Applying declination and grid correction

Purpose

The purpose of this document is to provide everyone involved with directional drilling and/or surveying operations with a clear and consistent method of correctly applying the correction factors relevant to the north reference in use. All directional drilling and/or MWD personnel should apply this method on every project without exception.

Every member of the team has the responsibility of checking the declination and grid correction to be correct when arriving on location. If there is anything that is not clear or if any discrepancy is found – no matter how small - the support office should be contacted without delay.

Definitions

Magnetic North
Magnetic North (MN) is the direction of a line from any geographical location (point) on the earth’s surface to the Magnetic North Pole.

True North
True North (TN) is the direction of a line from any geographical location (point) on the earth’s surface to the Geometric North Pole.

Magnetic Declination
Magnetic Declination (DEC) is the angular difference (east or west) between True North and Magnetic North. Declination is expressed as the angular rotation from True North to Magnetic North, whereby a negative sign is expressed as West and a positive sign as East. Thus, if the declination is negative (west), then Magnetic North lies west of True North:

![Figure 1 - Declination](image)

Obviously this image would be reversed if the declination were positive (east).
In accordance with the above definitions, True North is **always** calculated with the formula:

\[ TN = MN + \text{DEC} \]

Therefore, if the declination is \(-2.00^\circ\) (West) then the formula is calculated as:

\[ TN = MN + (-2.00^\circ) = MN - 2.00^\circ \]

**Grid North**

Grid North (GN) is the north reference within a local grid system (UTM, Lambert, etc.).

**Grid Correction or Convergence**

The Grid Correction or Convergence (CONV) is the angular difference between True North and Grid North. Grid Correction is expressed as the angular rotation from True North to Grid North, whereby a negative value lies to the West and a positive value to the East of True North.

![Figure 2 - Convergence](image)

In accordance with the above definitions, Grid North is **always** calculated with the formula:

\[ GN = TN - \text{CONV} \]

So if the grid correction is \(-2.00^\circ\) (West) then the formula is calculated as:

\[ GN = TN - (-2.00^\circ) = TN + 2.00^\circ \]

**Field procedure**

To ensure that the declination and grid correction are applied correctly at all times, the following field procedure should be adhered to by all personnel involved:

- Calculate the magnetic declination, include the sign as required (west is negative, east is positive).
- Calculate the grid correction, include the sign as required (west is negative, east is positive).
✓ Draw all north references in a schematic beginning with the True North arrow upwards (“pointing north”). Refer to the example in figure 4 below.

✓ Draw Magnetic North in the schematic according to its sign. If the Declination is negative (or West) draw the arrow to the left (west) of True North. If the Declination is positive (or east) then draw the line to the right (east) of True North.

✓ Draw Grid North in the schematic according to its sign. If the Grid Correction is negative (West) draw the line to the left (west) of True North. If the Grid Correction is positive (East) then draw the line to the right (east) of True North.

**Note:**

If both declination and grid correction are on the same side of True North, the arrows are drawn correctly in relation to the magnitude of the correction. Thus if the value of the declination is greater than the grid correction, the GN arrow should lie between the MN arrow and the TN arrow.

✓ Draw a survey direction to the right of the rightmost line sideways to the right (“pointing east”).

✓ From this schematic, the total correction can now simply be derived. First determine what must be done with the declination to arrive at the True North direction from the Magnetic North Direction. Secondly, repeat this process to arrive at Grid North direction from the True North direction to determine what must be done with the grid correction. Next combine these results to arrive at the total correction from Magnetic North to Grid North.

**Example**

Consider the following example data:

✓ - Declination: -2.00°

✓ - Grid correction: +3.00°

From this we derive that Magnetic North (MN) lies West of True North and that Grid North lies East of True North. Accordingly, we can draw the following schematic (fig. 3):

![Figure 3 – Example calculation](image)

From this schematic it is easy to determine that the angle between the Magnetic North and the survey is decreased to get to the angle between the True North and the Survey Direction. Thus to correct from Magnetic North to True North, the Declination value must **subtracted**.
In our case, $\text{TN} = \text{MN} – 2.00^\circ$. This is in accordance with the formula given earlier:

$$\text{TN} = \text{MN} + (-2.00^\circ) = \text{MN} – 2.00^\circ.$$ 

It can also be determined from this schematic that the angle between the True North and the survey is decreased to get to the angle between the Grid North and the Survey. Thus to correct from True North to Grid North, the Grid Correction value must **subtracted**.

In our case, $\text{GN} = \text{TN} – 3.00^\circ$. This again is in accordance with the formula given earlier:

$$\text{GN} = \text{TN} - (+3.00^\circ) = \text{TN} – 3.00^\circ.$$ 

Therefore, to correct a magnetic survey direction to Grid North, the Declination and Grid Correction must both be subtracted, which can be confirmed in figure 3:

$$\text{GN} = \text{MN} – 2.00^\circ - 3.00^\circ = \text{MN} – 5.00^\circ.$$ 

Or as per earlier formulas:

$$\text{GN} = \text{MN} + (-2.00^\circ) – (+3.00^\circ) = \text{MN} – 2.00^\circ - 3.00^\circ = \text{MN} – 5.00^\circ.$$ 

**Remember!**

Always draw the north arrows, then draw an imaginary survey (hole direction) arrow and from that determine your total correction. This is the best (and probably only) way to avoid confusion and misinterpretation.
Local coordinates and North reference used

What’s the “problem”?  

