HEAT EXCHANGER WORLD CONFERENCE & EXPO AMERICAS

2022

Welding Fabrication of Heat Exchanger Alloy Materials

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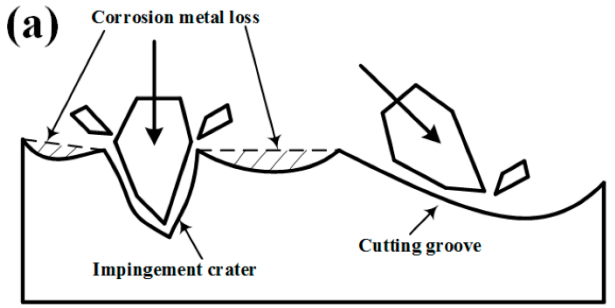
Challenges with Alloys

- We continue to use more advanced materials
  - Strength
  - Corrosion resistance
  - Weight
  - Temperature resistance

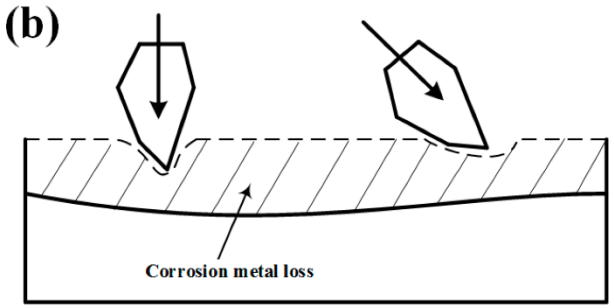
- We need to address and control
  - Welding metallurgy
  - Filler metal selection
  - Heat input

Heat Exchanger specific challenges

- High(er) Temperatures
- Erosion
- Corrosion



Erosion dominated



Corrosion dominated

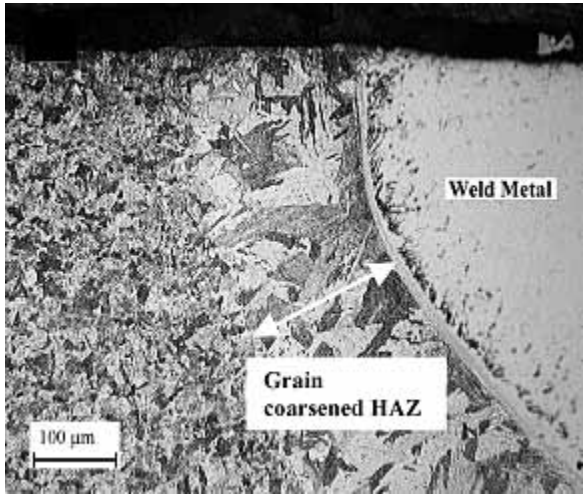
- Weldability
  - Tubesheet?
  - Tube-to-tube?
  - Other?
- Formability
  - Rolled tubes?

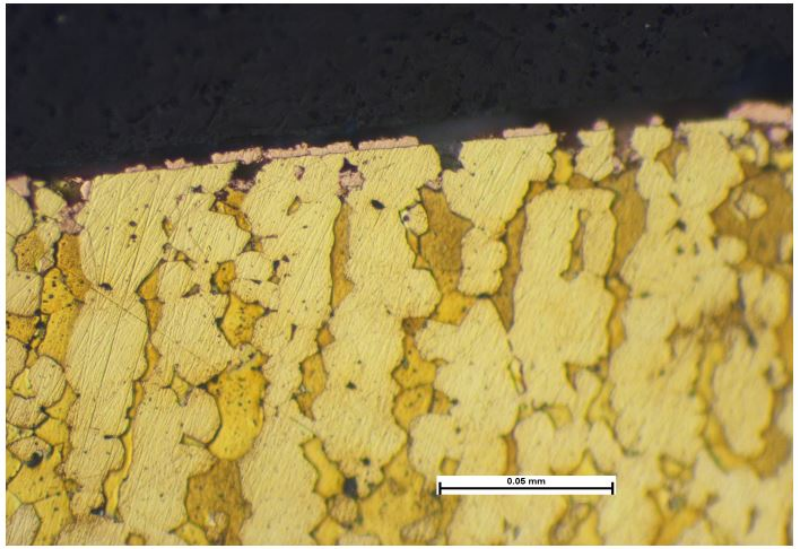
Who does the work, and who makes sure?

- OEM or contractor or in-house?
- Who specifies the material(s)?
- Who sets material specific joining requirements?
- Who defines the weld test parameters?

