

Encapsulation of fuel rods for transport

Simon Stanke



- Introduction
- Requirements for the can and the encapsulation process
- Design of the can and the encapsulation device
- Encapsulation process
- Process qualification
- Conclusion and outlook

The need for encapsulation of fuel rods:

There is a high demand for post-irradiation investigation of

1. Fuel rods with very high burn-up

- computer codes for fuel depletion and decay not validated
- no sufficient data about mechanical properties

2. Damaged fuel rods

- no sufficient data about mechanical properties
- danger of losing particles during transport

However, those rods have to be encapsulated in leak tight cans for a safe transport.

Current state of the art for encapsulated fuel rods:

1. Fuel rods stored in hot cells
→ Production of welded cans
2. Fuel rods stored in a pool
→ **No solution**



Underwater brazing device

Requirements for the can and encapsulation process

Requirements for the can:

- withstand normal conditions of transport,
- provide a leak tight barrier for the fuel,
- corrosion resistance,
- no free water in the cavity of the can,
- can filled with inert gas (e.g. Helium),
- designed to be handled in NPPs and Hot Cells.

Requirements for the can and encapsulation process

Requirements for the encapsulation process:

- installation operated in the fuel assembly pool,
- sufficient head of water,
- remote controlled brazing,
- high quality process control,
- documentation of process parameters,
- provide sufficient performance.

Design of the can and the encapsulation device

Design of the can:

- Tube

- Holes for handling
- Slits for dewatering

- Top plug

- Head for handling (adaptable)
- Brazing solder

- Bottom plug

- Filter
- Holes for dewatering
- Brazing solder



Design of the can and the encapsulation device

Design of the encapsulation device:

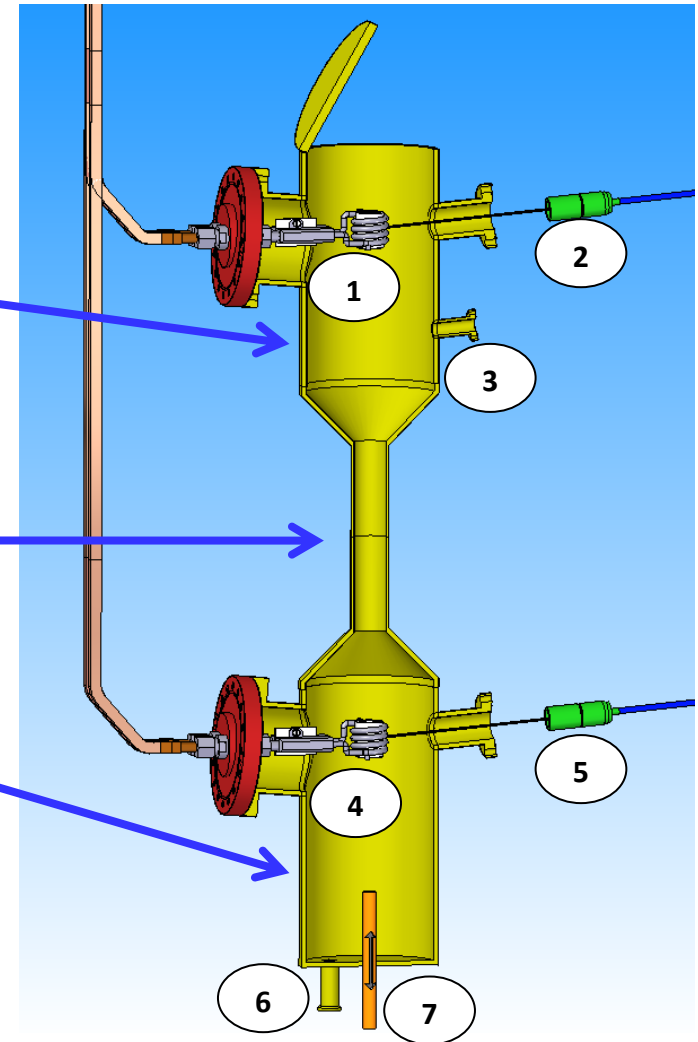
- Upper brazing station

- Inductor (1)
- Pyrometer (2)
- Connector (3)

