



## Report on entire Annex

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 style="text-align: center;"><b>INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES</b></p> <p style="text-align: center;"><b>PART I. DEFINITIONS AND SYMBOLS</b></p> <p style="text-align: center;"><b>CHAPTER 1. DEFINITIONS</b></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>		Not Applicable		
Chapter 1 Reference  Definition	<p><i>Approach phase.</i> The operating phase defined by the time during which the engine is operated in the approach operating mode.</p>		Not Applicable		
Chapter 1 Reference  Definition	<p><i>Climb phase.</i> The operating phase defined by the time during which the engine is operated in the climb operating mode.</p>		Not Applicable		



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Chapter 1 Reference  Definition	<b>Date of manufacture.</b> 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.		Not Applicable		
Chapter 1 Reference  Definition	<b>Derivative version.</b> 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 certificating 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>		Not Applicable		
Chapter 1 Reference  Definition	<b>Exhaust nozzle.</b> 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.		Not Applicable		
Chapter 1 Reference  Definition	<b>Non-volatile particulate matter (nvPM).</b> 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.		Not Applicable		



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Chapter 1 Reference  Definition	<b>Oxides of nitrogen.</b> 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.		Not Applicable		
Chapter 1 Reference  Definition	<b>Rated thrust.</b> For engine emissions purposes, the maximum take-off thrust approved by the certificating 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.		Not Applicable		
Chapter 1 Reference  Definition	<b>Reference pressure ratio.</b> 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>		Not Applicable		
Chapter 1 Reference  Definition	<b>Smoke.</b> The carbonaceous materials in exhaust emissions which obscure the transmission of light.		Not Applicable		



## Report on entire Annex

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Chapter 1 Reference  Definition	<b>Smoke Number.</b> The dimensionless term quantifying smoke emissions ( <i>see</i> 3 of Appendix 2).		Not Applicable		
Chapter 1 Reference  Definition	<b>Take-off phase.</b> The operating phase defined by the time during which the engine is operated at the rated thrust.		Not Applicable		
Chapter 1 Reference  Definition	<b>Taxi/ground idle.</b> 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).		Not Applicable		
Chapter 1 Reference  Definition	<b>Type certificate.</b> 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.- In some Contracting States a document equivalent to a type certificate may be issued for an engine or propeller type.</i>		Not Applicable		



Report on entire Annex

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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.		Not Applicable		



Report on entire Annex

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Chapter 2 Reference 2.0  Standard	<p style="text-align: center;"><b>CHAPTER 2. SYMBOLS</b></p> <p>Where the following symbols are used in Volume II of this Annex, they have the meanings ascribed to them below:</p> <p style="padding-left: 40px;">CO      Carbon monoxide</p> <p style="padding-left: 40px;"><i>D<sub>p</sub></i>      The mass of any gaseous pollutant emitted during the reference emissions landing and take-off cycle</p> <p style="padding-left: 40px;"><i>F<sub>n</sub></i>      Thrust in International Standard Atmosphere (ISA), sea level conditions, for the given operating mode</p> <p style="padding-left: 40px;"><i>F<sub>oo</sub></i>      Rated thrust (<i>see</i> definition)</p> <p style="padding-left: 40px;"><i>F*<sub>oo</sub></i>      Rated thrust with afterburning applied</p> <p style="padding-left: 40px;">HC      Unburned hydrocarbons (<i>see</i> definition)</p> <p style="padding-left: 40px;">NO      Nitric oxide</p> <p style="padding-left: 40px;">NO<sub>2</sub>      Nitrogen dioxide</p> <p style="padding-left: 40px;">NO<sub>x</sub>      Oxides of nitrogen (<i>see</i> definition)</p> <p style="padding-left: 40px;">nvPM      Non-volatile particulate matter (<i>see</i> definition)</p> <p style="padding-left: 40px;">SN      Smoke Number (<i>see</i> definition)</p> <p style="padding-left: 40px;">π<sub>oo</sub>      Reference pressure ratio (<i>see</i> definition)</p>		Not Applicable		



