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Standard for exploration and evaluation of hydrogeology, engineering geology and environment geology in coal beds

煤矿床水文地质、工程地质及环境地质勘查评价标准

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Standard for exploration and evaluation of hydrogeology, engineering geology and environment geology in coal beds

1 Scope

This standard specifies the basic guidelines for hydrogeological, engineering, and environmental geological work in the geological exploration of coal resources; it focuses on the technical requirements and working methods of the exploration.

This standard is applicable to the design and preparation, exploration and construction, geological research, geological report preparation and review, resource / reserve evaluation, mining right assessment, feasibility study at each stage of geological exploration of coal resources.

2 Normative references

The provisions in following documents become the provisions of this Standard through reference in this Standard. For the dated references, the subsequent amendments (excluding corrections) or revisions do not apply to this Standard; however, parties who reach an agreement based on this Standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB 3838 Environmental quality standards for surface water

GB 12719 Exploration specification of hydrogeology and engineering geology in mining areas

GB/T 14158 Survey code for regional hydrogeology, engineering geology and environmental geology

GB/T 14848 Quality standard for ground water

GB 50027 Standard for hydrogeological investigation of water-supply

DZ/T 0080 Specifications for geophysical logging of coal

DZ/T 0215 Specifications for coal, peat exploration

5 Hydrogeological exploration and evaluation

5.1 Degree of work

Pre-exploration stage: Hydrogeological work is generally not carried out.

General exploration stage: Roughly understand the hydrogeological conditions of the exploration area. Evaluate the economic significance of coal resources and the possibility of development and construction.

Detailed investigation stage: Basically, identify the hydrogeological conditions of the exploration area, evaluate the hydrogeological conditions that may affect the development and construction of the mining area, provide a basis for the overall development planning of the mining area.

Exploration stage: Detailed identification of the hydrological and geological conditions of the mine field, evaluation of the mine water-filling factors, budgeting of water yield at the pre-mined mining area, prediction of the possibility and location of water yield during the mining process, comment on possible changes in hydrogeological conditions after mining, evaluation of the utilization possibility and approach of mining water, provide geological data for the feasibility study and preliminary design of the mine construction.

5.2 Classification of hydrogeological exploration types

5.2.1 Well engineering coal mine

5.2.1.1 According to the characteristics of the water-containing space of the directly filling aquifer, the hydrogeological exploration of the coal bed is divided into three categories:

a) The first category, ore deposits dominated by loose pore aquifers, which are called pore-filled ore deposits;

b) The second category, ore deposits dominated by clastic rock aquifers, which are called fissure filling deposits;

c) The third category, ore deposits dominated by carbonate karst aquifers, which are called karst filling deposits. It is further divided into two sub-types according to their filling methods:

1) The first sub-category, karst filling deposits dominated by water yield from roof;

b) The unit water yield of directly filled aquifer is q < 1.0 L / (s • m), without strong water-rich rock formations that are difficult to drain.

5.2.2.2 Type II has medium hydrogeological conditions and easy to dry out:

a) The unit water yield of directly filled aquifer is 1.0 g / (s • m) ≤ q ≤ 10 L / (s • m), the aquifer is weak in water-richness;

b) The unit water yield of directly filled aquifer is 10.0 L / (s • m) < q ≤ 20.0 L / (s • m), but the recharge source is lacking.

5.2.2.3 Type III deposits have complicated hydrogeological conditions and difficult to dry out:

a) The unit water yield of directly filled aquifer is q > 10.0 L / (s • m), there is a large surface water body nearby and it is hydraulically connected to groundwater; or although the recharge conditions are not good, q > 20.0 L / (s • m);

b) Open-air direct filling aquifers are thick, widely distributed, has strong water-richness, which are prone to engineering geological problems such as quicksand and difficult to dry out.

5.3 Problems to be identified for various types of filling deposits

5.3.1 Pore-filled ore deposits

It shall focus on identifying the types of aquifers, distribution, lithology, thickness, depth, structure, grain size, roundness, sortability, cementation degree, water-richness, permeability, changes; identify the spatial distribution of quicksand layers and characteristics, the combined relationship of aquifers (water barriers), the hydraulic connection between aquifers, aquifers and weakly permeable layers, and surface water; evaluate the dredging conditions of quicksand layers and the effects of precipitation and surface water on mining of deposit.

5.3.2 Fissure-filed deposits

It shall emphatically investigate the thickness, depth, fissure properties, scale, development degree, distribution rules, filling conditions and water-richness of fractured aquifers; depth and weathering degree of rock weathering zone; the nature, shape and scale of tectonic fracture zone and its hydraulic connection with aquifers and surface water; the combined characteristics and proportion of fractured aquifers and their relative aquifers.

damage of the fault structure on the integrity of floor; analyze and demonstrate the segment which may produce lots of heaving floor and water yield.

