Posiva: current welding activities and future plans

FSW forum

Stockholm, 14.11.2012

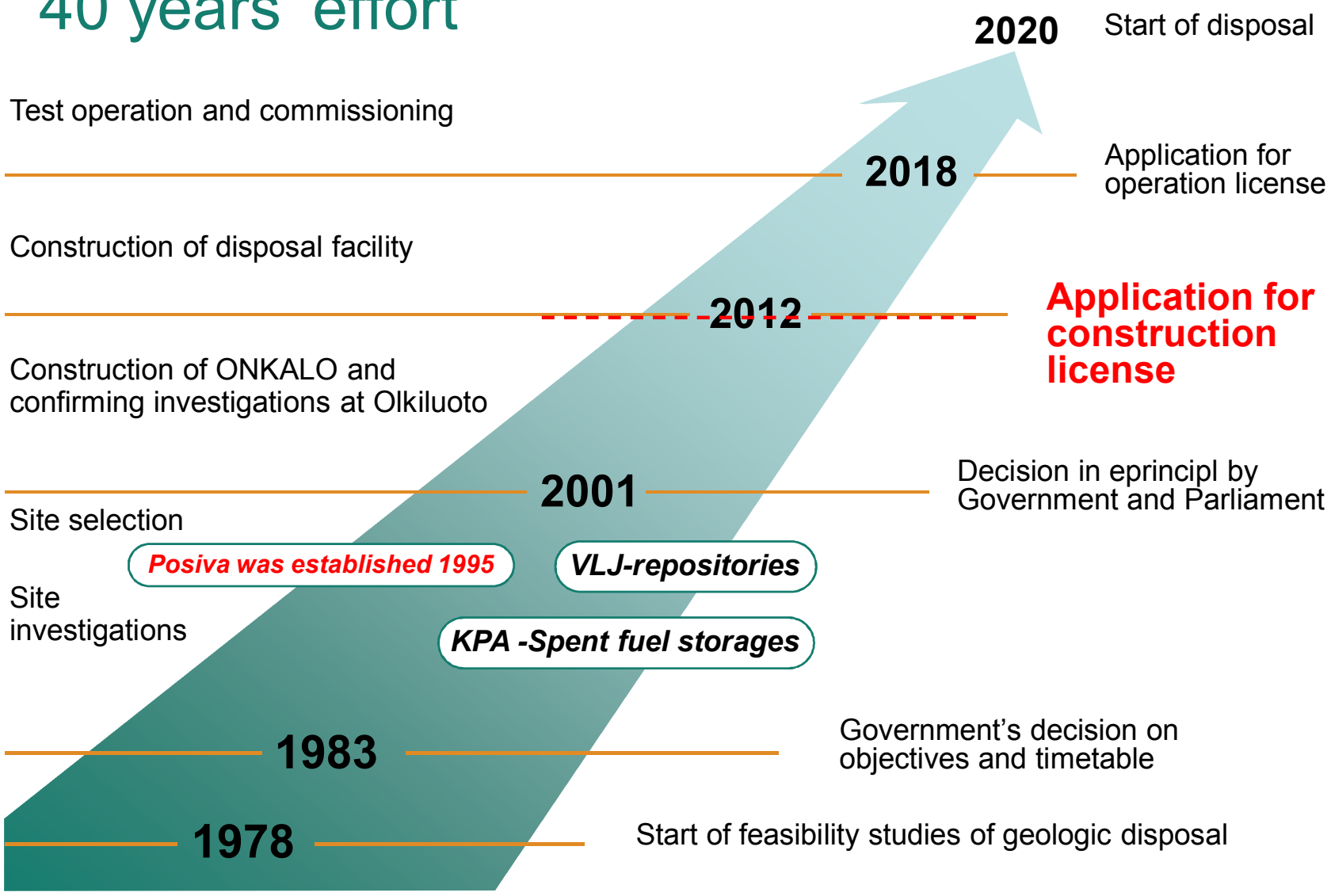
Presentation

- Posiva today: Onkalo
- Application for construction licence
- R&D plans
- Welding activities of the canister in Finland