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Chapter 1 Reference 1.1  Standard	<p style="text-align: center;"><b>PART II. VENTED FUEL</b></p> <p style="text-align: center;"><b>CHAPTER 1. ADMINISTRATION</b></p> <p>The provision of this Part shall apply to all turbine engine powered aircraft intended for operation in international air navigation manufactured after 18 February 1982.</p>		Not Applicable		
Chapter 1 Reference 1.2  Standard	<p>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.</p> <p><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></p>		Not Applicable		
Chapter 1 Reference 1.3  Standard	<p>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.</p>		Not Applicable		



Report on entire Annex

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Chapter 2 Reference 2.0  Standard	<p align="center"><b>CHAPTER 2. PREVENTION OF INTENTIONAL FUEL VENTING</b></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>		Not Applicable		
Chapter 1 Reference 1.1  Standard	<p align="center"><b>PART III. EMISSIONS CERTIFICATION</b></p> <p align="center"><b>CHAPTER 1. ADMINISTRATION</b></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>		Not Applicable		





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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>		Not Applicable		
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"> <li>a) name of certifying authority;</li> <li>b) manufacturer's type and model designation;</li> <li>c) statement of any additional modifications incorporated for the purpose of compliance with the applicable emissions certification requirements;</li> <li>d) rated thrust;</li> <li>e) reference pressure ratio;</li> <li>f) a statement indicating compliance with Smoke Number requirements;</li> <li>g) a statement indicating compliance with gaseous pollutant requirements.</li> </ul>		Not Applicable		



Report on entire Annex

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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.		Not Applicable		
Chapter 1 Reference 1.5  Standard	1.5 Contracting States shall recognize as valid engine exemptions for an engine production cut-off requirement granted by a certifying authority of another Contracting State provided that the exemptions are granted in accordance with the process and criteria defined in the <i>Environmental Technical Manual (Doc 9501), Volume II - Procedures for the Emissions Certification of Aircraft Engines</i> .		Not Applicable		



Report on entire Annex

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Chapter 2 Reference 2.1.1.1  Standard	<p style="text-align: center;"><b>CHAPTER 2. TURBOJET AND TURBOFAN ENGINES INTENDED FOR PROPULSION ONLY AT SUBSONIC SPEEDS</b></p> <p style="text-align: center;"><b>2.1 General</b></p> <p style="text-align: center;">2.1.1 Applicability</p> <p style="text-align: center;">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 certifying authorities make exemptions for:</p> <ul style="list-style-type: none"> <li>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; and</li> <li>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.</li> </ul>		Not Applicable		



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Chapter 2 Reference 2.1.1.2  Standard	2.1.1.2 In such cases, an exemption document shall be issued by the certifying authority, the identification plates on the engines shall be marked "EXEMPT NEW" or "EXEMPT SPARE" and the grant of exemption shall be noted in the permanent engine record. Exemptions shall be reported by engine serial number and made available via an official public register.		Not Applicable		
Chapter 2 Reference 2.1.1.3  Standard	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.  <i>Note.- In considering exemptions, certifying authorities should take into account the probable numbers of such engines that will be produced and their impact on the environment. When such an exemption is granted, the certifying authority should consider imposing a time limit on the production of such engines for installation on new aircraft. 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>		Not Applicable		
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).		Not Applicable		



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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).		Not Applicable		
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 <sub>x</sub> 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.		Not Applicable		
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 absolute humidity shall be 0.00634 kg water/kg dry air.		Not Applicable		



