CIVIL AVIATION REQUIREMENTS

SECTION 6 – DESIGN STANDARDS AND TYPE CERTIFICATION SERIES ‘C’ PART III

AEROPLANE CARBON DIOXIDE EMISSIONS CERTIFICATION – STANDARDS AND PROCEDURES

ISSUE I
May 2018

Director General of Civil Aviation
OFFICE OF THE DIRECTOR GENERAL OF CIVIL AVIATION
TECHNICAL CENTRE, OPP. SAFDARJUNG AIRPORT, NEW DELHI

RECORD OF REVISION

This CAR has been issued to formulate regulations towards engine emissions certification based on International Civil Aviation Organization's International Standards and Recommended Practices (SARPs) as contained in Annex-16, Environmental Protection, Volume-III "Aeroplane CO_2 Emissions". The CAR has been developed in line with the new requirements as proposed by Committee on Aviation Environmental Protection (CAEP) based on the deliberations held in various meetings and their final recommendations contained in the above ICAO Annex. The Record of Revisions to the aforesaid CAR will be mentioned as follows:

Sl. No.	Issue Number	Revision Number	Date	Remarks
1.	Issue - I	Revision - 0	XX/04/2018	Initial issue of CAR to adopt aeroplane CO_2 emissions standards as contained in Annex-16, Volume-III.

INTRODUCTION

Rule 49 of the Aircraft Rules, 1937 stipulates requirements for a Type Certificate (TC) in respect of a new type of aeronautical products such as aircraft, engine and propeller or change in type design in case of its derived version, designed and manufactured in India. The Type Certificate Data Sheet (TCDS), which forms the part of the Type Certificate, contains the certification basis in respect of that aircraft and the applicable certification basis as mentioned in CAR 21.17 and environmental protection requirements as mentioned in CAR 21.18. With the objective of compliance with the above mentioned rules, CAR, Section-6, Series-C, Part-III has been developed based on the International Standards and Recommended Practices (SARPs) contained in ICAO Annex-16, Volume-III.

This CAR is issued under the provisions of Rule 133A of the Aircraft Rules, 1937, for information, guidance and compliance by all such organizations who intend to design and develop aeronautical products in India for which a Type Certificate is to be issued by DGCA under the provisions mentioned in CAR 21.

The requirements contained in this CAR are in-line with the requirements as mentioned in ICAO Annex-16, Volume-III. It prescribes applicability, carbon dioxide emissions evaluation metric, reference aeroplane masses, measurement points, Instrumentation and measurement techniques for gaseous emissions, reference conditions and methods for determining aeroplane specific air range, test procedures, measurement of aeroplane specific air range, calculation of reference specific air range from measured data, and compliance procedure to the above requirements.

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CONTENTS

ENGINE EMISSIONS CERTIFICATION PROCEDURES FOR AIRCRAFT

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SUBPART – A: Certification Standard for Aeroplane CO_2 Emissions based on the Consumption of Fuel.

1. APPLICABILITY:

1.1 The provisions as mentioned at paragraphs 1.2 to 1.11 shall apply to all aeroplanes included in the classifications defined for CO_2 emissions certification purposes in Subpart B of this part where such aeroplanes are engaged in international operations.

1.2 CO_2 emissions certification shall be granted or validated by DGCA for an aeroplane on the basis of satisfactory evidence that the aeroplane complies with requirements that are at least equal to the applicable standards specified in this CAR.

1.3 DGCA shall recognize a CO_2 emissions certification granted by CAA of another Contracting State provided that the requirements under which such certification was granted are at least equal to the applicable standards specified in this CAR.

1.4 The requirements contained in the latest amendment of this CAR shall be applicable on the date of submission of application to DGCA for either a Type Certificate in the case of a new type or approval of a change in type design in the case of a derived version.

1.5 The date to be used by DGCA, in determining the applicability of the standards of this CAR, shall be the date on which the application for a Type Certificate was submitted by the applicant to DGCA.

1.6 An application shall be effective for the period of three or five years depending upon the aeroplane type. DGCA may grant an extension beyond the effective period in special cases however, the date of determining the applicability of the standards will remain unchanged.

1.7 For derived versions of non-CO_2 and CO_2-certified aeroplanes, the date on which "the application for the certification of the change in type design" was made will be the applicability dates. The date to be used by DGCA in determining the applicability shall be the date on which the application for the change in type design was submitted to DGCA that first certified the change in type design.

1.8 Where the provisions governing the applicability of the standards of this CAR refer to the date on which the certificate of airworthiness was first issued to an individual aeroplane, the date to be used by DGCA shall be the date on which the first certificate of airworthiness was issued by any Contracting State.

1.9 **Reserved.**

1.10 **Reserved.**

1.11 **Reserved.**

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SUBPART – B: Subsonic Jet Aeroplanes over 5700 kg and Propeller Driven Aeroplanes over 8618 kg.

