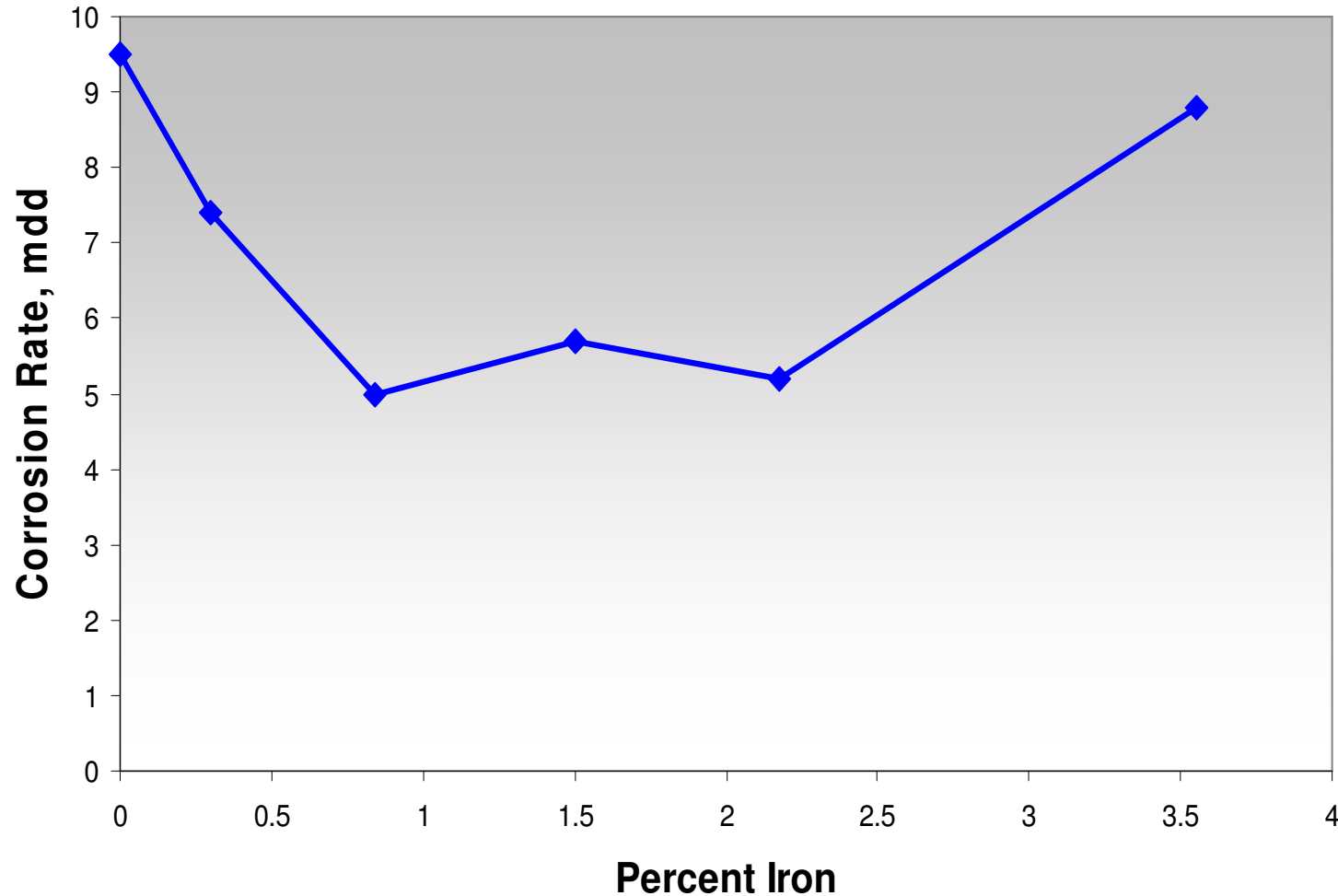


“THE IMPORTANCE OF IRON IN 90/10 COPPER-NICKEL”

THE HISTORY OF IRON IN **90/10 COPPER-NICKEL**

- **1949 – 1% max iron specified by ASTM B111
(thus 90/10 with no iron met spec.)**
- **1952 – “Corrosion-Resisting Characteristics of
Iron-Modified 90:10 Cupro Nickel Alloy”
presented at 8th annual NACE conference**
- **1952 – Iron specification was changed to 0.5-2.0%**
- **1960’s – Iron specification changed to current 1.0-1.8%**

THE EFFECT OF IRON ON THE GENERAL CORROSION RESISTANCE OF 90/10 COPPER-NICKEL



Erosion-Corrosion Rates and Magnetic Permeability Data for 90/10 Copper-Nickel at Two Flow Rates in Seawater **

