SEE HEAT BEFORE
IT BECOMES A FAILURE

Distributed Temperature Sensing for Continuous Thermal Intelligence

A Network Integrity Systems White Paper

THE CHALLENGE: Conventional inspections show isolated moments and locations for monitoring temperature. SENTINEL TS delivers a continuous temperature profile along critical infrastructure so operators can identify, locate, and act on abnormal temperatures before it escalates.

Thermal monitoring for data centers, power distribution, industrial assets, transportation infrastructure, and other mission-critical environments

Executive Summary

Heat is often the earliest visible signature of electrical stress, mechanical degradation, process upset, leakage, or fire. The operational challenge is not simply measuring temperature—it is knowing where conditions are changing across an entire asset, continuously and in time to intervene.

Distributed Temperature Sensing (DTS) turns an optical fiber into a linear temperature sensor. An interrogator unit launches light into the fiber and analyzes the small amount of light scattered back (Raman Backscatter) from points along its length. The timing and characteristics of that return signal are translated into a spatially resolved temperature profile, enabling thousands of virtual measurement locations without installing thousands of powered point sensors.

SENTINEL TS™ brings this capability into the NIS portfolio as an early-warning and asset-health solution. When deployed along busways, power cables, tunnels, pipelines, storage and production areas, or other temperature-sensitive infrastructure, it provides continuous visibility, precise event location, configurable alarms, and historical trend data. Through integration with INSIGHT™, thermal events can become actionable information for operations, security, facilities, and maintenance teams.

BOTTOM LINE **SENTINEL TS replaces thermal blind spots with a continuous layer of awareness—helping organizations prevent outages, reduce fire risk, prioritize maintenance, and protect critical operations.**

Why Point-in-Time Monitoring Leaves Gaps

Handheld infrared inspections, thermal cameras, thermocouples, and smart equipment sensors all have value. However, each observes a defined location, viewing angle, inspection interval, or device. A developing hot spot between inspection rounds—or outside the field of view of a camera—can remain undetected.

- Point sensors measure only where they are installed; failure can originate between those locations.
- Manual periodic inspections create a snapshot, not a continuous record of thermal behavior.
- Electrical or mechanically complex environments can make conventional wiring difficult, expensive, or unsafe.
- Large, linear assets may require hundreds or thousands of conventional measurement points to approach comparable coverage.
- Without accurate location and trend context, teams may struggle to distinguish a transient condition from a developing fault.

How Distributed Temperature Sensing Works

DTS uses light traveling through glass to measure temperature along the full length of an optical fiber. The fiber is both the sensing element and the signal pathway.

1. Launch. The DTS interrogator sends controlled laser pulses into the sensing fiber.
2. Scatter. As light travels through the glass, a small portion is naturally scattered back toward the interrogator.
3. Measure. The system analyzes temperature-dependent components of the returned light. In Raman-based DTS, the relationship between Stokes and anti-Stokes scattering is used to determine local temperature.
4. Locate. Optical Time Domain Reflectometry (OTDR) uses the return time of the scattered light to calculate where each measurement originated along the fiber.
5. Interpret. Software builds a continuous temperature profile, applies zones and alarm thresholds, and presents trends and events for operational response.

From a Fiber to a Thermal Map

Physical Layer	Measurement Layer	Operational Layer
Passive dielectric sensor cable follows the asset or protected route.	The interrogator resolves temperature by distance along the fiber.	Zones, thresholds, trends, alerts, and integrations support action.

Why Raman-Based Measurement Matters

In Raman-based systems, temperature is calculated from the relative behavior of two backscattered light components: Stokes and anti-Stokes. The anti-Stokes component is strongly temperature dependent, while the Stokes component provides a reference. Analyzing their relationship allows the system to calculate absolute temperature along the fiber. Because the measurement is optical, the sensor is naturally immune to electromagnetic and radio-frequency interference.

DESIGN IMPLICATION **System performance depends on the full sensing design—not only the interrogator. Fiber type, cable construction, attachment method, optical loss, calibration, zone design, spatial resolution, and update rate must be engineered for the asset and operating environment.**

What Continuous Thermal Intelligence Changes

Capability	Operational Value
Complete linear coverage	Measures continuously along the sensing route rather than only at isolated instrument points.
Early anomaly detection	Reveals hot spots, cold spots, and emerging thermal patterns before they become obvious failures.
Precise localization	Maps an alarm to a position along the fiber so teams know where to inspect and respond.
Passive field sensing	Uses dielectric fiber with no electrical power required along the sensing cable.
EMI/RFI immunity	Maintains measurement integrity in electrically noisy environments where conductive sensors can be challenged.
Scalable monitoring	A single interrogator can monitor extensive linear assets, reducing the number of discrete devices and field connections.
Trend-based maintenance	Historical profiles help identify degradation, changing load behavior, and recurring conditions.
System integration	Events and data can be incorporated into operational workflows, alarm management platforms, and industrial control environments.

SENTINEL TS for Mission-Critical Power Distribution

In data centers and other high-availability facilities, busways carry concentrated electrical loads through overhead and underfloor pathways. Connections, joints, tap-off units, end feeds, load imbalance, and installation issues can create localized heating. SENTINEL TS can be attached along the busway to create a continuous thermal profile that helps operators detect abnormal conditions early and correlate them with location and time.

