NSRP Welding Panel SP-7 Meeting

Applied Thermal Sciences
PO Box C - 1861 Main Street - Sanford, Maine 04073
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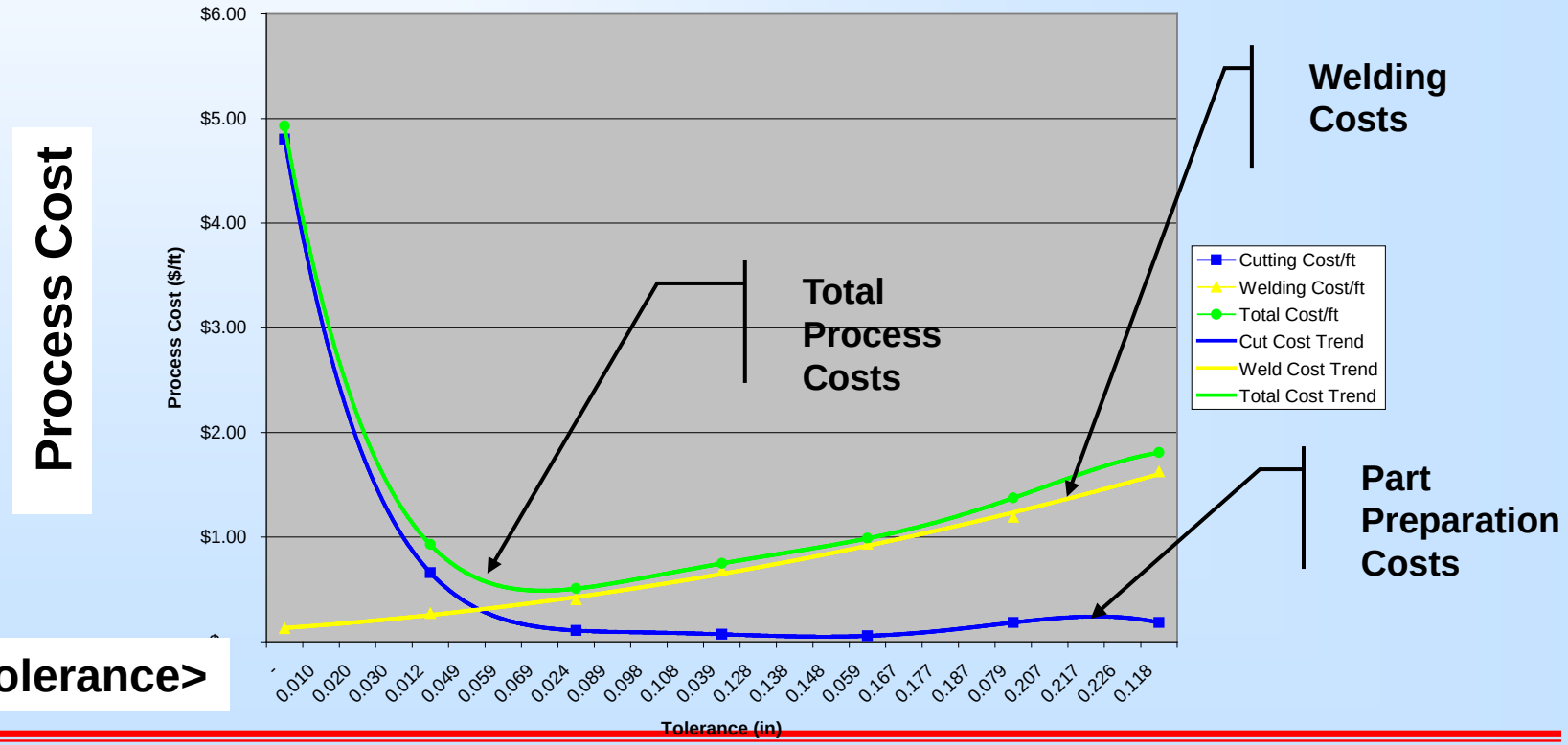
Update on HLAW Progress

- HLAW Process Qualification
- HLAW Operator Fume Exposure
- HLAW Diffusible Hydrogen Characteristics

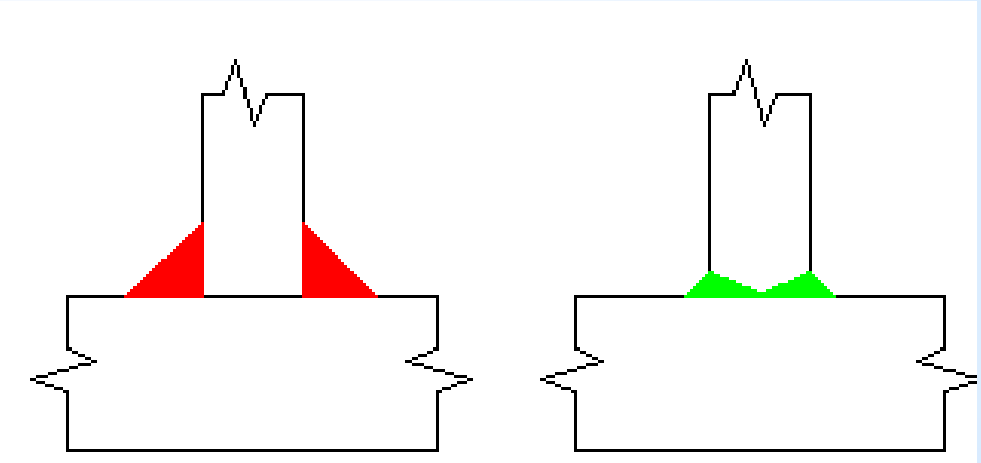
Update on HLAW Progress

- Optimize the *Control vs. Constraint* Equation
  - Part preparation costs decrease as tolerance increases
  - Welding costs increase as tolerance increases
  - Objective: develop a process that operates where combined cost for customer is minimized