1. APPLICABILITY:

1.1 The standards of this subpart shall, with the exception of amphibious aeroplanes, aeroplanes initially designed or modified and used for specialised operational requirements, aeroplanes designed with zero Reference Geometric Factor (RGF), and those aeroplanes specifically designed/modified for used for fire-fighting purposes, be applicable to:

a) Subsonic jet aeroplanes, including their derived versions, of greater than 5700 kg maximum take-off mass for which the application for a type certificate was submitted on or after 1 January 2020, except for those aeroplanes of less than or equal to 60,000 kg maximum take-off mass with a maximum passenger seating capacity of 19 seats or less,

b) Subsonic jet aeroplanes, including their derived versions, of greater than 5700 kg and less than or equal to 60,000 kg maximum take-off mass with a maximum passenger seating capacity of 19 seats or less, for which the application for a type certificate was submitted on or after 1 January 2023,

c) All propeller-driven aeroplanes, including their derived versions, of greater than 8618 kg maximum take-off mass, for which the application for a type certificate was submitted on or after 1 January 2020,

d) Derived versions of non-CO_2 certified subsonic jet aeroplanes of greater than 5700 kg maximum certificated take-off mass for which the application for certification of the change in type design was submitted on or after 1 January 2023,

e) Derived versions of non-CO_2 certified propeller-driven aeroplanes of greater than 8618 kg maximum certificated take-off mass for which the application for certification of the change in type design was submitted on or after 1 January 2023,

f) Individual non-CO_2 certified subsonic jet aeroplanes of greater than 5700 kg maximum certificated take-off mass for which a certificate of airworthiness was first issued on or after 1 January 2028, and

g) Individual non-CO_2 certified propeller-driven aeroplanes of greater than 8618 kg maximum certificated take-off mass for which a certificate of airworthiness was first issued on or after 1 January 2028.

Note. – Aeroplanes initially designed or modified and used for specialised operational requirements refer to aeroplane type configurations which, in the view of DGCA, have different design characteristics to meet specific operational needs compared to typical civil aeroplane types covered by the scope of this CAR, and which may result in a very different CO_2 emissions evaluation metric value.

1.2 Notwithstanding paragraph 1.1, DGCA may recognized aeroplanes on its registry that do not require demonstration of compliance with the provisions of this CAR for time limited engine changes. These changes in type design shall specify that the aeroplane may not be operated for a period of more than 90 days unless compliance with the provisions of this CAR is shown for that change in type design. This applies only to changes resulting from a required maintenance action.

1.3 The granting of an exemption for an aeroplane against applicability requirements specified in paragraph 1.1 shall be noted on the aeroplane statement of conformity issued by DGCA. DGCA shall take into account the numbers of exempted aeroplanes that will be produced and their impact on the environment. Exemptions shall be reported by aeroplane serial number.

2. CO_2 EMISSIONS EVALUATION METRIC:

2.1 The metric shall be defined in terms of the average of the 1/SAR values for the three reference masses defined in paragraph 3 below and the RGF defined in subpart D of this CAR. The metric value shall be calculated according to the following formula:

$$CO_2 \text{ emissions evaluation metric value} = \frac{(1/SAR)_{AVG}}{(RGF)^{0.24}}$$

Where: The metric value is quantified in units of kg/km and the CO_2 emissions evaluation metric is a SAR based metric adjusted to take into account fuselage size.

3. REFERENCE AEROPLANE MASSES:

3.1 The 1/SAR value shall be established at each of the following three reference aeroplane masses, when tested in accordance with these standards:

a) High gross mass: 92% MTOM,

b) Mid gross mass: Simple arithmetic average of high gross mass and low gross mass,

c) Low gross mass: $(0.45 \times MTOM) + (0.63 \times (MTOM^{0.924}))$,

where: MTOM is expressed in kilograms.

3.2 CO_2 emissions certification for MTOM also represents the certification of CO_2 emissions for take-off masses less than MTOM. However, in addition to the mandatory certification of CO_2 metric values for MTOM, above applicants may voluntarily apply for the approval of CO_2 metric values for take-off masses less than MTOM.

4. MAXIMUM PERMITTED CO_2 EMISSIONS EVALUATION METRIC VALUE:

4.1 The CO_2 emissions evaluation metric value shall be determined in accordance with the evaluation methods as prescribed in subpart C of this CAR.

4.2 The CO_2 emissions evaluation metric value shall not exceed the value defined in the following paragraphs:

a) For aeroplanes specified in above paragraphs 1.1 a), b) and c) with a maximum take-off mass less than or equal to 60,000 kg:

Maximum permitted value = $10^{(-2.73780+ (0.681310 * \log_{10} (MTOM)) + (-0.0277861 * (\log_{10} (MTOM))^{\wedge}2))}$

b) For aeroplanes specified in above paragraphs 1.1 a) and c) with a maximum take-off mass greater than 60,000 kg, and less than or equal to 70 395 kg:

Maximum permitted value = 0.764

c) For aeroplanes specified in above paragraphs 1.1 a) and c) with a maximum take-off mass of greater than 70,395 kg:

Maximum permitted value = $10^{(-1.412742 + (-0.020517 * \log_{10} (MTOM)) + (0.0593831 * (\log_{10} (MTOM))^{\wedge}2))}$

d) For aeroplanes specified in above paragraphs 1.1 d), e), f) and g) with a maximum certificated take-off mass less than or equal to 60,000 kg:

Maximum permitted value = $10^{(-2.57535 + (0.609766 * \log_{10} (MTOM))+(-0.0191302 * (\log_{10} (MTOM))^{\wedge}2))}$

e) For aeroplanes specified in above paragraphs 1.1 d), e), f) and g) with a maximum certificated take-off mass greater than 60,000 kg, and less than or equal to 70107 kg:

Maximum permitted value = 0.797

f) For aeroplanes specified in above paragraphs 1.1 d), e), f) and g) with a maximum take-off mass of greater than 70,107 kg:

Maximum permitted value = $10^{(-1.39353 + (-0.020517 * \log_{10}(MTOM)) + (0.0593831 * (\log_{10}(MTOM))^2))}$

5. REFERENCE CONDITIONS FOR DETERMINING AEROPLANE SPECIFIC AIR RANGE:

5.1 The reference conditions shall consist of the following conditions within the approved normal operating envelope of the aeroplane:

a) The aeroplane gross masses defined in paragraph 3,

b) A combination of altitude and airspeed selected by the applicant for each of the specified reference aeroplane gross masses,

Note: These conditions are generally expected to be the combination of altitude and airspeed that results in the highest SAR value, which is usually at the maximum range cruise Mach number at the optimum altitude. The selection of conditions other than optimum conditions will be to the detriment of the applicant because the SAR value will be adversely affected.

c) Steady (un-accelerated), straight, and level flight,

d) Aeroplane in longitudinal and lateral trim,

e) ICAO standard day atmosphere,

f) Gravitational acceleration for the aeroplane travelling in the direction of true north in still air at the reference altitude and a geodetic latitude of 45.5 degrees, based on g_0,

g) Fuel lower heating value equal to 43.217 MJ/kg (18,580 BTU/lb),

h) A reference aeroplane CG position selected by the applicant to be representative of a mid-CG point relevant to design cruise performance at each of the three reference aeroplane masses,

Note: For an aeroplane equipped with a longitudinal CG control system, the reference CG position may be selected to take advantage of this feature.

i) A wing structural loading condition, selected by the applicant for representative operations, conducted in accordance with the aeroplane's payload capability and manufacturer standard fuel management practices,

j) Applicant selected electrical and mechanical power extraction and bleed flow relevant to design cruise performance and in accordance with manufacturer recommended procedures,

Note: Power extraction and bleed flow due to the use of optional equipment such as passenger entertainment systems need not be included.

k) Engine handling/stability bleeds operating according to the nominal design of the engine performance model for the specified conditions, and

l) Engine deterioration level selected by the applicant to be representative of the initial deterioration level (a minimum of 15 take-offs or 50 engine flight hours).

5.2 If the test conditions are not the same as the reference conditions, then corrections for the differences between test and reference conditions shall be applied as described in subpart C of this CAR.

6. TEST PROCEDURES:

6.1 The SAR values that form the basis of the CO_2 emissions evaluation metric value shall be established either directly from flight tests or from a performance model validated by flight tests.

6.2 The test aeroplane shall be representative of the configuration for which certification is requested.

6.3 The test and analysis procedures shall be conducted in an approved manner to yield the CO_2 emissions evaluation metric value, as described in subpart C of this CAR. These procedures shall address the entire flight test and data analysis process, from pre-flight actions to post-flight data analysis.

Note: The fuel used for each flight test should meet the specification defined in either ASTM D1655-152, DEF STAN 91-91 Issue 7, Amendment 33.

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SUBPART – C: Determination of the Aeroplane Carbon Dioxide (CO_2) Emissions Evaluation Metric Value for Subsonic Jet Aeroplane over 5700 kg and Propeller Driven Aeroplane over 8618 kg.

1. INTRODUCTION:

1.1 The process for determining the CO_2 emissions evaluation metric value includes:

a) The determination of the reference geometric factor (Subpart D),

b) The determination of the certification test and measurement conditions and procedures for the determination of SAR (Section 2 of this subpart), either by direct flight test or by way of a validated performance model, including:

1) The measurement of parameters needed to determine SAR (Section 3 of this subpart),
2) The correction of measured data to reference conditions for SAR (Section 4 of this subpart), and
3) The validation of data for calculation of the certified CO2 emissions evaluation metric value (Section 5 of this subpart),

c) Calculation of the CO_2 emissions evaluation metric value (Section 6 of this subpart); and

d) Reporting of data to the certificating authority (Section 7 of this subpart).

Note - The instructions and procedures ensure uniformity of compliance tests, and permit comparison between various types of aeroplanes.

2. METHODS FOR DETERMINING SPECIFIC AIR RANGE:

2.1 Specific air range may be determined by either direct flight test measurement of SAR test points, including any corrections of test data to reference conditions, or by the use of a performance model approved by DGCA. A performance model, if used, shall be validated by actual SAR flight test data.

2.2 In either case, the SAR flight test data shall be acquired in accordance with the procedures defined in this standard and approved by DGCA.

2.3 Validation of the performance model should only need to be shown for the test points and conditions relevant to showing compliance with the standard.

Test and analysis methods, including any algorithms that may be used, should be described in sufficient detail.

3. Specific Air Range Certification Test and Measurement Conditions:

3.1 General:

3.1.1 This subpart prescribes the conditions under which SAR certification tests shall be conducted and the measurement procedures that shall be used.

3.1.2 Many applications for certification of a CO_2 emissions metric value involve only minor changes to the aeroplane type design. The resultant changes in the CO_2 emissions metric value can often be established reliably by way of equivalent procedures without the necessity of resorting to a complete test.

