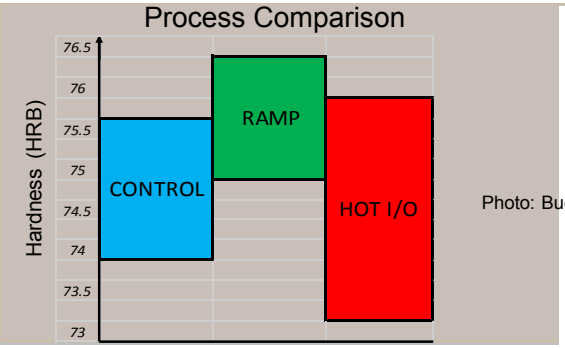
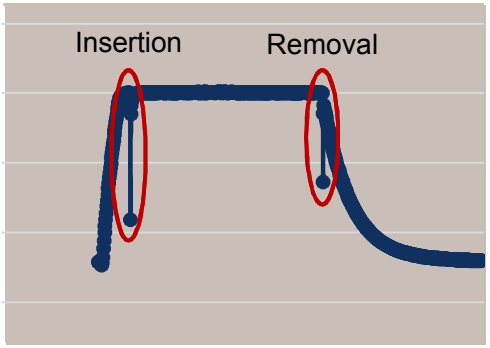
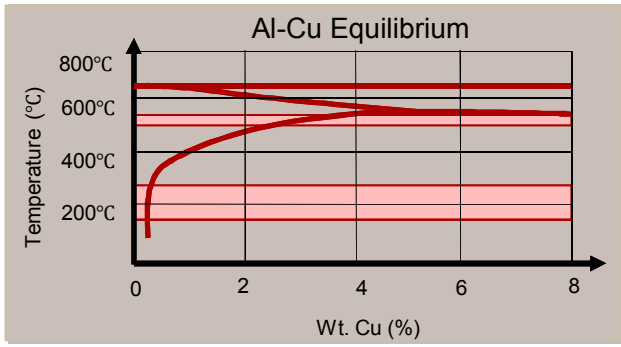
SAND2017-10207PE







Precipitation Hardening of 2219

Seth Dike

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Purpose

- A pressure vessel undergoes a series of unconventional, high temperature, thermal cycles manufacturing.
- The aging process during manufacturing is not well known; we want to understand the integrity of the vessel.
- Need for weldable alloy to serve as structure; 2219 is a top candidate.
- Study to act as a baseline: 2219 aged in air. Future work involves air-aging welds, then see both perform in a hydrogen environment.

Method

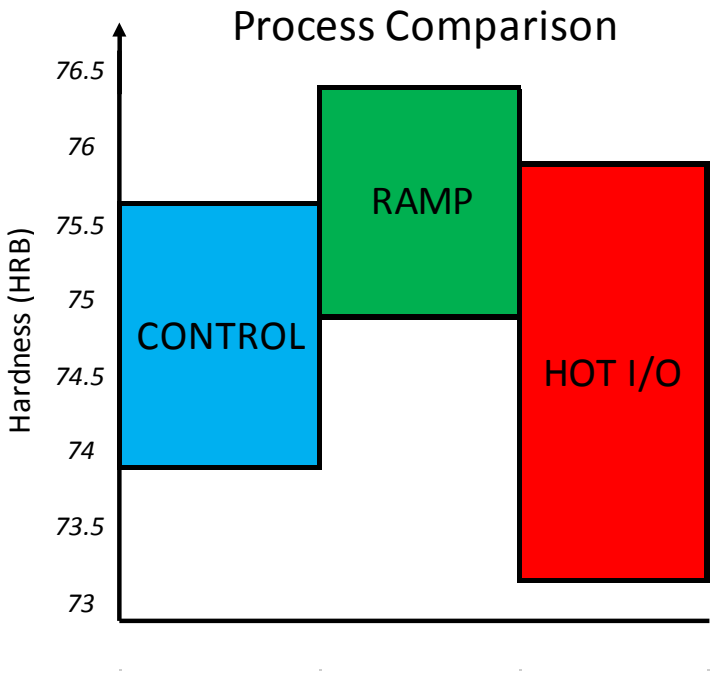
- Control: AA 2219-T8511 tempered bars.
  - Typical aging of bar: 191˚C for 18 hrs.
- Composition:

