795-kcmil, 3M™ Composite Conductor
Tensile Tests from Production Samples

3M Company
Purchase Order 0001595200

NEETRAC Project Number: 05-015

February, 2005

A Research Center of the
Georgia Institute of Technology

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SUMMARY

795-kcmil, 3M™ Composite Conductor was tensile tested as part of the quality control for 3M's composite conductor. A total of 21 samples were tested. Three samples failed at a location inadvertently damaged by a temporary clamp used during sample preparation. Two of the damaged samples failed before reaching the nominal rated breaking strength (RBS) of 31,134 lb. Eighteen (18) samples tested after the sample preparation problem was corrected demonstrate that the published RBS is appropriate for use in line designs in accordance with standard practices.

SAMPLES

1.0 Three (3) conductor sections, with 3M identification as follows:
- 1.1 Reel #Z3694 (approximately 200 ft)
- 1.2 Reel #Z3696 (approximately 100 ft)
- 1.3 Reel #Z3695 (approximately 100 ft)

PROCEDURE

Bolted clamps were installed on the sample ends before cutting a sample from the reel. The purpose for the clamps is to preserve the residual stresses from the manufacturing operation, and thereby ensure that a short tensile test sample properly represents the loading seen by in-service conductor.

Cast-resin laboratory fittings were used to terminate the test samples. The resin exerts no mechanical force until after curing. After the resin cures, the temporary bolted clamps are removed, and the test section is ready for the tensile test.

On three early tensile tests, the break occurred at the location of the temporary bolted clamp. The problem was traced to bending loads applied by the clamp, combined with excessive installation torque on the clamp bolts. The procedure was revised to use a less aggressive clamp, and to reduce the bolt torque to the minimum required to prevent slipping of any conductor component. Three (3) samples from Reel # Z3694 were affected before the problem was corrected. All other samples show no effect from the temporary clamp. Results for the damaged samples are reported, but in a group separate from the samples that failed at locations not affected by clamp damage.

Samples were pre-loaded to 1000 lb, and then pulled to destruction at a loading rate of 15,000 lb/min. A data acquisition system records time, tension, and actuator position 6 times per second for the duration of the test.

RESULTS

Table 1 shows results for the 18 valid test samples. Table 2 shows results for three samples that failed at a location damaged by the temporary clamp during sample preparation:

Table 1, Loads, % RBS, and Failure Modes for 795-kcmil, 3M™ Composite Conductor Samples

Sample #	Cut #, Reel ID	Max. Load	% RBS	Failure Mode/Comments
05015T01	1 st cut, sample Z3694	31,450	101	Gage section break ~16" from east end
05015T02	2 nd cut, sample Z3694	32,280	104	Gage section break ~2' from east end
05015T3A	4 th cut, sample Z3694	31,780	102	Break at mouth of west resin socket
05015T05	6 th cut, sample Z3694	31,580	101	Break adjacent to clamp location east end
05015T06	7 th cut, sample Z3694	33,290	107	Mid span break ~5' from west end
05015T08	9 th cut, sample Z3694	33,190	107	Mid-span break
05015T09	10 th cut, sample Z3694	32,810	105	Mid-span break
05015T10	11 th cut, sample Z3694	33,370	107	Mid-span break
05015T11	1 st cut, sample Z3696	32,000	103	Break at mouth of east resin socket
05105T12	2 nd cut, sample Z3696	32,430	104	Mid span break
05015T13	3 rd cut, sample Z3696	33,020	106	Mid span break
05015T14	4 th cut, sample Z3696	33,130	106	Mid span break
05015T15	5 th cut, sample Z3696	32,670	105	Mid span break
05015T16	1 st cut, sample Z3695	33,530	108	Mid span break
05015T17	2 nd cut, sample Z3695	33,240	107	Mid span break
05015T18	3 rd cut, sample Z3695	33,250	107	Mid span break
05015T19	4 th cut, sample Z3695	32,640	105	Mid span break
05015T20	5 th cut, sample Z3695	33,090	106	Mid span break

Table 2, Loads, % RBS, and Failure Modes for 795-kcmil, 3M™ Composite Conductor Samples Damaged by Bolted Clamp

Sample #	Cut #, Reel ID	Max. Load	% RBS	Failure Mode/Comments
05015T03	3 rd cut, sample Z3694	29,210	94	Failed at location of clamp (visible bend)
05015T04	5 th cut, sample Z3694	29,820	96	Failed at location of clamp (visible bend)
05015T07	8 th cut, sample Z3694	31,210	100	Failed at clamp location east end

Figure 1 shows load versus actuator displacement data for all samples tested. Figures 2 through 4 show the same data, sorted by reel #. Figure 5 shows the data from the three damaged samples.

