CASMaT
Villum Center for Advanced Structural and Material Testing

H-TRIS testing of foam cored sandwich panels for ship superstructures

Vasileios Karatzas[1], *Mohsen Rezaei*[1], *Pierrick Mindykowski*[2], *Grunde Jomaas*[2], *Christian Berggreen*[1]

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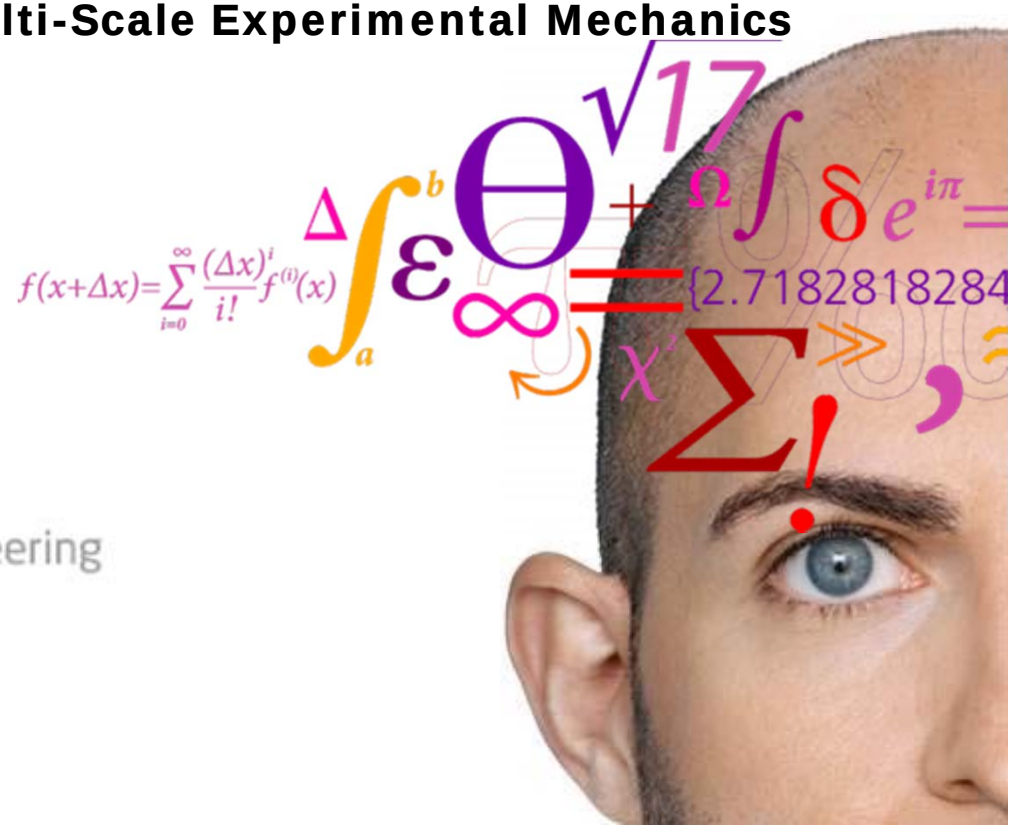
[1]DTU Mekanik, [2] DTU Byg



DTU Mechanical Engineering
Department of Mechanical Engineering

DTU Civil Engineering
Department of Civil Engineering

Composites in Marine Applications

Advantages:

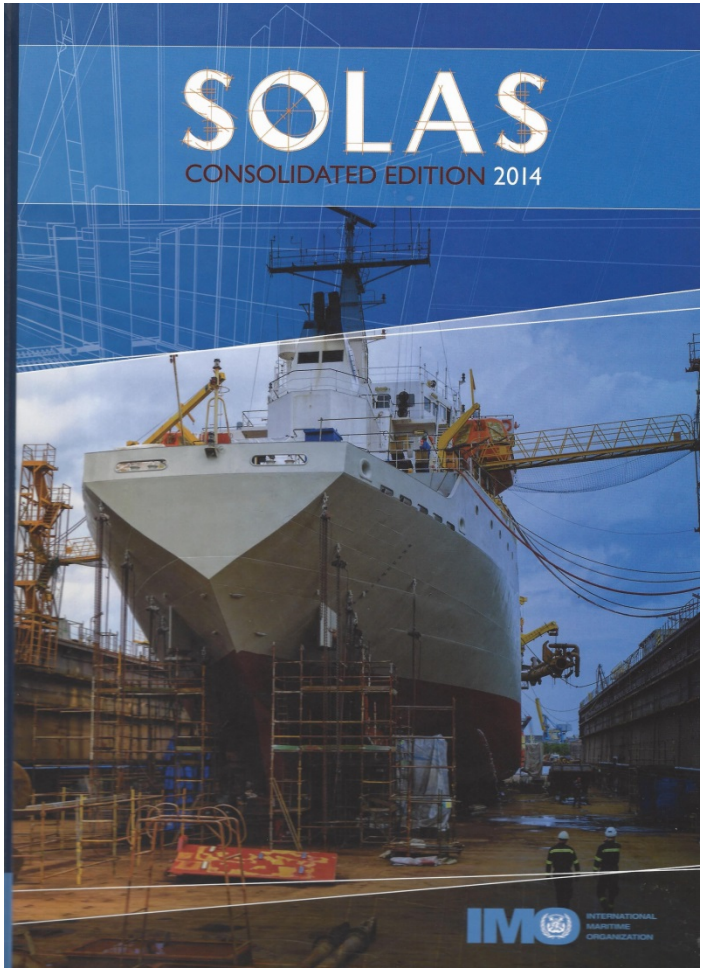
- Minimization of maintenance
- Lack of corrosion
- Prolongued fatigue life
- Lightweight

