CHAPTER 6
MASS AND BALANCE

6.1 INTRODUCTION

In order to achieve the performance and flight characteristics described in this Airplane Flight Manual and for safe flight operation, the airplane must be operated within the permissible mass and balance envelope.

The pilot is responsible for adhering to the permissible values for loading and center of gravity (CG). In this, he should note the movement of the CG due to fuel consumption. The permissible CG range during flight is given in Chapter 2.

The procedure for determining the flight mass CG position at any point in time is described in this Chapter. Over and above this there is a comprehensive list of the equipment approved for this airplane (Equipment List), as also a list of that equipment installed when the airplane was weighed (Equipment Inventory).

Before the airplane is delivered the empty mass and the corresponding CG position are determined, and entered in Section 6.3 - MASS AND BALANCE REPORT.

NOTE

Following equipment changes the new empty mass and the corresponding CG position must be determined by calculation or by weighing.

Following repairs or repainting the new empty mass and the corresponding CG position must be determined by weighing.

Empty mass, empty mass CG position, and the empty mass moment must be certified in the Mass and Balance Report by an authorized person.

NOTE

Refer to Section 1.6 - UNITS OF MEASUREMENT for conversion of SI units to US units and vice versa.

6.2 DATUM PLANE

The Datum Plane (DP) is a plane which is normal to the airplane's longitudinal axis and in front of the airplane as seen from the direction of flight. The airplane's longitudinal axis is parallel with the upper surface of a 600:31 wedge which is placed on top of the rear fuselage in front of the vertical stabilizer. When the upper surface of the wedge is aligned horizontally, the Datum Plane is vertical. The Datum Plane is located 2.194 meter (86.38 in) forward of the most forward point of the root rib on the stub wing.

6.3 MASS AND BALANCE REPORT

The empty mass and the corresponding CG position established before delivery are the first entries in the Mass and Balance Report. Every change in permanently installed equipment, and every repair to the airplane which affects the empty mass or the empty mass CG must be recorded in the Mass and Balance Report.

For the calculation of flight mass and corresponding CG position (or moment), the *current* empty mass and the corresponding CG position (or moment) in accordance with the Mass and Balance Report must always be used.

Condition of the airplane for establishing the empty mass:

- Equipment as per Equipment Inventory (see Section 6.5)
- Including brake fluid, lubricant (7.6 liter = 8 qts), plus unusable fuel (4 liter = approx. 1 US gal).

MASS AND BALANCE REPORT

(Continuous report on structural or equipment changes)

DA 40				Serial No.: 40.078				Registration: PH-45L			Page No.:		
				Changes in mass							Current Empty Mass		
	Entry No.		Description of Part or Modification	Addition (+)			Subtraction (-)						
Date	IN	OUT		Mass [kg]	Moment Arm [m]	Moment [kgm]	Mass [kg]	Moment Arm [m]	Moment [kgm]	Mass [kg]	Moment Arm [m]	Moment [kgm]	
26.03.01			upon delivery							769	1880	2443	
01-02 2015										769.4	2.443	1880	
										Lift gwk 1014			

6.4 FLIGHT MASS AND CENTER OF GRAVITY

The following information enables you to operate your DA 40 within the permissible mass and balance limits. For the calculation of the flight mass and the corresponding CG position the following tables and diagrams are required:

6.4.1 - MOMENT ARMS
6.4.2 - LOADING DIAGRAM
6.4.3 - CALCULATION OF LOADING CONDITION
6.4.4 - PERMISSIBLE CENTER OF GRAVITY RANGE
6.4.5 - PERMISSIBLE MOMENT RANGE

The diagrams should be used as follows, taking the fuel tank size into account:

Empty Mass

Take the empty mass and the empty mass moment of your airplane from the Mass and Balance Report, and enter the figures in the appropriate boxes under the column marked 'Your DA 40' in Table 6.4.3 - CALCULATION OF LOADING CONDITION.

Oil

The difference between the actual amount of oil in the engine (check with dipstick) and the maximum oil quantity is called 'Oil not added'; this mass and its related moment are counted as negative. The empty mass of the airplane is established with the maximum amount of oil in the engine, thus the 'missing' oil must be subtracted. If the airplane is flown with maximum oil, the 'Oil not added' entry should be zero.

