SOLAR WEATHER STATIONS SPECIFICATION GUIDE

2025

Environmental Monitoring Specifications, Requirements and Guidelines

CONTENTS

1 INTRODUCTION

This document presents the recommended technical and functional specifications for the equipment required for a typical meteorological station installed on a solar photovoltaics (PV) plant to adequately measure and monitor the relevant environmental conditions. It also provides insight into the importance of environmental condition monitoring for PV plant applications and the significance of different instrument performance parameters.

2 STANDARDS AND DEFINITIONS

2.1 IEC61724-1:2021

The IEC 61724-1 is an international standard published by the International Electrotechnical Commission (IEC) that is titled "Photovoltaic system performance - Part 1: Monitoring". The IEC61724-1 outlines the terminology, equipment, and methods for performance monitoring and analysis of photovoltaic systems.

The latest edition (2.0) of the IEC61724 standard was published in July 2021

2.2 ISO 9060:2018

The ISO 9060 is an international standard published by the International Organization for Standardization that is titled "Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation. The ISO 9060 establishes the classification and specification of instruments, including pyranometers, used to measure solar irradiation.

The latest edition (2.0) of the ISO 9060 standard was published in November 2018.

2.3 SYSTEM CLASSIFICATIONS

The IEC61724 defines a Class A system as a monitoring system designed for utility-scale PV systems and large commercial installations. This is typical of PV systems over the size of 1MW. “Class A system” refers to the classification of the entire monitoring system as per IEC61724-1.

2.4 DEVICE CLASSIFICATIONS

The ISO9060 classifies pyranometers based exclusively on the measuring specifications of the device. There are three distinct classes of pyranometers, namely: A.B and C.

The ISO9060 define Class A pyranometers are the most accurate instruments for measuring solar radiation. Class A pyranometers are often referred to as “Secondary Standard” pyranometers in older versions of the ISO 9060.

“Class A device” refers to the Class A classification of the respective irradiance measurement device as per ISO9060. “Class B device” refers to the Class B classification of the respective irradiance measurement device as per ISO9060.

2.5 SPECTRALLY FLAT

Different types of pyranometers have different spectral selectivity, meaning that they respond differently to different radiation wavelengths. Typically, solar PV modules have the most efficient absorption of solar radiation between 400nm and 1100nm wavelengths. The ISO9060 defines a spectrally flat pyranometer as one that does not show more than 3% deviation in responsivity between 350nm and 1500nm. All Kipp & Zonen SMP and CMP pyranometers are spectrally flat

2.6 FAST RESPONSE

The ISO9060 defines response time as the time it takes for a pyranometer to produce a stable output under realistic irradiance changes. The standard further defines a fast response pyranometer as one that has a response time of less than 0.5 seconds. The Kipp & Zonen SMP12 is a spectrally flat fast response pyranometer.

3 MEASUREMENT PARAMETER REQUIREMENTS

The IEC 61724-1 is an international standard published by the International Electrotechnical Commission (IEC) that is titled "Photovoltaic system performance - Part 1: Monitoring". The IEC61724-1 outlines the terminology, equipment, and methods for performance monitoring and analysis of photovoltaic systems. PV system performance monitoring is highly dependent on accurate weather data, and thus, the standard specifies the requirements for measuring and handling the required meteorological and environmental parameters.

3.1 CLASS A SYSTEMS

3.1.1 TYPICAL CLASS A SYSTEM

The standard calls for specific measurement either required or recommended for Class A systems. Table xx highlights the parameters required for all Class A systems.

PARAMETER	SYMBOL	UNITS	NUMBER OF SENSORS (based on plant size in MW)					
			<40	40 to 100	100 to 300	300 to 500	500 to 700	> 700
Plane of Array Irradiance (PoA)	G_i	W/m²	2	3	4	5	6	7 + 1 for every additional 200 MW
Global Horizontal Irradiance	GHI	W/m²	2	3	4	5	6	7 + 1 for every additional 200 MW
PV Module Temperature	T_{mod}	°C	6	9	12	15	18	21 + 3 for every additional 200 MW
Ambient Air Temperature	T_{amb}	°C	2	3	4	5	6	7 + 1 for every additional 200 MW
Wind Speed		m/s	2	3	4	5	6	7 + 1 for every additional 200 MW
Wind Direction		deg	2	3	4	5	6	7 + 1 for every additional 200 MW
Rainfall		cm	2	3	4	5	6	7 + 1 for every additional 200 MW

3.1.2 BIFACIAL CLASS A SYSTEM

The IEC61724 provides two options to determine the rear-side solar resource for bifacial systems.

Option 1 entails measuring the horizontal albedo with the option measuring the diffused irradiance, and using these parameters to estimate rear-side irradiance. Table xx details Option 1.

PARAMETER	SYMBOL	UNITS	NUMBER OF SENSORS (based on plant size in MW)					
			<40	40 to 100	100 to 300	300 to 500	500 to 700	> 700
Horizontal Albedo	ρ_H		2	3	4	5	6	7 + 1 for every additional 200 MW
Diffused irradiance (optional)	G_d	W/m^2	2	3	4	5	6	7 + 1 for every additional 200 MW

Option 2 entails directly measuring the rear-side in-plane irradiance using irradiance sensors mounted at the angle of the array on the rear side of the module. Table xx details Option 2.

PARAMETER	SYMBOL	UNITS	NUMBER OF SENSORS (based on plant size in MW)					
			<40	40 to 100	100 to 300	300 to 500	500 to 700	> 700
In-plane rear-side irradiance (rPoA)	G_i^{rear}	W/m^2	6	9	12	15	18	21 + 3 for every additional 200 MW

3.1.3 CLASS A SYSTEMS WITH SOILING AND SNOW

If typical annual soiling losses without cleaning expected to be > 2 %, then soiling is required to be measured in Class A systems. Furthermore, if typical annual snow losses without cleaning expected to be > 2 % and soiling measurement does not measure snow loss, then snow fall is required to be measured in Class A Systems.

Table xx highlights these parameter requirements for Class A systems impacted by soiling and snow losses.

