Activities on Dynamic Pressure

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Mass and Related Quantities

Dynamic Measurements

- Dynamic measurements are widely performed as a part of process control, manufacturing, product testing, research and development activities

- Measurements of dynamic pressure have especially a key role in several demanding applications, e.g., in automotive, marine and turbine engines

- However, if the sensors are calibrated with static techniques the sensor behavior and reliability of measurement results cannot be ensured in dynamically changing conditions

- To guarantee the reliability of results there is the need of traceable methods for dynamic characterization of sensors

EMRP IND09 Dynamic

- This EMRP Project (Traceable dynamic measurement of mechanical quantities) was an unique opportunity to develop a new field of metrology
- The aim was to develop devices and methods to provide traceability for dynamic measurements of the mechanical quantities force, torque, and pressure
- Measurement standards were successfully developed for dynamic pressures for limited range

Development work has continued after this EMRP Project: because the awareness of dynamic measurements, and challenges related with the traceability issues, has increased.

Industry Needs

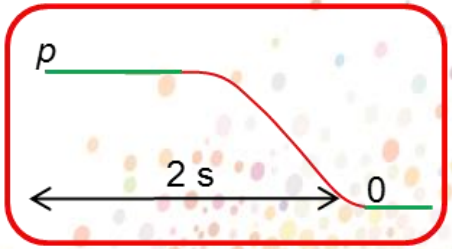
- To cover, e.g., the motor industry measurement range better
- To investigate the effects of pressure pulse frequency and shape
- To investigate the effects of measuring media
- To calibrate dynamic pressure sensors at operation conditions (high pressure and high temperature present at the same time, pressure constantly changing)
- To measure high temperatures under high pressures and a dynamic situation
- To lower measurement uncertainty of traceable dynamic calibration compared to traceable static calibration

Traceable dynamic pressure

STATIC CALIBRATION METHOD

NON-TRACEABLE DYNAMIC PRESSURE

Signal



Calibration

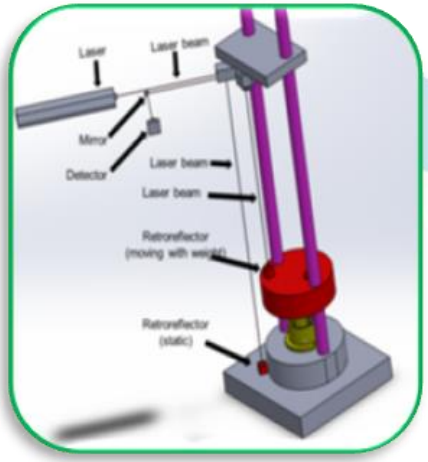
Dynamic pressure sensor

SHORTCOMINGS:
Shape of calibration signal different compared to operation
→ **non-traceable**

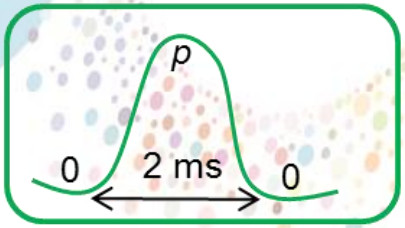
ACCURACY OF DYNAMIC PRESSURE MEASUREMENTS IS UNKNOWN?

DYNAMIC CALIBRATION

TRACEABLE DYNAMIC PRESSURE



Signal



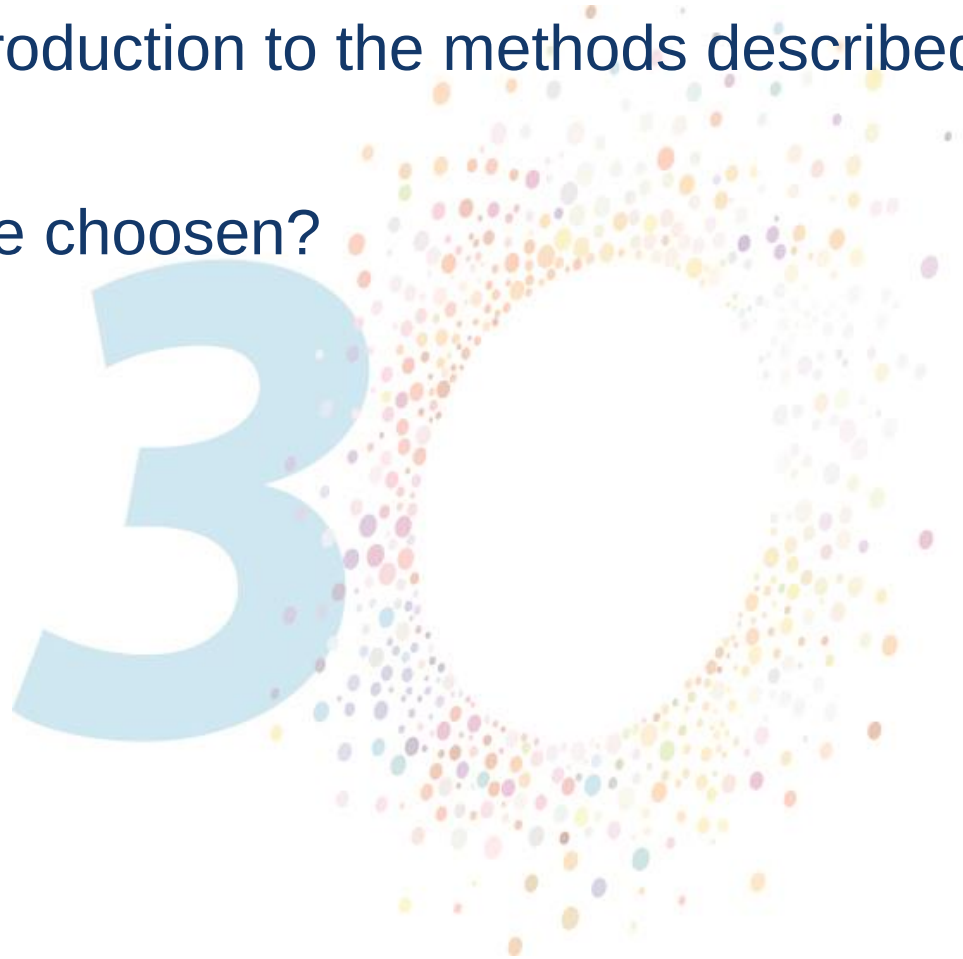
Calibration

Dynamic pressure sensor

BENEFITS:
Shape and duration of the calibration signal similar compared to operation
→ **traceable**

