SIXTH EDITION

PIPELINE RULES of THUMB HANDBOOK

Quick and accurate solutions to your everyday pipeline problems

E.W. McAllister, Editor

ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON • NEW YORK • OXFORD
PARIS • SAN DIEGO • SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO
Gulf Professional Publishing is an imprint of Elsevier

GPP

Gulf Professional Publishing is an imprint of Elsevier.
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
Linacre House, Jordan Hill, Oxford OX2 8DP, UK

♾ Recognizing the importance of preserving what has been written, Elsevier prints its books on acid-free paper whenever possible.

Library of Congress Cataloging-in-Publication Data
Pipeline rules of thumb handbook: quick and accurate solutions to your everyday
pipeline problems / E.W. McAllister—6th ed.
p. cm.
Includes index.
ISBN 0-7506-7852-6
1. Pipelines—Handbooks, manuals, etc. I. McAllister, E. W.

TJ930.P535 2005
665.5′44—dc22 2004059768

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

ISBN: 0-7506-7852-6

For information on all Gulf Professional Publishing publications
Visit our Web site at www.books.elsevier.com

05 06 07 08 09 10 9 8 7 6

Printed in the United States of America

Contents

1: General Information

Basic Formulas

1. Rate of Return Formulas:

$S = P(1 + i)^n$

a. Single payment compound amount, SPCA. The $(1+i)^n$ factor is referred to as the compound amount of $1.00.

b. Single payment present worth, SPPW:

$$P = S\left[\frac{1}{(1+i)^n}\right]$$

The factor $[1/(1+i)^n]$ is referred to as the present worth of $1.00.

c. Uniform series compound amount, USCA:

$$S = R\left[\frac{(1+i)^n - 1}{i}\right]$$

$$\text{The factor} = \left[\frac{(1+i)^n - 1}{i}\right]$$

is referred to as the compound amount of $1.00 per period.

d. Sinking fund deposit, SFD:

$$R = S\left[\frac{i}{(1+i)^n - 1}\right]$$

$$\text{The factor} = \left[\frac{i}{(1+i)^n - 1}\right]$$

is referred to as the uniform series, which amounts to $1.00.

e. Capital recovery, CR:

$$R = S\left[\frac{i}{(1+i)^n - 1}\right] = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

$$\text{The factor} = \left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

is referred to as the uniform series that $1.00 will purchase.

f. Uniform series present worth, USPW:

$$P = R\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

The factor $[((1+i)^n - 1)/i(1+i)^n]$ is referred to as the present worth of $1.00 per period.

where:

P = a present sum of money
S = a sum of money at a specified future date
R = a uniform series of equal end-of-period payments
n = designates the number of interest periods
i = the interest rate earned at the end of each period

strata. Longer crossings (especially large-diameter pipelines) that indicate gravel, cobble, boulders, or rock should have samples taken about 600–800 ft apart unless significant anomalies are identified that might necessitate more borings. All borings should be located on the crossing profile along with their surface elevations being properly identified. If possible, the borings should be conducted at least 25 ft off of the proposed centerline. The bore holes should be grouted upon completion. This will help prevent the loss of drilling slurry during the crossing installation.

Depth of Borings—All borings should be made to a minimum depth of 40 ft below the lowest point in the crossing or 20 ft below the proposed depth of the crossing, whichever is greater. In some instances, it may be beneficial to the owner and the contractor to install the crossing at a greater depth than the owner requires for his permit. It is suggested that all borings be through the same elevation to better determine the consistency of the underlying material and note any patterns that may be present.

Standard Classification of Soils—A qualified technician or geologist should classify the material in accordance with the Unified Soil Classification System and ASTM Designations D-2487 and D-2488. It is beneficial to have a copy of the field-drilling log completed by the field technician or driller. These logs include visual classifications of materials, as well as the driller's interpretation of the subsurface conditions between samples.

Standard Penetration Test (SPT)—In order to better define the density of granular materials, the geotechnical engineer generally uses the Standard Penetration Test (SPT) in general accordance with ASTM Specifications D-1586. This is a field test that involves driving a 2-in. split spoon sampler into the soil by dropping a hammer of a specific weight (usually 140-lb.) a specified distance (usually 30 in.) to determine the number of blows necessary to drive the sampler 12 in. In very dense soils, the field technician may note the number of blows required to drive the sampler less than the required 12 in. (i.e., 50 blows for 3 in.). The number obtained is the standard penetration resistance value (N) and is used to estimate the in situ relative density of cohesionless soils. Some geotechnical firms will conduct these penetration tests in cohesive materials and rock, and to a lesser extent, the consistency of cohesive soils and the hardness of rock can be determined.

