HIGH-SPEED TESTING OF PRESSURE SENSORS

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FACTORS INFLUENCING TEST APPROACH

- Type of sensor
  - Differential
  - Absolute
- Pressure range
- Temperature range
- Accuracy requirement
- Multiple sensors/pressure ranges
- Annual volume level
  - 100,000
  - Million +

IS IT JUST A TEST OR SOMETHING MORE?

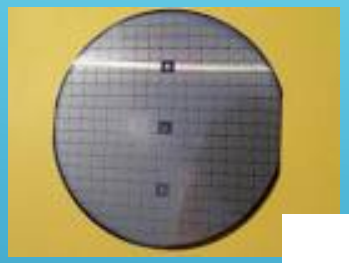
- A simple test
  - Very fast – only requires stabilization time
  - Little or no test time variability
  - Only one decision likely – reject or pass
- More complex tests might require more data
  - Warm-up characteristics
  - Response time
- Calibration
  - Requires time to manipulate sensor calibration
  - Might require multiple iterations
  - Might require multiple temperatures (multiple tests with tracking)

VOLUME – DAILY OR TOTAL?

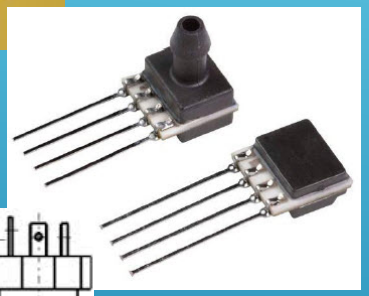
- One-time test of a large number of sensors
- Short – run test for one month or one year
- Consistent quantity for multiple years
  - More than 100,000 per year
  - More than 1 year
- More than one sensor part number?

AT WHAT LEVEL TO TEST
WHAT IS THE PHYSICAL CONFIGURATION?

Wafer level

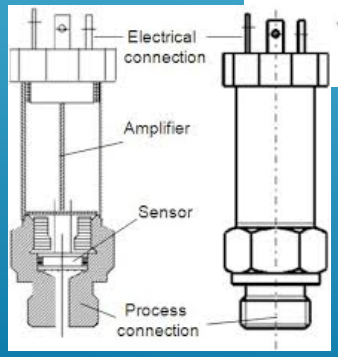


Die level



Partially assembled

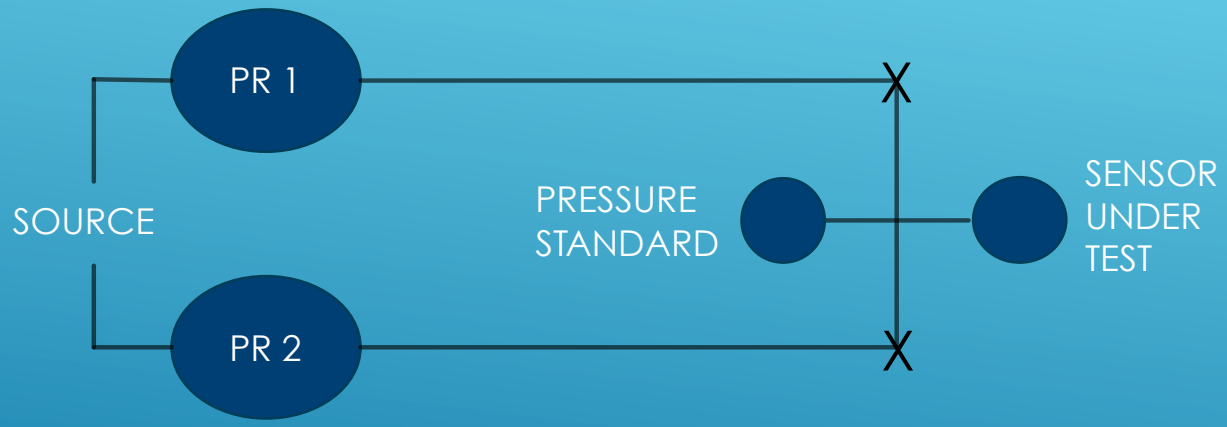
Fully assembled



METHODS OF APPLYING PRESSURE

- Pressure Regulator
  - Not too accurate or stable, but it is low in cost
  - Could be used if:
    - The sensor can be tested or calibrated "off point"
    - A pressure "standard" can be used to compensate test pressure
- Pressure controller
  - Easily programmable and is flexible
  - Response may be too slow for high-speed testing
  - Limited flow capacity
- Tank Farm
  - Will easily handle multiple test heads
  - Requires a dedicated tank for each pressure
  - Cannot be rapidly reset to a different pressure
- Dead Weight Tester
  - Normally not considered for high volume testing
  - Might be workable if testing must be done with a liquid

