Operation Principle and Application Description

Thermal Oil Heated Explosion-Proof Hot Box

1. Equipment Application

This equipment is a thermal oil indirect-heated explosion-proof hot box. It is mainly used for winter storage, freeze protection, controlled warming, and thawing of chemicals packed in drums or IBC containers.

The equipment is suitable for outdoor or low-temperature storage environments where chemicals may freeze, crystallize, become highly viscous, or take too long to thaw naturally at room temperature.

The purpose of this equipment is not high-temperature drying or rapid baking. Its main purpose is to keep chemical containers within a controlled, safe, and relatively uniform low-temperature range through forced hot-air circulation.

The equipment can be used for approximately 6 pcs of 1000L IBC containers, or equivalent palletized chemical drum storage, depending on the final loading arrangement.

---

2. Main Equipment Structure

The equipment adopts a single-level, three-chamber structure. Each chamber is designed to accommodate approximately 2 pcs of IBC containers. The complete unit can accommodate approximately 6 pcs of IBC containers.

The equipment mainly consists of the following parts:

1. Explosion-proof hot box chamber
2. SUS304 stainless steel inner chamber
3. Side air plenums and bottom air supply structure
4. Top return-air structure
5. Thermal oil heat-exchange coils
6. External thermal oil electric heater
7. Forced air circulation fans
8. Explosion-proof control cabinet
9. Gravity relief vents
10. Thermal insulation and outer shell structure

The inner chamber and air plenums are made of SUS304 stainless steel to improve corrosion resistance and cleanliness. The outer shell is made of painted Q235 carbon steel plate. The chamber is insulated to reduce heat loss during operation.

---

3. Main Technical Parameters

Equipment Name:
Thermal Oil Heated Explosion-Proof Hot Box

Effective Working Size:
W2700 × 3 chambers × H1400 × D1400 mm

Overall Equipment Size:
W9400 × H1780 × D1600 mm
Note: The external circulation fan motor protrudes approximately 400 mm.

Design Temperature:
60°C

Recommended Operating Temperature:
Approximately 45°C

Heating Method:
Thermal oil indirect heat exchange + forced hot-air circulation

Thermal Oil Heating Power:
90 kW
Configuration: 30 kW/unit × 3 units

Circulation Fan Power:
9 kW
Configuration: 1.5 kW/unit × 2 units/chamber × 3 chambers

Installed Power:
Approximately 100 kW

Inner Chamber Material:
1.2 mm SUS304 stainless steel plate

Air Plenum Material:
1.2 mm SUS304 stainless steel plate

Outer Shell Material:
1.2 mm Q235 painted cold-rolled steel plate

Insulation:
100 mm aluminum silicate fiber wool

Thermal Oil Heat-Exchange Pipe:
DN25 seamless stainless steel pipe with pressed aluminum heat-dissipation fins

4. Working Principle

This equipment uses thermal oil indirect heating. No direct electric heating elements are installed inside the hot box working chamber.

During operation, the external thermal oil electric heater first heats the thermal oil. The heated oil is then circulated through the heat-exchange coils installed inside the side air plenums.

The circulation fans blow air across the thermal oil coils. The air absorbs heat from the coils and becomes hot circulating air. The heated air is then supplied into the working chamber through the side air plenums and bottom air supply areas.

The hot air flows around the IBC containers or drum packages, transfers heat to the containers, and then returns through the top return-air area. After returning to the air plenum, the air passes across the heat-exchange coils again and continues circulating.

The circulation path can be understood as follows:

Thermal oil heater heats the oil
→ Hot oil enters the heat-exchange coils
→ Circulation fans blow air across the coils
→ Hot air is supplied from the side and bottom areas
→ Hot air flows around the IBCs or drums
→ Air returns from the top return-air area
→ Air enters the plenum again for reheating and circulation

Through this design, the equipment can provide stable heating and temperature maintenance for chemical containers without placing direct electric heating elements inside the chemical storage chamber.