5.4 Principles and quantity of exploration project layout

5.4.1 Layout principles of exploration project

5.4.1.1 Hydrogeological exploration in the exploration area (well) shall be carried out in combination with geological exploration. Hydrogeological exploration work shall, based on the study of geological and regional hydrogeological conditions, consider the thickness of aquifers, water-richness, water conductivity, recharge and drainage conditions, the way to fill the mine as a whole for investigation and research. For large water mining areas with complex hydrogeological conditions (well-fields that flood more than 100000 m^3 every day and night), the scope of work should be expanded to a complete hydrological unit.

5.4.1.2 The hydrogeological exploration must be based on the type of coal mine hydrogeology and the specific conditions of the exploration area. It shall clarify the issues that shall be focused on in this work, comprehensively use various exploration techniques (including drilling simple hydrogeology-engineering geological observation, hydrogeological survey and mapping, hydrogeological exploration, hydrogeological drilling, pumping test, long-term observation and sampling, other effective means) according to local conditions.

5.4.1.3 In general, dynamic observation shall be carried out for various filling deposits. Large water well fields (mining areas) with complex hydrogeological conditions shall establish a long-term observation network for groundwater dynamics.

5.4.1.4 Pumping test drilling during the exploration stage shall, based on the needs of the mine construction, be arranged in the initial mining area or in the early mining area, close to the segment wherein the direct filling aquifer is strong in water-richness and the fracture is well developed or close to the recharge boundary.

5.4.1.5 Pumping tests for groups of wells (interference well) with large flow rates and large drop depths shall be arranged in strong water-richness segments under the conditions that the natural flow field of groundwater has been controlled. The layout of the observation holes shall control different boundary conditions, incoming water directions, strong runoff zones, each runoff zoning, pay attention to regional control.

5.4.1.6 The pumping test of the fault zone shall, based on the development of the fault structure and the hydrogeological characteristics of the well field

5.5 Hydrogeological survey and mapping

Hydrogeological survey and mapping is divided into region and exploration areas. The scope of regional hydrogeological survey and mapping shall include a complete hydrogeological unit, focusing on identifying regional groundwater recharge, runoff, drainage conditions. Mining areas with simple hydrogeological conditions may not require regional hydrogeological survey and mapping. Hydrogeological survey and mapping of the mining area shall include the scope of the potential impact of the dredging of the deposit and the boundary of the recharge; the focus shall be on identifying the water-filling factors of the deposit and the hydrogeological boundary of the mining area. Regional hydrogeological survey and mapping is performed in accordance with GB/T 14158.

5.5.1 General requirements

5.5.1.1 The scale of hydrogeological survey and mapping shall be determined according to the stage of coal resource exploration and the complexity of hydrogeological conditions. Generally, it is 1:50000 to 1:25000 in the pre-exploration stage, general exploration stage, detailed exploration stage; 1:10000 to 1:5000 in the exploration stage.

5.5.1.2 Hydrogeological survey and mapping shall be based on the comprehensive collection of hydrological and meteorological data over the years in the mining area and adjacent areas, to carry out the following hydrogeological survey and mapping work:

a) Topographic features of the mining area, genetic types, lithological characteristics and distribution of Quaternary sediments;

b) The number of layers of aquifers (water barriers), lithology, thickness, occurrence, distribution range; the development of aquifer cracks, karst caves, water-richness, water resistance property of water barriers;

c) Groundwater recharge, runoff, drainage conditions, physical properties and chemical composition of groundwater, the hydraulic connections between aquifers and with surface water, delineation of hydrogeological boundaries of the mining area;

d) The elevation, stratum, lithology, way of exposure of springs and wells; the measured flow, water level, water temperature, physical and chemical properties of water, their dynamic changes;

e) The distribution of surface water, the elevation of flat water level and flood level, the extent and duration of flood inundation, the depth, area and storage capacity of surface water (such as reservoirs, ponds, etc.) that have an impact on mining;

extremely developed and prone to water leakage, it shall conduct statistics of the fissure rate; for fissure filling deposits which use where atmospheric precipitation and old well water as the main recharge sources, it shall collect the detailed data of the rainfall and rainfall intensity, pay attention to investigate the lithology, mechanical properties, groundwater level elevation of the coal seam's roof cover, whether there is a thick plastic aquifer cover (such as clay, kaolin, mudstone), the development of surface vegetation, the size of the slope angle, the cut degree of the ditch and its direction, delineate the catchment area and direct permeability zone and permeability of the mining area. Use the method of equilibrium observation of small watersheds to determine the atmospheric precipitation's infiltration coefficient, carry out detailed investigation of the development degree of the ground subsidence fissure and the distribution of spring water and its water quality changes in the old well mining area.

5.5.1.6 The karst-filling ore deposit shall focus on investigating the various morphology and geomorphology of karst, ascertaining the relationship between karst development and factors such as lithology and structure, as well as the distribution of karst in space, filling degree, water-richness and changes. The karst filling deposits mainly composed of karst gaps and karst caves shall be investigated for the lithology, structure, thickness of the overlying loose layer, or the thickness, weathering degree, and physical properties of the overlying rock weathering layer. Analyze the possibility of water yield, sand collapse, ground subsidence, degree of subsidence, distribution range and impact on pit water filling under neglected drainage conditions. For layered karst filling deposits, it shall also investigate the distribution of relative aquifers and weak aquifers.

