

## **Comparison Testing of ARMOR LACE™ and Other Boot Laces**

This memo summarizes recent boot lace performance tests conducted by Tension Technology International (TTI). The tests were conducted on the Armor Lace™ boot laces, on four conventional boot laces, and on four Kevlar™ boot laces.<sup>1</sup> The tests were performed by drawing these laces back and forth through a grommet until they failed.

### **Boot Lace Samples**

Table 1 summarizes information on the sources and characteristics of the tested boot laces. Photos 1 through 9 show the boot laces.

The construction of the shoe laces varied. Several, including the Armor Lace, were solid braid. Several were hollow braid sheath, with or without core. Several were flat braid.

The ProCare Kevlar lace comprised a polyester hollow-braid sheath and a solid-braid multi-color polyester core. I detected no Kevlar yarn in this product.

The gold Kevlar was a flat-braid construction of Kevlar strands. The black and gold Kevlar was a flat-braid construction comprised of two gold Kevlar strands and many black polyester strands.

### **Test Procedure**

The tests were conducted on a modification of the 4-station yarn-on-yarn abrasion test machine. That test machine is usually used to conduct yarn-on-yarn abrasion tests in accordance with industry standards.<sup>2 3</sup>

The modified test machine is shown in Figure 10. 1/4 inch brass grommets, similar to those used in boots, were inserted in holes drilled through aluminum angle bars. These bars were mounted on the four stations of the test machine.

The boot lace specimens was run through the brass grommet. Figures 11 and 12 shows a boot lace running through a grommet.

The boot lace specimen was pulled back and forth through the grommet with a stroke of 2 inches at a rate of one cycle per second. Cycles were counted. Each counter shut off automatically when the lace failed.

## Test Results

Table 2 shows the test results. Graphs 1 and 2 compare the test results. The cycles to failure are averages for at least four tests on each sample.

The Armor Lace boot lace lasted an average of 202,000 cycles, more than ten times longer than most of the other boot laces.

The Kevlar boot laces did not perform as well as the conventional boot laces. The gold Kevlar performed the best in this category, achieving an average of 9,500 cycles. The black and gold Kevlar boot lace, which contained only a few strands of Kevlar, lasted about two thirds the number of cycles as the gold boot lace which was all Kevlar.

The polyester boot lace performed best among the conventional boot laces, achieving an average of 38,800 cycles. Although the ProCare boot lace was claimed to contain Kevlar, it was all polyester, and did not perform as well as the other polyester boot lace. The leather boot lace performed the poorest, lasting an average of only 2,100 cycles.

The principal cause of failure of the boot laces in these tests was internal abrasion, caused by rubbing between strands as the boot lace bent and then unbent as it was pulled through the grommet. This is a common form of failure in cordage products.

Kevlar is particularly poor in strand-on-strand abrasion of this type. Polyester is relatively good.

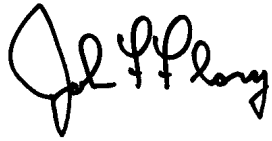
The Armor Lace boot lace is comprised of Vectran™ liquid crystal aromatic polyester fiber.<sup>4</sup> Vectran fiber is relatively good in resisting strand on strand abrasion. The Armor Lace failed through a combination of internal and external abrasion.

Photos 12A and 12B show the Armor Lace boot lace at two stages of testing. At 140,000 cycles, there was only modest abrasion. At 280,000 cycles, there was extensive abrasion, the boot lace was still usable, and it failed shortly after.

Many of the other boot laces suffered extensive abrasion long before complete failure, to the extent that they would be virtually unusable. Several of the boot laces essentially failed when their outer covers completely failed, even though the inner core remained intact. Photo 13 shows the ProCare Kevlar boot lace with the outer cover failed.

## Conclusions

Armor Lace boot lace performs ten times or more better than most other boot laces when pulled back and forth through a boot grommet. It performed more than twenty times better than the Kevlar boot laces which were tested. The Kevlar boot laces did not perform as well as most of the conventional boot laces which were tested.



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References:

1. Kevlar is the DuPont trade name for aramid fiber
2. Cordage Institute, "Test Method for Yarn-on-Yarn Abrasion, Wet and Dry", CI 1503, Cordage Institute, Wayne, PA, 2000
3. ASTM "Standard Test Method for Wet and Dry Yarn-on-Yarn Abrasion Resistance", ASTM D-6610, American Society for Testing and Materials, West Conshohocken, PA, 2008
4. Vectran is a product of Kuraray America, Inc., Fort Mill, SC.