Each point on a wellpath has three coordinate sets that determine its position in the horizontal plane:

**Geographical coordinates.**  
These are the coordinates on the earth’s surface expressed in degrees Latitude (North/South) and Longitude (East/West). As the surface of the earth is curved, the distance and direction between two points given in these coordinates are complex to calculate.

**Grid Coordinates.**  
These are the coordinates of the position relative to the local grid where Y is North/South and X is East/West. As the grid is a section of the earth’s surface, projected on a flat plane, distance and direction can simply be calculated by subtracting grid coordinates.

**Local coordinates.**  
These are the coordinates of the position relative to a local reference point. Usually this is the wellhead, platform center or some other fixed point in the vicinity.

The issue with local coordinates is that their values change depending on the north reference chosen (!!!). This is very important when working with slot or target coordinates which are usually given in grid coordinates.

Consider the following schematic:

![Figure 4 – Local coordinate example](image)

Figure 4 indicates that the coordinate lines, drawn perpendicular to and parallel to the north/south axis change if the north reference changes but the actual point remains unchanged. This may appear to be strange but consider the following:
Both the origin and point are given in grid coordinates. In other words: they lie on a grid map which is an absolute position in space. Therefore, their position relative to the earth will not change. However, when referencing to True North, the north/south and east/west axes are rotated by the Grid Correction in reverse (correcting from Grid to True rather than from True to Grid). This now gives the situation as depicted in figure 4.

Note that geographical and grid coordinates will never change, as they are - by definition - referenced to True North and Grid North respectively!

**Coordinate conversion**

To convert local coordinates (North/South and East/West) from one north reference to the other, convert the local coordinates to polar coordinates (distance and direction) and apply the grid correction to the direction (reverse when going from Grid North to True North). Then calculate the polar coordinates back to local coordinates (North/South and East/West). There is no simple and uniform formula to do this but it can be, quite easily, calculated with some basic trigonometry.

**Example**

Working from the above schedule, let’s assume the following:

- Grid correction is +5.00°
- Grid is UTM and coordinates are given in meters
- The grid coordinates of the wellhead (origin) are 5,909,562.90 N and 560,737.00 E
- The grid coordinates of the target location are 5,910,402.00 N and 561,737.00 E.

To calculate the local coordinates relative to True North, the following calculations must be made.

First the wellhead coordinates are subtracted from the target coordinates. The local target coordinates are then calculated as

\[
5,910,402.00 - 5,909,562.90 = 839.10 \text{ meter North}
\]

\[
561,737.00 - 560,737.00 = 1,000 \text{ meter East.}
\]

Note that the result is in meters and must be converted when drilling in feet! Special attention must be given to the position of the two points relative to each other. If the calculation is accidentally reversed the direction will be off by 180°!! It is therefore strongly recommended to always draw a quick sketch (drawing larger coordinate values to the right or above) to avoid mistakes.

Using 839.10 m North and 1,000 m East it is quite simple to calculate that this is equal to:

**1,305.41 meters in 50° Azimuth (Grid North).**
Use Pythagoras \( a^2 + b^2 = c^2 \) and ATAN\( (1,000 / 839.10) \) to arrive at this result.

Normally we would correct survey data from True North to Grid North and would therefore **subtract** the Grid Correction from a True North direction. In this case however, we must reverse the process as we wish to convert a Grid North direction to a True North direction. Therefore the Grid Correction is **added** to the 50° Azimuth we calculated. Thus the target direction referenced to True North is:

\[
50.00° + 5.00° = 55.00° \text{ Azimuth (True North)}.
\]

Now we can work back to local coordinates according to True North:

\[
\begin{align*}
N/S &= 1,305.41 \times \cos(55°) = 748.75 \text{ meter North} \\
E/W &= 1,305.41 \times \sin(55°) = 1,069.33 \text{ meter East}
\end{align*}
\]
Useful notes

Quick calculations

Hand calculating grid correction

A useful formula for calculating grid correction is the following:

\[ \text{CONV} = (\text{CM} - \text{LONG}) \times \sin(\text{LAT}) \]

Where:

- \( \text{CONV} \) = Grid Correction (Convergence)
- \( \text{CM} \) = Central Meridian of grid used
  (Typically 3° for UTM Zone 32N or 5° for UTM-5 in the Netherlands)
- \( \text{LONG} \) = Longitude of location (decimal degrees)
- \( \text{LAT} \) = Latitude of location (decimal degrees)

Important

The source of this formula is unknown and has only been confirmed for quite some UTM-3 and UTM-5 locations. For this reason it should only be used as a “rule of thumb” and quick checking of values provided. It should never be used as an official and/or definitive calculation.

Unlike Declination, Grid Correction is not time related; it remains the same at all times.

What to apply when

When correcting survey data, always take the north reference required and the actual survey tool into consideration. Gyro tools always measure True North and applying Declination is therefore not required. When working to True North, no Grid Correction must be applied; in this situation no correction at all should be applied to gyro survey data. Always be aware of this when accepting data from third parties involved on the project.

Known your references!

Data is rendered totally useless if no reference information is available! This applies to nearly all measurements we do in directional drilling.

Grid coordinates are meaningless until a full description of the grid used is available. Also pay attention to what units the coordinates the coordinates are in; some grids may be expressed in meters and others in feet or you may be drilling in different units.

Hole directions are meaningless unless the north reference used is known.

Local coordinates, measured depth and vertical depth are also meaningless if the correct reference point is unknown. Be careful with relative reference points! Any relative reference point (wellhead, platform center, RKB, etc.) must also be related to an absolute reference point.
such as geographical or grid coordinates of that point, RKB elevation from a fixed datum (MSL, LAT, NAP, etc.). Ground level is never an absolute reference!