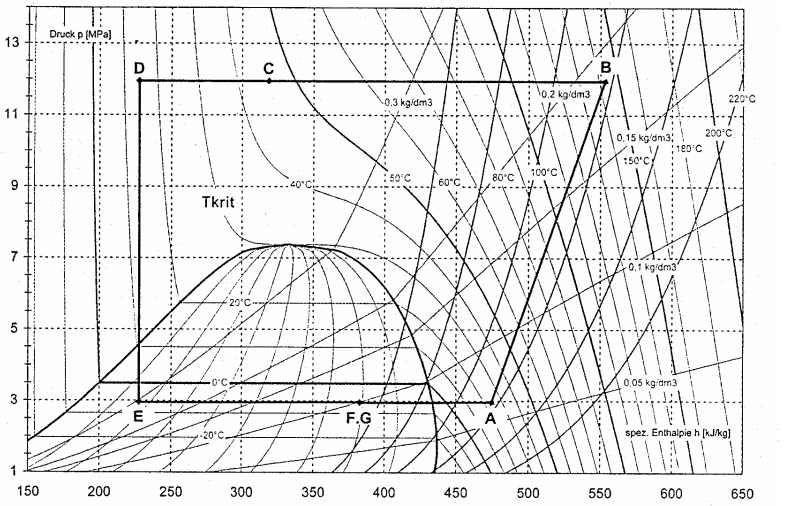
Integrated Pressure and Temperature Sensor for R744 Systems - UPDATE

By Cris Ruiz, Paul Gennissen and Roger Appelo



Integrated Pressure Temperature Sensor For R744

- MSG technology
- R744 specific constraints
- Design Parameters
- Design Status
- Calibration
- T Calibration
- Sensor Length
- Insertion Depth
- High Temperature Drift
- Conical Seal Test
- Project Planning
- Functionality on R744 System

MSG Technology

MSG technology

R744 specific constraints

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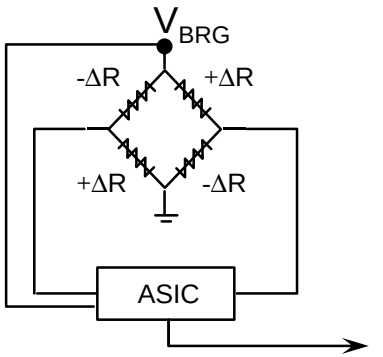
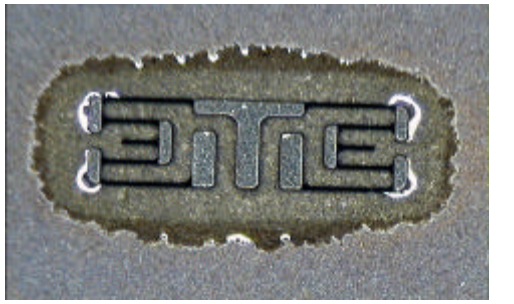
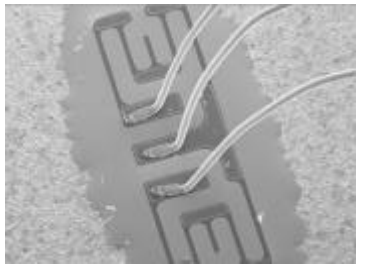
$$\Delta R = [\pi]\{\sigma\}$$



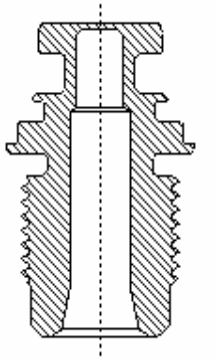


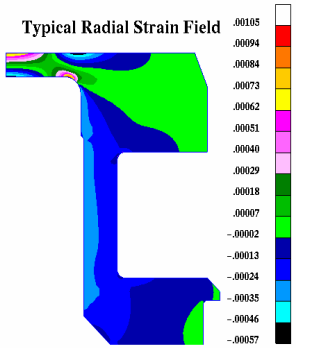


Highlights

Micro fused Silicon strain Gauge

- Pressure Sensor Technology
- Mono crystalline silicon gages
- SE size 0.5 mm x 1.5 mm x 10 µm
- FEA guides sense element geometry
- Strain gages are glass bonded over appropriate local stress field
- At full scale pressure $s_{max}/s_Y = 0.2$
- Extended Diagnostics





