Mechanical Property Shifts in the Pipe-Forming Process

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Overview

- UOE Pipe-Forming Process
- Background
- The Pipe
- Preparing Test Specimens
- Heat Treating
- Tensile Testing
- Results
- Conclusion

Pipe-Forming Process

- **UOE**

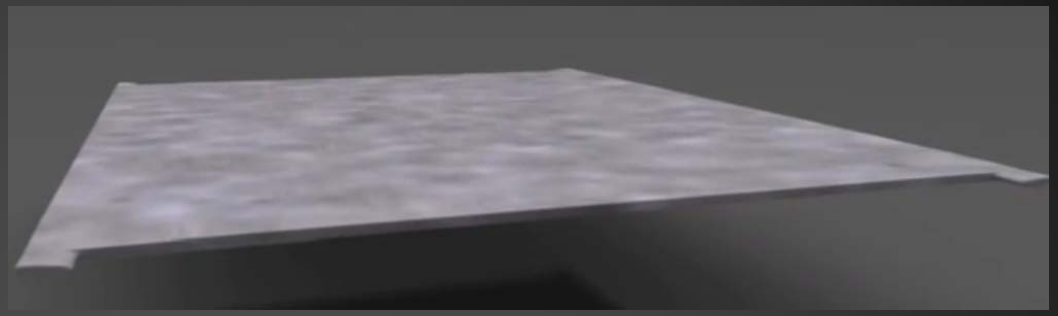
  a) Crimping

  b) U-ing

  c) O-ing

  d) Welding

  e) Expanding



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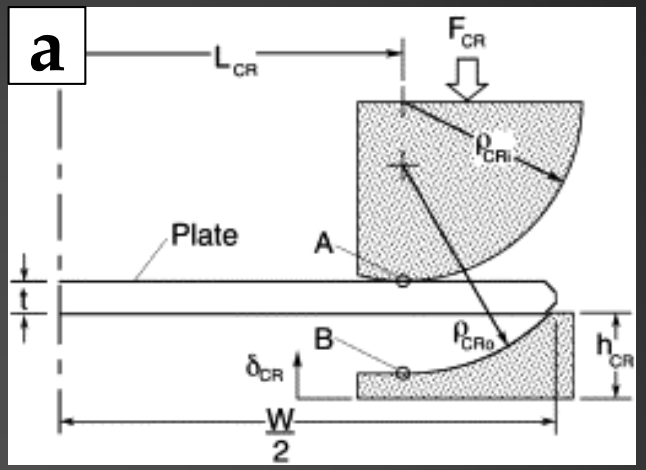

