Are We Measuring What We Think We Are Measuring?

Presentation #14099

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Objective

- A reminder to not forget the basics of:
  - ↗ Understanding what we measure
  - ↗ Understanding how we report results
  - ↗ Understanding how we interpret results

Understanding What We Measure

- The basic ammunition performance measurements:
  - ↗ Pressure
  - ↗ Velocity
  - ↗ Action time

We Love Our Data

- How often do we see test data reported like this:

AMMUNITION SINGLE SHOT TEST

Cartridge Temperature: -65°F

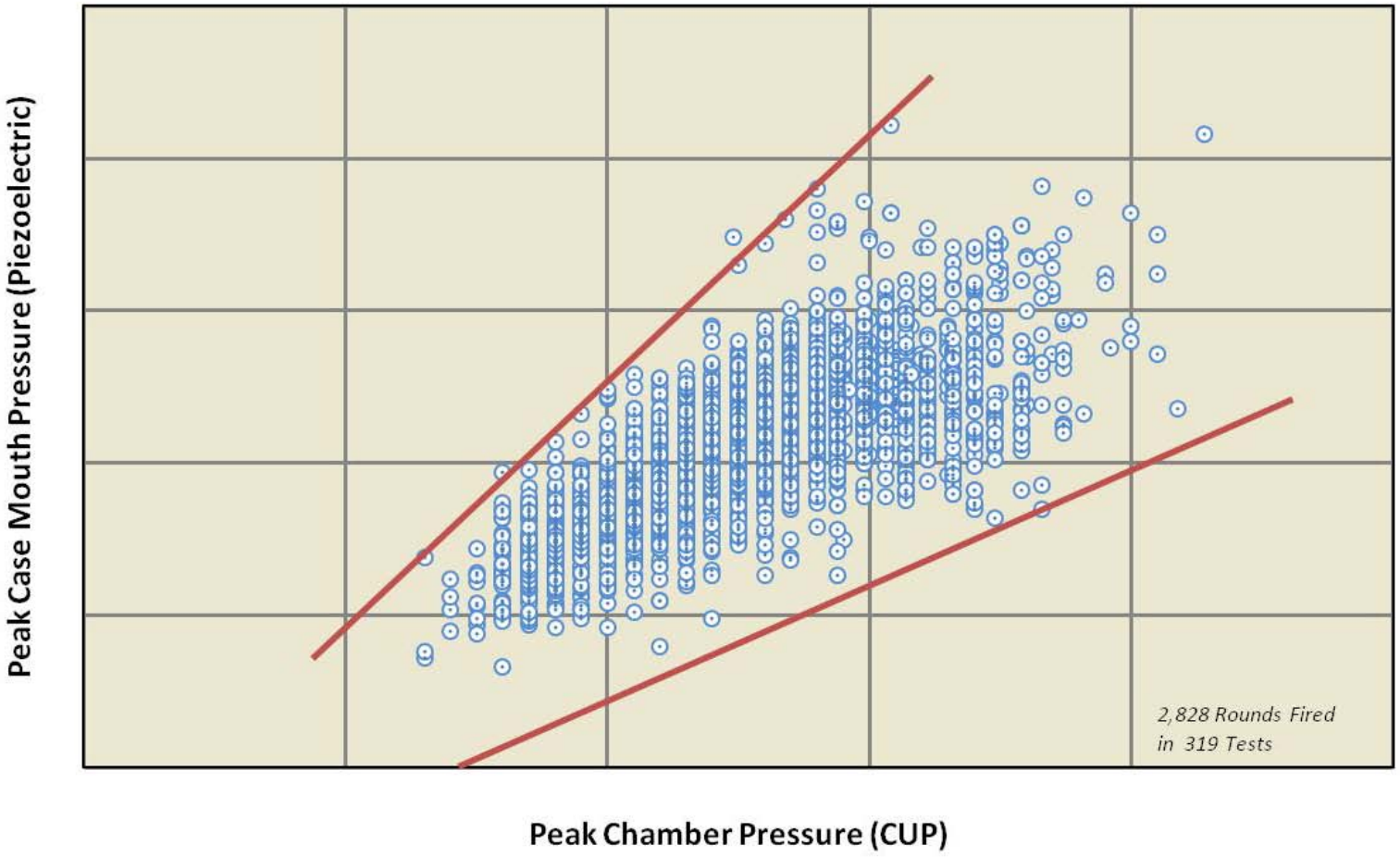
Ammo Lot:

Date	Time	Round Number	Case Mouth Pressure (psi)	Muzzle Pressure (psi)	Velocity at 78 feet (fps)	Action Time (msec)
5/5/08	12:36:05	1	44,687	5,756	3,380	4.89
5/5/08	12:39:26	2	45,493	5,587	3,390	4.84
5/5/08	12:43:24	3	45,420	5,867	3,387	4.86
5/5/08	12:46:30	4	45,761	5,692	3,380	4.76
5/5/08	12:50:44	5	45,284	6,021	3,405	4.86
5/5/08	12:54:34	6	46,299	5,855	3,418	4.84
5/5/08	12:57:41	7	45,718	5,856	3,393	4.85
5/5/08	13:00:46	8	45,810	5,788	3,391	4.98
5/5/08	13:06:00	9	45,737	5,688	3,413	4.77
5/5/08	13:09:22	10	45,047	5,950	3,388	4.77
5/5/08	13:12:31	11	45,679	5,740	3,389	4.93
5/5/08	13:18:37	12	45,205	5,978	3,404	4.75
5/5/08		13	45,399	5,929	3,389	4.92
			44,951	5,941	3,411	4.80
					3,415	4.74
					378	4.77
					396	4.72
					398	4.82
5/5/08	13:34:51		44,784	5,723	3,384	4.89

It is very detailed… but is it correct?

Pressure

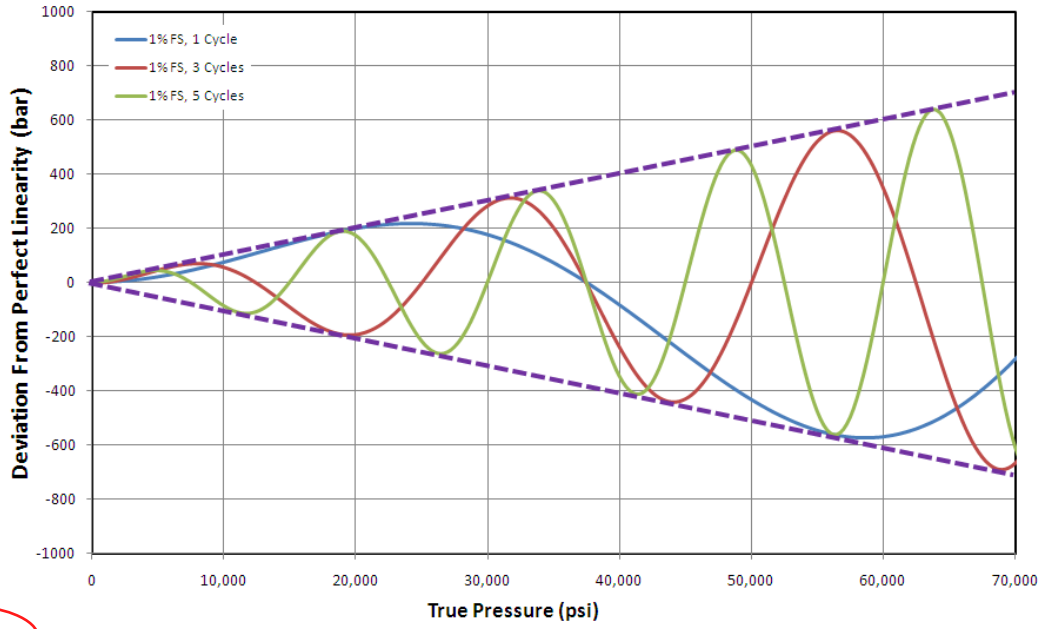
- Copper Crush Method versus Piezoelectric



