Summary of the usage rules for the calculation of position lines by altitude with the F-table – With notes

1. Enter the dead reckoning position (φ_g, λ_g), the φ_g at the nearest full degree of latitude φ_a and the observed altitude $\underline{\ast}$.

To 1. Assumed latitude (φ_a) is the full degree of latitude which lies closest to the dead reckoning latitude, it can be greater or less than the dead reckoning latitude. Observed altitude is the sextant reading uncorrected for refraction and height of eye.

2. Enter the hour angle calculated in the usual way, rounded to the next value divisible by 4^m and the δ.

To 2. To calculate the hour angle:

For a star or planet:

A. Determine the longitude in time using Table F V (page 65)
B. Subtract longitude in time if in W longitude (add if in E longitude) from GMT to get local mean solar time (LMST)
C. Take mean solar right ascension (m◯α) from the Yearbook (page I-IV of each month)
D. Add mean solar right ascension to LMST to get the hour angle of the first point of Aires (♈)
E. Take right ascension ($\ast\alpha$) and declination (δ) (for later use) of the star from the Yearbook (pages 172-175)
F. Subtract the right ascension of the star from the hour angle of the first point of Aries to calculate the hour angle of the star $\ast\tau$. Hint if $\ast\alpha >$ ♈ add 24 hours to ♈ to make the subtraction work out.
G. If $\ast\tau$ is less than 12^h then $12^h - \ast\tau$ = easterly hour angle, ; if $\ast\tau$ is larger than 12^h, then $\ast\tau - 12^h$ = westerly hour angle.
H. Determine assumed time t_a by rounding the hour angle up or down to the nearest value divisible by 4^m and note the time difference (Δt) plus or minus.

For the sun:

Steps A and B are the same

C. Determine the equation of time (e) from the Yearbook (page I-IV of each month
D. If e is positive, subtract it from LMST to get LST, if e is negative add it to LMST.
E. LST takes the place of $\ast\tau$. In steps G and H above.

3. Calculate h_b from observed ($\underline{\ast}$) and total correction (Gb.).16

To 3. Find the total correction (Gb.) for stars and planets in Table F VII (pages 70-71) enter the table with $\underline{\ast}$ at the left and move across to the column for height of eye in meters. For Planets, if in the Yearbook (page VIII to XIV of each month) there is a horizontal displacement use that to enter the small table at the bottom of the page with the horizon distance (sextant reading) and add the result algebraically to get the total correction. Subtract Gb. From ✳ to get the corrected altitude h_b.

For the Gb. for the sun use Table F VIII (pages 72-73). After determining the correction for height of eye as above at the bottom of the page note the correction for the lower or upper limb of the sun. Add these corrections algebraically and add or subtract the resulting Gb. to ◯ to get h_b.

4. Extract P with t_a and δ from Table F I (or Table F XI).

To 4. A. In table F I (pages 1-42) find the page with a set of columns matching the assumed hour angle. Enter the table with declination on the left or right and take the value of P. If there is a dotted line on the page and P is below it use table F XI.

B. In table F XI (page 76-88) find the page with a set of columns matching the assumed hour angle. Enter the table with the whole degrees of declination and the assumed hour angle and take P in degrees and minutes. Note the change value for each minute of declination.

C. Multiply the change value times the minutes of declination and add the resulting minutes to P to give the final P value. The table on page 88 is simply an exchange table to help with the step above.

Note: P is in degrees and tenths not degrees and minutes.

5. Extract U, V, and Gr. δ with t_a and φ_a from Table F I.

To 5. In table F I (pages 1-42) to find U, V and Gr. find the table with a set of columns matching the assumed hour angle. Enter the table from the left or right with the assumed latitude and take the values.

6. Determine the quadrant of the Azimuth.

Rule: If $t_{ö}$, then azimuth is East.

If t_w, then azimuth is West.

If $t > 6^h$, then azimuth is from the upper pole.

If $t < 6^h$, | δ has the same sign as φ and is larger than Gr. δ, then azimuth is from the upper pole.

| δ has the same sign as φ and is smaller than Gr. δ, then azimuth is from the lower pole.

| δ has the opposite sign φ, then azimuth is from the lower pole.

To 6. First determine E or W based on the designation of the star hour angle, enter that on the sight reduction form. Next determine S or N based on whether the hour angle is greater or less than 6^h and δ is the same or different sign than φ and greater or less than Gr. δ. Note that Gr. δ

is in degrees and tenths and δ is in degrees and minutes. Note: if you are in southern latitude then the upper pole is S. Enter that on the sight reduction form.

7. Designate U.

Rule: If $t < 6^h$, then U same as φ.

