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NWL LIMITS FOR SOME REFRACTORY MATERIALS

UCLA

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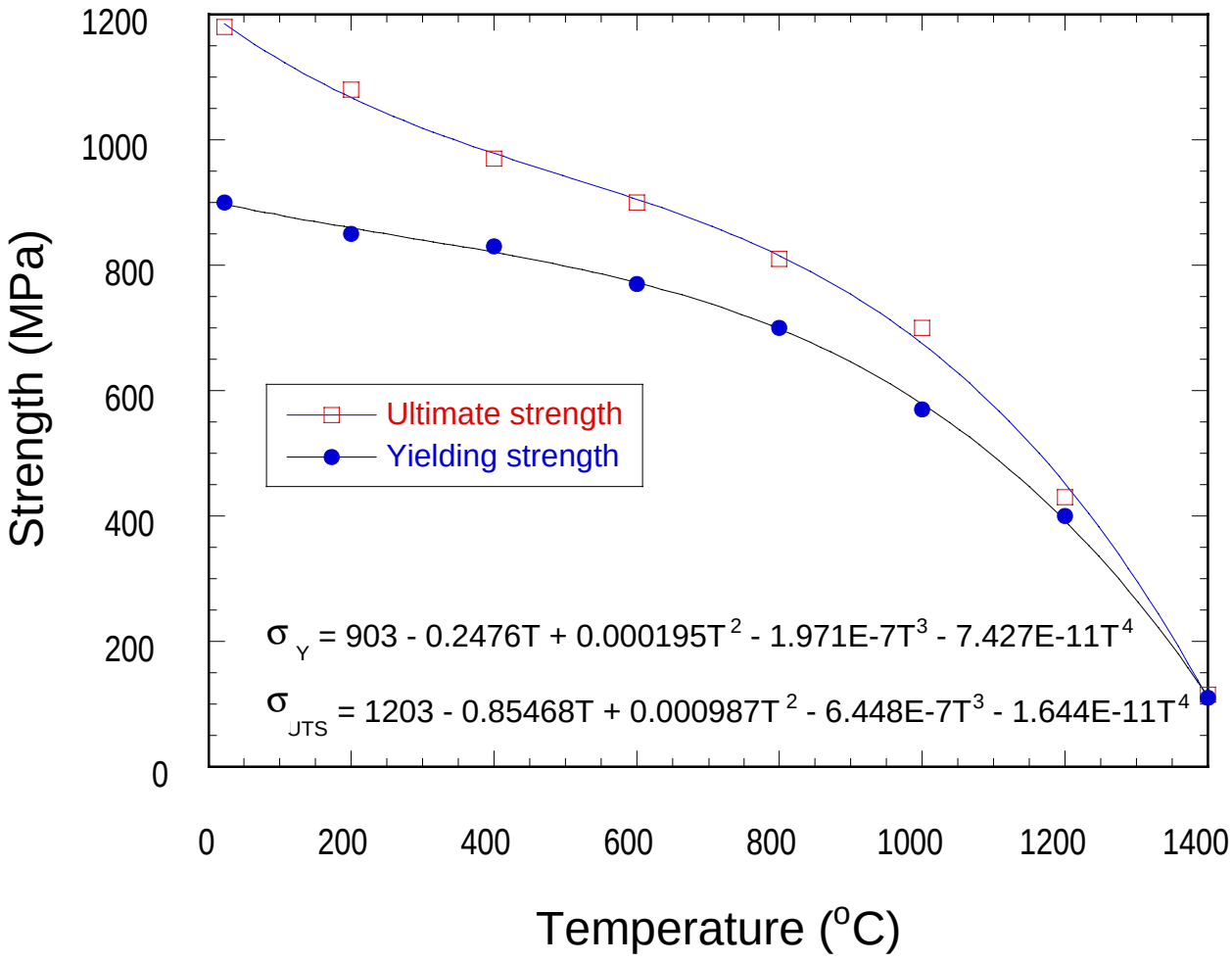
BACKGROUND

Three refractory materials are investigated for NWL capabilities. These are: TZM (Mo-0.5Ti-0.1Zr), Nb-1Zr, T111 (Ta-8W-2Hf)

