U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

MAY 11 1987

Mr. James K. Ferguson
General Manager
Artais, Inc.
4660 Kenny Road
Columbus, OH 43220

Dear Mr. Ferguson:

Attached is a copy of the current (5/11/87) AWOS weather/parameter algorithms. The margins are annotated to indicate the changes incorporated since August 13, 1986. The changes are a result of coordination with the NWS on the final draft of the Federal Standard Algorithms for Automated Weather Observing Systems Used for Aviation Purposes.

Sincerely,

Edward VanDuyne
Acting Manager, Weather Sensors Program

Attachment

cc: J. Parein - NWS/OSD31
J. Bradley/V. Nadolski - NWS/OSD32

5/11/87

AUTOMATED WEATHER OBSERVING SYSTEM (AWOS)

ALGORITHMS

1.1 General. - This document contains the Government-furnished algorithms to be used to derive weather observations for the AWOS.

If less than 75 percent of the maximum amount of data used in the computation of any parameter is available, the parameter shall be reported as "missing". This is in addition to other conditions for "missing" described elsewhere in these algorithms and those performed under data reduction checks.

All parameters are updated on a one-minute cycle, except for wind, which has a 5-second update, and the 12-hour average temperature, which has an hourly update.

Preprocessing of data from sensors with short time constants may be necessary to obtain averages for use in these algorithms. For example, it may be necessary to sample the temperature sensor every 10 seconds and compute a one-minute average for use in the temperature algorithm.

All midpoint values are rounded down.

1.2 Algorithms

1.2.1 Wind speed ($\overline{WS}$) and direction ($\overline{WD}$) algorithms. - Wind speed ($\overline{WS}$) and wind direction ($\overline{WD}$) are 2-minute running averages calculated from sensor readings taken at one-second intervals. They are calculated as follows:

(a) Each second, interrogate the wind speed and direction sensors.

(b) Each 5 seconds, compute a 2-minute running average (scalar average) for speed ($\overline{WS}$) and direction ($\overline{WD}$). $\overline{WD}$ shall be rounded to the nearest 10 degrees (from 10 to 360 degrees) and $\overline{WS}$ shall be rounded to the nearest knot.

(c) When $\overline{WS}$ is less than or equal to 2 knots, indicate calm for $\overline{WD}$ and $\overline{WS}$.

1.2.1.1 Wind gust (G) algorithm. - Wind gust (G) is based upon the highest 5-second average wind speed for the past 10 minutes. It is calculated as follows:

(a) Each 5 seconds, compute a 5-second average wind speed.

(b) Each 5 seconds, store the 5-second average wind speeds for the past minute.

(c) Each 5 seconds, compare the current 2-minute average wind speed ($\overline{WS}$) and the highest 5-second average for the past minute. If $\overline{WS}$ equals or exceeds 9 knots, and the difference between the highest 5-second average wind speed and $\overline{WS}$ equals or exceeds 5 knots, store the highest 5-second average wind speed as G.

(d) Each 5 seconds, compare the current $\overline{WS}$ and the highest G (if any) stored during the past 10 minutes. If the highest G is at least 3 knots higher than the current $\overline{WS}$ and $\overline{WS}$ is not calm, report G.

1.2.1.2 Variable wind direction algorithm. - Variable wind direction is a wind direction which varies around the 2-minute average wind direction ($\overline{WD}$) by 60 degrees or more. It is calculated as follows:

(a) Each 5 seconds, calculate a 5-second average wind direction. Round this average direction to the nearest 10 degrees (from 10 to 360 degrees).

(b) Each minute, if the current 2-minute average wind speed ($\overline{WS}$) is greater than 6 knots, compute the range of the 5-second average wind directions on each side of $\overline{WD}$.

(c) If the total range is 60 degrees or more, indicate a variable wind direction. Indicate the 5-second average wind direction extremes (rounded to the nearest 10 degrees) in a clockwise direction around and including $\overline{WD}$.

1.2.2 Temperature algorithms

(a) Ambient temperature ($\overline{T}$). Ambient temperature ($\overline{T}$) is a 5-minute average temperature calculated each minute from sensor readings taken at least once each minute. It is calculated as follows:

(1) At least once each minute, obtain the temperature from the ambient temperature sensor.

