EMS Brno

Data Acquisition Environment

Hardware - Software – Cloud application

www.emsbrno.cz

Notes on operation and maintenance of EMS Brno measuring systems

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Long-term operation of data acquisition equipment requires regular maintenance. The idea that the worry ends with the procurement of funds to purchase and install the equipment is not in line with reality. Maintenance intervals vary depending on the type and complexity of the measuring equipment but are never infinite. In this material I will try to mention the scope and method of maintenance according to the characteristic types of equipment supplied by EMS Brno.

1. Sensors with built-in data loggers or transmitting on an IoT network

Here, maintenance requirements are minimal and practically reduced to replacing the batteries and the desiccant with them. Exceptions are:

1.1. Minikin for radiation measurement

Purity of the optical diffuser. Under normal conditions, rain takes care of this, but in extremely dry and dusty environments, the sensitivity of the sensor is necessarily reduced by dust deposits. The disturbing factor is stale bird excrement. See 1.4.3 for further comments.

Tasks: To clean and control the horizontality.

1.2. Minikin THi with humidity sensor

The Honeywell humidity sensor used is housed under a sintered housing (porous sintered stainless steel) and the durability and stability of this sensor designed for the automotive and aerospace industries is surprisingly high. Unless exposed to hydrocarbons, ammonia or 100% humidity for long periods, the sensor will hold a measurement error within the technical parameter range (±3.5% r.h.) for up to ten years. There are therefore no maintenance requirements. However, in dusty environments, careful cleaning of the sensor surface (brush, soft cloth) may be recommended.

Tasks: Inspection and cleaning of sensor surfaces.

1.3. Increment sensors

First of all, it is important to note that these are in principle integrating sensors, which have a maximum range when reinstallation or tape release or replacement is required! Caution - with tape dendrometers it is generally true that folds in the tape increase the

temperature dependence of the measurement. When loosening the tape, the original bend should be straightened, e.g. with suitable flat-jawed pliers.

Tasks: Monitor the remaining of measuring range and energy in the battery until the next visit.

2. Measuring sets with their own data logger or transmitting in an IoT network

These are kits with a limited number of sensors connected by relatively short cables to small waterproof dataloggers with IR communication. The maintenance requirements are again minimal, the biggest problem here tends to be cables damaged by rodents. Long experience has shown that placing a datalogger under the ground surface is vulnerable to curious wild boars; they will dig up them, damage and leave it. Placing it on the surface of the ground is safe from this point of view, but damage to the connectors by rodent gnawing often occurs. So far, attaching to anything vertical at a height of at least 40 cm seems to be the most reliable.

2.1. MicroLog SP3 with gypsum blocks

The blocks have a relatively short life span, limited to two to three years in practice. After that, replacement is necessary. A warning for the case of already heavily eroded blocks is the slowly rising minimum soil potential value (above -0.04 MPa).

Tasks: Monitor the expected expiry date of the gypsum block.

2.2. Rain gauge sets

A chapter unto itself. I point out the vulnerability (moving mechanical parts) and on the other hand the irreplaceability of the measured data, spatially extremely heterogeneous by principle. The cleanliness of the flapping mechanism is crucial not only in terms of accuracy but also reliability. Particularly in dusty environments, muddy deposits form on the calibrated vessel, which fundamentally affect the function of the rain gauge. As with radiation sensors, bird excrement is a serious problem. In the case of under-crown rain gauges placed close to the ground, care must be taken on clogging mechanism with mud!

Tasks: Clean sieves, drain holes, moving parts and check the horizontality.

3. Data loggers housed in weatherproof enclosures

3.1. Air humidity

The majority of electronic equipment failures are caused by moisture inside the instrument enclosure. At this point, it should be emphasized that the commonly stated weatherproof rating (IP) is only a minor piece of information, as it is relatively easy to protect against rain and dust.

