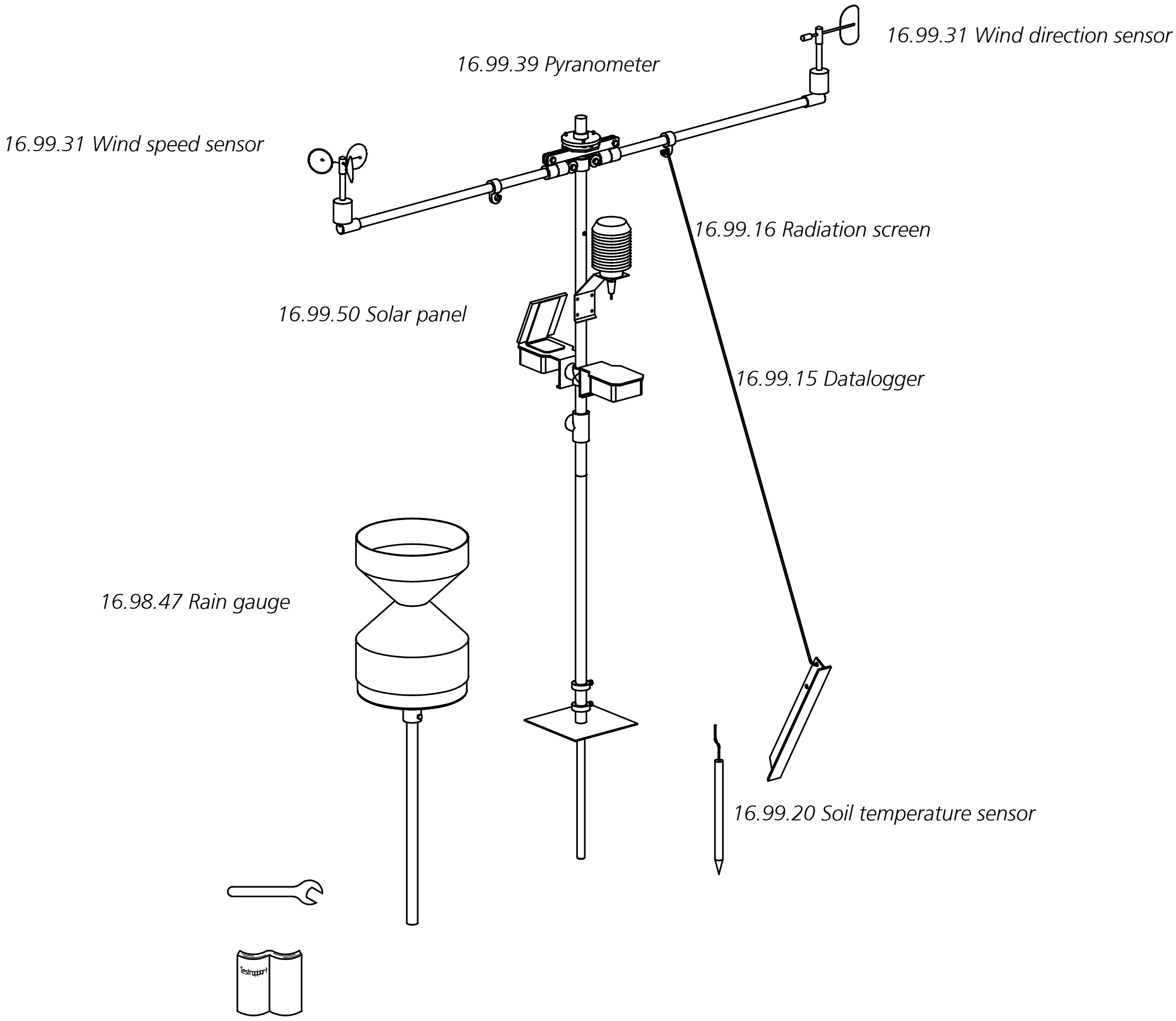
AUTOMATIC WEATHER STATION, 8 CHANNELS

OPERATING INSTRUCTIONS



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All it takes for environmental research