SOLAS Regulation

- Until Recently the SOLAS convention did not allow the use of combustible materials on board SOLAS ships

- In 2002 the **Regulation II-2/17** was introduced which allowed for ”Alternative design and arrangements” provided the same level of safety can be reached

- Prescriptive Approach
- Risk assesment/Fire engineering approach



Superstructures

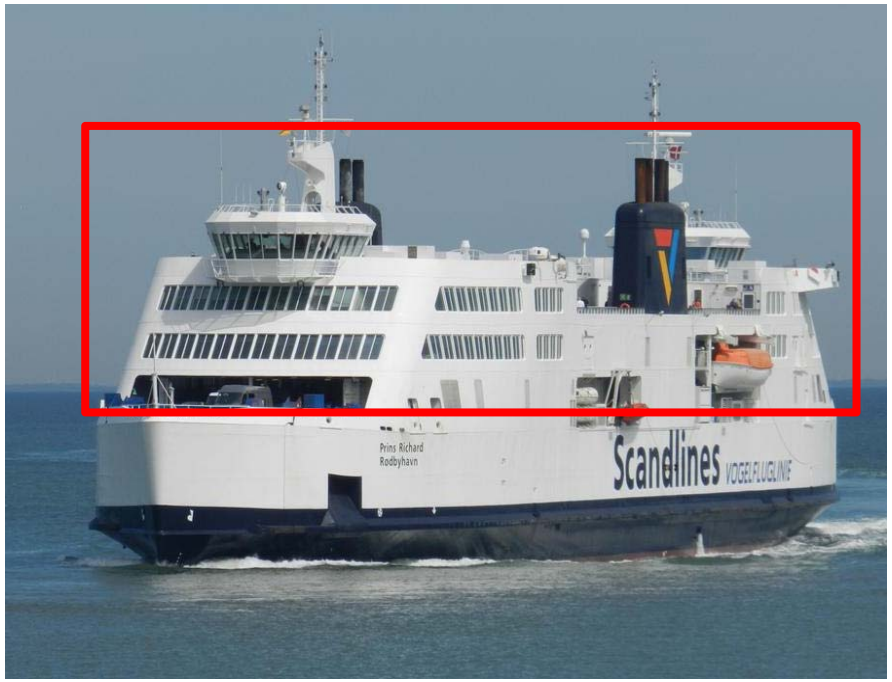
COMPASS (COMposite PASsenger Ships)

Superstructures are substantially larger in Passenger ships

-> greatly affect the stability

-> larger percentage of lightship

Large potential for retrofit and new-builds of passenger ships using composite materials