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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:  <table border="0" style="margin-left: 40px;"> <tr> <td><i>LTO operating mode</i></td> <td><i>Thrust setting</i></td> </tr> <tr> <td>Take-off</td> <td>100 per cent <i>Foo</i></td> </tr> <tr> <td>Climb</td> <td>85 per cent <i>Foo</i></td> </tr> <tr> <td>Approach</td> <td>30 per cent <i>Foo</i></td> </tr> <tr> <td>Taxi/ground idle</td> <td>7 per cent <i>Foo</i></td> </tr> </table>	<i>LTO operating mode</i>	<i>Thrust setting</i>	Take-off	100 per cent <i>Foo</i>	Climb	85 per cent <i>Foo</i>	Approach	30 per cent <i>Foo</i>	Taxi/ground idle	7 per cent <i>Foo</i>		Not Applicable				
<i>LTO operating mode</i>	<i>Thrust setting</i>																
Take-off	100 per cent <i>Foo</i>																
Climb	85 per cent <i>Foo</i>																
Approach	30 per cent <i>Foo</i>																
Taxi/ground idle	7 per cent <i>Foo</i>																
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.  <table border="0" style="margin-left: 40px;"> <tr> <td><i>LTO operating mode</i></td> <td><i>Time</i></td> </tr> <tr> <td colspan="2"><i>in operating mode, minutes</i></td> </tr> <tr> <td>Take-off</td> <td>0.7</td> </tr> <tr> <td>Climb</td> <td>2.2</td> </tr> <tr> <td>Approach</td> <td>4.0</td> </tr> <tr> <td>Taxi/ground idle</td> <td>26.0</td> </tr> </table>	<i>LTO operating mode</i>	<i>Time</i>	<i>in operating mode, minutes</i>		Take-off	0.7	Climb	2.2	Approach	4.0	Taxi/ground idle	26.0		Not Applicable		
<i>LTO operating mode</i>	<i>Time</i>																
<i>in operating mode, minutes</i>																	
Take-off	0.7																
Climb	2.2																
Approach	4.0																
Taxi/ground idle	26.0																



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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.		Not Applicable		
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.		Not Applicable		
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.		Not Applicable		
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.		Not Applicable		



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Chapter 2 Reference 2.2.1  Standard	<p style="text-align: center;"><b>2.2 Smoke</b></p> <p style="text-align: center;">2.2.1 Applicability</p> <p>The provisions of 2.2.2 shall apply to engines whose date of manufacture is on or after 1 January 1983.</p>		Not Applicable		
Chapter 2 Reference 2.2.2  Standard	<p style="text-align: center;">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> <p style="text-align: center;">Regulatory Smoke Number = <math>83.6 (Foo)^{-0.274}</math> 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>		Not Applicable		





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Chapter 2 Reference 2.3.1  Standard	<p style="text-align: center;"><b>2.3 Gaseous emissions</b></p> <p style="text-align: center;">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>		Not Applicable		



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Chapter 2 Reference 2.3.2  Standard	<p style="text-align: center;">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 style="padding-left: 40px;">Hydrocarbons (HC): <math>Dp / Foo = 19.6</math></p> <p style="padding-left: 40px;">Carbon monoxide (CO): <math>Dp / Foo = 118</math></p> <p style="padding-left: 40px;">Oxides of nitrogen (NOx):</p> <p style="padding-left: 20px;">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> <p style="padding-left: 60px;"><math>Dp / Foo = 40 + 2\pi\omega</math></p> <p style="padding-left: 20px;">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> <p style="padding-left: 60px;"><math>Dp / Foo = 32 + 1.6\pi\omega</math></p> <p style="padding-left: 20px;">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 style="padding-left: 40px;">1) for engines with a pressure ratio of 30 or less:</p>		Not Applicable		



## Report on entire Annex

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	<p>i) for engines with a maximum rated thrust of more than 89.0 kN:</p> $Dp / F_{oo} = 19 + 1.6\pi_{oo}$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p> $Dp / F_{oo} = 37.572 + 1.6\pi_{oo} - 0.2087F_{oo}$ <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> $Dp / F_{oo} = 7 + 2.0\pi_{oo}$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p> $Dp / F_{oo} = 42.71 + 1.4286\pi_{oo} - 0.4013F_{oo} + 0.00642\pi_{oo} \times F_{oo}$ <p>3) for engines with a pressure ratio of 62.5 or more:</p> $Dp / F_{oo} = 32 + 1.6\pi_{oo}$ <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>				



Report on entire Annex

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	<p>i) for engines with a maximum rated thrust of more than 89.0 kN:  <math>Dp / Foo = 16.72 + 1.4080\pi\omega</math></p> <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:  <math>Dp / Foo = 38.5486 + 1.6823\pi\omega - 0.2453 Foo - 0.00308\pi\omega Foo</math></p> <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:  <math>Dp / Foo = -1.04 + 2.0\pi\omega</math></p> <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:  <math>Dp / Foo = 46.1600 + 1.4286\pi\omega - 0.5303 Foo + 0.00642\pi\omega Foo</math></p> <p>3) for engines with a pressure ratio of 82.6 or more:  <math>Dp / Foo = 32 + 1.6\pi\omega</math></p> <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:</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:  <math>Dp / Foo = 7.88 + 1.4080\pi\omega</math></p>				



