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GENERAL GUIDELINES IN HEATING SYSTEM DESIGN IN CHINA

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ABSTRACT

A description of general guidelines in geothermal heating system design in China is presented in the following. The standard design deals with the geothermal resources evaluation, installation requirements of the well head equipments, different types of submersible pump houses, monitoring system, reinjection equipment, system of hot water supply, wordage in standards and making detailed explanation of the conventional sign specifications of geothermal utilization engineering.

1. INTRODUCTION

In recent years, geothermal utilization engineering in China has made considerable progress in technology. There has been created a series of new methods of geothermal utilization through technological innovation and process modification, improved resource utilization efficiency and the level of technology. The development and experience of the overall geothermal utilization technology makes geothermal utilization engineering in China ready for standardized development, for geothermal wellhead equipment, heating systems, water disposal facilities and utilization equipments, geothermal network monitoring system etc. It is essential to initiate standardization of technology as soon as possible, continuously perfect and normalize geothermal utilization market, and bring Chinese geothermal direct utilization up to world class level.

Iceland, the U.S.A., Japan and Italy have a great deal experience in geothermal utilization and have establish a perfectly standardized system for geothermal power generation and central heating systems, covering advanced technology and management. Chinese high-temperature geothermal resources are distributed in Tibet and Yun'nan with small scale geothermal power generation of about 30MW. With the improvement of the national economy, China began to compile Standards of Geothermal Power Generation in 2007. The China Ministry of Construction are responsibility for the geothermal projects. The China Power Company is involved in the majority of the work, and the Northeast Power Company of China takes care of the paper work. The Standards rigorously enforces and normalizes the designs of geothermal power generation, involving exploration of geothermal resource, technological design of power generation, control of corrosion and scaling, geological hazards, discharge requirement, and operating rules, etc. At present, the draft of the standards is being completed, and will be continuously perfected by soliciting to become more optimal.

Geothermal resources are distributed widely in Tianjin city, including about 250 geothermal wells in Tang, Han and Dagang, most of which are outside urban districts. Although administrative authorities have made some supervision, the quality and yield of geothermal wells are different, because technological designs fall behind and system designs are illogical and un-standardized. At the same time, the work carried out is often unacceptable, mostly because there' is no norm to follow, this makes the geothermal heating stations dissimilar with random installation of valves and pipelines. This arbitrary installation not only seriously violates a number of design specifications and requirements but also threatens the safety of operating personnel. Thus, it is necessary to establish a complete standardized industry design proposal.

Standardized design for the geothermal industry to effectively utilize geothermal resource are on their way and from now on the geothermal development and utilization will be according to standard, The standards will improve geothermal production, improve on environmental protection and sustainable development of geothermal resource.

2. MAIN CONTENTS OF THE STANDARDS

The standards include general principles and terms, geothermal engineering surveys, controls for corrosion and scaling, geothermal heating design units, geothermal heating system units, geothermal air conditioning system units, pump houses for geothermal wells, geothermal heating station units, geothermal heating terminal devices, geothermal hot water supply units, monitors and controls, environmental protection plans for geothermal development and utilization, plans for geothermal return irrigation, plans for dynamic monitoring of geothermal resources, guidelines for geothermal engineering, and testing methods and public acceptance.

2.1 Design Codes for Geothermal Pump House

2.1.1 Design requirements of ground pump house

Drainage channel in pump house should be installed to collect drainage from above-grade line water, equipment leakage and water from overhaul. The type of drain is determined according to working conditions (gravity drainage).

There must be a pressured drainpipe in the pump house. The drain-ability of the pressured drainpipe should be larger than the water output of the geothermal well. The tube for pressured drainage outlet should be 100mm above ground.

The well pump house should be equipped with anti-detonation lighting fixtures and ventilating & daylight windows.