Percent Iron in 90/10 Cu-Ni	Magnetic Permeability, μ			Erosion-Corrosion Rate, mdd					
				Velocity = 30 ft/s			Velocity = 15 ft/s		
	Cond. A	Cond. B	Cond. C	Cond. A	Cond. B	Cond. C	Cond. A	Cond. B	Cond. C
0.01	1.00	1.00	1.00	138	138	137	106	105	104
0.48	1.00	1.00	1.00	119	115	124	71	72	85
0.71	1.00	1.00	1.18	121	118	110	64	75	49
0.95	1.00	1.04	1.14	96	93	104	27	63	47
1.19	1.00	1.27	1.55	87	98	87	26	65	39
1.44	1.00	1.28	1.83	36	84	99	17	58	49
1.96	1.00	1.44	2.40	26	79	84	10	55	51

Condition A - Quenched from 900⁰ C. **Iron in solution.**

Condition B - Quenched from 900⁰ C; reheated 2 hours at 550⁰C, except for alloys containing 1.00% or more iron, which were reheated 2 hours at 600⁰C. **Partial precipitation of iron-rich phase.**

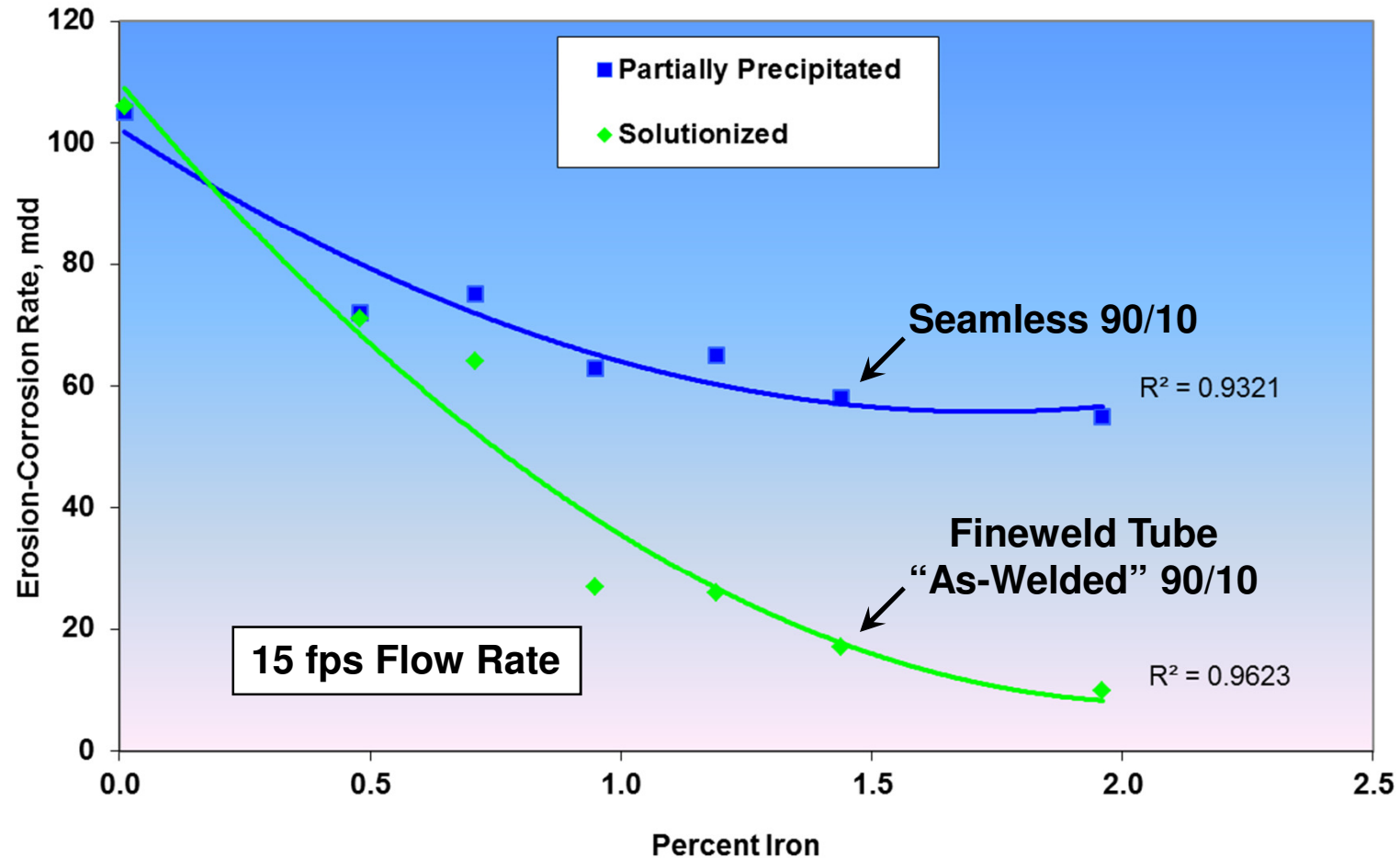
Condition C - Quenched from 900⁰ C; reheated 8 hours at 650⁰ C. **Maximum precipitation of iron-rich phase.**

