



*Long term experience with  
polypropylene thermal  
insulation on subsea pipelines*



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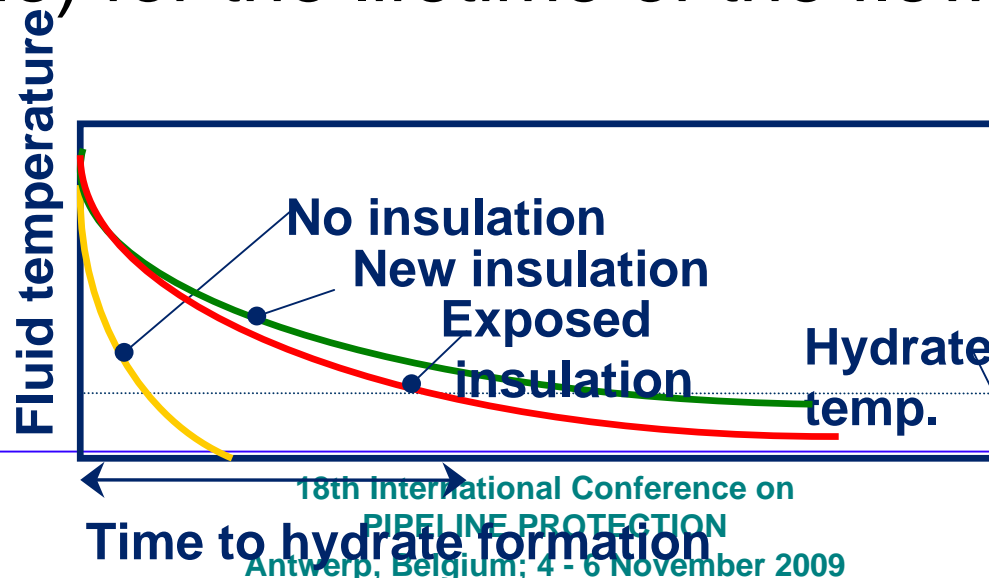
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- Use of Polypropylene Foam Insulation
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## Functional requirements for thermal insulation

Provide corrosion protection for the lifetime of the coated steel flowline

Provide the required thermal insulation (U-value) for the lifetime of the flowline



## Pipe steel types that have been insulated

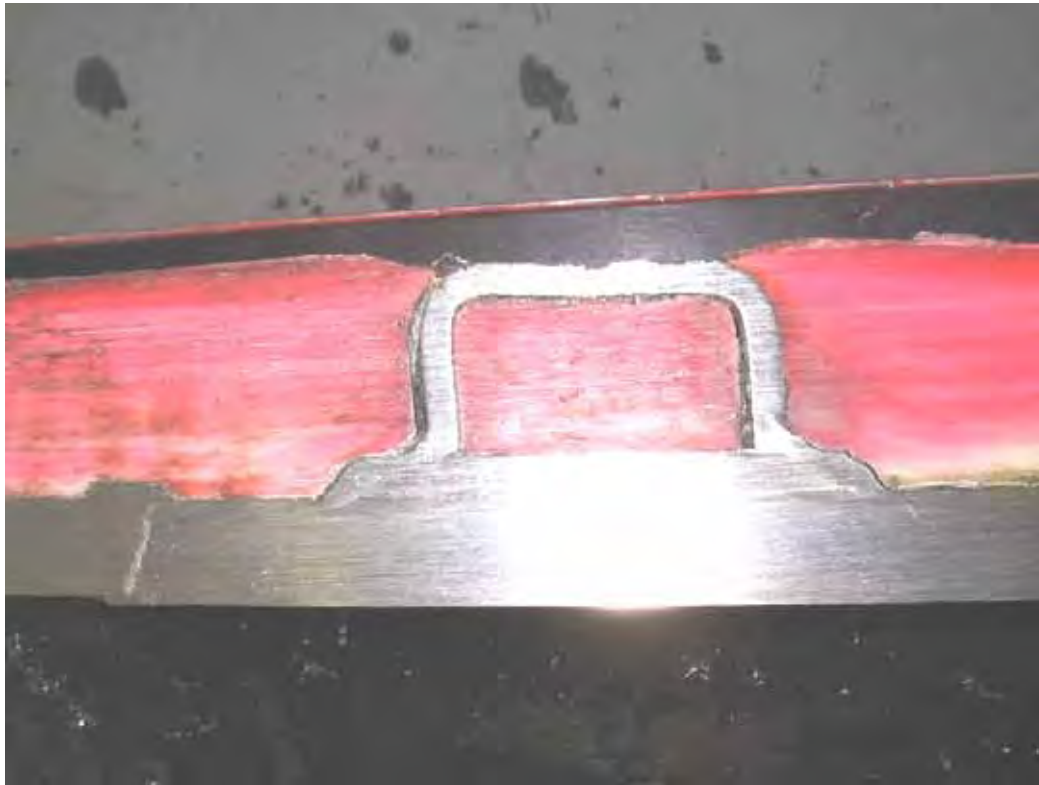
- ◆ Carbon steel
- ◆ SMSS (super martensitic stainless steel) 13 % Cr
- ◆ Carbon steel with stainless steel liner (Bubi)
- ◆ Clad steel (carbon steel with metallurgically bonded stainless steel liner)
- ◆ Duplex stainless steels