---

5. Reason for Using Thermal Oil Indirect Heating

This project involves chemicals such as glacial acetic acid, which may present flammable vapor risks. Glacial acetic acid has a relatively low flash point, so heating safety and temperature control stability must be carefully considered.

If electric heating elements are installed directly inside the working chamber, any flammable vapor, leakage, or localized high-temperature surface inside the chamber may increase ignition-source risk.

For this reason, this equipment adopts a thermal oil indirect heating system. The thermal oil heater is installed outside the chamber. Heat is transferred to the circulating air through thermal oil and heat-exchange coils.

The main advantages of this design are:

1. Reduced direct electric ignition-source risk inside the chamber
2. Smoother heating process and reduced local overheating risk
3. Better hot-air distribution and improved temperature control
4. Better suitability for low-temperature chemical storage, freeze protection, and thawing
5. Easier separation between the heating system, control system, and chemical storage area

It should be noted that thermal oil indirect heating does not mean absolute zero risk. The final explosion-proof classification, electrical certification, installation requirements, and site approval requirements must still be confirmed according to the customer's hazardous area classification, insurance requirements, and local regulations.

---

6. Airflow Circulation Design

This equipment uses a single-level structure to achieve more accurate chamber temperature control.

Each working chamber is equipped with its own circulation fans and thermal oil heat-exchange system. Hot air is supplied from the side air plenums and bottom areas, passes around the IBC containers, and returns from the top.

This airflow design helps the hot air surround the containers more evenly and improves temperature uniformity inside each chamber.

Compared with a separated double-level structure, a single-level structure is more suitable for controlling the temperature of each IBC storage position. A double-level structure may cause different temperature conditions between the upper and lower levels, uneven airflow distribution, and unstable return-air behavior.

For chemicals such as glacial acetic acid, the upper temperature limit is very important. Therefore, the equipment should avoid any local area becoming too hot or too cold.

The key design target is not simply to heat the chamber, but to keep every storage position within a stable, controllable, and relatively uniform temperature range.

---

7. Temperature Control Description

The design temperature of the equipment is 60°C. The recommended operating temperature is approximately 45°C. The actual set temperature should be determined according to the chemical SDS, storage requirements, safety requirements, and process requirements.

During operation, the temperature control system monitors the chamber temperature through temperature sensors and controls the operation of the thermal oil heater, oil circulation pump, and air circulation fans.

To improve safety, the system should include the following temperature control logic:

1. When the chamber temperature reaches the set value, the system stops or reduces heating output.
2. When the chamber temperature drops below the set value, the system resumes heating automatically.
3. If the temperature exceeds the safety limit, the system triggers an over-temperature alarm.
4. Operators must not increase the set temperature without authorization.
5. The actual operating temperature should always remain within the confirmed safe temperature range.

For low-flash-point chemicals such as glacial acetic acid, temperature control is one of the most critical safety factors. During operation, no storage position should exceed the allowed temperature range.

---

8. Explosion-Proof and Safety Design Description

This equipment is preliminarily designed for explosion-proof hot box applications. The main safety-related configurations include:

1. Explosion-proof circulation fan motors
2. Explosion-proof thermal oil heater assembly
3. Explosion-proof electrical control cabinet
4. Gravity relief vents
5. No direct electric heating elements inside the working chamber
6. Thermal oil indirect heat exchange through coils
7. SUS304 stainless steel inner chamber and air plenums
8. Thermal oil system equipped with explosion-proof oil circulation pump, explosion-proof electric shut-off valve, explosion-proof electric contact pressure gauge, high-level oil tank, and related auxiliary components

These configurations are intended to reduce ignition-source risk and temperature runaway risk during equipment operation.

However, the above configuration description does not mean that the equipment has already obtained Canadian local certification. Final compliance with cUL, CSA, Canadian HazLoc, insurance company requirements, local AHJ requirements, or other site approval requirements must be further confirmed according to the applicable Canadian standards and the customer’s site classification.

---

9. Applicable Materials and Use Conditions

This equipment is suitable for freeze protection, temperature maintenance, and low-temperature thawing of sealed chemical containers, including drums and IBC containers.

