DOCUMENT
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DOCUMENT TITLE
GENERAL OPERATIONS, FLIGHT PLANNING AND PERFORMANCE

CHAPTER 9 – PRESSURE ALTITUDE

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CONTENTS .... PAGE

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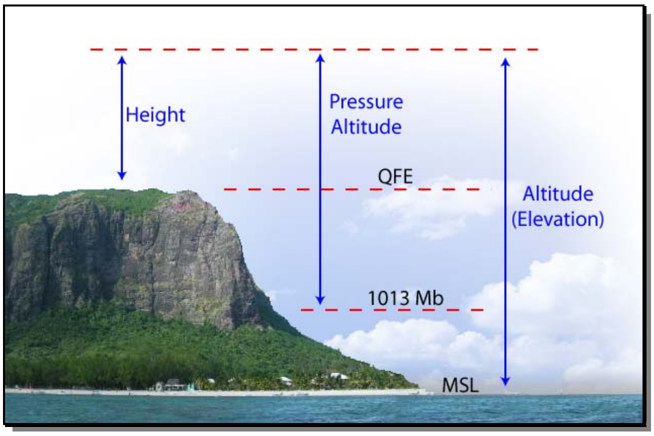
PRESSURE ALTITUDE

INTRODUCTION

Pressure altitude is the height above a standard datum plane. The aircraft altimeter is essentially a sensitive barometer calibrated to indicate altitude in the standard atmosphere. If the altimeter is set for 1013.25 hPa Standard Datum Plane (SDP), the altitude indicated is the pressure altitude, i.e. the altitude in the standard atmosphere corresponding to the sensed pressure.

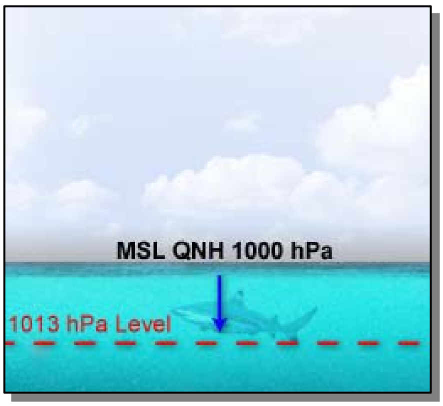


In other words, the SDP is a theoretical level where the weight of the atmosphere is 1013.25 hPa as measured by a barometer. As atmospheric pressure changes, the SDP may be below, at, or above sea level. Pressure altitude is important as a basis for determining aircraft performance as well as for assigning flight levels to aircraft.

The pressure altitude can be determined by either of two methods:

- By setting the barometric scale of the altimeter to 1013.25 hPa and reading the indicated altitude, or
- By applying a correction factor to the indicated altitude according to the reported "altimeter setting".

A QNH of 1000 hPa means that the pressure at MSL is 1000 hPa. The 1013 hPa pressure level will be below MSL because pressure reduces with increasing height and increases with reducing height.



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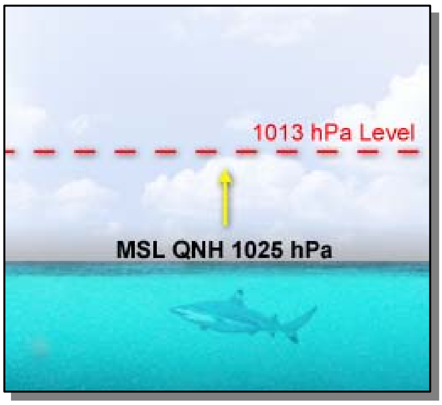


Similarly if the QNH is higher than 1013 hPa, say 1025 hPa, the 1013 hPa pressure level is above MSL.

PRESSURE HEIGHT CALCULATIONS

When close to sea-level air pressure reduces by about 1 hPa for every 30 feet increase in height. By accepting this approximation, the difference in feet between MSL and the 1013 hPa pressure level can be calculated.

Example 1

When the QNH is 1001 hPa, the 1013 hPa level is below MSL.