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On these operating instructions

☞ **If the text follows a mark (as shown on the left), this means that an important instruction follows.**

⚠ **If the text follows a mark (as shown on the left), this means that an important warning follows relating to danger to the user or damage to the apparatus.The user is always responsible for its own personal protection.**

Text **Italic indicated text indicates that the text concerned appears in writing on the display(or must be typed).**

1. Introduction

The Eijkelkamp automatic weather station has been developed for obtaining reliable information on agro-meteorological data in an uncomplicated way.
The parameters measured by the standard type are:
- ❒ wind-direction
- ❒ air-temperature
- ❒ humidity
- ❒ global radiation
- ❒ wind speed
- ❒ precipitation
- ❒ soil temperature
- ❒ air pressure

Except for the precipitation meter and the soil temperature the sensors have been pre-mounted on the mast in our plant. For this reason and because of the sophisticated design of the mast, it is possible, for two people, to set-up the station in an hour. The station is packaged in a strong container so as to avoid damage during transportation. The central part of the meteostation is the datalogger. It takes care for taking measurements on a time schedule. The measured values are stored in memory of the datalogger and can be downloaded with a (portable) computer. A complete explanation you will find in the datalogger manual. Before starting with measurements in the field it is advisable to get acquainted working with the datalogger first . Doing this in the office gives a comfortable condition learning to work with the datalogger. The datalogger is already programmed for your weather station application. So if you want, you can start immediately taking measurements.

2. Setting up a meteo-field

(page 2.5 Guide to Agric. meteorological Pract.)
The meteo-field should be fairly smooth and free of obstacles. Where possible it should be fitted with a green, close-cut, lawn. Where this is not possible due to natural circumstances a suitable ground cover, as present in the near surroundings, should be chosen. Under no condition the meteo-field should be covered by concrete, tarmac or stone.
Obstacles, such as trees, buildings and shrubs should be no closer than 8 to 10 times their height. There should be no objects in the vicinity that, during an important part of the day, cast their shade on the meteo-field. Short periods of shade at sunrise and sunset often are inevitable. Where possible the meteo-field should be situated on a location which, concerning natural conditions, represents the average regional conditions.
Locations near ponds, swamps, or with a strong supply of cold air, should best be avoided. Also the accessibility of the station should be considered in relation to maintenance and monitoring work.
Fencing is strongly advised to avoid unwanted visits by people and animals. In the event of using a fence with a height of 1.5 meter (assuming this to be a wired fence) the distance between instruments and fence should at least be 3 meter.

3. Setting up the weather station

1. Open the container, lift the station carefully out and place it on a soft underground.

☞ **Beware that some parts are demounted for transport!**

2. Now check, using the packing list, if all parts are present and undamaged.
   All components of course have been carefully checked in our plant.

3. Take the base plate, there is a long bar side for easy penetrateable soils and a short bar side in case of hard soils. Use a wooden hammer to drive it into the soil without deformation of the baseplate and its bars.

4. Place the station on top of the baseplate with two persons and turn the station so that the solar panel faces towards the south. On the southern hemisphere the solar panel should be facing the north.
   Secure the two locking screws to the base plate. If no solar panel is used position the case door facing to the north or for the southern hemisphere facing to the south.

⚠ **Take care that until the guy wires are mounted (see drawing page 11) one person holds the station, preventing it for falling over!**

5. The arms can now be folded out and fixed using the bolts, also mount the sensor arms and sensors wich are demounted for traveling.

6. Place all four ground pegs symmetrical so that almost the whole length of the guy wire is used. Fix the guy wires as tight as possible. See to it that the tensioning devices are not at their extreme setting. Next the guy wires are brought under tension in such a way that the mast is fixed as vertical as possible. Check using a level!

7. Place the cups of the wind speed meter on the axle of the instrument and carefully push them down. The cups are fitted properly as soon as they can not be lifted from the axle any more.

