

Volumetric Shrinkage Resulting From Blending Volatile Hydrocarbons with Crude Oils

API PUBLICATION 2509C
SECOND EDITION, DECEMBER 1967
REAFFIRMED, AUGUST 1987

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005



662.69
AME

MMCE LIBRARY

Volumetric Shrinkage Resulting From Blending Volatile Hydrocarbons with Crude Oils

Measurement Coordination

API PUBLICATION 2509C
SECOND EDITION, DECEMBER 1967

OFFICIAL PUBLICATION



REG. U.S. PATENT OFFICE

SPECIAL NOTES

1. API PUBLICATIONS NECESSARILY ADDRESS PROBLEMS OF A GENERAL NATURE. WITH RESPECT TO PARTICULAR CIRCUMSTANCES, LOCAL, STATE, AND FEDERAL LAWS AND REGULATIONS SHOULD BE REVIEWED.
2. API IS NOT UNDERTAKING TO MEET THE DUTIES OF EMPLOYERS, MANUFACTURERS, OR SUPPLIERS TO WARN AND PROPERLY TRAIN AND EQUIP THEIR EMPLOYEES, AND OTHERS EXPOSED, CONCERNING HEALTH AND SAFETY RISKS AND PRECAUTIONS, NOR UNDERTAKING THEIR OBLIGATIONS UNDER LOCAL, STATE, OR FEDERAL LAWS.
3. INFORMATION CONCERNING SAFETY AND HEALTH RISKS AND PROPER PRECAUTIONS WITH RESPECT TO PARTICULAR MATERIALS AND CONDITIONS SHOULD BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER OR SUPPLIER OF THAT MATERIAL, OR THE MATERIAL SAFETY DATA SHEET.
4. GENERALLY, API STANDARDS ARE REVIEWED AND REVISED, RE-AFFIRMED, OR WITHDRAWN AT LEAST EVERY FIVE YEARS. SOMETIMES A ONE-TIME EXTENSION OF UP TO TWO YEARS WILL BE ADDED TO THIS REVIEW CYCLE. THIS PUBLICATION WILL NO LONGER BE IN EFFECT AS AN OPERATIVE API STANDARD FIVE YEARS AFTER ITS PUBLICATION DATE OR, WHERE AN EXTENSION HAS BEEN GRANTED, UPON REPUBLICATION. THE STATUS OF THE PUBLICATION CAN BE ASCERTAINED FROM THE API AUTHORIZING DEPARTMENT (TELEPHONE 202 682-8000). A CATALOG OF API PUBLICATIONS AND MATERIALS IS PUBLISHED ANNUALLY AND UPDATED QUARTERLY BY API, 1220 L STREET, N.W., WASHINGTON, D.C. 20005.
5. 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.
6. 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 FEDERAL, STATE, OR MUNICIPAL REGULATION WITH WHICH THIS PUBLICATION MAY CONFLICT.

FOREWORD

The purpose of this bulletin is to present the best data currently available on the subject of volumetric changes resulting from blending volatile hydrocarbons (propane, butane, produced distillates, and natural gasolines) with crude oils.

Data contained herein correlate information made available to the Admixture Measurement Functional Group of the American Petroleum Institute's Committee on Crude Oil Measurements. (The functions of this group are now under the auspices of the Institute's Central Committee on Petroleum Measurement.) None of the experimental work was sponsored by the Admixture Measurement Functional Group. Although data were available to construct the included curves, the information is meager when considered in relation to the overall problem. The bulk of the data was obtained at concentrations at 20 percent or below. Therefore, users of the curves described herein should understand that they represent an average of data obtained with different materials at various conditions of temperature and pressure and by three basically different test methods.

Part I presents curves constructed from data made available by the following companies:

Atlantic Richfield Co.
Cities Service Pipe Line Co.
Humble Pipe Line Co.
Mobil Pipe Line Co.
Service Pipe Line Co.
Shell Pipe Line Corp.
Sun Oil Co.
Getty Oil Co.

Particular recognition is given to Service Pipe Line Company for authorizing Mr. W. E. Roads to devote time to the correlation of the data with the aid of the company's electronic computer.

Part II presents a generalized description of the three basic test methods and equipment used in obtaining the data from which the curves were calculated. Any of these three test methods is suitable for determining shrinkage when proper allowance is made for the test measurement accuracy of each method in relation to the mixture concentration desired.