Much more insidious is the *penetration of air moisture through the walls of enclosure (especially plastic ones) and rubber seals.* In addition, moisture also enters the enclosures through the cables. The only realistic protection here is a desiccant placed inside the enclosure. Most commonly used are bags with an absorbent - usually silica gel or finely ground dried clay. The disadvantage of this solution is the decreasing efficiency with time and the difficulty to indicate saturation.

Another option is the use of the saturated solution of inorganic salts, which keep the partial pressure of water vapor in the cabinet at a constant value. In a practical design, this is a transparent container filled with less than 20% of its volume with bulk potassium carbonate K_2CO_3 (potash). This simple facility keeps the humidity in the instrument enclosure below 50 % when the container contains less than about four times the volume of the powder originally poured in. Then simply empty the container and pour in a new batch of potash. The advantage, besides the guaranteed function, is the negligible cost of this chemical.

This solution is of course applicable to larger enclosures, fixed in a defined position (although potash is not corrosive, it will destroy electronics quite reliably if spilled) and with enough space for a container. GreyBox type dataloggers, which already come in a waterproof enclosure, use desiccant bags that can be replaced directly from the outside of the enclosure without opening the lid.

For information about the desiccant status, newer data loggers integrate an indoor humidity sensor with information directly in the data file and/or in a cloud application if the data is available online.

If a datalogger with inserted batteries (e.g. EdgeBox) is used, it is absolutely necessary to replace or at least *remove the dead batteries*. Unlike in the recent past, the electrolyte leaks from discharged alkaline batteries and if this happens, it usually means the destruction of the datalogger electronics. The new lithium-ion non-rechargeable batteries do not yet suffer from this problem and their use can be recommended; moreover, they have significantly better operating characteristics.

For dataloggers with built-in rechargeable lead-acid batteries, we recommend replacing them after three to four years.

CAUTION - It is essential to deactivate the solar panel before disconnecting the battery for any reason: Disconnect the connector, cover the panel with an opaque cloth, coat or disconnect from the terminal block inside the instrument box.

Tasks: Check and replace desiccants and batteries, replace rechargeable and backup batteries in a timely manner.

3.2. Lid or enclosure door seal

Every seal degrades over time. Pay attention to this seal every time you open the enclosure. With Hofmann enclosures, replacing the seal on site is very simple; the manufacturer will supply a replacement seal in a gauge. Also pay attention to any dirt on the seating surfaces or accidentally pinched internal connection cable.

Tasks: Check the condition of the enclosure door seals.

4. Devices with modem

With the increasing requirement for online access to measured data, larger measuring systems are commonly equipped with modems for data transmission in GSM networks (IoT sensors are a different chapter in this context). Due to their relative high power consumption, the modems are switched by the data logger at preset intervals and automatically switched off after data transmission finish. In this context, the energy resource requirements of frequent data transmission must be taken into account.

In terms of data transmission reliability, SIM cards are the weakest link, as their contacts sometimes oxidize and the transmission is unreliable. Therefore, the first attempt to restore the function is to wipe the contact side of the card with a clean cloth or paper napkin. Sometimes the only solution is to replace the SIM card with the new one. Generally, modem failures are orders of magnitude less likely than problems with SIM cards.

Experience with many devices shows that, for reasons known only to the GSM providers, communication sometimes fails while no problem can be found at the site itself. However, this is addressed in the cloud application, which is able to "make up" the missing data when the connection is re-established. In addition, EMS modems include a memory card with several years of measurement capacity in case of prolonged problems.

The last comment relates to the fairly strong current spikes in the modem power supply, especially after startup. An imperfect contact in the power supply can cause a short-term power failure leading to repeated reboots and subsequent limitations in the device's functionality.

5. Sensors

Basically everything mentioned in the chapters 1 a 2 applies here. To next sensors:

5.1. Mechanical anemometers

Like any device based on a mechanical principle, this type of sensor requires regular maintenance. Practically, it concerns the replacement of bearings. These must not be lubricated for reasons of sensitivity at low wind speeds. Although stainless steel ball bearings are now used exclusively, their service life is not infinite. This also applies to the wind vane, which is no less stressed. Don't be fooled by the fact that both move or spin - bearing fits are usually designed so that moving parts continue to move even with seized bearings, but there is no question of accuracy or subsequent life.