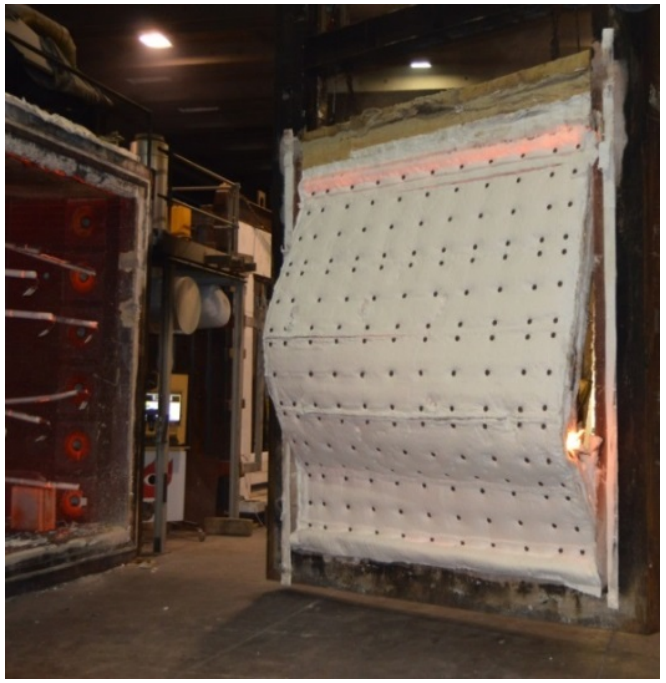
Testing Scales

Small scale tests
Cone Calorimeter

Not Fire resistance tests

Intermediate scale tests
H-TRIS

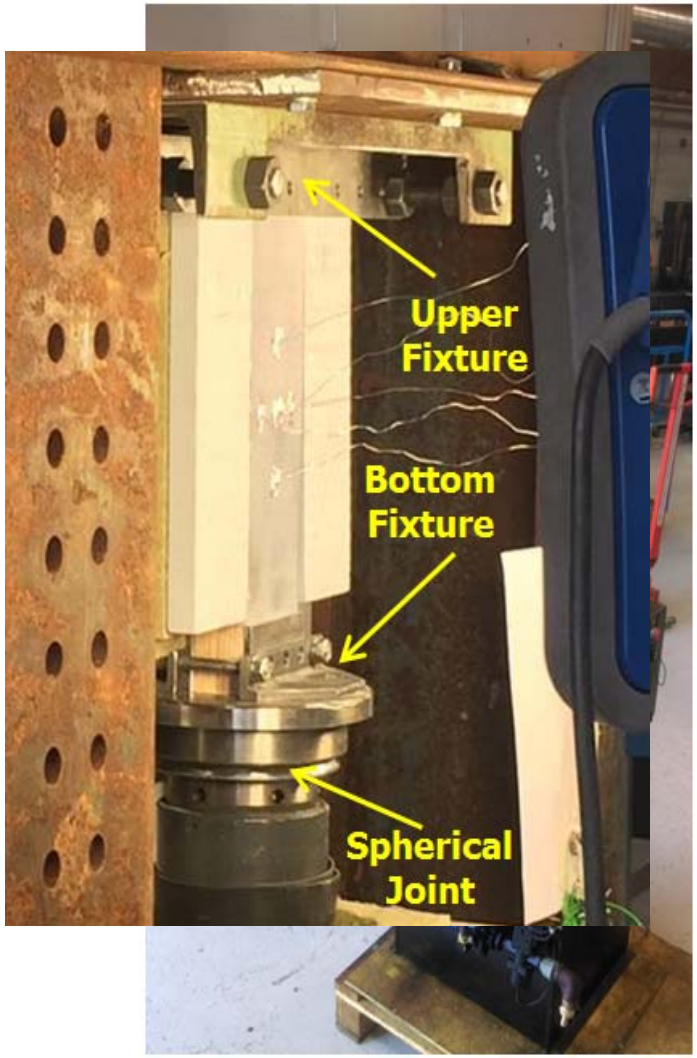
Can replicate the ISO834 curve + application of mechanical loading