Welding Consequences

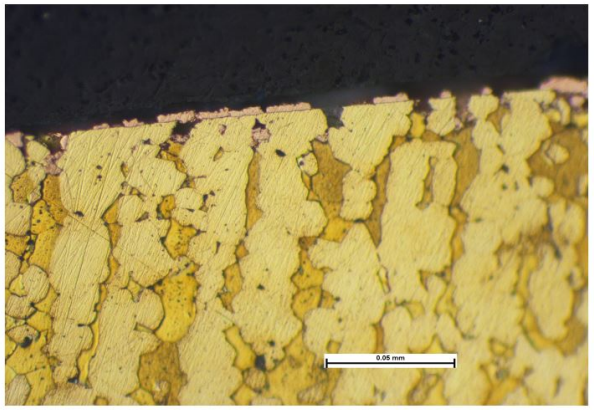
- De-alloying
- Change in microstructure





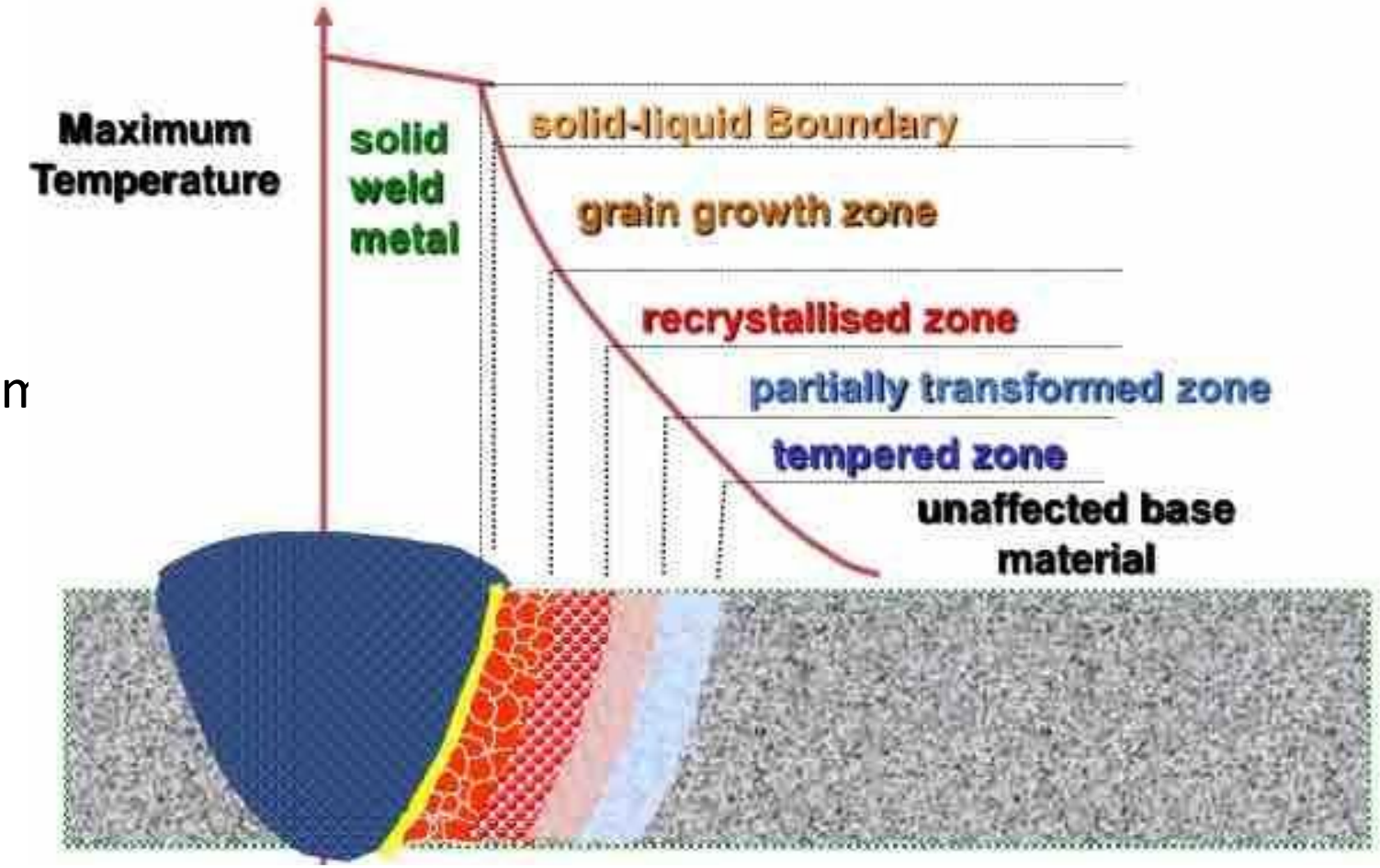
Dealloying

- We often think of this in brass
  - Loss of zinc
- We can lose elements across the arc, or due to remelt/ recast



