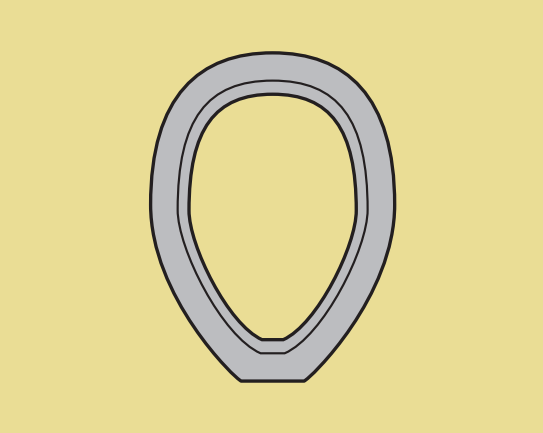
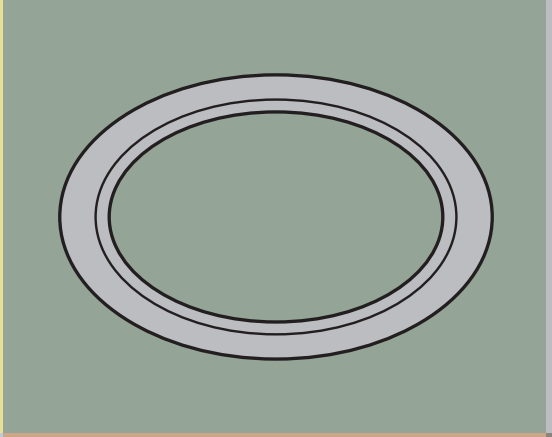
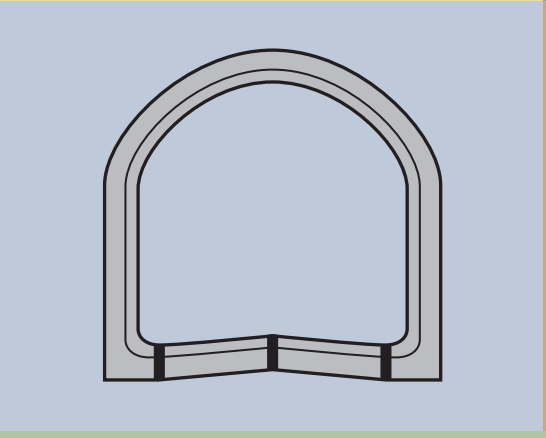
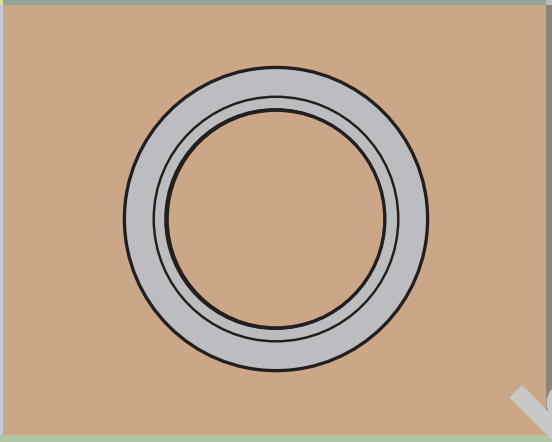
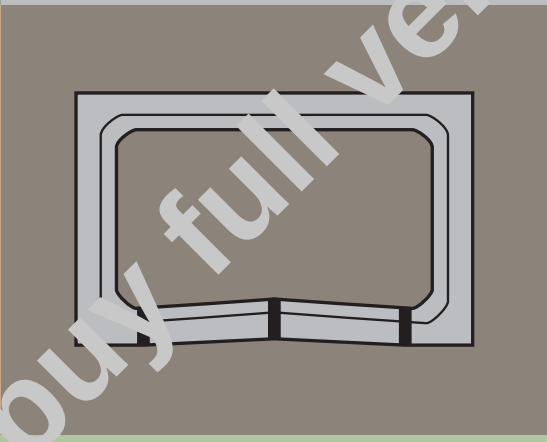

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Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes

Pipeline Infrastructure Committee

Edited by
Norman E. "Ed" Kampbell, P.E.
Jadranka Simicevic

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Prepared by
Pipeline Infrastructure Committee of the
Pipeline Division of the
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PREFACE

This Manual of Practice is intended to be a comprehensive and useful source of information for the design of flexible, close-fit linings for the renewal and/or rehabilitation of pipes designed for gravity flow, such as sanitary sewers, culverts, and storm sewers. This manual with its adoption by ASCE supersedes the use of "Appendix X1 Design Considerations" presented in the nonmandatory section of the ASTM Standard F-1216, which has been the default design method for circular pipes with no more than 10%ovality since its first publication in 1989. The design solution prescribed herein can be used for circular and noncircular geometries such as pipe-arch shapes and egg shapes (of all the various rise-to-span ratios), for elliptical-shaped pipes (horizontal and vertical) and box-shaped pipes (rectangular and square), and for other undefined site-specific shapes.

