Brief Discussion on Precautions for the Installation and Maintenance of Thermal Control Equipment in Thermal Power Plants

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Abstract: *Thermal control is an indispensable part of modern thermal power plants. With the rapid development of modern technology, the level of automation in thermal power plants has been significantly improved, and thermal control equipment plays an increasingly critical role in their operation. Given the complex and diverse on-site environment caused by the cogeneration characteristics of thermal power plants, the installation and maintenance of thermal control equipment are particularly important. Numerous details must be handled with caution to ensure stable operation and effective maintenance, avoiding potential risks and problems, thereby effectively improving production efficiency and ensuring stable and efficient thermal power production.*

Keywords: *automation; thermal control equipment; installation; operation; human-machine relationship*

Introduction

Thermal control, namely thermal automation and control, is an indispensable part of modern thermal power plants. With the rapid advancement of digital and information technology worldwide, particularly in China, the automation level of thermal power plants has been significantly improved. Distributed control systems and centralized control systems are becoming increasingly widespread, which highlights the growing importance of thermal control equipment in the thermal power field and enables numerous cutting-edge technologies to be integrated into the daily operation and maintenance of thermal power plants. On-site instruments, remote transmission instruments, actuators, and programmable logic controllers play a crucial role in thermal power plants, accurately monitoring and controlling production processes, allowing operators to comprehensively and easily grasp the operating status of power plants, thereby effectively improving production efficiency and ensuring stable and efficient thermal power production.

As combined production enterprises integrating power generation and heat supply, thermal power plants operate through a complex mechanism. In addition to relying on turbines and generators to achieve power generation, they must utilize waste heat to supply the thermal energy required for the circulation of heating networks. This dual functional demand increases the complexity of production sites, which in turn requires a wider variety of thermal control equipment and more diverse control functions to meet various production needs.

1. Common Precautions for the Installation and Maintenance of Thermal Control Equipment

1.1 Installation Precautions

1.1.1 Preliminary Preparation

Before installing thermal control equipment, the primary task is to carefully verify the consistency between the design drawings and the actual on-site conditions, particularly details such as equipment installation positions, pipeline layouts, and interface specifications, to ensure perfect alignment and avoid any potential conflicts. Upon delivery of the equipment, a thorough inspection of its exterior integrity, completeness of accessories and spare parts must be conducted, and each model, specification, and quantity should be checked against the design list to confirm consistency. For precision instruments such as transmitters and controllers, prior calibration is required to ensure that their factory accuracy

meets the design requirements.

1.1.2 Location Selection

When selecting the installation location for thermal control equipment, priority should be given to the convenience of operation and maintenance, ensuring sufficient space is reserved for operation and inspection, and avoiding installation at heights or positions that are inconvenient for observation and operation. Equipment should be kept away from strong magnetic fields, high-temperature heat sources, and vibration areas to prevent signal distortion or equipment damage. For equipment installed in outdoor or humid environments, waterproof covers must be added, and for explosion-proof areas, strict compliance with explosion-proof regulations is required, such as using sealed joints and grounding jumpers[1].

1.1.3 Pipeline and Wiring Installation

For gas or liquid instrument pipelines used in thermal control equipment, attention should be paid to the pipeline slope during layout, especially for hoses and bent gas pipes, ensuring no bends exist that may accumulate dirt and cause blockage. Long pipelines should be secured with fixed brackets at regular intervals to prevent fractures or loosened joints caused by vibration. Compressed air pipelines should be made of stainless steel or galvanized steel pipes, while hydraulic pipelines should use high-pressure seamless steel pipes or stainless steel pipes. Pipelines must remain clean and free of impurities. Interface connections should adopt ferrule or threaded connections, with threaded joints wrapped with PTFE tape or coated with sealing glue. Leak detection at the connections should be performed using soapy water to ensure no leakage. Pipelines should be neatly arranged, avoiding crossing or excessive bending. Sharp bends must be avoided during connection, and adequate allowance should be left to prevent hoses from being stretched or compressed. Long pipelines should be equipped with drain valves to regularly discharge condensate from inside the pipes.

1.2 Maintenance Precautions

1.2.1 Routine Inspection

During routine inspection of thermal control equipment, careful observation of its appearance and indicator light status is required.