5.5.2 Working methods

5.5.2.1 Before the survey and mapping work is carried out, it shall collect and study the past data of the exploration area and adjacent areas in detail, carry out site exploration, compare the design document according to the tasks in the exploration stage. The design document shall explain the purpose and task of survey and mapping, the scope of work, the requirements of the degree of work, the main working methods, the workload, the time and measures to complete the survey and mapping work. The design document can only work after being approved by the relevant superior or organization.

5.5.2.2 After entering the exploration area, first select the sections with good outcrop conditions and hydrogeological significance, measure the hydrogeological reference profile, study the stratigraphic sequence, contact relationship, and aquifer level, lithology, thickness, water content, karst and fissure development, describe the groundwater outcrop point.

5.5.2.3 The observation route of hydrogeological survey and mapping shall be

5.6.1.3 The use of the geophysical prospecting method may detect the following contents:

a) The thickness of the overburden layer, the spatial location of the hidden ancient river bed and the buried alluvial fan;

b) The lack of "skylights" and the thickness and water-richness of the gravel layer in the clay layer at the bottom of the Cenozoic;

c) The occurrence, spatial location and water-richness of geological structures such as faults, subsidence columns, fissure zones, rock veins;

d) Aquifers on the roof and floor of coal seams and the water-richness;

e) The spatial location of the old empty area and the situation of standing water;

f) The interface and distribution range of groundwater soluble solids, salt water, and freshwater;

g) The location of underground rivers and the distribution of hidden karsts;

h) The lower burial depth of the permafrost;

i) Groundwater level, flow direction and infiltration rate.

5.6.1.4 The arrangement of geophysical prospecting work, the determination of parameters, the number of inspection points and the repeated measurement errors shall comply with the provisions of MT/T 897 and MT/T 898.

5.6.1.5 Hydrological drilling shall be carried out for hydrological logging. It may carry out flow logging and ultrasonic imaging in areas where conditions permit, combining with the core drilling to divide the aquifer and water-impermeable layers, to provide the basis for obtaining relevant parameters.

5.6.1.6 For the geophysical prospecting data, comprehensive analysis shall be made in combination with the geological characteristics of the deposit and hydrogeological conditions, to propose the hydrogeological results.

5.6.2 Working methods

5.6.2.1 Surface geophysical prospecting

5.6.2.1.1 In the hydrogeological exploration, the surface geophysical prospecting methods mainly include the resistivity method, natural electric field method, charging method, frequency sounding method, induced polarization method, magneto-telluric method, seismic method.

corresponding comprehensive results drawings.

5.7 Simple hydrological and geological observations of borehole

5.7.1 General requirements

5.7.1.1 The simple hydrogeological observation of borehole is to use geological drilling observations to record data related to hydrogeology. The results are not only an important basis for studying and evaluating the hydrogeological conditions in the exploration area, but also the basis for rationally laying out specialized hydrogeological boreholes.

5.7.1.2 Boreholes for simple hydrogeological observations shall observe and record in detail the layer and depth where the phenomena such as water surge (leak), block loss, hole collapse, diameter reduction (expansion), gas escape, sand yield, drill drop, abnormal water temperature, etc. occur during drilling; measure the amount of yield (leaking) water; if necessary, it shall measure the approximate stable water level and perform a simple discharge (injection) water test.

5.7.1.3 Describe the core lithology, constructional structure, fracture properties, density, aquifer thickness, depth, weathering degree and depth of rock, karst form, size, filling condition, development depth, statistics of fracture rate, karst rate.

5.7.1.4 The drilling of a single aquifer (group) shall determine the approximate stable water level of the final borehole.

5.7.1.5 According to the specific hydrogeological conditions of the exploration area, when selecting the observation interval or observation content, it shall be proposed in the exploration design and specified in the borehole design (technical instruction).

5.7.1.6 For boreholes that requires consumption observation, the circulation system of flushing fluid shall comply with the drilling regulations; it shall conduct the inspection and acceptance before drilling, to guarantee the quality of observation results.

5.7.1.7 When leakage is found and needs to be blocked during the drilling process, it shall make detailed records for the depth of the starting and stoppage and the method, material, time, and effect.

5.7.2 Observation methods

a) Observation once every 1 h, no change in water level for 2 consecutive hours;

b) The water level changes in a single direction, the water level difference within 1 h does not exceed 5 cm; it has been continuously observed for 3 h;

c) The water level changes in a zigzag manner, the water level difference within 1 h does not exceed 10 cm; it has been continuously observed for 3 h;

d) Although the above requirements are not met, the total observation time has exceeded 24 hours.

5.7.3 Data arrangement

5.7.3.1 The original records of the simple hydrological and geological observations of the borehole shall be timely and true, which shall not be recorded afterwards. The observations must be complete and the records must be clear and not altered.