3.2 Flight test procedure:

3.2.1 **Pre-flight:** The pre-flight procedure shall be approved by DGCA and shall include the following elements:

a) **Aeroplane conformity:** The test aeroplane shall be confirmed to be in conformance with the type design configuration for which certification is sought.

b) **Aeroplane weighing:** The test aeroplane shall be weighed. Any change in mass after the weighing and prior to the test flight shall be accounted for.

c) **Fuel lower heating value:** A sample of fuel shall be taken for each flight test to determine its lower heating value. Fuel sample test results shall be used for the correction of measured data to reference conditions. The determination of lower heating value and the correction to reference conditions shall be subject to the approval of the certificating authority.

I. The fuel lower heating value should be determined in accordance with methods as defined in ASTM specification D4809-13.

II. The fuel sample should be representative of the fuel used for each flight test and should not be subject to errors or variations due to fuel being uplifted from multiple sources, fuel tank selection or fuel layering in a tank.

d) **Fuel specific gravity and viscosity:** A sample of fuel shall be taken for each flight test to determine its specific gravity and viscosity when volumetric fuel-flow meters are used.

I. When using volumetric fuel-flow meters the fuel viscosity is used to determine the volumetric fuel flow from the parameters measured by a volumetric fuel flow meter. The fuel specific gravity (or density) is used to convert the volumetric fuel flow to a mass fuel flow.

II. The fuel specific gravity should be determined in accordance with methods as defined in ASTM specification D4052-11.

III. The fuel kinematic viscosity should be determined in accordance with methods as defined in ASTM specification D445-15.

3.2.2 Flight test method:

3.2.2.1 The flight tests shall be performed in accordance with the following flight test method and the stability conditions described in paragraph 3.2.3.

3.2.2.2 Test points shall be separated by a minimum duration of two minutes, or separated by an exceedance of one or more of the stability criteria limits as prescribed in paragraph 3.2.3.1.

3.2.2.3 During the test conditions flown to determine SAR the following criteria should be adhered to:

a) The aeroplane is flown at constant pressure altitude and constant heading along isobars to the extent that is practicable;
b) The engine thrust/power setting is stable for un-accelerated level flight;
c) The aeroplane is flown as close as practicable to the reference conditions to minimize the magnitude of any corrections;
d) There are no changes in trim or engine power/thrust settings, engine stability and handling bleeds, and electrical and mechanical power extraction (including bleed flow). Any changes in the use of aeroplane systems that may affect the SAR measurement should be avoided; and
e) Movement of on-board personnel is kept to a minimum.

3.2.3 Test condition stability:

3.2.3.1 For a SAR measurement to be valid, the following parameters shall be maintained within the indicated tolerances for a minimum duration of 1 minute during which the SAR data is acquired:

a) Mach number within ±0.005;
b) Ambient temperature within ±1°C;
c) Heading within ±3 degrees;
d) Track within ±3 degrees;

e) Drift angle less than 3 degrees;
f) Ground speed within ±3.7 km/h (±2 kt);
g) Difference in ground speed at the beginning of the test condition from the ground speed at the end of the test condition within ±2.8 km/h/min (±1.5 kt/min); and
h) Pressure altitude within ±23 m (±75 ft).

3.2.3.2 Alternatives to the stable test condition criteria listed above may be used provided that stability can be sufficiently demonstrated to the certificating authority.

3.2.3.3 Test points that do not meet the stable test criteria defined in 3.2.3.1 should normally be discarded. However, test points that do not meet the stability criteria of 3.2.3.1 may be acceptable subject to the approval of DGCA, and would be considered as an equivalent procedure.

3.2.4 Verification of aeroplane mass at test conditions:

3.2.4.1 The procedure for determining the mass of the aeroplane at each test condition shall be subject to the approval of DGCA.

3.2.4.2 The mass of the aeroplane during a flight test should be determined by subtracting the fuel used (i.e. integrated fuel flow) from the mass of the aeroplane at the start of the test flight. The accuracy of the determination of the fuel used should be verified by weighing the test aeroplane on calibrated scales either before and after the SAR test flight, or before and after another test flight with a cruise segment provided that flight occurs within one week or 50 flight hours (at the option of the applicant) of the SAR test flight and with the same, unaltered fuel flow meters.

4. Measurement of Aeroplane Specific Air Range:

4.1 Measurement System:

4.1.1 The following parameters shall be recorded at a minimum sampling rate of 1 Hz:

a) Airspeed;
b) Ground speed;
c) True airspeed;
d) Fuel flow;
e) Engine power setting parameter (e.g. fan speed, engine pressure ratio, torque, shaft horse power);

f) Pressure altitude;
g) Temperature;
h) Heading;
i) Track; and
j) Fuel used (for the determination of gross mass and CG position).

4.1.2 The following parameters shall be recorded at a suitable sampling rate:
a) Latitude;
b) Engine bleed positions and power off-takes; and
c) Power extraction (electrical and mechanical load).

4.1.3 The value of each parameter used for the determination of SAR, except for ground speed, shall be the simple arithmetic average of the measured values for that parameter obtained throughout the stable test condition as prescribed in paragraph 3.2.3.1.

4.1.4 The rate of change of ground speed during the test condition is to be used to evaluate and correct any acceleration or deceleration that might occur during the test condition.

4.1.5 The resolution of the individual measurement devices shall be sufficient to determine that the stability of the parameters defined in paragraph 3.2.3.1 is maintained.

