VIP :

- Service Lifetime Prediction
- Edge Effect
- Building Application

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Swiss Federal Laboratories for Materials Testing and Research

- Samuel Brunner
- Reto Bundi

swiss energy

vip-bau.ch

HiPTI - High Performance Thermal Insulation
IEA/ECBCS Annex 39

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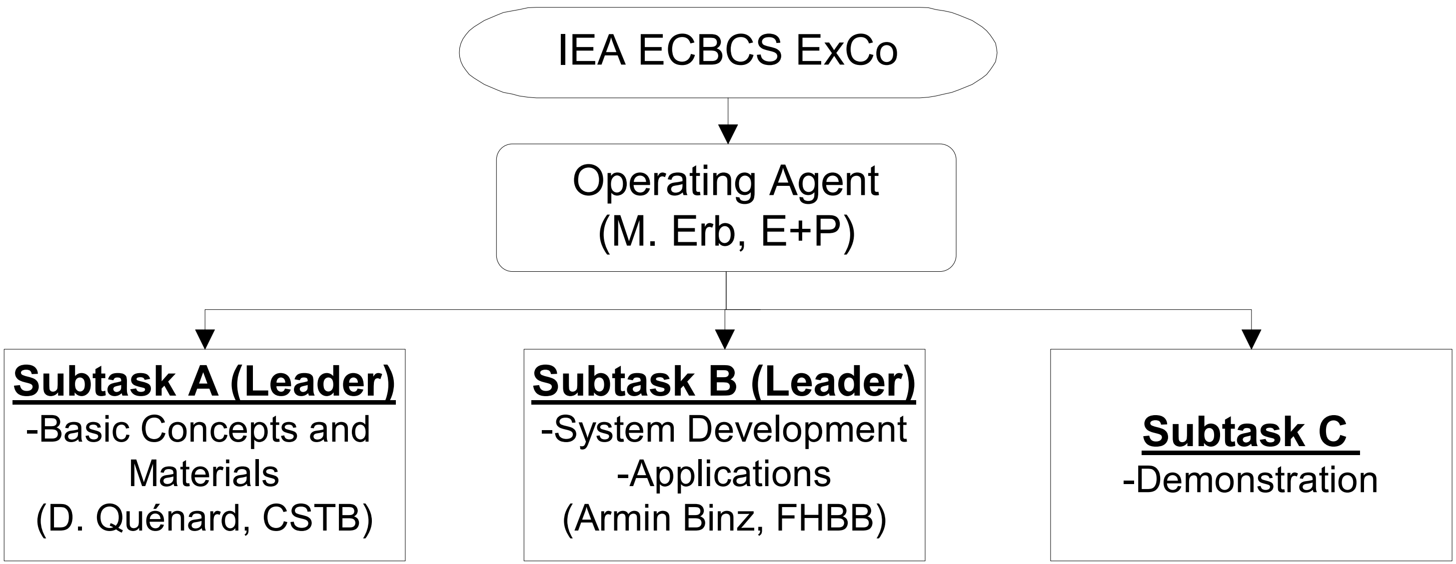
IEA ANNEX 39



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Main aims of IEA ANNEX 39

- making physical basics available
- developing service lifetime prediction models
- developing standardized guidelines for thermal calculations
- supporting VIP using companies
- ...

Involved Laboratories

- ZAE Würzburg (GER)
- TU Delft (NL)
- NRC Ottawa (CA)
- EMPA Duebendorf (CH)
- KTH Stockholm (SWE)
- ...

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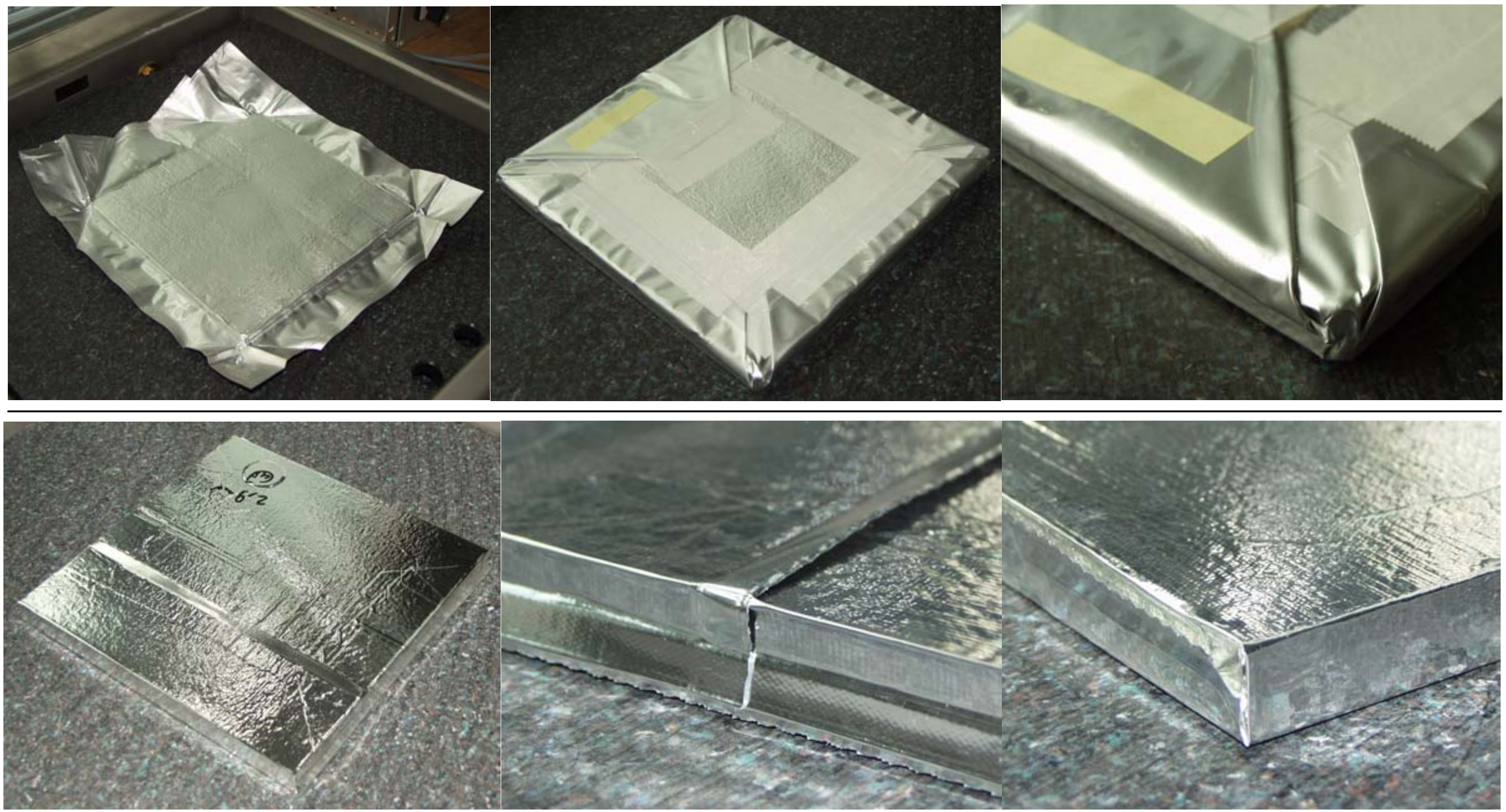
VIP-types in European market

Wrapping technology



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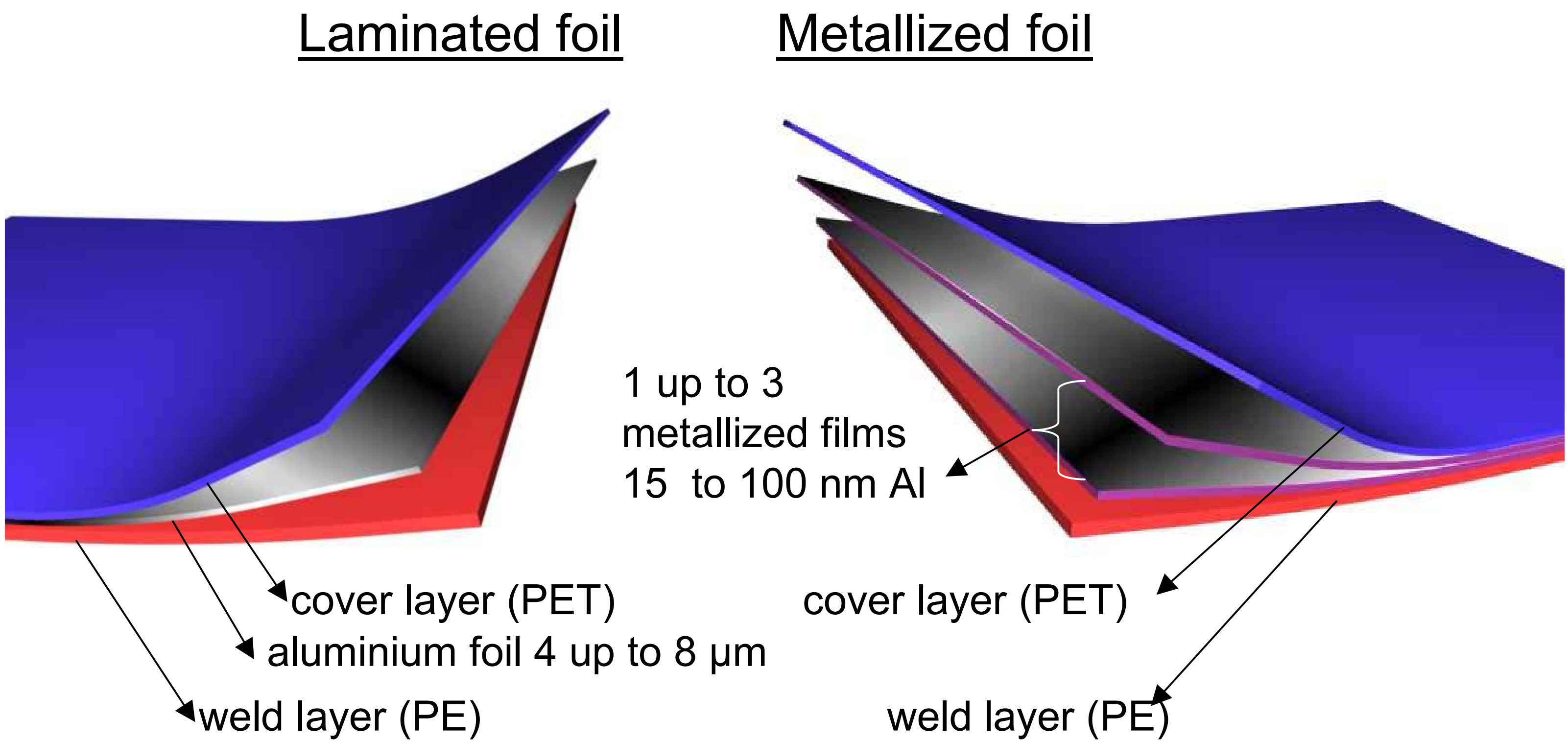
VIP-types in European market

