

# European Aviation Safety Agency

## Engine Type Certificate Data Sheet EASA.IM.E.002

Issue: 2  
Date: 16 March 2004  
Type: GE Aircraft Engines  
GE90 Series Engines

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GE90-76B GE90-85B GE90-90B GE90-77B GE90-94B	GE90-110B1 GE90-113B GE90-115B

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## SECTION 1 : GE90-76B, -77B, -85B, -90B, -94B

### I. General

**1. Type/Variants:** GE90-76B, GE90-85B, GE90-90B, GE90-77B, GE90-94B

**2. Type Certificate Holder:**

GE Aircraft Engines  
1, Neumann Way  
Cincinnati  
Ohio 45215-6310, USA

**3. Manufacturer:** GE Aircraft Engines

**4. JAA Validation Application Date:**

GE90-76B	GE90-85B	GE90-90B	GE90-77B	GE90-94B
24 Jan. 1992	24 Jan. 1992	14 Nov. 1995	Apr. 10, 1996	14 Dec. 1999

**5. JAA Validation Reference Date:** 2 Feb. 1992

**6. JAA Validation Recommendation Date:**

GE90-76B	GE90-85B	GE90-90B	GE90-77B	GE90-94B
03 Nov. 1995	03 Nov. 1995	22 Jan. 1997	22 Jan. 1997	08 Nov. 2000

**7. EASA Certification Date:**

GE90-76B	GE90-85B	GE90-90B	GE90-77B	GE90-94B
03 Nov. 1995	03 Nov. 1995	23 Jan. 1997	23 Jan. 1997	08 Nov. 2000

In accordance with article 2 paragraph 3 (a)(i) of EU Commission Regulation EC 1702/2003, the EASA Type Certificate for these engines is granted based on:

- the CAA United Kingdom validation letter issued following the JAA recommendation for the GE90-76B, GE90-85B, GE90-90B and GE90-77B engine models.
- the DGAC France Type Certificate issued following the JAA recommendation for the GE90-94B engine model.

### II. Certification Basis

**1. FAA Certification Basis details:** see FAA TCDS E00049EN

**2. EASA Certification Basis:**

The EASA Certification Basis is the JAA Joint Certification Basis described in paragraph 3.

### **3. JAA Joint Certification Basis:**

#### 3.1 JAA Airworthiness Requirements:

JAR-E Change 8 (dated 4 May 1990) plus Orange Paper E/91/1 (dated 27 May 1991, which embodied NPA-E-8, E-14, and E-15)

#### 3.2 JAA Special Conditions:

##### 3.2.1 GE90-76B, GE90-85B, GE90-90B, GE90-77B

- SC1 : JAR-E800 Bird Ingestion : Special condition based on the new identified 2.5 lb medium bird and 8 lb large bird threats.
- SC2 : JAR-E790 Ingestion of Rain and Hail : Special condition based on the new identified rain and hail threats.

##### 3.2.2 GE90-94B

- SC 1: JAR-E 800 Bird Ingestion: Special condition based on the NPAE-20 dated 3 December 1999.
- SC2 : JAR-E 790 Inclement weather : Special condition requesting compliance with JAR-E 790 Chg. 10.

3.3 JAA Exemptions: None.

#### 3.4 JAA Equivalent Safety Findings:

##### 3.4.1 GE90-76B

- JAR-E 740 (d)(1) - Time to accelerate from 10% to 95% T/O thrust
- JAR-E 840(a)(1)(2) or (3) - Rotor Integrity
- JAR-E 640(b)(1) - Static Pressure Tests
- JAR-E 740(f) - Speed limitations at Maximum Continuous rating.
- JAR-E 740 (f)(4)(iii) - 60s transient Take off EGT
- JAR-E-890 and E650 (b)(2) Thrust Reverser Tests

##### 3.4.2 GE90-85B, GE90-90B, GE90-77B

- JAR-E 740 (d)(1) - Time to accelerate from 10% to 95% T/O thrust
- JAR-E 840(a)(1)(2) or (3) - Rotor Integrity
- JAR-E 640(b)(1) - Static Pressure Tests
- JAR-E-890 and E650 (b)(2) Thrust Reverser Tests