In our example 6.0 qts have been measured on the dip-stick. We are thus 2.0 qts short of the maximum, which equates to 1.9 liter. Multiplying this quantity by the mass density of 0.89 kilograms per liter gives a mass of 'Oil not added' of 1.7 kg. (in US units: 2.0 qts multiplied by the mass density of 1.86 lb/qts gives a mass of 3.7 lb).

Baggage

The DA 40 may be equipped with one of the following baggage compartment variants:

(a) Standard baggage compartment.

(b) Standard baggage compartment with 'baggage tube'.

(c) Extended baggage compartment (OÄM 40-163). It consists of a forward and an aft part.

Depending on the baggage compartment variant installed in your DA 40 the following calculations must be done in Table 6.4.3 - CALCULATION OF LOADING CONDITION:

For variants (a) and (b) . . . . . use row 5 of the table; row 6 is filled with '0'

For variant (c) . . . . . use row 6 of the table; row 5 is filled with '0'

Fuel

a) Standard Tank:

The fuel quantity can be read on the fuel indicators.

NOTE

Depending on the type of fuel probes installed, the indicator can read a maximum of 15 US gal or 17 US gal (refer to Section 7.10 for details). When the fuel quantity indicator reads the maximum amount of fuel detectable, a fuel quantity up to 20 US gal can be in the fuel tank. In this case the fuel quantity must be measured with the fuel quantity measuring device (see Section 7.10 - FUEL SYSTEM).

b) Long Range Tank:

Read the fuel quantity indicated on the fuel quantity indicators.

NOTE

At an indication of 16 US gal the amount of auxiliary fuel can be determined by switching the AUX FUEL QTY switch to the respective position (LH or RH). The indicated auxiliary fuel quantity is added to the 16 US gal.

An auxiliary fuel quantity of less than 3 US gal cannot be indicated by the system. In this case the quantity must be determined by means of the fuel quantity measuring device (see Section 7.10 - FUEL SYSTEM).

CAUTION

The correct indication of the fuel quantity takes 2 minutes after actuation of the switch.

Moments

Multiply the individual masses by the moment arms quoted to obtain the moment for every item of loading, and enter these moments in the appropriate boxes in Table 6.4.3 - CALCULATION OF LOADING CONDITION.

Total Mass and CG

Add up the masses and moments in the respective columns. The CG position is calculated by dividing the total moment by the total mass (using row 7 for the condition with empty fuel tanks, and row 9 for the pre take-off condition). The resulting CG position must be within the limits.

CAUTION

For airplanes equipped with the optional Long Range Tank, a restricted range of permitted CG positions applies.

As an illustration the total mass and the CG position are entered on Diagram 6.4.4 - PERMISSIBLE CENTER OF GRAVITY RANGE. This checks graphically that the current configuration of the airplane is within the permissible range.

Graphical Method

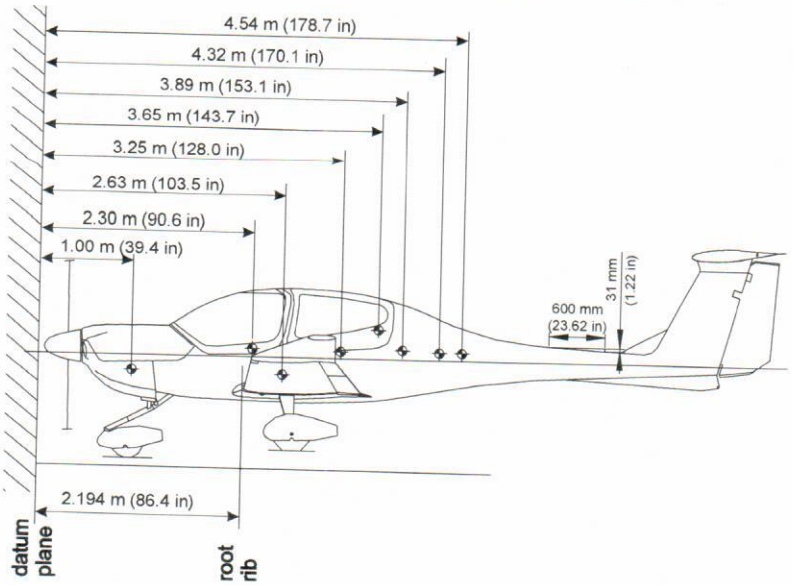
Diagram 6.4.2 - LOADING DIAGRAM is used to determine the moments. The masses and moments for the individual items of loading are added. Then Diagram 6.4.5 - PERMISSIBLE MOMENT RANGE is used to check whether the total moment associated with the total mass is in the admissible range.