Nuclear power in Finland today and near future

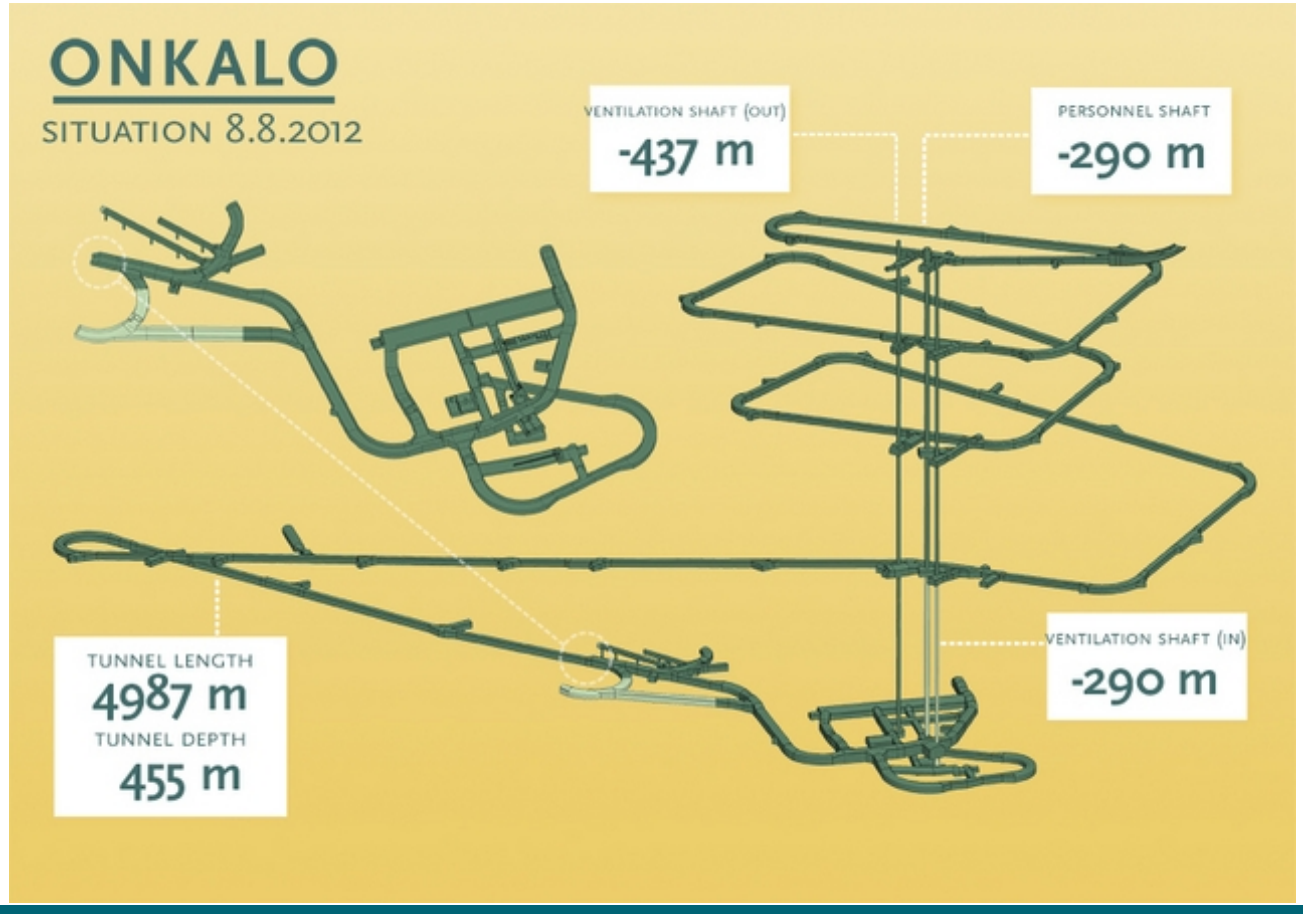
- 4 reactor in operation:
  - Loviisa: 2 PWR
  - Olkiluoto: 2 BWR
- 1 under construction: OL3, 1650 MW
- Decision in principle by Government and Parliament for 2 reactors: Fennovoima and TVO
    - TVO OL4
    - Fennovoima, Pyhäjoki

40 years' effort



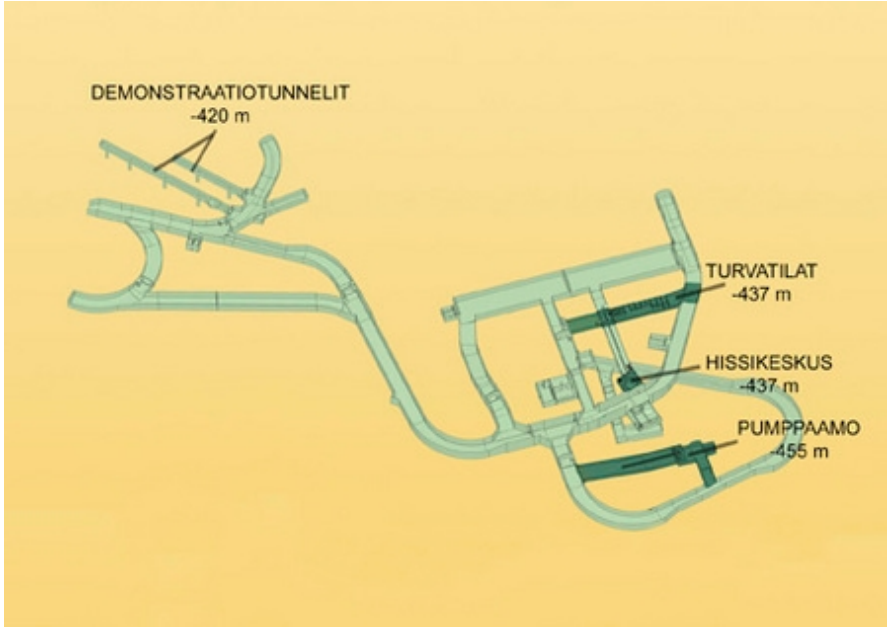
ONKALO Excavation Situation

- Excavation is almost ready



Posiva news 19.10.2012 10:54

- **Contracts for the technical level of ONKALO signed**
- Contracts have been signed for the construction of the building systems for the technical facilities of ONKALO, the Posiva underground characterization facility.



YJH-2012: Posiva R&D plan 2013-2015

- Contain detail plans for 2013-2015
- Essential topics for 2016-2019
- Include all activities: long-term safety, development of engineer barrier system, construction of plants etc.
- Report contain more than 370 pages
- similar to SKB's FUD= Forskning, Utveckling och Demonstration plan

Cansiter welding R&D in Finland

- Upto 58 EBW lid welds has been welded 2004-2012
  - full scale diameter, but 450 mm and 890 mm long tubes
- 2011: 3 lid welds and sealing test XK057
- 2012: few lid welding using good welding parameters
- Initial state of canister
  - ->2012 residual stress simulation and measurements
  - Creep tests and simulation
  - NDT and DT of weld:defects
- EBW R&D are almost ready
- Welding process selection: documentation and reporting under work: target selection at end 2013