5.7.3.2 The results of simple hydrological and geological observations of boreholes shall be arranged in time; the following data shall be provided:

a) Raw records of simple hydrogeological observations of boreholes;

b) Simple hydrogeological histogram of boreholes;

c) Statistical table of simple hydrogeological observations of boreholes.

5.7.3.3 According to the hydrogeological conditions of the exploration area, the necessary analysis maps are to be prepared as follows:

a) Zoning (segmentation) map of main aquifer’s consumption;

b) Change of thickness of main impervious rock formations;

c) Aquifer contour map.

5.8 Pumping test

5.8.1 General requirements

5.8.1.1 Pumping test is an important means for geological exploration of coal resources. Its purpose is to study the important hydrogeological characteristics of aquifers, obtain the aquifer's hydrogeological parameters, evaluate the aquifer's water-richness, provide data for estimating the water yield from the make a formal record. The water-stop inspection is performed before and after the borehole is swept by the water-stop closure. The change of water level in the pipe shall be less than 2 cm/h and maintained continuously for 3 hours.

5.8.1.10 If the water pumped out of the borehole by the pumping test is likely to seep into the aquifer again, measures must be taken to prevent leakage.

5.8.1.11 The filter shall be selected according to the lithology, crushing degree and particle composition of the aquifer. The pores on the filter shall be evenly distributed; the porosity is generally not less than 20%. Where a wound or bandaged filter is used, metal ribs shall be welded on the outer wall. The rib spacing selection shall be based on the principle that the filter screen does not contact the filter pipe.

5.8.1.12 The work design document must reach the machine crew before drilling construction; it shall explain to the construction crew the quality requirements for construction, principles of pumping tests, recording methods and precautions.

5.8.1.13 Before the pumping test, it shall thoroughly check the installation quality of the pumping equipment, various test instruments and tools for measuring water level, water volume, and water temperature, as well as the preparation of the original record form.

5.8.1.14 The pumping test method is divided into two types: stable flow and unsteady flow, which can be selected according to the generalized hydrogeological model and hydrogeological parameter calculation requirements.

5.8.1.15 After the end of the pumping test, acceptance ratings shall be made in accordance with the current quality standards in a timely manner.

5.8.2 Stable flow pumping test

5.8.2.1 Test pumping

5.8.2.1.1 Test pumping shall be carried out before formal pumping. Before the test pumping, the pumping layer (segment) shall be repeatedly pumped until the water from the borehole is clear and free of sediment. When washing the boreholes in the loose layer, pay attention to observe and record the particle size and volume of the washed-out sand, as well as the time and flow of the water from turbid to clear.

5.8.2.1.2 The test pumping shall be subjected to a maximum water level drop, to preliminarily understand the relationship between the water level reduction value and the amount of yield, in order to reasonably select the water level drop during formal pumping. All data on the test pumping process must be officially and the interruption time does not exceed 1 h, the pumping time before the interruption can still be counted into the extension time, otherwise it will be void. During the interruption of pumping time, it shall follow the requirements for observing stable (static) water level to observe the water level (including the observation hole), until the pumping is resumed.

5.8.2.2.7 The measurement of water temperature and air temperature should be observed at the same time every 2 h ~ 4 h during the pumping process. The accuracy requirement is 0.5 °C. When abnormal water temperature is found, well temperature shall be measured after pumping.

When measuring temperature, the thermometer shall be placed in a place where the air is unobstructed and shaded. It is strictly prohibited to place it in direct sunlight and other places where the temperature changes.

5.8.2.2.8 During the pumping process, it must draw the Q = j (S) and q = f (S) curves at any time, in order to find and correct errors in pumping in time.

5.8.2.2.9 Water samples shall be taken according to the design requirements before the end of the last depth drop.

5.8.2.3 Relative error requirements for fluctuations in water level and flow during stable time

5.8.2.3.1 When the water level's drop depth is greater than 5 m, the relative error of the main hole's water level fluctuation is not greater than 1%; when it is less than 5 m, the change of the water level of the main hole is less than 5 cm. The change of the water level of the observation hole is less than 2 cm. When the burial depth of the water level is greater than 100 m, it can be appropriately relaxed as appropriate.

5.8.2.3.2 Relative error of flow fluctuation: q ≥ 0.01 L / (s • m), not more than 3%; q < 0.01 L / (s • m), not more than 5%.

5.8.2.3.3 The calculation method of relative error of water level drop and flow fluctuation during stable time is as follows:

Relative error of fluctuation = (maximum difference between observation and average value / average value) x 100%

5.8.2.4 Observation requirements for stationary and restored water levels

5.8.2.4.1 Before and after the formal pumping, the pumping holes and observation holes shall be subject to the observation of stationary and restored water levels.

5.8.2.4.2 At the beginning of restoring the observation of water level, it is drop pumping. When pumping at a constant flow rate, the required change in flow rate is generally not greater than 3%; when pumping at a fixed drop, the water level's change rate is generally not more than 1%. Unsteady flow pumping shall generally use submersible pumps or deep well pumps.

