Wind Speed and Wind Direction Instruments Maintenance and Calibration Protocols

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1.0 INTRODUCTION

Wind speed and wind direction are measured at all climate monitoring stations operated by Alberta Agriculture and Forestry (AAF), which is an important aspect of climate monitoring and forecasting. Wind speed and direction data are used to develop maps and models which are integral to operations such as flood forecasting, fire forecasting, irrigation water management, crop production and crop insurance programs as well as for modelling, research and forecasting by other government and private agencies.

Wind speeds are measured using either the 3-cup (Met One 013A/014A anemometer) and/or the propeller (RMY Wind Monitor 05103) device types (Figure 1). Wind direction is measured with a vane (RMY Wind Monitor 05103) from which direction the air is moving that is aligned 0 degrees relative to true north.

For meteorological purposes, an installed height of a wind monitor device for wind speed and direction is 10 m above the ground. For agro-meteorological purposes, an installed height of a wind device for wind speed is 2 m above the ground. In the Alberta Environment and Parks (AEP) monitoring network, when monitoring in treed or forested areas the wind monitor should be located a minimum of 3 m above the forest canopy. If mounted on a Forestry lookout tower, the mounting boom should be on the tower leg facing the prevailing wind direction (usually W or NW).

Sensors are installed and maintained in a level position. Typically, at a height of 10 m they are mounted on tiltable towers and at 2 m they are mounted on poles that occasionally utilize arms to keep one sensor away from other mounted sensors. When mounted on arms, the sensor should be mounted preferably towards the prevailing winds and be of a dark (black preferably) colour when mounted near a solar radiation sensor.

No official formal standard operating procedure (SOP) for the measurements of wind speed and wind direction has been written by the Government of Alberta. Most knowledge has been passed on through demonstration, collaboration, and mentorship. Guidance was gained from the equipment manuals, as well as informal training from the vendor and other staff.

The objectives of this document are to record the SOP throughout the network and to ensure that each technologist adheres to these standards. The data collected from these sensors becomes part of the provincial archives and is used in many high level applications relating to climate data. The proper implementation of the standards will ensure the integrity of the network and the quality of data for the Alberta Climate Information Service.

Figure 1. Met One 013A/014A Speed Sensor (Left) and RMY 05103 Monitor (Right).

2.0 EQUIPMENT AND REPLACEMENT PARTS

The following describes the major types of equipment and replacement parts for both the Met One and RMY wind sensors. Manufacturers' specific parts have been utilized in the maintenance and calibration of these sensors to ensure they comply with the manufacturers' specifications throughout their lifecycle in the network. These parts can be purchased directly from the manufacturers or through brand specific approved vendors.

2.1 Field Maintenance Equipment and Replacement Parts:

- Met One 013A/14A c/w cable and/or RMY 05103 complete unit devices available at all times.
- Met One 013A/14A complete unit with new certified bearings/reed switch installed ready for annual field scheduled sensor swap.
- RMY 05103- (2) nose speed flange bearings #05163PG complete with #05190 bearing gap gauge and 1/16" hex wrench for in the field annual speed bearing replacement.
- Compass if needed for orientation/directional verification of the RMY.

2.2 In-house Bench Test Calibration/Maintenance Equipment and Replacement Parts:

- RMY Model 18802 Anemometer Drive for wind speed check.
- RMY Model 18112 Vane Angle Bench Stand for wind direction check.
- RMY Model 18331 Vane Torque Gauge for free direction rotation check.
- RMY Model 18310 Propeller Torque Disc for free speed rotation check.
- RMY 05163PG Flange Bearing (2 required per sensor).
- RMY 05124VG Vertical Shaft Bearing (2 required per sensor).
- RMY 05133B Potentiometer 10k (1 per sensor).
- RMY 05190 Bearing Gap Gage.
- RMY 05191 1/16 hex wrench.
- MET ONE 013A and 014A Pre-assembled Rebuild kit #2402 (1 per sensor) preferred or M1898 M1 Bearing (2 required) and L1184 Switch Reed W/Leads Straight Hamlin Mini 2-S.
- MET ONE 013A and 014A M1715 Magnet Assembly if requires replacing.
- Soldering station, solder/flux, needle nose pliers, Allen wrenches, drivers, clamps, etc.

