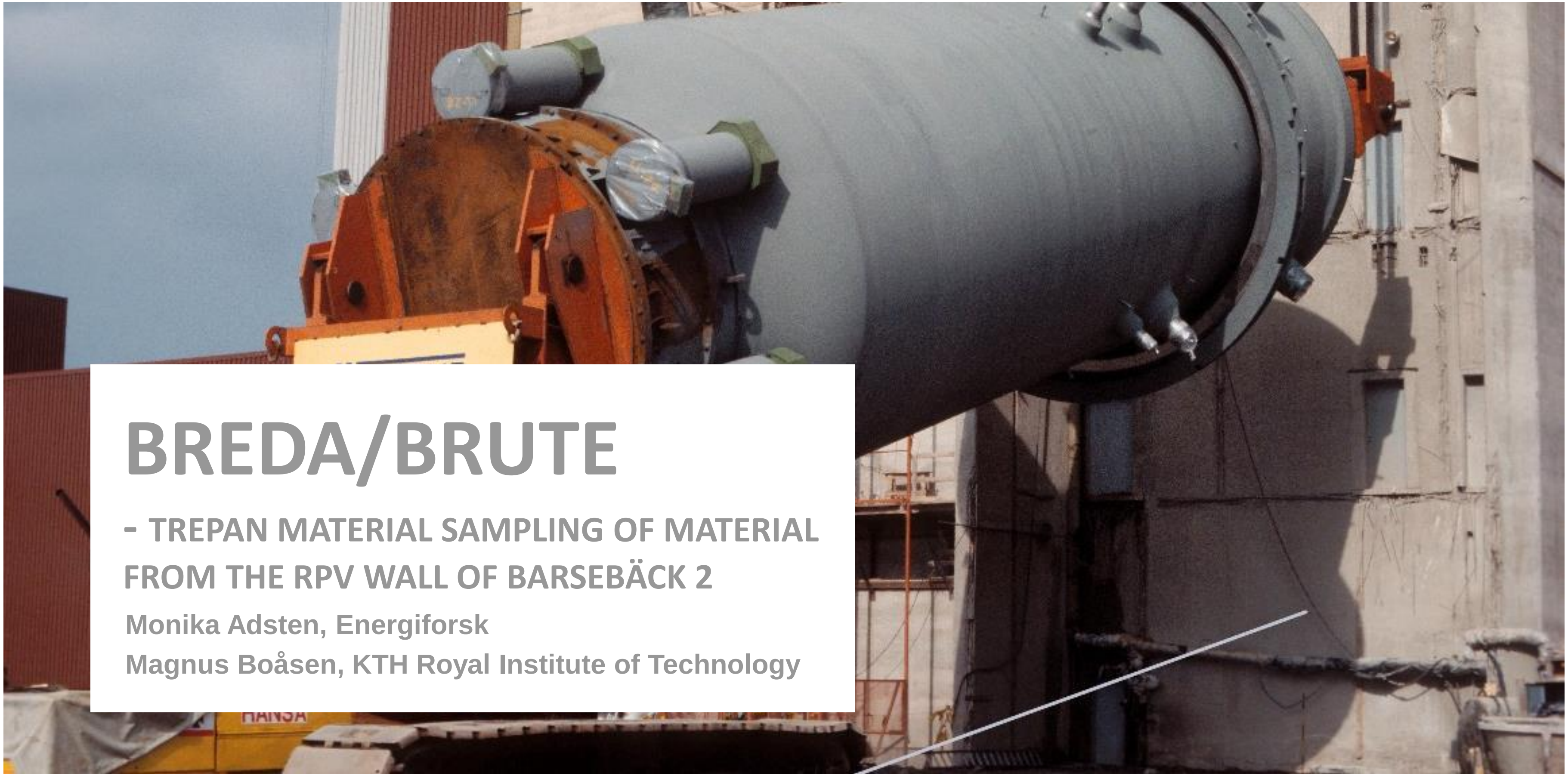

BREDA/BRUTE

- TREPAN MATERIAL SAMPLING OF MATERIAL FROM THE RPV WALL OF BARSEBÄCK 2

Monika Adsten, Energiforsk
Magnus Boåsen, KTH Royal Institute of Technology

Energiforsk

Motives

Ensuring safe operation and the durability of the reactor pressure vessel is one of the most important tasks to enable Long Term Operation

- Status of the RPV and possible degradation mechanisms
- Full surveillance program covering expected time of operation
- Availability of the right competence
- Up-to-date with latest research
- Scientifically based information to owners, authorities and the public

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Scope

- Determine the material/structure-parameters and chemical composition in welds in reactor pressure vessel and reactor pressure vessel head
- Compare analyses and tests of the harvested material to the surveillance material from Barsebäck 2
  - What is the impact of the surveillance sample size?
  - What about the weld material properties compared to vessel material?
  - What about other differences between RPV and surveillance samples, for example heat treatment?
  - How does that compare to results from other BWR plant surveillance programs?
  - Can Uddcomb RPV:s from BWR:s and PWR:s be included in the same prediction curve?
- Can miniature size samples be used to extend surveillance program?

