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AUS OPERATIONS, FLIGHT PLANNING AND PERFORMANCE

CHAPTER 13
DESCENT AND CRUISE PERFORMANCE

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SECTION 6 – DESCENT AND CRUISE PERFORMANCE

6.1 THE DESCENT

It is important to know the position of Top of Descent (TOD), the time taken and the fuel required for flight planning purposes.

6.1.1 Graphical representation of descent data

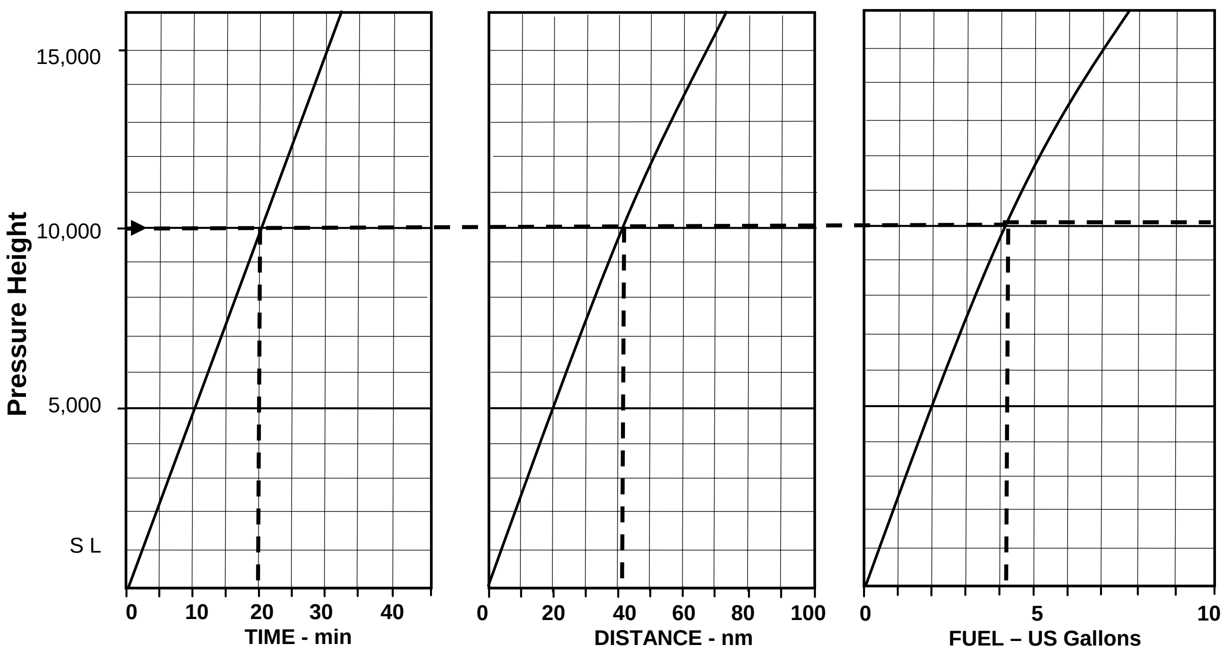
Refer to the Echo Mk IV "CRUISE-DESCENT PERFORMANCE" chart illustrated below.

This chart indicates the descent ETI, fuel and distance covered in ANM. The descent graph has NO TEMPERATURE or GROSS WEIGHT scale, as neither significantly affects an aircraft during the descent.

During descent the engine is at a low power setting so the effect of temperature variation is negligible, the main variable is the change of Pressure Altitude. Cruise-descents are therefore calculated from the Pressure Height at top of descent to the Pressure Height at bottom of descent.

The effect of wind is taken as an average, being the wind at the half-way level on descent.

CRUISE – DESCENT PERFORMANCE



Example 1

Refer to the graphs above and find the a) the time, b) the distance covered and c) the fuel used during a descent from 10,000 feet Pressure Height to sea level.

