QUANTIFYING THE DIFFERENCES IN TENSION AND TORQUE BETWEEN SNARED AMERICAN MARTEN (*Martes americana*) and SNOWSHOE HARE (*Lepus americanus*)

Final Report

By

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&

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DISCLAIMER

This study was conducted by the Alberta Research Council Inc. and was funded by the Interdepartmental Recovery Fund for Species at Risk - Environment Canada (EC). It was administered by Natural Resources Canada - Canadian Forest Service (CFS) in collaboration with the Newfoundland Marten Recovery Team - Accidental Snaring and Trapping Action Group, through the Fur Institute of Canada (FIC) and the Government of Newfoundland & Labrador Inland Fish & Wildlife Division. The views, statements and conclusions expressed, and the recommendations made in this report, are entirely those of the author(s) and should not be construed as the statements, conclusions, or opinions of members of the Alberta Research Council Inc., EC, CFS, FIC, or the NL Inland Fish & Wildlife Division.

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EXECUTIVE SUMMARY

On the Island of Newfoundland, the Newfoundland marten (*Martes americana atrata*), an endangered species, has suffered mortality in snares set for snowshoe hare (*Lepus americanus*). This by-catch necessitated the design of release devices, but these have proved prohibitive due to cost and difficulty of implementation. One possible solution is the use of a snare wire with properties that capitalise on differences in force exerted between snared marten and hare.

This study was conducted to quantify differences in torque and tension exerted by marten and hare in a snaring environment designed to emulate natural conditions. Ten hare and nine marten were live captured from the Alberta Foothills and Parkland ecoregions. Within the Alberta Research Council's Trap Testing Facility, these animals were snared using aircraft cable attached to a multi-channel force sensor. Force data were statistically analysed to examine differences in torque and tension between these two species.

Marten exerted a significantly larger average tension, maximum tension, maximum torque, and mean cumulative torque on the snare wire than did snowshoe hares. Approximately twice the force was generated by marten than by hares; based on these results, finding a wire that will retain hares and release marten appears feasible. This wire would require a strength and ductility that will permit structural failure within the stress range applied by marten, but not hares. Further mechanical tests on different wire types, that apply the force data gathered herein, is required before any definitive recommendations for snare wire types can be made. Potential experimental wires may include 1040 carbon steel, 8630 low-alloy steel, or 410 stainless steel.

Snares targeting red fox (*Vulpes vulpes*) on the Island also represent a mortality risk for Newfoundland marten. A stop device may facilitate the release of marten and the retention of foxes, if neck circumferences differ between these two species. We statistically analysed neck circumference data generated by ARC's Trap Effectiveness Program, and found that differences in neck circumference do exist. Based on these results, a stop device forming a snare circumference of *ca.* 160 mm should release the majority of marten and retain the majority of fox.

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CHAPTER 1. BACKGROUND AND RATIONALE

BACKGROUND

In 2000, the Committee on the Status of Endangered Species in Canada (COSEWIC) assigned *Endangered* status to the Newfoundland subpopulation of the American marten (*Martes americana atrata*). Loss of habitat through fire, insects, and logging; overtrapping; disease; and combinations of these perturbations, have all been blamed for the initial and continuing decline of the Newfoundland marten.

A National Recovery Plan (Forsey *et al.* 1995) was created that aims to establish two discrete populations on the Island with a minimum size of 350 animals each, and satellite animals numbering approximately 100. This plan also describes methods by which attempts will be made to curtail mortality. One of these methods is the development of a modified snowshoe hare snare (Forsey *et. al.* 1995).

Although trapping of marten in Newfoundland was outlawed in 1934, accidental mortality caused by snowshoe hare and fox snaring remains a concern. In response to these concerns, in 1992 the Newfoundland & Labrador Inland Fish & Wildlife Division (NL IFWD) contracted the Alberta Research Council, Inc. (ARC) to develop and test a modified snare (Proulx *et al.* 1994). Modified snares employ an anchored coil with a standard 25 gauge stainless steel snare wire looped around the coil. This design capitalised upon observed behavioural differences between hare and marten: hare tend to pull against a snare, whereas marten tend to twist along their own long axis. When tested in a controlled setting, this modified snare was successful in retaining 100% of hares and releasing 100% of marten, and was anticipated to retain >70% of hares and release >70% of marten on a trapline (Proulx *et al.* 1994).

With the development of this modified snare, Modified Snare Zones were established in Newfoundland at Northwest Grand Lake, Red Indian Lake, Terra Nova, and the Charlottetown enclave (Newfoundland & Labrador Inland Fish & Wildlife Division Hunting Guide 2001-2002).

The establishment of Modified Snare Zones was intended to allow culturally and financially important hare snaring activity to continue, while preventing endangered marten by-catch.

This modified coil snare has met with some success, but problems remain. The modified snare costs an order of magnitude more per set than conventional stainless steel wire snares. The modified snare requires skill and training to properly set; many snares are improperly set (Wayne Barney, pers.comm.) making them ineffective at releasing marten. Education and training programs underway in Newfoundland are making great strides at increasing adherence to modified snare regulations and improving correct setting rates. However, alternative approaches that are cost-comparable to standard stainless steel wire, with similarly simple setting requirements, are being explored. One of these approaches involves the use of a snare wire with physical and metallurgical properties that will capitalise on behavioural differences between hare and marten. If force – tension and torque – exerted by each of these species on a snare wire differs, a wire might be implemented that will release marten but retain hares. This would satisfy the mandates of the NL IFWD to provide wildlife harvest opportunities, while also achieving their endangered species recovery objectives.

OBJECTIVES

This study quantifies the relative differences in tension and torque exerted by snared snowshoe hare and marten, and uses this information to guide future efforts to assess a new hare-retaining marten-releasing wire to replace traditional 25 gauge stainless steel. We will also assemble a brief literature and data review on morphological differences between fox and marten, and make recommendations on snare stops that will prevent marten by-catch in fox snares.

