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## Development of the Fatigue Strength Testing Machine for Buried Polyethylene Valves for Gas

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### Abstract

According to the fatigue test requirements on polyethylene valves regulated by the ISO 8659 standards, the fatigue strength testing machine for polyethylene valves is designed. The mechanical structure, hydraulic system and control system of the fatigue testing machine are designed. They can realize the fatigue performance automatic testing of multiple types of polyethylene valves, data acquisition&processing and human-computer-interaction so as to improve the testing efficiency. The result of site testing shows that this testing machine can satisfy the fatigue test of DN20~DN75 valves.

### Keywords

Buried Polyethylene Valve; Fatigue Strength Testing; Test Machine; Structure Design.

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### 1. Introduction

Polyethylene valves are an important controlling component and safety part of the PE gas pipeline system. A series of domestic and foreign standards and requirements were made in light of its safety and application performance. In 1989, the ISO issued the *ISO 8659 PE Valves Fatigue Strength Testing Method*. In 1997, the ISO issued the *ISO 10933 Polyethylene(PE) Valves Used for Gas Allocation System* products standards. In 2002, the EU Standardization Organization approved the *EN1555-4 Polyethylene(PE) Pipeline System for Gas--Part 4:Valves* product standards, proposed the compulsory requirements on the mechanical properties and physical properties of PE valves and gave the requirements and testing methods for specific sealing tests, torsion tests and fatigue tests.

Since 2008, the PE valve industry in our country has been developed rapidly and the domestic sales volume is as high as 35,000-40,000. To standardize the production and testing of PE valves and improve the quality of homemade PE valves, the National Standardization Committee wrote and issues the national mandatory standards *GB15558.3-2008 Buried Polyethylene (PE) Pipeline System for Gas-Part 3: Valves* according to ISO 10933 and EN1555-4 standards to stipulate the materials, dimensions, appearance, mechanical properties, physical properties and relevant testing methods, excluding the requirements and testing methods of the fatigue strength performance indexes. Hence, domestic scholars and manufacturers' R&D of PE valves' testing equipment is mainly concentrated on the sealing tests, torsion tests and other factory-testing items and neglect the importance of PE valves' fatigue performance.

According to the requirements in *ISO 8659-1989 PE Valves' Fatigue Strength Testing Method*, this paper designed the fatigue strength testing machine for PE valves, designed the valve positioning device, the hydraulic system and the control system of the fatigue testing machine and performed site testing.

## 2. Structure Design of the Testing Machine

The fatigue testing machine for PE valves is mainly composed of the valve positioning device, the hydraulic system and the control system. The valve positioning device realizes the positioning of the PE valve and the opening&closing control of the valve. The hydraulic system provides the water medium of the stipulated pressure for the testing valve. The electricity-controlling part can realize the regular control of the valve opening&closing, the control of the hydraulic system and give the feedback of data processing, etc.

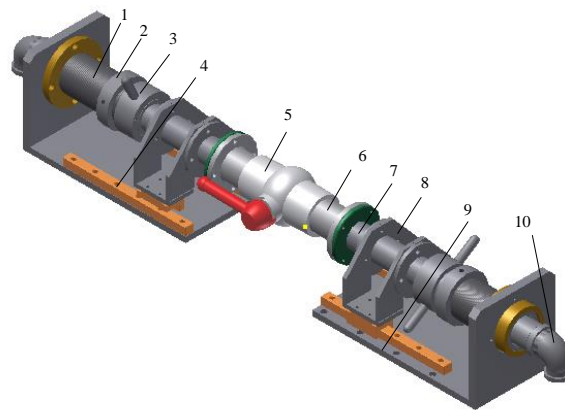


Figure 1. Valve Positioning Device Structure Diagram

1 lead screw 2 lock mother 3 hand wheel 4 straight line guide rail 5. PE valve 6 positioning flange 7 water flow tunnel 8 valve fixed support frame 9 supporting floor 10 elbow