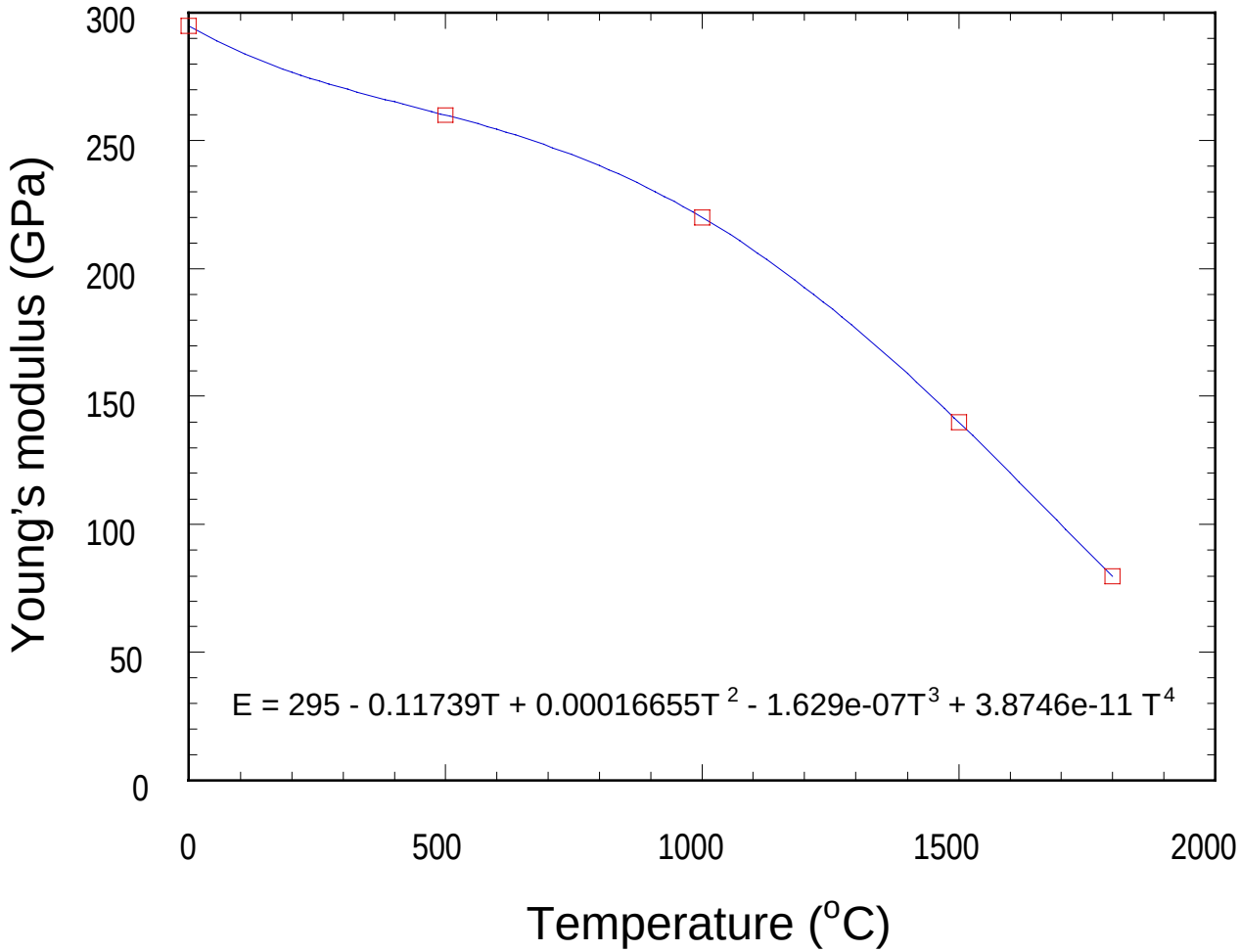
ASSUMPTIONS FOR NWL LIMIT CALCULATION:

- The first wall is a plate, subjected to plasma radiation and bulk heating. The wall is allowed to expand but not bend.
- Bulk heating = 10 w/cm^3 per 1Mw/m^2 NWL. Heat flux is taken to be 0.2 Mw/m^2 per 1 Mw/m^2 NWL.
- The temperature profile is parabolic; however, the thermal stress however is taken to be proportional to the temperature drop across the wall.
- A primary stress of 20 MPa.
- No radiation effects (creep or swelling) are considered.
- The stress limit is temperature dependent in case of V-Cr-Ti.

PROPERTIES OF TZM



Ultimate and yielding strength of TZM as a function of temperature.



