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Permafrost and cold-region environmental problems of the oil product pipeline from Golmud to Lhasa on the Qinghai–Tibet Plateau and their mitigation

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ABSTRACT

The 1076-km-long Golmud–Lhasa oil product pipeline is located closely parallel to the highway constructed 20 years earlier within the relatively narrow north–south engineering corridor crossing the treeless central area of the Qinghai–Tibet Plateau. Much of the corridor is at elevations exceeding 4500 m and high-elevation, generally warm permafrost is encountered in more than one-half of the length. The pipeline, transporting mostly diesel, motor and aviation fuels at ambient temperatures, is 159 mm in diameter, has a wall thickness of 6 mm and was buried in a trench at a nominal depth of between 1.2 and 1.4 m. The soils encountered, mostly periglacial sands, silts and gravels, often have elevated saline contents and are subject to severe wind erosion and occasional monsoon flash flooding conditions. During its first quarter century of operation, the pipeline suffered at least 30 significant leaks and four pipeline ruptures. About 337 km of the pipeline was extensively rehabilitated, including relocations or replacements in major problem areas and, where feasible for an existing pipeline, improvements in pipeline protection during 2001–2004. It was supposed to safely operate for another 30 years with proper checks and needed repairs. This paper provides a review on the history of the permafrost and cold regions environmental problems of the pipeline, and their major rehabilitation, repairs and problems in the future, which might have useful implications for similar oil product pipeline at high elevations or permafrost regions.

1. Introduction

The 1078-km-long, 159-mm diameter oil product pipeline from Golmud, Qinghai Province to Lhasa, Tibet Autonomous Region (Fig. 1) generally parallels the Qinghai–Tibet Highway (QTH) built in the mid-1950s. There were 28 pump stations (PS) and Lhasa distribution station originally designed along the route during 1974–1977, but only 12 of them are used. They include PS 1 at Xueshuihe (pipeline distance of 0 km), PS 3 at Nachitai (57 km), PS 5 at Xidatan (96 km), PS 6 at the Kunlun Mountain Pass (115 km), PS 9 at Wudaoliang (234 km), PS 12 at Tuotuohe (381 km), PS 14 at Yanshiping (461 km), PS 16 at Old Wenquan (523 km), PS 19 at Amdo (648 km), PS 22 at Nagqü (777 km), PS 26 at Damxung (933 km), and Lhasa Distribution Station (1076 km). The wall thickness of the pipe is 6 mm. The designed throughput is 90,000 tons of gasoline and 60,000 tons of diesels per year (about 5900 barrels per day assuming a specific gravity of 0.72–0.83 for oil products and for only 200 days a year). The designed maximum pressures of the oil are 6.27–10.0 MPa (about 900–1500 psi). The oil temperatures vary from −5 to +9 °C along the route in various seasons. Both infrastructures, along with the recently (2001–2006) constructed Qinghai–Tibet Railway (QTR), lie within the relatively narrow (a couple of hundreds of meters to 5–10 km) north–south Qinghai–Tibet Engineering Corridor on the eastern Qinghai–Tibet Plateau. Construction of the pipeline, conventionally buried in a trench at nominal depths of 1.2 to 1.4 m, was begun in 1974 to supply refined oil products for military and the growing city of Lhasa. Construction of the pipeline was completed in 1977 and throughput began. The ambient-temperature pipeline is not in operation from November to March of the following years because of decreased demand. The surface of the pipe was treated with anticorrosion proofing in combination with the typical cathodic protection as shown in Fig. 2. The cathodic protection by sacrificing the anode was provided, but it was less effective than anticipated. Since 1977, more than 30 product leaks and at least four pipeline ruptures have been reported.

The central government launched an extensive rehabilitation program for about 337 km of the pipeline in 2001–2004 at a cost of 326 million Yuan (about US$ 40 million). The intent was to provide repairs when needed, and to modify the routing where the operational history and research had indicated problem areas, and to ensure the integrity and safety of the pipeline for another 30 years, the designed lifetime of petroleum pipes without major repairs.