8. Fit the vane of the wind-direction meter by lightly pressing it on the axle. Keep turning until the mechanism catches. There is only one fitting point on the axle for the vane. If you do not succeed first check the saving notch in the axle and then the location of the ball in the cartridge of the vane. These should be right on top of each other. The cups as well as the vane can be removed from the instruments by keeping the instruments upside down (after unscrewing) and gently pressing on the cups and the vane.

9. Remove the hood from the precipitation meter by unscrewing the three head screws on the side of the precipitation meter and lifting the cap from the instrument. Remove the transport protection foam under the tipping bucket. The precipitation meter should be placed on a flat tile. To achieve a fully horizontal position the adjusting screws can be manipulated. Subsequently the hood is replaced and screwed down.

10. The logging device should now be operational. Check if all sensors are functioning and start the logger according to the logger manual instructions.

4. Radiation measurement (art.no.:16.99.39)

For measuring the global radiation a pyrano meter is used. This instrument measures the direct- and indirect short-wave radiation which falls on a horizontal surface from all directions under angles of 0° or more with this surface. The direct radiation is formed by the radiation reaching the surface straight from the sun. The indirect radiation is the radiation scattered by clouds and dust particles before reaching the surface.
Shortwave radiation is radiation with a wavelength between 300 and 3000 nm. By far the majority (more than 90%) of direct and indirect radiation has a wavelength in this region. For further definitions concerning radiation and radiation measurement we refer to the "Guide to Meteorological Instruments and Methods of Observation". The pyrano meter used for the station has a high grade silicon photocell sensitive for radiation with wavelength's between 350 and 1100 nm.
Maintenance of the sensor consists of cleaning. Preferably this should be done on a daily basis. Unfortunately in practice this is not always possible.

For recalibration the meters should be sent to a laboratory equipped for this purpose. To obtain optimum results this calibration should be executed every year. Often this is not possible. The next best thing is then to compare a new calibrated meter with a used one. This can be done most effectively by comparing the used and the calibrated meter over a period of two days. When doing so both pyrano meters should be set-up in exactly the same way. It is best to connect both pyranometers to a so called microV integrator (art. no.: 21.01) and subsequently to compare the results. The optimal condition for this operation is a cloudless sky. If this procedure shows that the calibration constant hardly changed (or not at all) re-calibration will not be necessary.

The two most important criteria of quality for pyrano meters are the cosine- and the azimuth response. In the ideal pyrano meter the relation of the cosine of the angle under which the radiation reaches a horizontal plane directly proportional to the responds of the pyrano meter. An example to clarify this: a parallel beam reaching the pyrano meter surface at a right angle means a certain value for W/m^2. If the same beam reaches under a 60° angle the ideal pyrano meter should only indicate half of the previous value as the cosine of 60 = 0.5.

The deviation of this ideal should be as small as possible (see graph in operating instructions of art. no.: 16.99.39). If a parallel beam reaches the pyrano meter under a certain angle to the horizontal plane and the meter is turned around its vertical axis it should, under the most ideal circumstances, indicate exactly the same value all the way round. The maximum error the sensor indicates when turned around its vertical axis is called the azimuth error. The smaller this error, the better the quality of the meter (see graph in operating instructions 16.99.39).

5. Wind speed meter (art.no.: 16.98.31)

The wind speed meter is a so called cup-anemometer with half conical cups. The meter makes about 1 revolution per 1.25 meter of air passed in the horizontal plane (depending on the calibration constant). On every rotation the magnetic switch is quickly closed and opened again. The resulting pulses are counted during the sample time. Subsequently the (average) wind speed is calculated based on the number of pulses in the sample time and the length of the sample time.
We call this value a measurement. Storing every measurement would use too much memory so a number of measurements is averaged and the highest and lowest values are calculated. The frequency of this procedure is determined by the storage interval. On delivery this value is set at 1 hour, but the user can adapt this value (for further information we refer to the relevant operating instructions).

