



TYPE-CERTIFICATE DATA SHEET

EASA.IM.A.022

DA 40

Type Certificate Holder
Diamond Aircraft Industries Inc.

1560 Crumlin Sideroad
London, ON, N5V1S2
Canada

For models: DA 40
 DA 40 D
 DA 40 F
 DA 40 NG

Issue 24: 22-Apr-2021





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SECTION A: DA 40

A.I. General

- | | |
|------------------------------------|---|
| 1. Data Sheet No.: | EASA.IM.A.022 |
| 2. a) Type: | DA 40 |
| b) Model: | DA 40 |
| c) Variant: | -- |
| 3. Airworthiness Category: | Normal
Utility |
| 4. Type Certificate Holder: | DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA |
| 5. Manufacturer: | DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA
161-93 (TCCA)

DIAMOND AIRCRAFT INDUSTRIES GMBH
N.A. OTTO-STR. 5
A-2700 WIENER NEUSTADT
AUSTRIA
AT.21G.0001 |
| 6. Certification Application Date: | 20-Feb-1997 |
| 7. (Reserved): | N/A |
| 8. (Reserved): | N/A |

A.II. EASA Certification Basis

See Note 13

- | | |
|--|---|
| 1. Reference Date for determining the applicable requirements: | 24-Oct-1998 |
| 2. Airworthiness Requirements: | JAR-23, Change -, issued 11-Mar-1994
JAR-1, Change 5, issued 15-Jul-1996 |





- | | |
|--------------------------------------|---|
| 3. Special Conditions: | (CRI F-01) Protection from the Effects of HIRF
(CRI F-03) Protection from the Effects of Lightning Strikes, Indirect Effects
(CRI O-01) Glider Towing
(CRI O-02) Tow Cable Retraction Mechanisms |
| 3. Exemptions: | None |
| 4. Deviations: | None |
| 5. Equivalent Safety Findings: | None |
| 6. Requirements elected to comply: | JAR-23, NPA 23-3, ACJ Material |
| 7. Environmental Standards: | ICAO, Annex 16, Volume 1, Third Edition, 1993
CRI A-03 for additional national requirements
<i>See Note 2</i>
CRI A-03 1200, for Take Off mass of 1200 kg
<i>See Note 11</i> |
| 8. Additional National Requirements: | None |
| 9. (Reserved) | N/A |

A.III. Technical Characteristics and Operational Limitations

- | | |
|----------------------------|--|
| 1. Type Design Definition: | Doc. No. D40-AW-0120, latest revision |
| 2. Description: | Single engine, four-seated cantilever low wing airplane, composite construction, fixed tricycle landing gear, T-tail |
| 3. Equipment: | Equipment list, AFM, Doc. No. 6.01.01, Section 6 |
| 4. Dimensions: | Span 11.94 m (39 ft 2 in)
Length 8.01 m (26 ft 3 in)
Height 1.97 m (6 ft 6 in)
Wing Area 13.54 m ² (146 sqft) |
| 5. Engine: | |
| 5.1.1 Model: | 1 Textron Lycoming IO-360 M1A |
| 5.1.2 Type Certificate: | FAA Engine Type Certificate Data Sheet 1E10 |
| 5.1.3 Limitations: | Max take-off rotational speed 2700 r.p.m.
Max continuous rotational speed 2400 r.p.m
For power-plants limits refer to AFM, Doc. No. 6.01.01, Section 2 |





6. Load factors: at V_A at V_{NE} with flaps in T/O or LDG position

Normal Category

Positive:	3.8	3.8	2.0
Negative	-1.52	0	

Utility Category

Positive:	4.4	4.4	2.0
Negative:	-1.76	-1	

7. Propeller:

- 7.1 Model: 1 MT-Propeller MTV-12-B/180-17()
() – designations: none or f
- 7.2 Type Certificate: EASA Propeller Type Certificate Data Sheet P.013
- 7.3 Number of blades: 3
- 7.4 Diameter: 1800 mm
- 7.5 Sense of Rotation: Clockwise
- 7.6 Setting: Low pitch setting: 10.5°
High pitch setting: 30°

8. Fluids:

- 8.1 Fuel: Refer to AFM Chapter 2, Section 2.14
- 8.2 Oil: Refer to AFM Chapter 2, Section 2.4
- 8.3 Coolant: None

9. Fluid capacities:

- 9.1 Fuel: Standard Fuel Tank:

Total:	156 liters	41.2 US Gallons
Usable:	152.2 liters	40.2 US Gallons

Long Range Fuel Tank:		<i>See Note 7</i>
Total:	193 liters	51 US Gallons
Usable:	189.2 liters	50 US Gallons
- 9.2 Oil:

Maximum:	7.70 liters	8 qts
Minimum:	3.785 liters	4 qts
- 9.3 Coolant system capacity: N/A





10. Air Speeds:
- Design Manoeuvring Speed v_A :
- | | |
|------------------|----------|
| 780 kg to 980 kg | 94 KIAS |
| above 980 kg | 108 KIAS |
- with MÄM 40-227 carried out
- | | |
|-------------------|----------|
| 780 kg to 1036 kg | 94 KIAS |
| above 1036 kg | 111 KIAS |
- Flap Extended Speed v_{FE} :
- | | |
|----------------|----------|
| full flaps | 91 KIAS |
| take-off flaps | 108 KIAS |
- Maximum structural cruising speed v_{NO}
(= Maximum structural design speed v_C):
- 129 KIAS
- Never exceed speed v_{NE} : 178 KIAS
11. Maximum Operating Altitude: 5000 m (16 404 ft)
12. All Weather Operations Capability: Day-VFR
Night VFR *See Note 3*
IFR *See Note 4*
Flight into expected or actual icing conditions is prohibited
13. Maximum Weights:
- Take-off:
- | | |
|-------------------|--|
| Utility Category: | 980 kg (2161 lb) |
| Normal Category: | 1150 kg (2535 lb) or
1200 kg (2646 lb) <i>See Note 11</i> |
- Landing:
- | | |
|-------------------|--|
| Utility Category: | 980 kg (2161 lb) |
| Normal Category: | 1092 kg (2407 lb) or
1150 kg (2535 lb) <i>See Note 10</i> |
14. Centre of Gravity Range:
- Forward limit:
- | | |
|--------------|---------------------|
| up to 980 kg | 2.40 m behind Datum |
| at 1200 kg | 2.48 m behind Datum |
- varying linearly with mass in between
- Rear limit:
- | | |
|---------------------------|---------------------|
| for all masses | 2.59 m behind Datum |
| with Long Range Fuel Tank | 2.55 m behind Datum |
15. Datum: 2.194 mm
in front of leading edge of stub-wing at the wing joint





16. Control surface deflections:

Aileron	up down	$20^{\circ}, \pm 2^{\circ}$ $13^{\circ}, +2/-0^{\circ}$
Elevator	(a) With Standard Fuel Tank: up down or values listed under (c) (b) With Long Range Fuel Tank: up down or values listed under (c) (c) With MTOM 1200 kg (MÄM 40-227) installed and for all configurations permitted: up down Serial Numbers 40.006 to 40.044 (except 40.030): Trim nose up Trim nose down Serial Numbers 40.030 and 40.045 and subsequent: Trim nose up Trim nose down With Standard Fuel Tank: Left Right With Long Range Fuel Tank (OÄM 40-071) or Large Rudder (MÄM 40-113) installed: Left Right Take off flap setting Landing flap setting	$23^{\circ}, \pm 1^{\circ}$ $15^{\circ}, \pm 1^{\circ}$ $23^{\circ}, +0/-1^{\circ}$ $16^{\circ}, +1/-0^{\circ}$ $18^{\circ}, +0/-1^{\circ}$ $16^{\circ}, +1/-0^{\circ}$ $+ 18^{\circ}, \pm 2^{\circ}$ $- 33^{\circ}, \pm 2^{\circ}$ $+ 12^{\circ}, \pm 2^{\circ}$ $- 39^{\circ}, \pm 2^{\circ}$ $29^{\circ}, \pm 1^{\circ}$ $31^{\circ}, \pm 1^{\circ}$ $24^{\circ}, \pm 1^{\circ}$ $26^{\circ}, \pm 1^{\circ}$ $20^{\circ}, \pm 2^{\circ}$ $42^{\circ}, \pm 1^{\circ}$
Trim tab (elevator neutral)	Trim nose up Trim nose down	$+ 18^{\circ}, \pm 2^{\circ}$ $- 33^{\circ}, \pm 2^{\circ}$
Rudder	Left Right	$29^{\circ}, \pm 1^{\circ}$ $31^{\circ}, \pm 1^{\circ}$
Flaps	Take off flap setting Landing flap setting	$20^{\circ}, \pm 2^{\circ}$ $42^{\circ}, \pm 1^{\circ}$
17. Levelling Means:	wedge 600 : 31	top surface of fuselage tube in front of dorsal fin
18. Minimum Flight Crew:	1 (Pilot)	
19. Maximum Passenger Seating Capacity:	3	
20. Baggage/Cargo Compartments:	Location	Max. allowable Load
	Behind Rear Seats	30 kg (66.14 lbs)
	Baggage Tube	5 kg (11.02 lbs)
	With Baggage Extension	45 kg (100 lbs) See Note 9





3. For Night VFR operation the optional design change OÄM 40-064 must be incorporated.
4. For IFR operation the optional design change OÄM 40-067 must be incorporated.
5. For glider towing operation the optional design change OÄM 40-063 must be incorporated.
6. (removed)
7. Long Range Tank, as defined in Optional Design Change OÄM 40-071, is applicable for the following serial numbers:

DA 40	40.030 through 40.079, 40.081 through 40.083, 40.085 through 40.199, 40.201 through 40.842, 40.844, 40.846 and subsequent.
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8. The tire dimension 15x6.0-6 is only approved in conjunction with the 18 mm MLG strut in accordance with MÄM 40-123 or the tall MLG strut in accordance to OÄM 40-283.
9. The increased baggage load is applicable if the baggage extension, Optional Design Change OÄM 40-163 is installed.
10. The landing mass of 1150 kg (2535 lbs) is only approved with Mandatory Design Change MÄM 40-123 or the tall MLG strut in accordance to OÄM 40-283 is installed.
11. The maximum take off mass of 1200kg (2646 lbs) is only approved if mandatory design change MÄM 40-227 and a main landing gear strut by MÄM 40-123 maximum landing mass of 1150 kg (2535 lbs) or the tall MLG strut in accordance to OÄM 40-283 is installed.
12. (removed)
13. At the time of certification, Special Conditions and ELOS' referenced in this TCDS have been enclosed in Certification Review Items (CRI) not publicly available. To provide publicly all necessary information, the text of SCs / ELOS' is given in Appendix A to this TCDS.





SECTION B: DA 40 D

B.I. General

1. Data Sheet No.: EASA.IM.A.022
2. a) Type: DA 40
b) Model: DA 40 D
c) Variant: --
3. Airworthiness Category: Normal
Utility
4. Type Certificate Holder: DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA
5. Manufacturer: DIAMOND AIRCRAFT INDUSTRIES GMBH
N.A. OTTO-STR. 5
A-2700 WIENER NEUSTADT
AUSTRIA
AT.21G.0001

DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA
161-93 (TCCA)

SHANDONG BIN AO AIRCRAFT INDUSTRIES
CO.,LTD
DAGAO, ZHANHUA COUNTY, BINZHOU
PEOPLE'S REPUBLIC OF CHINA
former EASA.21G.0014 *See Note 1*
6. Certification Application Date: 20-Feb-1997
for Major Change OÄM 40-100 - DA 40 D:
11-Jan-2002
7. (Reserved): N/A
8. (Reserved): N/A





B.II. EASA Certification Basis

See Note 14

1. Reference Date for determining the applicable requirements: 24-Oct-1998
2. Airworthiness Requirements: JAR-23, issued 11-Mar-1994, incl. Amdt. 1
JAR-1, Change 5, issued 15-Jul-1996
3. Special Conditions:
 - (CRI E-05) Reciprocating Engine using Jet Fuel
 - (CRI E-06) Use of Diesel Fuel and Diesel/Jet Fuel Blends for Reciprocating Engines
 - (CRI E-09) Engine Vibration Level
 - (CRI E-10) Engine Torque
 - (CRI F-01) Protection from the Effects of HIRF
 - (CRI F-03) Protection from the Effects of Lightning Strikes, Indirect Effects
 - (CRI F-06) Installation of a FADEC Diesel Engine and Propeller
 - (CRI F-07) Human Factors in Integrated Avionic Systems
 - (CRI F-08) Software, Hardware Assurance Level and Highly, Integrated or Complex Aircraft Systems
 - (CRI F-08) Software, Hardware Assurance Level and Highly Integrated or Complex Aircraft Systems
3. Exemptions: None
4. Deviations: None
5. Equivalent Safety Findings:
 - (CRI D-01) Single Lever Power Control
 - (CRI E-07) Coolant Tank
 - (CRI E-08) Electronically-controlled Reciprocating Diesel Engine
 - (CRI E-11) Fuel System – Hot Fuel Temperature
 - (CRI F-05) Powerplant Instruments
6. Requirements elected to comply: None
7. Environmental Standards: ICAO, Annex 16, Volume 1, Third Edition, 1993, Amdt. 7
JAR 36, issued 23-May-1997
CRI A-03 for additional national requirements

See Note 2





8. Additional National Requirements: N/A
9. (Reserved) N/A

B.III. Technical Characteristics and Operational Limitations

1. Type Design Definition: Doc. No. D40-AW-0129, latest revision
2. Description: Single diesel engine, four-seated cantilever low wing airplane, composite construction, fixed tricycle landing gear, T-tail
3. Equipment: Equipment list, AFM, Doc. No. 6.01.05, Section 6
See Note 9
4. Dimensions:
- | | | |
|-----------|----------------------|--------------|
| Span | 11.94 m | (39 ft 2 in) |
| Length | 8.01 m | (26 ft 3 in) |
| Height | 1.97 m | (6 ft 6 in) |
| Wing Area | 13.54 m ² | (146 sqft) |
5. Engine:
- 5.1.1 Model: 1 Technify Motors GmbH TAE 125-01 or TAE 125-02-99
See Note 10 and Note 11
- 5.1.2 Type Certificate: Engine Type Certificate Data Sheet EASA E.055
- 5.1.3 Firmware: MSB D4-044 *See Note 5*
- 5.1.4 Mapping MSB D4-044 *See Note 5*
- 5.1.5 Limitations: Max take-off rotational speed 2300 r.p.m.
Max continuous rotational speed 2300 r.p.m
(Propeller shaft r.p.m)
For power-plants limits refer to AFM, Doc. No. 6.01.05, Section 2
6. Load factors:
- | | at v_A | at v_{NE} | with flaps in T/O
or LDG position |
|------------------|----------|-------------|--------------------------------------|
| Normal Category | | | |
| Positive: | 3.8 | 3.8 | 2.0 |
| Negative | -1.52 | 0 | |
| Utility Category | | | |
| Positive: | 4.4 | 4.4 | 2.0 |
| Negative: | -1.76 | -1 | |
7. Propeller:
- 7.1 Model: 1 mt-Propeller MTV-6-A/187-129





- 7.2 Type Certificate: EASA Propeller Type Certificate Data Sheet P.094
- 7.3 Number of blades: 3
- 7.4 Diameter: 1870 mm
- 7.5 Sense of Rotation: Clockwise
- 7.6 Settings: Low pitch setting: 12 °
High pitch setting: 28 °
8. Fluids:
- 8.1 Fuel: Jet – Refer to AFM Chapter 2, Section 2.14 for approved fuel specifications
Diesel (EN 590) *See Note 6*
- 8.2 Oil: Engine: Shell Helix Ultra 5W30 synthetic API SJ/CF
For more details see AFM, Doc. No. 6.01.05, Section 2
Gearbox: Shell EP 75W90 API GL-4
For more details see AFM, Doc. No. 6.01.05, Section 2
- 8.3 Coolant: Water / Cooler Protection-Mixture
for more details see AFM, 6.01.05, Section 2
9. Fluid capacities:
- 9.1 Fuel: Standard Fuel Tank
Total: 113.6 liters 30 US Gallons
Usable: 106.0 liters 28 US Gallons

Long Range Fuel Tank (OÄM 40-130) *See Note 13*
Total: 155.2 liters 41 US Gallons
Usable: 147.6 liters 39 US Gallons
- 9.2 Oil: Maximum: 6.0 liters 6.3 qts
Minimum: 4.5 liters 4.8 qts
- 9.3 Coolant system capacity: Approx. 7 Liter
10. Air Speeds: Design Manoeuvring Speed v_A :
up to 980 kg 94 KIAS
above 980 kg 108 KIAS

Flap Extended Speed v_{FE} :
full flaps 91 KIAS
take-off flaps 108 KIAS





	Maximum structural cruising speed v_{NO} (= Maximum structural design speed v_C):	129 KIAS
	Never exceed speed v_{NE} :	178 KIAS
11. Maximum Operating Altitude:	5000 m (16 404 ft)	
12. All Weather Operations Capability:	Day-VFR Night VFR IFR	<i>See Note 3</i>
	Flight into expected or actual icing conditions is prohibited	
13. Maximum Weights:	Take-off:	
	Utility Category:	980 kg (2161 lb)
	Normal Category:	1150 kg (2535 lb)
	Landing:	
	Utility Category:	980 kg (2161 lb)
	Normal Category:	1092 kg (2407 lb) or 1150 kg (2535 lbs) <i>See Note 8</i>
14. Centre of Gravity Range:	Forward limit	
	up to 980 kg	2.40 m behind Datum
	at 1150 kg	2.46 m behind Datum
	varying linearly with mass in between	
	Rear limit	
	for all masses	2.59 m behind Datum
	with Long Range Fuel Tank (OÄM 40-130)	2.55 m behind Datum
15. Datum:	2.194 mm	
	in front of leading edge of stub-wing at the wing joint	
16. Control surface deflections:		
	Aileron	up $20^\circ, \pm 2^\circ$ down $13^\circ, +2/-0^\circ$
	Elevator	With Standard Fuel Tank: up $23^\circ, \pm 1^\circ$ down $15^\circ, \pm 1^\circ$ With Long Range Fuel Tank installed: up $23^\circ, +0/-1^\circ$ down $16^\circ, +1/-0^\circ$





Trim tab (elevator neutral)	Trim nose up	+ 12°, ± 2°
	Trim nose down	- 39°, ± 2°
Rudder	With Standard Fuel Tank:	
	Left	29°, ± 1°
	Right	31°, ± 1°
	With Long Range Fuel Tank (OÄM 40-130) or Large Rudder (MÄM 40-113) installed:	
	Left	24°, ± 1°
Flaps	Right	26°, ± 1°
	Take off flap setting	20°, ± 2°
	Landing flap setting	42°, ± 1°
17. Levelling Means:	wedge 600 : 31	
	top surface of fuselage tube in front of dorsal fin	
18. Minimum Flight Crew:	1 (Pilot)	
19. Maximum Passenger Seating Capacity:	3	
20. Baggage/Cargo Compartments:	Location	Max. allowable Load
	Behind Rear Seats	30 kg (66.14 lb)
	Baggage Tube	5 kg (11.02 lb)
	With Baggage Extension	45 kg (100 lb) <i>See Note 7</i>
21. Wheels and Tyres:	Nose Wheel Tyre Size	5.00 – 5
	Main Wheel Tyre Size	6.00 – 6 or
		15x6.0-6 <i>See Note 4</i>
	For approved types and rating see AMM, Doc. No. 6.02.01	
22. (Reserved):	N/A	

B.IV. Operating and Service Instructions

1. Flight Manual: Airplane Flight Manual Doc. No. 6.01.05-E
2. Technical Manual: Airplane Maintenance Manual Doc. No. 6.02.01 (incl. Airworthiness Limitations)
Service Information and Service Bulletins
3. Spare Parts Catalogue: Illustrated Parts Catalogue Doc. No. 6.03.05
4. Instruments and aggregates: refer to AMM Doc. No. 6.02.01 Chapter 1





B.V. Notes:

1. (a) Type Certificate Holder

Effective 15-Nov-2017, the design responsibility for the model DA 40 D is transferred from Diamond Aircraft Industries GmbH and EASA to Diamond Aircraft Industries Inc. and Transport Canada.

