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Eliminate 48 hour hold for SMAW temper bead welding

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Elimination of 48-Hour Hold for SMAW

- **The purpose of the 48-hour hold period prior to final examination is to address the potential for hydrogen induced cracking in low alloy steel materials.**
  - **EPRI has demonstrated machine GTAW produces very low hydrogen levels even when performed at ambient temperature in extreme humidity.**
- **A similar hold time was removed for temper bead welding using the GTAW process (Code Case N-432-1), with the following provisions:**
  - **Welding is performed using a minimum preheat of 300F.**
  - **After completion of the weld a "hydrogen post-bake" is completed at to provide a higher diffusion rate, if any hydrogen is present.**
- **It is overly conservative to require both a "post weld soak" and a 48 hour ambient temperature hold prior to NDE exam acceptance due to low-hydrogen performance of GTAW.**

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Elimination of 48-Hour Hold for SMAW

- Similarly, low hydrogen SMAW electrodes produce low levels of diffusible hydrogen.
  - Newer H4 and H8 specification for moisture resistant electrodes provide DH levels comparable to GTAW.
- A test matrix was developed to verify diffusible hydrogen levels associated with welding of P3, Group 3 materials.
  - Diffusible Hydrogen Evaluation of E8018-C3, E8018-NM and 7018-H4R Low Hydrogen Electrodes.
  - 3 different manufacturers (Lincoln, ESAB, & McKay).
  - Mockup with extreme conditions (electrodes exposed to high humidity & temperatures) with test coupons at RT (70F).

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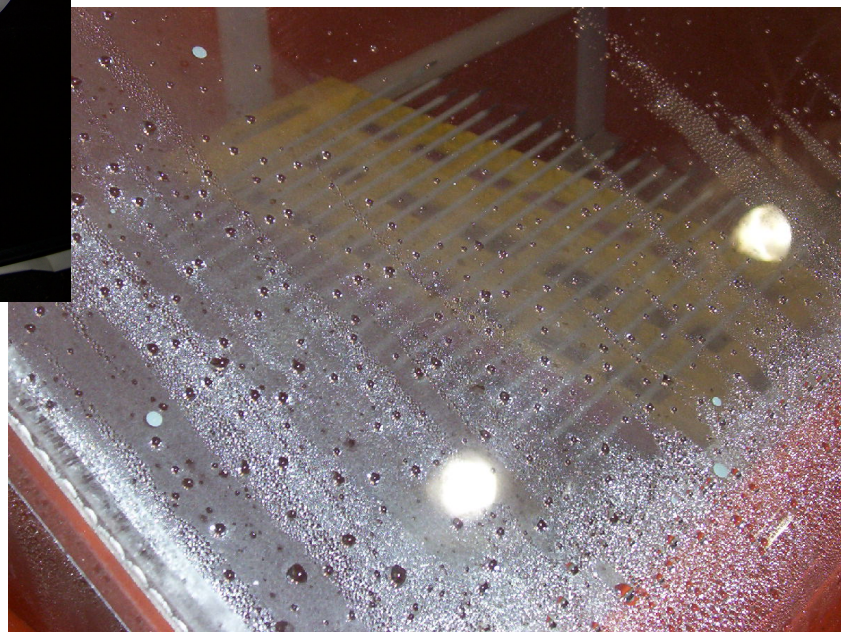
Available diffusible hydrogen – Storage Conditions



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Diffusible Hydrogen Test Results at Room Temperature 8018-C3

	E8018-C3 Low Hydrogen Electrodes		
Electrode Manufacturer	Vendor A (ml/100g)	Vendor B (ml/100g)	Vendor C (ml/100g)
0 Hours	1.6	1.5	1.3
12 Hours	N/A	N/A	N/A
24 Hours	3.3	2.8	2.6
72 Hours	2.7	6.0	3.6

- Electrodes held in exposure chamber @ >80% relative humidity/80F.
- Samples were at ambient preheat.
- 8018-C3 electrodes were NOT in compliance with newer Low H specifications, but still performed well.

