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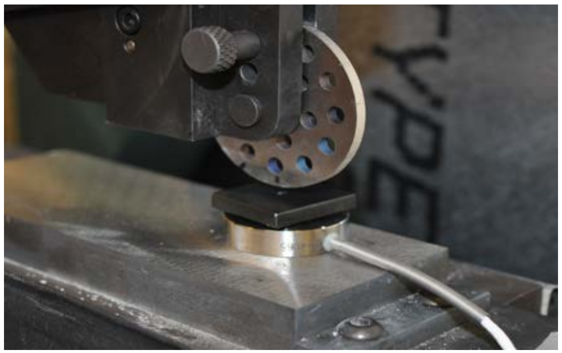

EXPLOSIVES TECHNOLOGIES GROUP
ETG

Load Verification of the ABL Friction Tester

Energetics Characterization, Org. 2555

Jason J. Phillips

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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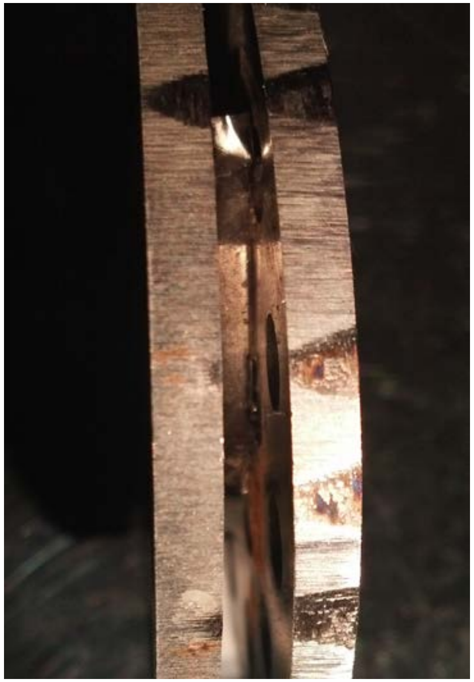
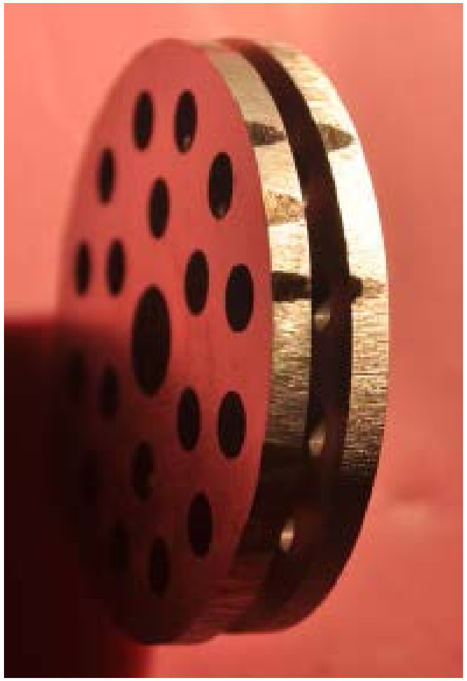
Load Variability





Photos used with permission from:

Hernandez, D., *ABL Friction Tester: Testing Below Self-Correcting Pressure*. 2013
Presented at the 2013 ET User's Group meeting: Park City, UT.

Load Variability (cont.)

- An internal SNL customer requested that the displayed load levels be verified.
- How closely do display values match actual loads? How much variance exists?

➢ Accepted factory stimulus levels

*Equivalent to the electronic display value (psi) due to the diameter of the ram

†Based on contact surface area of wheel/anvil, according to the instrument manual

