



International
Standard

ISO 10426-5

**Oil and gas industries including
lower carbon energy — Cements
and materials for well cementing —**

**Part 5:
Determination of shrinkage
and expansion of well cement
formulations**

*Industries du pétrole et du gaz, y compris les énergies à faible
teneur en carbone — Ciments et matériaux pour la cimentation
des puits —*

*Partie 5: Détermination du retrait et de l'expansion des
formulations de ciments pour puits*

**Second edition
2024-09**

Reference number
ISO 10426-5:2024(en)

Full document details: [ISO 10426-5-2024](#)

© ISO 2024  **Documents**
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, 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
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Determination of shrinkage or expansion under conditions of free access to water at atmospheric pressure — Annular ring test	2
4.1 General	2
4.2 Apparatus	2
4.2.1 Mould	2
4.2.2 Water curing bath	4
4.2.3 Temperature-measuring system	4
4.2.4 Atmospheric-pressure consistometer	5
4.2.5 Micrometer	5
4.3 Procedure	5
4.3.1 Preparation of the mould	5
4.3.2 Preparation of slurry	6
4.3.3 Filling of the mould	6
4.3.4 Test period	6
4.4 Measurement and calculations	7
5 Determination of shrinkage or expansion under impermeable condition at atmospheric pressure — Annular ring test in a re-sealable bag	9
5.1 General	9
5.2 Apparatus	9
5.2.1 General	9
5.2.2 Re-sealable bag	10
5.3 Procedure	10
5.4 Measurement and calculations	10
6 Determination of bulk shrinkage or expansion under impermeable condition and atmospheric pressure — Membrane test	10
6.1 General	10
6.2 Apparatus	11
6.2.1 Membrane	11
6.2.2 Water curing bath	11
6.2.3 Temperature-measuring system	11
6.2.4 Electronic scales	11
6.3 Procedure	11
6.3.1 Preparation of the membrane	11
6.3.2 Preparation of slurry	11
6.3.3 Filling of the membrane	11
6.3.4 Curing	11
6.4 Measurement and calculations	12
Annex A (informative) Determination of stress generated by expansion at elevated pressure and temperature	14
Annex B (informative) Determination of shrinkage or expansion under conditions of free access to water at elevated pressure — Annular ring test	20
Bibliography	22

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 3, *Drilling and completion fluids, well cements and treatment fluids*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Oil and gas industries including lower carbon energy*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 10426-5:2004), which has been technically revised.

The main changes are as follows:

- addition of the Introduction, with background information on expansion and shrinkage;
- addition of annular ring test under impermeable conditions at atmospheric pressure;
- inclusion of an informative annex describing a method to determine the stress generated by expansion under confined conditions at elevated temperature and pressure;
- inclusion of an informative annex describing the annular ring test at elevated pressure.

A list of all parts in the ISO 10426 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

When Portland cement reacts with water, there is an overall reduction in the absolute volume of components:

$$V_c + V_w > V_{ch} \quad (1)$$

where

V_c is the volume of cement;

V_w is the volume of water;

V_{ch} is the volume of cement hydrates.

In this document the absolute volume decrease $[(V_c + V_w) - V_{ch}]$ is referred to as hydration shrinkage, although in other documents it can also be referred to as chemical shrinkage, total chemical contraction, or hydration volume reduction.

Depending on the exposure conditions, presence of external stresses during setting and, most importantly, access to external water, the hydration shrinkage may lead to bulk shrinkage of the set cement.

The change in the sample dimensions is referred to as bulk shrinkage or expansion. Bulk shrinkage and expansion of the cement refer to the result of the measurement of a linear dimensional change or volume change. The volume to which all volume changes are related is the volume of the slurry immediately after mixing and emplacement in the experimental equipment. For small values of shrinkage or expansion, typically the case in well cement systems, the fractional volume dimensional change can be approximated as 3 times the fractional linear dimensional change.

Bulk shrinkage may cause:

- formation of a micro-annulus, potentially affecting cement evaluation logs;
- loss of zonal isolation leading to crossflow or sustained casing pressure;
- lack of a hydraulic seal when using cement inflatable packers;
- poor sealing of abandonment plugs.

