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Federal Department of the Environment,
Transport, Energy and Communications DETEC

Federal Office of Civil Aviation FOCA
Aviation Policy and Strategy Division

Directive 33-05-27

Subject:

Aircraft Engine Emissions Charges in Switzerland

Reference: 33-05-27

Applicable legislation:	See Appendix 2 (Swiss legal text)
Target group:	Airport operators Airport users
Version:	Version 1.1 Entry into effect of version 1.1 (update of legal bases): 1st June 2016 Entry into effect of original version 1.0: 1st June 2009
Formulation of text:	Theo Rindlisbacher, FOCA - LEUW
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Contents

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1. Introduction

1.1 Short History of Emissions Charges in Switzerland

Switzerland was (together with Sweden) one of the first countries in the world to introduce emissions charges. (1997 Zurich, 1998 Geneva, 2000 Berne, 2003 Basle (actually situated in France)). Switzerland introduced emissions charges with the primary focus on supporting and forcing the use of best available low emissions engine technology through financial incentives. The model was based on an engine classification scheme, with the best engine class paying no emissions charge and with the other classes paying corresponding additional percentages of the landing fee. At introduction of emissions charges, the previously existing landing fees had been reduced to the extent to ensure revenue neutrality for the airports. Up to now, emissions charges in Switzerland have been levied according to the Swiss engine classification scheme. This guidance describes the change to the European harmonised emission charging model, generally known as the "ERLIG model", "ECAC model" or the "ECAC 27/4 recommendation". The new model will be applied at major Swiss airports from spring 2010 in order to fulfil the need for European harmonisation.

1.2 Motivation and Background for the Model Change

In the year 2000, the European Aviation Industry called for harmonisation of existing emission charges models, as the models applied in Switzerland and in Sweden were different. Industry response addressed the engine classification scheme, as well: Putting engines into emission classes can lead to the situation that two engines with classification values near a class border may fall into different emission classes. So despite little differences in engine values, the emissions charge for such engines can be significantly different.

In 2001, ECAC (European Civil Aviation Conference) installed the ERLIG (Emission Related Landing charges Investigation Group), tasked to develop a harmonised model. Swiss airport and FOCA representatives have significantly contributed to ERLIG. Taking industry response into account, ERLIG developed a model that could do without any engine emission classes or setting class borders. The new model was based on a pure emissions approach, reinforcing the "polluter pays principle": The higher the emissions, the higher the charge. As the primary concern for local airport air quality was still NOx, the new model was primarily based on NOx emissions. In 2003, ERLIG was dissolved and ECAC released the new model as recommendation ECAC 27/4 under the title of "NOx Emission Classification Scheme for Aircraft". This was the birth of a European harmonised solution. Switzerland and Sweden went one step further and harmonised also the treatment of aircraft, which are not included in ECAC 27/4.

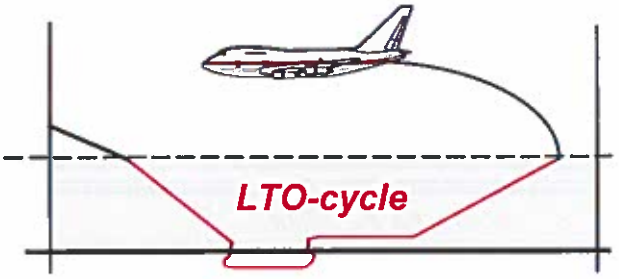
Sweden changed to the new model in 2004. In the same year, the UK started to apply emission charges at Heathrow airport, based on the ECAC model and the Swiss/Swedish addition for small aircraft. In 2008, emission charges were introduced in Germany, namely at Frankfurt, Munich and Cologne Airport, again based on the ECAC model and the Swiss/Swedish addition. In 2007, ICAO published ICAO Doc 9884: "*Guidance on Aircraft Emission Charges Related to Local Air Quality*", which contains the ECAC model as an example.

Swiss FOCA has supported the development and the application of a harmonised emissions charges model since 2000. The model change in Switzerland is a logical consequence of this activity and is enforced by the Swiss Confederation. FOCA initiated an adaptation of the legal bases in Switzerland. Under the Swiss ordinance of infrastructure, Swiss airports are obliged not only to levy an emissions charge but also to follow the recommendation of the Federal Department DETEC for the model that has to be applied. The obligation to levy an emission charge is laid down under the terms of Article 39 Paragraph 4 of the Law on Aviation (LFG; 748.0) and Article 47 Paragraphs 1 to 3 of the Ordinance on Airport Charges (748.131.3) as shown in Appendix 2 of this document.