The difference in pressure (hPa) between 1013 hPa and MSL:

= 1013 hPa - 1001 hPa

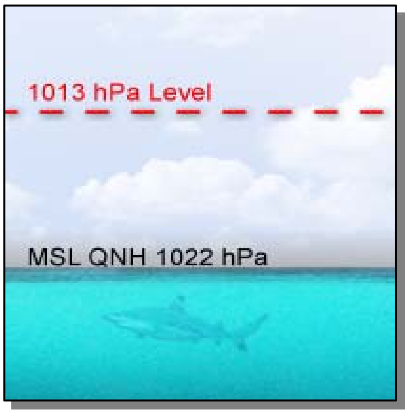
= + 12 hPa difference.

Now multiply the difference by 30 as 1 hPa requires a height change of 30 ft:

+ 12 hPa x 30ft = + 360ft

MSL is 360 ft ABOVE the 1013 hPa pressure level

Example 2



When the QNH is 1022 hPa, the 1013 hPa is above MSL.

The distance in feet between the 1013 hPa and MSL can be calculated in the same manner as in the previous example.

1013 hPa - 1022 hPa = - 9 hPa.

- 9 hPa x 30 ft = - 270 ft

The MSL is 270 ft BELOW 1013 hPa.

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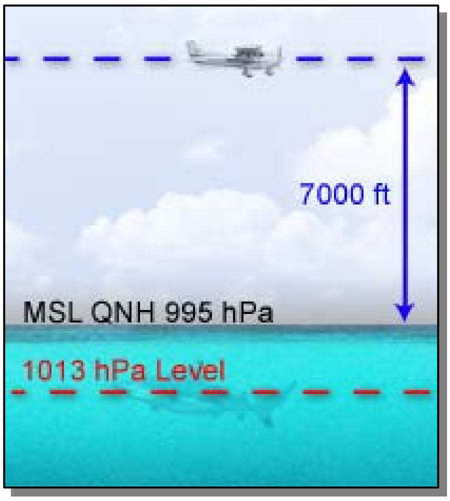
Note: If the QNH is always subtracted from 1013 hPa you will sometimes obtain a negative sign in front of the height differences. A negative sign means that the MSL pressure is below 1013 hPa. A positive sign indicates that MSL pressure is above 1013 hPa

This difference measured in feet may now be used to determine the Pressure Height at a particular elevation or altitude given the QNH



Given the following conditions:

Cruise Altitude	=	7000 ft
QNH	=	995 hPa

The pressure height at the cruise altitude may be calculated.

Cruising at an ALTITUDE of 7000ft means flying 7000ft above MSL. However, the pressure height is the height above the 1013 hPa pressure datum.

The Pressure Height at A070 (altitude 7000 ft.) is more than the altitude because the 1013 hPa pressure level is below MSL.

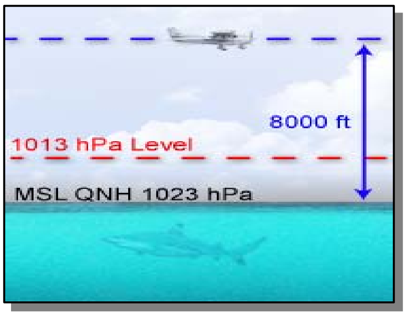
First find the distance in feet between 1013 hPa and MSL:

1013 hPa - 995 hPa = +18 hPa x 30 ft = + 540 ft

7000 ft + 540 ft = 7540 ft Pressure Height

RESULT: The Pressure Height at A 070 is 7540 ft.

Example 3



In this case, because the 1013 hPa pressure level is ABOVE MSL., SUBTRACT the difference between MSL and 1013 hPa from the 8000 foot distance between MSL and A080.

Notice that the correct mathematical sign will result if this procedure is used:

1013 hPa - QNH

1013 hPa - QNH 1023 hPa = - 10 hPa x 30 ft = - 300 ft.

The "-" sign automatically shows that you are to subtract:

8000 ft - 300 ft = 7700 ft PH

The Pressure Height at A080 is 7700 ft.

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RECAPITULATION OF PRESSURE HEIGHT CALCULATIONS

Pressure height is the measurement in feet above the 1013 hPa isobar. Create a diagram showing MSL with the QNH and the height above MSL. Pressure decreases as height increases and the position of the 1013 hPa isobar can then be determined relevant to the QNH. The difference in hPa can then be converted to feet and a correction to the height is then applied to find pressure height.

(1013 hPa - QNH) x 30 = height difference.

Altitude + height difference = Pressure Height.