The result found with the graphical method is however inaccurate. In doubtful cases the result must be verified using the exact method given above.

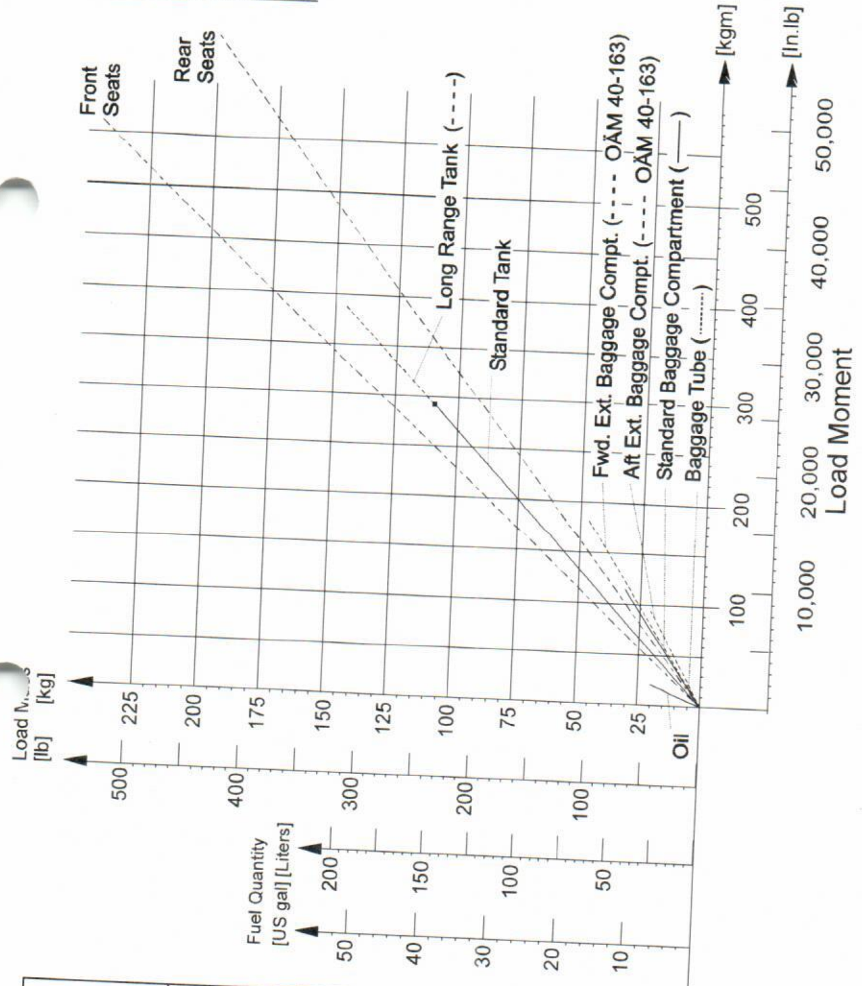
6.4.1 MOMENT ARMS

The most important lever arms aft of the Datum Plane:

- Oil	:	1.00 m	39.4 in
- Front seats	:	2.30 m	90.6 in
- Rear seats	:	3.25 m	128.0 in
- Wing tanks (Standard & Long Range)	:	2.63 m	103.5 in
- Baggage in standard baggage compartment	:	3.65 m	143.7 in
baggage in baggage tube	:	4.32 m	170.1 in
- Baggage in extended baggage compartment			
forward part	:	3.89 m	153.1 in
aft part	:	4.54 m	178.7 in



6.4.2 LOADING DIAGRAM



6.4.3 CALCULATION OF LOADING CONDITION

CAUTION

For airplanes equipped with the optional Long Range Tank, a restricted range of permitted CG positions applies.