The Appendix, "Tables for Predicting Volumetric Shrinkage," has been added to this edition. The first edition of this bulletin was published in 1962.

Further information is needed concerning volumetric changes resulting from petroleum admixtures. Companies which sponsor experimental work on this subject are urged to supply the data obtained to the director of the Division of Science and Technology, American Petroleum Institute.

CONTENTS

PART I—AVERAGE VOLUME CONTRACTION (SHRINKAGE) RESULTING FROM BLENDING OF PETROLEUM HYDROCARBONS

	PAGE
Introduction and Theory	5
Curves for Predicting Average Volume Shrinkage	5
Example of Use of Curves for Predicting Shrinkage	7
Effect of Temperature and Pressure on Volumetric Shrinkage	7
Calculation of Tables and Curves for Predicting Shrinkage	7

PART II—TEST METHODS FOR DETERMINING SHRINKAGE

Shrinkage Measurement Utilizing Modified P-V-T Apparatus	7
Description of Equipment	7
Procedure During Preparation and Filling of Equipment for Shrinkage Test	8
Procedure During Shrinkage Test	9
Accuracy	9
Shrinkage Measurement Utilizing Visual Volumetric Apparatus	10
Procedure	10
Calculation	12
Shrinkage Measurement Utilizing Specific Gravity Method	12
REFERENCES	13
APPENDIX—Tables for Predicting Volumetric Shrinkage	14

VOLUMETRIC SHRINKAGE RESULTING FROM BLENDING VOLATILE HYDROCARBONS WITH CRUDE OILS

PART I—AVERAGE VOLUME CONTRACTION (SHRINKAGE) RESULTING FROM BLENDING OF PETROLEUM HYDROCARBONS

Introduction and Theory

In recent years, crude oil pipelines have been used for transporting an increasing amount of light products such as butane, natural gasoline, and high-gravity produced distillates. Because of the physical nature of the crude oil system and the widely dispersed receipt points of the light components, such products usually are blended into the crude oil stream. Such blending actually is encouraged to reduce losses by evaporation of the lighter components and to minimize pump suction difficulties.

As a part of the conservation effort of the pipeline industry, the causes of oil losses in transit are being investigated continuously. Such an investigation of the volume loss experienced in systems handling the light components blended into a common crude oil stream indicated that the losses did not result entirely from increased evaporation but were caused partly by a phenomenon associated with the blending of the lighter components and the heavier crude oil. That is, when a lighter product such as butane or natural gasoline is mixed with crude oil, the resulting volume is less than the sum of the individual component volumes. This loss or shrinkage is only an "apparent loss" on a volume basis for there is, of course, no loss of weight as a result of the mixing operation.

In the blending of petroleum components having different physical properties, volumetric shrinkage occurs because the components do not form ideal solutions. In an ideal solution, the total solution volume is equal to the sum of the volumes of the components. In order for a solution to approach ideality, the molecules of the materials blended together must be similar in size, shape, and properties. If the nature of the molecules of the components differs appreciably, then deviation from ideal behavior may be expected. This deviation may be either positive or negative; that is, the total volume may increase or decrease when the components are blended.

Glasstone^{1a} states that if a solution of two or more components exhibits positive deviation from

Raoult's law, the observed vapor pressure and volume would be greater than if the components had formed an ideal solution. This he attributes to the mean attractive forces between the molecules in the mixture being smaller than for the constituents separately.

Conversely, if a solution should exhibit negative deviation from Raoult's law, usually there is a decrease in vapor pressure and volume on mixing. This is attributed to the mean attractive forces between the molecules in the mixture being greater than for the constituents separately.