## Field joint types

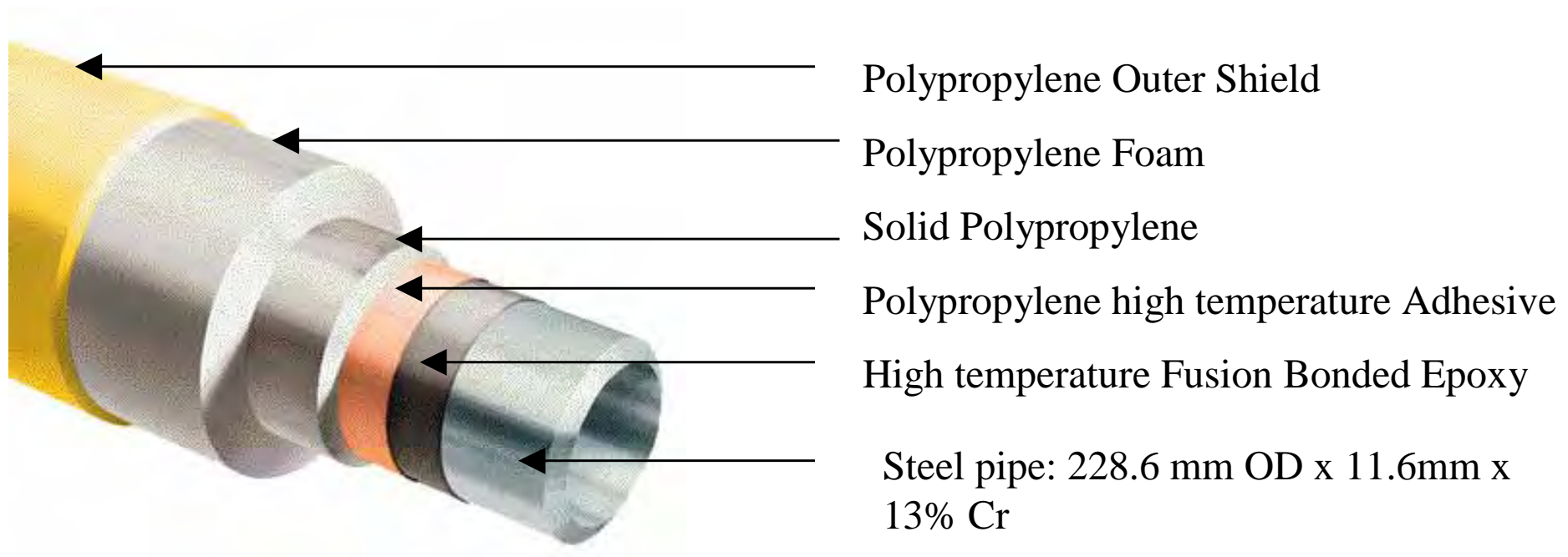
Field joint type	When used	Parent coating
Injection moulded polypropylene	Reeling / S-lay / onshore / offshore tie-in	Polypropylene foam
Flame spray polypropylene with polypropylene half shells	Offshore tie-in and field joints	Polypropylene foam
Solid polyurethane	S-lay / Stalk tie in (reeling)	Polypropylene (low temperature applications) Polyurethane



