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TECHNICAL REPORT

SOLAR SPECTRAL IRRADIANCE

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CONTENTS

SOLAR SPECTRAL IRRADIANCE

SUMMARY

CIE TC2-17 was formed with the purpose of updating CIE Publication No.20 (TC-2.2) "Recommendations for the integrated irradiance and the spectral distribution of simulated solar radiation for testing purposes". The present document is the first of two, of which the second will deal with solar simulators. It gives a brief overview of parameterization methods and contains a number of tables and figures for solar spectral irradiances for typical atmosphere conditions defined by a set of meteorological parameters. The calculated data show satisfactory agreement with results obtained by direct measurement.

DISTRIBUTION SPECTRALE DE L'ÉCLAIREMENT SOLAIRE

RÉSUMÉ

Le but de Comité Technique CIE TC2-17 était de mettre à jour la publication CIE n°.20 (TC2.2): "Recommendations concernant l'éclairement énergétique et la répartition spectrale du rayonnement solaire en vue de sa reproduction artificielle pour des essais". Le présent document est la première de 2 parties (la deuxième partie traitera des simulateurs solaires). Ce premier document décrit brièvement les méthodes de paramétrisation et présente des tables de données relatives à l'éclairement énergétique spectral du rayonnement solaire pour certains types de conditions atmosphériques définies par un ensemble de paramètres météorologiques. L'accord entre les valeurs calculées et les valeurs mesurées est satisfaisant.

SOLARE SPEKTRALE BESTRAHLUNGSSTÄRKE

ZUSAMMENFASSUNG

Die CIE TC2-17 hat die Aufgabe die Publikation CIE No.20 CIE2.2 "Empfehlung über die Gesamtbestrahlungsstärke und die spektrale Verteilung künstlicher Sonnenstrahlung für Prüfzwecke" auf den neuesten Stand zu bringen. Die vorliegende Publikation ist der erste Teil von zwei Teilen, von denen der zweite Solarsimulatoren behandeln wird. Der erste Teil, der hier vorliegt, gibt einen kurzen Überblick der Methoden der Parametrisierung und enthält Tabellen und Abbildungen für solare spektrale Bestrahlungsstärkeverteilungen für typische Zustände der Atmosphäre, die durch eine Gruppe meteorologischer Parameter definiert sind. Die berechneten Werte stimmen zufriedenstellend mit den Ergebnissen direkter Messugen überein.

1. INTRODUCTION

It was decided to revise and update CIE Publication No.20 (TC-2.2) 1972. The main reasons for this decision could be summarized as follows.

It has become obvious that the solar spectral irradiance data on which the recommendations in the original document were based were no longer the most reliable. During the past decade a vast amount of new data has become available both through modernized measurement techniques as well as improved modelling and parameterization methods. Contrary to the situation some years ago, the stage has now been reached where results for solar spectral irradiances at ground level as measured and those obtained by reliable modeling, using extraterrestrial data as basis, show agreement to accuracies well within predictable or estimable uncertainties. It has thus become possible to calculate solar spectral irradiance levels and characteristics for any site on earth provided appropriate meteorological and atmospheric parameters are applied in reliable modeling formulas. This enables close simulation of solar irradiance characteristics for any geographical site, without the need of having to make in situ measurements.

It is also desirable that the number of spectral bands for which integrated solar irradiance levels are given, should be increased, especially in the ultraviolet region where the degradation coefficient for organic material increases nearly exponentially with a decrease in wavelength.

The aim of the report is to present data and recommend methods for calculating the integrated and spectral irradiance of the extraterrestrial and ground level solar radiation as a basis for simulation for testing purposes.

These data are required in

* aerospace technique for testing satellites and space vehicles in sun simulators,
* space biology for testing biological objects under extra-terrestrial conditions in laboratory,

* technology for the purpose of testing the resistance of technical objects to irradiance in laboratories,
* biology and medical science for irradiation of organisms in solaria under the condition found in nature.
* photovoltaic conversion for precise calculation of efficiencies and testing in solar simulators.

The determination of the integrated irradiance of the extraterrestrial solar radiation, which was called "Solar Constant" after Pouillet as early as 1838, was originally based upon extrapolation of measured results at ground level. These were later followed by measurements from high mountain sites, balloons, aircraft and spacecraft.

For obtaining ground level spectral irradiance data, use has been made of modelling, using extraterrestrial data as a basis and taking into account atmospheric attenuation parameters. This has been supplemented by direct spectral measurements.

The following recommendations are based upon extraterrestrial data of the World Meteorological Organization (WMO), which was mainly derived from the data of Labs and Neckel, and of modeled data for atmospheric conditions based on the parameterization method according to Justus and Paris.

2. EXTRATERRESTRIAL SOLAR RADIATION

2.1 Extraterrestrial solar irradiance

From the sun, the planet Earth receives electromagnetic as well as corpuscular radiation. The electromagnetic radiation of the sun is called solar radiation. The solar radiation incident on the upper boundary of the terrestrial atmosphere is called extraterrestrial solar radiation.

Since the earth moves around the sun in an elliptical orbit, the ecliptic, during one year, the distance from the sun to the earth and hence the irradiance of extraterrestrial solar radiation varies with time of the year. The actual value E_{0J} of extraterrestrial solar irradiance on Julian day J, (J = 1,..., 365) is given by