USING A PRESSURE REGULATOR

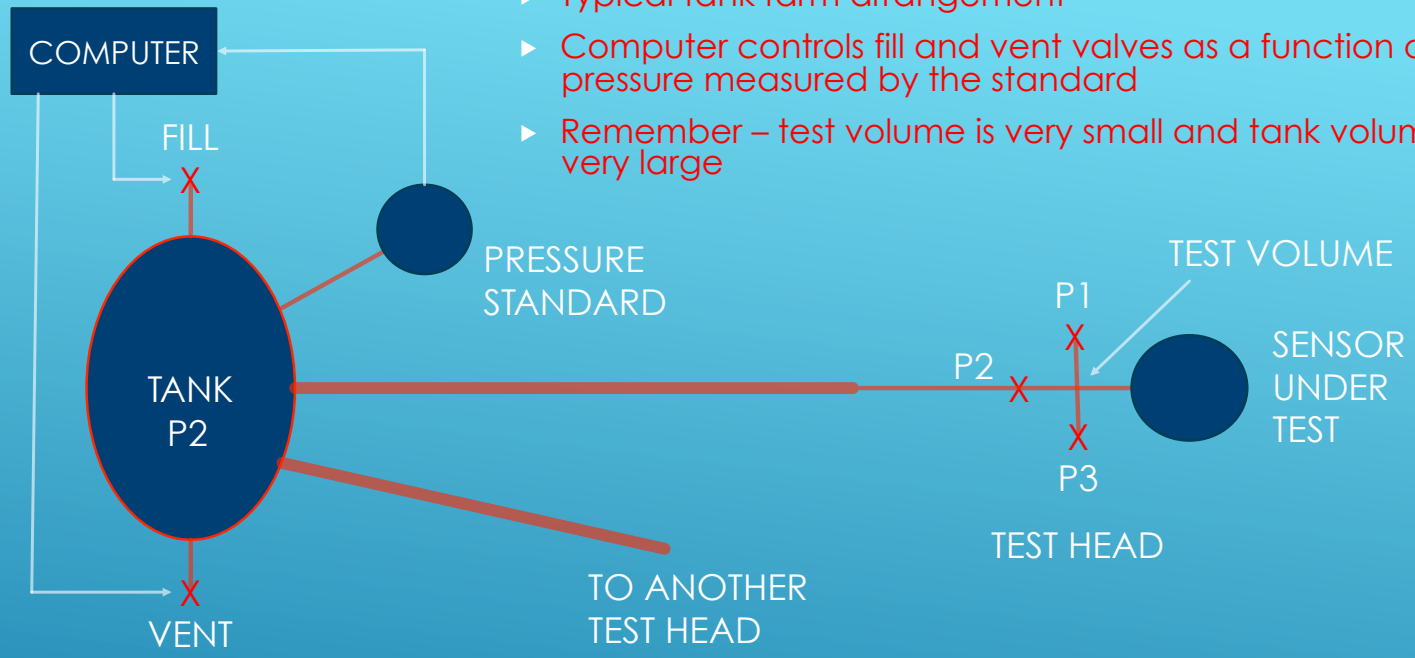


THE TANK FARM APPROACH:

- Relies on very large pressurized tanks supplying very small test volumes
  - As a starting point the tank volume should be at least 10,000 times the test volume
- Can apply a highly accurate pressure very quickly
  - Pressure stabilization times of less than 100 msec are attainable
  - Pressure stability can be equal to or better than the most accurate pressure standard
  - Each tested sensor can have pedigree traceable to NIST
- The system can be fault tolerant
  - Continuous self-monitoring
  - Leak testing of each sensor is practical
  - Self-diagnosis of faults is practical