Thinwalled "Shelby" Tube Sampling—Most geotechnical firms prefer to use a Thinwalled Tube Sampling method for obtaining samples of cohesive materials. These tests are conducted in general accordance with ASTM Specification D-1587. This test is similar to the Standard Penetration test except the sample is collected by hydraulically pushing a thinwalled seamless steel tube with a sharp cutting edge into the ground. The hydraulic pressure required to collect the sample is noted on the field log. This produces a relatively undisturbed sample that can be further analyzed in the laboratory. These samples can be field tested with handheld penetrometers, but more accurate readings of density and consistency can be obtained by performing unconfined compressive strength tests where the results are noted in tons per square foot. Generally, for directional drilling contractors a standard penetration test using the split spoon sampler described earlier will suffice in both materials.

Sieve Analysis of Granular Materials—A sieve analysis is a mechanical test of granular materials performed on samples collected in the field during the standard penetration test with the split spoon sampler. The split spoon samples are taken to the laboratory and processed through a series of screens. The sample provides a percentage analysis of the granular material by size and weight. It is one of the most important tests undertaken.

Rock Information—If rock is encountered during the soil investigation borings, it is important to determine the type, the relative hardness, and the unconfined compressive strength. This information is typically collected by the geotechnical drilling firm by core drilling with a diamond bit core barrel. The typical core sample recovered with this process has a 2-in. diameter. The type of rock is classified by a geologist. The geologist should provide the Rock Quality Designation (RQD), which rates the quality of the rock based on the length of core retrieved in relation to the total length of the core. The hardness of the rock (Mohs' Scale of Hardness) is determined by comparing the rock to ten materials of known hardness. The compressive strength is determined by accurately measuring the core and then compressing the core to failure. This information pertaining to the underlying rock formation is imperative to determine the type of downhole equipment required and the penetration rates that can be expected.

Pipe material selection

Wall Thickness—D/t "Rule of Thumb"—The following table provides generalized recommendations for the selection of steel pipe wall thicknesses relative to pipe diameter. These recommendations are meant to be used only as a starting point in the design. It is recommended that in the final design, specific stresses be calculated and compared with allowable limits.

(For high-density polyethylene (HDPE) pipe, a standard dimension ratio of D/t, SDR, of 11 or less is recommended and the pipe manufacturer should be consulted.)