3.0 MAINTENANCE/CALIBRATION PROCEDURES

The agro-meteorological station network of AAF has adopted a strict and comprehensive routine sensor maintenance protocol based on experience, in-house bench testing findings and manufacturer's recommendations that includes scheduled field inspections, partial/complete rebuilds, bench testing and sensor swaps and rotations coupled with data management quality assurance/quality control (QA/QC) checks to ensure the data being collected and stored is reliable and correct. All wind sensors are routinely rotated to other stations following in-house bearing replacements coupled with pre and post-bench testing to confirm speed and directional measurements (if applicable) to ensure recommendations and standards from the World Meteorological Organization (World Meteorological Organization, 2012) as well as the manufacturer are met.

3.1 Field Maintenance Procedures

3.1.1 **<u>Observation and Physical Field Maintenance Protocols</u>** for wind instruments are completed as a minimum twice a year: in the spring and fall. For wind direction, the RMY wind sensor vane "reference position" is orientated to true north when the junction box orientation ring and clamp mounted below the sensor is orientated facing south. True north can be referenced from fence lines and road allowances using grid north. However, to ensure reference accuracy an alternative way of orientating the sensor is accomplished by using a compass to orient to true north by Magnetic Declination Methods (calculator found at http://geomag.nrcan.gc.ca/apps/mdcal-eng.php). Proper siting guidelines calls for wind sensors and obstructions to have a separation distance of a minimum of 10 times the height of the obstruction. For sensors operated by AEP in the northern portions of the province at Forestry lookouts, these checks are performed once every two years unless the technologist has reason to suspect the data may be questionable (i.e. beyond acceptable variances). The following procedures are included when checking the wind instruments in the field:

- Inspection of the sensor cups, propellers and vanes to ensure no physical damage (e.g., dents or cracks), for example, from hail and birds.
- Observation that the cups and vanes move freely and are clean from obstructions.
- Visual check that instrument is level to a tolerance of ± 1.5 °.
- Listen for bearing noises when/where applicable.
- An operational wind speed accuracy of ± 0.5 m/s (1.8 km/h) with a wind direction accuracy of ± 5 ° is used following the R.M. Young standard calibration recommendation (R.M. Young Company, 2000).
- Subjectively compare wind speeds between sensors where applicable. As a simple comparison, the wind speed at a height of 2 m is approx. 25 % less than that at 10 m (Allen, 1998).
- Check for possible exposure changes and document if necessary.
- Check for possible senor orientation changes in wind direction sensors by observing junction box orientation is still facing south in the case of RMY 05103.
- Subjectively compare wind directions where actual data logger sensor output to the four co-ordinate directions (N-0 or 360, E-90, S-180 and W-270) or in reference to the orientation ring nipple when/where applicable. *Note: when RMY 05103 is in the 5 °e dead-band region, values may be unpredictable.*
- Observation of starting torque by temporary shielding it from the wind to observe start-up and stop responsiveness as an indicator of bearing fatigue and fouling. If there are any concerns the sensor bearing is replaced in the field or the sensor is swapped out instead of performing torque tests in the field. *Note: Met One anemometer will read a minimum of 1.6 km/hr due to programming offset to account for starting torque requirements.*
- Check the condition of all exposed conduit, cables, connectors and wire/cable ties for signs of UV breakdown or mechanical damage.
- Check that sensor support structures (e.g., poles, booms, towers, can truss) are vertically and/or horizontally level, secured and orientated correctly.
- Check guy wires, wire clips, turnbuckles, clamps, bolts, winches, lightning rods, grounding cables/rods and enclosure boxes for tightness and/or functionality.
- Inspect sensor wiring/enclosure boxes for weather seal damage and dryness.
- Before leaving site, prevent exposed unprotected metal parts from rusting by painting with cold-dip galvanizing paint or rust proofing coloured matched spray paint.
- Lubricate 10 m tower winch/cable, if necessary, with an anti-seize lubricant such as Coppercoat for ease of operation and to avoid corrosion.

