

# **Manual of Petroleum Measurement Standards Chapter 11.3.3**

## **Miscellaneous Hydrocarbon Product Properties—Denatured Ethanol Density and Volume Correction Factors**

SECOND EDITION, NOVEMBER 2015



AMERICAN PETROLEUM INSTITUTE

## 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 Standard should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

The examples in this Standard are merely examples for illustration purposes only. [Each company should develop its own approach.] They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

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

Where applicable, authorities having jurisdiction should be consulted.

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, 1220 L Street, NW, Washington, DC 20005.

*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.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

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, 1220 L Street, NW, Washington, DC 20005. 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, 1220 L Street, NW, Washington, DC 20005.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, [standards@api.org](mailto:standards@api.org).



## Contents

	Page
<b>1 Scope</b> .....	<b>1</b>
<b>1.1 General</b> .....	<b>1</b>
<b>1.2 Limits of Application</b> .....	<b>1</b>
<b>2 Normative References</b> .....	<b>1</b>
<b>3 Terms and Definitions</b> .....	<b>1</b>
<b>4 Implementation Procedures</b> .....	<b>3</b>
<b>4.1 Denatured 99+ % Fuel Ethanol</b> .....	<b>3</b>
<b>4.2 Denatured 95 % to 99 % Fuel Ethanol</b> .....	<b>4</b>
<b>5 Rounding</b> .....	<b>6</b>
<b>5.1 Data Level</b> .....	<b>6</b>
<b>5.2 Rounding of Numbers</b> .....	<b>6</b>
<b>Annex A (informative) Ethanol VCF Table Historical Information</b> .....	<b>7</b>
<b>Annex B (informative) U.S. Regulation of Alcohol for Fuel Use</b> .....	<b>10</b>
<b>Annex C (Informative) Denatured Ethanol Density Study</b> .....	<b>11</b>
<b>Annex D (informative) Ethanol/Water Mixtures</b> .....	<b>15</b>
<b>Bibliography</b> .....	<b>16</b>
<b>Figures</b>	
<b>A.1 U.S. Customs and Border Protection Directive on 99+ % Ethanol VCF</b> .....	<b>8</b>
<b>A.2 Data and the Applet Output Results</b> .....	<b>9</b>
<b>C.1 Denatured Ethanol Feedstock Densities (0 psig)</b> .....	<b>12</b>
<b>C.2 FS4 Data and the Applet Output Results</b> .....	<b>13</b>
<b>Tables</b>	
<b>1 Significant Digits for Bulk Quantities</b> .....	<b>6</b>
<b>C.1 Denatured Ethanol Feedstock Densities</b> .....	<b>12</b>
<b>C.2 Table 6C VCF values</b> .....	<b>13</b>
<b>D.1 API Applet Regression of Portions of OIML Table II</b> .....	<b>15</b>

## Introduction

Volume Correction Factors (VCFs) are used to correct observed liquid volumes at specific operating conditions to equivalent volumes at a standard temperature condition. The American Petroleum Institute provides procedures for calculating VCFs for Generalized Crude oils, Refined Products, Lubricating Oils, and Special Applications. These procedures are presented in API *MPMS* Ch. 11.1–2004/Adjunct to ASTM D1250-08/IP 200/08. The API has not previously addressed ethanol, considered a Special Application, in *MPMS* Ch. 11.1, so industry has used a variety of privately developed tables for both denatured 99+ % and denatured 95 % to 99 % fuel ethanol VCFs. (Denaturant requirements vary by country and if this standard is being used outside the United States, refer to the local jurisdiction for denaturant requirements.) The most commonly used table has been that of a large ethanol supplier, and it appears that U.S. Customs and Border Protection (CBP) and the Environmental Protection Agency (EPA) have adopted a variant of this table. The API, through a consortium of its member companies and in cooperation with the Renewable Fuels Association (RFA), commissioned an independent laboratory to take density measurements at various temperatures of pure (99.038 % by volume) ethanol and representative denatured fuel ethanols. The density data were obtained utilizing the best available commercial instrumentation and was then used to develop the VCFs provided in this standard.

# Miscellaneous Hydrocarbon Product Properties—Denatured Ethanol Density and Volume Correction Factors

## 1 Scope

### 1.1 General

This standard covers density and volume correction factors for denatured fuel ethanol. The actual standard consists of the explicit implementation procedures set forth in this document. Sample tables and other examples created from a computerized version of this implementation procedure are presented as examples only and do not represent the standard.

### 1.2 Limits of Application

This standard is applicable at any operating temperature to bulk (e.g. tank trucks, tank cargos, barges) denatured 95 % to 99 % fuel ethanol containing D4806 allowed denaturants (natural gasoline, gasoline blend stocks, and unleaded gasoline) and denatured, 99+ % fuel ethanol containing less than 1 % denaturant. This standard does not apply to undenatured ethanol of any purity.

## 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.

API MPMS Ch. 11.1–2004, *Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils* (includes Addendum dated September 2007).

API MPMS Ch. 12.1.1–2012, *Calculation of Static Petroleum Quantities—Upright Cylindrical Tanks and Marine Vessels*.

## 3 Terms and Definitions

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

### 3.1

#### **absolute density**

#### **RHO**

The mass of a substance per unit of volume at a specified temperature and pressure.

### 3.2

#### **alpha $\alpha$**

A product-specific thermal coefficient of expansion used in the API MPMS Ch. 11.1 equations for VCFs (Annex A).

### 3.3

#### **denaturants**

Materials added to ethanol under a formula approved by a regulatory agency to make it unsuitable for beverage use.

### 3.4

#### **denatured 95 % to 99 % fuel ethanol**

Fuel ethanol denatured with natural gasoline, gasoline blendstocks, or regular gasoline in accordance with US federal regulations.