Under normal usage and normal atmospherical conditions the bearing should last at least 2 to 3 years. After this period it is recommended to replace them, as worn bearing negatively influence the accuracy of measurement (bearing + key to unfasten the meter housing + mounting manual can be ordered at our address). If the anemometer is continuously exposed to salt particles in the air (near or on the sea) or highly polluted air (i.e SO_2 and NO_x) it could be wise to replace the bearing annually. The differences between two sets of new bearing are neglectable and recalibration after exchanging the bearing correctly should not be necessary.

Each rotor should however have its own calibration sheet on which its specific calibration values are written down. After exchanging a rotor i.e. after mechanical damage, the calibration value in the logging device should be changed as well (see operating instructions of the 16.99.15).
When used properly the rotor should last many years and only needs to be replaced after mechanical damage. You will find calibration data concerning the delivered rotor with the operating instructions of art. no.: 16.98.31.

To obtain the most reliable measurements the axis of the meter should be as vertical as possible. Deviations of more than 10° cause unnecessary wear and extensive deviations in the measurements. In case of normal fitting to the standard mast of the weather station the deviation can be limited to within 1°.

The anemometer is fitted to the mast at an altitude of 2 meter as is the norm for agro-meteorological measurements. When using the evaporation formulae according to Penman it is especially important for the wind velocity to be measured at an altitude of 2 meter. For general meteorological measurements an altitude of 10 meter is obligatory. It is possible to set up a 10 meter mast with a second anemometer to compare measurements to those from other stations.
A second possibility is to convert the wind speed at 2 meter to the velocity at 10 meter using the Hellman formula:

$V_2 = V_{10} (0.233 + 0.656 \log_{10} (2+4.75)$
V_2 = Wind speed at 2 meter
V_{10} = Wind speed at 10 meter

It speaks for itself that this formula will only produce a reasonable result if the anemometer is not hindered by obstacles in its vicinity.

Note: The magnetic switch is filled with a small quantity of mercury. Shocks and tremors during transport may cause the mercury divided in small globules. The result could be that the anemometer does not operate. This problem can be solved by keeping the instrument in a vertical position and shaking it downward a few times. Faulty magnetic switches do not belong in the environment but should be considered as chemical waste.

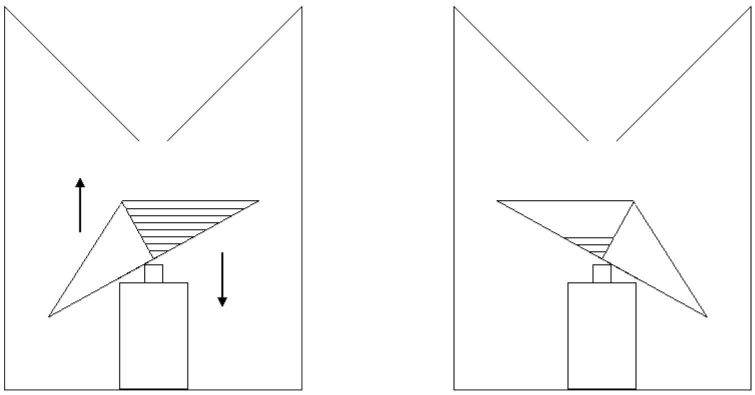
6. Wind vane (art. no.: 16.98.34)

The wind vane is of the potentiometer type. The housing of the meter contains a virtually completely closed wire wound precision potentiometer.
The small opening in the north of the potentiometer-ring is filled with insulating material, to allow the vane to rotate freely over the full 360 degrees. At the beginning of every sample period a measurement is registered. That will then be the actual wind direction. After a storage interval the average value of a series of measurements is taken and stored on the data cartridge.
Averaging the wind direction brings its own specific problem. It is not a scalar quantity but a vector quantity and should be averaged as such. This is taken into account in the logging device and the wind direction here is considered as a vector with a length of 1. Thus no length is accounted in relation to the wind velocity (of course the user could execute such an operation using the files on the PC). The average wind direction could be considered as the prevailing wind direction during as certain period.
Storing the momentary wind directions as such is not very useful as the wind direction can be very changeable especially at low wind speed.An example of the misunderstanding resulting from taking the wind direction as a scalar quantity as opposed to a vector quantity. The average of 350° and 10° would then be 180°. This would lead to the impression that the prevailing wind direction was from the south as opposed to the reality where the wind direction prevailed from the north.
Averaging vectors (direction of the resultants) in theory also produces problems. If for instance the wind comes from the west during 30 measurements and from the east during 30 other measurements this would result in a vector with a zero length. In practice such an event is unlikely to occur. But it remains more important to carefully interpret the results of wind direction measurement as to other measurements.

