

**University of Saskatchewan  
Department of Mechanical Engineering  
Standard Operating Procedure # HT0002**

**Procedure Title: Mobile Wind Energy Laboratory - MWEL**

**Minimum Review Requirements:**    **Annually**

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**1. Version History**

Version #: 1.2  
 Supersedes: 1.1

Handwritten amendments to the official procedures can be made by a single line through the text, along with the date, and initialed by the authorized individual making the correction. Changes are to be noted below. Formal changes to this SOP are made on the date of revision or sooner, where required.

Section	Changes made to official copy	Date	Initials
All	Rewritten into Dept standard format	Mar 2014	MTF
	-added sections 1-5 and 7-10		
All	Minor housekeeping	July 2016	MTF

Reference Only

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**2. Introduction**

This procedure outlines the basic operation and safety guidelines of the Mobile Wind Energy Laboratory (MWEL). This provides a technician or researcher with the basic background information needed to operate the MWEL. More detailed information regarding the hardware and software can be found in the MWEL Binder (located in 1B39.1.1). The MWEL was developed by the Department of Mechanical Engineering at the University of Saskatchewan. The idea behind the MWEL is to give students a hands-on experience using a wind turbine. The turbine is a stock Southwest Windpower AIR-X 400. An owner's manual, as well as an NREL performance report (obtained from Southwest Windpower) are available in the MWEL Binder.

**3. Definitions**

BS: Base Station  
HS: Hub Station  
IEC: International Electrotechnical Commission  
MS: Mobile Station  
MWEL: Mobile Wind Energy Laboratory  
NREL: National Renewable Energy Laboratory  
SOP: Standard Operating Procedure

**4. Personnel**

Persons authorized to perform this SOP:

By signing this form I acknowledge that I have read and understand this SOP, and that I will conduct myself in accordance with this SOP and the general laboratory rules.

**NOTE: ALL SIGNATURES MUST BE PRESENT ON THE SOP LOCATED IN THE YELLOW BINDER IN ROOM 1B39.1.1 – the Heat Transfer Departmental Assistant's Office.** Digital copies of SOP's are made available for reference and convenience only. Printed SOP's are valid for 24 hours only, after that time their accuracy must be verified with the **OFFICIAL HARDCOPY VERSION**. A reference copy of this SOP can be found in the MWEL binder (1B39.1.1).

Name (Print)	NSID	Dep't	Signature	Date

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## **5. Safety**

- When choosing a location for the MWEL be very aware of overhead electrical wires or obstructions. Do not raise the mast unless the area above and around the MWEL is clear of any obstructions.
- Only the person raising or lowering the mast should be within 10 ft of the trailer when operating the mast lift. All others should be at least 10 ft away.
- Ensure all four jacks are down and the trailer is level before lifting the mast.
- Make sure the turbine control is in the **Brake** position while raising or lowering the mast.
- If the turbine is still slowly spinning while you are lowering the mast, make sure nobody is in the way. **Note:** Sometimes, the brake does not work correctly – try placing the turbine control switch to the **Generate** position – this often works.
- Lock the instrumentation boxes whenever the MWEL is left unattended.

During the ME 328 F6 lab, students are allowed to play with the turbine to get a feel for how much torque is required to generate electricity. The following safety rules should be followed:

- Do not climb on the trailer.
- Be careful when touching the turbine blades as the edges are sharp.
- Do not spin the blades by the tips as the blades could break.
- The tail of the turbine should be held to ensure it does not spin around and hit somebody.

## **6. Procedure**

### **6.1 General Set-up**

The MWEL consists of a wind turbine mounted to the top of a mast, which is attached to a trailer. The general set-up of the trailer is as follows:

- Tow the trailer to an appropriate spot (be aware of any overhead obstructions).
- Lower the four jacks so that the weight of the trailer is removed from the two back trailer tires. Raise the small front tire of the trailer.
- Level the trailer by adjusting the four jacks.
- Secure the handles of the four jacks, as well as the hitch, with padlocks.
- Remove the bungee cords that hold the turbine in place for transportation.
- Unlock the two instrumentation boxes.

