

The Valley Group

a Nexans company



CAT-1 Transmission Line Monitoring System

Optimize your network capabilities

Dynamic real time line ratings...

Transmission line real time rating is the highest current that a power line can be operated at without violating safety codes, the integrity of line materials or network reliability. When line current increases, the conductor heats up, elongates and the line sags increase. If the line is operated beyond its maximum design temperature, the line sags may violate design clearances.

Traditionally, fixed thermal ratings have been applied by transmission owners. Such ratings are based on conservative assumptions of wind speed, ambient temperature and solar radiation, which are typically selected based on a 98% level. Thus, if the line were to be operated at its fixed thermal rating 100% of time, its temperature would be less than the maximum design value 98% of the time. In the remaining 2% of the time, the utility may run the risk of exceeding safety margins.

Use of the CAT-1 Transmission Line Monitoring System for dynamic ratings allows utilities and transmission operators to develop and apply line ratings in real time, based on actual weather conditions instead of fixed, conservative assumptions. Using patented temperature sensors, load cells, cellular or radio communications, and advanced rating algorithms, CAT-1 offers a powerful tool for maximizing the capabilities of transmission lines and avoiding unnecessary operator interventions for transmission line loading relief. Typically, dynamic ratings provide higher

line capabilities 98% of time and provide at least 15-30% additional capability for over 95% of time.

Because transmission systems require a very high level of reliability, unmonitored transmission networks can never be utilized at their full capabilities. A transmission network must always withstand the largest credible contingency, i.e. the loss of its most critical element. In effect, this means that the capabilities of major network paths are constrained by the ratings of lower voltage lines that underpin higher voltage lines. Because of load distribution factors, applying real time ratings to seemingly minor lines will provide an increase in the capability of the whole path which is many times higher than that of the monitored line.

CAT-1 meets the expectations of power utilities and transmission operators:

- Optimized use of infrastructure by maximizing the capacity of transmission paths
- Elimination of unnecessary and often risky operator interventions
- Quick reaction time for contingencies and responsiveness to weather
- Safe and reliable operation above static ratings
- Minimal disruption to the network when correcting line dispatch
- Meeting new transmission reliability regulations



...allow you to take cost-effective actions

CAT-1 Transmission Line Monitoring Systems are the fastest deployed and most economical solution for easing congestion and helping ensure the reliability of overhead lines. Accurate real time ratings provide advance warnings of reliability threats, while delivering significantly higher ratings in most cases.

Many utilities and transmission operators are reluctant to embrace new systems, fearing increased data clutter and workloads. CAT-1 operates "in the background", alarming only when specific conditions occur, and allowing operators to interrogate the systems in anticipation of system changes.

CAT-1 provides you with real time monitoring of the capabilities of your overhead transmission lines by measuring conductor tension and local weather parameters, and feeding the information back to your EMS/SCADA system.

You can then use this data to optimize the load on overhead lines, so that they can transmit more power, while ensuring that the sag remains well within safety limits.

Over 300 systems are now installed at 100 utilities worldwide to upgrade existing networks and improve the performance of new networks.

CAT-1 Transmission Line Monitoring Systems allow you to:

- Rapidly deploy solutions when capacity deficiencies are discovered
- Raise transmission capacity by 15-30% to avoid network congestion
- Accurately monitor sag on older lines, where design conditions are least certain
- Match overhead line ratings to actual load capacity and weather conditions
- Provide advance warning of impending clearance violations
- Avoid unnecessary operator actions



Why tension monitoring?

1 - Increases transmission capabilities by 10-30%, safely and economically.

- Unmonitored lines are operated on conservative assumptions (static or "book" ratings).
- When a transmission path is contingency-limited, a small rating increase in the limiting line makes a much larger improvement in the complete interface rating.

2 - Very high accuracy - measures sag within 1-2 inches (3-6 cm).

3 - Rates lines the same way they are designed.

- Each span must maintain mandated regulatory clearances to the ground.
- Keeping tensions above design minimum values guarantees safe clearances.
- Tensions vary due to variation in line currents, wind, solar radiation, and ambient temperature.

4 - Tension is directly related to average conductor temperature of the suspension section.