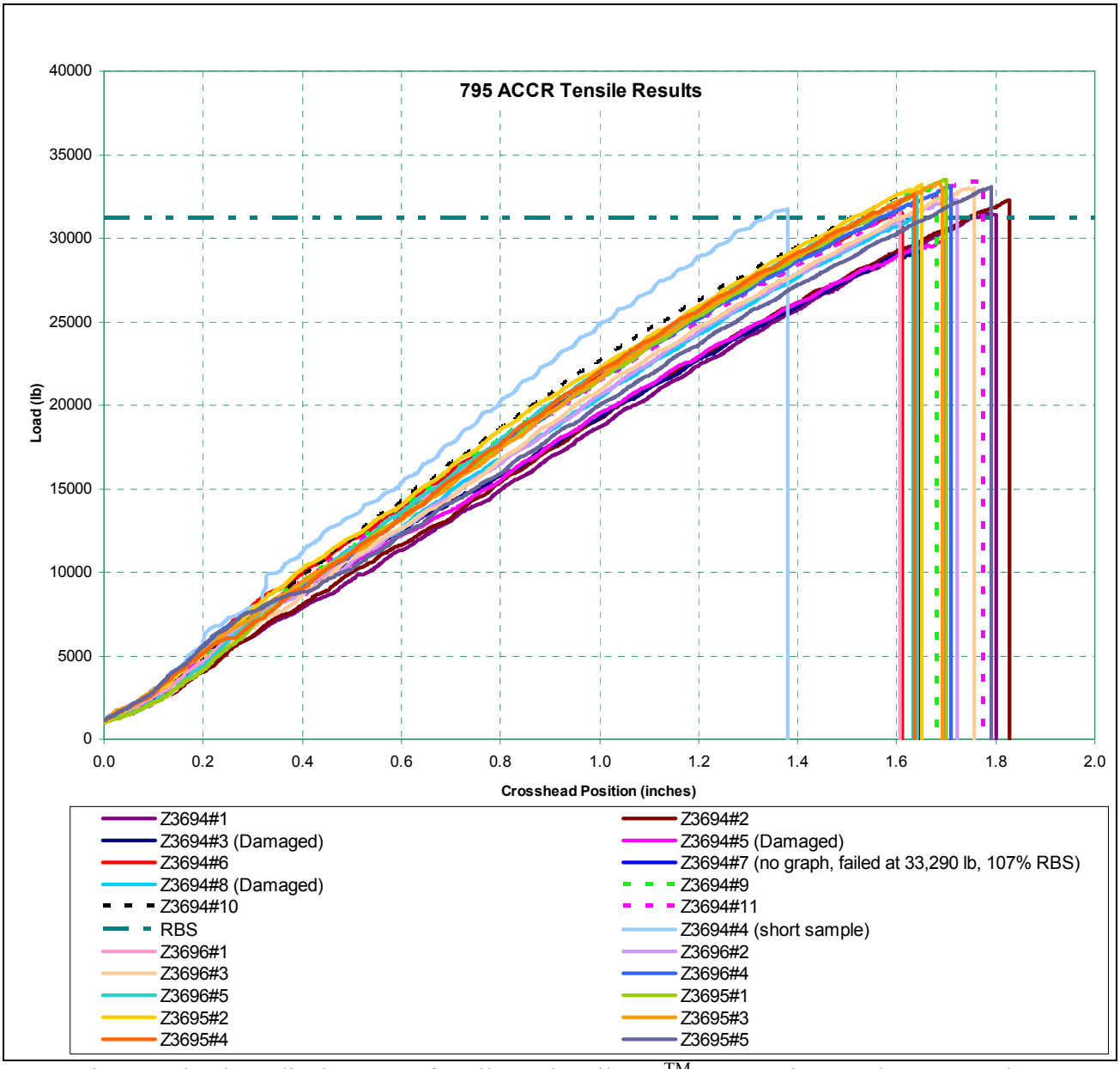

Figure 1, load vs. displacement for all 795-kcmil, 3M™ Composite Conductor samples. The same data are shown in groups in Figures 2 through 5.