Foil technology



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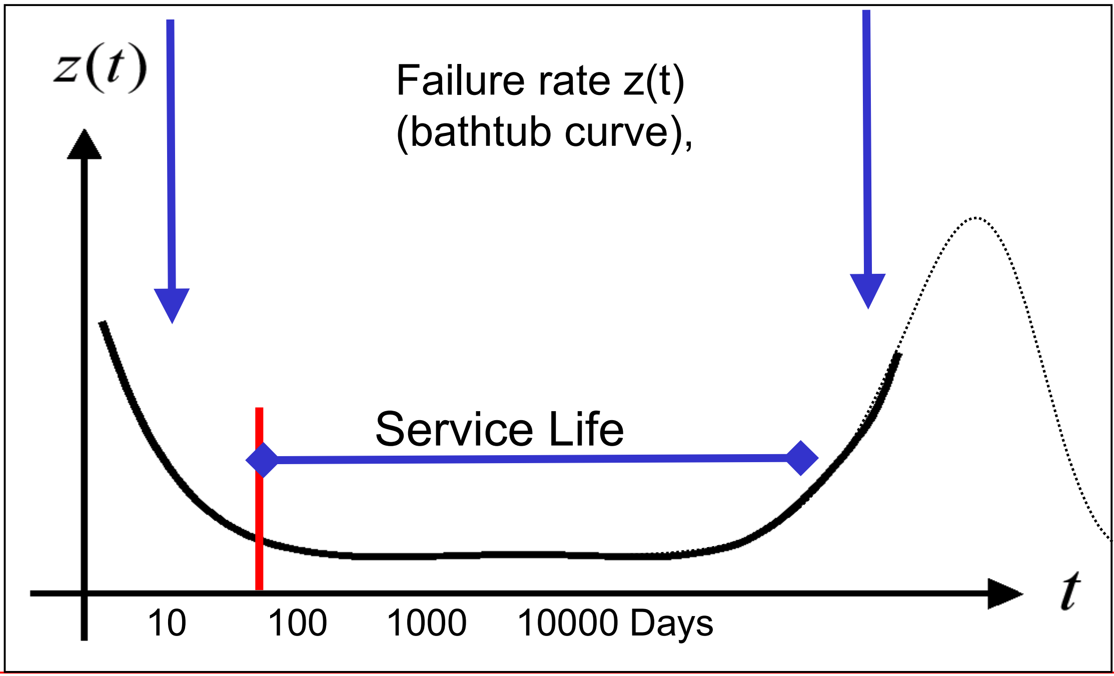
Service Life

- Early Life
  Childhood failure (due to imperfect production)
  evt. checked before installation

⇔ Aged
(due to diffusion to foil and seam as well as physical/chemical aging)



Criterion for end of the service life ?
depends on use,
=> Distribution

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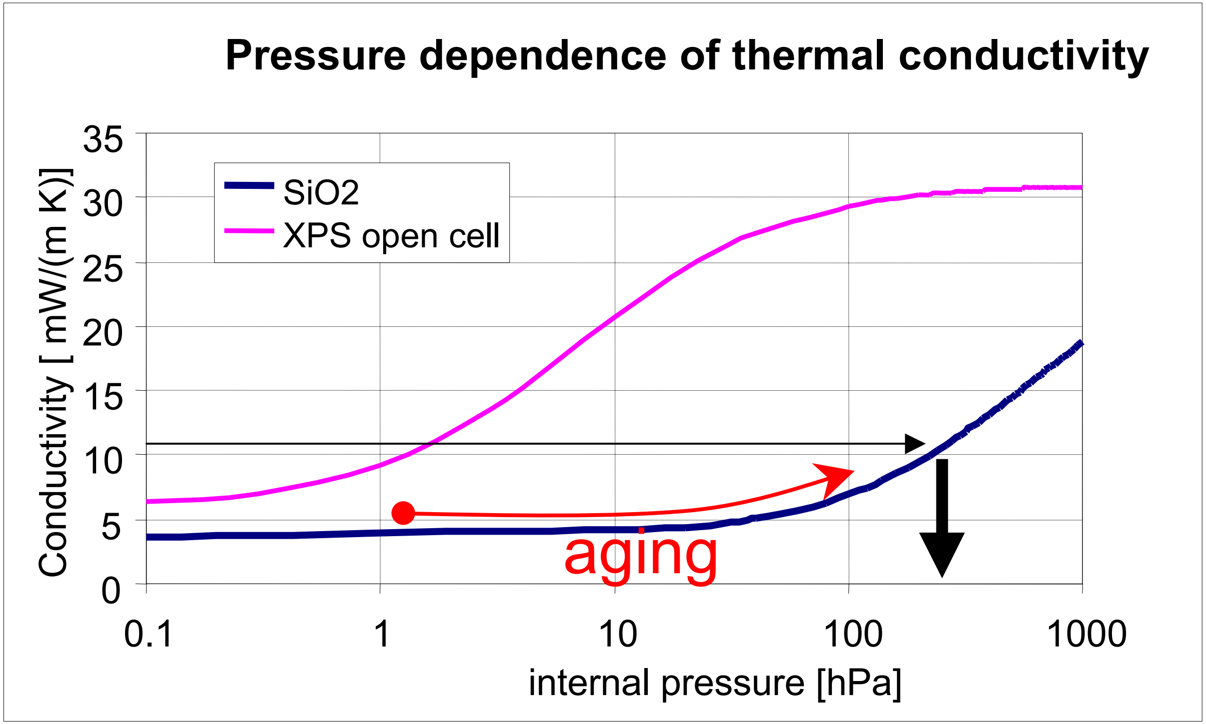
<u>Standard condition service life defined by ASTM 1484</u>
as the time at 24°C 50% r.h.
with center-of-panel conductivity below 11 mW/mK



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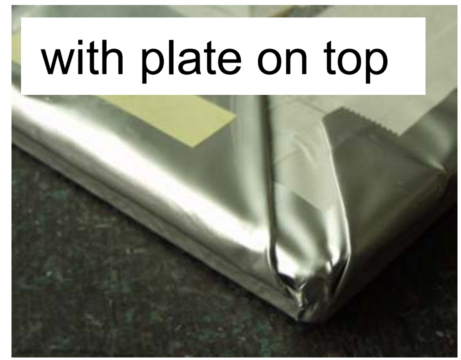
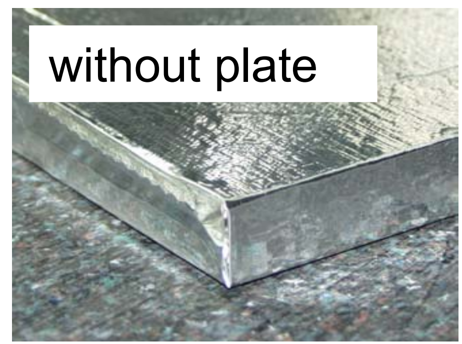
Measurement technique for internal pressure