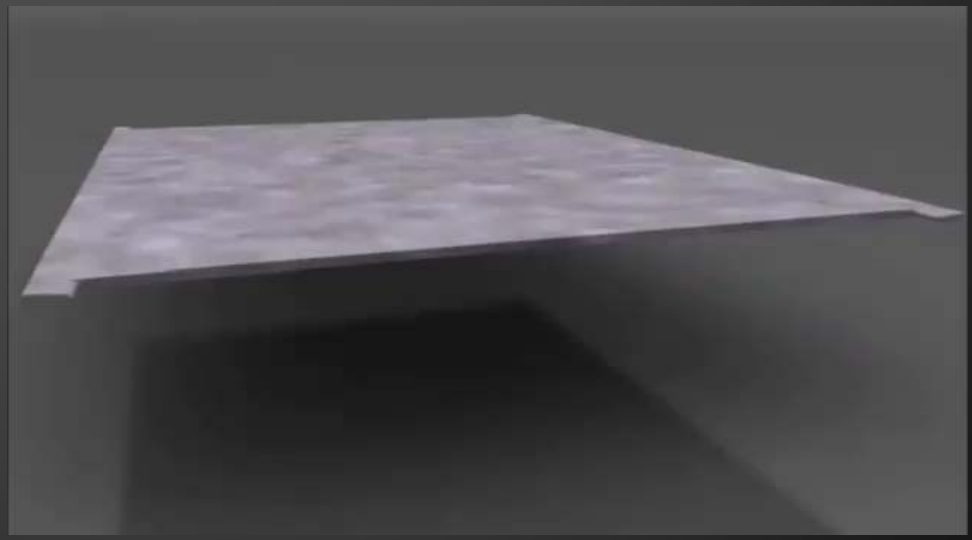

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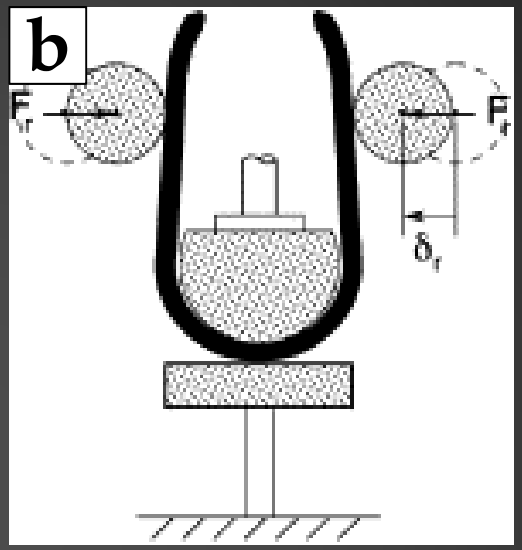

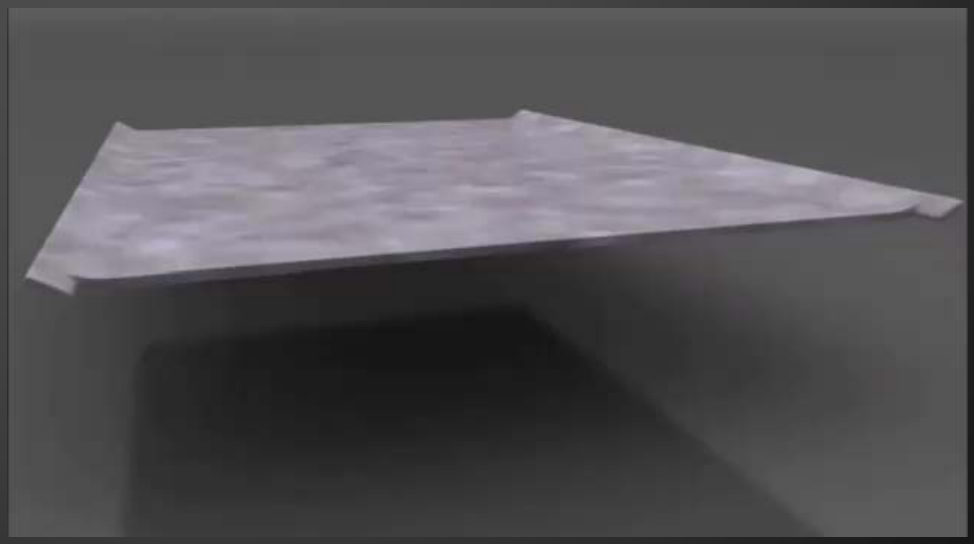

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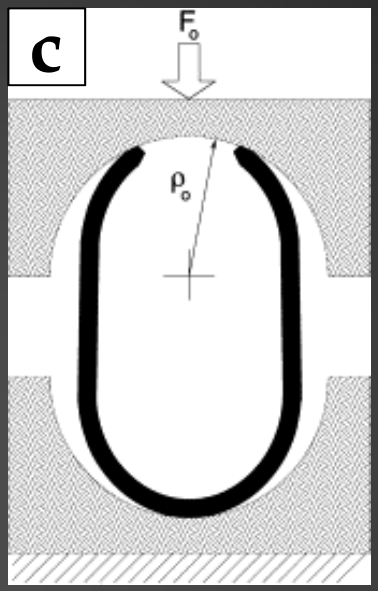