##### 3.4.3 GE90-94B :

- JAR-E 740 (d)(1) - Time to accelerate from 10% to 95% T/O thrust
- JAR-E 840(a)(1)(2) or (3) - Rotor Integrity
- JAR-E 640(b)(1) - Static Pressure Tests
- JAR-E-890 - Thrust Reverser Tests
- JAR-E 780 - Tests in Ice Forming Conditions

#### 3.5. JAA Environmental Standards:

- Emissions and Fuel Venting : ICAO Annex 16, Volume II, 2nd Edition, 1993.

## **III. Technical Characteristics**

### **1. Type Design Definition:**

As defined by the applicable GE90-76B, GE90-85B, GE90-90B, GE90-77B or GE90-94B Model List.

**2. Description:**

Dual Rotor, axial flow, high bypass ratio turbofan. The 10-stage compressor is driven by a 2-stage high pressure turbine. The single stage fan and the 3-stage low pressure compressor are driven by a 6-stage low pressure turbine. The engine includes the starter and the engine mount and does not include the thrust reverser.

**3. Equipment:**

Approved Equipment are included in Item III. 1.

**4. Dimensions:**

Overall Length	7283 mm	(286,9 inches)
Overall width	3871 mm	(152,4 inches)
Overall Height	3952 mm	(155,6 inches)

**5. Dry Weight:** 7892.5 kg (17400 lb.) See note 1.

**6. Ratings:**

Rating		GE90-76B	GE90-77B	GE90-85B	GE90-90B	GE90-94B
Thrust, kN (lb)	Take-off (5 minutes)	360,617 (81070)	363,420 (81700)	395,313 (88870)	418,133 (94000)	432,811 (97300)
	Maximum Continuous	335,529 (75430)	335,529 (75430)	361,329 (81830)	402,920 (90580)	402,919 (90580)
Flat rating ambient temperature, °C (°F)	Take-off	32.8 (91)	32.8 (91)	30 (86)	30 (86)	30 (86)
	Maximum Continuous	25 (77)	25 (77)	25 (77)	25 (77)	25 (77)

See notes 2 and 3.

**7. Control System:**

The engine is equipped with a Full Authority Digital Engine Control (FADEC) system.

Configuration Type Box: see notes 5 and 6

GE90-76B GE90-77B, GE90-85B, GE90-90B	GE90-94B
320-837-701-0	n/a
320-839-501-0	n/a
320-892-101-0	n/a
320-892-201-0	n/a
320-846-701-0	n/a
320-892-601-0	n/a
320-915-201-0	n/a
320-921-501-0	320-921-501-0

**8. Fluids**

8.1 Fuel:

The approved fuels and additives must conform to GE Specification D50TF2. Certain fuels such as those produced to CIS Specification GOST 10227-86 and PRC Specification RP# meet the requirements of D50TF2 by means of the specification. The engine will operate with a mixture of fuels or additives conforming to GE Specification D50TF2.

8.2 Oil:

The engine oil must be a synthetic type conforming to GE Specification D50TF1, Class B. For approved brand of oil refer to GE90 Service Bulletin 79-001.

**9. Aircraft Accessory Drives:**

DRIVE PAD	Rotation Facing Gearbox Pad	Gear Ratio to Core Speed	Horsepower Continuous Pad Rating kW (HP)	Shear Torque** N. m (in-lb)	Maximum Overhung Moment N.m (in-lb)
IDG (120 KVA)	CCW (*)	0.7974	181.3 (243)	1130 - 1187 (10000 - 10500)	226.0 (2000)
Hydraulic Pump	CCW	0.3783	63.5 (85)	480 - 548 (4250 - 4850)	26.0 (230)
VSCF/PMG Generator	CCW	2.4126	43.3 (58)	362 - 395 (3200 - 3500)	45.2 (400)
IDG Overload Limits	226.8 KVA (304 HP) for 5 minutes per 1000 hours of operation 302.9 KVA (406 HP) for 5 seconds per 1000 hours of operation 373.0 KVA (500 HP) electrical fault				
VSCF/PMG Overload limits	64.9 KVA (87 HP) for 5 minutes per 1000 hours of operation 86.5 KVA (116 HP) for 5 seconds per 1000 hours of operation 95.5 KVA (128 HP) electrical fault				