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CHAPTER 2: SNARING EXPERIMENTS ON MARTEN AND SNOWSHOE HARE

METHODS

Study Location

Snare testing occurred at the ARC Vegreville's Trap Effectiveness Testing Compound. The test pen consisted of a wire mesh enclosure *ca.* 10 m x 15 m in size, with trees, coarse woody debris, and vegetation within it to emulate a natural parkland / boreal environment. Snowshoe hares were live trapped in the vicinity of Vegreville, Alberta using Tomahawk Live Traps; marten were live trapped in the vicinity of Robb, Alberta, using Havahart Live Traps. To our knowledge there was no heterogeneity in trappability (Jolly and Dickson 1983) that may have biased this sample such that they were unrepresentative of their respective populations. All animals were housed at ARC in holding cages according to Canadian Council on Animal Care Guidelines (1984; 1993).

Experimental Design

We used 3/64 inch 1x7 strand aircraft cable as the experimental snare wire. Other wire types considered, including the 20 and 25 gauge stainless steel or brass alloys traditionally used for hare snaring, deform far too readily to reliably transmit torque and tension being exerted by a snared animal. The aircraft cable did not readily deform; it provided the most reliable transmission of force to the sensor, and therefore the most accurate data. Due to the properties of this wire, however, aircraft cable does not readily form a snare loop, so snares were fitted with a slim lock to facilitate snaring.

The snare wire was connected to a torque/tension sensor (AMTI Force /Torque Sensor Model MC3A-1-100{FZ}-50{MZ}), fitted with a Calex Bridge Amplifier (Model #347) to modify the excitation voltage. The sensor was bolted to the side of the test pen. It was protected with a metal shield, and small logs were placed beside the sensor/shield assembly to prevent the animal from back-torquing the snare wire. A Campbell Scientific CR-10X data logger recorded voltage data supplied by the sensor / amplifier. All snaring events were videotaped via remote camera.

Snowshoe hare were transferred from holding pens to the test pen 3-4 at a time to allow individuals time to acclimate. The experimental snare was then set; once a hare was snared, it was remotely monitored to ensure it did not become entangled, which would confound the force data. The experiment was terminated once the hare entered respiratory distress and movement ceased; the hare was then released. Ten (10) snowshoe hare were snared.

Marten were placed in the test pen one at a time. To capitalise on exploratory behaviour, marten were not given acclimation time; the experiment started upon their release. Termination occurred under the same criteria described for snowshoe hares. Although eleven (11) marten were obtained, two of these were in poor condition when trapped and died soon after acquisition. Nine (9) marten were deemed healthy enough to provide reliable force data and were snared.

Analysis

A standard conversion equation was applied to convert voltage data to tension and torque. These force data were plotted against time, then verified against video footage to ensure accuracy. In some cases, null data were not centred around a mean of zero as would be expected, possibility due to extreme cold temperatures acting on the force sensor. We calculated a linear correction factor and applied this to datasets that displayed this anomalous drift. After these corrections, null data were centred around zero +/- 0.01 pounds (tension) or inch-pounds (torque). Datasets were clipped to include only data from the second the animal entered the snare to the time it ceased struggling, or was released from the snare. Data possessed positive or negative values depending on axis of travel of the wire; these were converted to absolute values to provide direction-independent force data. Data were summarized, and analysed to produce estimates of maximum tension, average tension, maximum torque, and average torque for each animal. We contrasted these parameters across species using independent samples t-tests (SPSS Inc.).

RESULTS

The tension and torque exerted by each animal over time are graphically represented in Appendices 1 and 2. There were marked differences in force exerted by each species. Average tension was significantly different ($p<0.000$) between marten and hares (Table 1). Mean tension exerted by hares was 0.2205 pounds; mean tension exerted by marten was 0.6032 pounds. Maximum tension also differed significantly between species ($p = 0.003$; Table 1). The mean maximum tension exerted by hares was 2.8309 pounds, whereas mean maximum tension exerted by marten was 4.9694 pounds.

Table 1 Statistical analysis of force exerted by marten vs. snowshoe hares. Tests consisted of independent samples t-tests except where otherwise noted; results were considered significant at the $p = 0.05$ level.

Variable	**Hare**		**Marten**		**Test significance (p value)**
	Mean	**Std dev**	**Mean**	**Std dev**	
Average tension (pounds)	0.2205	0.05317	0.6302	0.1801	0.000
Maximum tension (pounds)	2.8309	1.0603	4.9694	1.6196	0.003
Average torque (inch-pounds)	0.2303	0.4132	0.2186	0.2032	0.939
Maximum torque (inch-pounds)	0.6930	0.9975	1.1883	1.4885	0.034 (Mann-Whitney U)
Mean cumulative torque (inch-pounds / second)	55.1937	48.3824	125.4383	63.1913	0.014

Differences in torque exerted by each species were more difficult to detect. A t-test comparing mean maximum torques across marten and hares was not significant ($p = 0.402$). However, mean maximum torque exerted by marten was almost twice that of hares (1.1833 *vs.* 0.6930 inch-pounds). We believed that large variability in the datasets (Table 1), combined with low sample size, render the test inappropriate. We therefore employed the nonparametric Mann Whitney U test, to detect differences in mean maximum torques. Results of this test suggested that maximum torques were indeed significantly different between marten and hares ($p = 0.035$; Table 1).

Average torque exerted did not differ significantly across species ($p = 0.939$; Table 1). Mean torque exerted by hares and marten was 0.2303 inch-pounds and 0.2186 inch-pounds respectively. However, examination of video footage revealed marked differences in behaviour of each species when in the snare. Hares tended to pull more and roll less, whereas marten exhibited heavy and sustained rolling behaviour. We concluded based on video examination and the nearly perfectly equal mean torques that the sensor was not measuring cumulative torque exerted. Although the 3/64 inch 1x7 strand aircraft cable was deemed the most appropriate for transmission of force data, it was still flexible; due to this flexibility the wire did loop back on itself when torqued. Looping relaxed the force on the wire, and prevented accurate measures of cumulative torque exerted. Thus the variable actually being measured was failure rate of the wire, which was obviously equal regardless of species. We compensated for this by adding each torque value, by second, to previous values, thus calculating effective cumulative torque. This statistic captures the overall torque exerted by each animal more accurately. We standardised for different capture times by averaging over the length of capture time for each animal. This mean cumulative torque measure was significantly different across species ($p = 0.014$; Table 1). Mean cumulative torque exerted by hares was 55.1937 inch-pounds / second; marten exerted 125.4383 inch-pounds / second, over twice the value for hares.