Update on HLAW Progress

HLAW Process Qualification for Tee Fabrication



Conventional Weld	Hybrid Laser Arc Weld
0.375-in fillet	Full penetration with 0.125-in fillet reinforcement
0.578 lb/ft	0.144 lb/ft

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Qualification of HSLA-80

- Mandatory
  - Comply with NAVSEA “Tech-Pub-248” *Special Weld*
- Desirable
  - Extend qualification to all edge-prep methods
    - oxy-fuel cut, plasma-arc cut and machined edges
  - Test alternative laser sources
    - Test one set of conditions with two different lasers
      - Trumpf YAG-disk and IPG Ytterbium-fiber
    - Check for variation
    - Establish that change of laser does not require complete requalification

Qualification of HSLA-80

Non-Destructive Testing (NDT)	Extent	Criteria
Visual (VT)	100%	MIL-STD-2035, Class I
Magnetic Particle (MT)	100%	MIL-STD-2035, Class I
Radiographic (RT)	100%	MIL-STD-2035, Class I
Mechanical (Destructive Tests)		
Macro section	2 Locations	Tech Pub 248
Micro-hardness[1]	2 Locations	Tech Pub 248
Transverse Side Bends	3	Tech Pub 248
Transverse Tensile	2	Tech Pub 248
Charpy Vee Notch (CVN):		*Informational*
Weld Metal	5 @ 0 F 5 @ -60 F	MIL-100S-1 Electrode Spec
AWM Tensile Test		*Informational*

Qualification of HSLA-80

Weld ID#	WM CVN @ 0 °F, ft-lb	WM CVN @ -60 °F, ft-lb	HAZ CVN @ -60 °F, ft-lb	Base Metal CVN @ -120 °F, ft-lb
3035	43	8	193	174
	90	20	182	177
	42	134	106	191
	224	31		
	188	6		
Average	**127**	**40**	**160**	**181**
Spec. req.	60 average	35 average	35 average	100 average
	Only one individual < 60 ft-lb and not < 50 ft-lb	Only one individual < 35 ft-lb and not < 25 ft-lb		

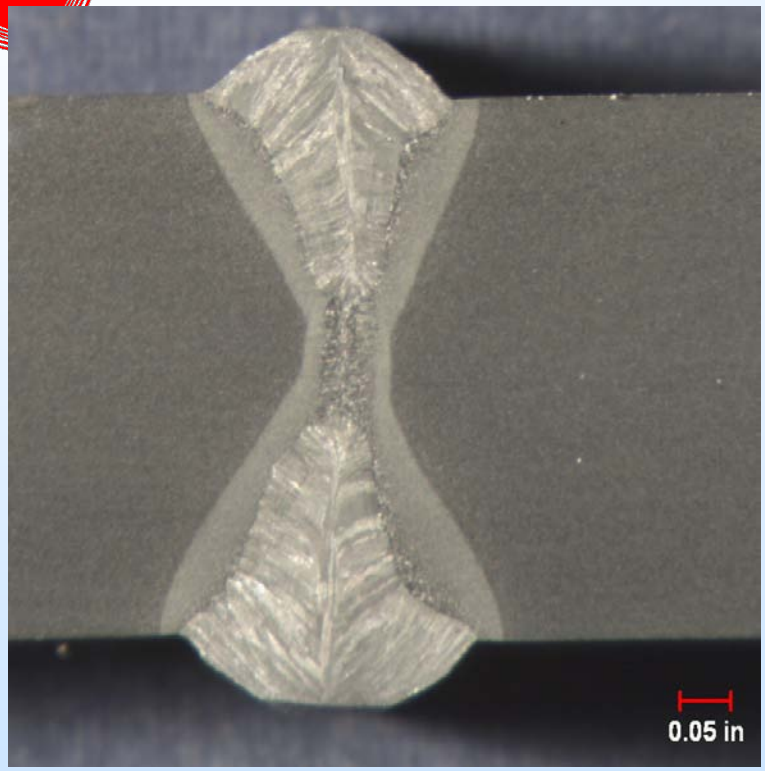
Qualification of HSLA-80

Weld Code	Electrode Type or Brand Name	Laser Type	WM CVN @ 0 °F, ft-lb (average)	WM CVN @ -60 °F, ft-lb (average)	NDT (RT) Results
3203	**MIL-120S**	**IPG**	**110***	**38***	**Pass**
3166	**MIL-140S**	**IPG**	**203***	**130**	**Pass**
3272	**Commercial Electrode A**	**IPG**	**68***	**47**	**Pass**
3275	**Commercial Electrode B**	**IPG**	**127**	**129**	**Pass**
3238	**Commercial Electrode C**	**IPG**	**164***	**129**	**Fail**
3283	**Commercial Electrode C**	**IPG**	**219**	**102**	**Pass**
Spec. req.			60 average	35 average	
			* = individual values below spec.		