Additives are available that can overcome the effects of hydration shrinkage and generate bulk expansion of set cement. In plug applications, bulk expansion of cement generates stress at the cement-rock or cement-formation interface. A method of measuring the stress generated by expansion in a plug-type geometry is given in [Annex A](#).

In this document, SI units are used; and where practical, U.S. customary units are included in brackets for information.

This document is based on API Technical Report 10TR 2.

Oil and gas industries including lower carbon energy — Cements and materials for well cementing —

Part 5: Determination of shrinkage and expansion of well cement formulations

1 Scope

This document provides the methods for the testing of well cement formulations to determine the dimension changes during the curing process (cement hydration) at atmospheric and elevated pressure and the stress generated by expansion in a confined environment under elevated temperature and pressure.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 10A, *Cements and Materials for Well Cementing*

API Recommended Practice 10B-2, *Recommended Practice for Testing Well Cements*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

bulk expansion

increase in the external volume or dimensions of a cement sample

3.2

bulk shrinkage

decrease in the external volume or dimensions of a cement sample

3.3

CEA

cement expansion additive

additive used in a cement slurry formulation to provide *bulk expansion* (3.1), or reduce *bulk shrinkage* (3.2)

3.4

hydration shrinkage

difference in the volume between the hydration products and the volume of the dry cement, additives and water

3.5**radial interface stress**

stress generated at the interface between the set cement and casing or borehole wall due to *bulk shrinkage* (3.2) or *bulk expansion* (3.1) of the cement

3.6**UCA**

ultrasonic cement analyser

instrument used for the non-destructive sonic determination of compressive strength of cement

4 Determination of shrinkage or expansion under conditions of free access to water at atmospheric pressure — Annular ring test

4.1 General

The annular expansion mould is a device suitable for measuring only the linear bulk shrinkage or expansion properties of a cement formulation. The magnitude of expansion depends on the amount and type of expanding agent, cement powder, slurry design and curing condition (pressure, temperature, time, fluid access). It should be noted that expansion is strongly affected by boundary conditions. The chemical process of synthetic mineral growth is strongly controlled by the state of stress and growth tends to occur relatively more in low stress locations, for example, in pore spaces within the cement matrix. Therefore, the degree of cement shrinkage and expansion is dependent on several conditions, not all of which can be uniquely defined. The test does not fully represent the annulus of a well.

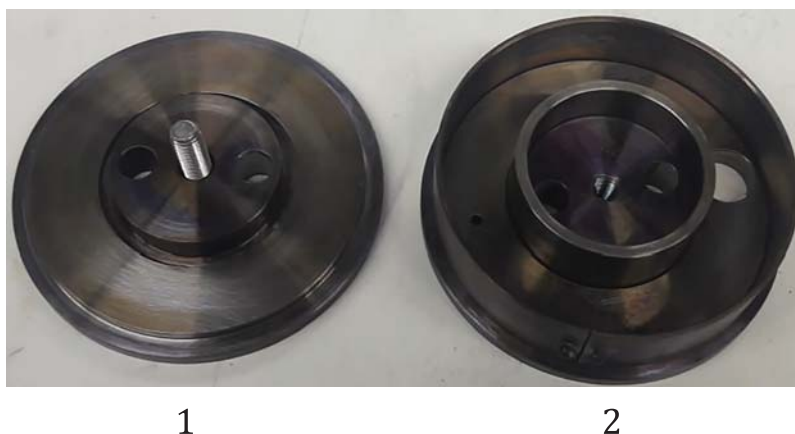
A method for determining the shrinkage or expansion at pressures above atmospheric pressure is given in [Annex B](#).

