review could then be used to analyze the program and provide feedback for improvement.

There are several methodologies that may be utilized to achieve the desired objectives, such as the Project Management Institute methodologies and Lean Six Sigma (i.e., Define, Measure, Analyze, Improve and Control).

6. Conclusion

Airport emissions contribute to the degradation of air quality in surrounding communities. Various emission sources can be found at airports such as aircraft, aircraft handling, vehicle traffic, infrastructure, and stationary emission sources.

Airport emissions inventory should always consider the larger environment that extends beyond the perimeter fence and property line of the airport. An emission inventory development should clearly determine the purpose, system perimeter, update frequency and level of accuracy/complexity.

Emission reduction measures primarily fall into three general categories: regulatory, technical, and operational. Using a combination of these measures is the optimum way forward when applied to a particular problem based on a case-by-case evaluation. Mitigation planning should adopt the (plan-do-check-act) management approach.

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