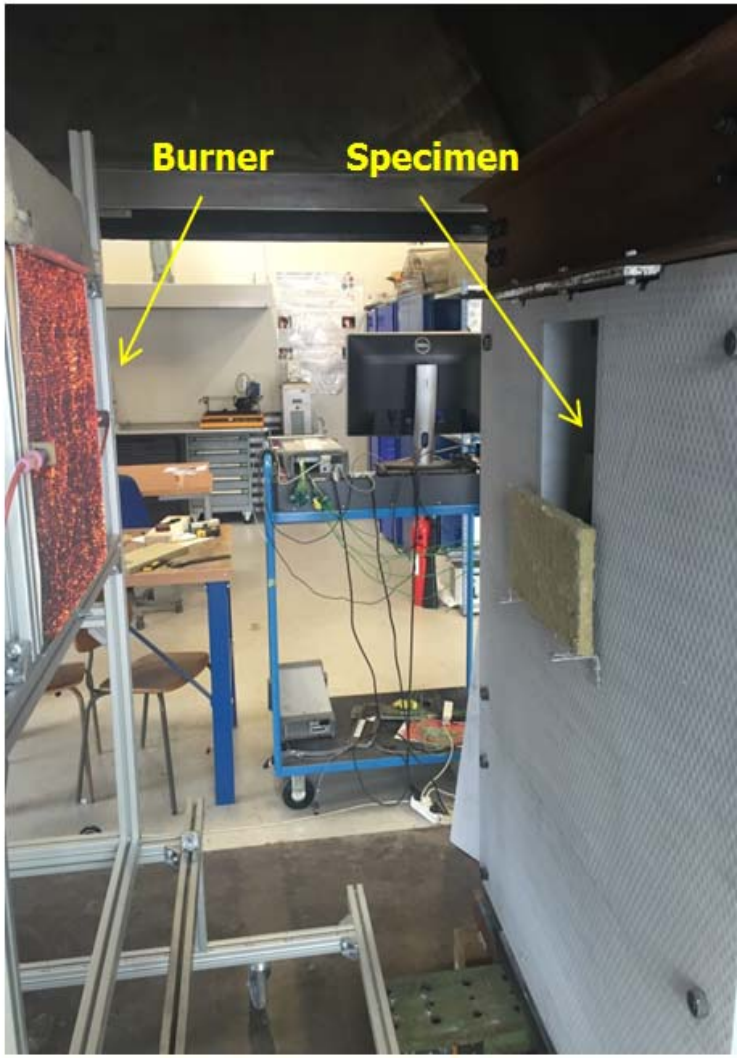


Full scale tests
FTP Code

Costly, Pass or fail tests

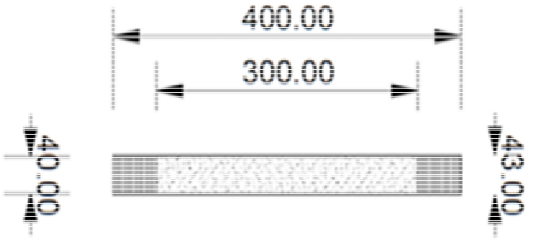
Developed Test Rig (H-TRIS)





Experiments

	Heat Flux	Mechanical Loading
Reference experiments	-	Up to ultimate failure (reference)
Constant Heat Flux experiments	3.6 kW/m^2	10 % of the ultimate load of the reference
	3.6 kW/m^2	20 % of the ultimate load of the reference
	3.6 kW/m^2	40 % of the ultimate load of the reference
	3.6 kW/m^2	60 % of the ultimate load of the reference
	3.6 kW/m^2	70 % of the ultimate load of the reference
ISOcurve experiments	a) 1.3 kW/m^2 for 1039 sec **followed by:** b) 3.6 kW/m^2 for 400 sec	15 % of the ultimate load of the reference