PARAMETER	SYMBOL	UNITS	Number of Sensors/measurements (based on plant size in MW)					
			<40	40 to 100	100 to 300	300 to 500	500 to 700	> 700
Soiling	SR		2	3	4	5	6	7 + 1 for every additional 200 MW

PARAMETER	SYMBOL	UNITS	Number of Sensors/measurements (based on plant size in MW)					
			<40	40 to 100	100 to 300	300 to 500	500 to 700	> 700
Snow		Cm	2	3	4	5	6	7 + 1 for every additional 200 MW

4 METEOROLOGICAL STATION CONFIGURATIONS

A meteorological station (herein referred to as "met station" is an integrated system consisting of instruments and sensors interfaced to a data management device. The instruments and sensors measure various atmospheric conditions, such as temperature, humidity, wind speed and direction, atmospheric pressure, and solar radiation, and the data generated by these instruments and sensors is processed by the data management device. Instruments and sensors may be installed on a single meteorological tower (herein referred to as "met tower") or may be distributed within the array of a PV plant and connected back to a met tower using an aggregation methodology.

4.1 BASIC METEOROLOGICAL STATION CONFIGURATION

A basic met station is defined as a met station that meets Class A system requirements without any conditional or optional requirements. A basic met station configuration will consist of the following arrangement:

DEVICE	QUANTITY	PARAMETER(S)
Class A Pyranometer	2	• GHI • POA
PV Module Temperature Sensor	3	• PV Module Temperature
Compact Weather Station	1	• Ambient Air Temperature • Wind Speed • Wind Direction • Rainfall
Data Management Device	1	

4.2 A TYPICAL METEOROLOGICAL STATION CONFIGURATION

A typical met station configuration is defined as a met station that meets Class A system requirements for a bifacial system that requires soiling mitigation.

A typical met station configuration will consist of the following arrangement:

DEVICE	QUANTITY	PARAMETER(S)
Class A Pyranometer	4[1]	• GHI • POA • Albedometer
Class B Pyranometers	3[1]	• rPoA

DEVICE	QUANTITY	PARAMETER(S)
PV Module Temperature Sensor	3	• PV Module Temperature
Compact Weather Station	1	• Ambient Air Temperature • Wind Speed • Wind Direction • Rainfall
Soiling Sensor	1	• Soiling Ratio (SR)
Data Management Device	1	

[1] Either 2 x Class A pyranometers for an albedometer setup or 3 x Class B pyranometers for In-plane rear-side irradiance (rPoA)

5 METEOROLOGICAL STATION COMPONENTS

5.1 IRRADIANCE

Irradiance is the measure of the power of sunlight that hits the PV module surface and is measured in watts per square meter (W/m²). Irradiance measurements are required for the following parameters:

- Global Horizontal Irradiance
- Plane of Array Irradiance (PoA)
- Horizontal Albedo
- Diffused irradiance
- In-plane rear-side irradiance (rPoA)

5.1.1 GLOBAL HORIZONTAL IRRADIANCE

Each met station shall be fitted with at least one (1) ISO9060 Class A Pyranometer installed horizontally at the met tower to measure GHI. For high-accuracy applications the pyranometer shall be a Kipp & Zonen SMP22 or equivalent. For standard applications the pyranometer shall be a Kipp & Zonen SMP10 or equivalent. For applications where built-in dew and frost mitigation is required, the pyranometer shall be a Kipp & Zonen SMP12.

The Pyranometer shall be installed on the met station tower at a height of at least 2 meters (6 feet 7 inches) above the finished ground level. It shall be installed in such a way that a shadow caused by surrounding objects will not be cast upon it at any time. This shall be achieved by ensuring the Pyranometer is at a distance of at least 10 times the height of any nearby objects.

5.1.2 PLANE OF ARRAY IRRADIANCE

- **Fixed-Tilt Array**

For fixed-tilt arrays, each met station shall be fitted with at least one (1) ISO9060 Class A Pyranometer installed at the met tower for every fixed angle orientation of the modules. For example, a single-tilt orientation, such as fixed tilt south orientation, shall require at least one pyranometer, while a duel-tilt orientation, such as a fixed tilt East-West orientation, shall require at least two pyranometers. The pyranometers shall be installed at the same angle of the orientation of the PV modules. For high-accuracy applications the pyranometer shall be a Kipp & Zonen SMP22 or equivalent. For standard applications the pyranometer shall be a Kipp & Zonen SMP10 or equivalent. For applications where built-in dew and frost mitigation is required, the pyranometer shall be a Kipp & Zonen SMP12.

The Pyranometer shall be installed on the met station tower at a height of at least 2 meters (6 feet 7 inches) above the finished ground level. It shall be installed in such a way that a shadow caused by surrounding objects will not be cast upon it at any time. This shall be achieved by ensuring the Pyranometer is at a distance of at least 10 times the height of any nearby objects.

- **Tracking Array**

For tracking arrays, each met station shall be fitted with at least one (1) ISO9060 Class A Pyranometer installed in the array on the PV module so that it remains in the same orientation as the module as the module tracks the sun throughout the day. For high-accuracy applications the pyranometer shall be a Kipp & Zonen SMP22 or equivalent. For standard applications the pyranometer shall be a Kipp & Zonen SMP10 or equivalent. For applications where built-in dew and frost mitigation is required, the pyranometer shall be a Kipp & Zonen SMP12.

The Pyranometer in the array shall be connected back to the nearest met station tower, from which it shall source its power as well as communicate the irradiance data back to.

5.1.3 HORIZONTAL ALBEDOMETER

Each met station that requires an albedo measurement shall be fitted with two (2) ISO9060 Class A Pyranometer installed in an albedo configuration. The two pyranometers shall be mounted back-to-back, with one of the pyranometers positioned horizontally to measure GHI and the other positioned inverted to the other to measure rGHI. For high-accuracy applications the pyranometer shall be a Kipp & Zonen SMP22 or equivalent. For standard applications the pyranometer shall be a Kipp & Zonen SMP10 or equivalent. For applications where built-in dew and frost mitigation is required, the pyranometer shall be a Kipp & Zonen SMP12.

The two pyranometers shall be installed on the met tower at least 1.5 meter (5 feet) above the finished ground level and shall be positioned with a distance of at least 1.8 (6 feet) meters between the pyranometers and the met tower. The pyranometers shall be installed in such a way that a shadow caused by surrounding objects will not be cast upon it at any time. This shall be achieved by ensuring the Pyranometer is at a distance of at least 10 times the height of any nearby objects.

5.1.4 IN-PLANE REAR-SIDE IRRADIANCE

Each met station on a bifacial PV plant shall be fitted with three (3) ISO9060 Class B Pyranometer installed in the array on the PV module and orientated in the opposite direction of the front of the module. The pyranometer shall be a Kipp & Zonen SMP6 or equivalent. For applications where built-in dew and frost mitigation is required, the pyranometer shall be a Kipp & Zonen SMP12.