CONCLUSIONS

There were statistically significant differences in amount of force exerted by snared marten and hares. Marten both pulled and rolled harder than did hares when snared, resulting in greater tension and torque on the snare wire. These results substantiate observations made by Proulx et al. (1994).

Detecting these differences was difficult. The original objectives of this research included the testing of one wire type that would potentially meet the criteria of releasing marten and retaining hares, but it quickly became evident that such a wire would not reliably transmit tension or torque. Therefore, the 3/64 1x7 aircraft cable was selected. While not feasible for the conservation of marten, it did provide the most reliable transmission of force from animal to sensor, and was the best option for accurate quantification of these data.

However, the aircraft cable was, by necessity, flexible, and was therefore susceptible to looping when torqued along its longitudinal axis several times. This looping relaxed the wire and prevented actual measures of torque exerted, especially by marten, which rolled extensively when snared. This problem is inherent to any material flexible enough to snare animals. We overcame this problem by creating estimates of cumulative torque for each species. As an index, mean cumulative torque is useful in comparisons across species, but it is likely not an accurate measure of actual force exerted. It does, however, allow us to make inferences regarding appropriate wire types for snaring hares and releasing marten.

Both tension and torque exerted by marten were approximately twice as high as exerted by hares. These differences indicate that it may indeed be possible to find, or create, a wire that will retain hares and release marten. A wire material is defined by its Young's modulus, yield strength, tensile strength, ductility, and toughness (Shackelford, 1988). By necessity, a snare wire will exhibit a high degree of flexibility; that is, the Young's modulus ("springiness") of the wire material must be sufficient to allow elastic deformation for forming a snare loop, but also allow for plastic deformation for forming the snare eyelet and anchor. The yield strength and tensile strength of the wire material should be such that plastic deformation occurs with an amount of stress (defined as load applied over cross-sectional area) appropriate to the snared animals. Most importantly, the wire material should have appropriate ductility, or percent elongation at point of failure. If a wire has high strength but low ductility, it will take a large amount of stress to bend it, but will snap when it does. This wire will be too brittle for snaring purposes, and will release either all animals or none, depending on the yield strength of the wire and force exerted. If a wire has low strength and high ductility, it will bend (exhibit plastic deformation) readily, but will sustain a great deal of strain before fracture, and will not release either species.

An appropriate snare wire must possess an intermediate measure of strength and ductility; to release marten and retain hare, a wire must fail (fracture) at a percent elongation achieved by an average marten, but remain intact at a percent elongation achieved by an average hare. Based on the differences in tension and torque we observed between the two species, finding or creating such a wire for use in Newfoundland is possible. However, much more information is required before a reliable recommendation of which wire(s) may serve this purpose can be forwarded.

RECOMMENDATIONS

Defining an appropriate snare wire to release marten and retain hares requires several more steps. First, an extensive investigation of the stress-strain curves of wires of different materials, and different gauges, must be undertaken. This must be accompanied by mechanical testing of potential wire types generated from this research, applying the force data gathered herein, to determine which wires will fail under species-specific stress values. This step is critical before any definitive recommendations for snare wire types can be made. The variability in the fracture point of potential wires in response to environmental conditions, in particular temperature, should also be evaluated. Finally, field trials measuring retention rates for hares, and compound trials measuring release rates for marten, should be conducted for each experimental wire.

In the interim, we can use our results to make some suggestions for wire materials with which to start. These suggestions are based on the assumption that a percent elongation at failure (ductility) of *ca.* 20% may provide a suitable wire. Materials with a high (*ca.* 40%) ductility, such as 304 stainless steel, may produce a wire that will deform but may not break and release marten. Materials with a lower (*ca.* 10%) ductility, such as zinc, will fracture readily and may release both species. Note that 20% ductility is only an assumption, and requires experimental testing via the means outlined above. The following metals are suggested start-points for future work; data are taken from Shackelford (1988):

Alloy	*Description*	*UNS Designation*	*Primary Constituent*
1040 carbon steel	Carbon steel: 1040 cold drawn, hot-reduced, no stress relief	G10400	Fe
8630 low-alloy steel	Cold drawn, hot-reduced, no stress relief	G86300	Fe
410 stainless steel (ferrous superalloy)	410 stainless, 595^{o}C temper	S41000	Fe

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CHAPTER 3: ANALYSIS OF DIFFERENCES IN NECK CIRCUMFERENCE BETWEEN MARTEN (*Martes americana*) AND RED FOX (*Vulpes vulpes*)

BACKGROUND

In addition to snowshoe hares, red fox (*Vulpes vulpes*) are also traditionally snared in Newfoundland. Fox snares represent another potential source of accidental Newfoundland marten mortality. Stopping mechanisms on fox snares could potentially solve this problem, but information on morphological differences between fox and marten is required to determine appropriate placement.

OBJECTIVES

We use existing data on marten and red fox neck circumferences to statistically test for differences between the two species.

METHODS

Proulx and Barrett (1990) conducted research assessing the efficacy of power snares to kill red fox. As part of the necropsies performed under this research, neck circumferences of all test animals were performed. Similar data has been garnered by the Alberta Research Council Inc. from marten as part of the Humane Trapping / Trap Effectiveness Program (1986-1999). We performed a t-test (SPSS Inc.) on neck circumference data from red fox (n=12) and marten n=(71).