BWR=Boiling Water Reactor
PWR=Pressurized Water Reactor

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BREDA

Magnus Boåsen's PhD-project financed by SSM and SKC

NKS-projects

BREDA Advisory group with representatives from plants, owner companies and authoritites

1	• **Material sampling** – Harvest irradiated material from the Barsebäck RPV	Ringhals, financed by Swedish NPPs
2	• **Measurements/testing**	BRUTE, Ulla Ehrnsten from VTT, financed by SAFIR
3	• **Evaluation/analysis** - Compare results to corresponding results from surveillance program	BRUTE, Ulla Ehrnsten from VTT, financed by SAFIR
4	• **Synthesis**	Jointly by Swedish and Finnish actors

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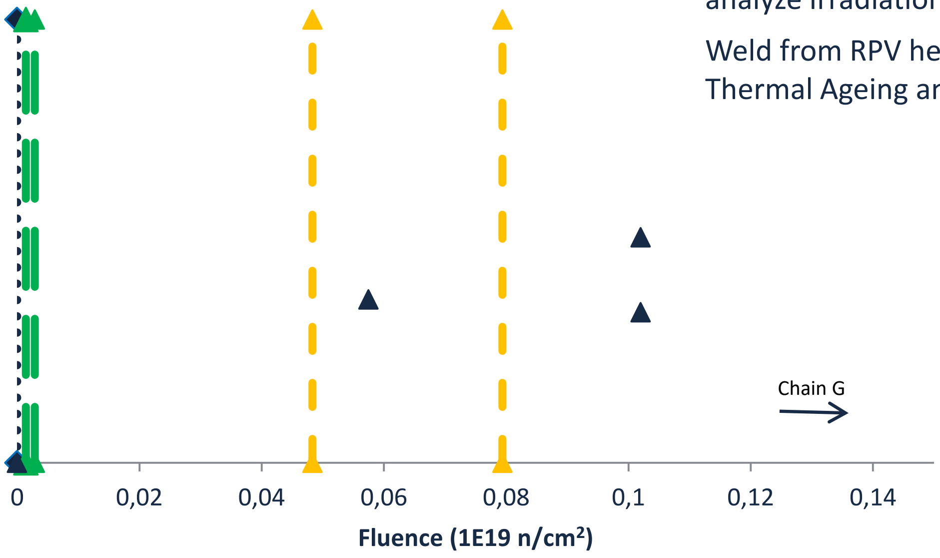
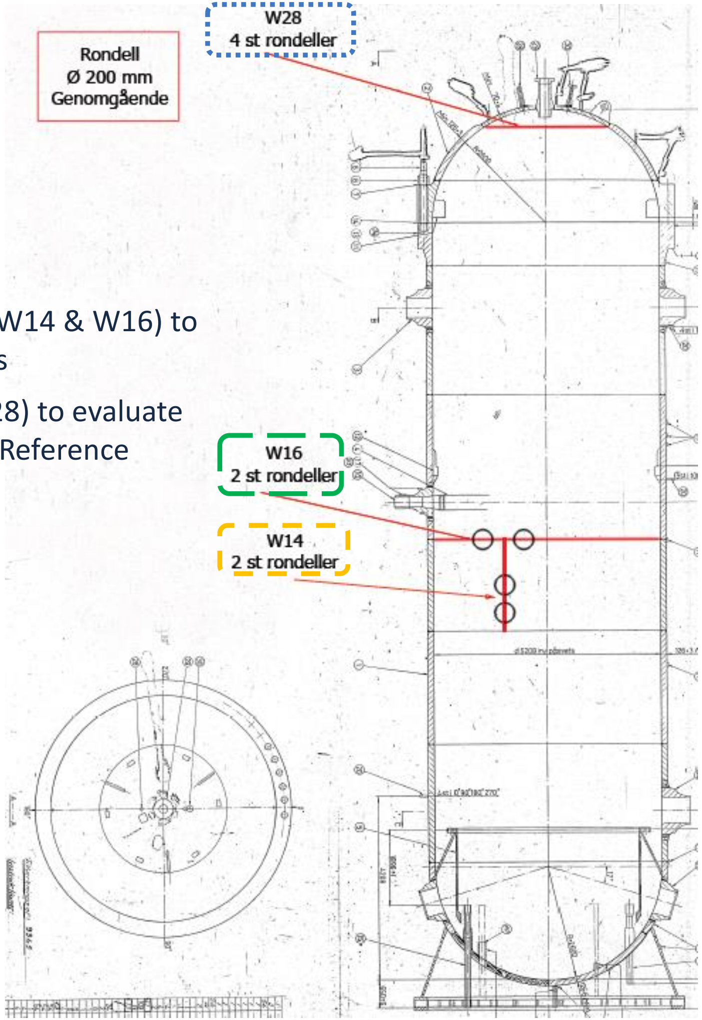
CUT-OUT B2