For the convenience of lifting the well pump, an electric hoist should be placed under the roof of the pump house and the clearing height between the inner beam and the floor should be no less than 7.2m. In places with no electric hoist, a lifting hole of 2m by 2m should be made in the roof of the pump house, where a tripod or hydraulic crane can be used to lift the well pump, and the clearing height between the inner beam and the floor should then be no less than 3.0m. The lifting hole can be made in a movable covering plate. Waterproof of the roof is essential.

2.1.2 Design requirements of underground/semi-underground pump house

Pump house underground/semi-underground are required to have a well-pump-overhaul lifting hole in the roof, an access manhole, air intake openings and exhaust vents, and should be waterproofed.

The air intake tube should be 300mm above surface level and the exhaust tube 500mm above surface level. The outdoor part of the air intake/exhaust tube should have a rain and dust proof cap.
There should be warning signs in the vicinity of the air intake/exhaust tube on the outside of the pump house in case that passers-by stumble get near the tubes.

When a geothermal well is artesian or the geothermal water temperature exceeds 45°C and an escape way should be constructed from the pump house in order to guarantee the safety of installation and overhaul personnel.

Anti-detonation lighting fixtures or water tight sockets should be fitted in the pump house.

The pressured drainpipe inside the pump house should lead directly to the drainage system outside the well pump house.

According to engineering demand, waterproof wall bushing should be embedded in the proper positions in the pump house to allow for electrical installations.

The pump house should include a drainage sump. There is a submerged waste pump in the drainage sump with uninterrupted power supply. The start-up and closing of the submerged waste pump should be controlled by an automatic control device, i.e. a level controller.

The underground/semi-underground pump house should not have a stud less than 3.0m must not be built under other buildings.

2.2 Installation Requirements of Wellhead Equipment

The construction of a reinforced concrete foundation should be executed step by step according to work drawings. In the process of construction, the foundation of cast-iron is firstly cast into the concrete foundation, the foundation of the cast-iron should be level and the inclination should not exceed 0.20 degrees. When the demand of concrete curing is met, a packing set is embedded into the stuffing box. When the geothermal water temperature exceeds 100 °C, high-temperature black-lead packing is adopted. After packing the packing gland is install fastened by screws to apply even pressure to the packing gland. If possible, a torque spanner is used to apply identical pressure to each screw at a specific numerical value prescribed in the design requirement, so that the only degree of freedom is for the bore-tube, and to ensure a no-leakage guarantee. This is the key to the installation quality of the well head assembly and the customer must pay high attention to this step. After the above-mentioned procedures, the upper part of the well head assembly and water pump can be installed and hereafter the tubing and monitors for the well head assembly. The installation and adjustment are completed after the test run.

2.3 Water Lifting Equipment of Geothermal Well

The main geothermal well water lifting device should be a heat resistant, submerged, electrical pump. The selection principle is determined according to quality, quantity, temperature, variable water level, hydrostatic level of the water, and effluent pressure at the wellhead. The water quality determines the material for the pump.

2.4 Requirements of Surface Matching Technology of Reinjection System

To ensure return-irrigation quality and quantity the wellhead should adopt the following technologies and equipment.

2.4.1 Rough filter

The rough filter is used to filter larger relative diameter grains remaining in the pipeline and other parts of the system in order to lessen the working load on fine filter, to decrease the times of back flush, and to increase the service life of the filter. Operating requirements are as follows:

(1) Install pressure monitor on both ends of the rough filter in order to identify the working state of the filter according to pressure change, and determine the time of washing filter material to ensure filtration effect.
(2) Select filtering material to ensure temperature and pressure resistance.

2.4.2 Fine filter

The fine filter can effectively acquire or absorb a portion of microorganism and bacteria. Operating requirements are as follows:

(1) Suitable as secondary filter.
(2) Closely observe pressure change at both ends of the filter, and replace or back flush filter in order to ensure working quality.