(b) Serial Numbers Eligible

40.080, 40.084 and D4.001 through D4.399 inclusive (except D4.013, D4.111, D4.198 through D4.201, D4.246, D4.362, D4.365, D4.379, D4.380, D4.383 through D4.388, D4.390, D4.391 and D4.393 through D4.398 inclusive) (Also refer to DA 40 NG data regarding conversion from DA 40 D to DA 40 NG.)

40.DS001 through 40.DS175 inclusive, excluding 40.DS173 (*see also Note 1 (c)(ii)*)

(c) Manufacturer Record (excluded serial numbers were not manufactured)

(i) The following serial numbers were manufactured by Diamond Aircraft Industries GmbH as the type certificate holder:

40.080, 40.084 and D4.001 through D4.399 inclusive, excluding D4.013, D4.111, D4.198 through D4.201, D4.246, D4.362, D4.365, D4.379, D4.380, D4.383 through D4.388, D4.390, D4.391, D4.393 through D4.398 inclusive.

(ii) The following serial numbers were produced by Shandong Bin Ao Aircraft Industries Co. Ltd. while Diamond Aircraft Industries GmbH was the type certificate holder:

40.DS001 through 40.DS175 inclusive, excluding 40.DS173

EASA POA EASA.21G.0014 has been revoked on 28-Oct-2019. No further production under this approval is possible

2. Approved Noise Levels are part of the EASA Noise TCDS.
3. For IFR operation the optional design change OÄM 40-136 or OÄM 40-193 must be incorporated.
4. The tire dimension 15x6.0-6 is only approved in conjunction with the 18 mm MLG strut in accordance with MÄM 40-123.
5. For approved engine software version (Firmware and Mapping) of TAE 125-01 or TAE 125-02-99 see DAI Service Bulletin MSB D4-044, latest issue.
6. Operation with Diesel fuel is only approved if MÄM 40-129 is incorporated.
7. The increased baggage load is applicable if the baggage extension, Optional Design Change OÄM 40-163 is installed.
8. The landing mass of 1150 kg (2535 lbs) is only approved with Mandatory Design Change MÄM 40-123 is installed.
9. Installation of the G1000 Integrated Avionic System is only approved if OÄM 40-193 (IFR) or 40-224 (VFR) is incorporated. For approved software version see DAI Service Bulletin MSB D4-045, latest issue.





10. Approved engine model for installation in the DA 40D:

- TAE 125-01 125-01-(005)-()
- TAE 125-02-99 125-02-(0001)-()

Engine TAE 125-02-99 was previously approved as TAE 125-02

11. Engine retrofit installation from engine TAE 125-01 to TAE 125-02-99 is approved by Design Change MÄM 40-256 with OSB D4-061.

12. Reserved

13. Long Range Tank, as defined in Optional Design Change OÄM 40-130, is applicable for the following serial numbers:

14. 40.080, 40.084, D4.001 and subsequent, 40.DS.001 and subsequent.

15. At the time of certification, Special Conditions and ELOS' referenced in this TCDS have been enclosed in Certification Review Items (CRI) not publicly available. To provide publicly all necessary information, the text of SCs / ELOS' is given in Appendix A to this TCDS.





SECTION C: DA 40 F

C.I. General

- | | |
|------------------------------------|---|
| 1. Data Sheet No.: | EASA.IM.A.022 |
| 2. a) Type: | DA 40 |
| b) Model: | DA 40 F |
| c) Variant: | -- |
| 3. Airworthiness Category: | Normal
Utility (see Note 6) |
| 4. Type Certificate Holder: | DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA |
| 5. Manufacturer: | DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA
161-93 (TCCA)

DIAMOND AIRCRAFT INDUSTRIES GMBH
N.A. OTTO-STR. 5
A-2700 WIENER NEUSTADT
AUSTRIA
AT.21G.0001 |
| 6. Certification Application Date: | 20-Feb-1997
8. July 2004 for DA 40 F (VÄM 40-002) |
| 7. (Reserved): | N/A |
| 8. (Reserved): | N/A |

C.II. EASA Certification Basis

See Note 9

- | | |
|--|---|
| 1. Reference Date for determining the applicable requirements: | 24-Oct-1998 |
| 2. Airworthiness Requirements: | JAR-23, Change -, issued 11-Mar-1994
JAR-1, Change 5, issued 15-Jul-1996 |





- | | |
|--------------------------------------|---|
| 3. Special Conditions: | (CRI F-01) Protection from the Effects of HIRF
(CRI F-03) Protection from the Effects of Lightning Strikes, Indirect Effects
(CRI O-01) Glider Towing
(CRI O-02) Tow Cable Retraction Mechanisms |
| 3. Exemptions: | None |
| 4. Deviations: | None |
| 5. Equivalent Safety Findings: | None |
| 6. Requirements elected to comply: | JAR-23, NPA 23-3, ACJ Material |
| 7. Environmental Standards: | ICAO Annex 16, Volume 1, Part 2, Chapter 10, Amendment 7, CRI A-03F |
| 8. Additional National Requirements: | None |
| 9. (Reserved) | N/A |

C.III. Technical Characteristics and Operational Limitations

- | | |
|----------------------------|--|
| 1. Type Design Definition: | Doc. No. D40-AW-0121, latest revision |
| 2. Description: | Single engine, four-seated cantilever low wing airplane, composite construction, fixed tricycle landing gear, T-tail, fix pitch propeller. |
| 3. Equipment: | Equipment list, AFM, Doc.No. 6.01.02, Section 6 |
| 4. Dimensions: | Span 11.94 m (39 ft 2 in)
Length 8.01 m (26 ft 3 in)
Height 1.97 m (6 ft 6 in)
Wing Area 13.54 m ² (146 sqft) |
| 5. Engine: | |
| 5.1.1 Model: | 1 Textron Lycoming O-360-A4M |
| 5.1.2 Type Certificate: | FAA Engine Type Certificate Data Sheet 286 |
| 5.1.3 Limitations: | Max take-off rotational speed 2700 r.p.m.
Max continuous rotational speed 2700 r.p.m
For power-plants limits refer to AFM, Doc. No. 6.01.02, Section 2 |





6. Load factors: at v_A at v_{NE} with flaps in T/O or LDG position

Normal Category

Positive:	3.8	3.8	2.0
Negative	-1.52	0	

Utility Category

Positive:	4.4	4.4	2.0
Negative:	-1.76	-1	

7. Propeller:

- 7.1 Model: 1 Sensenich 76EM8S10-0-63
or
1 MT-Propeller MT 188R135-4G
- 7.2 Type Certificate: FAA TCDS P4EA (Sensenich 76EM8S10-0-63)
or
EASA TCDS P.006 (mt propeller MT 188R135-4G)
- 7.3 Number of blades: 2
- 7.4 Diameter: 1930 mm (Sensenich 76EM8S10-0-63)
1880 mm (mt propeller MT 188R135-4G)
- 7.5 Sense of Rotation: Clockwise

8. Fluids:

- 8.1 Fuel: Refer AFM Chapter 2, Section 2.14 for approved fuel specifications
- 8.2 Oil: Refer AFM Chapter 2, Section 2.4 for approved oil specifications.
- 8.3 Coolant: N/A

9. Fluid capacities:

- 9.1 Fuel: Standard Fuel Tank:

Total:	156 liters	41.2 US Gallons
Usable:	152.2 liters	40.2 US Gallons

Long Range Fuel Tank (OÄM 40-071):	<i>See Note 8</i>	
Total:	193 liters	51 US Gallons
Usable:	189.2 liters	50 US Gallons
- 9.2 Oil:

Maximum:	7.70 liters	8 qts
Minimum:	3.785 liters	4 qts
- 9.3 Coolant system capacity: N/A





10. Air Speeds:
- Design Manoeuvring Speed v_A :
- | | |
|--------------|----------|
| up to 980 kg | 94 KIAS |
| above 980 kg | 108 KIAS |
- Flap Extended Speed v_{FE} :
- | | |
|----------------|----------|
| full flaps | 91 KIAS |
| take-off flaps | 108 KIAS |
- Maximum structural cruising speed v_{NO}
(= Maximum structural design speed v_C):
129 KIAS
- Never exceed speed v_{NE} : 178 KIAS
11. Maximum Operating Altitude: 5000 m (16 404 ft)
12. All-weather Operations Capability: Day VFR
Night VFR
IFR
Flight into expected or actual icing conditions is prohibited
13. Maximum Weights:
- Take-off:
- | | |
|-------------------|-------------------|
| Utility Category: | 980 kg (2161 lb) |
| Normal Category: | 1150 kg (2535 lb) |
- Landing:
- | | |
|------------------|--------------------|
| Utility Category | 980 kg (2161 lb) |
| Normal Category | 1150 kg (2535 lbs) |
14. Centre of Gravity Range:
- Forward limit
- | | |
|--------------|---------------------|
| up to 980 kg | 2.40 m behind Datum |
| at 1150 kg | 2.46 m behind Datum |
- varying linearly with mass in between
- Rear limit
- | | |
|---------------------------|---------------------|
| for all masses | 2.59 m behind Datum |
| with Long Range Fuel Tank | 2.55 m behind Datum |
15. Datum: 2.194 mm
in front of leading edge of stub-wing at the wing joint





16. Control surface deflections:

Aileron up $20^\circ, \pm 2^\circ$
down $13^\circ, +2/-0^\circ$

Elevator With Standard Fuel Tank:
up $23^\circ, \pm 1^\circ$
down $15^\circ, \pm 1^\circ$

With Standard Fuel Tank for intentional spinning:

See Note 6

up $21^\circ, \pm 0.5^\circ$
down $18^\circ, \pm 0.5^\circ$

With Long Range Fuel Tank (OÄM 40-071):

up $23^\circ, +0/-1^\circ$
down $16^\circ, +1/-0^\circ$

Trim tab Nose up $+ 12^\circ, \pm 2^\circ$
(elevator neutral) Nose down $- 39^\circ, \pm 2^\circ$

Rudder Left $24^\circ, \pm 1^\circ$
Right $26^\circ, \pm 1^\circ$

Flaps Take off flap setting $20^\circ, \pm 2^\circ$
Landing flap setting $42^\circ, \pm 1^\circ$

17. Levelling Means: wedge 600 : 31
top surface of fuselage tube in front of dorsal fin

18. Minimum Flight Crew: 1 (Pilot)

19. Maximum Passenger Seating Capacity: 3

20. Baggage/Cargo Compartments: Location Max. allowable Load
Behind Rear Seats 30 kg (66.14 lbs)
Baggage Tube 5 kg (11.02 lbs)
With Baggage Extension 45 kg (100 lbs) *See Note 5*

21. Wheels and Tyres: Nose Wheel Tyre Size 5.00 – 5
Main Wheel Tyre Size 6.00 – 6 or
15x6.0-6

For approved types and rating see AMM, Doc. No. 6.02.01

22. (Reserved): N/A





C.IV. Operating and Service Instructions

1. Flight Manual: Airplane Flight Manual Doc. No. 6.01.02-E
2. Technical Manual: Airplane Maintenance Manual Doc. No. 6.02.01
(incl. Airworthiness Limitations)
Service Information and Service Bulletins
3. Spare Parts Catalogue: Illustrated Parts Catalogue Doc. No. 6.03.01/02
4. Instruments and aggregates: refer to AMM Doc. No. 6.02.01 Chapter 1

C.V. Notes:

1. (a) Type Certificate Holder

Effective 15-Nov-2017, the design responsibility for the model DA 40 F is transferred from Diamond Aircraft Industries GmbH and EASA to Diamond Aircraft Industries Inc. and Transport Canada.

(b) Serial Numbers Eligible

40.FC001 and subsequent

(d) Manufacturing Record (excluded serial numbers were not manufactured)

(i) The following serial numbers were produced by Diamond Aircraft Industries Inc. under license while Diamond Aircraft Industries GmbH was the type certificate holder:

40.FC001 through 40.FC029 inclusive

(ii) The following serial numbers are designated for aircraft manufactured by Diamond Aircraft Industries Inc. as the type certificate holder:

40.FC030 and subsequent

2. Approved Noise Levels are part of the EASA Noise TCDS.
3. reserved.
4. (removed).
5. The increased baggage load is applicable if the baggage extension, Optional Design Change OÄM 40-163, is installed.
6. The DA40F is certified for intentional spin if OÄM 40-201 is installed.

The following additional Limitations/Conditions apply:

- Center of Gravity Range 2,45 – 2,50 m
- Maximum fuel loading 2x38 liters (2x10gal)





- Canopy Jettison System OÄM 40-203 must be installed
- Mt Propeller MT 188R135-4G must be installed
- Elevator settings must be according to OÄM 40-201
- Long Range Tank (OÄM 40-071) must not be installed
- Wheel fairings must not be installed
- Baggage is not allowed

7. (removed)

8. Long Range Tank, as defined in Optional Design Change OÄM 40-071, is applicable for the following serial numbers:

40.FC001 and subsequent.

9. At the time of certification, Special Conditions and ELOS' referenced in this TCDS have been enclosed in Certification Review Items (CRI) not publicly available. To provide publicly all necessary information, the text of SCs / ELOS' is given in Appendix A to this TCDS.





SECTION D: DA 40 NG

D.I. General

1. Data Sheet No.: EASA.IM.A.022
2. a) Type: DA 40
b) Model: DA 40 NG
c) Variant: --
3. Airworthiness Category: Normal
4. Type Certificate Holder: DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA
5. Manufacturer: DIAMOND AIRCRAFT INDUSTRIES INC.
1560 CRUMLIN SIDEROAD, LONDON ONTARIO,
N5V 1S2 CANADA
161-93 (TCCA)

DIAMOND AIRCRAFT INDUSTRIES GMBH
N.A. OTTO-STR. 5
A-2700 WIENER NEUSTADT
AUSTRIA
AT.21G.0001

SHANDONG BIN AO AIRCRAFT INDUSTRIES
CO.,LTD
DAGAO, ZHANHUA COUNTY, BINZHOU
PEOPLE'S REPUBLIC OF CHINA
former EASA.21G.0014 *See Note 1*
6. Certification Application Date: 20-Feb-1997
for Major Change VÄM 40-004 - DA 40 NG:
17-Jan-2008
7. (Reserved): N/A
8. (Reserved): N/A

D.II. EASA Certification Basis

See Note 11

1. Reference Date for determining the applicable requirements: 24-Oct-1998





2. Airworthiness Requirements: JAR-23, issued 11-Mar-1994, incl. Amdt. 1
3. Special Conditions:
 - (CRI E-05) Reciprocating Engine using Jet Fuel
 - (CRI E-06) Use of Diesel Fuel and Diesel/Jet Fuel Blends for Reciprocating Engines
 - (CRI E-09) Engine Vibration Level
 - (CRI E-10) Engine Torque
 - (CRI F-01) Protection from the Effects of HIRF
 - (CRI F-03) Protection from the Effects of Lightning Strikes, Indirect Effects
 - (CRI F-06) Installation of a FADEC Diesel Engine and Propeller
 - (CRI F-07) Human Factors in Integrated Avionic Systems
3. Exemptions: None
4. Deviations: None
5. Equivalent Safety Findings:
 - (CRI D-01) Single Lever Power Control
 - (CRI E-07) Coolant Tank
 - (CRI E-08) Electronically-controlled Reciprocating Diesel Engine
 - (CRI E-11) Fuel System – Hot Fuel Temperature
 - (CRI E-12) Electric Fuel Pumps
 - (CRI B-01) Stall Warning
 - (CRI F-05) Powerplant Instruments
6. Requirements elected to comply: None
7. Environmental Standards: ICAO, Annex 16, Volume 1, Chpt. 10, 5. Edition CS 36, Amendment 1
8. Additional National Requirements: N/A
9. (Reserved) N/A

D.III. Technical Characteristics and Operational Limitations

1. Type Design Definition: Doc. No. D40-AW-0130, latest revision
2. Description: Single diesel engine, four-seated cantilever low wing airplane, composite construction, fixed tricycle landing gear, T-tail, winglets (option)
3. Equipment: Equipment list, AFM, Section 6