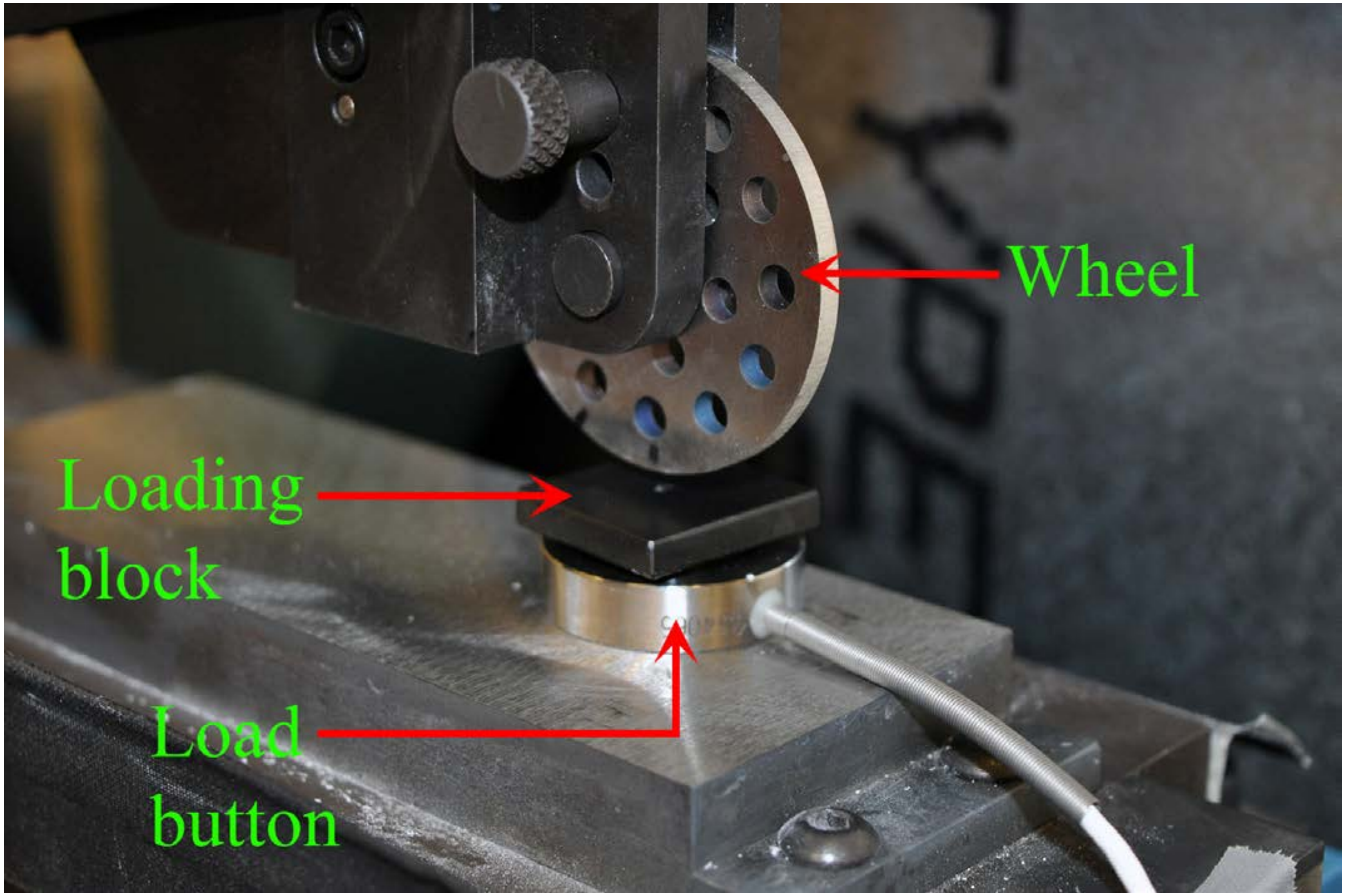
Displayed Load* (lbf)	Actual Pressure†	
	Pa	psi
10	0.96×10^8	13,900
13	1.17×10^8	17,000
18	1.48×10^8	20,700
24	1.68×10^8	24,400
32	1.96×10^8	28,500
42	2.31×10^8	33,300
56	2.60×10^8	37,700
75	2.96×10^8	43,000
100	3.36×10^8	48,600
130	3.86×10^8	55,000
180	4.52×10^8	65,500
240	5.17×10^8	75,000
320	5.96×10^8	86,500
420	6.82×10^8	99,000
560	7.93×10^8	115,000
750	9.17×10^8	133,000
1000	10.5×10^8	152,000

Pre-verification

- Zeroing procedure (from the manual) was completed prior to taking measurements.
- Machine was broken-in enough that the ram self-retracted when the bypass valve was opened.
- A calibrated load cell and digital display were acquired to measure the load (lbf) at each stimulus level.

- ➢ High accuracy compression load button (model LBMU - Interface, Inc.)
- ➢ Model 9320 indicator (Interface, Inc.) was used to take measurements in lbf

Load Measurement Setup



- 1in x 1in x 3/16in soft steel loading block (Morehouse Instrument Company, Inc.)