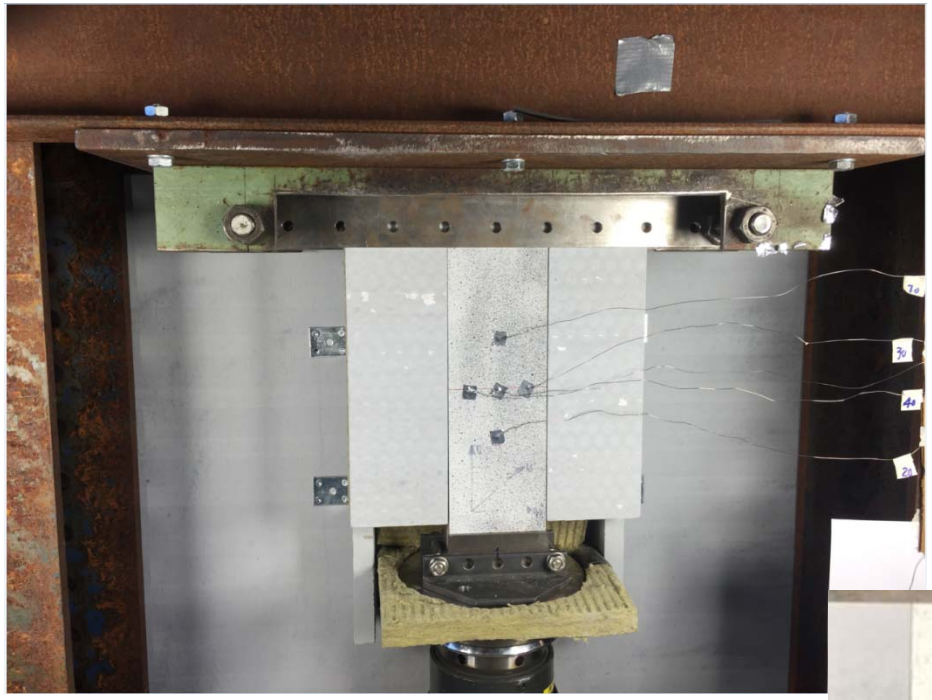
Minimum **3 Specimens** per case

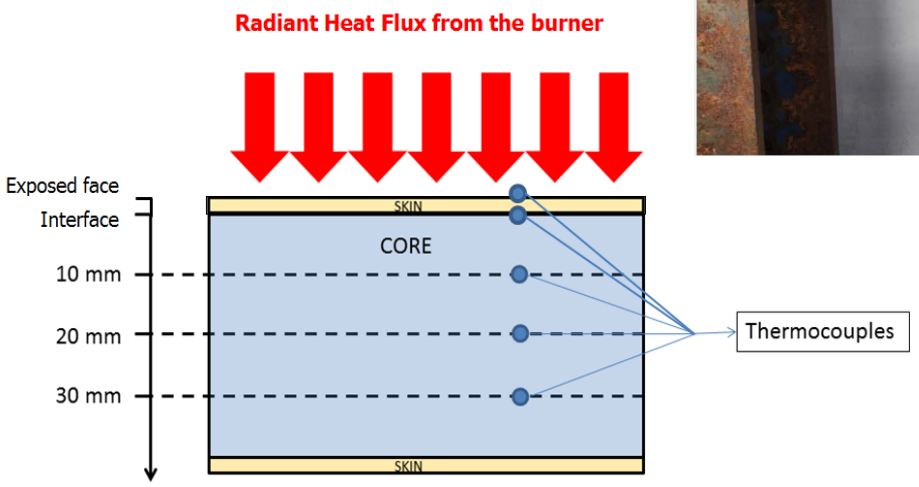
-Glass /Epoxy skin

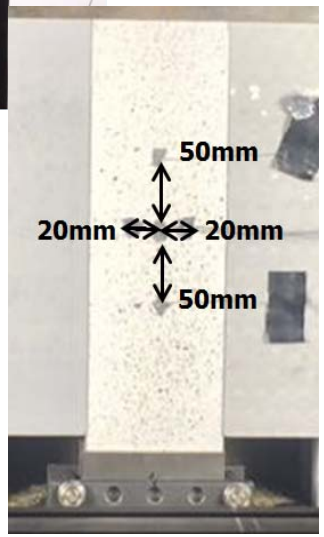
-PET core

Instrumentation

- **Recorded:**
- Displacement
- Load
- Deflections (DIC)
- Temperature (5 locations)



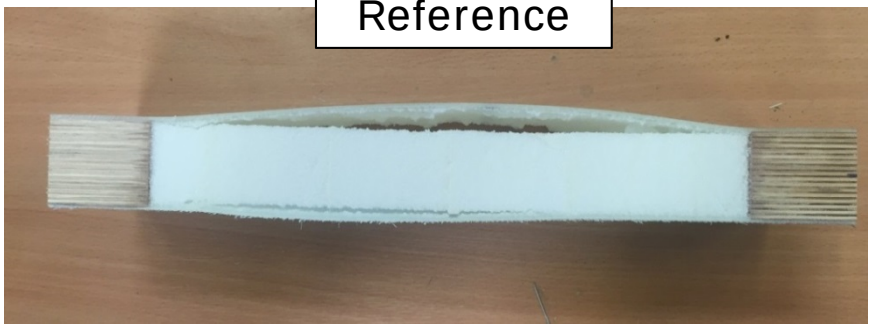




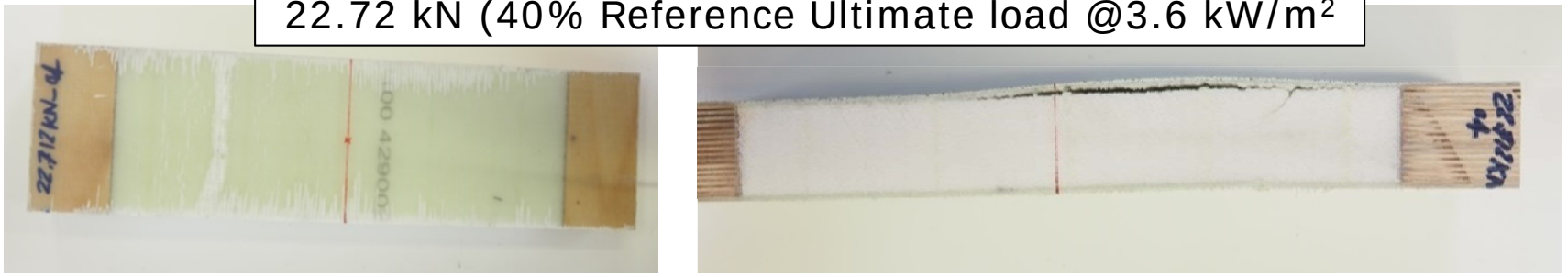
Results

- **Reference load:** 56.8 kN
- Failure due to debonding
- Local delamination preceded failure
- Excellent repeatability for the CHF tests