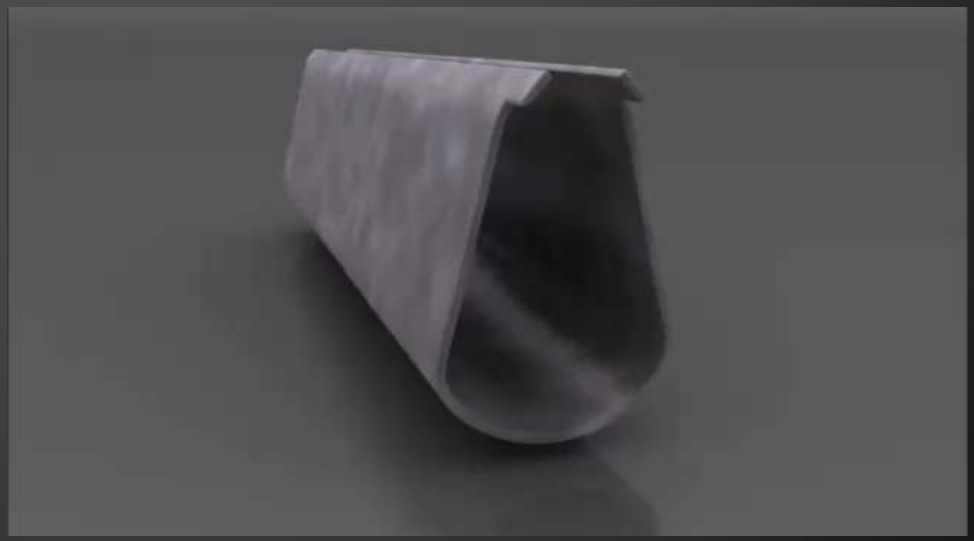

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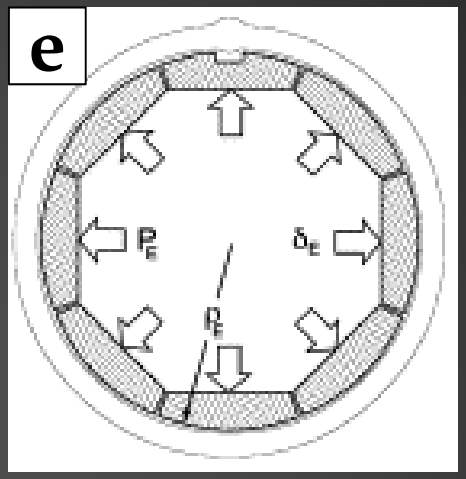
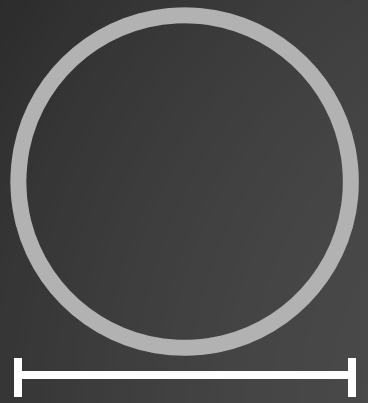


Background

- UOE process induces stresses in pipe
- UT Austin study – "UOE process resulted in a decrease of 33% in collapse pressure"
- How do we mitigate property losses?
  - Thicker pipes - $$$
  - Heat-treating
    - Quenching - ⬆ hardness/strength, ⬇ ductility
    - Tempering - ⬇ hardness/strength, ⬆ ductility