Pressure

- Piezoelectric Limitations

Range	bar	0 ... 6 000
Calibrated partial range	bar	0 ... 600
Overload	bar	6 600
Sensitivity	pC/bar	–1,4
Natural Frequency	kHz	>240
Rise time	µs	1
Linearity for all ranges	%FSO	±1
Acceleration sensitivity		
axial	bar/g	<0,002
transverse	bar/g	<0,005
Shock resistance		
axial	g	25 000
transverse	g	10 000
Temperature coefficient of the sensitivity	%/°C	±0,02

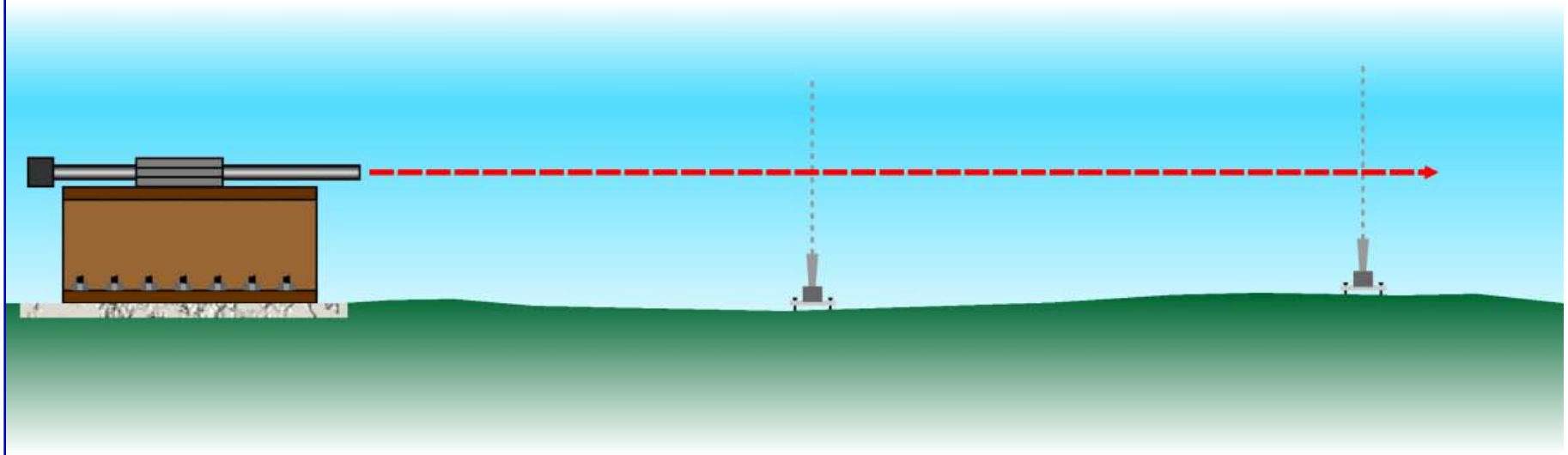


A 3, 4 or 5-point calibration won't enable non-linearity correction.

(Kistler Model 6215 data from www.kistler.com)

Velocity

- Typical Measurement Setup:



Typical Test Setup Parameters

5.2.1.2 The elevation or depression of the Mann barrel shall not exceed 5 degrees of angle above or below horizontal.

5.2.1.3 The velocity coils or photo screens for measuring projectile velocity shall be positioned at the following distances:

a. Minimum distance from gun muzzle to first screen - 3 meters

b. Minimum distance between first and second screens - 6 meters

The range at which the velocity is recorded (range midpoint) is defined as follows:

Range midpoint = (Distance from muzzle to first screen) + (Distance between screens)/2

Distances shall be measured accurately to the nearest 1.0 centimeter (cm).