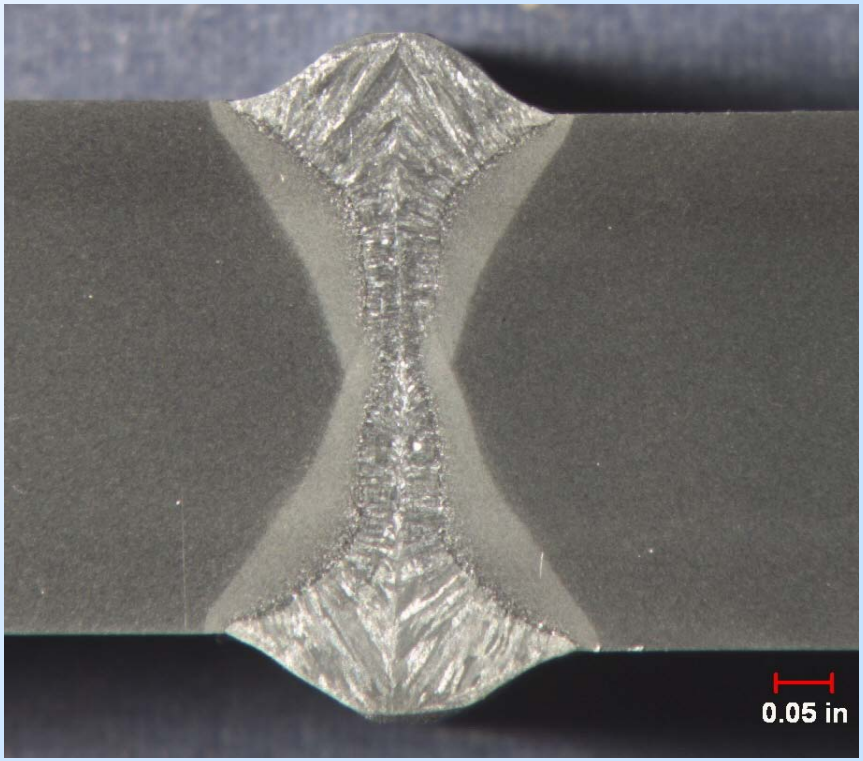
Qualification of HSLA-80

Weld ID#	Electrode	Thickness inch	Laser	Travel Speed, ipm (side 1/side 2)	WM CVN 0 °F, ft-lb (average)	WM CVN -60 °F, ft-lb (average)	NDT (RT) Results
R242	Commercial Electrode B	0.5	Trumpf	70/70	37	15	Pass
3275	Commercial Electrode B	0.5	IPG	70/70	127	129	Pass
3450	Commercial Electrode C	0.5	IPG	70/60	152	67	Fail
R316	Commercial Electrode C	0.5	Trumpf	60/60	98	91	Repaired, OK
3504	Commercial Electrode C	0.375	IPG	80/80	198	133	Pass
R342	Commercial Electrode C	0.375	Trumpf	80/80	119	70	Pass
Spec min.					60 average	35 average	

Qualification of HSLA-80



IPG Ytterbium Fiber Laser



Trumpf YAG-Disk Laser

Update on HLAW Progress

Process Qualification

- NAVSEA approval, 2007, aircraft carrier primary structure:
  - HSLA-65, butt and tee welds, 3/16”-3/8” , 3 heat inputs
  - Commercial supplier has purchased system
  - Includes weld inspection module
- ABS approval for NVR vessels (DDG-1000), 2/2009:
  - Up to 3/8” HSLA-80 butts and tees
  - Cross-qualification of DH-36
  - Commercial supplier considering implementation

Air Monitoring Evaluation of Hybrid Laser Arc Welding (HLAW) Operations

Daniel O. Chute, CIH, CSP,
Atrium Environmental Health and Safety Services, LLC,

and

Paul Blomquist,
Applied Thermal Sciences, Inc.

HLAW Fume Evaluations

Purpose:

- Verify that we do not expose our personnel to hazardous conditions
- Comply with regulations
- Inform the industry

HLAW Fume Evaluations

Engineering Advantages:

- Operator is remote from weld zone
- “Air knife” blows fume away from operator
- Amount of metal melted is very small;
- High travel speeds, short weld times;
- Minimal use of filler metals; and
- Exhaust ventilation can also be applied.