The Pipe

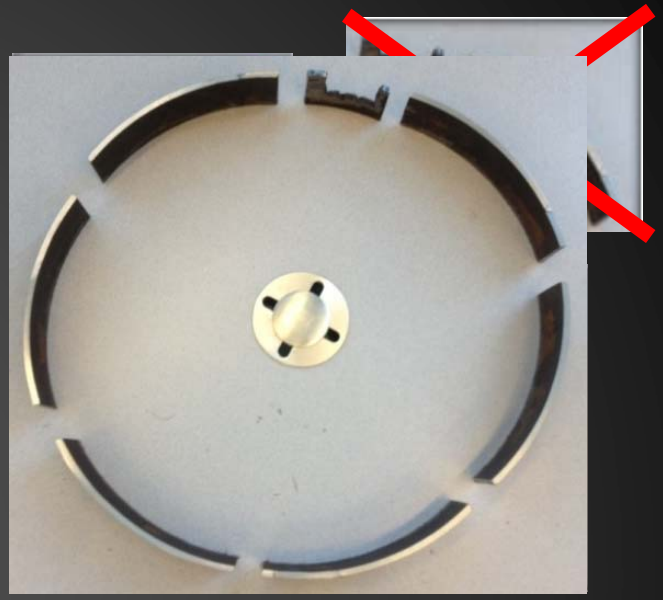
Front View

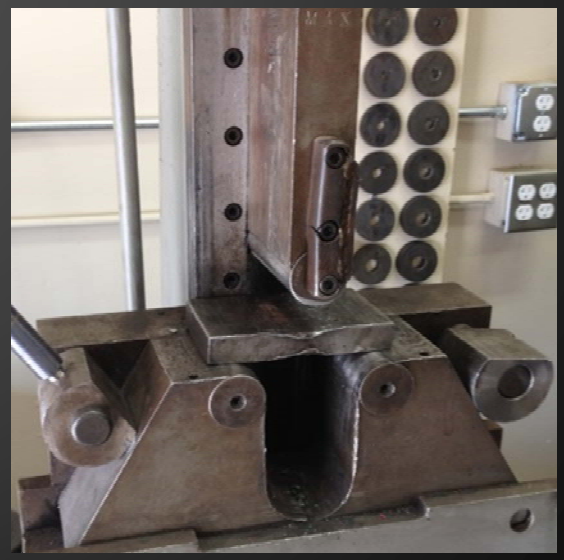


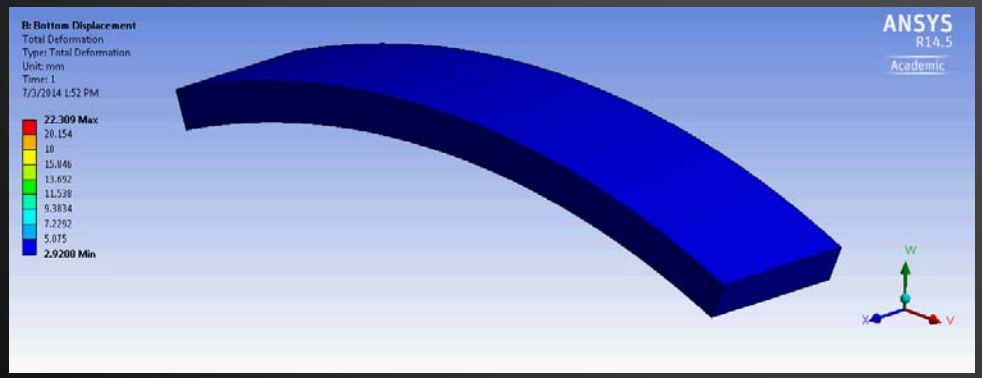
Side View

- Manufactured using UOE process
- Grade 70 Steel
  - Plate Yield Strength: 70 ksi min
- Normalization
  - Makes steel more uniform and ductile
  - Heating steel to 800-900°C, then air-cooling

