OTD Operations Technology Development

Guidelines for Cast-Iron Piping Winter Operations

To address concerns with cast-iron piping systems for natural gas distribution, researchers investigated the frost impact on a cast-iron system in New England and developed guidelines for initiating a leak-surveillance program for winter operations.

Project Description

Federal regulations require pipeline operators to have a procedure for continuing surveillance of their facilities, to identify problems, and take appropriate action for various situations, including leaks, breaks, and, for cast -iron (CI) piping systems, graphitization.

Incidents with cast-iron pipe have prompted state regulators in Pennsylvania to evaluate and modify the procedures regarding the frequencies of the CI winter surveillance. In response, a utility in the Northeast initiated a research program through OTD to provide an engineering-supported approach and procedure that can be used to identify the locations, durations, and frequencies of its CI winter surveillance.

In this project, a research team investigated the frost impact on the CI distribution system and provided guidelines regarding when to initiate and terminate a winter-surveillance program, and under what conditions.

Deliverables

The deliverables for this project include the research methodology, analysis of results, and user-friendly guidelines to assist in the condition assessment of the CI system and support a leak-surveillance program.

Frost heave formation at the pavement surface.

Benefits

The guidelines identify high-risk scenarios, pipe-condition ratings, and survey procedures for CI piping systems in winter operations. The analysis also provides indicators on the freeze effects which are tailored to the local characteristics and experience of each region in the study.

Technical Concept & Approach

The approach for this project involved:

- The establishment of a database of the leak-surveillance data, inspection and repair records, and historical data from participating utilities
- The correlation of existing CI leaks and breakage data due to frost impact with local site conditions, such as soil, weather, and construction practices
- The use of risk-analysis techniques for modeling the relationships between the various parameters and providing a risk-based assessment of the probabilities of failures (i.e., leak and breakage).

Specific tasks included:

- **An Assessment of the Utility CI Distribution System**

  Researchers investigated the characteristics of a cast-iron piping system in a utility's distribution network in terms of miles, location, and pipe properties (e.g., diameter, wall thickness, joint types, and age). Since soil data and environmental conditions change significantly within small areas, well-defined and discrete areas were selected to provide representative samples of the region and enable using manageable sets of weather and soil data.

- **Identification of the Parameters Affecting CI Performance**

  Researchers investigated the key factors that are associated with CI failures due to frost action. These factors include environmental conditions (e.g., soil temperature, freeze depth, and duration),

site characteristics (e.g., pipe and joint types, pipe size, and soil properties) and operation conditions.

- **A Risk-based Analysis for Condition Assessment**

  The technique for the assessment of the cast-iron pipes in frost conditions was based on the Fault Tree Analysis model and used the Isograph Reliability Workbench Program.

- **An Evaluation of Gas Migration Patterns**

  Investigators reviewed previous research on gas flow in soil and the effects of soil properties and leak characteristics on gas migration, followed by a study of available leak-surveillance data, inspection and repair records, historical data, and the operators' observations.

- **The Development of Implementation Guidelines**

  These guidelines will allow the utility to focus its leak-surveillance program on when and at what conditions it should initiate its response to frost impact on the cast-iron pipeline system.

Results

In 2013, investigators completed a statistical analysis of data sets of leaks and breakages of cast-iron pipes in the a major New England metropolitan area. The results established the basis for the evaluation of the frost impact on cast-iron pipes. Researchers established correlations of the pipe breakage with weather data and provided preliminary recommendations regarding the start and end dates for the winter leak survey.

In the project, researchers investigated CI winter leaks and breakage records of selected areas during the period from 2002 to 2012.

The cast-iron leak records during the winter months were mostly associated with joint leaks and main-line breaks. Very few records had other leak and break types (e.g., valves, fittings, and tap connections). Most of the broken mains occurred in small-diameter pipes. The database had negligible line breaks in pipe diameters at and above eight inches and almost no breaks occurred in pipes larger than 20 inches.

The rates of pipe breaks per mile varied during the period from 2002 to 2012 and ranged from 0.05 to 0.29 breaks per mile. These variations are mainly attributed to the various freeze conditions and durations during these years.

The soil properties in the region were obtained from the Soil Survey database of the U.S. Department of Agriculture. The soils were mostly gravely and loamy sand with low silt and clay contents. The correlations between the soil data and pipe breaks did not show a significant relationship. This is likely because the soil survey data did not fully represent the roadway and backfill materials around the pipes in the urban areas of the region.

Weather data was obtained from 10 weather stations in the region. The data was used to determine the correlation between pipe breaks and the freeze conditions in the various towns of the region. The occurrence of breaks correlated to the freeze conditions; and the prediction of the number of breaks is thus possible with the use of weather forecasts.

The duration of freeze during the winter season is the main parameter which affects the increase of pipe breakage rates. It is defined as "Freeze Days," which is the number of days per month with maximum daily temperature below or equal to 32^{o}F. The Freeze-Days parameter relates to the "Degree-Days" parameter, which is commonly referenced in the literature as the difference between the average daily temperature and 32^{o}F, multiplied by the number of the Freeze Days. The correlation between the Freeze Days and pipe breaks was evaluated in 18 towns in the region. The correlation showed that most of the winter breaks (90% of the cast-iron breaks) occurred after five days accumulation of the Freeze Days. This correlation can be used to establish a criterion for initiating winter patrols and to optimize the probabilities of detecting winter breaks.

The database shows that the major source for identifying cast-iron leaks in the winter months is the public notification of leaks; followed by company personnel and winter patrols.

The results show that the number of after-freeze breaks (i.e., during the thawing period) had a weak correlation with the total Freeze Days in the winter season. However, the records did not show after-freeze breaks when the duration of the freeze season was short (i.e., when all Freeze Days occurred in less than three months of the winter season).

Status

This project was completed with the release of a Final Report in January 2014.

For more information:

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