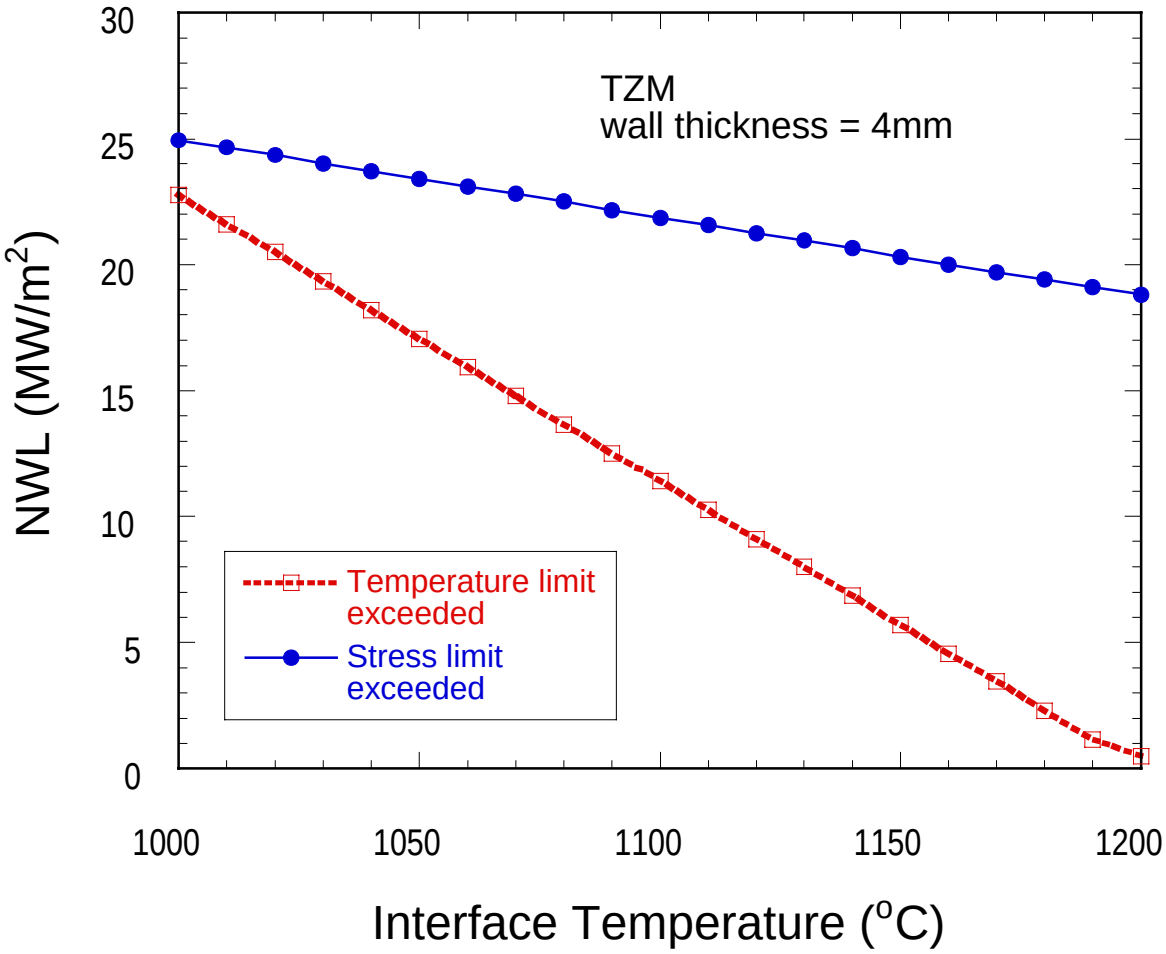
Young's modulus of TZM

OTHER PROPERTIES OF TZM

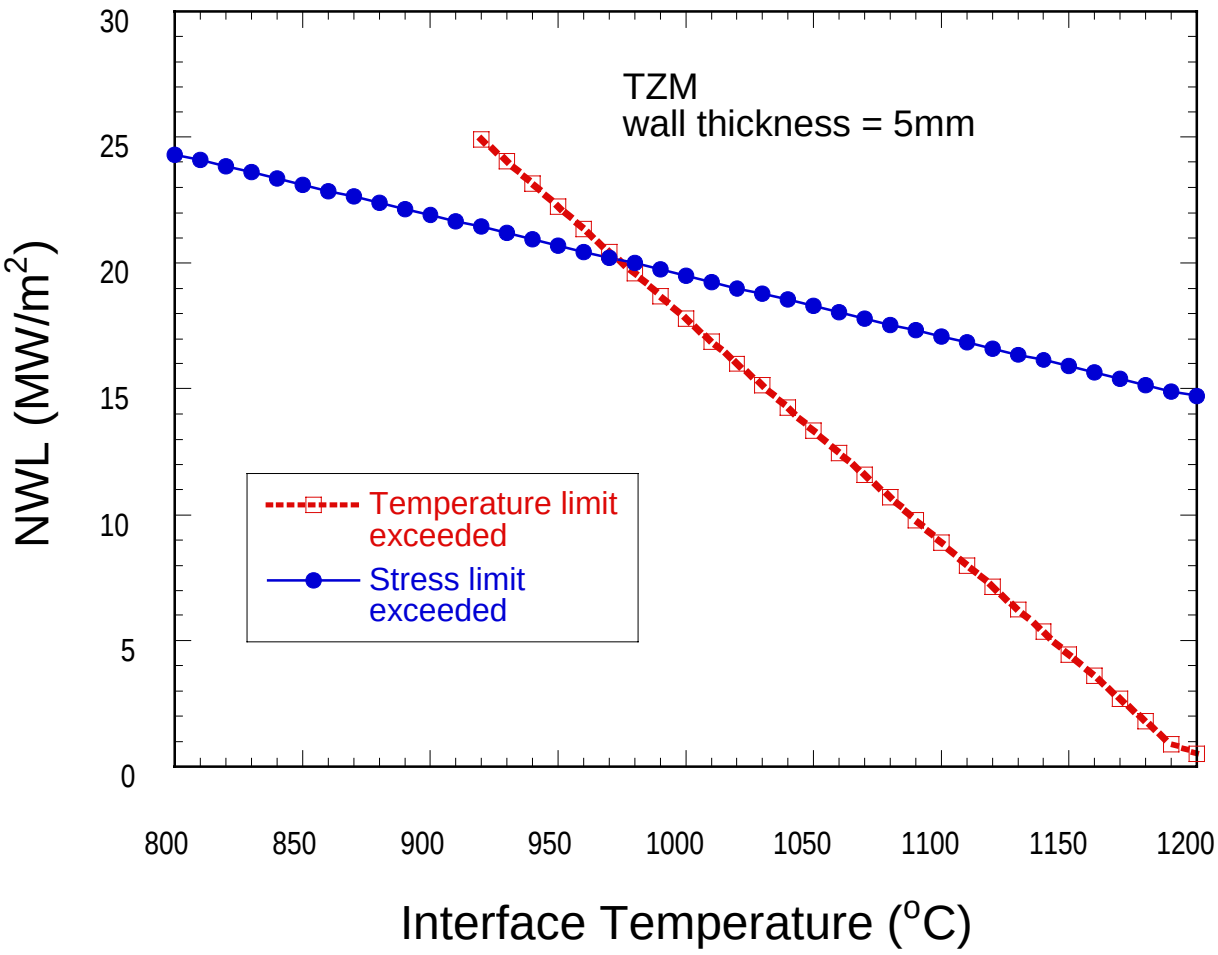
-- Maximum operating temperature up to ~ 1200 deg. C, limited by thermal creep considerations.

-- The coefficient of thermal expansion increases from 5ppm/•C at room temperature to 10 ppm/•C at 2000•C.

-- The thermal conductivity decreases in a linear fashion from 130 w/mK at room temperature down to 75 w/mK at 2000•C.