EBW Sealing test december 2011

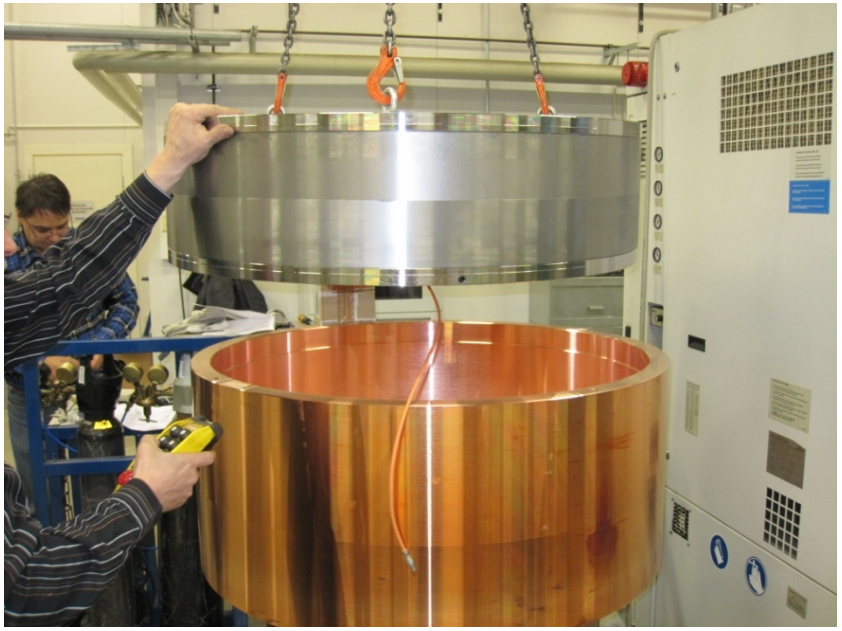
- Target was to test welding copper lid with insert which contain air (1 bar) not impacting to quality
- Evacuation of the vacuum between copper and cast iron insert has to be done in welding chamber.
- Monitoring vacuum levels between insert and copper canister
- Monitoring temperature of the components
- Results:
  - sealing without any problems
  - vacuum level rose little bit during welding, but did not impact welding
  - NDT: defect free weld

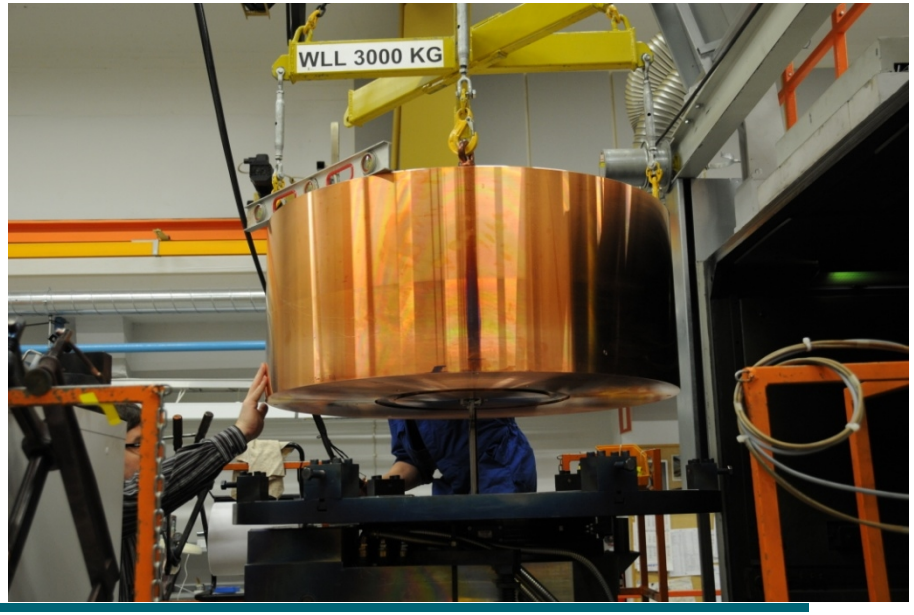
Sealing test XK057

Lid ready

for assembly

- **Tube with welded bottom and insert**





Residual stresses

Destructive testing

- hot tensile tests
- hardness
- Effect of the res. stresses on microstructure: EBSD
- Effect of welding parameters on res. stresses
- Annealing?

Residual stress mesurements

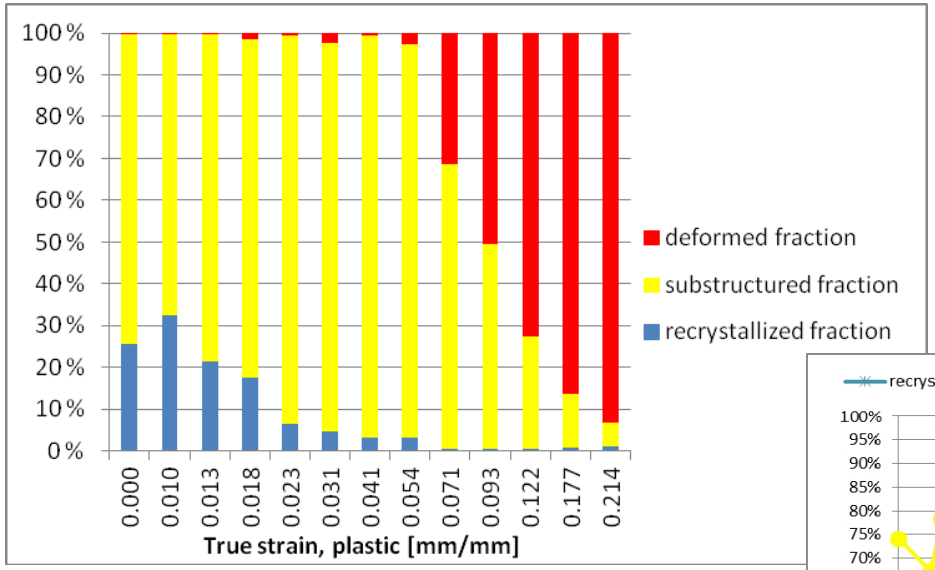
- CenterHD (ESPI)
- Contour method
- Deep Hole Drilling
- Bead on plate welds
- Lid weld