- Connecting tube

- Lower brazing station

- Inductor (4)
- Pyrometer (5)
- Connector (6)
- Remotely operated lift (7)



General steps:

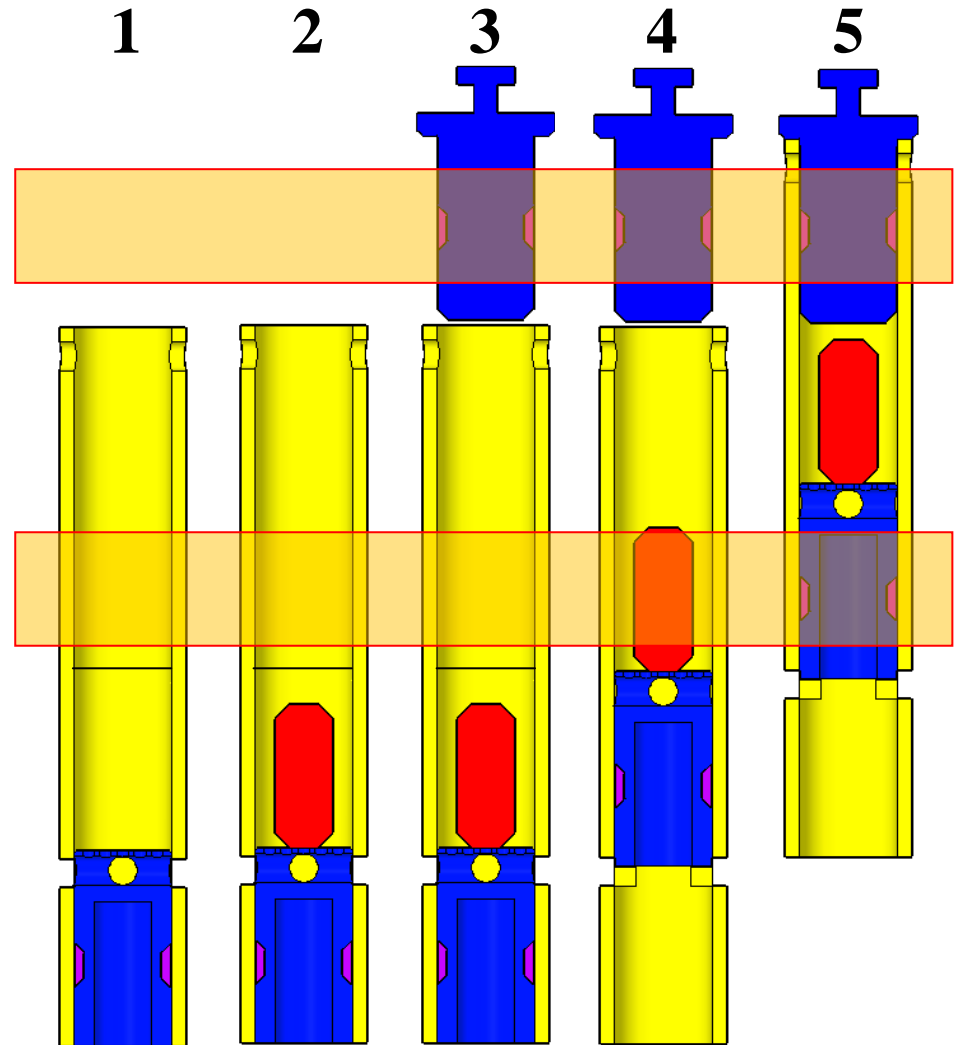
1. Loading of empty, preassembled can
2. Loading of fuel rod
3. Inserting top plug and closing of the device
4. Draining and drying
5. Filling with inert gas
6. Brazing
7. Leak test
8. Flooding of the encapsulation device, removal of sealed can



