A Simple Solution for a Complex Issue:
NERC Reliability Standards and 3M™ ACCR

Introduction

> "Access to electricity is particularly crucial to human development as electricity is... indispensable for certain basic activities, such as lighting, refrigeration and the running of household appliances, and cannot easily be replaced by other forms of energy. Individuals' access to electricity is one of the most clear and undistorted indications of a country's energy poverty status."
>
> *EIA, World Energy Outlook, 2010*

The electric utility industry's concerns about safeguarding the reliability of the electric grid are easy to understand. Electric power drives economic growth and sustainable job creation, provides for our safety and security, and enhances our quality of life. Also, outages are expensive. According to the U.S. Department of Energy (DOE), blackouts and brownouts reduce America's gross national product by $150 billion annually[1].

In fact, the idea of having reliability standards in place is not new to the industry. The North American Electric Reliability Council, precursor to today's North American Electric Reliability Corporation (NERC), was formed in the late 1960s by the utility industry itself, and adherence to NERC reliability standards, while voluntary, set the bar for "good utility practice"[2]. In fact, utilities have managed the grid so effectively that the DOE measures grid reliability at 99.97 percent[3].

But today the reliability environment has changed. NERC has been transformed from a voluntary organization to an official Reliability Organization for the United States and is now implementing legally enforceable reliability standards[4]. Utilities are wrestling with integrating intermittent generation resources and regional transactions into a grid that was not designed for them while also struggling with unprecedented public opposition to transmission construction; at the same time, compliance has become more onerous, complicated and expensive, with penalties for non-compliance that can reach up to $1 million a day[5].

This paper looks at a subset of these new standards – facilities ratings, transmission planning and special protection systems – and how an advanced 3M conductor technology, 3M™ Aluminum Conductor Composite Reinforced (3M ACCR), can help simplify compliance and make it more cost effective, while protecting the reliability of the system.

Facilities Ratings – Standards FAC-008 and FAC-009[6]

Standard FAC-008 requires transmission and generation owners to have a methodology in place and documented for assigning ratings to transmission facilities, including transmission lines. Standard FAC-009 requires transmission and generation owners to rate their transmission facilities using this methodology. While these standards may seem straightforward, compliance was complicated in 2010 when NERC issued its Facility Ratings Alert, recommending that transmission and generation owners "… review their current facility ratings methodology to verify the methodology used is based on actual field conditions"[7]. Assessments must consider ambient conditions, operating limitations, conductor-to-conductor clearances and conductor distance to objects occupying the right of way, including the ground itself[8].

"... an entity will receive highly favorable treatment in compliance space for its proactive approach to reliability and support of this recommendation."

North American Electric Reliability Corporation, "Q&A - Consideration of Actual Field Conditions in Determination of Facility Ratings", January 14, 2011, page 4.

Owners have 3 years to comply, and, at the end of each year, must provide a report summarizing the assessments and identifying all transmission facilities where as-built conditions are different from design conditions, resulting in incorrect ratings[9].

The issuance of this "recommendation" caused a flurry of activity, including webinars, compliance application notices (CANs) and supporting documents, as the industry sought clarification as to what was expected. And, while this NERC Alert is nominally a recommendation, NERC has made it clear that non-compliance has implications.

Therefore, participating in the assessments demonstrates a "culture of reliability" that is explicitly taken into account if a violation should occur and penalties are considered[10].

In addition, remediation is expected within one year from issue identification, or on a schedule approved by the regional entity[11]. In the meantime, any line with a discrepancy must be de-rated until the issue is fixed, affecting the amount of power that can be carried on the line during normal operation and contingencies[12]. This has a direct impact on a transmission owner's ability to comply with transmission planning standards as well.

Transmission Planning Standards – Standards TPL-001, 002, 003 and 004[13]

Systems must "…minimize the likelihood and magnitude of interruption of firm transfers or Firm Demand following Contingency events".

North American Electric Reliability Corporation, "Reliability Standard TPL-001-1", page 5, note b, Feburary 17, 2011.

Transmission planning standards specify that the Planning Authority and Transmission Planner must demonstrate that its portion of the system is planned such that the network can be operated under defined conditions. The conditions include normal operation (Category A), N-1 contingency (Category B), N-2 contingency (Category C) and extreme contingency (Category D). The system requirements vary depending on the defined condition being evaluated, but they must "… minimize the likelihood and magnitude of interruption of firm transfers or Firm Demand following Contingency events"[14]. In addition, the Planning Authority and Transmission Planner must provide a written summary of its plans to achieve the required system performance, including a schedule for implementation[15].

Special Protection Systems – Standards 003, 012, 013, 014, 015, 016 and 017 (plus separate standards for WECC)[16]

One way to meet the contingency planning standards is through implementing a special protection system (SPS), also known as a remedial action scheme (RAS). These systems are designed to detect abnormal or predetermined system conditions and take corrective actions, including managing demand and generation or system configurations to maintain stability, voltage levels or power flows[17]. They address problems that include over- or under-frequency, voltage collapse, generator instability, transfer limits, system separation, and equipment or transmission line thermal overload[18].

