OSHA adds value to business, work and life.
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Ventilation ductwork, fan housings and crawlspaces are confined spaces that may be considered PRCS.

Hazards include:
- rotating fans and mechanical systems
- heat and cold stress
- microbial hazards
- chemical, particulate and gaseous hazards
- constrictive or falling hazards.
Entryway to the third floor attic which contained the network of ventilation ductwork to be cleaned of lead particulate.
Electro-mechanical louvers to control airflow into branch ducts that feed other rooms.
Electrical equipment in use at the time of the accident

- Three HEPA vacuums, a halogen work light and a trouble light (not visible here)
- The first two vacuums and work light were plugged into two GFCIs to a 50-ft industrial extension cord
- #15 vacuum had its own extension cord and both cords were plugged into receptacles on the third floor
HEAT STRESS evaluated with WBGT readings & work practices

- Taken in the duct the next day at the same time of the accident in the area of the workers
- Moderate to heavy work load, tyvek clothing and respirators added to the heat load
- End of July, third floor attic of a school, outside temperature 80°F, 6:30 p.m.
- Deceased did not take breaks or drink fluids
- WBGT-TLV chart indicated 25% work 75% rest
Photo showing potential entrapment hazard with duct dropping to the basement area.
Ductwork dimensions after accident

- 76 inches
- 20 feet
- 41 inches

- All equipment was moved to the contractor’s warehouse
- Extensive tests were conducted on equipment
- Statements from employees were taken
Vacuum #15

- Inspection of this vacuum revealed the equipment grounding conductor (i.e., ground pin) was missing.
- Vacuum was plugged into a 30-foot long extension cord with no GFCI protection.
- Vacuum was run at the shop for one hour then tests on the case were conducted which indicated 55 volts was leaking to the case.
- Employees said they had received shocks prior to the accident when turning it on and off at the metal toggle switch.
Ohms Law

- \( I = \frac{E}{R} \)
- \( E = I \times R \)
- \( R = \frac{E}{I} \)

- \( I \) = current in amps
- \( E \) = volts
- \( R \) = resistance in Ohms

George Simon Ohm
1789 - 1854
Electrocution Levels

Based upon the work of
Professor Charles F. Dalziel
University of California at Berkley

Charles Dalziel was the inventor of the GFCI
First developed in 1961
NEC® required – Pools underwater lighting 1968
'71 NEC® – Outdoor receptacles (Effective 1973)
Construction (Effective 1974)
'75 NEC® – Bathrooms in dwellings

Actually used “grad students” to “assist” in his research.
Heart Fibrillation Threshold For Normal Healthy Adults.

Range of Maximum “Let-Go” Currents For Normal Healthy Adults.

Electrocution Curve
Minimum current/resistance/time for heart fibrillation

Ohms Law: \[ I = \frac{E}{R} \]

\[ I = \frac{55 \text{ Volts}}{500 \text{ Ohms}} \]

\[ I = 0.11 \text{ amps} = 110 \text{ milliamps} \]

*500 Ohms resistance of wet salty skin

50 milliamps is all that is needed for fibrillation

Reference chart for time/current/voltage
Heart Fibrillation Threshold for Normal Healthy Adults

Electrocution Curve

Range of Maximum “Let-Go” Currents For Normal Healthy Adults.

Time in Seconds

Current in Milliamperes

ELECTROCUTION CURVE
SUMMARY:

- Victim was sweating in the ventilation duct
- Dry bulb temperature was over 90°F
- Autopsy revealed a recent burn mark on his back (the exact distance from the floor to the vacuum metal handle attachment as if the victim was sitting on the duct floor leaning up against the vacuum)
- Other workers had received shocks from the vacuum when turning it on and off
- The vacuum was tested back at corporate’s warehouse - after an hour of operation the metal case indicated 55 volts to ground
CONCLUSION:

- The vacuum did not have a ground pin
- The vacuum’s faulted energy to the case >55 volts
- The victim was sweating and did not have very good resistance properties against electrical energy
- There was no attendant, the worker was tired and suffering from heat exhaustion
- Very little ventilation, hot halogen work lights, dust respirators, tyvek coveralls and moderate to heavy work all added to heat load
- The victim was tired, leaned up against the vacuum and stayed there for 2 to 4 seconds until his heart went into fibrillation; he then slumped over and other workers noticed him laying on the floor shaking
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