Report on entire Annex

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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> $Dp / Foo = 40.052 + 1.5681\pi\omega - 0.3615Foo - 0.0018\pi\omega Foo$ <p>2) for engines with a pressure ratio of more than 30 but less than 104.7:</p> <p>i) for engines with a maximum rated thrust of more than 89.0 kN:</p> $Dp / Foo = -9.88 + 2.0\pi\omega$ <p>ii) for engines with a maximum rated thrust of more than 26.7 kN but not more than 89.0 kN:</p> $Dp / Foo = 41.9435 + 1.505\pi\omega - 0.5823Foo + 0.005562\pi\omega Foo$ <p>3) for engines with a pressure ratio of 104.7 or more:</p> $Dp / Foo = 32 + 1.6\pi\omega$ <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>				



Report on entire Annex

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Chapter 2 Reference 2.4  Standard	<p style="text-align: center;"><b>2.4 Information required</b></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>		Not Applicable		
Chapter 2 Reference 2.4.1  Standard	<p style="text-align: center;">2.4.1 General information</p> <p>The following information shall be provided for each engine type for which emissions certification is sought:</p> <ul style="list-style-type: none"> <li>a) engine identification;</li> <li>b) rated thrust (kN);</li> <li>c) reference pressure ratio;</li> <li>d) fuel specification reference;</li> <li>e) fuel hydrogen/carbon ratio;</li> <li>f) the methods of data acquisition;</li> <li>g) the method of making corrections for ambient conditions; and</li> <li>h) the method of data analysis.</li> </ul>		Not Applicable		



## Report on entire Annex

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Chapter 2 Reference 2.4.2  Standard	<p style="text-align: center;">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"> <li>a) fuel flow (kg/s);</li> <li>b) emission index (grams/kg) for each gaseous pollutant; and</li> <li>c) measured Smoke Number.</li> </ul>		Not Applicable		
Chapter 2 Reference 2.4.3.1  Standard	<p style="text-align: center;">2.4.3 Derived information</p> <p style="text-align: center;">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"> <li>a) emission rate, i.e. emission index × fuel flow, (grams/s) for each gaseous pollutant;</li> <li>b) total gross emission of each gaseous pollutant measured over the LTO cycle (grams);</li> <li>c) values of <math>Dp / Foo</math> for each gaseous pollutant (grams/kN); and</li> <li>d) maximum Smoke Number.</li> </ul>		Not Applicable		



Report on entire Annex

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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.		Not Applicable		
Chapter 3 Reference 3.1.1  Standard	<p style="text-align: center;"><b>CHAPTER 3. TURBOJET AND TURBOFAN ENGINES INTENDED FOR PROPULSION AT SUPERSONIC SPEEDS</b></p> <p style="text-align: center;"><b>General</b></p> <p style="text-align: center;">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>		Not Applicable		
Chapter 3 Reference 3.1.2  Standard	<p style="text-align: center;">Emissions involved</p> <p>The following emissions shall be controlled for certification of aircraft engines:</p> <p style="margin-left: 20px;">Smoke</p> <p style="margin-left: 20px;">Gaseous emissions</p> <p style="margin-left: 40px;">Unburned hydrocarbons (HC);</p> <p style="margin-left: 40px;">Carbon monoxide (CO); and</p> <p style="margin-left: 40px;">Oxides of nitrogen (NO<sub>x</sub>).</p>		Not Applicable		





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Chapter 3 Reference 3.1.3.1  Standard	Units of measurement  The smoke emission shall be measured and reported in terms of Smoke Number (SN).		Not Applicable		
Chapter 3 Reference 3.1.3.2  Standard	The mass ( $D_p$ ) of the gaseous pollutants HC, CO, or NO <sub>x</sub> 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.		Not Applicable		
Chapter 3 Reference 3.1.4  Standard	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.		Not Applicable		
Chapter 3 Reference 3.1.5.1  Standard	Reference conditions  <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.		Not Applicable		