(\*) Counter Clockwise

(\*\*)Shear torque capability is a function of operator requirement. Consult GE Aircraft Engines for installed capability.

"KVA" stands for "1000 Volt Ampères"

**10. Maximum Permissible Air Bleed Extraction:**

	Allowable Bleed Limits (Percent)			
	Stage 4	Stage 7	Stage 10	Total
Below 23 percent N1K	7.8	1.8	13.6	15.4
23 to 31 percent N1K	7.6	1.6	12.8	14.4
31 to 57.4 percent N1K	7.4	1.3	12.6	13.9
57.4 to 80 percent N1K	7.2	1.3	12.6	13.9
80 to 96.8 percent N1K	7.0	1.3	6.5	8.3
Above 96.8 percent N1K	6.5	1.3	6.5	7.8

"N1K" is defined as  $N1/(\sqrt{T_{amb}} / \sqrt{288 K})$

**IV.Operational Limits:**

**1. Temperature Limits:**

1.1 Exhaust Gas Temperature (EGT), °C (°F):

	GE90-76B with configuration type box 320-837-701-0	GE90-76B with configuration type box 320-839-501-0 See note 5 (untrimmed values)	GE90-77B, GE90-85B, GE90-90B	GE90-94B
Take-off* (5 Minutes)	975 (1787)	1005 (1841)	1030 (1885)	1030 (1886)
* 60 seconds maximum transient	980 (1795)	1010 (1850)	n/a	n/a
Maximum Continuous	925 (1697)	955 (1751)	985 (1804)	1015 (1859)
Starting (Maximum on Ground)	750 (1382)	750 (1382)	750 (1382)	750 (1382)**
Starting (Maximum in Flight)	825 (1517)	825 (1517)	825 (1517)	825 (1517)
** 40 seconds start EGT exceedance	n/a	n/a	n/a	825 (1517)

EGT is measured at the inlet of the LP Turbine  
See note 3.

1.2 Oil Temperature, °C (°F):

Continuous Operation: 124 (255)  
Transient (15 minutes Maximum): 135 (275)

**2. Maximum Permissible rotor Speeds**

		GE90-76B	GE90-77B, GE90-85B, GE90-90B, GE90-94B
Take-off rpm (%)	Low Pressure Rotor (N1)*	2465 (109.0)	2465 (109.0)
	High Pressure Rotor (N2)**	10705 (114.7)	10918 (117.0)
Maximum Continuous rpm (%)	Low Pressure Rotor (N1)*	n/a, see note 11	2465 (109.0)
	High Pressure Rotor (N2)**	n/a, see note 11	10918 (117.0)

\* : 100 percent N1 is 2261,5 RPM

\*\* : 100 percent N2 is 9332,0 RPM

**3. Pressure Limits:**

3.1 Fuel Pressure Limits at Engine Pump Inlet:

The fuel pressure at the engine pump inlet must be between a minimum limit of not less than the greater of true vapour pressure plus 48,3 kPa (7.0 psig) or ambient plus 48,3 kPa (7.0 psig) and a maximum limit of 482,6 kPa (70 psig).

3.2 Oil Pressure Limits:

Low Pressure (differential): 69 kPa (10 psid). See note 4.

**4. Installation Assumptions:**

The installation assumptions are quoted in the Engine Installation Manual GEK 100704.

**5. Dispatch Limitations:**

Time Limited Dispatch Criteria : Criteria pertaining to the dispatch and maintenance requirements for engine control systems are specified in the GEAE Document GEK 103084 and the airworthiness limitations of the GE90 Engine Manual GEK 100700 which define the various configurations and maximum operating intervals.