NOTE

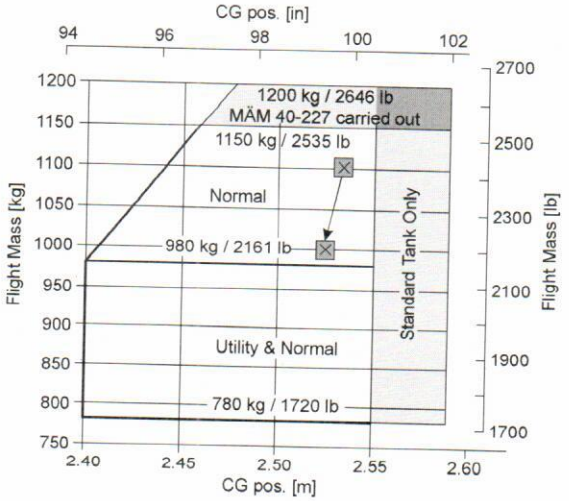
For the mass (weight) of the fuel, a density of 0.72 kg/liter (6.01 lb/US gal) is assumed. For the mass (weight) of the engine oil, a density of 0.89 kg/liter (1.86 lb/US qt, 0.84 kg/US qt) is assumed.

NOTE

In the following example it is assumed that the fuel tank is not full at take-off.

		DA 40 (Example)		Your DA 40	
		Mass [kg] [lb]	Moment [kg m] [in lb]	Mass [kg] [lb]	Moment [kg m] [in lb]
1	Empty mass (from Mass and Balance Report)	735 1620	1760 152,762	769.4	1880
2	Oil not added Lever arm: 1.00 m *(39.4 in)*	-1.7 -4	-1.7 -158		
3	Front seats Lever arm: 2.30 m *(90.6 in)*	150 331	345 29,989		
4	Rear seats Lever arm: 3.25 m *(128.0 in)*	75 165	243.8 21,120		
5	Standard baggage compt. Lever arm: 3.65 m *(143.7 in)*	0 0	0 0		
	Baggage tube Lever arm: 4.32 m *(170.1 in)*	0 0	0 0		
6	Fwd. extended baggage compartment Lever arm: 3.89 m *(153.1 in)*	27 60	105 9,186		
	Aft extended baggage compartment Lever arm: 4.54 m *(178.7 in)*	18 40	81.7 7,148		
7	Total mass & total moment with empty fuel tanks (Total of 1.-6.)	1003.3 2212	2533.8 220,047		
8	Usable fuel Lever arm: 2.63 m *(103.5 in)*	99.4 219	261.4 22,667		
9	Total mass & total moment including fuel (7. plus 8.)	1102.7 2431	2795.2 242,714		
10	The total moments from rows 7 and 9 (2533.8 and 2795.2 kgm) *(220,047 and 242,714 in.lb)* must be divided by the related total mass (1003.3 and 1102.7 kg respectively) *(2212 and 2431 lb)* and then located in Diagram 6.4.4 - PERMISSIBLE CENTER OF GRAVITY RANGE. As in our example CG positions (2.525 m and 2.535 m respectively) *(99.48 and 99.84 in)* and masses fall into the permitted area, this loading condition is allowable.				

6.4.4 PERMISSIBLE CENTER OF GRAVITY RANGE



The CG's shown in the diagram are those that from the example in Table 6.4.3 - CALCULATION OF LOADING CONDITION.

Forward Flight CG Limit:

2.40 m (94.5 in) aft of Datum Plane at 780 to 980 kg (1720 to 2161 lb)
2.46 m (96.9 in) aft of Datum Plane at 1150 kg (2535 lb)
linear variation between these values

