Alberta Farm Machinery Research Centre

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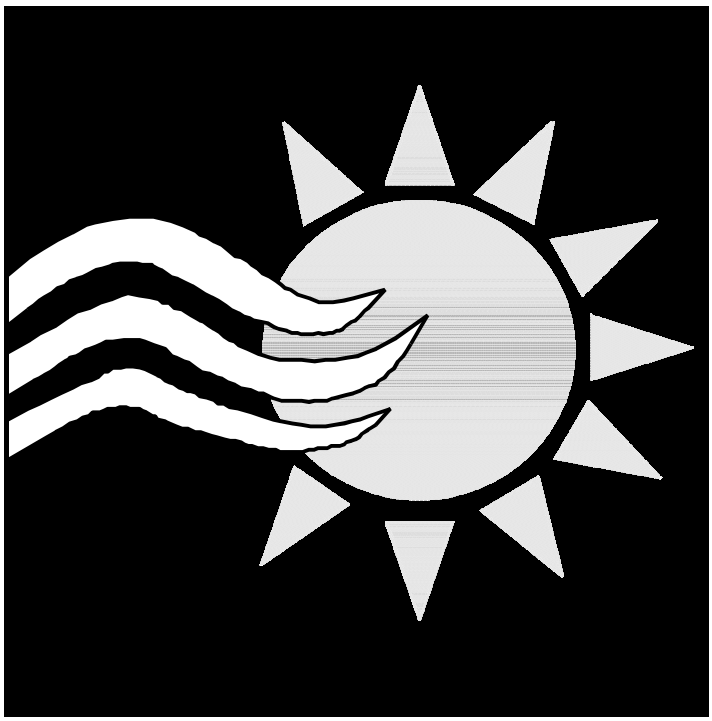
Summary Report 692



Alberta Renewable Energy Test Site

Summary of Wind and Solar Powered Pumping Units (1991 Test Season)

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

SUMMARY OF WIND AND SOLAR PUMPING SYSTEM TESTS (1991)

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Performance results, appearing in alphabetical order, are given for the following wind and solar water pumping systems.

SOLAR SYSTEMS

Canadian Agtechnology Partners:

- 2-47-T-M2
- 3-43-M-F4
- 4-47-T-RU
- 8-53-M-RU

Nor'Western Energy Systems Ltd.

- Solarflo

WIND SYSTEMS

- Delta 16
- Koenders
- Maverick Windmotor
- Softwind 21
- Prairie #PD8-6

RENEWABLE ENERGY PUMPING SYSTEMS

Renewable energy pumping systems have become economic alternatives for many agricultural applications. Typically, this type of pumping system is used in locations removed from an electric power source. In these instances, the cost of the pumping system is often less than the cost of extending the power lines from the nearest source. In Canada, the most common agricultural applications of these systems are livestock watering and sub-surface drainage. Livestock watering generally consists of pumping from a dug-out or stream to a watering trough to eliminate contamination of the water source. These systems can also be used to pump to pastures for livestock use as part of a grazing management system. Sub-surface drainage is installed to lower water tables or intercept discharge areas such as sidehill saline seeps or seepage from irrigation canals. The drains gravity feed to a central sump which is then emptied with a pumping system. Both livestock watering and sub-surface drainage are typically low lift applications less than 20 ft. (6 m).

TEST RESULTS

The following results have been extracted from the Lethbridge Wind Research Test Site report for the 1991 test season. The Lethbridge Wind Research Test Site was in operation from 1982 to 1991 and was managed most recently by the Alberta Farm Machinery Research Centre (AFMRC). The test site has since been relocated to Pincher Creek, Alberta and renamed the Alberta Renewable Energy Test Site. The detailed report used for this summary is available upon request from AFMRC.

The purpose of this summary is to condense the available information so that direct comparisons can be made among the various makes and models of the systems tested. This, in turn, will aid in the selection process of the right pumping system for a given application.

SCOPE OF TEST

The wind pumping system tests were performed in accordance with the Canadian Standards Association (CSA) Standard F417-M91 "Wind Energy Conversion Systems (WECS)-Performance". The solar pumping system tests also followed this standard in respect to instrumentation accuracy, sampling speed, averaging intervals and minimum data base requirements. The utilization of the above standard for the solar tests was required as no CSA field test standard has been prepared for solar pumping systems. Use of this standard also ensures uniformity of performance reporting. The Standard requires sampling the input energy (wind speed or incident solar radiation) and the performance variables of the pumping system at one sample per second and calculating ten minute averages. Each ten minute average is then grouped into a range of wind speeds or a range of solar radiation intensities. These ranges are, in turn, averaged, resulting in the final performance curve. The probability of these averages occurring are calculated to determine if they meet the Standard's minimum requirements.

For each system in this summary report, a performance page has been prepared. The performance page consists of a picture of the unit, a physical description of the system, a reporting of its reliability and graph(s) of its performance. In the case of wind systems, a graph of the expected pumping volume as a function of monthly mean wind speed has been produced. The performance graphs of the solar systems present the current draw of the pump and the voltage supplied by the solar panels. They also present the power draw of the pump and the resulting water flow (pumping rate). The Data Summary tables are available upon request.

CAP 2-47-T-M2 SOLAR PANEL

MANUFACTURER AND DISTRIBUTOR:

Canadian
Agtechnology Partners
P.O. Box 2457
Olds, Alberta, Canada
T0M 1P0
(403) 556-8779

PERFORMANCE:

Testing Period:	77 days
Period Operational:	77 days
Percent Availability:	100%

INSTALLED: July 5, 1991

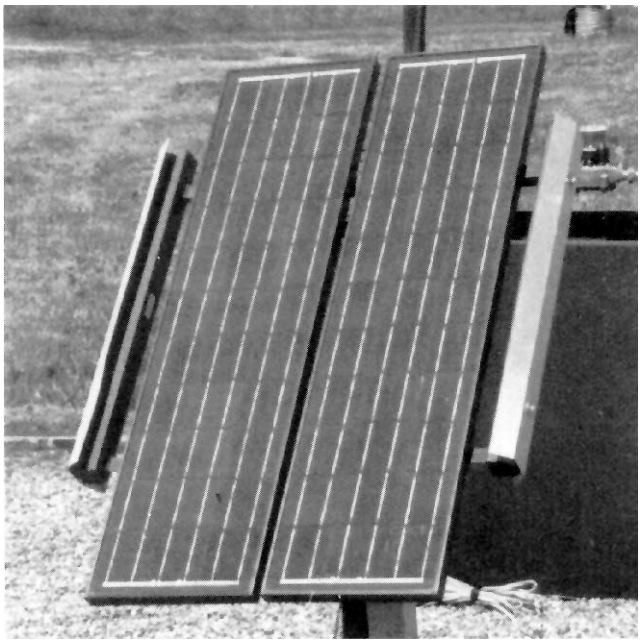

FIGURE 1. CAP 2-47-T-M2 Solar System.