**V. Operating and Service Instructions**

Engine Installation Manual	GEK 100704
Engine Operating Instructions	GEK 100703
Engine Maintenance Manual	D633W101-GEC, Part 1 and Part 2
Engine Overhaul Manual	GEK100700
Service Bulletins	

**VI. Notes**

**Note 1:** Dry weight includes basic engine accessories and optional equipment as listed in the manufacturer's engine specification.

**Note 2:** The engine ratings are based on dry sea-level static ICAO Standard Atmospheric Conditions, no installation effects, no customer bleed, no power extraction, and unity ram recovery. The engine ratings specified are the minimum guaranteed and are based on calibrated stand performance with the inlet, exhaust, and nacelle configured as specified in the Installation Manual GEK 100704.

**Note 3:** Take off rating is limited to a continuous period of not more than 10 minutes in the event of one engine inoperative.

**Note 4:** During negative-g operation only, it is permissible to operate below minimum oil pressure (69 kPa, differential pressure (10 psid) indicated) for a maximum of 15 seconds. See GE90 Operating Instructions, GEK 100703, Section 8.

**Note 5:** GE90-76B engines with configuration type box number 320-839-501-0 must incorporate the HP/LP turbine hardware and associated changes per GE Service Bulletin 72-169. The FADEC incorporates a 30°C shunt so that the indicated EGT limits remain unchanged at 980°C/975°C/925°C (trimmed values).

GE90 engines with configuration type box part numbers 320-892-101-0 or 320-892-201-0 must incorporate the PT25 extended wedge ice shield per GE90 Service Bulletin 77-008 and must incorporate FADEC software P/N 1853M99P06 (version 9.1.9.7) or later, per GE90 Service Bulletin 73.040.

**Note 6:** GE 90 models with configuration type box numbers 320-837-701-0, 320-839-501-0, 320-892-101-0, 320-892-201-0, 320-846-701-0, 320-892-601-0, and 320-915-201-0, have a minimum permissible N2 RPM of 6066 RPM for in flight operation during icing conditions.

GE 90 models with configuration type box number 320-921-501-0 have a minimum permissible N2 RPM of 6310 RPM for in flight operation during icing conditions.

**Note 7:** For ground operation in icing conditions, requirements and limitations are specified in the GE 90 Operating Instructions Manuel GEK 100703.

**Note 8:** Life limits established for critical rotating components are published in Chapter 5 of the GE90 Engine Overhaul Manual, GEK 100700.

**Note 9:** Power setting, power checks, and control of engine thrust output in all operations are based on GE engine charts referring to Fan Speed (N1). Speed sensors are included in the engine assembly for this purpose.

**Note 10:** The GE90 variants incorporate the following general characteristics:

GE90 variants	Characteristics
GE90-76B	Basic Model
GE90-77B	Same as GE90-76B except for improved HPT/LPT flowpath and higher takeoff thrust rating.
GE90-85B	Same as GE90-76B except for higher thrust ratings. Rating plug change
GE90-90B	Same as GE90-77B except for higher thrust ratings. Rating plug change
GE90-94B	Same as GE90-77B except for improved 3D Aero HPC and higher thrust ratings. Rating plug change

- The GE90-75B model has been deleted from the FAA TC on July 24, 1995
- The GE90-92B model has been deleted from the FAA TC on June 26, 2000

**Note 11:** GE90-76B model : according to the equivalent safety finding in II.7 , there are no limits for maximum continuous N1 and N2 speeds. For information purpose only : the values demonstrated during the FAR 33.87 test were N1 = 2390 rpm and N2 = 10590 rpm.

**Note 12:** The engine is approved for use with Boeing thrust reverser part number 315W1000.

**Note 13:** The loads resulting from a fan blade release at the inner flow path line are specified in the Engine Installation Manual. The loads for a fan blade release at the outer most retention groove have been determined and are available from GE.