5.2 PV MODULE TEMPERATURE

Each met station shall be complete with at least three (3) temperature sensors installed at three different locations on the back of a PV module in the array. The temperature sensors shall be fixed to the back of the module using a thermally conductive adhesive.

If the PV modules are bifacial, the temperature sensor and corresponding cables shall not obscure more than 10% of an PV cell in any of the modules.

Cables and wiring shall be routed in between cells where possible.

The temperature sensors shall be connected back to the nearest met station tower, from which it shall source its power as well as communicate the module temperature data back to.

5.3 WEATHER PARAMETERS

Each met station shall be equipped with one (1) all-in-one compact weather station to measure ambient temperature, humidity, air pressure, wind speed, wind direction, rainfall. The compact weather station shall be the Lufft WS600 or equivalent.

The compact weather station shall be installed on the met tower at least 2 meters (6 feet 7 inches) above the finished ground level and shall be positioned with a distance of at least 1 meter (3 feet 3 inches) between the pyranometers and the met tower.

5.4 SOILING

Each Met Station shall be equipped with one (1) optical soiling measurement device. The device shall be a DustIQ or equivalent.

The soiling measure device shall be installed either in between modules in the array or at the end of the row clamped to the last module in the row. The device shall be connected back to the nearest met station tower, from which it shall source its power as well as communicate the module temperature data back to.

5.5 DATA LOGGER

Each Met Station shall be complete with a data logger or data management device. The data logger shall be a Campbell Scientific CR1000Xe or equivalent. The data logger shall be able to interface with all Met Station and PV module measurement devices. The data logger shall interface onto the SCADA backbone network via a Modbus TCP/IP connection.

The data logger shall be housed in an IP65 enclosure suitable for outdoor installation with UV protection. The enclosure shall be supplied with necessary mounting equipment and all required accessories to install the data logger as well as interface the measurement devices to the data logger. All cable entry points on the enclosure shall be glanded appropriate to maintain IP rating.

The datalogger shall be complete with an 10/100 BASE RJ45 connector that supports Modbus TCP/IP to connect to the plant SCADA system. At a minimum the following Modbus registers shall be made available to the SCADA system:

#	DEVICE	PARAMETER	SENSOR SAMPLE RATE	SCADA RECORDING INTERVAL
1	SMP6/10/12/22	GHI	3 sec	1 min
2		Min GHI	5 min	15 min
3		Max GHI	5 min	15 min
4		Average GHI	5 min	15 min
5		Std Dev GHI	5 min	15 min
6		PoA	3 sec	1 min
7		Min PoA	5 min	15 min
8		Max PoA	5 min	15 min
9		Average PoA	5 min	15 min
10		Std Dev PoA	5 min	15 min
11		Albedo Gain	3 sec	1 min
12	BoP Temp Sensor	PV T_{mod}	3 sec	1 min
13		Min T_{mod}	5 min	15 min

#	DEVICE	PARAMETER	SENSOR SAMPLE RATE	SCADA RECORDING INTERVAL
14		Max T_{mod}	5 min	15 min
15		Average T_{mod}	5 min	15 min
16		Std Dev T_{mod}	5 min	15 min
17	WS500/600/800	Ambient Air Temperature	3 sec	1 min
18		Min T_{Amb}	5 min	15 min
19		Max T_{Amb}	5 min	15 min
20		Average T_{Amb}	5 min	15 min
21		Std Dev T_{Amb}	5 min	15 min
23		Wind Speed	3 sec	1 min
24		Min wind speed	5 min	15 min
25		Max wind speed	5 min	15 min
26		Average wind Speed	5 min	15 min
27		Std Dev wind speed	5 min	15 min
28		Wind Direction	3 sec	1 min
29		Std Dev wind direction	5 min	15 min
30		Precipitation Type	3 sec	1 min
31		Precipitation absolute	3 sec	1 min
32		Precipitation intensity	3 sec	1 min
33	DustIQ	Calibration Year	1 hours	On change
34		Calibration Month	1 hours	On change
35		Soiling Ratio (puck 1)	15 mins	1 hour
36		Soiling Ratio (puck 2)	15 mins	1 hour
37		Average soiling ratio	15 mins	1 hour
38		Tilt x-axis	1 hours	On change
39		Tilt y-axis	1 hours	On change
40	Battery Regulator	LV Voltage Input	5 min	15 min
41		LV Fault Indicator	5 min	15 min
42		Battery Bank Voltage	5 min	15 min
43	Enclosure	Datalogger Enclosure Door	Open/close	On change
44		Power Enclosure Door	Open/close	On Change

5.6 MOUNTING TOWER

Each Met Station shall have a Met Tower that shall be the central mounting point for all instruments mounted on the tower as well as the data logger enclosure and power enclosure.

Each Met Tower shall be an aluminum lattice self-standing tower with a minimum height of 2.44 meters (8 ft).

The Met Tower shall be supplied complete with a lightning protection system in accordance with IEC 62793. The Met tower shall be supplied with a earth connection to tie into the local earthing system.

5.7 POWER SUPPLY

Each Met Station shall be connected to the nearest low voltage (LV) power supply. The main point of connection shall be fitted with overvoltage protection. Any instruments that are connected directly to an LV power supply unit, shall also be fitted with overvoltage protection at the source.

Each Met Station shall be fitted with a battery back-up system or uninterrupted power supply (UPS). The Back up system shall be sized to ensure full autonomous operation of the entire Met Station for at least 48 hours. Batteries shall be lithium-ion. The back up system shall be complete with a battery charging regulator that shall ensure the batteries are cycled between 20% and 80% of the full capacity. The system status shall be made available on the datalogger and shall include, battery health, regulator status, and battery levels.