Method

a. Draw a horizontal line marking the PH (10,000 ft) through ALL three sections. This line will intersect with the lines plotted in each section.

b. From the intersection between the horizontal PH line and the first reference line in the first section, draw a vertical line downwards and read the descent ETI on the bottom scale (20 min).

c. From the intersection with the reference line in the middle section, draw a vertical line and read the descent distance (41nm).

d. From the intersection with the reference line in the third section draw a vertical line and read the descent fuel needed (4.2 US gals).

Answers -	**Time -**	**20 minutes**
	Distance -	**41 nm**
	Fuel used -	**4.2 US gallons**

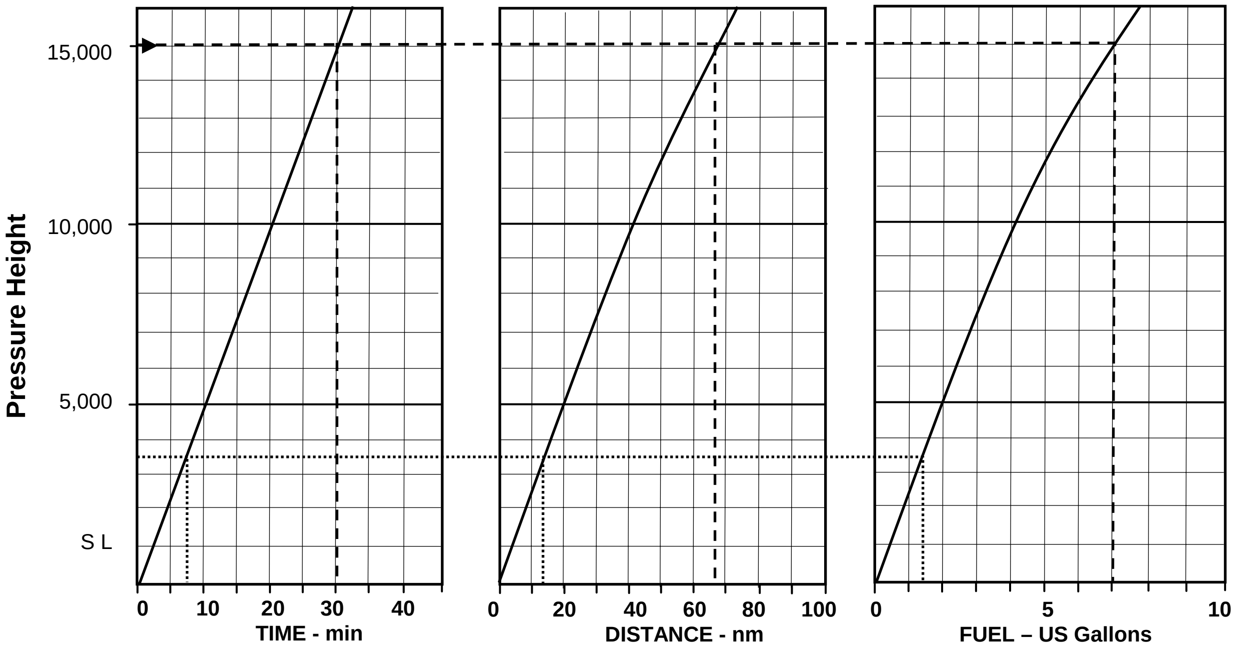
Not all descents will be to an aerodrome at MSL. When this occurs, the problem is approached in exactly the same manner as the Cruise- climb graph.
It is necessary to find the descent data from Top of Descent (TOD) to MSL and subtract the figures for a descent from the Bottom of Descent (BOD) down to MSL.

Example 2

Given the following information, refer to the graphs on the next page and find the a) time, b) distance covered and c) fuel used in NIL wind.