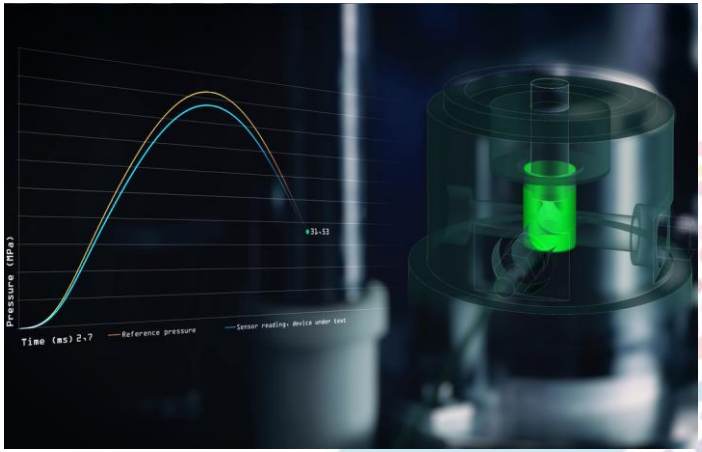
ACCURATE AND RELIABLE MEASUREMENTS OF DYNAMIC PRESSURES

- Short Introduction to the methods described next?
- Why were choosen?

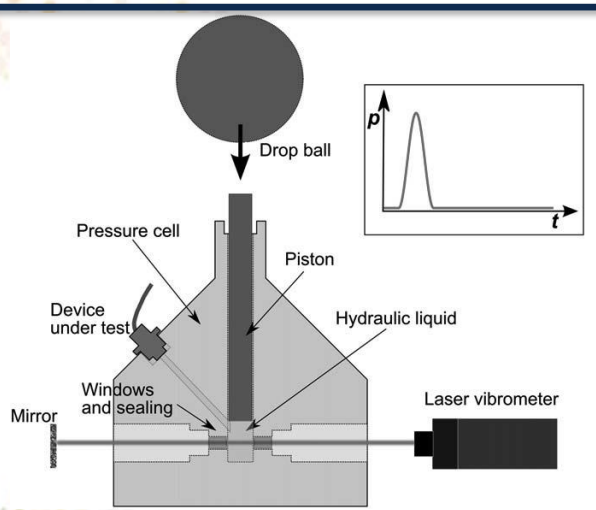


Traceable dynamic pressure: Drop weight method

- A mass piece or steel ball is dropped onto the piston, which compresses the liquid in the pressure chamber
- Pressure pulses of the order of a few milliseconds duration and peak values up to 500 MPa are generated



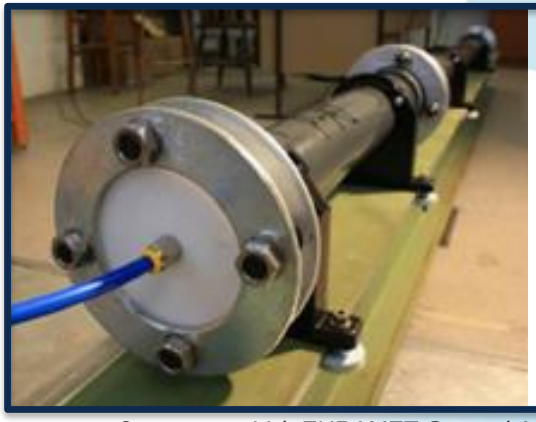
Traceable to SI units through interfero-metric measurement of the acceleration of the dropping weight during the impact, the effective area of the piston cylinder assembly and the mass of the accelerating weight



Traceable to SI units through measurement of the change in the index of refraction of the medium. The increase in the index of refraction is caused by increased density through the pressure rise

Traceable dynamic pressure: Shock tube method

- The shock tube consists of two straight tubes separated by a diaphragm and gas is added to the driver side until the diaphragm ruptures
- The driver gas generates a series of compression waves within the driven gas, which coalesce to form a shock wave, that propagates into the remaining, undisturbed, driven gas
- The release of pressure at the diaphragm causes an expansion wave to propagate back into the driver section
- At the same time, a contact surface between the driver and driven gases, propagates along the tube behind the shock front.
- The length of the driven tube section and the relative velocity between the shock wave and contact surface determine the time over which useful measurements can be made.



The pressures, temperature and densities generated within a uniform diameter, low-pressure, shock tube can be derived from ideal gas theory.

Actual and Future Work

A Pilot study started in 2016 - **EURAMET 1411, dynamic high pressure comparison, range 10 MPa to 500 MPa.**

More comparison measurements are needed, including overlapping ranges of different methods

New PRT (ID: IND MASS 053): Development of measurement and calibration techniques for dynamic pressures and temperatures (submitted for Industry Call 2017)

17 co-authors: NMIs, universities and relevant? important industrial partners

Thank you for your attention.

References:

- Downes, Knott and Robinson: Towards a shock tube method for the dynamic calibration of pressure sensors
- Bruns, Franke, Kobusch: Linking dynamic to static pressure by laser interferometry

Mass and Related Quantities