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## **6.2 Mast Raising/Lowering**

The mast is raised and lowered via a hydraulic cylinder operated from a 12 V hydraulic power pack located in the driver's side instrument box. There is an up/down switch used to operate the pump.

### **To raise the mast:**

- Remove the locking pin from the mast.
- Ensure there are no obstructions that the mast could hit when raised.
- If rotor torque and RPM are to be measured, turn on the power switch of the hub (you may need to install a fresh battery).
- Ensure that all other persons are at least 10 feet away from the trailer.
- Close the restrictor valve on the pump, then open it slightly, so that the mast will move slowly at the beginning.
- Press the 'up' button.
- Once the mast has started moving, open the restrictor valve on the pump so that the mast moves faster (this requires less battery power).
- When you approach the fully upright position of the mast, reduce the speed of the mast by closing the restrictor valve on the pump.
- Once the mast hits the stop, let go of the 'up' button. Do not keep going past this point, it may overstress the frame.
- Insert the locking pin to ensure the mast remains upright. You may need to play around with the up/down buttons to ensure the mast is in the right position to insert the locking pin.
- Place a padlock on the end of the locking pin to ensure it cannot be tampered with.

### **To lower the mast:**

- Ensure there are no obstructions in the path of the mast.
- Remove the padlock and the locking pin.
- Ensure all other persons are at least 10 feet away from the trailer.
- Close the restrictor valve on the pump, then open slightly.
- Press the 'down' button.
- Once the mast has started moving, open the restrictor valve on the pump so that the mast moves faster.
- When you approach the resting position of the mast, reduce the speed of the mast by closing the restrictor valve on the pump.
- Once the mast hits the rest, let go of the 'down' button.
- Secure the upper mast, as well as the turbine blades with bungee cords, for protection during transport.

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### **6.3 Turbine Control Operation**

The turbine is controlled using the *Turbine Control Switch* located in the driver's side instrumentation box. It has three modes:

- **Brake** – the rotor will be stopped (electromagnetic braking).
- **Free** – this will allow the turbine rotor to freely rotate with the generator output open circuit. This could cause the rotor to over-speed and should not normally be used.
- **Generate** – this is the normal mode for power generation. The generator output will be routed to the batteries.

Once the mast is raised and secured with the locking pin, the turbine can be switched to generate mode. Before lowering the mast, the turbine must be switched to brake mode and allowed to come to a complete stop.

### **6.4 Solar Control**

There are two solar panels mounted to the trailer, which are used to charge the main batteries when wind power is not sufficient. There is a *Solar Control Switch* located in the driver's side instrumentation box. **This switch is currently disconnected.** The solar panels are on all of the time. There is no danger of overcharging the batteries.

### **6.5 Load Regulation Control Operation**

In order to prevent overcharging the batteries, a resistive load is installed on the back of the instrumentation box. This voltage limiting system is controlled using the *Load Control Switch*, located in the driver's side instrumentation box. When the load control is 'on', the battery voltage will be limited to approximately 13.2 V. When the turbine is not operating, this switch should be turned off as there is a leakage current that will kill the batteries.

### **6.6 Battery Charger**

In the event that the batteries are not charged enough to raise/lower the mast (this requires a lot of battery power) there is an external battery charger attached to the batteries.

- Plug the power cord for the external charger into a wall outlet.
- The charger will default to the 2mA setting. Press the button until it changes to the 4mA setting.

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### **6.7 Data Acquisition Operation**

The data acquisition system consists of three modules:

- Hub Station (HS) – The hub of the turbine rotor (clear plastic extension).
- Mobile Station (MS) – Inside the passenger's side instrumentation box.
- Base Station (BS) – Notebook PC with dongle.

The **HS** contains instrumentation to measure the torque and RPM of the turbine.

- The HS equipment is turned on/off using the toggle switch located on the front of the turbine hub.
- Data is transmitted wirelessly to the MS.
- A red flashing LED on the HS indicates that the system is on.
- The battery inside the HS lasts approximately 18 hours before it needs to be recharged (spares are located in 1B39.1).

The **MS** contains the main data acquisition equipment, as well as a temperature sensor and barometric pressure transducer.