RESULTS

Summary statistics for neck circumference data are given in Table 2. Although the sample sizes differed between these two datasets, Levene's F test suggested variances between the two sets were equal, so the assumptions of a t-test were not violated by these data (Ambrose and Ambrose 1995). A two-tailed t-test revealed a significant difference in neck circumference between marten and fox ($p < 0.001$; Table 2). Mean marten neck circumference was 135.4 mm (s = 11.77); mean neck circumference for red fox was 170.4 mm (s = 10.83).

Table 2 Summary statistics of marten and fox neck circumferences.

	N	Mean (mm)	Std. deviation	Std. Error mean	Minimum (mm)	Maximum (mm)
marten	71	135.42	11.77	1.40	110	162
red fox	13	170.38	10.83	3.00	152	186

Table 3 Independent samples t-test of marten and fox neck circumferences (equal variances assumed).

t statistic	degrees of freedom	Sig. (2-tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
					Lower	upper
-9.959	82	0.000	-34.9621	3.5106	-41.9458	-27.9784

CONCLUSIONS

There was a statistically significant difference in the circumferences of red fox necks and marten necks sampled. Sample size of red fox was small; however, the equality of variance revealed by the F test, and high level of significance in the t-test, allow us to safely conclude that neck size differences are real. Although these animals were sampled from Alberta, we know of no geographic differences in neck size that make Newfoundland red foxes smaller, or Newfoundland marten larger. Our results indicate that a stop mechanism on a red fox snare may be an effective tool to prevent Newfoundland marten capture. Based on confidence intervals derived from these data, *ca.* 70% of red fox captured should be retained with a snare stop designed for 160 mm circumference (mean red fox neck size less one standard deviation). There was overlap in fox and marten neck sizes on either end of the data range; thus although a snare circumference of 150 mm would increase red fox retention, it would also retain a greater percentage of Newfoundland marten. Based on mean and maximum marten neck sizes, 95% of marten should be released with a snare stop designed for a 160 mm circumference (mean marten neck size plus two standard deviations). Retention rates of both marten and foxes should be tested under controlled conditions using snare stops within this circumference range.

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Tension (lbs) Exerted by Marten

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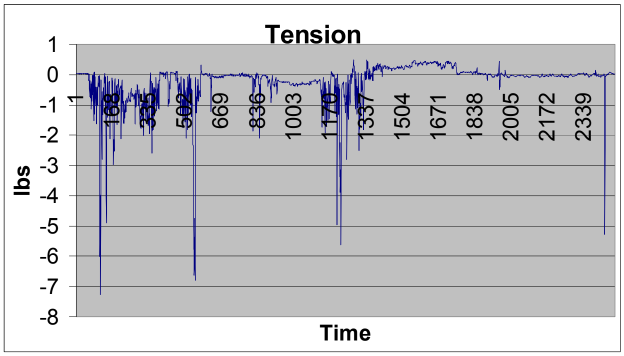

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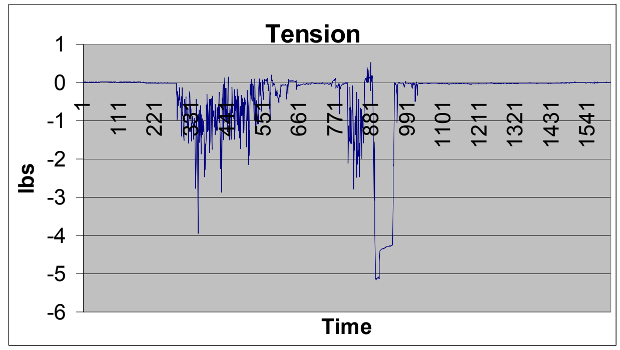

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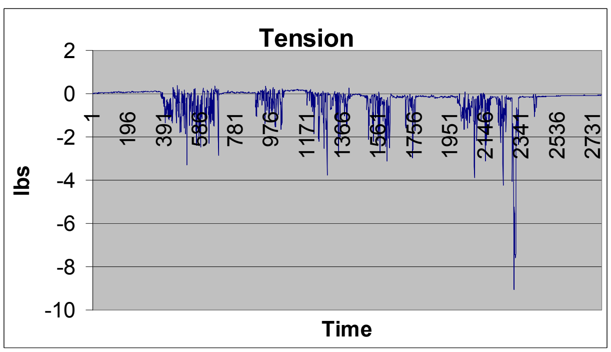

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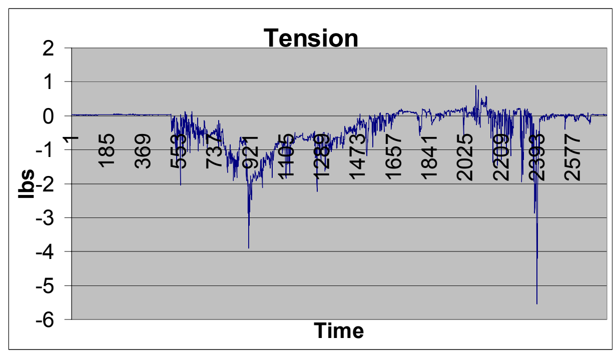

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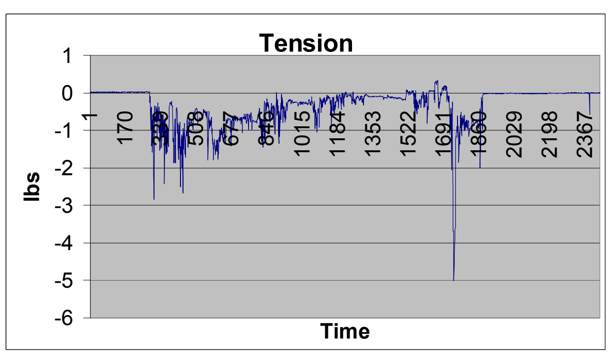