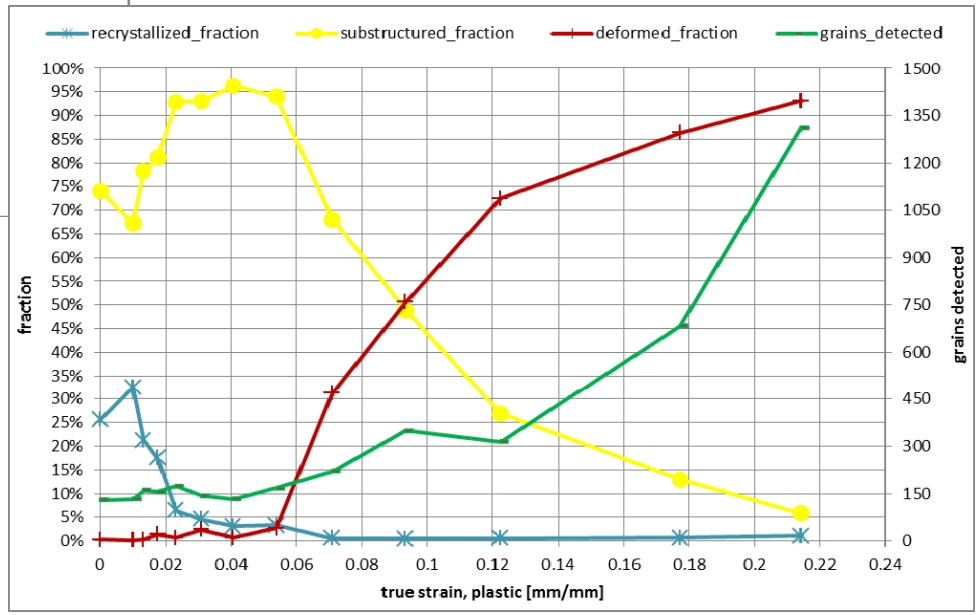
Deformation and residual stress simulation

- Temperature fields
- Stresses and strains
- Deformations
- Similarity: Full scale and short canister
- Similarity: bead on plates and lid weld
- 450 mm, 890 mm and full scale canisters are similar

Destructive testing: effect of residuals stresses on microstucture

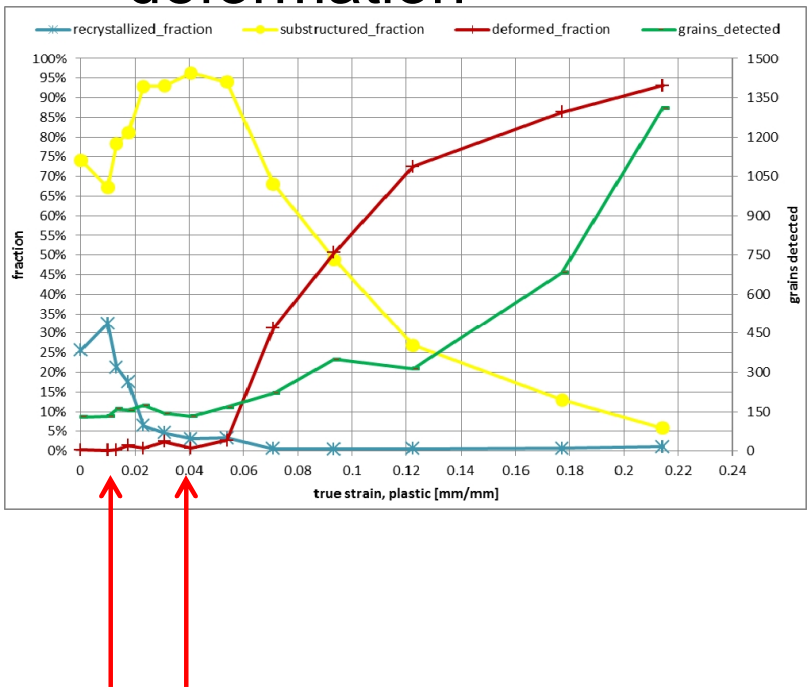
- stress vs. microstructure: cal. curves for EBSD

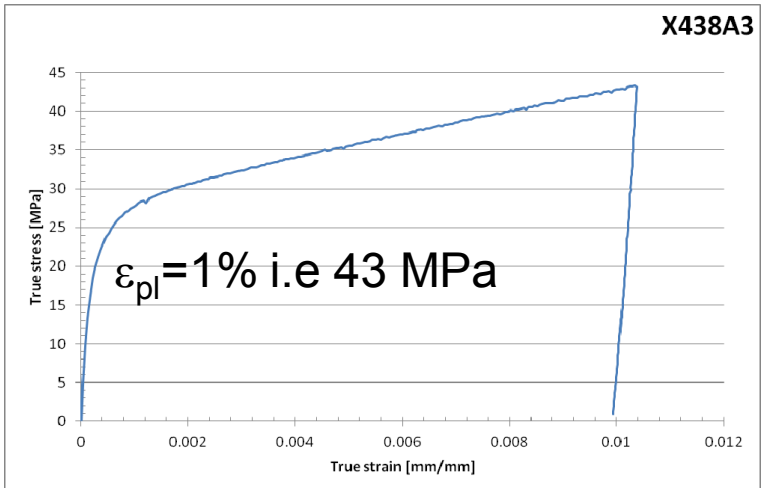




Destructive testing for residual stresses

- example 1% (43 MPa) and 4% (82 MPa) plastic deformation





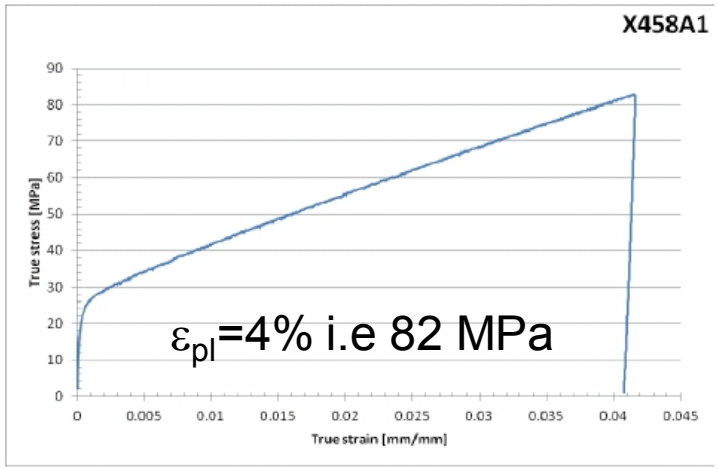


Figure 34. True stress vs. true strain curve in X458A1, tensile test number 06.