6 TECHNICAL DATASHEETS

6.1 PYRANOMETER DATASHEETS

6.1.1 HIGH-ACCURACY SPECTRALLY FLATCLASS A DATASHEET

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Kipp & Zonen	
2	**Model**		SMP22	
3	**Classification to ISO9060:2018**		Spectrally Flat Class A	
4	**Degree of protection**		IP67	
5	**Uncertainty Metrics**			
A	Response Time (63%)	*seconds*	0.7	
B	Response Time (95%)	*seconds*	2	
C	Spectral Range (20% points)	*nm*	210 – 3600	
D	Spectral Range (50% points)	*nm*	250 - 3500	
E	Zero offset A	*W/m²*	< ± 3	
F	Zero offset B	*W/m²*	< ± 1	
G	Total Zero Offset	*W/m²*	< ± 4	
H	Directional Response	*W/m²*	< ± 5	
	Non-Stability	*%*	0.5 (per year)	
I	Temperature Response	*%*	< ± 0.3% (-20°C to +50°C) < ± 0.3% (-40°C to +70°C)	
J	Clear sky GHI Spectral Error	*%*	< ± 0.04	
K	Field of view	*Degrees*	180	
L	Bubble Level Accuracy	*Degrees*	< ± 0.1	
6	**Power Consumption**	*mW*	<= 100	
7	**Serial Output**		Modbus RTU	
8	**Mean Time Between Failure**	*years*	> 10	
9	**Detector Type**		Thermopile	
10	**Operating Temperature**	*°C*	-40 to +70	

6.1.1 STANDARD CLASS A DATASHEET

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Kipp & Zonen	
2	**Model**		SMP10	

No.	Description	Unit	Specified	Offered
3	**Classification to ISO9060:2018**		Spectrally Flat Class A	
4	**Degree of protection**		IP67	
5	**Uncertainty Metrics**			
A	Response Time (63%)	*seconds*	0.7	
B	Response Time (95%)	*seconds*	2	
C	Spectral Range (20% points)	*nm*	270 – 3000	
D	Spectral Range (50% points)	*nm*	285 - 2800	
E	Zero offset A	*W/m²*	< ± 7	
F	Zero offset B	*W/m²*	< ± 2	
G	Total Zero Offset	*W/m²*	< ± 9	
H	Directional Response	*W/m²*	< ± 10	
	Non-Stability	*%*	0.5 (per year)	
I	Temperature Response	*%*	< 1% (-20°C to +50°C) < 2% (-40°C to +70°C)	
J	Clear sky GHI Spectral Error	*%*	< ± 0.1	
K	Field of view	*Degrees*	180	
L	Bubble Level Accuracy	*Degrees*	< ± 0.1	
6	**Power Consumption**	*mW*	<= 100	
7	**Serial Output**		Modbus RTU	
8	**Mean Time Between Failure**	*years*	> 10	
9	**Detector Type**		Thermopile	
10	**Operating Temperature**	*°C*	-40 to +70	

6.1.1 CLASS A WITH BUILT-IN DEW/FROST MITIGATION DATASHEET

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Kipp & Zonen	
2	**Model**		SMP12	
3	**Classification to ISO9060:2018**		Fast Response Spectrally Flat Class A	
4	**Degree of protection**		IP67	
5	**Uncertainty Metrics**			
A	Response Time (63%)	*seconds*	0.15	
B	Response Time (95%)	*seconds*	0.5	
C	Spectral Range (20% points)	*nm*	280 – 3000	
D	Spectral Range (50% points)	*nm*	285 - 2750	
E	Zero offset A	*W/m²*	< ± 1	
F	Zero offset B	*W/m²*	< ± 1.5	
G	Total Zero Offset	*W/m²*	< ± 3	
H	Directional Response	*W/m²*	< ± 10	
	Non-Stability	*%*	0.5 (per 5 years)	
I	Temperature Response	*%*	< 1% (-20°C to +50°C) < 2% (-40°C to +70°C)	

No.	Description	Unit	Specified	Offered
J	Clear sky GHI Spectral Error	*%*	< ± 0.1	
K	Field of view	*Degrees*	180	
L	Bubble Level Accuracy	*Degrees*	< ± 0.1	
6	**Includes Spectral Filter**		Yes	
7	**Power Consumption**	*W*	<= 3.5	
8	**Serial Output**		Modbus RTU	
9	**Mean Time Between Failure**	*years*	> 10	
10	**Detector Type**		Thermopile	
11	**Operating Temperature**	*°C*	-40 to +70	

6.1.1 PYRANOMETER VENTILATION UNIT DATASHEET

No.	Description	Unit	Specified	Offered
1	**Supply Voltage**	V_{dc}	12	
2	**Power Consumption**	*W*	11.8	
3	**Operating Temperature Range**	*°C*	-40 to +70	
4	**Zero Offset A Reduction**	*%*	50%	
5	**Degree of Protection**		IP68	
5	**Compatible sensors**		Kipp & Zonen CMP3, CMP6, CMP10, CMP21, CMP22, SMP3, SMP6, SMP10, SMP22	

6.2 MODULE TEMPERATURE SENSOR DATASHEET

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		-	
2	**Model**		-	
3	**Sensor Element**		PT1000	
4	**Measurement Range**	*°C*	-40 to 90	
5	**Uncertainty**	*°C*	±1	
6	**Supply Voltage**	V_{dc}	10 to 28	
7	**Communication Protocol**		Modbus RTU	
8	**Adhesive Thermal Conductivity**	W/m^2K	> 500	

6.3 COMPACT WEATHER STATIONS DATASHEETS

6.3.1 TEMP, HUMIDITY, PRESSURE, WIND SPEED & DIRECTION

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Lufft	
2	**Model**		WS500	
3	**Power Supply**			
4	**Degree of protection**			
	Communication Protocol		Modbus RTU	
5	**Ambien Air Temperature**			
A	Measurement Principal		NTC	
B	Measuring Range	*°C*	-50 to +60	
C	Resolution	*°C*	0.1	
D	Uncertainty	*°C*	±0.2	
6	**Relative Humidity**			
A	Measurement Principal		Capacitive	
B	Measuring Range	*%*	0 to 100	
C	Resolution	*%*	0.1	
D	Uncertainty	*%*	±2	
7	**Air Pressure**			
A	Measurement Principal		Capacitive	
B	Measuring Range	*hPa*	300 to 1200	
C	Resolution	*hPa*	0.1	
D	Uncertainty	*hPa*	±0.5	
8	**Wind Speed**			
A	Measurement Principal		Ultrasonic	
B	Measuring Range	*m/s*	0 to 75	
C	Resolution	*m/s*	0.1	
D	Uncertainty	*m/s*	±0.3	
9	**Wind Direction**			
A	Measurement Principal		Ultrasonic	
B	Measuring Range	*degrees*	0 to 359.9	
C	Resolution	*degrees*	0.1	
D	Uncertainty	*degrees*	±3	