The unit was operated for 28 years at T=270°C

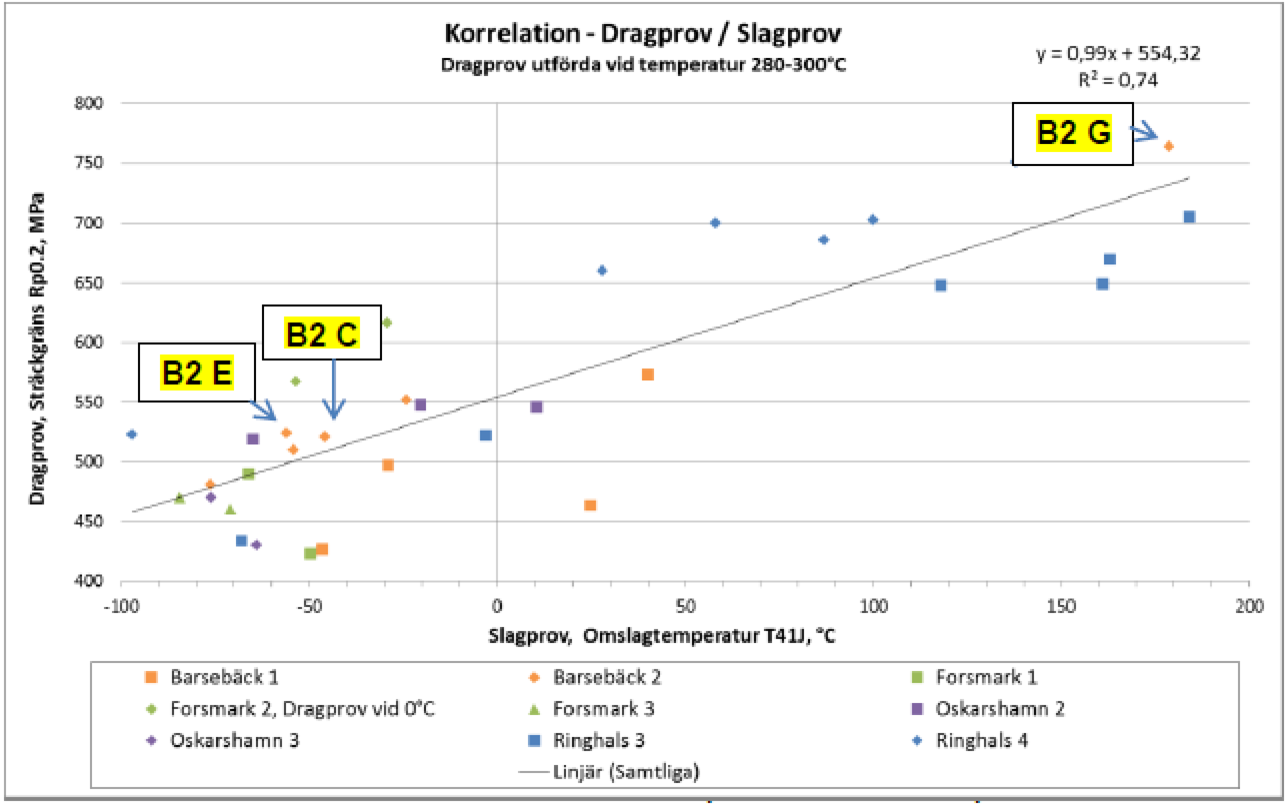


Welds from core region (W14 & W16) to analyze Irradiation effects

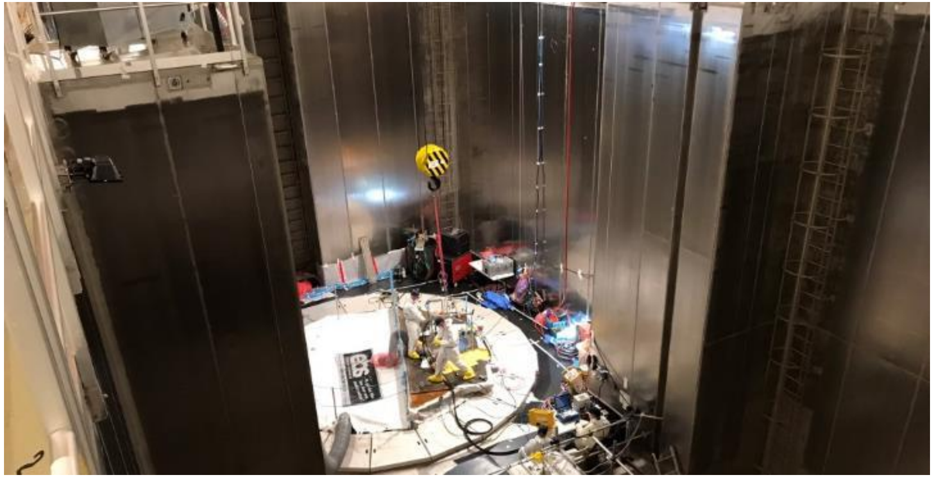
Weld from RPV head (W28) to evaluate Thermal Ageing and as a Reference

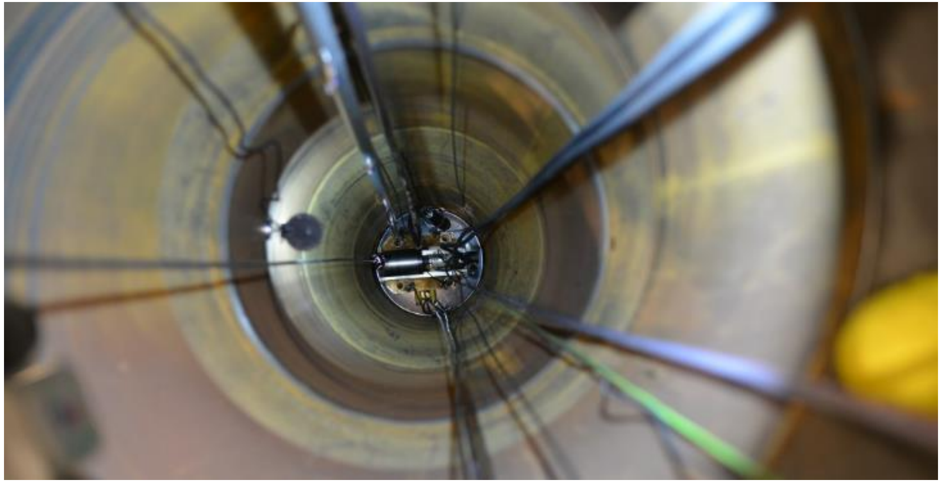


VATTENFALL


Korrelation - Dragprov / Slagprov
Dragprov utförda vid temperatur 280-300°C
y = 0,99x + 554,32
R² = 0,74
B2 G
B2 C
B2 E
Dragprov, Sträckgräns Rp0.2, MPa
800
750
700
650
600
550
500
450
400
-100
-50
0
50
100
150
200
Slagprov, Omslagtemperatur T41J, °C
Barsebäck 1
Barsebäck 2
Forsmark 1
Forsmark 2, Dragprov vid 0°C
Forsmark 3
Oskarshamn 2
Oskarshamn 3
Ringhals 3
Ringhals 4
Linjär (Samtliga)