Pre-Adjustment Load Measurements

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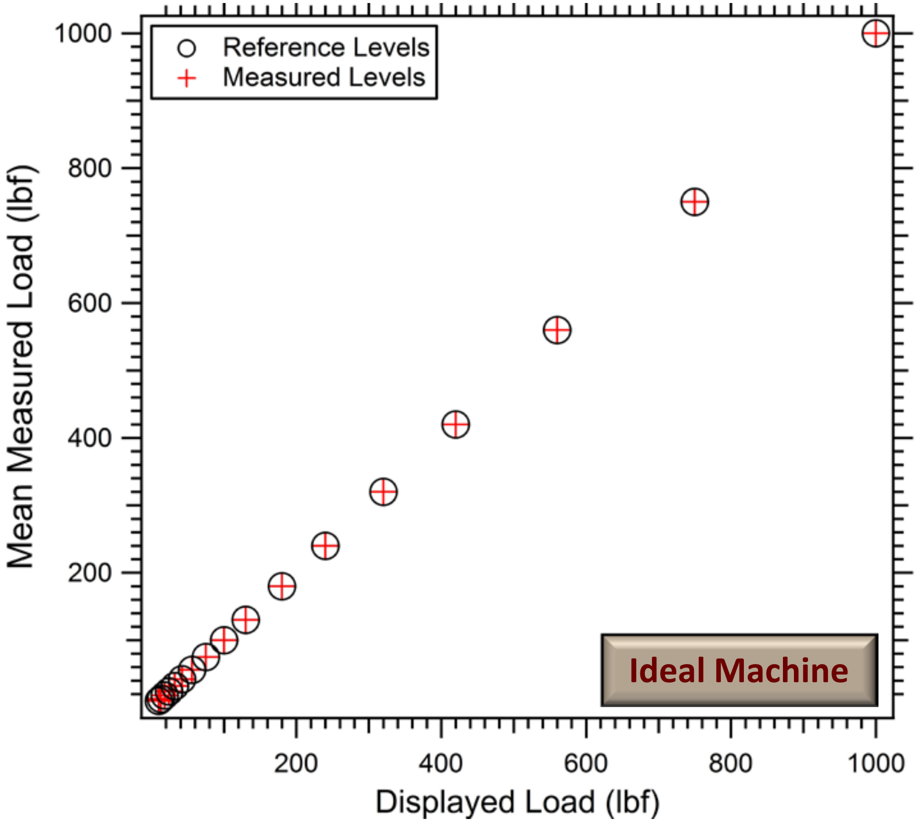
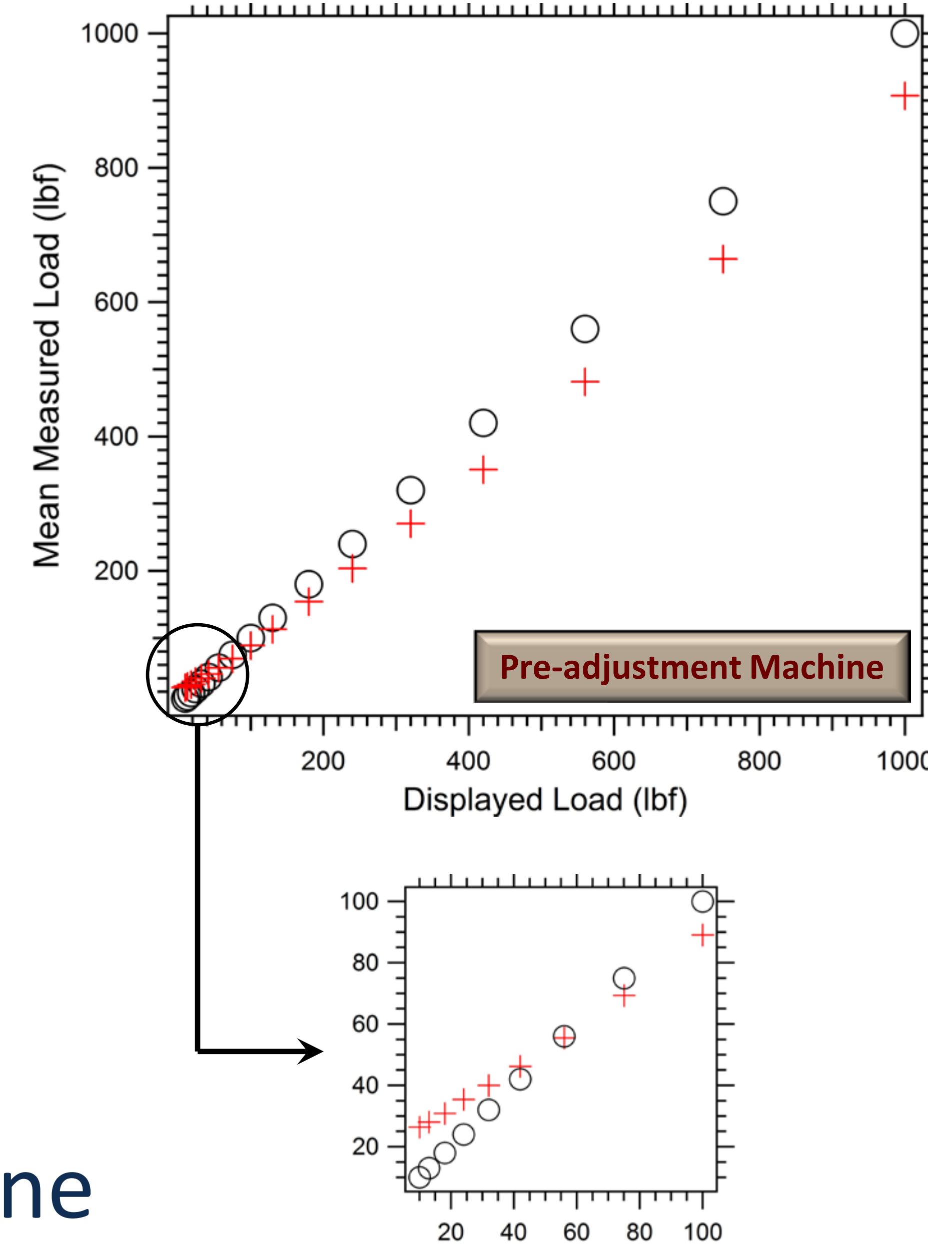
Displayed Load (lbf)	Measured Load (lbf) - Trial #									
	1	2	3	4	5	6	7	8	9	10
10	24.5	24.4	26.1	28.4	25.4	28.2	26.5	24.8	27.5	28.1
13	26.6	25.4	25.4	30.6	25.5	29.0	28.7	29.3	29.0	30.8
18	29.9	27.9	30.6	33.3	28.3	32.1	33.8	31.5	28.7	32.6
24	34.5	31.7	31.9	41.1	37.2	33.0	44.6	32.4	33.0	34.9
32	37.0	38.6	39.1	44.6	39.0	37.7	46.1	38.3	40.0	39.5
42	44.0	45.7	44.1	53.4	44.8	44.1	54.4	42.2	44.1	45.3
56	50.7	54.2	51.5	66.1	53.1	51.6	67.1	50.1	57.2	53.6
75	64.0	65.4	65.0	81.7	64.8	63.3	83.3	61.9	77.6	66.5
100	80.8	109.2	80.6	101.0	85.7	79.6	104.2	78.6	88.8	82.2
130	116.2	114.7	109.8	126.5	108.2	103.6	130.9	102.4	113.2	105.3
180	152.8	152.2	150.8	168.0	148.4	146.4	173.1	148.8	155.9	146.4
240	200.0	201.3	197.1	218.8	199.1	192.7	229.8	192.7	207.0	196.2
320	261.6	264.9	284.7	287.2	263.2	255.4	297.5	254.2	275.5	259.2
420	347.6	345.1	351.7	366.9	342.0	342.0	375.7	345.7	351.1	340.3
560	484.0	480.6	480.3	481.1	478.2	477.8	482.1	478.3	495.4	475.6
750	663.0	665.5	668.0	662.4	664.2	661.0	663.1	663.0	669.1	660.0
1000	908.7	909.4	914.4	908.8	906.0	905.3	894.6	905.2	914.3	903.4