4. Dimensions:
- | | | |
|-----------|-----------------------|--------------|
| Span | 11.63 m | (38 ft 2 in) |
| Length | 8.06 m | (26 ft 5 in) |
| Height | 1.97 m | (6 ft 6 in) |
| Wing Area | 13.244 m ² | (142,6 sqft) |
5. Engine:
- 5.1.1 Model: 1 Austro Engine E4, *See Note 7*
- 5.1.2 Type Certificate: Engine Type Certificate Data Sheet EASA E.200
- 5.1.3 Firmware: MSB 40NG-002 *See Note 3*
- 5.1.4 Mapping MSB 40NG-002 *See Note 3*
- 5.1.5 Limitations: Max take-off rotational speed 2300 r.p.m.
Max continuous rotational speed 2100 r.p.m
(Propeller shaft r.p.m)
For power-plants limits refer to AFM, Section 2
6. Load factors:
- | | at v _A | at v _{NE} | with flaps in T/O
or LDG position |
|-----------|-------------------|--------------------|--------------------------------------|
| Positive: | 3.8 | 3.8 | 2.0 |
| Negative | -1.52 | 0 | |
7. Propeller:
- 7.1 Model: 1 MT-Propeller MTV-6-R/190-69
- 7.2 Type Certificate: EASA Propeller Type Certificate Data Sheet P.094
- 7.3 Number of blades: 3
- 7.4 Diameter: 1900 mm
- 7.5 Sense of Rotation: Clockwise
- 7.6 Settings: Low pitch setting: 14.5°± 0.2° (@0.75R)
High pitch setting: 35°± 1.0° (@0.75R)
8. Fluids:
- 8.1 Fuel: Jet – Refer to AFM Chapter 2, Section 2.14 for approved fuel specifications
Diesel (EN590) *See Note 10*
- 8.2 Oil: Engine: Shell Helix Ultra 5W30
Refer to AFM Chapter 2, Section 2.4 for other approved oil specifications.
Gearbox: Shell SPIRAX GSX or S6 GXME 75W-80
- 8.3 Coolant: Water / Cooler Protection-Mixture
for more details see AFM, Section 2





9. Fluid capacities:

9.1 Fuel:

Standard Fuel Tank

Total: 113.6 liters 30 US Gallons
Usable: 106.0 liters 28 US Gallons

Long Range Fuel Tank

Total: 155.2 liters 41 US Gallons
Usable: 147.6 liters 39 US Gallons

9.2 Oil:

Maximum: 7.0 liters
Minimum: 5.0 liters

9.3 Coolant system capacity:

Approx. 7 Liter

10. Air Speeds:

Operating Manoeuvring Speed v_{0} :

up to 1080 kg 101 KIAS
from 1080 to 1180 kg 108 KIAS
above 1180 kg 113 KIAS

Flap Extended Speed v_{FE} :

full flaps 98 KIAS
take-off flaps 110 KIAS

Maximum structural cruising speed v_{NO}

(= Maximum structural design speed v_C):

130 KIAS

Never exceed speed v_{NE} :

172 KIAS

11. Maximum Operating Altitude:

5000 m (16 404 ft)

12. All Weather Operations Capability:

Day-VFR

Night VFR

IFR

Flight into expected or actual icing conditions is prohibited

13. Maximum Weights:

Take-off:

1280 kg (2822 lb)

1310 kg (2888 lb) *See Note 8*

Landing:

1216 kg (2681 lb)

1280 kg (2822 lb) *See Note 8*

Minimum Flight:

940 kg (2072 lb)

Maximum Zero Fuel:

1200 kg (2646 lb)

1265 kg (2789 lb) *See Note 8*





14. Centre of Gravity Range: Forward limit
from 940 to 1080 kg 2.40 m behind Datum
at 1310 kg 2.469 m behind Datum
varying linearly with weight in between
- Rear limit 2.53 m behind Datum
15. Datum: 2.194 mm
in front of leading edge of stub-wing at the wing joint
16. Control surface deflections:
- | | | |
|--------------------------------|-----------------------|-------------|
| Aileron | up | 20°, ± 2° |
| | down | 13°, +2/-2° |
| Elevator | up | 21°, +0/-1° |
| | down | 17°, +1/-0° |
| Trim tab
(elevator neutral) | Trim nose up | + 12°, ± 2° |
| | Trim nose down | - 39°, ± 2° |
| Rudder | Left | 24°, ± 1° |
| | Right | 26°, ± 1° |
| Flaps | Take off flap setting | 20°, ± 2° |
| | Landing flap setting | 42°, ± 1° |
17. Levelling Means: wedge 600 : 31
top surface of fuselage tube in front of dorsal fin
18. Minimum Flight Crew: 1 (Pilot)
19. Maximum Passenger Seating Capacity: 3
20. Baggage/Cargo Compartments:
- | Location | Max. allowable Load |
|-------------------------|----------------------------|
| Behind Rear Seats | 30 kg (66.14 lbs) |
| Baggage Tube | 5 kg (11.02 lbs) |
| Short Baggage Extension | 15 kg (33 lbs) See Note 4 |
| With Baggage Extension | 45 kg (100 lbs) See Note 4 |
21. Wheels and Tyres:
- | | |
|----------------------|---------------------------|
| Nose Wheel Tyre Size | 5.00-5, 6 PR, 120mph |
| OÄM 40-334: | 6.00-6, 6 PR, See Note 8 |
| Main Wheel Tyre Size | 15x6.0-6, 6 PR, 160 mph |
| OÄM 40-334: | 8.50-6, 6 PLY, See Note 8 |
22. (Reserved): N/A





D.IV. Operating and Service Instructions

1. Flight Manual: Airplane Flight Manual Doc. No. 6.01.15-E
2. Technical Manual: Airplane Maintenance Manual Doc. No. 6.02.15
(incl. Airworthiness Limitations)
Service Informations and Service Bulletins
3. Spare Parts Catalogue: Illustrated Parts Catalogue Doc. No. 6.03.15
4. Instruments and aggregates: refer to AMM Doc. No. 6.02.15 Chapter 1

D.V. Notes:

1. (a) Type Certificate Holder

Effective 15-Nov-2017, the design responsibility for the model DA 40 NG is transferred from Diamond Aircraft Industries GmbH and EASA to Diamond Aircraft Industries Inc. and Transport Canada.

(b) Serial Numbers Eligible

D4.111, D4.365, 40.N001 and subsequent (except 40.N183 through 40.N187, 40.N189 through 40.N211, 40.N213 through 40.N223, 40.N228 through 40.N234 and 40.N340 through 40.N344)

40.NS001 and 40.NS002 (*see also Note 1(c)(iii)*)

40.NC001 and subsequent

DA 40 D airplanes with Serial Numbers 40.080, 40.084, D4.001 and subsequent produced by Diamond Aircraft Industries GmbH may be converted to Model DA 40 NG by DAI approved Service Bulletin OSB D4-080, latest revision

(c) Manufacturer Record (excluded serial numbers were not manufactured)

- (i) The following serial numbers were produced by Diamond Aircraft Industries GmbH as the type certificate holder:

D4.111, D4.365, 40.N001 through 40.N346 inclusive, excluding 40.N183 through 40.N187, 40.N189 through 40.N211, 40.N213 through 40.N223, 40.N228 through 40.N234 and 40.N340 through 40.N344 inclusive.

- (ii) The following serial numbers were produced by Diamond Aircraft Industries Inc. under license while Diamond Aircraft Industries GmbH was the type certificate holder:

40.NC001 through 40.NC007 inclusive





- (iii) The following serial numbers were produced by Shandong Bin Ao Aircraft Industries Co. Ltd. Under license while Diamond Aircraft Industries GmbH was the type certificate holder:

40.NS001 and 40.NS002

EASA POA EASA.21G.0014 has been revoked on 28-Oct-2019. No further production under this approval is possible

- (iv) The following serial numbers are designated for aircraft manufactured by Diamond Aircraft Industries Inc. as the type certificate holder:

40.NC008 and subsequent

- (v) The following serial numbers are designated for aircraft manufactured by Diamond Aircraft Industries GmbH under license from Diamond Aircraft Industries Inc. as the type certificate holder:

40.N347 and subsequent

2. Approved Noise Levels are part of the EASA Noise TCDS.
3. For approved E4 engine software version see DAI Service Bulletin MSB 40NG-002, latest issue.
4. The baggage load in the short baggage extension is applicable if Optional Design Change OÄM 40-331 is installed. The increased baggage load of 45 kg (100 lbs) is applicable if the baggage extension, Optional Design Change OÄM 40-164, is installed.
5. For approved software version of the G1000 Integrated Avionic System see DAI Service Bulletin MSB 40NG-003, latest issue.
6. (removed)
7. Approved engine model configuration for installation in the DA 40 NG: E4-A
8. The following Design Mass Combinations are approved:

Installed Design Changes	Standard	MÄM 40-574 or OÄM 40-334	MÄM 40-662
MTOM	1280 kg (2822 lb)	1280 kg (2822 lb)	1310 kg (2888 lb)
MZFM	1200 kg (2646 lb)	1265 kg (2789 lb)	1265 kg (2789 lb)
MLM	1216 kg (2681 lb)	1280 kg (2822 lb)	1280 kg (2822 lb)

MTOM – Maximum Take-Off Mass MZFM – Maximum Zero Fuel Mass MLM – Maximum Landing Mass

9. For glider towing operation the optional design change OÄM 40-312 must be incorporated
10. Operation with Diesel fuel is only approved, if OÄM 40-370 is installed
11. At the time of certification Special Conditions and ELOS' referenced in this TCDS have been enclosed in Certification Review Items (CRI) not publicly available. To provide publicly all necessary information, the text of SCs / ELOS' is given in Appendix A to this TCDS.





ADMINISTRATIVE SECTION

I. Acronyms

None

II. Type Certificate Holder Record

Until 15-Nov-2017

Diamond Aircraft Industries GmbH
N.A. Otto-Str. 5
A-2700 Wiener Neustadt
Austria
EASA.21J.052

Since 15-Nov-2017

Diamond Aircraft Industries Inc.
1560 Crumlin Sideroad, London Ontario,
N5V 1S2 Canada

III. Change Record

Issue	Date	Changes	TC Issue No. & Date
Issue 1 through 22	-	Not published nor issued, those reflect the history of TCDS EASA.A.022 prior to type design transfer of the DA 40 to Diamond Canada/TCCA. For details refer to TCDS EASA.A.022 at Issue 22.	-
Issue 23	15-Nov-2017	First published issue for TCDS EASA.IM.A.022, after TC-Transfer of the original EASA TC A.022 at TCDS EASA.A.022, Issue 22 to Diamond Aircraft Industries Inc., Canada, with TCCA TC A-224.	15-Nov-2017
Issue 24	22-Apr-2021	Updated TCDS based on issue 09 and issue 10 of TCCA TCDS A-224 (Note: Aircraft produced by Wanfeng Aircraft Industry Co., Ltd., not approved for registration in EASA Member States) Corrections and clarifications Appendix A added	





APPENDIX A

Special Conditions (SC) and Equivalent Level of Safety (ELOS).
Text extracted from CRIs mentioned under Certification Basis.

Special Condition

CRI NO	Text
E-05	Use of Jet Fuel for Reciprocating Engines
E-06	Use of Diesel Fuel and Diesel/Jet Fuel Blends for Reciprocating Engines
E-09	Engine Vibration Level
E-10	Engine Torque
F-01	PROTECTION FROM THE EFFECTS OF HIRF
F-03	PROTECTION FROM THE EFFECTS OF LIGHTNING STRIKE; INDIRECT EFFECTS
F06	Installation of Full Authority Digital Engine Controlled (FADEC) reciprocate Diesel Engine and Propeller
F-07	Human Factors in Integrated Avionic Systems
F08	Software, Hardware Assurance Level and Highly, Integrated or Complex Aircraft Systems
O-01	Glider Towing
O-02	Tow Cable Retraction Mechanisms

Equivalent Safety Findings

CRI NO	Text
B-01	Stall Warning
D-01	Single Lever Power Control
E-07	Liquid Cooling – Coolant Tank
E-08	Electronically controlled reciprocating diesel engine
E-11	Fuel System - Hot Fuel Temperature
E-12	Fuel Pumps
F-05	Powerplant Instruments





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM	CRI:	E-05
	DIAMOND DA40	ISSUE:	Issue 5
		DATE:	13.01.10
		STATUS:	CLOSED

SUBJECT: Use of Jet Fuel for Reciprocating Engines

REQUIREMENTS: JAR 23.951 (c) ,23.971(c), 23.973 (a)(f),
23.1557(c)(1), 23.1093 (a), 23.955 (f)

ADVISORY MATERIAL: FAA AC 20-29B, FAA AC 20-122A, SAE AS 1852

POLICY REF.:

PRIMARY GROUP/PANEL:

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

Post TC

Special Condition

STATEMENT OF ISSUE

The Diamond DA40 aeroplane shall be equipped with a reciprocating diesel engine (Thielert TAE-125 or Austro Engine E4), certified under JAR-E/CS-E.

These engines are certified for operation with diesel fuel and Jet A-1 fuel. The use of diesel fuel will be covered by CRI E-06.

DISCUSSION

In current JAR 23 the use of jet fuel for operation of reciprocating engines was not envisioned. Therefore in some cases use of the term "turbine engines" in the requirement relates to the use of jet fuel rather than to the working principle and specific installation requirements of a turbine engine itself.





1. ACG/PCA POSITION

A) JAR 23.951 (c), Fuel system, 23.971 (c) fuel system drains

General, the fuel system requires sustained operation of the fuel system with water saturated fuel at most critical condition for icing for turbine engines only.

AC 20-29B, 6. Water in Fuel, describes why jet fuel (kerosene) is more susceptible to problems caused by water in fuel than gasoline especially at low temperatures.

Therefore ACG considers 23.951 (c) and 23.971(c) also applicable for aeroplanes equipped with reciprocating engines operated with jet fuel.

B) JAR 23.973 (a)(f) Fuel tank filler connection

It assumes that only turbine engines use kerosene and therefore requires the installation of fuel fillers with an opening diameters of 75 mm for aeroplanes equipped with turbine engines only.

Different fuel filler opening diameters were introduced into the requirement to avoid misfueling of gasoline operated aeroplanes with jet fuel and subsequent engine failures. AC 20-122A encourages the airport aviation community to use fueling equipment in compliance with SAE AS 1852. This standard requires larger diameter refueling nozzles for jet fuel refueling equipment.

Therefore ACG/EASA considers 23.973 (a)(f) also applicable for aeroplanes equipped with reciprocating engines operated with jet fuel.

This does not prevent misfueling with Avgas, which may be critical with this kind of installation. Special Attention must be given to clear and distinct markings according 23.1557 and information according 23.1521(d).

C) JAR 23.1557 (c) Fuel filler marking

JAR 23.1557 (c) (1) (i) requires reciprocating engine powered aeroplanes to be marked near the fuel filler cover with the word AVGAS and the minimum fuel grade. This requirement also assumes that reciprocating engines are operated with gasoline only.

Therefore ACG/EASA considers JAR 23.1557 (c) (1) (ii) applicable for aeroplanes equipped with reciprocating engines operated with jet fuel instead of JAR 23.1557 (c) (1) (i)

D) JAR 23.1093 Induction system icing protection

23.1093 requires a system to prevent and eliminate icing in the induction system for reciprocation engines. It is considered that gasoline fuel is used.

The tendency of icing with diesel engines is unknown.

It must be demonstrated that the engine installation is non critical for icing.





ACG/EASA considers 23.1093 (a) applicable.

E) JAR 23.955 (f) Fuel Flow

23.955 (f) require additional conditions to be demonstrated based on the specific features of Turbine engines. Also the specific effect of Jet fuel at low temperatures is included.

Therefore ACG/EASA considers JAR 23.955 (f) not applicable, but In addition to 23.955 (a), proper engine operation must be shown with the most critical fuel temperatur during operation.

F) Use of Additives for Jet Fuel

Because of the more prominent effects of water in jet fuel the use of additives to keep water suspended and limit microbial growth is very common. Many times those additives are already added during storage of fuel at the airport.

Therefore Diamond Aircraft has to establish the kind of additives and the minimum and maximum limits of additive content in the fuel. Proof of compatibility of the additives with the aeroplane fuel system has to be based on tests and/or material specifications. Limits established during engine certification have to be considered too.

G) Contamination Indicator JAR 23.1305(t)

Following the Argument of Items A) and E) for the specific features of turbine fuel and the fuel system, ACG considers 23.1305(t) also applicable for this installation. Alternate Means for Indication of Contamination would be acceptable, if safe function of the system is ensured based on tests and analysis.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM	CRI:	E-06
	DIAMOND DA40	ISSUE:	Issue 6
		DATE:	22.9.2008
		STATUS:	CLOSED

SUBJECT: Use of Diesel Fuel and Diesel/Jet Fuel Blends for Reciprocating Engines

REQUIREMENTS: JAR 23.1305 (t), 23.1521, 23.1557(c), 23.1583

ADVISORY MATERIAL: ---

POLICY REF.: ---

PRIMARY GROUP/PANEL: Powerplant

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

Post TC Special Condition

STATEMENT OF ISSUE

The Diamond DA40D aeroplane, equipped with a Thielert TAE-125 reciprocating diesel engine, was initially certified for jet fuel operation only, by major change OÄM 40-100. By major design change MÄM 40-129 operation of the aeroplane with diesel fuel in accordance with European Standard EN590, Jet A-1 and any mixture of those is requested. The use of biodiesel fuel is not covered by this CRI. The TAE125 engine itself is JAR-E certified for operation with diesel fuel and Jet A-1 fuel. The same situation apply for the Austro Engine E4 installation.

DISCUSSION

In current JAR 23 the use of jet fuel for reciprocating engines and especially the use of diesel fuel was not envisioned at all. In some cases use of the term "turbine engines" in the requirement relates to the use of jet fuel rather than to the working principle and specific installation requirements of a turbine engine itself.





To clarify these circumstances and establish special conditions for the use of jet fuel in the DA40D CRI E-05 was raised. With CRI E-06 the special character of diesel fuel is addressed.

Diesel fuel is generally a blend of kerosene and gasoil. Compared to Jet-A1 diesel fuel specification according to EN590 allows much wider production variations. Especially low temperature flow characteristics (properly represented by the Cold Filter Plugging Point – CFPP - in °C) may vary significantly, depending on seasonal grades chosen and geographical areas for which fuel is produced.

Due to the significant content of fuel components in diesel fuel with a higher boiling point (e.g. gasoil) its behavior at higher fuel temperatures can be considered better than jet fuel behavior. AVGAS on the other hand, creates much more problems at “hot weather” conditions.