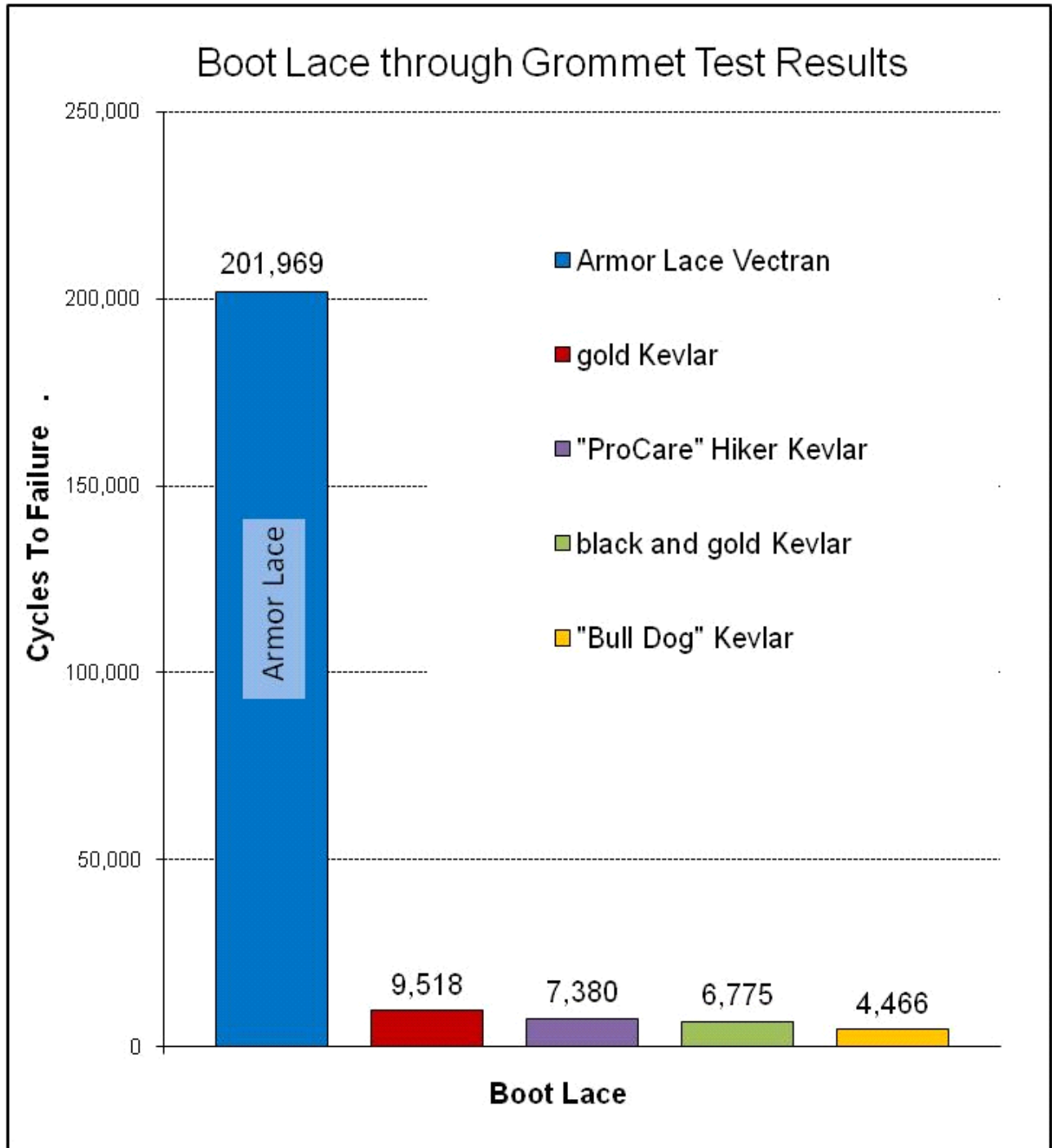


Chart 1 Comparison of Armor Lace and Conventional Boot Laces

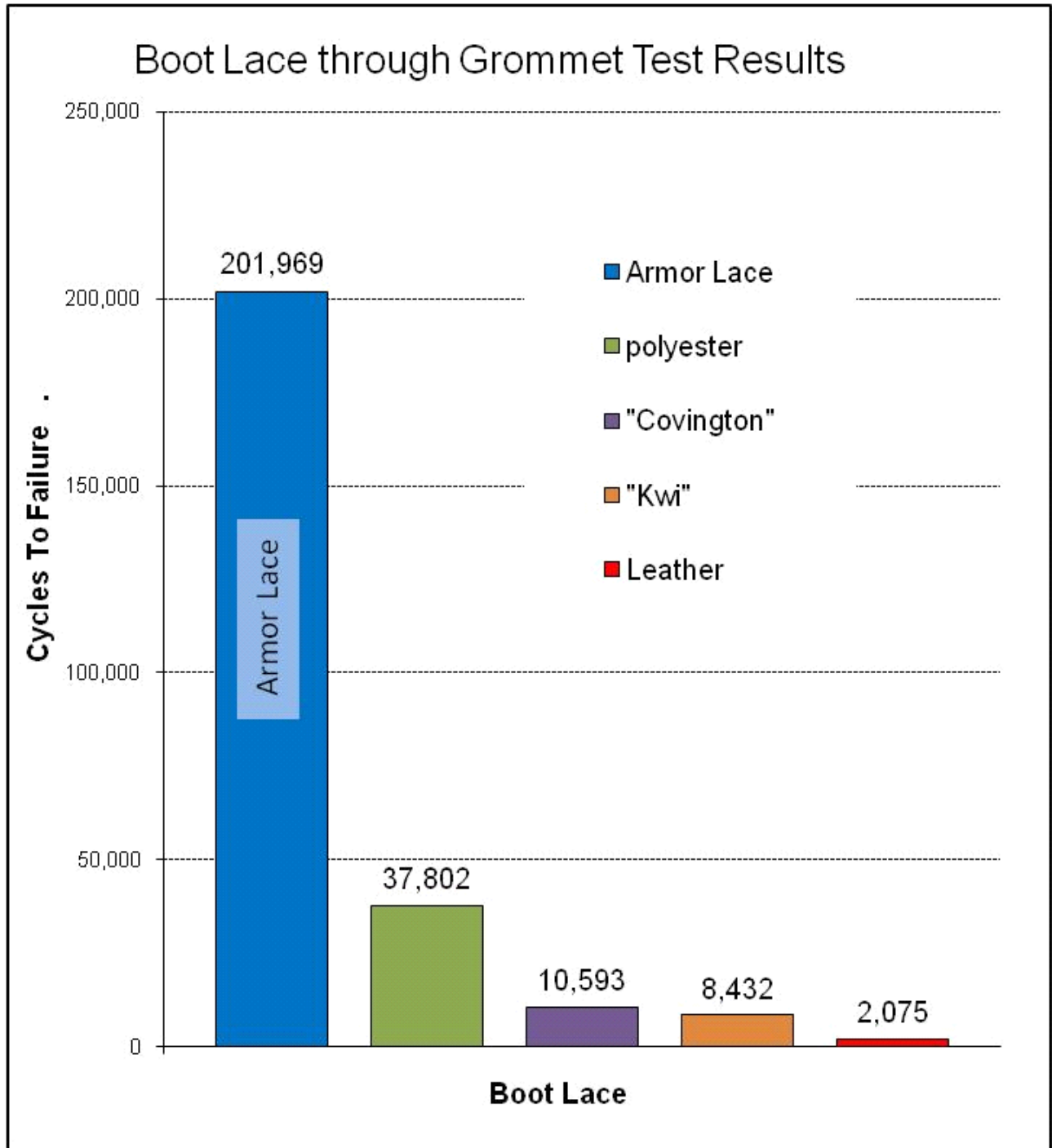


Chart 2 Comparison of Armor Lace and Conventional Boot Laces

<b>Table 1: Boot Lace Test Program Samples, Descriptions</b>			
Boot Lace	Description	Materials	Source
<b>Armor Lace</b>	small black firm round braid	Vectran	ArmorCord
<b>ProCare Hiker Kevlar</b>	large black hollo-braid sheath, multicolor solid-braid core	Polyester sheath Polyester core (no Kevlar)	Timberline
<b>Bull Dog Kevlar</b>	small black round braid	Kevlar	Hank's
<i>gold Kevlar</i>	flat braid, gold	Kevlar	Duluth, ShoeLacesExpress.com, Gemplers
<i>Black &amp; gold Kevlar</i>	flat braid, black with gold stripe	Kevlar and polyester	ShoeLacesExpress.com
<i>polyester</i>	brown small round braid sheath	polyester	local shoe store Morris Plains, NJ
<b>Covington</b>	brown and gold round braid	polyester sheath, cotton core	Sears
