Application Note 20804

TORQUEMETERS WITH EXTENDED MEASUREMENT RANGE

Extending a Torquemeters measurement range[1] can yield two valuable benefits. That is, an extended range Torquemeter:

1. Reduces the number of Torquemeters needed to test a wide torque range.
2. Can measure both high torsional peaks and low running torque without risking Torquemeter failure. Torquemeters must have simultaneous outputs on each range to provide this capability.

The advent of High Resolution Digital Torquemeters has tempted some suppliers to ***mistakenly claim those benefits.*** Installing an on-board, high resolution analog-to-digital converter (ADC) is equivalent to placing one downstream of a conventional analog output sensor. Both will provide high resolution and "extended" range, ***but only with significantly degraded accuracy.*** That's why all Torquemeter manufacturers offer many ranges to handle different capacities rather than a few models with extended range capability.

The table below compares performance of one such High Resolution Digital Torquemeter to a Himmelstein, MCRT®79007V(1-5), Dual Range Torquemeter. Himmelstein Dual Range units are calibrated[2], temperature compensated and specified on each range and both outputs are simultaneously available. The non-Himmelstein unit has an advertised resolution of 0.001% of full scale; it has only one signal output. Both devices have a full scale range of 100,000 lbf-in. The High Resolution Digital Torquemeter is re-scaled to 20,000 lbf-in to match the MCRT's Low Range. Error calculations include the only published error specifications for the High Resolution device: Non-linearity, Zero and Span Temperature Effects.

	Torque Errors @ 100,000 lbf-in		Torque Errors @ 20,000 lbf-in	
Error Source	High Resolution Torquemeter	MCRT® 79007V(1-5) High Range	High Resolution Torquemeter	MCRT® 79007V(1-5) Low Range
Non-linearity[3]	50 lbf-in	70 lbf-in	50 lbf-in	20 lbf-in
Zero Drift[4] for 70 °F Rise	210 lbf-in	70 lbf-in	210 lbf-in	35 lbf-in
Span Drift[5] for 70 °F Rise	210 lbf-in	70 lbf-in	210 lbf-in	35 lbf-in
Total Error—Worst Case[6]	470 lbf-in	210 lbf-in	470 lbf-in	90 lbf-in
Total Error—Statistical[7]	348 lbf-in	139 lbf-in	348 lbf-in	61.6 lbf-in

1. Measurement range may only be lowered; an increase is limited by the device's overload capacity and related danger of element failure.
2. Himmelstein Torquemeters and Systems are calibrated in our NVLAP ACCREDITED LABORATORY, Lab Code 200487-0, and are NIST traceable. NVLAP approved CALIBRATION CERTIFICATES are provided. For details visit www.himmelstein.com, or the "laboratory accreditation" link at www.nist.gov
3. Published non-linearity errors are ±0.05% for the High Resolution Torquemeter, ±0.07% for the MCRT 79007V High Range and ±0.1% for its Low Range.
4. Published Zero Drift (% of Full Scale/°F) for the High Resolution Torquemeter is ±0.003; the MCRT 79007V High Range is ±0.001 and its Low Range is ±0.0025.
5. Published Span Drift for the High Resolution Torquemeter is ±0.003 % of Full Scale/°F; the MCRT 79007V is ±0.001 and ±0.0025 % of Reading for each Range.
6. Worst Case Error is the sum of the component errors.
7. Statistical Error is the expanded uncertainty using a coverage factor, k = 2, at a 95% confidence level.

At full scale, under real-world conditions, the MCRT® 79007V has less than half the error of the High Resolution unit. At 20% of full scale (20,000 lbf-in), it's advantage is 5.6 times. At 4% of full scale (4,000 lbf-in) the advantage is greater than 7 times. At lower ranges much of the increased error is due to the impact of temperature effects. Nonetheless, ***with a virtually insignificant 5 °F rise, when the High Resolution device range is extended to 20,000 lbf-in, it's error is 62.7 lbf-in or 2.7 times that of the MCRT® Dual Range unit.***

A Torquemeter's test temperature is the sum of the ambient temperature and the rise generated during testing. Rotary power transmission, absorbing and producing devices are never 100% efficient. Their losses invariably generate heat and cause a temperature rise during testing. After test shut down, component temperatures usually rise further, during a soak period, before they return to room temperature. At the test start, Zero Errors due to ambient temperature can be electrically canceled. Uncompensated test generated temperature rises and ambient temperature changes occurring during the test cannot be canceled and will produce errors. Uncompensated temperature Span Errors can't be removed regardless of their source.

The High Resolution device employs a single shunt calibration circuit. It develops a cal signal, at the signal chain input, at 75% of full scale. That cal signal must be proportionately reduced when the range is re-scaled. Since there is only one shunt cal circuit, the reduction is handled by the processor after amplification and digitizing. As a result, the calibration input to the signal chain remains at 75% of full scale and ***can be much higher than the torque signal when the range is re-scaled.*** To the extent it is larger than the highest torque bridge output, it doesn't provide a realistic signal chain test. All MCRT® 79007V Dual Range Torquemeters have calibration signals for each range.

Re-scaling requires operation at proportionately reduced bridge signal levels. Since system noise remains unchanged, the measurement signal-to-noise ratio (SNR) is reduced. Externally generated noise exacerbates this problem. Reduced SNR can be a limiting factor when driveline or machine dynamics are at issue.

In summary, to achieve accurate, certifiable measurements, Torquemeters must be calibrated in a facility accredited by an internationally recognized agency such as NVLAP or A2LA. ***When a Torquemeter is correctly calibrated, digital field re-scaling does not transfer the accredited calibration to the re-scaled range(s). An accredited calibration must be done on every range used for accurate, traceable, certifiable measurements.*** Even when such rigorous multi-range calibrations are done, re-scaled Torquemeters can suffer significant errors from temperature effects and other factors. Himmelstein Series 79000V Dual Range Torquemeters mitigate many of those errors and provide significantly higher accuracy in extended range applications.

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