Environmental Monitoring in Pixels Outer Endcap

Mounting Temperature sensors

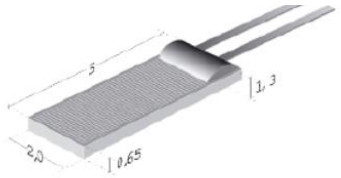
Dominic Howgill

08/05/2024

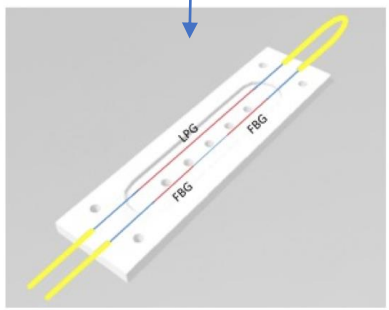
Overview

Quantities and types of sensors:

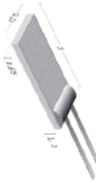
	Volume T sensors		Cooling T sensors		Humidity Optic fibres		FOS T Sensor		FOS RH sensor	
	half shell	Full shell	half shell	Full shell	half shell	Full shell	half shell	Full shell	half shell	Full shell
layer 4	8	16	10	20	0	0	0	0	0	0
layer 3	10	20	10	20	0	0	0	0	0	0
layer 2	14	28	10	20	3	6	3	6	3	6
Per Endcap		64		60		6		6		6
Total		128		120		12		12		12



PT10K
2-Wire NTC
Temperature
Sensor



FOS Package
With Fibre Optic
Humidity Sensors



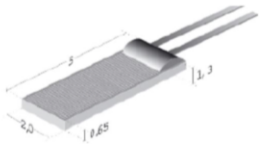
PT10K

HIH-4000
Honeywell
3-wire
Sensor

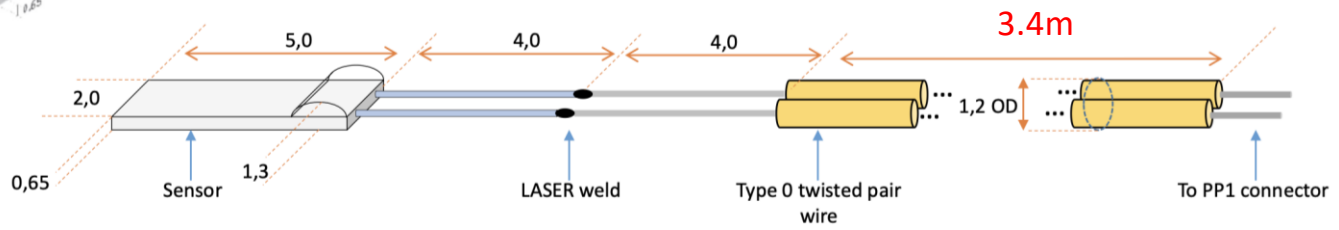
Overview

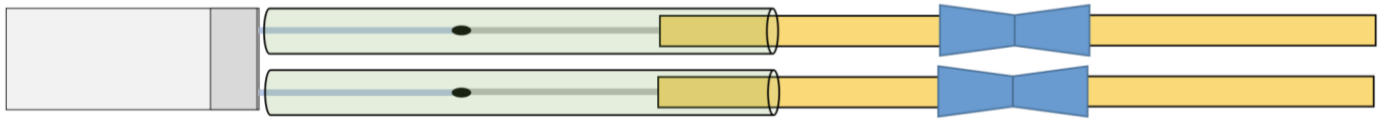
PT10K Sensor details

- **DCS providing sensor assembly as shown in diagram**
- **OEC Subsystem will dress / bundle these as required**



(Dimensions in mm)





Heat Shrink 12mm length
Further details to be confirmed

Splices (Optional, location determined by sub-systems)

