ANSI/AIHA Ventilation Standards - “A Consensus Approach”

J. Lindsay Cook, CIH, CSP
History of Standards Development

- **ASME**
  - 1914 Boiler & Pressure Vessel Code

- **NFPA**
  - Established 1896 to Establish sprinkler system uniformity
Some Standard Benefits:

- Simplify Product Development
- Reduce Costs
- Increase Productivity
- Ensure Safety
- Permit Interchangeability
- Enhance Acceptability
- Maintain Uniformity
Standards Development Organizations

- NEMA: Setting Standards for Excellence
- AIHA: Your Essential Connection
- NFPA
- UL: Working for a safer world
- SAE
- ASTM: INTERNATIONAL Standards Worldwide
- The American Society of Safety Engineers
American National Standards Institute

- ANSI is the National Standards Body for the United States
- Standards Are Adopted, Not Written, By ANSI
- Accredited SDO or Technical Committee
- May Be Mandatory, If Adopted Into Regulations (NEC)
Shifting Emphasis To International Standards

- ISO – International Organization for Standardization (1947)
- Harmonization of National Standards
- Remove Technical Trade Barriers
- Worldwide Market Acceptance
The Standards Process

- Based On Voluntary Consensus
- Supported By the Private Sector
- Work Done By Technical Committees
- Many Stakeholders
- Government & Industry Participate As Equals
Principles of Voluntary Consensus
### ANSI/AIHA Z9 Representation

<table>
<thead>
<tr>
<th>Alliance of American Insurers</th>
<th>US Department of the Navy</th>
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<tbody>
<tr>
<td>ACGIH</td>
<td>NSEMA</td>
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<td>American Foundrymen’s Society</td>
<td>General Motors</td>
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<tr>
<td>American Glovebox Society</td>
<td>Harvard University</td>
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<tr>
<td>AIHA</td>
<td>MIT</td>
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<td>American Petroleum Institute</td>
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<tr>
<td>Grinding Wheel Institute</td>
<td>American Public Health Association</td>
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<tr>
<td>NIOSH</td>
<td>Foundry Equip. Mfg. Association</td>
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<tr>
<td>US OSHA</td>
<td>US Air Force</td>
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</table>
ANSI/AIHA Ventilation Standards

Z9.1 - Ventilation and Operation of Open Surface Tanks
Z9.2 - Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems
Z9.3 - Spray Finishing Operations – Design Construction and Operation
Z9.5 - Laboratory Ventilation
ANSI/AIHA Ventilation Standards

Z9.6 - Exhaust Systems for Grinding, Polishing and Buffing

Z9.7 - Recirculation of Air From Industrial Process Exhaust Systems

Z9.9 - Portable Ventilation Systems

Standards Development

- Public - Private Partnership
- Voluntary Standards
- Private Sector Participation Is Critical
Information Resources

- www.aiha.org
- www.acgih.org
- www.ansi.org

Lindsay Cook

- www.ei1.com
ANSI/AIHA Z9.1 Ventilation Standard
Ventilation and Control of Airborne Contaminants During Open-Surface Tank Operations

John W Sheehy, PhD, CIH, PE
Z9.1 Subcommittee Members

- John Sheehy
- Jeff Burton
- Kathleen Paulson
- George Adams
- Charles Boone
- Ken Hankinson
- Frank Cichon
- Robert Hughes
Objectives
(for this edition)

• Stand alone document
• Incorporate new technology and experience
• Use a combination of control approaches to protect workers
• Allow for two LEV design approaches: Control Velocity or Hemeon
• Minimize duplications with ACGIH Industrial Ventilation Manual
Tanks with one-sided lateral exhaust hoods
Applications and Exclusions

• Applies to open surface tank (OST) operations: washing, electroplating, anodizing, pickling, degreasing, dipping, stripping, rinsing and similar operations
• Excludes molten material handling, surface coating by spraying, brushing, pouring etc. and wet sink operations in the semi-conductor industry
• Not intended to cover fire protection
Contents

