

# Testing Standard Sample Calibrating Device Developing of Entire Diameter Rock Gas Permeability and its Calibrating Technique to Value Tracing to Source

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**Abstract** Rock gas permeability is one of the most important foundation parameters during exploration and development of oil/gas fields. At present, only  $\Phi 25$  mm  $\times$  25 mm rock gas permeability testing standard material is produced and calibrated in China, the value tracing to the source and device calibration of other specification rock permeability devices are dependent on overseas, which seriously restricts the development of rock physical property testing technique. On the basis of deep analysis to calibrating technique of rock permeability testing device, this paper introduces the entire diameter rock permeability testing standard sample calibrating device from our own design and its calibrating technique to value tracing to source, which is a great breakthrough to calibrate big diameter rock gas permeability of various specifications using small diameter standard sample in China. The rock permeability calibrating device introduced in the paper granted the patent of invention in China, its calibrating method has been applied for the patent.

**Keywords:** calibrating device, calibrating technique, rock gas permeability, value tracing to source, entire diameter, standard material

## 1. Introduction

Rock gas permeability means the ability of gas passing through the porous rock medium under certain pressure. Rock permeability reflects the fluid's flowing ability in the stratum, which is one of the most important foundation parameters during exploration and development of oil/gas fields.

In recent years, the technique of analysis to the reservoir physical property has been developed so fast at home and abroad, on the basis of conventional (the specification of the core sample is  $\Phi 25 \times 25$  mm) rock permeability testing, with the technical research of EOR in oil field and the need of the research in deep tuff gas reservoir, successively, we develop the analysis technology of the big diameter (rock sample specification  $\Phi 38$ --110 mm) core porosity and man-made core (sample length > 50 mm) expelling and replacing experiment permeability. Permeability testing on different specifications of the rock sample

not only requires us to use different core holders, but also requires us to use the standard materials which are above National Second Level to do the value tracing to source<sup>[1]</sup>, check the testing equipment or the accuracy of the testing result will be doubted and can't be used as formal analysis data. At present, only  $\Phi 25 \times 25$  mm standard sample can be produced in China and can only calibrate the rock permeability testing device of this kind of the specification standard sample and devices calibration of other specification rock permeability testing standard sample calibrating device and the calibrating technique to value tracing to source based on it has solved the technical problems of the rock permeability testing devices calibration in various specifications at home. It is a breakthrough in rock physical nature testing technology by using the standard sample of one specification, which is made in China to calibrate rock permeability testing devices of various specifications. Rock permeability testing standard sample calibrating devices and its calibrating method have been applied

for the patent of practical new-style and invention respectively, and calibrating device has granted the patent of invention in China, the Patent No.: ZL02204325.X.

## 2. The present status quo of calibrating technology of rock permeability testing devices

The analysis data in the lab must be obtained accurately, objectively and impartially. All the value measuring devices should be calibrated regularly and can trace to the national standard to do the value tracing to source. According to the requirement of China Petroleum Trade Standard and American API Standard, every kind of rock permeability testing devices must be calibrated regularly by using standard materials, which are above National Second Level. Calibrate as the occasion demands, when the device testing status has the great change (e.g. replace the devices' parts after testing process).

As the aim of the exploration and development of oil/gas fields are different from that of the research in geology and minerals, we should check all kinds of rock samples in different specifications such as common rock samples  $\Phi 115 \times 100\text{mm}$ ,  $\Phi 100 \times 100\text{mm}$ ,  $\Phi 70 \times 100\text{mm}$ ,  $\Phi 38 \times 10\text{mm}$ ,  $\Phi 25 \times 25\text{mm}$  happened during the exploration and development of oil/gas fields. We should choose appropriate core holders when we test the core sample permeability of every specification, also calibrate by using standard sample of appropriate specification to make sure the accuracy of permeability testing.