- Overview
  the vacuum chamber





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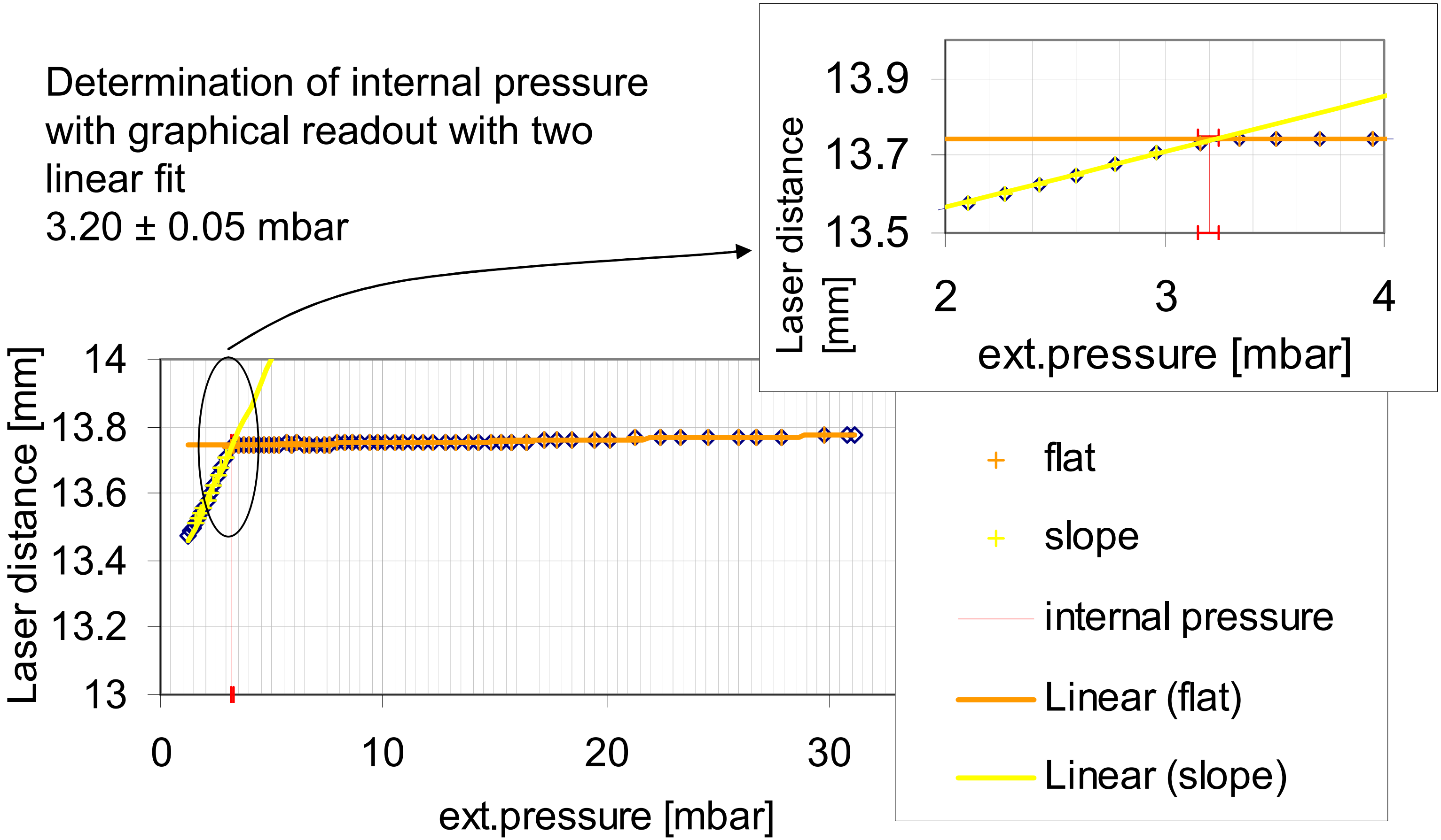
Two linear fit method for internal pressure measurements

- Determination of internal pressure with graphical readout with two linear fit
  3.20 ± 0.05 mbar



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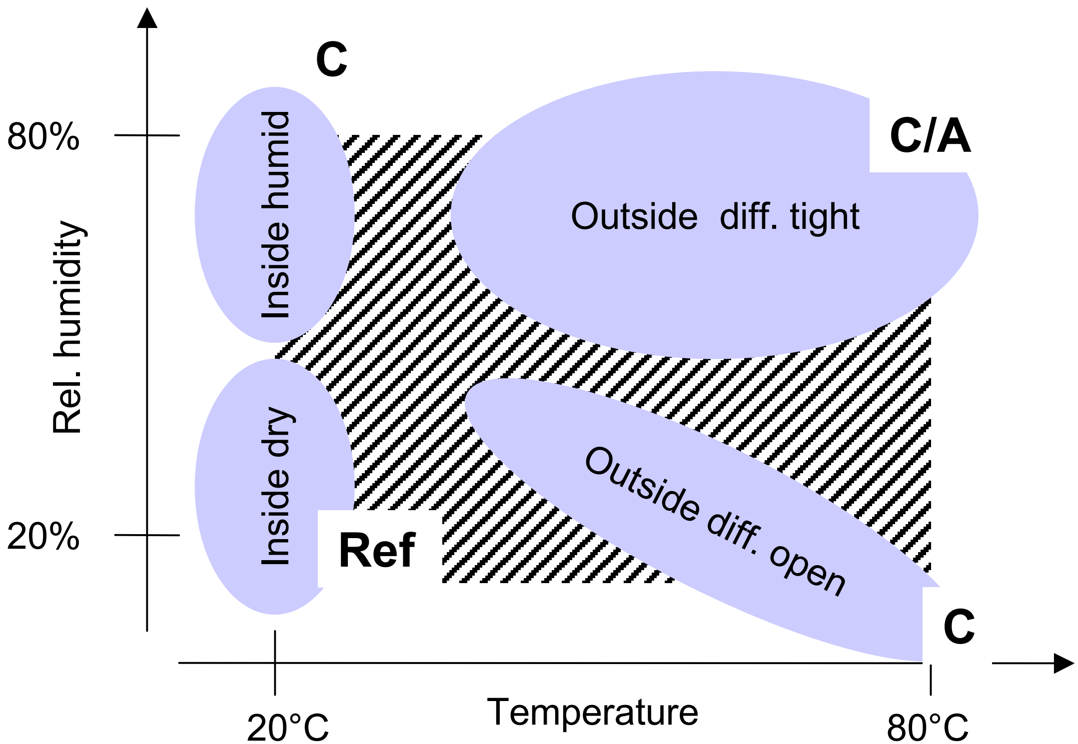
First measurements



- 30°C 90%r.H.
- 80°C dry

Preliminary test:

- under constant 80°C 80% r.h. (C) - as well as -
- alternating 80°C 80%r.h. with 25°C 50%r.h. in 8h / 4h steps (A)

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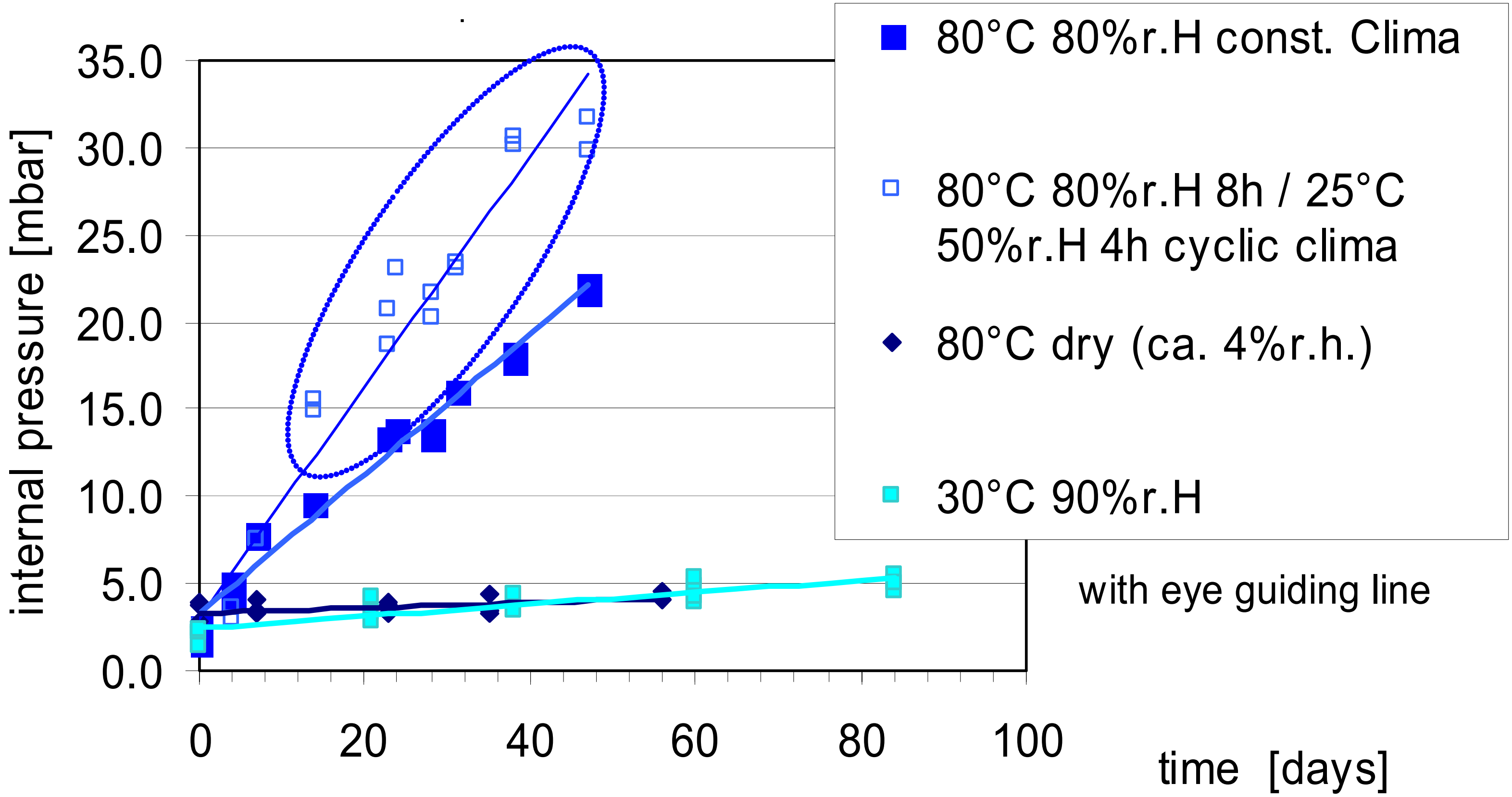
Results of first measurements