170 BAR PRESSURE ELEMENT

R744 Specific Constraints

Target:

Integration of pressure sensor and intrusive temperature sensor

CONTROL AND SAFETY

- Use existing sensing elements / ASIC → cost target <€3Δ
- In-flow sensing elements (T)
- Response time
  - Temperature second(s)
  - Pressure 10 ms
- Accuracy
  - Temperature ±3K
  - Pressure ±1.5%FS (3.75bar)
- "Thermal Constraints"
  - Sensing Elements Exposed To Gas Temperatures (~ 180°C)
  - Conditioning Electronics Thermally Insulated (max 135°C)

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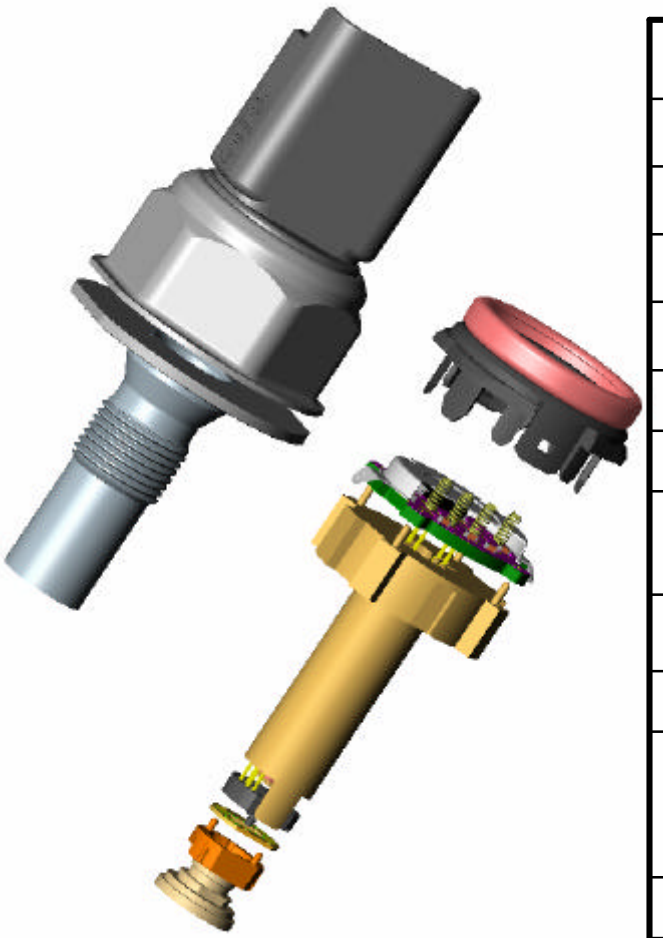
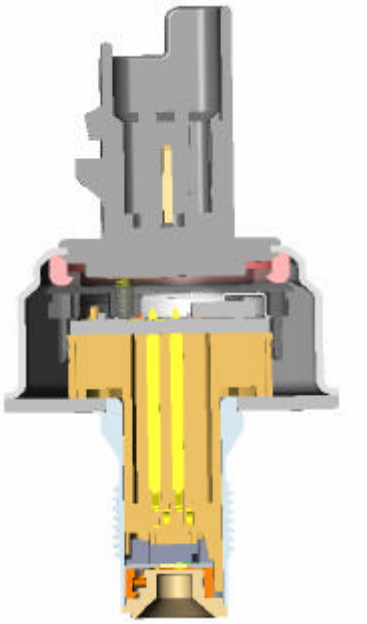