At present, only small diameter (Diameter 25mm) porous permeability standard material can be produced and recalibrated in China, for the calibration of permeability testing device of other specifications, we can take the following three methods:

First, use the standard sample matched to that from abroad to calibrate the devices (single in data, different in nominal dimension), one testing

specification device matches one set of the standard sample. If the standard sample doesn't match, or calibrating point and devices' measuring scope or measuring point have so wide a gap, calibrating will lose its meaning.

Second, take the indirect calibrating, as the devices don't have the standard samples calibrate directly, that is, check the measuring tools, such as the pressure meter, flow meter, etc. regularly, and keep it in mind that if the measuring tools are qualified, the results are qualified, too, we should often dismantle the devices' parts in this case, but it will make the damages of the air tight of the devices air path and the joint pieces, which will make the process of value tracing to source complicated.

Third, join the holder of  $\Phi 25\text{mm}$  to the big diameter permeability testing devices of every specification to calibrate the devices, supposing the status of the big diameter permeability testing is good.

The disadvantages of the later two methods exist that it's uneasy to check the effects of the air tight rock samples in holder during the testing, to dismantle the devices measuring parts, the value couldn't really trace to the materials based on national standard. On the other side, rock samples of every specification should be matched to the appropriate core holder, if permeability testing devices of every specification must be equipped with a set of standard samples, then, except rock permeability of specification diameter 25mm testing devices, which we can produce and recalibrate only in China, all the other permeability testing devices must be taken to authority organization abroad for recalibrating, this is a heavy burden for any company or research organization at home. In the meantime, because devices standard sample problems may also hinder the development of rock permeability testing technology, problems stated above don't have a better solution. According to the international standard regulations, rock permeability testing standard materials should be calibrated every two years. If the calibration problems of rock samples permeability

devices of different specifications can't be solved, the lab will not supply legal effect checking reports approved by State Bureau of Technical Supervision, analysis data can only be the reference and can't be used into oil/gas fields research as formal parameters, this surely will have great effect on the exploration and development of oil/gas fields.

### 3. Development of the entire diameter rock gas permeability testing calibrating device

In order to ensure the accuracy of transmitting analysis device value the most reliable method of checking devices is to use standard material to calibrate devices. In view of the reality that China can only produce and recalibrate diameter  $\Phi 25 \times 25\text{mm}$ , this specification permeability standard sample, we consider how to simulate small diameter standard sample into big diameter sample, try to solve the problems of calibrating big diameter permeability testing devices of various specifications and the value tracing to source by calibrating the value of small diameter standard sample.

Chart 1 A solid decompose chart of the entire diameter rock gas permeability testing calibrating device<sup>[2]</sup>. Six parts mainly compose rock permeability testing calibrating device: 1. The crust of the calibrating device; 2. O shape sealed coil; 3. Standard material; 4. Standard material protection ring with many gas conduit slots; 5. Bow shape board spring 6. Gyration ending cap

The entire rock gas permeability testing calibrating device can calibrate the permeability-testing device of core holder, which can hold samples above  $\Phi 38\text{mm}$  and also thinking about the convenience of composing and decomposing in the structure design of this calibrating device, special tools (for composing and decomposing) have been designed; so core holder of every specification only needs one calibrating device at least and can replace the inner small standard samples to change the calibrating value whenever necessary. Not only can it meet the calibrating of

permeability in the whole measuring scope, but also it can meet the calibrating to the devices in horizontal and vertical permeability testing directions, and then to ensure its value's accuracy and unity.

When in the practical use, according to testing and calculating method permeability calibrating device, as long as we have the core holder of appropriate specification, we can measure permeability calibrating value of gas flow in vertical and horizontal directions checking scope.