(2) Each minute, compute a 5-minute average (rounded to the nearest degree) and indicate this temperature ($\overline{T}$). If 5 one-minute values are available, compute $\overline{T}$ based on the 5 values. If only 4 one-minute values are available, compute $\overline{T}$ based on the 4 values (i.e., divide by 4). If less than 4 valid one-minute values are available, do not compute a current $\overline{T}$. Instead, use the most recent $\overline{T}$ computed within the past 15 minutes as the current $\overline{T}$. If no computed $\overline{T}$ values are available within the past 15 minutes, indicate the current $\overline{T}$ as missing.

(b) Twelve-hour average ambient temperature ($\overline{T}12$).

(1) Each hour on the hour (i.e., at 0000, 0100, 0200, etc.), compute an average of the current $\overline{T}$ and $\overline{T}$ computed on the hour 12 hours ago. This is $\overline{T}12$.

(2) Store $\overline{T}12$ for use in the sea level pressure algorithm.

1.2.3 Dew point ($\overline{T}d$) algorithm. - Dew point temperature ($\overline{T}d$) is a 5- minute average dew point temperature calculated each minute from sensor readings taken at least once each minute. It is calculated as follows:

(a) At least once each minute, obtain the dew point from the dew point sensor.

(b) Each minute, compute a 5-minute average dew point (rounded to the nearest degree) and indicate this dew point ($\overline{T}d$). If 5 one-minute values are available, compute $\overline{T}d$ based on the 5 values. If only 4 one-minute values are available, compute $\overline{T}d$ based on the 4 values (i.e., divide by 4). If less than 4 valid one-minute values are available, do not compute a current $\overline{T}d$. Instead, use the most recent $\overline{T}d$ computed within the past 15 minutes as the current $\overline{T}d$. If no computed $\overline{T}d$ values are available within the past 15 minutes, indicate the current $\overline{T}d$ as missing.

(c) If $\overline{T}d$ from (b), above, is 1 or 2 degrees higher than the 5-minute average temperature ($\overline{T}$), indicate $\overline{T}d$ equal to $\overline{T}$. If $\overline{T}d$ from (b), above, exceeds $\overline{T}$ by more than 2 degrees, indicate $\overline{T}d$ missing. If $\overline{T}$ is missing, indicate $\overline{T}d$ missing.

1.2.4 Pressure. - The AWOS includes at least two pressure sensors for quality control purposes.

The following definitions apply to AWOS installations:

Altimeter setting (AS) - The pressure value to which the altimeter of an aircraft on the ground is set so that it will indicate the field elevation (mean sea level) of the airport.

Field elevation (Ha) - The officially designated field elevation of an airport above mean sea level. It is the elevation of the highest point on any of the runways of the airport.

Density altitude (DA) - The altitude in the standard atmosphere where air density is the equivalent to that at the airport.

Pressure reduction ratio (r) - The ratio used to convert station pressure to sea level pressure. These values, in increments of 10°F, will be provided by the Government individually for each station. Linear interpolation of the"r" values to the nearest 1°F for computation of sea level pressures shall be performed in the system software. Note: Reduction constants, "c", are used instead of "r" at some locations where the station elevations are within approximately 50 feet of mean sea level. Reduction constants (c) will be provided by the Government in lieu of pressure reduction ratios (r) for applicable locations.

Zero point (Hz). - The height of the pressure sensor zero point above mean sea level.

Sensor pressure (P) - The atmospheric pressure at the actual elevation of the sensor (Hz).

Field pressure (Pa) - The atmospheric pressure computed for field elevation (Ha).

Station pressure (Ps) - The atmospheric pressure computed for the level of the station elevation (Hp). Station pressure (Ps) is equal to field pressure (Pa) for AWOS installations located at airports.

Sea-level pressure (SLP) - The atmospheric pressure at mean sea level. It may either be measured directly or, most commonly, computed from the station pressure.

Station elevation (Hp) - The officially designated height above mean sea level to which station pressure (Ps) pertains. Hp is the same as Ha for AWOS installations located at airports.

1.2.4.1 Field pressure (Pa) algorithm. - Field pressure (Pa) is computed from the lowest of at least two one-minute average sensor pressures ($\overline{P}$) and use of the hypsometric equation. Pa is calculated as follows:

(a) Each 10 seconds, read the two pressure sensors (located at elevation Hz) to the nearest 0.005 inHg. These values are P1 and P2.

(b) Each minute, compute a one-minute average for P1 and P2. These are $\overline{P}1$ and $\overline{P}2$.

(c) Each minute, compare $\overline{P}1$ and $\overline{P}2$. If $\overline{P}1$ and $\overline{P}2$ differ by more than 0.04 inHg, consider pressure as "missing" and do not compute any pressure dependent parameters.

