

Effectiveness of Commercially Available Portable LEV for Controlling Worker Exposures to Welding Fume

John Meeker, ScD, CIH
University of Michigan
meekerj@umich.edu

Introduction

- An extensive search of commercially available, portable local exhaust ventilation (LEV) systems for welding was conducted
- 10 LEV units were selected as possible candidates for future detailed assessment
 - Exposure control effectiveness
 - Usability, durability, availability
- Partnership for Advancing Control Technologies (PACT)
 - Trades, Contractors, Owners, LEV Manufacturers
 - Identified important selection criteria used to determine which LEV systems would be included in this subset of 10
 - The PACT then rated each system, resulting in rankings

Design/Type	Company	Product Name	Weight	Airflow (listed)	Filter(s)	Hose diam	Hose length	Noise
“Upright”	Lincoln	Miniflex	38 lbs.	135 cfm	HEPA	1 ¾”	8 – 24 ft	<70 dBA
	Plymovent	PHV	41 lbs.	135 cfm	HEPA	1 ¾”	8 – 24 ft	70 dBA
	Miller	FILTAIR 130	46 lbs.	132 cfm	See comments		8 – 34 ft	69 dBA @ 5 ft
	Aero/TEKA	Handycart	50 lbs.	190 cfm	Cartridge, PTFE coated, >99% efficient	1 ¾”	8 – 33 ft	62 dBA
“Suitcase”	Lincoln	X-TRACTOR 1GC	37 lbs.	115 cfm	High efficiency polyester	1 ¾”	8 – 45 ft	74 dBA
	Nederman	Fume Eliminator	35 lbs.	88 cfm	Cellulose, 99.7% efficient	1 ¾”	8 – 50 ft	73 dBA
	Trion	Air Boss One Man Portable	45 lbs.	220 cfm	HEPA		10 ft	85 dBA @ 5 ft
	Enviroflex	Portable Welding Smoke Extractor	43 lbs.	160 cfm	HEPA	1 ¾”	15 - 50 ft	
Other	Eurovac	Eurovac II Welding Portable	115 lbs	103 cfm	Cyclone + HEPA	1 ½”	25 ft +	“quiet”
	Sentry	Dual Arm Fume Extractor	55 lbs.	175 cfm per arm	HEPA	4”	4 – 20 ft	66 dBA

Most PACT Votes

June 8, 2012

- Trion, Air Boss One-Man Portable (LEV #7)
- Lincoln Electric, X-Tractor (LEV #5)



LEV #7



[Trion, Air Boss One Man Portable](#) (List Price: \$1200)

- Listed as 45 lbs.
- Similar in size and appearance to the Lincoln X-tractor and Nederman Fume Eliminator
 - However, the advertised airflow is substantially higher (220 cfm)
 - Note: it is difficult to compare flow rates between systems since methods and test conditions may vary
- Has a 35% ASHRAE pre-filter & HEPA main filter
- Equipped with a light signal notifying the operator when the filters need to be replaced

LEV #5



- [Lincoln Electric, X-Tractor 1C](#) (List Price: \$2875-\$3360)
 - Two motors for up to 115 cfm extraction capacity
 - Two speed settings (high or low)
 - Automatic or manual on/off
 - High efficiency, cleanable polyester filter
 - Filter can be cleaned while inside the machine using a unique compressed air rotary jet cleaning system
 - 16 foot flexible hose with a magnetic base nozzle for positioning near the weld
 - Low noise operation (74 dBA)



Methods

- Set-up
 - Pipefitters Local 597
- Materials
 - Stainless steel: AWS 304 (schedule 80)
 - 308/308L electrodes
 - Carbon steel: schedule 80
 - 6010 (root) & 7018 (fill) electrodes
- Welding Trials
 - SMAW
 - Random LEV and no LEV conditions (5x each)
 - 20-45 minutes each (trials without LEV shorter)



Methods

- Sample Collection and Analysis
 - OSHA ID215
 - NIOSH 7300
 - Real-time monitor (HazDust)
- Flow Rate Measures
 - Static pressure tap
- Statistical Methods
 - Student's t-test
 - Wilcoxon rank sum test



Results: Trion Air Boss



Trion Air Boss: CrVI

Table 1. CrVI ($\mu\text{g}/\text{m}^3$) concentrations, stainless steel welding

	N	Mean	Geometric Mean	Range	Hazard Ratio (mean/PEL)
No LEV	5	8.80	7.22	1.63-12.6	1.76
LEV	5	1.05	0.98 ^a	0.55-1.56	0.21

^a p-value = 0.002 comparing No LEV to LEV.

Trion Air Boss: Manganese

Table 2.1 Manganese concentrations (mg/m³) from welding of carbon and stainless steels

	N	Mean	Geometric Mean	Range	Hazard Ratio (Mean/TLV)
Carbon Steel					
No LEV	6	0.070	0.033	0.014-0.309	0.35
LEV	6	0.029	0.023 ^a	0.010-0.066	0.15
Stainless Steel					
No LEV	5	0.081	0.065	0.016-0.131	0.41
LEV	5	0.047	0.043 ^b	0.017-0.067	0.24

^a p-value = 0.26 comparing No LEV to LEV for carbon steel welding.