4.1.6 The overall SAR measurement system is considered to be the combination of instruments and devices, including any associated procedures, used to acquire the following parameters necessary for the determination of SAR:

a) Fuel flow;
b) Mach number;
c) Altitude;
d) Aeroplane mass;
e) Ground speed;
f) Outside air temperature;
g) Fuel lower heating value; and
h) Centre of gravity

4.1.7 The accuracy of the individual elements that comprise the overall SAR measurement system is defined in terms of its effect upon SAR. The cumulative error associated with the overall SAR measurement system is defined as the root sum of squares (RSS) of the individual accuracies.

4.1.8 Parameter accuracy need only be examined within the range of the parameter needed for showing compliance with the CO_2 emissions standard.

4.1.9 If the absolute value of the cumulative error of the overall SAR measurement system is greater than 1.5 per cent a penalty equal to the amount that the RSS value exceeds 1.5 per cent shall be applied to the SAR value corrected to reference conditions (section 5). If the absolute value of the cumulative error of the overall SAR measurement system is less than or equal to 1.5 per cent no penalty shall be applied.

5. Calculation of Reference Specific Air Range from Measured Data:

5.1 Calculation of SAR:

5.1.1 SAR is calculated from the following equation:

$SAR = TAS/W_f$

Where: i) TAS is the true air speed; and ii) W_f is total aeroplane fuel flow.

5.2 Corrections from test to reference conditions:

5.2.1 Corrections shall be applied to the measured SAR values to correct to the reference conditions specified in paragraph 5 of Subpart-B of this CAR. Corrections shall be applied for each of the following measured parameters that is not at the reference conditions:

I. **Apparent gravity:** Acceleration, caused by the local effect of gravity, and inertia, affects the test weight of the aeroplane. The apparent gravity at the test conditions varies with latitude, altitude, ground speed, and direction of motion relative to the Earth's axis. The reference gravitational acceleration is the gravitational acceleration for the aeroplane travelling in the direction of true North in still air at the reference altitude, a geodetic latitude of 45.5 degrees, and based on g_0.

II. **Mass/δ..:** The lift coefficient of the aeroplane is a function of mass/δ and Mach number, where δ is the ratio of the atmospheric pressure at a given altitude to the atmospheric pressure at sea level. The lift coefficient for the test condition affects the drag of the aeroplane. The reference mass/δ is derived from the combination of the reference mass, reference altitude and atmospheric pressures determined from the ICAO standard atmosphere.

III. **Acceleration/deceleration (energy):** Drag determination is based on an assumption of steady, unaccelerated flight. Acceleration or deceleration occurring during a test condition affects the assessed drag level. The reference condition is steady, unaccelerated flight.

IV. **Reynolds number:** The Reynolds number affects aeroplane drag. For a given test condition the Reynolds number is a function of the density and viscosity of air at the test altitude and temperature. The reference Reynolds number is derived from the density and viscosity of air from the ICAO standard atmosphere at the reference altitude and temperature.

V. **CG position:** The position of the aeroplane centre of gravity affects the drag due to longitudinal trim.

VI. **Aeroelastics:** Wing aeroelasticity may cause a variation in drag as a function of aeroplane wing mass distribution. Aeroplane wing mass distribution will be affected by the fuel load distribution in the wings and the presence of any external stores.

VII. **Fuel lower heating value:** The fuel lower heating value defines the energy content of the fuel. The lower heating value directly affects the fuel flow at a given test condition.

VIII. **Altitude:** The altitude at which the aeroplane is flown affects the fuel flow.

IX. **Temperature:** The ambient temperature affects the fuel flow. The reference temperature is the standard day temperature from the ICAO standard atmosphere at the reference altitude.

X. **Engine deterioration level:** When first used, engines undergo a rapid, initial deterioration in fuel efficiency. Thereafter, the rate of deterioration significantly decreases. Engines with less deterioration than the reference engine deterioration level may be used, subject to the approval of the certificating authority. In such a case, the fuel flow shall be corrected to the reference engine deterioration level using an approved method. Engines with more deterioration than the reference engine deterioration level may be used. In this case a correction to the reference condition shall not be permitted.

XI. **Electrical and mechanical power extraction and bleed flow:** Electrical and mechanical power extraction and bleed flow affects the fuel flow.

5.2.2 Post-flight data analysis includes the correction of measured data for data acquisition hardware response characteristics (e.g. system latency, lag, offset, buffering, etc.).

5.2.3 Correction methods are subject to the approval of DGCA. If the applicant considers that a particular correction is unnecessary then acceptable justification shall be provided to DGCA.

5.3 **Calculation of specific air range:**

5.3.1 The SAR values for each of the three reference masses defined in paragraph 2.3 of subpart-B of this CAR, shall be calculated either directly from the measurements taken at each valid test point adjusted to reference conditions, or indirectly from a performance model that has been validated by the test points. The final SAR value for each reference mass shall be the simple arithmetic average of all valid test points at the appropriate gross mass, or derived from a validated performance model. No data acquired from a valid test point shall be omitted unless agreed by DGCA.

5.3.2 Extrapolations consistent with accepted airworthiness practices to masses other than those tested may be allowable using a validated performance model. The performance model should be based on data covering an adequate range of lift coefficient, Mach number, and thrust specific fuel consumption such that there is no extrapolation of these parameters.