Distribution and treatment of non-aviation fuels from the refinery to the user is not controlled as tightly and strictly as for aviation fuel types (AVGAS, JET-A, etc.). Also availability of diesel fuel on airfields is currently not assured in the same manner as for aviation fuels. Nevertheless this situation is generally identical to the use of automotive gasoline in aviation. Diamond Aircraft has extensive experience using automotive gasoline for their JAR-22 and JAR-VLA products for more than a decade. Due account can be taken from this experience in addressing certification relevant effects of diesel fuel for similar supply conditions.

Based on this situation, some National Aviation Authorities applied additional conditions/restrictions for “Non Aviation Type Fuels”, see also National Operating Requirements (CRI A-04).

Lubricity of diesel fuel is, due to its gasoil and additive content, much better than lubricity of jet fuel. This fact is generally beneficial to the wear characteristics of pumps, valves, hydraulic controls, etc.

2. ACG/EASA POSITION

ACG as JAA-PCA proposes the following:

- A) Both, CRI E-05 and CRI E-06 have to be complied with to qualify the DA40D for operation with diesel fuel, jet fuel, and any mixture of both.
- B) Diesel fuel quality

It is assumed that diesel fuel according to EN590 without any reliable information about the seasonal grade is available to the pilot.

EN590 allows diesel fuels with a wide range of Cold Filter Plugging Points – CFPP (typically –44°C to +5°C).





- a) Diamond Aircraft (DAI) has to establish the most critical diesel fuel quality within the approved range of EN590 for which certification is requested.
Due consideration has to be given to the fact that operation at low ambient temperatures will be one of the critical applications for pure diesel fuel use. Further consideration should be given to the operational possibility of fueling the aircraft in one geographical area (e.g. southern Europe) and transferring and operating it in a different geographical area (e.g. northern Europe) with significant different environmental conditions on one tank filling.
Also fueling the aircraft in wintertime with a summer grade diesel should be considered
All tests and analysis have to be based on the critical selected diesel fuel quality.
- b) For the time being diesel fuel is not readily available at aircraft fueling facilities in a controlled manner. Therefore DAI has to define clear instructions, procedures, and limitations for the pilot to determine suitability of the diesel fuel offered. Among other aspects expectable fuel contamination for non-aviation fuels and seasonal grades for diesel fuel have to be assessed.

Acceptable limitations and procedures would be,

- i) establishing fuel temperature limitations above the highest CFPP which is used in EN590 diesel to ensure safe operation., or
- ii) establishing practical methods to allow the pilot to assess the quality of received fuel in regard of low temperature characteristics, or
- iii) establish operational procedures to confirm the suitability of received fuel in regard of low temperature characteristics for the temperature range to be expected during operation.

C) Low Temperature Behavior, Minimum Fuel Temperature

Diesel fuel is much more sensitive to fuel gelling and fuel freezing. The fuel system must be designed for safe diesel fuel operation without blocking of fuel filters or other components of the fuel system above an established minimum fuel temperature.

It should be demonstrated that the power available from the engine is not affected by the most adverse fuel temperature for flight.

The inconsistency of fuel temperatures throughout the fuel system have to be taken into consideration for the whole operating range of the aeroplane.

- a) DAI has to establish which aircraft operating phases and conditions are most critical to low fuel temperatures by analysis or tests.
- b) A representative minimum fuel temperature limit has to be established for the operating phase established under paragraph a) supported by tests, or analysis supported by tests.
- c) DAI has to prove by tests or analysis supported by tests that within the fuel system no fuel gelling will occur and the fuel system is capable of sustained operation throughout its flow and pressure range with diesel fuel initially saturated with water at 27°C and having 0,75 ccm of free water per 3,785 l added at temperatures equal to the minimum fuel temperature limit established under paragraph b) for all operating phases.
Also most adverse normal operating conditions in respect of aircraft altitudes, attitudes, and maneuvers have to be taken into consideration.

D) High Temperature Behavior





Generally diesel fuel is less susceptible to detrimental high temperature effects because of higher boiling point components in the fuel.
Nevertheless DAI has to show compliance with CRI E-11 also for diesel fuel.

E) JAR 23.1557 (c) Fuel Filler Marking

JAR 23.1557 (c) does not provide adequate fuel filler markings for reciprocating engine equipped aeroplanes operated with diesel fuel and jet fuel.

Fuel filler openings must be marked at or near the filler cover at least with the words "Jet-A1" and/or "Diesel EN590" as appropriate.

Reference to the approved AFM for agreed and accepted equivalent fuels may, if required, also be added."

Example:

JET – A1 DIESEL EN590

JET – A1 For alternate fuel see Flight Manual

F) Contamination Indicator JAR 23.1305(t)

JAR 23.1305(t) is applicable for this installation.

Alternate means of ensuring sufficient fuel supply to the engine would be acceptable, if safe function of the system is ensured based on tests and analysis.

Special consideration has to be given to the fact that contamination of non-aviation fuel, to a higher degree as of any aviation fuel, is much more likely due to less stringent fuel distribution requirements.

G) Limitations, Indications and Instrument Markings

Any limitations arising from this CRI which are currently not covered by JAR 23.1521 and JAR 23.1583 must be adequately marked on the respective instruments and listed in the Aeroplane Flight Manual Limitation Section.

Compliance showing with the conditions of CRI E-06 might lead to the establishment of specific temperature limitations for diesel fuel operation, which might differ from limitations established for jet fuel operation.

Instrument markings must allow the pilot to clearly distinguish for which type of fuel the marking is valid.

This can be done by supplementing the range marks with clear and distinctive symbols or additional placards attached immediately beside the respective instruments, quoting the limiting numbers/indications for the approved type of fuels.

JAR 23.1321 and 23.1337 have to be considered accordingly.

Sufficient readability must be ensured under all probable cockpit lighting conditions.





Any influence on the fuel quantity indication system and on the fuel flow indication system because of the use of diesel fuel has to be evaluated by tests, or analysis supported by tests and considered in the AFM in a conservative manner.

H) Operation with Blends of Diesel and Jet Fuel

Several fuel blends are possible depending on aeroplane refueling procedure. This can range from pure diesel fuel to pure jet fuel, from blends of diesel and jet fuel in any concentration and from pure diesel fuel in one tank and pure jet fuel in the other tank.

DAI has to assess all possible combinations of diesel and jet fuel blends and also distribution within the fuel storage system for which certification is requested. Acceptable procedures and limitations have to be developed and published in the AFM to safely operate the aeroplane within established limits.

For this following should be considered:

- a) fuel blend and distribution not known to the pilot,
- b) fuel blend and distribution known to the pilot,
- c) methods to verify fuel blend and distribution, if practicable.

It is very likely that the assessment will lead to some limitations different from pure jet fuel or diesel fuel limitations evaluated under paragraph G).

Only two discrete limitations for a single parameter at the low end, and two discrete limitations for the same parameter at the high end, are acceptable.

All fuel blends which would fall in-between those discrete limitations have to be assigned to one of the discrete limits in a conservative way.

Conditions of paragraph G) have to be considered accordingly.

I) Additives

- a) Diesel fuel does contain several additives to achieve specific fuel characteristics.

DAI has to assess the compatibility of those additives with fuel system materials and Jet-A1 fuel for all fuel blends for which certification is requested to ensure proper operation.

- b) For the use of additional fuel flow improvers DAI has to demonstrate that they
 - i) are approved by the engine manufacturer,
 - ii) are compatible with fuel system materials,
 - iii) the procedure to blend them into the fuel is clearly described in the AFM,
 - iv) any further limitation resulting from the use of fuel flow improvers is included into the AFM Limitation Section.
- v) Compliance according paragraph 1, C) has to be demonstrated for fuel blended with additives according 1, I, b) if a lower fuel temperature limit shall be established than for pure diesel fuel use.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM	CRI:	E-09
	DIAMOND DA40	ISSUE:	Issue 4
		DATE:	22.09.2008
		STATUS:	CLOSED

SUBJECT: Engine Vibration Level

REQUIREMENTS: JAR 23.251, 23.572, 23.573, 23.613, 23.627, 23.629

ADVISORY MATERIAL:

POLICY REF.:

PRIMARY GROUPE/PANEL: Structure

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

POST TC Special Condition

STATEMENT OF ISSUE

The Diamond DA40 aeroplane shall be equipped by major change with a four cylinder reciprocating diesel engine (Thielert TAE-125 or Austro Engine E4) certified under JAR-E/CS-E.

The TAE 125 engine employs three engine attachment points with vibration dampening shock mounts as a part of the engine design. To achieve a low vibration level these elements are softer than previous used installations.

The Austro Engine E4 has four engine attachment points.

Background:

Piston-Engine mechanical or structural failure modes which lead to imbalance and vibratory loads in the engine may happen during normal operation.

Also failure modes of the propeller must be taken into account.

The elastic engine mounts of the have an increased influence to the amount of vibratory loads dampening, but some of the failure modes may create frequencies that lead to higher loads than normally expected.

However, the higher cylinder-pressure at self-igniting engines leads to more significant effects to the imbalance at an engine failure mode. This condition is further exacerbated by the fact that the propeller will continue to windmill in the imbalance condition following engine shut down.





Suspect Operating & Failure Modes are the starting cycle, prop unbalance, self-ignition failure (running with one cylinder inoperative) and improper fuel scheduling.

These vibratory loads may cause damage to primary structure, critical systems and fatigue problems if not taken in consideration and seem to be significant relative to other portions of the design load spectrum for the airplane and the non fail safe three point engine attachment structure. Furthermore, vibrations on the instrument panel may create a problem for the pilot in flying the airplane.

DISCUSSION

1. ACG/EASA POSITION

It must be shown by a combination of tests and analysis, that a possible failure mode in the powerplant system, does not reduce the airplane's capability of continued safe flight and landing.

The vibration levels for all engine operating phases including starting and stoppage, with respect to failure modes must be established.

The evaluation must show, that these powerplant induced vibration levels will not cause damage to, but not limited to, engine mount structure, inlets, fuselage or wing, flight control surfaces, as well as critical equipment (including connectors) mounted on the engine or airframe.

The effect to the fatigue spectrum and flutter conditions caused by soft engine mounts which could create higher dynamic loads must be evaluated by a combination of tests and analysis.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM DIAMOND DA40	CRI:	E-10
		ISSUE:	Issue 4
		DATE:	13.01.2010
		STATUS:	CLOSED

SUBJECT: Engine Torque

REQUIREMENTS: JAR 23.361

ADVISORY MATERIAL: ---

POLICY REF.:

PRIMARY GROUPE/PANEL: Structure

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

POST TC Special Condition

STATEMENT OF ISSUE

The Diamond DA40 aeroplane shall be equipped with a four cylinder reciprocating diesel engine (Thielert TAE-125 or Austro Engine E4) certified under JAR-E/CS-E.

An engine using the diesel principle has a much higher compression and combustion ratio compared to conventional fuel-ignition reciprocating engines. The point of the highest torque is at a lower RPM value.

JAR23.361 considers a factor of two which has to be multiplied to the mean torque to establish the limit engine torque.

It is assumed that this factor is based on data from conventional fuel-ignition reciprocating engines and not applicable to these engines without additional justification.

It is also assumed that the engine limit torque is depending on the kind of engine combustion and the number of engine cylinders. The engine combustion in a diesel engine is pending on the system of fuel injection which may differ from type to type.





DISCUSSION

2. ACG/EASA POSITION

To ensure an equivalent level of safety ACG/EASA propose that the minimum factor of two, as required by 23.361(c)(3) must be proven by tests and analysis for the engine installation. If the test and analysis lead to a higher factor, than this one apply.

A comparison based on tests and analysis between the the Original Lycoming IO-360 engine and the TAE-125/E4 engine behaviors is an acceptable means of compliance.





austro CONTROL as PCA of Joint Aviation Authorities	CERTIFICATION REVIEW ITEM DIAMOND DA40	CRI: ISSUE: DATE: STATUS:	F-01 Issue 2 28.2.2000 CLOSED
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SUBJECT: PROTECTION FROM THE EFFECTS OF HIRF

REQUIREMENTS: JAR 23.1309; 23.1431(a)

ADVISORY MATERIAL: ---

POLICY REF.: ---

PRIMARY GROUPE/PANEL: Electric

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

Special Condition

STATEMENT OF ISSUE

The basic concern for better identification and protection from High Intensity Radiated Fields, has arisen for the following reasons:

- Operation of modern aircraft is increasingly dependent upon electrical/electronic systems, which can be responsive to electromagnetic interference.
- The increasing use of non metallic materials like carbon or glass fibre in the construction of the aircraft, reduces their basic shielding capability against the effects of radiation from external emitters.
- Those emitters are increasing in number and in power. They include ground based systems (communication, television, radio, radar), as well as emitters on ships or other aircraft.

JAA are presently developing in co-operation with the FAA, a regulatory project for HIRF. This project is co-ordinated by the FAA/JAA Electromagnetic Effects Harmonisation Working Group and relies heavily on work conducted by EUROCAE WG33, in co-operation with SAE-AE4R. This working group is now defunct. All the work of this Group is now being progressed by WG 14.

DISCUSSION





1. JAA (ACG/PCA) POSITION

The JAA (ACG/PCA) Team considers that the following Special Condition shall apply:

The aircraft electrical and electronic systems, equipment, and installations considered separately and in relation to other systems must be designed and installed so that:

- (a) Each function, the failure of which would prevent the continued safe flight and landing of the aircraft:
 - (1) Is not adversely affected when the aircraft is exposed to the Certification HIRF environment defined in Appendix 1.
 - (2) Following aircraft exposure to the Certification HIRF environment, each affected system that performs such a function automatically recovers normal operation unless this conflicts with other operational or functional requirements of that system.
- (b) Each system that performs a function, the failure of which would prevent the continued safe flight and landing of the aircraft, is not adversely affected when the aircraft is exposed to the Normal HIRF environment defined in Appendix 1.
- (c) Each system that performs a function, the failure of which would cause large reductions in the capability of the aircraft or the ability of the crew to cope with adverse operating conditions, is not adversely affected when the equipment providing these functions is exposed to the equipment HIRF test levels defined in Appendix 1.
- (d) Each system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions, is not adversely affected when the equipment providing these functions is exposed to the equipment HIRF test levels defined in Appendix 1.





Appendix 1

(a) *HIRF environments*

Table I lists the Certification HIRF environment required by Special Condition sub-paragraph (a)(1).

Table II lists the Normal HIRF environment required by Special Condition sub-paragraph (b).

(b) *Test levels for complying with Special Condition sub-paragraph (c)*

As a minimum, one of the following sets of equipment test levels shall be used:

(1) From 10 kHz to 400 MHz, use conducted susceptibility tests with CW and 1 kHz square wave modulation of depth greater than 90 percent. The conducted susceptibility current shall start at 0.6 mA at 10 kHz, increasing 20 dB per frequency decade to 30 mA at 500 kHz. From 500 kHz to 400 MHz, the conducted susceptibility current shall be 30 mA. From 100 MHz to 400 MHz, use radiated susceptibility tests at 20 v/m peak, with CW and 1 kHz square wave modulation of depth greater than 90 percent. From 400 MHz to 8 GHz use radiated susceptibility tests at 150 v/m peak with pulse modulation of 0.1 percent duty cycle with 1 kHz pulse repetition frequency. This signal should be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent. Also, from 400 MHz to 8 GHz use radiated susceptibility tests at 28 v/m peak with 1 kHz square wave modulation of depth greater than 90 percent. This signal should be switched on and off at a rate of 1 Hz.

(ref. ED-14D/DO-160D, Section 20, Cat. R)

(2) Or, from 10 kHz to 400 MHz, use conducted susceptibility tests with CW and 1 kHz square wave modulation of depth greater than 90 percent. The conducted susceptibility current shall start at 0.6 mA at 10 kHz, increasing 20 dB per frequency decade to 30 mA at 500 kHz. From 500 kHz to 400 MHz, the conducted susceptibility current shall be 30 mA. From 100 MHz to 400 MHz, use radiated susceptibility tests at 20 v/m peak, with CW and 1 kHz square wave modulation of depth greater than 90 percent. From 400 MHz to 8 GHz use radiated susceptibility tests at 150 v/m peak with pulse modulation of 4 percent duty cycle with a 1 kHz pulse repetition frequency. This signal should be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent. (ref. ED-14D/DO-160D, Section 20, Cat. R)

Or, the test level to be used during equipment testing may be based on the Normal environment in Table II with allowance made for aircraft attenuation using aircraft transfer function/attenuation curves. Testing must cover the frequency band of 10 kHz to 8 GHz.

(c) *Test levels for complying with Special Condition sub-paragraph (d)*

As a minimum, the following equipment test levels shall be used:

From 10 kHz to 400 MHz use conducted susceptibility tests, starting at 0.15 mA at 10 kHz, increasing 20 dB per frequency decade to 7.5 mA at 500 kHz. From 500 kHz to 400 MHz use conducted susceptibility tests at 7.5 mA. From 100 MHz to 8 GHz use radiated susceptibility tests at 5 v/m. (ref. ED-14D/DO-160D, Section 20, Cat. T)





(d) **Test procedures**

AC/AMJ 20.1317 Final Draft Issue (EEHWG Document WG-327) and EUROCAE ED-14D/RTCA Document DO-160D, Section 20 should be referred to for the applicability of tests and test details.

Table I

Certification HIRF Environment

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2000	200
2 GHz - 4 GHz	3000	200
4 GHz - 6 GHz	3000	200
6 GHz - 8 GHz	1000	200
8 GHz - 12 GHz	3000	300
12 GHz - 18 GHz	2000	200
18 GHz - 40 GHz	600	200

Table II

Normal HIRF Environment

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1300	160
2 GHz - 4 GHz	3000	120
4 GHz - 6 GHz	3000	160





6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150





austro CONTROL as PCA of Joint Aviation Authorities	CERTIFICATION REVIEW ITEM DIAMOND DA40	CRI: ISSUE: DATE: STATUS:	F-03 Issue 2 28.2.2000 CLOSED
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SUBJECT: PROTECTION FROM THE EFFECTS OF LIGHTNING STRIKE; INDIRECT EFFECTS

REQUIREMENTS: JAR 23.867, JAR 23.954, JAR 23.1309

ADVISORY MATERIAL: ---

POLICY REF.: ---

PRIMARY GROUPE/PANEL: Electric

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

Special Condition

STATEMENT OF ISSUE

The basic concern for better identification and protection from lightning indirect effects, has arisen for the following reasons:

- Operation of modern aircraft is increasingly dependent upon electrical/electronic systems, which can be responsive to lightning indirect effects.
- The increasing use of non metallic materials like carbon or glass fibre in the construction of the aircraft, reduces their basic shielding capability against the indirect effects of lightning.
- The lightning strike models of FAA AC20-136 used for system justification do not line up with latest models specified by internationally agreed EUROCAE/SAE documents.
- The zoning definitions of FAA AC20-53A which has been traditionally used, need to be updated to reflect current state of the art.