Part	Status:
Connector Assembly	B-sample ordered
Flange	Production part
Threaded pipe	B-sample ordered
Gasket	B-sample ordered
Cover	In production
EMC shield	B-sample ordered
Electronic module assembly	B-sample ordered
Inner connector	B-sample ordered
Gel Dam	B-sample ordered
Small PCB	B-sample ordered and received, already in use in A3 samples
Support ring	B-sample ordered
Sensing element	B-sample ordered High temp soak tests being performed

Design Parameters

- Tip Length
  - 1st proto types 'intrusive' for 32 mm
  - As of B-samples, tip length reduced to 22 mm
- Seal Geometry & Thread
  - Gas tight with sealing ring (Cu/Alu)
  - Gas tight with conical seal
    - Stainless into Alu (Production ?)
    - Stainless into Stainless (Experimental)
- Connector
  - 4 pin MQS;RD;Sicma2
  - 3 pin MQS;RD;Sicma2;VDA
- Output Signal
  - Dual Analog (Available, 4P)
  - LIN (New ASIC (!), 3P)



Calibration

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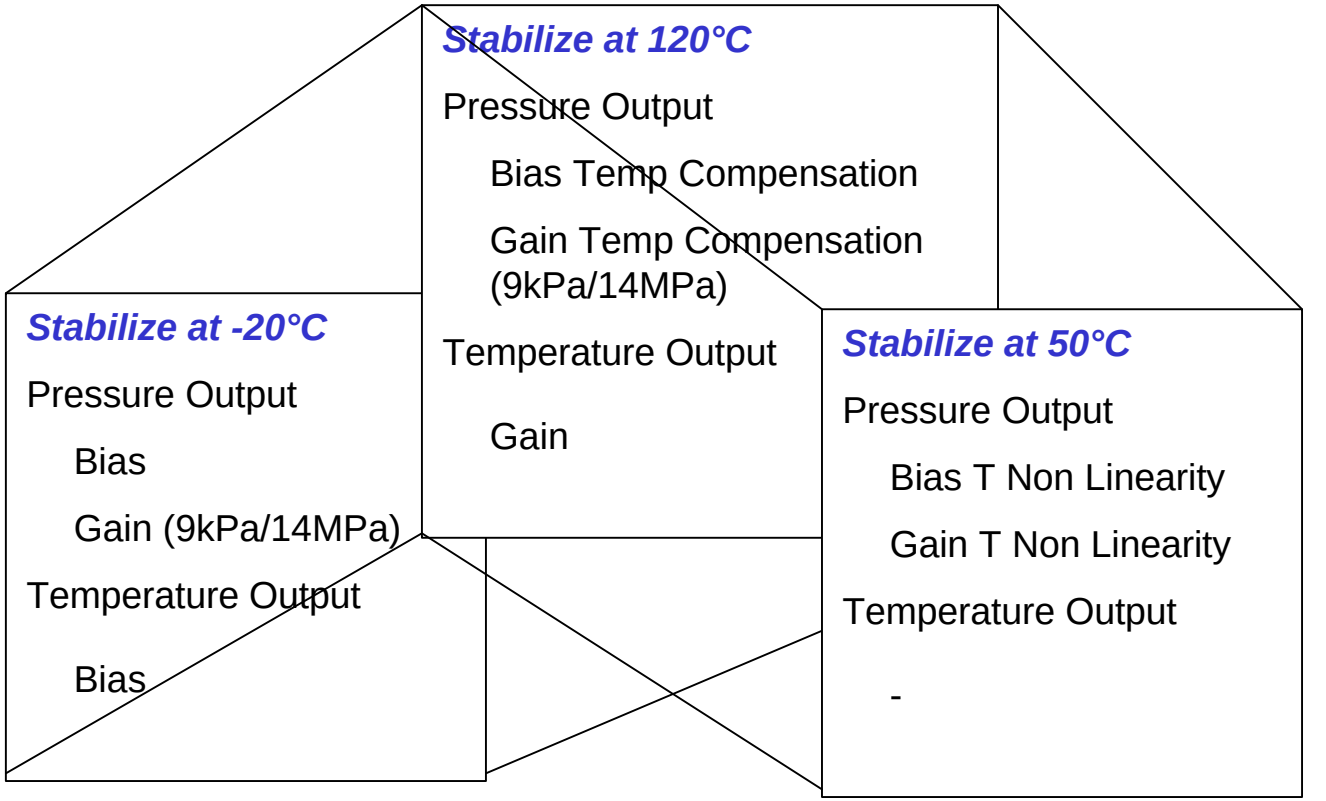
Since silicon based sensing technology is used, all sensors must be calibrated for P&T output

Currently the sensors are calibrated in a temperature chamber. The accuracy of the chamber is ±1°C.



