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**MIDDLETON SOLAR**

**DN5 and DN5-E**

**FIRST CLASS PYRHELIOMETER**

**USER'S GUIDE**

Edition: DN5-V2.2

Date: Feb. 2017



Middleton Solar, Australia.

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## 1 INTRODUCTION

The DN5 Pyrheliometer is for measuring solar direct radiation when aimed at the sun. The field of view is a solid angle of  $5^\circ$ . It exceeds the specifications for a First Class Pyrheliometer as listed in ISO9060. The DN5 has a passive microvolt output, and the DN5-E version has an in-built signal amplifier to give a millivolt output.

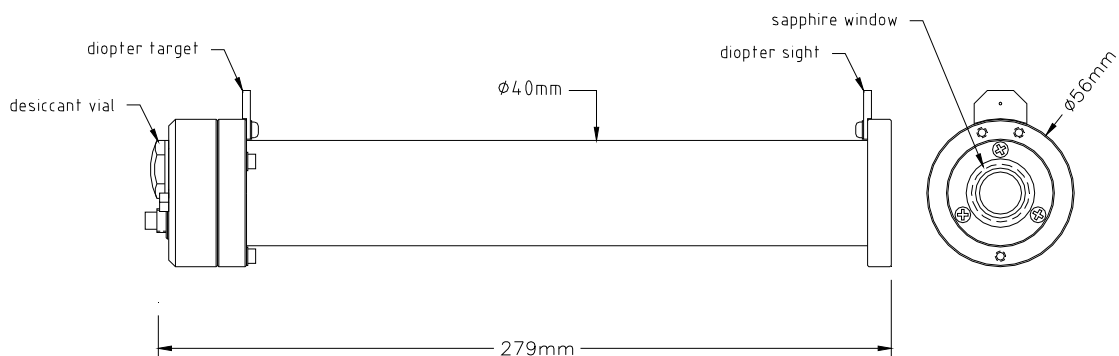
## 2 CONSTRUCTION

The body is manufactured from marine-grade aluminium and is anodised to provide a durable, corrosion-resistant finish. All fasteners are stainless steel. The window is made from optical sapphire which is superior to optical glass in spectral bandpass and hardness. The window is flush-mounted to prevent build up of rainwater or debris.

The DN5 has a twin-thermopile sensor that is based on a standard thermoelectric module. It has a sun-facing black receiver element and an identical reference element facing into the instrument body. The twin-thermopile sensor produces a voltage in direct proportion to the magnitude of the incoming solar radiation. The sensor unit is embedded in a thermal mass that is isolated from the instrument body. The twin-thermopile configuration, and isolated thermal mass, helps minimise zero-offset error when the instrument is subjected to rapid changes in environmental temperature. The sensor output is corrected for temperature dependence, and a separate sensor temperature output is provided so that the user can monitor temperature response.

The DN5 is hermetically sealed with a silica gel desiccant vial to prevent internal condensation. A diopter is attached to the body so that the instrument can be accurately aimed at the sun.

Figure 1. DN5 Pyrheliometer



See section 7 for an internal view of the DN5.

### 3 INSTALLATION

#### 3.1 MOUNTING and ALIGNMENT

For direct solar radiation measurement, select a site where the view the DN5 has of the sun is not obstructed between earliest sunrise and latest sunset throughout the year.

It is recommended that the DN5 be mounted to an automatic solar tracking system. Tracking alignment should be better than  $\pm 0.75^\circ$ . Take care that the DN5 alignment diopter is not obscured by the chosen tracker mount. An accessory Pyrheliometer Mount and Automatic Tracker (see Appendix B) are available from Middleton Solar.

Both the front diopter sight and rear diopter target have central "pinholes". When the DN5 is correctly aimed at the sun, direct light passing through the front pinhole will also pass through the rear pinhole, and can be seen as a bright spot on a card held behind the diopter target.

#### 3.2 ELECTRICAL CONNECTION, DN5

The DN5 lead cores are:

- red = signal output positive (typically  $7 \mu\text{V}$  per  $\text{W}/\text{m}^2$ )
- blue = signal negative
- (option: yellow & green = sensor temperature thermistor; see Appendix A)

The measurement equipment should have an input impedance of at least  $1\text{M}\Omega$ .

#### 3.3 ELECTRICAL CONNECTION, DN5-E

The DN5-E power supply requirement is 5.5 to 14.5VDC, 6mA. It can be conveniently powered from any 6V, 9V, or 12V source such as a datalogger, small power supply, or battery<sup>1</sup>. Operation of the instrument outside the specified voltage range will affect the signal output. The circuit board includes a fuse to protect against polarity reversal.