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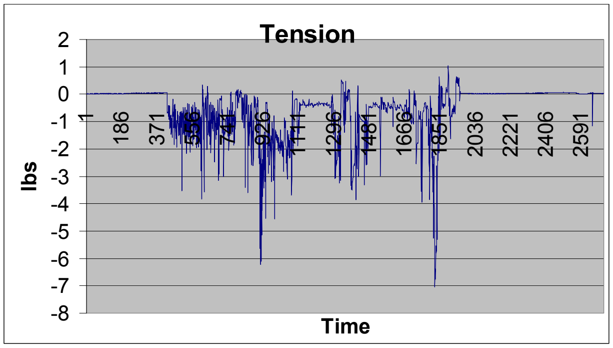

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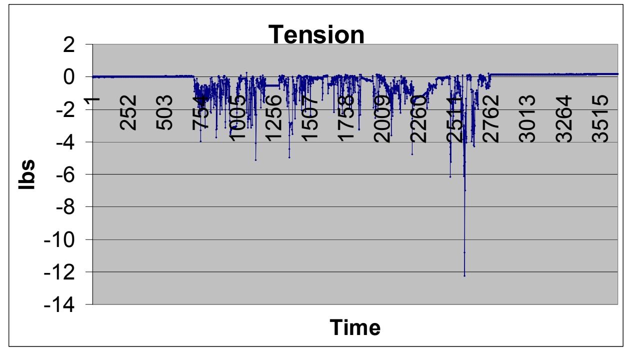

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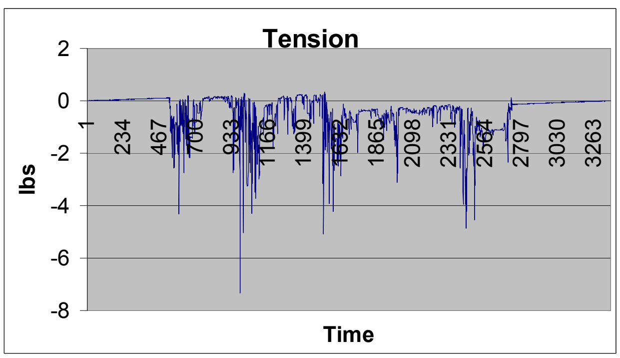

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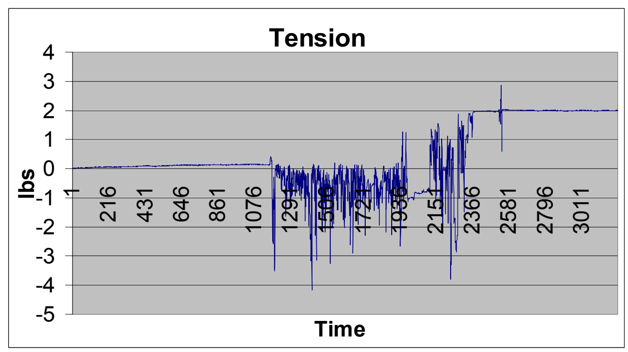
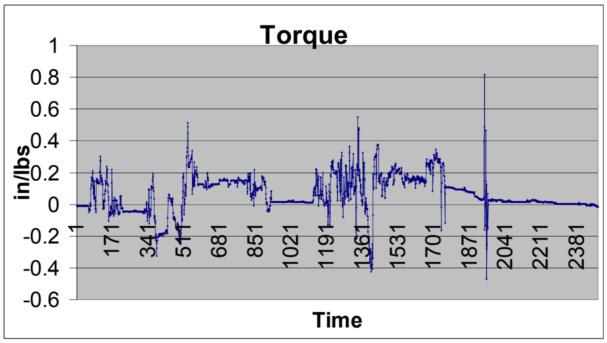


Torque (in/lbs) Exerted by Marten

M0301-2



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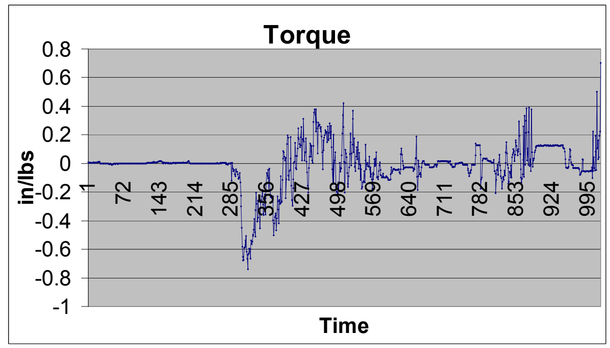

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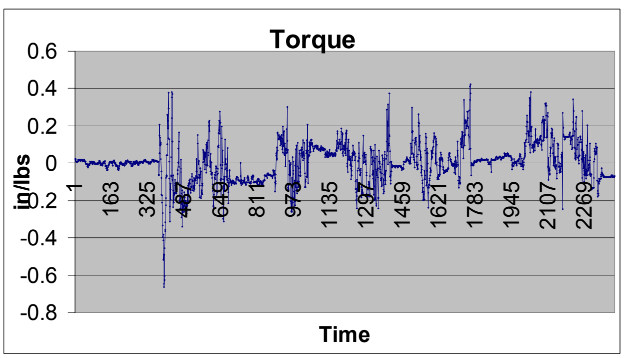

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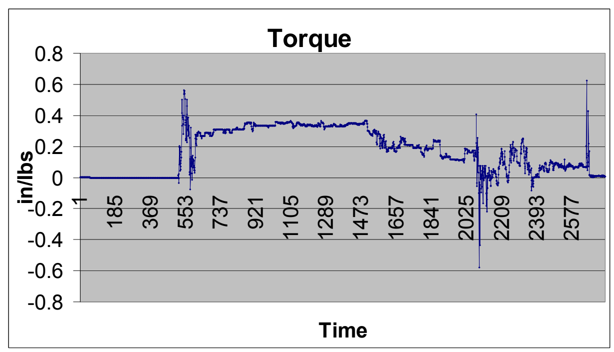