5.8.3.2 For the water level drop of the unsteady flow pumping test, the equipment capacity shall be used to perform one maximum drop, which is generally not less than 9 m. If the amount of yield water is greater than 140 m^3/h, the minimum drop depth shall not be less than 3 m when the drop cannot meet the above requirements due to conditions. When the water column above the bottom of the aquifer is less than 10 m, the maximum drop of the water level shall exceed 1/2 of the height of the water column.

5.8.3.3 Observation of water level and flow should be performed according to the time sequence of 1, 2, 3, 4, 6, 8, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100, 120 minutes after the start of pumping. The observation can be performed once every 30 minutes afterwards until the end. The observation hole's water level is observed simultaneously with the main hole.

5.8.3.4 The duration of pumping shall be determined according to the purpose of the test by referring to the water level drop - time semi-logarithmic curve S (or *h*)-lg*t* form. When the curve appears asymptotically with a fixed slope, the observation time shall be continued for a logarithmic period. When there is cross-current recharge, the observation time needs to reach the point when the curve passes the inflection point and becomes horizontal; when there is an observation hole, it shall be determined by the S (or *h*)-lg*t* curve of the representative observation hole.

5.8.3.5 When the pumping is interrupted for any reason before the pumping has achieved its purpose, the recovered water level shall be observed and the pumping shall be resumed after the water level has stabilized.

5.8.3.6 The requirements for the observation of the stationary water level and the restored water level during the pumping test at unsteady flow refer to 5.8.2.4.

5.8.4 Multiple-hole and group hole pumping test

5.8.4.1 Generally, large-diameter drilling is suitable for the main pumping hole for multi-hole and group-hole pumping tests.

5.8.4.1.1 Large-scale pumping tests should be carried out in the later stages of exploration. It must be based on obtaining hydrogeological conditions, natural flow fields and dynamic changes in the mining area.

5.8.4.1.2 Drop depth of water level, number of drops and duration of water dropping are determined according to hydrogeological conditions of the mining area, test purpose and calculation method. The amount of pumped water shall recharge). The sand content shall be determined if necessary. Refer to Appendix K for section selection and observation methods.

5.9.1.4 For ponds, lakes, inundated waterlogging and subsidence catchment areas, it shall select an easy-to-observe places to establish fixed stakes and water gauges; measure water depth, water accumulation range, water accumulation time; calculate the amount of water accumulation. When there are reservoirs near the exploration area, it shall collect the data such as the water level elevation, water depth, dam height, catchment area, reservoir capacity, water quality, leakage of the reservoir. For the surface seepage segment within the exploration area, the observation shall be made during the rainy season, record its range, estimate the leakage amount.

5.9.1.5 The arrangement of boreholes for groundwater dynamic observation shall be based on the principle of controlling the groundwater flow field and various boundaries and the flowing direction of pollution sources. When conditions permit, it may use such advanced equipment as telemetry and automatic observation systems. Observation of water temperature shall consider the effect of lag.

5.9.1.6 For the flow observation of artesian boreholes, springs, old well and underground dark river outlets, it generally uses the volume method, weir measurement method, flow meter. A simple pumping test may be carried out, if necessary, in the observation of private wells. The simple pumping shall form a certain head drop, until the water level is stable for 2 h.

5.9.1.7 Observation of production mines is mainly based on collecting observation data of mines. If necessary, observations can be made at the water outlets of the main aquifers passing through the laneway. For the water outlets exposed by the laneway, when the water outlet changes greatly, it shall be observed intensively, meanwhile it shall observe other water outlets underground and long-term observation points at surface.

5.9.1.8 If there are system dynamic observation data of adjacent wells with similar hydrogeological conditions, the work quantity of dynamic observation in the area can be reduced or not required.

5.9.2 Water sampling

5.9.2.1 Water samples are divided into simple analysis samples, full analysis samples, bacterial test samples, special analysis samples, isotope samples according to their analysis purposes and contents. General requirements for the quantity of various water samples: simple analysis sample 1 L ~ 1.5 L, full analysis sample 2.5 L, bacterial test sample 0.5 L, special analysis sample 5 L, isotope analysis sample 1 L.

5.9.2.2 Water samples from long-term observation points (stations) are

5.9.2.9.1 Simple analysis: Analyze the physical properties of water, total hardness, dry residue, pH value, chloride ion, sulfate, bicarbonate, nitrate, calcium, magnesium, iron ion, etc.

5.9.2.9.2 Full analysis: In addition to simple analysis items, it shall also analyze such items as temporary and permanent hardness of water, free and fixed and aggressive carbon dioxide, oxygen consumption and nitrite, carbonate, potassium, sodium, valence iron, aluminum, ammonium ion, potassium permanganate, silica, hydrogen sulfide, solids, alkalinity, etc.

5.9.2.9.3 Bacteria test: check the number of bacteria in 1 mL of water, determine the E. coli index, analyze infectious bacteria.

