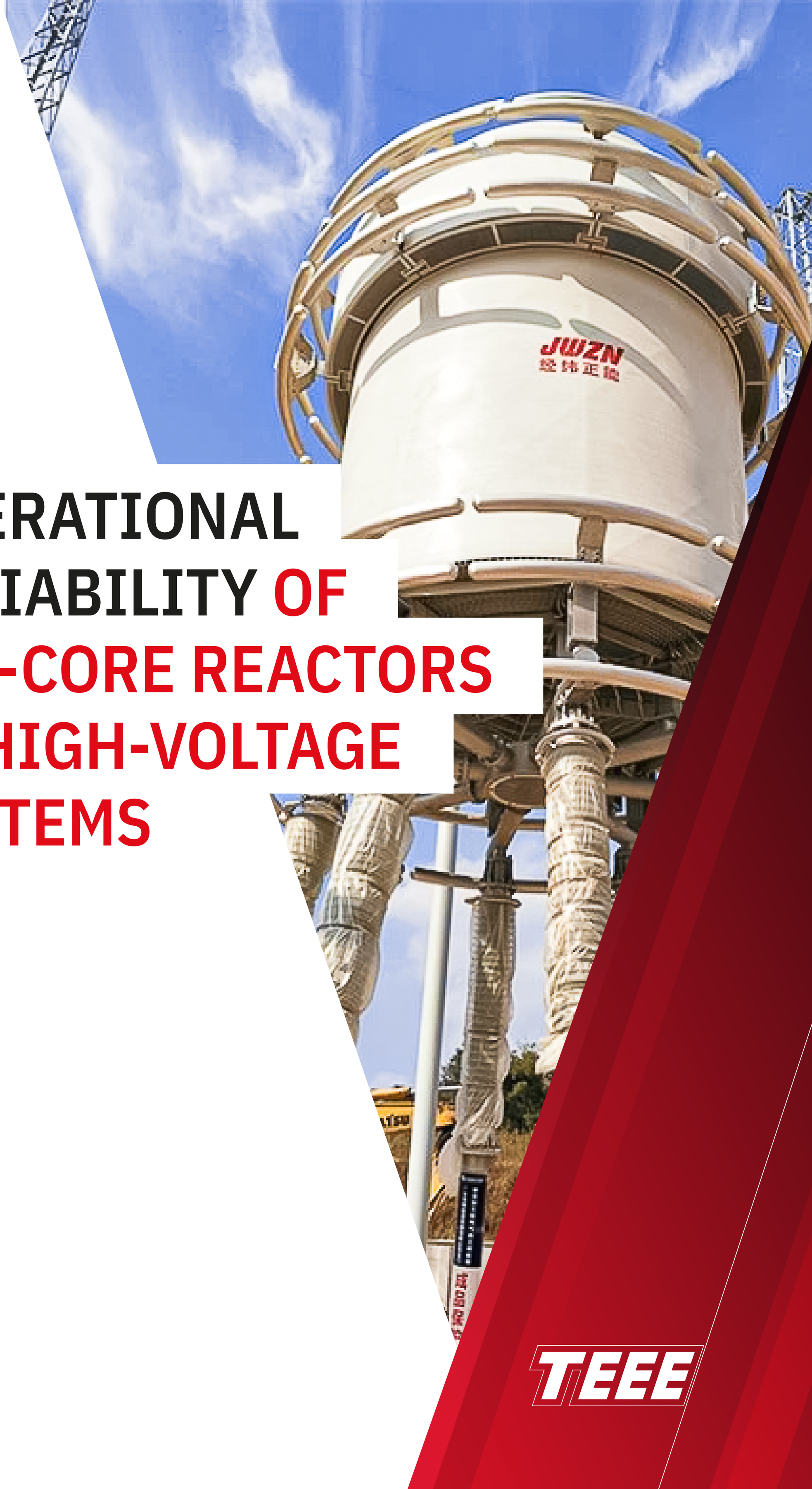


OPERATIONAL RELIABILITY OF AIR-CORE REACTORS IN HIGH-VOLTAGE SYSTEMS

TEEE

The operation of air-core reactors in high-voltage systems requires continuous technical decision-making in a context of variable load, harsh environmental conditions, and strong pressure for asset availability.

For operations and maintenance professionals, the main challenges are not in basic procedures, but in the correct interpretation of thermal behavior, early identification of degradation, and decision-making before small anomalies evolve into significant outages.