Temperature Calibration

MSG technology

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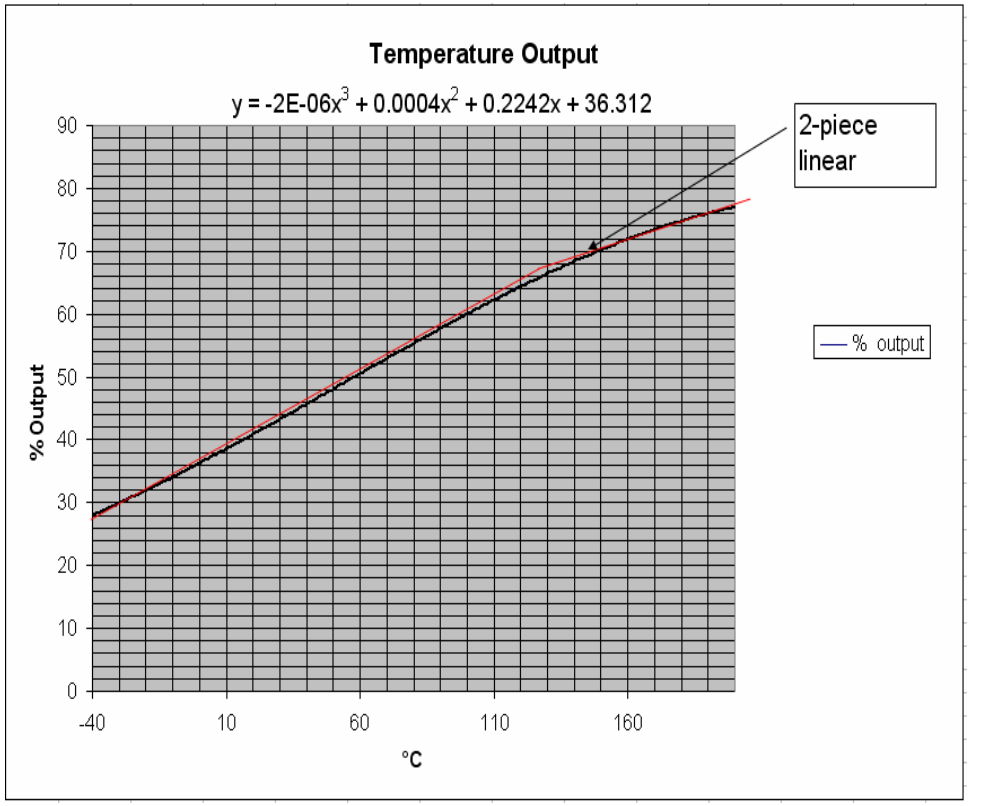
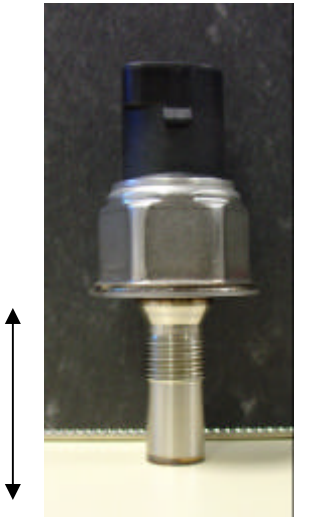
- March:
  the high calibration temperature
  raised to 150°C
- Remaining 3rd order error can be compensated by new ASIC (Timing).