TANK FARM SCHEMATIC

- Typical tank farm arrangement
- Computer controls fill and vent valves as a function of the pressure measured by the standard
- Remember – test volume is very small and tank volume is very large



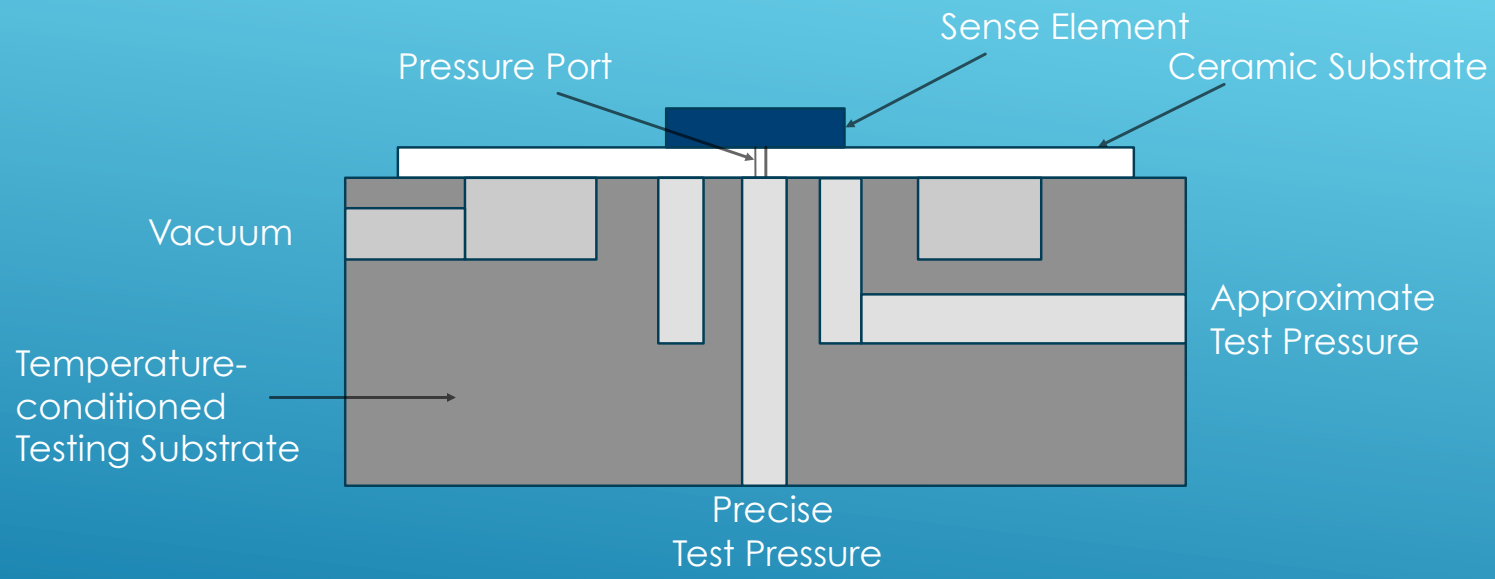
HOW TO SEAL THE PRESSURE

- O-ring or other elastomeric seal
  - Usually used as a face seal for maximum durability
  - Avoid sliding seals
  - Avoid using the final customer seal
- Avoid using the customer attachment (pipe threads, etc)
- Consider a custom design of the sealing system

A NOVEL SEALING APPROACH:

- Sense element mounted to a ceramic thick-film substrate
  - Provide a flat sealing surface without seals – 3 concentric pressure ports:
    - Central pressure port with precision test pressure applied
    - Second concentric port groove with non-precision test pressure
    - Third vacuum ring to hold substrate against pressure