Cruise	FL 150
TOAT at FL 150	ISA + 10
Aerodrome Elevation	3,000 ft
Surface Temp	+30°C

CRUISE – DESCENT PERFORMANCE



Calculation

a. Determine the PH at TOD:

PH = 15,000 ft

b. Determine the PH at BOD:

PH = 1013 hPa - 995 hPa
= 18 hPa x 30 ft / hPa
= 540 ft variation from ISA
= 3,000 ft + 540 ft = 3,540 ft

c. Extract the data from the graph and tabulate.

V. Displacement	ETI (min.)	Distance(ANM)	Fuel (US Gal)
TOD to MSL	30.0	67.0	7.0
- BOD to MSL	7.0	13.0	1.5
TOD to BOD	23.0	54.0	5.5

Answers -

ETI – 23 minutes **Distance – 54 miles** **Fuel used – 5.5 US galls**

6.2 THE CRUISE

It is a legal requirement to carry sufficient fuel for the flight plus mandatory reserves.

We will not always fly with full tanks as when extra fuel is carried, the weight is increased with the associated effect upon performance. This in turn will affect the amount of fuel required. To operate the aircraft in as economical a manner as possible, make reference to the cruise data available when planning the flight.

6.2.1 Representation of Cruise Data – TAS

The TAS of an aircraft depends on:

a. the DENSITY HEIGHT the aircraft is operating at, *and* ….

b. the IAS

The IAS in turn depends on:

a. Gross weight (lift required)

b. Cruise configuration

c. Cruise power selection

Refer to the table from the Echo Mk IV "CRUISE PERFORMANCE (TWO ENGINES) shown below.

ECHO Mk IV CRUISE PERFORMANCE CHART (TWO ENGINES)

TAS (Kt)																
Press Ht.	Temp	Gross Weight														
		2950 Kg					2500 Kg					2000 Kg				
		Maximum continuous power														
		75%	65%	55%	45%	35%	75%	65%	55%	45%	35%	75%	65%	55%	45%	35%
SL	ISA - 20	177	165	156	142	116	180	168	159	145	118	184	171	161	149	120
5,000		185	172	160	145	116	188	172	163	147	119	192	178	166	151	121
10,000		193	179	165	147	117	196	182	168	150	119	201	185	171	153	122
15,000		201	185	169	149	116	204	189	173	152	117	209	193	177	155	120
20,000		209	193	174	150	-	213	197	178	154	-	217	201	182	157	-
SL	ISA	181	168	158	144	116	184	171	161	146	118	188	174	164	149	121
5,000		189	175	162	146	117	192	178	165	148	119	198	181	169	152	122
10,000		197	182	166	148	117	200	185	170	151	119	205	189	174	154	122
15,000		205	189	171	150	114	208	192	176	154	116	213	196	184	156	118
20,000		213	198	177	151	-	217	201	180	154	-	221	208	189	157	-
SL	ISA + 20	185	171	160	145	116	187	174	163	147	119	191	177	166	151	121
5,000		192	178	166	147	117	195	181	166	150	119	200	185	171	153	122
10,000		200	185	170	149	116	204	188	173	152	118	208	192	175	155	121
15,000		209	193	173	151	-	212	196	178	154	-	217	200	182	157	-
20,000		216	201	179	149	-	221	205	183	152	-	225	209	186	155	-

For a single engine cruise, the aircraft can be expected to cruise at 5,000 feet with a TAS of 110 kt and a fuel flow of 25 GPH.

The left PRESSURE HEIGHT column is repeated three times. The next column shows TEMP as an ISA deviation. There are three tables to extract the TAS from. One table gives the TAS at any given Pressure Height at ISA - 20 conditions, the next lower one gives the TAS under ISA conditions, the last one at ISA + 20 conditions.

If the temperature is in between the listed temperature values, it will be necessary to interpolate.
The top of the table indicates that the table is sub-divided again, according to GROSS WEIGHT. Each gross weight sub-division lists the TAS at the various available cruise power settings.

Example 1
Use the chart on the previous page to extract the TAS under the following conditions.