<b>Kiwi</b>	black and brown round braid green core	polyester sheath, polypropylene core	Target
<i>leather</i>	brown, square cut	leather	various
<p><b>Bold</b> names are trade marks or trade names                      Names in <i>italics</i> are for distinction only and are not labels or trade marks</p>			

<b>Table 2: Boot Lace Test Program Samples, Test Results</b>				
Boot Lace	Weight, grams/meter	Cycles to Failure	Remarks	Breaking Strength
<b>Armor Lace</b>	4.7	202,000		771 lbs
<b>ProCare</b> Hiker Kevlar	6.3	7,400	sheath failure	sheath 261 lbs core 195 lbs
<b>Bull Dog</b> Kevlar	2.9	4,500		324 lbs
<i>gold Kevlar</i>	6.4	9,500		
<i>Black &amp; gold Kevlar</i>	4.3	6,800		
<i>polyester</i>	7.4	37,800	sheath failure	126
<b>Covington</b>	6.8	10,600		
<b>Kiwi</b>	4.5	12,000		
<i>leather</i>	5.4	2,100	external abrasion	56 lbs
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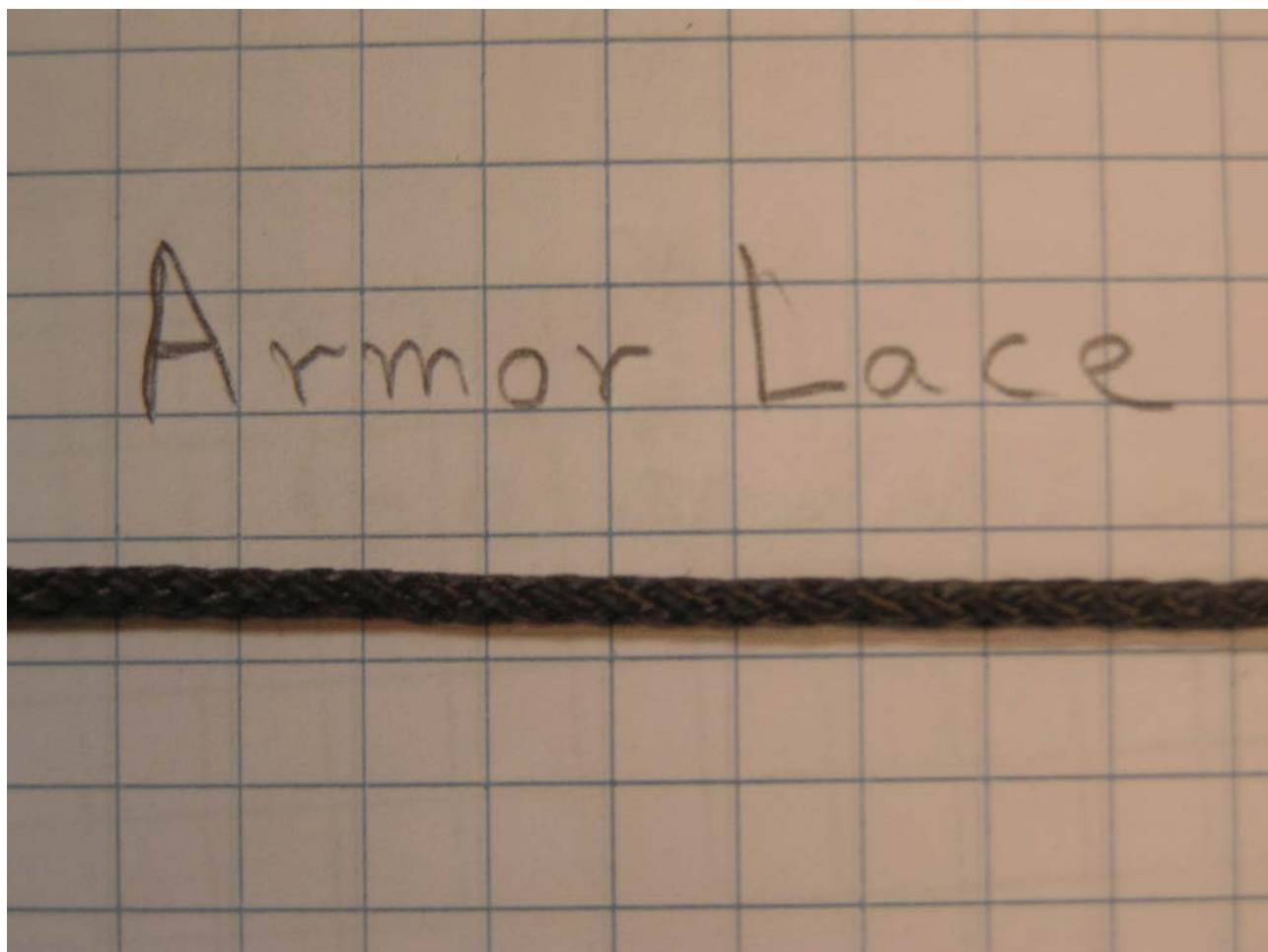