Destructive testing for residual stresses

- EBSD tensile test sample ε_{pl}=1,33%
- real weld sample ε_{pl}=1%

Band contrast of tensile tests 41 APPENDIX E

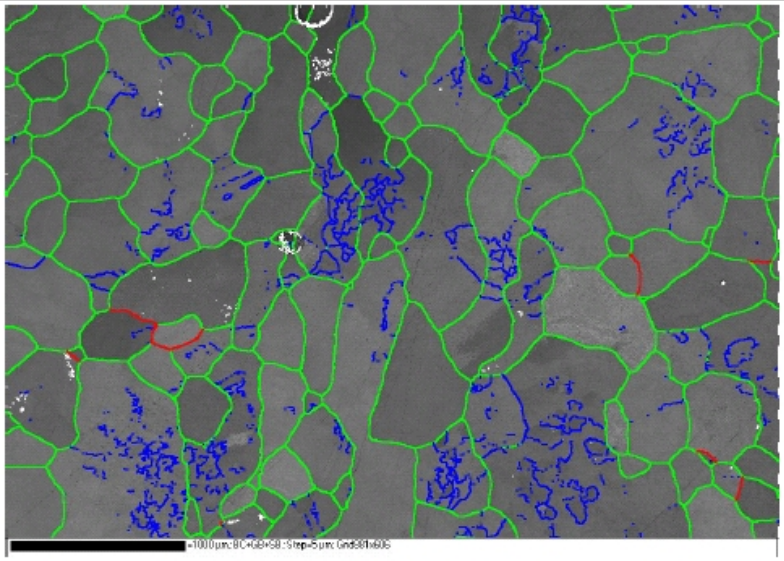


Figure 4. Specimen 02, strain $\varepsilon_{eng,pl}$=1.33 %.

APPENDIX N 168 Band contrast of cross-sections

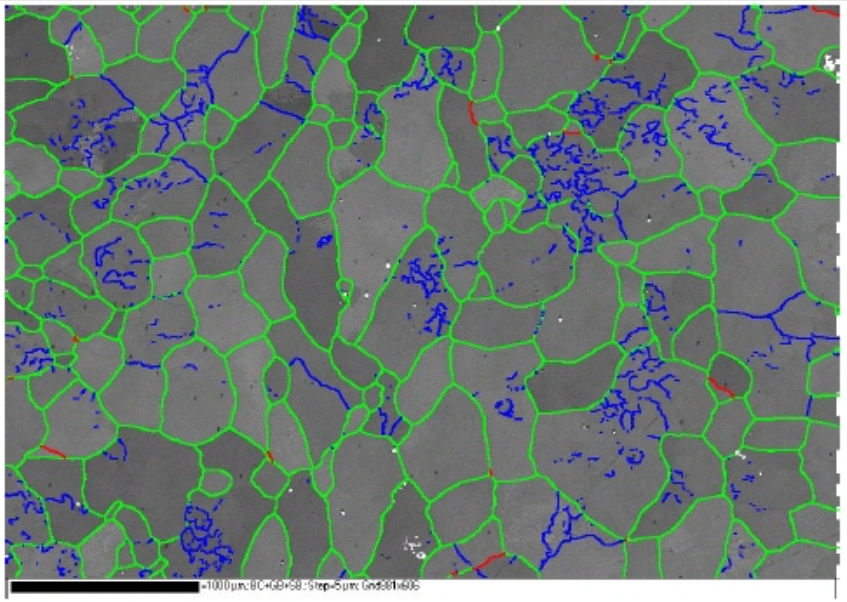


Figure 2 Sample Y436

EBSD: blue=RX, yellow=substructured Red deformed

1% deformation

43 MPa

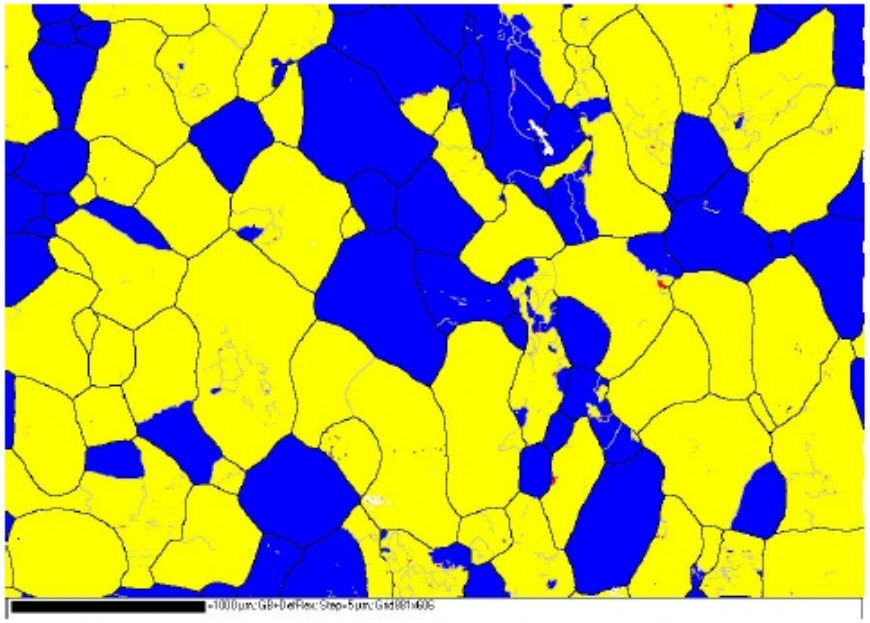


Figure 49. Specimen 01, strain $\varepsilon_{eng,pl}$=1.00 %.