**Note 14:** Repair of fan blade composite material in the root section of the fan blade up to the inner annulus flow path line is not permitted. Fan blades with non-serviceable conditions existing on metallic components, erosion coating or wear pads of the fan blade should be referred to GE Aircraft Engine for disposition.

## SECTION 2 : GE90-110B1, -113B, -115B

### I. General

1. **Type/Variants:** GE90-110B1, -113B, -115B

2. **Type Certificate Holder:**

GE Aircraft Engines  
1, Neumann Way  
Cincinnati  
Ohio 45215-6310, USA

3. **Manufacturer:** GE Aircraft Engines

4. **JAA Validation Application Date:**

GE90-110B1	GE90-113B	GE90-115B
8 May 2002	2 Jan. 2001	2 Jan. 2001

5. **JAA Validation Reference Date:** 27 Jun. 2000

6. **JAA Validation Recommendation Date:**

GE90-110B1	GE90-113B	GE90-115B
18 Dec. 2003	18 Dec. 2003	18 Dec. 2003

7. **EASA Certification Date:**

GE90-110B1	GE90-113B	GE90-115B
18 Dec. 2003	18 Dec. 2003	18 Dec. 2003

The EASA Type Certificate for these engines is granted based on the JAA recommendation and in accordance with article 2 paragraph 4 (d) of EU Commission Regulation EC 1702/2003.

### II. Certification Basis

1. **Reference Application Date for FAA Certification:** 27 Jun. 2000

2. **FAA Certification Date (FAA Type Certificate Data Sheet No. E00049NE):**

GE90-110B1	GE90-113B	GE90-115B
30 Jul. 2003	30 Jul. 2003	30 Jul. 2003

### **3. FAA Certification Basis:**

Federal Aviation Regulation (FAR) Part 33, effective February 1, 1965, including Amendments 33-1 through 33-20 inclusive, Special Condition Number SC-33-ANE-08-NE, Grant of Exemption Number 7953, Exemption to §33.73(b).

All GE90 engines approved under Type Certificate No. E00049NE comply with the fuel venting emissions and exhaust emissions requirements of FAR 34 effective September 10, 1990.

### **4. EASA Certification Basis**

The EASA Validation basis is the JAA Joint Certification basis described in paragraph 5 below.

### **5. JAA Joint Certification Basis:**

#### 5.1 JAA Airworthiness Requirements:

JAR-E Change 10 (dated 15 August 1999)

#### 5.2 JAA Special Conditions:

- SC1 : Medium and large Birds Ingestion
- SC2 : Programmable Logic device
- SC3 : Fan Blade Containment

#### 5.3 JAA Exemptions: None

#### 5.4 JAA Equivalent Safety Findings:

- JAR-E 800(b)(3) – "Additional assesment", as of Special Condition 1

#### 5.5 "Elect to comply" JAA Airworthiness Standards

- JAR-E 640 Pressure Loads as of amendment 11
- JAR-E 840 Rotor Integrity as of amendment 11
- JAR-E 510 Safety Analysis as of amendment 12

#### 5.6 JAA Environmental Standards:

- Emissions and Fuel Venting : ICAO Annex 16, Volume II, 2nd Edition, 1993.

## **III. Technical Characteristics**

### **1. Type Design Definition:**

As defined by the applicable GE90-110B1, GE90-113B, GE90-115B Model List.

### **2. Description:**

Dual Rotor, axial flow, high bypass ratio turbofan. The 9-stage compressor is driven by a 2-stage high pressure turbine. The single stage fan and the 4-stage low pressure compressor are driven by a 6-stage low pressure turbine. The engine includes the starter and the engine mount and does not include the thrust reverser.

### **3. Equipment:**

Approved Equipment are included in Item III. 1.