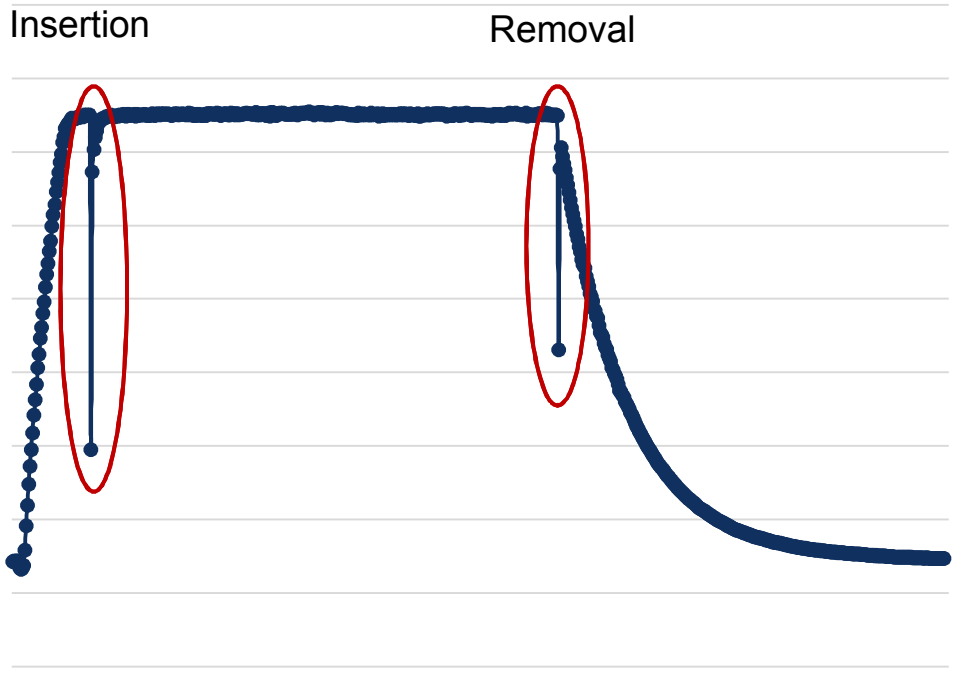
	Zn	Mg	Cu	Ni	Si	Fe	Mn	Cr	Ti	V	Zr
2219-T8511 (10019019)	0.06	0.02	6.0	n/r	0.05	0.12	0.26	n/r	0.03	0.08	0.10

- Solution-treated to T4 temper as specified in AMS 2772C.
- Aging temperature: 150˚C
  - representative of manufacturing steps
- Aging time: variable
  - Included as-received (T8511) samples to explore thermal stability of baseline material
- Rockwell Hardness Scale B characterizes aging.

