# Preparation and Testing of Foamed Cement Formulations at Atmospheric Pressure

API RECOMMENDED PRACTICE 10B-4
SECOND EDITION, OCTOBER 2015

REAFFIRMED, OCTOBER 2026



## Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Users of this recommended practice should not rely exclusively on the information contained in this standard. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Washington, DC 20001.

*Copyright © 2015 American Petroleum Institute*

## Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

The verbal forms used to express the provisions in this recommended practice are as follows:

— the term “shall” denotes a minimum requirement in order to conform to the recommended practice;

— the term “should” denotes a recommendation or that which is advised but not required in order to conform to the recommended practice;

— the term “may” is used to express permission or a provision that is optional; and

— the term “can” is used to express possibility or capability.

Informative elements: As used in a standard, “informative” denotes elements that: identify the standard, introduce its content, and explain its background, development, and its relationship with other standards; or provide additional information intended to assist the understanding or use of the standard.

Normative elements: As used in a standard, “normative” denotes elements that describe the scope of the standard and that set out provisions that are required to implement the standard.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, NW, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, NW, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Washington, DC 20001, standards@api.org.

## Contents


Page

1 Scope . . . 1

2 Normative References . . . 1

3 Terms, Definitions, and Symbols . . . 1
3.1 Terms and Definitions . . . 1
3.2 Symbols . . . 3

4 Sampling . . . 4
4.1 General . . . 4
4.2 Method . . . 4

5 Slurry Calculations . . . 4
5.1 Introduction . . . 4
5.2 Calculation of Base Cement Slurry Composition With and Without Surfactant(s) . . . 4
5.3 Determination of Slurry Volume and Mass . . . 5

6 Base Cement Slurry Preparation and Testing . . . 9
6.1 General . . . 9
6.2 Conditioning Procedures . . . 9
6.3 Density Measurement . . . 9
6.4 Stability of Unfoamed Base Cement Slurry . . . 9
6.5 Determination of Rheological Properties . . . 9
6.6 Determination of Static Fluid Loss . . . 9
6.7 Determination of Thickening Time . . . 10
6.8 Determination of Compressive Strength . . . 10
6.9 Compatibility . . . 10

7 Preparation of Foamed Cement Slurry at Atmospheric Pressure . . . 10
7.1 Unfoamed Base Cement Slurry Preparation . . . 10
7.2 Blending Apparatus . . . 11
7.3 Generation of a Foamed Cement Slurry . . . 12

8 Atmospheric Testing of Foamed Cement Slurries . . . 14
8.1 General . . . 14
8.2 Determination of Foamed Cement Slurry Density . . . 14
8.3 Determination of Foamed Cement Slurry Stability . . . 14
8.4 Determination of Compressive Strength . . . 19

**Annex A** (informative) **Nitrogen Density, $\rho_{N2}$** . . . 21

**Annex B** (informative) **Nitrogen—A Real Gas** . . . 28

**Annex C** (informative) **Nitrogen Compressibility Factor, $Z$ (Dimensionless)** . . . 30

**Annex D** (informative) **Example Calculations for the Preparation of Foamed Cement Slurry at Atmospheric Pressure** . . . 37

**Bibliography** . . . 40

## Contents

Page

**Figures**

**1 Blending Container and Multi-blade Assembly . . . . . 11**
**2 Example of Curing Mold for Evaluation of Foamed Cement Slurry Stability . . . . . 18**
**3 Evaluation Report Form: Foamed Cement Slurry Stability at Temperature <90 °C (194 °F) . . . . . 20**

**Tables**

**A.1 Nitrogen Density (kg/m3) from Temperature and Absolute Pressure in SI Units . . . . . 22**
**A.2 Nitrogen Density (lbm/gal) from Temperature and Absolute Pressure in USC Units . . . . . 25**
**C.1 Nitrogen Compressibility Factor from Temperature and Absolute Pressure in SI Units . . . . . 31**
**C.2 Nitrogen Compressibility Factor from Temperature and Absolute Pressure in USC Units . . . . . 34**

# Preparation and Testing of Foamed Cement Formulations at Atmospheric Pressure

## 1 Scope

This standard defines the test methods including the generation of unfoamed base and their corresponding foamed cement slurries at atmospheric pressure. These procedures are developed for foaming cement slurries with air, at atmospheric conditions, which could mimic a foam quality experienced with nitrogen at downhole conditions; they may be modified to accommodate other gases such as nitrogen. Slurries that are foamed with nitrogen, and their properties, will also be discussed within this standard as they are relevant to the scope of the standard.

This standard does not address testing at pressures above atmospheric conditions, nor does this standard include or consider the effects of nitrogen solubility in the nitrogen fraction calculations.

## 2 Normative References

The following referenced documents are indispensable for the application 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. However, not all documents listed may apply to your specific needs. The body of the standard should be referred to for how these documents are specifically applied. For a list of other standards associated with this standard, see the Bibliography.

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

API Recommended Practice 10B-3, *Recommended Practice on Testing of Deepwater Well Cement Formulations*

## 3 Terms, Definitions, and Symbols

### 3.1 Terms and Definitions

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

**3.1.1**
**additive**
Material added to a cement slurry to modify or enhance some desired property.

**3.1.2**
**batch mixing**
Process of mixing and holding a volume of cement slurry prior to placement in the wellbore.

**3.1.3**
**cement**
**Portland cement**
Material formed by the grinding of clinker, generally consisting of hydraulic calcium silicates and aluminates and usually containing one or more of the forms of calcium sulfate added during grinding.

**3.1.4**
**compatibility**
Capacity to form a fluid mixture that does not undergo undesirable chemical and/or physical reactions.

**3.1.5**
**compressive strength**
Strength of a set cement sample measured by the force required to cause it to fail in compression, expressed as force per unit area.