**4. Dimensions:**

Overall Length	7281 mm	(286,67 inches)
Overall width	3769 mm	(148.38 inches)
Overall Height	3926 mm	(154.56 inches)

**5. Dry Weight:** 8761.1 kg (19315 lb.). See note 1.

**6. Ratings:** See notes 2 and 3 .

Rating		GE90-110B1	GE90-113B	GE90-115B
Thrust, kN (lb)	Take-off (5 minutes)	492,685 (110,760)	505,006 (113,530)	513,947 (115,540)
	Maximum Continuous	489,304 (110,000)	489,304 (110,000)	489,304 (110,000)
Flat rating ambient temperature, °C (°F)	Take-off	33 (92)	30 (86)	30 (86)
	Maximum Continuous	25 (77)	25 (77)	25 (77)

**7. Control System:**

The engine is equipped with a Full Authority Digital Engine Control (FADEC) system.

Configuration Type Box: 390-850-001-0.

**8. Fluids**

8.1 Fuel:

The approved fuels and additives must conform to GE Specification D50TF2. Certain fuels such as those produced to CIS Specification GOST 10227-86 and PRC Specification RP# meet the requirements of D50TF2 by means of the specification. The engine will operate with a mixture of fuels or additives conforming to GE Specification D50TF2.

8.2 Oil:

The engine oil must be a synthetic type conforming to GE Specification D50TF1, Class B. For approved brand of oil refer to GE90 Service Bulletin 79-001.

**9. Aircraft Accessory Drives:**

DRIVE PAD	Rotation Facing Gearbox Pad	Gear Ratio to Core Speed	Horsepower Continuous Pad Rating kW (HP)	Shear Torque(**) N. m (in-lb)	Maximum Overhung Moment N.m (in-lb)
IDG (120 KVA)	CCW (*)	0.7974	181.3 (243)	1130 - 1187 (10000 - 10500)	226.0 (2000)
Hydraulic Pump	CCW	0.3783	63.5 (85)	480 - 548 (4250 - 4850)	26.0 (230)
VSCF/PMG Generator	CCW	2.4126	43.3 (58)	362 - 395 (3200 - 3500)	45.2 (400)
IDG Overload Limits	226.8 KVA (304 HP) for 5 minutes per 1000 hours of operation 302.9 KVA (406 HP) for 5 seconds per 1000 hours of operation 373.0 KVA (500 HP) electrical fault				
VSCF/PMG Overload limits	64.9 KVA (87 HP) for 5 minutes per 1000 hours of operation 86.5 KVA (116 HP) for 5 seconds per 1000 hours of operation 95.5 KVA (128 HP) electrical fault				

(\*) Counter Clockwise

(\*\*) Shear torque capability is a function of operator requirement. Consult GE Aircraft Engines for installed capability. 100 percent core speed is 9,332 RPM

"KVA" stands for "1000 Volt Ampères"

**10. Maximum Permissible Air Bleed Extraction:**

	Allowable Bleed Limits (Percent)			
	Stage 4	Stage 7	Stage 9	Total
Below 27 percent N1K	7.6	1.5	11.2	12.7
At 51 percent N1K	7.6	1.5	11.5	13.0
At 80 percent N1K	7.6	1.5	12.0	13.5
At 88 percent N1K	7.6	1.5	11.0	12.5
At 93 percent N1K	7.6	1.5	8.0	9.1
Above 93 percent N1K	7.6	1.5	7.3	9.1

"N1K" is defined as  $N1/(\sqrt{T_{amb}} / \sqrt{288 \text{ K}})$

**IV. Operational Limits:**

**1. Temperature Limits:**

1.1 Exhaust Gas Temperature (EGT), °C (°F):

	GE90-110B1, -113B, -115B
Take-off* (5 minutes, see note 3)	1090 (1994)
*: 30 seconds maximum transient	1095 (2003)
Maximum Continuous	1050 (1922)
Starting (Maximum on Ground)	750 (1382)
Starting (Maximum in Flight)	825 (1517)

EGT is measured at the inlet of the LP Turbine

1.2 Oil Temperature, °C (°F):

Continuous Operation: 132 (270)  
Transient (15 minutes maximum): 143 (290)

