Status Report

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Outline

1. Proto 18
2. Foil
3. Proto 8
4. Miscellaneous
5. Outlook
6. Back Up Slides

Proto18: Thermal Study

- Proto18:Thermal Study

Introduction

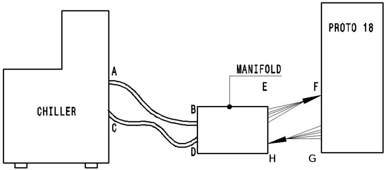
Why is important make a thermal analysis?

- We should work at $-25°C$.

Previous analysis

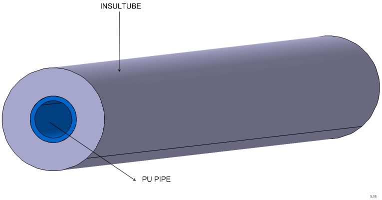
- Heat transfer inside *Proto 18* :
  - Pre amplifiers Heat.
  - Exchange with the atmosphere.
- Now heat exchange along the pipes will be analyzed.

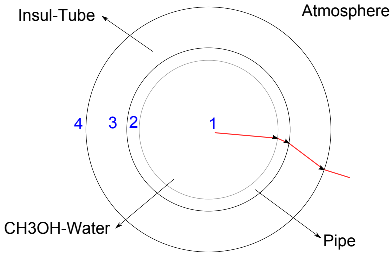
Configuration



- Chiller, manifold and *Proto 18* .
- 2 big pipelines ($\bar{AB}$ & $\bar{CD}$)
- 5 pipelines from manifold to *Proto 18* ($\bar{EF}$).
- 5 pipelines from *Proto 18* to manifold. ($\bar{GH}$)

Pipeline analisys ($A\bar{B}$)

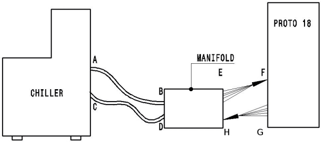




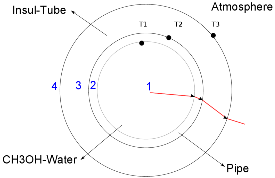
Regions of exchange

- 1-2
  Laminar forced convection inside the pipes.
- 2-3
  Conduction between the pipes and the Insul-Tubes.
- 3-4
  Laminar natural convection between the Insul-Tubes and the atmosphere.

Thermal Results



- $Q_{\bar{AB}} \approx 8.44(W)$
- $Q_{\bar{CD}} \approx 8.44(W)$
- $Q_{\bar{EF}} \approx 16.3(W)$
- $Q_{\bar{GH}} \approx 16.3(W)$



- $T_{1\,big} \approx -24.74^{\circ}C$
- $T_{2\,big} \approx -23.1^{\circ}C$
- $T_{3\,big} \approx 11.36^{\circ}C$

- $T_{1\,small} \approx -24.83^{\circ}C$
- $T_{2\,small} \approx -21.64^{\circ}C$
- $T_{3\,small} \approx 9,8^{\circ}C$

Heat Exchange

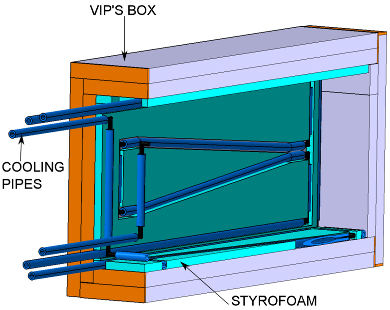
$$Q_{total} = Q_{PA} + Q_{P18} + Q_{Pipes} \approx 1.8 + 7.92 + 49.48 \approx 59.2(W)$$

Proto18:Insulation

- Proto18:Insulation

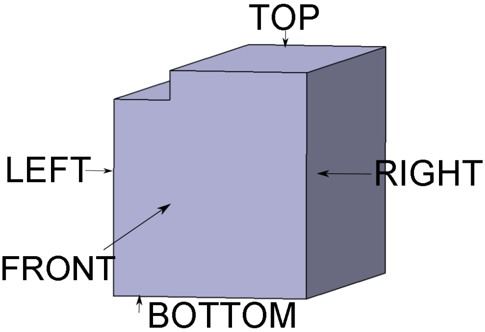
Introduction

The Insulation system of *Proto 18* is composed by Cooling System, Styrofoam Layer and VIP's Box.



