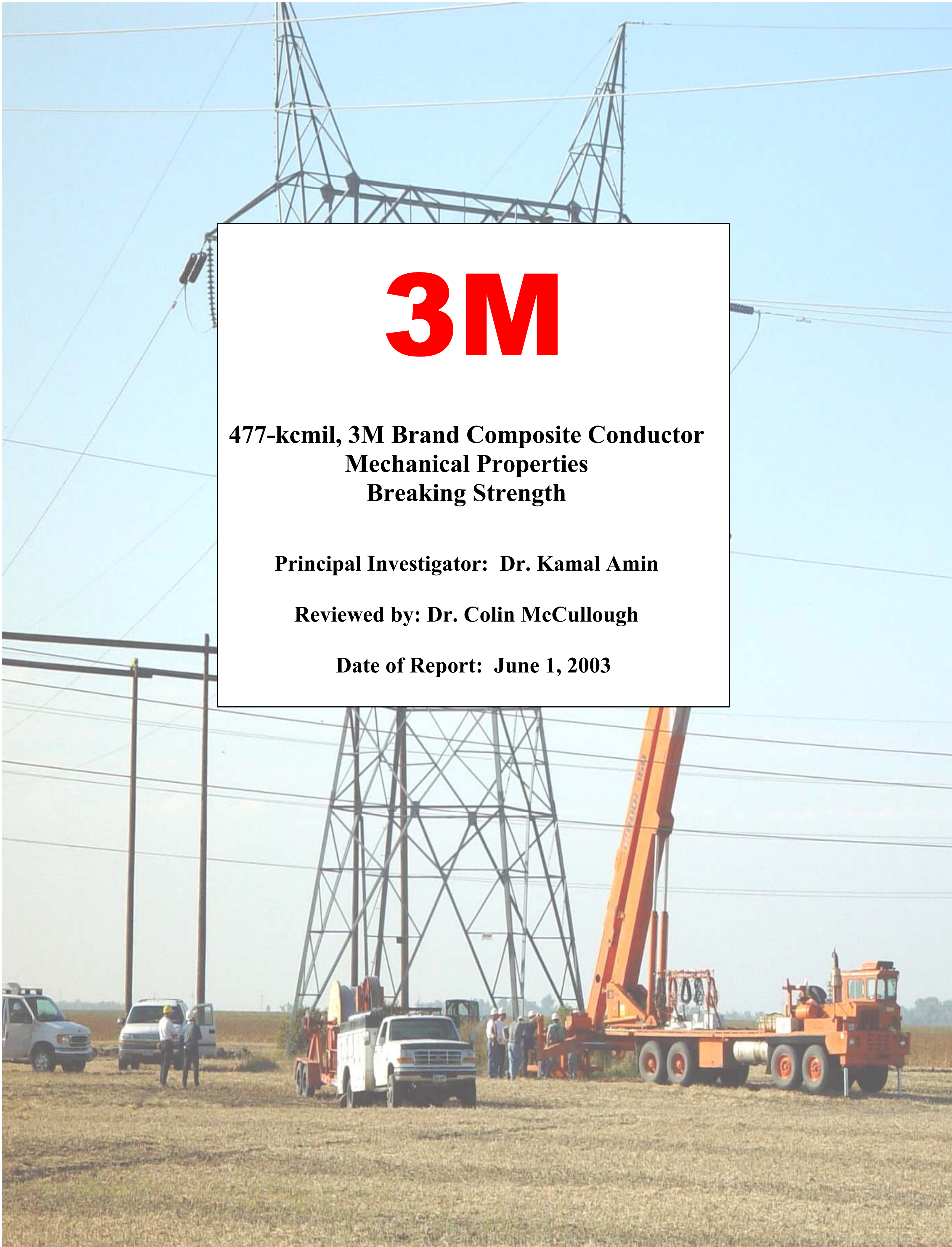

3M

477-kcmil, 3M Brand Composite Conductor
Mechanical Properties
Breaking Strength

Principal Investigator: Dr. Kamal Amin

Reviewed by: Dr. Colin McCullough

Date of Report: June 1, 2003

477 kcmil, 3M Brand Composite Conductor
Mechanical Properties
Breaking Strength

Summary:

The load to failure of 477-kcmil 3M Brand Composite Conductor was measured from tension tests. Tested samples produced loads to failure in the conductor above 100% RBS (Rated Breaking Strength).

Samples;

477-kcmil 3M Composite Conductor were cut to lengths of 10ft (3.05m) and 20ft (6.1m), and fitted with resin terminations at both ends.