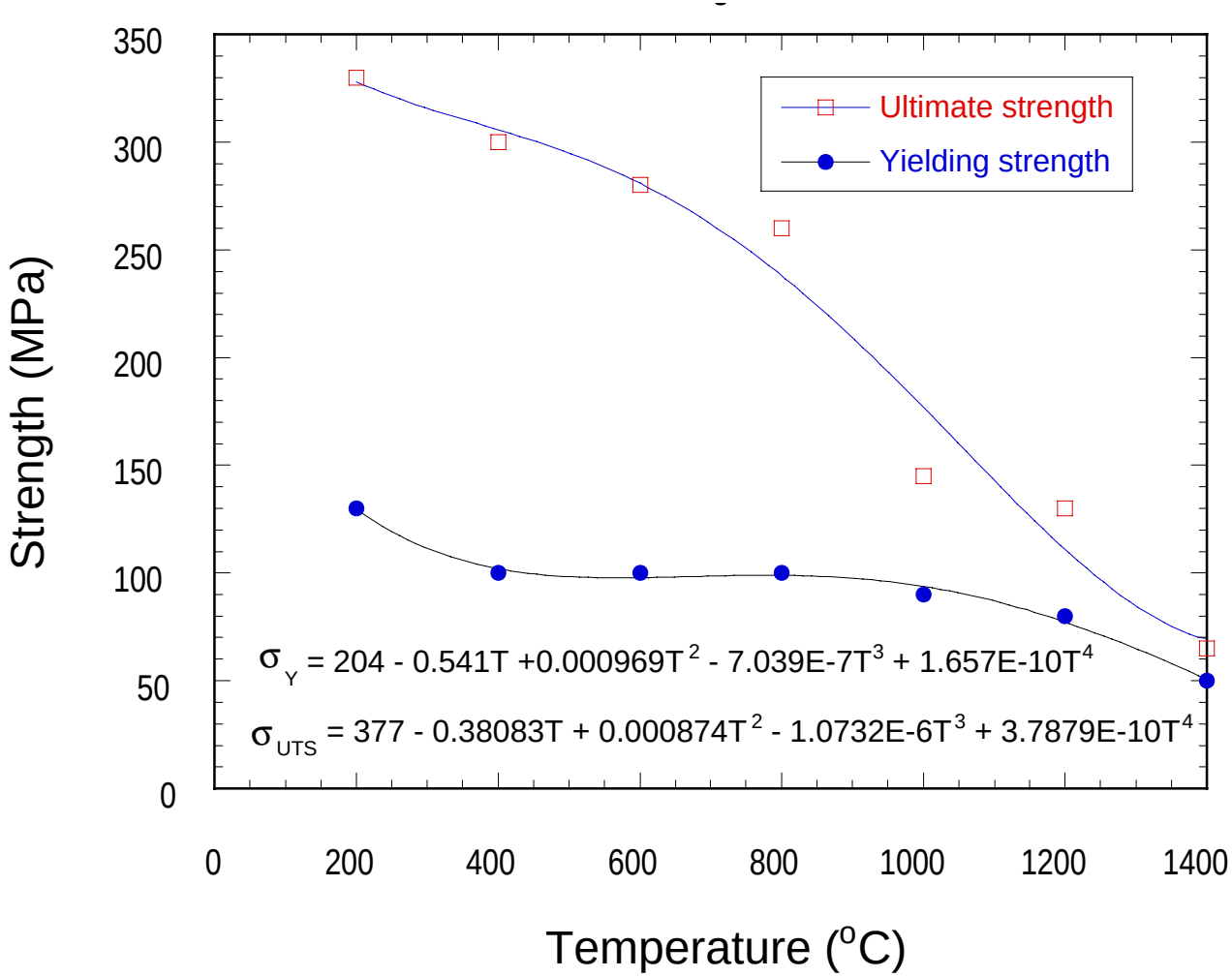


NWL Limits for a 4mm thick TZM wall.



NWL Limits for a 5mm thick TZM wall.

