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Annex Reference	ENVIRONMENTAL PROTECTION Standard or Recommended Practice	State Legislation, Regulation or Document Reference	Level of implementation of SARP's	Text of the difference to be notified to ICAO	Comments including the reason for the difference
Chapter 1 Reference Definition	<p>INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES</p> <p>PART I. DEFINITIONS AND SYMBOLS</p> <p>CHAPTER 1. DEFINITIONS</p> <p>Where the following expressions are used in Volume II of this Annex, they have the meanings ascribed to them below:</p> <p><i>Afterburning.</i> A mode of engine operation wherein a combustion system fed (in whole or part) by vitiated air is used.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Approach phase.</i> The operating phase defined by the time during which the engine is operated in the approach operating mode.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Climb phase.</i> The operating phase defined by the time during which the engine is operated in the climb operating mode.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 1 Reference Definition	Date of manufacture. The date of issue of the document attesting that the individual aircraft or engine as appropriate conforms to the requirements of the type or the date of an analogous document.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	Derivative version. An aircraft gas turbine engine of the same generic family as an originally type-certificated engine and having features which retain the basic core engine and combustor design of the original model and for which other factors, as judged by the certifying authority, have not changed. <i>Note.— Attention is drawn to the difference between the definition of “derived version of an aeroplane” in Volume I of Annex 16 and the definition of “derivative version” in this Volume.</i>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	Exhaust nozzle. In the exhaust emissions sampling of gas turbine engines where the jet effluxes are not mixed (as in some turbofan engines, for example) the nozzle considered is that for the gas generator (core) flow only. Where, however, the jet efflux is mixed the nozzle considered is the total exit nozzle.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	Non-volatile particulate matter (nvPM). Emitted particles that exist at a gas turbine engine exhaust nozzle exit plane that do not volatilize when heated to a temperature of 350°C.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 1 Reference Definition	<i>Oxides of nitrogen.</i> The sum of the amounts of the nitric oxide and nitrogen dioxide contained in a gas sample calculated as if the nitric oxide were in the form of nitrogen dioxide.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Rated thrust.</i> For engine emissions purposes, the maximum take-off thrust approved by the certifying authority for use under normal operating conditions at ISA sea level static conditions, and without the use of water injection. Thrust is expressed in kilonewtons.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Reference pressure ratio.</i> The ratio of the mean total pressure at the last compressor discharge plane of the compressor to the mean total pressure at the compressor entry plane when the engine is developing take-off thrust rating in ISA sea level static conditions. <i>Note.— Methods of measuring reference pressure ratio are given in Appendix 1.</i>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Smoke.</i> The carbonaceous materials in exhaust emissions which obscure the transmission of light.	Article 9(2) of Reg. (EU)2018/1139	No Difference		

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Chapter 1 Reference Definition	<i>Smoke Number.</i> The dimensionless term quantifying smoke emissions (see 3 of Appendix 2).	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>State of Design.</i> The State having jurisdiction over the organization responsible for the type design.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Take-off phase.</i> The operating phase defined by the time during which the engine is operated at the rated thrust.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Taxi/ground idle.</i> The operating phases involving taxi and idle between the initial starting of the propulsion engine(s) and the initiation of the take-off roll and between the time of runway turn-off and final shutdown of all propulsion engine(s).	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 1 Reference Definition	<i>Type Certificate.</i> A document issued by a Contracting State to define the design of an aircraft, engine or propeller type and to certify that this design meets the appropriate airworthiness requirements of that State. <i>Note 1.— In some Contracting States a document equivalent to a Type Certificate may be issued for an engine or propeller type.</i> <i>Note 2.— In some Contracting States the Type Certificate may also certify that the design meets the appropriate aircraft engine emissions requirements of that State.</i>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference Definition	<i>Unburned hydrocarbons.</i> The total of hydrocarbon compounds of all classes and molecular weights contained in a gas sample, calculated as if they were in the form of methane.