HLAW Fume Evaluations

Collected baseline exposure monitoring data

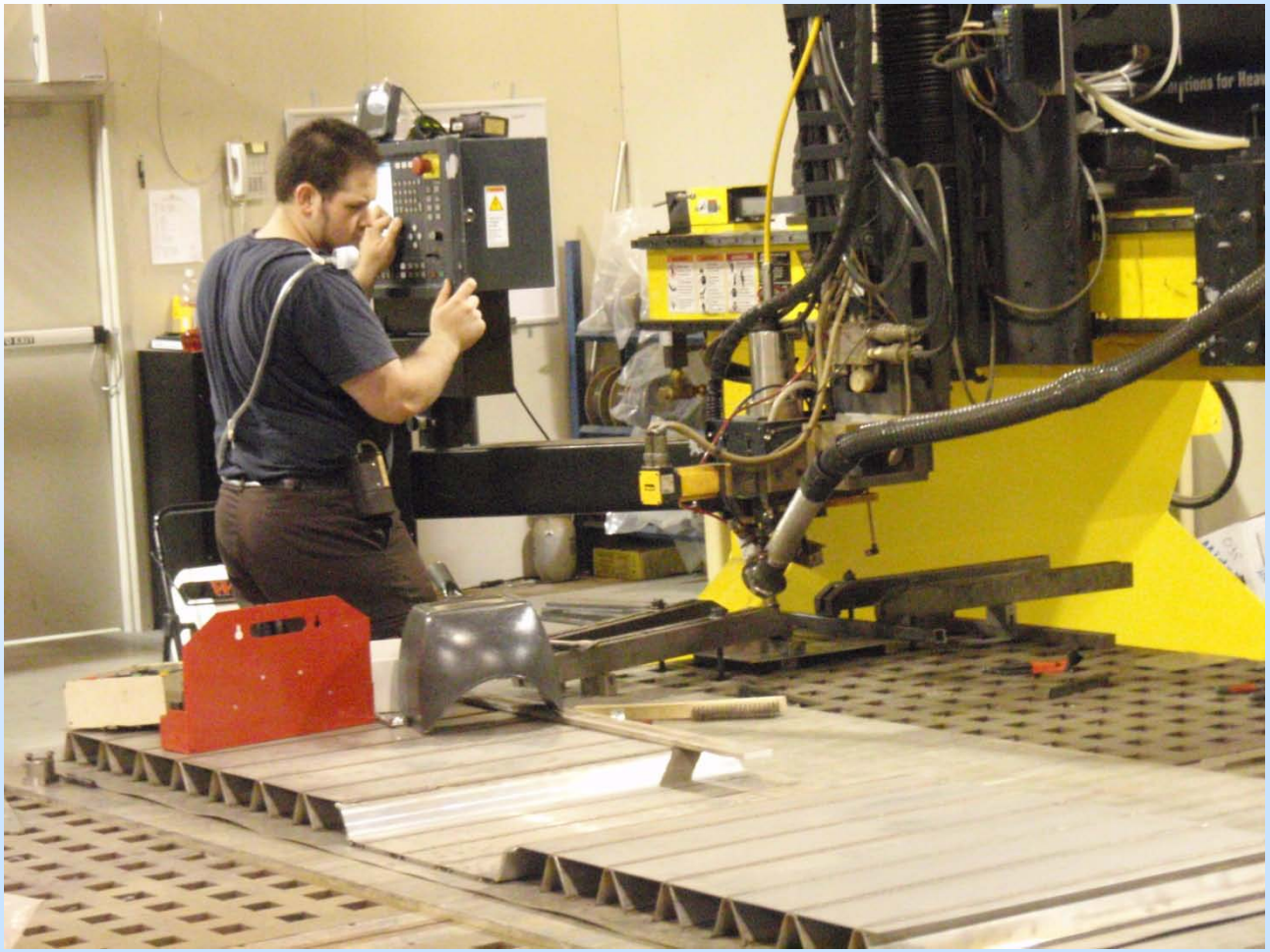
Representative HLAW work, with
- variations in base metal type;
- size and thickness;
- different filler metals;
- different parameters; and,
- exhaust ventilation.

HLAW Fume Evaluations

- Air samples collected by CIH
  - IAW OSHA Method 125G/NIOSH 7300
  - 35mm MCE filter, 0.8micron pore size.
- Analysis by AIHA lab accredited for metals.

- Testing included both PBZ and Area
- Air samples collected under these operating conditions:
  - Metal type/thickness;
  - Filler metal/wire;
  - Arc current & time per weld cycle;
  - Laser power; and,
  - Gas flow.