6. Validity of Results:

6.1 The 90 percent confidence interval shall be calculated for each of the SAR values at the three reference masses.

6.2 If clustered data is acquired independently for each of the three gross mass reference points, the minimum sample size acceptable for each of the three gross mass SAR values shall be six.

6.3 Alternatively SAR data may be collected over a range of masses. In this case the minimum sample size shall be twelve and the 90 per cent confidence interval shall be calculated for the mean regression line through the data.

6.4 If the 90 percent confidence interval of the SAR value at any of the three reference aeroplane masses exceeds ±1.5 per cent, the SAR value at that reference mass may be used, subject to the approval of the certificating authority, if a penalty is applied to it. The penalty shall be equal to the amount that the 90 per cent confidence interval exceeds ±1.5 per cent. If the 90 per cent confidence interval of the SAR value is less than or equal to ±1.5 per cent no penalty need be applied.

6.5 Methods for calculating the 90 percent confidence interval are given in ICAO Doc 9501 Volume III.

7. Calculation of the CO_2 Emissions Evaluation Metric Value:

7.1 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.

8. Reporting of Data to DGCA:

8.1 The following information shall be provided for each aeroplane type and model for which CO_2 certification is sought:

a) Designation of the aeroplane type and model;
b) General characteristics of the aeroplane, including centre of gravity range, number and type designation of engines and, if fitted, propellers;
c) Maximum take-off mass;
d) The relevant dimensions needed for calculation of the reference geometric factor; and
e) Serial number(s) of the aeroplane(s) tested for CO_2 certification purposes and, in addition, any modifications or non-standard equipment likely to affect the CO_2 characteristics of the aeroplane.

8.2 **Reference conditions:**

8.2.1 The reference conditions used for the determination of specific air range shall be provided to DGCA as per paragraph 5 of subpart-B of this CAR.

8.3 **Test data:**

8.3.1 The following measured test data, including any corrections for instrumentation characteristics, shall be provided for each of the test measurement points:

a) Airspeed, ground speed and true airspeed;
b) Fuel flow;
c) Pressure altitude;
d) Static air temperature;
e) Aeroplane gross mass and centre of gravity for each test point;
f) Levels of electrical and mechanical power extraction and bleed flow;
g) Engine performance:
h) Fuel lower heating value;
i) Fuel specific gravity and kinematic viscosity if volumetric fuel flow meters are used (paragraph 3.2.1d);
j) The cumulative error (RSS) of the overall measurement system (paragraph 4.1.6);
k) Heading, track and latitude;

l) Stability criteria (paragraph 3.2.3.1);
m) Description of the instruments and devices used to acquire the parameters necessary for the determination of SAR, and their individual accuracies in terms of their effect on SAR (paragraphs 4.1.5 and 4.1.6);

8.4 **Calculations and corrections of SAR test data to reference conditions:**

8.4.1 The measured SAR values, corrections to the reference conditions, and corrected SAR values shall be provided for each of the test measurement points.

8.5 **Derived data:**

8.5.1 The following derived information shall be provided for each aeroplane tested for certification purposes:

a) The specific air range (km/kg) for each reference aeroplane mass and the associated 90 per cent confidence interval;
b) The average of the inverse of the three reference mass specific air range values;
c) The reference geometric factor, and
d) The CO_2 emissions evaluation metric value.

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SUBPART – D: Reference Geometric Factor.

1. Reference Geometric Factor

1.1 The reference geometric factor (RGF) is a non-dimensional parameter used to adjust $(1/SAR)_{AVG}$. RGF is based on a measure of fuselage size normalised with respect to 1 m^2, and is derived as follows:

a) For aeroplanes with a single deck determine the area of a surface (expressed in m^2) bounded by the maximum width of the fuselage outer mould line (OML) projected to a flat plane parallel with the main deck floor; and

b) For aeroplanes with an upper deck determine the sum of the area of a surface (expressed in m^2) bounded by the maximum width of the fuselage outer mould line (OML) projected to a flat plane parallel with the main deck floor, and the area of a surface bounded by the maximum width of the fuselage OML at or above the upper deck floor projected to a flat plane parallel with the upper deck floor is determined; and

c) Determine the non-dimensional RGF by dividing the areas defined in 1(a) or 1(b) by 1 m^2.

1.2 The RGF includes all pressurised space on the main or upper deck including aisles, assist spaces, passage ways, stairwells and areas that can accept cargo and auxiliary fuel containers. It does not include permanent integrated fuel tanks within the cabin or any unpressurized fairings, nor crew rest/work areas or cargo areas that are not on the main or upper deck (e.g. 'loft' or under floor areas). RGF does not include the cockpit crew zone.

1.3 The aft boundary to be used for calculating RGF is the aft pressure bulkhead. The forward boundary is the forward pressure bulkhead except for the cockpit crew zone.

1.4 Areas that are accessible to both crew and passengers are excluded from the definition of the cockpit crew zone. For aeroplanes with a cockpit door, the aft boundary of the cockpit crew zone is the plane of the cockpit door. For aeroplanes having optional interior configurations that include different locations of the cockpit door, or no cockpit door, the boundary shall be determined by the configuration that provides the smallest cockpit crew zone. For aeroplanes certified for single-pilot operation, the cockpit crew zone shall extend half the width of the cockpit.