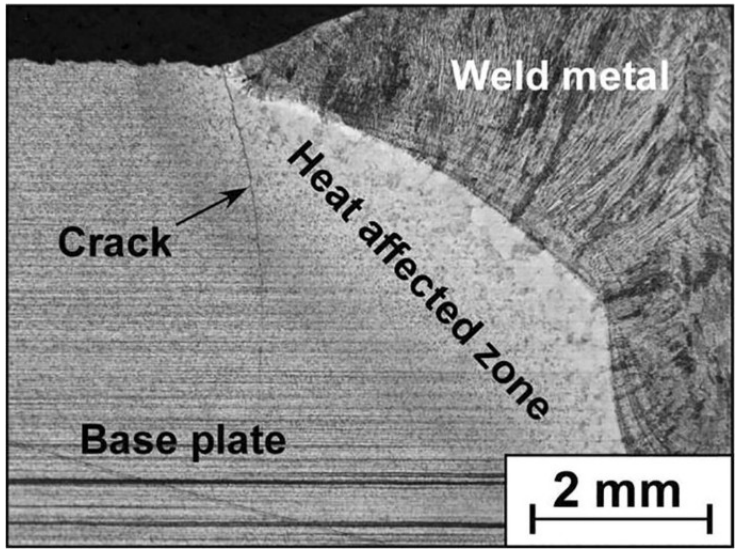
Dealloying

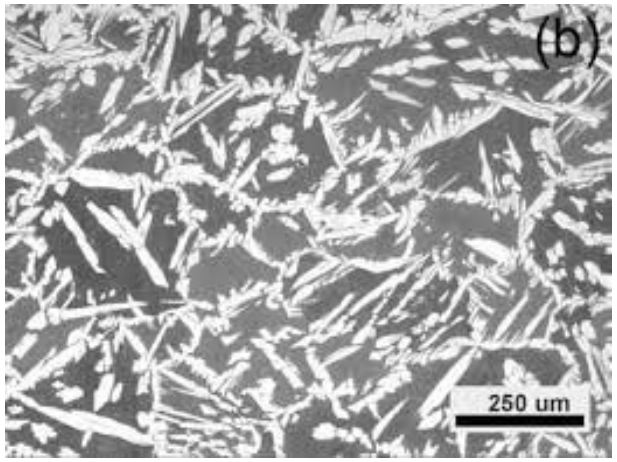
- Cr and Mn can be problematic.
  - Most filler metals are overmatched, which normally solves the problem
- Nitrogen, often present in strong, pitting resistant alloys, is easy to lose.
  - Filler is overmatched, but what about remelt zone?