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2 Standard	<p>CHAPTER 2. SYMBOLS</p> <p>Where the following symbols are used in Volume II of this Annex, they have the meanings ascribed to them below:</p> <p>CO Carbon monoxide</p> <p>D_p The mass of any gaseous pollutant emitted during the reference emissions landing and take-off cycle</p> <p>F_n Thrust in International Standard Atmosphere (ISA), sea level conditions, for the given operating mode</p> <p>F_{oo} Rated thrust (<i>see</i> definition)</p> <p>F^*_{oo} Rated thrust with afterburning applied</p> <p>HC Unburned hydrocarbons (<i>see</i> definition)</p> <p>NO Nitric oxide</p> <p>NO₂ Nitrogen dioxide</p> <p>NO_x Oxides of nitrogen (<i>see</i> definition)</p> <p>nvPM Non-volatile particulate matter (<i>see</i> definition)</p> <p>SN Smoke Number (<i>see</i> definition)</p> <p>π_{oo} Reference pressure ratio (<i>see</i> definition)</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 1 Reference 1.1 Standard	PART II. VENTED FUEL CHAPTER 1. ADMINISTRATION 1.1 The provisions of this part shall apply to all turbine engine powered aircraft intended for operation in international air navigation manufactured after 18 February 1982.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference 1.2 Standard	1.2 Certification related to the prevention of intentional fuel venting shall be granted by the certifying authority on the basis of satisfactory evidence that either the aircraft or the aircraft engines comply with requirements of Chapter 2. <i>Note.— The document attesting certification relating to fuel venting may take the form of a separate fuel venting certificate or a suitable statement contained in another document approved by the certifying authority.</i>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference 1.3 Standard	1.3 Contracting States shall recognize as valid a certification relating to fuel venting granted by the certifying authority of another Contracting State provided the requirements under which such certification was granted are not less stringent than the provision of Volume II of this Annex.	Article 9(2) of Reg. (EU)2018/1139	No Difference		

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Chapter 2 Reference 2 Standard	<p>CHAPTER 2. PREVENTION OF INTENTIONAL FUEL VENTING</p> <p>Aircraft shall be so designed and constructed as to prevent the intentional discharge into the atmosphere of liquid fuel from the fuel nozzle manifolds resulting from the process of engine shutdown following normal flight or ground operations.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference 1.1 Standard	<p>PART III. EMISSIONS CERTIFICATION</p> <p>CHAPTER 1. ADMINISTRATION</p> <p>1.1 The provisions of 1.2 to 1.5 shall apply to all engines and their derivative versions included in the classifications defined for emission certification purposes in Chapters 2, 3 and 4 where such engines are fitted to aircraft engaged in international air navigation.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 1 Reference 1.2 Standard	<p>1.2 Emissions certification shall be granted by the certifying authority on the basis of satisfactory evidence that the engine complies with requirements which are at least equal to the stringency of the provisions of Volume II of this Annex. Compliance with the emissions levels of Chapters 2 and 3 shall be demonstrated using the procedure described in Appendix 6.</p> <p><i>Note.— The document attesting emissions certification may take the form of a separate emissions certificate or a suitable statement contained in another document approved by the certifying authority.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference 1.3 Standard	<p>1.3 The document attesting emissions certification for each individual engine shall include at least the following information which is applicable to the engine type:</p> <ul style="list-style-type: none"> a) name of certifying authority; b) manufacturer's type and model designation; c) statement of any additional modifications incorporated for the purpose of compliance with the applicable emissions certification requirements; d) rated thrust; e) reference pressure ratio; f) a statement indicating compliance with Smoke Number requirements; g) a statement indicating compliance with gaseous pollutant requirements; h) a statement indicating compliance with particulate matter requirements. 	Article 9(2) of Reg. (EU)2018/1139	Different in character or other means of compliance	The information of items (d) and (e) is included in the Engine Type Certificate Data Sheet and not provided for any individual engine.	



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Chapter 1 Reference 1.4 Standard	1.4 Contracting States shall recognize as valid emissions certification granted by the certifying authority of another Contracting State provided that the requirements under which such certification was granted are not less stringent than the provisions of Volume II of this Annex.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference 1.5 Standard	1.5 Contracting States shall recognize as valid engine exemptions granted by the competent authority of another Contracting State having jurisdiction over the organization responsible for production of the engine, provided that an acceptable process was used. <i>Note.— Guidance on acceptable processes and criteria for granting exemptions is provided in the Environmental Technical Manual (Doc 9501), Volume II — Procedures for the Emissions Certification of Aircraft Engines.</i>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 1 Reference 1.6 Standard	1.6 Unless otherwise specified in this volume of the Annex, the date to be used by Contracting States in determining the applicability of the Standards in this Annex shall be the date when the application for a Type Certificate for engines of a type or model was submitted to the State of Design, or the date of submission under an equivalent application procedure prescribed by the certifying authority of the State of Design.