4.16 % deformation

82 MPa

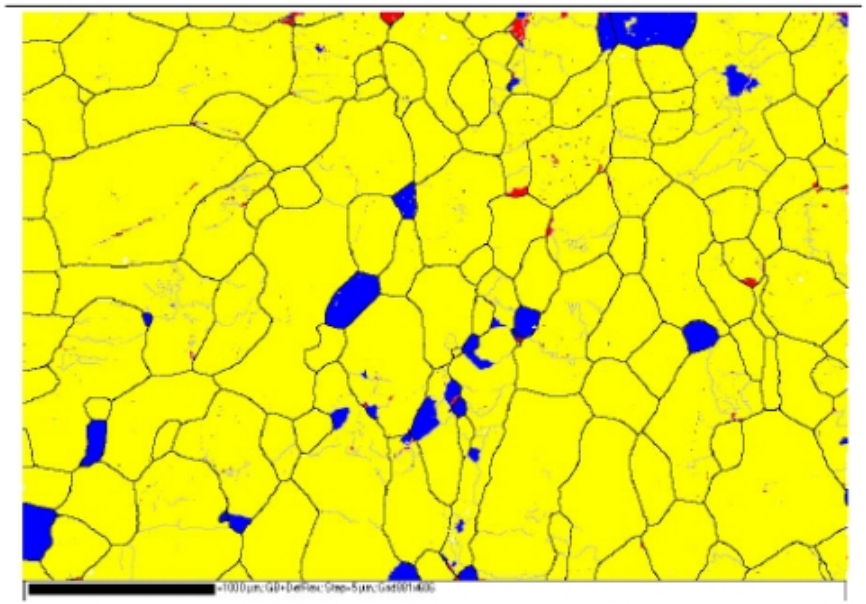
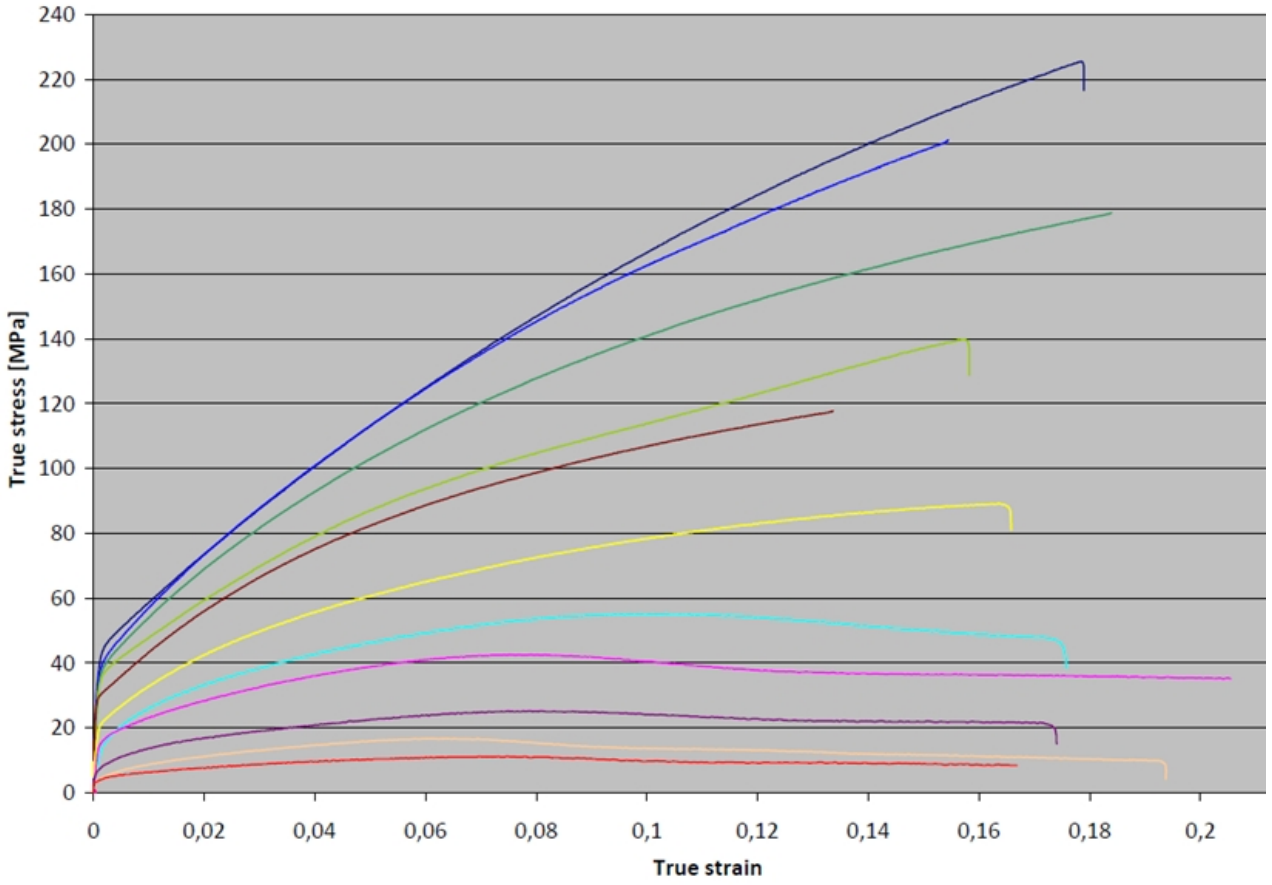


Figure 54. Specimen 06, strain $\varepsilon_{eng,pl}$=4.16 %.