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Results of Diffusible Hydrogen Tests at 80F/80%RH

- 150F and 300F preheat tests were planned but considered unnecessary since RT represents worst case conditions
  - Vendor B electrodes (worst case) still met H8 or better low hydrogen performance for up to a full day of exposure. This would be in excess of utility electrode storage limits.
    - Vendor B electrodes provided from utility warehouse.
  - 8018-C3 electrodes tested were NOT manufactured to meet newer H4/H8 low hydrogen specifications.
    - Vendor A & C met new specification performance out to 3 days of exposure.
- Added 8018-NM and 7018-H4R electrodes to matrix. Both conform to newer AWS H4 Low Hydrogen specifications.
- Exposure increased to >90/90 for 96 hours (in excess of AWS standard testing procedure) to address utility requests for more severe tests.

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Diffusible Hydrogen Test Results at Room Temperature 8018-NM

	E8018-NM Low Hydrogen Electrodes		
Electrode Manufacturer	*Vendor A (ml/100g)*	*Vendor B (ml/100g)*	*Vendor C (ml/100g)*
0 Hours	---	---	1.7
12 Hours	---	---	N/A
24 Hours	---	---	2.4
72 Hours	---	---	2.2

- 8018-NM Electrodes conform to AWS H4 requirements for Low Hydrogen Electrodes.
- Exposed at >90F and >90% r.h. with samples at ambient preheat.

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Diffusible Hydrogen Test Results at Room Temperature 7018-H4R

	E7018-4HR Low Hydrogen Electrodes		
Electrode Manufacturer	Vendor A (ml/100g)	Vendor B (ml/100g)	Vendor C (ml/100g)
0 Hours	n/a	n/a	---
48 Hours	n/a	n/a	3.5
96 Hours	n/a	n/a	3.3

- 7018-H4R electrodes conformed to newer AWS H4 low hydrogen requirements.
- Exposed at >90F and >90% r.h. with samples at ambient preheat.
- Extended Test to 96 hours for 7018-H4R.

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P-3-Group 3 Weld Coupons

- Performed welding on P3, Group 3 plates using 'Vendor B' electrodes exposed @ >90% humidity/90F for 96 hours.
  - Diffusible hydrogen measured at extreme conditions with samples welded at RT.
- Metallography performed on coupons:
  - No defects defects associated with hydrogen (i.e. underbead cracking, porosity, etc…)
  - Weldability of electrodes unchanged.

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Diffusible Hydrogen Test Results at Room Temperature 8018-C3 (Vendor B)

	1/8-in. E8018-C3 Low Hydrogen Electrodes		
Electrode Manufacturer Vendor B		Room Temperature (ml/100g)	
0 Hours		1.5	
24 Hours		2.8	
72 Hours		6.0	
96 Hours		10.5	

- For comparison purposes and to support utility electrode storage tests, Vendor B electrodes, were tested with exposure out to 96 hours.
- Exposed at >90F and >90% r.h. (96 hour only).
- 0 to 72 hour exposure at 80F/80% R.H.

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Elimination of 48-Hour Hold for SMAW

- EPRI is conducting additional testing, but current results illustrate that use of newer H4 or H8 specification electrodes will provide extremely low hydrogen performance comparable to GTAW.
- Earlier low hydrogen electrodes, when stored and handled properly, can provide excellent performance.
- National Board of Boiler Inspectors (NBBI) does not require a post-weld hydrogen bake for examination nor 48 hour hold if electrodes meeting H4 specifications are used for repairs (RD-1040).

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Proposal for Elimination of 48 hour hold for SMAW

- Proposed Code action would be to eliminate 48 hour hold time for Temper Bead Welding using H4 or H8 specification electrodes.
- Would require same conditions as currently in place for GTAW:
  - 300F Preheat
  - Post Weld Hydrogen Bake

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