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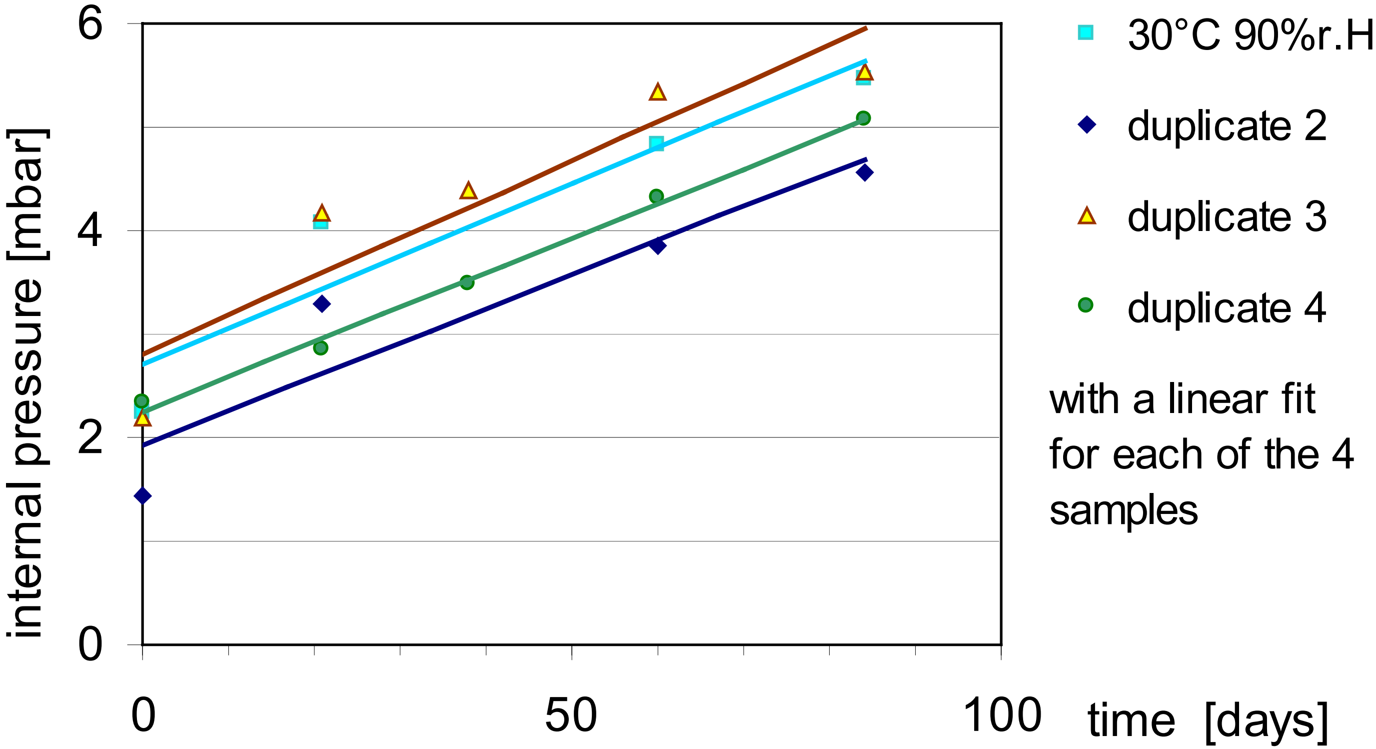
Detail of 30°C 90% r.h. condition



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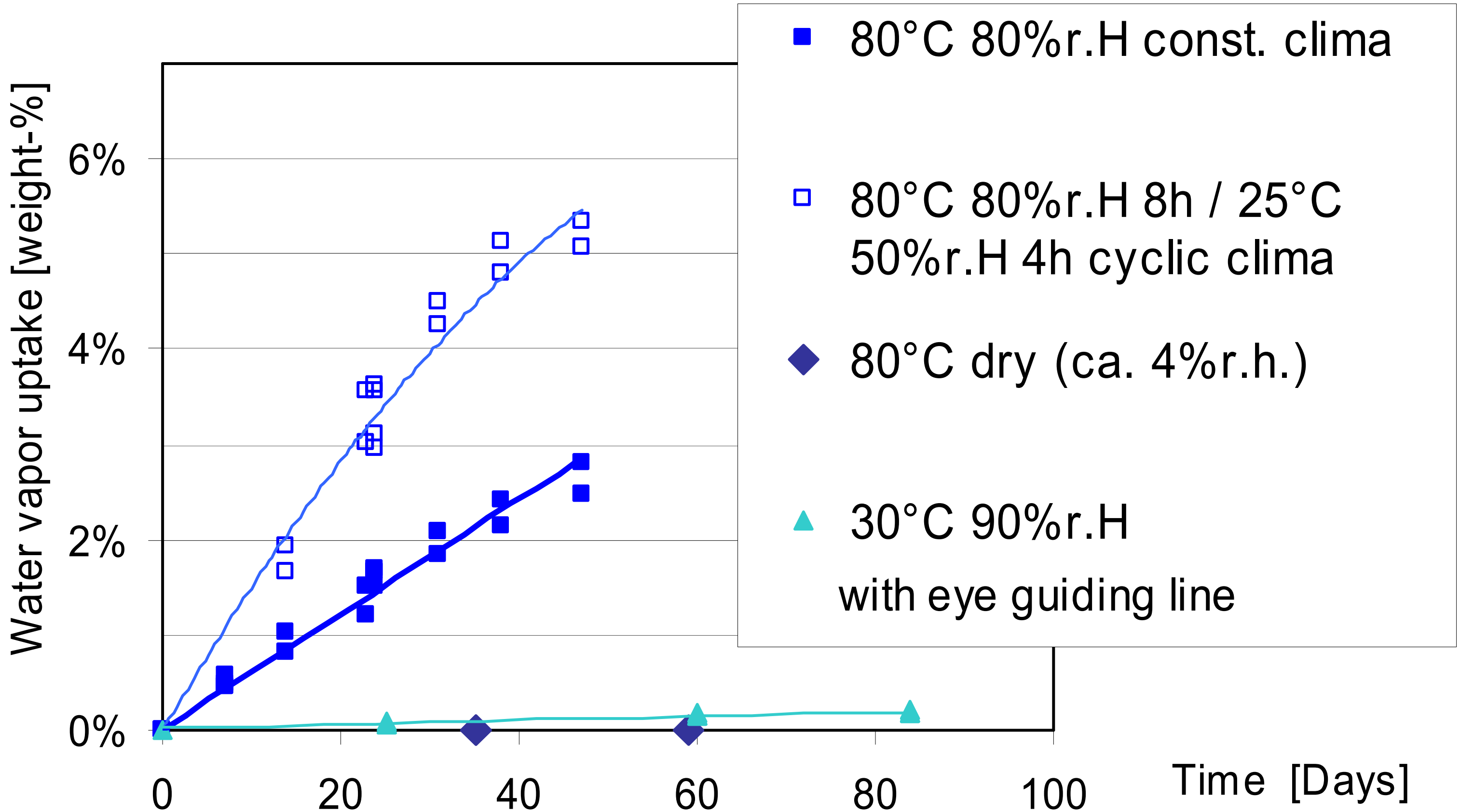
Water uptake



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Outlook

- Determination of acceleration factors for different Temperature and Humidity condition. -> Aging model for moderate in-use condition
- Statistical Analysis with
  -> Reliability function, dependent on applied stress and dimensions (seam length / surface)
- Definition of typical usage conditions, for which a service life of 25 respective 50 years is very likely.

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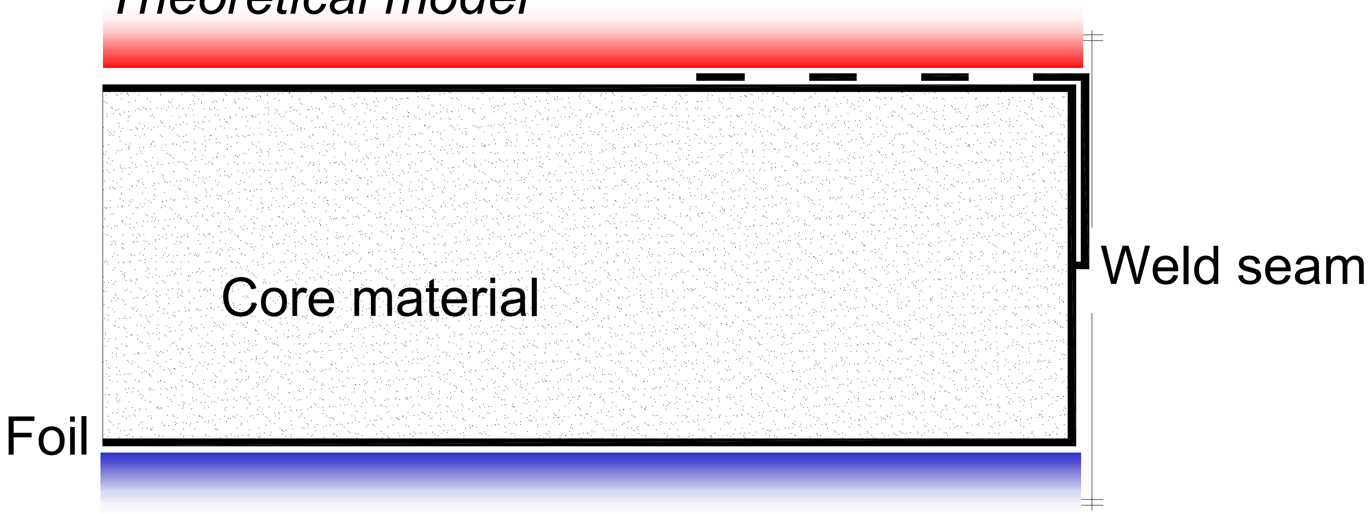
Development of calculation models

Theoretical model



Characteristic of materials

Foil (PUR/PP/PET/PE/AL ect.): known values (λ)
Core material: measured conductivity (λ)