Encapsulation process

Loading of fuel rod, positioning of the plugs:

- 1: Loading position
- 2: Loading of fuel rod
- 3: Inserting the top plug
- 4: Pushing up the bottom plug
- 5: Brazing position



Test stand:

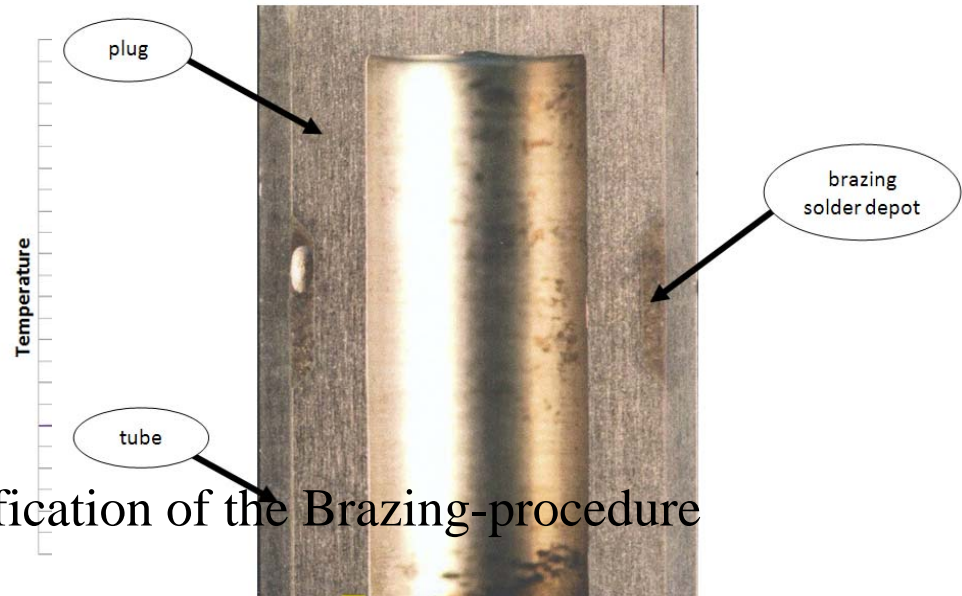
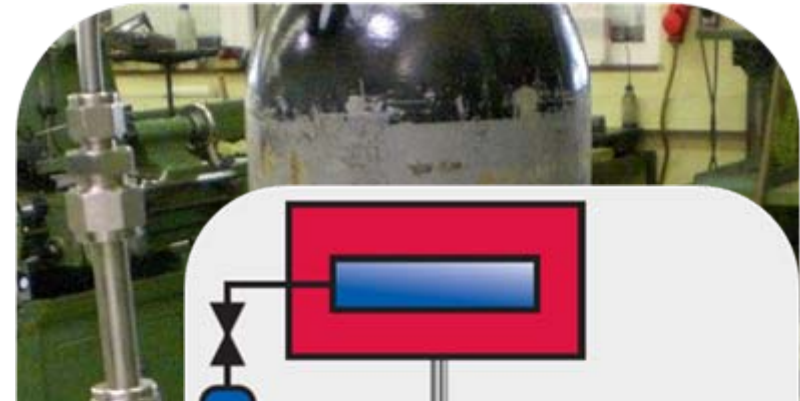
- Built for process qualification with BAM (competent authority)
- Capable to produce cans with a length of 750mm
- Use of final design plugs
- Displaying all important steps of the encapsulation process



Tests and results:

- ✓ - Determination of the right parameters (heating gradient and holding time)
- ✓ - Helium-Leakage test
- ✓ - Pressure test (7 MPa)
- ✓ - Metallographic analysis (not finished)

➔ Promising results for the qualification of the Brazing-procedure



- Encapsulation process meets the requirements as described
- Procedure qualification is on its way
 - (Some results of the metallographic investigation have to be awaited)
- Manufacturing of the production installation is on the way
- First hot application planned for the next few months

Thank you for your attention!