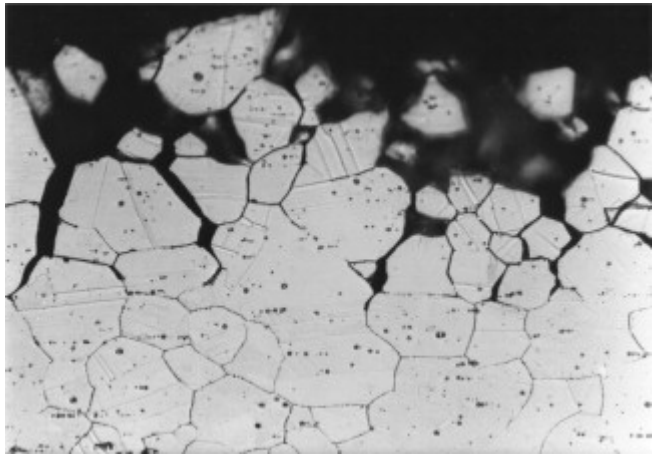


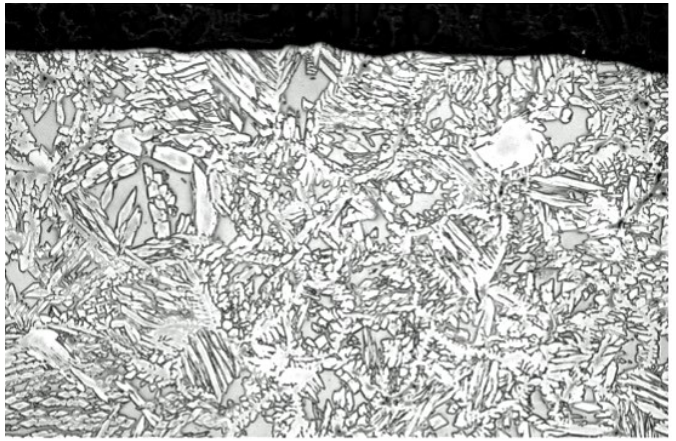
Microstructure

- HAZ Grain coarsening
- Precipitation
- Solidification behavior
- Alloy influence