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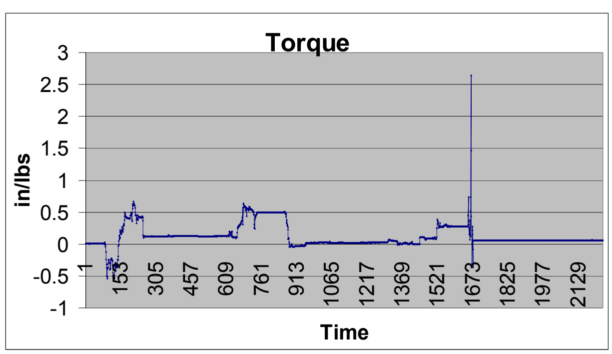

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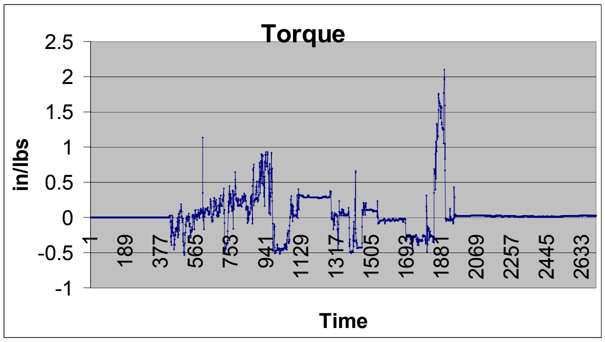

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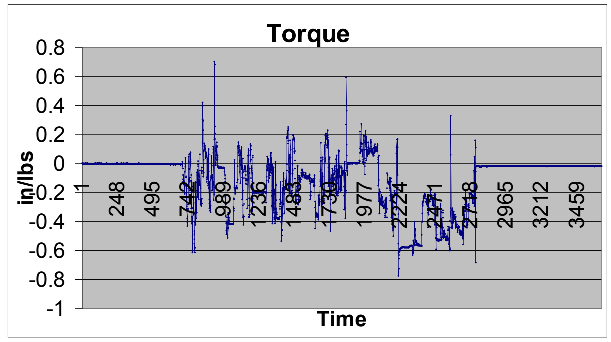

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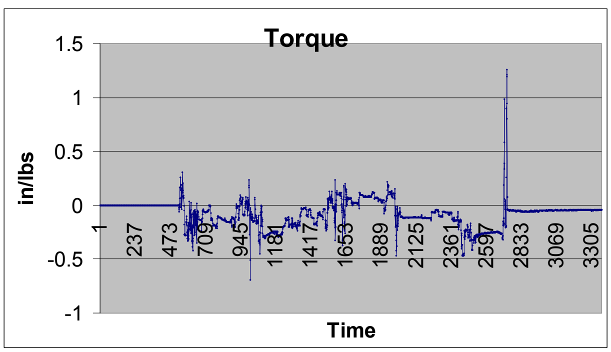
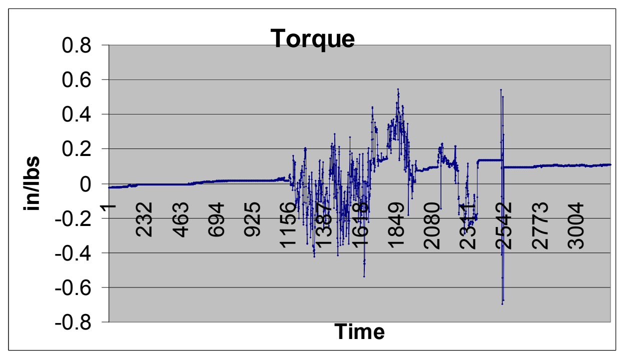
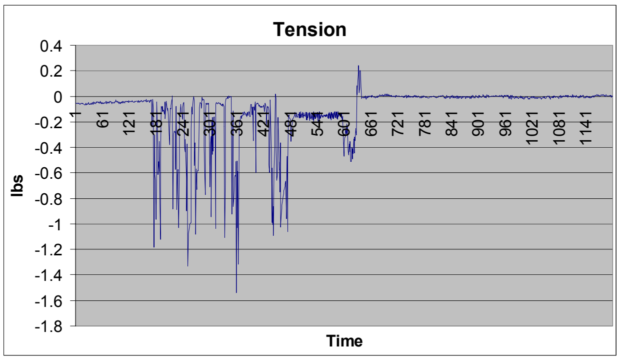


M0311-2



Tension (lbs) Exerted by Snowshoe Hare

0304



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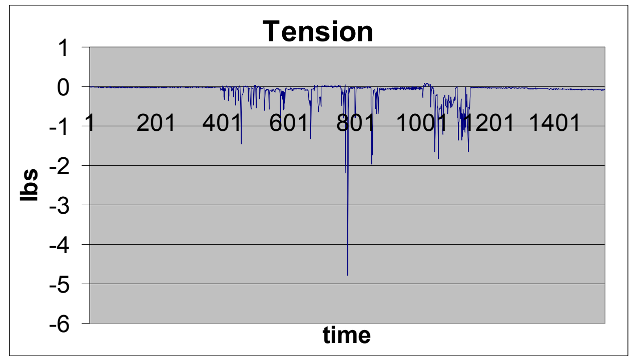

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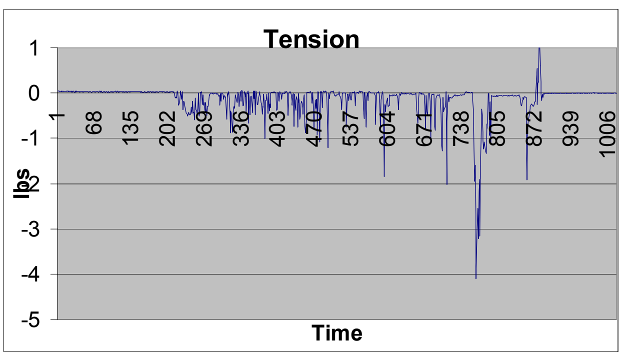