The primary task is to check whether the equipment's exterior is intact, ensuring no damage or looseness, particularly at exposed joints, which must be assessed for potential risks of signal interruption. Any abnormalities should be reported immediately, and consideration should be given to whether forced parameter adjustments are necessary. For equipment in operation, unusual sounds or vibrations can be used to determine whether jamming exists.
The status of indicator lights is a crucial criterion for determining whether the equipment is operating normally. It must be ensured that the operation indicator light is illuminated properly, with no fault or alarm signals. The panel display values should remain within the normal range, and there should be no abnormal pointer oscillation or sudden changes in readings.

Fault diagnosis and troubleshooting should follow the principle of "from external to internal, from simple to complex," checking external factors such as power supply, wiring, and pipelines first, and then investigating internal faults such as damage to circuit board components. The system's self-diagnosis function can be used to locate problems, supplemented by historical trend analysis to identify fault patterns. If faults with potential risks are encountered, safety measures must be taken immediately, and the issue should be reported. Personal safety should be ensured first, followed by securing equipment operation safety. Before handling live equipment, power must be cut off and verified; for high-temperature and high-pressure pipelines, pressure should be released, and the system cooled down beforehand. Arbitrary modification of parameters in operating equipment or disabling protective instrument signals is strictly prohibited. Any necessary modification must undergo strict approval procedures, be carried out under supervision, and be properly documented.

1.2.2 Regular Maintenance

When formulating a regular maintenance and inspection plan for equipment, product manuals or manufacturer recommendations must be strictly followed. Measuring and metering devices should be regularly calibrated according to prescribed procedures. Before maintenance, power disconnection, pressure release, and other safety isolation measures must be carried out to avoid disassembly or assembly under pressure. Regular maintenance work includes cleaning and tightening of wiring

connections. For some critical equipment, professional maintenance by the manufacturer may be considered to ensure equipment performance and safety[2].

2. Precautions for the Installation and Maintenance of Local Instruments

The installation design of local instruments should prioritize convenient observation for inspection personnel. The installation position should be determined based on the method of sampling, with appropriate selection of sampling components, materials, and installation methods, while ensuring stability and ease of maintenance to reduce failure rates and guarantee long-term reliability.

2.1 Installation Precautions

For local thermometers, both visibility and operational convenience must be considered. The installation position should be easy to observe and away from interference sources, with an appropriate distance maintained from the temperature sampling point. The protective tube of the temperature-sensing element should be in full contact with the measured medium. When installed on pipelines, the thermometer should be positioned vertically or inclined 45 degrees counter to the flow direction, meeting technical requirements. For pressure vessels, it is recommended to use a sleeved thermometer with a thermometer well, which seals the sampling port and allows quick replacement without isolating the pipeline when the thermometer is damaged, ensuring production safety and continuity.

For pressure gauges used in water pressure measurement, to protect them from water hammer, a primary-side valve and a damping bend should be installed between the pressure gauge and the pressure tapping point. The primary-side valve facilitates pipeline isolation, allowing safe replacement if the gauge is damaged. The pressure gauge should use a secondary-side instrument valve with a venting function, and the vent port should be directed away from personnel activity areas to ensure safety and convenient maintenance, guaranteeing measurement accuracy and operational safety.

2.2 Maintenance Precautions

If instruments are placed in humid or splash-prone environments for extended periods, instruments with excellent waterproof performance must be used.

Instruments should be calibrated regularly, and calibration records must be completed, indicating the calibration date, standard instrument number, calibration results, and the next calibration date. A calibration label showing the calibration date, calibrator, and validity period should be affixed. If unqualified instruments are detected during the calibration process, they must be replaced, and the replacement instruments should also undergo calibration. Records must be properly maintained, and historical data should be traced to determine the period of inaccuracy.

3. Precautions for the Installation and Maintenance of Remote Transmission Instruments

Remote transmission instruments are key devices in thermal control instrumentation that directly participate in automated production, functioning as the “eyes and ears” of the automatic control system. They directly affect the monitoring accuracy and safety of industrial production processes[3-5].

3.1 Installation Precautions

The installation process of remote temperature measurement elements is similar to that of thermometers, but there is no need to consider instrument visualization. The focus should be on ensuring measurement accuracy and meeting process specifications to achieve precise temperature monitoring and control.

