IRRADIANCE AND SPECTRAL DISTRIBUTION OF HOT BODIES

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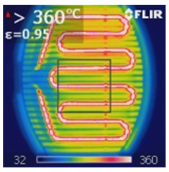
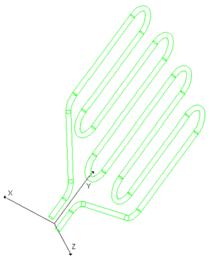
ABSTRACT

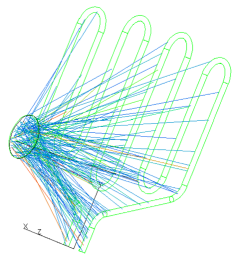
Exposure limits for optical radiation given by international commissions (e.g. ICNIRP, International Commission on Non-Ionizing Radiation Protection) exist for both, skin and the eye for different photobiological hazards (e.g. infrared eye, skin thermal). The ICNIRP exposure limits were adopted by the EU directive "optical radiation" in order to protect workers from overexposure to optical radiation at the workplace. This directive has to be implemented in Austria by 2010. As a complete evaluation of the workplace is time consuming and requires a wide knowledge about measurement techniques and instruments a rough estimation of the exposure situation at the workplace by a model can help to safe time and money. Unnecessary exposure measurements can be avoided, if the exposure limits are not exceeded. A self developed evaluation tool provides the opportunity to evaluate a variety of heat emitting sources and identify potential hazardous emitters of infrared radiation. Spectral irradiance and spectral distribution of infrared emitting objects are simulated and compared to exposure limits. The simulation is validated by measurements.

METHODS

The self – developed evaluation tool gives the user the opportunity to estimate potential hazards fast and accurate and allows calculating the irradiance and the spectral distribution of a variety of hot bodies. Simplified models on a series of emitting objects are developed. The concept of black- and graybody is applicable assuming worst case considerations. The optomechanical software TracePro® is used to simulate the spectral radiation distribution of emitting objects (e.g. grill pan, industrial ovens). Irradiance data is evaluated twice, by simulations and measurements respectively, and is cross checked.







Input parameters for simulations:

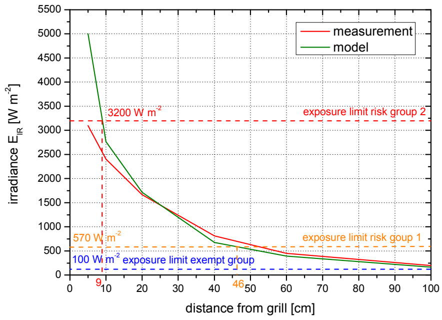
- Geometry of the emitter
- Dimensions (A)
- Surface temperature (T1)
- Skin surface temperature 32 °C (T2)
- Emissivity ε = 1
- Receiver setup (distance, angle, …)
- Wavelength range

Assumptions:

- Steady state (no temperature changes)
- Homogenous source characteristics
- Skin temperature 32 °C
- Lambertian surface characteristics
- Lambertian irradiation characteristics
- Blackbody or graybody concept

VALIDATION

Validity is achieved by comparing measurement with simulation data. Selected emitting sources are evaluated, showing an excellent accordance between measured and simulated data. The simulation data from the software TracePro® matches well to the data measured, considering the excepted inaccuracies.

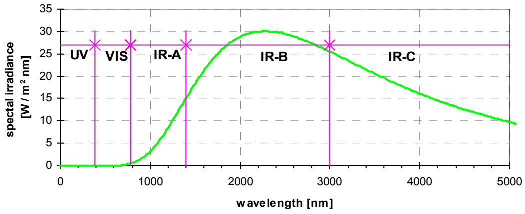


distance [cm]	measurement [W m^{-2}] 780 nm – 3000 nm	model [W m^{-2}] 780 nm – 3000 nm	Δ [%]
10	2400	2764	15
20	1667	1716	3
40	811	676	16
60	450	392	13
100	199	162	18

RESULTS

The self- developed evaluation tool is used to give a first, rough estimation of the investigated heat emitting source. The examiner obtains sufficient insight of the source characteristics and will be able to draw a decision on the necessity for a detailed source workplace examination.

The application of the tool shall be illustrated on a possible scenario; a glass oven with a square port (30 x30 cm) and a material temperature of T = 1000°C and an emissivity ε = 0.7; the receiver is positioned in 200 cm distance.



The simulation shows that the major output of radiant exitance power is in the IR-B (56.87 %) and the IR-C (37.95 %) region of the irradiated spectrum, with a total radiant emittance power of 9356 W (Stefan – Boltzmann law).

	VIS (380 nm – 780 nm)	IR-A (780 nm – 1400 nm)	IR-B (1400 nm – 3000 nm)	IR-C (3000 nm – 1 mm)
Radiant Emittance Power [W]	4	480	5321	3551
Percentage [%]	0.04	5.13	56.87	37.95

	exposure limit [W/m^2]	irradiance simulation [W/m^2]
IR eye	100	331
skin (thermal)	3556	331
retina (weak visual stimulus)	471	0

Further the exposure limits for the human skin and eye are compared with the simulated irradiance data. The exceedance of the exposure limits for skin and eye lead to the conclusion whether a detailed workplace analysis is advisable or not.

DISCUSSION

The self- developed evaluation tool presents an adequate instrument to roughly evaluate the irradiance and the spectral distribution of hot bodies, which can be found in industrial environments. Thus the process of estimation is optimized, decisions on further exposure measurements are fast and accurate. The self – developed evaluation tool contains huge potential to be expanded and to contribute to further research issues. With regards to the EU directive "optical radiation" the model helps to identify hazardous sources of IR radiation and to avoid unnecessary detailed workplace evaluations.

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Note: This poster was originally published under our company's former name Austrian Research Centers.