Report on entire Annex

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Chapter 3 Reference 3.1.5.2  Standard	<p><i>Thrust settings</i></p> <p>The engine shall be tested at sufficient power 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 output as agreed by the certificating authority.</p> <table border="0" style="width: 100%;"> <tr> <td style="text-align: right;"><i>Operating mode setting</i></td> <td style="text-align: right;"><i>Thrust</i></td> </tr> <tr> <td style="text-align: right;">Take-off cent <math>F^{*_{00}}</math></td> <td style="text-align: right;">100 per</td> </tr> <tr> <td style="text-align: right;">Climb cent <math>F^{*_{00}}</math></td> <td style="text-align: right;">65 per</td> </tr> <tr> <td style="text-align: right;">Descent cent <math>F^{*_{00}}</math></td> <td style="text-align: right;">15 per</td> </tr> <tr> <td style="text-align: right;">Approach cent <math>F^{*_{00}}</math></td> <td style="text-align: right;">34 per</td> </tr> <tr> <td style="text-align: right;">Taxi/ground idle cent <math>F_{00}</math></td> <td style="text-align: right;">5.8 per</td> </tr> </table>	<i>Operating mode setting</i>	<i>Thrust</i>	Take-off cent $F^{*_{00}}$	100 per	Climb cent $F^{*_{00}}$	65 per	Descent cent $F^{*_{00}}$	15 per	Approach cent $F^{*_{00}}$	34 per	Taxi/ground idle cent $F_{00}$	5.8 per		Not Applicable		
<i>Operating mode setting</i>	<i>Thrust</i>																
Take-off cent $F^{*_{00}}$	100 per																
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Descent cent $F^{*_{00}}$	15 per																
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Chapter 3 Reference 3.1.5.3  Standard	<p><i>Reference emissions landing and take-off (LTO) cycle</i></p> <p>The reference emissions LTO cycle for the calculation and reporting of gaseous emissions shall be represented by the following time in each operating mode.</p> <table border="0" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;"><i>Phase</i></td> <td style="text-align: center;"><i>Time</i></td> </tr> <tr> <td style="text-align: center;"><i>e in operating mode, minutes</i></td> <td></td> </tr> <tr> <td style="text-align: center;">Take-off</td> <td style="text-align: center;">1.2</td> </tr> <tr> <td style="text-align: center;">Climb</td> <td style="text-align: center;">2.0</td> </tr> <tr> <td style="text-align: center;">Descent</td> <td style="text-align: center;">1.2</td> </tr> <tr> <td style="text-align: center;">Approach</td> <td style="text-align: center;">2.3</td> </tr> <tr> <td style="text-align: center;">Taxi/ground idle</td> <td style="text-align: center;">26.</td> </tr> <tr> <td style="text-align: center;">0</td> <td></td> </tr> </table>	<i>Phase</i>	<i>Time</i>	<i>e in operating mode, minutes</i>		Take-off	1.2	Climb	2.0	Descent	1.2	Approach	2.3	Taxi/ground idle	26.	0			Not Applicable		
<i>Phase</i>	<i>Time</i>																				
<i>e in operating mode, minutes</i>																					
Take-off	1.2																				
Climb	2.0																				
Descent	1.2																				
Approach	2.3																				
Taxi/ground idle	26.																				
0																					
Chapter 3 Reference 3.1.5.4  Standard	<p><i>Fuel specifications</i></p> <p>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.</p>		Not Applicable																		
Chapter 3 Reference 3.1.6.1  Standard	<p style="text-align: center;">Test conditions</p> <p>The tests shall be made with the engine on its test bed.</p>		Not Applicable																		



Report on entire Annex

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Chapter 3 Reference 3.1.6.2  Standard	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.		Not Applicable		
Chapter 3 Reference 3.1.6.3  Standard	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.		Not Applicable		
Chapter 3 Reference 3.1.7  Standard	When test conditions differ from the reference conditions in 3.1.5, the test results shall be corrected to the reference conditions by the methods given in Appendix 5.		Not Applicable		