6.3.1 TEMP, HUMIDITY, PRESSURE, WIND SPEED & DIRECTION, PRECIPITATION

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Lufft	

No.	Description	Unit	Specified	Offered
2	**Model**		WS600	
3	**Power Supply**			
4	**Degree of protection**			
5	**Ambien Air Temperature**			
A	Measurement Principal		NTC	
B	Measuring Range	*°C*	-50 to +60	
C	Resolution	*°C*	0.1	
D	Uncertainty	*°C*	±0.2	
6	**Relative Humidity**			
A	Measurement Principal		Capacitive	
B	Measuring Range	*%*	0 to 100	
C	Resolution	*%*	0.1	
D	Uncertainty	*%*	±2	
7	**Air Pressure**			
A	Measurement Principal		Capacitive	
B	Measuring Range	*hPa*	300 to 1200	
C	Resolution	*hPa*	0.1	
D	Uncertainty	*hPa*	±0.5	
8	**Wind Speed**			
A	Measurement Principal		Ultrasonic	
B	Measuring Range	*m/s*	0 to 75	
C	Resolution	*m/s*	0.1	
D	Uncertainty	*m/s*	±0.3	
9	**Wind Direction**			
A	Measurement Principal		Ultrasonic	
B	Measuring Range	*degrees*	0 to 359.9	
C	Resolution	*degrees*	0.1	
D	Uncertainty	*degrees*	±3	
10	**Precipitation**			
A	Measurement Principal		Radar Sensor	
B	Measuring Range (drop size)	*mm*	0.3 to 5	
C	Resolution	*mm*	0.01	
D	Precipitation Type		Rain, Snow	
E	Precipitation Intensity Range	*mm/h*	0 to 200	

6.3.1 WIND SPEED & DIRECTION

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Lufft	
2	**Model**		WS200	
3	**Power Supply**			
4	**Degree of protection**			
8	**Wind Speed**			
A	Measurement Principal		Ultrasonic	
B	Measuring Range	*m/s*	0 to 75	
C	Resolution	*m/s*	0.1	
D	Uncertainty	*m/s*	±0.3	
9	**Wind Direction**			
A	Measurement Principal		Ultrasonic	
B	Measuring Range	*degrees*	0 to 359.9	
C	Resolution	*degrees*	0.1	
D	Uncertainty	*degrees*	±3	

6.4 SOILING MEASUREMENT DEVICE DATASHEET

No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Kipp & Zonen	
2	**Model**		DustIQ	
3	**Soiling Ratio Range**	*%*	50 to 100	
4	**Transmission Loss (TL)**	*%*	0 to 50 (1 – SL)	
5	**TL Uncertainty**	*%*	±10 % of SL reading ± 1 %	
6	**Operating temperature**	*°C*	-20 to +60	
7	**PV Panel Temperature Sensor**	*seconds*		
A	Sensor Range	*°C*	-20 to +100	
B	Sensor Accuracy	*°C*	± 1	
8	**Digital Tilt Sensor**	*nm*		
A	Sensor Range	*degrees*	-180 to +180	
B	Sensor Accuracy	*degrees*	± 1	
9	**Communication**		Modbus RTU	
10	**Daisy-chain capability**	*yes/no*	Yes	
11	**Daisy-chain capacity**		Up to 3 in one chain	
12	**Power Supply**	V_{DC}	12 to 30	
13	**Power Consumption**	*W*	< 2.5	
14	**Degree of Protection**		IP65	

6.5 SNOW SENSOR

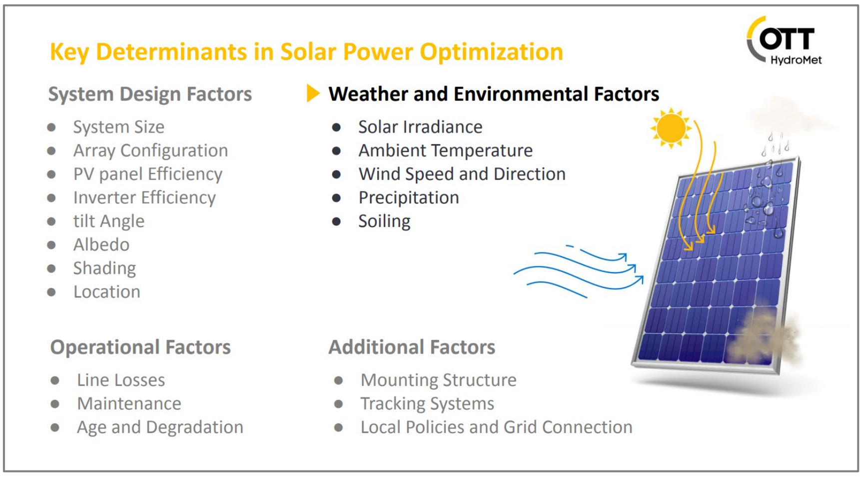
No.	Description	Unit	Specified	Offered
1	**Manufacturer**		Lufft	
2	**Model**		SHM31	
3	**Snow Depth Range**	*m*	0 to 15	
4	**Measurement uncertainty**		± (5 mm + 0.06 %)	
5	**Power Supply**	V_{dc}	12 / 24	
6	**Power Requirements** (without heater)	*W*	0.7	
7	**Power Requirements** (with heater)	*W*	3.4	
8	**Classification to IEC 60825-1**		Laser Class 2	
9	**Degree of Protection**		IP68	
10	**Communication**		Modbus RTU	

6.6 DATALOGGER DATASHEET

No.	Description	Unit	Specified	Offered
1	Voltage Input			
2	Communication Type		10/100BASE Ethernet	
3	Communication Protocol		Modbus TCP/IP	
4	Communication Cable		Copper Ethernet	
5	Communication Connector		RJ45	
6	digital/pulse inputs		> 4	
7	analogue inputs		> 4	
	Interface			
	Simple File Format export			
	Serial Port(s)		> 2	
	Storage Capacity		Min. 30 days of data	
	Time Synchronization		NTP	

7 IMPORTANCE OF ENVIRONMENTAL MEASUREMENTS

Solar photovoltaics (PV) is one of the fastest growing sources of renewable energy and is a key driver in shaping the global energy landscape. Enhancing the performance of solar PV and maximizing the efficiency of PV plants is dependent on multiple factors. A critical group of factors that impact solar PV performance are the those concerning weather and environmental conditions.



7.1 PERFORMANCE RATIO

The Performance Ratio (PR) is a critical indicator used in solar PV performance monitoring to quantify the overall efficiency of a solar PV plant. At the core, the PR is a comparison of the actual energy output from a PV system against the theoretical energy output of that system if it were operating at maximum efficiency under the environmental conditions it was exposed to.

$$PR = \frac{Energy\ Output_{Actual}}{Energy\ Output_{Theoretical}}$$

The PR of a solar PV system is critical for numerous reasons, including but not limited to operational oversight, system performance benchmarking, financial viability assessment, and enabling system quality assurance and control.