Pressure height is the height in the International Standard Atmosphere where the pressure occurs. A low QNH (lower than 1013) results in pressure height greater than altitude.

<u>Lower pressure = Higher pressure height</u>

Conversely:

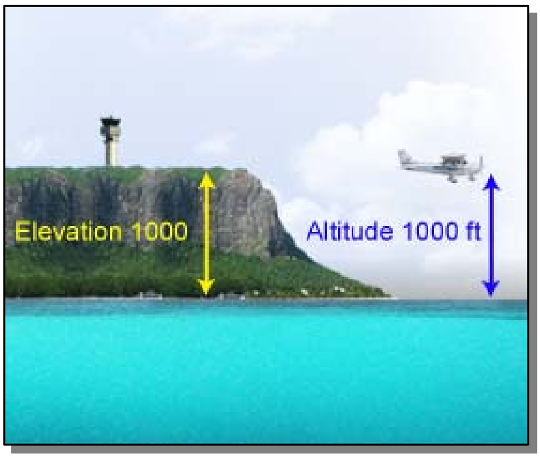
<u>Higher pressure = Lower pressure height</u>

AERODROME PRESSURE HEIGHT CALCULATIONS

When you compare the definitions for ALTITUDE and ELEVATION you will find that there is no difference except that ALTITUDE refers to something which is flying and ELEVATION refers to something which is affixed to the earth's surface.

Elevation and Altitude are both heights AMSL.

The Pressure Height of an ELEVATION is found in the same way as the Pressure Height of an ALTITUDE.



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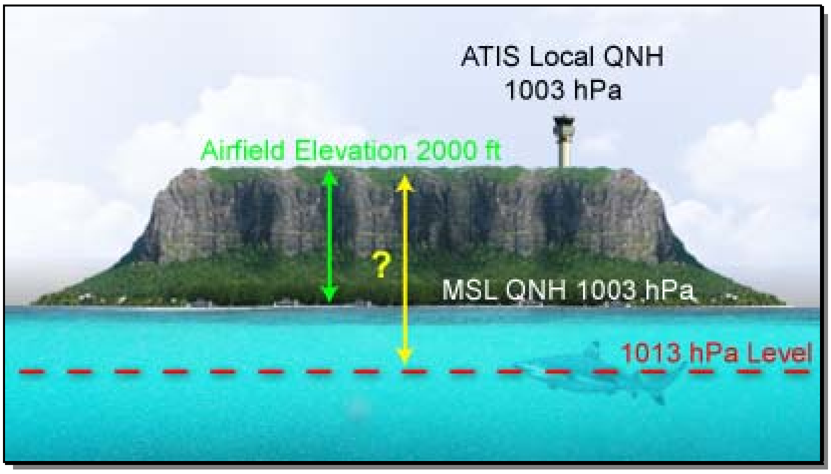
Example 1



Difference between 1013 and MSL:

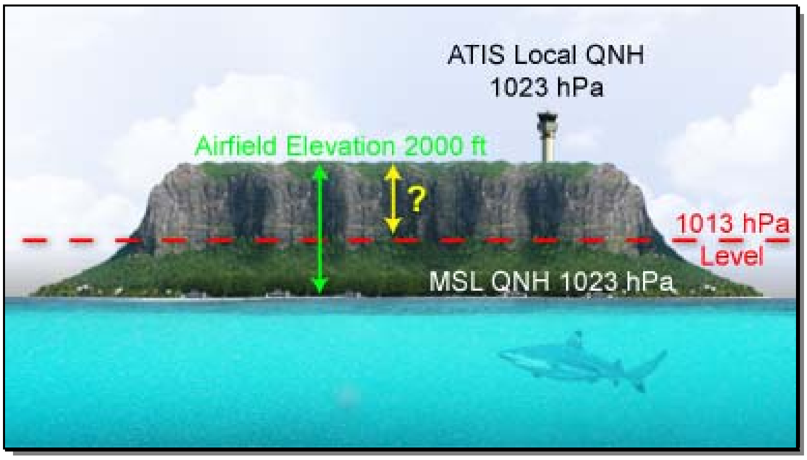
1013 hPa - 1003 hPa = + 10 hPa x 30 ft = +300 ft

Add 300 ft to the elevation:

2000 ft + 300 ft = PH 2300 ft

Note: Because the QNH is lower than 1013, pressure height is greater than elevation. Performance at this 2000 ft aerodrome will be (in terms of pressure) as it would be at 2300 feet in standard conditions.