Photo 1      Armor Lace Boot Lace



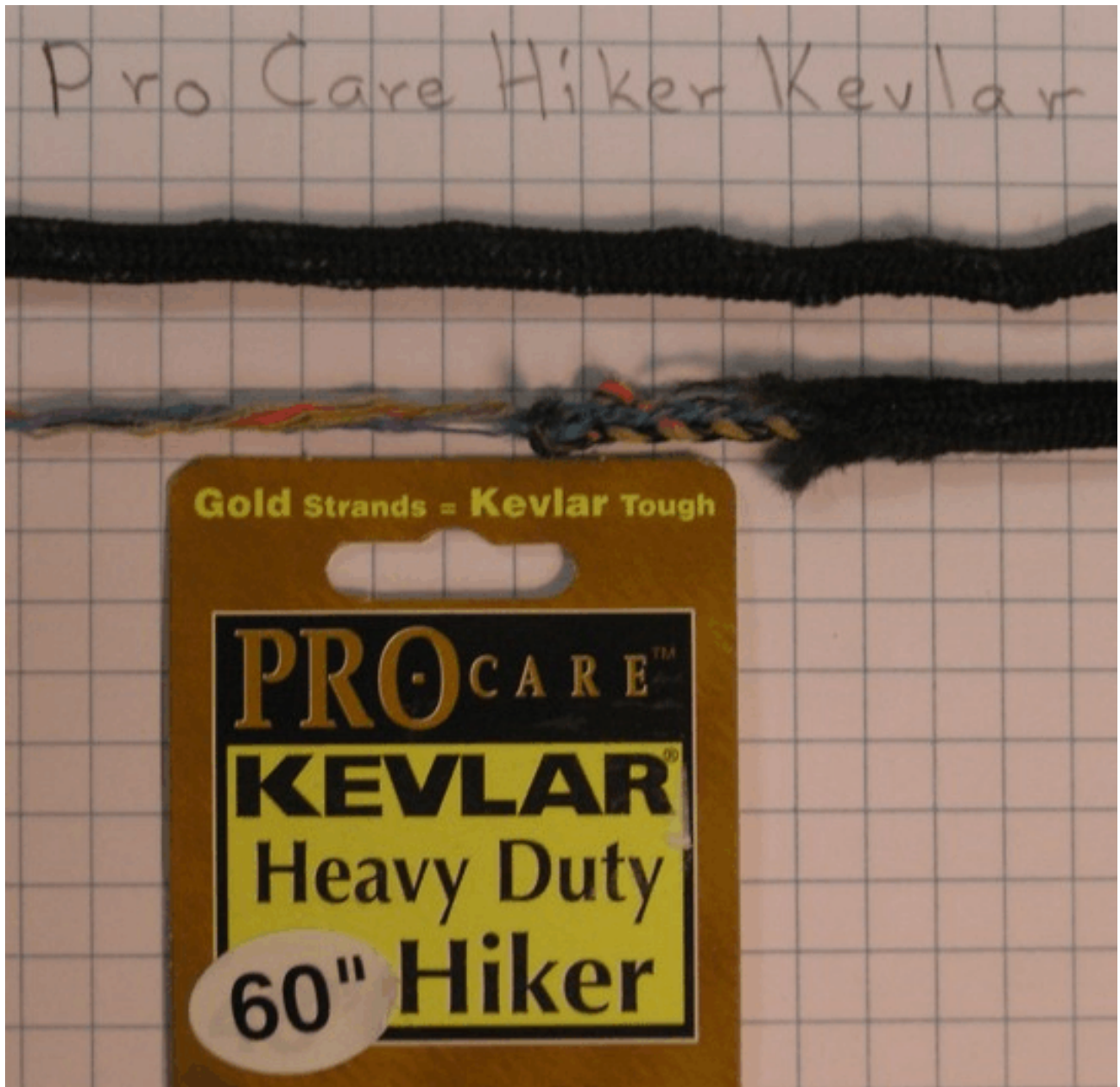


Photo 2 ProCare Hiker Kevlar Boot Lace

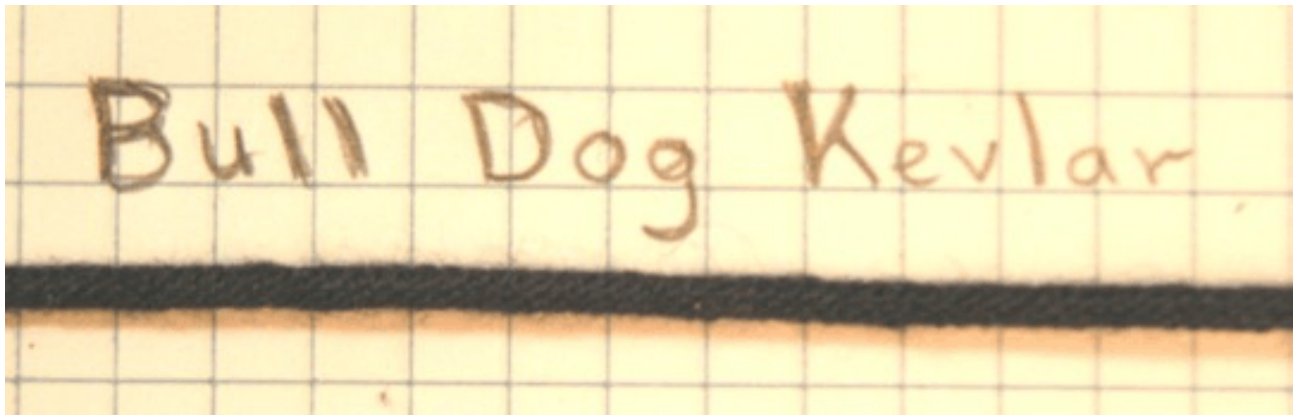