Gross Weight	2,500 kg
Cruise at	A050
QNH	1013 hPa
TOAT	ISA
Cruise Power	55%

a. A050 at 1013 hPa is a PH of 5,000 ft. The temperature is ISA. Go to the ISA rows and read across the row for 5,000 feet.

b. Find the section representing the Gross Weight of 2,500 kg. In this section find the power setting for 55%.

c. Move downwards and find where the horizontal entry (5,000 ft - ISA) intersects the vertical entry (2,500 kg - 55% power). Extract the result (TAS 165 kt).

Answer - 165 kt.

Example 2

Refer to the chart below and find the TAS using the listed conditions.

Gross Weight	2,725 kg
Cruise at	FL 150
TOAT	ISA - 20
Power	45%

ECHO Mk IV CRUISE PERFORMANCE CHART (TWO ENGINES)

TAS (Kt)																
Press Ht.	Temp	Gross Weight														
		2950 Kg					2500 Kg					2000 Kg				
		Maximum continuous power														
		75%	65%	55%	45%	35%	75%	65%	55%	45%	35%	75%	65%	55%	45%	35%
SL	ISA - 20	177	165	156	142	116	180	168	159	145	118	184	171	161	149	120
5,000		185	172	160	145	116	188	172	163	147	119	192	178	166	151	121
10,000		193	179	165	147	117	196	182	168	150	119	201	185	171	153	122
15,000		201	185	169	149	116	204	189	173	152	117	209	193	177	155	120
20,000		209	193	174	150	-	213	197	178	154	-	217	201	182	157	-
SL	ISA	181	168	158	144	116	184	171	161	146	118	188	174	164	149	121
5,000		189	175	162	146	117	192	178	165	148	119	198	181	169	152	122
10,000		197	182	166	148	117	200	185	170	151	119	205	189	174	154	122
15,000		205	189	171	150	114	208	192	176	154	116	213	196	184	156	118
20,000		213	198	177	151	-	217	201	180	154	-	221	208	189	157	-
SL	ISA + 20	185	171	160	145	116	187	174	163	147	119	191	177	166	151	121
5,000		192	178	166	147	117	195	181	166	150	119	200	185	171	153	122
10,000		200	185	170	149	116	204	188	173	152	118	208	192	175	155	121
15,000		209	193	173	151	-	212	196	178	154	-	217	200	182	157	-
20,000		216	201	179	149	-	221	205	183	152	-	225	209	186	155	-

a. The GW of 2,725 kg is in between 2,950 kg and 2,500 kg.

b. The TAS at 2,950 kg is 149 kt. The TAS at 2,500 kg is 152 kt.

c. The TAS at 2,725 kg = (149kt + 152 kt) / 2 = 150.5 = 151 kt.

Answer - 151 kt

Example 3

Refer to the chart above and find the TAS using the listed conditions.

Gross Weight	2,500 kg
Cruise at	FL 135
TOAT	ISA
Power	55%

a. FL 135 is between 10,000 ft PH and 15,000 ft. The temperature is ISA.

b. First find the TAS at 2,500 kg GW and 10,000 ft ISA = 170 kt

c. Find the TAS at 2,500 kg GW and 15,000 ft: ISA = 176 kt

d. Calculate how many ft the cruise PH is above 10,000 ft:

13,500 ft - 10,000 ft = 3,500 ft

e. Find how much the TAS increases per foot between 10,000 ft and 15,000 ft by dividing the DIFFERENCE IN TAS by the difference in height. The result is then multiplied by 3,500 ft to find the amount by which the TAS increases from 10,000 ft to the cruise PH of 13,500 feet:

$$\frac{176\text{ kt} - 170\text{ kt}}{5{,}000\text{ ft}} \times 3{,}500\text{ ft} = 4.2\text{ kt}$$

f. Add the TAS increase to the 10,000 ft TAS:

170 kt + 4.2 kt = 174.2 kt = 174 kt

Answer - 174 kt.