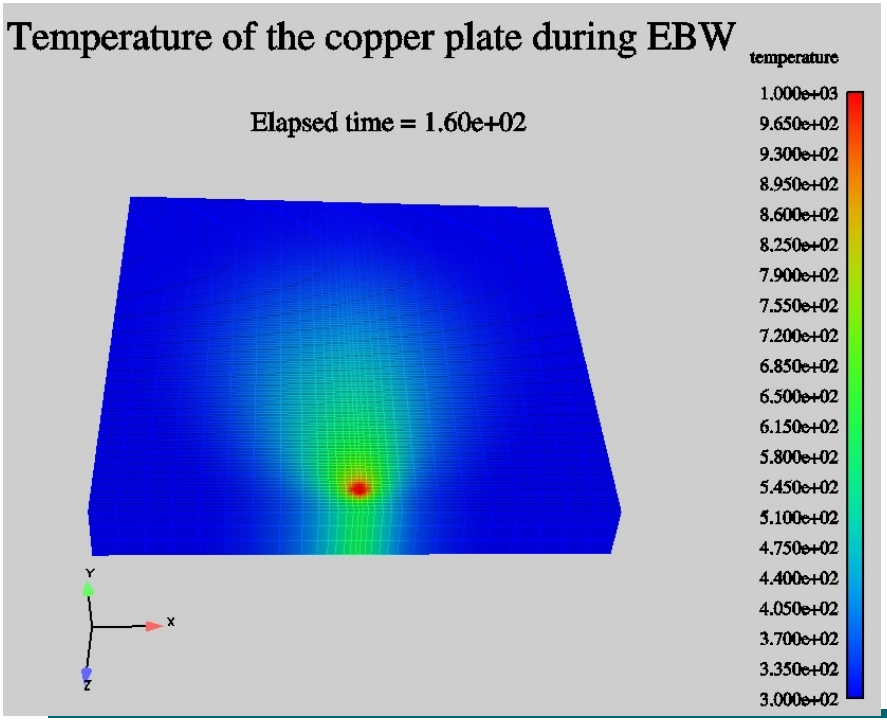
Deformation simulation: material properties

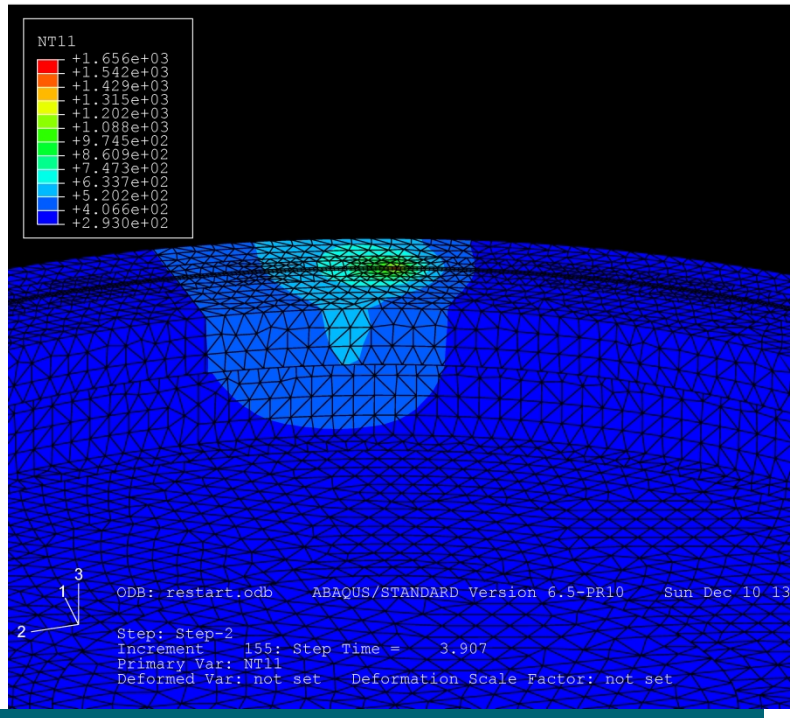
- true strain vs.strain as function of temperature etc.



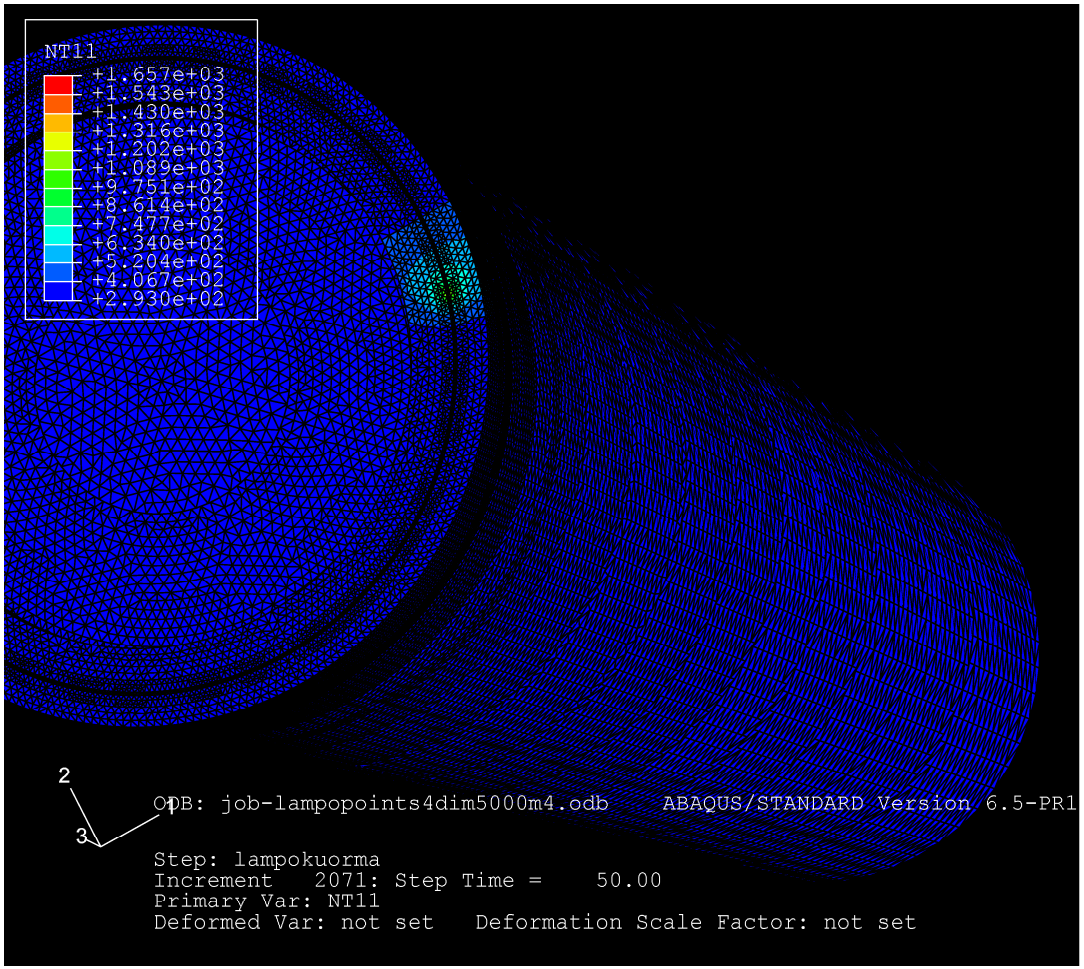
Simulating of heat transfer and residual stresses (2007-2012)