(d) Each minute, using the lower of $\overline{P}1$ and $\overline{P}2$, compute field pressure (Pa) using the equation:

$$Pa = \overline{P} \times 10^{(KH/\overline{T}r)}$$

Where: $\overline{P}$ = Lower of $\overline{P}1$ and $\overline{P}2$
K = 0.00813
H = Difference, in feet, between the elevation of the pressure sensors (Hz) and the field elevation of the airport (Ha).
$\overline{T}r$ = Current 5-minute average temperature ($\overline{T}$) in degrees Rankine, i.e., $\overline{T}r = \overline{T} + 460$.

1.2.4.2 Altimeter setting (AS) algorithm. - Altimeter setting (AS) is calculated from field pressure (Pa) and field elevation (Ha) as follows:

(a) Each minute, calculate the altimeter setting (AS) using the equation:

$$AS = (Pa^{N} + KHa)^{1/N}$$

Where: Pa = Field pressure
N = 0.1903
K = 1.313×10^{-5}
Ha = Field elevation of the airport in feet above mean sea level.

(b) If Pa is missing because $\bar{T}r$ is missing, compute AS using the equation:

$$AS = (\bar{P}^{N} + KHz)^{1/N}$$

Where: $\bar{P}$ = Lower of $\bar{P}1$ and $\bar{P}2$
N = 0.1903
K = 1.313×10^{-5}
Hz = Elevation of the pressure sensors in feet above mean sea level.

(c) Round to the nearest 0.01 inHg.

1.2.4.3 Density altitude (DA) algorithm. - Density altitude (DA) is calculated from field pressure (Pa) and the temperature in degrees Rankine ($\bar{T}r$) as follows:

(a) Each minute, compute DA in feet using the equation:

$$DA = 145{,}366 \left[1 - \left(\frac{17.326\ (Pa)}{\bar{T}r} \right)^{0.235} \right]$$

Where:
Pa = Field pressure to the nearest 0.01 inHg
$\bar{T}r$ = Current 5-minute average temperature ($\bar{T}$) in degrees Rankine, i.e., $\bar{T}r = \bar{T} + 460$.

(b) Report DA to the nearest 100 feet when DA is more than 1000 feet above field elevation (Ha).

(c) If DA cannot be computed (e.g., Pa and/or $\bar{T}r$ missing), report DA as missing.

1.2.4.4 Sea-level pressure (SLP) algorithm. - Sea-level pressure (SLP) is calculated from field pressure (Pa), which is the same as station pressure (Ps) for AWOS installations located at airports, and a pressure reduction ratio (r) or a pressure reduction constant (c) as follows:

(a) Each minute, calculate the sea level pressure (SLP) in millibars using the equation:

$$SLP = 33.864 \, (Pa) \, (r)$$

Where: Pa = Field pressure to the nearest 0.01 inHg.

r = Pressure reduction ratio. This ratio is determined each minute using the table of "r" values provided by the Government and the 12-hour average temperature ($\bar{T}12$) computed on the hour. For example, "r" at 20 minutes past the hour is computed from the table of "r" values using the $\bar{T}12$ value computed on the hour. Linear interpolation of the "r" value to the nearest 1°F is required.

(b) Round SLP to the nearest 0.1 millibar.

(c) For some stations within approximately 50 feet of mean sea level, SLP = 33.864 (Pa) + c, where "c" is the reduction constant.

1.2.5 Ceiling/sky condition algorithm. - Ceiling and sky condition are determined from sensor outputs at least every 30 seconds integrated over a 30-minute sample period. A weighting scheme is employed for data collected during the last 10 minutes of the 30-minute sample period to make the algorithm more responsive to rapid changes in ceiling/sky conditions. Heights are reported in hundreds of feet (e.g., 30 represents a height of 3,000 feet). Ceiling and sky condition are determined as follows:

1.2.5.1 Data collection

(a) At least once every 30 seconds, sample the cloud height sensor.

(b) At least once each 30 seconds, store the lowest cloud height, obscuration aloft height, contact height (CH), or vertical visibility (VV) detected (i.e., hit) or negative response (i.e., no hit).

(c) At least once each 30 seconds, round the lowest hit to the nearest 100 feet, except hits within 500 feet of the design range of the sensor shall be rounded down to the nearest 1000 feet, e.g., hits between 12,000 and 12,500 feet are rounded to 12,000 feet. Midpoint values shall be rounded down, except hits at 50 feet or less are rounded up to 100 feet.