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 1 Reference 1.7 Standard	1.7 An application for a Type Certificate for engines of a type or model shall be effective for the period specified in the designation of the airworthiness regulations appropriate to the engine of a type or model, except in special cases where the certificating authority accepts an extension of this period. When this period of effectivity is exceeded and an extension is approved, the date to be used in determining the applicability of the Standards in this Annex shall be the date of issue of the Type Certificate or approval of the change in the type design, or the date of issue of approval under an equivalent procedure prescribed by the State of Design, less the period of effectivity.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.1.1.1 Standard	<p>CHAPTER 2. TURBOJET AND TURBOFAN ENGINES INTENDED FOR PROPULSION ONLY AT SUBSONIC SPEEDS</p> <p>2.1 General</p> <p>2.1.1 Applicability</p> <p>2.1.1.1 The provisions of this chapter shall apply to all turbojet and turbofan engines, as further specified in 2.2 and 2.3, intended for propulsion only at subsonic speeds, except when the certificating authority or the competent authority having jurisdiction over the organization responsible for production of the engine grants exemptions for:</p> <p>a) specific engine types and derivative versions of such engines for which the Type Certificate of the first basic type was issued or other equivalent prescribed procedure was carried out before 1 January 1965;</p> <p>b) a limited number of engines over a specific period of time beyond the dates of applicability specified in 2.2 and 2.3 for the manufacture of the individual engine.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.1.1.2 Standard	<p>2.1.1.2 In such cases, an exemption document shall be issued by the certifying authority or the competent authority having jurisdiction over the organization responsible for production of the engines, the identification plates on the engines shall be marked “EXEMPT” and the grant of exemption shall be noted in the permanent engine record. The certifying authority or the competent authority having jurisdiction over the organization responsible for production of the engines shall take into account the numbers of exempted engines that will be produced and their impact on the environment. Exemptions shall be reported by engine serial number and made available via an official public register.</p> <p>Recommendation.— <i>When such an exemption is granted, the certifying authority or the competent authority having jurisdiction over the organization responsible for production of the engines should consider imposing a time limit on the production of such engines.</i></p> <p><i>Note.</i>— <i>Further guidance on issuing exemptions is provided in the Environmental Technical Manual (Doc 9501), Volume II — Procedures for the Emissions Certification of Aircraft Engines.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.1.3 Standard	<p>2.1.1.3 The provisions of this chapter shall also apply to engines designed for applications that otherwise would have been fulfilled by turbojet and turbofan engines and which are designed as an integrated propulsive power plant and certified with a rated thrust.</p> <p><i>Note.</i>— <i>Guidance material is provided in the Environmental Technical Manual (Doc 9501), Volume II — Procedures for the Emissions Certification of Aircraft Engines.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.1.2 Standard	2.1.2 Emissions involved The following emissions shall be controlled for certification of aircraft engines: Smoke Gaseous emissions Unburned hydrocarbons (HC); Carbon monoxide (CO); and Oxides of nitrogen (NOx).	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.3.1 Standard	2.1.3 Units of measurement 2.1.3.1 The smoke emission shall be measured and reported in terms of Smoke Number (SN).	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.3.2 Standard	2.1.3.2 The mass (<i>Dp</i>) of the gaseous pollutant HC, CO or NO _x emitted during the reference emissions landing and take-off (LTO) cycle, defined in 2.1.4.2 and 2.1.4.3, shall be measured and reported in grams.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.4.1 Standard	2.1.4 Reference conditions 2.1.4.1 <i>Atmospheric conditions</i> The reference atmospheric conditions for engine performance shall be ISA at sea level except that the reference humidity shall be 0.00634 kg water/kg dry air.	Article 9(2) of Reg. (EU)201 8/1139	No Difference		



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Chapter 2 Reference 2.1.4.2 Standard	2.1.4.2 <i>Thrust settings</i> The engine shall be tested at sufficient thrust settings to define the gaseous and smoke emissions of the engine so that mass emission rates and Smoke Numbers can be determined at the following specific percentages of rated thrust as agreed by the certifying authority:	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.4.3 Standard	2.1.4.3 <i>Reference emissions landing and take-off (LTO) cycle</i> The reference emissions LTO cycle for the calculation and reporting of gaseous emissions shall be represented by the following time in each operating mode.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.4.4 Standard	2.1.4.4 <i>Fuel specifications</i> The fuel used during tests shall meet the specifications of Appendix 4.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.5.1 Standard	2.1.5 Test conditions 2.1.5.1 The tests shall be made with the engine on its test bed.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.1.5.2 Standard	2.1.5.2 The engine shall be representative of the certificated configuration (<i>see</i> Appendix 6); off-take bleeds and accessory loads other than those necessary for the engine's basic operation shall not be simulated.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.1.5.3 Standard	2.1.5.3 When test conditions differ from the reference atmospheric conditions in 2.1.4.1, the gaseous emissions test results shall be corrected to the reference atmospheric conditions in accordance with the procedures of Appendix 3.