The wind vane needs hardly any maintenance accept for cleaning the meter now and then. The meter should be placed level as much as possible to avoid measuring errors. This is especially important at low wind velocity. Under normal usage the potentiometer will last over 10 years. If worn it can be replaced.

7. Rain gauge (art. no.: 16.98.47)

The rain gauge is a so called tipping bucket gauge. It consists of a funnel leading to the tipping buckets.



There are two tipping buckets separated by a partition. They have been mounted on an axle near the partition in such a way that the whole acts like a kind of balance. One of the buckets always ends up on top and the other at the bottom. If water is caught in the funnel the top bucket is filled until it is so heavy that it tips down then the other bucket rises and is filled. The buckets have been balanced in such a way that they tip at the point at which the quantity of water they caught is equivalent to 0.2 mm of rain on the surface of the funnel.
Each time the buckets tip down they pass a magnetic switch. This way a pulse is sent to the logging device.

☞ **It is very important for the buckets to be balanced properly.**

It is known that rain gauges of the tipping buckets type show a certain alinearity under high rainfall. This is caused by the fact that raindrops falling into the bucket which is tipping, are not counted. The chance part of the shower is not taken into account depends on the funnel surface, the size of the buckets and the intensity of the shower.
If funnel surface and size of the buckets are known it is possible to make a graph of the measured amount of rain (number of pulses times 0.2 mm) and the actual quantity of rain.

Research proved that the alinearity is very small and of no importance to most agro-meteorological research (for extremely accurate measurements (computer) calculated corrections are possible).

In contrast to this minor disadvantage we find substantial advantages such as simple and durable construction, great reliability and little maintenance.

To obtain reliable rain-figures the positioning is very important. The funnel should be 100% level. There should be no objects in the vicinity of the rain gauge which could interfere with the wind profile. It is most practical to simply place the meter on a concrete tile on the ground.
Sometimes the so called English setting is preferred. This set-up possibly allows even better results. For details we refer to the W.M.O. manual no. 8.

Maintenance of the rain gauge involves keeping the funnel and the buckets clean.

8. Soil temperature sensor (art. no.: 16.99.20)

The soil temperature sensor consists of an stainless steel tube with a thermistor element in the tip. A thermistor element is a resistance element of which the electrical resistance is measured. The resistance changes due to the temperature.
Only during the very brief measuring time a current is sent through the resistance so that there will be no self-heating effect. This way accurate and reliable measurements can be executed to determine the often minute changes in soil temperature.
The thermometer sensor should be placed entirely underground because otherwise the section above ground level could be heated by the sun. The sensor needs no maintenance. As the resistance is very stable recalibration of the sensor is not necessary for a longer period of time.

9. Relative humidity and temperature (art. no.: 16.99.15)

The relative humidity is defined as the relation between the partial vapour pressure 'e' and the saturated vapour pressure 'es'. It is usually represented by a percentage: Relative humidity = e/es x 100.
The saturated vapour pressure 'es' is temperature related. For further information we refer to the existing manuals.

The moisture sensor consists of a polymer plate clamped between two flat electrodes. This way it forms a capacitor. The polymer responds to a change in the relative humidity by releasing or absorbing an amount of moisture until a new equilibrium is achieved.This procedure takes little time (63% of end-value in 10 seconds). The amount of moisture in the plate is determined by measuring the relative dielectric constant of the plate. This figure varies with the humidity.