5.9.2.9.4 Special analysis: The analysis item depends on the purpose of sample analysis. Generally, it analyzes the content of rare and harmful ions such as copper, lead, zinc, arsenic, mercury, cobalt, uranium, fluorine, cadmium, cyanide in water, or carry out analysis according to the items specified for specific purposes.

5.9.2.9.5 Isotope testing: Select test items as required.

5.9.3 Data arrangement

5.9.3.1 The original records of field observations must be filled in carefully, the content is complete, clear, and not altered. All observation results must be sorted and checked on the same day. If there are any doubts or abnormalities, they shall be retested and corrected the next day. The original records shall be sorted and bound in time.

5.9.3.2 All observation and exploration data shall be carefully analyzed and researched and incorporated into relevant chapters and drawings of the geological report.

5.9.3.3 According to the observation content, it generally requires preparing and submitting the following charts:

a) Comprehensive curve of dynamic changes (including water level, flow, precipitation, evaporation, water temperature, air temperature, etc.);

b) Groundwater table contour (isobar chart);

c) Hydro-chemical maps;

d) Dynamic observation statistics;

e) Water quality chemical analysis results;

f) Relation curve diagram of production mine drainage and related factors

6 Engineering geological exploration and evaluation

6.1 Exploration types

6.1.1 According to the engineering geological characteristics of coal seams and surrounding rocks as well as the layer where main engineering geological problems occur, it is divided into three categories:

The first category is loose and weak rock, which is dominated by Quaternary sand, gravel and clay, or rocks dominated by tertiary weakly cemented sandy and clay rock. The stability of the rock mass depends on the lithology, the stratum structure, the condition of saturation; the stability is poor. The exploration shall focus on ascertaining the lithology, structure, physical and mechanical characteristics of the rock (soil) mass.

The second category is massive rock, which is dominated by igneous rocks and crystalline metamorphic rocks. It is in block structure; the stability of rock mass depends on the development degree of tectonic fracture zone, alteration zone and weathering zone. Generally, the stability of rock mass is good. The exploration shall focus on ascertaining the distribution, production, extension, filling, roughness, combination relationship of the levels II and III structural planes (Appendix B), the width and fragmentation degree of the alteration zone, the depth of the weathering zone, the degree of weathering.

The third category is layered rocks, which is dominated by clastic rocks, sedimentary metamorphic rocks, volcanic sedimentary rocks, carbonate rocks. It is in layered structure, anisotropy of rock mass, large change in strength. The stability of rock mass is mainly determined by the weak surface between layers, weak interlayers, structural fragmentation and weathering degree of rock mass. The exploration shall focus on ascertaining the characteristics of rock formation combination, the location and quantity of weak interlayers, the mineral composition and thickness of clay, its hydraulic and physical and mechanical properties.

6.1.2 According to terrain, geomorphology, stratigraphic lithology, geological structure, weathering and karst development degree, quaternary cover thickness, groundwater hydrostatic pressure and other factors, the complexity of engineering geological exploration is divided into three types:

Simple type: The topography and landforms are simple; the topography is conducive to natural drainage. The lithology of the stratum is single, the geological structure is simple, the occurrence is gentle, the karst is not developed. The rock mass is dominated by whole block or thick-layered structure. The rock has a high strength and good stability. The rock mass is direction of the main structural lines, the distribution, occurrence, scale, and filling and water filling conditions of the structural planes at all levels; determine the level of the structural planes (Appendix B) and the major unfavorable dominant structural plane; point out its impact on coal seam mining.

6.2.2.1.3 Measure the physical and mechanical parameters of various rocks (soils) on the roof and floor of mineable coal seams and surrounding rocks of wells and laneways; find in detail the rock mass structure and rock mass quality; refer to Appendix C and F to evaluate the quality and stability of rock mass.

6.2.2.1.4 In high geo-stress areas with strong tectonic activity, when conditions permit, it shall make special geo-stress measurements to determine the direction and magnitude of the maximum principal stress.

6.2.2.1.5 To enlarge and deepen the exploration of mining area, it is necessary to investigate in detail various engineering geological problems that have occurred in the mining of the deposit, to find out the conditions and causes, to carry out corresponding work on the possible engineering geological problems that may arise from the enlarging and deepening process.

6.2.2.2 Open-pit mining

6.2.2.2.1 In addition to meeting the above-mentioned corresponding requirements for well-drilling, in the exploration stage, it shall also meet the relevant requirements for exploration of slope and peeling strength.

6.2.2.2.2 Slope exploration:

a) Loose rock (soil) slopes: Find out the lithology, thickness, structure of the rock (soil) layer; the mineral composition, content, distribution range, physical and mechanical properties (especially shear resistance) and water-physical property of the clay rock; the hydraulic pressure and permeability of the aquifer; the location and characteristics of the rock layer interface with significant differences in mechanical strength;

b) Stratified rock slopes: Identify the layers, lithologies, thicknesses, occurrences, distributions of weak interlayers; mineral composition, content, physical mechanics, and water-physical properties of clay mineral; the development degree and combination of various structural planes; hydraulic pressure of the aquifer, etc.;

c) Massive rock slopes: Find out the occurrence of the slopes and various structural planes, the combination relationship, the development degree of the structural planes, the composition, distribution and physical and mechanical properties of the fillings.