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.2.1 Standard	2.2 Smoke 2.2.1 Applicability The provisions of 2.2.2 shall apply: a) to engines whose date of manufacture is on or after 1 January 1983 and before 1 January 2023; and b) to engines with a maximum rated thrust of less than or equal to 26.7 kN whose date of manufacture is on or after 1 January 2023.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.2.2 Standard	<p>2.2.2 Regulatory Smoke Number</p> <p>The Smoke Number at any of the four LTO operating mode thrust settings when measured and computed in accordance with the procedures of Appendix 2, or equivalent procedures as agreed by the certifying authority, and converted to a characteristic level by the procedures of Appendix 6 shall not exceed the level determined from the following formula:</p> $\text{Regulatory Smoke Number} = 83.6 (Foo) - 0.274$ <p>or a value of 50, whichever is lower</p> <p><i>Note.— Guidance material on the definition and the use of equivalent procedures is provided in the Environmental Technical Manual (Doc 9501), Volume II — Procedures for the Emissions Certification of Aircraft Engines.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.3.1 Standard	<p>2.3 Gaseous emissions</p> <p>2.3.1 Applicability</p> <p>The provisions of 2.3.2 shall apply to engines whose rated thrust is greater than 26.7 kN and whose date of manufacture is on or after 1 January 1986 and as further specified for oxides of nitrogen.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.3.2 Standard	<p>2.3.2 Regulatory levels</p> <p>Gaseous emission levels when measured and computed in accordance with the procedures of Appendix 3 and converted to characteristic levels by the procedures of Appendix 6, or equivalent procedures as agreed by the certifying authority, shall not exceed the regulatory levels determined from the following formulas:</p> <p>Hydrocarbons (HC): $Dp / Foo = 19.6$</p> <p>Carbon monoxide (CO): $Dp / Foo = 118$</p> <p>Oxides of nitrogen (NOx):</p> <p>a) for engines of a type or model for which the date of manufacture of the first individual production model was before 1 January 1996 and for which the date of manufacture of the individual engine was before 1 January 2000:</p> $Dp / Foo = 40 + 2\pi\omega$ <p>b) for engines of a type or model for which the date of manufacture of the first individual production model was on or after 1 January 1996 or for which the date of manufacture of the individual engine was on or after 1 January 2000:</p> $Dp / Foo = 32 + 1.6\pi\omega$ <p>c) for engines of a type or model for which the date of manufacture of the first individual production model was on or after 1 January 2004:</p> <p>1) for engines with a pressure ratio of 30 or less:</p> <p>i) for engines with a maximum rated thrust of more than 89.0 kN:</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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	$Dp / Foo = 19 + 1.6\pi_{oo}$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p> $Dp / Foo = 37.572 + 1.6\pi_{oo} - 0.2087 Foo$ <p>2) for engines with a pressure ratio of more than 30 but less than 62.5:</p> <p>i) for engines with a maximum rated thrust of more than 89.0 kN:</p> $Dp / Foo = 7 + 2.0\pi_{oo}$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p> $Dp / Foo = 42.71 + 1.4286\pi_{oo} - 0.4013 Foo + 0.00642\pi_{oo} \times Foo$ <p>3) for engines with a pressure ratio of 62.5 or more:</p> $Dp / Foo = 32 + 1.6\pi_{oo}$ <p>d) for engines of a type or model for which the date of manufacture of the first individual production model was on or after 1 January 2008 or for which the date of manufacture of the individual engine was on or after 1 January 2013:</p> <p>1) for engines with a pressure ratio of 30 or less:</p> <p>i) for engines with a maximum rated thrust of more than 89.0 kN:</p> $Dp / Foo = 16.72 + 1.4080\pi_{oo}$				



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	<p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p> $Dp / Foo = 38.5486 + 1.6823\pi\pi\pi - 0.2453 Foo - 0.00308\pi\pi\pi Foo$ <p>2) for engines with a pressure ratio of more than 30 but less than 82.6:</p> <p>i) for engines with a maximum rated thrust of more than 89.0 kN:</p> $Dp / Foo = -1.04 + 2.0\pi\pi\pi$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p> $Dp / Foo = 46.1600 + 1.4286\pi\pi\pi - 0.5303 Foo + 0.00642\pi\pi\pi Foo$ <p>3) for engines with a pressure ratio of 82.6 or more:</p> $Dp / Foo = 32 + 1.6\pi\pi\pi$ <p>e) for engines of a type or model for which the date of manufacture of the first individual production model was on or after 1 January 2014 and for which an application for a Type Certificate was submitted before 1 January 2023:</p> <p>1) for engines with a pressure ratio of 30 or less:</p> <p>i) for engines with a maximum rated thrust of more than 89.0 kN:</p> $Dp / Foo = 7.88 + 1.4080\pi\pi\pi$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p>				



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	$Dp / Foo = 40.052 + 1.5681\pi_{oo} -$				
Chapter 2 Reference 2.4 Note	2.4 Information required <i>Note.— The information required is divided into three groups: 1) general information to identify the engine characteristics, the fuel used and the method of data analysis; 2) the data obtained from the engine test(s); and 3) the results derived from the test data.</i>		Not Applicable		