AS12013566 (25mm Ammo Ballistic Test Methods)
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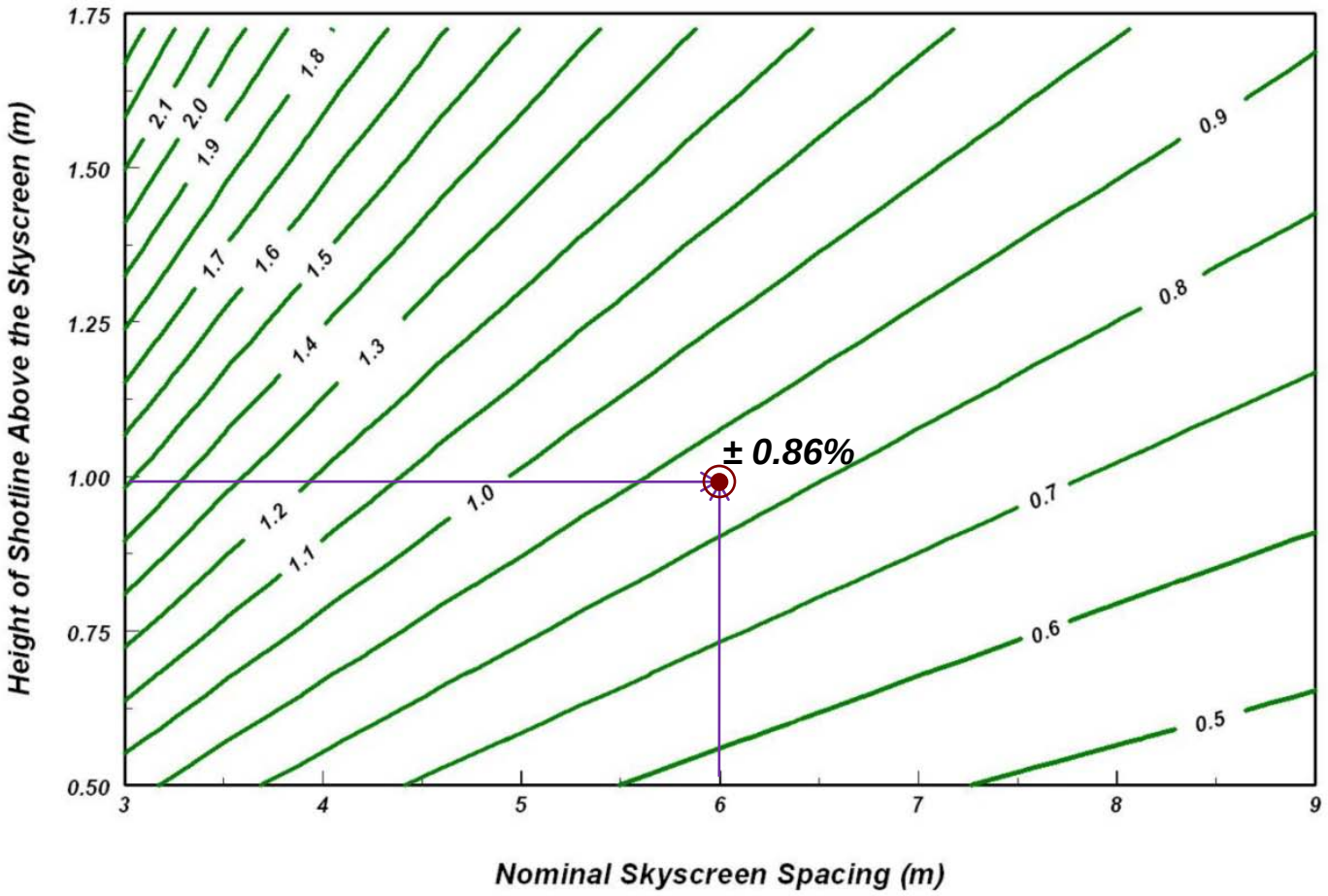
Assume Typical Setup Errors

- Assume the spacing of the skyscreens at ground level is known to ± 0.5 cm
- Assume the skyscreens are vertical to ± 1°
- Assume the shotline is horizontal to ± 2.5°
- Assume the skyscreens are at the same elevation
- Assume our ability to measure elapsed time is perfect

Velocity Measurement Uncertainty (±)



- Spacing: ± 0.5 cm
- Vertical Alignment: ± 1°
- Shotline: ± 2.5°
- Timing Error: Zero

The uncertainty associated with a 3,300 ft/s velocity measurement is ± 28 ft/s!