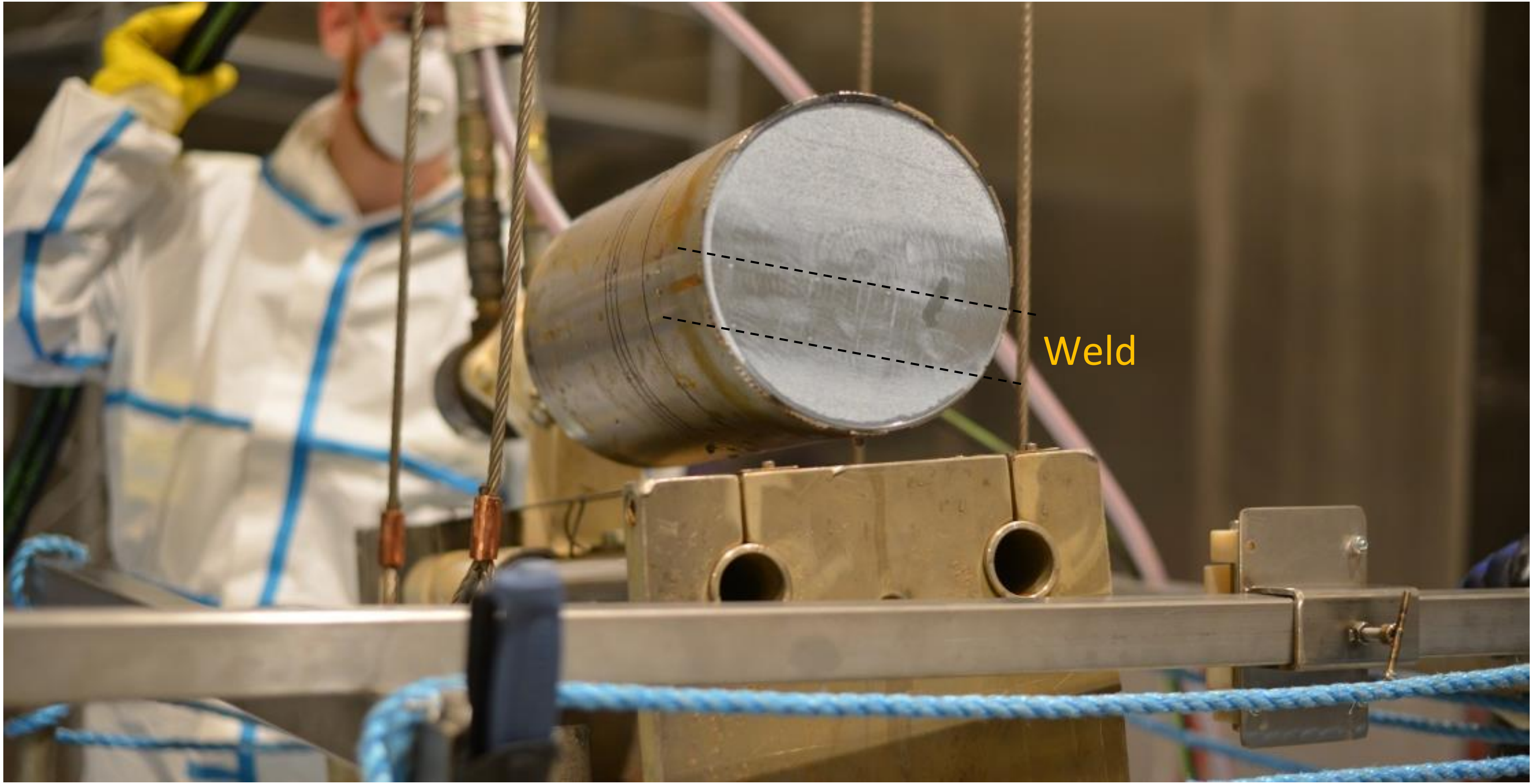
OVERVIEW OF WORK SPACE



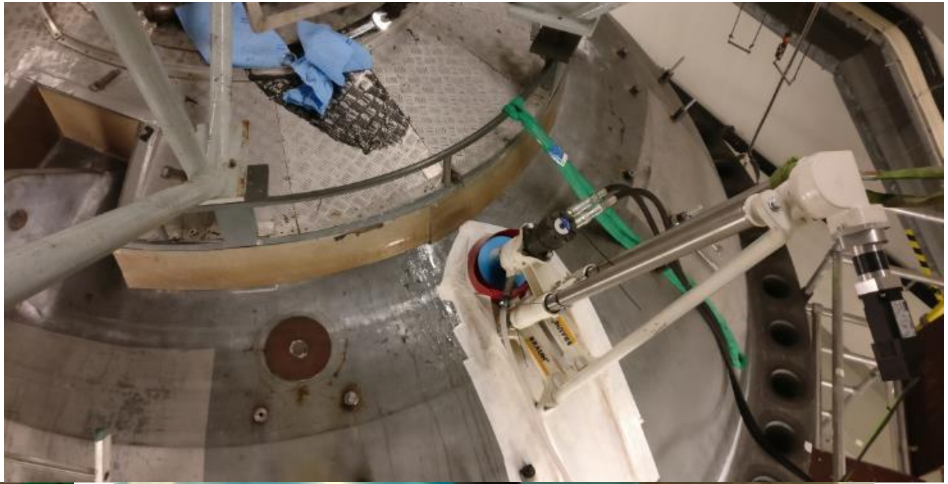


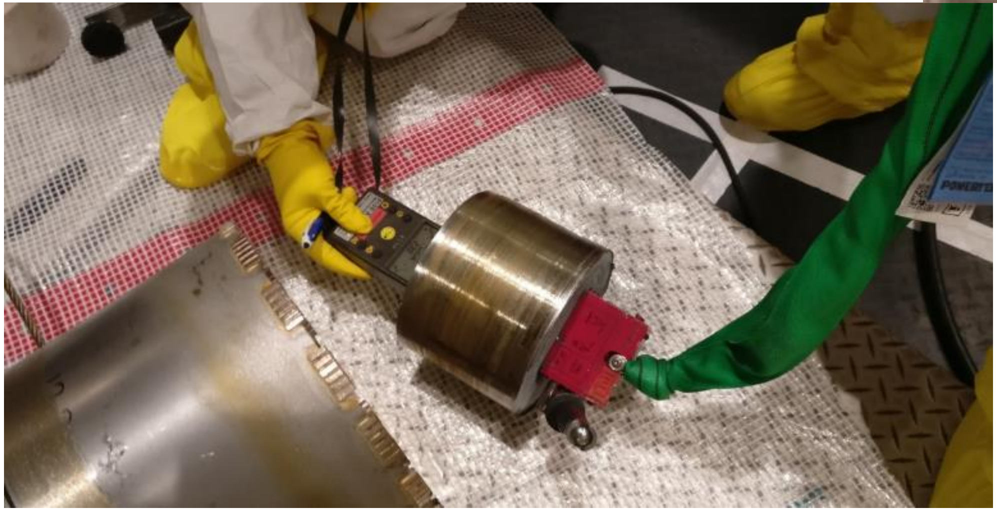
REACTOR PRESSURE VESSEL

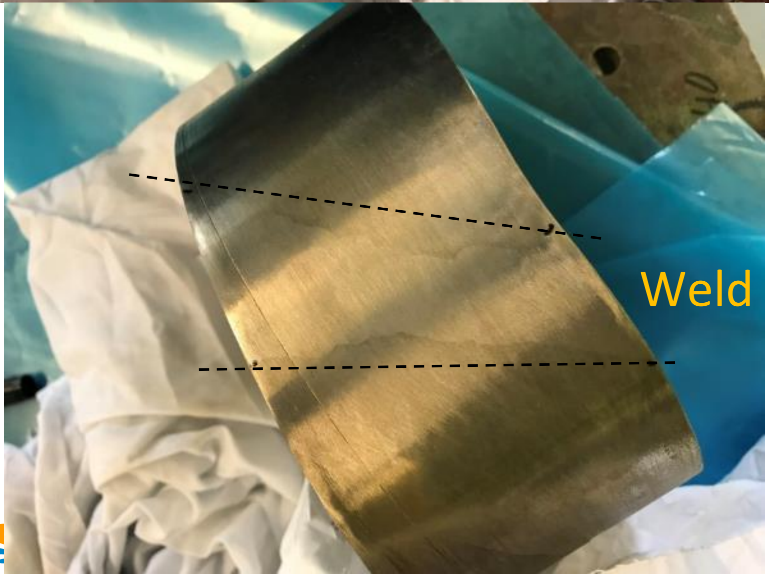
VATTENFALL


Weld

REACTOR PRESSURE VESSEL HEAD





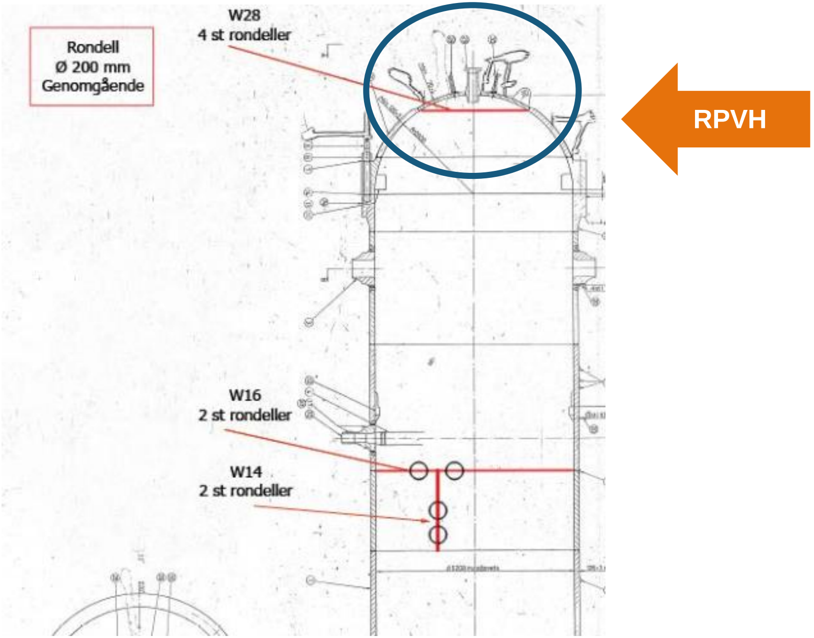


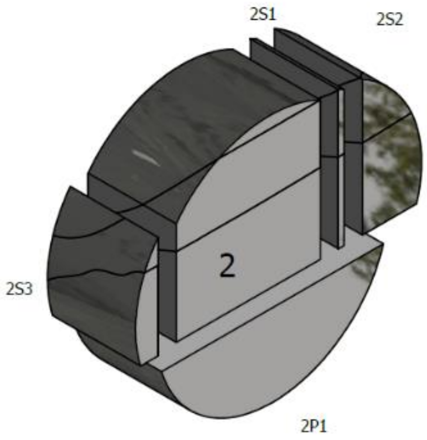
IMPACT TESTING OF RPVH-WELD METAL

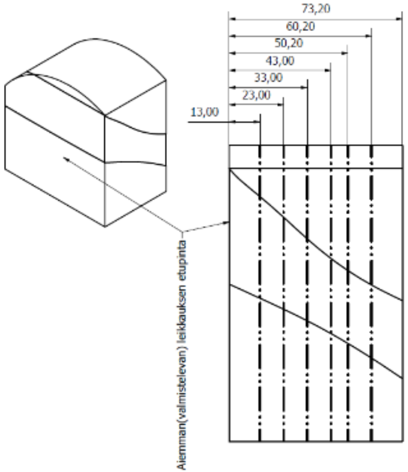
Slides from Pentti Arffmann at VTT