Photo 3 Bull Dog Kevlar Boot Lace

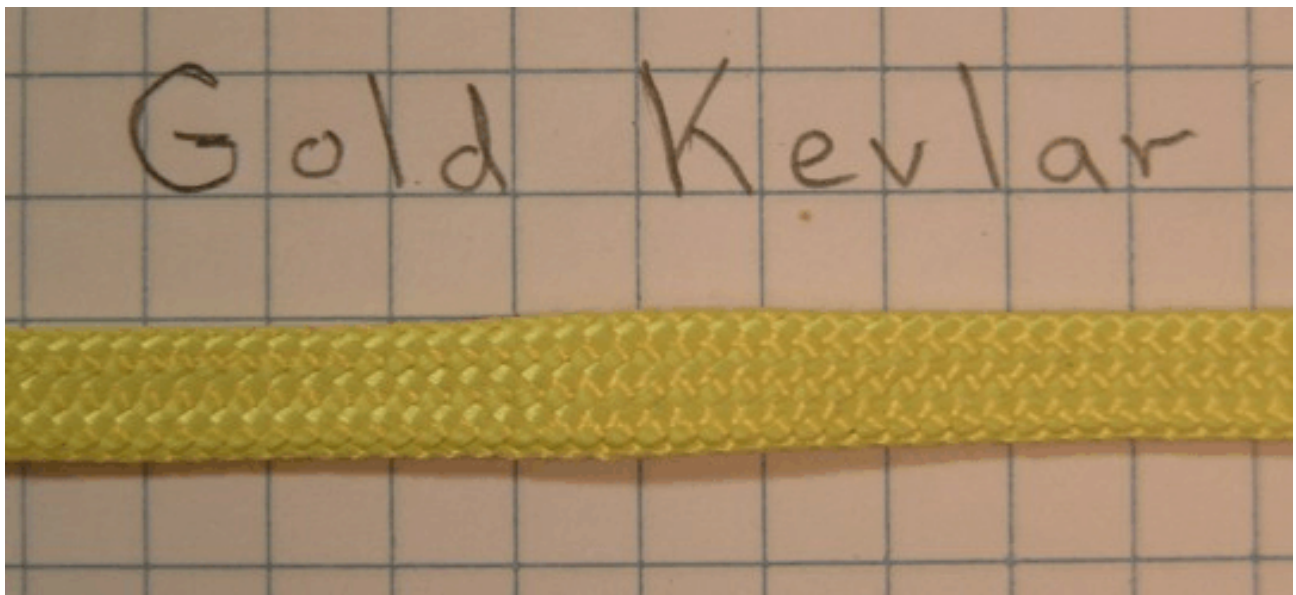


Photo 4 Gold Kevlar Boot Lace



Photo 5 Black and Gold Kevlar Boot Lace