- Fill holes by poles or towers from animal activity to minimize injury and or water ponding.
- Refer to manufacturer's user manuals for proper recommended installation practises of their sensors.

3.1.2 **Mechanical Field Maintenance Protocols** for wind instruments are completed as a minimum once per year. Data logger programming multipliers and offsets do not have to be changed for sensor exchanges if exact model. Refer to sensor manuals and data logger manuals for specific programming instructions if necessary. *Note: if using a Met One 013A/14A anemometer, a minimum wind speed of 1.6 km/hr will always show even if no wind present due to an accepted offset in programming to allow for bearing torque; and an RMY wind monitor will have a dead-spot of 5 ° facing north.* Data logger maintenance flags are set whenever work is being performed in the field that will affect data. These following procedures should be completed in the field:

- Wind speed bearings are replaced annually for all wind sensors and wind monitors.
- For the anemometer (Met One 013A/14A): the sensor is replaced with a different unit that has a new manufacturer calibrated bearing/reed switch re-build kit installed and tested in-house in the off-season. The sensor is replaced either in the spring or fall maintenance run but ideally replacing it during the spring is preferred to ensure best data quality, since this sensor is used primarily for evapotranspiration calculations during the growing season.
- For the wind monitor (RMY 05103): the speed bearings of all wind speed sensors are replaced annually usually in the spring in the field. In the northern portions of the province, especially at AEP sites co-located at Forestry lookout towers, this maintenance is performed once every two years. Use a soft cloth to wipe off any accumulated dirt or grit from the shaft and nose cone of the sensor. *Note: the potentiometers are tested and replaced and re-tested on all wind direction sensor every eight years in-house unless there is any indicators or concerns of pre-mature wear and/or damage which in that case the complete sensor device is replaced and documented.*

At field maintenance, any wind sensor that appears questionable (structural damage or material degradation) is replaced. The device is then labeled accordingly for in-house bench testing, pre and post-maintenance calibration verification and documentation.

3.2 In-House Calibration/Maintenance Procedures

3.2.1 Anemometer: MET ONE 013A/14A

Annually each anemometer is swapped out from the field for a complete bearing/reed switch replacement. These two components are replaced together preferably as a re-build kit pre-assembled by Met One Instruments Inc. These rebuild kits are available directly from the manufacturer.

Since the internal parts are pre-assembled, all that is needed is to:

- Remove the cup assembly and check damage/replacement if needed.
- Remove the three Phillips screws at the top of the sensor and lift out the bearing mount assembly
- Unsolder the leads of the reed switch and solder the two lead wires back on to the switch of the rebuild kit.
- Spin the shaft to verify switch operation by listening for switch closure.
- Reassemble sensor.
- Replace the sticker on top of the cup assembly if required.
- Put some heat shrink on the upper part of the housing shaft to help minimize dust from entering the bearing mount.
- Cover/Protect serial numbers from weathering damage by covering with tape or similar product.

After this is all completed, manually spin the cup assembly once again to ensure it spins freely. If the cup assembly hub has not been disassembled its original position then it is assumed to still conform to standards.

An anemometer drive can be used to test the bearings but since we are using certified tested re-build kits directly from the manufacturer it is not necessary. These rebuild kits have been tested for Torque, End Play, Duty Cycle, Output Frequency and Hi-Pot to new sensor specifications.

After installation, readings from a data logger and clean noise from the bearings ensure that the installation is good. Each sensor has a unique serial number and all servicing work performed as well as its history is documented in our inventory database.

For troubleshooting, if there is no sensor output (or consistently reading only 1.6 due to program offset) then there may be a problem with the reed switch, and if cups assembly is noisy or not spinning at outputs less than 3 km/hr, then the bearings may be faulty.

For more detailed information and diagrams, refer to the manufacturer's manual (Campbell Scientific (Canada) Corp., 2017) (Met One Instruments/Campbell Scientific (Canada) Corp., n.d.).