Putting together a compliant SPS is a complex task that includes defining logic protocols, minimum and maximum remedial actions and maximum allowable response time[19]. Utilities may need to invest in condition-sensing, arming, logic processing, communications and action equipment[20]. Ongoing maintenance and operations must be established and followed. NERC standards also require redundancy – a single SPS component failure cannot prevent the system from meeting performance requirements[21]. Risks include the system not tripping when it is needed or tripping when not needed[22].

NERC has seven individual standards in place governing special protection systems, as well as additional standards for the Western Electricity Coordinating Council (WECC). They apply to transmission owners and operators, generation owners and reliability organizations who are required to have procedures in place for tracking these systems, testing and maintaining them, tracking system triggers and misoperations, correcting problems and communicating with other protection and control systems, all of which require significant data and documentation (see Standards referenced above).

In all this complexity, a little simplicity

For clearance issues or thermally-limited transmission lines, there is a simple solution available–reconductor with advanced 3M™ ACCR.

While no one can argue with the importance of protecting transmission system reliability, it is also clear that meeting today's level of required compliance is complicated, with potentially expensive consequences. One tool cannot address all that is required.

However, when facility rating mitigation, contingency condition requirements or special protection systems are driven by clearance issues or thermally-limited transmission lines, there is a simple solution available – upgrade existing lines by reconductoring with advanced transmission technology, such as 3M™ Aluminum Conductor Composite Reinforced (ACCR).

ACCR is a high-temperature, low-sag conductor specifically designed as a drop-in replacement for standard ACSR or ACSS conductors on existing lines – while delivering as much as twice the capacity.

3M ACCR is the result of extensive technical development and years of testing in laboratories and in the field by both 3M, located in St. Paul, Minnesota, and the DOE through a joint program and in collaboration with several North American electric utilities[23]. Through years of testing and commercial use, its behavior under a wide range of ambient and operating conditions is well-understood, documented and modeled, providing solid substantiation for compliance documentation.

For copies of all 3M™ ACCR lab and field test results, visit www.3m.com/ACCR

3M™ Aluminum Conductor Composite Reinforced (ACCR)

Reconductoring with 3M™ ACCR can eliminate thermal constraints impacting contingency operations and the need for special protection systems. It can also correct clearance issues when nearby structures, topography or other factors have changed over time.

3M™ ACCR offers an upgrade of up to twice the capacity, using existing corridors and towers while maintaining tensions and clearances. Its unique properties can also be used to improve tensions and clearances with smaller upgrades or at existing capacity ratings. For example, utilities in Maine and Tennessee are upgrading transmission lines with ACCR to meet updated Army Corps of Engineers clearance requirements across waterways.

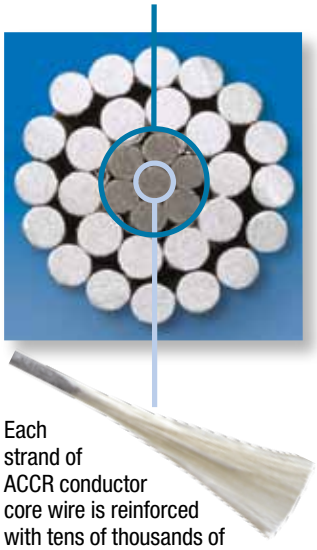
Because existing towers are used, line upgrades with ACCR can typically be done at a much lower cost than rebuilds. The upgrade would not change transmission line footprints, structure height or line appearance, so it can help minimize the impact on property owners, the environment and surrounding facilities. As a result, it can simplify or, in some cases, eliminate lengthy, complicated and expensive permitting processes. The installation process of replacing existing conductor with 3M ACCR is simple and quick, allowing a quick return to required levels for de-rated lines.

Table 1

Core Property Comparison: ACCR vs. ACSR/ACSS

Conductor Core Material	3M™ ACCR Aluminum Matrix	ACSR/ACSS Steel
Strength (ksi)	200	185
Density (lbs/in^3)	0.122	0.282
Strength/Density	1,681	656
Coefficient of Thermal Expansion (10^{-6}/°F)	3.5	6.7

Advanced materials technology from 3M



Each strand of ACCR conductor core wire is reinforced with tens of thousands of ultra high-strength aluminum oxide fibers.

The 3M ACCR core is stranded from composite wires composed of high purity aluminum reinforced with alumina fibers. The outer, current-carrying wires are hardened aluminum zirconium alloy.

Compared to ACSR and ACSS, the 3M ACCR core can offer:

- twice the strength-to-weight ratio
- half the thermal expansion for less sag at high temperatures.

These attributes can result in two or more times the ampacity while maintaining or improving clearances, tensions and mechanical loads on structures. In addition, all-aluminum 3M ACCR is just as durable as standard conductors, even if operated at high temperatures for long periods of time in extreme environments.

3M™ ACCR can be used to reconductor a single tension segment, from dead-end to dead-end, to correct a facility ratings issue, or to reconductor an entire line for needed contingency capacity.