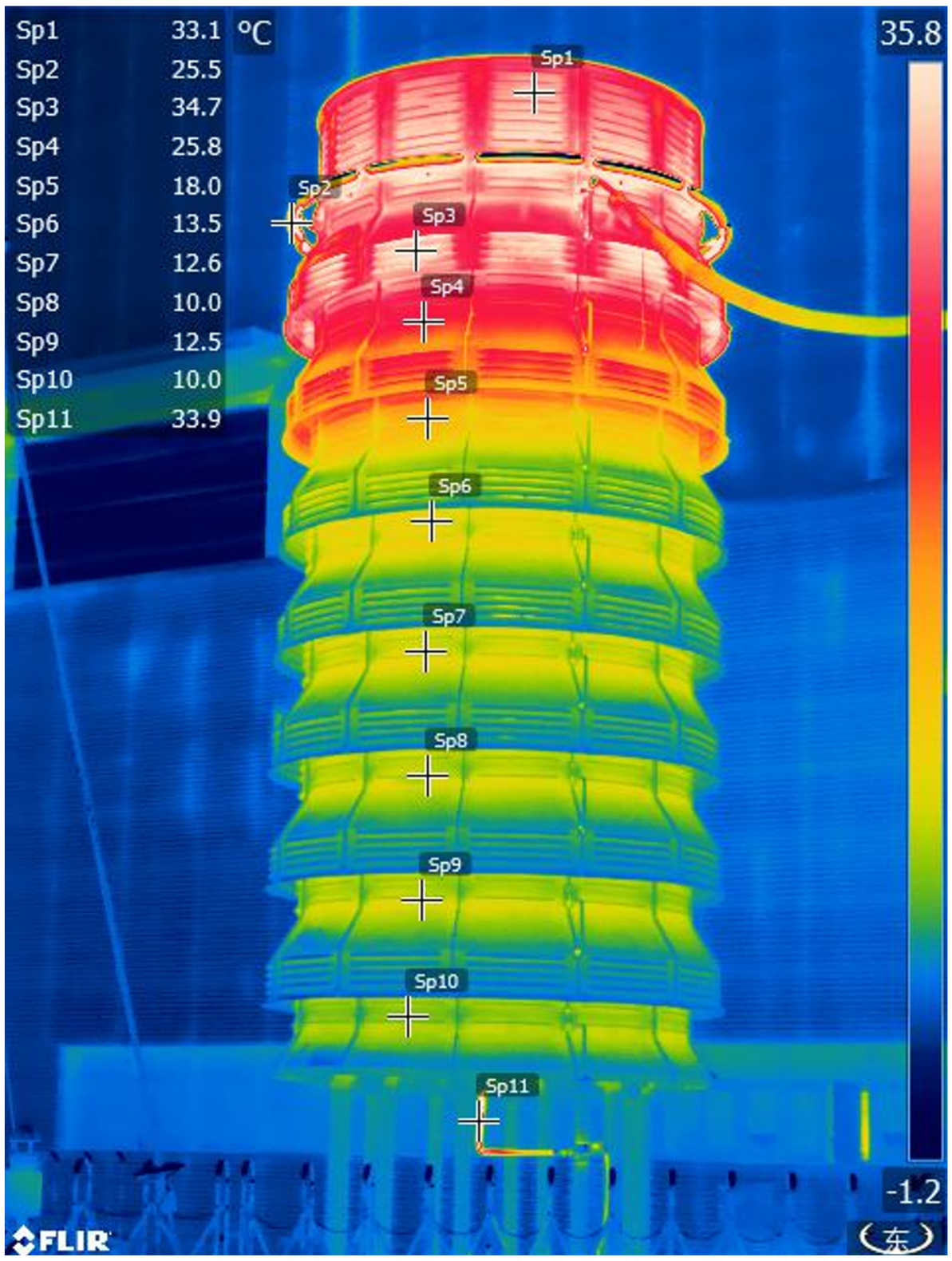
Our technical team of specialists is available to support you in identifying and classifying anomalous behavior in air-core reactors.



The content of this white paper covers technical criteria applied to operational reliability, with a focus on thermal distribution, recurring hotspots, trend-based monitoring, failure modes observed in the field, and the practical implications of modularity and planned interventions. This knowledge exchange contributes to increasing operators' understanding of the real operating characteristics of their assets.

The objective is to support more predictable operations, reduce unplanned outages, and provide technical references for maintenance decisions aligned with the actual behavior of the equipment throughout its lifecycle.

REAL THERMAL BEHAVIOR UNDER CONTINUOUS OPERATION



Under continuous operation, the performance of air-core reactors is governed by the direct relationship between electrical current, resistive losses, and heat dissipation through natural convection. The interaction of these three variables defines the final temperature of the equipment. TEEE uses conductors with 99.9% purity to achieve the lowest possible resistive losses.

A key difference compared to oil-filled equipment is that air-core reactors do not benefit from significant thermal damping due to thermal inertia.

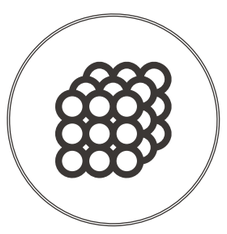
This characteristic requires that reliability analysis be based on **thermal trends over time**, rather than on isolated absolute values. Small, persistent temperature variations, especially in specific regions of the winding, are more relevant than occasional excursions.

