Research and application of calibrating device for pipeline detector

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Abstract: Underground pipeline is an important part of urban infrastructure, known as the "lifeline" of the city. At present, there are many incomplete data of urban ground line pipelines, only part of the data is not high precision or inconsistent with the status quo, which is easy to cause serious accidents in the construction of underground pipelines often cut or damaged, so it is particularly important to establish a reliable underground pipeline database as soon as possible. Pipeline detectors currently occupy tens of thousands of units in the market, and the annual growth rate of 20%~30%. At present, the positioning error (sounding error) of pipeline detector is faced with the problem of undetermined and untraceable. The relevant calibration device established in this paper can provide reliable data and provide strong guarantee for the data of pipeline detector.

1. Introduction

With the development of cities, underground pipelines are laid more and more closely, especially electric communication pipelines, street lamps, gas pipelines and telecommunication pipelines. Underground pipelines are mainly non-metallic pipelines and metal pipelines. In the early stage of urban construction, underground metal pipelines are more and more buried. With the development of cities and the importance of underground pipelines becoming increasingly prominent, it is particularly important to study the detection technology and detection instruments for metal pipelines. At present, pipeline detector is a necessary instrument for water supply companies, gas companies, railway communications, municipal construction, industrial and mining, infrastructure units to transform, repair, and survey underground pipelines. It can not destroy the ground under the condition of soil, It can quickly and accurately detect the position, direction and depth of underground water pipes, metal pipes and cables, as well as the position and size of anticorrosion damage points of steel pipes [1]. From 1990 to 2011, the length of underground pipelines of gas, heat supply, drainage and water supply in Chinese cities increased by 8.16 times, reaching 1.48 million km [2]. Underground pipe detector developed earlier in foreign countries, with high level and variety, including Rady series from The United Kingdom, Dynatel series from the United States, CAS series from Chinese Academy of Sciences, GXY-2000/3000 underground pipeline detector from Xi’an Hua Ao, Nanjing Hua Zhuo Electronic Industry Co., LTD., Jiangsu Sheng Li and other companies. At present, there are about 10,000 pipeline detectors in use in China, and the number of such instruments is growing at a rate of 20% to 30%.

At present, the equipment has not issued the relevant calibration specification and the lack of pipeline detector data verification means, which makes the reliability of data collected by the equipment have hidden dangers. Hidden danger exists in the data of underground pipeline detection,
which is bound to bring unnecessary excavation for subsequent construction. In view of the current situation, this paper proposes a calibration method of pipeline detector and designs a calibration device of pipeline detector. Quantitative analysis of the positioning error (sounding error) of pipeline detector by using the calibration device of pipeline detector can ensure the accuracy and reliability of data and effectively reduce the serious accidents of cutting or damaging underground pipelines in construction.

2. Pipeline detector
At present, the common detection methods in urban comprehensive underground pipeline survey are mainly pipeline detector detection and detection radar detection, and pipeline detector is used frequently [3]. The pipeline detector can detect the position, direction and depth of the pipeline without damaging the ground cover [4]. It consists of a transmitter and a receiver. The transmitter can apply a special signal current to the pipeline under test, generally using direct connection method, induction method and clamp method three excitation modes. The receiver has a built-in induction coil, which receives the magnetic field signal of the pipe and generates an induced current through the induction coil to calculate the direction and path of the pipe. There are three reception modes for general receivers: peak mode, valuation mode and wide peak mode. The line detector has a portable design with a rugged case that is pressure-resistant and suitable for field operations. It is easy to operate and can be completed by two people [5].

3. Calibration device for pipeline detector
The front view of calibration device of pipeline detector proposed in this paper is shown in Figure 1, in which metal pipelines of a certain caliber are placed horizontally at the bottom, and then a soil layer of 1m depth and 10m length (minimum 6m length) is buried. Soil layers of 1m depth are successively buried on the right side of the soil layer, making the maximum depth to 6m depth. The width of the soil layer is uniformly set to 1.2m. The repeatability of the sounding error measured by the pipeline detector at 1m depth, the indication error measured by the sounding value at 1m, 2m, 3m, 4m, 5m, 6m and other heights, and the measurement results of the pipeline detector were evaluated by other factors affecting the measurement uncertainty. The buried depth is measured by steel ruler or steel measuring tape.