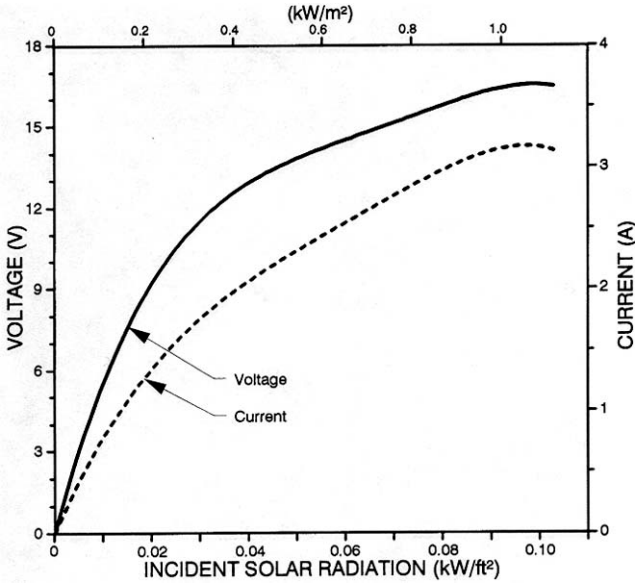

FIGURE 2. Voltage and Current versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 2
Panel Manufacturer: Siemens
Power Rating @ 77°F (25°C) and 93 W/ft^2-(1000 W/m^2): 47 W/panel
Configuration: parallel
Mount: tracking
Pump Type: floating centrifugal (M2)

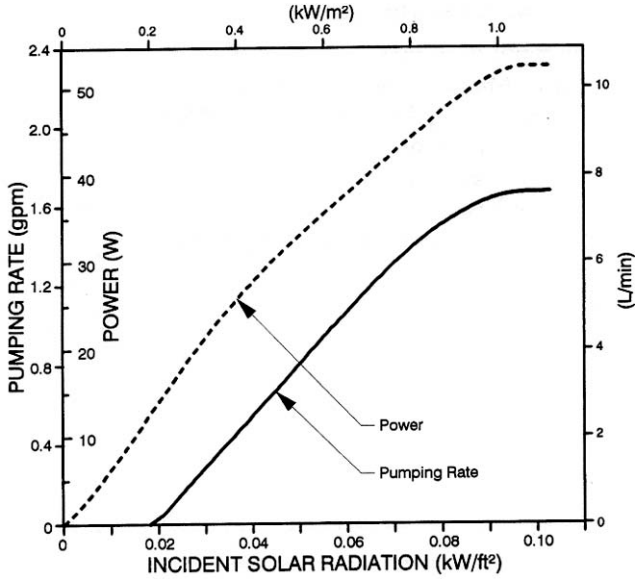

FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

CAP 3-43-M-F4

MANUFACTURER AND DISTRIBUTOR:

Canadian
Agtechnology Partners
P.O. Box 2457
Olds, Alberta, Canada
T0M 1P0
(403) 556-8779

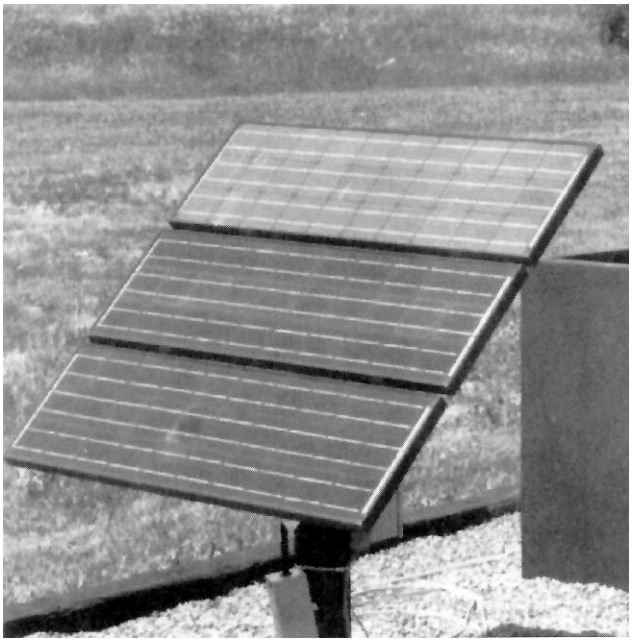

FIGURE 1. CAP 3-43-M-F4 Solar System.

PERFORMANCE:

Testing Period:	106 days
Period Operational:	106 days
Percent Availability:	100%

INSTALLED: June 5, 1991

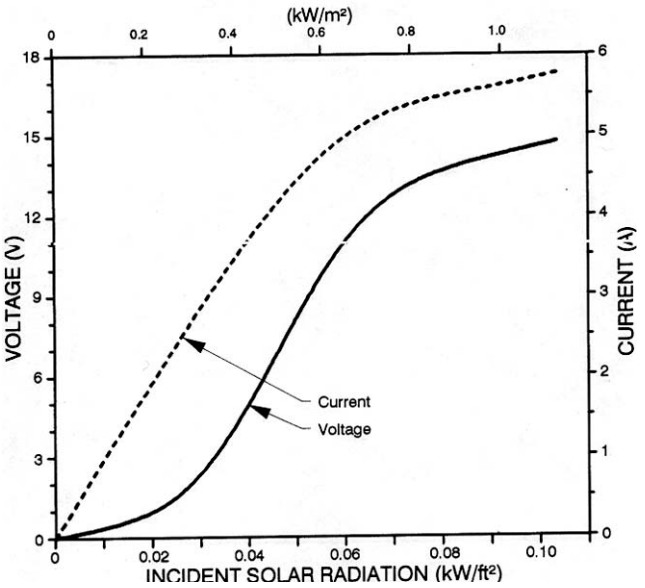

FIGURE 2. Voltage and Current versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 3
Panel Manufacturer: Siemens
Power Rating @ 77°F (25°C) and 93 W/ft^2-(1000 W/m^2) : 43 W/panel
Configuration: parallel
Mount: fixed
Pump Type: 4 valve diaphragm (F4)