Preparing Test Specimens







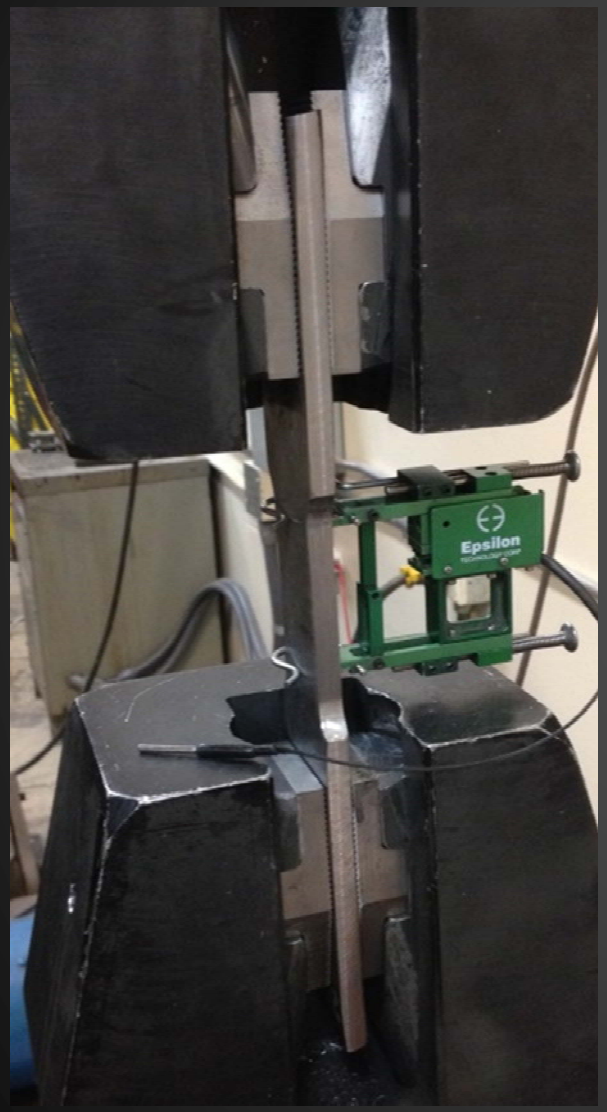
Preparing Test Specimens

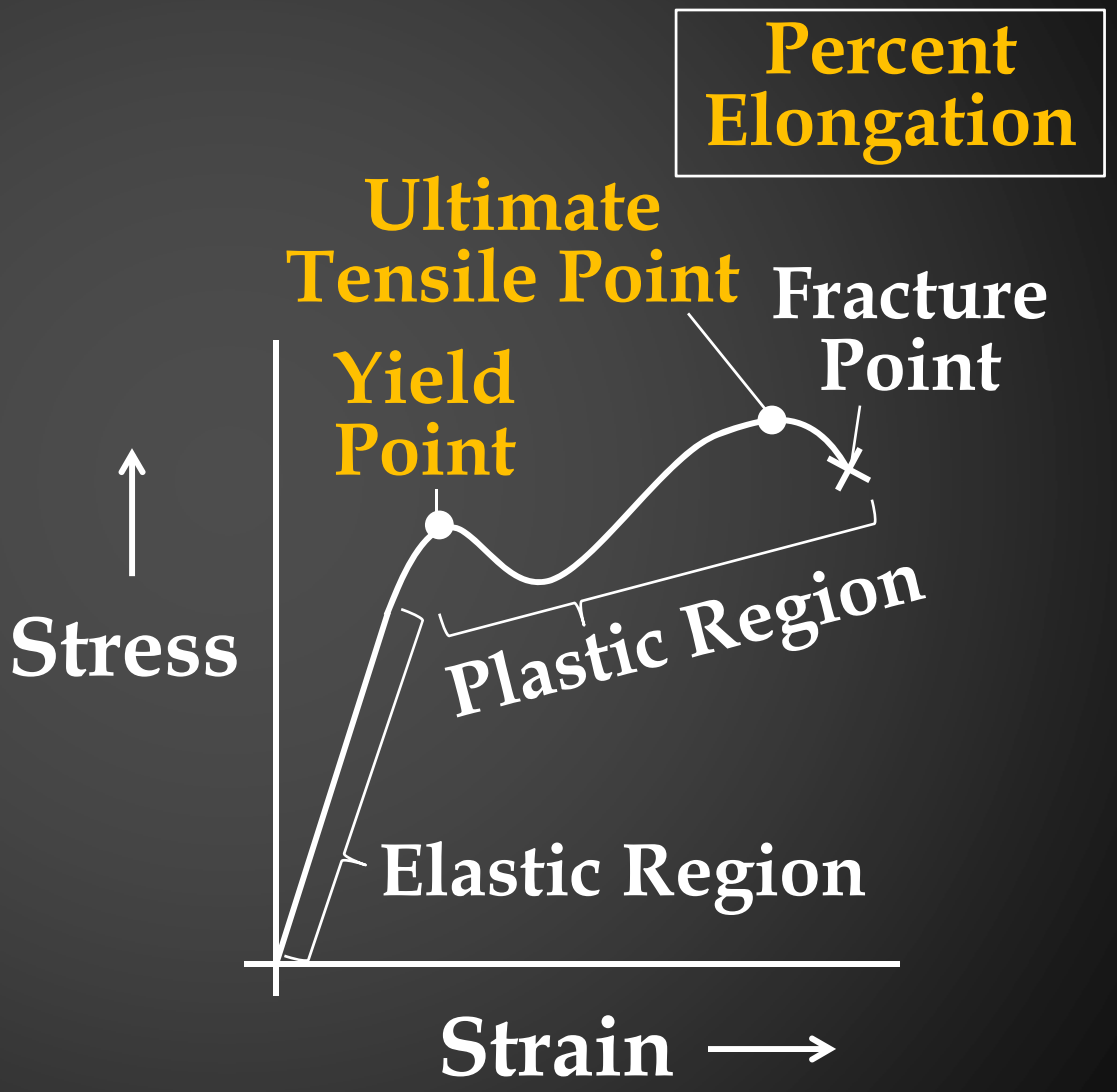
Dog Bone Test Specimen

Heat Treating

- Sample 1: Unheated
- Sample 2: Unheated
- Sample 3: Quench
  - 593°C for 1 hour
  - Room temp water
- Sample 4: Hot quench
  - 800°C for 1 hour
  - Room temp water
- Sample 5: Quench + Temper
  - 593°C for 1 hour
  - Ice water
  - Reheated to 450°C for half hour
  - Air-cooled

Tensile Testing





Results

Sample	Treatment	Yield Strength (ksi)	Ultimate Strength (ksi)	Percent Elongation (%)
1	Unheated	73.4	98.2	30.5
2	Unheated	69.4	93.1	30.5
3	593°C for 1 hour, Room-temp water	86.0	98.0	27.0
4	800°C for 1 hour, Room-temp water	58.6	96.2	26.5
5	593°C for 1 hour, Ice water, Reheated to 450°C for half hour, Air cooled	92.0	99.0	29.0

Conclusion

- Quench + temper process most effective in mitigating property losses
- Unheated samples had greatest ductility
- Additional research required
- Future work
  - Additional samples (plate and pipe)
  - Different heat treatments

Acknowledgements

- Lemmy Meekisho
- Kristina Rodgers
- Bob Turpin
- Mark Boling
- William Wood
- Tom Quayle
- PSU REU Program
- National Science Foundation