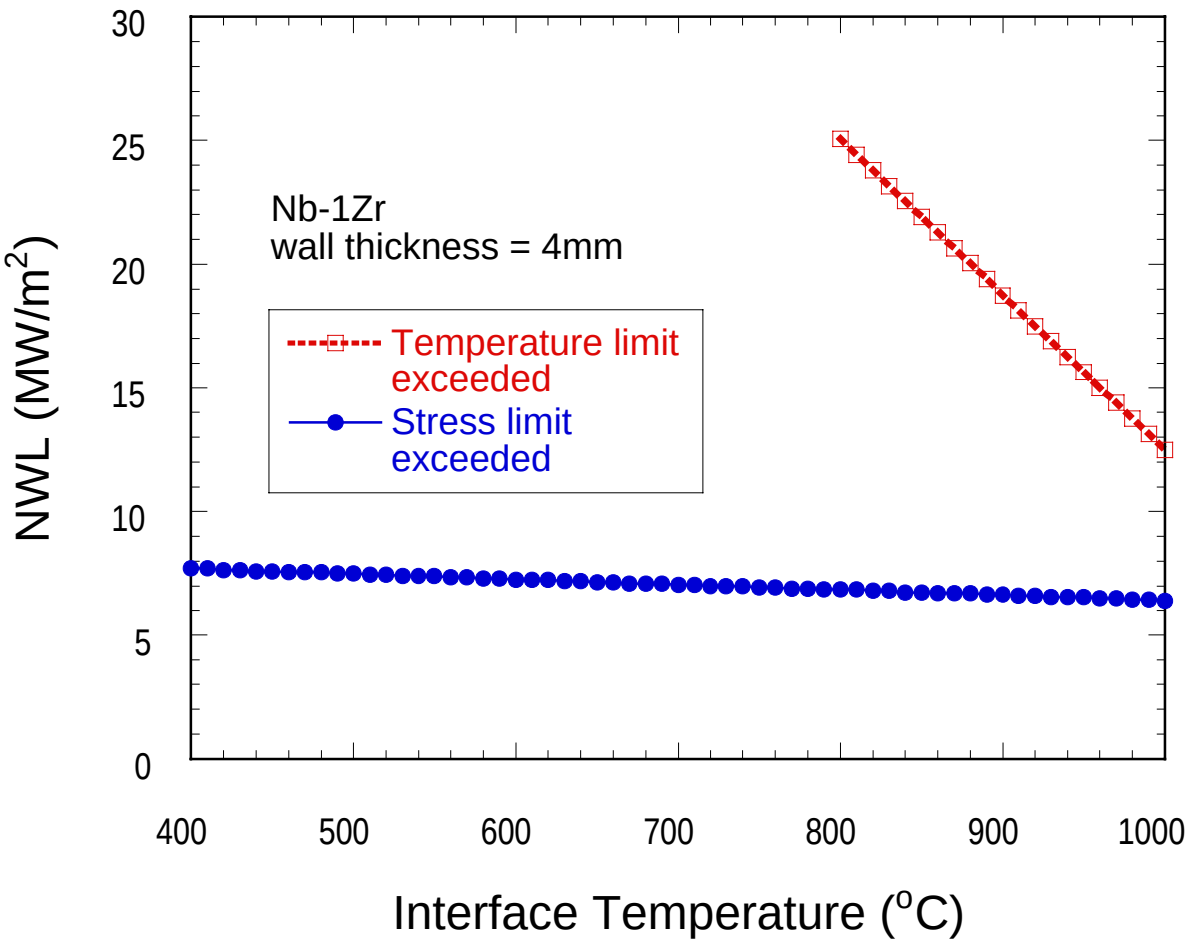
PROPERTIES OF Nb-1Zr



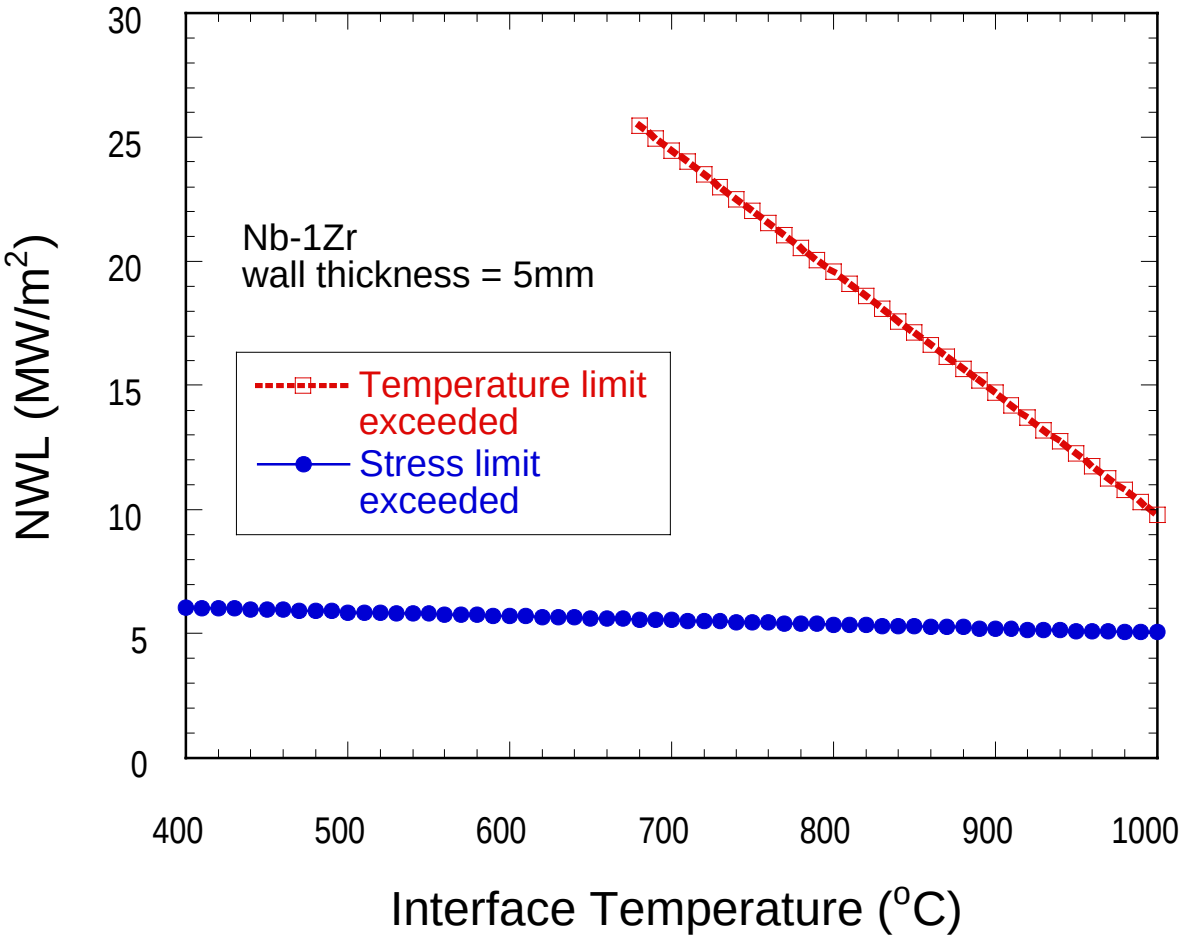
Strength of Nb-1Zr as a function of temperature.