Chapter 2 Reference 2.4.1 Standard	2.4.1 General information The following information shall be provided for each engine type for which emissions certification is sought: a) engine identification; b) rated thrust (kN); c) reference pressure ratio; d) fuel specification reference; e) fuel hydrogen/carbon ratio; f) the methods of data acquisition; g) the method of making corrections for ambient conditions; and h) the method of data analysis.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.4.2 Standard	<p>2.4.2 Test information</p> <p>The following information shall be provided for each engine tested for certification purposes at each of the thrust settings specified in 2.1.4.2. The information shall be provided after correction to the reference ambient conditions where applicable:</p> <ul style="list-style-type: none"> a) fuel flow (kg/s); b) emission index (grams/kg) for each gaseous pollutant; and c) measured Smoke Number. 	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 2 Reference 2.4.3.1 Standard	<p>2.4.3 Derived information</p> <p>2.4.3.1 The following derived information shall be provided for each engine tested for certification purposes:</p> <ul style="list-style-type: none"> a) emission rate, i.e. emission index × fuel flow, (grams/s) for each gaseous pollutant; b) total gross emission of each gaseous pollutant measured over the LTO cycle (grams); c) values of Dp / Foo for each gaseous pollutant (grams/kN); and d) maximum Smoke Number. 	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 2 Reference 2.4.3.2 Standard	2.4.3.2 The characteristic Smoke Number and gaseous pollutant emission levels shall be provided for each engine type for which emissions certification is sought.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.1 Standard	<p>CHAPTER 3. TURBOJET AND TURBOFAN ENGINES INTENDED FOR PROPULSION AT SUPERSONIC SPEEDS</p> <p>3.1 General</p> <p>3.1.1 Applicability</p> <p>The provisions of this chapter shall apply to all turbojet and turbofan engines intended for propulsion at supersonic speeds whose date of manufacture is on or after 18 February 1982.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Annex Reference	ENVIRONMENTAL PROTECTION Standard or Recommended Practice	State Legislation, Regulation or Document Reference	Level of implementation of SARP's	Text of the difference to be notified to ICAO	Comments including the reason for the difference
Chapter 3 Reference 3.1.2 Standard	3.1.2 Emissions involved The following emissions shall be controlled for certification of aircraft engines: Smoke Gaseous emissions Unburned hydrocarbons (HC); Carbon monoxide (CO); and Oxides of nitrogen (NOx).	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.3.1 Standard	3.1.3 Units of measurement 3.1.3.1 The smoke emission shall be measured and reported in terms of Smoke Number (SN).	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.3.2 Standard	3.1.3.2 The mass (Dp) of the gaseous pollutants HC, CO, or NOx emitted during the reference emissions landing and take-off (LTO) cycle, defined in 3.1.5.2 and 3.1.5.3 shall be measured and reported in grams.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.4 Standard	3.1.4 Nomenclature Throughout this chapter, where the expression $F*_{oo}$ is used, it shall be replaced by F_{oo} for engines which do not employ afterburning. For taxi/ground idle thrust setting, F_{oo} shall be used in all cases.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 3 Reference 3.1.5.1 Standard	3.1.5 Reference conditions 3.1.5.1 <i>Atmospheric conditions</i> The reference atmospheric conditions shall be ISA at sea level except that the reference absolute humidity shall be 0.00634 kg water/kg dry air.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.5.2 Standard	3.1.5.2 <i>Thrust settings</i> The engine shall be tested at sufficient thrust settings to define the gaseous and smoke emissions of the engine so that mass emission rates and Smoke Numbers corrected to the reference ambient conditions can be determined at the following specific percentages of rated thrust as agreed by the certifying authority.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.5.3 Standard	3.1.5.3 <i>Reference emissions landing and take-off (LTO) cycle</i> The reference emissions LTO cycle for the calculation and reporting of gaseous emissions shall be represented by the following time in each operating mode.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.5.4 Standard	3.1.5.4 <i>Fuel specifications</i> The fuel used during tests shall meet the specifications of Appendix 4. Additives used for the purpose of smoke suppression (such as organo-metallic compounds) shall not be present.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 3 Reference 3.1.6.1 Standard	3.1.6 Test conditions 3.1.6.1 The tests shall be made with the engine on its test bed.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.6.2 Standard	3.1.6.2 The engine shall be representative of the certificated configuration (<i>see</i> Appendix 6); off-take bleeds and accessory loads other than those necessary for the engine's basic operation shall not be simulated.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.6.3 Standard	3.1.6.3 Measurements made for determination of emission levels at the thrusts specified in 3.1.5.2 shall be made with the afterburner operating at the level normally used, as applicable.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.1.6.4 Standard	3.1.6.4 When test conditions differ from the reference conditions in 3.1.5, the test results shall be corrected to the reference conditions in accordance with the procedures of Appendix 5.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 3 Reference 3.2.1 Standard	<p>3.2 Smoke</p> <p>3.2.1 Regulatory Smoke Number</p> <p>The Smoke Number at any thrust setting when measured and computed in accordance with the procedures of Appendix 2 and converted to a characteristic level by the procedures of Appendix 6 shall not exceed the regulatory level determined from the following formula:</p> <p style="text-align: center;">Regulatory Smoke Number = $83.6 (F^{*oo}) - 0.274$ or a value of 50, whichever is lower</p> <p><i>Note.— Certifying authorities may alternatively accept values determined using afterburning provided that the validity of these data is adequately demonstrated.