- Continuously monitor busway surface temperature along the full sensing route.
- Detect and locate abnormal heating at joints, tap-off units, end feeds, and other critical areas.
- Establish zone-specific thresholds based on asset design and operating conditions.
- Track temperature behavior over time to support condition-based and predictive maintenance.
- Provide real-time alarm visibility to operators.

NIS product positioning and busway application. https://www.networkintegritysystems.com/sentinel-ts

Applications Beyond the Busway

The same continuous, spatially resolved temperature profile can support many linear and distributed assets. The sensing cable and deployment design are selected for the temperature range, environment, mechanical demands, and required response.

Power cables and substations. Identify hot spots, loading issues, joint degradation, and abnormal thermal behavior across underground, subsea, overhead, or station assets.

Tunnels and transportation. Provide linear heat and fire detection where smoke movement, airflow, distance, or access can complicate conventional detection.

Pipelines and industrial processes. Recognize temperature anomalies associated with leakage, process changes, insulation degradation, or equipment conditions.

Storage and production facilities. Monitor long perimeters, conveyors, cable trays, tanks, and hazardous or difficult-to-access areas.

Renewable and conventional energy. Support thermal monitoring across generation, transmission, and balance-of-plant infrastructure.

Geotechnical and environmental systems. Observe temperature changes that reveal flow, seepage, or subsurface behavior when the installation is engineered for the application.

Alarm Strategy: Turning Data Into Action

The value of a DTS deployment is determined by the quality of its alarm strategy. A single high-temperature limit may be useful, but mission-critical applications often benefit from multiple event types and context-aware rules.

- Absolute temperature alarms when a location exceeds a defined safe threshold.
- Rate-of-rise alarms when temperature changes faster than expected.
- Differential alarms when one zone deviates from neighboring or comparable sections.
- Pre-alarms that create time for verification and controlled intervention before a critical trip point.
- Persistent-condition logic that reduces nuisance alarms from brief, non-actionable fluctuations.
- Zone-specific rules that reflect different equipment, loads, ambient conditions, or consequences.

WITH INSIGHT™ SENTINEL TS events can be consolidated with other NIS sensing and security data to support real-time visibility, notifications, event history, and a more unified response workflow.

Engineering a Successful Deployment

DTS is a system—not a cable placed near an asset. Reliable results begin with application engineering and continue through installation, calibration, commissioning, alarm design, integration, training, and lifecycle support.

1. Define the objective	Clarify the failure modes, required warning time, monitored assets, consequence of failure, and response ownership.
2. Survey the route	Document asset geometry, fiber access, environmental exposure, hazardous-area requirements, optical distances, splices, and installation constraints.
3. Design the sensing layer	Select appropriate fiber and cable construction, mounting or thermal-coupling method, loop topology, redundancy, zones, and service access.
4. Configure measurement	Balance sensing range, spatial resolution, update interval, signal-to-noise ratio, and alarm sensitivity for the operating case.
5. Establish the baseline	Commission under known conditions, validate location mapping, confirm thermal response, and record normal operating profiles.
6. Integrate and train	Connect alarms, define escalation procedures, and train operators and maintainers.
7. Verify over time	Periodically validate system health, reference conditions, alarm logic, asset changes, and response performance.

Performance Trade-Offs to Address Up Front

- Range, spatial resolution, update time, and temperature precision are interdependent; optimizing one may affect another.
- Thermal coupling between sensor cable and asset strongly influences response and accuracy.
- Connectors, splices, bends, and attenuation affect optical signal quality.
- Single-ended and double-ended configurations offer different resilience and compensation options.
- Ambient conditions and asset segmentation should inform baseline creation and alarm thresholds.
- Existing dark fiber may be reusable when fiber type, route, attenuation, access, thermal coupling, and environmental suitability are verified.

Why Network Integrity Systems

NIS approaches distributed sensing as an operational solution—not a standalone instrument.

Headquartered in Hickory, North Carolina, Network Integrity Systems has more than two decades of experience applying optical sensing technology in U.S. Government, military, critical infrastructure, data center, and enterprise environments. That background shapes how SENTINEL TS is designed, deployed, integrated, and supported: the objective is actionable awareness tied to a real response plan.

- One experienced partner for consultation, design, installation, commissioning, integration, training, and support.
- A broader portfolio spanning thermal monitoring, perimeter protection, access-point sensing, network infrastructure security, and alarm management.
- Software integration for centralized event visibility.
- Mission-centric engineering that accounts for the asset, environment, operational risk, and customer workflow.
- U.S.-based accountability and support from a company trusted in high-reliability and national-security environments.

SENTINEL TS™ Continuous thermal awareness for the infrastructure you cannot afford to lose.

Conclusion

Thermal failures rarely begin as catastrophic events. They begin as a connection that runs warmer than its peers, a localized rise that persists, a process condition that drifts, or a section of infrastructure that behaves differently from its baseline. The challenge is seeing those changes early enough—and knowing exactly where they are occurring.

SENTINEL TS transforms optical fiber into a continuous temperature-monitoring layer across critical assets. By combining distributed measurement, precise event location, intelligent alarm strategy, and NIS implementation expertise, organizations gain the information needed to act before abnormal heat becomes downtime, damage, or danger.

Learn more: networkintegritysystems.com/sentinel-ts

Technical note: *Specifications vary by configuration and project design. Confirm sensing range, resolution, update interval, accuracy, cable construction, certifications, interfaces, and environmental ratings with NIS.*