OTHER PROPERTIES OF Nb-1Zr

- Elastic modulus 104 GPa.
- The average value of the coefficient of thermal expansion is 7.2 ppm/•C in the range room temperature (RT) to 100•C, 7.88 ppm/•C in the range RT-1000•C, and 10 ppm/•C in the range RT to 1500•C.
- The thermal conductivity increases linearly from 52 w/mK at RT to 65 w/mK at 600•C.
- The recommended maximum operating temperature is about 1200•C based on thermal creep considerations.

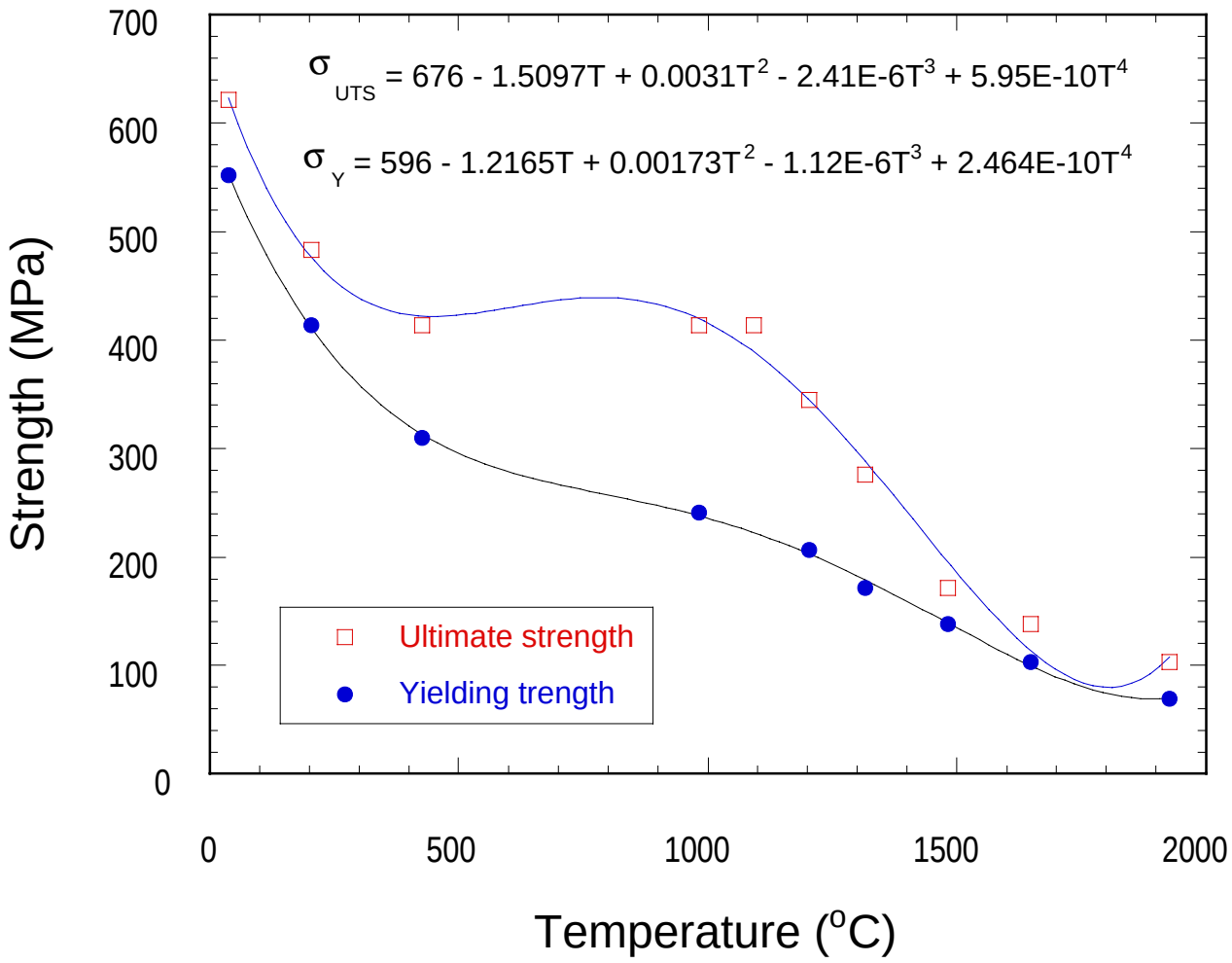


NWL limits for a 4mm thick Nb-1Zr wall.