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 3 Reference 3.3.1 Standard	<p>3.3 Gaseous emissions</p> <p>3.3.1 Regulatory levels</p> <p>Gaseous emission levels when measured and computed in accordance with the procedures of Appendix 3 or Appendix 5, as applicable, and converted to characteristic levels by the procedures of Appendix 6 shall not exceed the regulatory levels determined from the following formulas:</p> <p>Hydrocarbons (HC): $Dp / F^{*oo} = 140(0.92)^{\pi oo}$</p> <p>Carbon monoxide (CO): $Dp / F^{*oo} = 4\,550(\pi oo) - 1.03$</p> <p>Oxides of nitrogen (NOx): $Dp / F^{*oo} = 36 + 2.42\pi oo$</p> <p><i>Note.— The characteristic level of the Smoke Number or gaseous pollutant emissions is the mean of the values of all the engines tested, measured and corrected to the reference standard engine and reference ambient conditions, divided by the coefficient corresponding to the number of engines tested, as shown in Appendix 6.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 3 Reference 3.4.1 Standard	<p>3.4 Information required</p> <p><i>Note.— The information required is divided into three groups: 1) general information to identify the engine characteristics, the fuel used and the method of data analysis; 2) the data obtained from the engine test(s); and 3) the results derived from the test data.</i></p> <p>3.4.1 The following information shall be provided for each engine type for which emissions certification is sought:</p> <ul style="list-style-type: none"> a) engine identification; b) rated thrust (kN); c) rated thrust with afterburning applied, if applicable (kN); d) reference pressure ratio; e) fuel specification reference; f) fuel hydrogen/carbon ratio; g) the methods of data acquisition; h) the method of making corrections for ambient conditions; and i) the method of data analysis. 	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 3 Reference 3.4.2 Standard	<p>3.4.2 Test information</p> <p>The following information shall be provided for each engine tested for certification purposes at each of the thrust settings specified in 3.1.5.2. The information shall be provided after correction to the reference ambient conditions where applicable:</p> <ul style="list-style-type: none"> a) fuel flow (kg/s); b) emission index (grams/kg) for each gaseous pollutant; c) percentage of thrust contributed by afterburning; and d) measured Smoke Number. 	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 3 Reference 3.4.3.1 Standard	<p>3.4.3 Derived information</p> <p>3.4.3.1 The following derived information shall be provided for each engine tested for certification purposes:</p> <ul style="list-style-type: none"> a) emission rate, i.e. emission index \times fuel flow, (grams/s), for each gaseous pollutant; b) total gross emission of each gaseous pollutant measured over the LTO cycle (grams); c) values of Dp / F^{*00} for each gaseous pollutant (grams/kN); and d) maximum Smoke Number. 	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 3 Reference 3.4.3.2 Standard	<p>3.4.3.2 The characteristic Smoke Number and gaseous pollutant emission levels shall be provided for each engine type for which emissions certification is sought.</p> <p><i>Note.— The characteristic level of the Smoke Number or gaseous pollutant emissions is the mean of the values of all the engines tested, measured and corrected to the reference standard engine and reference ambient conditions, divided by the coefficient corresponding to the number of engines tested, as shown in Appendix 6.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.1.1 Standard	<p>CHAPTER 4. PARTICULATE MATTER EMISSIONS</p> <p>4.1 General</p> <p>4.1.1 Applicability</p> <p>4.1.1.1 The provisions of this chapter shall apply to all aircraft engines, as further specified in 4.2, intended for propulsion only at subsonic speeds.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.1.2 Standard	<p>4.1.1.2 Specific provisions for the relevant engine categories shall apply as detailed in section 4.2, except when the certifying authority or the competent authority having jurisdiction over the organization responsible for production of the engines grants exemptions for a limited number of engines over a specific period of time beyond the dates of applicability specified in 4.2 for the manufacture of the individual engine.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 4 Reference 4.1.1.3 Standard	<p>4.1.1.3 In such cases, an exemption document shall be issued by the certifying authority or the competent authority having jurisdiction over the organization responsible for production of the engines, the identification plates on the engines shall be marked "EXEMPT" and the grant of exemption shall be noted in the permanent engine record. The certifying authority or the competent authority having jurisdiction over the organization responsible for production of the engines shall take into account the number of exempted engines that will be produced and their impact on the environment. Exemptions shall be reported by engine serial number and made available via an official public register.</p> <p>Recommendation.— <i>When such an exemption is granted, the certifying authority or the competent authority having jurisdiction over the organization responsible for production of the engines should consider imposing a time limit on the production of such engines.</i></p> <p>Note.— <i>Further guidance on issuing exemptions is provided in the Environmental Technical Manual (Doc 9501), Volume II — Procedures for the Emissions Certification of Aircraft Engines.</i></p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.2 Standard	<p>4.1.2 Emissions involved</p> <p>The purpose of this section is to control non-volatile particulate matter mass (nvPM) emissions.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 4 Reference 4.1.3.1 Standard	4.1.3 Units of measurement 4.1.3.1 The concentration of nvPM mass shall be measured and reported in micrograms/m ³ .	