Step response of pressure gauges

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Dynamic response of pressure gauges

• Started several years ago on industrial pressure transmitters
• Some simple tests made with fast-opening valve

• Test of negative step response on vacuum gauges

• Shock tube measurements
Early tests

- Testing industrial pressure gauges and transmitters
- Relatively slow, typically around 1s
- “Fast” piezoresistive pressure gauge as reference sensor
- Fast opening valve as step generator
- Pressure levels around 200kPa
Early test

- Step response tests on industrial pressure gauges
- Long response times, around 1s
Early tests

- Strange behaviours on some gauges
Early tests

• Strange behaviours on some gauges
Step response on vacuum gauges

- Negative step from 100kPa(abs) to around 50Pa(abs)
- Using static expansion
- Volume ratio ~1/2500
- Valve conductance ~4.8l/s
- Piezoresistive reference sensor
- CDG for determining pressure in expansion volume
- Step times around 0.1s
Valve and reference sensor

- Valve mounted directly to large vessel for fast response
Details of sensor setup

Reference sensor outer diameter 5mm, almost flush mount gives an negligible internal volume

Almost total volume of the volume to expand consists of the T-piece needed for mounting of test sensor
Step response of reference system

- Step times around 0.1s
- Final pressure around 50Pa
- Pressure stabilised in expansion vessel after about 0.15s
Second setup, results

- Noisy signal from $P_{\text{ref}}$ at lowest pressure
- Smoothing $P_{\text{ref}}$ gives a more comparable result showing very good agreement between $P_{\text{ref}}$ and $P_{\text{volume}}$ after stabilisation.
Test of vacuum gauges

A sample of gauges tested:

• Standard CDG with analogue signal conditioner
• Standard pirani gauge with analogue signal conditioner
• Active CDG with signal conditioner
• Active CDG without signal conditioner
• Active gauge with multiple sensors
Test results: Analogue capacitance diaphragm gauge

- Analogue voltage output taken from signal conditioner
- About 0.25 s response time
- Smooth and well predictable behaviour
Test results: Analogue pirani gauge

- About 0.15s response time
- Large overshoot before slope
Test results: Active CDG with signal conditioner

- Faster than the active pirani but ...
- Similar behaviour regarding response time and smoothness
Test results: Active CDG without signal conditioner

- Same gauge as in previous slide
- Raw signal directly from gauge
- Time discreet signal with update interval of 10ms
Test results: Active gauge with multiple sensors

- Time-discreet behaviour similar to previous gauge
- Update interval 75ms
Positive step response
High pressure tests

• Using shock tube to generate extremely fast pressure pulses
  – Rise time well below 1µs
  – Shock amplitudes used around 200kPa.

• Two gauges to determine shock speed (0.5m apart, close to end)
• High speed signal conditioner, PXI-based, 8 ch at 208kS/s, 2 ch at 100MS/s, simultaneous sampling.
Test gauge mounting

- Test gauge(s) flush mounted at tube end
- Possibility to mount several gauges in symmetrical positions
Repeatability

- The pressure shock repeats very well
- Three consecutive tests:

![Graph showing pressure shock repeats over time](image)

- 50MS/s
- 1 piezoelectric Gauge
- 3 consecutive bursts
Difference between piezoresistive and piezoelectric gauge

- Discharge of piezoelectric gauge?
- Heating effects seen on piezoresistive gauge?
- Pre-shock noise due to vibrations in tube
Conclusions and future

- Working system for step response of vacuum gauges down to ~50Pa
- Very repeatable results on shock tube
- Still some problems with fibre optic sensor, mainly due to signal conditioning.

- Future work involves improving shock tube performance, different membrane materials and solving the problem with the fibre optic sensor.