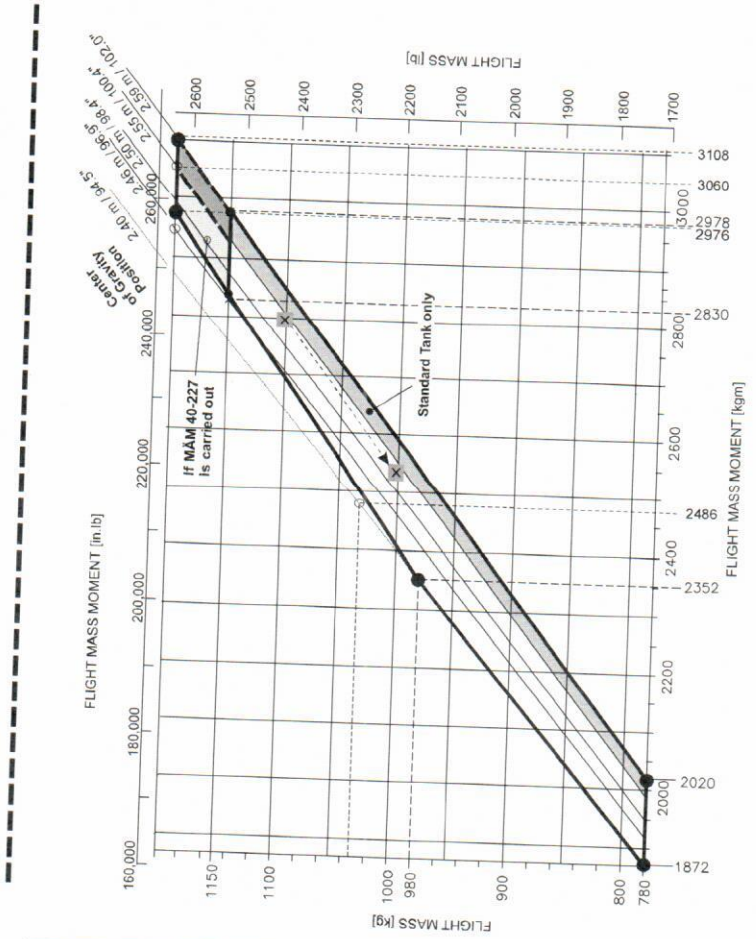
If MÄM 40-227 is carried out:

2.40 m (94.5 in) aft of Datum Plane at 780 kg to 980 kg (1720 lb to 2161 lb)
2.48 m (97.6 in) aft of Datum Plane at 1200 kg (2646 lb)
linear variation between these values

Rearward Flight CG Limit:

2.59 m (102.0 in) aft of Datum Plane (Standard Tank)
2.55 m (100.4 in) aft of Datum Plane (with Long Range Tank installed)

6.4.5 PERMISSIBLE MOMENT RANGE



6.5 EQUIPMENT LIST AND EQUIPMENT INVENTORY

All equipment that is approved for installation in the DA 40 is shown in the *Equipment List* below.

The items of equipment installed in your particular airplane are indicated in the appropriate column. The set of items marked as 'installed' constitutes the *Equipment Inventory*.

NOTE

The equipment listed below cannot be installed in any arbitrary combination. The airplane manufacturer must be contacted before removing or installing equipment, with the exception of replacing a unit by an identical unit.