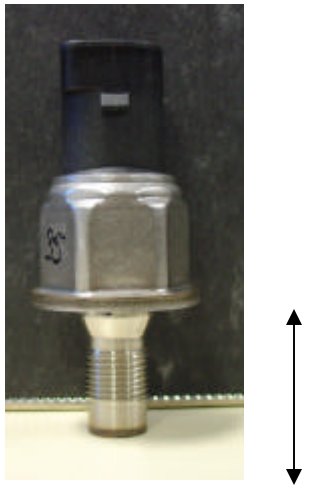


Sensor Length

- Two A-type prototypes have been tested.
- At low mass flows the length of the sensor is an important factor. At higher mass flows the performance difference does not justify cost delta.
- At very high heat flows (R744 system) the short version is expected to be adequate for dynamicity and accuracy.



32mm



22mm

Insertion Depth

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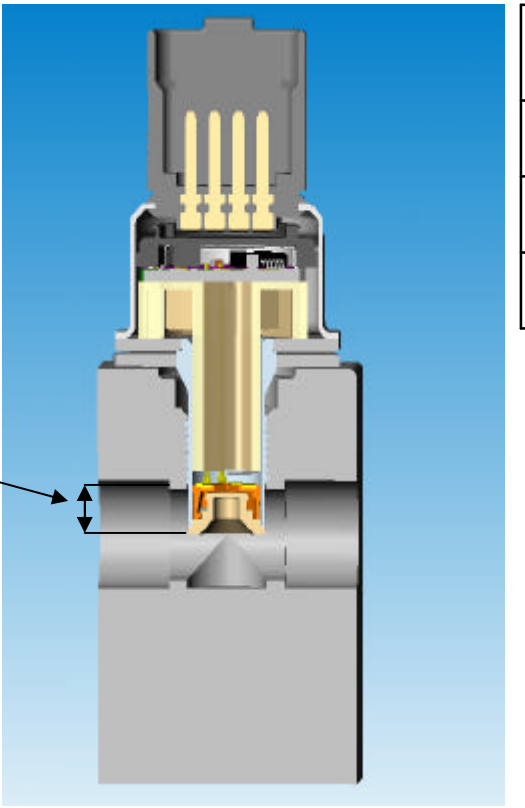

Number of rings	Protrusion inside tubing
0	6.5mm
2	4.5mm
3	2.8mm

Potential Issue : Pressure Drop

From tests at TI Holland, it seems 4mm of protrusion still give good results. In a R744 system, the amount of heat flowing through is about 100 times larger. Good results can be expected with less insertion depth (2mm).

High Temperature Drift

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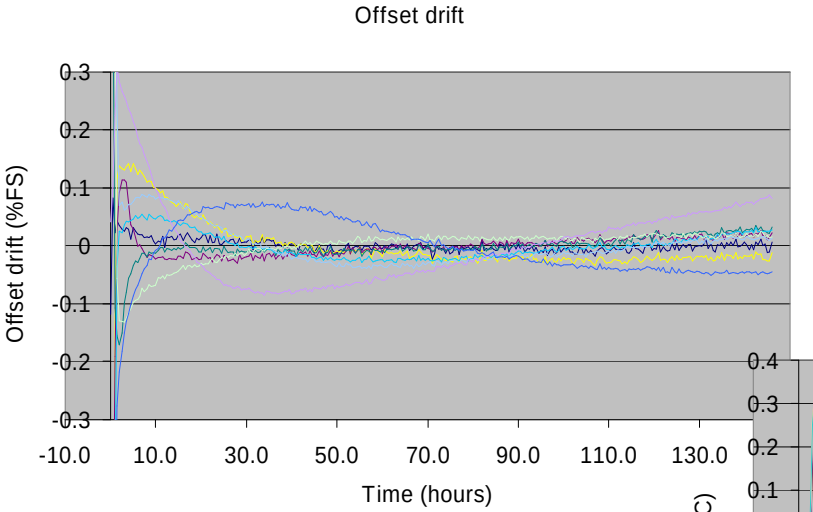
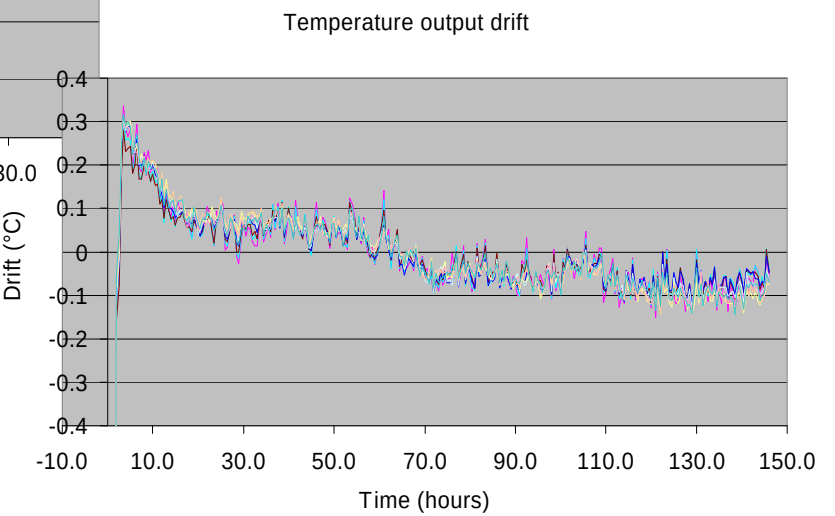
The sensing elements tend to have some drift at 180°C (<0.5% / 0.3K), but it clearly stabilizes after several hours.