Mean	σ (95%)
26.4	3.2
28.0	4.2
30.9	4.2
35.4	8.6
40.0	5.9
46.2	8.3
55.5	12.4
69.4	16.3
89.1	22.8
113.1	19.0
154.3	18.3
203.5	24.1
270.3	30.0
350.8	23.2
481.3	11.0
663.9	5.8
907.0	11.4

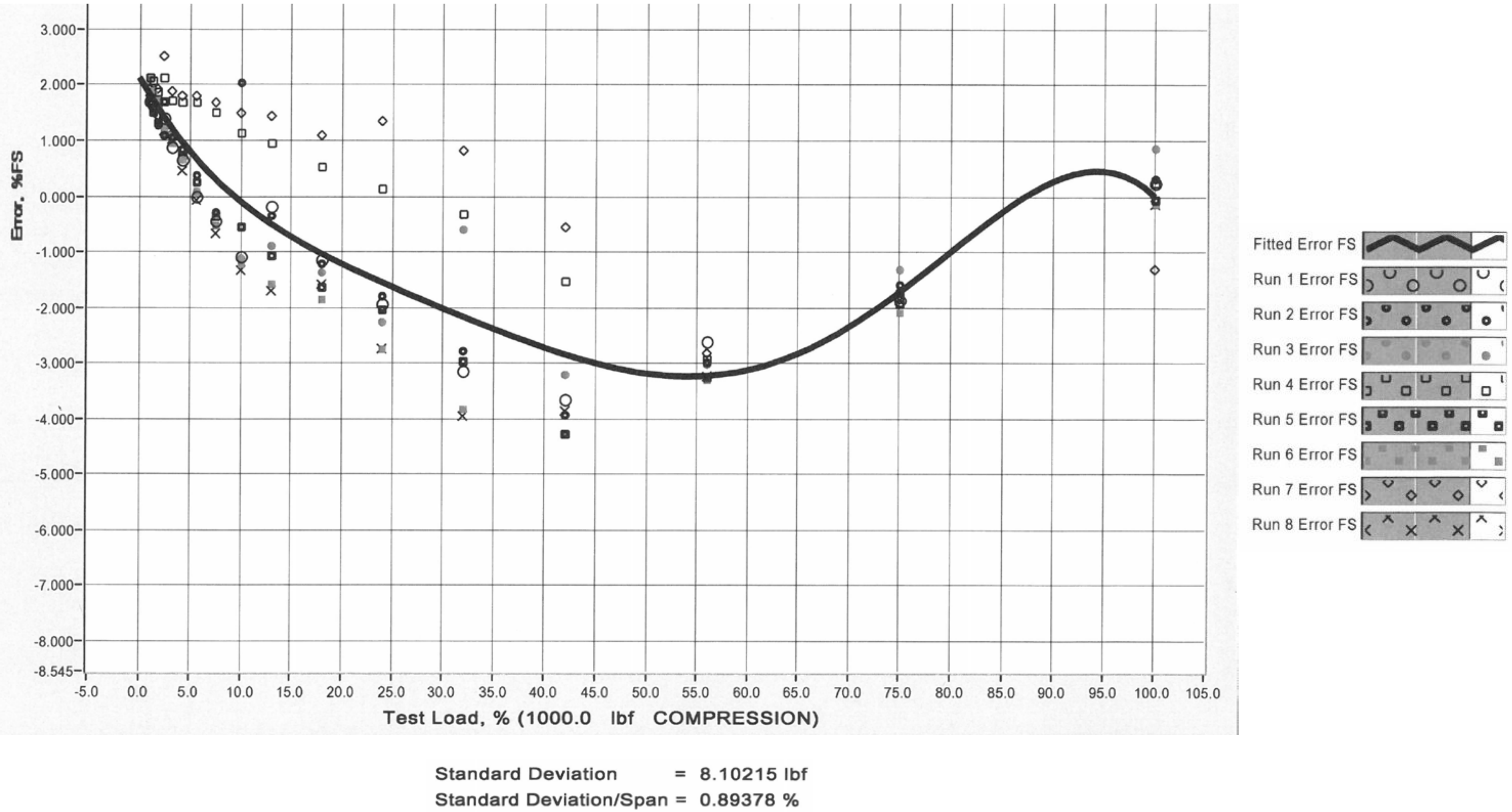
- Trials were split among 3 different operators to maximize the included variability.