Photo 6 Polyester Boot Lace

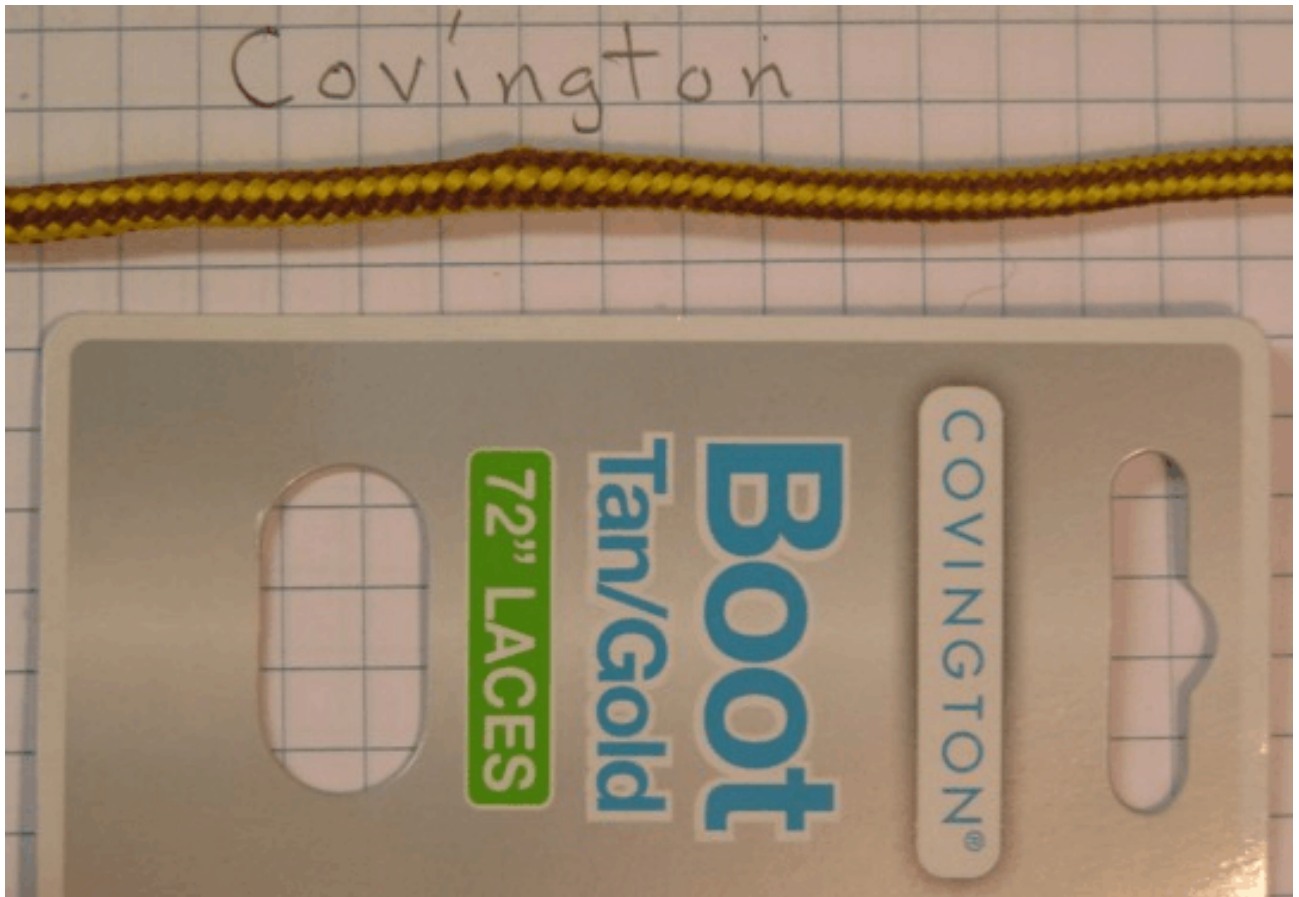


Photo 7 Covington Boot Lace



Photo 8 Kiwi Boot Lace