2. Description of the Model

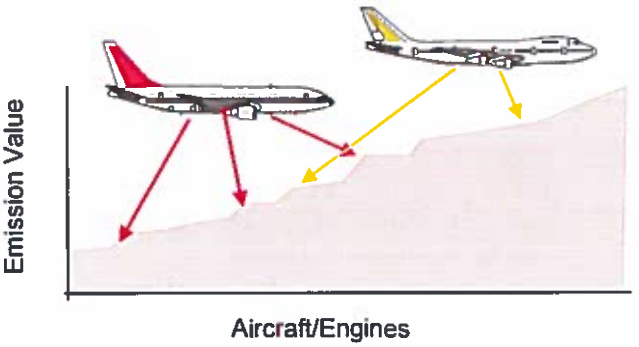
2.1 General Principle

- **The basis for the model** is the calculation of the **absolute aircraft engine NO_x emissions in the standardised landing and take-off cycle (LTO)** used for ICAO aircraft engine emissions certification. (For consideration of additional pollutants, see the footnote below.)



Basis: LTO NOx Emissions

- An emission value is assigned to the absolute emission mass of an aircraft. **The greater the emissions mass of an aircraft, the higher the emission value. If different engine options are available for a certain aircraft type, the aircraft emission value varies with the LTO NO_x emissions of the selected engines.** [1]



- The charge is levied with an emission value related surcharge and therefore **the emissions charge varies linearly and according to a continuous scale with the emissions.**

An Aircraft Emission Value is assigned to the aircraft according to the actually fitted propulsion engines.

[1] In most cases, the emission value is identical to the LTO NOx emissions. Some very rare old engines with lower combustion efficiency have comparatively low NOx emissions but do not comply with current emissions standards for unburned hydrocarbon pollutants. In such cases, a correction factor "a" is applied taking pollutants from incomplete combustion into account (see Appendix 1 for details).

2.2 Aircraft fitted with Turbofan, Jet and Turboprop Engines

a) Regulated engines

Aircraft Emission Value = Number of Engines * a * LTO NOx Emissions

(Calculated according to formula in Appendix 1.)

b) Unregulated engines with emissions data available to FOCA

Aircraft Emission Value = Number of Engines * LTO NOx Emissions

(Calculated according to formula in Appendix 1)

c) Unregulated engines with no emissions data available to FOCA

Aircraft Emission Value = Value indicated in the Business-Jet and Turboprop section of the FOCA Matrix below

For Business-Jet aircraft with unknown engine emissions, aircraft emission values are assigned from table 1 below according to

- Maximum thrust rating per engine (depending on whether it is below 16 kN (kilonewton) or between 16 and 26.7 kN rated thrust).
- Number of engines.

For Turboprop aircraft with unknown engine emissions

- only the number of engines needs to be known.

Table 1: FOCA Aircraft Emission Value Matrix

# Eng.	Piston: Turbodiesel Microlight Ecolight	Piston: Conventional up to 200 hp	Piston: Conventional 200-400 hp	Piston: Conventional >400 hp	Helicopter <1000 shp	Helicopter >1000 shp	Business-Jets (<16 kN)	Business-Jets (>16 but < 26.7 kN)	Turboprops
1	0.1	0.2	0.4	0.5	0.2	0.7	0.5	1.0	0.8
2	0.2	0.4	0.8	1	0.4	1.4	1.0	2.0	1.6
3	-	0.6	1.2	1.5	-	2.1	1.5	3.0	2.4
4	-	0.8	1.6	2	-	2.8	-	-	3.2

Examples:

A business Jet with three turbofan engines, each rated at 14 kN (kilonewton) thrust, and unknown emissions data is given an Aircraft Emission Value of 1.5

A turboprop engine powered aircraft with two turboprop engines and unknown emissions data is given an Aircraft Emission Value of 1.6

2.3 Piston Engine Aircraft and Helicopters

Aircraft Emission Value = Value indicated in the Piston and Helicopter section of the FOCA Matrix below

For piston engine aircraft and helicopters, aircraft emission values are assigned from table 1 below according to

- Engine type (piston engine of a microlight/ecolight aircraft, conventional piston engine, turbodiesel piston engine, helicopter engine (piston and turboshaft)
- Engine size (rated horsepower resp. shaft horsepower)
- Number of engines.