Example 2



Find the height difference between 1013 hPa and MSL:

1013 hPa - 1023 hPa = - 10 hPa x 30 ft = - 300 ft

Add - 300 ft to the elevation:

2000 ft + - 300 ft = 2000 ft - 300 ft = PH 1700 ft

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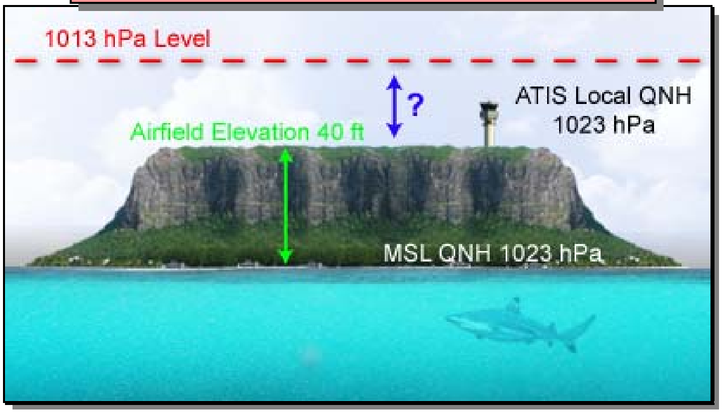
Example 3

Note: A pressure height can be negative.



Find the height difference between MSL and 1013 hPa:

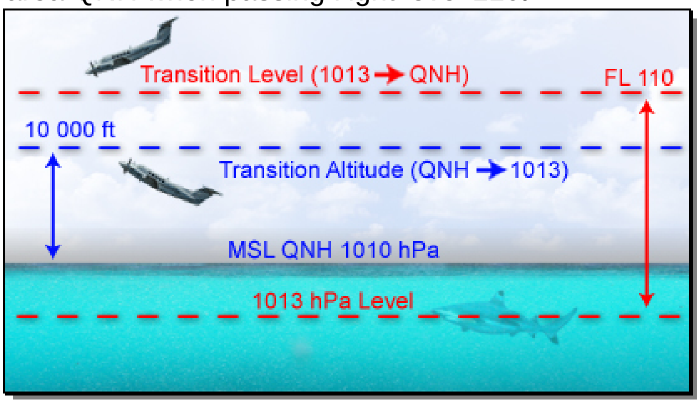
1013 hPa - 1023 hPa = - 10 hPa x 30 ft = - 300 ft

Add the difference to the elevation:

40 ft + - 300 ft = 40 ft - 300 ft = PH - 260 ft

THE FLIGHT LEVEL

A Flight Level is a pressure level above 1013 hPa. To operate at a flight level the altimeter subscale is set to 1013 as the aircraft passes through a "transition altitude" on climb. In Australia this is done at an altitude of 10000 ft. On descent from a flight level the altimeter subscale is set to the area QNH when passing flight level 110.



When cruising above the transition level the HEMISPHERICAL tracking rules still apply: When tracking East the aircraft must choose odd thousands of feet (15000, 17000, 19000,etc) and when tracking West even thousands (14000, 16000, 18000,etc).

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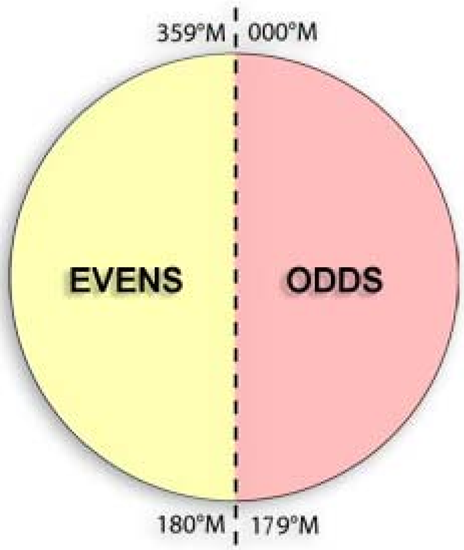