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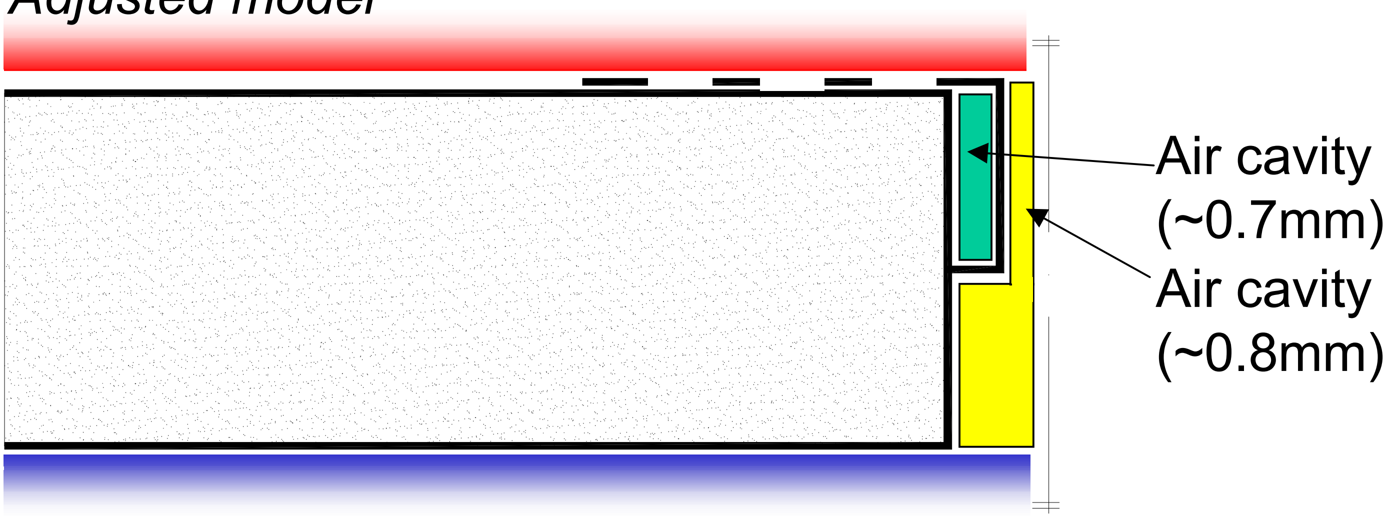
Development of calculation models

Adjusted model



Characteristic of materials

Foil (PUR/PP/PET/PE/AL ect.): known values (λ)
Core material: measured conductivity (λ)
Air cavity: according to CEN prEN ISO 10077-2

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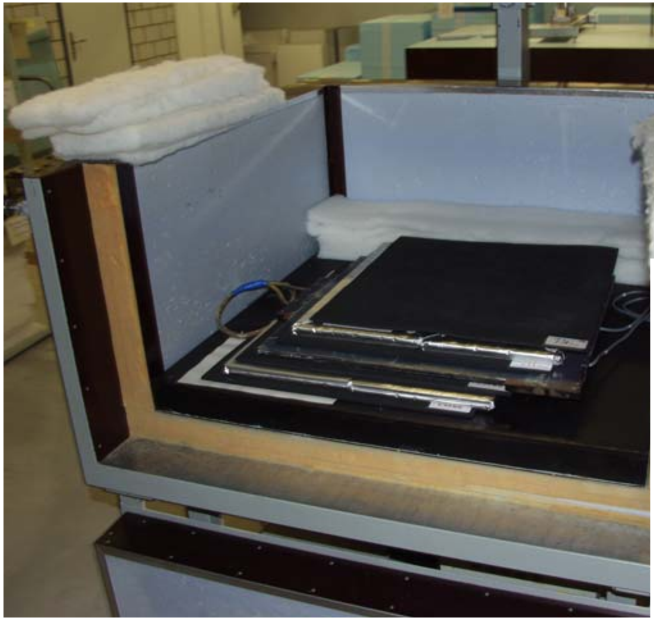
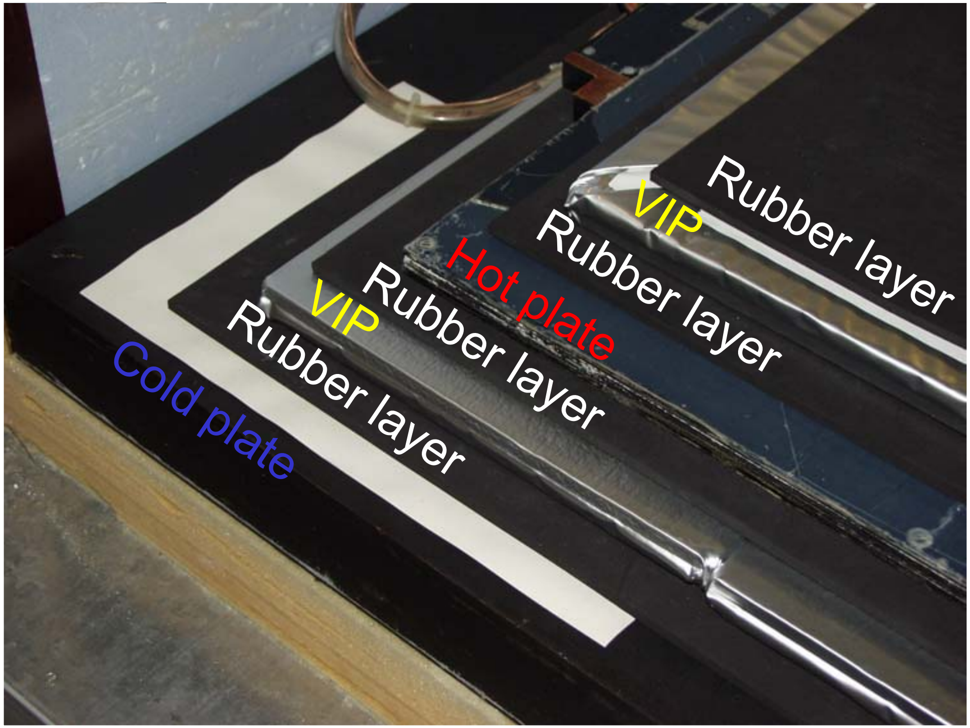


Measuring arrangement



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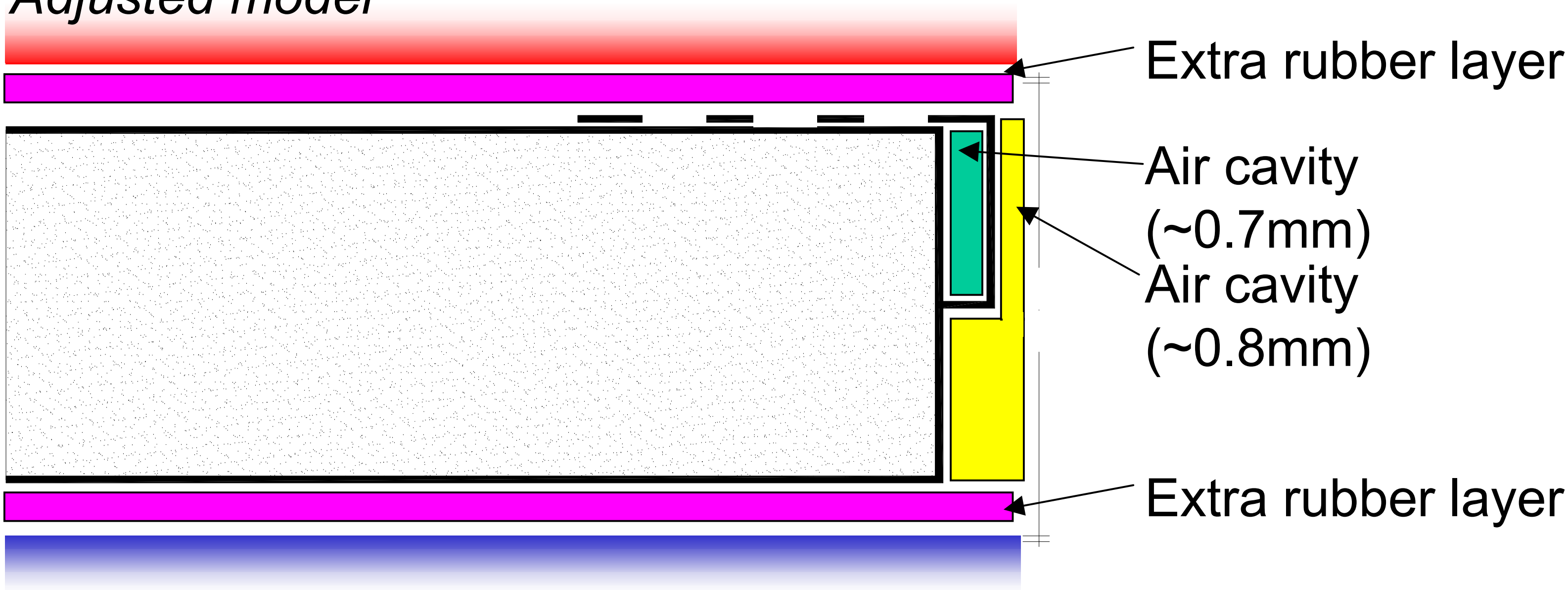
Development of calculation models