The IEC calls out certain environmental parameter measurements as requirements for all Class A photovoltaic systems. These parameters are critical to understand the environmental conditions under which a system is operating, and includes:

1. Solar Irradiance
2. Ambient Air Temperature
3. PV Module Temperature
4. Wind Speed and Direction
5. Rainfall

Another important environmental factor to consider is local soiling conditions and the resulting soiling build up on PV modules.

7.2 SOLAR IRRADIANCE

Solar irradiance refers to the amount of electromagnetic radiation received from the sun. It is typically measured in watts per square meter (W/m^2). Solar irradiance has a direct correlation with the potential energy output of a solar PV system.
There are 7 different types of irradiance measurements typically used in solar PV systems:

- **Global Horizontal Irradiance (GHI)**
  GHI refers to the amount of irradiance received on the front side of a horizontal surface.
- **Rear-Global Horizontal Irradiance (rGHI)**
  GHI refers to the amount of irradiance received on the back side of a horizontal surface.
- **Plane-of-Array Irradiance (PoA)**
  PoA refers to the amount of irradiance received on the front side of surface that is in line with the orientation and angle of the solar PV modules in a PV system.
- **Rear-Plane-of-Array Irradiance (rPoA)**
  rPoA refers to the amount of irradiance received on the back side of surface that is in line with the orientation and angle of the solar PV modules in a PV system.
  (i.e. the rear side of a PV module).
- **Direct Normal Irradiance (DNI)**
  DNI refers to the amount of irradiance received on a surface that is perpendicular to the sun and is only concerned with the direct sunlight.
- **Diffused Horizontal Irradiance (DHI)**
  DHI refers to the amount of scattered irradiance received on a horizontal surface (i.e. the amount of irradiance received on a horizontal surface without the inclusion of GHI and DNI)
- **Albedo**
  Albedo is a measure of the amount of irradiance reflected by a surface. It is typically expressed as the ratio of rGHI to GHI and typically ranges from 0 to 1, where 1 represents total reflection.

Pyranometers can be used to measure GHI, rGHI, PoA, rPoA and DHI. Pyrheliometer can be used to measure DNI.

7.2.1 PYRANOMETERS

A pyranometer is an instrument that measures the solar radiation over a hemispherical field of view (180°). The ISO9060 classifies pyranometers based exclusively on the measuring specifications of the device and provides three distinct classes of pyranometers (A, B, and C). Class A pyranometers are the most accurate instruments, followed by class B, and then Class C.

7.2.2 PYRANOMETER PERFORMANCE PARAMETERS

There are multiple parameters and corresponding performance guard bands that are used to differentiate between the three classes. These parameters include:

- **Response Time**
  The time it takes for a pyranometer to produce a stable output under realistic irradiance changes.
- **Zero Off-Set**
  Zero-offset a measure of the stability of the zero-point of the pyranometer. It essentially refers to the base-line measurement of the pyranometer in the absence of irradiance. The ISO9060 refers to three types of zero off-sets (A, B, and C).
  - **Zero Off-Set A**
    The response of a pyranometer to the influence of thermal radiation. The ISO9060 prescribes limits for a pyranometer's response to a net thermal radiation of -200 W/m^2
  - **Zero Off-Set B**
    The response of a pyranometer to the change in ambient temperature conditions. The ISO9060 prescribes limits for a pyranometer's response to a change in ambient temperature of 5°C per hour.
  - **Zero Off-Set C**
    The total zero off set of a pyranometer including both **Zero Off-Set A** and **Zero Off-Set B**, as well as any other sources of off set. These may include off sets caused by heat dissipated by electronics in the instrument, deviations cause by the electronics themselves, and temperature differentials in the instrument itself. **Zero Off-Set C**, therefore, represents the overall deviation of the pyranometer in the absence of irradiance.
- **Non-Stability**
  Non-stability is the measure of the change in responsivity of the pyranometer over time. This is sometimes referred to as a drift in the pyranometer, though drift is only a subcomponent of non-stability. The non-stability of the pyranometer is indicative of the change in accuracy of the pyranometer over time, and it is the reason that regular re-calibration of the sensor is necessary. Non-stability is measured and tested through the process of calibration, allowing the comparison between an operating pyranometer's reading and that of a controlled reference device. Determining an accurate non-reliability rating is highly depending on measuring the performance of multiple devices over time. The lower the non-stability rating, the more reliable the pyranometer is expected to be over time.
- **Non-linearity**
  Non-linearity refers to the percentage at which the output from a pyranometer deviates from the actual irradiance measure. Ideally, pyranometers should have a linear response whereby the changes in the output from a sensor is proportional to the change in irradiance. The non-linearity is the measure of the disproportionality in the sensor. The Non-Linearity parameter according to ISO9060, is the percentage of deviation at an

irradiance of 500 W/m^2, due to changes in irradiance ranging from 100 W/m^2 to 1000 W/m^2. Non-linearity is crucial for understanding the overall pyranometer accuracy as it is indicative of the pyranometers consistency across varying irradiance levels.

- **Directional Response**
  Directional response refers to how accurately a pyranometer is able to measure irradiance across a range of varying angles of incidence. The ISO9060 prescribes the range of permissible deviation in output from the pyranometer for angles between 0° and 90° in any direction when exposed to 1000 W/m^2 of radiation at normal incidence. Directional response is crucial for understanding the overall pyranometer accuracy as it is indicative of how accurately the pyranometer will measure as the angle of exposure changes throughout the day. A lower directional response is indicative of a more accurate pyranometer throughout the course of a day.
- **Spectral Error**
  Irradiance is emitted in various colors and wavelengths of light, including light across the visible spectrum, and invisible spectrum (ultraviolet and infrared). Spectral Error is a measure of how accurately a pyranometers responds to these varying wavelengths. It is expressed as a percentage of the deviation of the actual output of a pyranometer from the expected output across the different wavelengths of light. It is indicative of how accurately a pyranometer captures the full range of sunlight, and how accurately it performs across varying solar conditions.