### 4. Calibrating method of rock permeability testing calibrating device

The entire diameter rock gas permeability testing calibrating device can use  $\Phi 25 \times 25\text{mm}$  standard samples made in our country to calibrate the standard samples which calibrated diameter is above  $\Phi 38\text{mm}$ , also can use  $\Phi 25 \times 25\text{mm}$  standard samples to calibrate core permeability testing devices of various specifications. Two ways to use this calibrating device:

#### 4.1 Calibrate big diameter samples by using small diameter samples

In this case, the supplied length and diameter when doing the permeability calibrating are the outer length and diameter of this calibrating device, the conversion coefficient of this calibrating value is to convert the length and diameter of small standard sample to the function of the length and diameter of this calibrating device, conversion formula is:

$$K_n = K_s \frac{l_n \cdot d_s^2}{l_s \cdot d_n^2}$$

where

$K_n$  – calibrating value after converted

$K_s$  – calibrating value of the original standard sample

$l_n, d_n$  – the length and diameter of the crust

$l_s, d_s$  – the length and diameter of the original standard sample

On the basis of the method above, we can make a conversion chart according to the small standard

sample series that we've had, put all the calibrating value into this chart, which comes from the conversion after we put all the small samples into this installation, to form the big standard samples series, this is easy to manage and use and the conversion error is too tiny to calculate, and it can be applicable for the nationwide production of the big standard sample series in the future.

#### 4.2 The direct calibrating rock permeability testing devices of various specification by using small diameter standard sample

In this pattern, the entire diameter rock gas permeability testing calibrating devices only play a role of filter container, at this time, the calibrating to rock permeability testing device can directly use the small diameter standard samples made in our country, the calibrating value can also use the small diameters'. There isn't any conversion error among rock

permeability testing devices of different specification when doing device calibrating, this is better use for the lab.

As table 1 shows, this is the testing records, which is used small standard samples in May, 2004, when calibrating big diameter (sample testing specification is  $\Phi 100\text{mm}$ ) permeability testing devices by using the entire diameter rock gas permeability testing calibrating devices. Through using the calibrating devices designed and developed by our own, we've successfully solved the devices checking problems of the rock permeability testing devices of various specification, and have met the need of the exploration and development of oil/gas fields.

**Table 1** Testing Records of Rock Gas Permeability testing Devices

Instrument Model		QSY-II		Instrument No.		7809				
Outward Appearance		In good condition								
Working medium		Air		Atmospheric pressure kPa		100.0		Temperature °C		18.0
Sample No.	Specification		Calibrating value $10^{-3} \mu\text{m}^2$	Testing pressure MPa	Permeability $10^{-3} \mu\text{m}^2$				Relative Error %	Testing result
	Length cm	Diameter cm			1	2	3	average		
A47	2.493	2.478	0.227	0.4	0.225	0.225	0.226	0.225	0.7	qualified
B47	2.479	2.483	0.900	0.4	0.901	0.903	0.900	0.901	-0.1	qualified
A38	2.497	2.466	0.610	0.4	0.610	0.610	0.610	0.61	0.0	qualified
C47	2.526	2.536	9.440	0.4	9.41	9.43	9.42	9.42	0.2	qualified
D47	2.497	2.508	35.40	0.4	35.5	35.4	35.4	35.4	-0.1	qualified

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## 5. Conclusion

5.1 The designed and developed entire diameter rock gas permeability testing calibrating device applies for the calibrating of various specification rock permeability testing device known at home and abroad, solved one of the big technical problems which having troubled rock permeability recently in oil/gas fields, achieved the nationalization of value calibrating of standard samples and rock permeability testing

devices, the value can be traced to standard material of National Second-Level.

5.2 The success of the research into this calibrating device and calibrating method, have solved the value of the big diameter rock samples permeability of various specifications and of the porosity tracing to source, ensuring the accuracy and the reliability of the testing results, which can meet the scientific research and the requirements of the comparison of

international analysis data.

5.3 The entire diameter rock gas permeability testing calibrating device has granted the patent of practical new style invention in china, and its calibrating method is the pioneer in china through patent document index, it has been applied for the patent, the method is scientific and a creation technology with independent knowledge property.

5.4 The success of the research in this installation and calibrating method, gives the technical support to develop rock physical nature testing technology in china, and can meet the different needs in exploration and development in oil/gas fields better, only for one item, to send the standard material abroad for recalibrating can save 40,000 dollars one year. This technology also created the material condition for our development of the standard material of the national rock permeability testing of various specifications, and can get well social economic efficiency.