Equipment Used:

The shorter 10ft samples were tested at the Xcel Energy test laboratories in Minneapolis, MN, in a horizontal tensile machine with a Sheffer Hydraulic ram. The load cell was a BLH Type T2P1 load cell with a maximum capacity of 50,000 lbs. The digital readout was a Daytronics Model 3270P, accurate to 10 Lbs. The longer samples were tested at NEETRAC (National Electric Energy Testing Research and Applications Center) in Atlanta, GA, and were terminated using resin terminations. In this case an MTS Servo-hydraulic tensile machine, Control # CQ 0195 was used, with a Dynamics Research Corporation (DRC)/NEETRAC cable extensometer, Control # CQ 3002, and a National Instruments AT-MIO-16XE-50 computer data acquisition interface.

Conductor Specification:

See Appendix A

Procedure:

477-kcmil 3M Composite Conductor samples of length 10ft (3.05m) were cut from a spool supply and terminated at each end using a resin wire-lock system cast into cast iron spelter-sockets. Hose clamps were applied 11in from each end and the aluminum strands were cut about 3in from the end to expose the core. The aluminum strands over the remaining 8in were flared open (moving both layers in a direction opposite to the stranding direction). Next the tape was removed from the core over the 8in length and the aluminum strands moved back in the stranding direction but left flared to allow for cleaning. The cables were hung vertically and the ends submerged in an ultrasonic bath containing MEK (Methyl Ethyl Ketone) as the cleaning solution. Samples were removed from the ultrasonic bath after 20 minutes, dried using an air blower and then hung vertically in the spelter-socket using a fixture. Resin (wire-lock compound) was prepared and poured into the metal ends. Samples were left to allow the resin to cure prior to testing. The longer length samples were prepared using a similar procedure, and required ring clamps around the conductor free ends during handling, cutting, and end preparation. This preserves the "as-manufactured" placement of the conductor components, and ensures each layer is loaded realistically during testing

Testing of the short samples utilized a preload to 25% RBS and then holding the load for 10 minutes, followed by reloading at a rate of 5000 Lbs/minute to failure. The load was displayed on a counter and recorded manually along with any details of acoustic cracking noise or other observations. After testing, the failure location was recorded and the aluminum strands were removed and the core examined. The longer samples were loaded uniformly at a rate of 10,000 Lbs/min to failure, with the free-span conductor length of 19 feet (5.6m).

Test Results:

The following table summarizes load to failure, failure location and comments:

Failure Load, (Lbs)	Failure Load, (kN)	%RBS	Gauge Length (ft)	Comments
21040	93.6	108%	10	In gage 30" from resin end
19140 19620 19780	85.1 87.3 88.0	98% 101% 102%	10 10 10	In resin termination In resin termination In conductor at 1/3 gage
20400	90.7	105%	19	At end of resin termination
21070	93.7	108%	19	Failed in mid span (after stress-strain test)
19640	87.3	101%	10	At end of resin termination

RBS = 19,476 Lbs

A typical conductor failure at the epoxy end

All but one sample failed at loads > 100% RBS. The one test sample that failed below 100% RBS, did so at a resin termination, rather than in the gauge length. Thus, the test is affected by the resin termination. ANSI C119.4 (1998) – section 4.4.3 for full tension connectors, gives some guidance to the acceptance criteria. Recognizing that failure is often within the termination, the connector should hold at least 95% of the conductor's rated breaking strength when failure occurs in the termination. Thus, the test that failed at 98% RBS suggests the conductor strength is, with high probability, satisfactory.

Conclusion

Tensile tests performed on 477-kcmil 3M Composite Conductor indicate the conductor meets the Rated Breaking Strength.

Appendix A: 477 kcmil, 3M Composite Conductor Specification

Conductor Physical Properties		
Designation		477-T16
Stranding		26/7
kcmils	kcmil	477
Diameter		
indiv Core	in	0.105
indiv Al	in	0.135
Core	in	0.32
Total Diameter	in	0.86
Area		
Al	in^2	0.374
Total Area	in^2	0.435
Weight	lbs/linear ft	0.539
Breaking Load		
Core	lbs	11,632
Aluminum	lbs	7,844
Complete Cable	lbs	19,476
Modulus		
Core	Msi	31.4
Aluminum	Msi	8.0
Complete Cable	Msi	11.2
Thermal Elongation		
Core	10^-6/F	3.5
Aluminum	10^-6/F	12.8
Complete Cable	10^-6/F	9.2
Heat Capacity		
Core	W-sec/ft-C	13
Aluminum	W-sec/ft-C	194

Conductor Electrical Properties		
Resistance		
DC @ 20C	ohms/mile	0.1832
AC @ 25C	ohms/mile	0.1875
AC @ 50C	ohms/mile	0.2061
AC @ 75C	ohms/mile	0.2247
Geometric Mean Radius	ft	0.0290
Reactance (1 ft Spacing, 60hz)		
Inductive Xa	ohms/mile	0.4296
Capacitive X'a	ohms/mile	0.0988