C_V vs. K or Valve Flow Coefficient vs. Resistance Coefficient

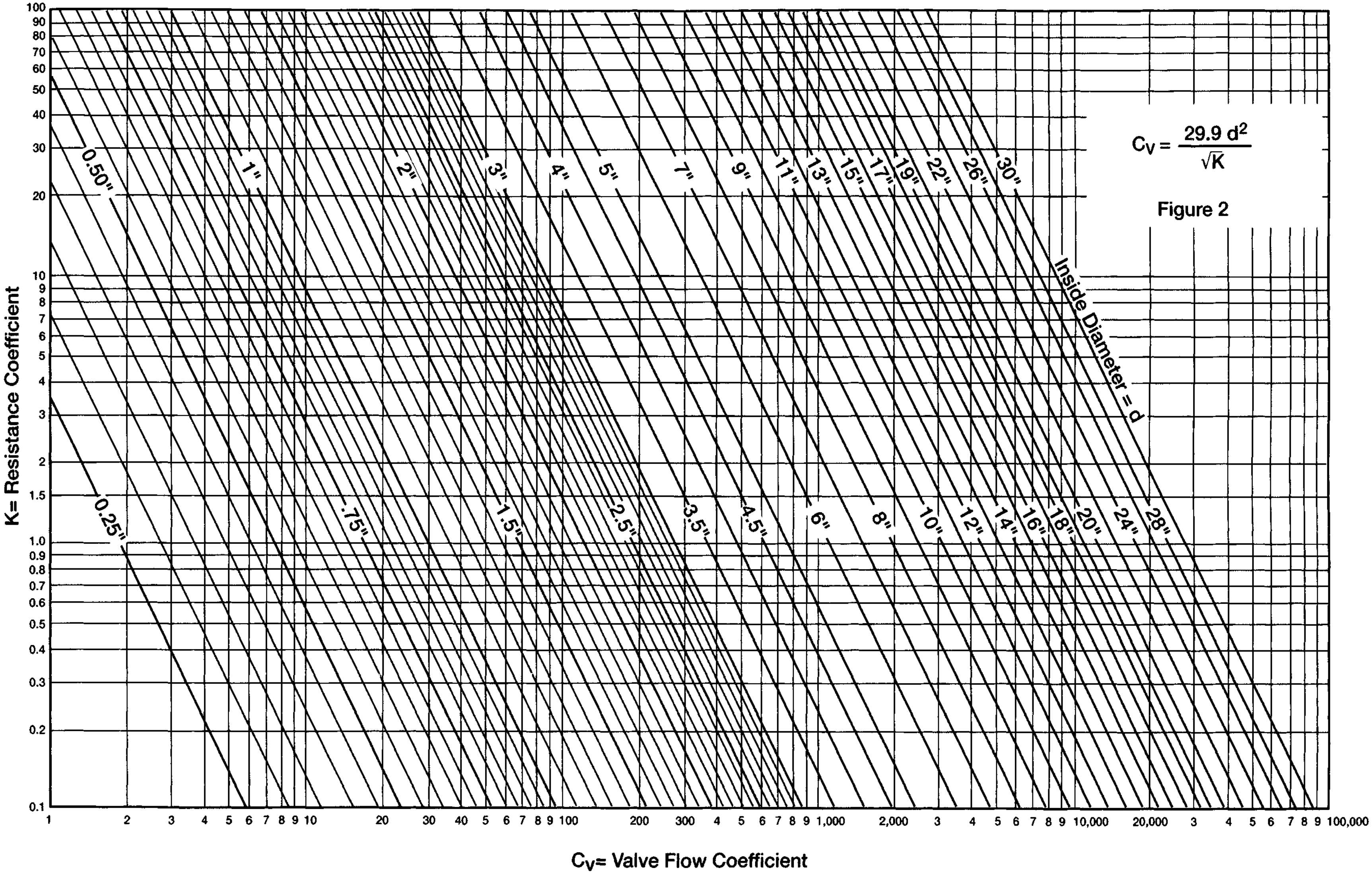

Figure 2. C_v versus K values for valves.

Q = Volumetric flow rate, gal/min
ρ = Fluid density, lb/cubic ft
μ = Fluid viscosity, centipoise
μa = Fluid viscosity, lb/(ft)(sec)
v = Average fluid velocity, ft/sec
w = Mass rate of flow, lb/hr

Example.

Given:
water at 200°F
d = 4-in. schedule 40 steel pipe
Q = 415 gal/min
ρ = 60.13 lb/cubic ft
μ = 0.3 centipoises

Obtain the Reynolds number and the friction factor.

Connect	With	Mark or Read
Q = 415	ρ = 60.13	W = 200,000
W = 200,000	d = 4-in. schedule 40	Index
Index mark	μ = 0.3	Re = 1,000,000

At Re = 1,000,000 read f = 0.017 from the graph on the center of the nomograph.

Figure 2 is an enlarged version of the friction factor chart, based on Moody's data[1] for commercial steel and wrought iron. This chart can be used instead of the smaller version shown in Figure 1.

Reference

1. Moody, L. F., *Transactions, American Society of Mechanical Engineers*, 66, 671 (1944).

Nomograph for calculating pressure drop of liquids in lines for turbulent flow

The nomograph (Figure 1) is based on a modified version of the Fanning equation. It gives the pressure drop per 100 ft of pipe for liquids flowing through a circular pipe. The basic equation is:

$$P_{100} = \frac{0.0216\, f\rho Q^2}{d^2} = 4{,}350\frac{f\rho q^2}{d^2} = 0.000336\frac{fW^2}{d^5\rho}$$
$$= 0.1294\frac{fv^2\rho}{d}$$

where:

P_{100} = Pressure loss per 100 ft of pipe, psi
f = Friction factor ($4 \times f'$ in Fanning equation)
ρ = Fluid density, lb/cu. ft
d = Tube internal diameter, in.
W = Flow rate, lb/hr
Q = Flow rate, gal/min
q = Flow rate, cu. ft/sec

The Moody[1] friction factor and relative roughness generalized charts (Figures 2 and 3) are also included for use with the nomogram.

Example. The estimated Reynolds number is 100,000 when water is flowing at a rate of 100 gal/min and a temperature of 70°F. Find the pressure drop per 100 ft of 2-in. diameter pipe, the relative roughness from Figure 3 is 0.0009.

At e/d = 0.0009 and Re = 100,000, the friction factor, f, is 0.022 from Figure 2.

Using Figure 1:

Connect	With	Mark or Read
f = 0.022	ρ = 62.3 lb/cu. ft	Intersection at Index 1
Index 1	Q = 100 gal/min	Intersection at Index 2
Index 2	d = 2-in.	P = 8 psi per 100 ft of pipe

Source

Flow of Fluids Through Valves, Fittings and Pipe, Technical Paper No. 410, 3-11, Crane Company, Chicago (1957).
Anon., *British Chemical Engineering*, 2, 3, 152 (1957).

Reference

1. Moody, L. F., *Transactions, American Society of Mechanical Engineers*, 66, 671 (1944).