Ideal Machine
vs.
Pre-adjustment Machine

Measured Load Error (% Full Scale)

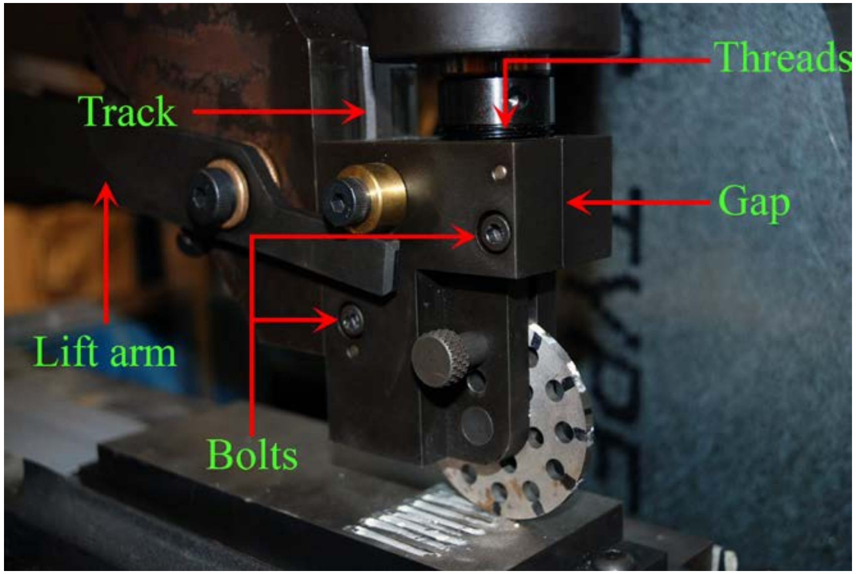


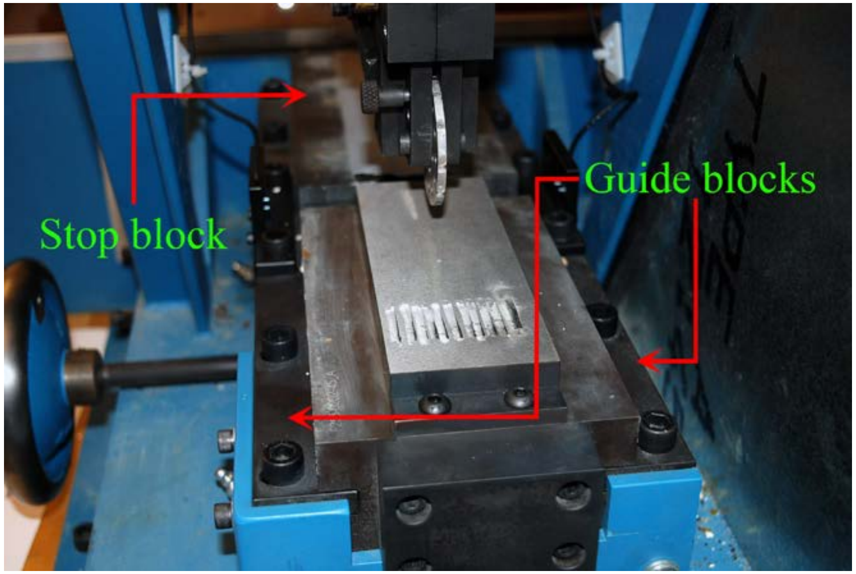
Note: Only 8 of 10 trials of data were able to be plotted by the data analysis program.

Causes of Variability

- Lead cause believed to be excessive mechanical play, or "slop", present in the system. Each mechanical linkage contributes variability:
  - Wheel-pin
  - Wheel housing-track
  - Wheel housing-ram
  - Anvil carriage-rollers
  - Etc.
- Since multiple mechanical linkages are located between the pressure transducer and the sample interface, all of the variance is incorporated into the displayed load simultaneously.