• Purpose of Z9.1 standard: to protect the health of workers
• Open-surface tank operations classified according to risk
• Exposure and emission control requirements to maintain air contaminants below acceptable limits
• Local exhaust ventilation design including push-pull ventilation and general ventilation
Hard chrome plating tank with push-pull ventilation
Contents (cont)

- Ventilation for vapor degreasing tanks
- Special precautions for cyanide
- Operation and maintenance of ventilation systems
- Selection of respirators
- Audit form
Enhancements

- Recommends a combination of control approaches
- References SMACNA for construction and material specifications
- LEV design in the case of multiple tanks
- 2-column format
Enhancements (cont)

- Emphasizes user’s role in evaluating cyanide hazard
- Expands discussion of preventive maintenance for OST ventilation systems
- Audit form to assist in compliance with the standard
Acid cleaning line and exhaust hood
Use Combination of Control Methods

Consider a combination of control approaches to reduce exposures below acceptable limits:

• Substitution
• Isolation
• Automation
• Local exhaust ventilation
• Automatic tank covers
Multiple Tanks

- The user shall take into account the effect on emissions and controls when multiple tanks are in close proximity to one another.
- Where many tanks are in a room, the design air flow rate added together may create significant turbulence.
- Hemeon design method may be better suited with multiple tanks.
Maintenance

- Ventilation systems need to be designed for preventive maintenance.
- Clean-outs that allow access to ductwork, plenums and slots for cleaning and preventive maintenance should be provided.
- A periodic maintenance schedule should include for example:
  - Monthly: Open and clean the slots
  - Quarterly: Inspect all system hoods, plenums, ductwork, fans and air pollution control devices
Maintenance (cont)

- Every six months- Open the fan motor housing and check the belt to make sure it is tight and not slipping

Results from a study of a furniture stripping operation over 7 years showed lack of access and poor maintenance reduced exhaust volumes by 2/3 and increased exposures 5 fold. Upgrading the ventilation system to include easier access and cleanouts improved the LEV performance to its original state.
Contact Information

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JSheehy@cdc.gov
ANSI/AIHA Ventilation Standards
Z-9.2 Fundamentals

Kathleen M Paulson, PE

Engineering Service Center
Port Hueneme, CA
Fundamentals is ..... 

- Designer Qualifications
- Exhaust Hoods
- Ductwork
- Fans & Air Movers
- Air Cleaning Devices
- Makeup Air Systems
- System Operation, Management & Commissioning
Typical Uses for Z9.2 ....

- Develop an IV system from “scratch”
- Design a system for a new technology
- Basis for a statement of work.
- Teaching primer
- Audit tool
Z-9.2 Committee Members Who Worked on the Standard

D. Jeff Burton  Kappy Paulson
George Adams       Tom Smith
Shawn Chesney      Jeff Throckmorton
Bob Hughes         Leighton Turner
Z-9.2 Format

- Two Column for use as a technical standard.
  - Left column - Mandatory
  - Right column – Clarifications or Explanatory
- Appendix A – Non-mandatory Comments
- Appendix B - Audit Form
Z-9.2 Plant Layout & Construction

- Layout makes sense
- Housekeeping – easy cleaning & maintenance
- Fire & local bldg codes
- Handling radioactive material
Z-9.2 Make Up Air Systems

- Quantity AND Distribution
- Recirculating Air Systems
Z-9.2 Exhaust Hoods

- Capture
- Containment
- Airflow requirements
Z-9.2 Ductwork & Stacks

- Minimum Transport Velocity
- Balanced Systems
  - By design
  - With dampers & orifice plates
- Stacks – location location location

Leftover Parts

Duct tape & flex tube

Plastic pipe in a wood shop
These were DESIGNED.

Air should all go in the same direction.

Smooth Transitions.