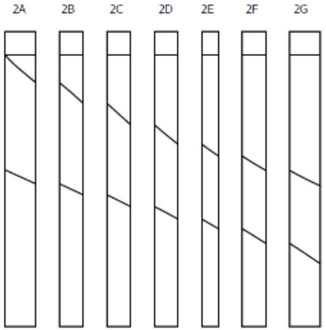
Test material from the RPV head

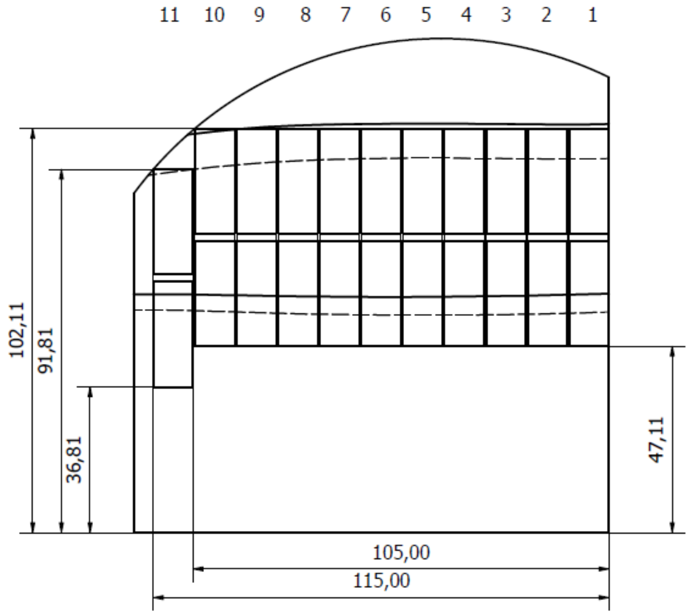
- Non-irradiated → simple to handle
- Possibility to ensure test method for the more valuable irradiated specimens
- Weld is slanted in the trepan → amount is even more limited
  - Specimens were taken from two trepans




2S1
2S2
2
2S3
2P1


73,20
60,20
50,20
43,00
33,00
23,00
13,00
Aiemman(valmistelevan) leikkauksen etupinta