Excessive Mechanical Play Reduction





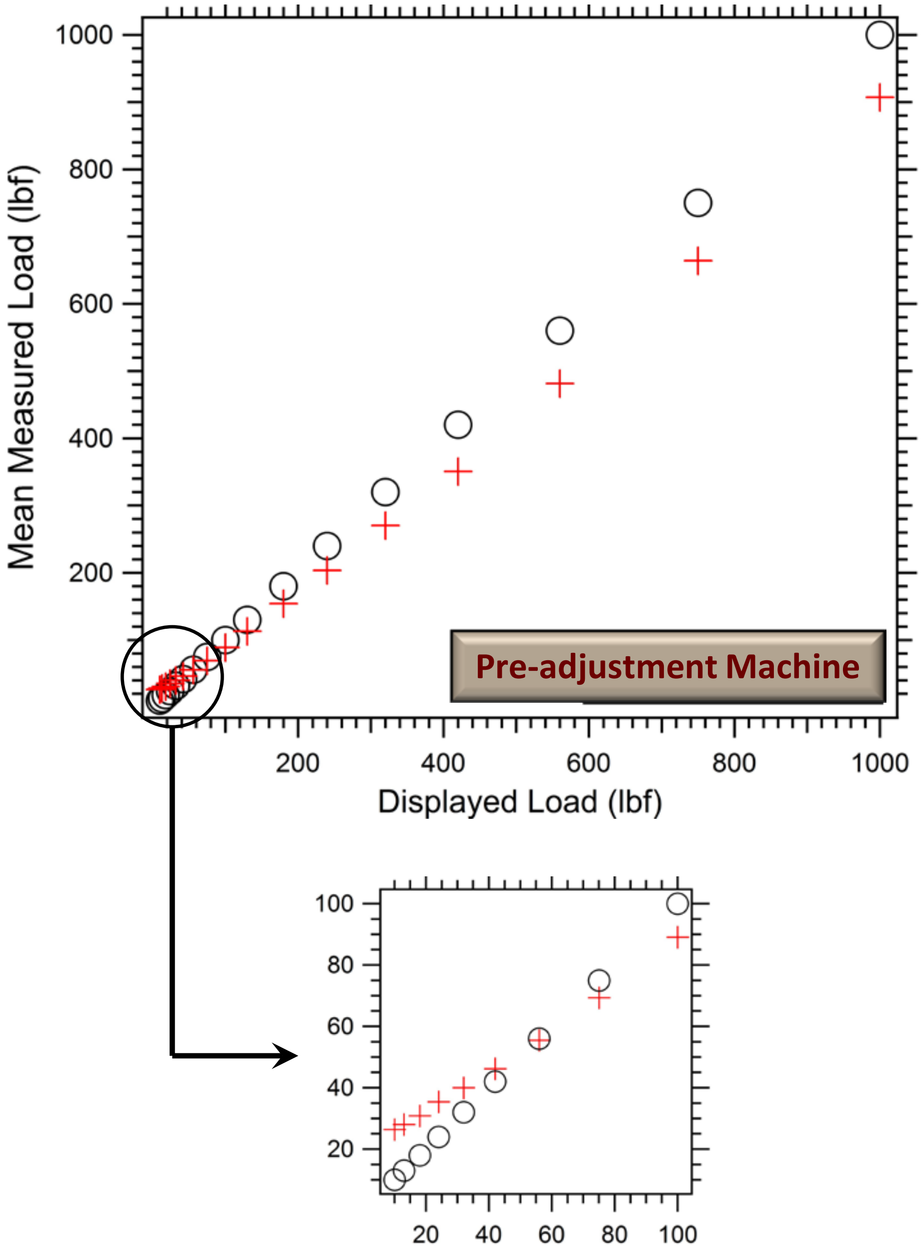
1. Remove the lift arm to prevent damage from over-travel.
2. Remove the wheel and stop block. Slide the anvil carriage to the left to gain clearance. One or both of the guide blocks should be removed, also.
3. Extend the ram downward until the wheel housing clears the track (to allow for rotation).
4. Loosen the bolts, and tighten the wheel housing onto the end of the ram to reduce wobble.
5. Retighten bolts, attempting to minimize the spacing in the gap without severely restricting track motion.
6. Reinstall the guide blocks per the manual, as well as the stop block and wheel.