Appropriate for contaminant.
Z-9.2 Air Cleaning Equipment

- In US, primary driver is EPA, state & local regulations.
- Not all processes have regulatory limits. Some companies and organizations use a good community neighbor policy.
- Remember disposal costs
  - Moved away from water wash paint booths liquid waste disposal = $$$ than solid
Z-9.2 Fans & Air Movement Devices

Simple bearing problem not identified during TAB.

Systems Effects
Sustainability
Safety
Maintainability

Choked exhaust = 1” wg
Z-9.2 Management of LEV Systems

JUST DO IT!

- Prepare a written policy
- Enforce work practices
- Invoke a monitoring Program

Use the Audit in Appendix
Z-9.2 Commissioning

- Not just at project completion
  - Programming, Design, Installation, Construction, Acceptance & Post Acceptance

- Documentation
Z-9.2 Operation And Management

- Preventative Maintenance
  - Indicators (gauges, sensors & monitors)
  - Periodic (daily, weekly, monthly, annually)
  - Careful about contracting
    - Supply/Exhaust in the Hangar

- Crisis Maintenance
  - Threat to occ. safety & health and envi compliance
Z-9.2 Testing, Balancing & Operations Checks

- TAB is only a small part of Commissioning – the close to The End part of the Construction.

- TAB does NOT confirm control of stressors of concern. Need both safety & health evaluation.

- Often overlooked or deleted due to project cost overruns or enthusiasm over finally finishing project.

WITHOUT TAB,
WHAT IS YOUR BASELINE?

George M. Adams, PE

Z9.3 Spray Finishing

- As with all Z9 Standards, developed to “protect the health of personnel ....during spray finishing operations”.
Z9.3 Spray Finishing

- Does not apply to building exterior, inside fixed tanks.

- Does not apply to small hand spray cans.

- But should be followed where applicable.
Z9.3 Spray Finishing

- Recently rewritten into two-column format.

- Thanks Jeff
Z9.3 Spray Finishing

- Coordinates well with NFPA 33
- Duct construction in conjunction with SMACNA Standards.
- Fans selected according to AMCA Bulletin 210.
Z9.3 Spray Finishing

- Velocity capable of controlling the contaminant.
- Sufficient flow rate to keep the solvent concentration below 25% of the LFL.
As with all Z9 Standards, developed to protect the health of personnel during spray finishing operations.
Z9.3 Spray Finishing

- Stack positioned and with a high enough velocity to preclude re-entrainment.
ANSI/AIHA Z9.5 - Laboratory Ventilation

- Lou DiBerardinis, Chair
- Doug Walters, Associate Chair
- D. Jeff Burton
- Steve Crooks
- Gregory DeLuga
- Edgar Galson
- Daniel Ghidoni
- Todd Hardwick
- Ron Hill
- Dale Hitchings
- Gerhard Knutson
- Victor Neuman
- John Price
- Gordon Sharp
- Thomas Smith
- J. Lindsay Cook (ex-officio)
SHALL

• Ventilation Management Program
• Chemical Hygiene Plan
• Responsible Person
• Hazard Assessment
• Records
Non Quantative Shalls

- Laboratory Chemical Hoods
- Volume Flow Rates (AC/HR)
- Hood Location
- Directional Airflow
- Noise
- Emergency Mode
- Work Permit
<table>
<thead>
<tr>
<th>Hood Criteria</th>
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<tbody>
<tr>
<td><strong>Face Velocity</strong></td>
</tr>
<tr>
<td><strong>Minimum Exhaust Volume</strong></td>
</tr>
<tr>
<td><strong>Flow Measuring Device</strong></td>
</tr>
<tr>
<td><strong>Posting</strong></td>
</tr>
</tbody>
</table>
The performance tests shall include:

- Exhaust Flow Measurements
- Hood Static Pressure Measurement
- Face Velocity Tests
- Auxiliary Air Velocity Tests (if applicable)
- Cross Drafts Velocity Tests
- Airflow Visualization Tests
- Tracer Gas Containment Tests
Tracer Gas Containment Tests