Adjusted model



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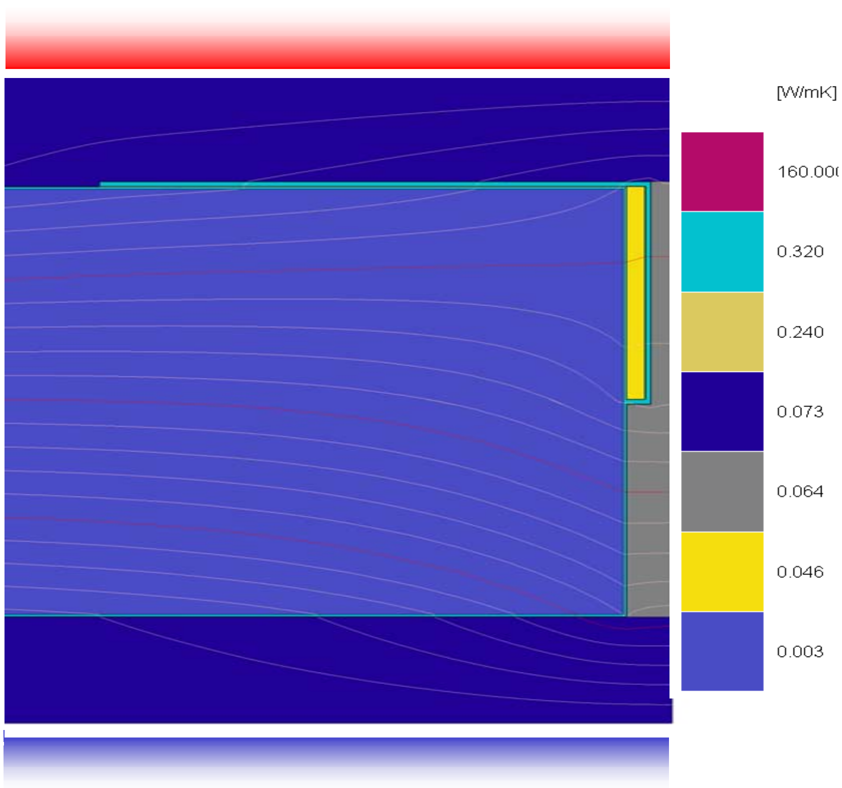
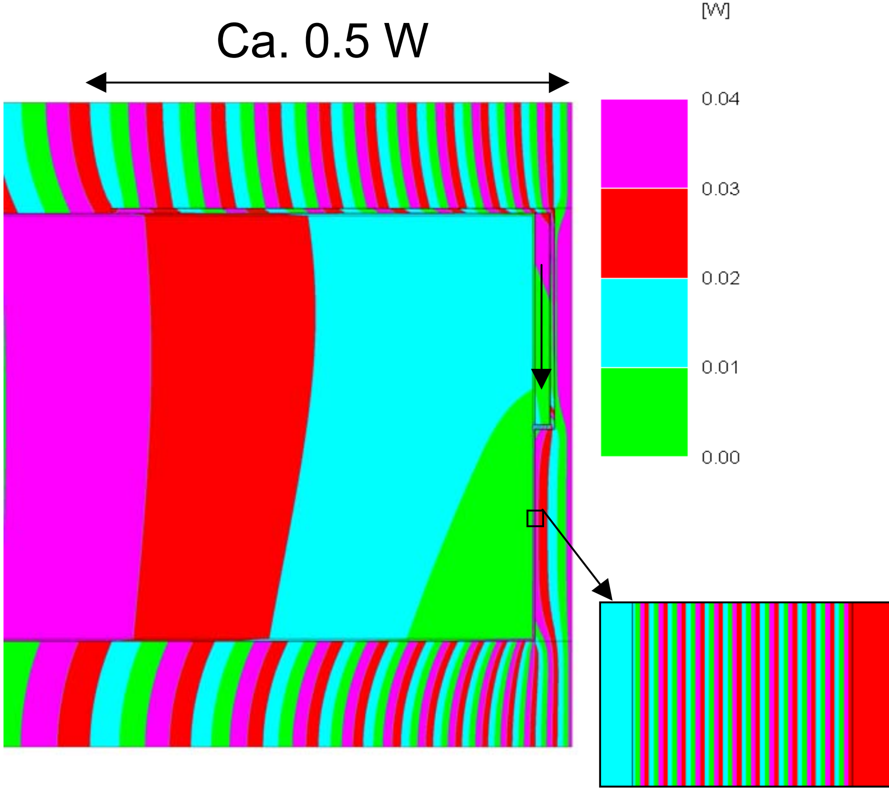
Solution with rubber shift

Alu laminated foil





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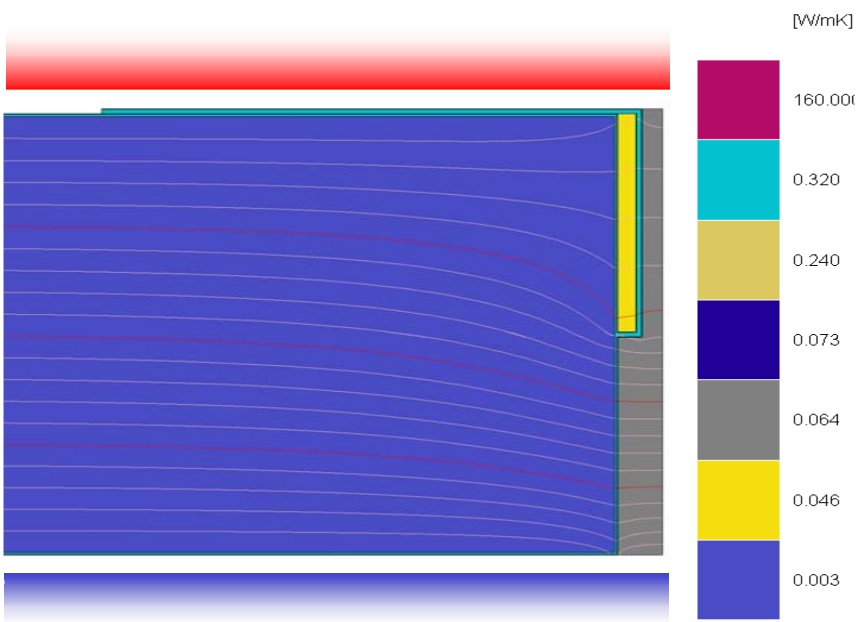
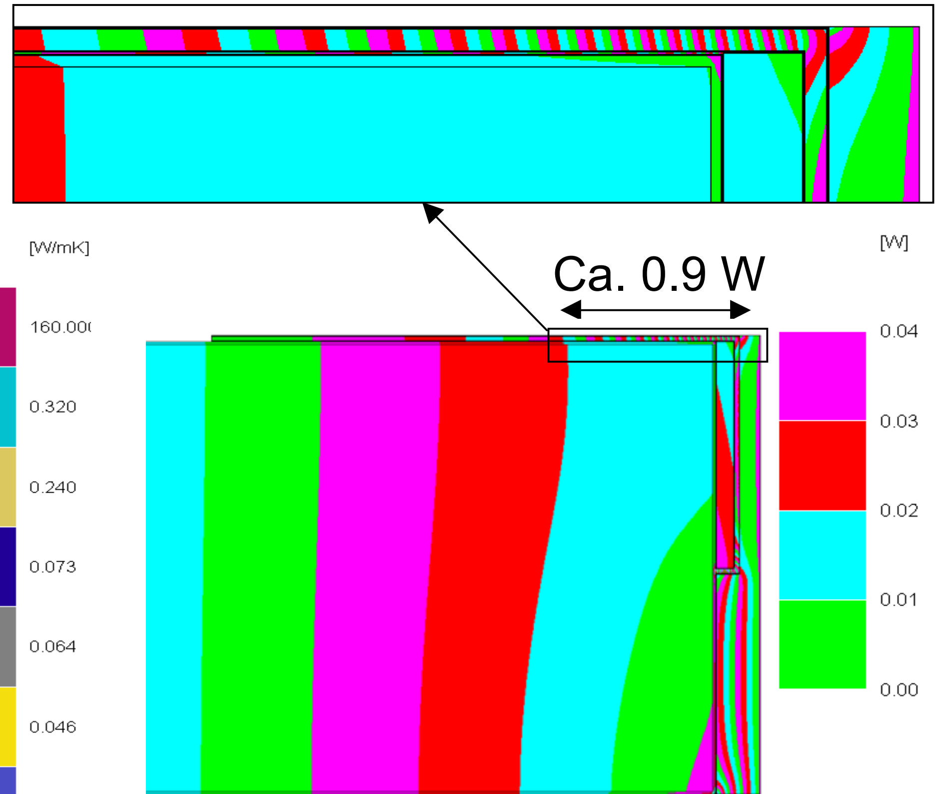
Solution without rubber layer

Alu laminated foil





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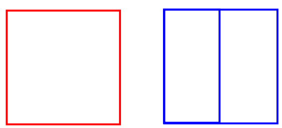
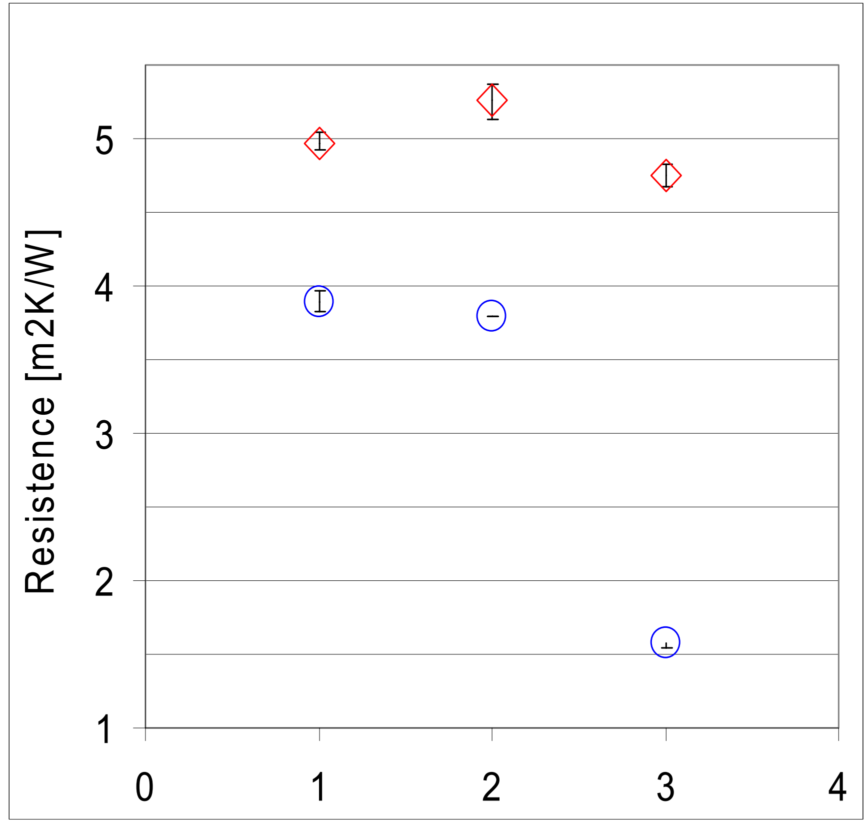
Summary table