Cable Bundles & Flavours

Atmospheric Sensors	Bundles Per Half Shell	Per endcap	Both Endcaps Total	# cables per bundle	Verify no. of cables
Layer 2	2	4	8	7	56
Layer 3	2	4	8	5	40
Layer 4	2	4	8	4	32
No. of Flavours:	3	No. of Bundles:	24	Total Sensors:	128
Cooling Pipe Sensors	Bundles Per Half Shell	Per endcap	Both Endcaps Total	# cables per bundle	Verify no. of cables
Layer 2 Exhaust	1	2	4	3	12
Layer 2 Inlet	2	4	8	3	24
Layer 3 Exhaust	1	2	4	3	12
Layer 3 Inlet	2	4	8	3	24
Layer 4 Exhaust	1	2	4	3	12
Layer 4 Inlet	2	4	8	3	24
Layer 2/3/4 Com. Inlet	3	6	12	1	12
No. of Flavours:	7	No. of Bundles:	48	Total Sensors:	120

Atmospheric Sensors

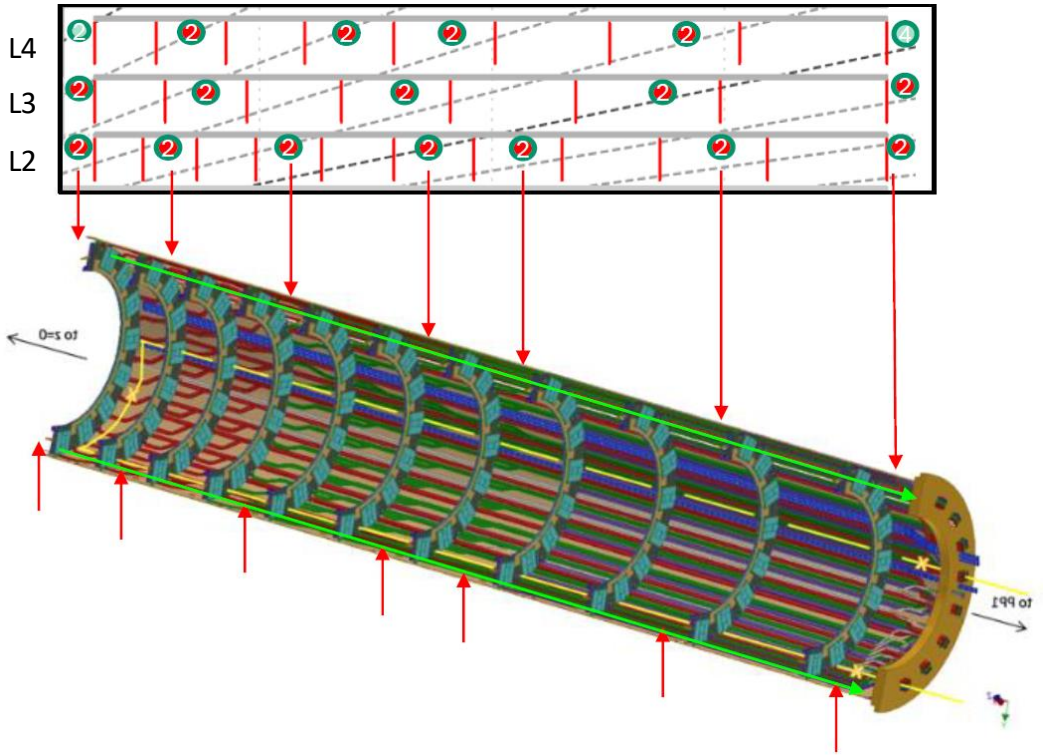
Requirements: Atmospheric Sensors

Positioning
- Multiple positions across the length of endcap, roughly midway between half rings
- Placed on all three layers
- Away from sources of heat/cold, to the extent this is possible
- Symmetric top and bottom near y-axis to measure differential temperature
- Mirrored across each half shell providing sensor redundancy

Attachment
- Brackets made from rad-hard material (CF, PEEK or ULTEM)
- T Sensor sensitive region open to environment
- Bracket adhered to half-shell holding sensor at some radius R from the shell
- Removable connection to sensor (temporary joint) preferred

Routing
- Route near to the edge of half shell minimizing the routing in ϕ
- Min. bend radius defined by wire/ harness dimensions
- Slack for length changes due to temperature effects
- Cable harness affixed at strategic positions for strain relief and prevent unwanted movement

Integration:
- Assembled to the half cylinders after cooling and (before or during) type 1 electrical services