The tracer gas containment tests shall be conducted as described in the ASHRAE 110 “Method of Testing Performance of Laboratory Fume Hoods” or by a test recognized to be equivalent:
Ongoing or Routine Hood and System Tests

Routine performances tests shall be conducted at least annually or whenever a significant change has been made to the operational characteristics of the hood system.
Exhaust Discharge

- Minimum Discharge Velocity - 3000 fpm
- Minimum Stack Height - 10 feet
- -----Except-----
- Appendix 3
Energy Conservation Issues

- Recirculation of Room Exhaust Air
- Variable Air Volume Systems
- Manifolded Systems
- Automatic Sash Closers
- Air Change per Hour
- Enclosures
- Ductless Hoods
Hood Diversity \[= \frac{\text{Hoods in Use}}{\text{Total Hoods in System}}\]

CFM Diversity \[= \frac{\text{Exhaust CFM in Use}}{\text{Total Exhaust CFM needed}}\]
Requirements

• Communicate Limitations to Users
• Alarm Systems
• Label Restrictions
• Determine Minimum Exhaust Requirements
• Consider Future Needs
Product Definition

Low Flow Hood:

Fume hood designs that provide a reduction in required exhaust volume from the traditional 100 fpm @ the sash full open vertical position.
Product Definition

Low Velocity Hood:

Fume hood designs that provide a reduction in required exhaust volume and provide proper containment* with the sash full open vertically at face velocities of 60 fpm or less.

* 4.0 AM 0.05 ppm
Recordkeeping

- As Built Drawings
- Commissioning Report
- Testing and Balancing Reports
- Inspection Reports
- Maintenance Logs
- Reported Problems
- System Modifications
- Equipment Replacement or Modifications
Questions

Lou DiBerardinis
Director, EHS Office
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ANSI/AIHA Z9.6 - Exhaust Systems for Grinding, Polishing, and Buffing

Mark Lee Rollins, CIH, CSP
History of Z9.6

- Originally a standard developed by the Industrial Hygiene Codes Committee of the American Foundrymen’s Association (AFA)
- Approved by the Board of Directors on December 4, 1936
History of Z9.6

- AFA submitted standard to American Standards Association (now ANSI)
- Z9 Committee on exhaust systems
- Standard issued as Z43.1-1941
- Reissued under Z9 guidance as Z43.1-1966
History of Z9.6

- ANSI withdrew Z43.1 in 1988, as no further work had been done on it and it needed updating
- Z9 chartered in 1992 to rewrite as Z9.6
- Standards issued in 1999
Definition - Grinding

- “ANSI B7.7-2003 Safety Requirements for Abrading Materials with Coated Abrasive Systems section 6.3.21:
  “Grinding: abrading heavy amounts of material from a work-piece using an abrasive tool.”
- Term is applied to all types of stock removal using grinding wheels, also commonly used to describe operations performed by machines using coated abrasive belts and discs.
Definitions - Buffing

- “polish or shine with a piece of soft material”
- Usually a buffing wheel or buffing belt in industry
  - Often done with no abrasive agents
Definitions - Polishing

- “make smooth and shiny by rubbing with fine abrasive particles”
- Similar to buffing operation with added very fine abrasives
Air Contaminants - Grinding

- Air contaminants are material being ground as well as the abrasive wheel
  - ratios of 90:1 to 100:1 or more
- Large (non-respirable) to very small (sub-micron) particles
- Sometimes done “wet” which minimizes particulate air contaminants
Air Contaminants - Buffing

- Air contaminants are material being buffed as well as the buffing wheel
- Most very small (sub-micron) particles
  – although not a lot given off, compared to grinding and polishing operations
Air Contaminants - Polishing