(d) At least once each 30 seconds and after rounding, assign hits to bins established as specified below. Hits midpoint between bins shall be assigned to the lower bin.

(1) Surface to 5,000 feet: Use 100-foot bins starting with 100 feet (i.e., 100, 200, 300... etc...5,000).

(2) Above 5,000 feet: Use 200-foot bins (i.e., 5,000, 5,200, 5,400... etc...12,000).

1.2.5.2 Weighting

(a) Each minute, add the following to obtain the total number of weighted possible hits during the past 30 minutes. Include those scans when a hit was detected as well as those when no hit was detected, except exclude those scans when no hit was detected due to a sensor error/fault.

(1) 20 times the number of sensor scans per minute during the most recent 10-minute period; plus

(2) 20 times the number of sensor scans per minute for the 20 minute period preceding (1).

(b) Actual hits for the most recent 10-minute period shall be counted as two hits. Hits during the preceding 20-minute period shall be counted once.

1.2.5.3 Clustering bins. - Each minute, cluster bins established during the 30-minute sampling period using the following criteria:

(a) Determine the number of bins (paragraph 1.2.5.1(d)). If there are 5 or less bins, go to paragraph 1.2.5.4 (combining clusters), otherwise continue.

(b) The bins shall be ordered from the lowest to the highest height.

(c) Calculate the least square distance between all adjacent bins using:

$$D = \left(\frac{N(J) \times N(K) \times [H(J) - H(K)]^2}{N(J) + N(K)} \right)^{1/2}$$

Where:

D = least square distance
H = bin height
N = number of hits in that bin
(J) = bin for the higher height
(K) = bin for the lower height

(d) Combine the two adjacent bins having the smallest least square distance. If more than one pair of bins have the same least square distance, combine the pair with the lowest height.

(e) Combine the bins using the formulas below:

$$\text{HEIGHT:} \quad H(L) = \frac{[N(J) \times H(J)] + [N(K) \times H(K)]}{N(J) + N(K)}$$

$$\text{NUMBER OF HITS:} \quad N(L) = N(J) + N(K)$$

Where H(L) is the height of the combined bin rounded to the nearest bin height in paragraph 1.2.5.1(d), and N(L) is the number of hits for the combined bin.

(f) The H(L) and N(L) bin shall replace the H(J), H(K), N(J) and N(K) bins. Now, if there are more than 5 bins (or clusters), return to step (b). Otherwise, continue to the next step (combining clusters).

<u>1.2.5.4 Combining Clusters</u>. - Each minute, after clustering of bins has been completed, determine if the clusters can be combined using the following criteria:

(a) Group the clusters in ascending order.

(b) Compute the height difference of all adjacent clusters.

(c) If the lower height of any adjacent pair is equal to or less than 1,000 feet, and the difference between heights is 300 feet or less, go to (h) and combine the clusters. If the difference is greater than 300 feet, continue to the next pair.

(d) If the lower height of any adjacent pair is greater than 1,000 feet, and the difference between heights is 400 feet or less, go to (h) and combine the clusters using the equations. If the difference is greater than 400 feet, continue to the next pair.

(e) If the lower height of any pair is greater than 3,000 feet, and the difference between heights is 500 feet or less, go to (h) and combine the clusters. If the difference is greater than 500 feet, continue to the next pair.

(f) If the lower height of any adjacent pair is 5,000 feet or higher, and the difference between heights is 800 feet or less, go to (h) and combine the clusters. If the difference is greater than 800 feet, continue to next pair.

(g) If the lower height of any adjacent pair is 8,000 feet or higher, and the difference between heights is 1,600 feet or less, go to (h) and combine the clusters. If the difference is greater than 1,600 feet, continue to next pair. When all cluster pairs have been tested, go to (j).

(h) Combine the clusters using the equations in paragraph 1.2.5.3(e).

(i) When two clusters are combined the new cluster height shall be rounded and assigned a height as specified in paragraph 1.2.5.1(d). The new cluster shall replace the two that were combined, the clusters reordered and the process of combining continued (i.e., return to (a), above). All adjacent pairs shall continue to be examined until no further combining is possible.

(j) At the end of this combining process, all cluster heights shall be rounded as specified below. Midpoint values shall be rounded down. Cluster heights shall now be referred to as H_C.

(1) Heights surface to 5,000 feet - nearest 100 feet starting with 100 feet (i.e., 100, 200,...etc...5,000)

(2) Heights 5,000 to 10,000 feet - nearest 500 feet (i.e., 5,000, 5,500, 6,000...etc...10,000)

(3) Heights above 10,000 feet - nearest 1,000 feet (i.e., 10,000, 11,000, 12,000)

1.2.5.5 Computation of cloud amount

(a) Obtain the total number of weighted possible hits from paragraph 1.2.5.2.