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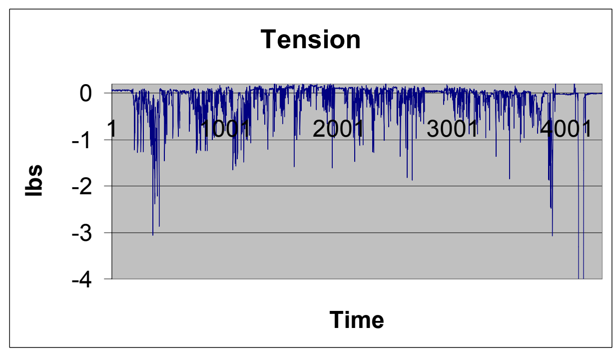

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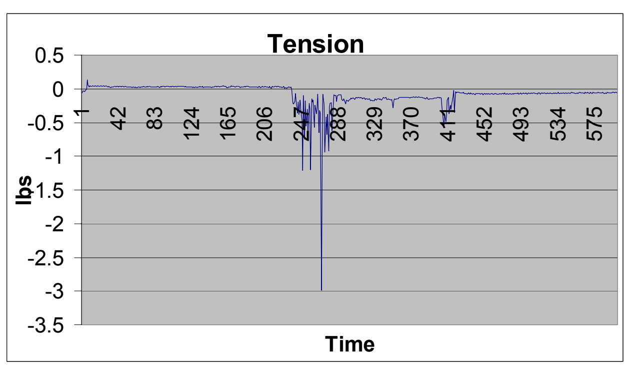

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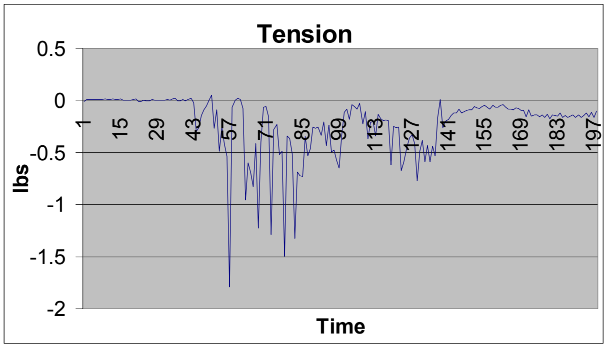

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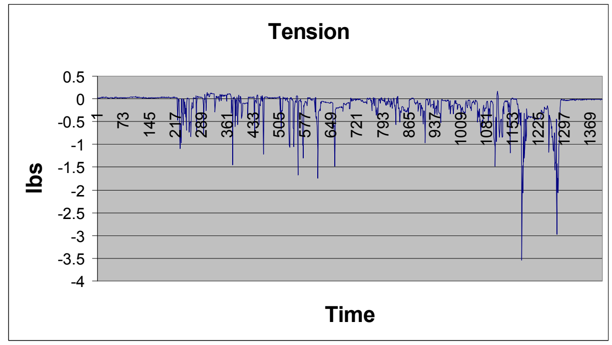

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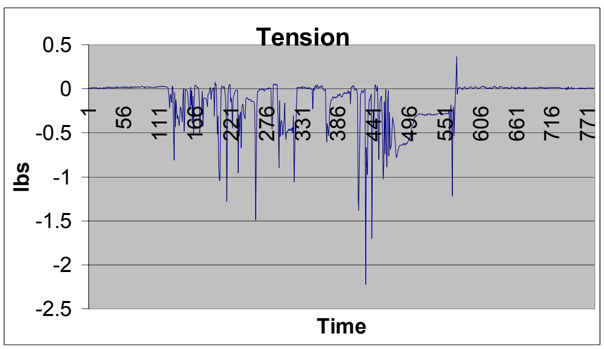

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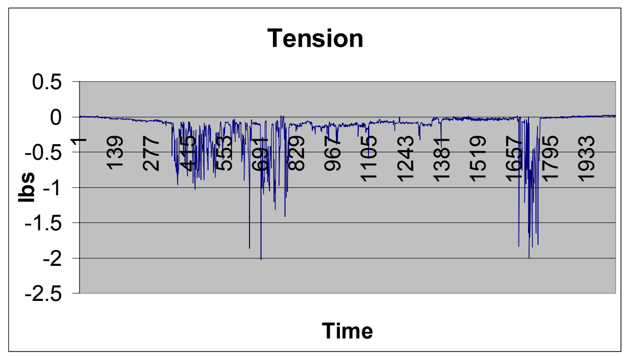

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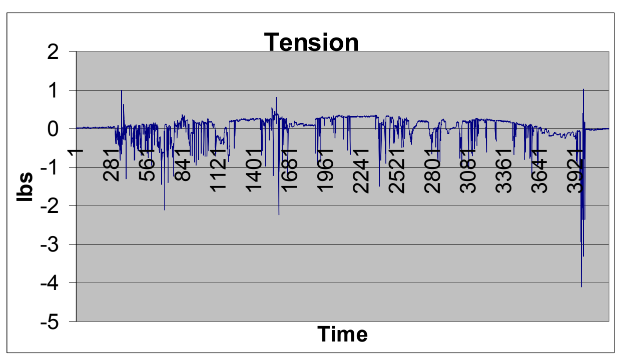
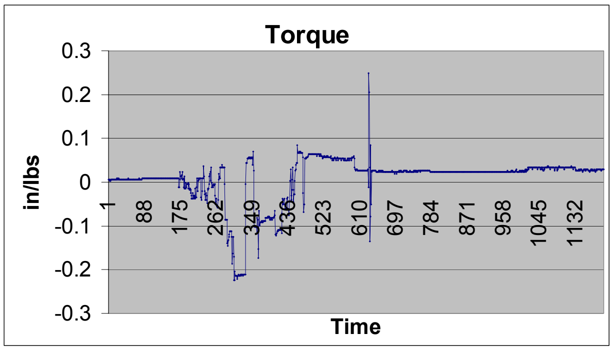
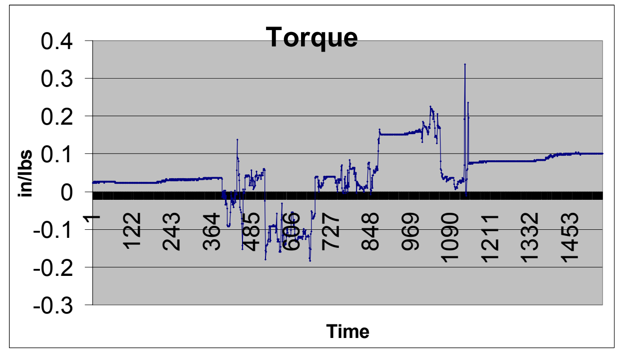