A short stabilization process of sensing elements will be implemented, and therefore less drift over life after calibration will be achieved.





Conical Seal Test

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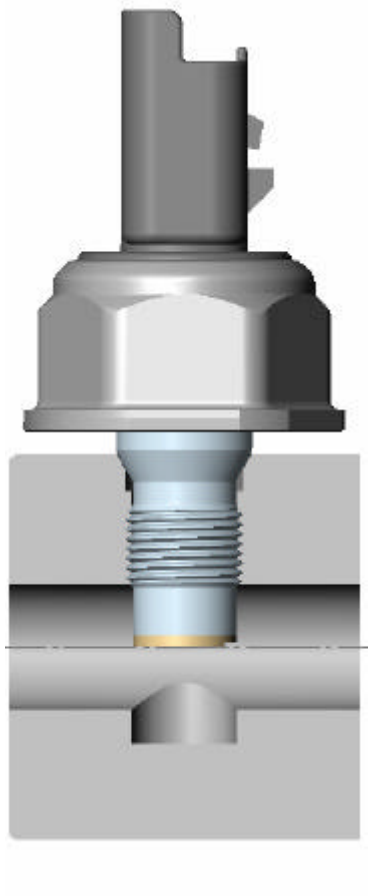

Test:

1. A Helium leaktest is performed on 25 samples placed in the adapters with a torque of 35NM.
2. The ten samples, together with their adapters, are subject to a pressure and temperature cycle with the following characteristics: 200.000 cycles from .1MPa to 20MPa while simultaneously asynchronous being thermal cycled from -40 to + 200 °C.
3. The samples are subject to helium test and the leak-values recorded again.

Results: Leak values “0”

The tests were repeated with the same sensors and counterparts 2x times after every time the sensors and counterparts were disassembled.

Results: No leakage found.

Preliminary results of similar tests with stainless steel counterparts have shown that all sensors passed the test.