Atmospheric Sensors

Solutions for Atmospheric Sensors

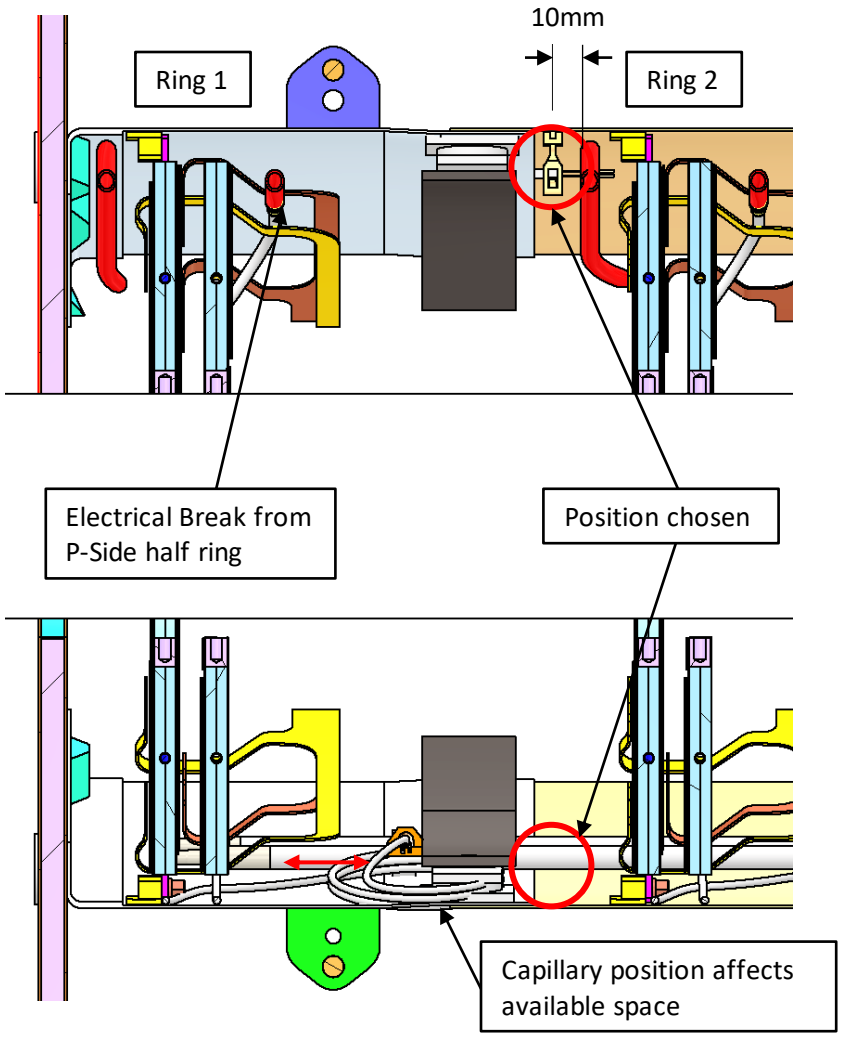
Positioning

- Z-Position mapped on L2 (and L3, L4)
- Proximity to nearest hot/cold source documented
  - Closest is 10mm near Ring 2 (See diagram)
  - 2nd Closest is 25mm
- Challenges:
  - Proximity to nearby structures/ heat sources
  - Maintaining symmetry in x-axis
  - Avoid clashes from half ring structures when the two half shells are joined together

- **Phi Position**
  - **10mm from half shell edge**
  - Gives allowance for cable routing at edge of half shell

Note:

Until final position of capillaries is determined, the Z position of Atmospheric T sensors is not set in stone and may change slightly



Atmospheric Sensors

Solutions for Atmospheric Sensors

CAD Model:

The solution shown is a low mass design comprised of two parts:

- Base
- Sensor clip

The base component is mounted to the CF shell during integration
(Tooling for this needs to be designed)
Separately the main body is clipped onto the sensor.