6.2.2.2.3 Exploration of strength of exfoliation:

6.4.5.3.4 The sampling specifications and quantity can be determined according to the specific requirements of the laboratory.

6.5 Engineering geological evaluation

6.5.1 Evaluation requirements

Engineering geological evaluation shall be based on the identification of engineering geological conditions in combination with mining methods, to give qualitative and semi-quantitative predictions of slope stability or the quality of coal seam roofs & floors and surrounding rock masses.

6.5.2 Evaluation of slope stability

6.5.2.1 Evaluation of the stability of hard and semi-hard rock * slopes; according to the combination relationship between the slope and various structural planes, as well as the condition of weak interlayers, analyze and predict the segments, ranges, deformation properties of the slope that may slide and deform, the possible positions of the sliding surface and the cutting surface; according to needs, use the analogy and empirical data method to recommend the final slope angle.

* According to the uniaxial ultimate compressive strength (R) of the rock, the rock strength is divided into hard R ≥ 60 MPa; semi-hard 60 MPa ~ 30 MPa; weak R ≤ 30 MPa.

6.5.2.2 Stability evaluation of loose weak rock slopes: Generally, the proposed stope is divided into different engineering geological regions, to carry out the stability evaluation by zones. It shall use the test results of rock and soil samples and the actual data of adjacent open-pit coal mines, to recommend the final slope angle. For slopes with saturated sand layers, it shall carry out special pre-draining tests and saturated shear tests as required. Based on the tests, recommend the slope angle.

6.5.3 Evaluation of rock mass of roof and floor of coal seam and surrounding rock

It should use two methods for comparison and evaluation. The commonly used methods are rock mass quality coefficient method and rock mass quality designation method.

6.5.3.1 Rock mass quality coefficient (Z) method: Use the formula (4) to calculate the rock mass quality coefficient Z. Use the Table C.2 in Appendix C to determine the quality of the rock mass.

$$Z = IfS \qquad \cdots\cdots (4)$$

engineering geological explorations, identify initially the environmental geological background and current status of the exploration area and the main environmental geological problems exist; study the inducing factors, active laws and harmful degrees of adverse geological phenomena; take representative samples of the existing pollution sources (substances) in the exploration area analysis and testing; make a preliminary assessment of the environmental geology of the exploration area.

7.1.5 Exploration stage: Basically identify the environmental geological background and status quo in the coal mine area and the main environmental geological problems; focus on the environmental geological problems related to coal mine development activities; study the adverse geological phenomena and ecological impacts that may arise from coal development; put forward to corresponding prevention suggestions.

7.2 Environmental geological investigation

7.2.1 Regional stability investigation: collect historical seismic data near the exploration area; investigate the geological structure and new tectonic activity; analyze whether there are active faults.

7.2.2 Investigate the social environment, ecological environment and natural geographical environment (tourist area, cultural relics protection area, nature protection area, etc.) where the exploration area is located.

7.2.3 Investigation of the exploration area

a) Investigate and collect the environmental background value (primary pollution value) or control value of surface water and groundwater;

b) Conduct field investigation of landslides, land collapse, flash floods, mudslides, and other physical geological phenomena and ground buildings and land resource pollution in the area affected by the development;

c) Investigate the occurrence status, content, distribution law and influence of substances that may become pollution sources in geological bodies;

d) Where there is hot (gas) water in the investigation area, it shall find out the distribution, control factors, water temperature, flow rate, gas in water and chemical composition; understand the conditions for recharge, runoff, drainage of hot (gas) water;

e) According to the corresponding requirements of DZ/T 0215, select boreholes for ground temperature measurement, to determine the constant temperature zone’s depth, temperature and ground temperature

When conducting environmental geological investigation, areas with conditions shall adopt comprehensive methods including remote sensing technology.

7.2.6 Geophysical exploration

7.2.6.1 Geophysical exploration (hereinafter referred to as geophysical prospecting) shall be carried out in close combination with other methods. It shall be determined based on factors such as the geological environmental conditions of the exploration area, the physical characteristics of the geological body, the main environmental geological problems to be identified. The focus is on locations that are difficult to judge on the surface but need to be addressed.

7.2.6.2 The geophysical prospecting mainly identifies the following environmental geological problems:

a) The location, scope, area of damage to the aquifer and water barrier by human engineering activities as well as the water-containing and barrier properties;

b) The spatial distribution of the landslide, the geological structure and the burial of the landslide bed;

c) The distribution location and scope of the goaf, the old well, and the karst subsidence columns, as well as their water filling conditions;

d) Variations of groundwater level and groundwater mineralization, saltwater distribution range, interface of saltwater and freshwater, etc.