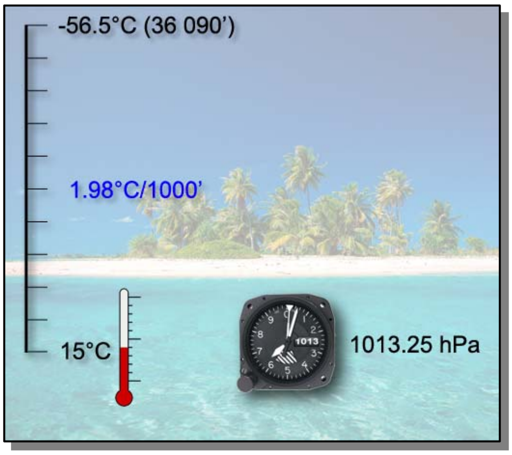
Notice that the last two "0" numerals are never going to change and so the cruising level is divided by 100. The result represents a PRESSURE HEIGHT INDEX and is called a FLIGHT LEVEL.

14,000 ft PH = FL 140. 15,500 ft PH = FL 155.

Flight levels are used ONLY above the transition altitude.

ISA TEMPERATURE AND LAPSE RATE

In ISA conditions the temperature at 1013 hPa is +15 °C. The temperature decreases at a rate of approximately 2° / 1000 ft height gain up to 36,000 feet where the temperature stabilises at about -57°C.



The ISA temperature can be found by applying the temperature lapse rate to the pressure height.

For example the ISA temperature at a pressure height of 5,000 feet is found as follows:

Climbing from 0 ft. Pressure height (1013 hPa) to 5,000 ft: the temperature is assumed to drop at the standard lapse rate.

5,000 ft at 2°C / 1000 ft = 5 x 2 = 10°C

The temperature will drop 10°C in 5000 ft.

Given that the temperature at 1013 hPa is +15°C and at 5,000 ft is 10°C lower, the ISA temperature at 5,000 ft pressure height is +5°C

The same procedure using brackets: +15°C - (5 x 2) = +5°C

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Note: To find the ISA temperature at a given elevation/altitude, first find the corresponding PRESSURE HEIGHT. This is height in the standard atmosphere.

Example 1

Find the ISA temperature at FL180 if the QNH is 1023 hPa.

At FL 180 the PH is 18,000 ft. and so there is no need to consider QNH.

The temperature will reduce by:

18 x 2 = 36°C

The ISA temperature at FL 180 is:

+15° - 36°C = - 21°C

or:

15°C - (18 x 2) = - 21°C

Example 2

Find the ISA temperature at an altitude of 6,500 ft if the QNH is 1002 hPa.

Firstly calculate the PH:

1013 hPa - 1002 hPa = 11 hPa x 30 ft = 330 ft.

6,500ft + 330ft = 6,830ft PH

Calculate the temperature drop in 6,830 ft (work to the nearest 500ft)

7000 ft = 14°C temperature reduction

Now the ISA temperature can be calculated.

+15°C - 14°C = +1°C

ANSWER: The ISA temperature at 6500 ft altitude is +1°C

Example 3

Find the ISA temperature at an altitude of 6,500 ft if the QNH is 1002 hPa.

Firstly calculate the PH:

1013 hPa - 1002 hPa = 11 hPa x 30 ft = 330 ft.

6,500ft + 330ft = 6,830ft PH

Calculate the temperature drop in 6,830 ft (work to the nearest 500ft)

7000 ft = 14°C temperature reduction

Now the ISA temperature can be calculated.

+15°C - 14°C = +1°C

ANSWER: The ISA temperature at 6500 ft altitude is +1°C

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Example 4

Find the ISA temperature at an altitude of 9,500 ft if the QNH is 1031 hPa.

Firstly calculate the PH at 9,500 ft.

(1013 – 1031) hPa = - 18 hPa x 30 ft = - 540 ft

9,500 ft + - 540 ft = 9,500 ft - 540 ft = PH 8,960 ft

Now calculate the temperature drop for 8,960 ft:

9,000ft (to the nearest 500ft) = 18°C

Now find the ISA temperature at 9000 feet pressure height:

+15°C - 18°C = -3°C

ANSWER: The ISA temperature at 9500 ft altitude is - 3°C.

OAT AND DEVIATIONS FROM ISA

When ambient temperatures are different from the standard (as they most often are) then they can be expressed as a numerical deviation from what the temperature would have been at that pressure height on a standard day.