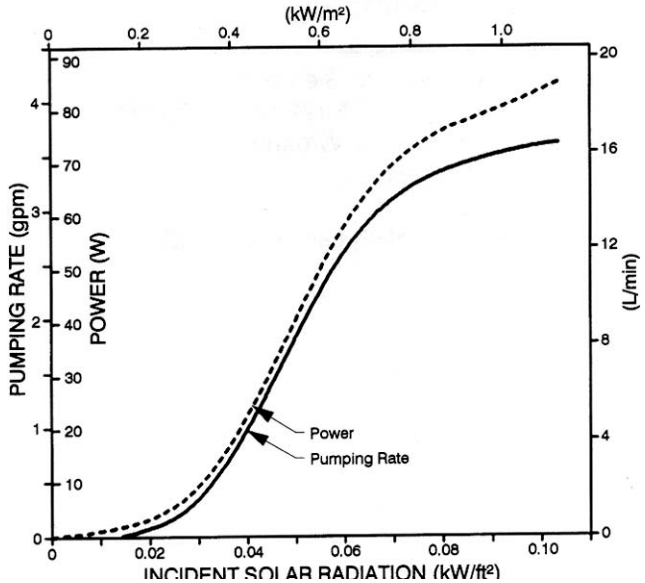

FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

CAP 4-47-T-RU

MANUFACTURER AND DISTRIBUTOR:

Canadian
Agtechnology Partners
P.O. Box 2457
Olds, Alberta, Canada
T0M 1P0
(403) 556-8779

PERFORMANCE:

Testing Period:	106 days
Period Operational:	106 days
Percent Availability:	100%

INSTALLED: June 5, 1991

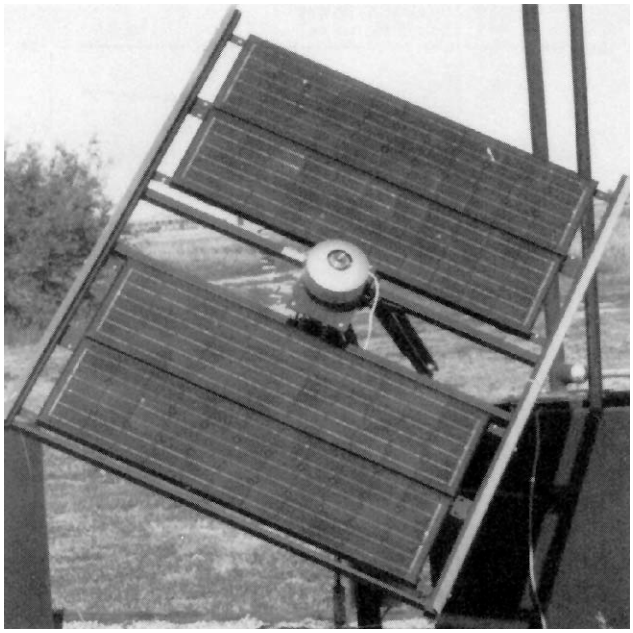

FIGURE 1. CAP 4-47-T-RU Solar System.

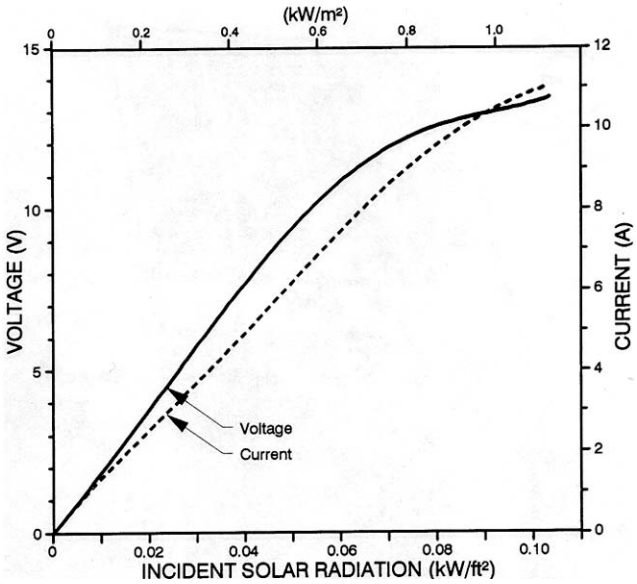

FIGURE 2. Voltage and Current versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 4
Panel Manufacturer: Siemens
Power Rating @ 77°F (25°C) and 93 W/ft^2-(1000 W/m^2) : 47 W/panel
Configuration: parallel
Mount: tracking
Pump Type: floating centrifugal (RU)

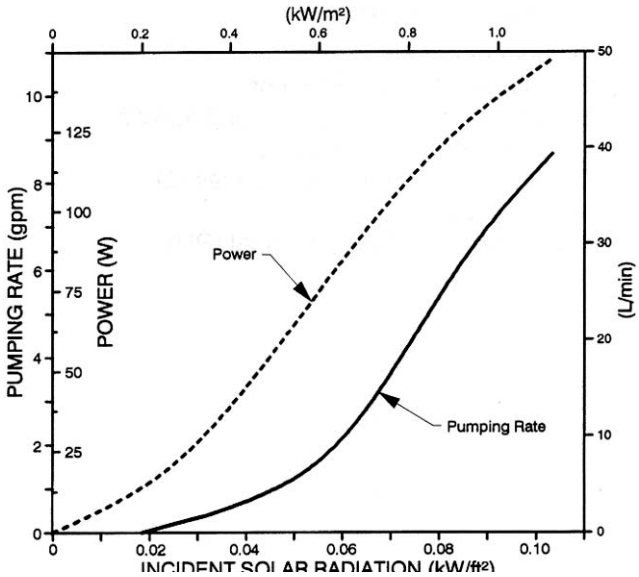

FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

CAP 8-53-M-RU

MANUFACTURER AND DISTRIBUTOR:

Canadian
Agtechnology Partners
P.O. Box 2457
Olds, Alberta, Canada
T0M 1P0
(403) 556-8779

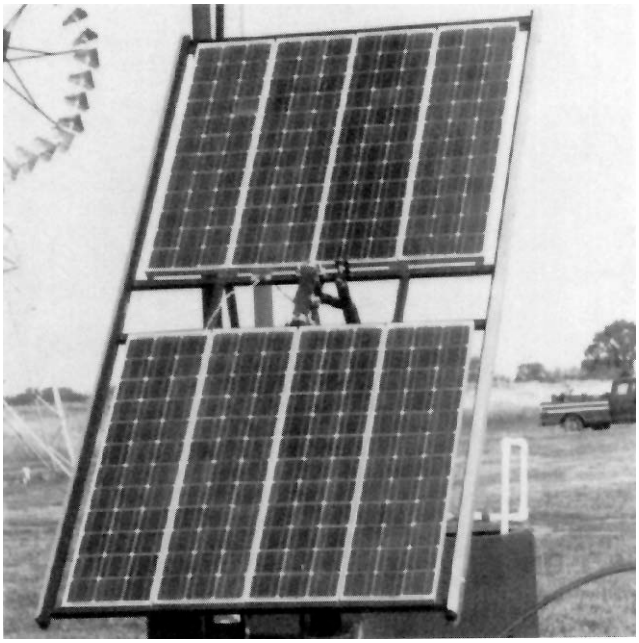

FIGURE 1. CAP 8-53-M-RU Solar System.

PHYSICAL DESCRIPTION:

Number of Panels: 8
Panel Manufacturer: Siemens
Power Rating @ 77°F (25°C) and 93 W/ft^2-
(1000 W/m^2) : 53 W/panel
Configuration: parallel (4) X series (2)
Mount: fixed
Pump Type: floating centrifugal (RU)

PERFORMANCE:

Testing Period:	63 days
Period Operational:	63 days
Percent Availability:	100%

INSTALLED: July 18, 1991

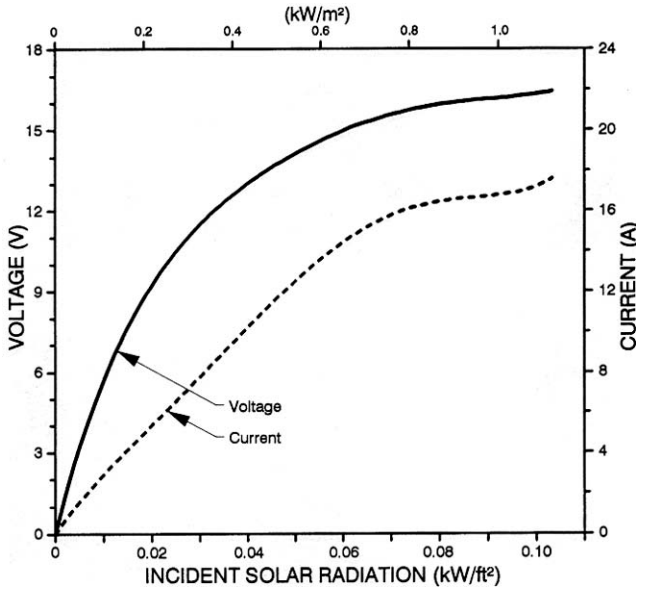

FIGURE 2. Voltage and Current versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

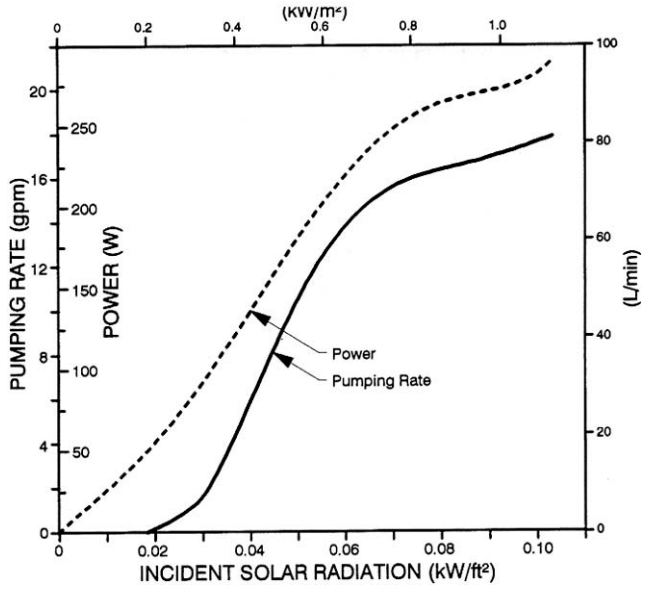

FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

NESL SOLARFLO

MANUFACTURER AND DISTRIBUTOR:

Nor'Western Energy
Systems Ltd.
Box 7, Site 32, R.R. 7
Calgary, Alberta, Canada
T3E 6W3
(403) 249-3337

PERFORMANCE:

Testing Period:	60 days
Period Operational:	60 days
Percent Availability:	100%

INSTALLED: July 22, 1991

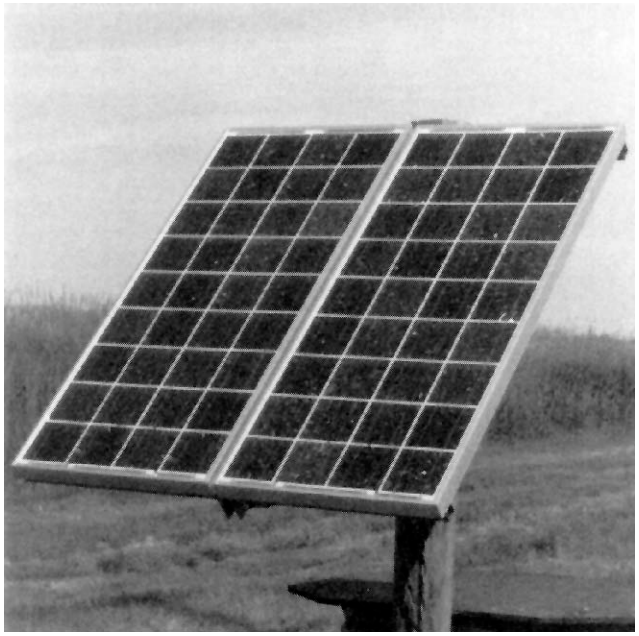

FIGURE 1. NESL SOLARFLO Solar System.

