FUEL CALCULATIONS

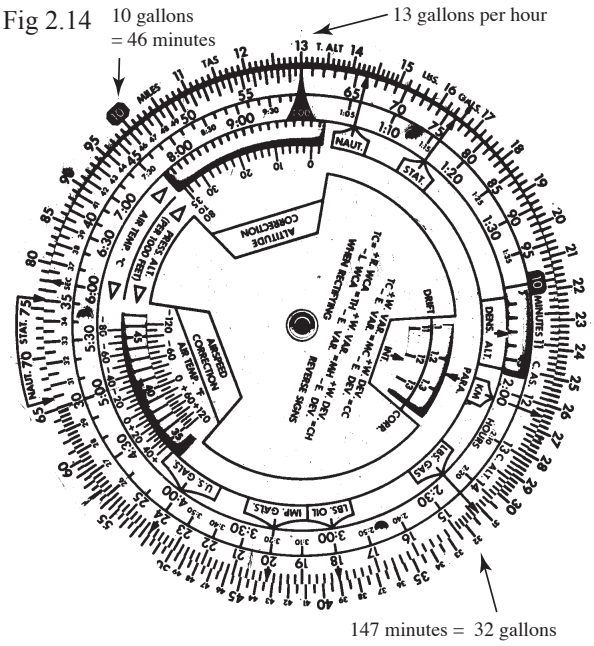
You don't need me to tell you that the calculation of fuel required for a particular flight is very high on the priority list of flight planning considerations. Fortunately the calculation is simple. If you know the fuel consumption rate [fuel flow] during cruise and the time interval for the flight, the fuel that will be consumed can be calculated on your flight computer. The calculation is exactly the same as the speed, time and distance calculations that we have just discussed, except that instead of dealing with a number of miles per hour, we are considering a number of gallons or litres per hour - the arithmetic is the same. The fuel flow for your aeroplane is found in the Owner's Manual performance section, which lists the fuel flow to expect for various power settings. The time interval can be calculated as in the examples on page 20 to 23.

EXAMPLE

The estimated time interval [ETI] for a flight has been calculated as 147 min. If the fuel flow during cruise is 13 gph, how much fuel will be consumed during the flight?

SOLUTION

Fig 2.14



Consider the outside scale on the computer [the one that you called miles in the speed, time and distance problems]. This scale now represents gallons [or litres, if you are working in litres]. Locate the hour marker on the minutes scale and place it against the number of gallons per hour - in this case 13 [Fig 2.14].

Now locate 147 on the minutes scale [the inside, moving scale]. Against this read the number of gallons that will be consumed during the flight - between 31.5 and 32 gal. We would call it 32 gal. If you know the number of gallons you have to burn, you can calculate the number of minutes it will take to burn them. In the example above, how many minutes would it take to burn 10 gallons?

SOLUTION

Locate 10 on the gal scale [outside scale] and read 46 min against it on the inside scale. 10 gal would last 46 min at this consumption rate.

EXERCISE N 5

Supply the missing values in the table below.

GPH	MIN	GAL
9.0	150	--------
14.0	--------	32
8.5	73	--------
11.4	--------	55

Answers to Exercise N5

23 gal
137 min
10.4 gal
290 min

RESERVES AND MARGIN FUEL

The actual fuel that we expect to consume in flight is called the **fuel flow**. You may have noticed that we have ignored the extra fuel that would be burnt in climb. For light general aviation aircraft, operating below 10 000 ft, if we ignore the climb and the descent and plan the whole flight at cruise rate, the resulting Trip fuel is quite accurate enough in practice. Your instructor may show you some "rules of thumb" that are often used to fine tune the figure a little, however, in the examination and in the rest of the exercises in this course, we simply ignore the climb and descent when calculating Trip fuel.

Having calculated Trip fuel, I think you would agree that it would be a very brave/bold pilot who then departed on the proposed flight with just that much fuel in the tanks! Both the law, regulation 234 of the Civil Aviation Regulations, and common sense demand that the pilot and operator of the aircraft take reasonable steps to ensure that sufficient fuel and oil is carried to ensure that the proposed flight may be undertaken *safely.*

It is left to the pilot and/or operator to decide what 'reasonable steps' should be taken however, the CAA have issued a Civil Aviation Advisory Publication [CAAP] which suggests standards which it believes would be regarded by a court as being 'reasonable'.

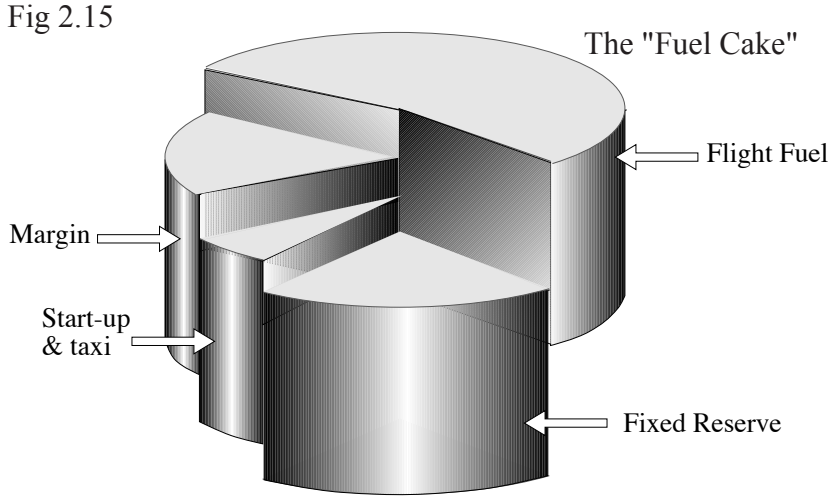
Most operators require a fixed number of gallons or litres to be added to the Trip fuel to allow for unexpected delays in landing such as circuit congestion, go arounds, or holding due to a preceding aircraft being unable to vacate the runway etc. Sometimes the fixed reserve is specified as a number of minutes of flying time, typically 45 min. Often an additional allowance is made for the fuel used in start up, taxi and engine run up [Fig 2.15].