- **Temperature Response**
  Temperature response is the percentage change in a pyranometers sensitivity due to the change in ambient air temperature conditions. This is indicative of how the pyranometer accuracy changes with changes in the temperature. The ISO9060 prescribes the acceptable percentage of deviation between -10°C to 40°C relative to a signal from the pyranometer generated at 20°C. The smaller the temperature response, the more accurate the pyranometer across varying ambient air temperatures.
- **Tilt Response**
  Tilt response is the percentage change in a pyranometers sensitivity as it is tilted from 0° to 180°. This is indicative of how the pyranometer accuracy changes as the orientation of the pyranometer changes. The ISO9060 prescribes the acceptable percentage of deviation between 0° and 180° relative to a signal from the pyranometer generated at 0° (horizontal orientation) at 1000 W/m^2 of irradiance. The smaller the tilt response, the more accurate the pyranometer across varying angles of orientation.
-
- **Spectral Selectivity**
  Spectral selectivity refers to a pyranometers ability to respond to different radiation wavelengths. Solar PV modules have the most efficient absorption of solar radiation between 400nm and 1100nm wavelengths. The ISO9060 defines the permissible percentage of deviation in responsivity of pyranometers in the range of 350 nm to 1500 nm.

- **Signal Processing Errors**
  Signal processing errors refers to any inaccuracies that are introduced by the conversion or amplification of the raw signal generated in a pyranometer. This can be occur when the raw signal is process by internal electronics in the pyranometer, such as when a raw millivolt signal is processed into a digital irradiance value.

7.2.3 PYRANOMETER CLASSIFICATIONS

The ISO9060 uses the above performance parameters to define the classifications of pyranometers.

Parameter	Unit	Class			Kipp & Zonen Class As			Other Class As
		A	B	C	SMP22	SMP12	SMP10	
Response Time	secs	< 10	< 20	< 30	< 2	< 0.5	< 2	<0.5
Zero-Off Set a	W/m^2	±7	±15	±30	±3	±1	±7	±1
Zero Off-Set B	W/m^2	±2	±4	±8	±1	±1.5	±2	±1
Zero Off-Set C	W/m^2	±10	±21	±7	±4	±3	±9	±2
Non-Stability	%	±0.8	±1.5	±3	±0.5	±0.5	±0.5	±0.5
Non-Linearity	%	±0.5	±1	±2	±0.2	±0.2	±0.2	±0.2
Directional Response	W/m^2	±10	±20	±30	±5	±10	±10	±10
Spectral Error	%	±0.5	±1	±5	±0.04	±0.1	±0.1	±0.2
Temperature Response	%	±1	±2	±4	±0.3	±1	±1	±0.5
Tilt Response	%	±0.5	±2	±5	±0.2	±0.2	±0.2	±0.2
Spectral Selectivity	%	±3	±5	±10	±3	±3	±3	±3
Additional Signal Processing Error	W/m^2	±2	±5	±10	±1	±3	±2	±1

7.2.4 ADDITIONAL CLASSIFICATIONS

Along with the three classes of pyranometers, the ISO9060 also defines sub-classifications namely, fast response and spectrally flat.

- **Spectrally Flat**
  The ISO9060 defines a spectrally flat pyranometer as one that has a spectral selectivity of no more than ±3% deviation in responsivity between 350nm and 1500nm. A pyranometer must be spectrally flat to qualify as a Class A device, according to ISO9060.
- **Fast Response**
  The ISO9060 defines a fast response pyranometer as one that has a response time of less than 0.5 seconds.

7.3 AMBIENT AIR TEMPERATURE

PV module performance has an inverse relationship with module temperature. Generally, as the temperature of the PV module increases, the resistance within the solar cell increases, causing the efficiency and output of the module decreases.

Measurement of the ambient air temperature is critical for three major reasons.

1. Increases in ambient air temperature can lead to decreases in output and efficiency.
2. By monitoring the ambient air temperature, one is able to confirm that all system components are operating within the specified temperature range.
3. Ambient air temperature has an impact on pyranometer accuracy and performance (*see Temperature Response above*)

7.4 MODULE TEMPERATURE

As mentioned above, PV module performance has an inverse relationship with module temperature. Thus, it is critical to measure the temperature of the PV module to analyze its performance.

7.5 WIND SPEED AND DIRECTION

Wind speed and direction measurements are critical for two main reasons.

1. Wind can have a cooling effect on the PV modules. This may help improve module efficiency by reducing the overall module temperature.
2. Wind can also be a source of mechanical stress on the modules. Understand wind speed and direction is particularly important for tracking PV systems to prevent potential damage to the modules and mounting structures.

7.6 PRECIPITATION

Precipitation measurements are critical for two main reasons.

1. Precipitation can have a cleaning effect on PV modules by washing away dust and debris that may block irradiance from reaching the module.
2. Heavy rains can potentially damage PV modules and mounting structure.

7.7 SOILING

Soiling refers to the amount of dirt, dust, and contaminants that collects on the surface of the photovoltaic modules in an array. Soiling impacts the overall efficiency of a PV module and PV plant by block irradiance from reaching the solar cells inside the modules. Thus, soiling is a critical factor that may impact the overall performance ratio of a plant. Soiling loss refers to the percentage drop in power output due the accumulation of soiling on a module or within an array.

Soiling can also refer to the accumulation of dirt, dust, and contaminants on the dome of a pyranometer or irradiance measurement device.

The IEC61724-1:2021 discusses the importance of soiling mitigation both for PV modules and for irradiance measurement devices.

7.7.1 SOILING OF PV MODULES

The IEC61724 defines “soiling ratio”, “soiling level”, and “soiling rate” to measure and monitor soiling conditions in a PV plant

- **Soiling Ratio**
  Soiling Ration (often demarcated as *SR*) is the ratio between the actual power output under the existing soiling conditions versus the expected power output under completely clean conditions.
- **Soiling Level**
  Soiling level (often demarcated as *SL*) is the percentage of power lost because of soiling build up on modules and is the complement of *SR* (i.e. *1 – SR)*
- **Soiling Rate**
  Soiling rate is expressed as the percentage rate of change of the soiling ration over a certain period of time, typically a day.

There are two prominent measuring principles used to measure soiling.

- **Reference System**
  Comparing the output from a clean reference PV module to that of a PV module soiled under operational conditions.
- **Optical Sensors**
  Detection of soiling on a surface by measuring the impact of soiling on light transmission or reflection.

Measurement of the soiling ratio is a requirement for IEC61724 Class A systems when the expected annual soiling loss is greater than 2%. This is usually determine using historical weather data or site assessment data before a PV plant is constructed.

7.7.2 SOILING OF IRRADIANCE MEASUREMENT DEVICES

Soiling on an irradiance measurement device will block the radiation from reaching the detector and will cause a reduction in the output measurement that does not correspond with the real mount of irradiance present. Since solar irradiance has a direct correlation with the potential energy output of a solar PV system, an inaccurate irradiance measurement will lead to an inaccurate performance ratio calculation.