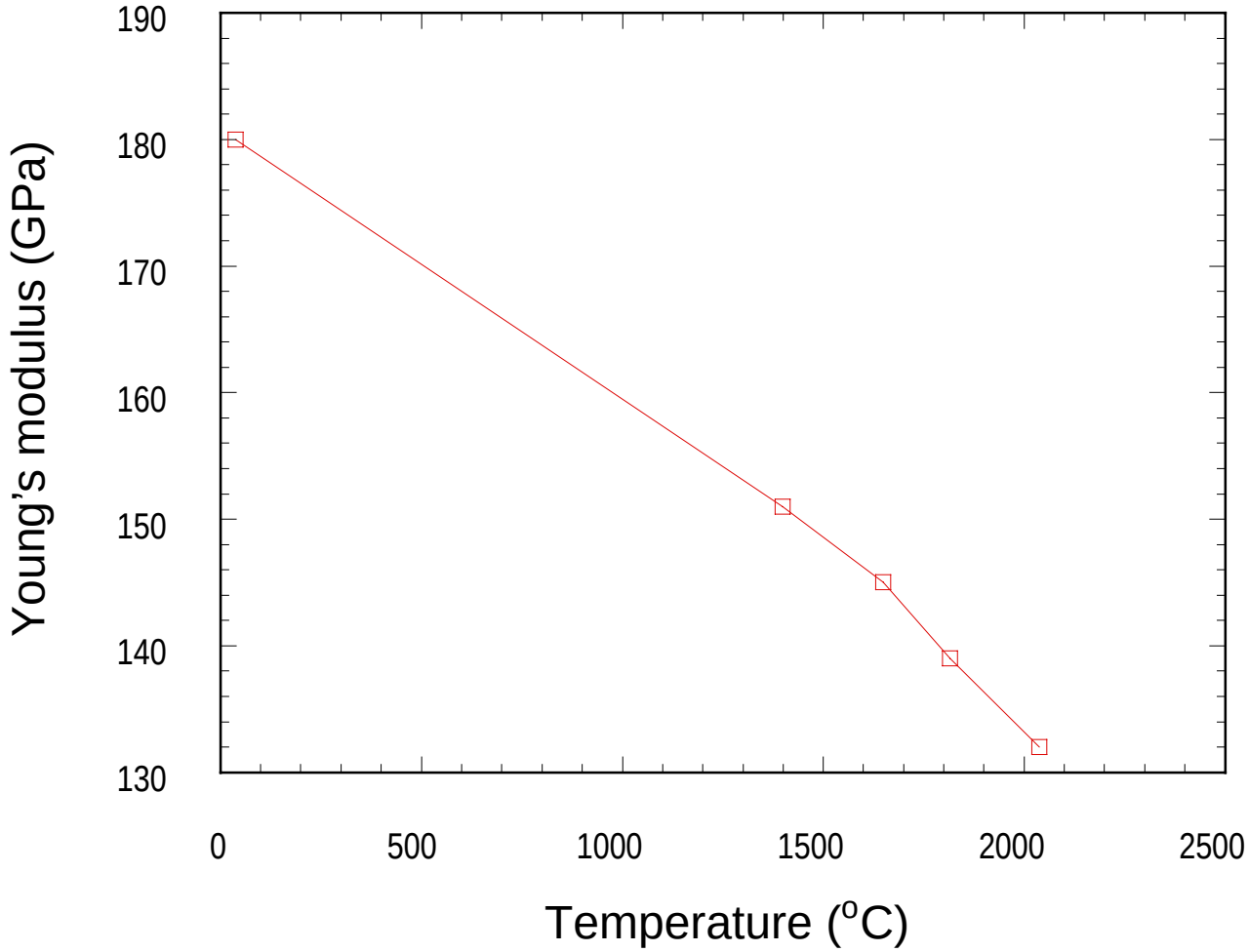


NWL limits for a 5mm thick Nb-1Zr wall.

PROPERTIES OF T111



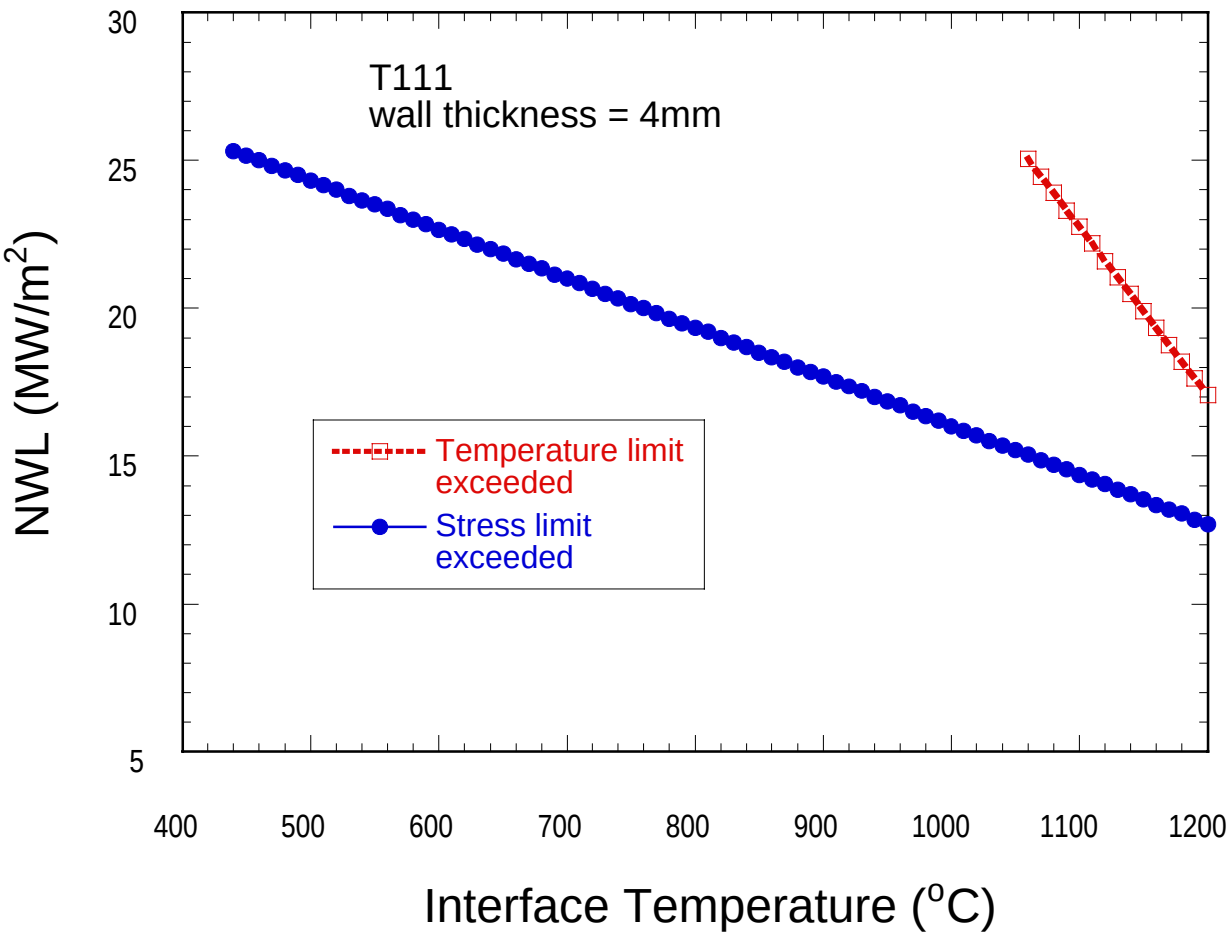
Strength of T111 as a function of temperature.