1.5 Figures A 2-1 and A 2-2 provide a notional view of the RGF boundary conditions.

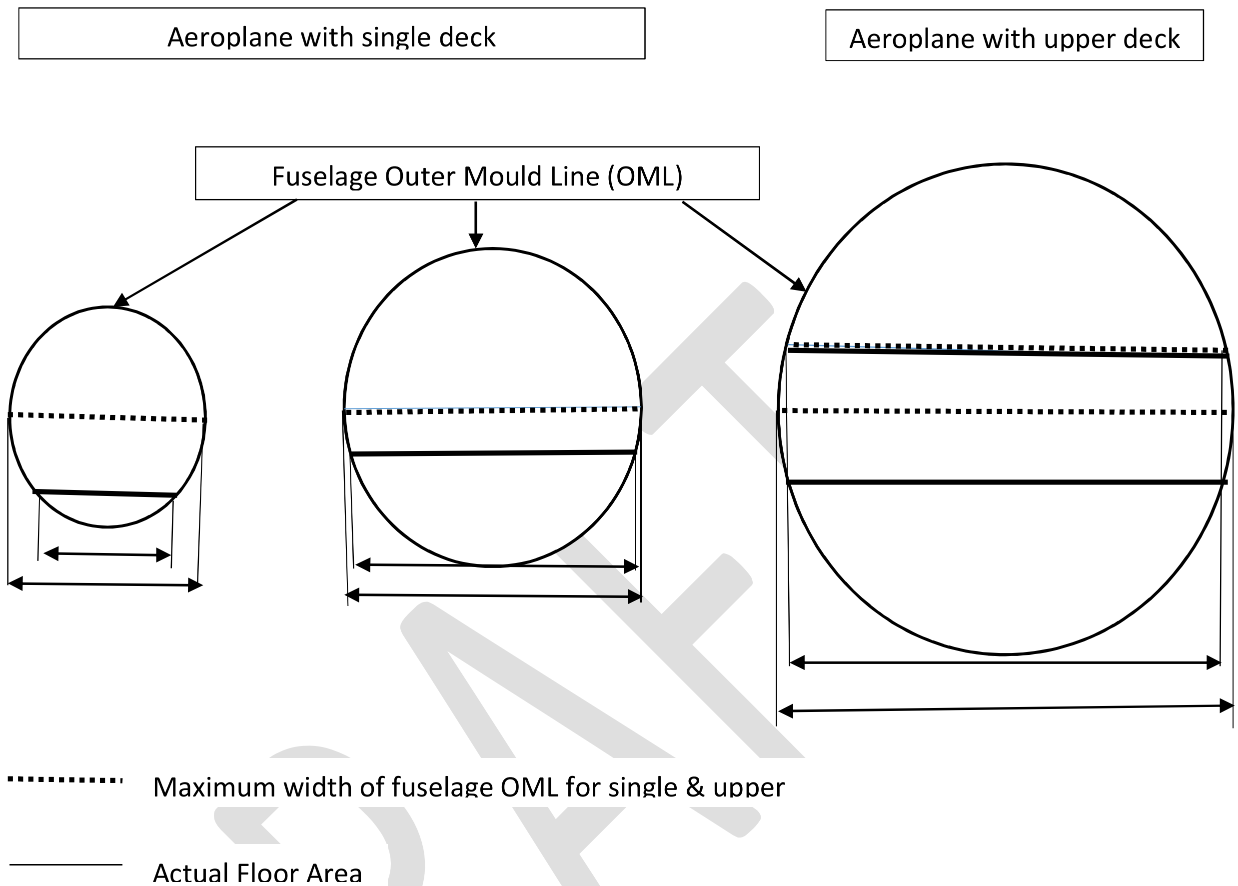

Figure A 2.1 – Cross-sectional

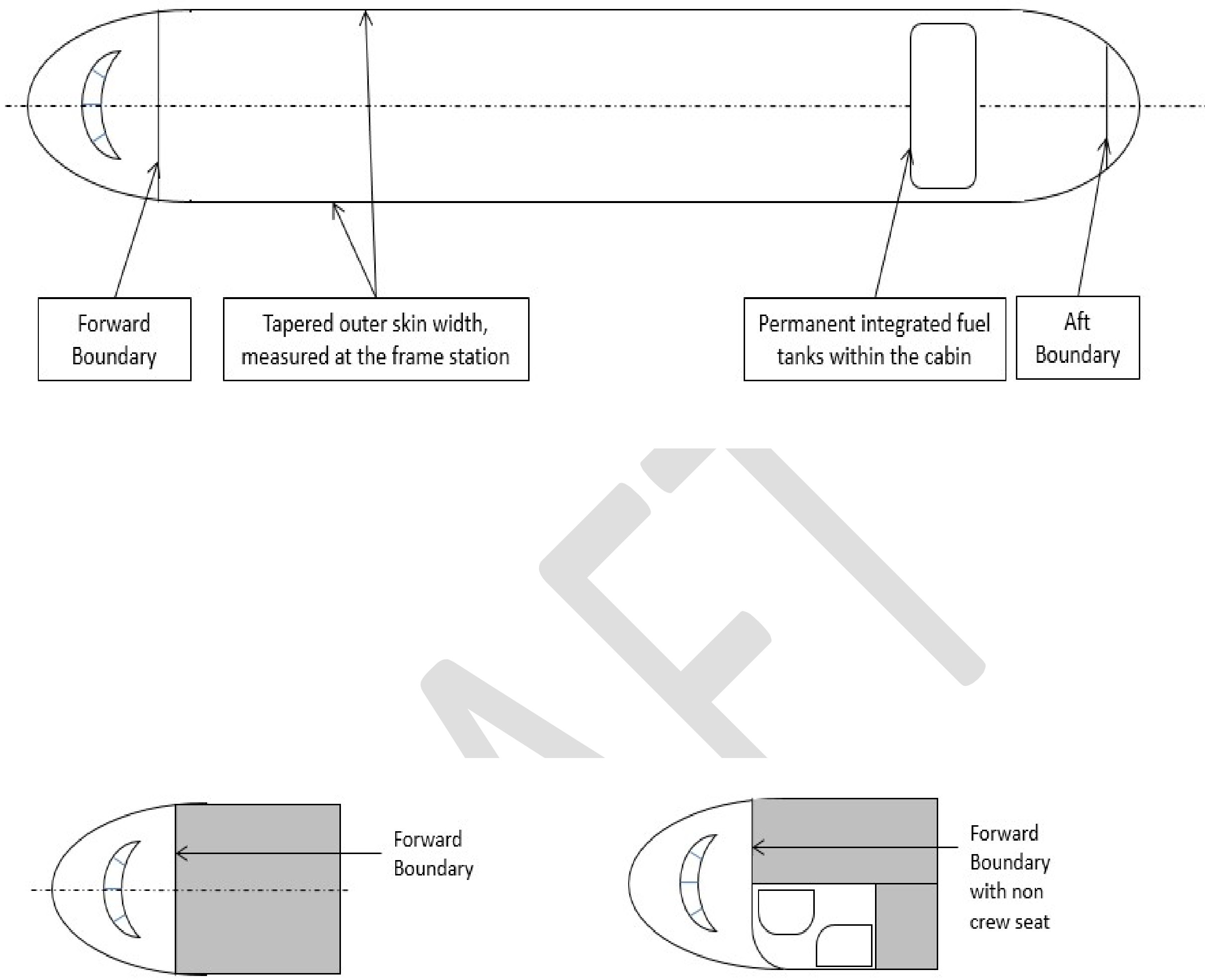

Figure A 2.2 – Longitudinal View

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1. **Aeroplane:** A power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight.

2. **Cockpit crew zone:** The part of the cabin that is exclusively designated for flight crew use.

3. **Derived version of a non-CO_2-certified aeroplane:** An individual aeroplane that conforms to an existing Type Certificate, but which is not certified to Annex 16 Volume III, and to which changes in type design are made prior to the issuance of the aeroplane's first certificate of airworthiness that increase its CO2 emissions evaluation metric value by more than 1.5% or are considered to be significant CO2 changes.

4. **Derived version of a CO_2-certified aeroplane:** An aeroplane which incorporates changes in type design that either increase its maximum take-off mass, or that increase its CO2 emissions evaluation metric value by more than:

   a) 1.35% at a maximum take-off mass of 5 700 kg, decreasing linearly to,
   b) 0.75% at a maximum take-off mass of 60 000 kg, decreasing linearly to,
   c) 0.70% at a maximum take-off mass of 600 000 kg, and
   d) a constant 0.70% at maximum take-off masses greater than 600 000 kg.

   Note — where the certificating authority finds that the proposed change in design, configuration, power or mass is so extensive that a substantially new investigation of compliance with the applicable airworthiness regulations is required, the aeroplane will be considered to be a new type design rather than a derived version.

5. **Equivalent procedure:** A test or analysis procedure which, while differing from the one specified in this volume of Annex 16, in the technical judgement of the certificating authority yields effectively the same CO_2 emissions evaluation metric value as the specified procedure.