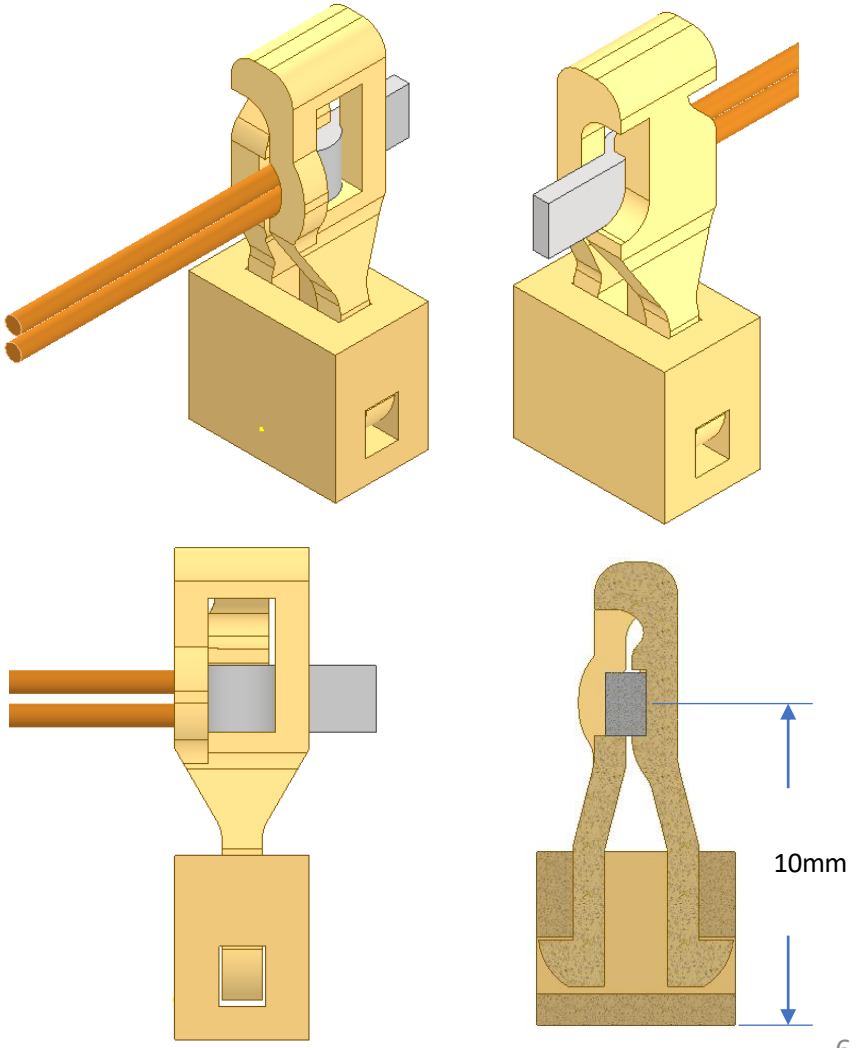
Several advantages:

- **Reduces risk of bracket damage or obstruction during integration**
- **Assemble sensor to sensor clip prior to integration in a controlled manner**
- **Allows sensor harness to be moved away before installing half-rings**

Prototype:

3D Printed
ASA (FDM Method)

Production: 3D Printed PEEK



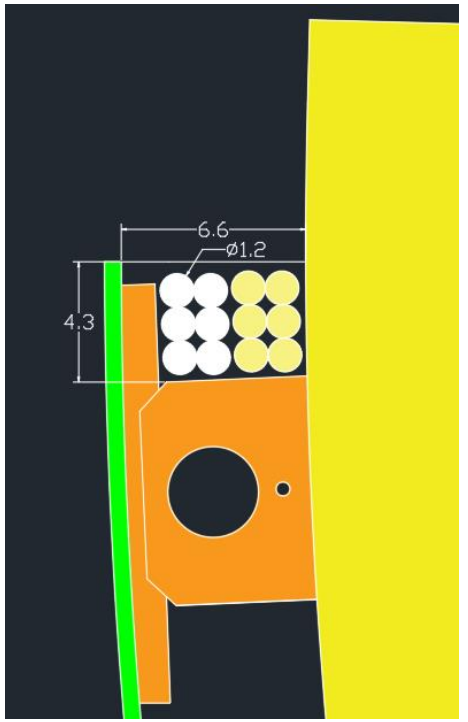
Atmospheric Sensors

Solutions for Atmospheric Sensors

Routing:

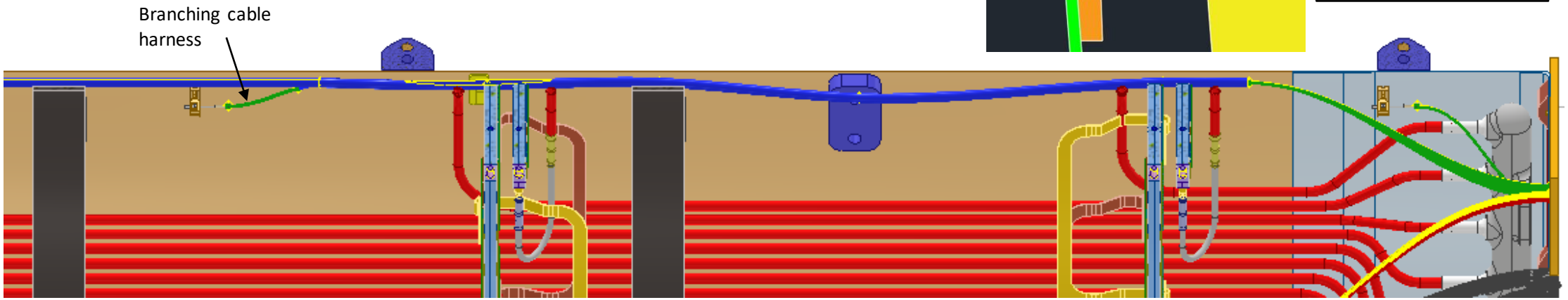
The routing of the temperature cable harness is located at the outer edge of the half shell. As there are harnesses on both half shells, these must not go outside this envelope in order to integrate the two halves.

The cable harnesses branch at each sensor position.
These will be “laced” with Nomex cord creating cable bundles but maintaining flexibility allowing cables to slide over each other.



Left: Ring 11 on Layer 2 Cross section showing the cable routing.

Note this is worst case scenario (including Cooling Harness) and shows there is space for harness to pass through, providing there is compliance in the harness construction



Cooling Pipe sensors

Requirements: Cooling Pipes Sensors

Positioning

- Three locations around half ring:
  - On capillary branch at common supply line branching point
  - Close to Inlet to half ring
  - Close to Exhaust from half ring
- Three half-rings per layer (Low, mid & high Z) on all layers

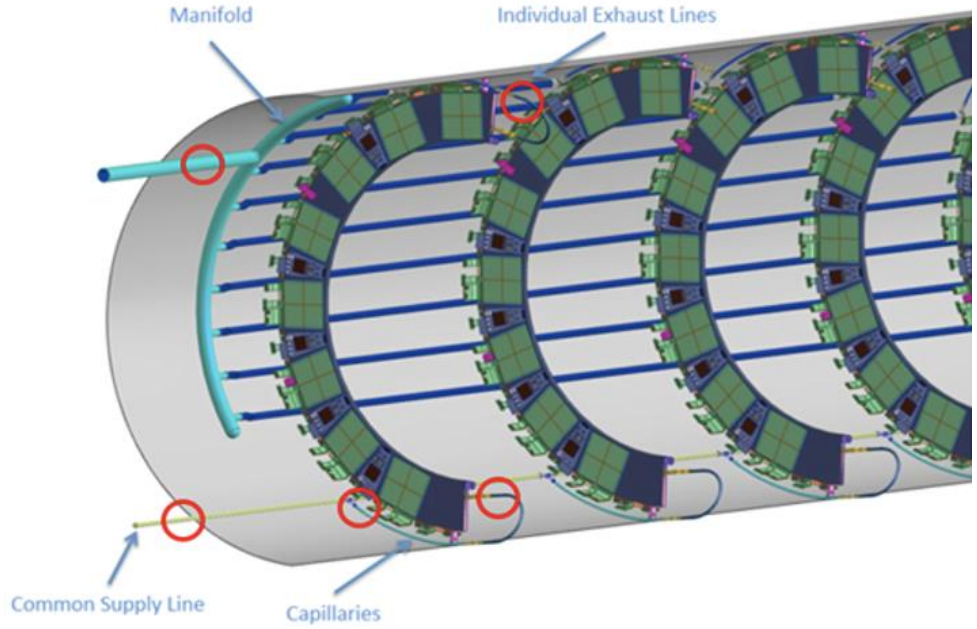
Attachment

- Fixture made from rad-hard materials (CF, PEEK, ULTEM, Kapton, etc.)
- Mounted to titanium pipe or electrical break
- Provides good and reliable thermal contact between sensor and pipe
- Compact to avoid clashes and nearby sensitive components