If $t > 6^h$, then U opposite φ.

Generate $\delta + U$ (add algebraically).

To 7. Determine the sign of U based on the whether the hour angle is greater or less than 6^h. To generate $\delta + U$ if N add, if S subtract from the declination.

8. Take the log sin from the value calculated after step 7 from table F II and add to V.

To 8. A. In Table FII (page 43-58) find the page with the degrees of $\delta + U$ in bold numbers on the top or bottom and enter the table on the right or left with the minutes of $\delta + U$. Note the log sin in the degrees column.

B. Calculate the difference between the log sin from step 1 and the log sin for the next higher minute. Find the exchange table (on the right of the log sin tables) with that difference on the top. Enter with the tenths of minutes on the left and note the log sin in the minutes column. Add this value to the log sin from step 1 above.

C. To add the log sin of the value calculated in A and B above to V ignore the leading 9. Add the next 5 digits. If the sum exceeds 99,999 subtract 100,000 from it by dropping the first digit. The result will be 9.xxxxx.

9. With this sum take the altitude from table F II.

To 9. A. In Table F II (page 43-58). Find the closest value of log sin of $V + (\delta + U)$ (determined in step C above) that does not exceed the value. Note the degrees and minutes.

B. To get the tenths of minutes calculate the difference between the log sin value from step 1 and the log sin for the next higher minute. Find the exchange table (on the right of the log sin tables) with that difference on the top. Follow down to the difference between the actual $V + (\delta + U)$ and the closet value in the table. Read the tenths of minutes at the left. Add this to the degrees and minutes from step 1.

10. With h and P take azimuth from Table F I. The sought after P-value is located here below the dotted line, for more accurate azimuth determination use Table F XI.

To 10. In Table I (pages 1-42) find the closest match of P and h and read the azimuth at the bottom of the table. Hint: Start with the h and scroll down the pages until you find a value for P that is close. Then compare the three values for P on that page to find the best match.

11. Take the hour angle correction (Correction for t) from table F III with φ_a, Az and the seconds neglected in the rounding of the hour angle (Δt).

Rule: Correction for t = + if calculated with too great an assumed t,

Correction for t = – if calculated with too small an assumed t.

To 11. A. In table F III (page 59-63) find the table with the correct assumed latitude at the top or bottom on the left. Move up or down the column to the closet value to the azimuth.

B. Move across the table to the right to the column corresponding to the number of seconds in Δt first interpolate for the number of seconds then interpolate for the azimuth.

C. To determine if the correction is positive or negative - "if calculated with too great an assumed t" means that Δt is positive and the hour angle was rounded up; "if calculated with too small an assumed t" means that Δt is negative and the hour angle was rounded down.

D. Add or subtract the correction for t from h. The result is h_r.

E. Subtract h_r from h_b to get Δh.

12. Plotting position lines.

a) Without baseline shift:

The starting point for the plotting of all observations is φ_a and λ_g (Examples 1 and 2).

To 12. This is straight forward plot of each position line from the same assumed latitude and DR longitude on a chart or graph paper. If Δh is positive plot it in the direction of the azimuth, if negative plot in the opposite direction of the azimuth.

If one is using graph paper (as a U-boat navigator would) instead of a nautical chart or plotting sheet, to determine the change in longitude:

A. Take the horizontal distance on the graph paper from O_a to the O_w and measure it in miles using the vertical axis (where 1 minute = 1 nautical mile).
B. Multiply this value by the secant of the assumed latitude to get the difference in longitude. Or, as the navigator probably did it, draw the triangle with the horizontal distance O_a to the O_w , the angle being the assumed latitude and take the hypotenuse and measure it against the vertical axis.

This technique is used in all of the example problems

b) With baseline shift:

Either

for all observations apply to the O_a [assumed position] of the last observation the corrected latitude difference and signs of the positions established this way

or

take the latitude corrections (Correction for φ) from Table F IV with Az and $\varphi a – \varphi g$ and apply them to the calculated altitude, then plot all observations from the dead reckoning position for the last observation made (See Examples 3b and 4b).

A. In Table F IV (page 64) to determine the correction for latitude enter the table with $\varphi a – \varphi g = \Delta\varphi$ and read across to the azimuth (interpolate as necessary). Apply the sign rule at the bottom of the table.

B. Algebraically add the correction for t and the correction for latitude to h to get h_r.

C. Subtract h_r from h_b to get Δh.

[Note: $_g$ means estimated (geschätzt), $_a$ means assumed (angenommen), $_b$ means correction (beschickung), $_r$ means computed (berechnet), $_ö$ means east, $_w$ means west]