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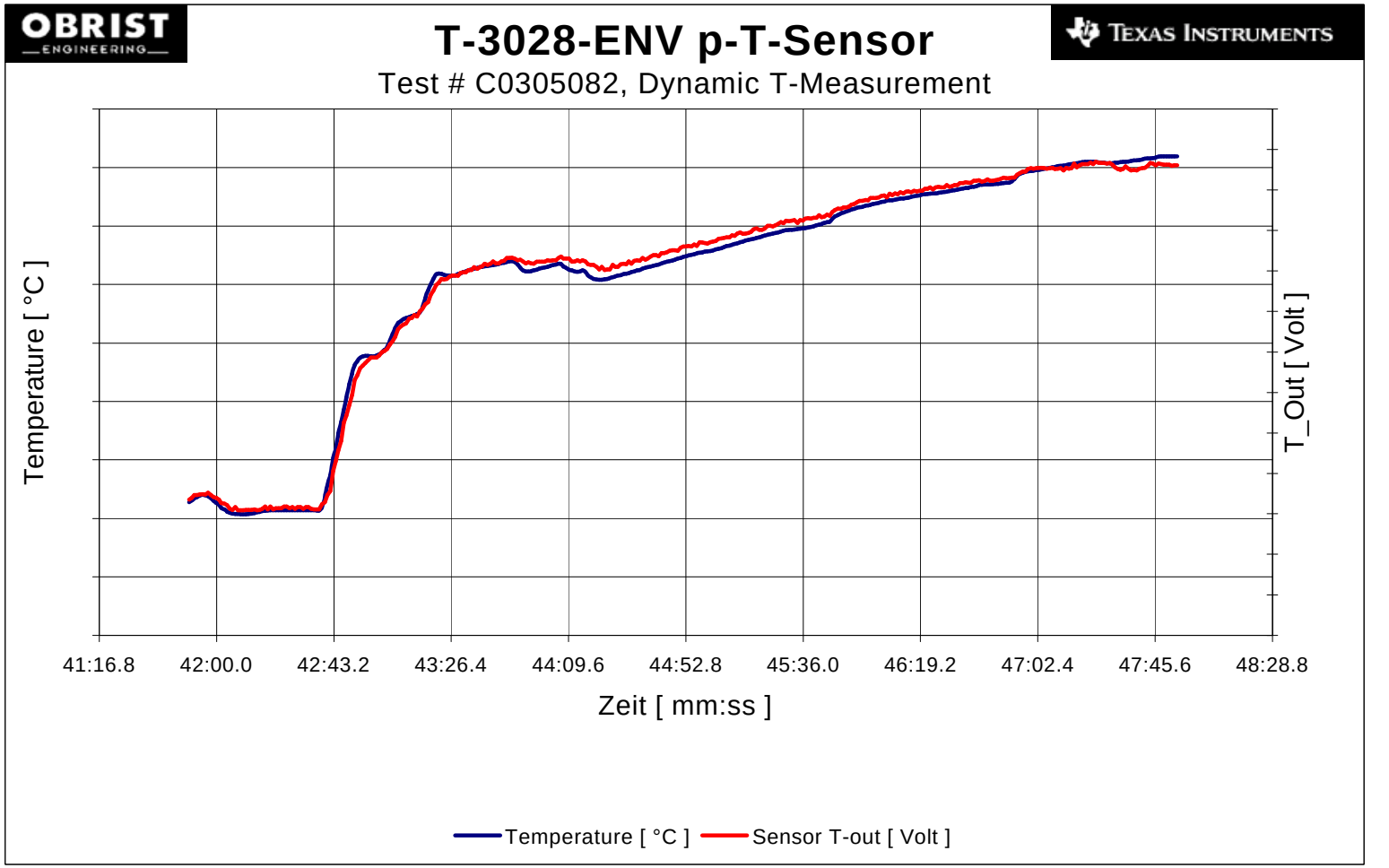

Project Planning

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B Samples Softtooling ordered

- Assembly May
- Customer B-samples available

DV May-July

- DV Report Early August

TI Available For:

- Testing/Support
- Sampling
- Concept Derivates

Backwards planning,

assuming MY2008 Launch (PILOT PROJECT)

CY2007 SOP

⇒ **Early CY2007 PPAP**

⇒ **2/3Q2006 PV (!)**

⇒ **1Q2006 C samples**

⇒ **3/4Q2005**

⇒ **Line build**

⇒ **Hard tooling (Plastics/Metals)**

⇒ **2Q2005 Commercial commitment**

⇒ **3Q2004 commitment for new ASIC**

Acknowledgements

- Thanks to the Ministry of VROM of the Netherlands through ROB Program executed by Novem

- Thank you for the attention!