HLAW Fume Evaluations



HLAW Fume Evaluations

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HLAW Fume Evaluations

Metals Tested

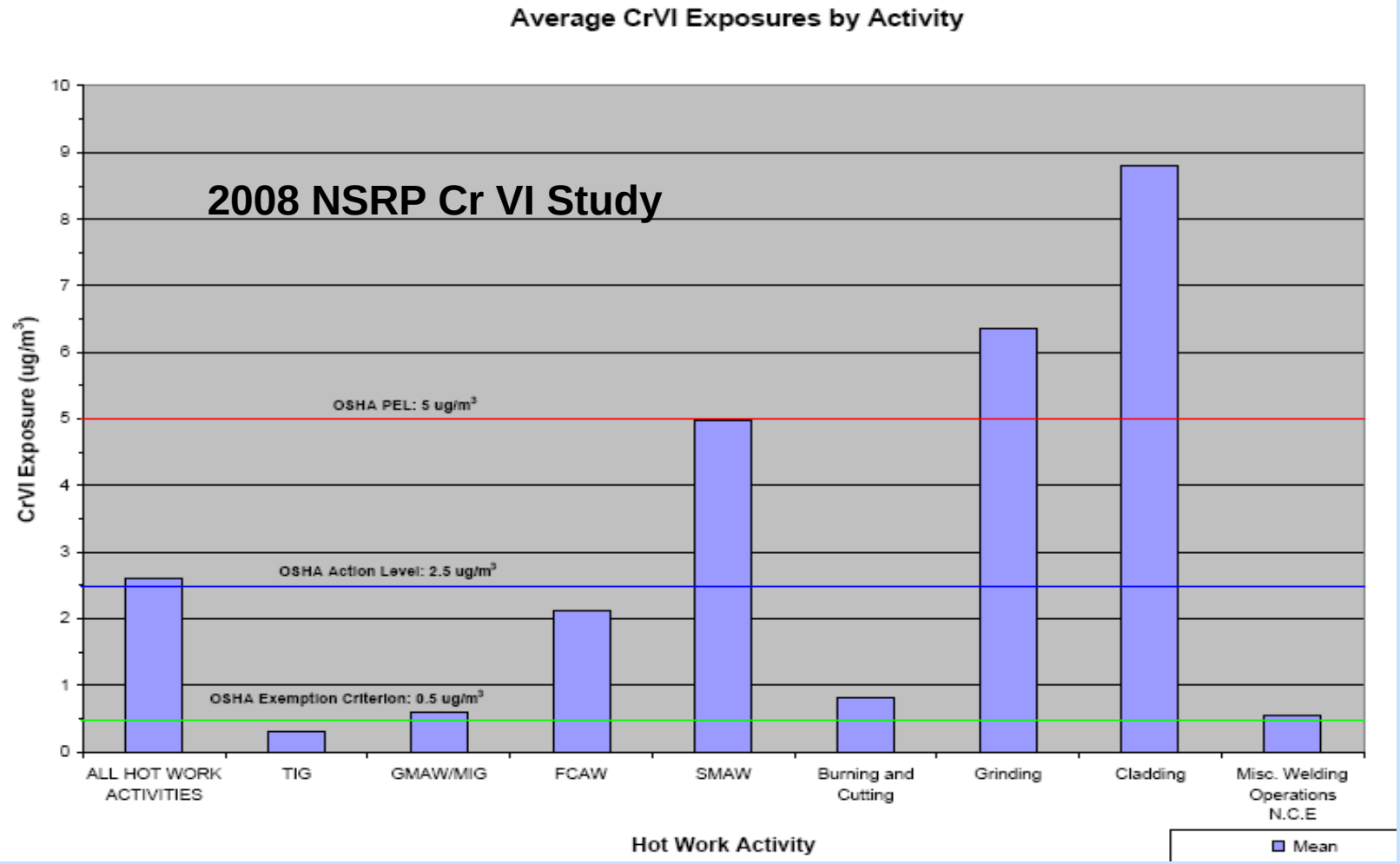
- Cadmium
- Cobalt
- Chromium
- Copper
- Lead
- Manganese
- Nickel
- Iron Oxide
- Zinc Oxide