Method

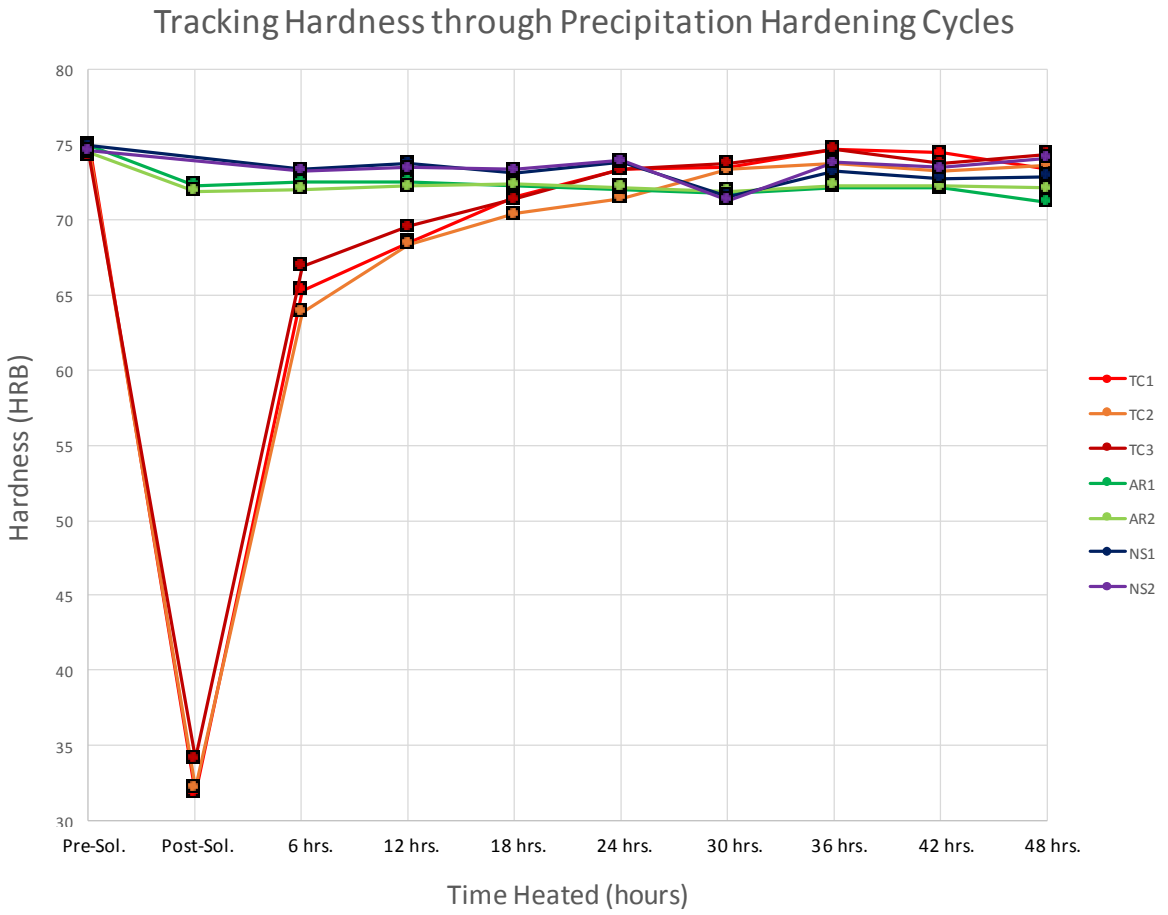
- Sample undergoes temperature ramping - not inserted hot.
- Fan-assisted furnace cooling.