Cooling System

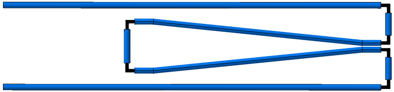
- The cooling system length has been increased.
- There are different configurations depending on the shape.
- There is not pipes on the front face to reduce the material budget.



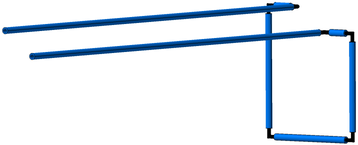
Material	Polyurethane (PU)
ϕ_i(mm)	4
ϕ_o(mm)	6

Cooling System

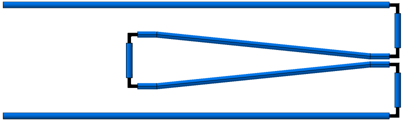
Left and bottom:



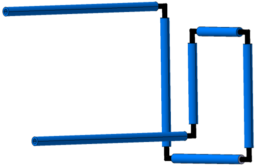
Top:



Right:

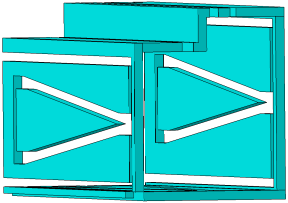


Back:



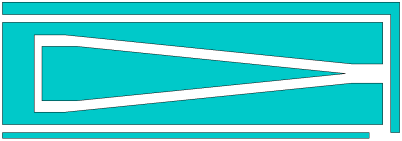
Styrofoam

- Styrofoam has been selected to insulate due to his low thermal conductivity $k \approx 0.03(\frac{W}{m \cdot K})$.
- It covers the space between Shell and VIP's Box.
- In the back face it is not sure if Styrofoam will be used or replaced by granulate Aerogel.

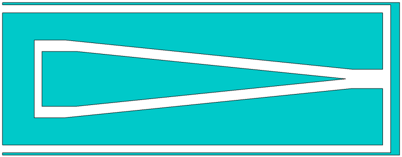


Styrofoam

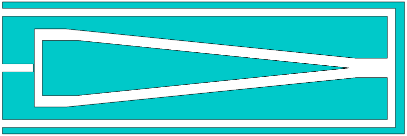
Left:



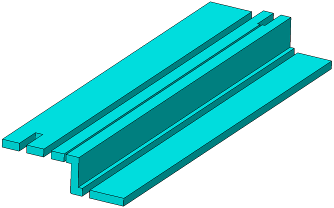
Right:



Bottom:



Back:



VIP's Box

The vacuum Insulation Panel (VIP) has been selected for the insulation due to its good properties.

VIP's more important property

Properties	Units	Value
Thermal Conductivity (k)	$(\frac{W}{m \cdot K})$	0.005

VIP's Box

- Official dimensions are not accurate because of the flaps.
- The *Catia V5* design has been made with parameters to take in account the flaps.

  Thickness$\approx +3mm(13mm)$
  Length$\approx$ +4mm (2mm/side)
  Width$\approx$ +2mm

- The design also has different steps to avoid straight lines between inside and outside.

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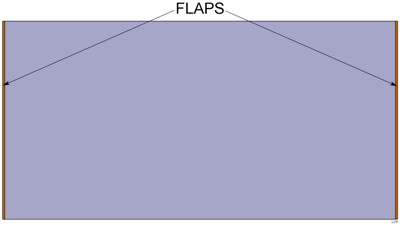