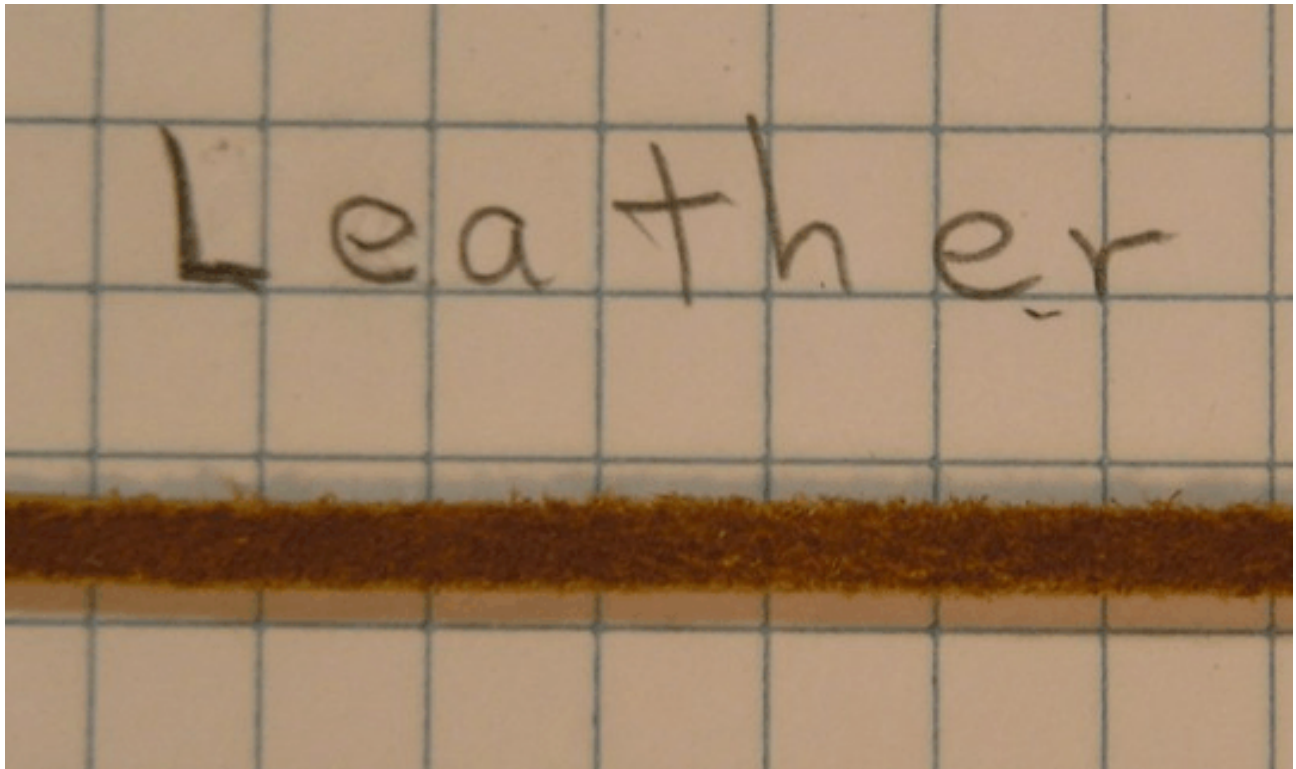


Photo 9      Leather Boot Lace

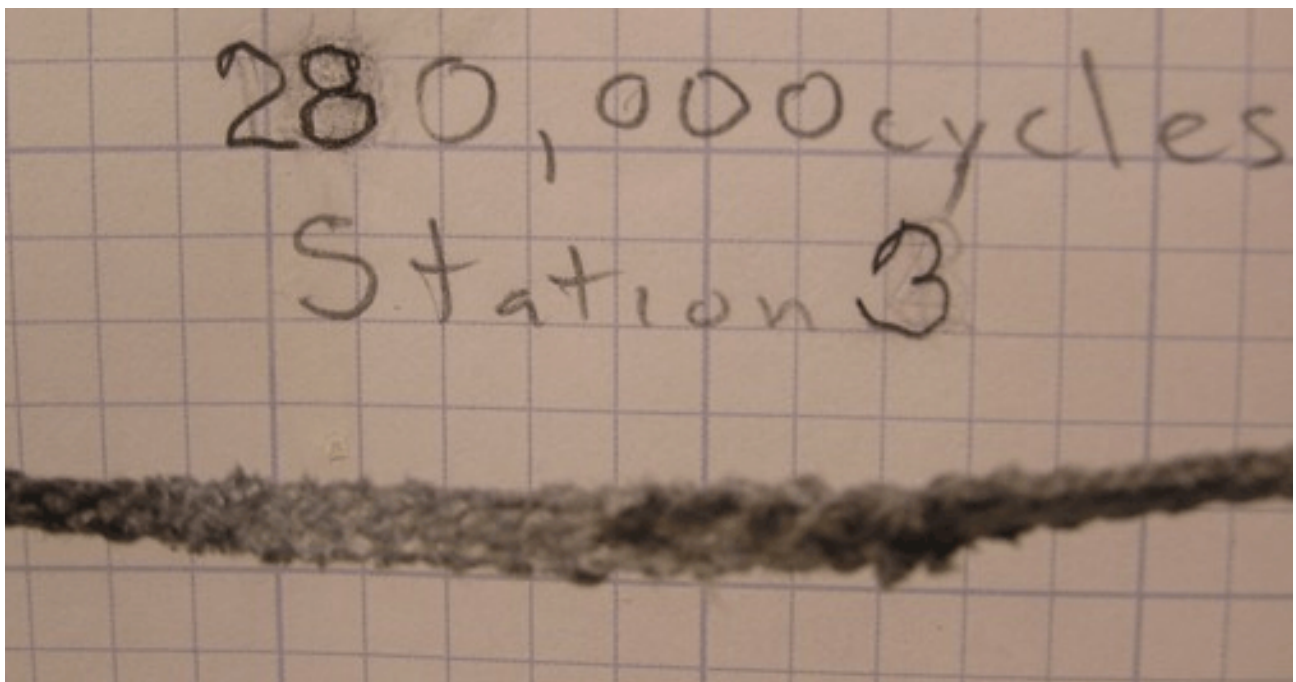
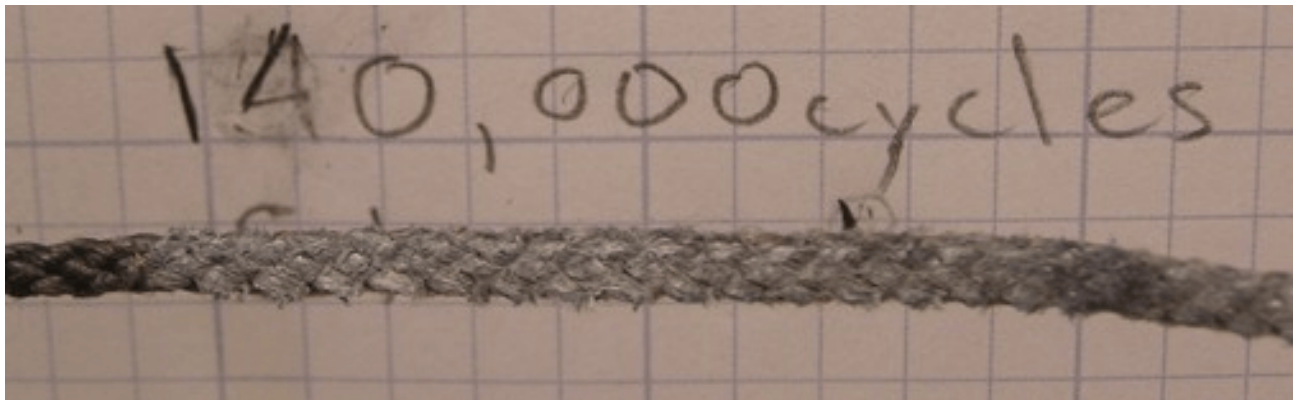