Action Time

- Measurements for electrically-primed ammunition are generally pretty clear:

4.6.2.3 Action time. The sample cartridges shall be fired from the single-shot barrel in accordance with AMCR 715-505 and conditioned and shot at two temperature ranges: 68 to 72°F, and -60 to -70°F. The time between application of firing pulse and the exit from the muzzle of the projectile shall be measured. The action time shall comply with the requirements of 3.2.1.2.

AS-6120A (PGU-28A/B)
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4.5.4 Action time. The test rounds shall be conditioned at -54°C, 21°C and 71°C and fired from a test fixture barrel. The time between application of voltage to primer and exit of the projectile from the muzzle shall be measured. The time shall comply with requirement of 3.13. Any corrected action time of 2.40 milliseconds or less shall be disregarded as an instrumentation error.

MIL-C-63982A (M789)
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Action Time

- Percussion-primed? Not as simple:

4.6.6 Action time. The method of test shall be as specified in AS12013566.

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4.6.2.1 Chamber pressure and action time. The cartridges shall be tested in accordance with AS12013566, excluding alternate method for obtaining chamber pressure by measuring case mouth pressure. Chamber pressure shall be measured with a piezoelectric transducer that conforms to drawing 12910127. The cartridges shall be conditioned for a minimum of four hours at the applicable temperature and fired from a Mann barrel.

MIL-PRF-71140A (M793)
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AS12013566 neither defines “action time” nor how to measure it.

Action Time

- The M793 specification defines action time:

6.12.1 Action time. Action time is defined as the time period between the initial contact of the weapon firing pin against the primer and the exit of the projectile from the muzzle.

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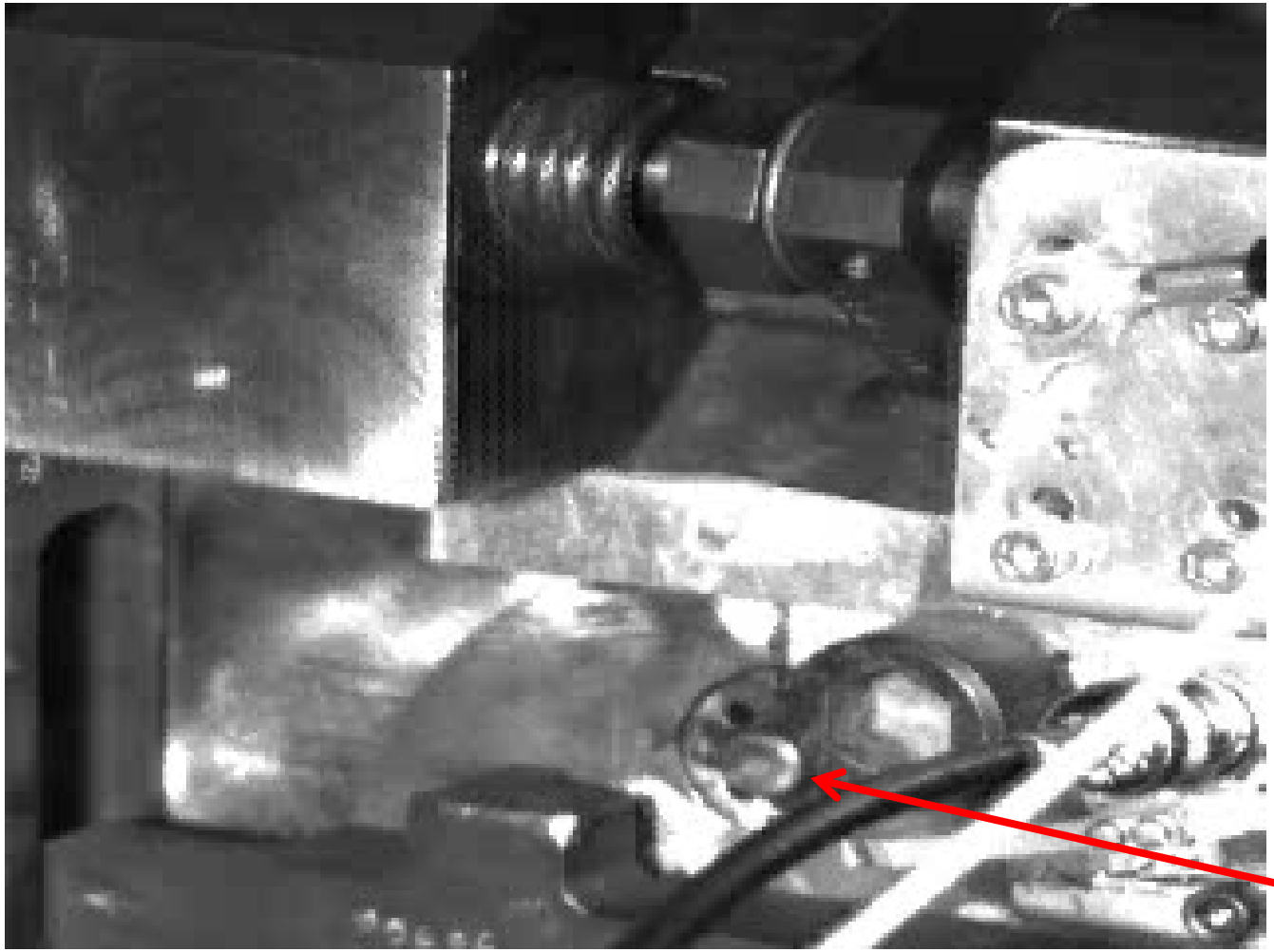
Typical Breech Behavior



