Temperature Measurement Second Edition
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Contents

Preface to the 2nd Edition

Temperature influences all natural physical phenomena as well as physiological, technological and thermal processes. It is one of the most important parameters in any kind of research.

From the vast and ever growing number of possible methods of temperature measurement, that best suited for each application should be chosen in order to attain readings which are as precise as possible. As the errors of the method are more important in most cases than those of the instrumentation, this book concentrates on the analysis of the different temperature measurement methods and sources of errors.

The scope of the book covers all of the principal temperature measurement methods and instruments. Special stress is placed on such problems as temperature measurement of solids, liquids and gases as well as temperature measurement in industrial heating appliances.

Many new achievements, additions and developments, as well as literature references, are included to update a most of the material contained in the 1-st Edition of 1991. This updating has also lead to eliminating the descriptions of some of the obsolete and obsolescent, or less popular methods and techniques of temperature measurement.

Some chapters have been extended or reorganised in view of the developing perception of the grouping in temperature measurement. Fibre optic and noise thermometry are extensively described together with distributed parameter sensors. Major reorganisation of the presentation of the theory and applications of optical pyrometry has been undertaken. A new chapter, devoted to practical applications of pyrometers, has been introduced.

Other chapters are thoroughly revised versions of those from the 1st Edition or perhaps completely new. One completely new chapter considers the application of computer technique in temperature measurement. A second completely new chapter examines and describes all of the problems associated with signal conditioning, hardware components, hazardous area measurements and recording methods. Fuzzy logic together with software methods for temperature measurement and the influence of the techniques of Virtual Instrumentation are also described. Temperature measurement in medicine is an important addition to this 2nd Edition.

A large number of numerical examples, tables and diagrams are given to provide assistance in choosing and implementing the temperature measuring system best suited for a particular application. Many references enable the reader to find supplementary information regarding those aspects which could not be treated in detail in the book.

This book is intended for engineers, pure and applied scientists and student readerswho wish to master the beautiful art of temperature measurement.

The authors extend their thanks to Prof W. Nawrocki and gratefully acknowledge his contribution on noise thermometry.

Autumn 2001

The Authors

List of Principal Symbols

A	amplitude, area
a	thermal diffusivity
C	radiation constant, electrical capacitance
c	specific heat
D, d	diameter
E	thermal emf
e	thermal emf in a junction
f	frequency, function
$G(s), F(s)$	transfer function
$G(j\omega), F(j\omega)$	frequency response
I	electric current
K	gain
k	general coefficient
L	time lag also called dead time
l	length
N	time constant
P	power
Q	energy
q	heat flux density
R	resistance
r	radius
s	Laplace operator
T	temperature in K
t	time, temperature in °C
V	voltage, volume
v	velocity
W	thermal resistance, radiant intensity
α	heat transfer coefficient, coefficient of linear thermal expansion, temperature coefficient of resistance, absorptivity
β	coefficient of cubic thermal expansion
Δ	error, difference, amplitude, sampling time
δ	relative error, penetration depth
ε	emissivity
ϑ	temperature in °C or °F
Θ	excess temperature over a reference temperature such as ambient or original value
λ	wavelength, thermal conductivity
ρ	density, reflectivity, resistivity
Φ	heat flux or rate of heat flow
φ	phase angle

ω	angular frequency
τ	transmissivity

Subscripts

a	adjustable, ambient, average
C	correction, corrector
c	compensating, conduction
d	disturbance
e	effective, end-value, equivalent
gr	grey body
i	indicated, input value
k	convection
l	leads, limit value, loop
M	measuring instrument
n	nominal value
o	black body, output value
r	radiation, reference, reflection, relative
s	set-point value, shield, solid
T	temperature sensor
t	true value
w	wall
λ	spectral

Subject Index