(b) Calculate the cluster factors (R_C) using the following formula for each cluster, starting with the lowest cluster at height H_C.

$$R_C = \frac{\text{Number of Weighted Cluster Hits}}{\text{Weighted Possible Hits}}$$

(c) If R_C of each cluster is less than 0.06 or there are no clusters (i.e., no hits), and the visibility ($\overline{V}$) rounded to the nearest reportable value (paragraph 1.2.6.2(g)) is:

(1) "Missing" and $\overline{T}$ minus $\overline{Td}$ is equal to or less than 4 degrees, or if either $\overline{T}$ or $\overline{Td}$ is missing, indicate the ceiling/sky condition as "missing". If $\overline{T}$ minus $\overline{Td}$ is 5 degrees or more, indicate no clouds below the design range of the sensor.

(2) Less than 1/4 mile, indicate an indefinite zero obscured ceiling/sky condition (i.e., W0X).

(3) Equal to or greater than 1/4 mile, but less than 1/2 mile, indicate an indefinite 200 foot obscured ceiling/sky condition (i.e., W2X).

(4) Equal to or greater than 1/2, but less than one mile, indicate an indefinite 500 foot obscured ceiling/sky condition (i.e., W5X).

(5) Equal to or greater than one, but less than two miles and precipitation (as reported in the AWOS observation) is :

a Reported, indicate an indefinite 700 foot obscured ceiling/sky condition (i.e., W7X).

b Not reported or missing, indicate a partially obscured sky condition, (i.e., -X).

(6) Equal to or greater than two miles, indicate no clouds below the design range of the sensor.

(d) If R_C of any cluster at height H_C is equal to or greater than 0.06, calculate the cloud cover factor, R_L, for each cluster (hereafter referred to as layer) height using the following formula, starting with the lowest layer.

$$R_L = \frac{\sum_{L=1}^{N} \text{(WEIGHTED ACTUAL LAYER HITS)}}{\text{WEIGHTED POSSIBLE HITS}}$$

Where: N = Layer number starting with the lowest layer

Weighted Actual Layer Hits = Number of weighted hits, paragraph 1.2.5.2(b), in the layer at height H_C.

Weighted Possible Hits = Number of possible hits calculated per paragraph 1.2.5.2(a).

(e) If there is more than one layer, apply the summation principle. For example, if a lower layer at height H_{C1} has 25 weighted hits and the next layer at H_{C2} has 13 weighted hits, R_L for H_{C2} would be computed using 38 for the number of weighted hits in that layer. Exception: If R_L for any layer is less than 0.06, the number of hits in that layer is not added to any other layer. However, the total number of weighted possible hits (paragraph 1.2.5.2(a)) shall not be reduced.

(1) Add the following factors to the R_L value for each layer based upon the visibility value ($\overline{V}$) rounded to the nearest reportable value (paragraph 1.2.6.2(g)).

a If $\overline{V}$ is less than or equal to 1/4 mile, add 0.6. Preface the ceiling/sky condition with "-X" (partially obscured).

b If $\overline{V}$ is greater than 1/4 but equal to or less than one mile, add 0.4. Preface the ceiling/sky condition with "-X" (partially obscured).

c If $\overline{V}$ is greater than one but equal to or less than two miles, add 0.2. Preface the ceiling/sky condition with "-X" (partially obscured).

d If $\overline{V}$ is greater than two but less than three miles, no adjustment is made. However, the ceiling/sky condition is prefaced with "-X" (partially obscured).

e If $\overline{V}$ is equal to or greater than three miles, the ceiling/sky condition is <u>not</u> prefaced with "-X" (partially obscured).

f If $\overline{V}$ is "missing" and $\overline{T}$-$\overline{T}d$ is:

1 Equal to or more than 5 degrees, no adjustment is made and the ceiling/sky condition is <u>not</u> prefaced with "-X" (partially obscured).

2 Equal to or less than 4 degrees and R_L for the <u>lowest</u> layer is:

a) Equal to or greater than 0.50, no adjustment is made. However, the ceiling/sky condition is prefaced with "-X" (partially obscured).

b) Less than 0.50, indicate the ceiling/sky condition as "missing".