4.2 Apparatus

4.2.1 Mould

4.2.1.1 General

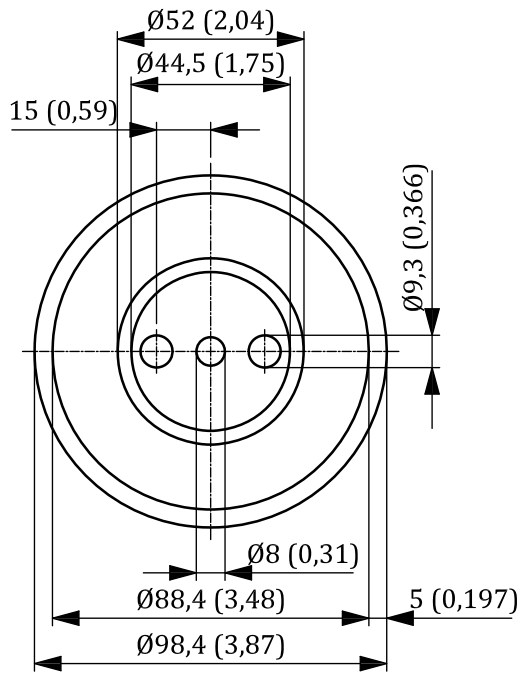
Use corrosion-resistant material (e.g. stainless steel). The outer diameter (OD) of the internal ring shall be $50,8 \text{ mm} \pm 0,3 \text{ mm}$ ($2,0 \text{ in} \pm 0,01 \text{ in}$) and the OD of the external ring shall be $88,9 \text{ mm} \pm 0,3 \text{ mm}$ ($3,5 \text{ in} \pm 0,01 \text{ in}$). See [Figures 1](#), and [2](#).



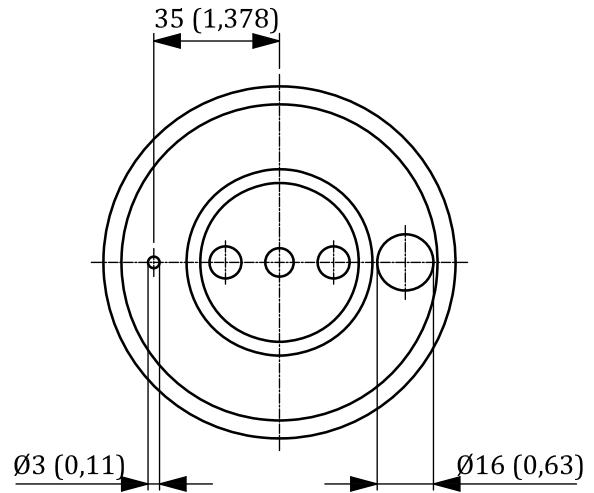
Key

- 1 bottom plate
- 2 inner and outer rings placed on the top plate (step d of [4.3.1](#))

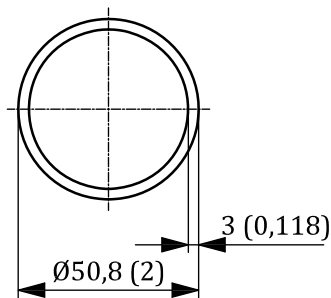
Figure 1 — Typical mould assembly



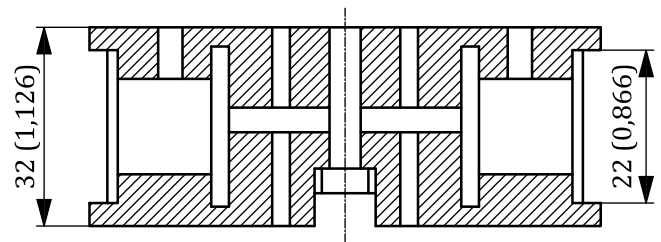
a) Base



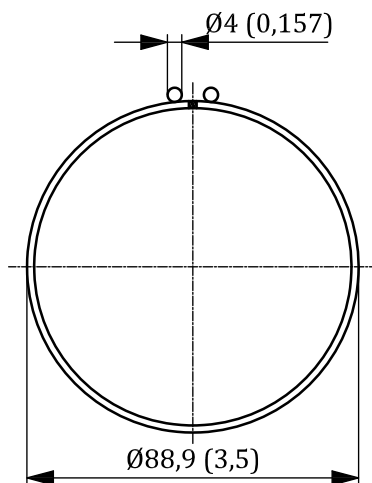
b) Lid



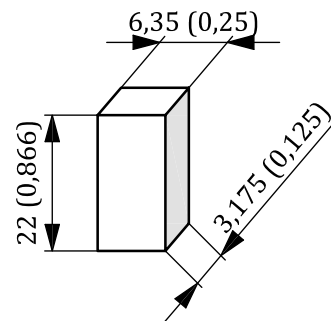
c) Internal ring



d) Annular ring mould



e) External ring



f) Spacer block

Figure 2 — Schema of typical mould assembly parts