ACCR also helps reduce installation time, which is a factor when an important line has been de-rated for clearance issues or when additional capacity is needed for contingencies. For example, a water crossing in Brazil was installed in just six days, compared to the lengthy permitting and construction time that would have been required to replace towers and set new foundations in the river. Also, sections of a line in Georgia were upgraded with ACCR within firm 10 week outage windows.

A Technology Partner You Can Trust

There are scores of 3M™ ACCR Conductor installations throughout the world – each 100 percent successful to date.

3M's advanced materials expertise, extensive lab and field testing, and close collaboration with utility and industry experts have all combined to make ACCR conductor one of the most trusted new grid technologies.

For more than 100 years, customers have counted on 3M to help them succeed. For more than 60 years, 3M's Electric Markets Division has provided innovative solutions to electric utilities. In ACCR conductors, utility professionals are finding a proven, reliable, versatile and cost-efficient tool for delivering electric power with minimal environmental and community disturbances.

A tool to help manage compliance

When faced with a NERC compliance issue due to a clearance problem or a thermally limited line, transmission stakeholders can de-rate the line, implement a complex and highly-regulated special protection system or remedial action scheme, or rebuild the line to correct the problem. Or, in many cases, they can reconductor the existing transmission line using 3M™ ACCR to obtain the clearances and contingency capacity required. Construction and its impacts can be avoided, thereby simplifying installation and permitting, and saving additional costs by avoiding penalties, lost transactions, and generation or demand curtailments. Although maintaining system reliability is an important and complex task, advanced technology like 3M ACCR can help build the grid robustness and flexibility that are increasingly in demand and help the utility industry keep the nation's lights on for years to come.

For more information, write to accr@mmm.com, phone 1.800.245.3523, or visit us on the web at www.3M.com/accr.

References

1. *The Smart Grid: An Introduction*, A report prepared for the U.S. Department of Energy, publication date not given, p. 5.

2. North American Electric Reliability Corporation (NERC), *NERC Operating Manual*, December 2010, p. HIST-1.

3. *The Smart Grid: An Introduction*, A report prepared for the U.S. Department of Energy, publication date not given, pp. 5, 8.

4. NERC webpage, www.nerc.com, About NERC, Company Overview.

5. Federal Power Act, 16 U.S.C § 825o-1(b), Section 316A, as amended by the Energy Policy Act of 2005.

6. NERC Reliability Standard FAC-008-3 – Facility Ratings, May 24, 2011 and Standard FAC-009-1, February 7, 2006.

7. NERC, *Facility Ratings Alert Recommendation to Industry: Consideration of Actual Field Conditions in Determination of Facility Ratings*, October 7, 2010, p. 1.

8. NERC, *NERC Facility Design, Connections, and Maintenance (FAC) Assessment Plan Review*, May 11, 2011, p. 3.

9. Ibid., pp. 2 – 3.

10. NERC, *Q&A – Consideration of Actual Field Conditions in Determination of Facility Ratings*, January 14, 2011, p. 5.

11. NERC, *Compliance Application: FAC-008 and FAC-009*, January 7, 2011.

12. NERC, *NERC Facility Design Connections and Maintenance (FAC) Assessment Plan Review Criteria,* May 11, 2011, p. 4 and NERC *Q&A – FAC Assessment Plan Review Criteria*, May 12, 2011, p. 4.

13. NERC Reliability Standard TPL-001-1 – System Performance Under Normal Conditions, February 17, 2011; TPL-002-1b – System Performance Following Loss of a Single BES Element, February 17, 2011; TPL-003-1a – System Performance Following Loss of Two or More BES Elements, February 17, 2011; TPL-004-1 – System Performance Following Extreme BES Events, February 17, 2011.

14. Ibid., p. 5, note b.

15. Ibid., pp. 1 – 2.

16. NERC Reliability Standards, Standard PRC-003-1 – Regional Procedure for Analysis of Misoperations of Transmission and Generation Protection Systems; WECC Standard PRC-004-WECC-1 – Protection System and Remedial Action Scheme Misoperation, October 29, 2008; Standard PRC-012-0 – Special Protection System Review Procedure, April 1, 2005; Standard PRC-013-0 – Special Protection System Database, April 1, 2005; Standard PRC-014-0 – Special Protection System Assessment, April 1, 2005; Standard PRC-015-0 – Special Protection System Data and Documentation, April 1, 2005; Standard PRC-016-0.1 – Special Protection System Misoperations, May 13, 2009; Standard PRC-017-0 – Special Protection System Maintenance and Testing, February 8, 2005; WECC Standard PRC-STD-003-1 – Protective Relay and Remedial Action Scheme Misoperation, March 12, 2007.

17. NERC website, www.NERC.com.

18. *WECC Remedial Action Scheme Design Guide*, March 14, 2006, p. 3.

19. Ibid.

20. Ibid., pp. 5 – 9.

21. NERC Standard PRC-012-0 – Special Protection System Review Procedure, April 1, 2005, p. 1.

22. McCalley, James and Weihui Fu, "Reliability of Special Protection Systems", *IEEE Transactions on Power Systems*, Vol. 14, No. 4, November 1999, p. 1401.

23. Funding agreement DE-FC02-02-CH11111.

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