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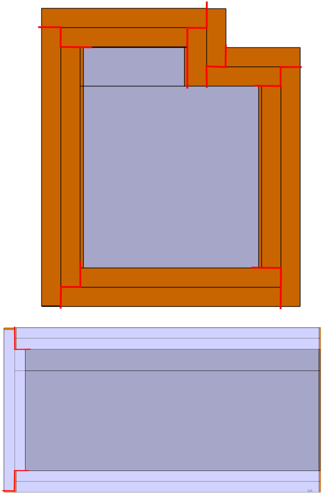
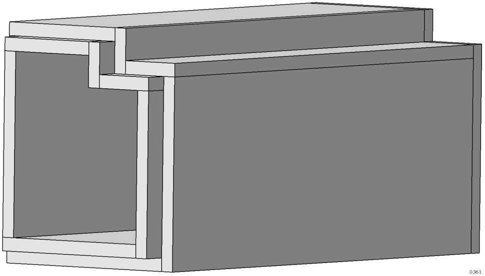


VIP's Box

Due to new changes in the structure of the *Proto 18* , a new VIP's box has been designed.



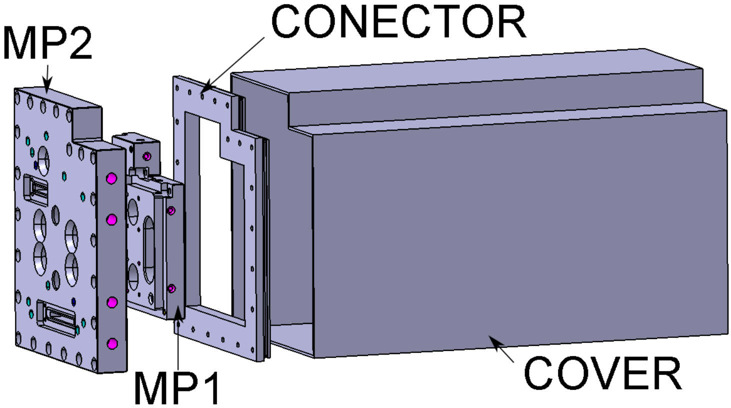
The new step is to fit inside the new cover that would be explained later.

Proto18:Structure

- Proto18:Structure

Introduction

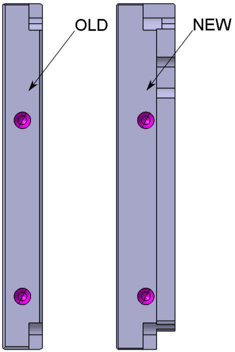
The Structure modified has been the Mounting plate 1 (MP1), Mounting Plate 2 (MP2) and Cover.



Mounting Plate 1

Back pipeline has been located inside MP1 to increase the heat exchange.

- The thickness of MP1 increases to surround the pipeline.
- One slot has been created to contain it.



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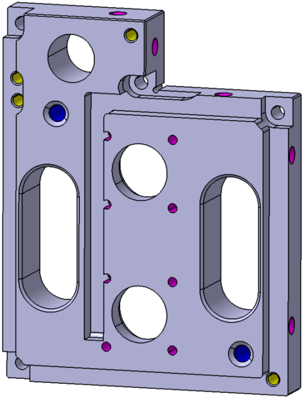
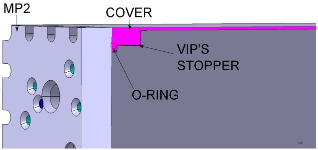


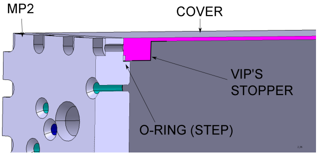
Mounting Plate 2

Different proposals for the O-ring have been discussed. The O-ring creates N_2 Overpressure and air tightness.

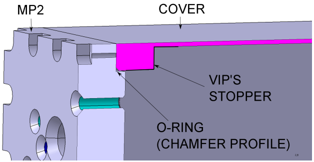
Proposal 1:



Proposal 2:

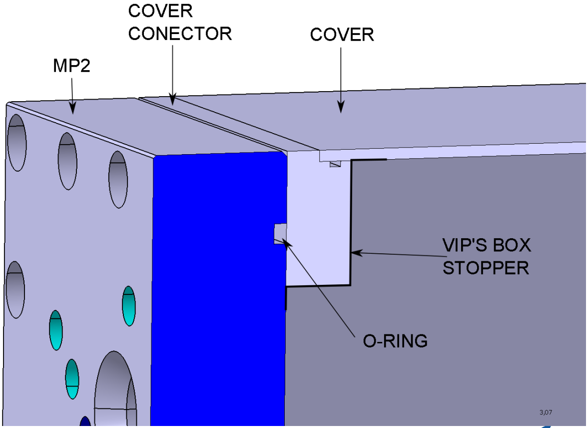


Proposal 3:



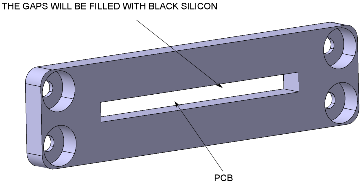
Mounting Plate 2

Final Choice:



Mounting Plate 2

- PCB Patch Panel has been selected to take away the wires and cables of the sensors.
- 2 different connectors have been designed to fix the PCB Patch Panel.
- Each connector has an O-ring to make *Proto 18* air tight and it will be shielded with black silicon to make it light tight also.



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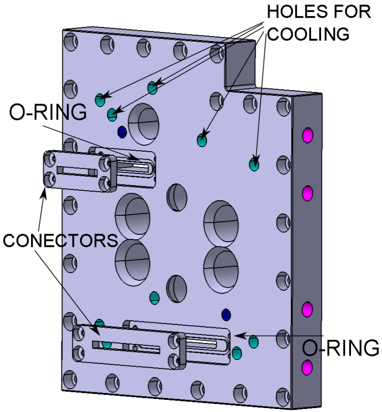
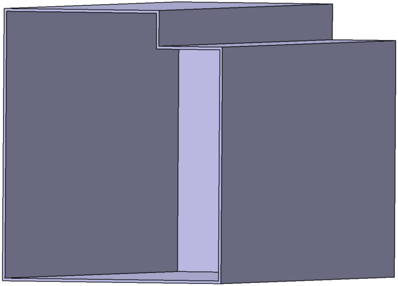


Cover

After O-ring proposal was selected, a new cover was needed for the new requirements.

- Main part has exactly the same guidelines.
- A new connector has been developed to make the cover easier to be manufactured.
  - It is the part which makes pressure against MP2.
  - This part is glued the main part (slot for the exceed of glue).



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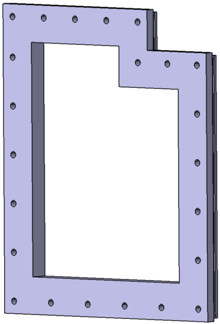

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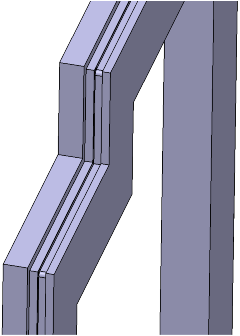


Proto18:Sensors

- Proto18:Sensors

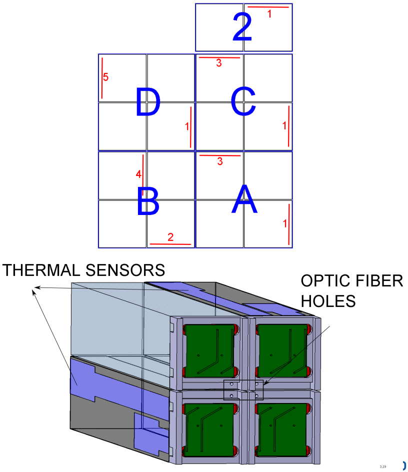
Introduction

There are 2 different kind of sensors:

1. Thermal sensors.
   - Jumo pt100: To control the temperature inside the structure.
   - Crystal Sensors: Measure the temperature along the crystal.
2. Humidity sensors.
   - Honeywell HIH-4000-003: They are located between Styrofoam and close to *Jumo pt100* sensors.

Crystal Thermal Sensors

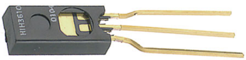
- 2 sensors per crystal.
- 18 sensors for all the config.
- The groups depend on Optic Fiber holes.