## Anode attachment – for cathodic protection and direct electric heating (DEH)



## Five layer polypropylene foam system

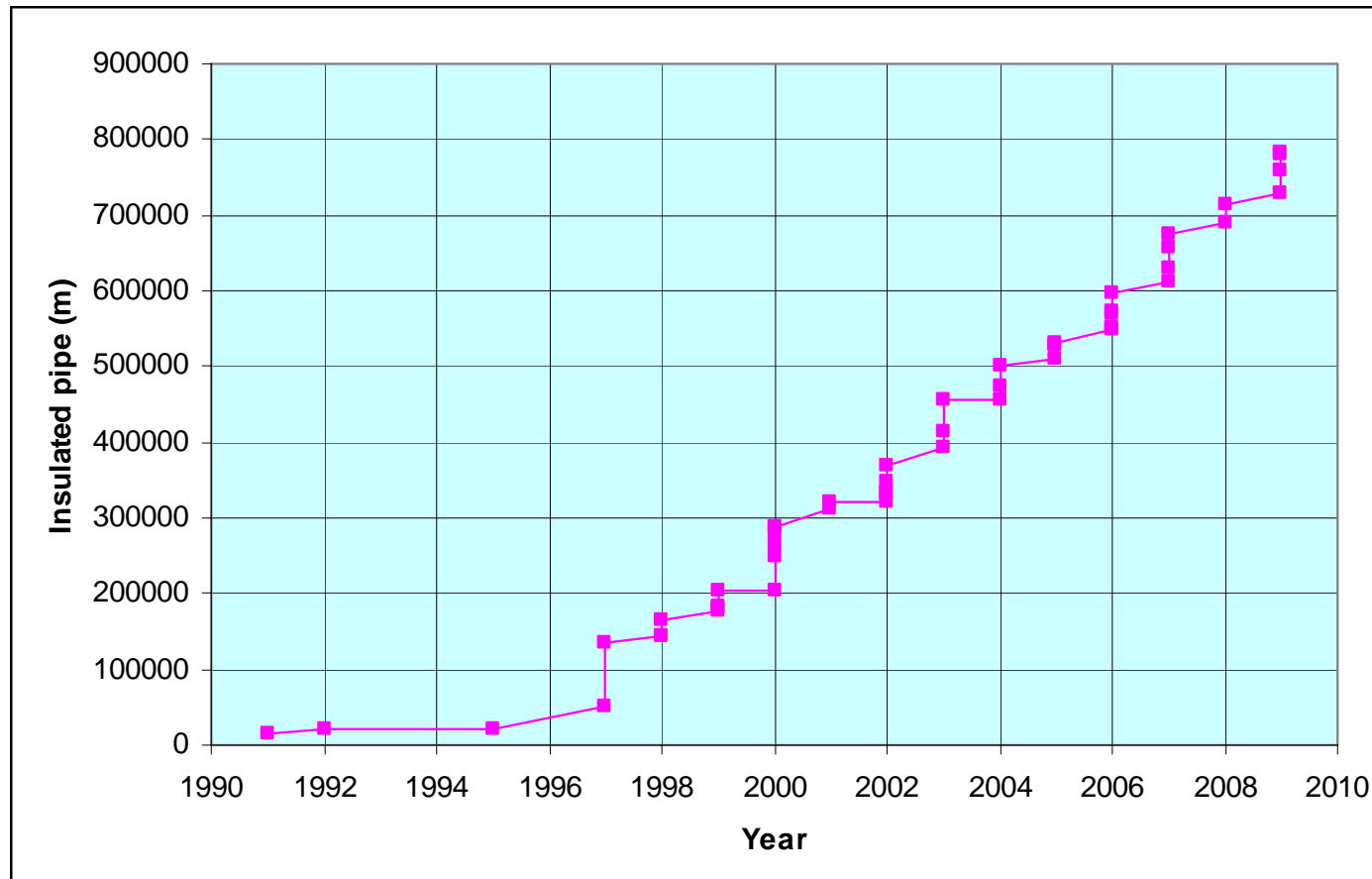


## Polypropylene foam insulated pipelines in Statoil

Feature	Ranges
First installation	1991
Length installed	784 000 m
Diameters insulated	200 – 500 mm / 8-20 “
Water depths	82 - 390 m
Design temperatures	65 – 155 °C
U-values	3 – 8 (W/m <sup>2</sup> K)
Highest thickness	78.3 mm
Installation methods	S-lay and reeling

