UK Atomic Energy Authority

NEURONE: NADM 2024 Summary

Dr David Bowden – Materials Science and Engineering Group Leader (metallics) & NEURONE programme lead

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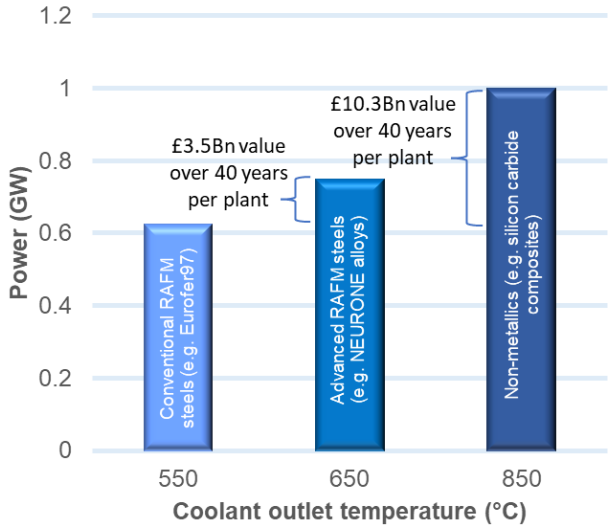
What is NEURONE?

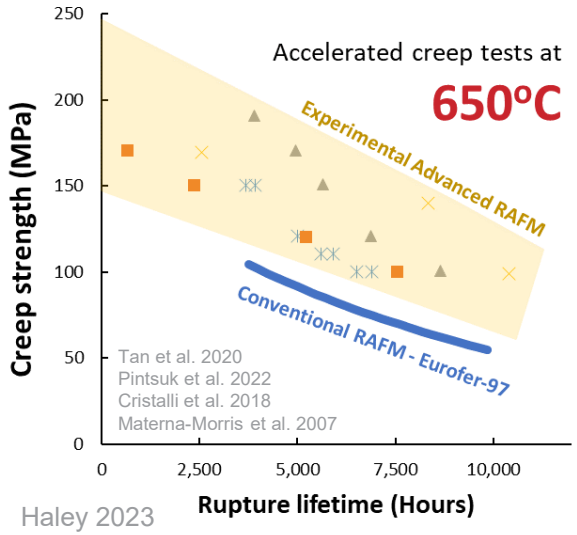
NEUtron iRradiatiOn of advaNced stEels

Aim:

Develop and deliver an industrially scalable fusion-grade advanced steel capable of operating at 650°C in a fusion breeder-blanket environment.

- Total value of programme, plus in-kind contributions: £14.6m
- April 2023 until March 2028
- 40 collaborators across 11 organisations