2. Existing environment

Most of the engineering corridor traversed by the oil product pipeline is at elevations greater than 4000 m, and is generally flat-

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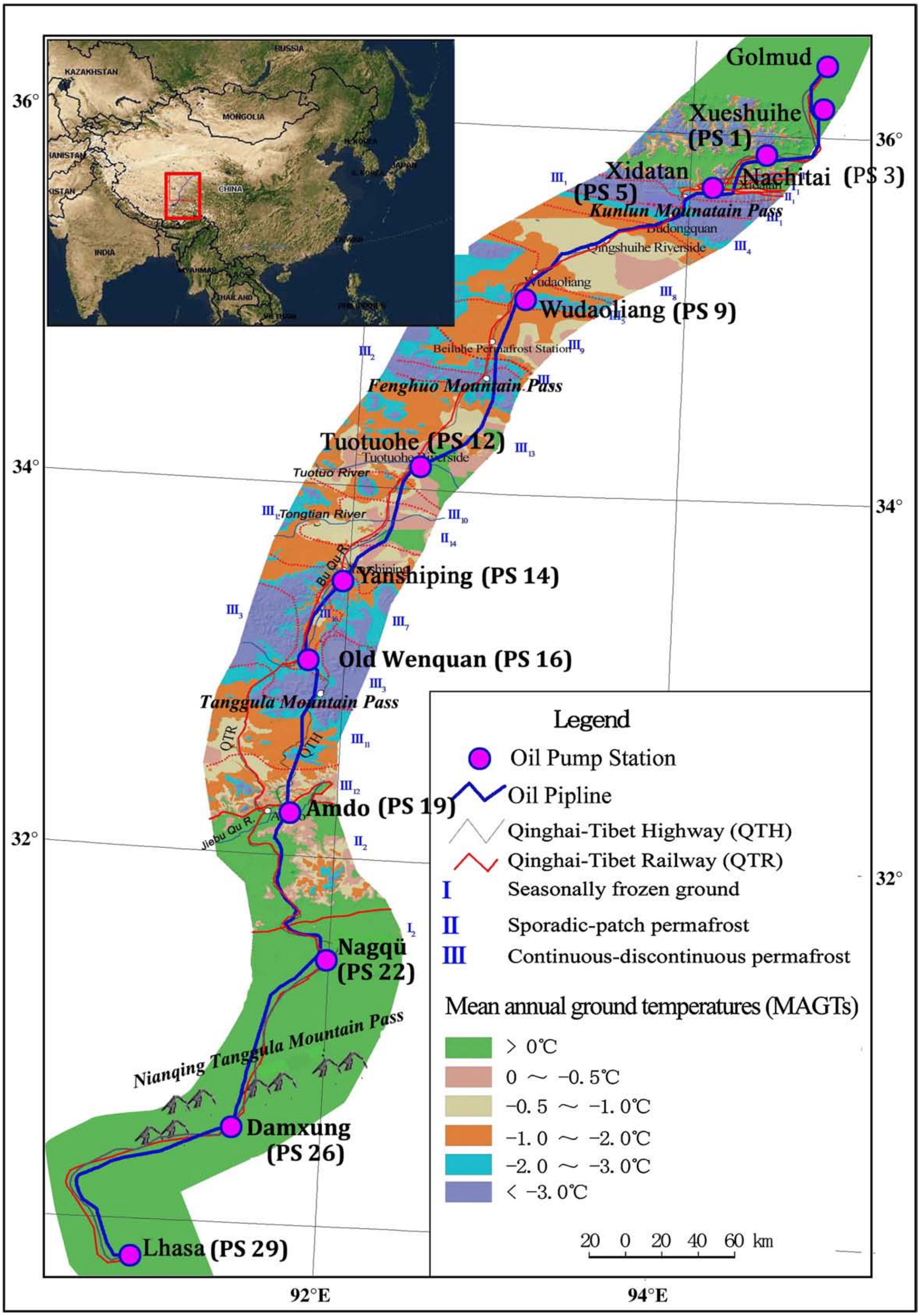

Fig. 1. Route map of the Golmud–Lhasa products oil pipeline in the interior of the Qinghai–Tibet Plateau (revised from Jin et al. (2008a)).

lying and treeless until approaching Nagqü in the south. The landscape tends to be pastoral with short, hardy grasses, occasionally with patches of low (2–3 m) shrubs, significantly large areas of bare sands and gravels, and occasional areas of wetlands. The corridor is crossed by three significant east–west trending mountain ranges (the Kunlun, Tanggula and Nyainqên Tanglha) and impacted by four lesser groups of mountains (the Hoh Xil, Fenghuo, Kaixinling, and Taoerjiu). The Kunlun Range in the north is the most extensive; the Tanggula Pass in the south, 90 km south of Old Wenquan, is the highest area (5078 m) crossed by the pipeline. The plateau area, associated with the Himalaya