In some cases it may be advantageous to convert all the PRESSURE HEIGHTS into DENSITY HEIGHTS to reduce the number of interpolation exercises. By entering the chart at Pressure Height and ISA temperature a DENSITY HEIGHT is being used.

Example 4

Refer to the chart on the previous page and find the TAS using the listed conditions.

Gross Weight	2,500 kg
QNH	1013.2 hPa
TOAT	ISA + 20
Cruise Power	45%

a. Find the cruise DENSITY HEIGHT:

PH = 10,000 ft; ISA Deviation = ISA + 20

DH = 10,000 ft + (+ 20 x 120)

= 12,400 ft

b. 12,400 ft is between 10,000 ft and 15,000 ft. Calculate the number of feet the DH of 12,400 ft is above 10,000 ft:

12,400 ft - 10,000 ft = 2,400 ft

c. Find the TAS at 10,000 ft ISA = 151 kt

d. Find the TAS at 15,000 ft, ISA = 154 kt

e. Find the difference in the TAS between 10,000 ft and 15,000 ft:

154 kt - 151 kt = 3 kt

f. Find the TAS increase from 10,000 ft to 12,400 ft:

$$\frac{3\text{ kt}}{5{,}000\text{ ft}} \times 2{,}400\text{ ft} = 1.44\text{ kt} = 1\text{ kt}$$

g. Add the TAS increase to the TAS at 10,000 ft:

151 kt + 1 kt = 152 kt TAS

Answer - 152 kt

By using the ISA + 20 table and comparing the values extracted using the table, it will be found that the results are identical.

In the previous example it would have been easier to use the ISA + 20 table. However, usually ISA deviations fall in between the tabulated values.

When selecting a cruise power setting, it is necessary to find the DH. It may save time to use DH in the ISA table.

During the cruise the Gross Weight of the aircraft will reduce due to Fuel Burn Off (FBO). Maintaining a given power setting would result in a constant increase in TAS.

To avoid problems for planning, divide the flight into several SEGMENTS or ZONES. Estimate the FBO per zone and subtract half of that FBO from the estimated GW at the start of the zone (ESTIMATED START ZONE WEIGHT – (ESZW). The result is the ESTIMATED MID ZONE WEIGHT (EMZW). If the flight is planned on the EMZW the TAS can be used as an average for that zone.

6.2.2 Representation of Cruise Performance - Power Setting

In order to maintain a certain TAS and Fuel Flow, it is necessary to find the cruise power setting to be used.

Refer to the Echo Mk IV Manual PERFORMANCE CHART shown on the next page. This chart indicates the RPM, Manifold Pressures and Fuel Flow (FF) for various power settings and altitudes.

The power setting selected is as a percentage of maximum continuous power. The setting must be from within the heavy border for each altitude.

This table is presented for Pressure Height at ISA temperatures. When using it, enter with Density Height to find correct values for manifold pressure.

For a given RPM and percentage power, the Manifold Pressure will change for lean or rich mixtures. The Fuel Flow will depend on the mixture setting.

The Fuel Flow given on the chart is for ONE ENGINE ONLY. The Echo Mk IV is a twin engine aircraft and for normal operations the total fuel flow will be double the figure presented in the chart.

Note:

The figures enclosed within the heavy lines in the chart are the settings for recommended cruise operation. RICH mixture must be used for all power settings higher than those recommended for cruise.