It is for this reason that the IEC61724 states that, for Class monitoring systems, irradiance measurement devices must be cleaned at least once a week to mitigate the impact of soiling on irradiance measurements.

7.8 SOLUTION OFFERINGS

OTT HydroMet has an extensive portfolio of products under various reputable brands, such as Kipp & Zonen and Lufft, that offer accurate and compliant measurement solutions for the key weather parameters that need to be monitored on solar PV plants.

PARAMETER	SYMBOL	UNITS	OTT HydroMet Offering	
			Brand	Model(s)
Plane of Array Irradiance (PoA)	G_i	W/m²	Kipp & Zonen	SMP10, SMP12, SMP22
Global Horizontal Irradiance	GHI	W/m²		SMP10, CMP22
Ambient Air Temperature	T_{amb}	°C	Lufft	WS200, WS300, WS400, WS500, WS600, WS800
Wind Speed		m/s		
Wind Direction		deg		
Rainfall		cm		
Horizontal Albedo	ρ_H		Kipp & Zonen	SMP10, SMP12, SMP22, CMP10, CMP22
In-plane rear-side irradiance (rPoA)	G_i^{rear}	W/m²		SMP6, SMP10, SMP12, SMP22, CMP6, CMP10, CMP22
Soiling	SR			DustIQ
Snow		Cm	Lufft	SHM31

7.8.1 SOLAR IRRADIANCE

OTT HydroMet, under the Kipp & Zonen brand, has an extensive range of Class A, B, and C pyranometers to meet all irradiance measurement needs.

Class A Pyranometers	
Product	**Benefit**
SMP22, CMP22	Most accurate Class A pyranometers on the market due to best-in-class spectral range, directional error, spectral error, and temperature response. Developed with both temperature and irradiance outputs for scientific grade measurements. (SMP = digital Version ; CMP = Analog Version)
SMP12	Spectrally flat Fast response Class A pyranometer with integrated dew and frost

	prevention and best-in-class digital tilt monitoring that requires no recalibration.
CMP21	Spectrally flat Class A pyranometer with both temperature and irradiance analogy outputs, design for scientific grade measurements.
SMP10, CMP10	Classic spectrally flat class A pyranometer design to last over 10 years. (SMP = digital Version ; CMP = Analog Version)
Class B Pyranometers	
SMP6, CMP6	Classic spectrally flat class B pyranometer design to last over 10 years. (SMP = digital Version ; CMP = Analog Version)
Class C Pyranometers	
SMP3, CMP3	Classic spectrally flat class C pyranometer design to last over 10 years. (SMP = digital Version ; CMP = Analog Version)
CM4	Class C pyranometer designed to operating in extreme temperatures up to 150 ºC.
SP Lite 2	Reliable and cost-effective class C pyranometer
RT1	Designed for easy mounting in rooftop solar applications and includes an integral module temperature sensor

7.8.2 WEATHER PARAMETERS

OTT HydroMet, under the Lufft brand, has an extensive range of compact weather stations to meet all weather parameter measurement needs.

Product	Precipitation (Tipping Bucket)	Precipitation (Ultrasonic)	Relative Humidity	Barometric Pressure	Ambient Air Temperature	Wind Direction	Wind Speed	Lightning Strikes
WS100		✔						
WS200		✔				✔		
WS300			✔	✔	✔			
WS400		✔	✔	✔	✔			
WS401	✔		✔	✔	✔			
WS500			✔	✔	✔	✔	✔	
WS600		✔	✔	✔	✔	✔	✔	
WS601	✔		✔	✔	✔	✔	✔	
WS800		✔	✔	✔	✔	✔	✔	✔

No.	Standard	Title
1.	IEC 61439	low-voltage switchgear and controlgear assemblies
2.	IEC 60297	Mechanical structures for electronic equipment –. Dimensions of mechanical structures
3.	IEC 62109	Safety of power converters for use in photovoltaic power systems
4.	IEC 11801	Information technology — Generic cabling for customer premises
5.	IEC 60189-2	Low-frequency cables and wires with PVC insulation and PVC sheath
6.	IEC 14763-3	Implementation and operation of customer premises cabling - Part 3: Testing of optical fiber cabling
7.	IEC 61280-4-1	Fiber optic communication subsystem basic test procedures
8.	IEC 61282	Fiber optic communication system design guides
9.	IEC 62446	Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection
10.	IEC 61724	Photovoltaic system performance
11.	IEC 62443	Industrial communication networks – Network and system security
12.	IEC 61850	Communication networks and systems for power utility automation
13.	IEC 61753	Fiber optic interconnecting devices and passive components – Performance standard
14.	IEC 61754	Fiber optic interconnecting devices and passive components – Fiber optic connector interfaces
15.	IEC 61755	Fiber optic interconnecting devices and passive components – Connector optical interfaces
16.	IEC 61643	Low-Voltage Surge Protective Devices
17.	IEC 90604-2	Photovoltaic devices – Part 2: Requirements for photovoltaic reference devices
18.	IEC 90604-5	Photovoltaic devices - Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method
19.	IEC 60664	Insulation co-ordination for equipment within low-voltage systems
20.	IEC 60364–7-712	Electrical installations of buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
21.	IEC 60793-1	
22.		

<u>FUTURE EDITS</u>

	DESCRIPTION	LOCATION	ADDED BY
1.	Write description and specifications for installation details on the module (location, height etc.)	Tracking Array	C. Plaatjes
2.	Determine whether to include a section on diffused irradiance and write up corresponding specification.	Diffused Irradiance	C. Plaatjes
3.	Include section on sensor fault flagging and alarming when sensor is detached if and when Hydra is developed.	BOP Temp	C. Plaatjes
4.	Determine whether to include a section on snow sensor and write up corresponding specification.	Snow Sensor	C. Plaatjes
5.	Update datalogger model once a standard model is decided (currently spec'ed as Campbell CR1000Xe)	Datalogger	C. Plaatjes
6.	Modbus registers to be updated as standard map is developed	Modbus Map	C. Plaatjes
7.	Write up specification on enclosures, materials, and mechanical spec	Enclosures	C. Plaatjes
8.	If we specify a diffused sensor, then accompanying datasheet to be included.	DHI Datasheet	C. Plaatjes
9.	Include technical datasheet for mounting tower once standardized	Met Tower	C. Plaatjes
10.	Update datalogger datasheet once standard model is decided	Datalogger datasheet	C. Plaatjes
11.	Include technical datasheet for enclosures once specification is written	Enclosure	C. Plaatjes
12.			
13.			
14.			
15.			
16.			