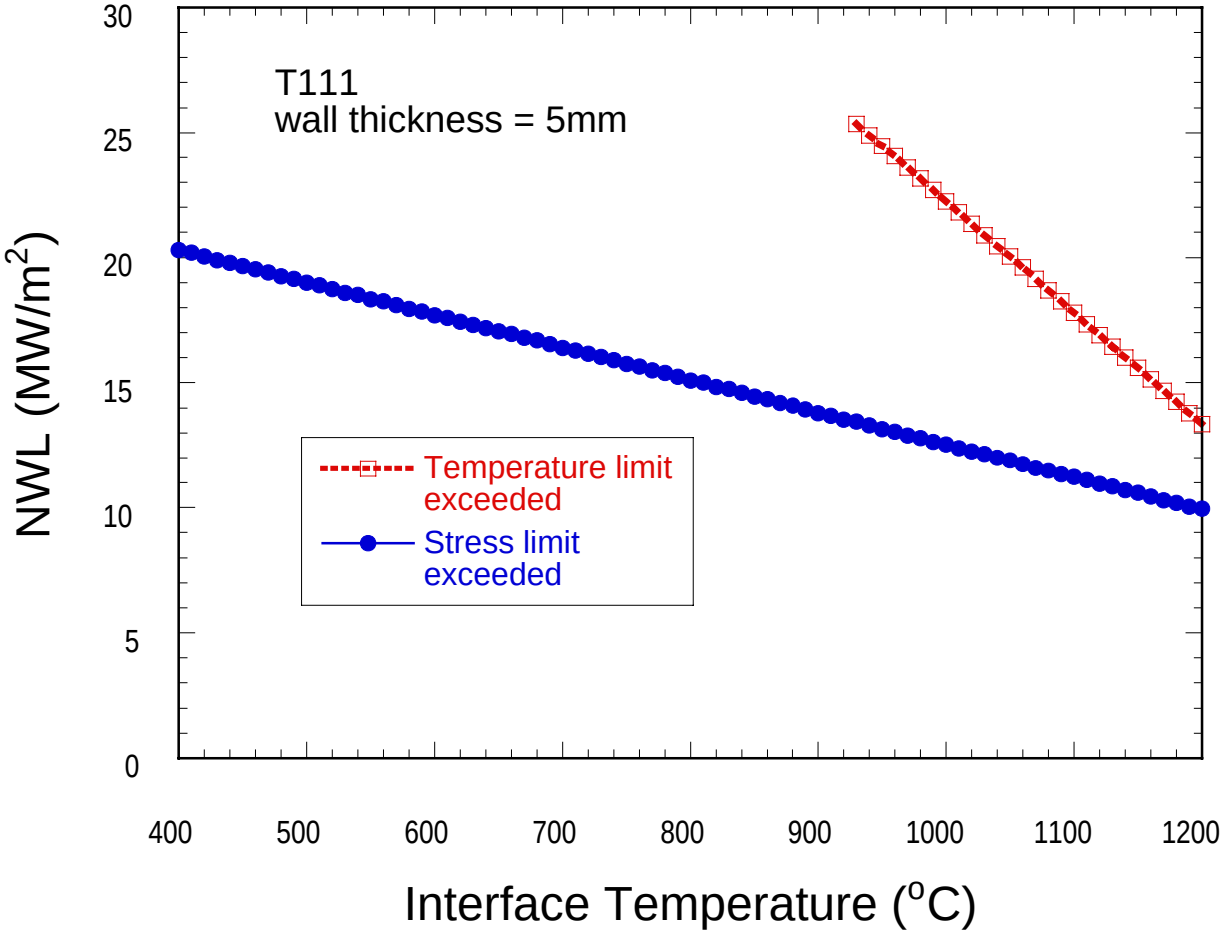
Modulus of T111 as a function of temperature.

OTHER PROPERTIES OF T111

- The thermal conductivity increases from 42 w/mK at RT to 55 w/mK at 870 •C.
- The coefficient of thermal expansion increase from ~ 5ppm/K at RT to ~7.6 ppm/K at 1600 •C.
- The recommended maximum operating temperature is about 1500 •C; approximately half the melting point of the alloy.



NWL Limits for a 4 mm thick T111 wall.



NWL Limits for a 5 mm thick T111 wall.