

Strain-Based Design of X80 Gas Pipeline in Seismic Area in China

Hong Gao, Maotang Wang and Zhifeng Yu
China Petroleum Pipeline Bureau, Langfang
Langfang, Hebei, CHINA

ABSTRACT

The current status of strain-based design in China and the main aspects of China's Second West-East Gas Pipeline project are introduced. It is evident that this pipeline needs to be designed using strain-based design as it crosses many seismically active faults. This paper introduces codes for pipeline design in seismic areas. A comparison between Chinese and Japanese codes reveals some inconsistencies and potentially problematic areas. The strain capacity of both conventional X80 and high deformation X80 pipes is compared. The allowable strains of the Second West-East Pipeline are calculated using the Chinese code and empirical equations. The feasibility of strain-based design for this planned X80 pipeline is demonstrated. The unresolved issues of strain calculation are highlighted.

KEYWORDS: natural gas pipeline, strain capacity, X80, seismic design

INTRODUCTION

China's first West-East Gas Pipeline was successfully completed in October, 2004. Now China is planning its second West-East Gas Pipeline to meet its rapidly increasing natural gas consumption. The second project will exceed the first West-East project in many aspects. In addition to the use of large diameter, high pressure, and high steel grades, the new project will use some new technologies that were not used in the first project, such as state-of-art strain-based design methodology in seismic areas.

Strain-based design is not a new concept in China, but in-depth scientific studies have been limited. New studies are being carried out when the concept is being applied to the new pipeline project. In the past, pipelines were mainly designed on the basis of stresses. Steps were taken in pipeline routing to avoid areas of ground movements. When large strains were inevitable, such as in seismic areas and active fault crossings, the strains were kept under certain values. This concept is included in SY/T 0450 Code for Seismic Design of Oil and Gas Steel Pipeline, SY/T 0015.2 Design Code for Aerial Crossing Engineering and some other codes.

For the planned second West-East pipeline, however, the above referenced codes are not enough, as high strength large diameter X80 linepipes will be used. The procedure of computing strain demand and capacity is no longer suitable. To apply the strain-based design in the second project, strain demand and allowable strain of the X80 pipeline is discussed in this paper.

THE SECOND WEST-EAST GAS PIPELINE

The main line of the second west-east pipeline starts from Xinjiang autonomous region, crosses Gansu, Ningxia, Shanxi, and Henan provinces, and ends in Hubei province. Two branch lines start from Hubei and end in Shanghai and Guangzhou, respectively. The total length is about 7000 km (4375 miles). The main line has a diameter of 1219 mm (48 inch), a design pressure of 12 MPa (1740 psi), and steel grade of X80. The branch lines have a diameter of 1016 mm (40 inch), a design pressure of 10 MPa (1450 psi), and steel grade of X80. The wall thickness is listed in Table 1 by area classification. The pipeline will cross 600 km (375 miles) seismic areas with peak acceleration of 0.15 m/s², and 700 km (438 miles) of 0.2 m/s². It will cross or be close to 30 active faults.

Table 1 Wall thickness (mm) of the Second West-East Pipeline

Diameter (mm)	Area classification			
	1	2	3	4
1219	18.4	22	26.4	33
1016	12.8	15.3	18.4	23

STRAIN-BASED DESIGN IN CODE FOR SEISMIC DESIGN OF OIL AND GAS STEEL PIPELINE

In China, the seismic design code was issued 15 years ago. It was revised in 2004. Some problems have been found when using the code for strain-based design.

Main Provisions in SY/T 0450-2004 Code for Seismic Design of Oil and Gas Steel Pipeline

General Requirements

- This code is applicable to seismic designs of oil and gas pipelines in area with peak acceleration of 0.05g-0.4g. When pipeline crosses areas with peak acceleration of more than 0.4g or special seismic requirements are needed, special studies shall be carried out.
- Pipeline site shall be classified into three types: stiff, normal, and soft. Site characteristics can refer to Table 2. In the table, the first, second, and third group can be determined according to GB50011 Code for seismic design of buildings.