## Reference

- [1]Huang Futang. 1994, 67-69, Core Analysis Handbook, Beijing, Petroleum Industry Publishing House
- [2]Cheng Xianmei, Pan Hao. 2003-8-13, The Entire Diameter Rock Gas Permeability Testing Calibrating Device [p] Patent in China:02204325.X

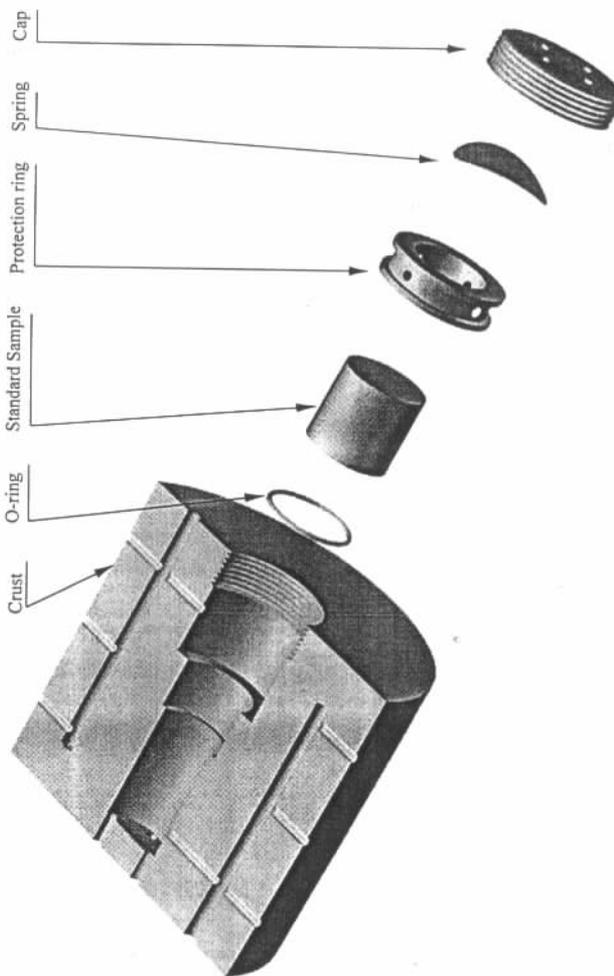


Chart 1 A solid decompose chart of the entire diameter rock gas permeability testing calibrating device

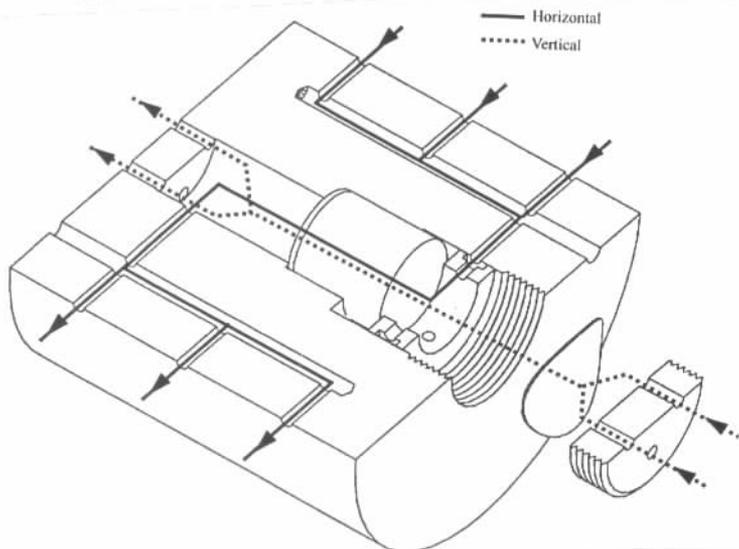


Chart 2 Sketch map of flowing gas in testing