Table 1: FOCA Aircraft Emission Value Matrix

# Eng.	Piston: Turbodiesel Microlight Ecolight	Piston: Conventional	Piston: Conventional	Piston: Conventional	Helicopter	Helicopter	Business-Jets	Business-Jets	Turboprops
		up to 200 hp	200-400 hp	>400 hp	<1000 shp	>1000 shp	(<16 kN)	(>16 but < 26.7 kN)	
1	0.1	0.2	0.4	0.5	0.2	0.7	0.5	1.0	0.8
2	0.2	0.4	0.8	1	0.4	1.4	1.0	2.0	1.6
3	-	0.6	1.2	1.5	-	2.1	1.5	3.0	2.4
4	-	0.8	1.6	2	-	2.8	-	-	3.2

Examples:

A turbodiesel engine powered aircraft with one engine is given an Aircraft Emission Value of 0.1

A Microlight aircraft (called Ecolight in Switzerland) is given an Aircraft Emission Value of 0.1

A conventional piston engine powered aircraft with an engine rated at 257 horsepower is given an Aircraft Emission Value of 0.4

A twin engine powered helicopter with each engine rated at 750 shaft horsepower is given an Aircraft Emission Value of 0.4

2.4 Calculation of the Emissions Charge

- **Emission Charge (CHF) = Aircraft Emission Value * Tariff in CHF**

3. List of Engine and Aircraft Emission Values

A) Public List

- The list of **engine names with corresponding emission values** is publicly available and can be downloaded at www.bazl.admin.ch → for specialists → aircraft → emissions landing charges.

B) Non-public List

- The FOCA provides an **aircraft engine combinations list** to Swiss airports, which apply emissions charges. The list contains more than 30 000 tail numbers and assigned engine codes, number of engines and the aircraft emission value for all individual aircraft that have been flying in Switzerland during the last decade. This list is the primary source of information for small airports, which do not need individual engine data and merely require information linking tail number, aircraft and engine type to an aircraft emission value.

- This list is not publicly available. It is shared solely between FOCA and the airports, and in return for airports' efforts to continuously provide FOCA with detailed statistical data.

→ The centralised distribution of the FOCA engine data base, the collection, review and redistribution of aircraft engine assignments - normally on an annual basis – contributes to uniform application of the emissions charges model and helps to ensure that a given aircraft is assigned the same emission value at all airports.

→ FOCA also actively exchanges aircraft-engine and emission value lists with foreign authorities to further improve consistency in the application of the ECAC Model.

4. Entry into Effect

This updated directive enters into effect on 1st June 2016

Federal Office of Civil Aviation

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Appendix 1: Model Calculation Details

a) Mathematical formula for all regulated engines and for unregulated turbofan, jet and turboprop engines with known emissions data:

$$\text{EmissionValue Aircraft} = a * \#\text{Engines} * \sum_{LTO-\text{modes}} \left(60 * time * fuelflow * NOx_{Emissionfactor} \div 1000\right)$$

where:

a = 1 if the characteristic certification LTO Hydrocarbon emissions per rated thrust (HC Dp/Foo) is less than or equal to the current ICAO standard of 19.6 g/kN rated thrust or for unregulated engines.

a > 1 if the characteristic certification LTO Hydrocarbon emissions per rated thrust (HC Dp/Foo) is greater than the current ICAO standard.
a = HC Dp/Foo /19.6, with a maximum value for 'a' of 4.0

LTO-Modes: ICAO Certification LTO Modes: Take-off, Climb, Approach, Taxi

Table 2: LTO-Modes, associated times and thrust or power settings

	Regulated and unregulated turbofan or jet engines		Turboprop engines	
LTO Modes	time in mode (Minutes)	% of maximum rated thrust	time in mode (Minutes)	% of maximum rated shaft horsepower
Take-off	0.7	100%	0.7	100%
Climb	2.2	85%	2.2	85%
Approach	4.0	30%	4.0	30%
Taxi	26	7%	26	Idle*

*Difference in the standard ICAO LTO mode, as shown in the Swedish Defence Research Agency (FOI) study, FOI Memo 01-4245

time: time in mode as shown in table 2 (in minutes)

Engines: number of engines fitted to the aircraft

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

$NOx_{Emissionfactor}$ Measured NOx-Emission factor per mode (in g/kg fuel)

Emission factors and fuel flow for the four modes and the hydrocarbon certification value are taken from the ICAO engine database (regulated engines). Emissions data for unregulated engines are taken from the FOCA and FOI emissions database. The FOCA website provides additional information:

For engine emission data sources:

www.bazl.admin.ch → For Specialists → Aircraft → Emission Certification

For engine lists with calculated engine emission values and the ECAC 27/4 recommendation:

www.bazl.admin.ch → For Specialists → Aircraft → Emissions Landing Charges

Appendix 2: Swiss Legal Text

The obligation to levy an emission charge is laid down under the terms of Article 39 Paragraph 4 of the Law on Aviation (LFG; 748.0) and Article 47 Paragraphs 1 to 3 of the Ordinance on Airport Charges (748.131.3)

Application of the polluter pays principle is laid down under the terms of Article 2 of the Law on Environment (USG; 814.01):

Legal text in German language

Art. 39 LFG (748.0)

4 Der Flughafenhalter berücksichtigt bei der Festlegung der Gebühren namentlich die folgenden Kriterien:

a. höchstzulässiges Abfluggewicht des Luftfahrzeugs;
b. Passagierzahl;
c. Lärmerzeugung;
d. Schadstoffemission.

Art. 47 Verordnung über Flughafengebühren (748.131.3)

Berücksichtigung der Lärm- und Schadstoffemissionen

1 Bei der Festlegung der Flugbetriebsgebühren sind Luftfahrzeuge mit geringen Auswirkungen auf die Umwelt bevorzugt zu behandeln.

2 Die Beurteilungsmethoden zur Festlegung dieser Auswirkungen müssen dem anerkannten Stand der Technik entsprechen. Das BAZL kann geeignete Beurteilungsmethoden empfehlen.

3 Zu berücksichtigen sind mindestens die folgenden Emissionen:

a. die Lärmentwicklung der Luftfahrzeuge beim Start entlang des Flugweges;
b. die Emissionen von Stickoxid und von Kohlenwasserstoff (Hydrocarbon, HC) der Luftfahrzeuge im Start- und Landezyklus.

Art. 2 USG (814.01)

Wer Massnahmen nach diesem Gesetz verursacht, trägt die Kosten dafür.

Legal text in French language

Art. 39 LA (748.0)

4 L'exploitant de l'aéroport fixe le montant des redevances en se fondant notamment sur les critères suivants:

a. masse maximale au décollage de l'aéronef;
b. nombre de passagers;
c. émission de bruit;
d. émission de substances nocives.

Art. 47 Ordonnance sur les redevances aéroportuaires (748.131.3)

Prise en compte des émissions de bruit et de substances polluantes

[1] Les tarifs des redevances aéroportuaires sont établis de manière à favoriser les aéronefs qui ont un impact limité sur l'environnement.

[2] Les méthodes d'évaluation de cet impact doivent correspondre à l'état de la technique. L'OFAC peut recommander des méthodes d'évaluation appropriées.

[3] Il sera pris en compte au minimum les émissions suivantes:

a. les émissions de bruit des aéronefs au décollage le long de la trajectoire de vol;
b. les émissions d'oxyde d'azote et d'hydrocarbures (Hydrocarbon, HC) des aéronefs durant le cycle de décollage et d'atterrissage.

Art. 2 LPE (814.01)

Celui qui est à l'origine d'une mesure prescrite par la présente loi en supporte les frais.

Legal text in Italian language

Art. 39 LNA (748.0)

[4] Per stabilire le tasse l'esercente dell'aeroporto tiene segnatamente conto dei seguenti criteri:

a. peso massimo ammissibile dell'aeromobile al decollo;
b. numero di passeggeri;
c. impatto fonico;
d. emissioni di sostanze nocive.

Art. 47 Ordinanza sulle tasse aeroportuali (748.131.3)

Considerazione delle emissioni di rumore e di sostanze nocive

[1] Nel determinare le tasse per le operazioni di volo, gli aeromobili a ridotto impatto ambientale beneficiano di un trattamento di favore.

[2] I metodi di valutazione per determinare questo impatto devono corrispondere allo stato della tecnica riconosciuto. L'UFAC può raccomandare metodi di valutazione appropriati.

[3] Vanno considerate almeno le emissioni seguenti:

a. l'evoluzione del rumore degli aeromobili al decollo lungo la traiettoria di volo;
b. le emissioni di ossido di azoto e di idrocarburo («hydrocarbon», HC) degli aeromobili durante il ciclo di decollo e di atterraggio.

Art. 2 LPAmb (814.01)

Le spese delle misure prese secondo la presente legge sono sostenute da chi ne è la causa.