

PD ISO/TR 21414:2016



BSI Standards Publication

Hydrometry — Groundwater — Surface geophysical surveys for hydrogeological purposes

bsi.

...making excellence a habit.™

National foreword

This Published Document is the UK implementation of ISO/TR 21414:2016.

The UK participation in its preparation was entrusted by Technical Committee CPI/113, Hydrometry, to Subcommittee CPI/113/1, Hydrometric methods and instrumentation.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2016.

Published by BSI Standards Limited 2016

ISBN 978 0 580 79191 8

ICS 07.060

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 April 2016.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

TECHNICAL
REPORT

ISO/TR
21414

First edition
2016-02-15

**Hydrometry — Groundwater —
Surface geophysical surveys for
hydrogeological purposes**

*Hydrométrie — Eaux souterraines — Relevés géophysiques de surface
pour des besoins hydrogéologiques*



Reference number
ISO/TR 21414:2016(E)

© ISO 2016



COPYRIGHT PROTECTED DOCUMENT

© ISO 2016. Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

	Page
Foreword	vi
Introduction	vii
1 Scope	1
2 Terms and definitions	1
3 Units of measurement	2
4 Purpose of geophysical survey	5
5 Planning	6
5.1 General considerations.....	6
5.2 Access to the area.....	6
5.3 Equipment.....	6
5.4 Safety and precautions in operation.....	6
5.5 Planning of survey.....	7
5.6 Quality control in field data collection.....	7
5.7 Site/area details.....	7
6 Electrical resistivity	7
6.1 Purpose.....	7
6.2 Principles of measurement.....	8
6.3 Instruments.....	13
6.4 Field procedures.....	13
6.5 Processing of data.....	15
6.6 Interpretation.....	15
6.7 Advantages.....	17
6.8 Disadvantages.....	17
6.9 Limitations.....	17
7 Self-potential	18
7.1 Purpose.....	18
7.2 Principles of measurement.....	18
7.3 Instrument.....	18
7.4 Field procedures.....	18
7.5 Processing of data.....	19
7.6 Interpretation.....	19
7.7 Advantages.....	19
7.8 Disadvantages.....	19
7.9 Limitations.....	19
8 Frequency domain electromagnetic (horizontal loop)	20
8.1 Purpose.....	20
8.2 Principles of measurement.....	20
8.3 Instrument.....	21
8.4 Field procedures.....	21
8.5 Processing of data.....	22
8.6 Interpretations.....	22
8.7 Advantages.....	22
8.8 Disadvantages.....	23
8.9 Limitations.....	23
9 Transient (time domain) electromagnetic	23
9.1 Purpose.....	23
9.2 Principles of measurement.....	23
9.3 Instrument.....	23
9.4 Field procedures.....	24
9.5 Processing of data.....	24
9.6 Interpretation.....	24

9.7	Advantages	24
9.8	Disadvantages	24
9.9	Limitations	25
10	Very low frequency (VLF) electromagnetic	25
10.1	Purpose	25
10.2	Principles of measurement	25
10.3	Instrument	25
10.4	Field procedures	26
10.5	Processing of data	26
10.6	Interpretation	26
10.7	Advantages	27
10.8	Disadvantages	27
10.9	Limitations	27
11	Seismic refraction	27
11.1	Purpose	27
11.2	Principles of measurement	27
11.3	Instruments	31
11.4	Field procedure	31
11.5	Processing of data	32
11.6	Interpretation	32
11.7	Advantages	32
11.8	Disadvantages	32
11.9	Limitations	32
12	Seismic reflection	32
12.1	Purpose	32
12.2	Principles of measurement	33
12.3	Instrument	33
12.4	Field procedures	33
12.5	Acquisition and processing of data	34
12.6	Interpretation	34
12.7	Advantages	34
12.8	Disadvantages	34
12.9	Limitations	35
12.10	Comparison of seismic refraction and reflection methods	35
13	Magnetic	35
13.1	Purpose	35
13.2	Principles of measurement	35
13.3	Instrument	36
13.4	Field procedures	36
13.5	Processing of data	37
13.6	Interpretation	38
13.7	Advantages	38
13.8	Disadvantages	38
13.9	Limitations	38
14	Gravity	38
14.1	Purpose	38
14.2	Principles of measurement	38
14.3	Instrument	39
14.4	Field procedure	39
14.5	Processing of data	39
14.6	Micro-gravity measurements	39
14.7	Interpretation	40
14.8	Advantages	40
14.9	Disadvantages	40
14.10	Limitations	40