4. Field experiments
In this paper, the underground pipeline detector of Vivax Metrotech brand is adopted, and the uncertainty of emission frequency measurement results of the pipeline detector is \( U_{rel}=4.3 \times 10^{-6} \) (\( k=2 \)).

4.1. Experiment 1
According to the site situation, the direct connection method is used to test the underground metal pipelines on site. The current applied by the direct connection method is 100mA. See the next page for the detection data and results.
Figure 2. Detection area and location map.

Table 1. No schematic diagram of comparison measurement results.

| Line dot | Number/location | Feature point description | Environment description | Soil type       | Stimulating way | Pipeline buried depth (m) |
|----------|-----------------|----------------------------|--------------------------|-----------------|-----------------|--------------------------|
| Log1     | The valve       | The starting point         | The sidewalk             | Concrete, tile  | direct connection| 1.01                     |
| Log2     | /               | straight line              | The pavement             | Concrete, tile  | direct connection| 1.22                     |
| Log3     | The door of the factory | straight line | The pavement             | Concrete, tile  | direct connection| 1.28                     |
| Log4     | /               | straight line              | The pavement             | Concrete, tile  | direct connection| 1.27                     |
| Log5     | /               | inflection point           | The pavement             | Concrete, tile  | direct connection| 1.32                     |
| Log6     | /               | straight line              | The pavement             | Concrete, tile  | direct connection| 1.10                     |
| Log7     | /               | straight line              | The pavement             | Concrete, tile  | direct connection| 1.16                     |
| Log8     | /               | straight line              | The pavement             | Concrete, tile  | direct connection| 1.11                     |
| Log9     | /               | destination                | The pavement             | Concrete, tile  | direct connection| 1.02                     |
4.2. Experiment 2
The pipeline detector adopts direct connection method, the frequency of transmitter is 8.19 KHz, the current of transmitter is set as 100mA, and the object to be measured is copper core cable. The position of the measuring point is the distance from the edge of the road. The actual position is the distance from the edge of the road.

Table 2. Schematic diagram of comparison measurement results.

| Pipeline point | Measuring point location (mm) | actual position (mm) | Positioning error (mm) | Actual buried depth (m) | Measure the depth of burial (m) | Buried depth error (m) | measured current (mA) |
|----------------|-----------------------------|----------------------|------------------------|------------------------|-------------------------------|-----------------------|----------------------|
| 1              | 334                         | 335                  | 1                      | 0.555                  | 0.55                          | -0.005                | 85.1                 |
| 2              | 212                         | 205                  | -7                     | 0.706                  | 0.69                          | -0.016                | 58.8                 |
| 3              | 179                         | 185                  | 6                      | 0.643                  | 0.64                          | -0.003                | 86.3                 |
| 4              | 163                         | 170                  | 7                      | 0.512                  | 0.51                          | -0.002                | 83.7                 |
| 5              | 273                         | 276                  | 3                      | 0.455                  | 0.46                          | 0.005                 | 83.7                 |
| 6              | 350                         | 348                  | -2                     | 0.475                  | 0.47                          | -0.005                | 85.7                 |

As shown in the table above, the absolute value of the maximum measurement error of positioning is 0.007m, and the absolute value of the maximum measurement error of burial depth is 0.016m.

5. Conclusion
In this paper, two different groups of experiments were compared. One group of experiments did not compare the measurement results, and the other group of experiments was compared with the results of the steel tape. The measurement results with the comparison results were more reliable. The calibration method and calibration device proposed in this paper can not only effectively calibrate the pipeline detector, but also effectively calibrate the ground penetrating radar (with non-metallic pipeline), pipeline avoidance instrument, cable detector and other ground penetrating equipment.

The measurement method is mainly used for the sounding experiment of the ground exploration equipment, so the equipment can be used to achieve the requirements of the depth of the related equipment, this measurement method has a certain versatility, has broad application prospects.
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