7.3 Environmental geological assessment

7.3.1 Evaluation of regional stability

According to the activity of the fault and the engineering geological conditions, initially clarify the regional stability and its impact on the engineering buildings.

7.3.2 Evaluation of water environmental quality

7.3.2.1 Basic evaluation: Evaluate the approximate natural state (or the surface, groundwater material combination and its geological environment background status) before being damaged by pollution.

7.3.2.2 Evaluation of the status quo: Semi-quantitative evaluation of the impact of human engineering activities on the surface, groundwater quality, water volume, as well as the possible environmental hydrogeological problems.

7.3.2.3 Evaluation methods: Background value comparison method, pollution source comparison method, standard comparison method, water quality index

K.5.1.1 For each flow measurement, it shall make water depth measurement on all velocimetry vertical lines of the flow measurement section at the same time. For each vertical line, it shall continuously take more than two readings and take the average.

K.5.1.2 The distribution of velocity measurement points (including location and number) on the vertical line shall be determined based on the water depth and model of the velocimeter, taking into account the wind and waves, the composition of the bottom of the river bed, water regime and ice regime. Generally, it may refer to the requirements of Table K.2.

K.5.1.3 The duration of the speed measurement at each measuring point is generally not less than 100 s. Such duration may be shortened appropriately in the flood period, but it shall be not less than 50 s. When the river soars and falls or is seriously affected by floating objects and drift ice, it can be shortened to not less than 20 s. When the velocity pulsation is serious at the measurement point, it shall extend the speed measurement duration.

a) Selection of buoys: The buoys shall not be too smooth. The shape of the buoys can be cylindrical, cross-shaped or square. When the wind and waves are strong, it may attach heavy objects below, but the depth of the part below water shall be not more than 1/10 of the water depth. The buoys used during the day shall have prominent signs; during velocimetry in night-time, it shall be equipped with lighting equipment;

b) Arrangement of buoy: It can be released by measuring boat or buoy dispenser according to different river width and flow velocity. If the river is not wide, it can be launched directly by manpower. When it is launched, it shall be launched sequentially from one shore to the other. In order to grab the flood, it may launch the midstream first. Buoys shall be evenly distributed throughout the river. The number of effective buoys shall generally be 10 ~ 20, which may be appropriately increased or decreased depending on the width of the river. Where there is a single stream of water, there shall be not less than 3 ~ 5 effective buoys per stream of water.

K.5.2 Midstream buoy method

The midstream buoy method is used to measure the maximum flow velocity in the mainstream part of the river. It shall launch not less than 3 ~ 5 buoys (or floating objects) in one velocimetry. Select 2 ~ 3 effective buoys which have the shortest duration, run normally, have the difference of running duration of not more than 10% ~ 15%. Take the average of the flow velocity. If the number of effective buoys is insufficient, it shall launch additional buoys. The launching requirements are same as that for the water surface buoy method.

K.5.3 Small buoy method

a) Small buoys can be obtained from local materials, generally made of small wooden boards, wherein the part above the water surface shall be as small as possible;

b) The number of effective buoys as launched each time shall be not less

S - Water level drop, in meters (m);

B - Horizontal length of laneway, in meters (m);

h - Height of the water column from the dynamic water level to the floor permeable layer, in meters (m);

M - The thickness of aquifer, in meters (m);

R - Influence radius, in meters (m);

r_0 - “Big well” radius, in meters (m);

R_0 - “Big well” influence radius, in meters (m).

L.4 Water balance method

The water balance method is a method for obtaining the yield water in the mining area based on the principle of water balance, using the relationship between the recharge water and the consumed water of the directly-filling aquifer when the mining conditions of the deposit are ascertained.

Under the condition that the recharge conditions and recharge of the direct-filling aquifer are easy to find out, the equilibrium method can often obtain satisfactory calculation results.

The input item of the mine-filling aquifer generally consists of the following parts:

Q_1 - The amount of water that the atmospheric precipitation seeps into and recharges the aquifer, in cubic meters per day (m^3/d);

Q_2 - The amount of water flowing into the aquifer of the mining area from the same aquifer in other areas, in cubic meters per day (m^3/d);

Q_3 - The amount of water flowing into the filling aquifer from other aquifers in the mining area, in cubic meters per day (m^3/d);

Q_4 - The amount of surface water as seeped into the recharged aquifer, in cubic meters per day (m^3/d);

Q_5 - The amount of irrigation water, wastewater, artificial make-up water, drainage flowing into the aquifer of the mining area, in cubic meters per day (m^3/d).

The discharge of mine filling aquifer generally consists of the following parts:

Q_1' - The amount of water consumed by evaporation from the aquifer, in cubic meters per day (m^3/d);

Q_2' - The amount of water flowing from the aquifer of the mining area to the same layer in the periphery of the mining area, in cubic meters per day (m^3/d);

Q_3' - The amount of water flowing from the aquifer of the mining area to other

------ The End ------