3.2.2 Wind Monitor Sensor: RMY 05103

All wind monitors are scheduled to be removed from the field every 8 years, unless performance warrants removing them sooner, for in-house bench servicing. In-house bench servicing involves:

- Verification/Testing the sensor relating to wind speed and direction before and after maintenance is performed.
- Replacement of (2)-flange bearings in the nose and (2)-vertical shaft bearings as well as the potentiometer in the main housing.
- Documentation/Archiving the before and after test results and work done.

The how-to procedure for this servicing is outlined in detail in the manufacturers' manual (Campbell Scientific (Canada) Corp., 2017) (R.M. Young Company, 2000).

"Pre and Post" excel maintenance sheets "R.M. Young Calibration and Maintenance.xls" are used to document the testing procedures and actual results compared to theoretical. Once completed, these actual documents are archived on the internal shared drive and filed by serial number and date e.g. 4555 y2017 m02 d13. The maintenance history record and location of the sensor is entered into the internal shared drive.

These maintenance sheets refer and use the following standards based on the published operational accuracy recommendations (R.M. Young Company, 2000) to determine if a sensor fails or passes:

- Wind direction torque – Pass = 0-30 gm-cm
- Wind speed threshold – Torque = 2.6 gm-cm
- Wind speed signal – Pass = ± 0.5 m/s
- Wind directional signal – Pass = ± 5 °

3.2.3 Wind Monitor RMY 05103 Lab Check Worksheet – Before Maintenance

The following document is a representation of a typical lab check worksheet. These sheets can be created in Microsoft Excel or similar program to include automatic calculations with Pass/Fail outcomes.

R.M. Young (05103) Calibration and Maintenance

Serial #

Date

Wind Direction Torque Pass = 0-30 gm-cm

	Pass	Fail
CW		
CCW		

Wind Speed Threshold Torque = 2.6 gm-cm

	Pass	Fail
CW		
CCW		

Wind Speed Signal (Km/hr) Pass = ± 1.8 km/h

RPM	Theoretical	Actual	Diff	Pass/Fail
200	3.5		3.5	FAIL
1000	17.6		17.6	FAIL
2000	35.3		35.3	FAIL
4000	70.6		70.6	FAIL
6000	105.8		105.8	FAIL
8000	141.1		141.1	FAIL

Wind Direction Signal (Degrees) Pass = ± 5 °

Theoretical	Actual	Diff	Pass/Fail
30		30	FAIL
60		60	FAIL
90		90	FAIL
120		120	FAIL
150		150	FAIL
180		180	FAIL
210		210	FAIL
240		240	FAIL
270		270	FAIL
300		300	FAIL
330		330	FAIL
340		340	FAIL
350		350	FAIL
355		355	FAIL
0		0	PASS

Notes:	

Maintenance

	Yes	No
Replace flange bearings		
Replace shaft bearings		
Replace potentiometer		

3.2.4 Wind Monitor RMY 05103 Lab Check Worksheet – After Maintenance

Wind Direction Signal (Degrees) Pass = ± 5 °

Theoretical	Actual	Diff	Pass/Fail
30		30	FAIL
60		60	FAIL
90		90	FAIL
120		120	FAIL
150		150	FAIL
180		180	FAIL
210		210	FAIL
240		240	FAIL
270		270	FAIL
300		300	FAIL
330		330	FAIL
340		340	FAIL
350		350	FAIL
355		355	FAIL
0		0	PASS

Wind Speed Signal (Km/hr) Pass = ± 1.8 km/h

RPM	Theoretical	Actual	Diff	Pass/Fail
200	3.5		3.5	FAIL
1000	17.6		17.6	FAIL
2000	35.3		35.3	FAIL
4000	70.6		70.6	FAIL
6000	105.8		105.8	FAIL
8000	141.1		141.1	FAIL