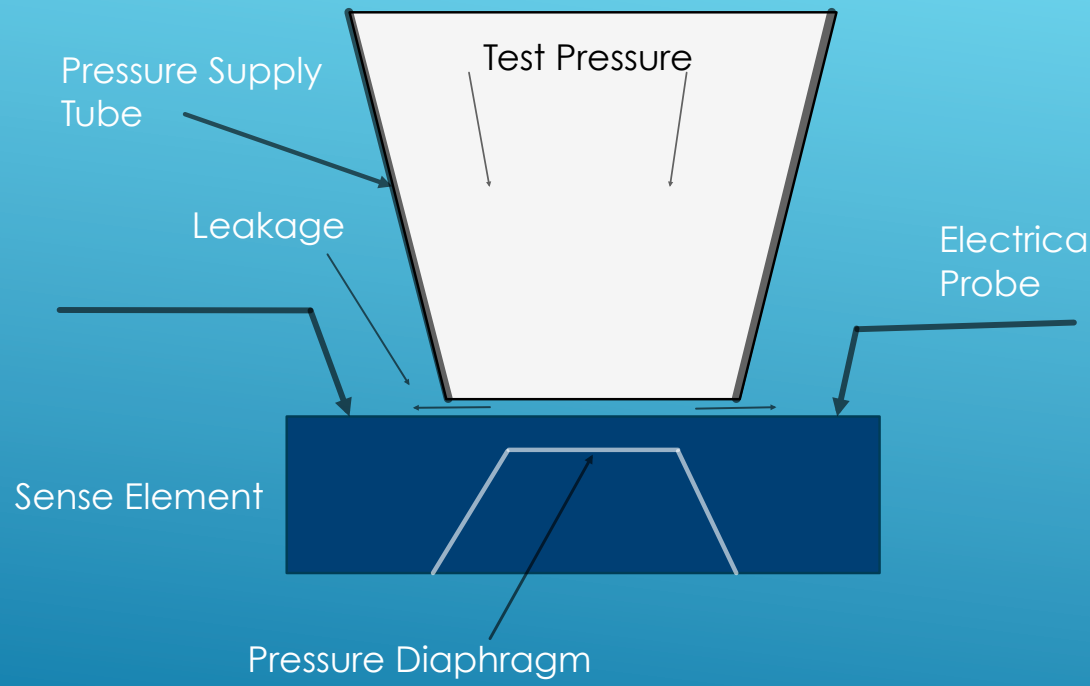
CERAMIC SUBSTRATE-LEVEL TESTING



ANOTHER NOVEL SEALING APPROACH:

- Testing silicon in wafer, sawn wafer or die form:
  - Use standard probe head to make electrical connections
  - A tube on probe head comes close (but doesn't touch) to die surface, leaving a known leak path
    - Tube face covers diaphragm area
    - The tube has a large flow area compared to leakage flow area
    - Leak path area is small and consistent
    - Error due to leakage can then be compensated for

TESTING IN DIE FORM – AN INTERESTING OPTION



SOME OTHER CONSIDERATIONS

- Keep the data?
  - For statistical purposes
  - Serialize the parts – keep each part attached to its data
- What to do with the rejects
  - Immediately remove
  - Keep as placeholders (trademark of a poor system design)

ONE PROCESSING OPTION: BATCH PROCESSING

- Test multiple sensors in one fixture
  - Multiple sensors are transported, pressurized, powered, pressurized, and tested as a group
  - The size of each fixture determines the number of batches required
  - How do you handle a missing part or a failed part?
    - If a part leaks or if it is shorted, how do you find it?
    - What happens if one location in a fixture is "bad?"
    - Several bad locations will reduce through-put
- And this is only a small sample of potential operational problems!

A SECOND PROCESSING OPTION: SINGLE-PIECE FLOW

- Emphasis is on how to move a large number of simple carriers about
- Synchronized movement works best when:
  - There is little or no variation in test times
  - Each component of the line is very reliable
- A non-synchronized contains buffers (queue's) between processes
  - There can be significant variability in test times
  - The individual machines can be less than perfectly reliable
  - Through-put flexibility is more easily attained
- This is often the least expensive and most effective method

HIGH-SPEED PRESSURE SENSOR TESTING CONCLUSIONS:

- The optimum approach depends heavily on:
  - The type of sensor
  - The volume profile
  - The business model

Commonsense Engineering

Simple, Effective Practices for Engineering and Quality Control

Common Sense: Sound practical judgment that is independent of specialized knowledge, training, or the like; normal native intelligence.

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Thank you for attending!

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