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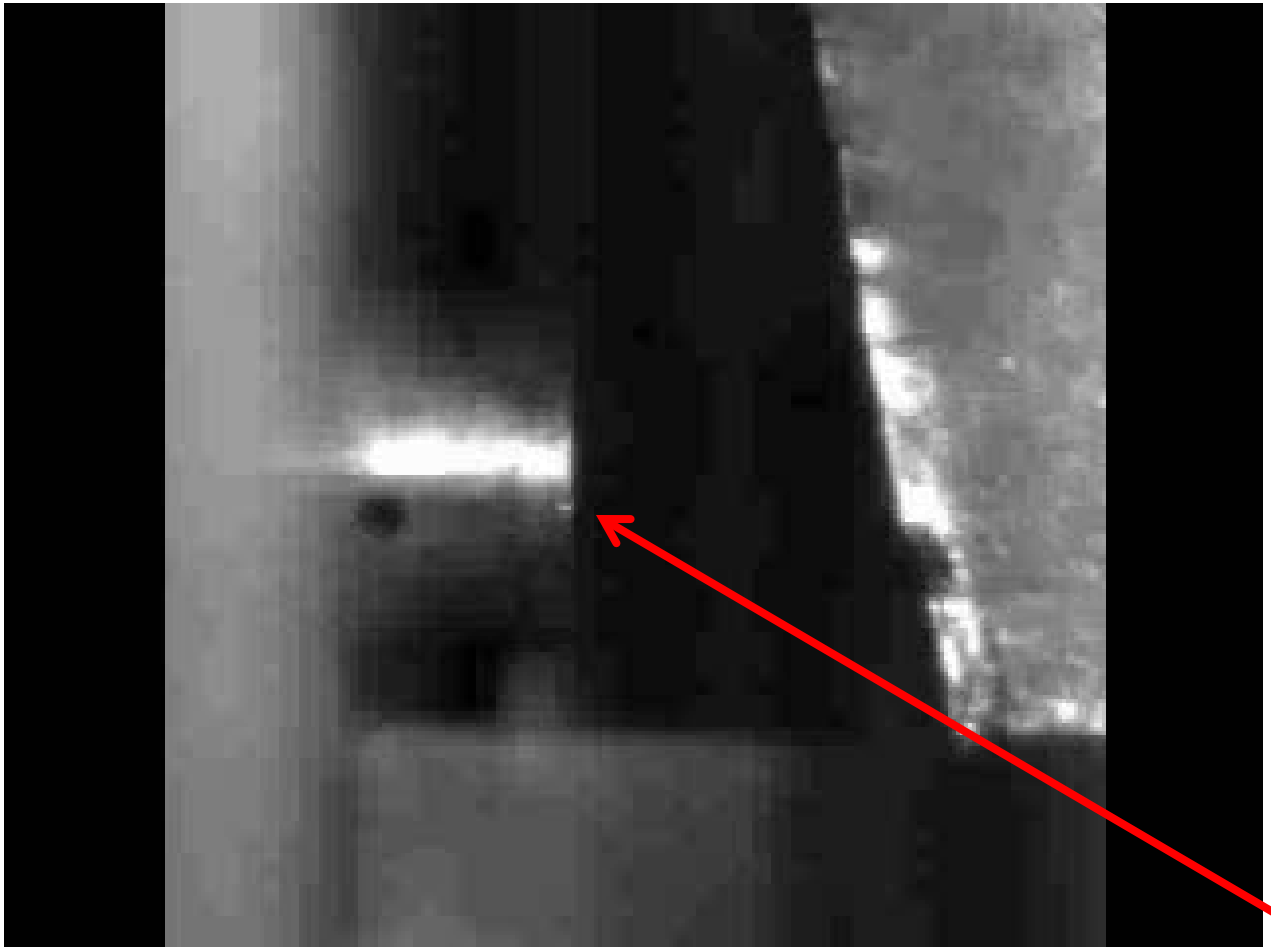
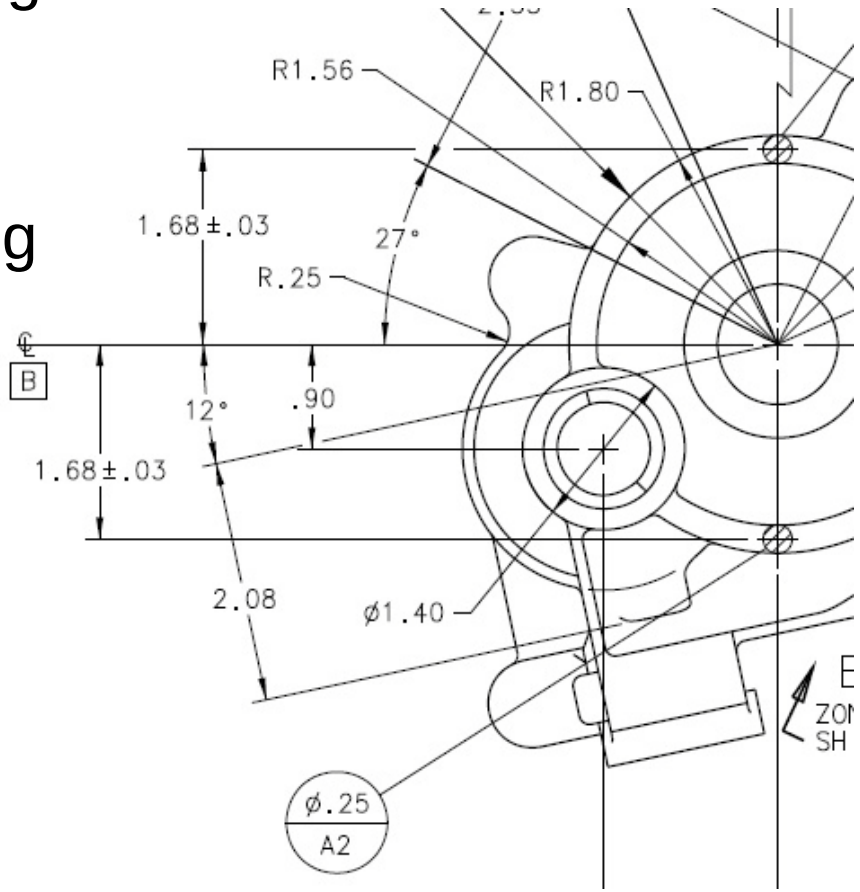


The Bottom Line

We wouldn't put dimensions on a drawing without considering their tolerance.

Why don't we do the same thing with measurements?



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