3 "Missing" (i.e., if either $\overline{T}$ or $\overline{T}d$ is "missing") and R_L for the <u>lowest</u> layer is:

a) Equal to or greater than 0.50, no adjustment is made and ceiling/sky condition is <u>not</u> prefaced with "-X" (partially obscured).

b) Less than 0.50, indicate the ceiling/sky condition as "missing".

g As a result of the additive factors specified in paragraphs a, b and c, above, R_L may exceed 1.0. If so, truncate R_L at 1.0.

(2) If the current R_L is equal to or greater than 0.45 but less than 0.50, and the R_L height is within 200 feet of the height of the lowest broken layer for the previous minute, add 0.05 to the current R_L.

(3) Each minute, using the current R_L value (as modified by paragraphs (1) and (2), above) report layers as follows:

a If the R_L is equal to or greater than 0.06 but less than 0.50, the layer shall be reported as scattered.

b If R_L is equal to or greater than 0.50 but equal to or less than 0.87, the layer shall be reported as broken.

c If R_L is greater than 0.87, the layer shall be reported as overcast:

1.2.5.6 Reporting cloud layers and their priority

(a) If R_L is less than 0.06, report no clouds below the design range of the sensor.

(b) Obscured ceilings/sky conditions are reported as specified in paragraph 1.2.5.5(c).

(c) Partially obscured sky conditions are reported as -X. "-X" shall also be used to prefix ceiling/sky condition as specified in paragraph 1.2.5.5(e)(1).

(d) Up to three layers can be reported; however, if there is more than one overcast layer, the lowest is reported and the other(s) shall be disregarded.

(e) Layers shall be reported from the lowest to the highest using the height H_C assigned to each layer.

(f) If there are more than three layers, the three lowest layers shall be reported using the priority listed below:

(1) The lowest scattered layer.
(2) The lowest broken layer.
(3) The lowest overcast layer.
(4) The second lowest scattered layer.
(5) The second lowest broken layer.
(6) The highest broken layer.
(7) The highest scattered layer.

(g) Starting with the lowest layer, if for any layer reported, the height (H_C) is less than or equal to 5,000 feet and is within plus/minus 100 feet of a layer height reported for the previous minute, use the height (H_C) ascribed to the previous minute if that height value is unoccupied. If the height (H_C) of any layer is greater than 5,000 feet and is within plus/minus 500 feet of a layer height reported for the previous minute, use the height (H_C) ascribed to the previous minute if that height value is unoccupied. The sky condition designation (i.e., scattered, broken or overcast) shall not change as a result of these procedures.

1.2.6 Visibility

1.2.6.1 Photometer. - A photometer shall be provided with the visibility sensor to indicate day or night ambient light levels. The photometer establishes the setting of the "day/night switch" to determine whether the extinction coefficient computed by the visibility sensor is to be translated to visibility by a day or night equation.

1.2.6.2 Visibility ($\overline{V}$) algorithm. - Visibility ($\overline{V}$) is the horizontal visibility near the earth's surface representative of visibility conditions in the vicinity of the visibility sensor. It is determined from sensor outputs at 10-second intervals that are used to compute a one-minute average extinction coefficient. The one-minute extinction coefficient average is converted to a one-minute visibility (V) value through either a day or night visibility equation. The visibility (V) values are averaged (harmonic average) over a 10-minute period to determine $\overline{V}$. $\overline{V}$ is calculated as follows:

(a) Each 10-seconds, interrogate the visibility sensor.

(b) Each minute, compute a one-minute average extinction coefficient from the sensor outputs.

(c) Each minute, check the photometer for day/night status. If the photometer is not operational, set indication to day.

(d) Each minute, convert the one-minute average extinction coefficient value to visibility (V) rounded to the nearest 0.1 statute mile (from 0.1 to 10.0) using the following equations:

(1) For day V

$$V = 3/\sigma$$

(2) For night V

$$.00336 = \frac{e^{-\sigma V}}{V}$$

Where:

σ = extinction coefficient in miles^{-1}
e = 2.718

(e) Each minute, compute a 10-minute harmonic average of the visibility (V) values for the past 10-minutes. This is $\overline{V}$. The equation for a harmonic average is as follows:

$$1/\overline{V} = 1/n\ (1/V_1 + 1/V_2 + 1/V_3 \ldots 1/V_n)$$

Where:

n = Total number of V values

(f) Each minute, round $\overline{V}$ to the nearest reportable value given in (g), below. Values of $\overline{V}$ less than 0.2 are reported as less than 1/4; values equal to or greater than 0.2 but equal to or less than 0.375 are reported as 1/4.