^b p-value = 0.19 comparing No LEV to LEV for stainless steel welding.

Air Boss Performance: Air Flow

Table 4. Hood static pressure (SP_h) and estimated flow rate in cubic feet per minute (cfm) following each LEV control trial

	Trial #	SP_h (inches water)	Flow rate (cfm)
Initial Measure	0	2.54	136
Stainless Steel	1	2.56	137
	2	2.48	135
	3	2.49	135
	5	2.49	135
Carbon Steel	1	2.58	137
	2	2.53	136
	3	2.48	135
	4	2.37**	132
	5	2.31	130
	6	1.98	120

Results: Lincoln X-Tractor



Lincoln X-Tractor: CrVI

Table 1. CrVI ($\mu\text{g}/\text{m}^3$) concentrations, stainless steel welding

	N	Mean	Geometric Mean	Range	Hazard Ratio (mean/PEL)
No LEV	5	9.12	3.17	0.63-30.6	1.8
LEV	5	0.52	0.40 ^a	0.25-1.45	0.10

^ap-value = 0.02 comparing No LEV to LEV.

Lincoln X-Tractor: Manganese

Table 2. Manganese concentrations (mg/m^3) from welding of carbon and stainless steels

	N	Mean	Geometric Mean	Range	Hazard Ratio (Mean/TLV)
Carbon Steel					
No LEV	5	1.28	0.38	0.058-3.58	6.4
LEV	5	0.037	0.035 ^a	0.024-0.065	0.19
Stainless Steel					
No LEV	5	0.022	0.019	0.008-0.038	0.11
LEV	5	0.011	0.008 ^b	<0.005-0.025	0.05

^a p-value = 0.03 comparing No LEV to LEV for carbon steel welding.

^b p-value = 0.05 comparing No LEV to LEV for stainless steel welding.

*Inclusion of worker in a multivariable model strengthened the association between LEV use and reduced manganese exposure for carbon steel welding ($p < 0.0001$).

X-Tractor Performance: Air Flow

?	Trial#?	SP _h (inches?water)?	Flow?rate?(cfm)?
Initial?Measure?	0?	3.56?	229?
?	?	?	?
Stainless?Steel?	1?	3.04?	195?
?	2?	3.15?	202?
?	3?	3.14?	202?
?	4?	3.05?	196?
?	5?	2.94?	189?
?	?	?	?
Carbon?Steel?	1?	3.27?	210?
?	2?	3.23?	207?
?	3?	2.99?	192?
?	4?	2.98?	191?
?	5?	2.98?	191?
?	?	?	?

Summary & Discussion

- Strong evidence that both tested systems, if used correctly, can significantly reduce CrVI exposures when welding stainless steel
 - 87% and 86% reductions in CrVI with X-Tractor and Air Boss, respectively.
 - For both LEV systems, mean CrVI concentrations were above OSHA PEL without LEV, but all samples were below the Action Level with use of LEV.
- Lincoln X-Tractor system also provided substantial reductions in manganese (91% reduction).
 - For carbon steel, without LEV 3 of 5 samples were above 2012 TLV; with LEV, no samples were above the TLV.
 - Airflow was much higher (>189 cfm) than advertised (115 cfm).
- For the Trion Air Boss, reductions in Mn not significant.
 - Possibly due to lower Mn concentrations in trials without LEV, between-trial variability, and/or sample size/statistical power limitations.
 - Airflow was much lower (<137 cfm) than advertised (220 cfm).
- These results warrant “real-world” field testing of effectiveness.

Comparison of LEV Units Tested



Comparison of LEV Units Tested

Lincoln X-Tractor

- Mean CrVI : **0.52 $\mu\text{g}/\text{m}^3$**
 - Maximum: **1.45 $\mu\text{g}/\text{m}^3$**
- Mean Mn: **0.04 mg/m^3**
 - Maximum: **0.07 mg/m^3**
- Advertised air flow: **115 cfm**
- Measured air flow: **229 cfm**
- Listed weight: **37 lb.**
- Listed noise: **74 dBA**
- List price: **\$2,875 - \$3,360**

Trion AirBoss

- Mean CrVI: **1.05 $\mu\text{g}/\text{m}^3$**
 - Maximum: **1.56 $\mu\text{g}/\text{m}^3$**
- Mean Mn: **0.03 mg/m^3**
 - Maximum: **0.07 mg/m^3**
- Advertised air flow: **220 cfm**
- Measured air flow: **136 cfm**
- Listed weight: **45 lb.**
- Listed noise: **85 dBA (@ 5 ft)**
- List price: **\$1,200**

LEV #9 – Testing June 2014

[Eurovac II Welding Portable](#) (cost \$1,575)

- Selected for testing due to its unique design
 - Has a cyclonic pre-selector as well as a HEPA filter
 - larger particles are removed before getting to the filters
 - can improve performance and reduce maintenance needs.
- Heavier than other units described here at 115 lbs.
 - However, comes attached to a 2-wheeled hand cart
- The unit has two take-offs for use with one or two hoses/hoods/welders at a time.