The return irrigation system of the bedrock geothermal reservoir requires filtration treatment of the return irrigation water to remove suspended solid material. Filtration accuracy should be 50μm and the filtration may be one-stage filtration. For porous- geothermal reservoirs, the filtration accuracy of should be 3-5μm, and suspended particles and bacteria should be filtered at the same time. Rough and fine filtration should be combined.

2.4.3 Exhaust tank

An exhaust tank should be installed in front of the pressure pump and the return-irrigation wellhead in order to extract superfluous gas (such as methane and carbon dioxide) before return irrigation to avoid the formation of gas bubbles, due to pressure change and oxygen binding. Operating requirements are as follows:

(1) According to the gas composition in gas-sample analysis reports it should be determined whether to install an exhaust tank. Furthermore the scale and capacity of the exhaust tank should be estimated.
(2) While installing the exhaust tank, an automatic exhaust steam valve should be mounted on top of the tank in order to release volatile gas from the tank. Furthermore, an exhaust duct should be build to discharge released gas out of the equipment room.

2.5 Terminal Device of Geothermal Heating

For indirect geothermal supply systems, the method of selecting radiators is the same as for conventional heating. For direct geothermal supply systems, metal radiators are not applicable as terminal devices, due to risks of corrosion.

To increase the geothermal utilization rate, backwater temperatures must be decreased. The methods are as follows:

a. To adopt multi-stage series system;
b. To adopt low-temperature facilities, namely, fan coils and floor radiation heating.

2.6 Geothermal Hot Water Supply

2.6.1 Iron removal from geothermal water

Iron removal from geothermal water is generally carried out by oxidation processes, where ferrous iron is changed into ferric iron by an oxidant and then removed.

Natural-oxidation iron removal makes use of an oxidation reaction where oxygen is dissolved in the geothermal water to remove iron. Natural aeration is most economic, but the oxidation rate is very slow, and the reaction time is long, which is not favoured for heat preservation. Natural-manganese iron removal is a contact catalysis iron-removal technique, it catalyzes the oxidation reaction of ferrous iron in geothermal water, so that the oxidization rate is accelerated and not affected by the pH value of the geothermal water.

The water-gas jet pump iron removal system has the advantage of high oxygen dissolution, small operation area, low investment cost and wide use. The constraint hot-blast aeration tower iron removal system has a high oxygen dissolution efficiency, can remove carbon dioxide from the water, increase the pH value of the water but involves large investments and a large operation are.

2.6.2 Water supply network

The geothermal Hot-water supply system adopts either a single pipe system or a double pipe system. The single pipe system transports hot water to the customers and low temperature water is discharged. Double pipe systems supply hot water for heating, then the tail water returns through return pipes to be mixed with more geothermal water for supplying domestic hot-water.

The Pipe material of the water supply network should be selected according to quality and temperature of the geothermal water. For geothermal water with light corrosivety metal pipes will suffice but water and of high corrosivity should be made of non-metal pipes.

Burried piping of the hot-water networks is generally divided into non-compensating pipes and compensating pipes. The non-compensation piping can be applied to the domestic hot-water network, because of the low supply temperature. Compensation piping is used for transporting geothermal water of high temperature in non-metal pipes of high expansivity. However, the design should include additional devices compensating for thermal-expansion.

2.7 Dynamic Monitor of Geothermal Resource and Heating System

The dynamic monitor monitors dynamic and static parameters of geothermal wells, to assess the development of the geothermal resources and to keep the service condition optimal.

Because of the geothermal water's characteristics, the installation of the testing meters are constructed during installation, in order to ensure the accuracy of test data and the service life of the testing meter.

2.7.1 Assembling Method of Electromagnetic Flow-meter

Assembling the electromagnetic flow-meter on the main pipe is according to work drawings. The assembly of the electromagnetic flow-meter should conform to requirements, such as: The water flow and arrows should point in the same direction, and the rotary angular pitch should be less than 20 degrees.