Before use, the customer should confirm the following information:

1. SDS documents of the chemicals
2. Flash point of the chemicals
3. Recommended storage temperature
4. Maximum allowable heating temperature
5. Whether the containers are fully sealed
6. Whether there is any leakage, vapor release, or venting risk
7. Site hazardous area classification
8. Local electrical and explosion-proof certification requirements

This equipment should not be used for the following conditions:

1. Heating open containers
2. Heating leaking or damaged containers
3. Heating unknown chemicals without SDS confirmation
4. High-temperature drying beyond the allowed temperature range
5. Applications with significant flammable vapor release
6. Installation in unconfirmed hazardous locations without proper evaluation

---

10. Basic Operating Procedure

1. Before operation, check the equipment body, doors, seals, fans, thermal oil system, and control cabinet.
2. Confirm that the thermal oil level, oil piping, valves, and oil circulation pump are in normal condition.
3. Confirm that there is no leakage, foreign material, or flammable residue inside the working chamber.
4. Place the IBC containers or drum packages into the corresponding working chamber.
5. Confirm that the containers are intact, sealed, undamaged, and free from leakage.
6. Close and lock the doors properly.
7. Turn on the power supply and start the control system.
8. Start the circulation fans and thermal oil heating system.
9. Set the working temperature according to the chemical safety requirements.
10. During operation, regularly observe the chamber temperature, oil pressure, fan status, and alarm status.
11. After heating or temperature maintenance is completed, stop the heating system and allow the temperature to stabilize before opening the doors and unloading the containers.
12. If abnormal alarms, odor, leakage, abnormal temperature, or fan failure occurs, stop the equipment immediately and inspect the system.

---

11. Safety Precautions

1. Do not exceed the confirmed maximum safe operating temperature.
2. Do not heat leaking, damaged, opened, or unknown chemical containers.
3. Do not open the doors randomly during operation.

4. Do not conduct open-flame work, welding, grinding, or spark-generating work near the equipment.
5. Do not modify temperature control parameters, over-temperature protection settings, or safety interlocks without authorization.
6. Do not remove or bypass explosion-proof components, safety switches, or alarm devices.
7. Ensure suitable ventilation conditions around the equipment.
8. The equipment should only be operated by trained personnel.
9. For use in Canada, the customer should confirm local certification, insurance, electrical approval, and installation requirements.
10. Any chemical storage safety requirement should be based on the SDS and local regulations.

---

12. Maintenance and Inspection Recommendations

To ensure long-term safe and stable operation, the following items should be checked regularly:

1. Check whether the thermal oil level is normal.
2. Check whether the thermal oil piping, joints, and valves have leakage.
3. Check whether the circulation fans operate smoothly and without abnormal noise.
4. Check whether the temperature sensors and temperature controllers display correctly.
5. Check whether the electrical components inside the control cabinet are loose, overheated, or aged.
6. Check whether the door seals are in good condition.
7. Check whether the gravity relief vents are blocked.
8. Check whether the air plenums and return-air areas are blocked.
9. Check whether there is any chemical residue or corrosion inside the chamber.
10. Conduct no-load operation testing and over-temperature protection testing periodically.

---

13. Summary

This thermal oil heated explosion-proof hot box is a special-purpose equipment designed for chemical freeze protection, temperature maintenance, and low-temperature thawing in cold environments.

Its core design concept is to use an external thermal oil heater and internal thermal oil heat-exchange coils to transfer heat indirectly, and then use forced air circulation to provide stable and controllable low-temperature heating for IBC containers or drum packages.

Compared with direct electric heating, this design reduces direct electric ignition-source risk inside the working chamber and improves temperature control stability. It is more suitable for chemical storage applications where temperature safety is critical, such as glacial acetic acid storage.

The key focus of this equipment is safety, temperature uniformity, and controllability, rather than maximum heating speed. Final operating conditions, explosion-proof classification, certification requirements, and local approval requirements should be jointly confirmed by the customer based on the site environment, SDS documents, insurance requirements, and local regulations.