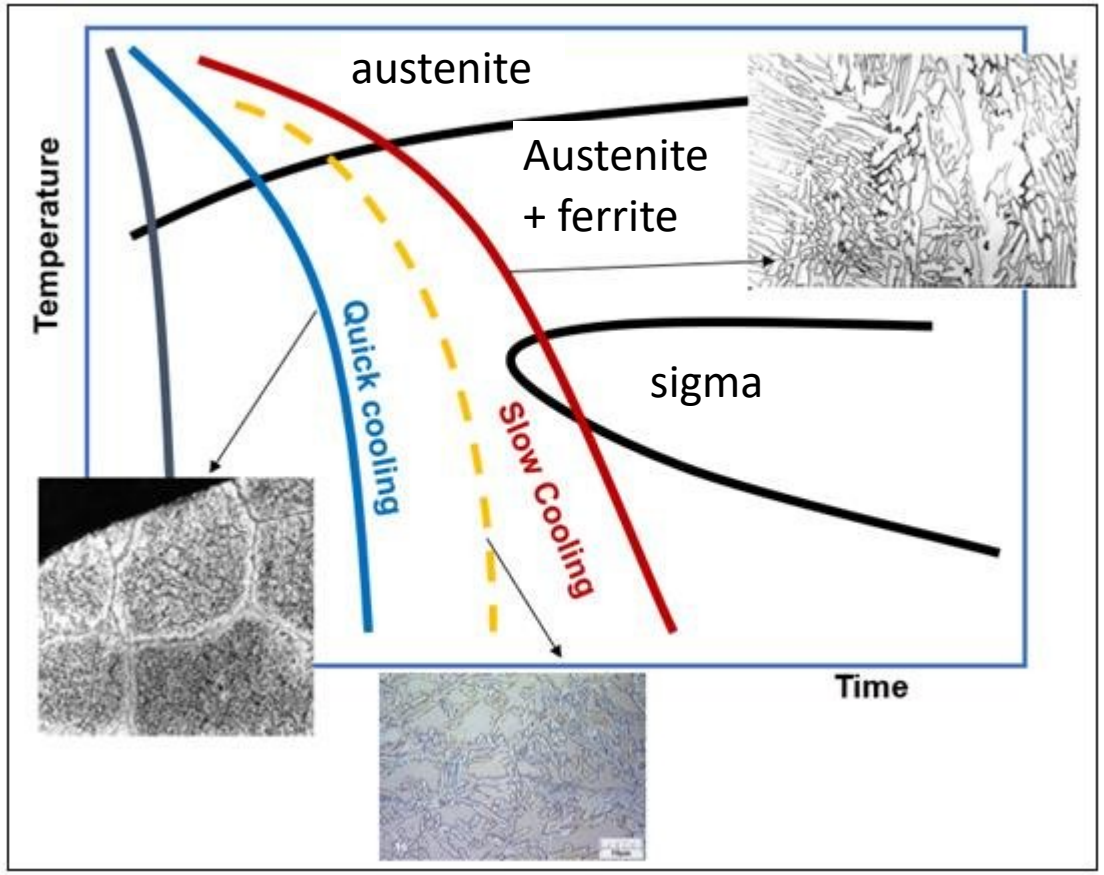




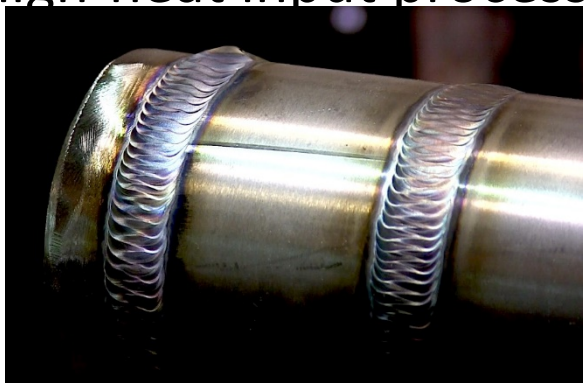




Microstructure & Heat

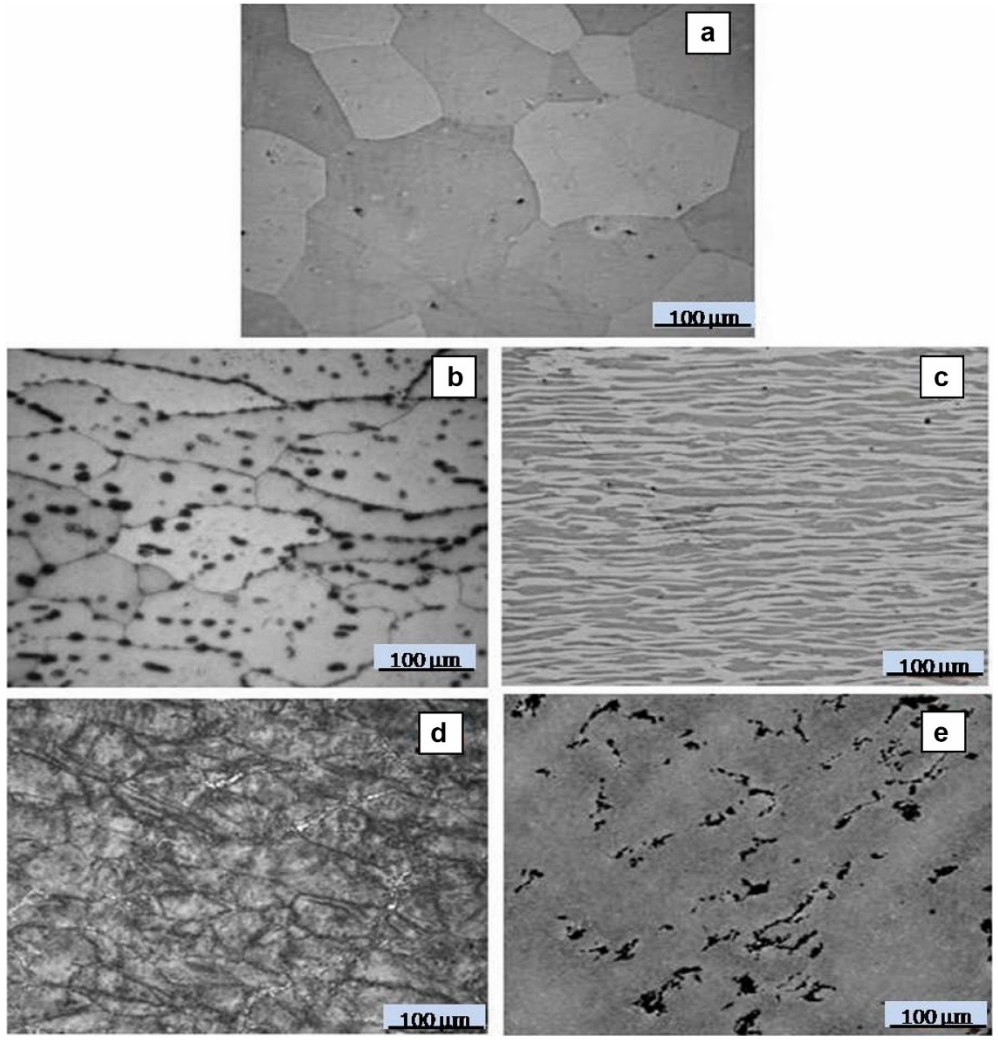


- Microstructure problems can be heat input related
  - What can we do?
  - Stringer technique vs weave
  - Specify maximum heat input and interpass temps
  - Beware high-heat input processes
    - TIG!