6. **Maximum passenger seating capacity:** The maximum certificated number of passengers for the aeroplane type design.

7. **Maximum take-off mass:** The highest of all take-off masses for the type design configuration.

8. **Performance model:** An analytical tool or method validated from corrected flight test data that can be used to determine the SAR values for calculating the CO_2 emissions evaluation metric value at the reference conditions.

9. **Optimum conditions:** The combinations of altitude and airspeed within the approved operating envelope defined in the aeroplane flight manual that provides the highest specific air range value at each reference aeroplane mass.

10. **Reference geometric factor:** An adjustment factor based on a measurement of aeroplane fuselage size derived from a two-dimensional projection of the fuselage.

11. **Specific air range:** The distance an aeroplane travels in the cruise flight phase per unit of fuel consumed.

12. **State of design:** The State having jurisdiction over the organization responsible for the type design.

13. **Subsonic aeroplane:** An aeroplane incapable of sustaining level flight at speeds exceeding a Mach number of 1.

14. **Type Certificate:** 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.

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ANNEXURE -II

SYMBOLS

Where the following symbols are used in this CAR, they have the meanings and where applicable the units ascribed to them below:

Abbreviations	Meaning
AVG	Average
CG	Centre of gravity
CO2	Carbon dioxide
g0	Standard acceleration due to gravity at sea level and a geodetic latitude of 45.5 degrees, 9.80665 (m/s2)
Hz	Hertz (cycles per second)
MTOM	Maximum take-off mass (kg)
OML	Outer mould line
RGF	Reference geometric factor
RSS	Root sum of squares
SAR	Specific air range (km/kg)
TAS	True air speed (km/h)
Wf	Total aeroplane fuel flow (kg/h)

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