Tension Link Calibration: Pin Size Is the Critical Variable

A case study in evidence-based force calibration decisions

Tension link end-users frequently insist on calibrating their links with the as-used shackles and pins installed in the load train, on the assumption that exact replication of in-service hardware is necessary for an accurate calibration. The full as-used assembly often exceeds the throat clearance of standard high-capacity calibration machines. The question is whether the shackle's inclusion materially changes the calibration result, and if it does not, what variables actually do.

A high-capacity tension link end-user requested calibration of their link with the service shackle and pins installed in the load train, on the basis that the calibrated configuration must replicate the in-service configuration exactly. Together with metrology engineers, sales engineering, and laboratory staff at the Morehouse calibration laboratory, the application was evaluated to identify the relevant pain points:

- The full as-used assembly, including a rated lifting shackle, exceeded the working envelope of standard deadweight calibration machines
- Existing industry guidance was sparse and partly contradictory regarding the relative contributions of shackles, pin geometry, and pin orientation to indicated error
- The cost of accommodating the full assembly (special fixturing, larger calibration machines) needed to be weighed against the actual measurement value gained
- The end-user needed quantitative evidence to make an informed choice between calibration paths

With these constraints in mind, a body of evidence was developed through a series of controlled tests on representative tension dynamometers. The objective was to quantify which variables in the load path materially drive indicated error, and which do not.

TEST 1: PIN DIAMETER DOMINATES INDICATED ERROR

A Dillon ED-2000 Plus tension dynamometer was loaded to a true 50 000 lbf using two different load pins. With an undersized pin, the dynamometer indicated 49 140 lbf, an error of 860 lbf, or 1.72 % at full scale. After replacing the undersized pin with a correctly sized pin, the indicated reading returned to 50 000 lbf at the same applied load.

Wrong pin diameter: 49 140 lbf indicated

Correct pin diameter: 50 000 lbf indicated

The same effect was observed across multiple tension links of similar design. Pin diameter is the single largest controllable contributor to indicated error and can produce errors more than an order of magnitude larger than the link's published accuracy class. **Pin selection also has a safety dimension:** manufacturer-recommended pin diameters are tied to the loadcell's rated capacity, and pins smaller than recommended can cause loadcell failure under load.

TEST 2: PIN ORIENTATION AND PIN-TO-PIN VARIATION

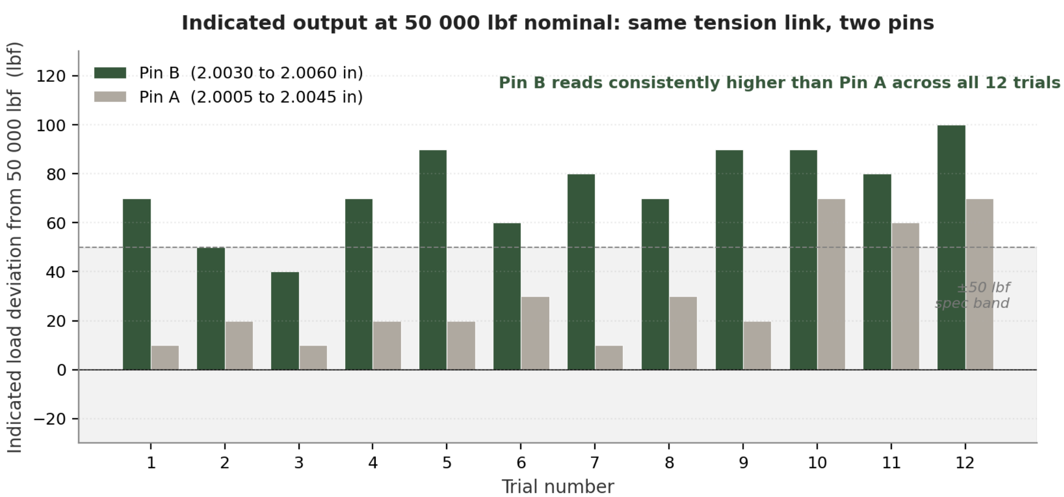
A controlled study was conducted on a Dillon EDXtreme tension dynamometer (ID B03601) at 50 000 lbf nominal applied load. Two nominally identical 2-inch pins (Pin A and Pin B) were each marked into four 90-degree quadrants. The dynamometer was loaded across eight trials, with both pin assemblies broken down and rebuilt between trials to capture realistic reassembly variation. Pin diameters across the two pins varied by approximately 0.005 in, well within ordinary manufacturing tolerance.