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.3.2 Standard	4.1.3.2 The nvPM mass emitted during the reference emissions landing and take-off (LTO) cycle, defined in 4.1.4.2 (<i>LTO_{mass}</i>), shall be measured and reported in milligrams.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.3.3 Standard	4.1.3.3 The nvPM number emitted during the reference emissions landing and take-off (LTO) cycle, defined in 4.1.4.2 (<i>LTO_{num}</i>), shall be measured and reported in number of particles.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.4.1 Standard	4.1.4 Reference conditions 4.1.4.1 <i>Atmospheric conditions</i> The reference atmospheric conditions for the reference standard engine shall be ISA at sea level except that the reference humidity shall be 0.00634 kg water/kg dry air.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 4 Reference 4.1.4.2 Standard	4.1.4.2 <i>Reference emissions landing and take-off (LTO) cycle</i> The engine shall be tested at sufficient thrust settings to define the nvPM emissions of the engine so that nvPM mass emission indices (EImass) and nvPM number emission indices (EInum) can be determined at the reference emissions LTO cycle thrust settings and at thrusts producing maximum nvPM mass concentration, maximum EImass and maximum EInum as agreed by the certifying authority. For the calculation and reporting of nvPM emissions, the reference emissions LTO cycle shall be represented by the following thrust setting and time in each following operating mode:	Article 9(2) of Reg. (EU)201 8/1139	No Difference		
Chapter 4 Reference 4.1.4.3 Standard	4.1.4.3 <i>Fuel specifications</i> The fuel used during tests shall meet the specifications of Appendix 4.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.5.1 Standard	4.1.5 Test conditions 4.1.5.1 The tests shall be made with the engine on its test bed.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 4 Reference 4.1.5.2 Standard	4.1.5.2 The engine shall be representative of the certificated configuration (<i>see</i> Appendix 6); off-take bleeds and accessory loads other than those necessary for the engine's basic operation shall not be simulated.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.5.3 Standard	4.1.5.3 When test conditions differ from the reference atmospheric conditions in 4.1.4.1, Elmass and Elnum shall be corrected to the engine combustor inlet temperature under the reference atmospheric conditions in accordance with the procedures of Appendix 7.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.1.5.4 Standard	4.1.5.4 The maximum nvPM mass concentration shall be corrected for dilution and thermophoretic losses in the Collection Part of the sampling system in accordance with the procedures of Appendix 7. The Elmass and Elnum shall be corrected for thermophoretic losses in the Collection Part of the sampling system and fuel composition in accordance with the procedures of Appendix 7.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.2.1.1 Standard	4.2 Non-volatile particulate matter emissions 4.2.1 Applicability 4.2.1.1 The provisions further specified in 4.2.2 and 4.2.3 shall apply to all turbofan and turbojet engines of a type or model with a rated thrust greater than 26.7 kN.	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 4 Reference 4.2.1.2 Standard	4.2.1.2 The provisions of this chapter shall also apply to engines designed for applications that otherwise would have been fulfilled by turbojet and turbofan engines and which are designed as an integrated propulsive powerplant and certified with a rated thrust.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.2.2.1 Standard	4.2.2 Regulatory levels 4.2.2.1 <i>Maximum nvPM mass concentration</i> For an engine whose date of manufacture of the individual engine is on or after 1 January 2020, the maximum nvPM mass concentration obtained from measurement at sufficient thrust settings, in such a way that the emission maximum can be determined, and computed in accordance with the procedures of Appendix 7 and converted to characteristic levels by the procedures of Appendix 6, or equivalent procedures as agreed by the certificating authority, shall not exceed the regulatory level determined from the following formula: <i>Note.— Since there is a correlation between nvPM mass concentration and Smoke Number, the regulatory level in 4.2.2.1 was derived from the Smoke Number regulatory level. Further information is provided in the Environmental Technical Manual (Doc 9501), Volume II — Procedures for the Emissions Certification of Aircraft Engines.</i>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 4 Reference 4.2.2.2 Standard	<p>4.2.2.2 <i>nvPM mass and nvPM number emitted during the reference LTO cycle</i></p> <p>The nvPM mass and nvPM number emission levels when measured and computed in accordance with the procedures of Appendix 7 and converted to characteristic levels by the procedures of Appendix 6, or equivalent procedures as agreed by the certifying authority, shall not exceed the regulatory levels determined from the following formulas:</p> <p>a) <i>LTOmass</i>:</p> <p>1) for engines of a type or model for which the date of manufacture of the individual engine was on or after 1 January 2023:</p> <p>i) for engines with a maximum rated thrust of more than 200 kN:</p> $LTOmass/Foo = 347.5$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 200 kN:</p> $LTOmass/Foo = 4646.9 - 21.497Foo$ <p>2) for engines of a type or model for which an application for a Type Certificate was submitted on or after 1 January 2023:</p> <p>i) for engines with a maximum rated thrust of more than 150 kN:</p> $LTOmass/Foo = 214.0$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 150 kN:</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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	$LTO_{mass}/Foo = 1251.1 - 6.914Foo$ b) LTO_{num} : 1) for engines of a type or model for which the date of manufacture of the individual engine was on or after 1 January 2023: i) for engines with a maximum rated thrust of more than 200 kN: $LTO_{num}/Foo = 4.170 \times 10^{15}$ ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 200 kN: $LTO_{num}/Foo = 2.669 \times 10^{16} - 1.126 \times 10^{14}Foo$ 2) for engines of a type or model for which an application for a Type Certificate was submitted on or after 1 January 2023: i) for engines with a maximum rated thrust of more than 150 kN: $LTO_{num}/Foo = 2.780 \times 10^{15}$ ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 150 kN: $LTO_{num}/Foo = 1.490 \times 10^{16} - 8.080 \times 10^{13}Foo$				