Airplane Serial No.:	40078	Registration: PH-USL		Date: 12. Feb. 02	
Description	Type	Part No.	Manufacturer	S/N	instal led
LIGHTS					
Map/Reading light assy crew		W1461.0.010	Rivoret	N. A.	☑
Cabin light		W1461.0.010	Rivoret	N. A.	☑
Instr./Radio lights dimmer assy		WW-LCM-002	White Wire	N. A.	☑
Glareshield lamp assy		DA4-3311-10-01	DAI	N. A.	☑
Glareshield light inverter		APVL328-8-3-L-	Quantaflex	N. A.	☑
Strobe/Pos. light assy LH	A600-PR-D-28	01-0790006-05	Wheelen	N. A.	☑
Strobe/Pos. light assy RH	A600-PG-D-28	01-0790006-07	Wheelen	N. A.	☑
Strobe light power supply LH/RH	A490ATS-CF-	01-0770062-05	Wheelen	N. A.	☑
Taxi light	70346	01-0770346-05	Wheelen	N. A.	☑
Landing light	70346	01-0770346-03	Wheelen	N. A.	☑
Electroluminescent lamps	Quantaflex 1600		Quantaflex	N. A.	☑
NAVIGATION					
Pitot/Static probe, heated		DAI-9034-57-00	DAI	N. A.	☑
P/S probe HTR fail sensor		DA4-3031-01-00	DAI	N. A.	☑
Altimeter inHg/mbar, primary[5]		5934PD-3	United In.	422070	☑
Altimeter inHg/mbar, primary[5]	LUN 1128	1128-14B6	Mikrotechna		☐
Altimeter inHg/mbar, second.[5]		5934PD-3	United In.	423164	☑
Altimeter inHg/mbar, second.[5]	LUN 1128	1128-14B6	Mikrotechna		☐
Vertical speed indicator [6]		7000	United In.	295053	☑
Vertical speed indicator [6]	LUN 1144	1144-A4B4	Mikrotechna		☐
Airspeed indicator [1]		8025	United In.	179118	☑
Airspeed indicator [1]	LUN 1116	1116-B4B3	Mikrotechna		☐
Outside air temp. indic.		301F (C)	Davtron	A5131	☑
Magnetic compass		C2400L4P	Airpath	N.A.	☑
Compass system C/O[1]	KCS 55A		Bendix/King		
Slave gyro	KG 102 A	060-00015-0000	Bendix/King	47895	☑
HSI	KI 525A	066-03046-0007	Bendix/King	91479	☑
Slaving unit	KA 51B	071-01242-0001	Bendix/King	32783	☑
Flux valve	KMT 112	071-01052-0000	Bendix/King	64040	☑
Dir. gyro, free[5]	AIM2051BLD	5050031-931	BF-Goodrich		☐
Attitude indicator	AIM1100-28L	5040111-936	BF-Goodrich		☐
Attitude indicator	AIM1100-28LK	5040111-938	BF-Goodrich	25058	☑
Turn coordinator w/o AP pickup	1394T100-(3Z)		Mid Continent In.		☐
Turn coordinator	1394T100-(12RZ)		Mid Continent In.	2104-287	☑
Marker antenna	CI102		Comant	1074342	☑
DME	KN 62A	066-01068-0004	Bendix/King	30375	☑
DME antenna	KA60	071-01174-0000	Bendix/King	N.A.	☑
Transponder[2]	KT 76A	066-01062-0010	Bendix/King		☐
Transponder[6]	KT 76C	066-01156-0101	Bendix/King		—
XPDR antenna	KA60	071-01591-0001	Bendix/King	N.A.	☑
Altitude digitizer		D120-P2-T	TCI	77858	☑
ADF	KR87	066-01072-0004	Bendix/King	73228	☑
ADF antenna	KA44B	071-01234-0000	Bendix/King	76487	☑
ADF indicator	KI227	066-03063-0001	Bendix/King	60084	☑

6.5 EQUIPMENT LIST AND EQUIPMENT INVENTORY

The following items are added to the Equipment List:

Airplane Serial No.: 40078		Registration: PH-USL		Date: 10-05-09	
Description	**Type**	**Part No.**	**Manufacturer**	**S/N**	**in-stalled**
EQUIPMENT					
ELT unit	ME 406	453-6603	Artex		✓
ELT Buzzer		452-6505	Artex		✓
ELT Antenna	WHIP	110-773	Artex		✓
ELT Remote Switch (ACE)		453-0023	Artex		✓
ELT Module Interface		453-1101	Artex		✓