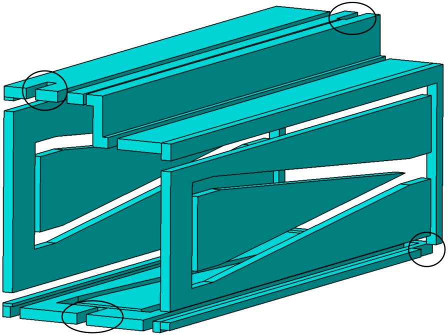


Sensors

Thermal Sensor:

Humidity Sensor:





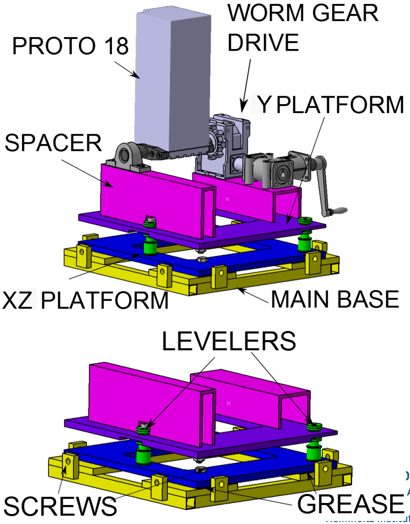
- The location of Sensors has been design to measure in differents points inside the strucure.
- It allows calculate the different gradients (Temperature, Humidity) along the *Proto 18* .

Proto18: Alignment System

- Proto18: Alignment System

Alignment System

- Worm Gear Drive→It allows the rotation $(0 - 90^\circ)$
- Main Base→ It Supports the structure.
    - Foot Levellers.
    - Holder to transport it.
- XZ Platform → It allows translations in XZ plane (Horizontal). Also it allows angles in that plane.
    - Grease is used to decrease friction.
- Y Platform → It allows displacements which change the height (Vertical). It allows angles in that direction.
    - 3 Levelers.
- Spacers → It supports all the mechanisms.
- Fixing Screws → Fix the final position in all the Platforms.



Alignment System Proposals

Some proposals have been designed. The final choice is being designed now and would be a combination/mixture of the Proposal 2 and Proposal 3.

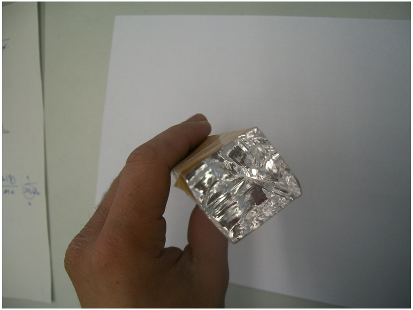
- Proposal 2:

Foil

- Foil

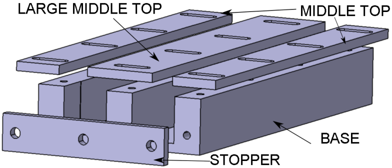
Introduction

- Foil used is *3M Daylighting Film DF2000MA*.



Tooling

- The tooling does not have to scratch the foil.
- It has to shape the foil with the crystals dimension
- Foil is baked for 2 hours at 100 °C in a oven.



Shaping Test

Some ideas has been tested for the foil:

- Fix the position of foil profile with needles.
- Glue the profile on the protective layer.
- How to cut and fold the profile.

- Bake the foil less time but increasing the temperature.
- Use a different tool.

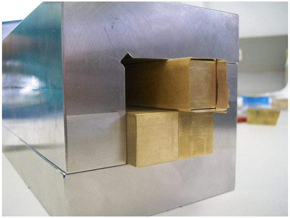
Finally:

- The Foil is glued on the protective layer.
- The profile is bending inside the tooling.

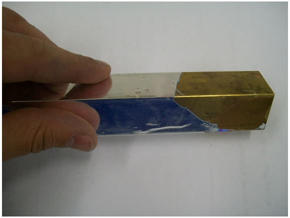
Shaping Tests

The profile was glued to the foil.

First test without the final tooling.



Test with extra temperature. Foil protective layer was melted.