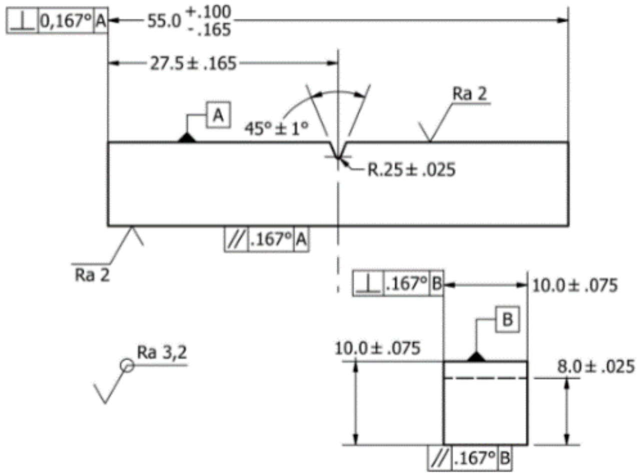

2A
2B
2C
2D
2E
2F
2G


11 10 9 8 7 6 5 4 3 2 1
102,11
91,81
36,81
47,11
105,00
115,00

Charpy V impact testing

- Charpy V specimen
  10x10x55 mm

- Manufactured using Electric Discharge Machining



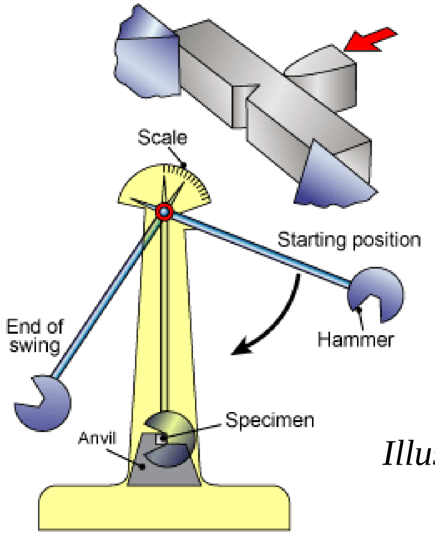