Tasks: Check the date of the recommended bearing replacement, check the sensor horizontality and the orientation of the vane.

5.2. Humidity sensors

This type of sensor is the second most problematic after rain gauges, albeit for a different reason. Moisture sensors have undergone remarkable developments in recent years towards stability and accuracy, but the question of realistic durability in harsh outdoor environments still remains. There is also the problem that declining accuracy is difficult to indicate. Manufacturers address this by recommending recalibration at given intervals, which is not a cheap affair, not to mention measurement lockout or the need to use the backup sensor.

Another strategy is the sensor design allowing easy replacement of the measuring chip in the field. The EMS33H, EMS33S and EMS36S use this solution, which is also significantly cheaper than recalibration. The interval between chip changes is still a matter of operating experience, but so far, in our experience, even after three years of operation of these sensors, replacement of the measuring chip does not seem necessary.

Tasks: Check the date of recommended recalibration or chip replacement.

5.3. Radiation sensors in terms of recalibration

The diffuser material of the sensor - where the radiation enters the sensor - and which is exposed to the external environment plays a crucial role. Sensors with a glass dome or glass diffuser are very stable in this respect. The EMS11 and EMS12 series sensors are of this design and, in our experience, practically do not need recalibration, although for demanding measurements a five-year interval between recalibrations may be recommended.

Tasks: To clean and check the horizontality.

6. Sap-flow

I list this as a separate chapter because it is quite a complex system. The only way to check function is to look at the downloaded data. Maintenance is mainly about connecting the instruments to the battery. Terminals can be loose, oxidized, etc. WARNING - no sap-flow system will start if the supply voltage is less than 12 V and the power supply is not sufficiently sized so that the voltage does not drop below 11 V when the sensors start!

Each sap-flow system of EMS Brno production is equipped with function indicators. For more information see the respective operating instructions. Here I will give only a few information that is usually forgotten:

- EMS 81 and EMS 64 with built-in datalogger – connection of the power supply is indicated by the trill.
- EMS 81 and EMS 64 in the SDI-12 sensor version – connection of the power supply is indicated by "beep".
- EMS 81 and EMS 64 in the SDI-12 sensor version "beeps" their address when the magnet is brought close to the face of the electronic module (a long "beep" means five short ones). In the event of a fault, they also "beep" the error code number after a separation chord.
- The voltage between the electrodes of the EMS 81 can reach up to 200 V peak. Handle with care!
- The removed thermocouple needle of the SF 81 sensor from spruce, pine and similar resine-full trees cannot usually be easy inserted back into its original place. When it comes to replacing the sensor at intervals of tens of minutes, the needle can usually be inserted back into its original place with the utmost care. Anointing of the needle surface with edible oil will help.

ATTENTION: For the TC-120 temperature sensor for EMS 51 series sap flow meters, the bottom reference needle can no longer be repaired or replaced for technical reasons and further production of these sensors is impossible for the same reasons. Please keep this in mind when handling the sensor!

- An insufficiently tightened connector for connecting the SF 81 thermocouple set to the electronic module can cause rainwater to enter the module and destroy expensive electronics.
- Unconnected connectors in the cable network must always be sealed with special plugs designed for this purpose.

- Don't underestimate the details of installing sapflow sensors, especially the insulation against weather and sunlight. Applies to both small-diameter and large-bore sensors. Every detail is backed by 40 years of development.
- For small diameter sensors, thoroughly clean the stem of anything that may prevent perfect contact with the heating elements of the sensor.