If the electromagnetic flow-meter cannot be assembled according to drawings because of on-site conditions, the electromagnetic flow-meter should be assembled according to other installation methods shown on the product description. It is, however, a must that the electromagnetic flow-meter is assembled in front of all diversion conduits and equipment at the geothermal wellhead.

The electromagnetic flow-meter should be equipped with a calibration certificate from the manufacturer and should be calibrated periodically.

2.7.2 Assembling method of water level monitor

A test probe is installed together with a submerged electrical pump. The Probe should be fixed 1m below the position where the submerged electric pump is connected to the second column pipe. The test probe is fixed with a buckle with a rubber liner and it should not be too tightly fixed. The signal-line protective sleeve must be connected section by section to the pump line until the outgoing-line flange is reached at the wellhead.

During installation, the bottom of the test probe must not be hidden or blocked by any object, the sealing between the test probe and ventiduct wire must not be destroyed, and the test probe must not be handled recklessly.

The outgoing-line flange should be a pressed flange to ensure an air-tight space at the head in order to prevent air breakage which accelerates the well, pump and pipe corrosion, and to provide convenience for dismounting.

2.7.3 Assembling method of lower-machine installation

Installation of brackets to fix the casing: If the field conditions are bad or is the waterproofing is insufficient, a water-proof baffle should be installed on top of the casing.

It is important to ensure that the two brackets are level while the mounting casing bracket and the height of the two brackets should be suitable for maintenance.

2.7.4 Power requirement

The power requirement is a 220V AC power supply, and the power supply capacity should be larger than 500VA. Earth terminals should exist.

2.7.5 Installation requirements of the signal transmission line

The signal transmission line could include a common signal line or shielding signal line. The signal transmission line uses different colours to distinguish earth wires and signal lines of different sensors. Centralize wiring and all the lines should enter the connecting bridge. Open lines should not be permitted.

Communication modes, such as GPRS, ADSL or LAN should be available in the field. Multible communication network signal quality should be taken into account in the installation of the communication system. Radio communication in the shielding areas should be avoided.

2.8 Geothermal Heating Engineering Construction, Inspection and Acceptance

Geothermal engineering quality not only relates to design but also to construction. A qualified construction supervisor who has a strong sense of responsibility is crucial for the geothermal engineering inspection. A detailed inspection is important as the last "checkpoint" for the quality of the geothermal engineering.

3. WORDAGE IN THE STANDARDS

In establishing the standards, the wordage concerned in policies, technologies and safety in clauses for the operation and management of the Norm is explained.

3.1 Compulsory Execution and Requirements

To express that the content is very strict and must be complied with, "must" and "strictly prohibited" should be written in bold, for example:

(1) It is **strictly prohibited** adding anticorrosion agent into geothermal fluid of geothermal return irrigation exploitation heating system
(2) Geothermal utilization rates in heating engineering **must** be above 65% and utilization rates less than 65% are **strictly prohibited**
(3) Discharge temperature **must** be less than 35 °C
(4) If the geothermal water temperature exceeds 45 °C, the well pump **must** have an escape way
(5) When fitting an electric hoist on the roof of the pump house, the architect **must** take the total hoisting load into consideration.

3.2 General Requirements

To express that the wording is strict, include "should" or "should not", for example:

(1) After geothermal heating, return irrigation should be executed on the same/different formation through the return irrigation well. Return irrigation in a different formation should conform to requirements of the local administrative authority
(2) Tail water discharge should conform to national discharge standards
(3) The geothermal water inlet temperature at the heat pump unit should be controlled and should not exceed the range of equipment parameters
(4) The signal transmission line uses different colours to distinguish the earth wire and the signal line of different sensors. All the signal transmission lines should enter the connecting bridge (PVC tube or trunking). Open lines should not be permitted.

3.3 Suggestive Requirements

To express necessity, write in permissive condition, for example:

(1) In permissive condition, underground/semi-underground pump houses should not be adopted

(2) pump house must not be built under permanent structure
(3) Geothermal return irrigation system must be a complete closed system. In the design, adopt measures to reduce air invasion, including a wellhead nitrogen detector, corrosion-proof pipes, and pump tubes for return irrigation.