Wind Speed Threshold Torque = 2.6 gm-cm

	Pass	Fail
CW		
CCW		

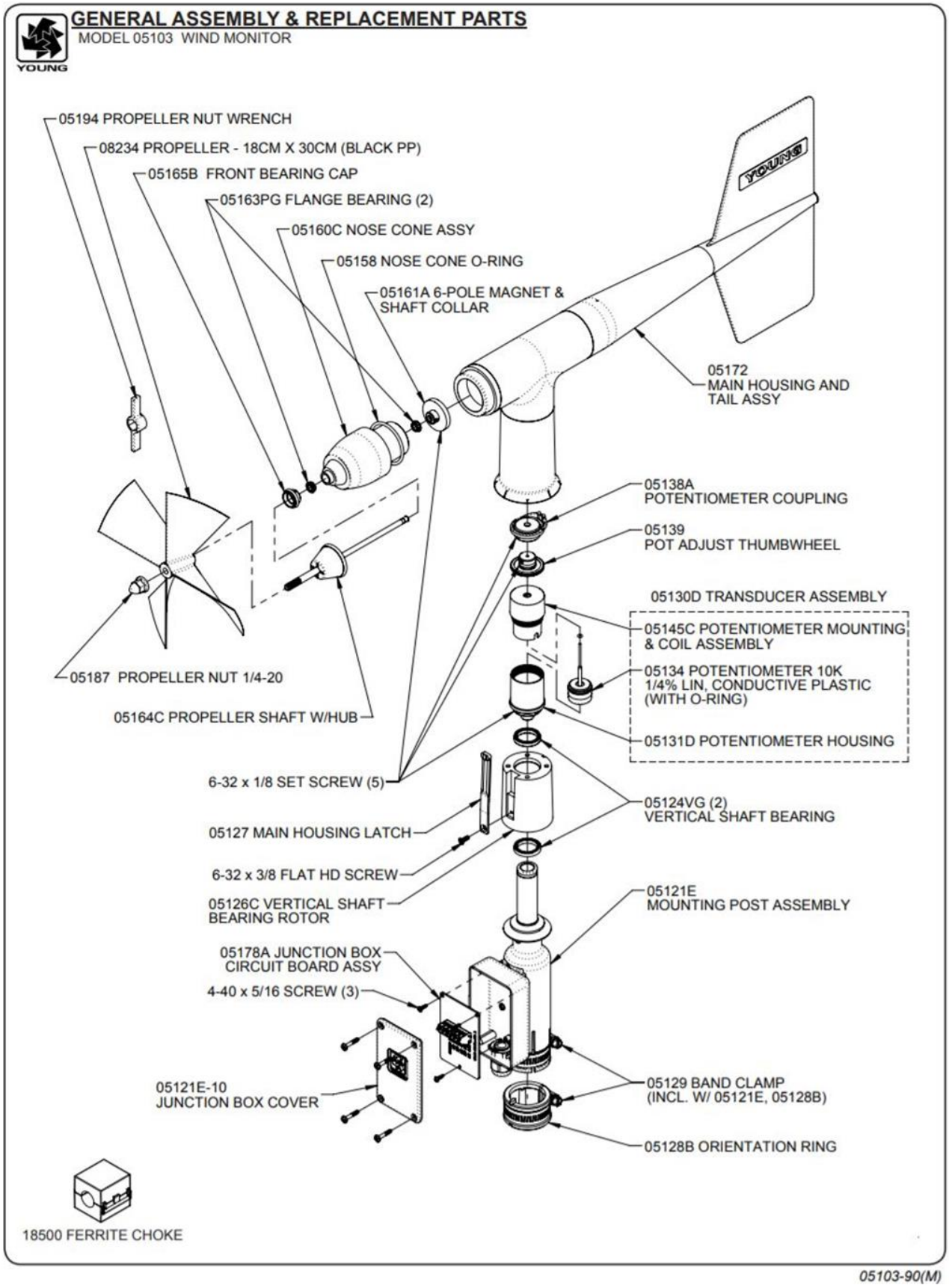
Wind Direction Torque Pass = 0 - 30 gm-cm

	Pass	Fail
CW		
CCW		

Technologist

3.2.5 Wind Monitor RMY 05103 Parts

The following diagram presents the components for the RMY 05103 wind monitor unit (R.M. Young Company, 2000).



4.0 ACKNOWLEDGEMENTS

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