The DN5-E lead cores are:

- red = power supply positive (5.5 to 14.5 V)
- blue = power supply negative
- yellow = signal output positive (typically  $1 \text{mV}$  per  $\text{W}/\text{m}^2$ )
- green = signal negative
- (option: black & white = sensor temperature thermistor (see Appendix A))

The measurement equipment should range up to 2V and have an input impedance of at least  $1\text{M}\Omega$ .

The supply negative (blue core) and the signal negative (green core) are joined inside the DN5-E body. Avoid ground loop induced interference in your measurement setup by ensuring there is only one ground point. If a mains-sourced power supply is used the recommended procedure is to ground the supply

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<sup>1</sup>A fresh 9V alkaline PP3 battery will last 60 hr (continuous).

negative at the power supply, and if a datalogger is used the recommended procedure is to use differential input. Grounding of the power supply will also protect against the possibility of mains frequency interference exceeding the common mode rejection limit of the datalogger.

#### 4 MAINTENANCE

Keep the window clean. Use only water and mild detergent to gently wash the surface. If the window is cracked or pitted it should be replaced.

The DN5 contains a desiccant to ensure that the interior remains dry and free from condensation. The desiccant is orange silica gel (non-toxic). The silica gel changes from orange to clear (or green) if moisture has entered the instrument.

To access the silica gel unscrew the rear dehydrator cap and withdraw the desiccant vial. Take care to correctly position the O-ring seal when refitting the dehydrator cap.

#### 5 CALIBRATION

Each DN5 Pyrheliometer is individually calibrated during manufacture by outdoor comparison to a reference Pyrheliometer.

The calibrated sensitivity is inscribed on an identification label on the body of the instrument.

It is recommended that the pyrheliometer calibration be checked annually.

6 TECHNICAL SPECIFICATION

parameter	ISO 9060 First Class	DN5 & DN5-E
response time	< 20s (95%)	< 10s (95%)
zero offset response (5°C/hour)	± 3 W.m <sup>-2</sup>	< ± 1 W.m <sup>-2</sup>
non-stability (1 year interval)	± 1%	< 0.2%
non-linearity (100 - 1000 W.m <sup>-2</sup> )	± 0.5%	< ± 0.5%
spectral selectivity (350-1500nm)	± 1%	± 0.5%
temperature response (50°C span)	± 2%	± 1% (-10 to +40°C)
tilt response (at 1000 W.m <sup>-2</sup> )	± 0.5%	none

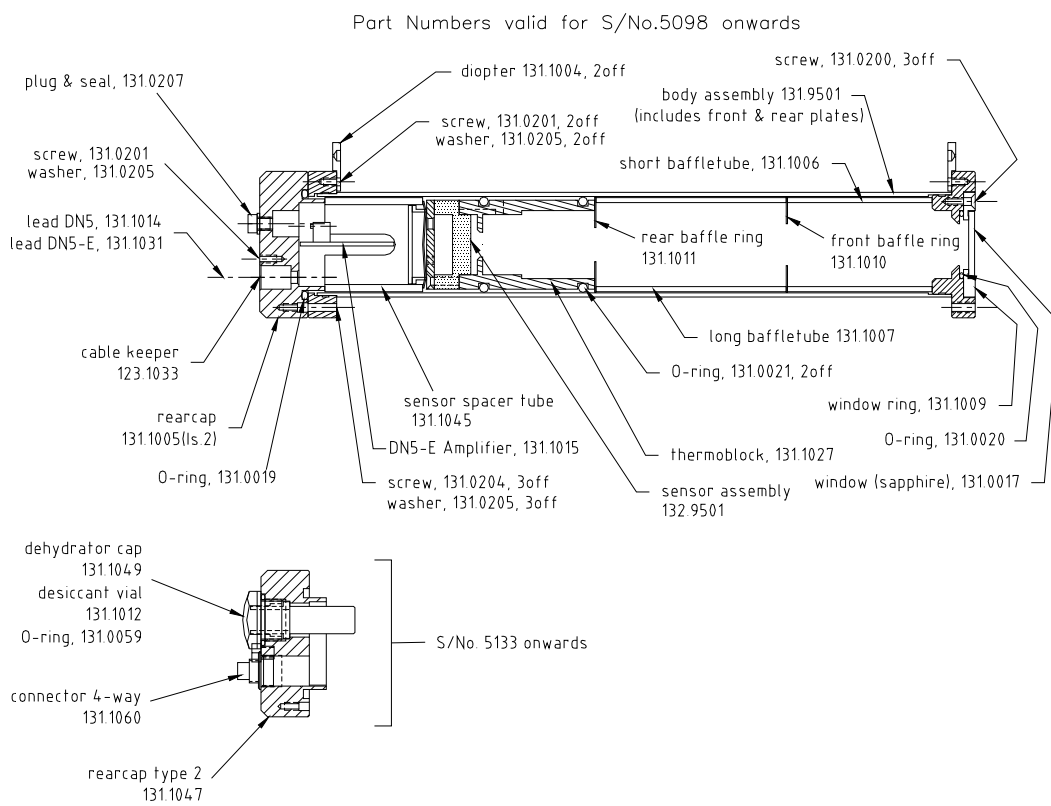
full opening angle <sup>2</sup>	5.0°
slope angle	1.0°
limit angle	4.0°
irradiance	0 – 4,000 W.m <sup>-2</sup>
spectral range (nominal)	200 – 5,000nm
sensitivity (typical)	7-9 µV/W.m <sup>-2</sup> (DN5) 1 mV/ W.m <sup>-2</sup> (DN5-E)
calibration accuracy	± 2% (factory certificate); traceable to WRR
operating temperature	-40 to +60°C
output impedance	DN5 45-50Ω, DN5-E 65Ω
power supply requirement (DN5-E)	5 to 15VDC, 6mA
temperature output (optional)	YSI 44031 thermistor (10KΩ @ 25°C)
window material	optical sapphire, 2mm thick
body construction	anodized marine-grade aluminium
fasteners	stainless steel
desiccant	silica gel (orange, non-toxic), externally accessible
lead	6m, with connector at instrument end
weight	0.75kg (excluding lead)