15	Other techniques	40
15.1	Induced polarization	40
15.1.1	Purpose	40
15.1.2	Principles of measurement	41
15.1.3	Instrument	41
15.1.4	Field procedures	41
15.1.5	Processing of data	42
15.1.6	Interpretation	42
15.1.7	Advantages	42
15.1.8	Disadvantages	42
15.1.9	Limitations	42
15.2	Mise-a-la-masse	42
15.2.1	Purpose	42
15.2.2	Principles of measurement	42
15.2.3	Instrument	43
15.2.4	Field procedures	43
15.2.5	Processing of data	43
15.2.6	Interpretation	43
15.2.7	Advantages	44
15.2.8	Disadvantages	44
15.2.9	Limitations	44
15.3	Ground-Penetrating Radar (GPR)	44
15.3.1	Purpose	44
15.3.2	Principles of measurements	44
15.3.3	Field procedures and data acquisition	45
15.3.4	Interpretation	47
15.3.5	Advantages	49
15.3.6	Disadvantages	49
16	Report writing and presentation of results	50
	Bibliography	52

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#).

The committee responsible for this document is ISO/TC 115, *Hydrometry*, Subcommittee SC 8, *Ground water*.

Introduction

Groundwater is available almost everywhere. Access to clean water is a human right and a basic requirement for economic development. The safest kind of water supply is the use of groundwater. However, its distribution is not uniform due to varying hydrogeological, topographical and climatic conditions. As a result, groundwater is not always available in the required quantity and/or quality, particularly in hard rock terrains where fractures and weathered zones are the primary conduits for groundwater storage and flow. Detailed knowledge on the extent, hydraulic properties, and vulnerability of groundwater reservoirs is necessary to enable a sustainable use of the resource. Therefore, collection of information on prospective groundwater zones, although costly, is essential. Geophysical methods are currently recognized as cost-effective techniques useful for collecting groundwater information. Measuring physical properties of the earth and their variation and then associating these properties with hydrogeological characteristics is the objective of groundwater geophysics.

Of the various geophysical techniques available today, the electrical resistivity method is probably most commonly used due to its relatively simple and economical field operation, its effective response to groundwater conditions and the relative ease with which interpretations can be made. This type of survey is occasionally supplemented by other techniques such as induced polarization, spontaneous potential, and Mise-a-la-Masse galvanic electrical techniques. Other geophysical methods in order of preference used for hydrogeological purpose are electromagnetic, seismic refraction, magnetic, gravity and seismic reflection surveys. More recently developed geophysical techniques include ground probing radar and nuclear magnetic resonance. Because surface geophysical surveys are carried out at the surface of the earth, the responses received from different geological demarcations. Ambiguity exists in interpreted results and the effective application of these methods often depends on the skill and experience of the investigator, knowledge of local hydrogeological conditions, and the utility (and limitations) of the technique(s) themselves. The application of two or more geophysical techniques is a useful approach to reduce ambiguity. Integration of information from other disciplines, such as remote sensing, geologic mapping, hydrogeological characterization, chemical analysis of well water samples, etc., is also useful for interpreting geophysical field data.

Modern geophysical techniques are highly advanced in terms of instrumentation, field data acquisition, and interpretation. Field data are digitized to enhance the signal-to-noise ratio and computers are used to more accurately analyse and interpret the data. However, the present-day potential of geophysical techniques has probably not been fully realized, not only because such surveys can be expensive, but also because of the inadequate understanding of the application of relevant techniques in diverse hydrogeological conditions.

Hydrometry — Groundwater — Surface geophysical surveys for hydrogeological purposes

1 Scope

The application of geophysical methods is an evolving science that can address a variety of objectives in groundwater investigations. However, because the successful application of geophysical methods depends on the available technology, logistics, and expertise of the investigator, there can be no single set of field procedures or approaches prescribed for all cases. This Technical Report provides guidelines that are useful for conducting geophysical surveys for a variety of objectives (including environmental aspects), within the limits of modern-day instrumentation and interpretative techniques, are provided. The more commonly used field techniques and practices are described, with an emphasis on electrical resistivity, electromagnetic, and seismic refraction techniques as these are widely used in groundwater exploration. Theoretical aspects and details of interpretational procedures are referred to only in a general way. For full details, reference is intended to be made to specialized texts listed in the Bibliography.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1

acoustic impedance

product of seismic velocity and density of a layer

2.2

anisotropy

variation in physical property with direction of measurement

2.3

apparent resistivity

ratio of measured voltage to input current multiplied by the *geometric factor* (2.16) for the electrode configuration

2.4

blind zone

layer having seismic velocity less than that in the layer overlying it

2.5

Bouguer correction

correction made in observed gravity data to account for the attraction (gravitational) of the rock between the datum and the plane of measurement

2.6

Bouguer anomaly

anomaly obtained after applying latitude, terrain, and elevation (free air and Bouguer) corrections to the observed gravity value and finally subtracting it from measured value at some particular station in the survey area

2.7

contact resistance

electrical resistance developed between an electrode planted in the ground and the ground material immediately surrounding it