**2. Maximum Permissible rotor Speeds**

		GE90-110B1, -113B, -115B
Take-off rpm (%)	Low Pressure Rotor (N1)*	2602 (110.5)
	High Pressure Rotor (N2)**	11292 (121)
Maximum Continuous rpm (%)	Low Pressure Rotor (N1)*	2602 (110.5)
	High Pressure Rotor (N2)**	11292 (121)

\* : 100 percent N1 is 2355.0 RPM

\*\* : 100 percent N2 is 9332,0 RPM

**3. Pressure Limits:**

3.1 Fuel Pressure Limits at Engine Pump Inlet:

The fuel pressure at the engine pump inlet must be between a minimum limit of not less than the greater of true vapour pressure plus 48,3 kPa (7.0 psig) or ambient plus 48,3 kPa (7.0 psig) and a maximum limit of 482,6 kPa (70 psig).

3.2 Oil Pressure Limits:

Low Pressure (differential): 69 kPa (10 psid). See Note 4.

**4. Installation Assumptions:**

The installation assumptions are quoted in the Engine Installation Manual GEK 109995.

## 5. Dispatch Limitations:

Time Limited Dispatch Criteria : Criteria pertaining to the dispatch and maintenance requirements for engine control systems are specified in the Airworthiness Limitations section of the GE90-100 Engine Overhaul Manual GEK109993.

## V. Operating and Service Instructions

Engine Installation Manual	GEK109995
Engine Operating Instructions	GEK109994
Engine Maintenance Manual	D633W101-GEC, Part 1 and Part 2
Engine Overhaul Manual	GEK109993
Illustrated Parts Catalogue	GEK110005
Service Bulletins	-

## VI. Notes

**Note 1:** Dry weight includes basic engine accessories and optional equipment as listed in the manufacturer's engine specification.

**Note 2:** The engine ratings are based on dry sea-level static ICAO Standard Atmospheric Conditions, no installation effects, no customer bleed, no power extraction, and unity ram recovery. The engine ratings specified are the minimum guaranteed and are based on calibrated stand performance with the inlet, exhaust, and nacelle configured as specified in the Installation Manual GEK 109995.

**Note 3:** Take off rating is limited to a continuous period of not more than 10 minutes in the event of one engine inoperative.

**Note 4:** During negative-g operation only, it is permissible to operate below minimum oil pressure (69 kPa, differential pressure (10 psid) indicated) for a maximum of 15 seconds. See GE90 Operating Instructions, GEK109994, Section 8.

**Note 5:** For ground operation in icing conditions, requirements and limitations are specified in the GE 90 Operating Instructions Manual GEK109994.

**Note 6:** Life limits established for critical rotating components are published in Chapter 5 of the GE90 Engine Overhaul Manual, GEK109993.

**Note 7:** Power setting, power checks, and control of engine thrust output in all operations are based on GE engine charts referring to Fan Speed (N1). Speed sensors are included in the engine assembly for this purpose.

**Note 8:** The GE90-100 series variants incorporate the following general characteristics:

GE90 variants	Characteristics
GE90-110B1	Same as GE94B except for changes in fan, LPC, HPC, HPT and LPT hardware, rotor speeds and temperature ratings.
GE90-113B	Same as GE90-110B1 except for higher Take-off thrust rating. Rating plug change.
GE90-115B	Same as GE90-110B1 except for higher Take-off thrust rating. Rating plug change.

**Note 9:** The engine is approved for use with Boeing thrust reverser part number.

315W1298-1	Left Engine Left Hand
315W1298-2	Left Engine Right Hand
315W1298-3	Right Engine Left Hand
315W1298-4	Right Engine Right Hand

**Note 10:** The loads resulting from a fan blade release at the inner flow path line are specified in the Engine Installation Manual.

**Note 11:** Repair of fan blade composite material in the root section of the fan blade up to the inner annulus flow path line is not permitted. Fan blades with non-serviceable conditions existing on metallic components, erosion coating or wear pads of the fan blade should be referred to GE Aircraft Engines for disposition.

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