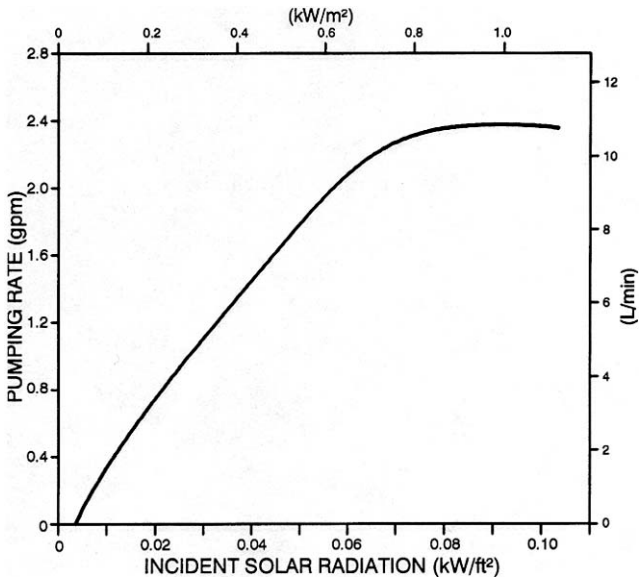

FIGURE 2. Pumping Rate versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 2
Panel Manufacturer: Kyocera
Power Rating @ 77°F (25°C) and 93 W/ft^2-(1000 W/m^2) : 50 W/panel
Configuration: parallel
Mount: fixed
Pump Type: diaphragm (SolarFlo)

DELTA 16

MANUFACTURER AND DISTRIBUTOR:

Dutch Industries Ltd.
705 - 1st Avenue
Regina, Sask., Canada
S4N 4M4
(306) 949-9522

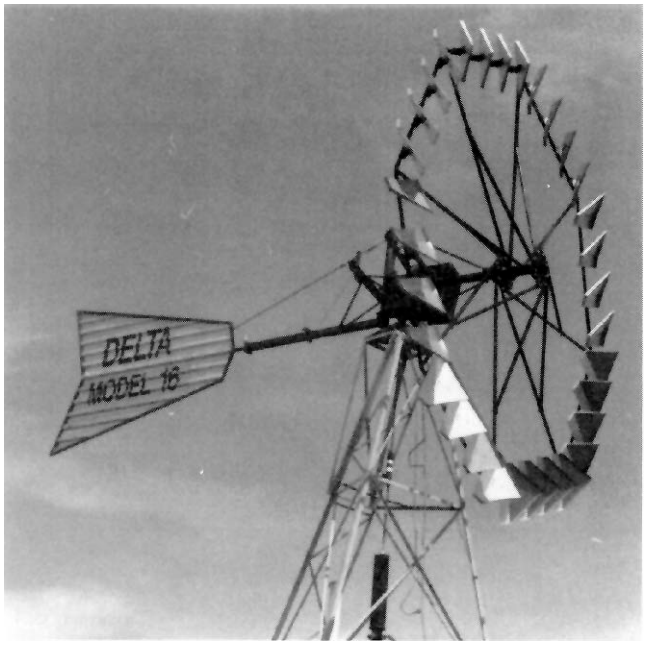

FIGURE 1. DELTA 16 Wind Turbine.

PERFORMANCE:

Testing Period:	52 days
Period Operational:	52 days
Percent Availability:	100%

INSTALLED: July 29, 1991

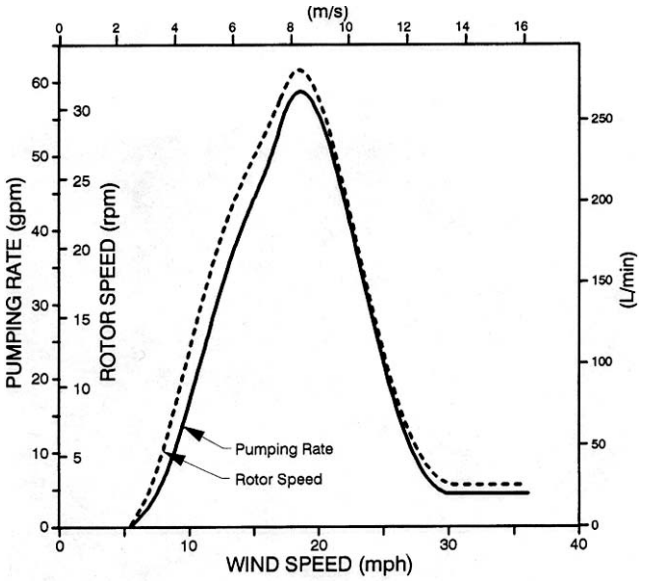

FIGURE 2. Pumping Rate and Rotor Speed versus Wind Speed for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
Axis: horizontal
Rotor Diameter: 15.8 ft (4.82 m)
Swept Area: 80.5 ft^2 (7.48 m^2)
Number of Blades: 32
Blade Design: Delta Wing
Blade Material: mild steel (20 GA)
Hub Height: 27 ft (8.25 m)
Transmission: direct drive
Gear Ratio: 1:1
Pump Type: reciprocating piston
Pump Size: 9.7 in (246 mm) diameter
Stroke: 6.5 in (165 mm)
Pumping System Description:
reciprocating rod connected to positive displacement pump