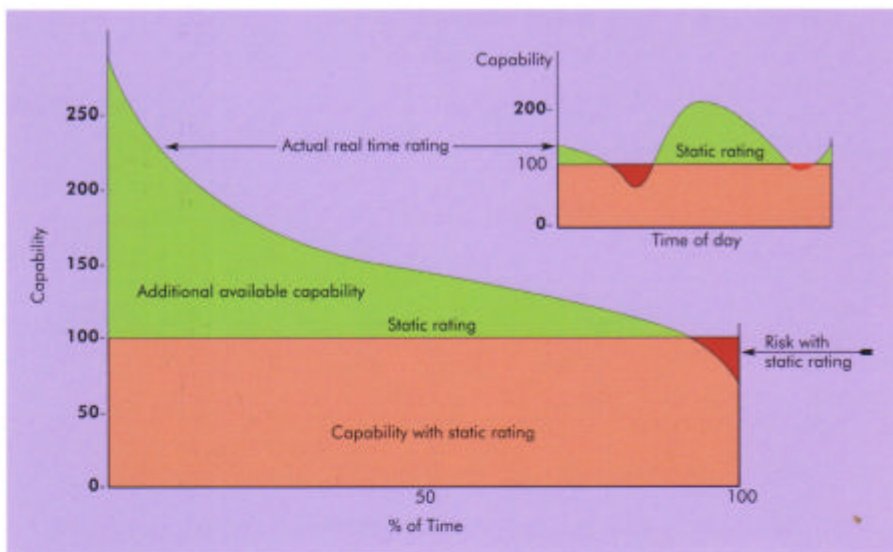
- Weather data and spot conductor surface temperature are not accurate measures.

5 - Even conservative «book» ratings are not 100% safe and reliable.

- Safe ratings should be based on zero wind, unless the lines are monitored.

6 - The most widely accepted thermal rating method in the world.

- Over 100 utilities have installed more than 300 CAT-1 systems* on 5 continents.
- Over two thirds of the 30 largest utilities in North America use CAT-1.
- The majority already use CAT-1 for real time rating data direct to their EMS.



Additional available capability with CAT-1 real time rating

CAT-1 system components



CAT-1 main unit

CAT-1 main unit

- Weatherproof aluminum enclosure with electronics
- Solar power supply and backup battery
- Cellular or radio communications
- Ambient temperature sensor

Load cells*

- Each of two load cells measures the tension of one suspension section
- Electrical protection for lightning and high voltage environment



Load cell installed at deadend structure

Net Radiation Sensor (NRS)**

- Ingenious method of modeling line temperature without load
- Combines ambient temperature with wind and solar effects, emissivity and conductor time constant
- Greatly simplifies measurements and rating calculations

CATMaster Base Station

- 19 inch rack mount
- Converts data to utility's EMS protocol
- Seen as addressable RTU by EMS

IntelliCAT for Windows software

- Fast and easy way to integrate real time ratings to EMS
- Ratings direct to operator's console
- No need to maintain a custom EMS application
- Dynamic ratings and load convergence alarms
- Pre-contingency transient (STE)
- Data quality monitoring

*U.S. Patent #5,918,288
**U.S. Patent #5,559,430

Accurate and easy-to-use thermal rating data

The data you need

Tensions, Net Radiation Temperatures, sags, clearances, conductor temperature, capability.

CAT-1 measures the most meaningful data for rating calculations. Tensions and Net Radiation Temperatures (NRT). Tension and NRT measurements both take into account the effects of ambient temperature along with wind and solar effects, emissivity and conductor time constant. The result ?

- Simplified rating calculations
- Highly accurate ratings

Getting from Tension to Ratings

Figure 1 shows how CAT-1 measurements are used to calculate the rating information of the most interest to you - conductor temperature, sags, clearances, and real time ratings.