Balancing Act: Sloppy vs. Smooth

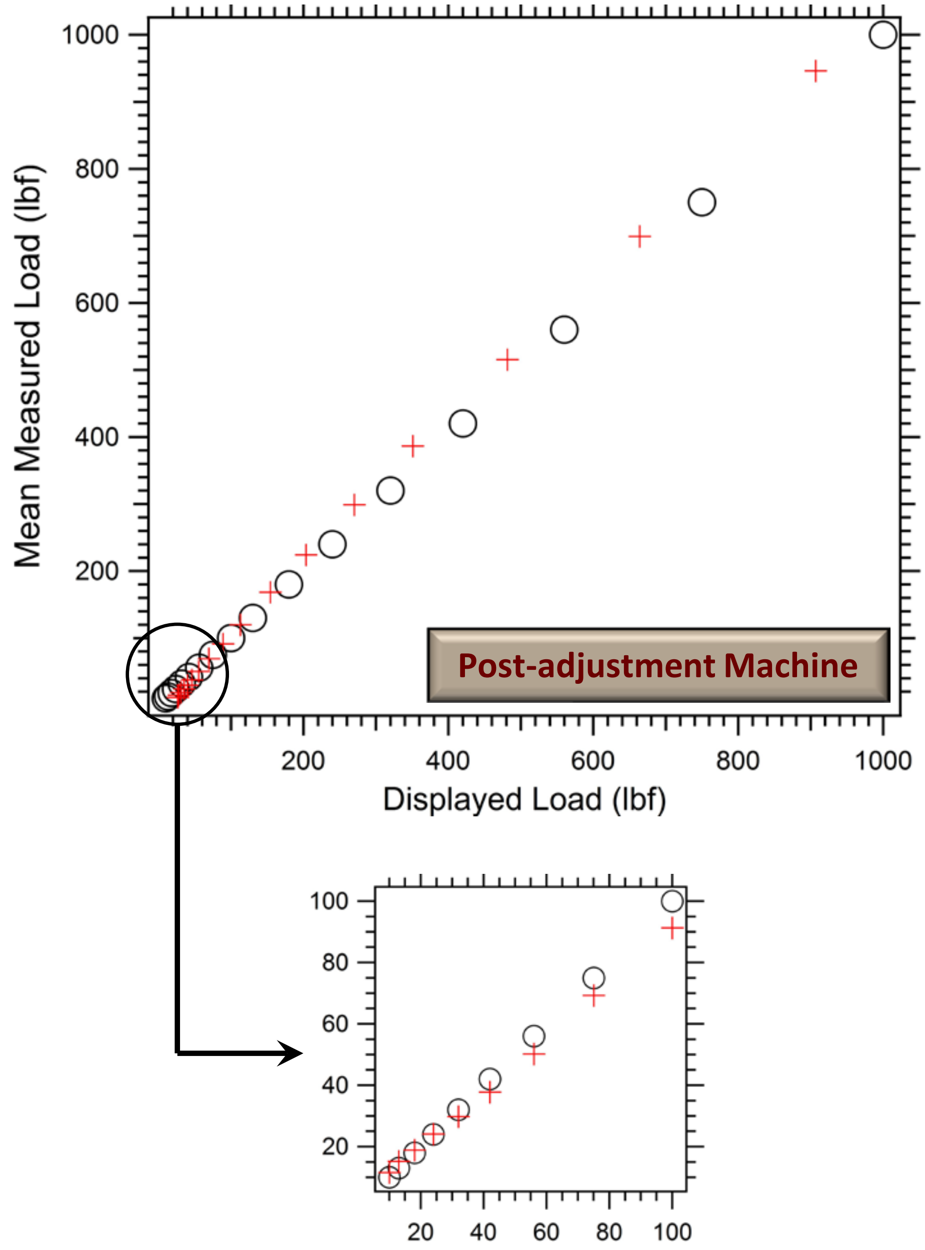
- Do not overtighten the bolts
  - Track Issues
    - If the left bolt is overtightened, it will restrict ease of motion in the track, contributing to excessively high pressure readings
    - This will also hinder self-retracting of the ram upon opening of the bypass valve.
    - The wheel housing should be snug, yet still slide freely in the track.
    - **Light** lubrication of the track would be beneficial. A dry lubricant would reduce contamination buildup.
  - Wheel Issues
    - If the right bolt is overtightened, it will increase the difficultly of rotating the wheel between trials
    - This will also increase the difficulty of removing/installing wheels
    - Lubrication is not recommended due to proximity to the sample interface

Post-Adjustment Load Measurements

Displayed Load (lbf)	Measured Load (lbf) - Trial #										Mean	σ (95%)
	1	2	3	4	5	6	7	8	9	10		
10	16.1	11.9	9.5	16.3	8.8	7.8	14.3	10.3	10.9	9.8	**11.6**	6.0
13	17.1	15.3	16.4	16.7	16.2	11.0	15.5	17.5	14.2	11.7	**15.2**	4.5
18	20.0	16.7	22.8	21.9	16.8	16.1	20.2	20.0	16.8	17.2	**18.9**	4.8
24	26.7	20.1	23.9	26.7	26.9	20.2	24.8	25.1	24.4	22.6	**24.1**	5.0
32	31.9	23.1	30.5	31.5	31.9	25.2	30.5	32.0	31.8	29.4	**29.8**	6.2
42	39.8	35.9	33.6	40.3	41.1	36.3	40.9	38.0	36.8	35.5	**37.8**	5.2
56	54.0	45.6	48.8	50.5	45.9	54.7	51.9	51.9	48.7	49.5	**50.2**	6.1
75	73.4	70.3	61.5	70.1	69.0	73.4	70.5	70.3	67.1	67.0	**69.3**	7.0
100	92.5	90.8	88.4	91.9	86.5	97.5	91.5	93.6	89.1	90.7	**91.3**	6.1
130	124.1	119.3	118.0	122.7	114.2	122.8	122.9	119.3	120.1	116.4	**120.0**	6.4
180	172.8	170.4	164.4	166.4	164.3	166.0	170.8	170.1	170.2	168.6	**168.4**	5.9
240	222.6	224.6	219.4	218.0	218.6	218.4	232.0	234.5	227.1	224.4	**224.0**	11.6
320	299.5	297.2	292.1	294.5	296.2	290.4	309.0	307.8	301.2	302.5	**299.0**	12.4
420	382.1	382.7	384.3	379.0	384.9	376.4	395.6	395.8	391.2	394.2	**386.6**	14.1
560	523.4	513.4	512.0	509.8	507.9	508.5	524.8	518.9	518.0	518.4	**515.5**	12.1
750	704.5	700.3	691.9	693.4	694.1	696.6	705.8	701.3	702.3	700.6	**699.1**	9.6
1000	948.7	945.2	940.8	943.9	943.6	946.0	948.7	947.8	949.4	946.8	**946.1**	5.5