This manual is written in such a manner as to guide the design engineer in assessing the existing soil–structure interaction system, estimating the state of the stresses in that system, and designing the wall thickness of a close-fit flexible liner that will need to be installed to efficiently carry the loads that will likely come onto it after it is installed.

The contents of this manual represent the collected background and experience of many learned professionals active throughout the world in the evaluation and rehabilitation of the existing buried pipe structures.

This manual was produced under the guidance of Norman E. "Ed" Kampbell, task group chair. The authors are

Brian Dorwart
Norman E. "Ed" Kampbell
David Kozman
Lynn E. Osborn
Jadranka Simicevic

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Task Group Members on *Design of Close-Fit Liners for the Rehabilitation of Gravity Pipes*

Norman E. Kampbell, *Chair*	Rehabilitation Resource Solutions
Kelly Derr, *Vice Chair*	Brown & Caldwell
David Kozman, *Secretary*	HammerHead Trenchless
Brian Dorwart	Brierly Associates
Lynn Osborn	LEO Consulting
Jadranka Simicevic	JPS Consulting
John Struzziery	Town of Hull

Blue Ribbon Panel Reviewers

Ian Moore, Queens University
Olivier Thépot, Eau de Paris
John Schroeder, Hazen and Sawyer
Chris Macey, AECOM

NASSCO

NASSCO is honored to co-publish this Manual of Practice with UESI and ASCE. This effort began many years ago within NASSCO when Ed Kampbell, P.E., who had developed new design procedures for cured-in-place pipe (CIPP), suggested that NASSCO produce a CIPP design manual. After much discussion, it was agreed that ASCE would be a more appropriate organization to undertake this initiative.

Discussions with ASCE began even prior to UESI becoming ASCE's ninth institute. A work effort was started within the Pipeline Division's Trenchless Installation of Pipelines (TIPs) Committee, and after several years of writing, reviewing, and conversing, this Manual of Practice has become a reality.

NASSCO is currently collaborating with UESI and ASCE on more manuals for copublishing. Based on the success of this Manual of Practice, we see future opportunities for developing additional educational resources with UESI and ASCE and appreciate the opportunity to partner with UESI and ASCE to set standards for the assessment, maintenance, and rehabilitation of underground infrastructure.

Sheila Joy
Executive Director
NASSCO, Inc.

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Many sources of information are available to the practicing engineers to turn to and collect the individual pieces of engineering information necessary to understand and apply the design of the various close-fit renewal and/or rehabilitation techniques for culvert, sanitary, and storm sewer pipes. However, what has been lacking to date is a single comprehensive document that places the state-of-the-art present-day design information into one source that is readily available to the consulting engineers and can be easily revised as new engineering knowledge on the subject becomes available.

Arriving at an appropriate design for the renewal of an existing buried pipe structure requires a markedly different approach than the design of a new buried pipe installation and is, in general, more difficult. This is because the type and magnitude of loading coming onto the liner other than groundwater pressure, if any, and how that loading is transferred to the new liner is governed by the in-place performance of the surrounding soil(s) and the existing pipe's current structural condition; or, in other words, it depends on the current state of the stresses, material properties, and contact conditions in the existing soil–structure interaction system.

In a new buried pipe installation design, the quality and extent of the local soil conditions can be addressed by the design engineer's choice of the embedment material to use, the effective width of the trench, compaction level of the embedment material(s), and any special structural details that need to be employed (e.g., stay in place shoring, geotextile wraps, special foundations) to contribute to a successful design life for the proposed buried pipe structure. The design engineer for a new pipe project can further overcome the challenges of the installation site by choosing between a rigid pipe material and a flexible pipe material to address the project site's specific installation and/or safety issues. In a pipe renewal design, the design engineer has to work with a pipe in a given condition and with the given choice of liner material and method of installation. The magnitude of loading coming onto the liner and how that loading is transferred to the new liner is governed by the in-place performance of the surrounding soil and the existing pipe's current structural condition; or, in other words, it depends on the current state of the stresses, material properties, and contact conditions in the existing soil–pipe interaction system.

> The real behavior of structures in contact with ground involves an interactive process beginning with the construction phase and ending with a state of balance after a period of adjustment of stresses and strains within the structure and within the ground influenced by the structure. (Thorburn 1985)