JAA are presently developing in co-operation with the FAA, a regulatory project for lightning protection. This project is co-ordinated by the FAA/JAA Electromagnetic Effects





Harmonisation Working Group and relies heavily on work conducted by EUROCAE WG31, in co-operation with SAE-AE4L.

DISCUSSION

2. JAA (ACG/PCA) POSITION

The ACG/PCA Team considers that the following Special Condition shall apply:

Aircraft electrical and electronic systems, equipment, and installations considered separately and in relation to other systems must be designed and installed according to the following:

- (a.) Each function, the failure of which would prevent the continued safe flight and landing of the aircraft--
 - (1) Must not be adversely affected during and after exposure of the aircraft to the lightning environment; and
 - (2) Each affected system that performs such a function must automatically recover normal operation following aircraft exposure to the lightning environment unless this conflicts with other operational or functional requirements of that system.
- (b) Each system that performs a function, the failure of which would cause large reductions in the capability of the aircraft or the ability of the crew to cope with adverse operation conditions, may not be damaged and must be recoverable in a timely manner after exposure to the lightning environment.
- (c) Each system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the crew to cope with adverse operation conditions, may not be damaged and must be recoverable in a timely manner after exposure to the lightning environment.

For compliance with the above mentioned Special Condition, the following Interpretative Material and Acceptable Means of Compliance shall be used:

- Environment and test waveforms defined in EUROCAE document ED-84 (Aircraft Lightning environment and Related Test Waveforms)
- Lightning zoning as defined in EUROCAE document ED-91 (Aircraft Lightning Zoning Standard) instead of AC 20-53A.
- Acceptable Means of Compliance as defined in EUROCAE document ED-81 (Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning). This document will be eventually replaced by a new AC/AMJ 20-136A.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM	CRI:	F06
	DIAMOND DA40	ISSUE:	Issue 6
		DATE:	22.09.2008
		STATUS:	CLOSED

SUBJECT: Installation of Full Authority Digital Engine Controlled (FADEC) reciprocate Diesel Engine and Propeller

REQUIREMENTS: JAR 23.1309 (a) – (e)

ADVISORY MATERIAL: GAI-20, AMJ 20X1

POLICY REF.:

PRIMARY GROUPE/PANEL: Electric Panel

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

POST TC

Special Condition / Acceptable Method of Compliance

STATEMENT OF ISSUE

The Diamond DA40 airplane shall be equipped by major change with a reciprocating diesel engine (Thielert TAE-125 or Austro Engine E4) certified under JAR-E/CS-E.

These engines using the diesel working principle and is fully electronically controlled and needs electrical power for continuous operation.

In addition, the propeller is controlled by the same FADEC system.

It is assumed that when JAR 23.1309 was developed, the use of electronic control systems for engines was not adequately covered. Therefore the JAR 23.1309 requirements were not applicable to systems certified as part of the engine (reference JAR 23.1309(f)(1)).

Digital electronic control systems includes inputs from airplane data and power sources and outputs to other airplane systems (i.e. engine instruments, electrical power supply and there control). The applicable airworthiness regulation do not contain adequate or appropriate safety standards for the installation of such a design feature.

Although the parts of the system that are not certified with the engine could be evaluated using the criteria of JAR 23.1309, the integral nature of systems such as these makes it unfeasible to evaluate the airplane portion of the system without including the engine portion of the system. However, JAR 23.1309(f)(1) again prevents complete evaluation of the installed airplane system since evaluation of the engine system's effects is not required.

Therefore, this special condition is proposed to evaluate the installation of the electronic engine control system for compliance with the requirements of JAR 23.1309(a) through (e).





The engine control system in this installation does include the electronic propeller control, detailed described in CRI D-01, this is a part of the propeller certification as agreed at the engine certification (see JAA TCDC JAA/E/02-030 Note 10) and is also addressed in this Special Condition for the DA40 installation.

The intend of this special Condition is also applied by the FAA to similar products. In showing compliance to this special Condition HIRF and Lightning Test Conditions as defined in CRI F-01, F-02 and F-03 apply for.

DISCUSSION

3. ACG/PCA POSITION

Austro Control as JAA PCA proposes the following :

1.1. PRECAUTIONS

1.1.1. General

The introduction of electronic technology can entail the following:

- a. A greater dependence of the Engine/Propeller Control System on the aircraft owing to the use of electrical power and/or data supplied from the aircraft.
- b. Risk of significant failures common to Engine/Propeller Control Systems of the aircraft which might, for example, occur as a result of-
 - i. insufficient protection from electromagnetic disturbance (lightning, internal or external radiation effects),
 - ii. insufficient integrity of the aircraft electrical power supply
 - iii. insufficient integrity of data supplied from the aircraft,
 - iv. hidden design faults or discrepancies contained within the design of the propulsion system control software, or
 - v. omissions or errors in the system specification.

Special design and integration must therefore be taken to minimize these risks.

1.1.2. Objective

The introduction of electronic control systems should provide for the aircraft at least the equivalent safety, and the related reliability level, as achieved by Engine/Propellers equipped with hydromechanical control and protection systems.

1.1.3. Precaution Relating to Engine/Propeller Control, Protection and Monitoring

The software associated with Engine/Propeller control, protection and monitoring functions must have a quality level and architecture appropriate to their criticality.

4. Precautions relating to Engine/Propeller independence from the aircraft

1.1.4.1. Precautions relating to electrical power supply and data from the aircraft

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When considering the objectives of paragraph 1.2. due consideration must be given to the reliability of electrical power and data supplied to the electronic controls and peripheral components . Therefore the potential adverse effects on Engine/Propeller operation on any loss of electrical power supply from the aircraft or failure of data coming from the aircraft must be assessed during the Engine/Propeller installation.

The use of either the aircraft electrical power network or electrical power sources specific to Engine/Propeller, or the combination of both may meet the objectives. Defects of aircraft interface data may be overcome by other data references specific to the Engine/Propeller.

5. Local events

- a. In designing and installing an electronic control system to meet the objectives of paragraph 1.2. special consideration needs to be given to local events. Examples of local events including fluid leaks, mechanical disruptions, electrical problems, fires or overheat conditions. An overheat condition results when the temperature of the electronic control unit is greater than the safe design operating temperature declared by the Engine/Propeller manufacturer. This situation can increase the failure rate of the electronic control system.
- b. Whatever the local event, the behavior of the electronic control system must not cause a hazard to the aircraft. This will require consideration of effects such as the control of the overspeed of the Engine, transients effects or inadvertent Propeller pitch change under any flight condition. When the demonstration that there is no hazard to the aircraft is based on the assumption that there exists another hazard function to afford the necessary protection, it must be shown that this function is not rendered inoperative by the same local event (including destruction of wires, ducts, power supplies).
- c. Specific design features or analysis methods may be used to show compliance with respect to hazardous effects. Where this is not possible, for example due to the variability or the complexity of the failure sequence, then testing may be required. These tests shall be agreed with the Authority.

1.1.5. Precautions Relating to Failure Modes Common to Engine/Propeller Control Systems.

1.1.5.1. Environmental Effects

Special attention should be given to any conditions which could affect Engine/Propeller Control Systems. For example, incorrect operation under hot ambient conditions.

1.1.5.2. Lightning and other electromagnetic effects

Electronic control systems are sensitive to lightning and other electromagnetic interference. The system design shall incorporate sufficient protection in order to ensure the functional integrity of the control system when subjected to designated levels of electric or electromagnetic fields, including external radiation effects.





The validated protection levels for the Engine/Propeller electronic control systems shall be detailed by the manufacturer in an approved document. For aircraft certification, the aircraft manufacture shall substantiate that these levels are adequate.

1.1.6. Aircraft electrical power supply

If the aircraft electrical system supplies power to the Engine/Propeller control system at any time, the power supply quality, including transients or failures, must not lead to a situation identified by the Engine manufacture, which is considered by the aircraft manufacture to be a hazard to the aircraft.

1.1.7. Data exchanged with the aircraft

- a. Aircraft must be protected from unacceptable effects or faults due to a single cause, affecting the Engine/Propeller Control System.
- b. Any precautions needed may be taken either through the aircraft system architecture or by logic internal to the electronic control system.





1.2. INTER – RELATION BETWEEN ENGINE/PROPELLER AND AIRCRAFT CERTIFICATION

1.2.1. Objective

To satisfy the JAR aircraft requirements, such as JAR 23.901, JAR 23.903 and JAR 23.1309, an analysis of the consequences of failures of the system on the aircraft has to be made. The Engine/Propeller manufacturer should, together with the aircraft manufacturer, ensure that software levels and safety and reliability for the electronic control system are consistent with these requirements.

1.2.2. Interface Definition

- a. The interface has to be identified for the hardware and software aspects between the Engine, Propeller and the Aircraft systems in the appropriate documents.
- b. The Engine/Propeller/aircraft documents should cover in particular –
 - i. Development assurance level for the software (per function if necessary),
 - ii. The reliability objectives for –
Engine shut-down in flight,
Loss of Engine/Propeller control,
 - iii. The degree of protection against lightning or other electromagnetic effects (e.g. level of induced voltages that can be supported at the interfaces),
 - iv. Engine, Propeller and aircraft interface data and characteristics, and
 - v. Aircraft power supply and characteristics

1.2.3. Distribution of Compliance Tasks

The tasks for the certification of the aircraft propulsion system equipped with electronic controls may be shared between the Engine, Propeller and Aircraft manufacturers. The distribution of these tasks between the manufacturers shall be identified and agreed with the appropriate Engine and Aircraft Authorities (an example is given in paragraph 1.3).

Appropriate evidence provided for Engine/Propeller certification should be used for aircraft certification. For Example, the quality of any aircraft function software and Aircraft/Engine/Propeller interface logic already demonstrated for Engine/Propeller & Control certification should need no additional substantiation for aircraft certification.

Aircraft certification shall deal with the specific precaution taken in the physical and functional interface with the Engine/Propeller & Control.





1.3. CONVERSION TABLE

An example of tasks distribution between Engine/Propeller and aircraft manufacturers.

TASKS	SUBSTANTIATION BY ENGINE /PROPELLER Designer	SUBSTANTIATION BY AIRCRAFT Designer	
		with data supplied by engine manufacturer	with its own data
ENGINE /PROPELLER CONTROL AND PROTECTION	- Safety objective	Consideration of common mode effects (including software)	
	- Software level	- Reliability	
		- Software Level	
MONITORING	- Independence of control ad monitoring parameters	- Monitoring Parameter reliability	- Indication system reliability - Independence engine/engine
AIRCRAFT DATA	- Protection of engine from aircraft data failures - Software level		- Aircraft data reliability - Independence engine/engine
CONTROL SYSTEM ELECTRICAL SUPPLY			- Reliability of quality of aircraft supply, if used - Independence engine/engine
ENVIRONMENTAL CONDITIONS	- Equipment protection	- Declared capability	- Aircraft design
LIGHTING AND OTHER ELECTROMAGNETIC EFFECTS			- Aircraft wiring protection
FIRE PROTECTION	- Equipment protection	- Declared capability	- Aircraft design





1.4. COMPLIANCE DEMONSTRATION

The installation of the TAE-125 engine equipped with electronic engine control system must comply with the intent of Sec. 23.1309(a) through (e) .

The Items 1.1, 1.2 and 1.3 of this Special Condition is an acceptable method of compliance.

Installation Requirements of the engine and propeller designer, for the engine, propeller and propeller control must be considered.

The intent of this requirement is not to re-evaluate the inherent hardware reliability of the engine with the FADEC as certified under JAR-E, JAR-P itself, but rather determine the effects, including environmental effects addressed in Sec. 23.1309(e), on the airplane systems and engine control system when installing the engine on the DIAMOND DA 40 airplane.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM	CRI:	F-07
	DIAMOND DA40	ISSUE:	Issue 3
		DATE:	13.2.2006
		STATUS:	CLOSED

<u>SUBJECT:</u>	Human Factors in Integrated Avionic Systems
<u>REQUIREMENTS:</u>	JAR 23 Change 1
<u>ADVISORY MATERIAL:</u>	DOT/FAA/CT-96/1 , AC23.1311-1A
<u>POLICY REF.:</u>	---
<u>PRIMARY GROUPE/PANEL:</u>	Flight
<u>NEXT ACTION BY:</u>	---
<u>CRI CLOSURE TARGET:</u>	post TC

Special Condition

STATEMENT OF ISSUE

The DA40 should be certified to include the Garmin G-1000 Integrated Avionic System as the standard equipment or to retrofit. This CRI is generally applicable only to the original applicant seeking issuance of a type certificate (TC) and supplemental type certificate (STC) for the initial approval of the new type design or a change in the type design.

The Garmin G1000™ is a completely integrated avionics system designed to fit a broad range of aircraft models. It's an all-glass flightdeck with a Primary Flight Display PFD and a Multi Function Display MFD that presents flight instrumentation, location, navigation, communication, engine instrumentation and identification data on large-format, high-resolution displays.

Up to now no specific CS/ JAR23 guidance material is available to address the human factor Issue of such a Installation. The available JAR25 guidance material as INT/POL/25/14 is not completely suitable for a single pilot CS23 aeroplane operating in the general aviation environment. Therefore the following items have been extracted.

The following novel design features have been identified which requiring a special condition in accordance to part 21A.16.

- Introduction of a new technology
- Introduction of a new concept of interfacing with the pilot
- Different use of an equipment, with or without its integration in interfaces.

This novel technology is also introducing a novel concept, which alters the manner of the pilot work and due to the increased automation also to tasks and /or monitoring functions which he had been previously responsible.





This all lead also to new procedures and methods by the use of the existing air traffic system, offering safety enhancements but may allow mis-interpretations and may have a increased potential for error.

However, if commonly-held beliefs and understanding or conditioned practices and learned procedures are changed significantly by the introduction of a new technology or concept, then it is clear that a significant amount of proving research regarding the human factor is required. This may simply be done by experience and expert judgment of appropriately qualified staff, but substantial investigation may be required for safety relevant Issues.

DISCUSSION

3. ACG/PCA Position

Austro Control (ACG) is designated as the responsible party for the STC with letter P-EASA.IM.A.S.01023 and in General for Changes on the DA40.

In accordance with part 21A.16, ACG has determined that the Installation of the Garmin G1000 Integrated Avionic System in the Diamond DA 40 aircraft has *Novel Features* that requires a Special Condition for certification regarding the Human Factor aspect.

Accordingly, in the absence suitable alternative material, the following Special Condition and acceptable Method of compliance is proposed

2.1 Special Condition:

a) The design of the integrated flight deck interface must adequately address the foreseeable performance, capability and limitations of the Pilot.

b) More specifically, the Team must be satisfied with the following aspects of the flight deck interface design:

- i. ease of operation including automation;
- ii. the effects of pilot errors in managing the aircraft systems, including the potential for error, the possible severity of the consequences, and the provision for recognition and recovery from error;
- iii. workload during normal and abnormal operation; and
- iv. the adequacy of feedback, including clear and unambiguous:
 - presentation of information;
 - representation of system condition by display of system status;
 - indication of failure cases, including aircraft status;
 - indication when pilot input is not accepted or followed by the system;
 - indication of prolonged or severe compensatory action by a system when such action could adversely affect aircraft safety.
 - Indication of reversionary and backup modes





2.2 Demonstration of Compliance

2.2.1 Implementation

It is envisaged that the Flight Test Panel would manage implementation. The following is a proposal for interpretative material associated to the special condition. This will call for:

- i) General Assessment: A general review of Human Factors issues arising from integrated use of the flight deck.
- ii) Novel features: Careful exploration of specific Human Factors issues arising from the novel integrated avionic system in the flight deck.

2.2.2 It is important that the effort for consideration of human factors is focused upon any risks relevant to aircraft safety that may be raised by the novel features of the flight deck design. As clarification, some example topic areas have been suggested in italicised text beneath each of the specific criteria listed in paragraph 2.3 below. Examples are offered for illustration purposes, but evaluation against the listed criteria should not be restricted to only these examples.

2.2.3 The applicant should show how they have considered and applied a consistent approach across the flight deck in order to avoid confusion. This may be achieved by the use of a flight deck philosophy document that will :

- a. Identify the Applicants Philosophy on design principles such as:
 - Crew alerting and prioritization of aural
 - Use of colors
 - Location of controls
 - Menu structures
 - Crew interaction with displays
 - Display reversion
 - Automation principles
 - System feedback to the crew
- b. Identify relevant assumptions concerning use of the Flight Deck Interface, such as:
 - The pilot accommodation.
 - The operational environment.
 - The aircraft operator [e.g., use of user modifiable checklists, presentation of planning data].

2.2.4 The applicant should prepare a dedicated plan for addressing human factors aspects in flight deck certification. This plan should include:

- a. Identify items in the proposed design that are considered new or novel,
- b. Identify how they will address the potential for crew related risk that may arise from these items, including their relationship to conventional features. For this purpose, they may select a format including each novel item:
 - Novel Item name
 - Risk Potential arising from crew interface
 - Design Objectives in managing those risks
 - How Foreseeable Performance of crew will be addressed
 - How Ease of Use will be addressed
 - How Effects of Error will be addressed
 - How Task Distribution will be addressed





- How Adequacy of Feedback will be addressed
 - Other foreseeable concerns
 - JAR / FAR paragraphs also relevant
 - Certification credit events where the design will be exposed to the Team for formal evaluation of the item.
- c. Show the planned development schedule including the manufacturer / customer internal assessments and ‘proof of concept’ activities, which may be observed by some Team members.
- d. Describe the planned resources that will be available for development activity, in particular mock-ups, active representations and simulation.
- 2.2.5 Evaluation trials will need to include demanding scenarios representative of each flight phase (flight preparation, taxi, take-off, climb, cruise, approach, landing, go-around, and holding) with standard pilot tasks (flight path control, flight path management, communication, aircraft system management) and using all the available interface means (e.g. communication through data link if proposed). Scenarios shall include Normal, Abnormal and Emergency situations. The applicant should propose the means and methods by which these scenarios can be assessed in a realistic environment.
- 2.2.6 The applicant should identify, where appropriate, the recommended Pilot Operating Philosophy and the procedures.
- 2.2.7 A formal certification event should be designated by the applicant to permit an evaluation by the JAA team in order that it might satisfy itself that compliance of the design with the Special Condition has been achieved.