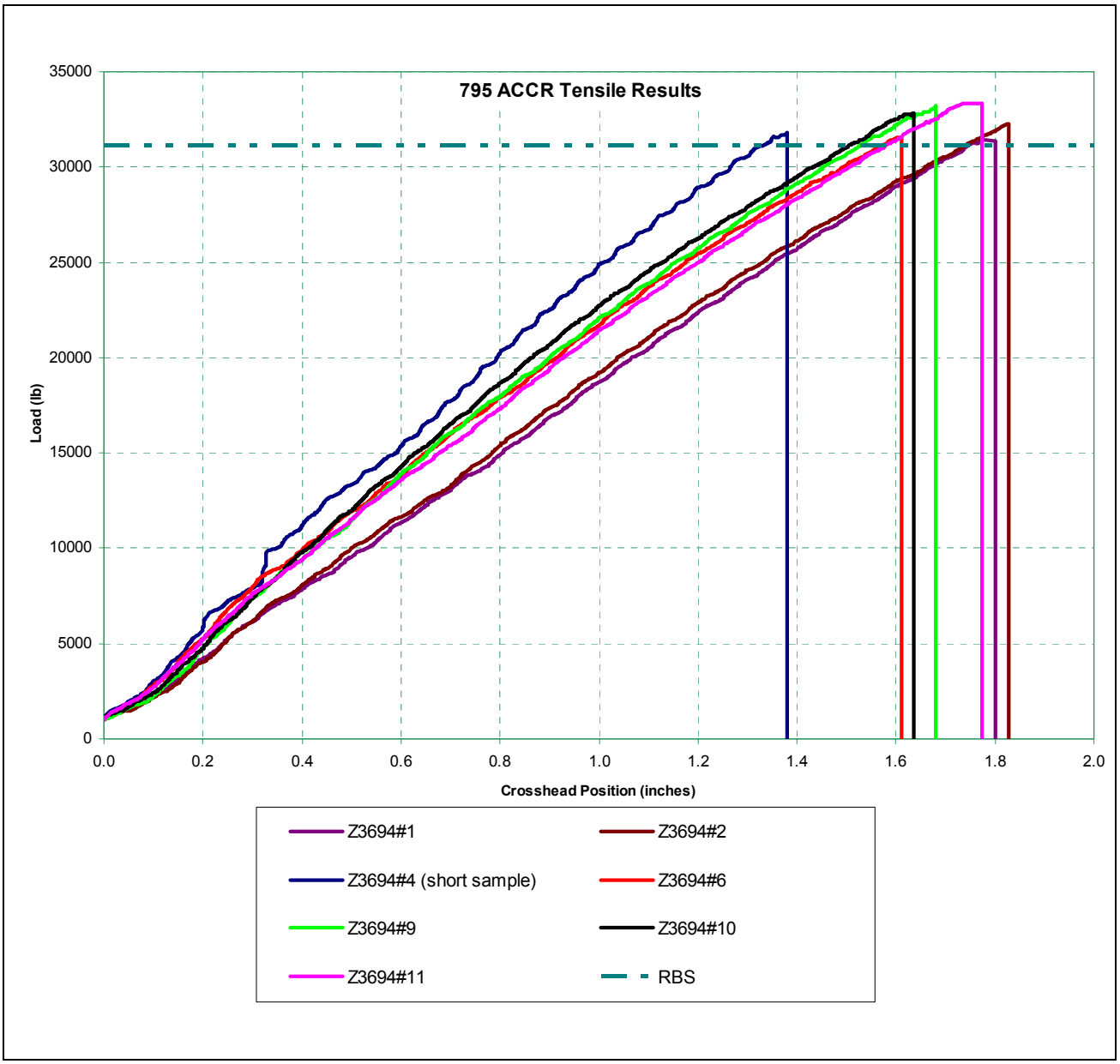

Figure 2, test data for samples cut from Reel # Z3694

Notes:

1) Samples 3, 5, and 8 failed at damage from overaggressive application of bolted clamps. See Figure 5 for data from Samples 3, 5, and 8.
2) Data from Sample 7 was inadvertently overwritten. The paper back-up show the breaking load for Sample 7 is 33,290 lb (107% RBS).