Routing

- Route near to the edge of half shell minimizing the routing in ϕ
- Min. bend radius defined by wire/ harness dimensions
- Slack for length changes due to temperature effects
- Affixed at strategic positions for strain relief and prevent unwanted movement

Layer 2 Shown at High Z Rear Support Flange, Ring 11



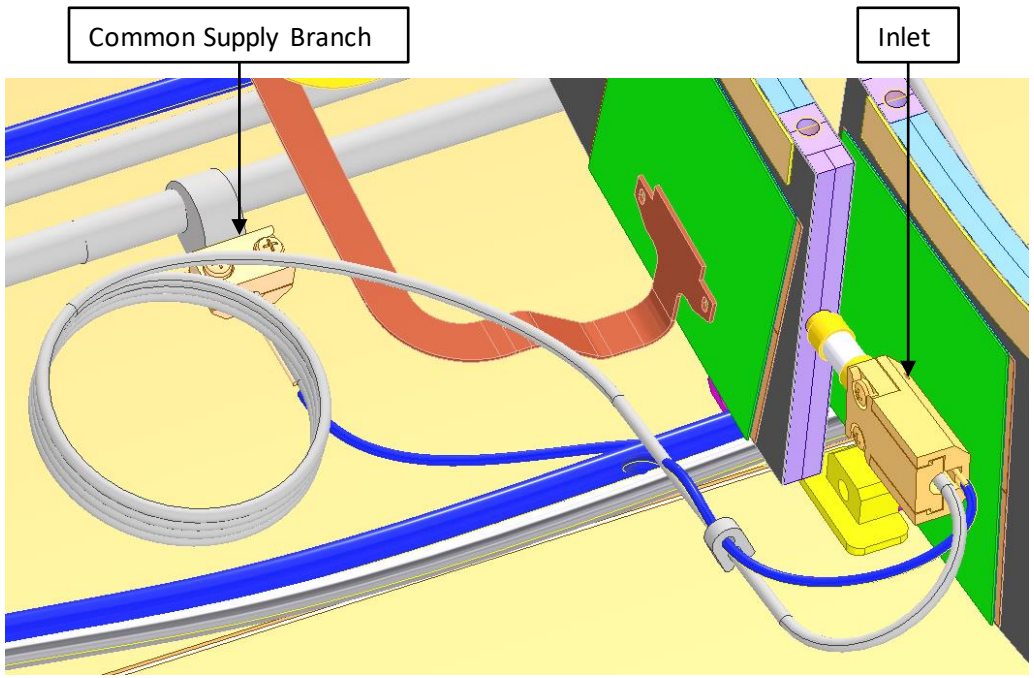
Cooling Pipe sensors

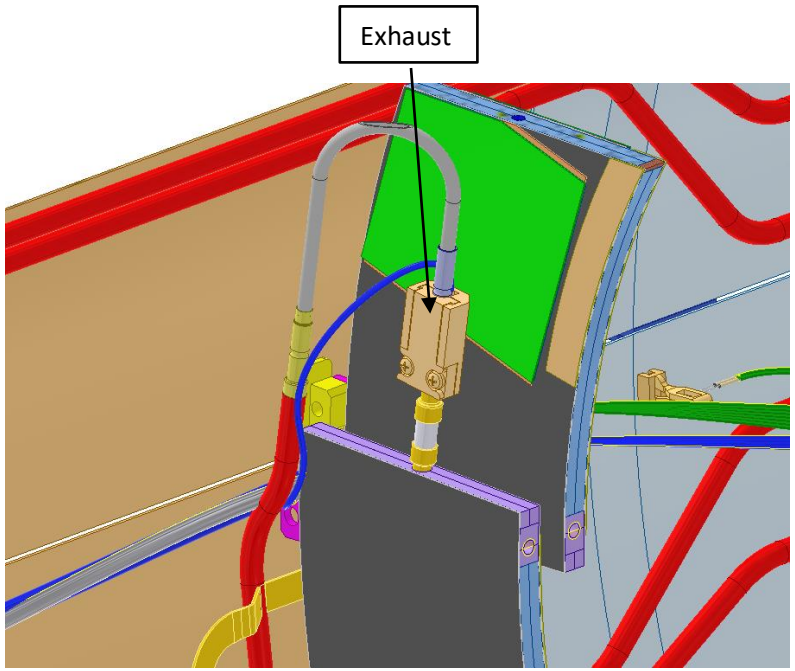
Solutions for Cooling Pipe Sensors

Positioning

L2: Rings 1, 6, & 11
L3: Rings 1, 5 & 8
L4: Rings 1, 5 & 9

In each of these selected rings, the sensors are mounted to the pipes in three locations as shown in the images below.