Airplane Serial No.:	40078	Registration:	PH-USL	Date:	12. Feb. 02

Description	Type	Part No.	Manufacturer	S/N	installed
NAV antenna coupler	CI505		Comant		☑
VOR/LOC/GS antenna		CI157P	Comant		☑
NAV/COM #1[1]	KX125	069-01028-1101	Bendix/King		☐
NAV/COM #1 volt conv.[1]	KA39	071-01041-0001	Bendix/King		☐
NAV #1[1]	KX155A	069-01032-0201	Bendix/King		☐
NAV #1[1]	KX165A	069-01033-0101	Bendix/King	1755	☑
NAV #2	KX155A	069-01032-0201	Bendix/King	20627	☑
CDI, VOR/LOC #1[5]	KI 208	066-03056-0000	Bendix/King		☐
CDI, VOR/LOC #2	KI 208	066-03056-0000	Bendix/King	71692	☑
GPS[10]	KLN 89B	066-01148-0102	Bendix/King		☐
GPS[10]	KLN 94	069-01034-0101	Bendix/King	1888	☑
GPS antenna	KA 92	050-03318-0000	Bendix/King	37772	☑
GPS/AP switch assy	MD41-528		Mid Continent	G21189	☑
ENGINE	IO-360 M1A		TextronLycoming	L-30226-51A	☑
ENGINE FUEL CONTROL					
Fuel flow transmitter	VM1000	3010032	Vision Microsyst.	N.A.	☑
Fuel pressure transmitter	VM1000	3010017	Vision Microsyst.	N.A.	☑
ENGINE IGNITION SYSTEM[11]					
SlickSTART booster	SS1001		Unison		☑
Lasar ignition controller	LC-1002-03	LC-1002-03	Unison		☐
Lasar ignition harness	LH-1004-43		Unison	N.A.	☐
Magneto RH/LH	4370/4347		Slick		☑
Magneto RH/LH	4770/4771		Slick		☐
ENGINE INDICATING					
RPM sensor	VM1000	3010005	Vision Microsyst.	N.A.	☑
Manifold pressure sensor	VM1000	3010016	Vision Microsyst.	N.A.	☑
Cyl. head temp. probes (4 each)	VM1000	1020061	Vision Microsyst.	N.A.	☑
EGT probes	VM1000	1020060	Vision Microsyst.	N.A.	☑
Data processing unit[12]	DPU	4010067	Vision Microsyst.		☐
Data processing unit[12]	DPU	4010081	Vision Microsyst.	78631	☑
Intergr. engine data display	VM1000	4010050	Vision Microsyst.	77959	☑
IO board assy[13]		3020003	Vision Microsyst.	N.A.	☐
IO board assy[13]		3020018	Vision Microsyst.	N.A.	☑
ENGINE OIL					
Oil temperature sensor	VM1000	3010021	Vision Microsyst.	N.A.	☑
Oil pressure transducer	VM1000	3010018	Vision Microsyst.	N.A.	☑
ENGINE STARTING					
Starter	149-24LS		SKYTEC	F4L-250107	☑

Airplane Serial No.:	40078	Registration:	PH-USL	Date:	12. Feb. 02

Description	Type	Part No.	Manufacturer	S/N	installed
PROPELLER	MTV-12-B/180-17		mt-Propeller	01472	☑
GOVERNOR	C-210776		Woodward		☐
TRANSPONDER	GTX 330		Garmin		✓
AIRPLANE FLIGHT MANUAL		Doc. No 6.01.01	DAI	N.A.	☑

Place: LOAN Date: 12. Feb. 02 Signature: Hr. Kienbink

1. One of the following COM #1 units may be installed:
   KX 125 (including KA 39) or KX 155A (OÄM 40-085) or KX 165A (OÄM 40-083).
2. One of the following intercoms may be installed:
   KMA 28 (OÄM 40-067) or PM 1000 II.
3. One of the following flight timers may be installed:
   Part No. 85094-12 (MÄM 40-029) or Part No. 85000-12.
4. One of the following Annunciator Panels may be installed:
   DAI Annunciator Panel or White Wire WW-IDC-001(OÄM 40-060).
5. One of the following altimeters may be installed as primary altimeter:
   United Instruments 5934PD-3 or Mikrotechna 1128-14B6.
   One of the following altimeters may be installed as secondary altimeter:
   United Instruments 5934PD-3 or Mikrotechna 1128-14B6.
6. One of the following vertical speed indicators may be installed:
   United Instruments 7000 or Mikrotechna 1144-A4B4.
7. One of the following airspeed indicators may be installed:
   United Instruments 8025 or Mikrotechna 1116-B4B3.

8. One of the following systems may be installed:
   Compass System KCS 55A (OÄM 40-067) or
   Directional Gyro AIM 205-1BLD (including CDI #1 KI 208; OÄM 40-055).
9. One of the following transponders may be installed:
   KT 76A or KT 76C (OÄM 40-067).
10. One of the following GPS units may be installed:
    KLN 89 or KLN 94 (VFR: OÄM 40-065; IFR: OÄM 40-067).
11. One of the following ignition systems may be installed:
    SlickSTART booster with Slick 4370/4347 magnetos (OÄM 40-073) or
    LASAR ignition controller & harness with Slick 4770/4771 magnetos.
12. On of the following combinations of DPU and I/O board assy. may be installed:
    DPU 4010067 with I/O board assy. 3020003 or
    DPU 4010081 with I/O board assy. 3020018 (MÄM 40-039/a)