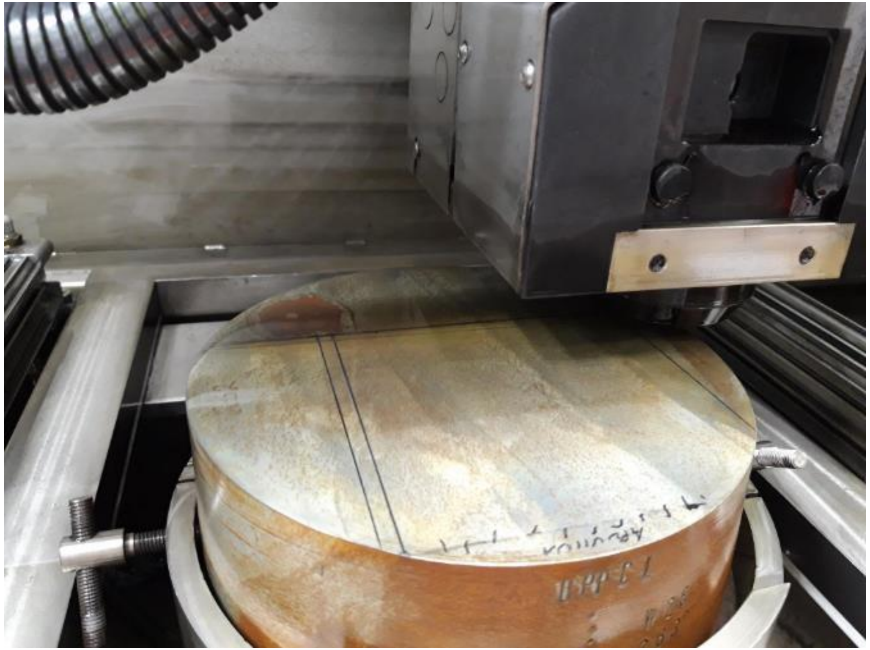
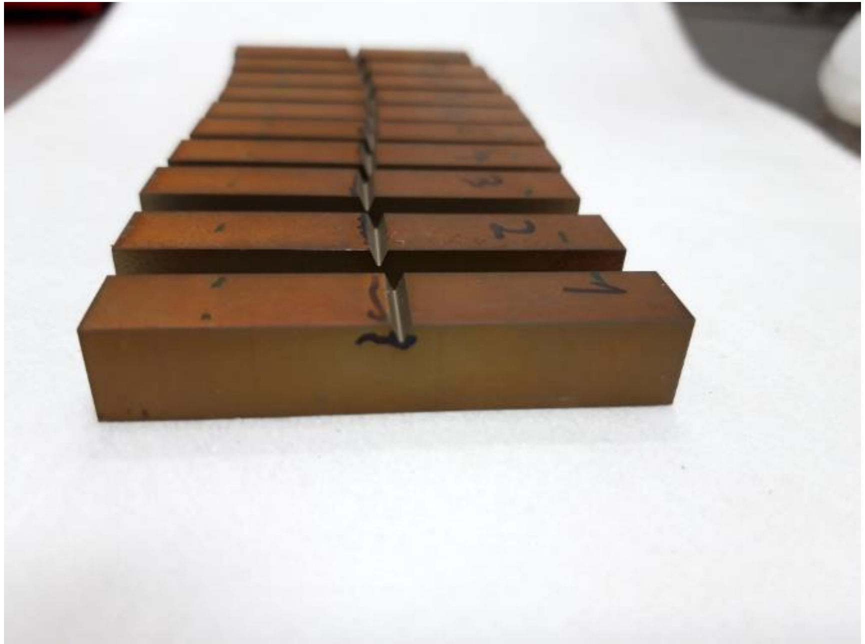


Illustration from TWI





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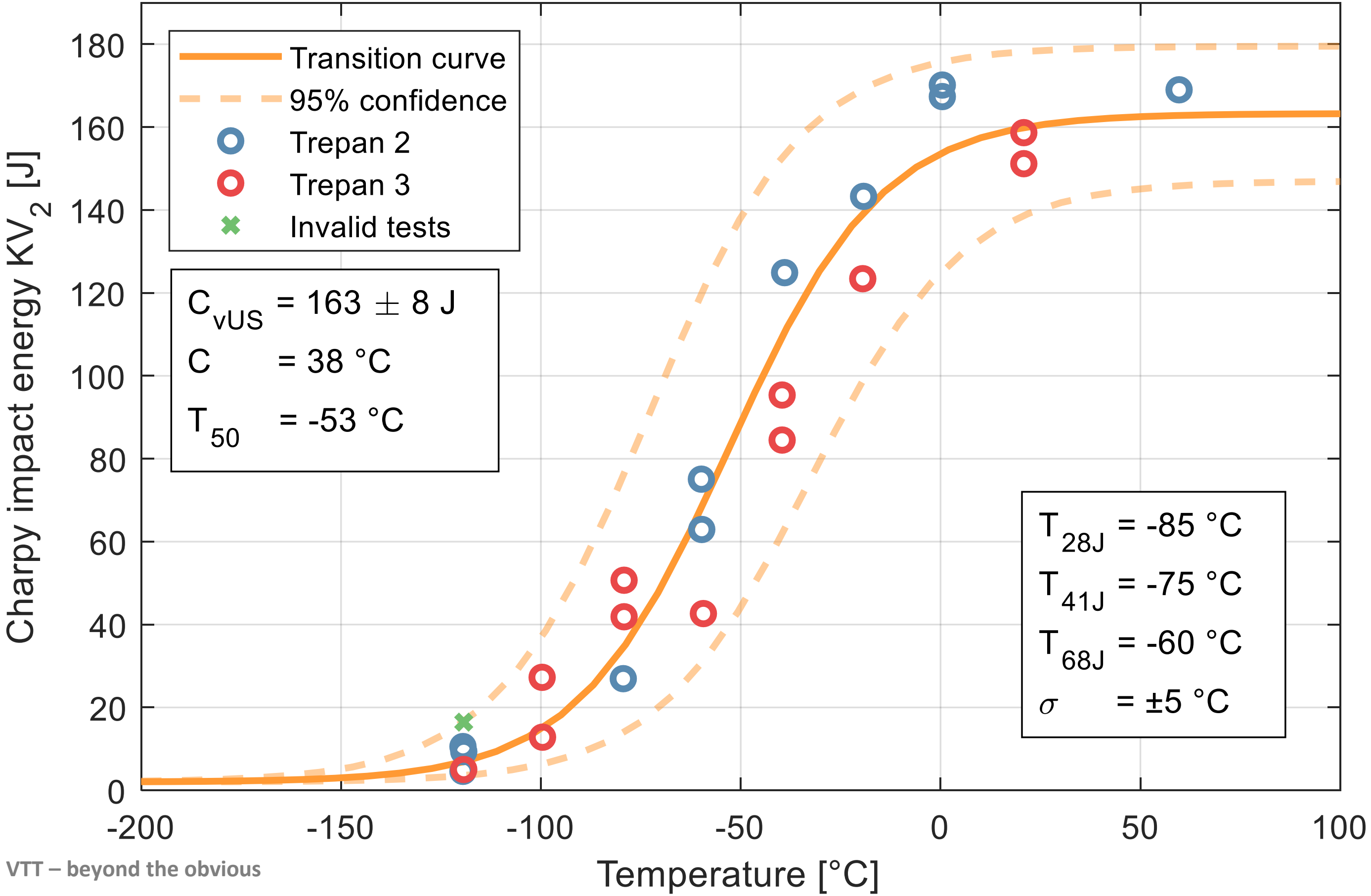
Impact energies form a clear transition curve