4. CONVENTIONAL SIGN SPECIFICATIONS OF GEOTHERMAL UTILIZATION ENGINEERING

4.1 Universal Equipment Legend and Description

Conventional signs and description of universal equipment should conform with the *Water Supply & Drainage Drafting Standard* (GB/T 50106-2001) and *Heating Engineering Drafting Standard* (CJJ/T 78-97) presented in Table 1, 2 and 3.

TABLE 1: System diagram legends for equipment used in geothermal well systems

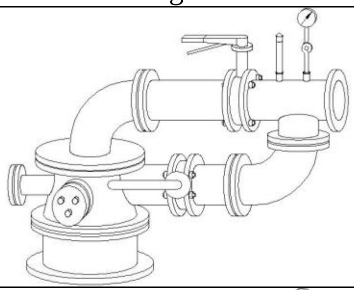
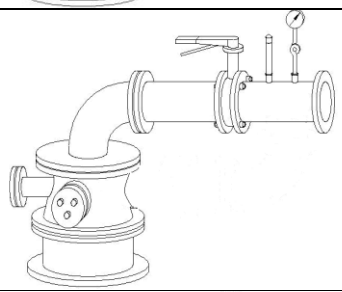
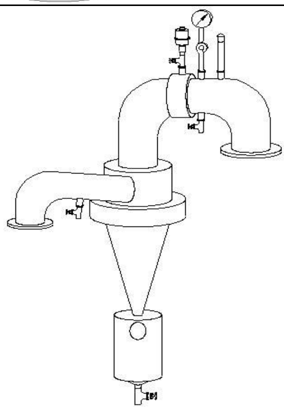
Geothermal Wellhead System		
Equipment Name	Diagram Name	Legend
Wellhead Equipment	System Diagram （ For artesian well ）	
	System Diagram （ for non-artesian well ）	
Desander	System Diagram	

TABLE 1: System diagram legend for water pumps

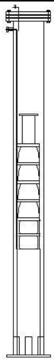
Water Pump		
Equipment Name	Legend	
	System Diagram	Horizontal Plan
Submersible Electric Pump		

TABLE 3: Universal Pipeline Legend

Pipe Name	Legend
Living water supply pipe	——J——J——J——
Living hot-water supply pipe	——RJ——RJ——
Living hot-water return pipe	——RH——RH——
Heating water supply pipe	——H——H——H——
Heating water return pipe	——HR——HR——
Direct-drinking water pipe	——ZY——ZY——
Drainage pipe	——P——P——P——

5. SOCIAL AND ENVIRONMENTAL BENEFIT

The geothermal industry standards will be publicly available. It will normalize the technology for the geothermal industry, improve the standardization level of geothermal engineering, serve as a guide for high level planning and construction, normalize the operation of geothermal utilization engineering, and improve the quality of geothermal construction. At the same time, the standards will enhance the supervision of geothermal central heating and power stations, and accelerate innovation. Furthermore, it will bring geothermal utilization to a scientific level.

REFERENCE

[3] Wang Kun, 2000: *Reservoir Evaluation For the Wuqing Geothermal Field*[C], , Tianjin, China, Proceedings of World Geothermal Congress 2000, p232.

[1] Wang Rongguang, Zhang Yufeng, Yang Wei, 2002: *The characteristics and Save Energy Effects of Low Temperature Radiation Heating System* [J], Taiyangneng Xuebao, 23 (4):455-456.

[2] Zhu Jailing Wang Kun Lei Haiyan, 2007: *The Study of Optimal Exploitation Cases with Geothermal Reinjection Around Out of Production Zone,* ACTA Energiae Solaris Sinica, Vol. 27, No.6.

[4] Zhu Jialing, et al. 2006: *Geothermal Exploitation and Utilization Technology* [M], Beijing, P260-268.