- The data acquisition is controlled by an Arduino control board.
- There is an on/off switch which powers the automation. This must be turned on to capture data.
- Data is averaged over a 5 sec period and recorded to an SD card every 5 sec.
- Some data is also displayed on the LCD display.
- The MS can send data to the BS if the BS antenna is within range of the MS.

The **BS** consists of an XBEE wireless module inside a box with an antenna on top. The BS receives data from the MS and transmits it to a computer through a USB connection. A LabVIEW program is used to display the data on the computer. To do this:

- Open the LabVIEW vi (current version number is recorded in the MWEL Binder).
- Ensure that the MS power is turned on.
- Start the LabVIEW program.
- Select the communication port from the drop down menu in the bottom left corner. Press 'Start' under the drop down menu.
- Before stopping the program, press 'Stop' below the communication port drop down menu.
- Stop the LabVIEW program.

The MWEL can be operated without the BS, if the goal is just to record data. Data can be extracted from the SD card in the MS. The data is recorded as 'Bits' and must be converted to proper engineering units. Refer to the Operation Manual for directions.

The following data is recorded:

- Date/Time
- Turbine torque



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- Turbine RPM
- Wind Speed
- Wind Direction
- Barometric Pressure
- Temperature – Ambient, Instrumentation, and Load
- Battery Voltage
- Battery Current
- Load Current

### **6.8 General Take-down**

- After the mast has been lowered turn off the power using the main cut-off switch.
- Secure the turbine in place by fixing a bungee cord around the blades and another bungee cord from the trailer to the tail of the turbine. This secures the turbine for transportation.
- Lower the small front tire of the trailer.
- Release the four jacks and rotate them into storage position. Ensure the lock pins are secured.
- Store the extra padlocks and locking pin for the mast in one of the instrumentation boxes.
- Lock the two instrumentation boxes.

### **7. Equipment or Materials Required**

- MWEL keys
- MWEL Operation Manual – MWEL Binder (1B39.1.1)
- Rechargeable batteries for the HS (there are three batteries, along with a charger, stored in 1B39.1)
- MWEL laptop – optional (1B39.1.1)
- Hub Station – optional (1B39.1.1)

### **8. Regulatory / Standards**

The following standards were used in the set-up of the MWEL:

- IEC 61400-2 ed. 2.0 – Wind turbines – Part 2: Design requirements for small wind turbines.
- IEC 61400-12-1 ed. 1.0 – Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines.

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## 9. Trouble Shooting

If you encounter problems that you are unsure how to deal with, consult the Heat Transfer Departmental Assistant, or Prof. Retzlaff. The following is a list of possible problems that might occur.

Problem:	Look for
There is no power to the system	<ul style="list-style-type: none"><li>- is the main cut-off switch turned off?</li><li>- is the power on the instrumentation off?</li></ul>
Mast won't raise/lower	<ul style="list-style-type: none"><li>- is the restrictor valve on the pump fully closed?</li><li>- are the batteries fully charged?</li><li>- is the main cut-off switch turned off?</li></ul>
HS won't connect to MS	<ul style="list-style-type: none"><li>- is the HS battery charged?</li><li>- wiggle the HS battery to ensure a good connection</li><li>- toggle the switch on the HS</li></ul>
The turbine is not operating	<ul style="list-style-type: none"><li>- is the turbine control in generate mode?</li><li>- is the wind speed greater than the cut-in speed for the turbine (~3.5 m/s)</li></ul>
Data is not being recorded	<ul style="list-style-type: none"><li>- is the power on the instrumentation off?</li><li>- is there an SD card in the SD card holder?</li></ul>

## 10. References

Air X Owner's Manual, 2008. Southwest Windpower, Inc., Flagstaff, AZ, USA.

IEC 61400-2 ed 2.0, 2006. Wind Turbines – Part 2: Design requirements for small wind turbines, International Electrotechnical Commission, Geneva, Switzerland.

IEC 61400-12-1 ed 1.0, 2005. Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines.

MWEL Operation Manual, 2014. Department of Mechanical Engineering, University of Saskatchewan, Saskatoon, SK, Canada.

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