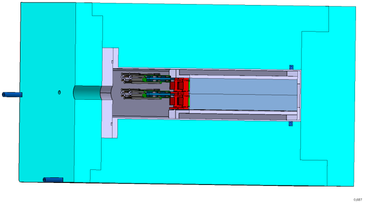


Foil was fixed with needles.

Proto8

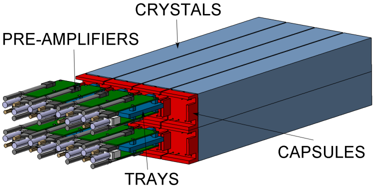
- Proto8

Introduction



- The *Proto 8* is a project for the final thesis of Christina and Pascal.
- It has followed the *Proto 18* guidelines.
- It is provided of 8 $PbWO_4$ crystals.

Electronics

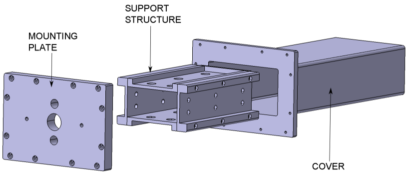


- Electronic Proposale:
  - Trays → Avoid movements and fit onto Intermediate Shell. Wires are used for connections.
  - Capsule → It Fixes the APD in crystal and holds the Pre-Amps .

Structure

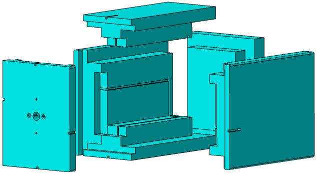
The Structure is in charge of reach the light & air tightness as well as support the crystals and distribute the temperature.

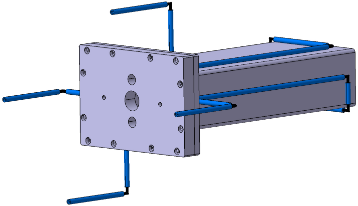
- Support Structure → To Hold on the crystal during the movements (0-90°).
- Cover → To contain the Crystals & electronics and Support Structure.
- Mounting Plate → To shield the cover to reach the light tightness.



Insulation System

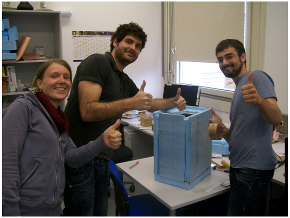
- Styrofoam layer → A box has been made with different steps to stop the air.
  - The properties of the Styrofoam as the same as the one in *Proto 18* .
  - Thickness=100mm
- Cooling pipeline → The same pipes of *Proto 18* are used in *Proto 8*
- N_2 pipeline→ To remove and avoid the water inside the structure.





Assembly Process

Styrofoam:



Miscellaneous

- Miscellaneous

Final Arrangement

For the Final Arrangement of the ward End Cap some ideas are being developed.

- Catia V5 Skeleton
  - Planes, parameters and points which are useful to arranged the different elements of F. A.
- File Naming
  - It tries to avoid the nomenclature problems between all the people involve in $\overline{\text{P}}$ANDA .
  - It follows the Guidelines of Philippe and has been adapted for our case.

File Naming

There are 5 different groups :

Electro Mechanic Calorimeter (EM)

Backward End Cap (EB):

Sections (EM):Main sections of EB.

- General quarter (GQ)
- Structure (ST)
- Tooling (TO)
- Integration(IN)
- Service (SE)

Parts of each section.The name depends on the element, for ST:

- Alignment System (AL)
- Support (SP)

Elements:Regarding to the part, the number of elements could be completely different. for Insert of 16 (16)):

- Crystals (C)
- Pre-amplifiers (M)
- Frame (F)
- APD (A)
- Capsules (P)
- Insert (I)
- Tray (T)
- PCB (B)
- Reflective Foil (R)

File Naming

There are also some parameters to identify what kind of file it is.

Parameter	Naming	Parameter	Naming
Part	P	Assembly	A
Drawing	D	Naming	N
Procedure	R	Downstream	+
Upstream	–	Left side	L
Right side	R		

Example

EMEBQG16CP–L01

Outlook

- Analysis of the speeds inside all the pipes.
- Heat loses in the manifold.
- Continue with the structure of *Proto 18* (fist we have to discuss about the final dimension of Carbon Fiber Alveoli).
- After *Proto 8* assembly maybe insulation system of *Proto 18* has to be analyzed again.

