APPENDIX B
Measurement Equipment Generals

General Information

Application of UV radiation becomes more and more important in the last couple of years. Along with classical application fields like disinfection of liquids, UV radiation is more and more applied in air cleaning, paint curing and other chemical, catalytic or analytic processes.
According to the specific process a minimum energy flux or an accurate level of irradiation is required. In both cases the radiated power or intensity respectively has to be measured. This helps to avoid over- or underdosing and saves energy resources.

Methods of measurement

There are 2 different methods:

- ⇨ qualitative and quantitative evaluation of the overall process of using UV irradiation.

  This includes bacteriological and chemoanalytic methods, that can give precise results. It is used to characterize the performance in the design and certification process of systems. Due to high cost of time consuming bacteriologic analysis this method cannot be used for instant measurement.

  Alternatively selected operation condition like irradiance E_e and radiant flux can be measured by keeping other operating parameters constant.

- ⇨ measurement of UV intensity.
  This is subject of the following chapter.

Measurement of UV-intensity

Measurement of radiometric quantities like irradiance E_e, radiant density L_e, radiant intensity I_e and radiant flux Phi_e are very expensive if conducted in the spectral band of UV radiation. A large number of boundary conditions have to be observed, resulting in a very complex physical-mathematical process of measurement value calculation. This makes it very difficult to conduct measurements outside of a well equipped laboratory.
Serial measurements can only be conducted if a minimum set of specified boundary conditions are maintained. This set of boundary conditions includes a defined geometry, sensor configuration and calibration data and allows a quantitative estimation.

UV-measurement via semiconductor sensors

UV measurements, using semiconductor sensors are widely used. While operated within the specifications, this sensors return a signal, that is proportional to the incoming radiant energy.

Depending on the sensitive material, this sensors have a characteristic spectral sensitivity that can include a large range of wavelength (infrared, visible light, UV-A, UV-B and UV-C).

Often the range of sensitivity is adopted to the specific application by using appropriate filters or material doping. The resulting electrical output signal (normally current) must be conditioned and calibrated to get results with adequate accuracy.

Absolute Measurement
As already stated, the correct measurement of radiometric quantities is very difficult and requires special sensors and geometrical arrangements for specific measurement problems. Finally a photodiode receives irradiation, converts it into an electrical signal that is processed with calibrated data and the result represents the radiometric value.
This method is called **absolute measurement** because the result can be traced back to a physical quantity. It requires a sensor, that responds a predefined electrical signal from a fixed physical quantity. Typical specifications are 20mA is equivalent to 100W/m² or 2V is equivalent to 150W/m².

The calibration is unchangeable for each sensor and cannot be adopted to a specific measurement problem. This means that only sensors with a matching calibration can be used. This can cause problems in stock holding, because a large number of different sensors have to be ready for use.

With the digital calibrated sensor ZED provides a solution for this problem. This sensor converts the incoming irradiation into a digital number. By this method the process of converting an analog signal and its limits are avoided.

Relative Measurement
In most application it is just required to keep a certain level of irradiance. A relative value as a percentage will ensure that the irradiation is high enough to keep the process running properly. This is called **relative measurement**, because no reference to a radiometric quantity is required.

ZED offers a wide variety of sensor monitor combinations. The basic principle of this combination is that an UV photodiode delivers a current signal that is linear to the irradiation over a range of multiple magnitudes. The current signal is processed with variable gain and converted into a voltage signal by a monitor device. This allows the monitoring of a wide range of UV intensities.

Automatic adjustment

Elder monitor devices used potentiometers to adjust sensitivity manually. The new designed monitors use processor controlled sensitivity switches as well as mathematical models to provide optimal performance for different application.

The monitor models PRO11 and PRO16 allow an automatic adjustment. By a menu option a known actual measurement value can be assigned to a defined end value. This process is usually done after the monitored lamp is changed.

New lamps usually have an UV output of 110% and reach their nominal value of 100% after a run time of 100h. By doing the adjustment to a level of 110% right after changing the lamp an adequate adjustment for the whole lamp life is achieved.

Digital sensors

ZED's digital sensors have the following advantage over analog sensors:

- ⇨ one sensor can be used for a wide range of intensity
- ⇨ reading of absolute UV values in W/m²
- ⇨ digital data transfer via industrial bus system
- ⇨ high noise immunity for rough industrial environment
- ⇨ simple parallel operation of multiple sensors
- ⇨ low amount of cabling

This could be achieved by integration of complete analog signal processing in the sensor body. After analog/digital conversion, the digital signal is averaged and transmitted via RS485 interface. The supervising system can process the measured data after requesting measurements by calling the addressed sensor.