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Chapter 3 Reference 3.4.1  Standard	<p style="text-align: center;"><b>Information required</b></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 tests(s); and 3) the results derived from the test data.</i></p> <p>The following information shall be provided for each engine type for which emissions certification is sought:</p> <ul style="list-style-type: none"> <li>engine identification;</li> <li>rated output (in kilonewtons);</li> <li>rated output with afterburning applied, if applicable (in kilonewtons);</li> <li>reference pressure ratio;</li> <li>fuel specification reference;</li> <li>fuel hydrogen/carbon ratio;</li> <li>the methods of data acquisition;</li> <li>the method of making corrections for ambient conditions;</li> <li>and</li> <li>the method of data analysis.</li> </ul>		Not Applicable		
Chapter 3 Reference 3.4.2  Standard	<p style="text-align: center;">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"> <li>fuel flow (kilograms/second);</li> <li>emission index (grams/kilogram) for each gaseous pollutant;</li> <li>percentage of thrust contributed by afterburning; and</li> <li>measured Smoke Number.</li> </ul>		Not Applicable		



Report on entire Annex

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Chapter 3 Reference 3.4.3.1  Standard	<p style="text-align: center;">Derived information</p> <p>The following derived information shall be provided for each engine tested for certification purposes:                      emission rate, i.e. emission index × fuel flow, (grams/second), for each gaseous pollutant;                      total gross emission of each gaseous pollutant measured over the LTO cycle (grams);                      values of <math>D_p / F^*_{oo}</math> for each gaseous pollutant (grams/kilonewton); and                      maximum Smoke Number.</p>		Not Applicable		
Chapter 3 Reference 3.4.3.2  Standard	<p>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>		Not Applicable		



Report on entire Annex

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Chapter 4 Reference 4.1.1  Standard	<p style="text-align: center;"><b>CHAPTER 4. PARTICULATE MATTER EMISSIONS</b></p> <p style="text-align: center;"><b>4.1 General</b></p> <p style="text-align: center;">4.1.1 Applicability</p> <p>The provisions of this chapter shall apply to all aircraft engines, intended for propulsion only at subsonic speeds, for which an application for type certification is submitted to the certifying authority. Specific provisions for the relevant engine categories shall apply as detailed in section 4.2.</p>		Not Applicable		
Chapter 4 Reference 4.1.2  Standard	<p style="text-align: center;">4.1.2 Emissions involved</p> <p>The purpose of this section is to control non-volatile particulate matter mass (nvPMmass) emissions.</p>		Not Applicable		
Chapter 4 Reference 4.1.3  Standard	<p style="text-align: center;">4.1.3 Units of measurement</p> <p>The concentration of nvPM mass (nvPMmass) shall be reported in µg/m<sup>3</sup>.</p>				





Report on entire Annex

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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 absolute humidity shall be 0.00634 kg water/kg dry air.		Not Applicable		
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 following specific percentages of rated thrust and at thrusts producing maximum nvPMmass concentration, maximum EImass and maximum EInum as agreed by the certificating authority:  <i>LTO operating mode</i> <i>Thrust setting</i>  Take-off                                      100 per cent <i>Foo</i> Climb                                         85 per cent <i>Foo</i> Approach                                    30 per cent <i>Foo</i> Taxi/ground idle                         7 per cent <i>Foo</i>		Not Applicable		
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.		Not Applicable		



## Report on entire Annex

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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.		Not Applicable		
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.		Not Applicable		
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, E <sub>mass</sub> and E <sub>num</sub> shall be corrected to the engine combustor inlet temperature under the reference atmospheric conditions in accordance with the procedures of Appendix 7.		Not Applicable		
Chapter 4 Reference 4.1.5.4  Standard	4.1.5.4 The maximum n <sub>vPMmass</sub> concentration and E <sub>mass</sub> and E <sub>num</sub> shall be corrected for thermophoretic losses in the collection part of the sampling system in accordance with the procedures of Appendix 7.		Not Applicable		