Haley 2023

Economic | Performance | Scalability

NEURONE Objectives

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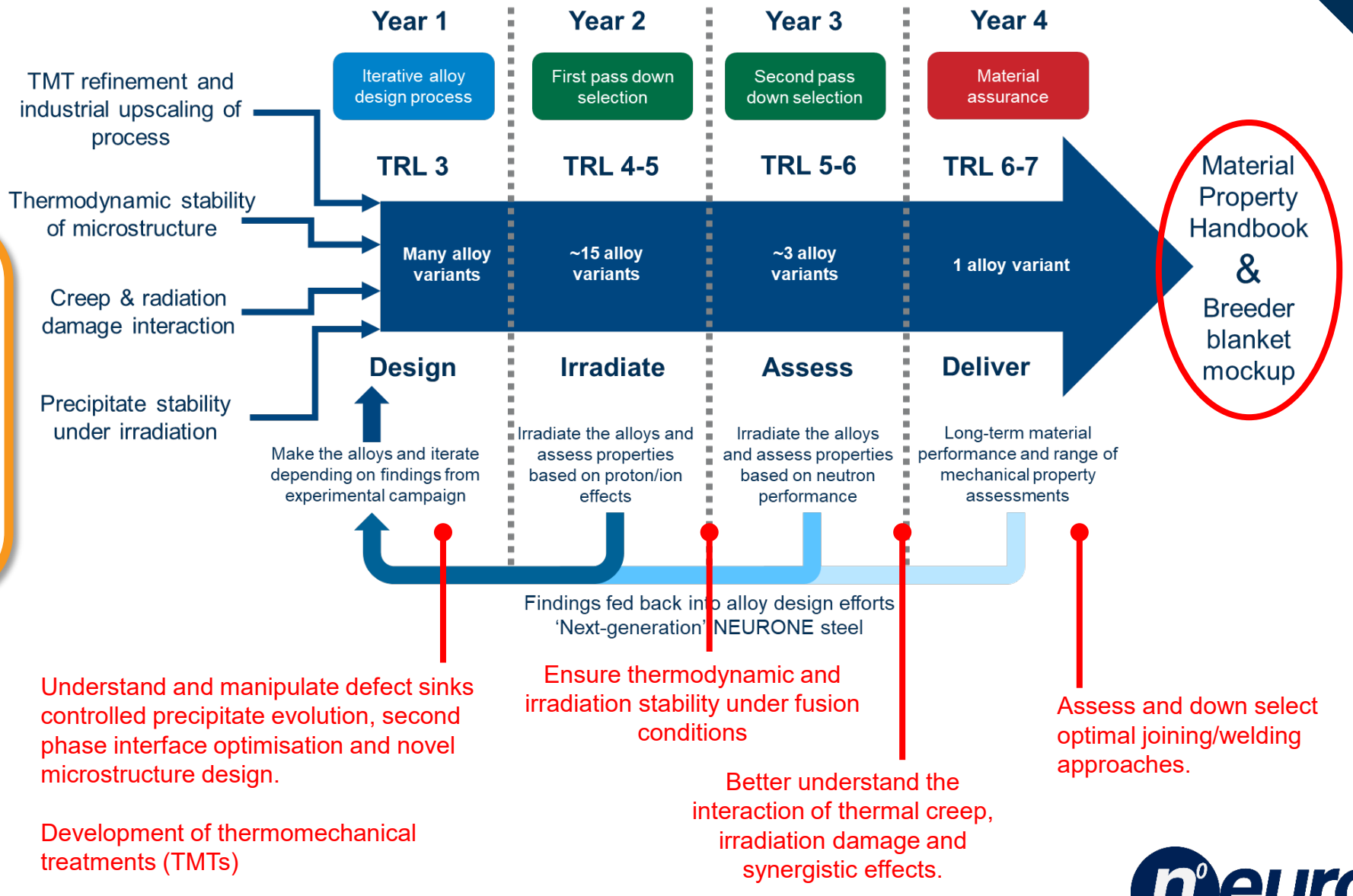
Using reduced-activation ferritic-martensitic (RAFM) steels as a basis.

We are developing Advanced RAFM (ARAFM) steels



Work packages and partners

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WP1: Alloy development and upscaling

Dr. David Bowden

Swansea University Prifysgol Abertawe

Prof. Nicolas Lavery

Dr. Stephen Jones

University of Sheffield

Prof. Eric Palmiere

Prof. Mark Rainforth

WP2: Irradiation

Dr. Slava Kuksenko

Materials Processing Institute

Dr. Richard Birley

Dr. Peter Barnard

UNIVERSITY OF BIRMINGHAM

Dr. Sandy Knowles

SHEFFIELD FORGEMASTERS

Prof. Jesus Talamantes-Silva

Dr. Marcus Crabbe

ANSTO

Prof. Lyndon Edwards

Prof. Michael Moody

UNIVERSITY OF BIRMINGHAM

Prof. Enrique Jiminez-Melero

WP3: Microscopy and characterisation

Dr. Jack Haley

MANCHESTER 1824 The University of Manchester

Dr. Ed Pickering

UNIVERSITY OF OXFORD

Dr. Paul Bagot

WP4: Micromechanical testing

Dr. James Gibson

UNIVERSITY OF OXFORD

Prof. Dave Armstrong

Materials Processing Institute

WP5: Bulk mechanical testing

Dr. Jim Johnson

Imperial College London

Dr. Catrin Davies

Swansea University Prifysgol Abertawe

Prof. Mark Whittaker

Prof. Rob Lancaster

WP6: Manufacture and joining

Dr. Paul Goodwin

University of Strathclyde Glasgow

Prof. Brad Wynne

WP7: Modelling

Dr. Chris Hardie

Imperial College London

Dr. Mark Wenman

Prof. Robin Grimes

Independent advisors

Dr. Peter Morris
Ex-Tata / 9Cr steel development

Prof. Ted Darby
Ex-RR / Fission / C&S / qualification

Matthew Green
Liberty / 9Cr steel development

Plus:

- 6 PDRA's
- 9 PhDs
- Hosted five summer students, with capacity to host 15 more in future years

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Alloy development approach

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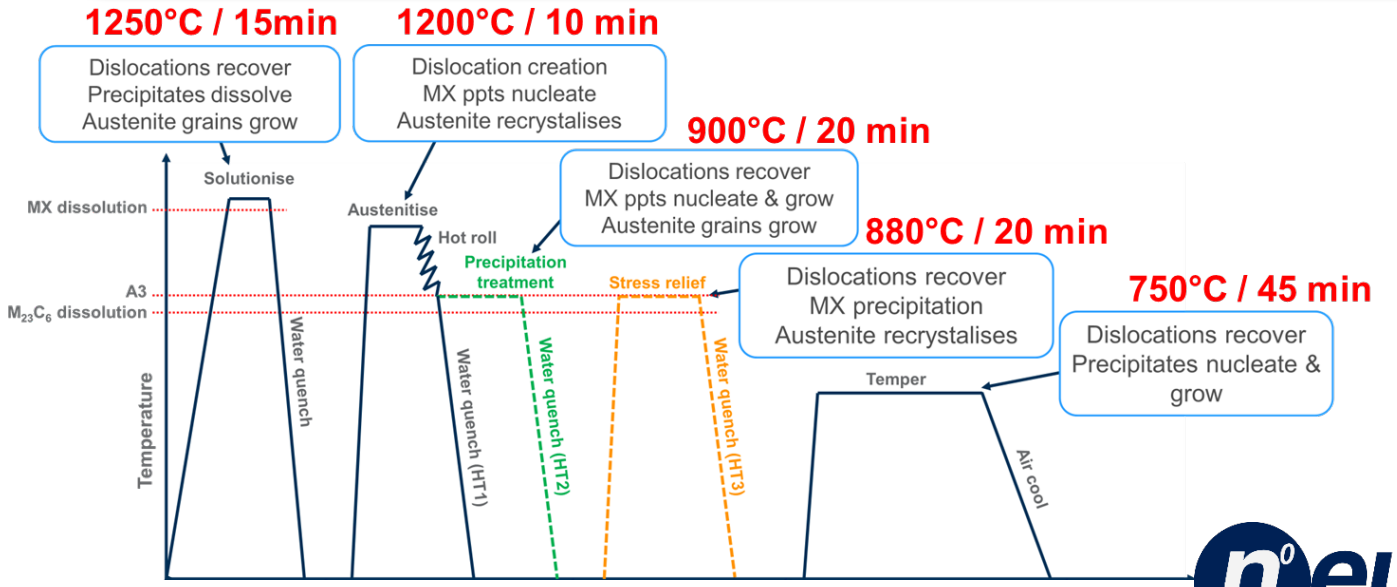
- Carbide & Nitride strengthening
- Boron strengthening
- Boron refinement
- In-melt oxide strengthening
- Intermetallic strengthening