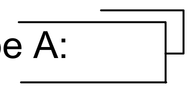
	Description		Measurement		
	t Alu [µm]	Edge Type	R_{core} [m²K/W]	R_{edge} [m²K/W]	ψ [mW/m K]
Type 1	0.12	A	5.0	3.9	6.9
Type 2	0.3	B	5.3	3.8	9.2
Type 3	8	A	4.8	1.6	52.8



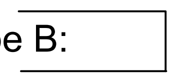


Edge Type:

Type A:



Type B:



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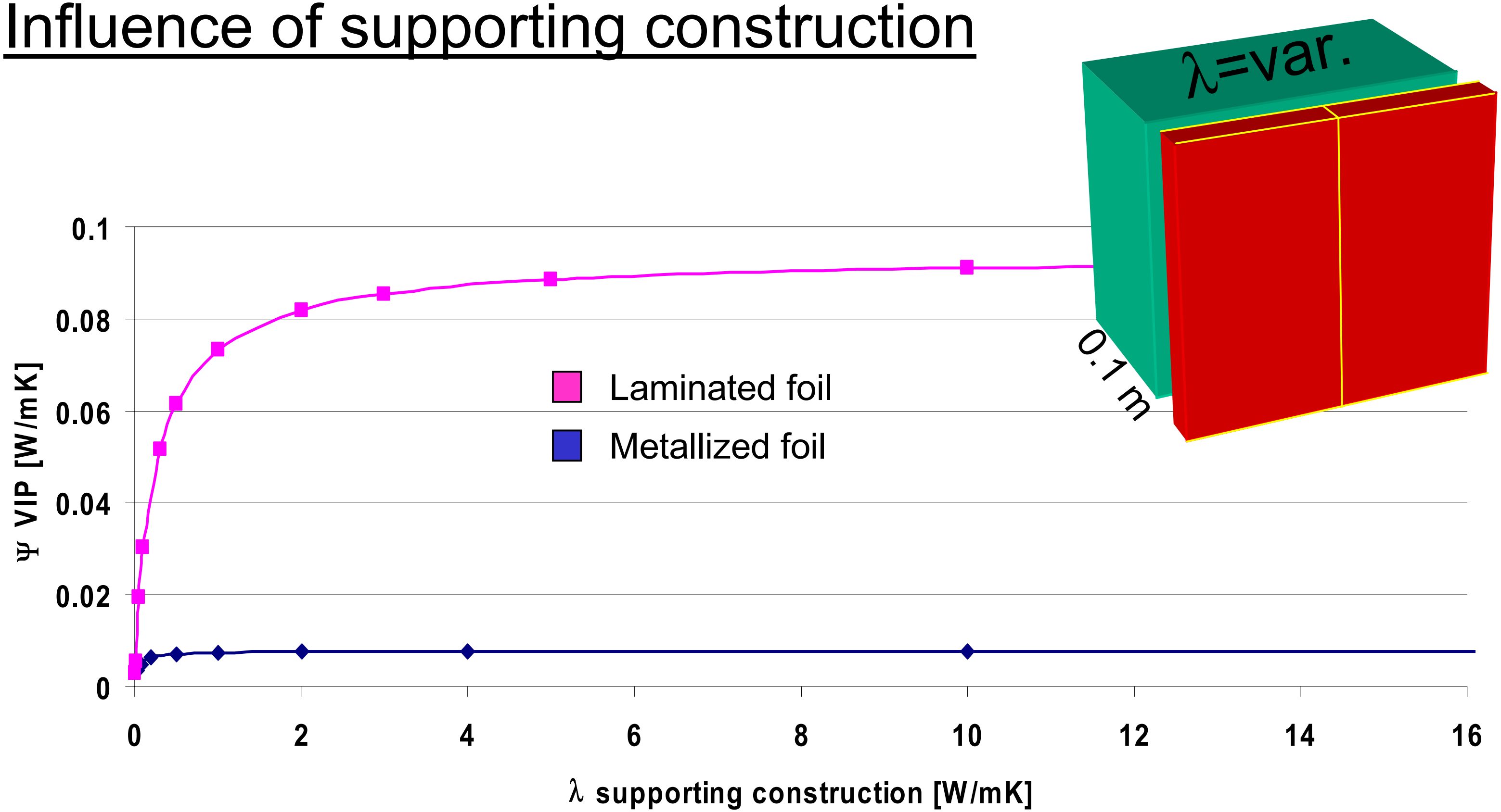
Influence of supporting construction



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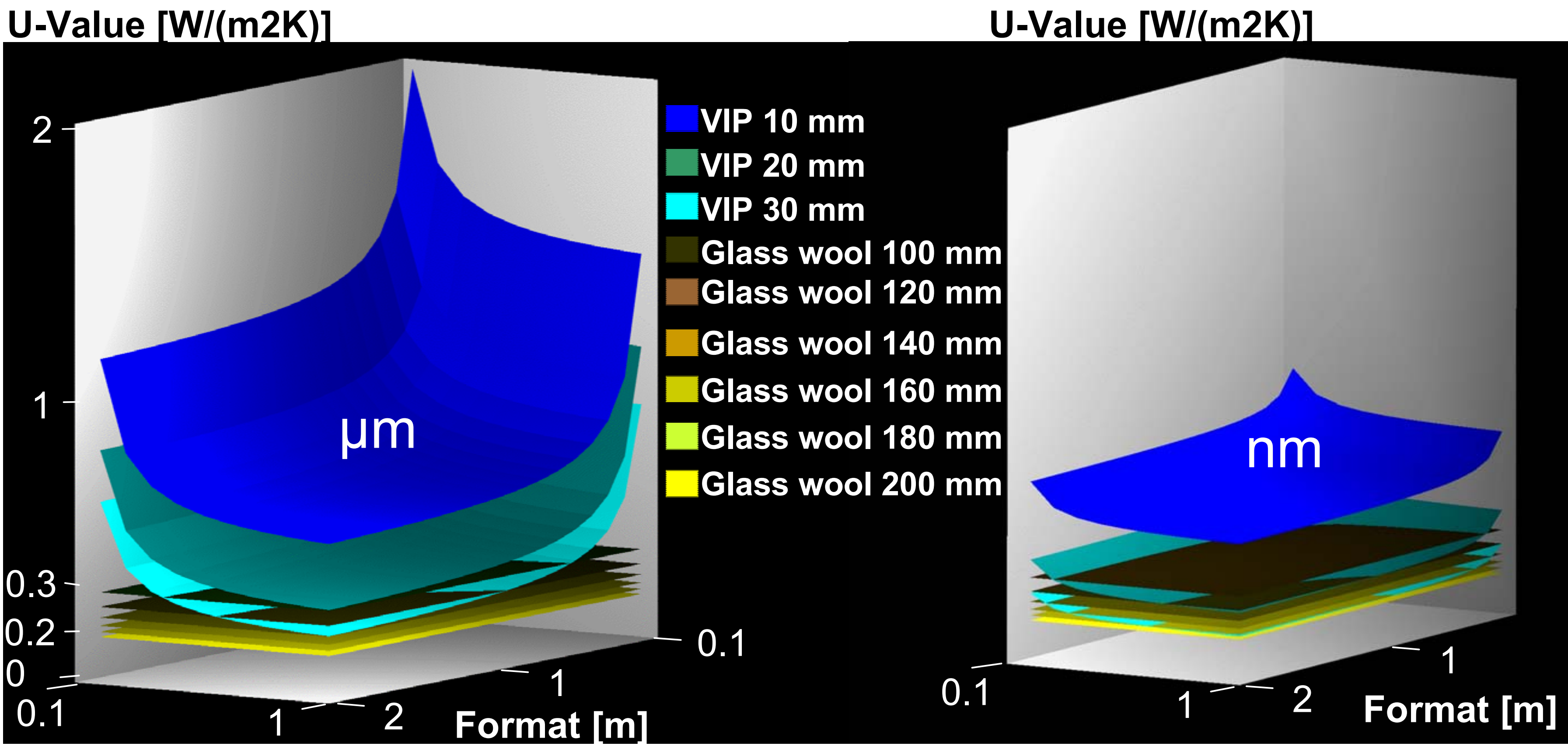
Influence of Edge effect on the U-Value



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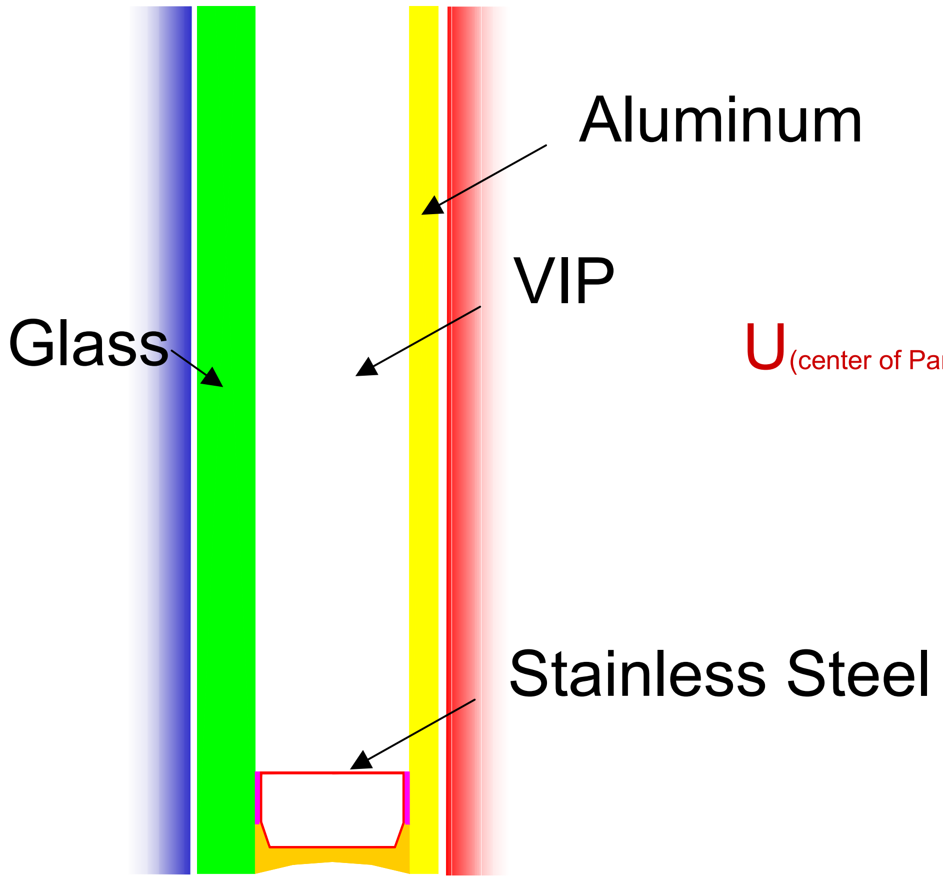
Example of VIP in building application



$U_{(center\ of\ Panel)} = 0.18 - 0.3\ W/(m^2K)$?