2.3 Evaluation Criteria

For each feature to be evaluated, considerations may include:

2.3.1 Foreseeable Performance, Capabilities and Limitations of the Pilot

- a. Occasional error is a normal characteristic of skilled human performance [*e.g., where a single error would impact safety, the pilot should be supported by the design or, if not practicable, operating procedures or training*].
- b. Pilot capacity is not limitless in terms of working memory [*e.g. pilot should not be expected to hold in mind long alphanumeric sequences*] long term memory [*e.g. without regular practice, pilots training and skill may fade over time*] and attention [*e.g. supplemental systems may impact safety if they are slow, distracting or difficult to use; the presentation of non-functional information should be avoided; simultaneous tasks and demands on the pilot should be minimized*]
- c. Established practices and conventions may influence pilot actions, especially under stressful conditions. [*e.g. if a certain location on the flight deck has been associated with a particular function in many previous aircraft, it is foreseeable that some pilots may erroneously reach to that position for the function even if trained to find it elsewhere.*]
- d. Available pilot capacity may be reduced during failure conditions or under stress; hence the additional need to apply unfamiliar procedures at such a time should be avoided. This should be achieved within the design.
- e. Expectation may bias pilot’s perception and thus important information that is contrary to expectation must be particularly explicit.
- f. A high rate of false warnings is likely to reduce the effectiveness of genuine warnings.
- g. Cultural differences may exist and could be relevant to some design expectations [*e.g. on use of English alphabet for sequencing*:].





2.3.2 Ease of Use [including Automation]:

- a. Iterative involvement of test pilots and operational pilots in the development of such systems is likely to result in an improved product; this should include representations [e.g. simulation] that have a degree of realism appropriate to the level of assessment and the use of scenarios including those that are most likely to address system vulnerability and risk related situations.
- b. The application of consistent philosophies may also contribute to 'ease of use'.
- c. Further considerations in achieving 'ease of use' may be obtained from EN ISO 14307 on Human Centered Design Processes for Interactive Systems.

Examples: Flight Deck Philosophies that is logical and consistently applied. The design should be such that effective use by pilots is likely, giving consideration to the expected pilot training [e.g. number of VNAV modes]. CCD(Cursor control device) characteristics, including accessibility; compatibility with existing CCD conventions; resistance to inadvertent operation (e.g. by position); software control laws / gains / operating characteristics for accuracy and speed; use with right and left hand, dominant and non-dominant hand; operation under vibration / turbulent conditions;

2.3.3 Effects of Error:

- a. The systematic evaluation of the contribution of the effects of error to safety risk in the operational environment.
- b. Error in routine tasks [such as data entry or misreading digits] is a normal characteristic of human performance, and such errors are considered probable.
- c. The recognition that the absence of a particular pilot error during development simulation activity does not prove that such an error can never occur in service.

Examples: To include pilot response to system failure, and also error during normal (and abnormal) operations that do not occur during a response to a failure of the system on which the error is made. It is not acceptable to assume that all errors (e.g., simple slips and lapses) can be eradicated by training.

2.3.4 Workload

- a. The introduction of new or novel design features may potentially affect workload or awareness across time; some tasks may become more time consuming or exclusive. Such effects should be explored.
- b. The quantity, similarity and function of tasks that are conducted through a single device or access point should be investigated for peaks or 'bottlenecks' at busy or critical periods.
- c. The risk from task interruption [and potentially remaining incomplete] may also be related to design characteristics [such as the need to withdraw from one menu to access another in an automated system].

Examples: Time taken to access features of systems that are time critical; time taken head down during busy phases of flight (especially where lookout required); time sharing of devices for dissimilar tasks (e.g. Multi-Function Display); critical task times in comparison with previous designs; system status following interrupted tasks.

2.3.5 Adequacy of Feedback

- a. Consistent application of feedback philosophy (*Dark-Quiet, Green Light, ..*).
- b. Evaluation of effectiveness of method and format of feedback (*look and feel*).
- c. Sub-categories as outlined below:





- i) Presentation of information
Examples: Symbol readability in vibrating conditions; display colour philosophy.
- ii) Representation of system condition by display of system status
Examples: Awareness of system status despite extensive use of MFD and large number of display choices through “Windowing”; draws attention to status change.
- iii) Indication of failure cases, including aircraft status
Examples: Potential obscuration of information by pop-up menus.
- iv) Indication when pilot input is not accepted or followed by the system
- v) Indication of prolonged or severe compensatory action by a system when such action could adversely affect aircraft safety
Examples: Automated flight control that may be designed such that the adjustment reaches the end of its travel before the pilot is made suddenly aware of the situation.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM	CRI:	F08
	DIAMOND DA40	ISSUE:	Issue 2
		DATE:	19.9.2005
		STATUS:	CLOSED

SUBJECT: Software, Hardware Assurance Level and Highly, Integrated or Complex Aircraft Systems

REQUIREMENTS: JAR 23.1309 (a) and (b)

ADVISORY MATERIAL: ED 12B, ED 79, ED 80; SAE ARP4761

POLICY REF.:

PRIMARY GROUP/PANEL: Avionics Panel

NEXT ACTION BY: Diamond / Garmin

CRI CLOSURE TARGET: post TC

Post TC

Acceptable Method of Compliance

STATEMENT OF ISSUE

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The Garmin G1000™ is a completely integrated avionics system designed to fit a broad range of aircraft models. It's an all-glass flightdeck with a Primary Flight Display PFD and a Multi Function Display MFD that presents flight instrumentation, location, navigation, communication, engine instrumentation and identification data on large-format, high-resolution displays.

JAR 23.1309 has to be demonstrated, no JAA guidance material for Software and Hardware Assurance level definitions and certification considerations for highly integrated or complex aircraft systems is available.





1. ACG/PCA POSITION

1.1. APPLICABILITY.

This CRI is generally applicable only to the original applicant seeking issuance of a type certificate (TC) and supplemental type certificate (STC) for the initial approval of the new type design or a change in the type design. This document addresses general applicability, and it should not be utilised to replace any specific guidance intended for individual types of equipment, systems, and installations. Because § 23.1309 is a regulation of general requirements, it should not be used to supersede any specific requirements of JAR 23. However, since software is not addressed elsewhere in JAR 23, the software development assurance criteria of this CRI are applicable. For example, § 23.1311, Electronic display instrument systems, has specific requirements on the number of electronic displays required for attitude, airspeed, and altitude; therefore, § 23.1309 should not be used to increase or decrease the requirements (except for determining the Software Development Assurance Level). For either mechanical or analog electromechanical systems, or both, where the installation is not complex, the single-fault concept and experience that are based on service-proven designs and engineering judgement are appropriate.

§ 23.1309 is applicable to the installation of all airplane systems and equipment, which includes pneumatic systems, fluid systems, electrical/electronic systems, mechanical systems, and powerplant systems included in the airplane design, except for the following:

- (1) Systems and installations approved only as part of a type-certificated engine or propeller, and
- (2) The flight structure (such as wings, fuselage, empennage, control surfaces, mechanical flight control cables, pushrods, control horns, engine mounts, and structural elements of the landing gear) requirements are specified in Subparts C and D of JAR 23.

1.2. DEVELOPMENT ASSURANCE FOR AIRBORNE SYSTEM AND APPLICATIONS.

- a. **Background:** ED 12B provides an acceptable means for showing that software complies with pertinent airworthiness requirements.
- b. **Acceptable Application of Software Development Assurance Levels:** It is necessary to consider the possibility of requirement, design, and implementation errors in order to comply with the requirements of § 23.1309(b). Errors made during the design and development of systems have traditionally been detected and corrected by exhaustive tests conducted on the system and its components by direct inspection and by other direct verification methods capable of completely characterising the performance of the system. These direct techniques may still be appropriate for simple systems, which perform a limited number of functions and which are not highly integrated with other airplane systems.

- (1) For more complex or integrated systems, exhaustive testing may either be impossible because all of the systems states cannot be determined or it may be impractical due to the number of tests that must be accomplished. For these types of





systems, compliance may be shown by the use of Software Development Assurance Levels. The Software Development Assurance Levels should be determined by the severity of potential effects on the airplane in case of system malfunctions or loss of functions.

(2) Criteria for Software Development Assurance Levels of Part 23 airplanes are shown in AC 23.1309-1C. The levels defined in the AC are considered acceptable instead of the Software Development Assurance Levels defined in paragraph 2.2.2 in ED 12B. Additional guidelines, which may be used for determining Software Development Assurance Levels, are described in ARP 4754. Because these documents were not developed simultaneously, there are differences in the guidelines and terminology.

(3) Equipment installed in Part 23 airplanes that performs functions addressed by ETSO standards should meet applicable ETSO standards, but the equipment is not required to have ETSO authorisation. Some ETSO equipment specifies minimum Software Development Assurance Levels. Software for non-TSO equipment installed in Part 23 airplanes may use the Software Development Assurance Levels in lieu of the levels specified in the ETSO.

c. *Acceptable Application of Hardware Development Assurance Levels:* Also for airborne electronic hardware it is necessary to consider the possibility of requirement, design, and implementation errors in order to comply with the requirements of § 23.1309(b). The use of increasingly complex electronic hardware in the DA 40, more of the safety critical aircraft functions generates new safety and certification challenges. These challenges arise from a concern that said aircraft functions may increasingly difficult to manage due to the increasing complexity of the hardware. To counteract this perceived escalation of risk it has become necessary to ensure that the potential for hardware design errors is addressed in a more consistent and verifiable manner during both the design and certification process.

(1) EUROCAE ED-80 provides guidance for design and assurance of airborne electronic hardware from conception through initial certification and subsequent post certification product improvements to ensure continued airworthiness. It was developed based on showing compliance with certification requirements for transport category aircraft and equipment but the document may be used in order to define Levels as shown in the AC 23.1309-1C.

(i) Terminology

- **Programmable Logic Device (PLD)** - A component that is purchased as an electronic component and altered to perform an application specific function. PLDs include, but are not limited to, Programmable Array Logic components (PAL), Programmable Logic Array components, General Array Logic components (GAL), Field Programmable Gate Array components, and Erasable Programmable Logic Devices.
- **Application Specific Integrated Circuit (ASIC)** - Integrated Circuits which are developed to implement a function, including,





but not limited to: gate arrays, standard cell, and full custom components encompassing linear, digital, and mixed mode technologies.

- **Simple Hardware Item** - A hardware item is considered simple if a comprehensive combination of deterministic tests and analyses can ensure correct functional performance under all foreseeable operating conditions with no anomalous behaviour.
- **Complex Hardware Item** - All items that are not simple are considered to be complex. See definition for Simple Hardware Item.
- **Commercial Off-the-Shelf (COTS) Component** - Component, integrated circuit or subsystem developed by a supplier for multiple customers, whose design and configuration is controlled by the supplier's or industry specification.

Note: ED-80 Appendix C defines COTS. Examples of COTS components include resistors, capacitors, microprocessors, unprogrammed Field Programmable Gate Array (FPGA) and Erasable Programmable Logic Devices (EPLP, PLD), other integrated circuit types and their implementable models, printed wiring assemblies and complete LRUs which are typically available as a catalogue item.

(ii) In addition, this CRI supplements document ED-80 to provide further guidance applicable to complex digital devices such as Application Specific Integrated Circuits (ASICs) and Programmable Logic Devices (PLDs) which may be used in systems with safety implications for the aircraft. These devices are often as complex as software controlled microprocessor-based systems hence they need a rigorous and structured design approach to satisfy applicable functional and safety requirements.

(2) ED-80 does not address the modifiable aspects of a digital device where a part or the entirety of the embedded logic can be changed at any time from an external source without modification of the device hardware. In such cases, in addition to the ED-80 guidance material for the hardware, the applicant will need to consider applying the guidelines of Sections 2.4 and 2.5 of EUROCAE document ED-12B concerning user modifiable software, option selectable software, and field loadable software.

(3) Certification Plan

(i) Each complex digital device should be listed in a certification plan together with its classification and a description of its function. The plan should identify hardware design standards appropriate to the device, and record the intent to satisfy ED-80 and ED-12B as applicable. The certification plan





should identify the certification data to be delivered to, or made available to, the authority.

(ii) Where alternative methods to those described in ED-80 are proposed, the applicant should explain their interpretation of the basic objectives, describe the alternative methods, and present to the authority at an early stage, their justification of equivalence.

(iii) If reverse engineering of a device is proposed, the applicant should present and justify to the authority the strategy to be used.

(4) Validation Process

(i) The specification, safety requirements and derived requirements should be identified and validated. This could be satisfied either by review, analysis or simulation, or a combination of these methods. Completion of the validation processes should be based on defined criteria.

(ii) The validation processes should be documented as required by the hardware control category as defined in ED-80.

(5) Verification Process

(i) If a Hardware Description Language (HDL), as defined in ED-80 is used, code standards for this language consistent with the system safety objectives should be defined, and conformance to those standards should be established.

(ii) To demonstrate freedom from unacceptable robustness defects, requirements based testing should be defined to cover normal and abnormal operating conditions.

(iii) Test cases should be reviewed to confirm appropriate test case selection.

(6) Traceability

(i) Traceability between the specification requirements, the conceptual design (i.e. high level architecture and detailed functional description), the detailed design (i.e. HDL), and the implementation, should be ensured.

(ii) Traceability between the requirements and design items of 1.2.c.(6)(a), and the corresponding verification or validation activities, should be ensured.

(7) Configuration Management: For complex digital devices, documented change control and problem reporting should be implemented at an early stage of the project when the process of configuration identification (as defined in ED-80) commences. This may need to precede the baseline from which certification credit is claimed.





d. Certification Considerations For Highly-Integrated Or Complex Aircraft Systems

The EUROCAE ED-79 provides certification aspects of highly-integrated or complex systems installed on the DA 40, taking into account the overall aircraft operating environment and functions. The term “highly-integrated” refers to systems that perform or contribute to multiple aircraft level functions. The term “complex” refers to systems whose safety cannot be shown solely by test and whose logic is difficult to comprehend without the aid of analytical tools.

- (1) The ED 79 addresses the total life cycle for systems that implement aircraft-level functions. It excludes specific coverage of detailed systems, software and hardware design processes beyond those of significance in establishing the safety of the implemented system. More detailed coverage of software aspects of design are dealt with EUROCAE ED-12B. Coverage of complex hardware aspects of design are dealt with in EUROCAE ED-80. Methodologies for safety assessment processes are outlined in SAE document ARP4761.





austro CONTROL as PCA of Joint Aviation Authorities	CERTIFICATION REVIEW ITEM DIAMOND DA40	CRI: ISSUE: DATE: STATUS:	O-01 Issue 5 11.9.2001 CLOSED
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<u>SUBJECT:</u>	Glider Towing
<u>REQUIREMENTS:</u>	JAR 23
<u>ADVISORY MATERIAL:</u>	-
<u>POLICY REF.:</u>	-
<u>PRIMARY GROUPE/PANEL:</u>	Flight, Structure
<u>NEXT ACTION BY:</u>	---
<u>CRI CLOSURE TARGET:</u>	Operational Approval

STATEMENT OF ISSUE

Diamond applied for Equipment Installation and Operational Approval of Glider Towing in DA 40 aeroplane.

Certification for this purpose is not new, but there is no JAA harmonized requirement known.

Unless a General JAA Policy is available this CRI is issued to develop a DA 40 specific requirement, which shall include all NAA Comments or ANDR. This shall ensure and shall make it possible, that the installation is equal in all JAA countries.

DISCUSSION

6. ACG/PCA POSITION

ACG proposed the following Special Condition related to unconventional use of product, based on the certification of aeroplanes and powered sailplanes for glider towing in Austria.

A: GENERAL

A1: Applicability

JAR-23, Diamond DA 40 (basic requirement)

Only single glider towing is covered by this special condition, multi glider tows (more than one glider at the same time) needs more detailed investigations.





B: FLIGHT

B1: Proof of Compliance

In addition to basic certification requirement a minimum of 3 tows with representative gliders must be shown.

The representative fleet of all kind of requested gliders in all critical combinations of max.,min.weight,aerodynamical characteristics,max,min speeds,ground handling,enviromental conditions must be shown.

Special attention and testing is required for sailplanes with bottom tow hook installation.

B2: Take Off

The performance requirement for take-off roll and take-off distance from JAR 23.53 must be shown for the complete tow formation in the conditions of 23.45.

The take-off distance must not exceed 500m, when taking off from a dry, level, hard surface at sea level.

B3: Climb

The climb performance requirement from JAR 23.65 must be shown for the complete tow formation in the conditions of 23.45 and 23X63.

The climb rate must not be less than 1,5 m/s at 450m MSL at ISA +20°C.

B4: Tow Speeds

The minimum and maximum tow speed must be determined by flight tests under condition of B1.

Minimum tow speed must not be less than $1,2 \cdot V_{s1}$ of the tow plane.

Maximum tow speed must not be higher than V_a .

B5: Controllability and Manoeuvrability

The General Controllability, Manoeuvrability and Control forces required in the basic requirement must be shown for the complete tow formation except for the following conditions:

- Sideslip,
- Speeds more than the established maximum towing speed
- Other tow cable length as determined under F2(c)
- More than 30° left and right lateral sailplane position
- More than 15° up and down position of sailplane
- Aerobatic manoeuvres
- Power Off Conditions
- Elevator Control force in manoeuvres

B6: Stall Warning

An adequate Stall Warning compared to the basic requirement must be shown for the tow condition. (Note: Stall testing as for aircraft certification is not required, only the stall warning must be addressed)

III. B7: Tow Cable release

The tow cable release of the glider within the speeds of B4 may not cause a unsafe condition for the tow plane.