Photo 10 Test Machine



Photos 11 A and B Details of Grommet with Boot Lace





Photos 12 A and B    Armor Lace Boot Lace Wear at 140,000 and 280,000 Cycles

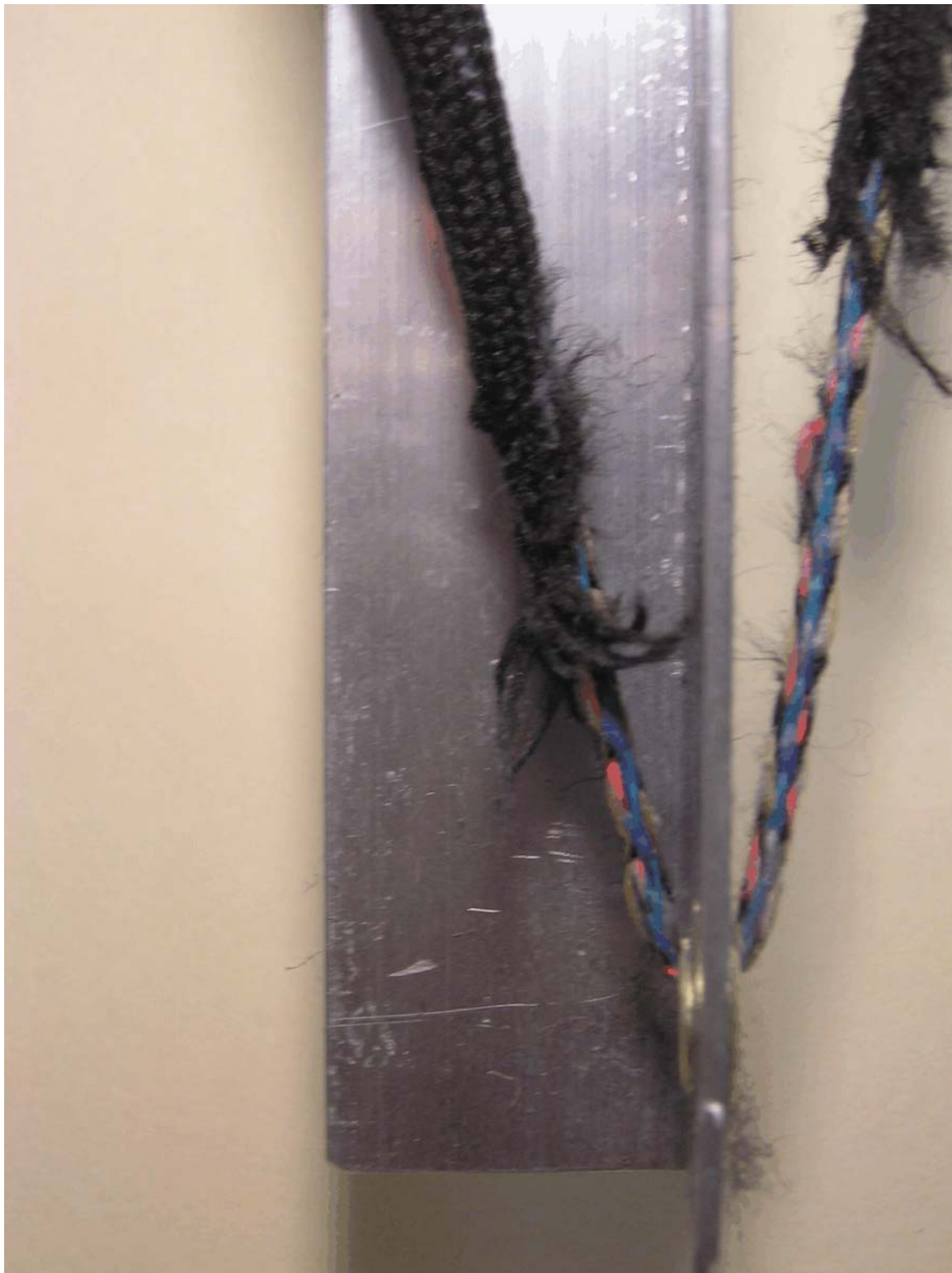


Photo 13 ProCare Boot Lace, Cover Failure