THANK YOU FOR YOUR ATENTION!

"An inventor is a person who makes an ingenious arrangement of wheels, levers and springs, and believes it civilization."

Bierce, Ambrose(1842-1914).

1-2 Turbulent forced convection

Once the data of the coolant is already known, to calculate heat transfer coefficient it is necessary to follow the next steps :

- Reynolds Number

$$R_e = \frac{V_s \cdot D_H}{\nu} \quad (1)$$

- With Dittus-Boelter correlation Heat transfer coefficient is:

$$h_i = \frac{k}{D_H} \cdot 0.023 \cdot {R_e}^{0.8} \cdot {P_r}^{0.4} \quad (2)$$

3-4 Laminar natural convection

Assumed theories

- Energy conservation.
- h has a value for the air inside a office $\in (6-30)\frac{W}{m^2 \cdot K}$

The equation for the heat exchange is also known:

$$\dot{Q}(\frac{W}{m}) = \frac{\Delta T}{\frac{1}{2\cdot\pi\cdot R_o\cdot h_o} + \frac{\ln(R_o/R_m)}{2\cdot\pi\cdot k_{it}} + \frac{\ln(R_m/R_i)}{2\cdot\pi\cdot k_{PU}} + \frac{1}{2\cdot\pi\cdot R_i\cdot h_i}} \quad (3)$$

- Convection (3-4)
- Conduction (2-3)
- Convection (1-2)

3-4 Laminar natural convection

To calculate h_o it is necessary to iterate. The steps are:

- Calculate a estimated heat exchange usin equation of heat exchange showed before and assuming a random value of h_o from the range that appears before.
- With the formula of the heat exchange in convection is possible to know $\Delta T(^\circ C)$ between the last wall and the air.

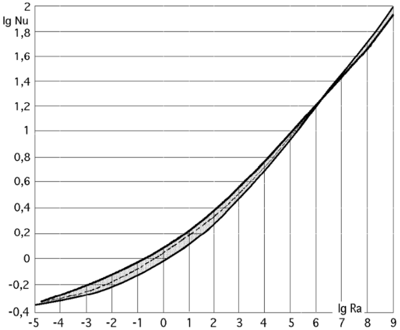
$$Q = A \cdot h_o \cdot \Delta T$$

3-4 Laminar natural convection

- As this case is Laminar natural convection, Grashoff and Raygleigh Numbers are needed:

$$G_r = \frac{g \cdot \beta \cdot \Delta T \cdot D_H^3}{\nu^2} \quad (4) \qquad R_a = G_r \cdot P_r \quad (5)$$

- The Nusselt Number approach for this case is:



3-4 Laminar natural convection

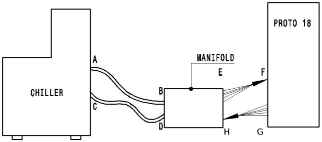
Once Nusselt Number is known:

$$h'_o = \frac{N_u \cdot k}{D_H} \tag{6}$$

It is necessary to iterate as many as possible to get a constant value for h'_o. Once it is fixed, the heat exchange is:

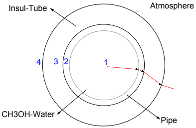
- Radial Direction: Last value of $\dot{Q}$
- Longitudinal direction: $Q = \dot{Q} \cdot l$

Temperatures



In the case of the ΔT along the pipe $\bar{AB}$:

$$Q = \dot{m} \cdot C_p \cdot \Delta T$$
$$\Delta T = \frac{Q}{\dot{m} \cdot C_p} \qquad (7)$$



The different temperatures in radial direction at the beginning of the pipe are:

$$\Delta T_{1-2} = h_i \cdot 2 \cdot pi \cdot R_i$$
$$\Delta T_{2-3} = \frac{2 \cdot \pi \cdot k_{PU}}{\ln(R_m/R_i)}$$
$$\Delta T_{3-4} = h_o \cdot 2 \cdot pi \cdot R_o$$