IV. B8: Landing

Procedure for handling the tow cable during landing must be determined by tests.





C: STRUCTURE

C1: Proof of structure

Compliance with the Strength and Deformation, Structural Analysis and Load Test requirement from the base requirement must be shown for the tow condition and installation.

C2: Towing loads

(a) The tow must be initially assumed to be in stabilized level flight, with a minimum tow rope load of 50 daN acting at the towing hook in following direction:

- (1) horizontally rearward
- (2) in plane of symmetry rearward and downward at an angle of 20° to the horizon
- (3) in plane of symmetry rearward and upward at an angle of 40° with the horizon
- (4) horizontally rearward and sideward at an angle of 30° with the plane of symmetry

Lower tow rope loads may be acceptable if shown by detailed analysis

(b) The highest rated ultimate strength of the weak link (Q_{nom}) for the towed sailplanes must be established.

(c) With the tow initially assumed to be subjected to the same conditions as specified in C2(a) the tow rope load due to surging suddenly increases to Q_{nom} . The resulting tow rope load increment must be balanced by linear and rotational inertia forces and superimposed to loads from C2(a).

C3: Strength of launching hook attachment

The launching hook attachment must be designed to carry a limit load of $1,5 \cdot Q_{nom}$ as defined in C2(b), but not less than 600 daN acting in directions of C2(a).





D: DESIGN and CONSTRUCTION

D1: Cable Systems

Each additional cable system installed with the tow installation must comply with the basic requirement of the towing plane

D2: Release mechanisms

There must be a release mechanisms installed to give the tow pilot the ability to quick disconnect the tow formation

(a) The release mechanisms must be approved.

AMC D2(a)

ALufttüchtigkeitsforderungen für Schleppkupplungen (LFK) ≅ issued 11.8.1976 or later by LBA is an acceptable means as an approved specification.

(b) It must be extremely improbable for bolts or other projections on the release mechanism itself or the structure surrounding the mechanism, including the landing gear, to foul the towing rope.

(c) It must be shown that the release force will not exceed the force limit of the base tow plane requirement, when on a cable Q_{nom} (see C2(b)) is applied in any direction described in C2(a) and that the release mechanism functions properly under any operating condition.

The release force must not be more than 20 daN, even if a cable force of 600 daN is applied on the tow rope.

(d) The range of travel of the release lever in the cockpit, including free travel, must not exceed 120 mm.

(e) The release lever in the cockpit must be arranged and designed so that the pilot force as defined in D2(c) can be easily applied

(f) A visual inspection of the release mechanism must be easily possible.

IEM D2(f)

The possibility to open the release mechanism on the tow hook assembly for ground handling is recommended.

(g) The release mechanism must be so installed that there is no interference between the tow rope and any control surface when the towed sailplane is in any position of C2(a) and the controls are operated through their full angular movement.

(h) The towing hook must be suitable protected against inadvertent release.

(i) The release control system must be designed to actuate the release mechanism of each launching hook at the same time, where more than one launching hook is fitted or a clear method must be established to prevent confused operation of the individual emergency releases.

D3: Colour marking and arrangement of cockpit controls

Towing cable release must be of yellow/red colour and installed for an operation with the same pilots hand as the power lever.

D4: Tow cable retraction mechanisms

If a tow cable retraction mechanisms is installed, it must be of an approved type. (see CRI O-2)





E: POWERPLANT

E1: Engines

No Change to JAR 23

E2: Fuel System

No Change to JAR 23

E3: Cooling test procedure for reciprocating engine

Cooling test procedure as required by the base requirement for the tow plane must be carried out with the critical speeds and power settings for the complete tow formation established in Section B.

The critical engine temperature must be determined.

F: EQUIPMENT

F1: Powerplant Instruments

A cylinder head temperature indicator or a indicator of the critical temperature determined in E3 must be installed.

For turbine powered aeroplanes, the indicator of the determined critical temperature for towing must be installed.

F2: Miscellaneous equipment

For towing flights the following additional equipment must be installed:

(a) A adjustable mirror so that the pilot, when strapped in his seat, has full and unrestricted view of the towed sailplane in the positions according C2.

(b) An indication to the pilot for the tow rope position or a second mirror to the tow hook if not covered by F2(a)

(c) A tow rope of approved type including at least one weak link and connecting ring.

The tow rope strength, length and flexibility must be established.

AMC F2(c)

„LBA-Lufttüchtigkeitsforderungen für den Schleppflug“ is an acceptable specification

V.

VI.

VII. G: OPERATING LIMITATIONS and INFORMATION

G1: Maintenance Manual

The Maintenance Manual must be amended for the tow installations

G2: Operating Limitations

The following additional Information must be furnished in the AFM:

(a) Maximum weight in towing condition

(b) Maximum weight of the towed sailplane

(c) Maximum and minimum permissible towing speed

(d) All other limitations as a result of Section B

(e) Strength and Definition of tow rope or weak link as necessary





G3: Operating data and procedures

Information concerning normal and emergency procedures for the tow other pertinent information necessary for safe operation must be furnished, including:

- (a) Special attention for sailplanes with bottom tow hook installation
- (b) tow upsets
- (c) different type of sailplanes
- (d) different speed problem
- (e) take off distances in tow configuration
- (f) climb performance
- (g) landing procedure

G4: Performance Information

The following information must be in addition furnished:

- (a) demonstrated crosswind velocity in tow configuration
- (b) Take-off performance versus density altitude including the qualitative influence of grass runways & rainy conditions.

The determination of density altitude must include any combination of Temp. From ISA to ISA +20 and altitudes of 0 to 900m MSL.





austro CONTROL as PCA of Joint Aviation Authorities	CERTIFICATION REVIEW ITEM DIAMOND DA40	CRI: ISSUE: DATE: STATUS:	O-02 Issue 3 25.1.2001 CLOSED
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SUBJECT: Tow Cable Retraction Mechanisms

REQUIREMENTS: JAR 23

ADVISORY MATERIAL: -

POLICY REF.: -

PRIMARY GROUPE/PANEL: Flight, Structure

NEXT ACTION BY: ---

CRI CLOSURE TARGET: Operational Approval

STATEMENT OF ISSUE

Diamond applied for Equipment Installation of an Electric Tow Cable Retraction Mechanisms in DA 40 aeroplane.
Certification for this Equipment is not new, but there is no JAA harmonized requirement known.

Unless a General JAA Policy is available this CRI is issued to develop a DA 40 specific requirement, which shall include all NAA Comments or ANDR. This shall ensure and shall make it possible, that the installation is equal in all JAA countries.

The DA 40 shall be Certified for Glider Towing Operation with CRI O-01.
CRI O-01 D4 notes that an cable retraction mechanisms must be of an approved type.
This CRI specifies the requirement for approval.

DISCUSSION

7. ACG/PCA POSITION

ACG proposed the following Special Condition related to unconventional use of product, based on the certification of aeroplanes and powered sailplanes for glider towing in Austria.





A: GENERAL

A1: Applicability

CRI O-01 remain unchanged and compliance must be shown also for this Installation if different.

B: FLIGHT

B1: The Tow Cable retraction must be possible without exceptional pilot skill and without affecting normal pilot activities.

B2: Tow Cable retraction during tow must be impossible.

B3: Emergency release during towing must not hazard the safety of the tow plane or glider.

B4: The tow cable position for towing, and the fully stowed position must be indicated to the pilot. The amount of tow cable extended must be indicated to the pilot.

AMC B4

If the fully stowed position is indicated in the cockpit, a mirror showing clearly the remaining amount of cable aft of the fuselage is an acceptable method.

B5: Retraction of the tow cable up to the designated max. retraction speed must not damage the structure.

C: STRUCTURE

C1: If the cable retraction unit is not the tow load implementation point, it must be equipped with a load limiting device or designed for the max cable loads.

C2: The mounting structure must be comply to CRI O-01 C2 , JAR 23.337 and 23.341 whichever is higher.

D: DESIGN and CONSTRUCTION

D1: Any Part (incl. Tow rope) of the mechanism must not interfere with the structure and Steering of the tow aeroplane.

D2: The Tow rope must be protected against internal looping.

D3: The structure must protected acc. JAR 23.609.

D4: The Electric Installation must comply with JAR 23.1365.

D5: If more than one towing system is installed the release control system must be designed to actuate the release of all towing systems at the same time, or a clear method must be established to prevent confused operation of the individual emergency releases.

D6: The installation must comply to JAR 23.867.

D7: The Tow Cable Release Handle must be marked Red or Yellow/Red with an Installation of D5.

G: OPERATING LIMITATIONS and INFORMATION

The following additional Information must be furnished in the AFM:

Maximum permissible tow cable retraction speed and placarded plainly visible to the pilot.

Banner Towing is not allowed with the retraction mechanism.





European Aviation
Safety Agency

Certification Review Item

DA 40 NG

Stall Warning

Doc. No. : **CRI B-01**

Nature : **ELOS**

Release : -

Revision : issue 2

Date : 7.Mar.2010

Status : Closed

SUBJECT: Stall Warning
CRI TYPE: Equivalent Level of Safety
REQUIREMENTS: CS/JAR 23.207(c)
GUIDANCE MATERIAL: CS/JAR 23 Book 2 (Flight Test Guide, FTG)
PRIMARY GROUP / PANEL: Flight
SECONDARY GROUP / PANEL: PCM
CRI CLOSURE TARGET: Before TC
NEXT ACTION BY: ---

STATEMENT OF ISSUE

A clear and distinctive stall warning is mandated by JAR/CS 23.207(a).

(a) There must be a clear and distinctive stall warning, with the flaps and landing gear in any normal position, in straight and turning flight.

From the Flight Test Guide (paragraph 89 (a) (1) "Purpose", emphasis added):

The purpose of this requirement is to ensure an effective warning in sufficient time to allow a pilot to recover from an approach to a stall without reaching the stall.

In order to work reliably as an indication of an impending stall, the stall warning should not be activated prematurely, so to avoid an adaption to the warning by the pilot which would lead to a greatly reduced observance to the warning. This concept of "nuisance warnings", which are false positive warnings, are apparent in paragraph 23.207(d), where it is stated that the stall warning should not activate during a normal takeoff and approach and to landing.

(d) When following the procedures of CS 23.1585, the stall warning must not occur during a take-off with all engines operating, a take-off continued with one engine inoperative or during an approach to landing.

The requirement 23.207(c) codifies the "warning in sufficient time" as a speed margin of 5kt (9.3m/s) between the stall warning and stall.





(c) During the stall tests required by CS 23.201 (b) and CS 23.203 (a) (1), the stall warning must begin at a speed exceeding the stalling speed by a margin of not less than 9.3 km/h (5 knots) and must continue until the stall occurs.

During certification testing of the DA 40 NG aircraft, it was found that both goals – avoidance of nuisance (early) warnings and fulfilment of the 5kt speed margin – could not be achieved in every weight, CG configuration and stall condition combinations.

Therefore, an equivalent level of safety is proposed in this CRI.

BACKGROUND

The DA 40 NG is an additional Variant of the DA 40 EASA TV A.022. In the DA 40 NG is very similar to the DA 40 D with the difference that the engine TAE 125 certified in the DA 40 D is replaced by the Austro Engine E4 engine. This engine is heavier than the original TAE, resulting in an increase of the maximum takeoff mass from 1200 kg to 1280 kg.

The overall aerodynamic design as well as the stall warning device is unchanged. The flight CG range remains in principle unchanged but is valid now also for the higher maximum flight mass.

The DA 40 is an evolution of the H36 Powered sailplane in different versions, following the DV/DA20 as a VLA and finally the DA 42 twin engine airplane with the same aerodynamic concepts and behaviours. The used airfoils using the same principles as a high lift airfoil, consequently similar low speed characteristics.

The handling qualities at low speed and during stall at the complete fleet can be considered as gentle.

For these kinds of airfoils, meeting the certification requirements can be very challenging. Several different rulemaking activities are addressing this issue. Even the DA 42 is equipped with a special device limiting the maximum angle of attack.

DISCUSSION

General Rulemaking History of Stall Definition and Stall Warning

The definition of the stalling speed is important for all following assumptions which are based on the stalling speed. One of the Items is the stall warning which is related to the stalling speed.

The stall warning definition in the CS23 is already very old and based on aerodynamic profiles having a sharp lift to angle of attack relevance at maximum lift. Modern airfoils are now producing a maximum lift over a wide angle of attack range and a gradual loss of lift.

This already leads to a number of rulemaking activities which are listed in the appendix for reference.

Due to the small deviation from the current requirements and the fact that the DA 40 NG is only a variant to the DA 40, an ELOS to the stall warning is more appropriate than a special condition to the stall speed





DA 40 NG Specific Design and Behaviour

Working principle of the stall warning device

The stall warning device installed in the DA 40 NG is a pressure activated noisemaker (air horn) that is triggered by negative pressure on the wing leading edge. The pressure at the leading edge is picked up by a non-adjustable hole in the leading edge. This hole is set by a tool during the manufacturing process. The activation pressure in the horn is defined. It therefore acts as an angle of attack sensor.

Definition of the stall speed

In its entire flight envelope the DA 40 NG is elevator limited (i.e. the elevator deflection reaches the end stop before C_{Lmax} is reached), the stall event is defined by either 2 (two) seconds after the elevator reaches the back stop or when the minimum steady flight speed is reached within the 2 seconds. In case that the aircraft does not develop a minimum steady flight speed, the stall occurs 2 seconds after reaching the back stop. This is accordance to 23.201.

The speed evolution of the DA 40 NG before, at and after the elevator reaches the back stop is shown in Figure 1. This is true for all weight-CG positions.

With the DA 40 NG, the airspeed decreases throughout the approach to the stall with the steady rate of 1kt/s. At or shortly after the elevator reaches the back stop, the airspeed reaches a minimum and increases again up to 2 seconds where the elevator reached the back stop (Figure 1). Consequently, the determined stalling speed V_S is higher than short before reaching the stop.

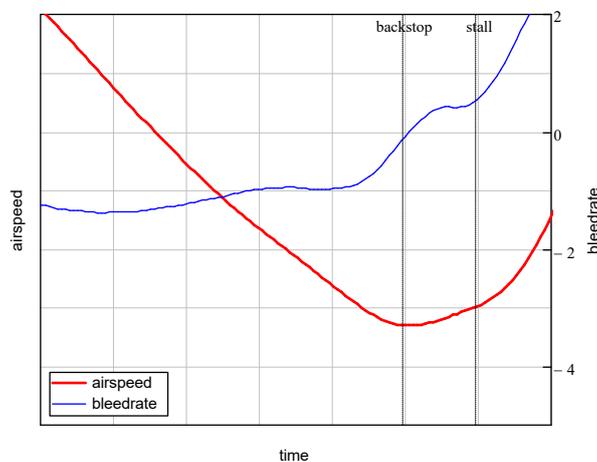


Figure 1: Airspeed and bleed rate during stall





Stall warning during takeoff

The critical part for certification of the stall warning for normal operations is during takeoff. The stall warning may sound at rotation and continue intermittently shortly after rotation. This behaviour is aggravated during operation on unpaved surfaces and gusty wind condition, including crosswinds.

One possible remedy is to increase the rotation speed. This will decrease the occurrence of the nuisance stall warning during rotation. There are, however, limitations on how far the rotation speed can be reasonably increased, each affecting flight safety and handling qualities:

- Aircraft held on ground after sufficient lift is generated to conduct a safe takeoff. This would lead to a condition requiring higher pilot's skill as the aircraft is already generating enough lift (i.e. the aircraft wants to fly) so that the ground stability is significantly reduced. This behaviour is aggravated in cross wind conditions and gusty wind conditions – exactly the conditions where the stall warning is most susceptible to false (nuisance) warnings and the reason for the rotation speed increase is most prominent.
- Rotation speed too close to the 50ft speed (defined as $1.2 \cdot V_{S1}$). This condition results in a high pitch rate during rotation to avoid exceeding the 50ft speed. This aggressive manoeuvre is not consistent with takeoff procedures in comparable aeroplanes that use a low to medium pitch rate during rotation.
 - Increasing the 50ft speed beyond $1.2 \cdot V_{S1}$. An increased 50ft speed could alleviate the effects discussed in the previous point. However, this would also negatively affect flight safety: In this class of aircraft, the aerodynamic V_x (speed of best climb gradient) is below $1.2 \cdot V_{S1}$. An increase in climb speed would therefore result in a decreased climb gradient, which would be detrimental to flight safety in a single engine aeroplane. This is not a prudent option. Addressing the Human Factor, an increase of the rotation speed will lead to a general dismissal of the recommended rotation speed and the pilot will follow the tendency of the airplane and make a liftoff prior the rotating speed, ignoring the stall warning. This again constitutes a nuisance warning.

In this light, the rotation speed of the DA 40 NG is increased to a justifiable value without compromising flight safety. In addition, a weight dependant rotation speed is introduced. With these airspeeds, the stall warning is set so that it will not activate during a normal takeoff on a calm day from a paved surface. A spurious activation of the stall warning during crosswind, gusts and operation on unpaved surfaces is consciously accepted. A note in the flight manual reflects this circumstance.

Stall warning during approach to stall

With the settings described above, the stall warning activates 5-11 kts before the stall event in most cases. In some cases – light weight, especially forward CG – the full 5kt margin can not be reached. The reason is evident in Figure 2. The aircraft decelerates with a rate of 1kt/s until the elevator reaches the back stop. After that, no more deceleration takes place and the airspeed increases again for the two seconds up to the stall. Due to this fact, a constant speed reduction to the stall cannot be obtained.





The stall warning activates prior to the back stop and therefore prior to the stall, but due to the fact that the airspeed increases after the back stop is reached does not give the 5kt margin in every weight-CG condition combinations.

A change in the stall warning schedule – to give a greater margin from the warning speed to the stall speed – would also increase the stall warning margin overall as well as having the stall warning active during all takeoff procedures, as described above.