Report on entire Annex

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Chapter 4 Reference 4.2.1  Standard	<p style="text-align: center;"><b>4.2 Non-volatile particulate matter emissions</b></p> <p style="text-align: center;">4.2.1 Applicability</p> <p>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, and their derivative versions, with a rated thrust greater than 26.7 kN and whose date of manufacture of the individual engine is on or after 1 January 2020.</p>		Not Applicable		
Chapter 4 Reference 4.2.2  Standard	<p style="text-align: center;">4.2.2 Regulatory levels</p> <p>The maximum nvPMmass concentration [<math>\mu\text{g}/\text{m}^3</math>] 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 certifying authority, shall not exceed the level determined from the following formula:</p>		Not Applicable		



Report on entire Annex

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Chapter 4 Reference 4.2.3  Standard	<p style="text-align: center;">4.2.3 Reporting requirement</p> <p>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 certifying authority:</p> <ul style="list-style-type: none"> <li>a) characteristic level for the maximum nvPMmass concentration (<math>\mu\text{g}/\text{m}^3</math>);</li> <li>b) fuel flow (kg/s) at each thrust setting of the LTO cycle;</li> <li>c) E<sub>mass</sub> (mg/kg of fuel) at each thrust setting of the LTO cycle;</li> <li>d) E<sub>num</sub> (particles/kg of fuel) at each thrust setting of the LTO cycle;</li> <li>e) maximum E<sub>mass</sub> (mg/kg of fuel); and</li> <li>f) maximum E<sub>num</sub> (particles/kg of fuel).</li> </ul>		Not Applicable		



Report on entire Annex

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Chapter 4 Reference 4.3.1  Standard	<p style="text-align: center;"><b>4.3 Information required</b></p> <p style="text-align: center;"><i>Note.- The information required is divided into two groups: 1) general information to identify the engine characteristics, the fuel used and the method of data analysis; and 2) the data obtained from the engine test(s).</i></p> <p style="text-align: center;">4.3.1 General information</p> <p>The following information shall be provided for each engine type for which emissions certification is sought:</p> <ul style="list-style-type: none"> <li>a) engine identification;</li> <li>b) rated thrust (kN);</li> <li>c) reference pressure ratio;</li> <li>d) fuel specification reference;</li> <li>e) fuel hydrogen/carbon ratio;</li> <li>f) the methods of data acquisition;</li> <li>g) the method of making corrections for thermophoretic losses in the collection part of the sampling system; and</li> <li>h) the method of data analysis.</li> </ul>		Not Applicable		



Report on entire Annex

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Chapter 4 Reference 4.3.2  Standard	<p style="text-align: center;">4.3.2 Test information</p> <p>For each test the following information shall be reported:</p> <ul style="list-style-type: none"> <li>a) net heat of combustion (MJ/kg);</li> <li>b) fuel hydrogen content (mass %);</li> <li>c) fuel total aromatics content (volume %);</li> <li>d) fuel naphthalenes (volume %); and</li> <li>e) fuel sulphur (mass %).</li> </ul>		Not Applicable		



Report on entire Annex

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<p>Chapter 1 Reference 1.0.1</p> <p>Recommendation</p>	<p style="text-align: center;"><b>PART IV. NON-VOLATILE PARTICULATE MATTER ASSESSMENT FOR INVENTORY AND MODELLING PURPOSES</b></p> <p style="text-align: center;"><i>Note 1.- The purpose of this part is to provide recommendations 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 system, the collection part and the thermophoretic losses calculation are described in Appendix 7.</i></p> <p style="text-align: center;"><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 style="text-align: center;"><b>Recommendation 1.-</b> For inventory and modelling purposes, the aircraft turbine engine manufacturers should determine the nvPM mass and nvPM number system loss correction factors (<i>kSL<sub>mass</sub></i> and <i>kSL<sub>num</sub></i>) using the methodology described in Appendix 8 and should report these factors to the appropriate authority.</p>		<p>Not Applicable</p>		



Report on entire Annex

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Chapter 1 Reference 1.0.2  Recommendation	<b>Recommendation 2.-</b> <i>For inventory and modelling purposes, the nvPM mass and number concentration obtained in accordance with the procedures of Appendix 7 should be corrected for system losses using the methodology described in Appendix 8.</i>		Not Applicable		

- END -