ZULU MK XV ENGINE PERFORMANCE CHART

Pressure Height	Power	3200	3000	2800 RPM		2600 RPM		2400 RPM		2200 RPM		Power	Fuel flow	
		Rich	Rich	Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean	%	Rich	Lean
	%	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg		GPH	GPH
Zero	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	26.5	26.9	28.7	28.7	29.3	30.2	31.8	32.7	-	-	75	19.7	16.3
	65	23.1	23.5	24.9	24.9	25.9	26.4	28.4	28.9	-	-	65	16.9	14.0
	55	19.9	20.3	21.2	21.5	22.7	23.0	25.2	25.5	29.9	30.2	55	14.1	11.8
	45	-	17.4	18.3	18.4	19.8	19.9	22.3	22.4	27.0	27.1	45	11.8	10.2
	35	-	-	-	-	16.4	16.5	18.9	19.0	23.6	23.7	35	9.3	8.6
5,000 feet	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	26.0	26.4	27.3	28.2	28.8	29.7	31.3	32.2	-	-	75	19.7	16.3
	65	22.6	23.0	23.9	24.4	25.4	25.9	27.9	28.4	-	-	65	16.9	14.0
	55	19.4	19.8	20.7	21.0	22.2	22.5	24.7	25.0	29.4	29.7	55	14.1	11.8
	45	-	-	17.8	17.9	19.3	19.4	21.8	21.9	26.5	26.6	45	11.8	10.2
	35	-	-	-	-	15.9	16.0	18.4	18.5	23.1	23.2	35	9.3	8.6
10,000 feet	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	25.5	25.9	26.8	27.7	28.3	29.2	-	-	-	-	75	19.7	16.3
	65	22.1	22.5	23.4	23.9	24.9	25.4	27.4	27.9	-	-	65	16.9	14.0
	55	18.9	19.3	20.2	20.5	21.7	22.0	24.2	24.5	28.9	29.2	55	14.1	11.8
	45	-	-	-	-	18.8	18.9	21.3	21.4	26.0	26.1	45	11.8	10.2
	35	-	-	-	-	15.4	15.5	17.9	18.0	22.6	22.7	35	9.3	8.6
15,000 feet	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	25.0	25.4	26.3	27.2	27.8	28.7	-	-	-	-	75	19.7	16.3
	65	21.6	22.1	22.9	23.4	24.4	24.9	26.9	27.4	-	-	65	16.9	14.0
	55	18.4	18.8	19.7	20.0	21.2	21.5	23.7	24.0	-	-	55	14.1	11.8
	45	-	-	-	-	18.3	18.4	20.9	21.0	25.5	25.6	45	11.8	10.2
	35	-	-	-	-	-	-	17.4	17.5	22.1	22.2	35	9.3	8.6
20,000 feet	100	29.0	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	24.6	25.0	-	-	-	-	-	-	-	-	75	19.7	-
	65	21.2	21.7	22.5	23.0	-	-	-	-	-	-	65	16.9	14.0
	55	18.0	18.4	19.3	19.6	20.8	21.1	23.3	23.6	-	-	55	14.1	11.8
	45	-	-	-	-	17.9	18.0	20.5	20.6	-	-	45	11.8	10.2

Example 1

What is the correct MP and predicted fuel flow under the following conditions?

Cruise Density Height	5,000 ft
Selected Power	55%
Selected RPM	2,600
Mixture	lean

ZULU MK XV ENGINE PERFORMANCE CHART

Pressure Height	Power %	3200	3000	2800 RPM		2600 RPM		2400 RPM		2200 RPM		Power %	Fuel flow	
		Rich	Rich	Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean		Rich	Lean
		"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg		GPH	GPH
Zero	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	26.5	26.9	28.7	28.7	29.3	30.2	31.8	32.7	-	-	75	19.7	16.3
	65	23.1	23.5	24.9	24.9	25.9	26.4	28.4	28.9	-	-	65	16.9	14.0
	55	19.9	20.3	21.2	21.5	22.7	23.0	25.2	25.5	29.9	30.2	55	14.1	11.8
	45	-	17.4	18.3	18.4	19.8	19.9	22.3	22.4	27.0	27.1	45	11.8	10.2
	35	-	-	-	-	16.4	16.5	18.9	19.0	23.6	23.7	35	9.3	8.6
5,000 feet	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	26.0	26.4	27.3	28.2	28.8	29.7	31.3	32.2	-	-	75	19.7	16.3
	65	22.6	23.0	23.9	24.4	25.4	25.9	27.9	28.4	-	-	65	16.9	14.0
→	55	19.4	19.8	20.7	21.0	22.2	22.5	24.7	25.0	29.4	29.7	55	14.1	11.8
	45	-	-	17.8	17.9	19.3	19.4	21.8	21.9	26.5	26.6	45	11.8	10.2
	35	-	-	-	-	15.9	16.0	18.4	18.5	23.1	23.2	35	9.3	8.6