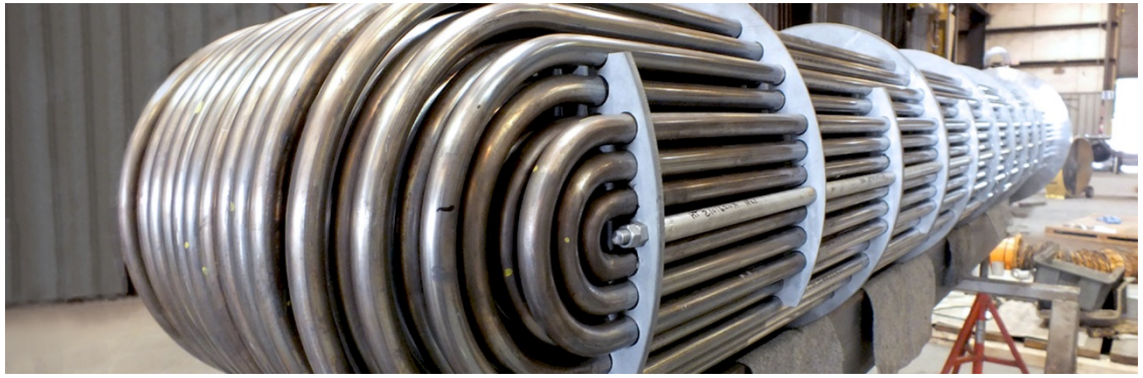
Microstructure and Alloying

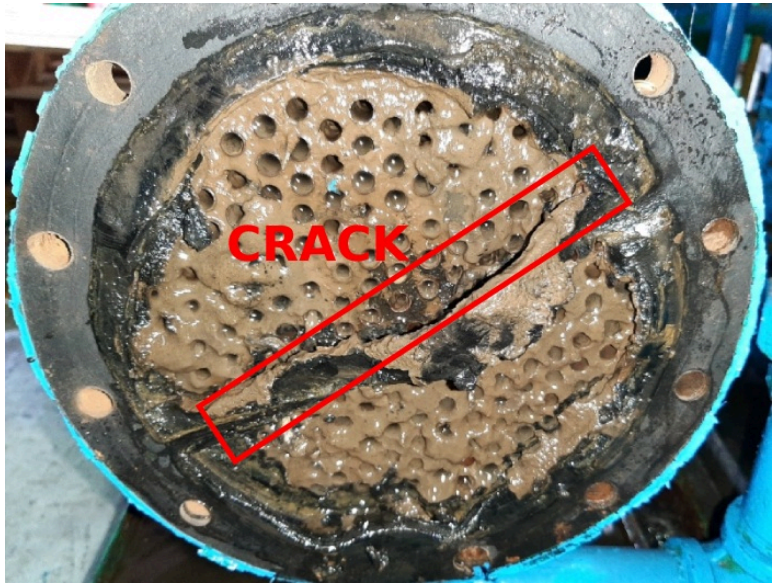
- Filler metal is critical, especially on higher alloys
- Dissimilar metals
  - Tube to Tubesheet?
- Buttering
  - Transitioning from high alloy to more economical material
- We can’t always just match alloy content.



Specific Materials

- A couple of more advanced alloys
- Some ideas on what can happen





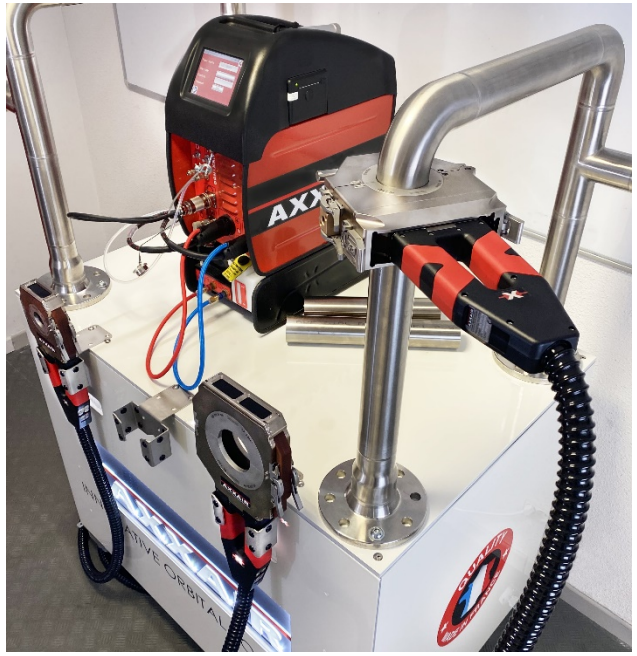
- Can we as designers/engineers limit

AL-6XN

- Orbital (autogenous) is dangerous

- Alloying system is disrupted
  - Undesirable phases
  - Excess ferrite
  - Reduced corrosion