Baseline tests from Studsvik

Reported by Studsvik in 1990

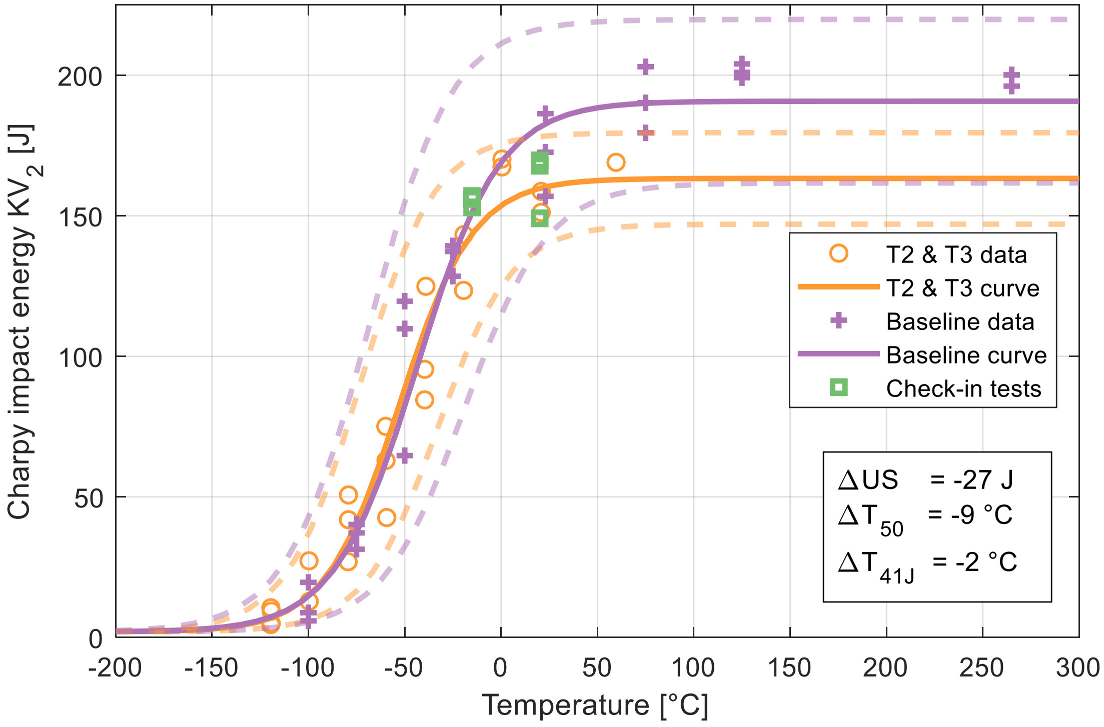
Chemical composition slightly different from measurement in BRUTE

ELEMENT	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Co
BASE LINE	0.084	0.22	1.53	0.011	0.004	0.13	0.45	1.47	0.064	0.008
B2 W28	0.057	0.15	1.43	0.008	0.007	0.03	0.41	1.47	0.06	0.02

Comparison to baseline results

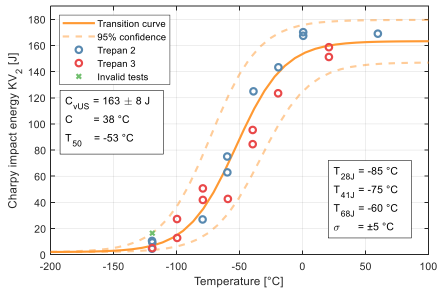
No shift in the transition temperature compared to baseline tests!

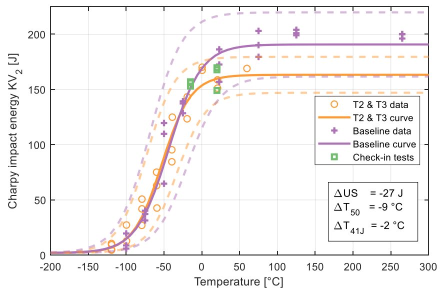
- ΔT 41J = -2°C, while σ = ±5°C
- No thermal embrittlement
- Possible decrease in upper shelf energy
- Good agreement with check-in data



Conclusions of initial testing

- New facilities at VTT are up and running
- No shift in the transition temperature
  - ΔT 41J = -2°C, while σ = ±5°C
  - >> No thermal embrittlement
- Upper shelf impact energy has decreased by 27J (approx. 15%)
  - Chemical composition different in baseline material
    - Especially C from baseline to BRUTE: 0.084% > 0.057%
  - Partially due to scatter?





Acknowledgements

KTH VETENSKAP OCH KONST

Energiforsk

VTT

VATTENFALL

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Swedish Radiation Safety Authority

nks
Nordic nuclear safety research