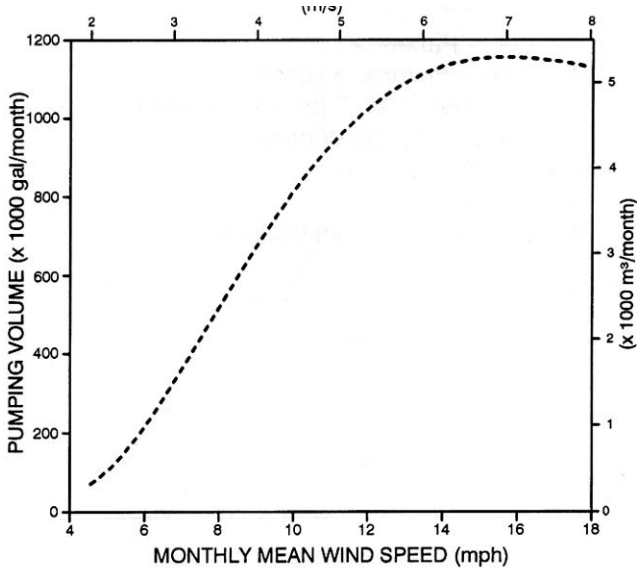

FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

KOENDERS

MANUFACTURER AND DISTRIBUTOR:

Koenders Mfg. Co. Ltd.
P.O. Box 171
Englefield, Saskatchewan, Canada
S0K 1N0
(306) 287-3139

PERFORMANCE:

Testing Period:	90 days
Period Operational:	78 days
Percent Availability:	86.7%

INSTALLED: June 14, 1991

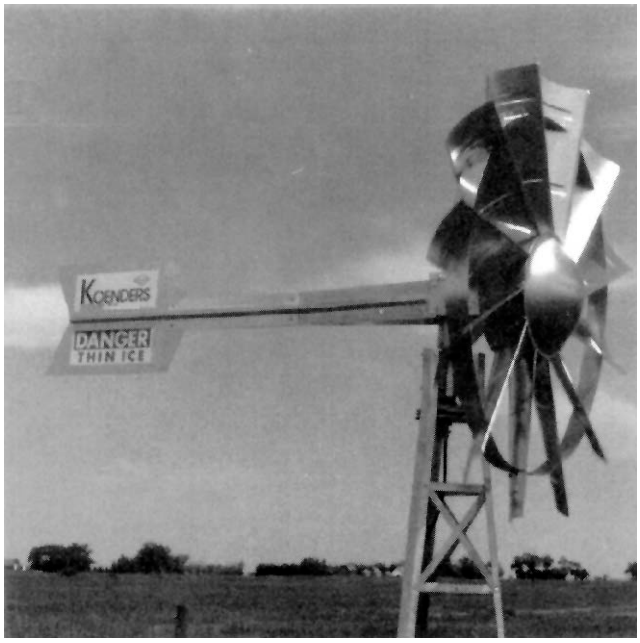

FIGURE 1. Koenders Wind Turbine.

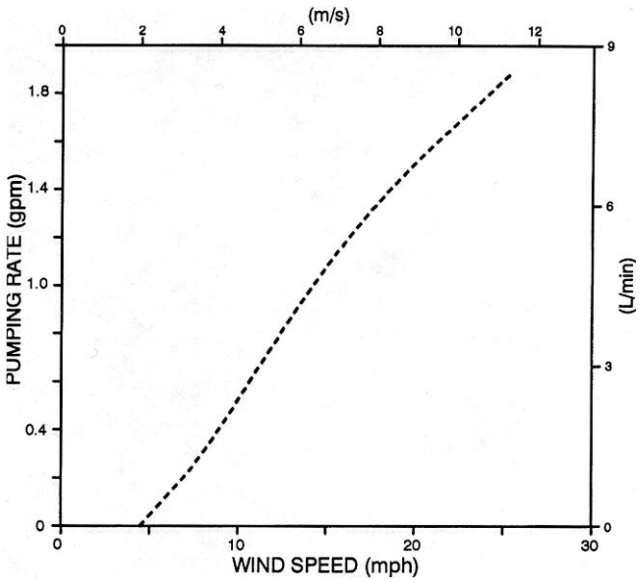

FIGURE 2. Pumping Rate versus Wind Speed for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
Axis: horizontal
Rotor Diameter: 5.1 ft (1.57 m)
Swept Area: 21 ft^2 (1.948 m^2)
Number of Blades: 12
Blade Design: proprietary
Blade Material: galvanized steel
Hub Height: 12 ft (3.66 m)
Transmission: direct drive
Pump Type: air operated proprietary system
Pumping System Description:
windmill driven diaphragm injects air into pump

MAVERICK WINDMOTOR

MANUFACTURER AND DISTRIBUTOR:

Maverick Wind Energy Ltd.
P.O. Box 2707
Pincher Creek, Alberta, Canada
T0K 1W0
(403) 627-3630
(403) 627-3091

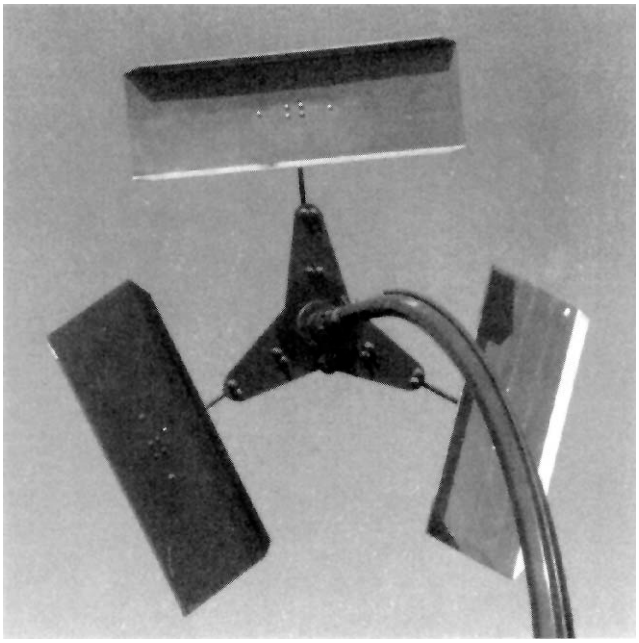

FIGURE 1. Maverick Windmotor Wind Turbine.