- So what do we do
  - PWHT (solution anneal at ~2,100 degrees)



AL-6XN

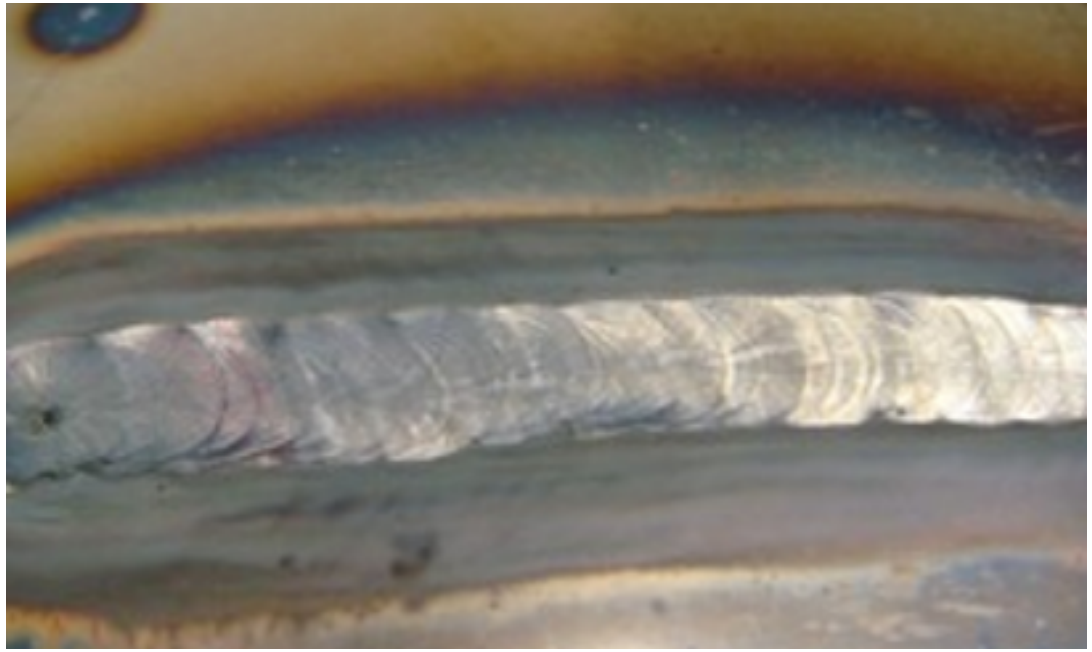
- So what do we do
  - No autogenous welding
  - Overmatch Ni and Mo
  - Consider some N_2 in the gas.

2205 Superduplex

- Overmatching common
- Extra Ni and N for austenite formation
  - Very common to use 2209 to weld 2205

- Solidifies as ferrite (strong)
- During cooling, transformation to austenite (resistant)
- Finishes solidification as ~50/50