➢ Over 59 hours of sampling

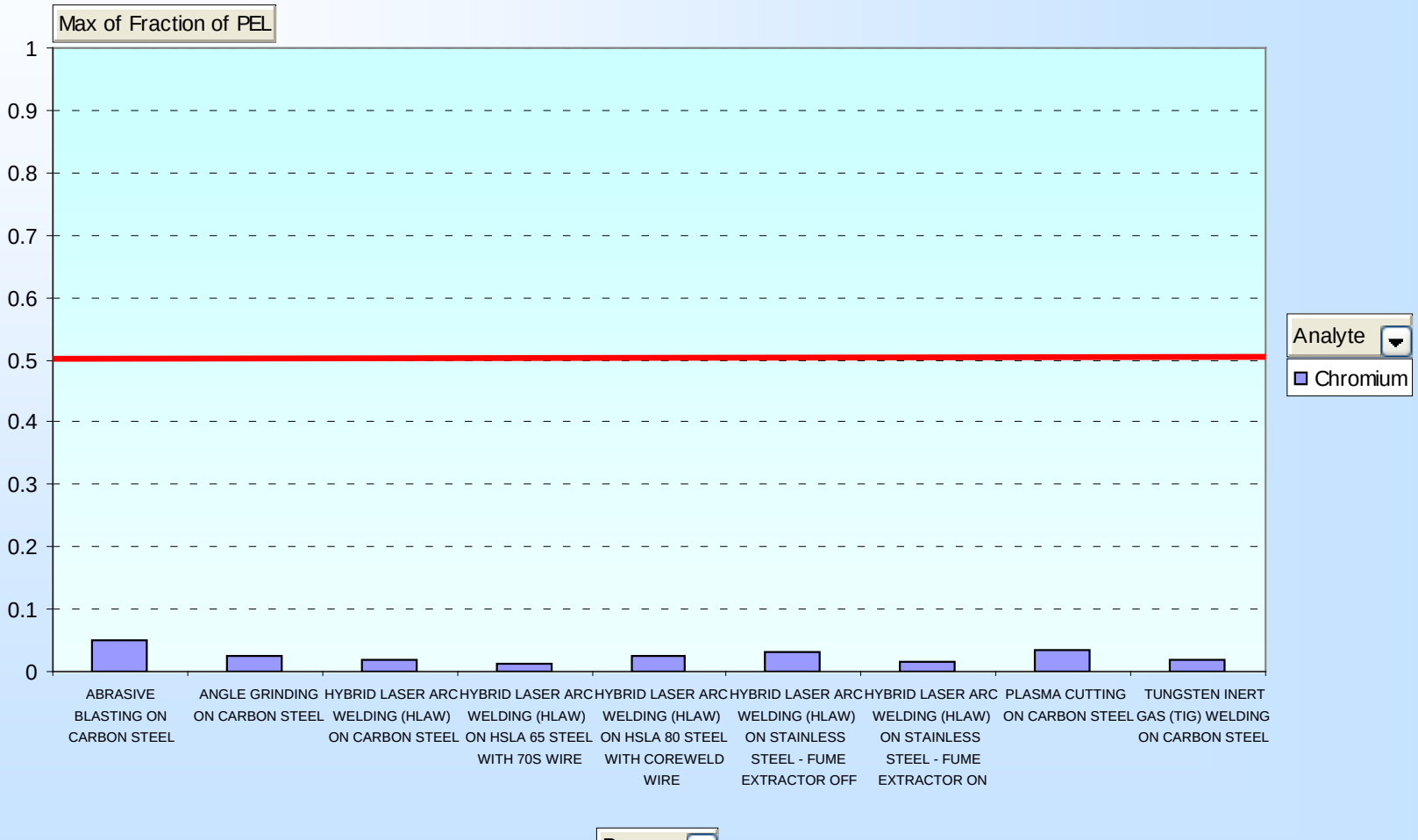
Results

➢ All air sample results were below OEL for the nine metals tested in each air sample.

Comparative Data on Cr VI



HLAW Chromium



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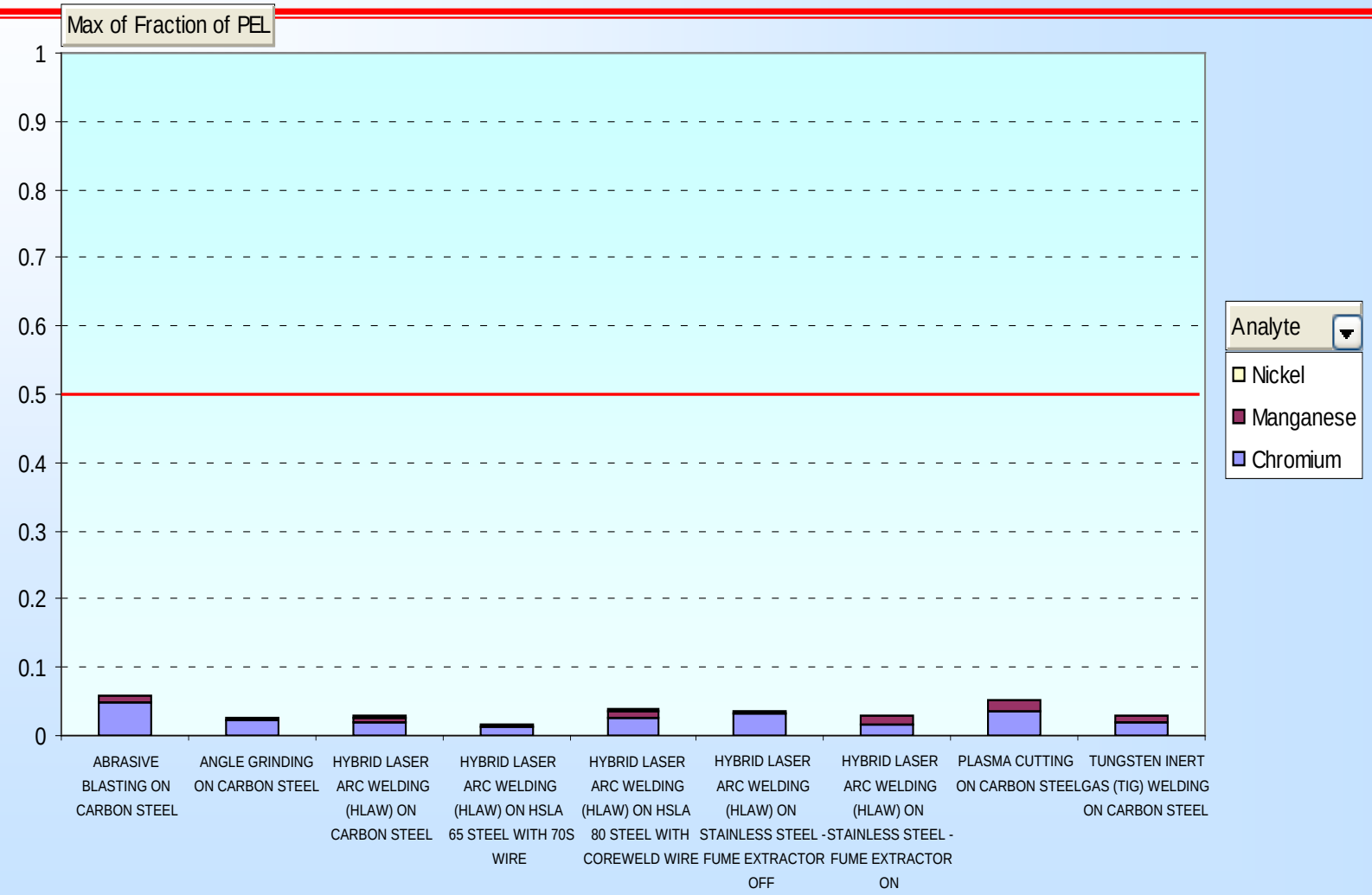
ATS - HLAW & Other Ops



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HLAW Fume Evaluations

- This data indicates that in a production shop environment:
- HLAW generates airborne fume exposures to welders which are substantially lower than historical levels observed and reported for other commonly observed welding processes.
- Air sampling for exposure monitoring of any type of welding should include process-specific performance information to ensure that valid comparisons can be made.
- This information includes items such as
  - welding process,
  - base metal,
  - filler metal,
  - power settings,
  - arc time,
  - work area dimensions,
  - operator position and
  - the use of ventilation.