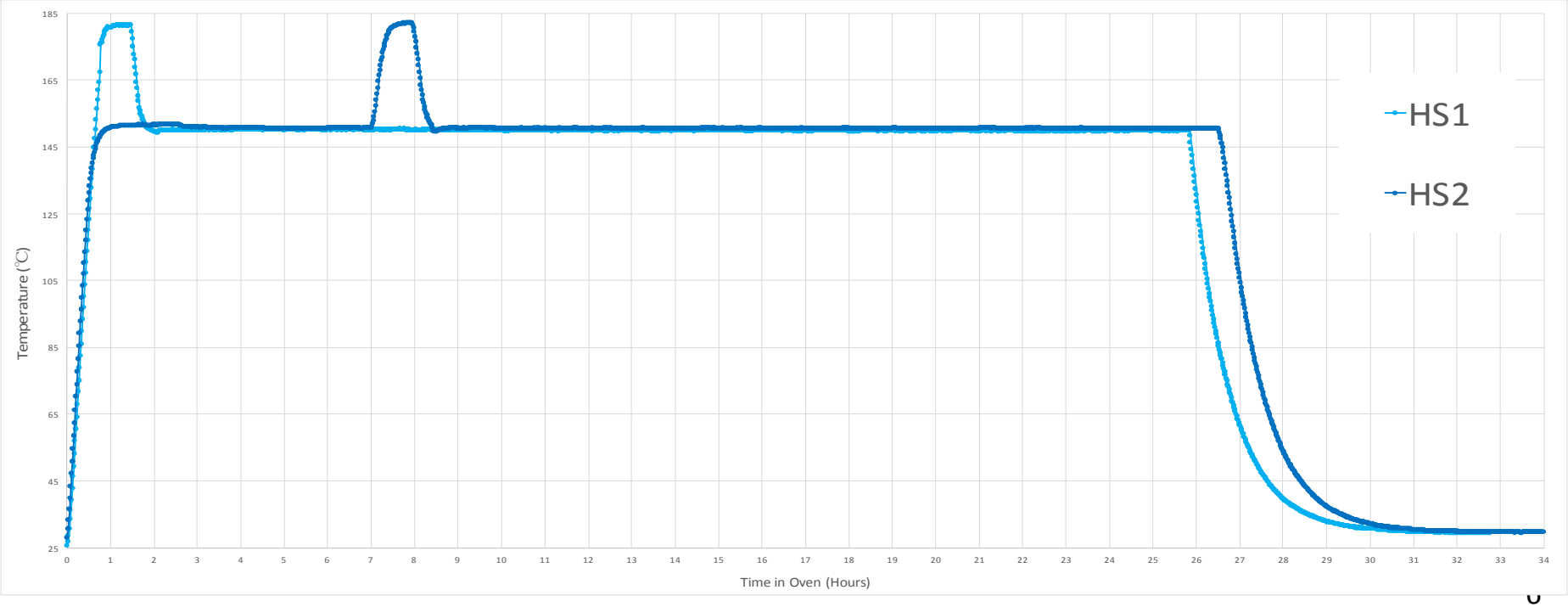
Phase I

- Solution treated samples start matching hardness of controls after 4 periods of cycling.
- Pre-Sol hardness taken closest to edge of sample – possible reason for discrepancy.



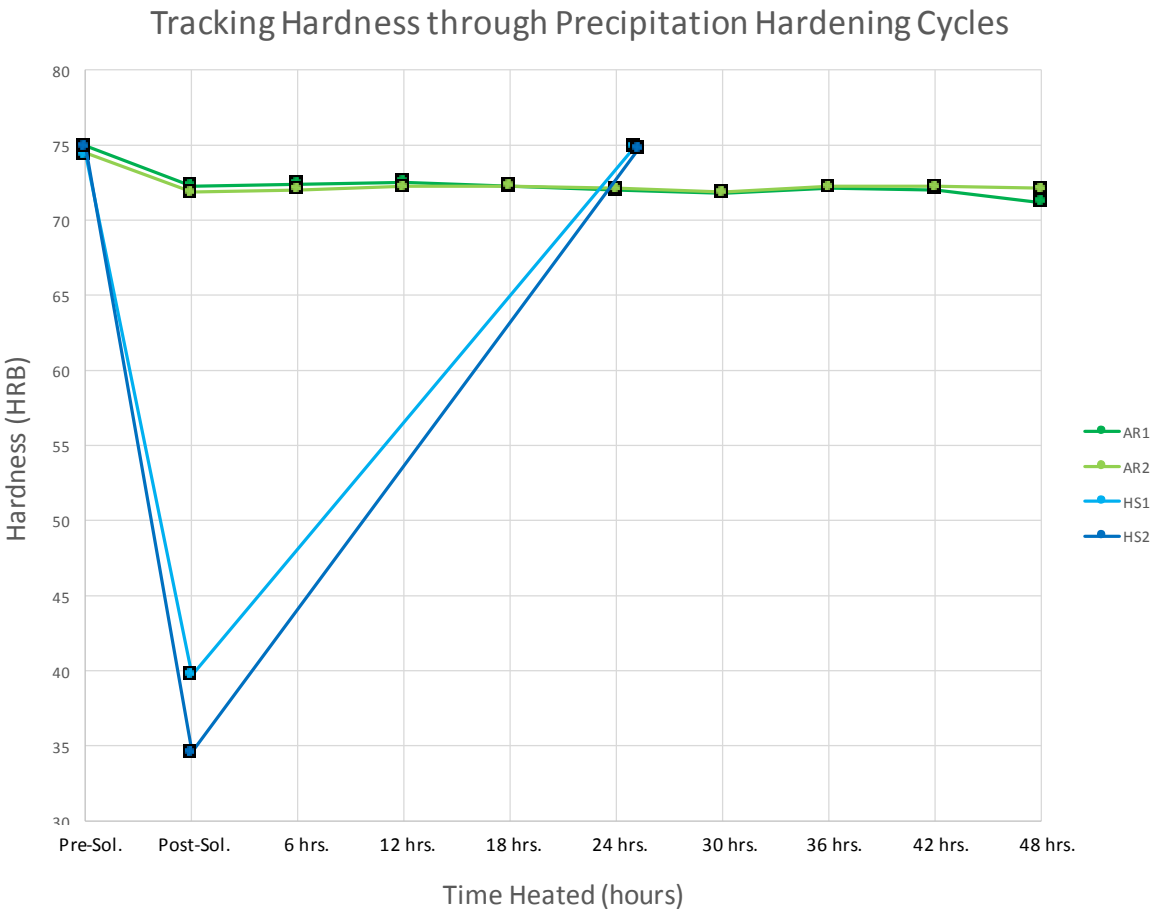
Phase II

- Based off of the findings from Phase I, testing parameters were set to one continuous cycle with duration of 24 hours at 150℃ and 30 minutes at 180℃.
- HS1 includes its 180℃ peak at start; HS2 peaks after 6 hours.