Note: Only part of the chart has been reproduced for use in this example. The relevant columns have been highlighted for easy reference.

Solution

a. Enter the table at the black arrow in the Pressure Height column with DH 5,000 ft at 55% power and draw a line horizontally through the table.

b. Find on the top the column representing 2,600 RPM and LEAN mixture. Move vertically downwards until intersecting the horizontal height reference. The required MP is 22.5"Hg

c. Enter the Fuel Flow column at LEAN mixture and move vertically downwards until intersecting the height line.

Answer - The fuel flow is 11.8 Gal / hr / engine x 2 = **23.6 US Gal / h total**

Example 2

Refer to the table and find the MP and total FF under the following conditions:

Cruise at	FL 130
TOAT	ISA + 8
Power setting	45%
Mixture	Lean
RPM	2,400

ZULU MK XV ENGINE PERFORMANCE CHART

Pressure Height	Power %	3200	3000	2800 RPM		2600 RPM		2400 RPM		2200 RPM		Power %	Fuel flow	
		Rich	Rich	Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean		Rich	Lean
		"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg	"Hg		GPH	GPH
10,000 feet	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	25.5	25.9	26.8	27.7	28.3	29.2	-	-	-	-	75	19.7	16.3
	65	22.1	22.5	23.4	23.9	24.9	25.4	27.4	27.9	-	-	65	16.9	14.0
	55	18.9	19.3	20.2	20.5	21.7	22.0	24.2	24.5	28.9	29.2	55	14.1	11.8
	45	-	-	-	-	18.8	18.9	21.3	21.4	26.0	26.1	45	11.8	10.2
	35	-	-	-	-	15.4	15.5	17.9	18.0	22.6	22.7	35	9.3	8.6
15,000 feet	100	34.5	-	-	-	-	-	-	-	-	-	100	31.7	-
	75	25.0	25.4	26.3	27.2	27.8	28.7	-	-	-	-	75	19.7	16.3
	65	21.6	22.1	22.9	23.4	24.4	24.9	26.9	27.4	-	-	65	16.9	14.0
	55	18.4	18.8	19.7	20.0	21.2	21.5	23.7	24.0	-	-	55	14.1	11.8
	45	-	-	-	-	18.3	18.4	20.9	21.0	25.5	25.6	45	11.8	10.2
	35	-	-	-	-	-	-	17.4	17.5	22.1	22.2	35	9.3	8.6

Note: Only part of the chart has been reproduced for use in this example. The relevant columns have been highlighted for easy reference

a. Find the cruise DH:

PH = 13,000 ft

DH = 13,000 ft + (+8 x 120)

= 13,960 ft

b. Interpolate between 10,000 feet and 15,000 feet:

13,960 ft - 10,000 ft = 3,960 ft higher than 10,000 ft.

At 10,000 ft MP = 21.4" and FF = 10.2 x 2 = 20.4 Gal/h.

At 15,000 ft MP = 21.0" and FF = 10.2 x 2 = 20.4 Gal/h.

MP drops 0.4"Hg in 5,000 feet.

(0.4" / 5,000ft) x 3,960 ft = 0.31

= 0.3" drop to 13,960 ft.

21.4" at 10,000 ft - 0.3" drop = 21.1 " MP at 13,960 ft.

Answer - MP 21.1" Hg. FF = 20.4 US Gal/h.