(g) Reportable values for $\overline{V}$ are: less than 1/4, 1/4, 1/2, 3/4, 1, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/2, 3, 3 1/2, 4, 5, and greater than 5 (or 5, 7, and 10 for sensors tested to 10 miles).

<u>1.2.6.3 Variable visibility algorithm.</u> - Variable visibility is indicated when the 10-minute harmonic average visibility ($\overline{V}$) is less than 3 miles and the individual one-minute visibility values (V) vary by one or more reportable values during a 10-minute period. It is calculated as follows:

(a) Each minute, compare the current V with the V value for the preceding minute. If the difference between the V values is greater than 0.5 miles, maintain a file of the positive or negative changes. Note: For the purpose of this file, V values are truncated at 5 miles, i.e., V values greater than 5 miles are treated as 5 miles.

(b) Each minute, examine the past 10 minutes of data. If the number of V changes in the file is equal to or greater than 3, and the sign of the change has changed at least twice, and the current $\overline{V}$ is less than 3 miles, indicate variable visibility in the form:

VSBY min V max

Where: Min = Minimum V value generated during the past 10 minutes and rounded to the nearest reportable value.

Max = Maximum V value generated during the past 10 minutes and rounded to the nearest reportable value.

<u>1.2.7 Precipitation occurrence/type/accumulation/intensity algorithms</u>

<u>1.2.7.1 Precipitation occurrence/type algorithms.</u> - Precipitation occurrence/type is determined from one-minute sensor outputs integrated over a 10-minute period. Three indications within 10 minutes are required to trigger the beginning of precipitation. Once started, precipitation is assumed to continue for at least 10 minutes. The end of precipitation is signaled when less than 2 indications occur in a 10 minute period; thus, precipitation is reported during intermittent conditions. Precipitation occurrence/type is determined as follows:

(a) Each minute, examine the sensor for an indication of precipitation occurrence and type during the past minute. Store this output.

(b) Each minute, examine the current output and the output for the most recent 10-minute period. If 3 positive indications of precipitation are generated within this 10-minute period, the type of precipitation is reported (Note: It is understood that precipitation is occurring when the type is reported).

(1) Only one type of precipitation is reported. The type reported is based upon the type(s) indicated during the most recent 10-minute period in accordance with the following priority.

Hail
Ice pellets
Snow
Rain
Drizzle
Precipitation (Type not determined)

(2) The initial precipitation type reported shall be the highest priority type of the 3 positive indications stored during the most recent 10-minute period.

(3) Once precipitation type is initiated, the type reported shall be the highest priority type stored during the most recent 10-minute period.

(4) Once precipitation type has been generated, a type shall be reported for at least 10 minutes.

(5) After the initial 10 minute period, precipitation occurrence/type is ended when less than 2 positive indications of precipitation are generated during a 10-minute period.

(6) Store the type of precipitation reported for use in the precipitation accumulation algorithm.

1.2.7.2 Precipitation accumulation algorithm. - Precipitation accumulation is the cumulative amount of liquid or liquid equivalent precipitation. The accumulation process starts and ends each hour on the hour (i.e., at 0000, 0100, 0200, etc.). Precipitation accumulation is reported each minute. Thus, the precipitation accumulation reported on the hour is the cumulative amount over the past hour or, if precipitation occurrence was not reported on the past hour, since precipitation occurrence was first reported. The amount reported between hours represents the cumulative amount since the accumulation process began on the hour to the time of the observation or, if precipitation occurrence was not reported on the hour, to the time precipitation occurrence was first reported. Precipitation accumulation is determined as follows:

(a) Each hour on the hour (i.e., at 0000, 0100, 0200, etc.), start and end the precipitation accumulation process.

(b) Each minute, interrogate the precipitation accumulation sensor and round the cumulative amount detected since the accumulation process began ((a), above) to the nearest 0.01 inch.

(c) Each minute, determine if precipitation occurrence is being reported.

(d) Each minute, indicate the precipitation accumulation as follows:

(1) None - None is indicated by the absence of an amount.

(2) Trace - Trace is indicated when the accumulation is less than 0.005 inch. Trace is also indicated when precipitation occurrence is currently being reported or has been reported since the accumulation process began, but no accumulated amount is detected by the precipitation accumulation sensor. Trace is indicated as 0.00.

(3) Amounts equal to or greater than 0.005 inch - Indicate the amounts to the nearest 0.01 inch in inches/tenths/hundredths, e.g., 1.02.