Test setup: B03601 dynamometer with Pin A (top) and Pin B (bottom), each marked into Q1–Q4 quadrants

Findings:

- **Pin rotation alone**, rotating the same pin through four quadrants, moved the indicated output by tens of pounds within a single pin.
- **Pin-to-pin diameter variation** produced a consistent 50 lbf to 80 lbf bias at 50 000 lbf, with the larger pin (Pin B) always reading higher.
- **Total spread across all conditions**: 90 lbf at 50 000 lbf nominal, or 0.18 % of applied load. Combined standard deviation: 29.8 lbf.

13 of 24 trials fell outside a ±50 lbf spec (±0.1 % of full scale) at 50 000 lbf nominal.
More than half of the trials failed a tolerance band that many tension link users assume their instrument is comfortably meeting in service. The cause was pin geometry alone: the same link, the same applied load, just different pins and orientations.



Pin B (larger diameter) reads consistently higher than Pin A across all 12 paired trials. The larger pin's readings frequently exceed the ±50 lbf spec band; the smaller pin's readings remain within it.

The combined error budget from pin diameter (1.72 %) and pin rotation/wear (0.18 %) can easily exceed 2 %, far larger than the published accuracy class of most tension links.

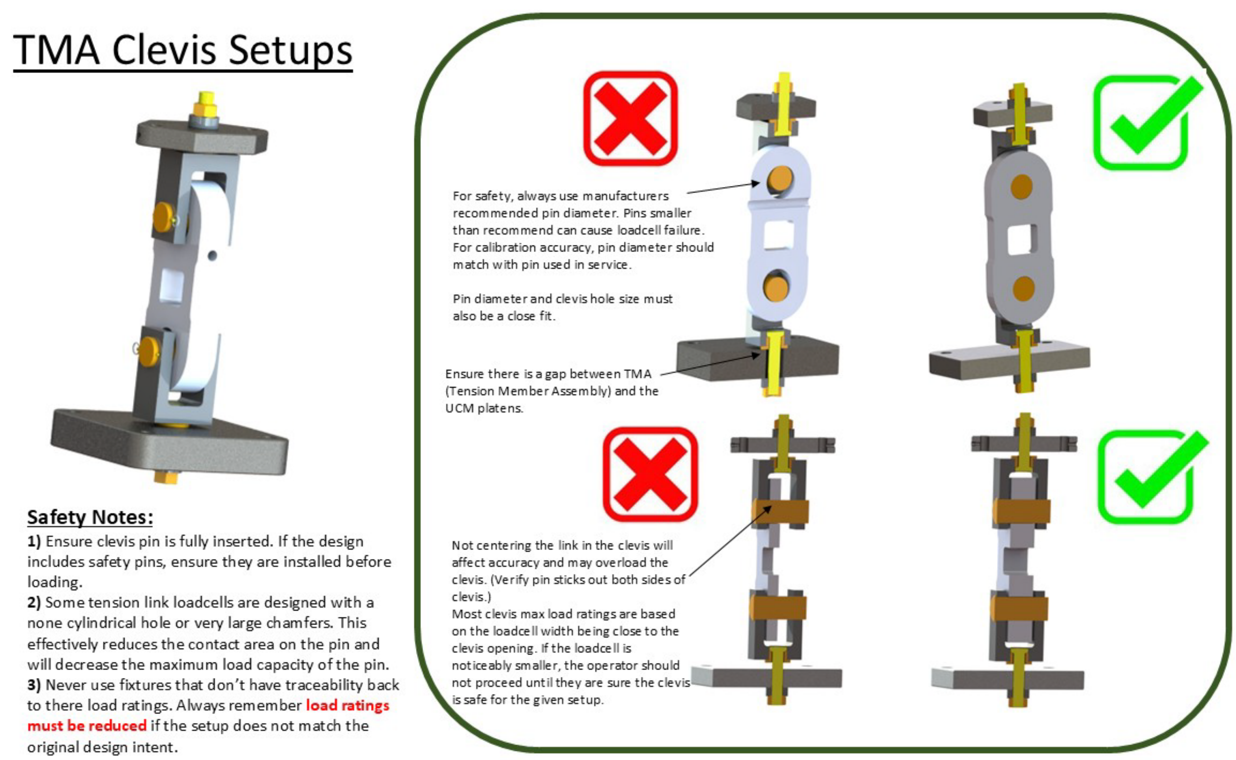
TEST 3: SHACKLE INCLUSION DOES NOT MATERIALLY CHANGE THE INDICATED READING

Across the test configurations evaluated, the shackle bow itself was not observed to materially change the indicated reading on a tension link once the pins were correct. The shackle sits outside the link's instrumented section, and once the pin-to-bushing interface is right, the shackle is effectively load-transparent. This finding is consistent with Dillon's published guidance, which addresses pin selection but does not present quantified shackle-effect data. **Important caveat:** this conclusion applies to tension links specifically. Shackle-pin sensors, load pins, and other weighing-device geometries can have very different sensitivities to surrounding hardware, and the tension-link result should not be generalized to those instruments.

THE MOREHOUSE IMPACT

The body of evidence enabled the end user to make an informed cost-versus-value decision and provided Morehouse with a defensible framework for future customers. Three actions emerged as the high-leverage controls for any tension link to the end-user:

1. **Match the pin first.** Pin diameter, surface condition, and bushing fit are the highest-leverage variables under user control. The pin used in service should be specified (and ideally shipped) for calibration, so that it becomes part of the calibrated measurement system.
2. **Document orientation when service use is fixed.** If the link is installed in a fixed orientation in service, mark both the pin head and the link body before shipping (a photograph helps). The as-calibrated orientation should be recorded on the certificate so the calibration reflects the as-used condition.