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Chapter 4 Reference 4.2.3 Standard	4.2.3 Reporting requirement The manufacturer shall report the following values of nvPM emissions measured and computed in accordance with the procedures of Appendix 7, or any equivalent procedures as agreed by the certificating authority: a) maximum EImass (milligrams/kg of fuel); and b) maximum EInum (particles/kg of fuel).	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.3 Note	4.3 Information required <i>Note.— The information required is divided into three groups: 1) general information to identify the engine characteristics, the fuel used and the method of data analysis; 2) the data obtained from the engine test(s); and 3) derived information.</i>		Not Applicable		



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Chapter 4 Reference 4.3.1 Standard	4.3.1 General information The following information shall be provided for each engine type for which emissions certification is sought: a) engine identification; b) rated thrust (kN); c) reference pressure ratio; d) fuel specification reference; e) fuel hydrogen/carbon ratio; f) the methods of data acquisition; and g) the method of data analysis.	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.3.2.1 Standard	4.3.2 Test information 4.3.2.1 The following information shall be provided for each engine tested for certification purposes: a) fuel net heat of combustion (MJ/kg); b) fuel hydrogen content (mass %); c) fuel total aromatics content (volume %); d) fuel naphthalenes content (volume %); and e) fuel sulphur content (ppm by mass).	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 4 Reference 4.3.2.2 Standard	<p>4.3.2.2 The following information, as measured and computed in accordance with the procedures of Appendix 7, or any equivalent procedures as agreed by the certifying authority, shall be provided for each engine tested for certification purposes:</p> <p>a) fuel flow (kg/s) at each thrust setting of the LTO cycle;</p> <p>b) Elmass (milligrams/kg of fuel) at each thrust setting of the LTO cycle;</p> <p>c) Elnum (particles/kg of fuel) at each thrust setting of the LTO cycle.</p>	Article 9(2) of Reg. (EU)201 8/1139	No Difference		



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Chapter 4 Reference 4.3.3.1 Standard	<p>4.3.3 Derived information</p> <p>4.3.3.1 The following derived information shall be provided for each engine tested for certification purposes:</p> <p>a) emission rate, i.e. $E_{\text{mass}} \times \text{fuel flow}$, (milligrams/s) for nvPM mass;</p> <p>b) emissions rate, i.e. $E_{\text{num}} \times \text{fuel flow}$, (particles/s) for nvPM number;</p> <p>c) total gross emission of nvPM mass measured over the LTO cycle (milligrams);</p> <p>d) total gross emission of nvPM number measured over the LTO cycle (particles);</p> <p>e) values of LTO_{mass}/Foo (milligrams/kN);</p> <p>f) values of LTO_{num}/Foo (particles/kN); and</p> <p>g) maximum nvPM mass concentration (micrograms/m³).</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		
Chapter 4 Reference 4.3.3.2 Standard	<p>4.3.3.2 The characteristic levels shall be provided for the maximum nvPM mass concentration, the LTO_{mass}/Foo and the LTO_{num}/Foo for each engine type for which emissions certification is sought.</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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Chapter 1 Reference 1.0.2 Standard	<p>PART IV. NON-VOLATILE PARTICULATE MATTER ASSESSMENT FOR INVENTORY AND MODELLING PURPOSES</p> <p><i>Note 1.— The purpose of this part is to provide Standard and Recommended Practices on how to calculate the nvPM mass and number correction factors for the nvPM system losses other than the Collection Part thermophoretic losses. The nvPM sampling and measurement system, the Collection Part and the thermophoretic losses calculation are described in Appendix 7.</i></p> <p><i>Note 2.— The nvPM mass and number system loss correction factors permit an estimation of the concentration of the nvPM mass and number at the exhaust of the aircraft engine from the nvPM mass and number concentration obtained in accordance with the procedures of Appendix 7.</i></p> <p>For engines of a type or model subject to Part III, Chapter 4, and for which the date of manufacture of the individual engine was on or after 1 January 2023, the nvPM mass and nvPM number system loss correction factors (kSL_mass and kSL_num), and EImass and EInum corrected for system losses shall be reported to the certifying or competent authority as designated by the State in accordance with the procedures of Appendix 8, or equivalent procedures as agreed by the certifying authority.</p> <p>Recommendation.— For inventory and modelling purposes, the nvPM mass and nvPM number emissions</p>	Article 9(2) of Reg. (EU)2018/1139	No Difference		



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	<i>obtained in accordance with the procedures of Appendix 7 should be corrected for system losses using the methodology described in Appendix 8.</i>				

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