1.2.7.3 Precipitation intensity algorithm. - Precipitation intensity shall be indicated when a measurement of intensity is available from the precipitation sensor. The intensity indicated shall be for the precipitation type determined per paragraph 1.2.7.1, above; except no intensity shall be reported for hail and precipitation (type not determined). Intensity shall be reported as light unless there are at least two indications of moderate or heavy intensity within the past 5 minutes. If there are at least two indications of moderate or heavy intensity within the past 5 minutes, moderate intensity shall be reported unless there are at least two indications of heavy intensity, in which case heavy intensity shall be reported.

1.2.8 Thunderstorm algorithm. - This algorithm assumes that lightning flash data are received from a network and processed into appropriate geographical areas before being sent to the AWOS. Thunderstorm occurrence is defined as occurring at the airport or in the appropriate octant(s) in the vicinity of the airport. Three or more cloud-to-ground lightning flashes occurring within 15 minutes within 10 nautical miles of the airport reference point (ARP) shall designate a thunderstorm at the airport. Three or more cloud-to-ground lightning flashes occurring within 15 minutes within an appropriate octant(s) shall designate a thunderstorm(s) in the vicinity of the airport. The ending of a thunderstorm at the airport or in one or more of the vicinity octants is defined as the absence of a cloud-to-ground lightning flash for 15 minutes in the appropriate area(s). Thunderstorm indication is determined as follows:

(a) Each minute, accept lightning flash data from the lightning detection network. Data from the network shall include time of the lightning flash and the appropriate bin area.

(b) Each minute, file lightning flash data into bin areas established as follows:

(1) At airport (ten nautical miles or less from the ARP).

(2) North (N) octant (more than 10 but 30 nautical miles or less from the ARP between the 337.5 and 022.5 degree radials).

(3) Northeast (NE) octant (more than 10 but 30 nautical miles or less from the ARP between the 022.5 and 067.5 degree radials).

(4) East (E) octant (more than 10 but 30 nautical miles or less from the ARP between the 067.5 and 112.5 degree radials).

(5) Southeast (SE) octant (more than 10 but 30 nautical miles or less from the ARP between the 112.5 and 157.5 degree radials).

(6) South (S) octant (more than 10 but 30 nautical miles or less from the ARP between the 157.5 and 202.5 degree radials).

(7) Southwest (SW) octant (more than 10 but 30 nautical miles or less from the ARP between the 202.5 and 247.5 degree radials).

(8) West (W) octant (more than 10 but 30 nautical miles or less from the ARP between the 247.5 and 292.5 degree radials).

(9) Northwest (NW) octant (more than 10 but 30 nautical miles or less from the ARP between the 292.5 and 337.5 degree radials).

(c) Each minute, count the number of lightning flashes in each bin area for the past 15 minutes. If the count is equal to or greater than 3, indicate a thunderstorm for that bin area(s). Once indicated, a thunderstorm is assumed to continue for at least 15 minutes.

(d) Each minute, in each bin area where a thunderstorm is indicated, determine the time of the most recent lightning flash. If the difference between the current time and the time of the most recent lightning flash is 15 minutes or less, continue to indicate a thunderstorm for that bin area. If the difference is more than 15 minutes, terminate the thunderstorm for that bin area.

1.2.9 Alert criteria. - The digital message from the AWOS shall contain an alert character(s) to be read by video devices to generate an appropriate alert. This character(s) shall identify the reason(s) for the alert (i.e., indicate the weather parameter(s) causing the alert). The requirements specified herein as "local requirements" shall be programmed into the system along with other site specific information before shipment of the system from the manufacturer. The criteria for generating alerts shall be as follows:

(a) Ceiling. - The ceiling forms or decreases to less than, or dissipates or increases to be equal to or greater than:

(1) 3000 feet
(2) 1000 feet
(3) 500 feet
(4) Local requirements (up to two additional values)

(b) Sky condition. - A layer of scattered clouds is present below:

(1) 1000 feet and no clouds were reported below 1000 feet in the preceding observation.

(2) Local requirement (up to one additional value)

(c) Visibility. - The visibility decreases to less than, or if below, increases to equal or exceed:

(1) 3 miles
(2) 2 miles
(3) 1 1/2 miles
(4) 1 mile
(5) Local requirements (up to four additional values)

(d) Precipitation or other weather phenomena. - Any type of precipitation or other weather phenomena begins or ends.

(e) Wind. - A change in wind direction when the wind speed is greater than five knots that would revise the landing runway to a new preferred direction. (The AWOS system shall be capable of accepting local requirements for up to six runway directions).