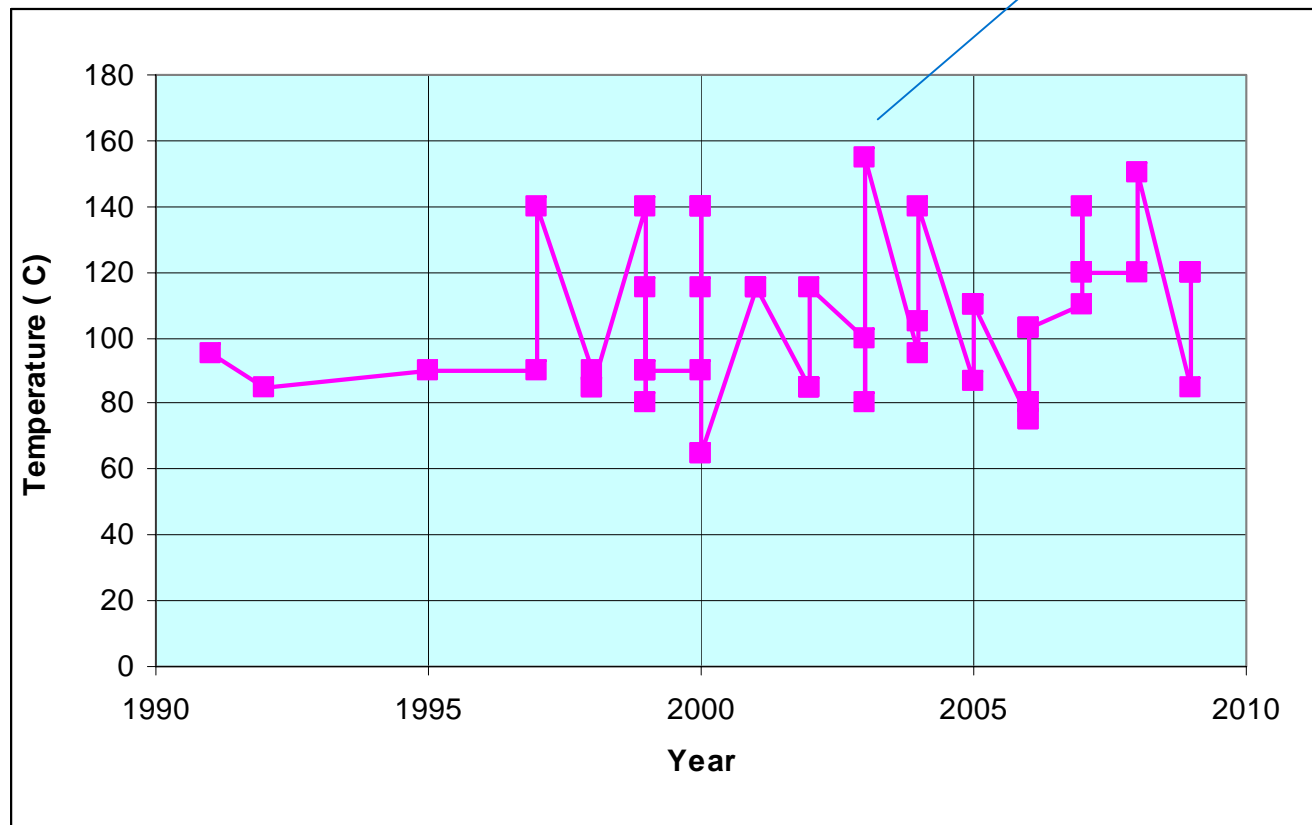


## Installed pipelines with polypropylene foam insulation in Statoil

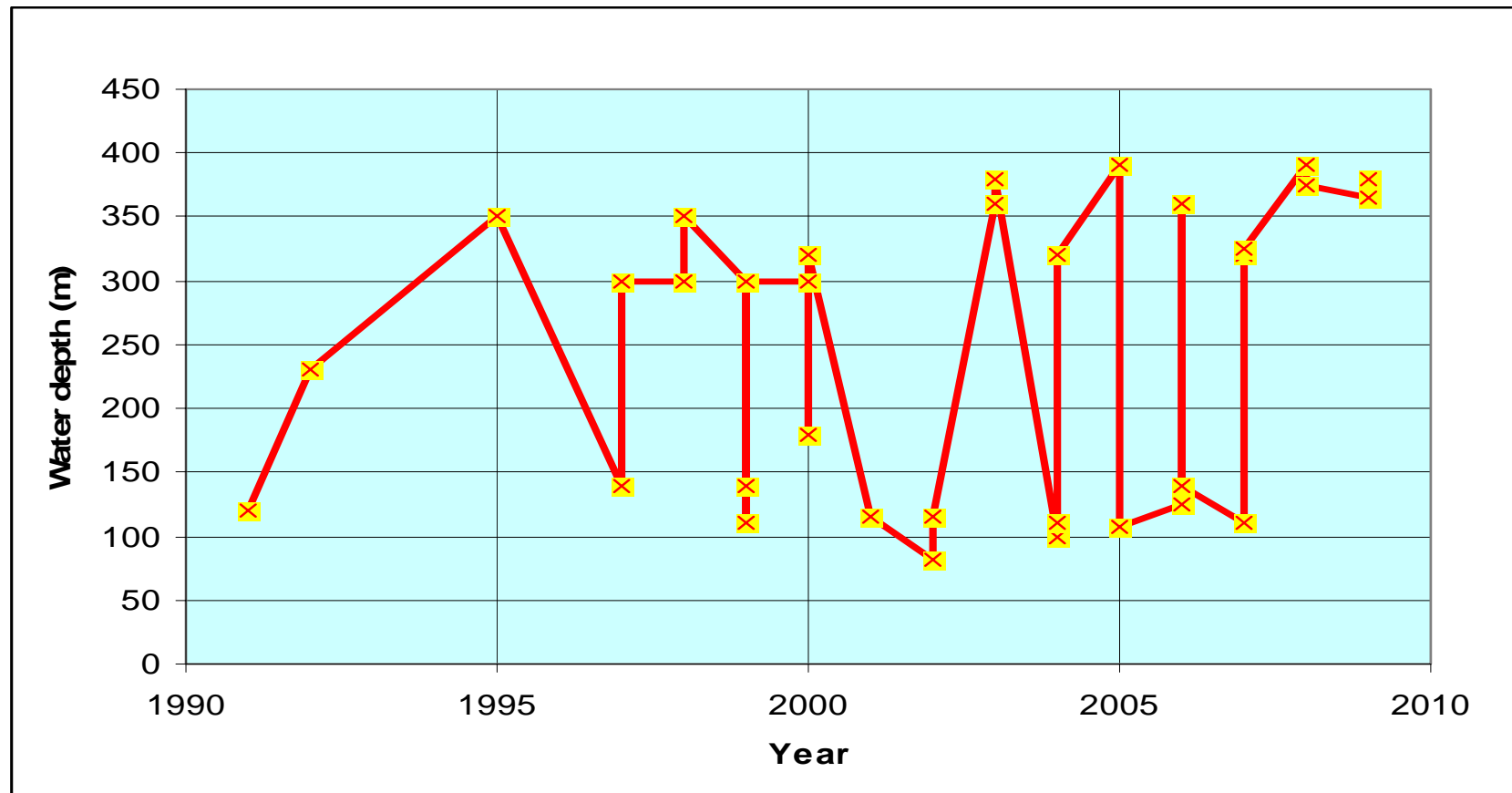


# Design temperatures for the subsea flowlines

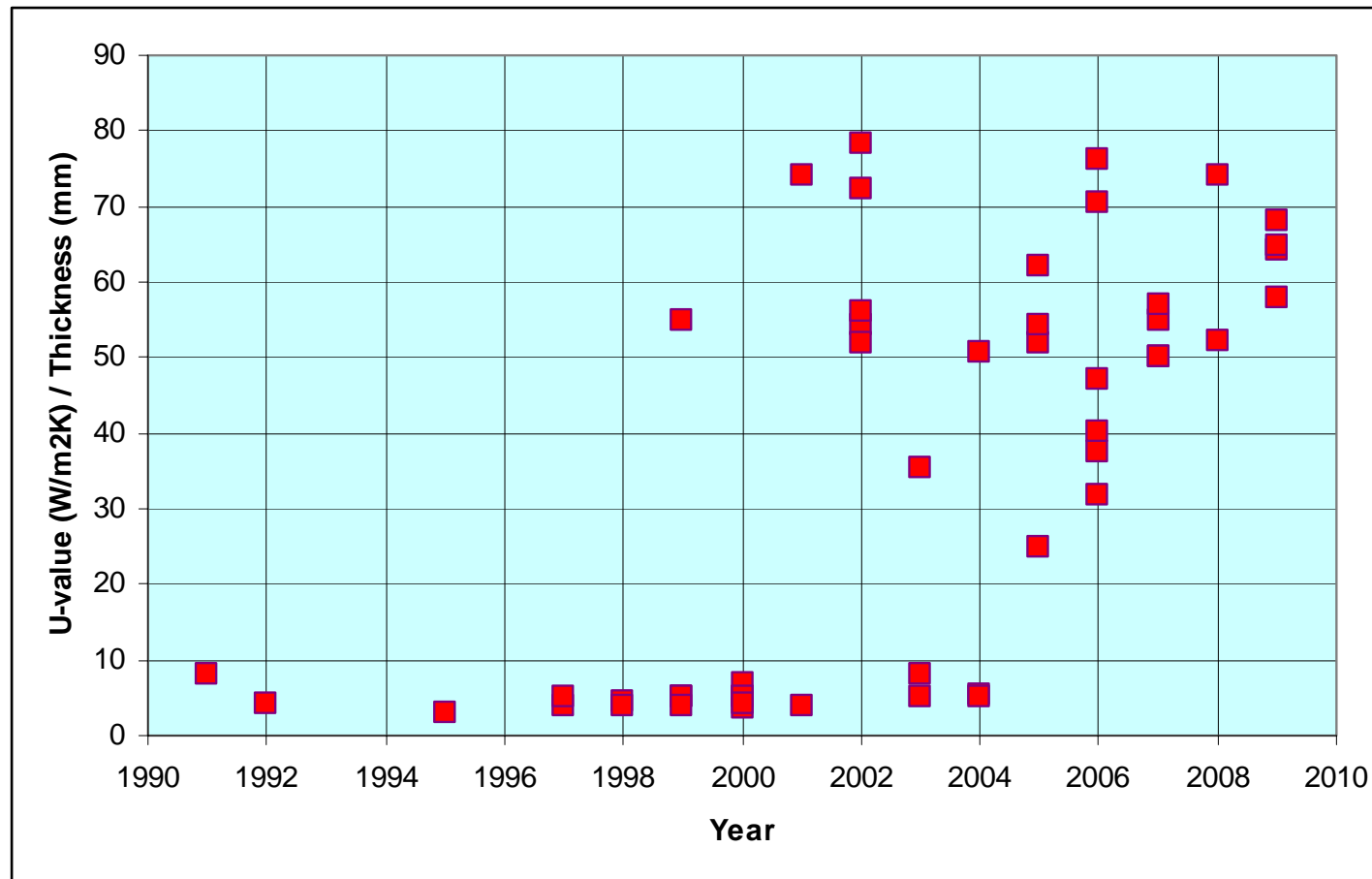
**Kristin**



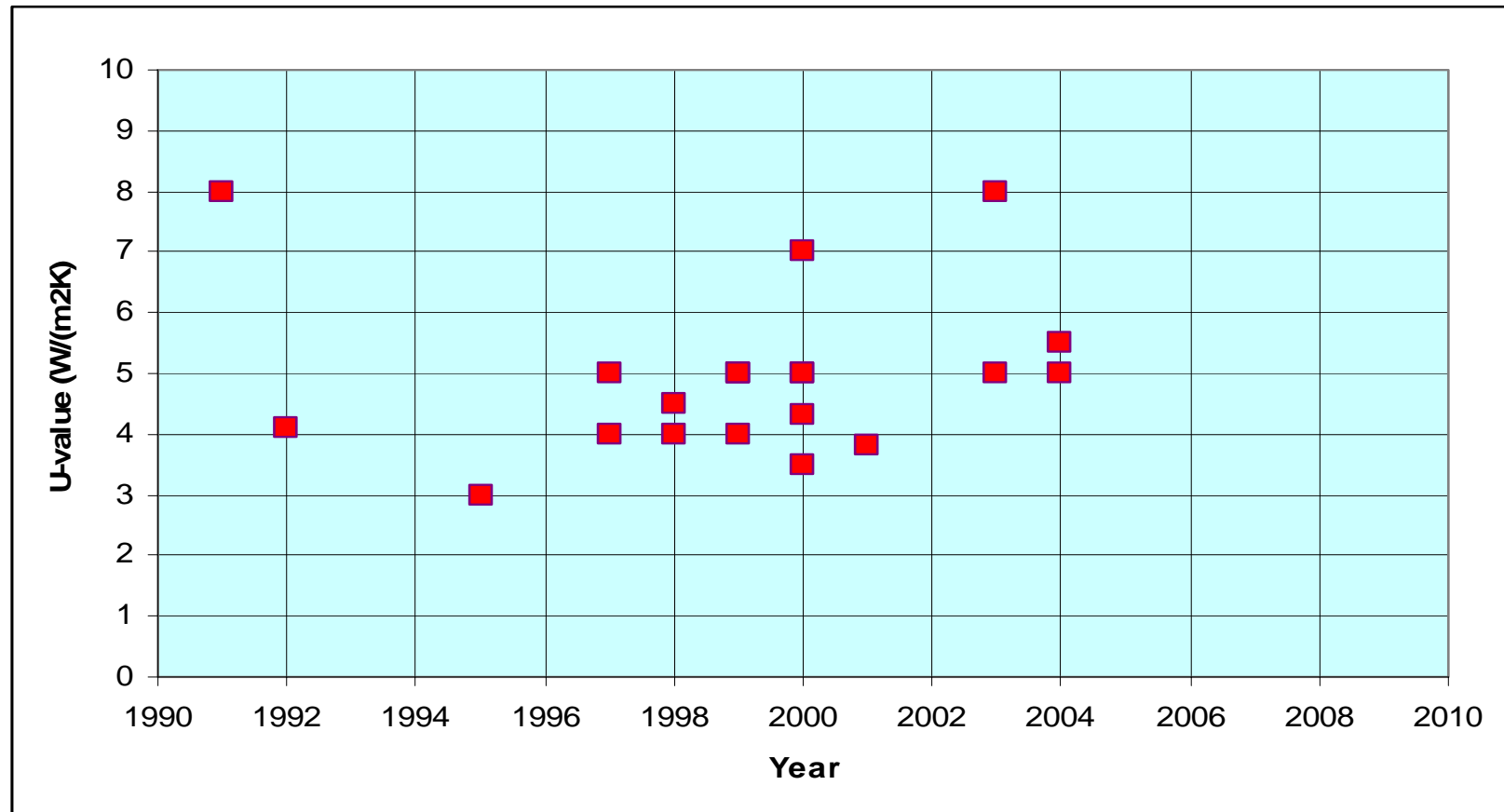
## Water depth of installed pipelines



## U-values ( W/m<sup>2</sup>K) or coating thickness



## U-values for some of the flowlines



## Insulation application discrepancies

- ◆ Density outside the required specification