The pressure tapping point of remote pressure transmitters should be carefully selected on a straight pipe section where the medium flows linearly, away from elbows and valves, to avoid interference from vortices and turbulence. When measuring gas, the tapping point should be located at the top of the pipeline; when measuring liquid, it should be placed at the lower half of the pipeline. The positive and negative pressure impulse pipes of differential pressure instruments must be kept at the same ambient temperature to prevent measurement errors caused by temperature differences.

When installing flow meters, ensure that the upstream and downstream straight pipe lengths meet

the installation requirements of the flow meter. The installation position should be as low as possible to ensure the pipeline is fully filled with fluid, and the instrument's orientation should align with the pipeline's designed flow direction.

For analog signal remote transmission instruments, cable transmission distances should be minimized to reduce signal attenuation and interference. Signal cables and power cables must be laid separately; if sufficient distance cannot be maintained, metal partitions should be used for isolation to prevent interference from power cables. Shielded cable layers should be grounded at a single end, and unshielded cables should be laid through galvanized steel pipes or cable trays. Connections must be secure, and multi-strand wires should be crimped with terminals to prevent loose connections or short circuits. Clear labeling is required, spare cores should be insulated, and circuit diagrams should be stored in sealed form inside junction boxes.

3.2 Maintenance Precautions

Maintenance requirements are similar to those of local instruments, but special attention should be paid to checking whether junction boxes are intact, whether box covers and screws are loose, and whether any wiring shows obvious looseness.

In the control room, data from the upper computer should be compared with on-site instrument displays to check whether the signal transmission line is stable and whether fluctuations are caused by electromagnetic interference or poor contact.

Like local instruments, remote transmission instruments require regular cleaning of dirt, pipeline drainage, and leakage inspection. For exposed instruments or those operating in harsh environments, protective measures must be checked for integrity. Additionally, terminal screws should be tightened regularly to prevent loosening or poor contact caused by vibration.

4. Precautions for the Installation and Maintenance of Actuators

Actuators are key components in industrial automation control systems, responsible for converting control signals into mechanical actions, serving as the primary devices for remote operation and control in thermal power plants.

4.1 Installation Precautions

The installation environment of actuators must comply with design requirements for temperature, humidity, vibration, and explosion-proof standards. The installation position should allow convenient observation, operation, and maintenance, and should be as close as possible to the controlled equipment to minimize mechanical lag. For regulating actuators, the valve stem must be kept vertical to avoid jamming or leakage. For on-off actuators, such as ball valves and butterfly valves, the fully open and fully closed positions must meet process requirements. Exposed transmission components should be equipped with protective covers to prevent personal injury. Warning signs must be placed in handwheel operating areas to indicate manual/automatic switching methods and rotation directions to ensure operational safety.

After installation, the power source must be disconnected first, and the actuator should be manually operated to check the flexibility of moving parts, ensuring no jamming, abnormal noise, or excessive tightness. The travel limits of fully open and fully closed positions should be checked for consistency with remote feedback. Afterward, the power source can be connected for no-load and load trial runs in sequence[6-8].

4.2 Precautions for Electric Actuators

When designing the power supply for electric actuators, it is necessary to ensure sufficient power capacity and compliance with grounding system requirements. During routine maintenance, power supply voltage should be checked and recorded. Before powering on, motor insulation resistance must be tested to prevent short circuits or grounding faults.

For wiring connections, power cables and signal cables should be laid separately to avoid electromagnetic interference. Shielded twisted-pair cables should be used for signal transmission, with the shielding layer grounded at a single end, typically on the control room side. During wiring, strict

adherence to terminal wiring diagrams and instructions is required, particularly ensuring correct power phase sequence and accurate polarity of control signal lines. These measures ensure the proper operation of electric actuators and enhance system stability and reliability.

Proper sealing of actuator junction boxes is crucial. Explosion-proof cable glands or waterproof connectors should be used at cable inlets to ensure tight sealing. Extra cable entry holes should be sealed with sealing plugs to prevent dust and moisture ingress. The grounding terminal of the electric actuator must be reliably connected to the system grounding network to ensure stable circuit operation.

During trial operation, the motor's rotation direction and speed must be tested first. For regulating actuators, the input signal should be gradually increased from low to high. Before performing maintenance on electric actuators, the power supply must be disconnected, and a warning sign reading "Do Not Close—Work in Progress" should be hung at the switch.