PHYSICAL DESCRIPTION:

Turbine Type: downwind
Axis: horizontal
Rotor Diameter: 8 ft (2.44 m)
Swept Area: 50.4 ft^2 (4.68 m^2)
Number of Blades: 3
Blade Design: proprietary
Blade Material: extruded aluminum
Hub Height: 25 ft (7.62 m)
Transmission: direct drive
Gear Ratio: 1:1
Pump Type: helical progressing cavity
Pump Size: 2 in (51 mm) diameter
Pumping System Description:
direct cable drive from rotor to pump

PERFORMANCE:

Testing Period:	92 days
Period Operational:	90 days
Percent Availability:	97.8%

INSTALLED: June 19, 1991

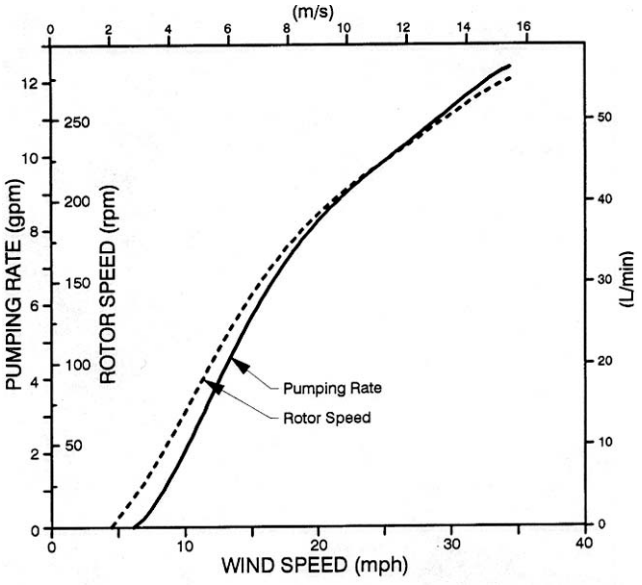

FIGURE 2. Pumping Rate and Rotor Speed versus Wind Speed for an 18 foot (5.5 m) Lift.

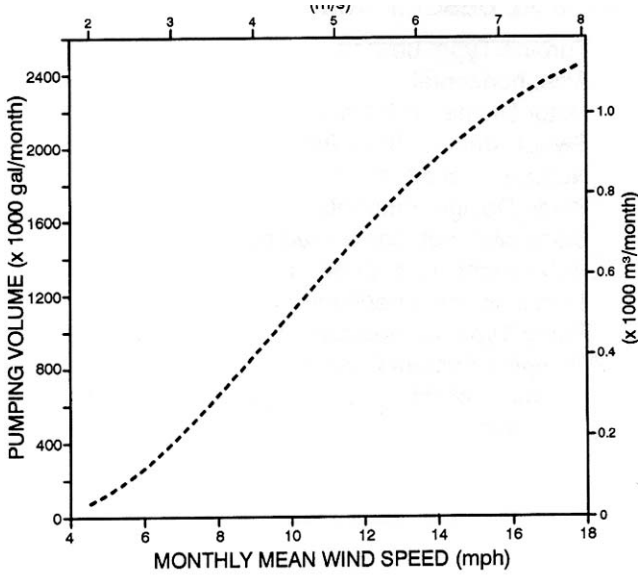

FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

SOFTWIND 21

MANUFACTURER AND DISTRIBUTOR:

Wind Baron Corp.
3920 East Huntington Drive
Flagstaff, Arizona, U.S.A.
86004
(602) 526-6400

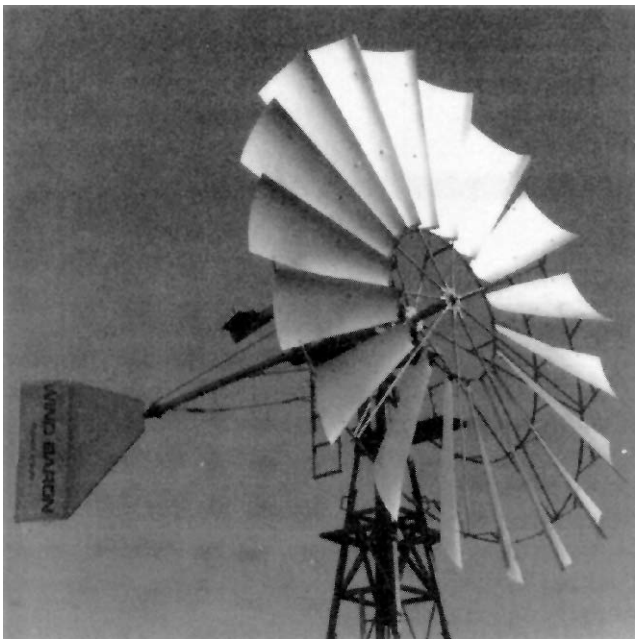

FIGURE 1. Softwind 21 Wind Turbine.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
Axis: horizontal
Rotor Diameter: 21 ft (6.4 m)
Swept Area: 346.34 ft^2 (32.17 m^2)
Number of Blades: 18
Blade Design: high torque sails
Blade Material: galvanized steel
Hub Height: 40 ft (12.2 m)
Transmission: mechanical gearing
Gear Ratio: 3.25:1
Pump Type: reciprocating piston
Pump Size: 12 in (305 mm) diameter
Stroke: 20.4 in (518 mm)
Pumping System Description:
reciprocating rod connected to positive displacement pump

PERFORMANCE:

Testing Period:	126 days
Period Operational:	123 days
Percent Availability:	97.6%

INSTALLED: May 16, 1991

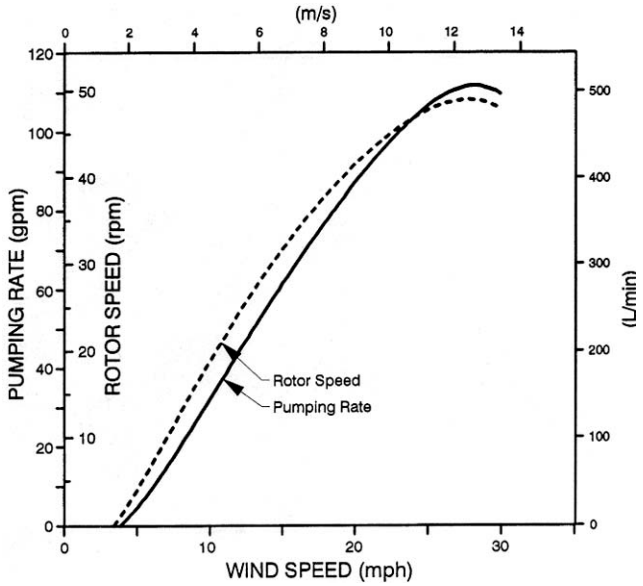

FIGURE 2. Pumping Rate and Rotor Speed versus Wind Speed for an 18 foot (5.5 m) Lift.