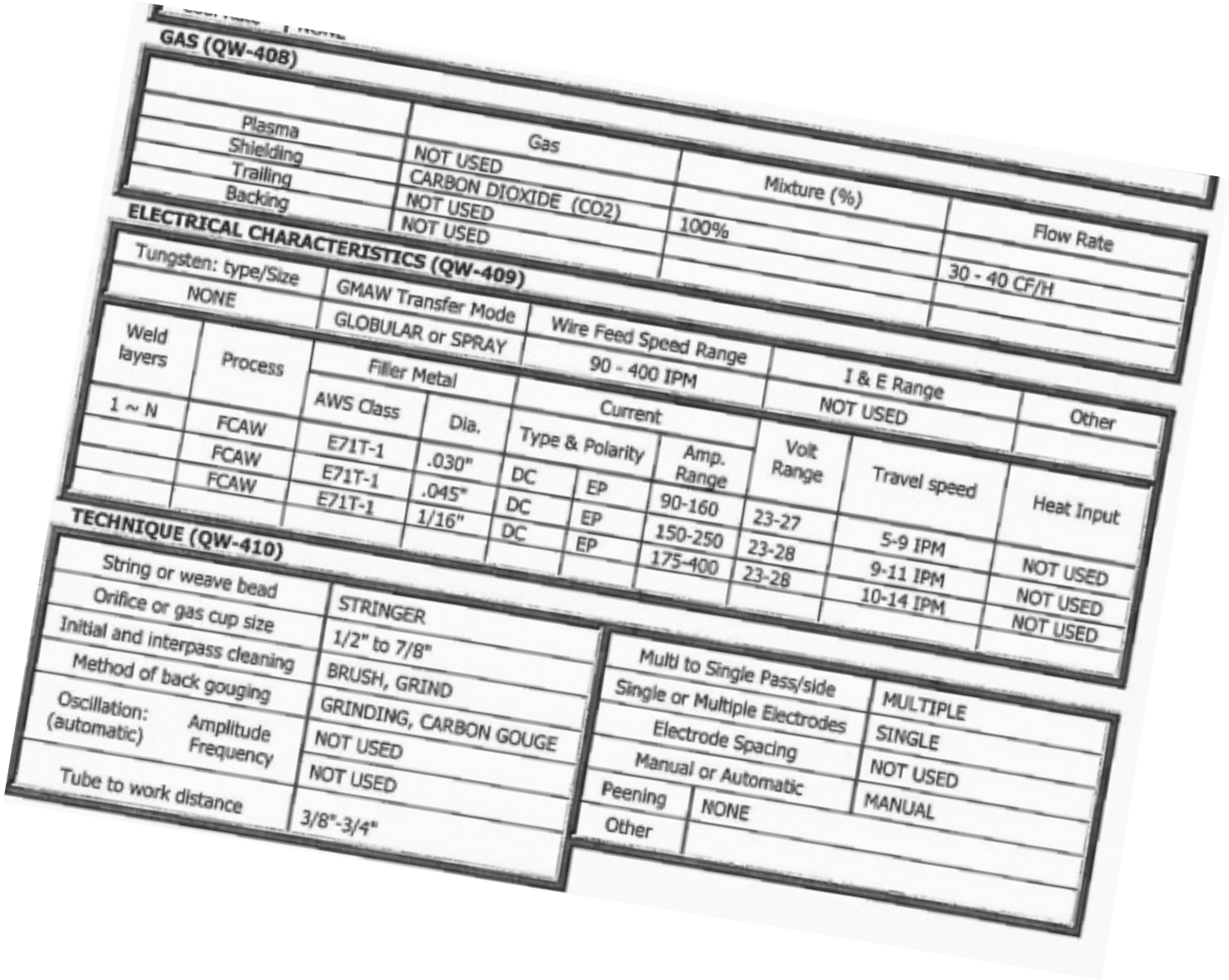
2205 and heat input



- Thick metal, low heat input
  - Fast solidification
  - Excess ferrite
  - Loss of corrosion resistance
- Thin metal, high(er) heat input
  - Slow cooling
  - Excess austenite
  - Loss of strength

What can we do?

- Write good specifications
  - Control Heat input
  - Specify overmatching filler
  - PWHT as needed
  - Diligently review weld procedures
    - BEFORE FABRICATION
  - Perform owners inspection



GAS (QW-408)

	Gas	Mixture (%)	Flow Rate
Plasma	NOT USED		
Shielding	CARBON DIOXIDE (CO2)	100%	30 - 40 CF/H
Trailing	NOT USED		
Backing	NOT USED		

ELECTRICAL CHARACTERISTICS (QW-409)

Tungsten: type/Size	GMAW Transfer Mode	Wire Feed Speed Range	I & E Range	Other
NONE	GLOBULAR or SPRAY	90 - 400 IPM	NOT USED	

Weld layers	Process	Filler Metal AWS Class	Filler Metal Dia.	Current Type & Polarity		Current Amp. Range	Volt Range	Travel speed	Heat Input
1 ~ N	FCAW	E71T-1	.030"	DC	EP	90-160	23-27	5-9 IPM	NOT USED
	FCAW	E71T-1	.045"	DC	EP	150-250	23-28	9-11 IPM	NOT USED
	FCAW	E71T-1	1/16"	DC	EP	175-400	23-28	10-14 IPM	NOT USED

TECHNIQUE (QW-410)

String or weave bead	STRINGER
Orifice or gas cup size	1/2" to 7/8"
Initial and interpass cleaning	BRUSH, GRIND
Method of back gouging	GRINDING, CARBON GOUGE
Oscillation: Amplitude (automatic)	NOT USED
Oscillation: Frequency (automatic)	NOT USED
Tube to work distance	3/8"-3/4"

Multi to Single Pass/side	MULTIPLE
Single or Multiple Electrodes	SINGLE
Electrode Spacing	NOT USED
Manual or Automatic	MANUAL
Peening	NONE
Other	

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- Questions?
- Comments?
- Astute Observations?