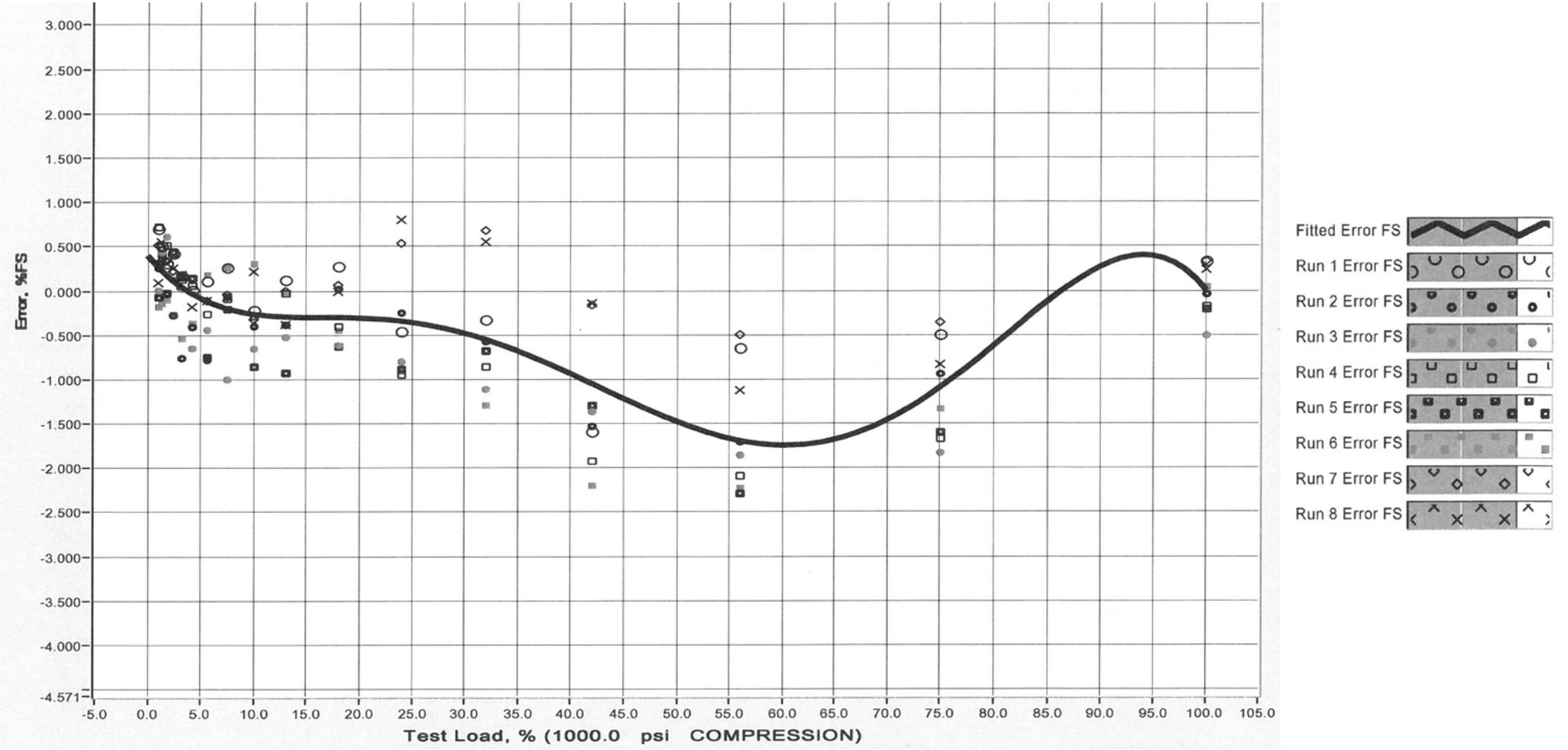


Mean Measured Load (lbf)
Displayed Load (lbf)
Pre-adjustment Machine
1000
800
600
400
200
200
400
600
800
1000
100
80
60
40
20
20
40
60
80
100



Mean Measured Load (lbf)
Displayed Load (lbf)
Post-adjustment Machine
1000
800
600
400
200
200
400
600
800
1000
100
80
60
40
20
20
40
60
80
100

Measured Load Error (% Full Scale)



Standard Deviation = 4.31758 lbf
Standard Deviation/Span = 0.45662 %

Note: Only 8 of 10 trials of data were able to be plotted by the data analysis program.

Conclusions

- Complete instrument redesign?
  - This would require a large undertaking and much vetting to gain viability and acceptance. This would also require much time and capital.
  - A more practical approach is to improve the existing procedures.
  - Modifying the existing design may be possible to reduce variances.
- A simple procedure to quickly calibrate the hydraulic pressure transducer to more closely match measured load values would be beneficial.
- Remove of as much mechanical play as possible without compromising the instrument functions:
  - Raising/lowering of the wheel carriage, smoothly with minimal binding
  - Rotating/removal and installation of friction wheels

Acknowledgements

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