STRAND ANNEALING AT OLIN BRASS PUTS IRON INTO SOLUTION



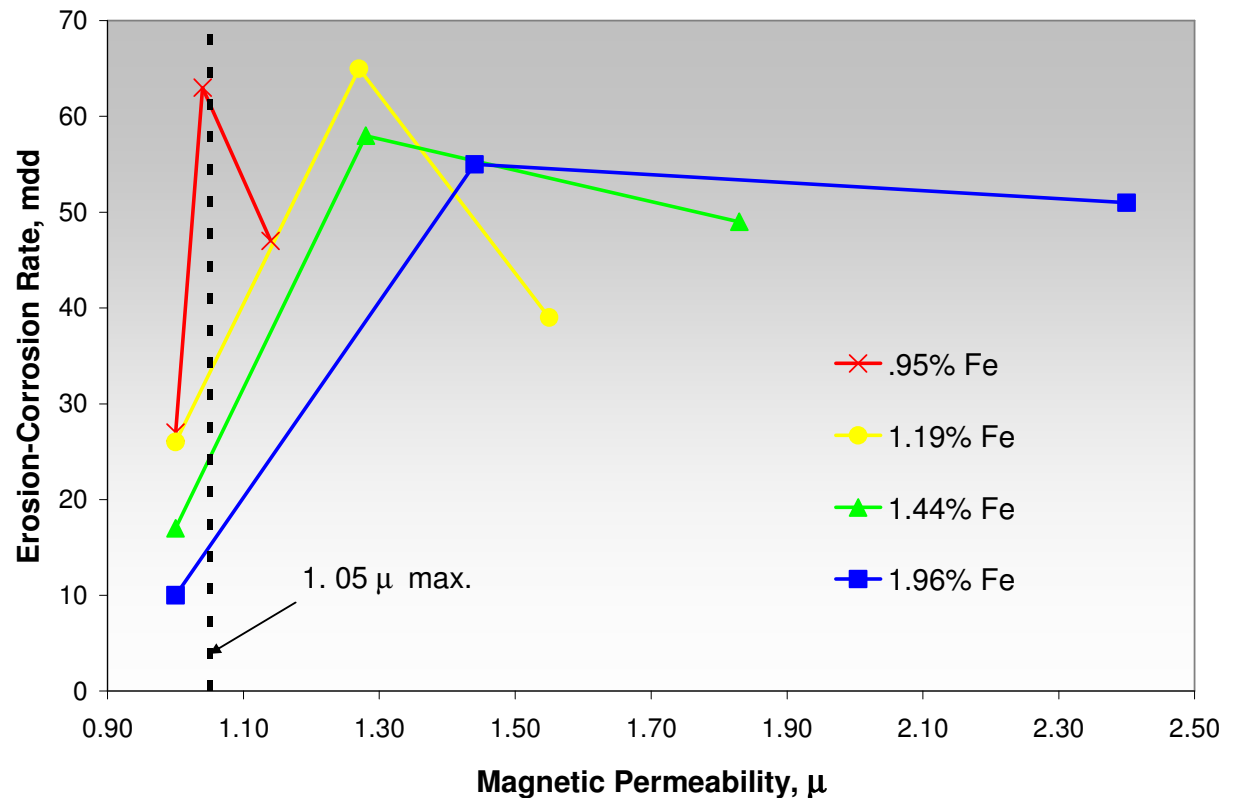
Continuous strand annealing, versus batch annealing, is utilized and results in a more uniform temper from one tube to another; this is beneficial for the rolling of tubes into tubesheets. The Strand Annealing furnaces include a water quench at the exit end of the furnaces. 90/10 copper-nickel includes 1.0-1.8% iron, and the resistance of 90/10 copper-nickel to erosion-corrosion and stress corrosion is optimized when the iron is present in solid solution; our high temperature strand anneal followed by a water quench puts the iron in solid solution.

THE EFFECT OF SOLUTIONIZED IRON ON THE EROSION-CORROSION RESISTANCE OF 90/10 COPPER-NICKEL **



THE IMPORTANCE OF *MAGNETIC PERMEABILITY* AS A SPECIFICATION FOR 90/10 COPPER-NICKEL

A restrictive iron content of 1.2-1.8% AND a magnetic permeability of 1.05 μ maximum optimizes the erosion-corrosion resistance of 90-10 copper-nickel



**THE EFFECT OF SOLUTIONIZED IRON ON
THE STRESS CORROSION RESISTANCE OF
90/10 COPPER-NICKEL ****

**STRESS CORROSION TEST RESULTS
IN MOIST AMMONIA (pH =10.3)**

90/10 with No Iron – Cracks @ 36 h

90/10 with 1.5% Iron (Precipitated Iron) – Cracks @ 110 h

90/10 with 1.5% Iron (Solutionized Iron) – No Cracks @ 1000 h

HOW TO OPTIMIZE THE EROSION-CORROSION AND STRESS CORROSION RESISTANCE OF 90/10 COPPER-NICKEL

- **Specify a Restricted Iron Content of 1.2-1.8% Iron.**
- **Specify a Magnetic Permeability of 1.05 μ maximum.**