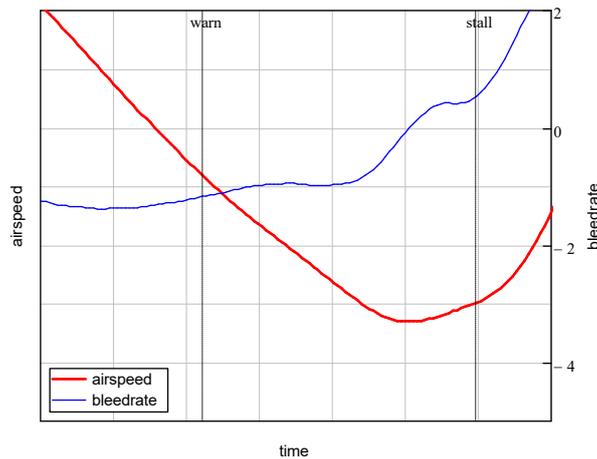


Figure 2: Stall warning during stall

In order to compensate for the fact that a constant deceleration of 1kt/s cannot be maintained after the control reaches the back stop up to the stall speed, but the stall warning requirement mandates a speed margin to the stall speed, a different method is introduced:

On a non-elevator limited aeroplane, a constant speed reduction of 1kt/s from the activation of the stall warning to the stall event for the minimum 5kt speed margin is equal to a *5s time margin* between stall warning and stall event. For the application of a stall warning margin to elevator limited aeroplanes, the same 5s time margin between the stall warning and stall event is considered equivalent, if the speed reduction is kept constant at 1kt/s up to the point where the control reaches the back stop.

DA 40 Service History related to Stall/Spin Accidents

The DA 40 series are produced since 2000 with more than 1400 units. They are used in a large number for flight training. Stall is a standard practice in flight training and numerous stalls exercises are performed in this environment

The variant DA 40 F is certified for intentional spin. The design is in principle the same but with different flight control settings and only in limited configurations. The flight campaign has been demonstrated that spin entry needs definitive pilot action. An entry into spin is only possible with a deliberate, large control input during the stall. This has been confirmed with the spin testing of the DA 40 NG.

The statistic shows no stall/spin accidents as a result of an inadvertent spin entry or delayed stall recovery.

Technical Solutions





The following technical solutions have been discussed and evaluated during the development of the DA 40 NG:

- Changing the stall warning schedule only
The required 5kt margin between stall warning and stall, together with an avoidance of the nuisance warnings, is only achieved in a certain weight band. A functioning stall warning (both for the 5kt margin between stall and warning as well as for the absence of early warnings) for a heavy weight was unusable for a light weight, and visa-versa.
- Additional Stall Stripes to create a natural warning (23.207(b))
One of the two existing stall strips the inner one was extended. No significant natural stall warning was produced.
- Extending the elevator travel
Increasing the elevator up travel would decrease the stall speed, therefore also increasing the margin between stall warning and stall. An increase in elevator travel aggravates both the stall behaviour and spin behaviour. This is detrimental to the overall safety of the aeroplane.
- Different type of aural warning
No other type of stall warning was considered. The prevalent stall warning systems used in general aviation aircraft are angle of attack sensors. All of them are subject to the same, fundamental issue encountered with the current system on the DA 40.

EQUIVALENT LEVEL OF SAFETY

The proposed, tested and discussed technical solutions have not adequately addressed the overall intent of the JAR/CS 23 with relation to the handling qualities and safety of the DA 40 NG airplane. Any solution has different disadvantages; therefore the following equivalent level of safety (ELOS) to 23.207(c) has been defined:

- For conditions, such as combinations of weight and CG, where 23.207(c) cannot be met, it must be demonstrated during the stall tests as required by JAR 23.201(b) and JAR 23.203(a)(1), that the aural stall warning activates not less than 3 knots prior the stall speed and must continue until the stall occurs.
- In addition, it must be demonstrated by tests that the inherent aerodynamic stalling qualities under that conditions must be such, that the pilot is able to take the averting action even with the reduced speed of warning. JAR/CS 23.201(d) and 23.203(b) must be met with the recovery initiated not less than 5s after the stall warning begins.

It is assumed that the requirements of JAR/CS 23.207 apply without any other deviation.





Introduction of SLPC for reciprocating engines improves safety by substantially reducing pilot workload and enhances engine performance and fuel efficiency by optimizing propeller torque and speed relations.

SLPC installations do not foresee independent adjustment of propeller torque, speed, and fuel scheduling as it is assumed in JAR 23.777 (d), 23.779 (b), 23.781 (b), and 23.1141 (a).

Therefore compliance with all the standards of above paragraphs (control location, control shape and colour for power, propeller speed, and mixture lever) cannot be demonstrated for SLPC installations.

3. ACG/PCA POSITION

ACG considers the required standards for the power lever, as set forth in JAR 23.777 (d), 23.779 (b), and 23.781 (b) (location, shape, color, motion and effect), appropriate for the only engine control lever of a SLPC installation.

Compliance of the SLPC installation with above mentioned power lever requirements will provide an equivalent level of safety and therefore fulfill JAR 23.1141 (a) with respect to JAR 23.777 (d).

Maximum Take Off Manifold Pressure as required by 23.33(d)(2) is considered as maximum Take Off Power.

To ensure the equivalent level of safety to existing split lever designs, means must be established for Power verification checks and propeller governing checks.





DISCUSSION

8. ACG/EASA POSITION

ACG/EASA consider the requirements of 23.1061 and 23.1063 applicable for the closed loop cooling system engine installation in the DA40, except that 23.1061(b) is not applicable for the expansion tank and the overflow bottle. 23.1063 must be demonstrated for the expansion tank only.

The installation requirements from the engine manufacturer must be met.

To ensure an equivalent level of safety to the general intent of 23.1061(b) for a safety margin in case of coolant fluid loss, the following applies:

- The expansion tank capacity with the overflow bottle must be large enough to ensure safe operation of the cooling system in case of cooling fluid loss during normal operation. This must be demonstrated by analysis and tests, unless a system is installed, that gives the pilot adequate indication of a low fluid level. The minimum and maximum fluid level must be established.
- The expansion tank and the overflow bottle must be able to withstand the vibration, inertia and fluid loads to which it may be subjected in operation.





DISCUSSION

9. ACG/EASA POSITION

JAR 23 addresses several paragraphs to reciprocating engines which uses conventional control and ignition systems. The general intent of JAR 23 covers also this engine if the electronic control of the fuel injection system is considered equivalent to an ignition system and the electronic engine control is considered equivalent to a mechanical engine control. The requirements of JAR-E/CS-E concerned are addressed by the approved engine installation requirement.

4. Electronic powerplant controls:

These engine designs are equipped with electronic powerplant control. ACG/EASA considers JAR 23.1141 and JAR 23.1143 basically designed for mechanical controls fully applicable also for this type of controls and compliance must be demonstrated.

5. Diesel principle without ignition:

Requirement for Ignition switches: This type of engine will not incorporate an ignition system. However for the Certification Team the electronic engine control system of this installation has the same critical function as an ignition system on a conventional reciprocating engine. Therefore the requirements of JAR 23.1145 shall be met by the Electronic engine control respectively.

6. Permanent electrical power:

23.1165: JAR 23 in its current issue covers the Airplanes with battery ignition system in 23.1165. The needs for permanent electrical power are identical to the ECU Electrical Power requirement. The Certification Team believes that the ECU System of this installation will fulfill the same critical function as the battery ignition system identified in 23.1165. Therefore the requirement of 23.1165 shall be met respectively.

The minimum requirement for the electrical power system is considered adequately addressed in 23.1309, 23.1351, 23.1353, 23.1357, 23.1359, 23.1361, 23.1365 and 23.1367.

The installation requirements for the engine as a result of the engine certification must be considered.

The engine qualified for the installation in the DA40 must be adequately defined by ECU, software and mapping-PNo. and Revision Status as addressed by the engine installation requirements..

ACG considers the use of electrical power generated by the engine electrical power system for aircraft electrical systems to be considered independent according to 1309(f) to achieve the same level of reliability and dependency as for conventional engine installations.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM	CRI:	E-11
	DIAMOND DA40	ISSUE:	Issue 5
		DATE:	13.01.10
		STATUS:	CLOSED

SUBJECT: Fuel System - Hot Fuel Temperature

REQUIREMENTS: 23.961, 23.1309

ADVISORY MATERIAL: -

POLICY REF.: -

PRIMARY GROUP/PANEL: Systems

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

Post TC

Equivalent Level of Safety/Acceptable Means of Compliance

STATEMENT OF ISSUE

The Diamond DA40 aeroplane shall be equipped with a reciprocating diesel engine (Thielert TAE-125 or Austro Engine E4), certified under JAR-E/CS-E.

These engines is certified for operation with diesel fuel and Jet A-1 fuel and any mixture thereof..

Certification requirements for use of Diesel fuel will be covered in CRI E-06.

Due to engine design a significant amount of return fuel flow at relatively high temperature (up to 80°C) is routed back to the main tank. In addition the installation of aluminum fuel tanks within the composite wing shells reduces the cooling capacity of the wing airflow compared to an integral metal fuel tank design.

The impact of elevated fuel temperature on fuel system hot weather operation, fuel tank flammability, and aircraft structure shall be covered by this CRI.





DISCUSSION

7. ACG/EASA POSITION

A) Fuel System Hot Weather Operation – Equivalent Level of Safety (ELOS)

Due to engine design high volume, high temperature fuel returns into the main tank. This might lead to significantly higher fuel temperatures in the tank as required by JAR23.961 for testing (fuel initially heated to 43°C).

- a) Diamond Aircraft (DAI) has to establish the maximum fuel temperature in the main tank likely to occur under most adverse normal operating conditions during a specified hot day. Also most adverse conditions in respect of main tank fuel content during maximum fuel temperature establishment have to be taken into consideration.
- b) Compliance with JAR23.961 has to be demonstrated with fuel initially heated to the maximum fuel temperature established under paragraph a) above.

B) Fuel Tank Flammability – Acceptable Means of Compliance (AMC)

Due to the expected elevated temperature level within the fuel tanks and the physical, chemical, and thermal properties of JET A-1 fuel an ignitable fuel/air vapor within the tank should be assumed during all aeroplane operating conditions.

During JAR23.1309 compliance showing for the aeroplane fuel system all possible ignition sources shall be taken into consideration.

Guidelines for the evaluation of possible ignition sources can be found in AC25.981-1B and DOT/FAA/AR-98/26.

C) Proof of Structure (Temperature Loading) – Acceptable Means of Compliance (AMC)

Evaluation of material strength properties for composite materials as a function of environmental conditions is regulated by CRI C-01 which was already used for initial DA40 certification.

Because of elevated temperatures of the fuel return flow surface temperatures of fuel system components might well exceed structural temperature limits imposed during initial DA40 certification. Influence on structure temperatures will be strongly depending on fuel system component arrangement and installation.

Therefore special attention should be paid on structural component temperatures resulting from fuel system component arrangement and installation under most adverse operating conditions and structural temperature limits evaluated according to CRI C-01.





 European Aviation Safety Agency	Certification Review Item DIAMOND AIRCRAFT INDUSTRIES DA 40 NG Fuel Pumps	Doc. No. : CRI E-12 Nature : SC/ESF Release : 1
		Revision : Issue 1 Date : 24 Mar 2010 Status : Closed

SUBJECT	:	Fuel Pumps
REQUIREMENTS	:	JAR 23.991(a), 23.991(b)
ADVISORY / GUIDANCE MATERIAL	:	-
POLICY REFERENCE	:	--
PRIMARY GROUP / PANEL	:	Powerplant
SECONDARY GROUPE / PANEL	:	Electric
CRI CLOSURE TARGET	:	--
NEXT ACTION BY	:	--

STATEMENT OF ISSUE

JAR 23.991 (a) (1), applicable for reciprocating engines, can not be directly complied with using Austro Engine E4 compression ignition (diesel) engines installed in the DA40NG.

JAR 23.991 (b) can not be complied with in the same way as in traditional reciprocating aircraft engine installations.

Therefore the applicant is requesting a special condition/equivalent safety finding under the provisions of Part 21, 21A.16B (b) and 21A.21(c)(2).

BACKGROUND

The Diamond DA40NG aeroplane shall be equipped with a Austro Engine E4 (AE300) compression ignition engine certified under CS-E (TC E.200).

A high pressure fuel pump, generating the required fuel rail pressure, is provided as part of the engine type design and directly driven by the engine. Nevertheless this pump requires a positive inlet supply pressure of 4 to 7 bar. To achieve this supply condition an electrically powered booster pump upstream of the fuel rail pressure pump is required during all engine operation. This booster pump is considered to be a main pump in the sense of 23.991(a).

For reciprocating engines 23.991 (a) (1) requires that at least one main pump per engine has to be directly driven by the engine. As the E4 engine does not provide any additional mechanical drive pads to attach a booster pump this paragraph can not be complied with.

23.991 (b) requires the power supply of the main pump and the emergency pump to be independent of each other. Traditionally this is being achieved by a mechanically powered main fuel pump, directly driven by the engine, and an electrically driven emergency pump. The DA40NG fuel system design does not comply with this traditional layout.





In the DA40NG installation 2 identical electrically powered booster pumps are installed in parallel. Each pump is dedicated to and controlled by one of the two Electronic Engine Control Units (EECU) channels. The pump dedicated to the channel in control is electrically powered and serves as the main pump as long as the channel remains in control. The other pump, controlled by the channel presently in standby mode, is either in standby or can be manually switched on and serves as an emergency pump. As soon as the control is, either automatically or manually, transferred from one channel to the other the dedicated pumps change their role also.

The emergency pump electrical supply system is designed such that the designated emergency pump is being powered, even if an EECU control channel swap takes place, as long as the emergency fuel pump switch is set to on.

The electrical system architecture of the DA40NG provides a dedicated electric bus for each ECU channel and its related fuel pump. Under normal conditions both busses are powered by either the aircraft main battery (battery master on, engine master switch off) or by the alternator (battery master on/off, engine master switch on). In addition the ECU B bus, which is isolated by diodes from the rest of the engine/aircraft electrical system, has an additional and independent power supply. This is the ECU backup battery.

In the case of a total electrical failure of the aircraft (battery) and engine (alternator) electrical system this ECU backup battery supplies at least 30 min of electrical power to the ECU B channel and its dedicated fuel pump, actuators and sensors.

DISCUSSION

EASA Position:

In the case that the applicant can not demonstrate compliance with 23.991 (a) (1) EASA considers following conditions appropriate for an equivalent safety finding:

Main pumps

Each fuel pump required for proper engine operation, or required to meet the fuel system requirements of this subpart (other than those in sub-paragraph (b)), is a main pump. In addition

1. If the main fuel pump is not directly attached to and driven by the engine then it has to be powered by a source which is directly driven by the engine, inherent to the engine system and remains available and operational even in the case that deliveries of engine system services to the airframe are discontinued.
2. Reliability of such a main pump drive system must be sufficiently equivalent to other essential services required by the engine.
3. There must be at least one main pump available for each engine independently of the engine control mode;
4. Failures and malfunctions of any main pump may not adversely affect operation of any other pump;
and





5. For each main pump, provision must be made to allow the by-pass of each positive displacement fuel pump other than the high fuel pressure pump approved as part of the engine.

In the case that the applicant can not demonstrate compliance with 23.991 (b) by providing two different fuel pump drive modes for the main and emergency pump (e.g. mechanical/electrical, hydraulic/electrical, etc.) EASA considers following conditions appropriate for an equivalent safety finding:

Emergency pumps

1. There must be an emergency pump immediately available to supply fuel to the engine if any main pump (other than the high fuel pressure pump approved as part of an engine) fails.
2. Failures and malfunctions of the emergency pump may not adversely affect operation of any other pump.
3. Main pump and emergency pump power supply systems must be sufficiently segregated to insure that failures and malfunctions in the emergency pump system does not impair functioning the main pump power supply system.
4. The reliability of the emergency pump system must be adequate for the class of aeroplane and the effect of a complete engine failure on the safety of flight.
5. If any advantage is taken from an automatic pump switching function during compliance showing then it must be obvious to the pilot by means of indication or/and annunciations if automatic pump switching is no longer adequately available (e.g. due to ECU channel or pump failures).
6. Adequate check procedures for maintenance and check and contingency procedures for operation have to be developed and published.

Supplying power to the main or emergency pump must be possible for at least 30 minutes after isolating the engine system from the aircraft system regardless of the state and functioning of the aircraft electrical system (e.g. aircraft master switch off).

Compliance showing for this CRI must be supported by tests demonstrating proper fuel pump and electrical supply switching capability and proper engine operation during and after these switching actions.





 European Aviation Safety Agency	CERTIFICATION REVIEW ITEM DIAMOND DA40	CRI:	F-05
		ISSUE:	Issue 7
		DATE:	26.01.2010
		STATUS:	CLOSED

SUBJECT: Powerplant Instruments

REQUIREMENTS: JAR 23.1305, 23.1521(b)(2),(c)(2)

ADVISORY MATERIAL:

POLICY REF.:

PRIMARY GROUPE/PANEL:

NEXT ACTION BY: ---

CRI CLOSURE TARGET: ---

POST TC

Equivalent Safety Finding

STATEMENT OF ISSUE

The Diamond DA40 aeroplane shall be equipped with a reciprocating diesel engine (Thielert TAE-125 or Austro engine E4) certified under JAR-E/CS-E. This engine is using a single power lever for engine power control, by adjusting the power output with fuel-metering and constant RPM control following an electronic datafield-control.

With the diesel principles a manifold pressure indicator is not an adequate indication of power output.

Some other limitations established by TAE/AE require additional indications.

DISCUSSION

4. ACG/PCA POSITION

It is assumed that the intent of powerplant Instruments is the following:

- The pilot must be able to monitor established engine limitations
- The pilot must be able to set and monitor engine power.
- Standardisation of engine instruments

Therefore ACG considers 23.1305 and 23.1521 applicable also for the installation of the TAE-125/ E4 diesel engine in the DA40 aeroplane except :

- Any indication required to monitor an established engine limitation must be





furnished unless it is shown that the limitation will not be exceeded in all intended operations, instead of 23.1305(p).

- A engine power output indicator instead of a manifold indicator required by 23.1305(h) and 23.1521(b)(2) ,(c)(2)
- A cooling fluid temperature indicator instead of a cylinder head indicator required by 23.1305(f)
- Indication required by CRI E-05 and E-06 due to the fuel used in the system equivalent to 23.1305(t) and (u).

JAR23.1305 (g) requires a fuel pressure indicator for fuel pump feed engines.

A low fuel pressure warning light in combination with a fuel flow meter is considered equivalent to a fuel pressure indicator. A fuel pressure warning light is an immediate warning for the pilot in case of fuel pressure loss.

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