- EVRAZ North America

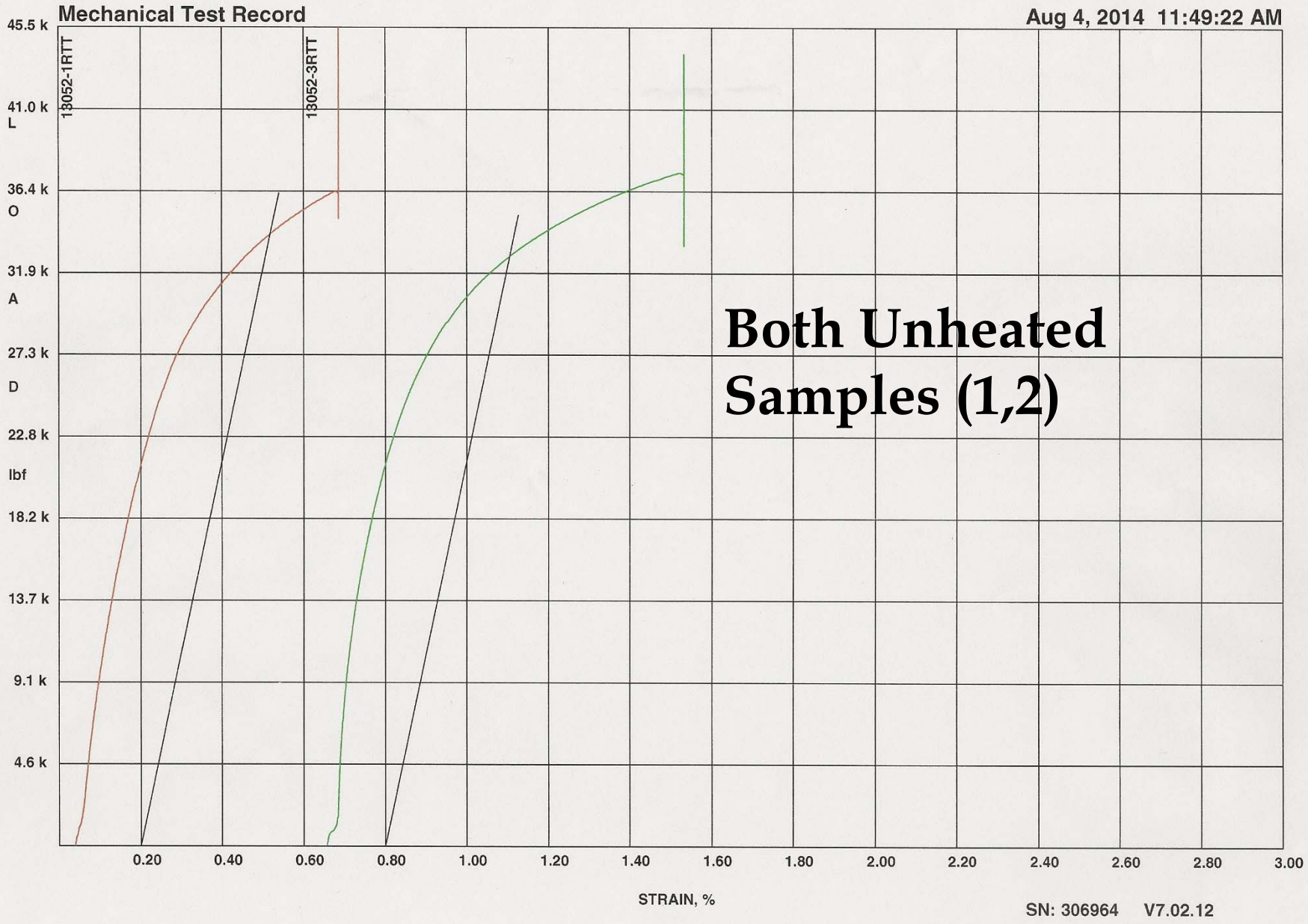
- IMR KHA

References

- **Slide 1 image: http://www.sunnysteel.com/welding.php#.U_B1z_nOZFI**
- **Slides 3-8 images/animation: https://www.youtube.com/watch?v=Akk7YWUUp_Q**
- **Slides 4-6, 8 images: http://www.engr.mun.ca/~spkenny/Courses/Undergraduate/ENGI8673/Reading_List/2007_Herynk_UOE_UOC.pdf?origin=publication_detail**
- **Slides 10-14 images: Taken by Valerie Chen**

- **Dossett, Jon L., and Howard E. Boyer. *Practical Heat Treating*. Revised/Expanded ed. Materials Park, Ohio: ASM International, 2006.**
- **Herynk, M.D., S. Kyriakides, A. Onoufriou, and H.D. Yun. "Effects of the UOE/UOC pipe manufacturing processes on pipe collapse pressure." *International Journal of Mechanical Sciences* 49 (2006): 533-553.**
- **Senthilkumar, T., and T.K. Ajiboye. "Effect of Heat Treatment Processes on the Mechanical Properties of Medium Carbon Steel." *Journal of Minerals & Materials Characterization & Engineering* 11 (2012): 143-152.**