### 2.1 Structural Design of the Valve Positioning Device

The structure diagram of the valve positioning device is shown in Figure 1. When the valve is installed or removed, the hand wheel can realize the positioning flange’s movement along the straight line guide rail; the valve fixed support frame only restrains the water flow tunnel in the radial direction. When the valve is closed, the hydraulic system pumps water into the water flow tunnel of the valve positioning device through the elbow and exerts pressure in the water flow’s direction on the valve. This pressure functions directly on the support floor with enough strength, ensuring that the position of the valve doesn’t move thereabouts. In the valve tests, the positioning flange press tight on the valve and the lock mother locks the lead screw tight. And, high elastic sealing rings are arranged at the ends of the flange to ensure that the valve doesn’t leak. The positioning flange’s structure is shown in Figure2. The valve switch is driven by the motor. For PE valves, the speed of motors less than DN50 is 30 r/min~50 r/min; PE valves of the specification lager than DN50, the motor speed is 10 r/min~30 r/min. The drive assembly is shown in Figure 3.

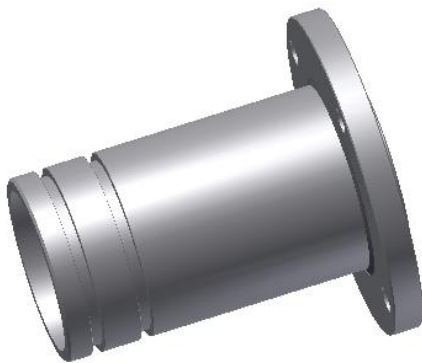


Figure 2 Valve Fixing Flange Structure

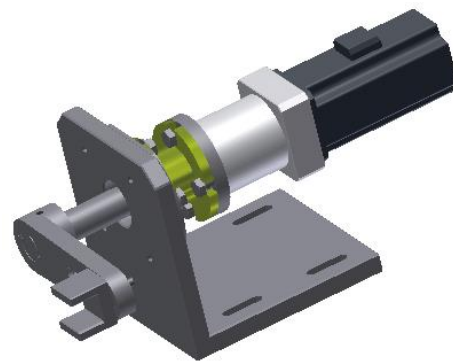


Figure 3 Valve Drive Assembly

## 2.2 Design of the Hydraulic System

The hydraulic system can realize the functions of valve body test, liquid insulation and measurement of circuit pressure. This machine adds in the pressure declining leakage testing method to determine whether the valve has leakage. In testing, pump the valve with a liquid pressure of 2.0 Mpa. Then, cut the pressure source to maintain the pressure; the pressure maintaining time is 5 s~20s. The valve opening residence time is 5 s~20s. According to the data changing tested by the pressure sensor, it can be decided whether there is leakage of the valve in the fatigue testing process.

## 2.3 The Electronic Control System

The electronic control system is mainly composed of the testing part, the controlling part and the data display&analysis part. The testing part mainly tests the valve switch torque variation and the pressure & water temperature changing of the hydraulic system. The controlling part mainly controls the drive assembly operation, the pressure source and the thermal insulation water tank. The data display&analysis part mainly realizes the data acquisition of the torque sensor, the pressure sensor and the temperature sensor, monitors the operation status of the testing machine and generates the torque changing curve, etc.

## 3. Testing Performance and Testing Data

This testing machine can realize the fatigue tests of PE valves of seven specifications of 20~DN75. The torque is 500Nm, the precision is  $\pm 0.1\%$ . The water temperature is  $20^{\circ}\text{C}$ , the precision is  $\pm 2^{\circ}\text{C}$ . The pressure is 1.0Mpa, the precision is  $\pm 1\%$ . The measurement range of the pressure sensor is 0~1.5Mpa, the precision is  $\pm 0.25\text{FS}$ . The fatigue test of the DN63 PE valve was performed on this testing machine. The testing machine can realize the anticipated functions.

## 4. Conclusion

This paper designed the PE valve fatigue strength testing machine according to the requirements in ISO 8659—1989 *PE Valves' Fatigue Strength Testing Methods* and filled the blank of PE valve fatigue testing equipment at home. This testing machine has a high automatic level. It is convenient for use and can realize the fatigue strength tests of PE valves of seven different specifications at the same time.

## Acknowledgments

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