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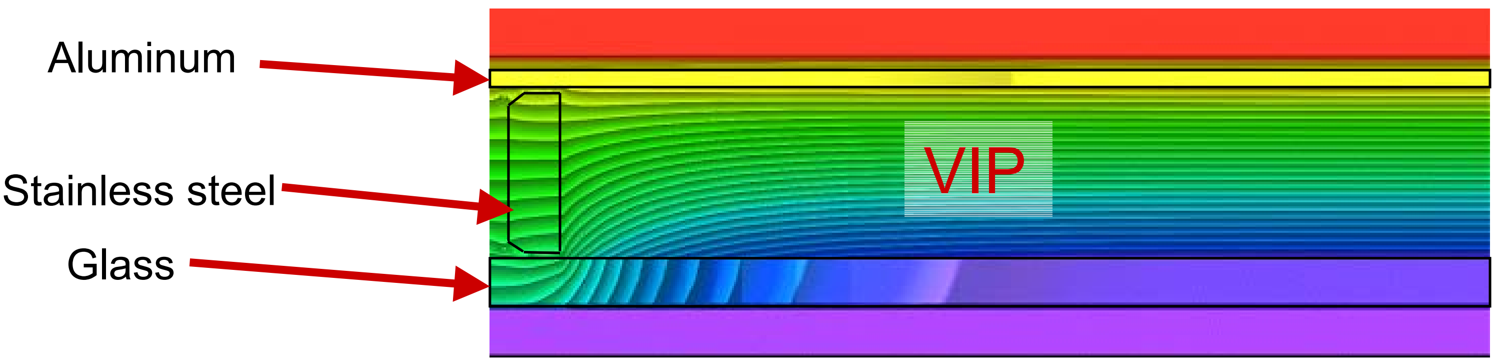
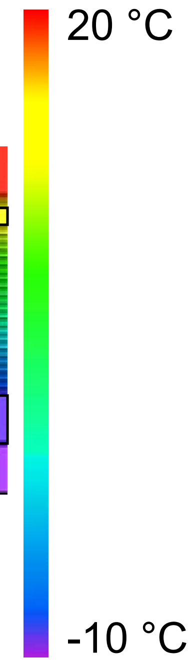
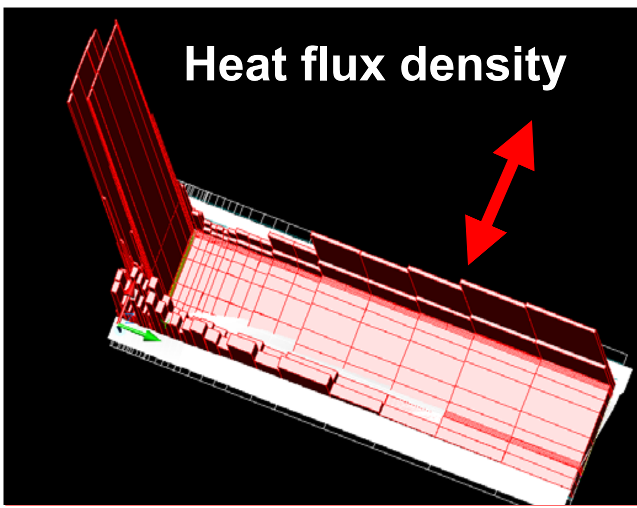
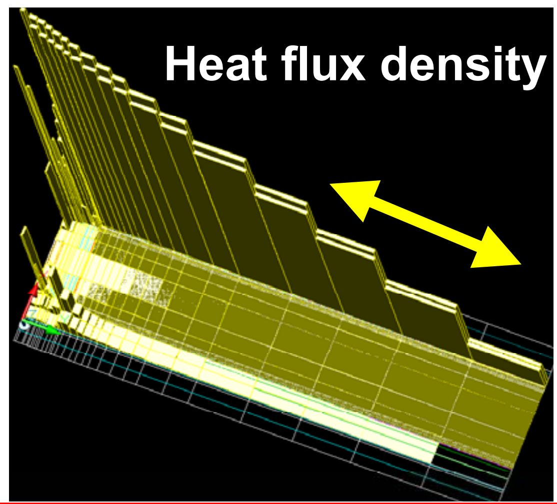
Example of VIP in building application

Ψ = 0.2 W/mK   U = 1 W/m²K   (1m²)









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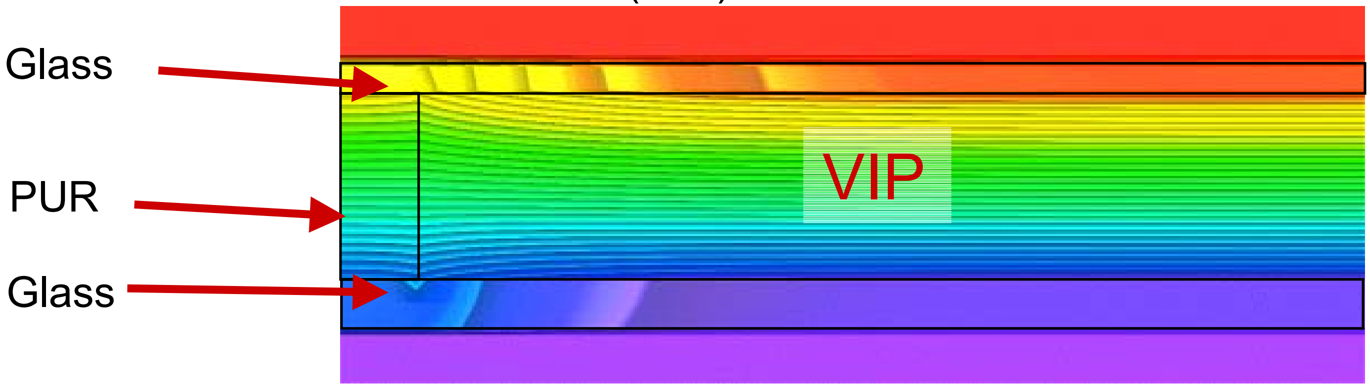
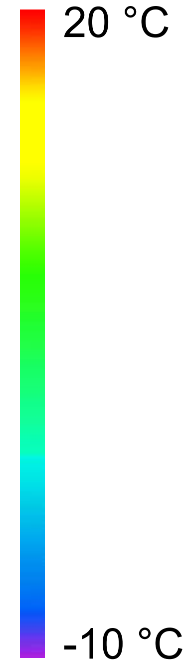
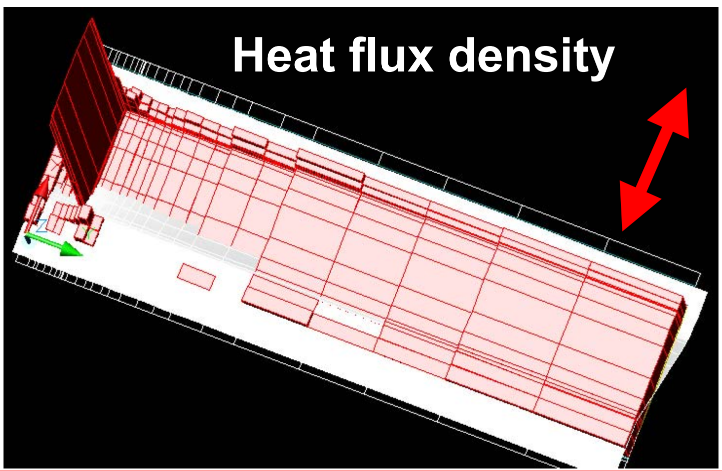
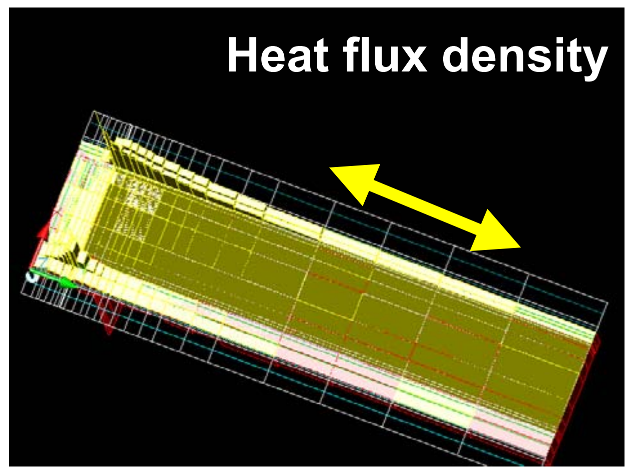
Example of VIP in building application

Ψ = 0.1 W/mK   U = 0.58 W/m^{2}K   (1m^2)









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Conclusions

- Humidity has bigger influence in early pressure rising than temperature

- Metalized foil minimize the edge heat losses by factor 5-8 compared with laminated aluminum foils
- Edge heat losses has to be taken into account by calculating U-values OR
- Edge heat loss coefficient must be shown when showing λ-values!
- Edge heat losses of VIP applications can be much higher than those of the VIP itself (By factor 100 or more!)

Outlook

- U-value of entire wall system measured in the hotbox will be compared against simulated values.