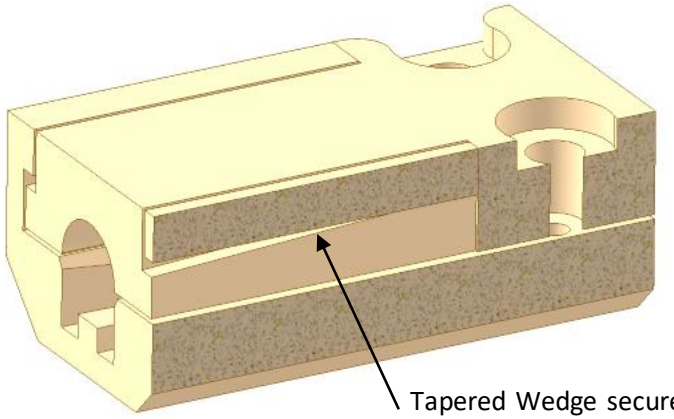


Cooling Pipe sensors

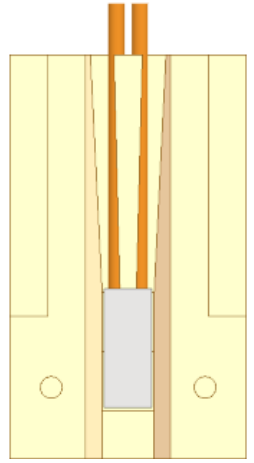
Solutions for Cooling Pipe Sensors

Attachment

- Two-part mechanical assembly
- Tapered wedge and PEEK screws provides two layers of fixation
- Sensor fits into channel



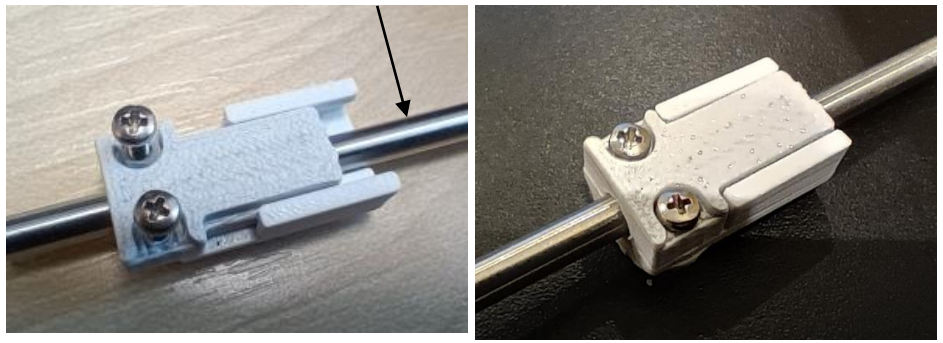
Tapered Wedge secures mount to pipe before the screws are tightened



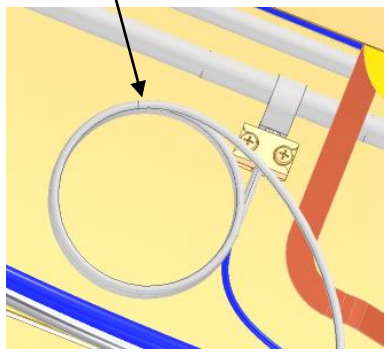
PT10K fits into channel

Prototype:
3D Printed ASA

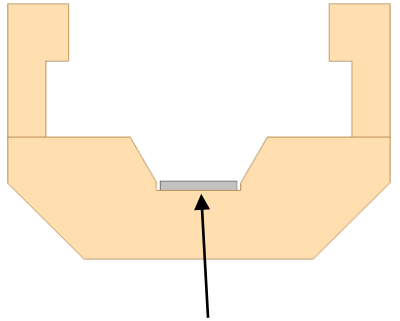
Diameter Ø3.18 matches electrical break



Diameter Ø1.6 capillary tube



Very little space on capillary branching straight leg – can we increase?
Bracket has tapered wedge section removed in order to fit in this location