BUT WAIT!!!! THERE's MORE!!!

HLAW Fume Evaluations

This *Documentation* is in DRAFT format, and its content is subject to change. We are providing it as such because we believe it is important to provide access as early as practical to the data and technical information cited herein which are the basis for the proposed TLV(s)®, BEI(s)®, and related notations.

MANGANESE, ELEMENTAL and INORGANIC COMPOUNDS

CAS number: 7439-96-5 (Manganese)

Empirical formula: Mn

TLV–TWA, 0.02 mg/m^3, as Mn, Respirable particulate matter
0.2 mg/m^3, as Mn, Inhalable particulate matter

A4 — Not Classifiable as a Human Carcinogen

TLV® Recommendation

The respiratory tract is the most important portal of entry for manganese in the occupational setting. The inhalation toxicity of manganese is a function of particle dosimetry and subsequent pharmacokinetic events. Particles depositing in the upper respiratory tract and major intrathoracic airways (cleared mainly by mucociliary clearance) are swallowed into the gastrointestinal tract where absorption is quite low (about 3–5%). Little absorption of manganese oc-

concluded that an eight-hour TWA exposure of approximately 1.0 mg Mn/m^3 (total dust) could lead to pre-clinical effects in the nervous system, lungs, and blood of workers exposed for less than 20 years (Roels et al., 1987b). A male fertility study in the same cohort (Lauwerys et al., 1985) suggested that exposure to 1.0 mg Mn/m^3 (total dust) may impair male fertility.

In a second cross-sectional study, Roels and co-workers (1992) found neurotoxic effects in workers

Update on HLAW Progress

HLAW

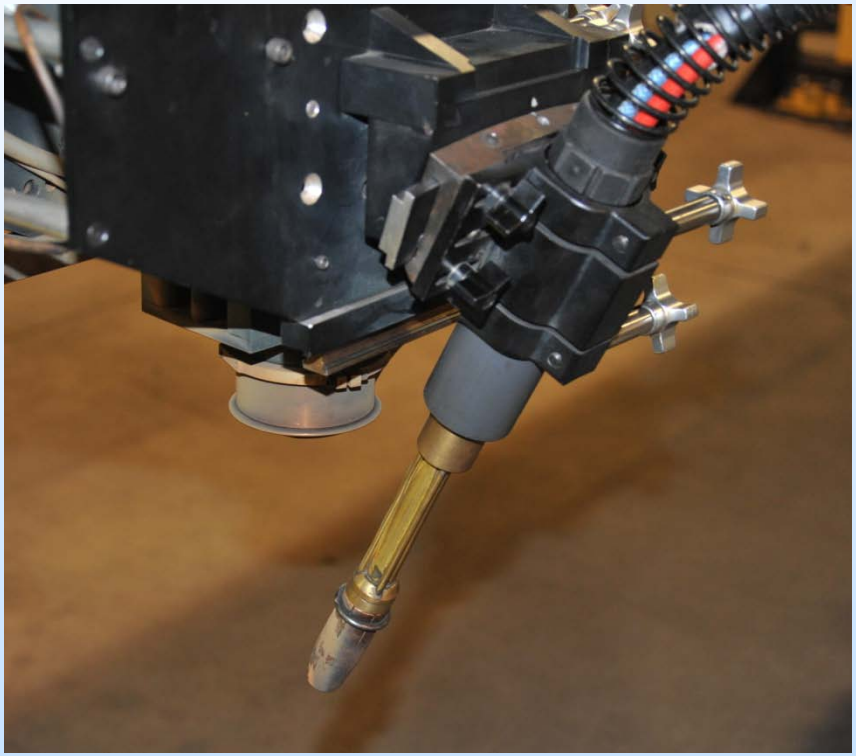
Diffusible Hydrogen Characteristics

Diffusible Hydrogen Testing

- Testing in progress, limited early results
- In accordance with AWS A4.3
- “Gas chromatograph” testing at ESAB, Hanover
- Production wire taken from warehouse stock
- Baseline H2 tests performed at ESAB
- Coupons prepared at ESAB, shipped to ATS
- ESAB tests duplicated at ATS
- Various HLAW procedures
- Various autogenous LBW procedures
- Shielding gas dew point checked at ATS
- Final “Bracket” testing done at ESAB