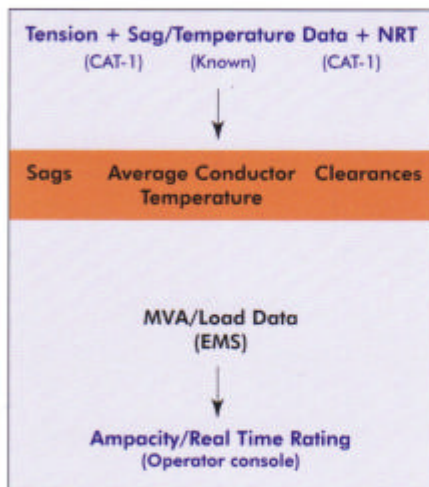


Figure 1 - Tension to Real Time Rating

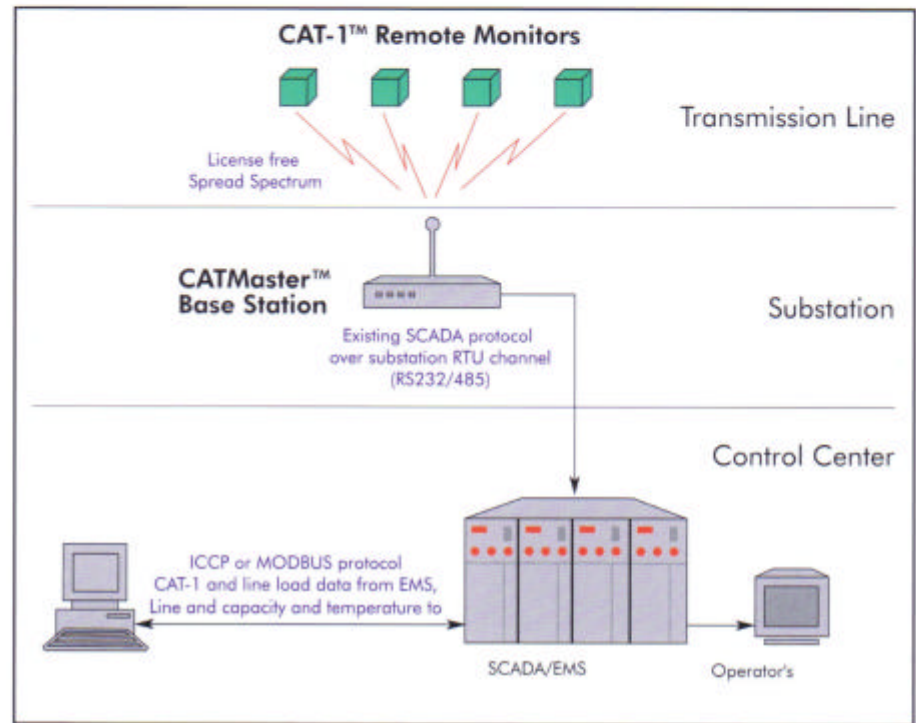


Figure 2 - Typical CAT-1 System Block Diagram

End to end solution

- Data from remote monitors on transmission lines
- Conversion to utility's own EMS protocol
- IntelliCAT for Windows calculates continuous ratings, provides dynamic alarms and calculates transient ratings
- Fully automated to operator's console
- As close to plug and play as an engineered solution can be (Figure 2).

Why are increased ratings possible?

- 1- A change in wind speed from 2 ft/sec to 4 ft/sec (0.6-1.2m/sec) increases capability by 20-30%.
 - Wind is the most significant weather variable influencing ratings.
 - Knowing actual, instead of assumed wind effects is critical.

2 - High winds and high ambient temperatures generally coincide.

- Provides favorable daytime rating conditions.
- Simple «ambient-adjusted» ratings thus are often erroneous and may be dangerous.

3 - Wind data from meteorological sites is poorly suited for ampacity analysis.

- Simultaneous wind speed measurements at two sites one mile apart typically vary in a 2:1 ratio.
- Anemometers have stall speeds of 4-5 ft/sec, (1.2-1.5m/sec) exaggerating the occurrence of thermally limiting «calm».
- Meteorological sites are in very different terrain and elevation than transmission corridors.

Why real time ratings?

Allows full utilization of CAT-1 for economic benefits throughout your network

- What do your operators normally do in a contingency situation?
- If a power plant is down, do you import expensive power from a neighboring utility?
- What if a tieline load exceeds its static rating?
- Do you have to start up expensive gas turbines?