Torque (in/lbs) Exerted by Snowshoe Hare

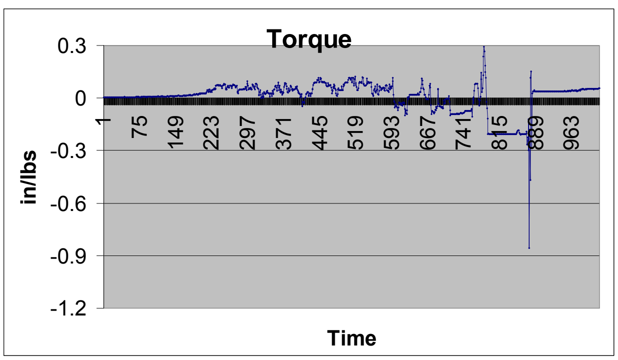
0304



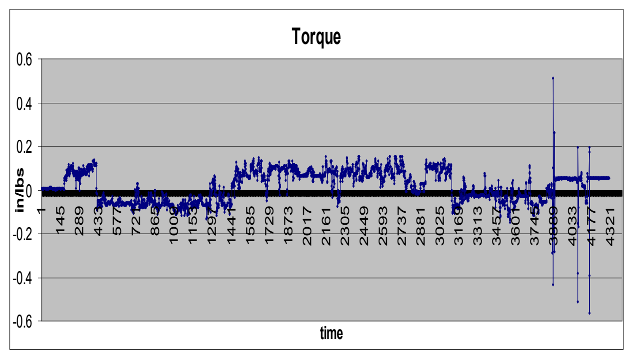
0305



0306



0307



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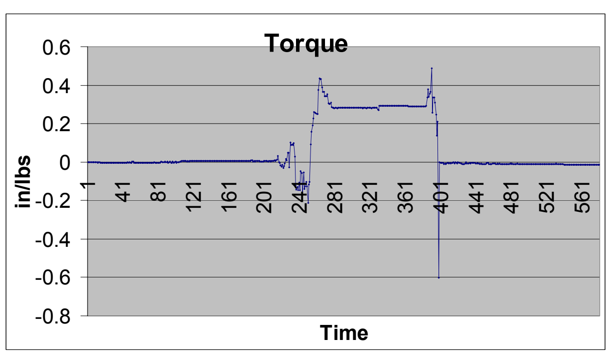

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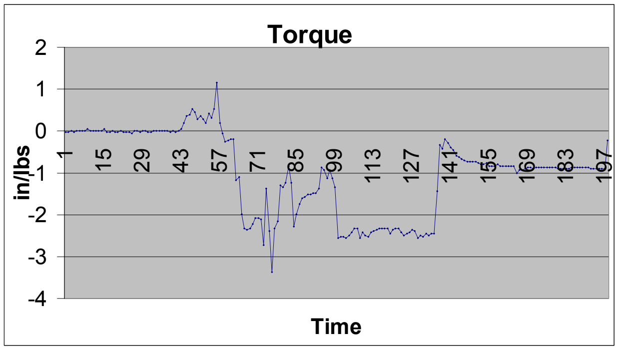

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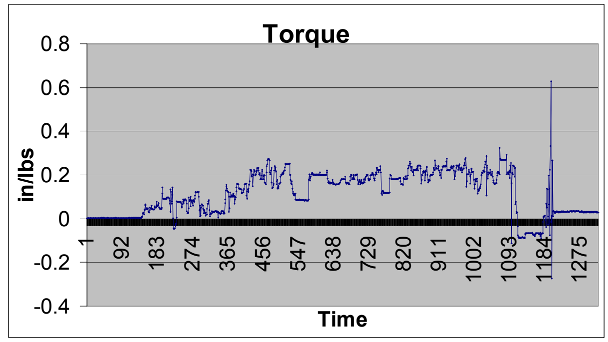

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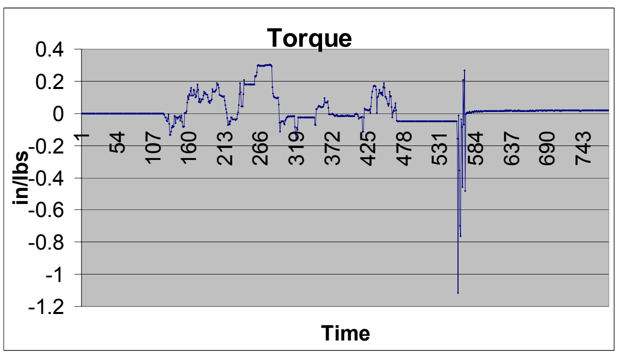

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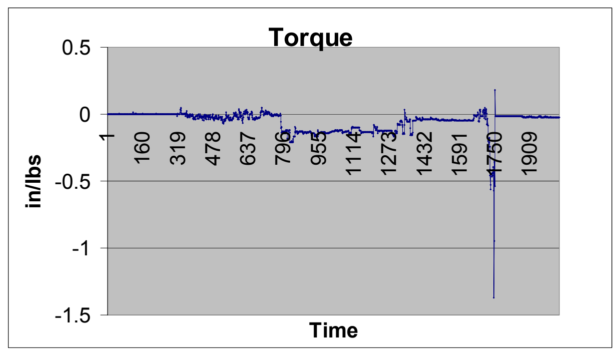

0313