- ◆ Eccentric placement of steel pipe in foam
- ◆ Lack of bond between the three-layer coating and insulation
- ◆ Cracking of external weight coating
- ◆ Irregular outer surface from unstable process conditions
- ◆ Cracking of factory coating due to less flexible FBE
- ◆ Cracking of factory coating and PP field joint
- ◆ Cracking in coating at the spool base due to roller boxing

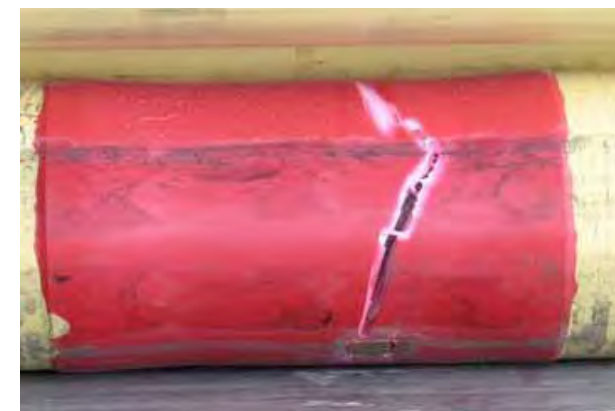
## High temperature qualification – 155 C

- A temperature – time profile for the production from the reservoirs
- The flowlines were used as heat sinks to lower the well stream temperature to acceptable 132 °C for the risers and production facilities
- A close to solid PP insulation system
- Flow assurance based on direct electric heating (DEH)
- Special attention to anode connections to keep water away from SMSS surface



## Field joints and installation

- ◆ Cracks in injection moulded polypropylene field joints
- ◆ Cracks in tie-in joints both injection moulded polypropylene and polyurethane
- ◆ Cracks in the parent insulation material
- ◆ Buckling of steel pipes in field joints due to strain concentration associated with the coating
- ◆ Cracks in connection with anode brackets





## In-service experience – hydrogen cracking



## In-service experience – polyurethane field joints



## Flame spray polypropylene





## Key to successful projects

- ◆ Direct involvement of own personnel with the pipe coater, i.e. increased internal knowledge base
- ◆ Quality issues has been solved between pipe coaters and end user
- ◆ All technical discussions has been solved between the end user and pipe coater
- ◆ High quality of the final deliveries



## Conclusions

PP based foam has been the base case for most pipeline projects with insulation requirements since the first installation in 1991

The system was further developed and qualified for high temperature applications through an active involvement with the coating system supplier

The in-service operational experience after installation has been excellent.



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