THERMAL DISTRIBUTION AND HOTSPOTS IN AIR-CORE REACTORS

Thermal distribution in air-core reactors is not homogeneous. Temperature differences between the bottom and top sections of the reactor can reach up to 60°C.

Winding geometry, spacing between coils, local ventilation, and proximity to metallic structures directly influence hotspot formation.

RECURRING HOTSPOTS TYPICALLY OCCUR:



In regions with higher current density



At mechanical interfaces or connections



In areas with restricted airflow

Long-term reliability depends on the ability of the design to minimize thermal gradients, not only on meeting average temperature limits.

TEEE reactors are designed to meet, at a minimum, IEC criteria. However, under extreme conditions, more restrictive temperature limits may need to be specified by the customer.

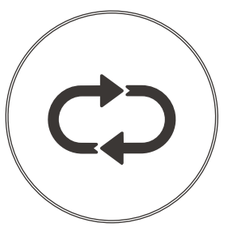
THERMAL MONITORING:
PROPER TECHNICAL INTERPRETATION

Thermal monitoring, typically performed using infrared cameras, provides useful information only when analyzed as a time series. Isolated readings do not allow reliable conclusions about equipment condition.

PROPER INTERPRETATION CONSIDERS:



Correlation between temperature and current



Repeatability of the thermal profile across phases



Influence of environmental conditions



Consistent time evolution

Alarm systems based solely on absolute thresholds tend to trigger either unnecessary or delayed interventions.

If you identify any abnormal temperature pattern, contact us for technical support in diagnostics.

OBSERVED FAILURE MODES AND ASSOCIATED PHYSICAL MECHANISMS

The most relevant failure modes in air-core reactors are associated with cumulative processes:

Progressive increase in electrical resistance at connections

Localized thermal degradation of insulating materials

Gradual loss of thermal margin under high load conditions

Accumulation of contamination and airflow restriction

These mechanisms evolve slowly and can be mitigated when identified early.

We recommend inspecting the reactor whenever an outage is scheduled. This inspection should preferably be performed annually (basic visual inspection) and should not exceed a maximum interval of six years (detailed visual inspection). During detailed inspections, attention should be given to connection degradation, electrical tracking, and external contamination restricting airflow. For further details, refer to the O&M manual supplied with the reactor.

FIELD INTERVENTIONS AND MODULARITY



The ability to perform modular interventions has a direct impact on asset availability. In air-core reactors, modularity is effective when:

- ☑ **Physical access to the coils is feasible**
- ☑ **Replacement does not significantly impact downtime**
- ☑ **Intervention criteria are clearly defined**

Planned interventions, based on consistent technical diagnostics, significantly reduce operational risk compared to emergency corrective actions.

OPERATIONAL COMPARISON:
DRY-TYPE VS OIL-FILLED REACTORS



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Reator a ar

From an operational perspective, the differences go beyond environmental aspects.

Oil-filled reactors introduce additional variables such as fluid aging, chemical analysis, sealing systems, and leakage risks. These factors increase diagnostic uncertainty and expand maintenance scope.

Air-core reactors eliminate these variables, allowing operational analysis to focus directly on electrical and thermal parameters, with reduced ambiguity.

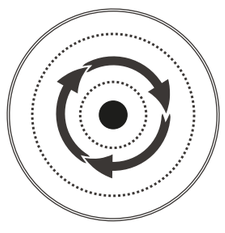
ITEM	OIL-FILLED REACTOR	AIR-CORE REACTOR
Footprint (L × W)	3.0 × 8.1 m	3.0 × 8.0 m
Weight	80 t	16 t
Losses (% per capacitor)	≤ 0.3%	≤ 0.3%
Automatic voltage sharing per reactor	No	Yes
Use of oil	Yes	No
Fire protection system	Required	Not required
On-site installation	Complex	Simple
Transport and delivery	Complex	Simple

POST-ENERGIZATION TESTING AND INITIAL MONITORING

AFTER ENERGIZATION, INITIAL MONITORING SHOULD FOCUS ON:



Thermal stabilization under nominal load



Repeatability of behavior across phases



Acoustic and mechanical behavior

This initial period establishes the baseline for all future reliability analysis.

FINAL CONSIDERATIONS

The operational reliability of air-core reactors is directly associated with the predictability of their thermal behavior and the clarity of the indicators used in the field.

Designs that prioritize uniform thermal distribution, electrical stability, and accessibility for intervention enable earlier operational decisions with lower impact and reduced risk.

teee.company

GLOBAL LEADER IN AIR-CORE REACTORS

TEEE was founded in 2014, inheriting an industrial legacy from a group with more than 85 years of history. This strong background allows the company to combine tradition and innovation in the development of high-performance air-core reactors.

Our innovative DNA and comprehensive portfolio, ranging from blocking coils to smoothing reactors up to 1100 kV, have earned the trust of customers in more than 39 countries.

Rely on TEEE’s expertise to drive your projects forward.

Choose TEEE and shape your future with cutting-edge reactor technology.

Smart solutions in premium reactors.



@teee-reactors

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