3. **Decide on shackle inclusion based on cost versus value.** The default and most cost-effective path is to ship the link alone and calibrate on a deadweight machine, which provides the lowest available measurement uncertainty. Where audit, contractual, or higher-confidence reasons require the full as-used assembly to be calibrated together, Morehouse can accommodate the complete assembly with shackles installed in our 112 000 lbf Universal Calibrating Machine (UCM). The trade-off is higher shipping cost, an additional setup fee, and a slightly larger reported uncertainty than deadweight.



General Safety Tips for Calibration

S	**S**upervision. Supervision of inexperienced employees is essential. Only employees with good mechanical and strong safety aptitudes should use calibration equipment
M	**M**arked. Only use fixtures that are marked or traceable to their rated capacity.
A	**A**lone**.** Never work on large machines alone.
C	**C**ondition. Always check the condition of adapter, machine and loadcell. No damaged threads, no bent or distorted parts, no visible cracks
S	**S**afety Factor. Never assume a fixture has a safety factor above its rated capacity.

SAFETY CONSIDERATIONS

Pin selection is not solely a measurement-accuracy concern. The same variables that drive the indicated error also affect the structural integrity of the calibrated assembly:

- **Undersized pins compromise rated capacity.** Manufacturer-recommended pin diameters are specified for the rated load capacity of the loadcell. Pins smaller than recommended can cause loadcell failure under load.
- **Clevis hole and pin fit affect maximum capacity.** Most clevis maximum load ratings assume the loadcell width is close to the clevis opening. If the loadcell is noticeably smaller than the opening, the operator should verify the clevis is rated for the given setup before proceeding.
- **Setup eccentricity can overload the clevis.** Not centering the link in the clevis can affect accuracy. Verify the pin sticks out from both sides of the clevis, and ensure all safety pins are installed before loading.
- **Non-cylindrical pin holes reduce capacity.** Some tension link loadcells are designed with non-cylindrical holes or large chamfers, which reduce the contact area on the pin and decrease its maximum load capacity. Load ratings must be reduced when the setup does not match the original design intent.
- **General calibration safety (SMACS):** require Supervision of inexperienced operators; never work alone on large machines; use only Marked fixtures traceable to a rated capacity; verify Condition of adapter, machine, and loadcell before every calibration; never assume a Safety factor above rated capacity.

FORCE CALIBRATION SOLUTIONS BY MOREHOUSE

Force calibration can be difficult, but Morehouse is here to help. We welcome the opportunity to review your application, evaluate available calibration paths, and produce a calibration that gives you a defensible measurement value in service. Contact us at (717) 843-0081 or sales@mhforce.com for a consultation.