7. General principles

- Never wrap disconnected or damaged connectors with insulating tape (the exception is repairs with self-vulcanizing tape, but this should be done by an experienced worker). Moisture is held under the tape and will destroy a connector or other elements faster than if left without such protection. Hang disconnected connectors that must remain in the field at least 50 cm from the ground so that the contacts are pointing down. Do not wrap them!
- Charge the power or backup batteries at least once every three months during periods of inactivity.
- For solar powered devices, never disconnect the battery before the solar panel! The voltage of an unloaded panel reaches values that can damage or destroy electronic devices.
- Do not forget to remove the potash container, if installed, before transporting the equipment.

8. Practical recommendations for checking measuring equipment

8.1. Takeaway:

Flat screwdriver 2.5 mm, 3 mm, 5 mm, pozidrive size 2, 3
Cutting pliers
Pliers with narrow, preferably flat, jaws
Tweezers
Universal wrench with flat jaws
Key to open the instrument panel
RailBox module removing tool
Flat wrench 10, 13 mm
Pocket knife
Linear and round spirit level for radiation sensors
Multimeter

Spare batteries - several of each type used
Replacement glass fuses 2,5 A
PVC insulation tape
Self-vulcanizing tape
Stretch tape
Double-sided adhesive tape
Scotchlok connectors two sizes (for quick connection of broken wires in cables)
IrDA/USB data cable
RS232/USB data cable with 2.5 mm Jack connector
MicroLog case opener
Minikin case opener
Waterproof permanent fix (not Centropen!)
IrDA head holder for Minikin Tie
IrDA head holder for DRL26
WD40 spray
Repellent
Binding wire spool
Plastic tightening strips (zip ties) - two lengths
Drying bags of all three sizes
Desiccant (potash powder or bags)
Brush for cleaning the MicroLog housings before opening and for cleaning the rain gauge
The role of paper kitchen towels
A computer with a good battery and a current version of Mini32 installed
Keys or cards for access to the plots/facilities

8.2. Check before you go:

- Battery status in the multimeter
- Computer battery charge status
- Voltage of batteries to be replaced in the field (must be around 13 V)
- Completeness of equipment
- Whether there are older files on the laptop from the devices we intend to visit. (for possible restoration of damaged configurations) and the current version of the Mini32 software. **ATTENTION:** New sensors or dataloggers may not be supported by older software versions!

8.3. After downloading the data:

- Take at least a brief look at all the variables in "Browsing" mode to see if there are no glaring problems.
- Ensure that the last values in the file are at the time of your visit and therefore that the device is still working.

8.4. In case of a problem:

- Check the fuse if installed (in EdgeBox or RailBox datalogger cabinets).
- Press the datalogger function check button, if equipped. The check LED should flash three times. In the event of a fault, it will flash 10 times yellow.
- Check if the red light inside the dataloggers turns on when the magnet is approached (applies to Minikins, MicroLogs, RoundBox, GreyBox, denrometers).
- Check the connection to the battery (screw terminals, clamp terminals).
- Measure the lead acid battery voltage (it should be at least 11.5 V, but that means it is already discharged). The voltage of a battery charged by photovoltaic panels during the day with occasional sunshine should fluctuate between 13 and 14 V.
- Measure the supply voltage inside the enclosure as close as possible to the datalogger or sensor supply. It should be equal to the voltage of the battery or internal batteries.
- Try downloading the data to your computer, preferably also HCM
- Try sending the data by manually switching on the modem.
- Call for help directly from the site (Kučera +420 731 616 416, Tuček (hardware) +420 731 616 419 or Bellan (cloud application) +420 733 203 139).

8.5. Check before leaving the site:

- Closing the instrument enclosure doors.
- Tightening the screws of the MicroLog, DRL26 datalogger caps (if something was loose, e.g. when changing batteries).
- Pulling out the manual modem start switch (on older systems).
- Re-inserting tampered connectors.
- Reliability of battery connection contacts.

- Battery voltage after replacement (approx. 12 V for eight monocells).
- Remaining life of built-in batteries (info is written in downloaded files).
- Whether the dryer has been replaced.
- Whether everything is clean, leveled, visually undamaged

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