Some useful terms (Linearity, Resolution, etc)

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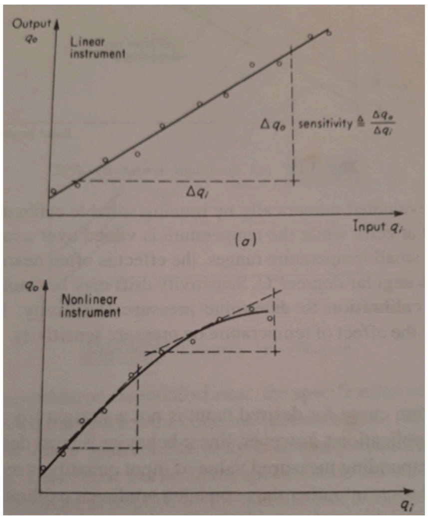
Static Sensitivity

- Static sensitivity is slope of the calibration curve (= $\Delta q_o / \Delta q_i$)
- Allows comparison of different instruments, in their ability to detect changes to the input
- Note, instrument's sensitivity to interfering and/or modifying inputs also of interest
- For example, for a pressure gauge, temperature may change the graduations due to expansion/ contraction of scale – interfering input
- Temperature can also change modulus of elasticity of spring – modifying input



Drift

- Two types of drifts: *zero* drift and *sensitivity* drift or scale-factor drift
- For zero drift: vary only temperature and record output.
- For sensitivity drift: Hold temperature constant; vary input (say, pressure) and record output
- Repeat the above exercise for a different (const) temperature; thereby showing the effect of temperature on pressure sensitivity
- Can quote drift as xyz angular degree/^{o}C
- Usually not possible to correct for these drifts
- Drifts used in estimating the overall system errors due to temperature
- Can run calibration tests *before* and *after* an experiment to estimate the amount of drift

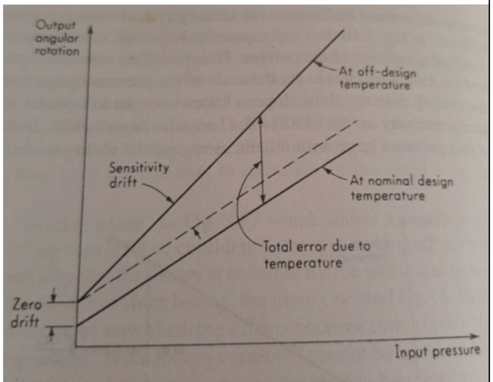


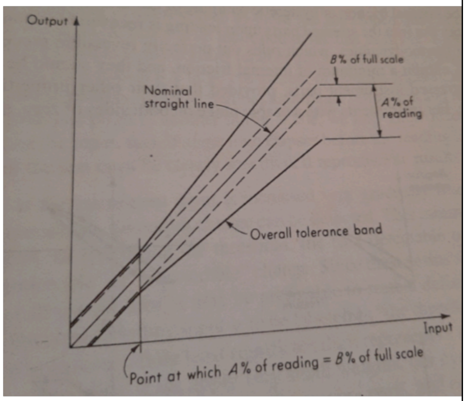
Fig. 3.18 *(c) Zero and sensitivity drift.*

Linearity

- Linear input-output relation is desirable
  - Conversion from scale reading to corresponding input value is convenient
  - When part of control system, linear behaviour simplifies design and analysis
- Thus, the degree of conformity to straight-line behaviour is common
- Linearity specified as maximum deviation of any calibration point from least-squares fit line
- This deviation can be expressed as % of actual reading, or % of full-scale reading, or combination of the two

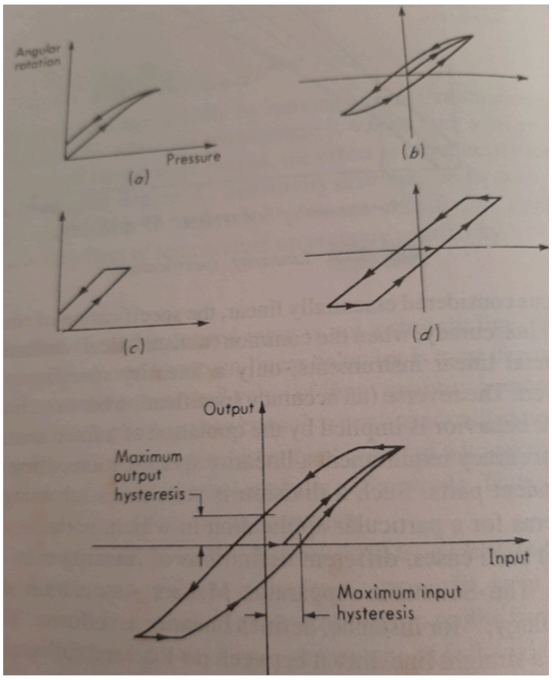
Linearity (contd.)

- Therefore,
  Linearity = +/- A% of reading, or +/- B% of full scale, whichever is greater
- The first part shows that we want constant percentage of non-linearity
- The second part shows that the above is not possible for points close to zero
- Note that in instruments considered linear, specification of non-linearity is equivalent to specification of overall inaccuracy



Hysteresis

- The non-coincidence of loading and unloading curves due to internal friction or hysteretic damping of the stressed part is called hysteresis
- Hysteresis effects also show up in electrical phenomena (eg. magnetic hysteresis of iron in field coils)
- The numerical value of hysteresis specified in terms of input or output, as a percentage of full scale
- When total hysteresis has a large component of internal friction, time effects during hysteresis may cause confusion, as relaxation and recovery times are usually slow
  - Better to specify time sequence of test to obtain reproducible results



Threshold

- If the instrument input is increased gradually from zero, there will be some minimum value below which no output change can be detected – this minimum value is called *threshold* of the instrument
- When instrument is refined to get its threshold close to 0, then random fluctuations (called *noise floor*) put a lower bound on what can be measured
- That is, input truly zero, but output a small fluctuation. Now, input changed to non-zero value. The smallest change that we can detect in the output (distinguish signal from noise)

Resolution

- If the input is increased slowly from some arbitrary (non-zero) input value, the output does not change until a certain input increment is exceeded – called resolution
- Resolution measures the smallest measureable *input change* while threshold measures the smallest measureable *input*

Scale readability

- For analog output instruments, the smallest change in reading that can be read
- Scale readability depends on both the instrument and the observer

Span

- The range of variable that an instrument is designed to measure is called its span
- Equivalently, we have low operating limit and high operating limit
- For linear instruments, we have “linear operating range”

- For dynamic measurements, we use *dynamic range* – ratio of the largest to the smallest dynamic input that the instrument will faithfully measure
- Measured in decibel (dB) = 20 log N
- Eg. dynamic range of 60 dB indicates that instrument can handle a range of input sizes of 1000 to 1

Homework

- The purpose of this exercise is to measure anything convenient and learn from this experience (i.e., learning by doing).
- Think of something that you can measure. Some examples:
  - Volume of room where you are sitting
  - Area of a ball
  - Amount of water added to a flower pot
  - Time to walk around a garden
  - Average speed to walk/drive from home to (old) school
  - ..
- Present a brief report on:
  - What did you measure?
    - Why do you want to measure it?
  - How did you measure? (i.e., Some details about the procedure)
    - Can you think of any issues with the procedure?
    - How can you improve the procedure?
  - How did you obtain the quantity of interest?
    - How does your quantity of interest depend on the procedure adopted?