<sup>2</sup> long body with 2.5° Field Of View is available on special request: models DN5-2.5, DN5-E2.5

## 7 SPARE PARTS

Spare parts may be ordered from the manufacturer or through an approved distributor. For your convenience the part name and number is shown in Figure 2. Please quote both when ordering. It is also important when ordering parts to include the model type (DN5 or DN5-E) and serial number of the instrument, as inscribed on the identification label.

Figure 2. DN5 Spare Parts



APPENDIX A: SENSOR TEMPERATURE vs THERMISTOR RESISTANCE  
For instruments fitted with optional sensor temperature output

YSI 44031 Thermistor (accuracy =  $\pm 0.2^{\circ}\text{C}$ )

Temperature ( $^{\circ}\text{C}$ )	Resistance ( $\Omega$ )	Temperature ( $^{\circ}\text{C}$ )	Resistance ( $\Omega$ )
-30	135,200	15	15,130
-29	127,900	16	14,500
-28	121,100	17	13,900
-27	114,600	18	13,330
-26	108,600	19	12,790
-25	102,900	20	12,260
-24	97,490	21	11,770
-23	92,430	22	11,290
-22	87,660	23	10,840
-21	83,160	24	10,410
-20	78,910	25	10,000
-19	74,910	26	9605
-18	71,130	27	9227
-17	67,570	28	8867
-16	64,200	29	8523
-15	61,020	30	8194
-14	58,010	31	7880
-13	55,170	32	7579
-12	52,480	33	7291
-11	49,940	34	7016
-10	47,540	35	6752
-9	45,270	36	6500
-8	43,110	37	6258
-7	41,070	38	6026
-6	39,140	39	5805
-5	37,310	40	5592
-4	35,570	41	5389
-3	33,930	42	5193
-2	32,370	43	5006
-1	30,890	44	4827
0	29,490	45	4655
1	28,150	46	4489
2	26,890	47	4331
3	25,690	48	4179
4	24,550	49	4033
5	23,460	50	3893
6	22,430	51	3758
7	21,450	52	3629
8	20,520	53	3504
9	19,630	54	3385
10	18,790	55	3270
11	17,980	56	3160
12	17,220	57	3054
13	16,490	58	2952
14	15,790	59	2854



## APPENDIX B: ACCESSORIES

### B-1 PYRHELIOMETER MOUNT (PM02)

The PM02 can accommodate one DN5 Pyrheliometer. Thumbscrews are provided so that the Pyrheliometer can be precisely aligned. The PM02 has a mount clamp to attach to Trackers with a 1 inch or 25mm axle.

### B-2 AUTOMATIC PASSIVE TRACKER (APT-01)

The APT-01 is a fully automatic tracker with integrated control computer and GPS. It is designed to aim a pyrheliometer continuously at the sun for accurate DNI measurement. The APT-01 includes an integrated pyrheliometer mount.

### B-3 FILTER WHEEL (FW01)

Three threaded holes are provided on the window face of the DN5 to accommodate an accessory Filter Wheel. The FW01 is fitted with three coloured glass filters (Schott OG530, RG630, RG695; all 0.91 reflection factor) but can accommodate up to five filters.