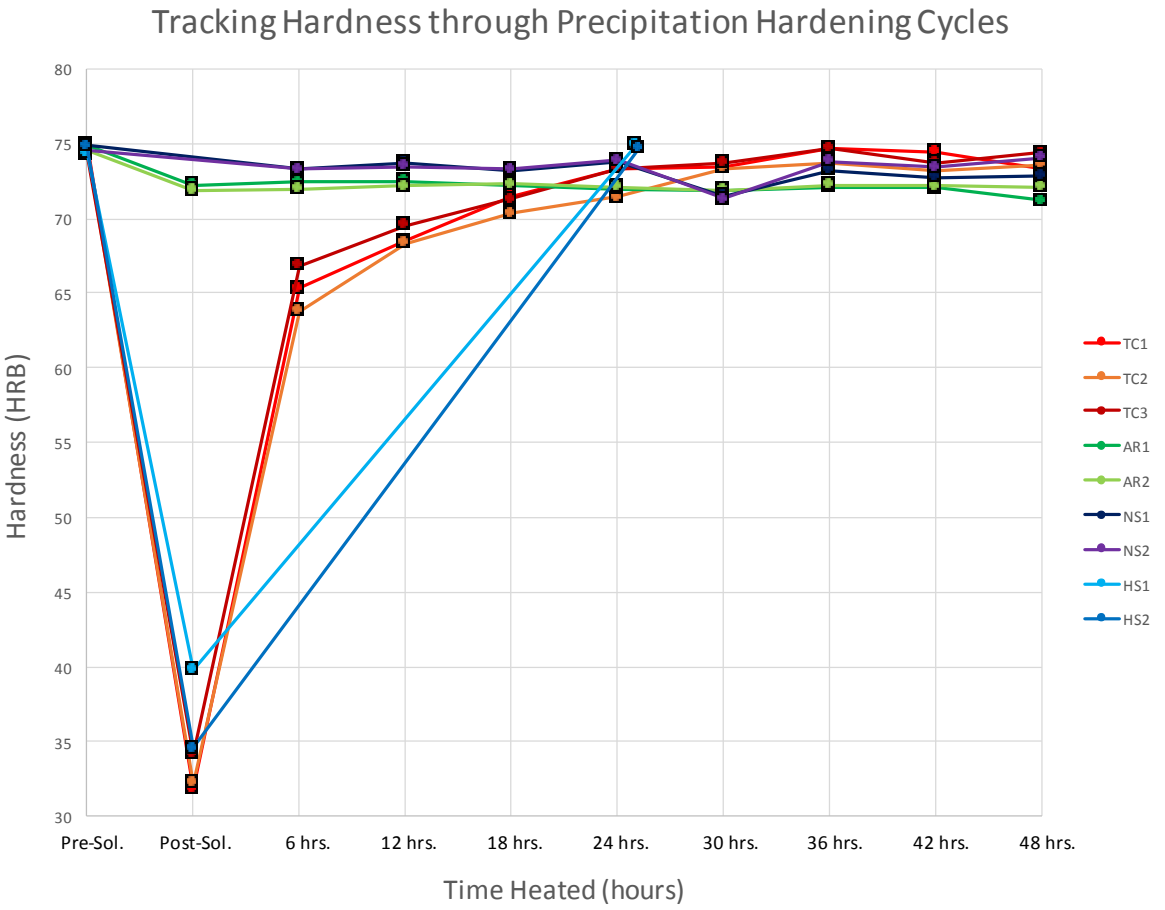
Phase II

- Hardness regained after only 24.5 hours.



Comparison of all aging data

- Aging at 150°C
  - Phase I: 36 hours to peak
  - Phase II: 24 hours to regain properties.
- Short term thermal excursions at 180°C accelerate aging (shorter times to peak hardness for aging at nominal temperature of 150°C).