- full scale canister 450 mm, 900mm and 5 m long
- heat transfer: similarity OK -> stresses should be similar
- Plate weld give same results especially near field





Full scale canister: heat transfer

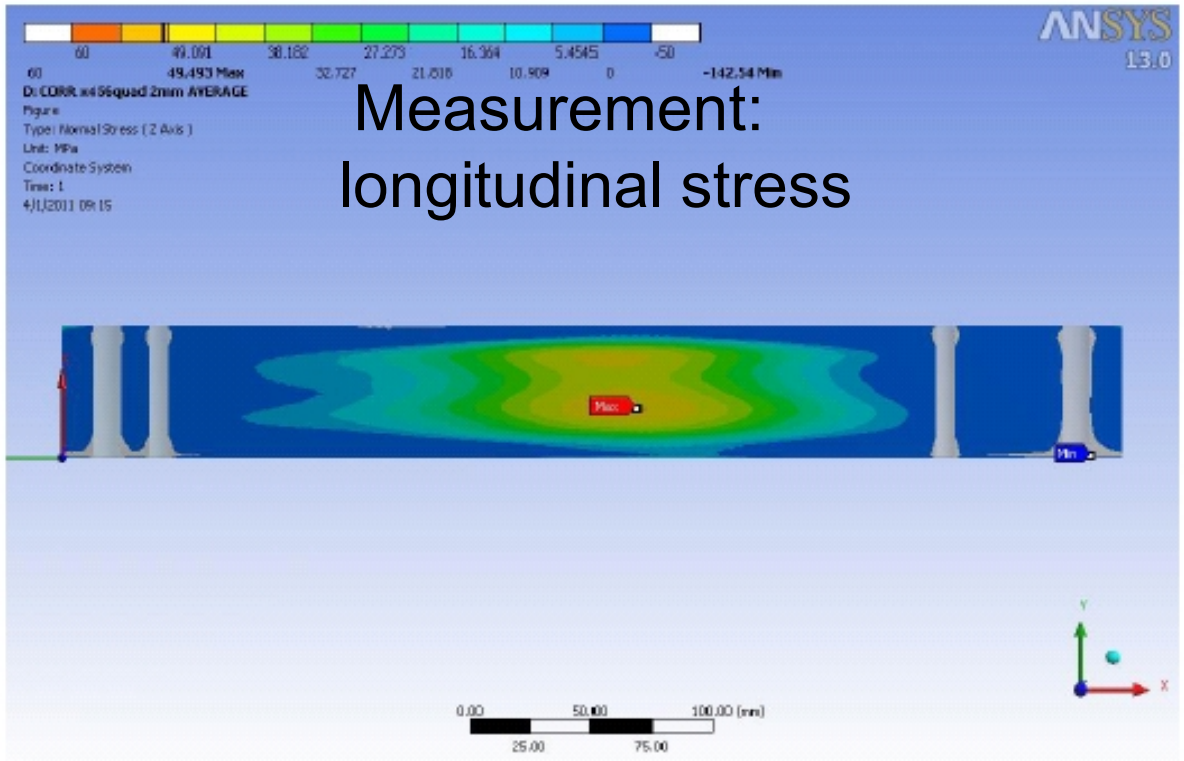


Residual stress: measurements/simulation

- Center hole drilling measurements: approx. 10-30 MPa
- Contour method measurements: approx. 40-50 MPa
- Deep hole drilling measurements: going on
- Destrucive tests:EBSD and hardness test
  - EBSD calibration curve as function of elongation
  - preliminary results: plastic deformation of the fusion zone much lower comparing to Hans Gripenberg residual stress measurements
  - preliminary: plastic deformation approx. 1% i.e. approx. 40 MPa (weld softer than base material)
- Simulations:plate tests approx. 40-50 MPa similar to measurements
- Simulations: lid weld going on, similar to plates,macroscopic deformation similar to measurements

Contour measurement

- Max. residual stresses 41-58 MPa depending on welding parameters
- Preliminary conclusion: stress level approx. 40-50 MPa, needs comprehensive analysis



EBW creep tests

- Preliminary results:
  - include primary creep, secondary creep and residual stresses
  - simulation time 0-100 000 years
  - The predicted relaxed stresses (v-M) after external loading are moderate
  - the impact of weld residual stresses and the lower creep rupture properties of the EB seem not to be detrimental to the predicted long term creep response

Other issues like FSW in Finland

- 2 FSW production machine
- 1 FSW R&D machine: TKK
- No large national R&D projects like earlier: deep recession in Finland certain areas
- TTK has now one student: master thesis under work
  - funded by KYT project i.e. independent nuclear waste funding
  - 3 months period in Japan Tohoku, γ–γ' cobalt (Co-Al-W) tool testings
  - 12-16 mm thick Cu-OFP

Conclusion

- Application for construction licence will be placed in time at the end of 2012
- R&D of the EBW will be ready early 2013
- both EBW and FSW good for sealing canister
- there are some open issues still left
- Time schedule (Posiva) has not changed: end 2013 selection of welding method
- 2014 -> developing open issues, specification of the equipment for purchacing and acceptance, final system description, qualification routines for process and personel,

POSIVA