4.3 Precautions for Pneumatic and Hydraulic Actuators

Pneumatic actuators require particular attention to air source quality during operation. During installation and routine maintenance, the stability of air source pressure should be checked, and the condition of the filter pressure-reducing valve should be inspected regularly to ensure no damage. Impurities in the air source treatment device must be cleaned periodically, and filter elements should be replaced at regular intervals. When installing pneumatic diaphragm actuators, the diaphragm head must be kept vertically upward to avoid stroke deviation caused by gravity. For piston-type actuators, the cylinder axis should align with the valve stem axis to reduce the impact of lateral forces.

Pneumatic and hydraulic pipelines are critical systems, and the following points must be observed to ensure their proper operation:

An air filter pressure-reducing valve should be installed near the actuator to regulate input air pressure and filter impurities. Maintaining the normal operation of pneumatic and hydraulic pipelines is essential for system stability and requires sufficient attention and proper maintenance[9].

For hydraulic actuators, as with electric actuators, fire safety must be prioritized. Oil tanks and pipelines should be kept away from heat sources, open flames are strictly prohibited nearby, and fire extinguishers must be equipped. Pressure gauges and shut-off valves should be installed at the connections of hydraulic oil pumps, cylinders, and pipelines to facilitate observation, adjustment, and maintenance. An exhaust valve should be installed at the highest point, and air in the pipeline must be discharged before startup. The motor temperature rise of electric actuators must not exceed the specified value to prevent overload heating and potential fire hazards.

During the trial operation of pneumatic and hydraulic actuators, the working pressure must be carefully increased to the rated pressure while observing whether the actuator operates smoothly and whether any leakage occurs. Before maintaining pneumatic actuators, the air source must be shut off and pressure released, and a warning sign stating "Do Not Operate—Work in Progress" must be hung on the air source valve.

4.4 Common Fault Troubleshooting

4.4.1 Actuator Response Delay or Jamming

The issue may be caused by mechanical blockage or insufficient lubrication; foreign objects should be removed, and lubrication should be replenished. For pneumatic actuators, low air source pressure may also be a cause, which requires air source pressure adjustment.

4.4.2 Abnormal Remote Feedback Signal, Inconsistent with Local Indication

Check whether the wiring of the actuator sensor is correct, whether the settings of the electric actuator are properly configured or have been reset, whether internal components show wear, and whether there is a short circuit or interference in the signal line.

4.4.3 Abnormal Noise or Vibration of the Actuator

The problem may result from poor gear meshing, loose components, or unbalanced load; fixed components should be checked and tightened if necessary. Structural adjustments or even reinstallation should be carried out if required.

5. Precautions for Long-Term Equipment Maintenance

5.1 Spare Parts Storage

Spare parts should be prepared according to equipment models, stored in designated warehouses, and a spare parts inventory ledger should be established. Replacement time and failure causes should be recorded in the equipment ledger in a timely manner to facilitate traceability and analysis.

5.2 Technological Upgrades

For technologically advanced equipment, it is necessary to keep track of manufacturers' technical updates and evaluate outdated equipment to improve system reliability and automation levels. Attention should be paid to the development of multiple manufacturers, and backup plans should be formulated for equipment that cannot be repaired due to discontinued production by suppliers[10].

5.3 Information Recording

When recording in the equipment ledger, detailed information such as installation date, model, location, connection method, commissioning data, and relevant personnel information must be documented and archived for future reference. For intelligent equipment, configuration parameters and screen information should be captured and stored, and control system backups should be created, with data transferred to dedicated storage devices. A full life-cycle archive of equipment, including installation and commissioning, maintenance and calibration, and fault handling information, should be established to provide data support for equipment management. Whether for new equipment or equipment already in use, detailed records and archive management must be maintained to ensure the smooth progress of equipment management work.

Conclusion

The installation and maintenance of thermal control equipment in thermal power plants require comprehensive consideration of both equipment technology and production specifications. Only through thorough and rigorous installation, meticulous and careful routine inspections and maintenance, and scientific and effective record management can equipment be kept in optimal condition, providing reliable assurance for the safe and economical operation of generating units. The installation and maintenance of thermal control equipment in thermal power plants must also keep pace with industry technological advancements, continuously improving the level of automation and intelligence of thermal control systems to reduce manual maintenance costs. In this way, production and operation in thermal power plants can become safer, more stable, and more efficient, bringing greater economic benefits to enterprises.

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