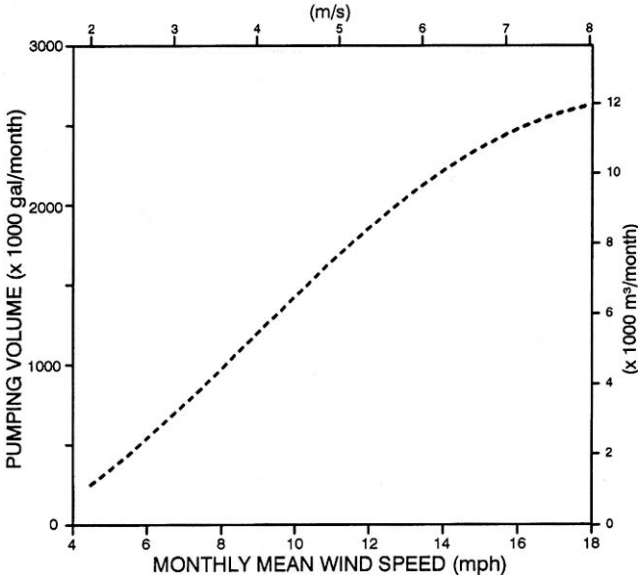

FIGURE 3. Pumping Volume versus Month;y Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

PRAIRIE #PD8-6

MANUFACTURER AND DISTRIBUTOR:

Prairie Ditching Ltd.
418 - 26 Street South
Lethbridge, Alberta, Canada
T1J 3R2
(403) 327-8280

PERFORMANCE:

Testing Period:	16 days
Period Operational:	16 days
Percent Availability:	100%

INSTALLED: July 24, 1991

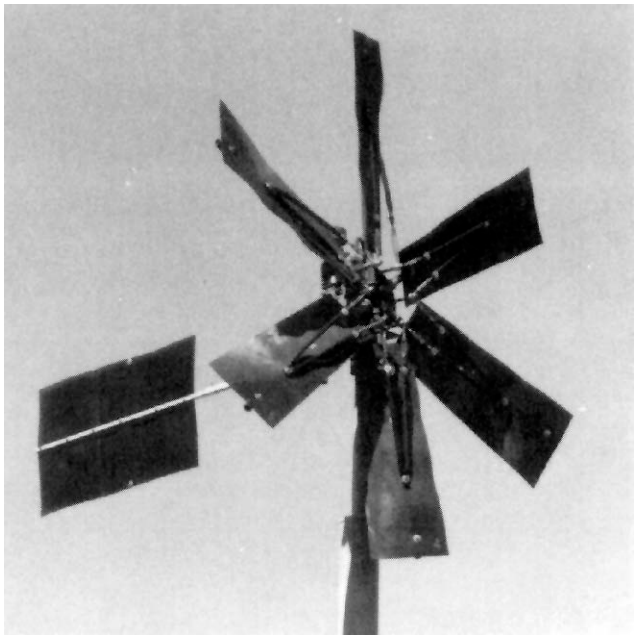

FIGURE 1. Prairie #PD8-6 Wind Turbine.

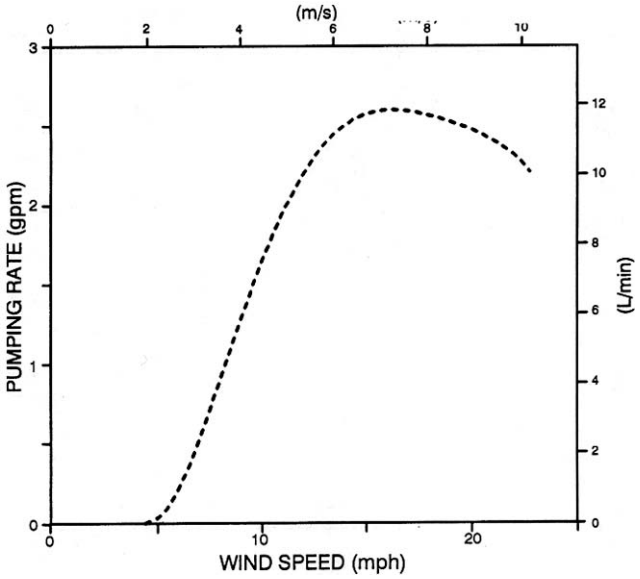

FIGURE 2. Pumping Rate versus Wind Speed for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
Axis: horizontal
Rotor Diameter: 7.3 ft (2.24 m)
Swept Area: 42.2 ft^2 (3.924 m^2)
Number of Blades: 6
Blade Design: proprietary
Blade Material: polyethylene
Hub Height: 25.4 ft (7.74 m)
Transmission: direct drive
Pump Type: air lift
Pumping System Description:
windmill driven air compressor

ALBERTA FARM MACHINERY RESEARCH CENTRE
3000 College Drive South
Lethbridge, Alberta, Canada T1K 1L6
Telephone: (403) 329-1212
FAX: (403) 329-5562
http://www.agric.gov.ab.ca/navigation/engineering/afmrc/index.html

Prairie Agricultural Machinery Institute
Head Office: P.O. Box 1900, Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-2555

Test Stations:
P.O. Box 1060
Portage la Prairie, Manitoba, Canada R1N 3C5
Telephone: (204) 239-5445
Fax: (204) 239-7124

P.O. Box 1150
Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-5033
Fax: (306) 682-5080