Instead, a progressive utility would use CAT-1 systems for the real time rating of key transmission lines as a superior economic alternative.

Are your contingencies costly?

With a real time CAT-1 System:

- The operator can safely load the lines above their «book» rating (an estimated rating).
- The operator will see the current real time rating (the actual rating) of each suspension section (Figure 3).
- Lines can be operated at the generally higher real time rating.
- An algorithm calculates the maximum safe load for the operator.
- In most cases, imported energy and startup of expensive backup generation can be delayed or prevented.

Are you running your lines safely?

- In some cases, lines cannot be run at even supposedly conservative static ratings!
- Monitored lines can be operated 100% safely and reliably.

Example – 3 month payback:

The line was operated above the static limit for 167 hours (Figure 4), allowing the utility to avoid «a significant amount» of energy redispatch. The utility calculated less than 3 month payback for total installed cost including all:

- Acquisition, installation, and calibration
- Engineering project management
- Field verification of ratings

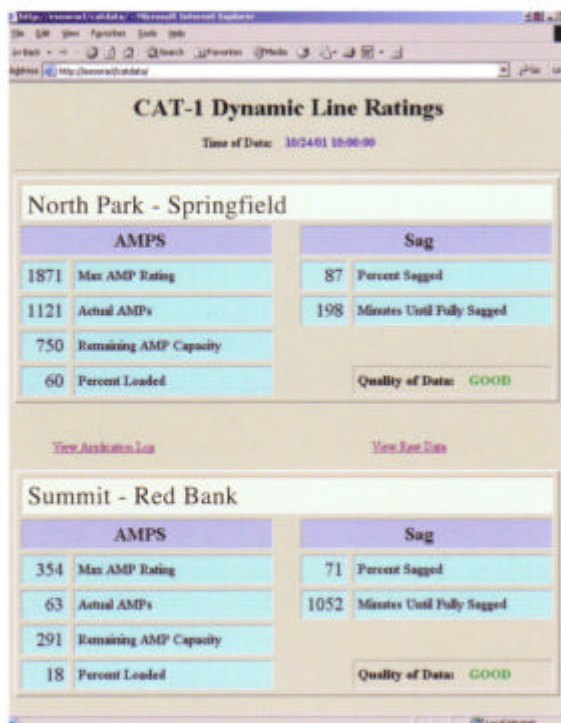


Figure 3. Operator's screen with CAT-1 real time rating

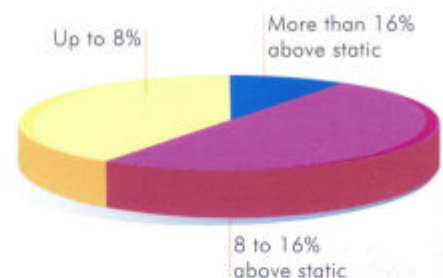


Figure 4. Line was operated above static limit for 167 hours

CAT-1 operating modes



Data Logging Mode/ Clearance Warning Mode

- Cellular communications for data downloads
- Analog or digital cellular, including GSM
- Provides a warning of any impending clearance violation*

Real time ratings

- Radio communications via CATMaster to your EMS
- Provides the actual, accurate real time rating instead of static rating «approximation»
- Provides alarms of impending clearance violations*
- Ratings are continuously displayed in a format familiar to system operators
- Alarm handling follows established procedures

Thermal rating applications

- Economy transactions
- Better operating decisions
- Postponing construction
- Avoiding unnecessary contingency actions
- Improving generation dispatch
- Economically optimized choice between thermal rating and physical uprating
- Fastest transmission solution for new generation



Other applications

- Studies of advanced conductors
- Icing
- Annealing
- High temperature creep
- Wind loads

Versatility and reliability

Over 15 years of high reliability in a variety of high voltage environments

- At voltages up to 500 kV
- At temperatures as low as -40°C
- At temperatures as high as $+50^{\circ}\text{C}$
- Performance not affected by weather, rain, wind, snow, or fog
- A self calibrating system
- Solar powered
- No moving parts
- No maintenance except battery change every 5 years

*U.S. Patents #5,235,861, #5,517,864, #5,559,430, #5,918,288



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