The temperature is measured using a resistance thermometer. The resistance thermometer is very stable thus recalibration should not be necessary.
The humidity sensor should be recalibrated every six months. This can be done by the user and is fairly simple. For a description of the procedure we refer to the operating instructions.

To achieve proper air-temperature measurement the sensor should be protected against direct sunshine. For this reason the sensor is placed in a white radiation shield. Given sufficient natural ventilation this set-up provides excellent measuring results. Deviations can be caused by very low wind speed, especially in combination with intense radiation activity from the sun (deviating temperature), of extreme humidity (deviating measurement of relative humidity). The latter is worsened by the cap protecting the sensor. Forced ventilation systems bring their own problems as a result of which a solution to this situation is not simple. We are actively searching for improvement. The problem, fortunately, rarely occurs.

10. Other sensors

The sensors most commonly used for agro-meteorological applications have been installed on the station. Except for these sensors a wide variety of others could be connected. For instance for:

- Net radiation measurement
- PAR-quantum measurement
- Volume percentage soil moisture
- Soil suction (tensiometer)
- Leaf-wetness periods
- UVA or UVB and UVAB radiation
- Thermal flux in the ground
- EC of fluids
- Water level

If you have any other questions concerning these and other measurements we are happy to provide advise.

11. Reference evapotranspiration (ET)

Using the radiation sensor (art.no. 16.99.39/16.98.36) and the air temperature sensor of the data logger (art.no. 16.99.15/16.98.41), reference evapotranspiration (ET) can easily be calculated with the Makkink (1957) evapotranspiration model. This model gives an accurate and reliable estimation of the reference evapotranspiration for a well watered short grass (reference crop) over a wide range of climatical environments.

The reference ET can be transferred using a crop factor to calculate the evapotranspiration for a specific crop. The crop factor should be known for the crop of interest.

By this estimation of the ET, irrigation can be scheduled more efficient, and crop damage due to water shortage or water surplus can be prevented. At the same time the cost of water (and energy) can be reduced by the more efficient scheduling.1987, the national weather service (KNMI) in Holland has been using the Makkink model as the reference evapotranspiration as well. Previously, the Penman model was used.

The ET with the Makkink (1957) model is calculated as follows:

$$ET = C \frac{S}{S + \gamma} Rg$$

ET = evapotranspiration for a short (8-15 cm) well watered grass (W m^{-2}) [Calculation]
C = constant for grass (i.e. 0.65) [Constant]
s = slope of the saturation vapour pressure temperature curve (Pa K^{-1}) [Calculation]
γ = psychrometer coefficient (i.e. 65 Pa K^{-1} for low altitude (1000 m) weather stations) [Constant]
Rg = global radiation (W m^{-2}) [Data]

Using one-hour weather data the ET is transferred to equivalent millimeters water by:

$$\frac{ET\ (Wm^{-2}) * 60\ (sec) * 60\ (min)}{\lambda\ (J\ kg^{-1})}$$

λ = latent heat for vaporization (i.e. 2.4 x 106 J Kg^{-1}) and 1 W m^{-2} = 1 J s^{-1} m^{-2}.

On the diskette an example spreadsheet file (Makkink.wk1) can be used to calculate the Makkink evapotranspiration for your own collected weather data. This file is presented in Lotus 123 format, which can also be read by

Symphony, Quattro Pro or Excell. To import your weather files into this example file, the following procedure can be used:

1. Load example evaporation calculation file Makkink.dif or Makkink.xls into a spreadsheet.

2. Import the weather data file into the free colums of this spreadsheet.
   For 16.98 stations use the data files with the *.dat extensions, for 16.99 stations use the data files with the *.txt extensions.
   Select the comma separated file format.

The calculations and used formula's are also stepwise described in the example file Makkink.

When combining the evaporation pan with the weather station, the ET can also be calculated using the data from the pan. The evaporation pan can also be used to verify the ET as estimated with the Makkink ET model. For a graphical display of the Makkink model and a comparison with evaporation data collected with a evaporation pan, please see figure 1 and 2.
Please remark that these results are compatible even under these extreme conditions.

Appendix: fixing the guy wires