Diffusible Hydrogen Testing

HLAW Head; Test Welds; Coupon & Clamps

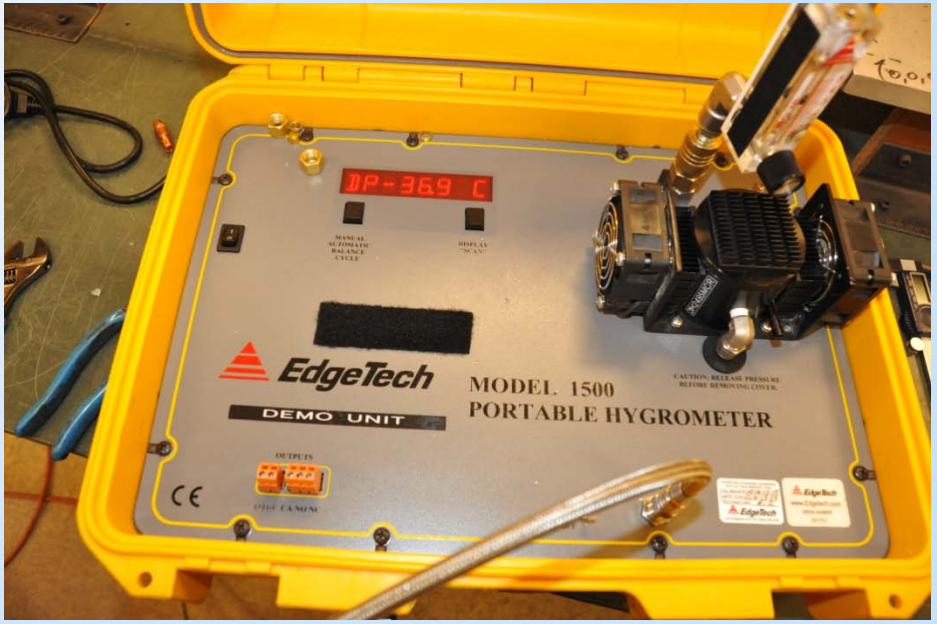


Diffusible Hydrogen Testing

Vises, Tooling and Quench Tanks

Diffusible Hydrogen Testing

Shielding Gas Dew Point Testing



Diffusible Hydrogen Test Plan

Process	Filler Metal	Progression	Laser Power	WFS	Amps	Volts	Weld Speed	Comments
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Unwelded specimens to determine if Hydrogen pickup has occurred due to exposure
GMAW	CW-110	GMAW-with Drag angle	n/a	430	280	30	14	Duplicate of original ESAB test performed at Hanover (2.5)
LBW	None	Autogenous	7	n/a	n/a	n/a	14	Autogenous Weld Hydrogen pickup at travel speed of ESAB GMAW
LBW	None	Autogenous	7	n/a	n/a	n/a	50	Autogenous Weld Hydrogen pickup at mid-range travel speed
LBW	None	Autogenous	7	n/a	n/a	n/a	80	Autogenous Weld Hydrogen pickup at typical HLAW travel speed
HLAW	CW-110	Laser-Leading	7	600	328	30	80	HLAW Hydrogen pickup at recent PQR parameters (ATS ID#3525)
HLAW	CW-110	Laser-Leading	3.5	600	314	27.5	75	HLAW Hydrogen pickup at recent lightweight Tee welding parameters (ATS ID#3597)
HLAW	CW-110	Laser-Leading	7	430	270	30	80	HLAW Hydrogen pickup at Test 2 laser power but with ESAB GMAW wire feed speed
HLAW	CW-110	GMA-Leading	7	600	310	30	80	HLAW Hydrogen pickup at Test 2 parameters but with GMAW leading

Diffusible Hydrogen Test Results

Process	Filler Metal	Progression	Laser Power	WFS	Amps	Volts	Weld Speed	total H2 ml	H2 ml/100gm	Comments
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	n/a	Unwelded specimens to determine if Hydrogen pickup has occurred due to exposure
GMAW	CW-110	GMAW-with Drag angle	n/a	430	280	30	14	0.493	2.7	Duplicate of original ESAB test performed at Hanover (2.5)
LBW	None	Autogenous	7	n/a	n/a	n/a	14	0.015	n/a	Autogenous Weld Hydrogen pickup at travel speed of ESAB GMAW
LBW	None	Autogenous	7	n/a	n/a	n/a	50	0	n/a	Autogenous Weld Hydrogen pickup at mid-range travel speed
LBW	None	Autogenous	7	n/a	n/a	n/a	80	0	n/a	Autogenous Weld Hydrogen pickup at typical HLAW travel speed
HLAW	CW-110	Laser-Leading	7	600	328	30	80	0.038	0.9	HLAW Hydrogen pickup at recent PQR parameters (ATS ID#3525)
HLAW	CW-110	Laser-Leading	3.5	600	314	27.5	75	0.053	1.1	HLAW Hydrogen pickup at recent lightweight Tee welding parameters (ATS ID#3597)
HLAW	CW-110	Laser-Leading	7	430	270	30	80	0.023	0.8	HLAW Hydrogen pickup at Test 2 laser power but with ESAB GMAW wire feed speed
HLAW	CW-110	GMA-Leading	7	600	310	30	80	0.07	1.8	HLAW Hydrogen pickup at Test 2 parameters but with GMAW leading

Diffusible Hydrogen Testing

Summary

- Early results are promising
- ATS process verified to match AWS A4.3
- Autogenous LBW has “low to no” pickup
  - Lower speed (14 ipm) showed low pickup
  - Higher speeds (50 & 80 ipm) showed no pickup
- HLAW procedures show low H pickup
  - Proportional to travel speed, less to wire feed speed
  - Laser-lead H2 lower (0.9-1.1) than GMAW (2.5)
  - GMAW-lead H2 closer (1.8) to GMAW (2.5)
  - GMAW-lead vice Laser lead needs further testing
- Further analysis will determine H2 per total melt volume

Questions?