ASME STANDARDS TECHNOLOGY, LLC

STP-PT-079

LOCAL HEATING OF PIPING: THERMAL ANALYSIS

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FOREWORD

The objective of this project is to perform thermal analysis of pipeline heating configurations, with the intention of creating guidelines for the sizing of heating bands.

The author acknowledges, with deep appreciation, the activities of ASME staff and volunteers who have provided valuable technical input, advice and assistance with review of, commenting on, and editing of, this document.

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EXECUTIVE SUMMARY

The initial phase of the project served to calibrate and verify the modeling assumptions used for the thermal analysis via comparison with experimental measurements taken for two post weld heat-treated pipes using multiple heating band configurations. The second phase analyzed five pipe diameters. The intent of the second phase was to determine appropriate sizing requirements for heating bands in order to minimize temperature variation around the weld location, for pipe diameters ranging from 6 to 30 inches.

The calibration cases were run to steady state while the thermal contact resistance was adjusted to match the centerline inside diameter (ID) temperature measurements from the experimental cases. The outside diameter (OD) temperature probes were set to adjust the power input such that their value matched the experimental measurements at the same locations.

The prediction model cases were run to steady state. Five different pipe diameters were investigated with three different pipe thicknesses per diameter. The heat band (HB) and gradient control band (GCB) were iteratively increased in length until the maximum temperature difference in the soak band (SB) was less than 15°F. This occurred with four to six iterations per geometry. The trend of these iterations followed roughly a power relation between temperature differences desired to HB lengths required.

The HB lengths required for a temperature difference in the SB of 15°F when plotted against OD and t/OD are nearly planar. These HB lengths were found to be much larger than is recommended in AWS D10.10 (American Welding Society, 1999), and this difference increases with pipe diameter due to increasing natural convection effects. The results of these analyses can be used to develop new HB sizing guidelines for AWS D10.10.

ABBREVIATIONS AND ACRONYMS

ASME	American Society of Mechanical Engineers
AWS	American Welding Society
BPVC	Boiler and Pressure Vessel Code
CHT	Conjugate Heat Transfer
CFD	Computational Fluid Dynamics
FEA	Finite Element Analysis
GCB	Gradient Control Band
HB	Heat Band
ID	Inside Diameter
OD	Outside Diameter
PWHT	Post Weld Heat Treatment
SB	Soak Band

1 INTRODUCTION

The objective of this project was to perform thermal analysis of pipeline heating configurations, with the intention of creating guidelines for the sizing of heating bands. The analysis consisted of two phases. The initial phase served to calibrate and verify the modeling assumptions used for the thermal analysis via comparison with experimental measurements taken for two post weld heat treated pipes using multiple heating band configurations. The second phase analyzed five pipe diameters. The intent of the second phase was to determine appropriate sizing requirements for heating bands in order to minimize temperature variation around the weld location, for pipe diameters ranging from 6 to 30 inches. The results of these analyses can provide refinement of the requirements found in AWS D10.10 [1] regarding the width of the soak band, heated band and gradient control band as a function of pipe diameter, thickness and heating rate/holding time to help ensure that the through-wall temperature difference does not exceed 15°F within the soak band region. Once these requirements are determined, they can be used to update the technical rules in the appropriate ASME BPVC construction and B31 piping codes.