Thanks for listening!
Questions?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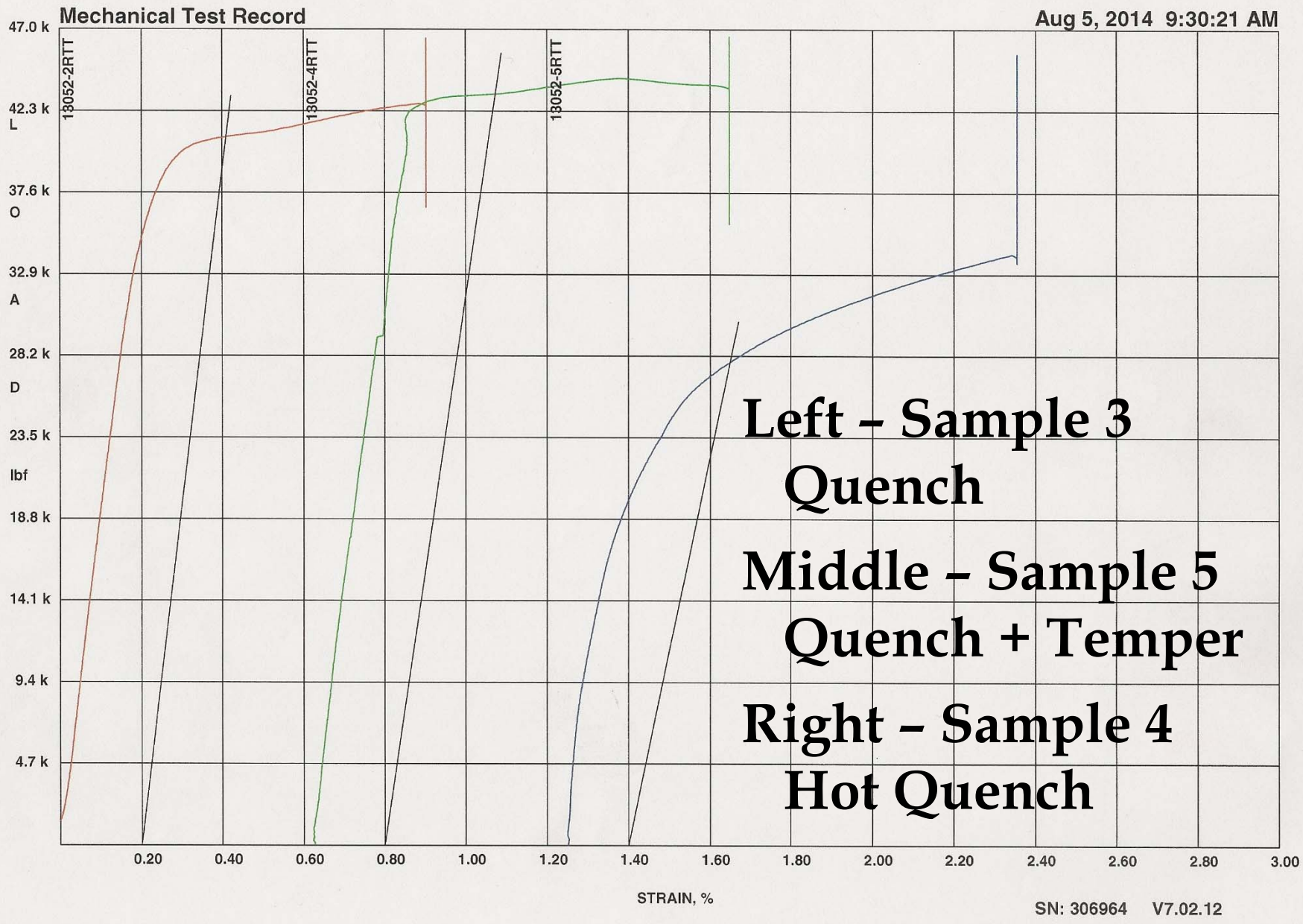
13052-1RTT
13052-3RTT
45.5 k
41.0 k
L
36.4 k
O
31.9 k
A
27.3 k
D
22.8 k
lbf
18.2 k
13.7 k
9.1 k
4.6 k
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
STRAIN, %
SN: 306964
V7.02.12
Both Unheated
Samples (1,2)