Reference

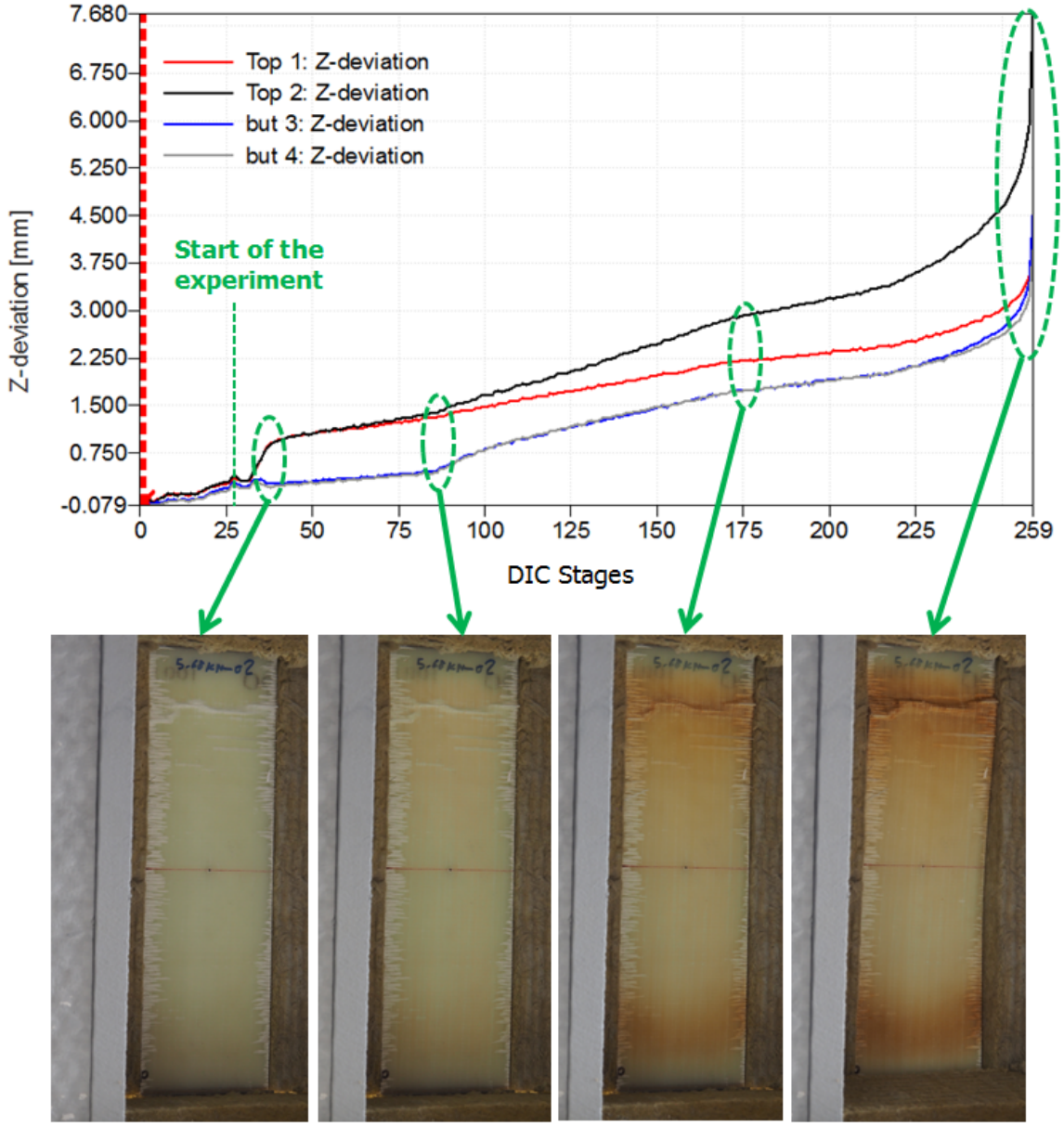


22.72 kN (40% Reference Ultimate load @3.6 kW/m^2



5.68 kN (10% Reference Ultimate load @3.6 kW/m^2

Results



- Association of Deflections to