EXAMPLE
Your operator requires you to carry a fixed reserve of 45 min at cruise consumption rate, and 2 gal start up and taxi allowance. What is the minimum fuel required for a flight with an ETI of 133 min if the fuel flow in cruise is 12 gph?

SOLUTION.

Trip fuel	133 min @ 12 gph	= 27 gal
Fixed reserve	45 min @ 12 gph	= 9 gal
Start up/taxi		= 2 gal
Minimum fuel required		= 38 gal

Fig 2.15

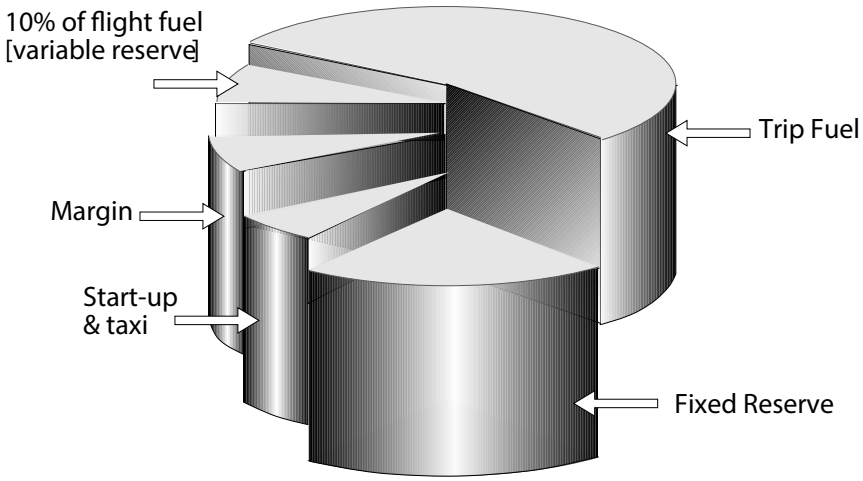


If you carry more than the minimum fuel, any fuel you have over and above the 38 gal required is referred to as the margin.

USING A VARIABLE RESERVE

In addition to the fixed reserve, some operators require the Trip fuel to be increased by a fixed percentage, usually 10%, to allow for en-route factors such as unexpected headwinds, diversions around weather, excursions off the planned track etc. Because the amount of additional fuel required varies with the original Trip fuel, this is known as a variable reserve [Fig 2.16].

Fig 2.16



The minimum fuel required for a flight that requires a variable reserve is found by multiplying the Trip fuel by 1.1, this increases it by 10%, or by finding 10% of the Trip fuel and adding it on along with the fixed reserve and the taxi allowance if applicable. To return to the example on the previous page, if a variable reserve of 10% had applied, the minimum fuel required would have been:

SOLUTION

Trip fuel	133 min @ 12 gph	= 27 gal
Variable reserve	10% of 27	= 2.7 gal
Fixed reserve	45 min @ 12 gph	= 9 gal
Start up/taxi		= 2 gal
Minimum fuel required		= 40.7 gal

or

Trip fuel 27 gal x 1.1		= 29.7 gal
Fixed reserve	45 min @ 12 gph	= 9 gal
Start up/taxi		= 2 gal
Minimum fuel required		= 40.7 gal

IFR flights and charter flights usually carry the 10% variable reserve but there is no reason why an operator cannot require it on all flights.
As far as the examination is concerned, you will be told by the examiner exactly what the fuel policy is. However, the normal state of affairs in examinations is that the variable reserve will not be applied to private flights, therefore questions at the PPL level will not specify a variable reserve, while questions at the CPL level normally will.

FINDING THE SAFE ENDURANCE WITHOUT A VARIABLE RESERVE

Instead of finding the Trip fuel *required* for a particular flight, you may sometimes wish to find the maximum Trip fuel *available.* That is, given the actual fuel on board at start up, put the reserves aside and find the maximum fuel that may now be used as Trip fuel. If we then apply the cruise fuel consumption rate to that Trip fuel, we can find how many minutes that fuel would represent. The time for which we can fly on the Trip fuel available is called the safe endurance.

EXAMPLE This time we'll work in litres [l]

Given

Total fuel on board at start up	200	l
[No variable reserve required]		
Fixed reserve required by operator	40	l
Start up & Taxi allowance	5	l
Fuel flow in cruise	45	lph

Find the maximum Trip fuel available and the safe endurance.

SOLUTION

Total fuel on board at start up	= 200	l
Less the fixed reserve of 40 lt	= 160	l
Less the start up & taxi allowance	= 155	l
Maximum Trip fuel available	= 155	l
@ 45 lph	= 207	min
The safe endurance	**= 207**	**min**

FINDING THE SAFE ENDURANCE WITH A VARIABLE RESERVE

Now let's rework the exercise above and include a requirement for a 10% variable reserve.

SOLUTION

Total fuel on board at start up	= 200	l
Less the fixed reserve of 40 lt	= 160	l
Less the start up & taxi allowance	= 155	l
110% of Trip fuel available	= 155	l
Trip fuel available 155÷1.1	= 141	l
& 45 lph	= 188	min
The safe endurance	**= 188**	**min**