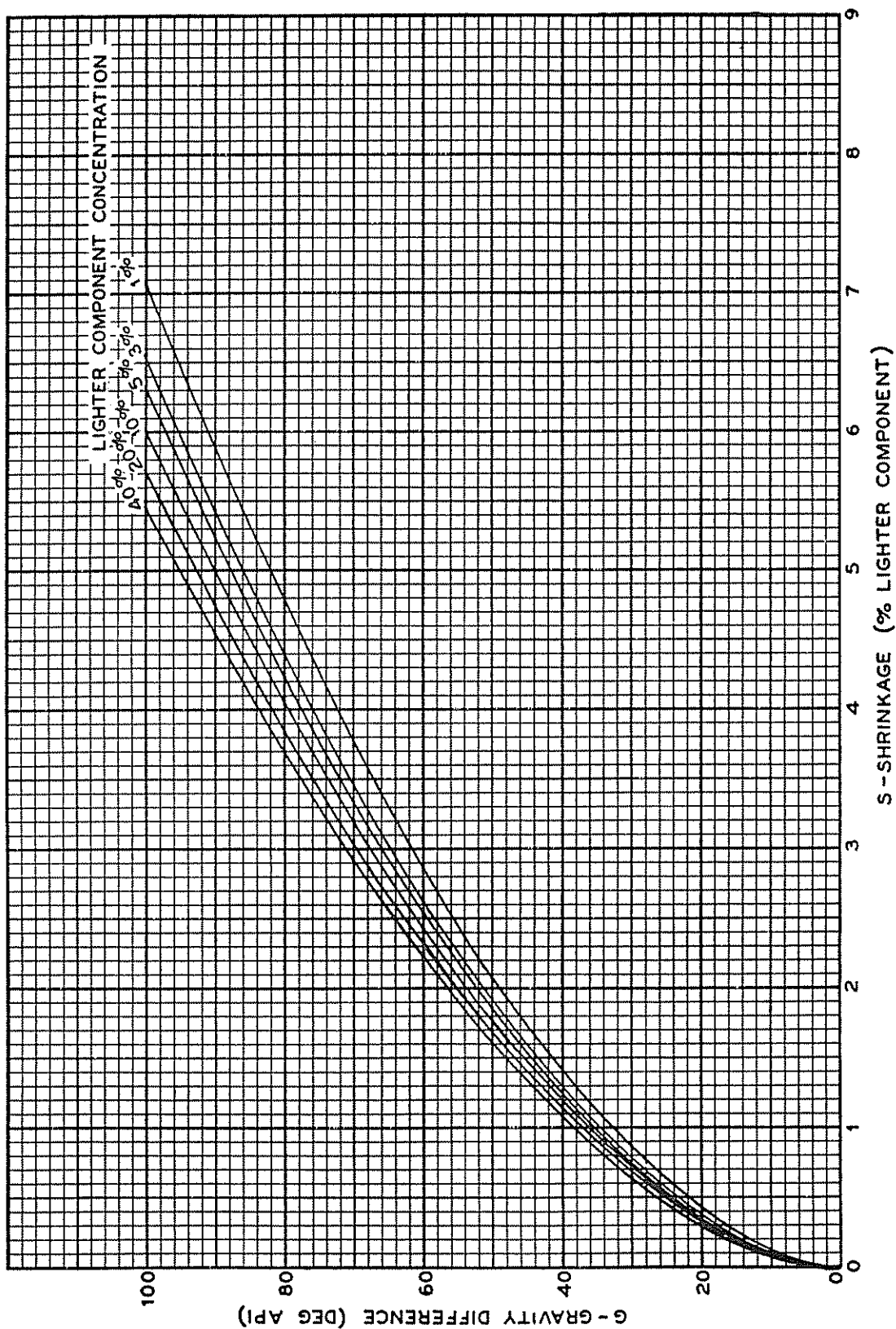
Inasmuch as petroleum components contain molecules of various sizes and weights, solutions of two separate components are seldom ideal. Consequently, it is to be expected there may be a change in volume associated with the mixing or blending of petroleum components of varying gravities and molecular structure.

All available test data covering blends of lighter and heavier petroleum components (e.g., butane with crude oil) indicate that the change in volume is negative in direction resulting in a shrinkage of the total volume.

Curves for Predicting Average Volume Shrinkage

The curves shown in Fig. 1 were constructed from data furnished by companies named in the Foreword in accordance with a correlation suggested to Interstate Oil Pipe Line Company² (presently Humble Pipe Line Company) by Dr. F. D. Rossini, of Carnegie Institute of Technology. Test data were obtained through methods described in Part II. All of the experimental work was not performed at the same pressures and temperatures. However, in view of the limited test results available, it was necessary to assume that the deviations in the test conditions and methods would not be great enough to prevent fitting of curves by statistical methods. Generally accepted methods of testing for correlation have shown that this assumption was justified for the average curves desired. Complete description of the correlation methods used and the computer program may be

^a Refers to REFERENCES on p. 13.



NOTE: Factors equivalent to the percentage shrinkage are given in the Appendix tabulation.

FIG. 1—Curves for Estimating Volume Change When Blending Volatile Hydrocarbons with Crude Oil.