the initiation and evolution of damage

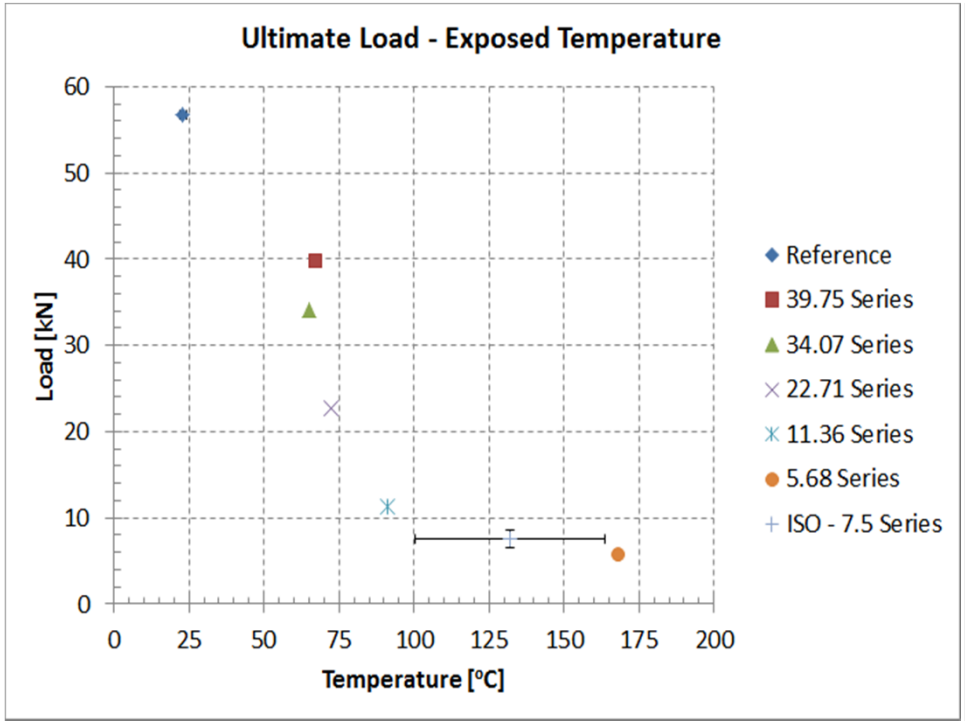
Results

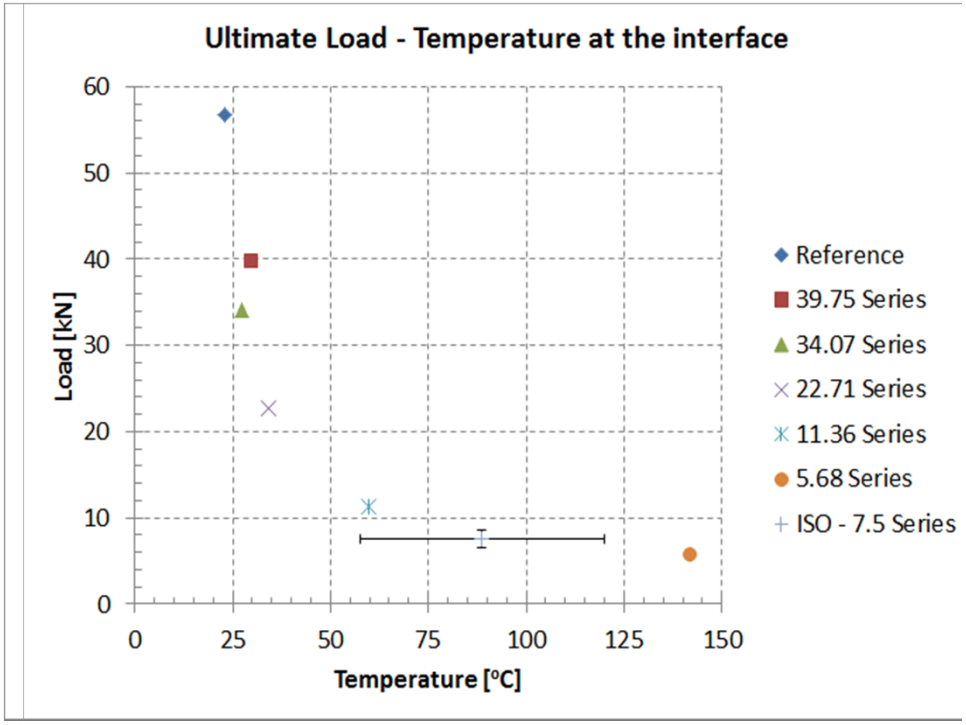
- Ultimate load bearing Capacity as a function of temperature (CHF):