When the temperature is colder or warmer than under ISA conditions, we call this an ISA deviation.

Under ISA conditions the temperature at 1013 hPa would be +15°C. However, if the actual temperature measured is +20°C then we can say that it is 5°C warmer than ISA.

We express that as: ISA + 5

If the 1013 hPa temperature is + 9°C we can say that it is: 15°- 9° = 6°C colder than ISA.

We express that as: ISA – 6

The expressions "ISA + 5" and "ISA - 6" are called **ISA DEVIATIONS**.

Converting ISA Deviation into OAT (Outside Air Temperature) :

If the temperature is ISA+8 (or any other ISA deviation) the OAT can be found.

ISA + 8 means that it is 8°C warmer than ISA.

At 1013 hPa the ISA temperature is +15°C.

The OAT is therefore:

+15°C + 8°C = + 23°C.

Example 1

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If the deviation is ISA - 4, what is the OAT at zero pressure height?

ISA - 4 means that it is 4°C COLDER than ISA.

The ISA temperature at MSL = +15°C.

The OAT = +15 - 4 = +11°C.

ISA Deviation at a Given Altitude/Elevation

To calculate the ISA deviation at any given height, we need to find out first the ISA temperature at that height and then compare the ISA temperature with the actual OAT measured at that height.

Example 2

Find ISA Deviation at A080

Cruise Altitude:	8,000 ft
Area QNH:	996 hPa
OAT at A080:	+13°C

The Pressure Height at A080 is:

1013 hPa - 996 hPa = 17 hPa x 30 ft = 510 ft

8,000 ft + 510 ft = PH 8,510 ft

The temperature reduction in °C from 1013 hPa to 8510 ft:

8,510 / 1,000 = 8.5 x 2 =17°C

The ISA temperature at A080 (PH 8,510 ft)

ISA = +15°C - 17°C = -2°C

By comparing the ISA temperature (-2°C) with the actual OAT (+13) the ISA deviation can now be found:

It is +13 - - 2 (or) +13 + 2 (or) +15°C warmer than ISA at A080.

ANSWER: The ISA Deviation is ISA + 15

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Example 3

Find the surface temperature as an ISA Deviation.

Airfield Elevation: 820 ft

Local QNH: 1001 hPa

Surface temperature: +4°C

Calculate the airfield Pressure Height:

1013hPa - 1001hPa = 12hPa x 30 ft = 360 ft

820 ft + 360 ft = 1,180 ft

Calculate the ISA temperature at PH 1,180 ft:

1180 / 1000 = 1 x 2 = 2°C temperature drop

ISA temperature = +15°C - 2°C = +13°C

The temperature deviation from ISA:

+13°C - +4°C = +13 - 4 = +9°C; (it is 9°C colder than ISA.)

Write the result as ISA Deviation:

ISA - 9

Example 4

Find OAT at a given height from an ISA Deviation

FL 160

Area QNH: 1020 hPa

OA: ISA+5

Calculate the Pressure Height:

FL 160 = PH 16,000 ft

The ISA temperature at 16,000 ft PH is:

16,000 / 1000 = 16 x 2 = 32°C temperature drop.

+15 - 32 = an ISA temperature of -17°C.

But ISA + 5 means that is 5°C warmer than ISA.

Therefore the OAT = -17°C + 5°C = -12°C.

The OAT at FL 160 is - 12°C.

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Example 5

Find the OAT in degrees C at A055.

Cruise altitude:	5500 ft
Area QNH:	1032 hPa
OAT:	ISA - 10°

The PH at A055 is:

1013 hPa - 1032 hPa = -19 hPa x 30 ft = -570 ft

5500 ft + - 570 ft = 5500 ft - 570 f = 4930 ft

The ISA temperature at PH 4930 ft (A055) is:

Because the difference between 4930 ft and 5000 ft is relatively small and because these calculations are really approximations, then:

5000/1000 = 5 x 2 = 10°C temp. drop

+15 - 10 = ISA temp. +5°C

Assess the ISA deviation as a difference from ISA temperature:

ISA - 10 means it is 10°C colder than ISA.

Apply the deviation to the ISA temperature:

+5°C - 10°C = - 5°C

The OAT at A055 is - 5°C.

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