Sensor fits proud of the mount ensuring contact with pipe

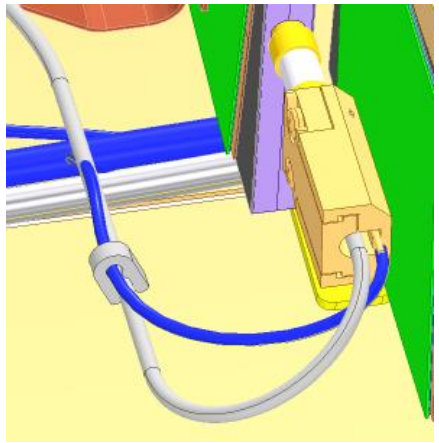
Cooling Pipe sensors

Solutions for Cooling Pipe Sensors

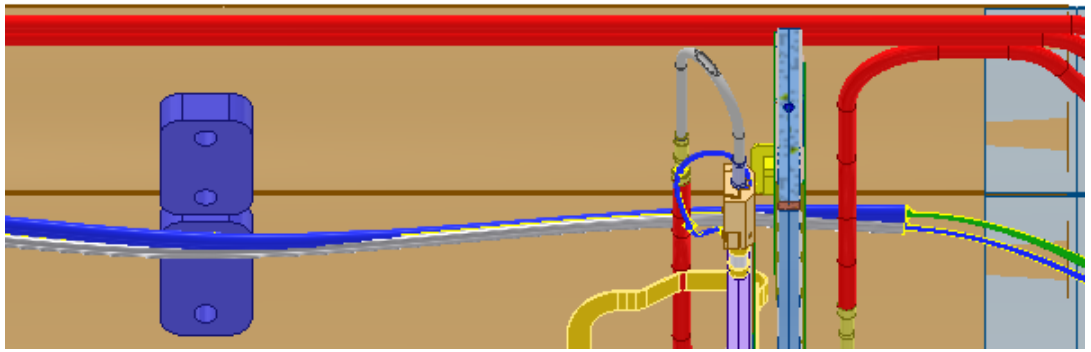
Routing

The routing is along the same path as atmospheric sensors with branched connections at each ring location.

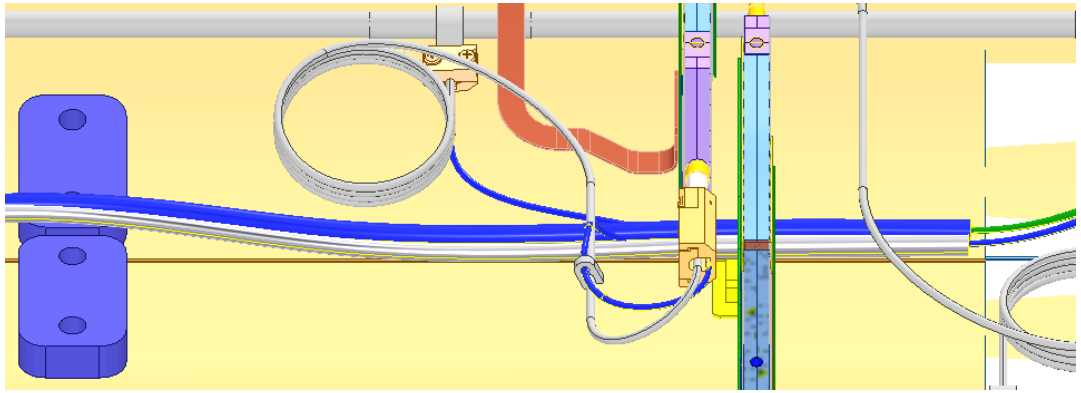
A clip (or likely PEEK cable tie) secures the excess twisted pair onto the capillary, with enough slack to account for expansion/contraction



L2 Ring 11 - Exhaust



L2 Ring 11 - Inlet



Cooling Pipe sensors

Some further work:

- Routing detail to include fixation points and methods (not yet fully defined)
- Prototyping of smaller capillary cooling pipes attachment and verification of sensor performance
- Confirmation of final Z positions for Atmospheric sensors

Thank you for your attention