Mechanical Test Record
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42.3 k
L
37.6 k
O
32.9 k
A
28.2 k
D
23.5 k
lbf
18.8 k
14.1 k
9.4 k
4.7 k
13052-2RTT
13052-4RTT
13052-5RTT
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
STRAIN, %
SN: 306964 V7.02.12
Left – Sample 3
Quench
Middle – Sample 5
Quench + Temper
Right – Sample 4
Hot Quench

Pipe Expansion Tool

Image from http://www.hizanherz.co.uk/images/TOOLZONE/TZAU083/AU083.jpg

Iron-Carbon Phase Diagram

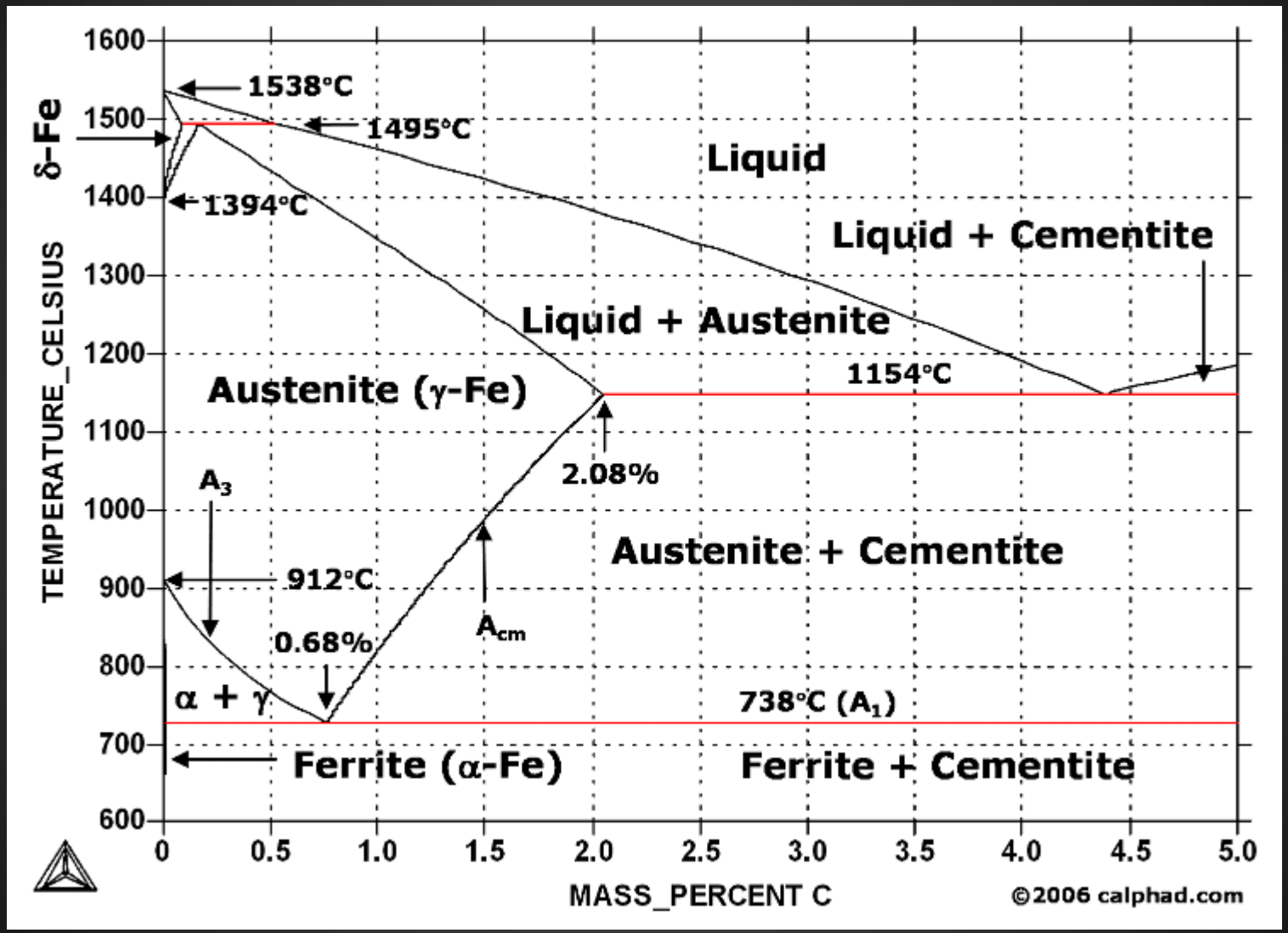

Image from http://www.calphad.com/iron-carbon.html