

Stress analysis methods for underground pipe lines

Elements include pipe movement, anchorage force, lateral soil force, soil friction, soil-pipe interaction

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ANALYZING an underground pipe line is quite different from analyzing plant piping. Special problems are involved because of the unique characteristics of a pipe line, code requirements and techniques required in analysis. Elements of analysis include pipe movement, anchorage force, soil friction, lateral soil force and soil-pipe interaction.

Unique characteristics. To appreciate pipe code requirements and visualize problems involved in pipe line stress analysis, it is necessary to first distinguish a pipe line from plant piping. Unique characteristics of a pipe line include:

- **High allowable stress.** A pipe line has a rather simple shape. It is circular and very often runs several miles before making a turn. Therefore, the stresses calculated are all based on simple static equilibrium formulas which are very reliable. Since stresses produced are predictable, allowable stress used is considerably higher than that used in plant piping.
- **High yield strength pipe.** To raise the allowable, the first obstacle is yield strength. Although a pipe line operating beyond yield strength may not create structural integrity problems, it may cause undesirable excessive deformation and possibility of strain follow up. Therefore, high test line pipe with a very high yield to ultimate strength ratio is normally used in pipe line construction. Yield strength in some pipe can be as high as 80 percent of ultimate strength. All allowable stresses are based only on yield strength.

- **High pressure elongation.** Movement of a pipe line is normally due to expansion of a very long line at low temperature difference. Pressure elongation, negligible in plant piping, contributes much of the total movement and must be included in the analysis.

- **Soil-pipe interaction.** The main portion of a pipe line is buried underground. Any pipe movement has to overcome soil force, which can be divided into two categories: Friction force created from sliding and pressure force resulting from pushing. The major task of pipe line analysis is to investigate soil-pipe interaction—which has never been a subject in plant piping analysis.

Code requirements. Pipe lines normally are designed, constructed, inspected and operated according to minimum federal safety standards stipulated in Title 49 of Code of Federal Regulations.^{1,2} The standards base for the analysis are ANSI B31.4, "Liquid Petroleum Transportation Piping Systems,"³ and ANSI B31.8, "Gas Transmission and Distribution Piping Systems."⁴

Because it is more economical to ship gas at the lowest temperature possible, the stress problem involved in a gas line is less severe than that in an oil line. The following discussion will be based mainly on ANSI B31.4 which is made a part of 49-CFR Part 195, but the philosophy presented should be applicable to gas pipe lines as well. This section covers only the rules that are pertinent to stress analysis, however, and requirements are revised frequently to reflect results of new developments.

Wall thickness. The first step in stress analysis is to calculate wall thickness required. (The diameter of the pipe is generally determined by a different discipline of engineering.)

According to the code, nominal wall thickness of straight sections of steel pipe shall be equal to or greater than t determined in accordance with the following equation:

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Piping and Pipeline Calculations Manual Philip Ellenberger, 2014-01-22 Piping and Pipeline Calculations Manual Second Edition provides engineers and designers with a quick reference guide to calculations codes and standards applicable to piping systems The book considers in one handy reference the multitude of pipes flanges supports gaskets bolts valves strainers flexibles and expansion joints that make up these often complex systems It uses hundreds of calculations and examples based on the author's 40 years of experiences as both an engineer and instructor Each example demonstrates how the code and standard has been correctly and incorrectly applied Aside from advising on the intent of codes and standards the book provides advice on compliance Readers will come away with a clear understanding of how piping systems fail and what the code requires the designer manufacturer fabricator supplier erector examiner inspector and owner to do to prevent such failures The book enhances participants understanding and application of the spirit of the code or standard and form a plan for compliance The book covers American Water Works Association standards where they are applicable Updates to major codes and standards such as ASME B31.1 and B31.2 New methods for calculating stress intensification factor SIF and seismic activities Risk based analysis based on API 579 and B31.4 Covers the Pipeline Safety Act and the creation of PHMSA

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