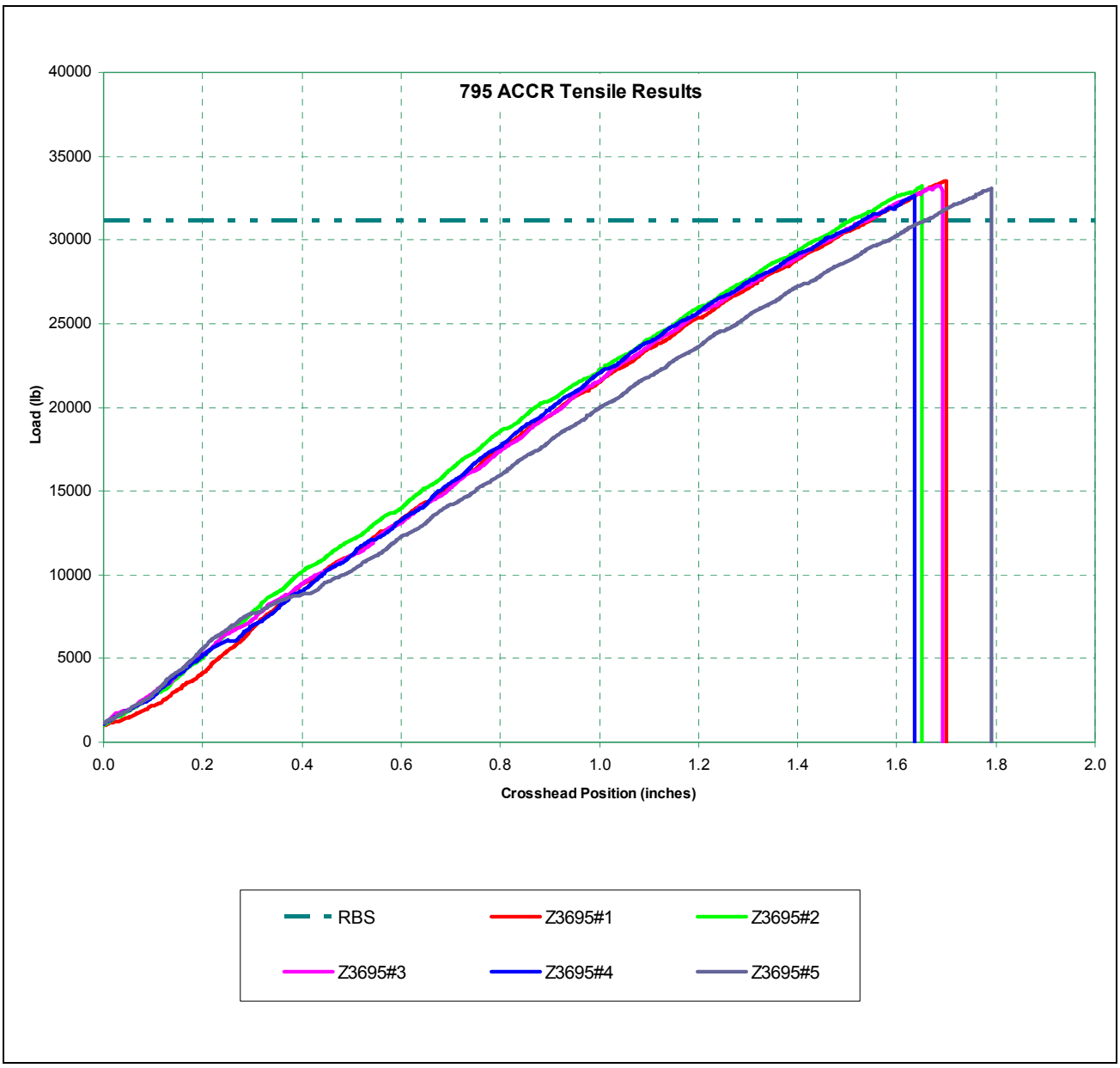

Figure 3, load vs. displacement data for samples cut from reel #Z3695

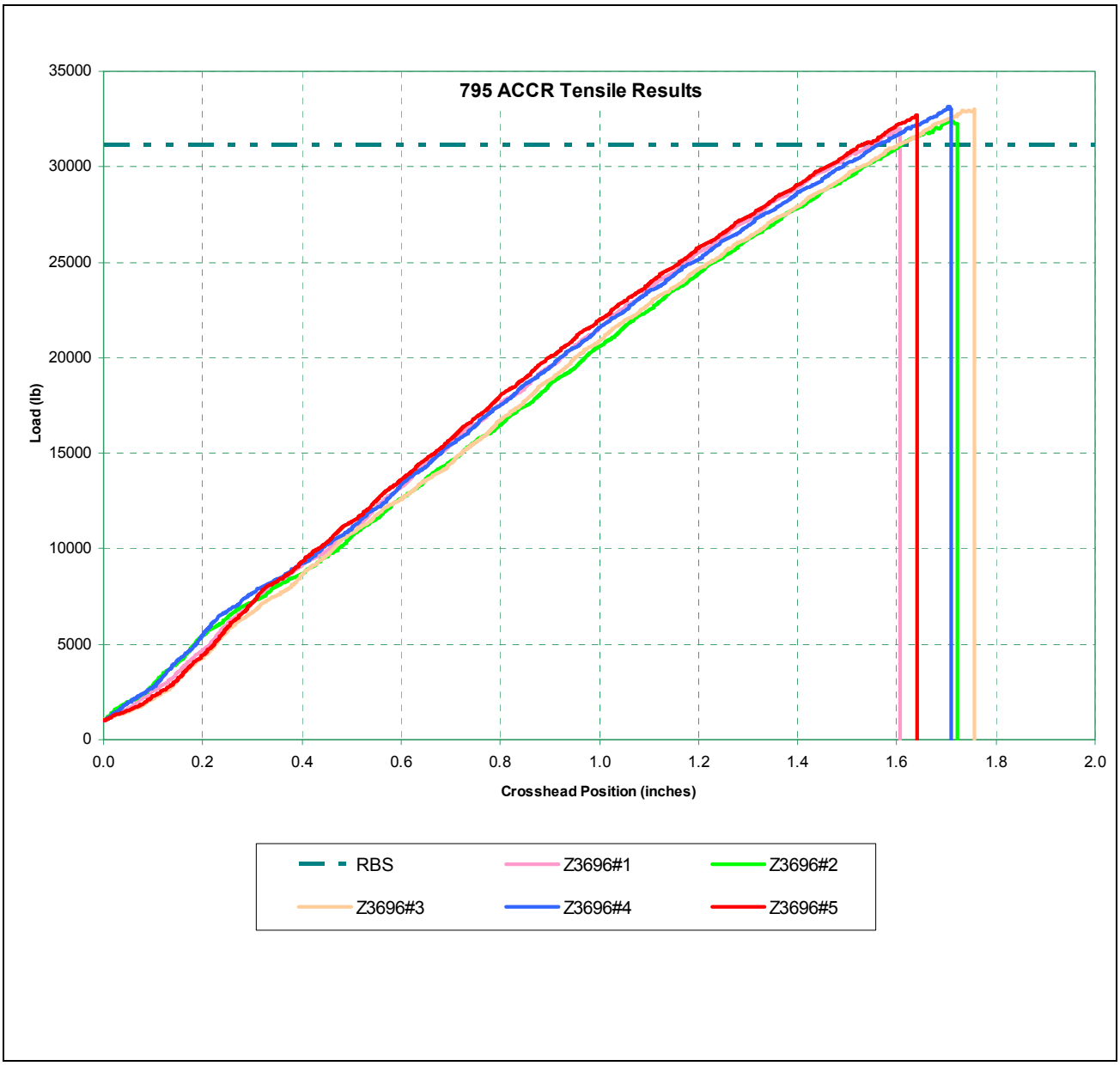

Figure 4, load vs. displacement for samples cut from reel # Z3696

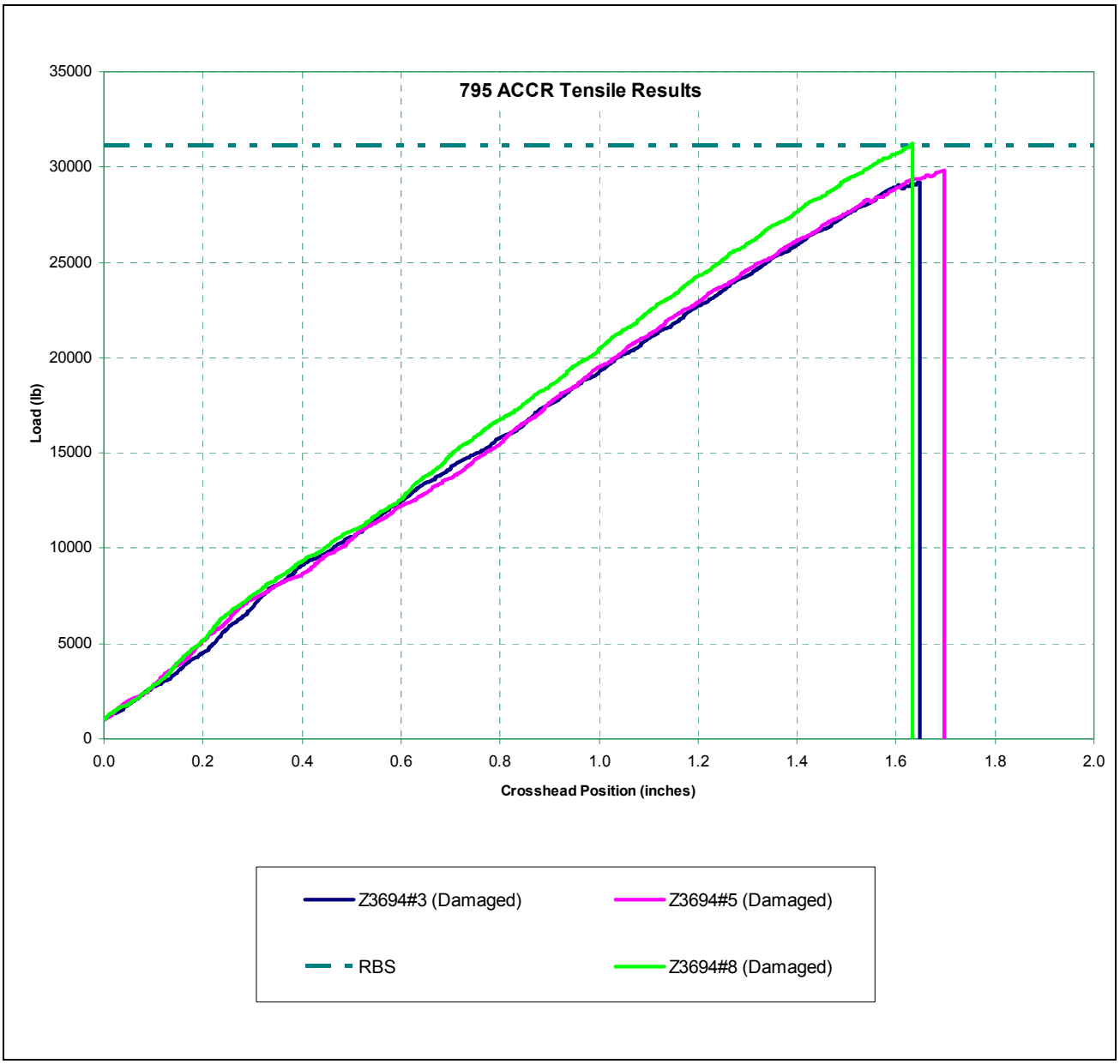

Figure 5, test data for samples inadvertently damaged during sample preparation

CONCLUSIONS

Test results support use of a nominal RBS of 31,134 lb for line designs using the 795-kcmil, 3M™ Composite Conductor. In accordance with regulations and design conventions, connectors should be expected to hold 95% or RBS, and lines should be designed and constructed such that line tension will not exceed 60% RBS when loaded to the region's specified ice and wind loads.

The test data are processed in a spreadsheet for analysis and graphical presentation shown in this report. The data were sorted to provide the statistical analysis shown in Table 3.

Table 3, Statistics for 795-kcmil, 3M™ Composite Conductor test data						
Sample set	Breaking loads (lb)				% RBS (31,134 lb)	
	Max	Min	Mean	Std Dev.	Max	Min
All samples (21)	33,530	29,210	32,330	1,163	108	94
All except damaged samples (18)	33,530	31,450	32,710	650	108	101
Damaged only (3, all from reel Z3694))	31,210	29,210	30,080	1,025	100	94
Reel Z3694, undamaged only (8)	33,530	31,450	32,708	650	108	101
Reel Z3695 (5)	33,530	32,640	33,150	326	108	105
Reel Z3696 (5)	33,130	32,000	32,650	458	106	103

EQUIPMENT LISTING

1) MTS Servo-hydraulic tensile machine, Control # CQ 0195 (load and crosshead data)

REFERENCES AND STANDARDS LISTING

1) ASTM E4, (Calibration of Load Testing Machines)