Within the limits of reduced-activation requirements

- Casting
- Forging
- Rolling
- Heat treatments

Aligning closely and early on with what can be achieved at scale



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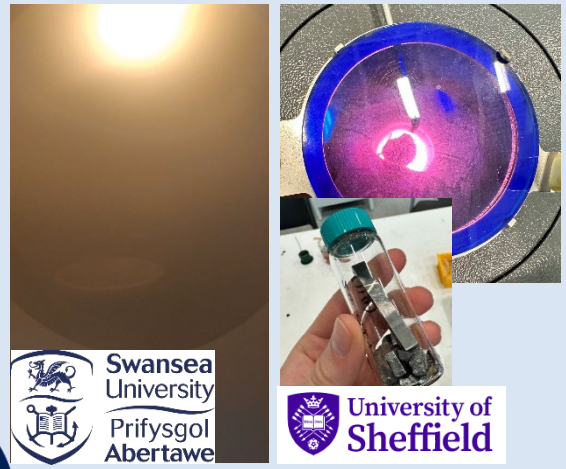
Programme highlights to date

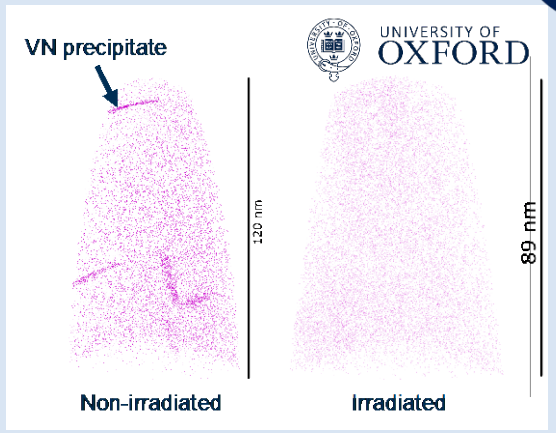
~5.5 tonnes of Eurofer97 (reference baseline) RAFM steel produced using electric arc furnace facilities. A UK first for this type of steel.

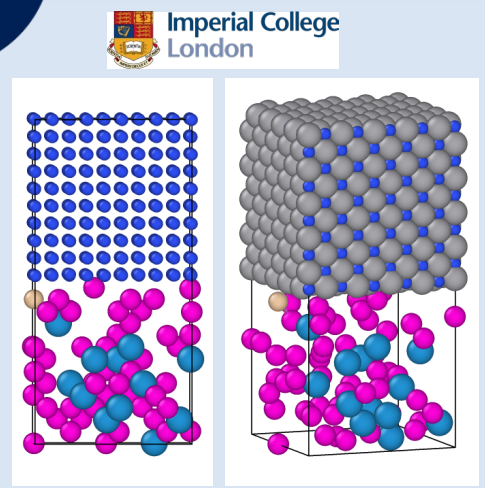


Over 30 prototype alloys produced with over 100kg of ARAFM steel scaled up. Exploring carbonitride, boron and intermetallic phase strengthening.

Study of vanadium nitride stability in alloys implanted using Fe^{2+}, utilising TEM and APT.

J. Haley et al., Short communication: Complete dissolution of MX-phase nanoprecipitates in fusion steels during irradiation by heavy-ions, J. Nucl. Mater. 596 (2024) 155115. https://doi.org/10.1016/j.jnucmat.2024.155115.





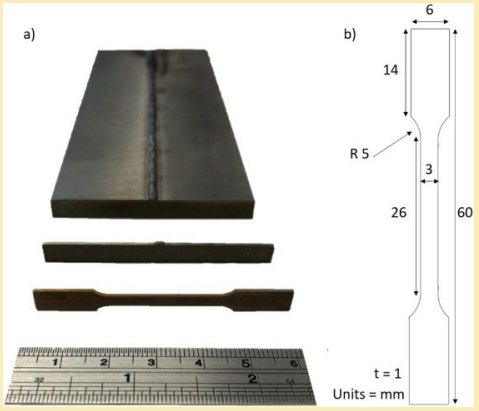
First DFT modelling results to assess stability of carbo-nitrides under irradiation, leading to a publication. Initial interface modelling using the MD creation-relaxation algorithm (CRA)

Next milestones

Commencing creep testing of new ARAFM grades to validate performance against Eurofer97.

Scaling up new ARAFM alloys from 150g lab-scale melts to 50kg VIM ingot sizes.

Begin PIE of neutron irradiated samples from ANSTO (OPAL) and ORNL (HFIR).



Initial joining studies using 5T UK Eurofer97 ingot.

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Thank you for listening

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