a) At the exposed face

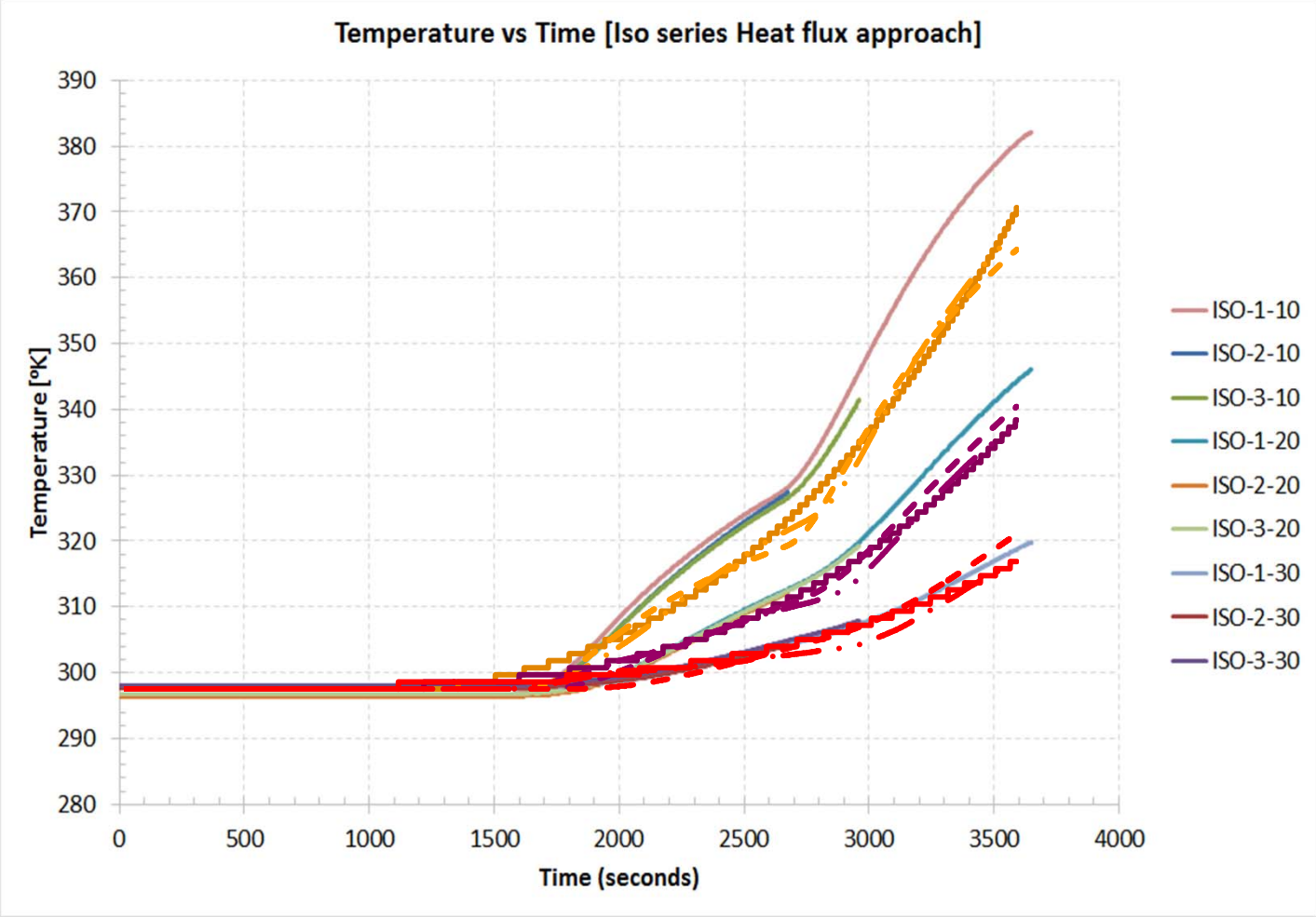
b) At the interface

- Excellent repeatability for the (CHF), a clear trend is visible
- Poor repeatability for the ISO tests





Results


Temperature vs Time [Iso series Heat flux approach]
Temperature [°K]
390
380
370
360
350
340
330
320
310
300
290
280
0
500
1000
1500
2000
2500
3000
3500
4000
Time (seconds)
ISO-1-10
ISO-2-10
ISO-3-10
ISO-1-20
ISO-2-20
ISO-3-20
ISO-1-30
ISO-2-30
ISO-3-30

Conclusions

- **Experimental Campaign**
- Good repeatability for the majority of the conducted experiments
- Ultimate failure due to debonding (strong dependency to the Temperature at the interface)
- Better understanding of the damage initiation and evolution
- A simple phenomenological approach for the selected material which looks promising
- The ISO834temperature curve could be successfully reproduced by the H-TRIS
- Significantly lower operational cost and reduced testing time compared to furnace tests
- **Remarks**
- Complicated failure mechanisms which are interdependent and competing
- Dedicated fracture mechanics tests are needed to investigate in depth the potential of the simplified approach

Thank you for your attention!