Recent Literature Studies

- Wang et al. study[1]
  - focused on aging optimization: 24 hours, 165°C
  - 6.6% Cu
  - 150˚C/24hr: UTS = 58 ksi
- Sandia 2219
  - 6% Cu
  - 150˚C/24hr: UTS = 63 ksi

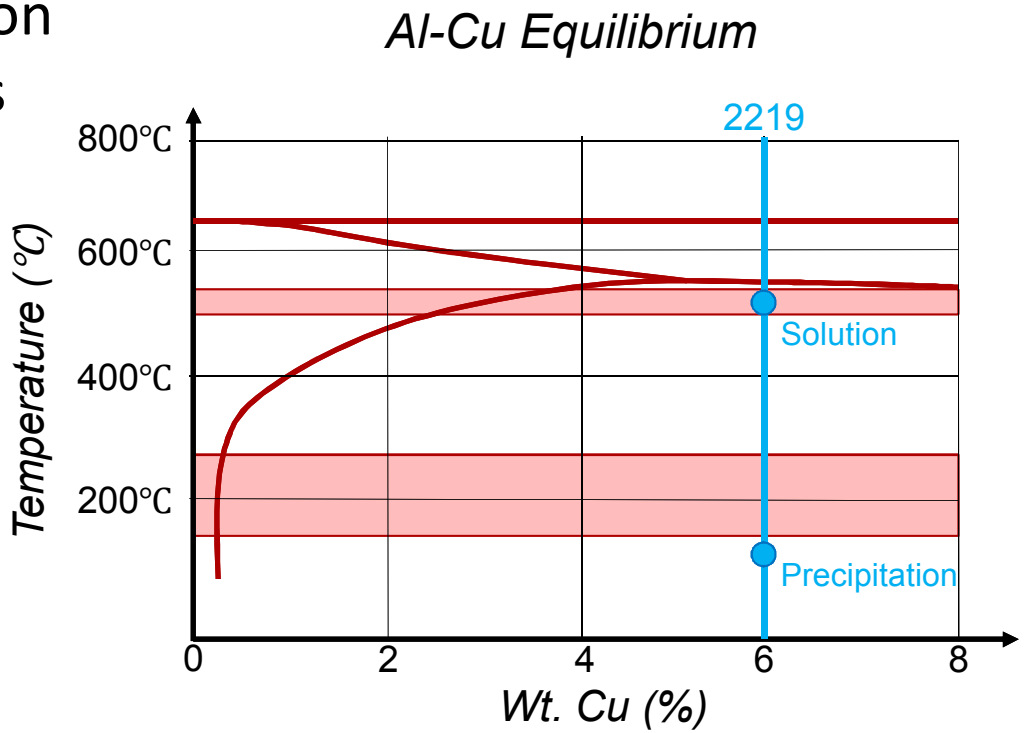
1 Wang, Huimin, et al. “Microstructure Evolution and Mechanical Properties of 2219 Al Alloy During Aging Treatment.” *Journal of Materials Engineering and Performance*, vol. 26, no. 4, 2017, pp. 1475–1482., doi:10.1007/s11665-017-2621-y.

Standards

- AMS 4162D: 2219-T8511 extrusions
  - Minimum UTS = 58 ksi (longitudinal)
  - Minimum UTS = 56 ksi (long transverse)
- ASTM B211: 2219-T851 bar
  - Minimum UTS = 57 ksi (diameter: 2-4 inch)
- This study (estimated using ASTM E140 and A370)
  - Phase I: UTS = 64.8 ksi
  - Phase II: UTS = 65.8 ksi
  - As-received UTS = 65.8 (hardness conversion)
  - As-received UTS = 63.4 ksi (tensile test)

Discussion

- Phase I's cycles are not run at typical precipitation temperatures. Phase II's 180℃ cycle enters this range (165-235℃).
- Initial testing shows solution-treated 2219 maintains its desired properties after aging processes.



Plot remade from source to display range of heat treat temperatures.[2]

2 "Aluminum: Properties and Physical Metallurgy." *Aluminum: Properties and Physical Metallurgy - ASM International*, www.asminternational.org/home/-/journalcontent/56/10192/06236G/PUBLICATION/.

Conclusions

- Hardness of T8511 temper can be achieved by aging T4 temper at 150˚C for 24hr.
  - Aging appears dominated by total time at aging temperature.
  - Intermediate thermal cycles (cooling to room temperature and re-heating to aging temperature) do not affect hardness evolution.
  - Short-term thermal excursions to 180˚C do not significantly affect hardness evolution for 24hr aging time.