- Air contaminants are material being polished as well as the fine abrasive polishing media
- Again, most are very small (sub-micron) particles
- Size somewhat dependent on size of polishing compound
Raw Drawings
Minimum face velocity = 200 fpm
Entry loss
\[ h_e = 1.78 \, VPs + 1.0 \, VPd \]

Figure 6—Portable grinder work exhaust hood and branch duct connections.
Example for:
X = 4 inch
A = 3 inch by 4.5 inch

<table>
<thead>
<tr>
<th>$V_s$</th>
<th>Q, cfm</th>
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<tbody>
<tr>
<td>1000</td>
<td>52</td>
</tr>
<tr>
<td>2000</td>
<td>100</td>
</tr>
<tr>
<td>3000</td>
<td>150</td>
</tr>
<tr>
<td>4000</td>
<td>210</td>
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<td>5000</td>
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<td>7000</td>
<td>360</td>
</tr>
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<td>8000</td>
<td>420</td>
</tr>
<tr>
<td>9000</td>
<td>470</td>
</tr>
<tr>
<td>10,000</td>
<td>520</td>
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$Q = 0.043 V_s (10X^2 + A)$

Minimum duct velocity = 3500 fps

$V_s = 0.25 V_P$

$X =$ distance from hood face to center of wheel, ft

$A =$ hood face area, ft$^2$

$Vs =$ wheel speed, surface feet per minute (sfm)

$Vs = \pi (D/12) R$

$D =$ diameter in inches

$R =$ rpm of grinding wheel

Figure 2—Surface grinder. [From Industrial Ventilation — A Manual of Recommended Practice, 23rd Ed. Copyright 1998. Reprinted with permission of the American Conference of Governmental Industrial Hygienists.]
Minimum duct velocity = 4000 fpm

Entry loss

\( h_e = 0.45 \ V P_d \) for tapered take-off
\( h_e = 0.65 \ V P_d \) for straight take-off

<table>
<thead>
<tr>
<th>Wheel dia. inches</th>
<th>Volume exhausted, ft(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 12</td>
<td>220</td>
</tr>
<tr>
<td>over 12 to 19</td>
<td>390</td>
</tr>
<tr>
<td>over 19 to 30</td>
<td>610</td>
</tr>
<tr>
<td>over 30 to 36</td>
<td>880</td>
</tr>
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Note: If grinding wheels are used for disc grinding purposes, hoods must conform to structural strength and materials as described in American National Standard for the Use, Care, and Protection of Abrasive Wheels, ANSI B7.1

Figure 12—Horizontal single-spindle disc grinder exhaust hood and branch duct connections.
Other Standards

- ANSI Z9.2 - Fundamentals Governing the Design and Operation of Local Exhaust Systems
- ANSI/AIHA Z9.7 - Recirculation of Air from Industrial Process Exhaust Systems
- ANSI B7.1 - Safety Requirements for the Use, Care, and Protection of Abrasive Wheels
- ANSI Z87.1 - Practice for Occupational/Educational Eye and Face Protection
- ANSI Z88.2 - Respiratory Protection
Other References

- Industrial Ventilation: A Manual of Recommended Practice (ACGIH)
- TLVs and BEIs booklet (ACGIH)
- NFPA 91-2004, Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids
- NFPA 651-1998, Machining and Finishing of Aluminum and the Production and Handling Aluminum Products
Purpose of Z9.6

- Protect the health of personnel engaged in and working in the vicinity of grinding, polishing and buffing operations
- Control contaminants generated by those operations
ANSI/AIHA Z9.7 - Recirculation of Process Air Form Industrial Process Exhaust Systems

George M. Adams, PE
Z9.7 Recirculation

- Developed to establish the minimum criteria for the recirculation of industrial process ventilation systems.
Z9.7 Recirculation

- Does not apply to operations conducted outside a building.

- Does not apply to air returned through an air handling unit.
Z9.7 Recirculation

- Recently rewritten into two-column format.

- Thanks Lindsay
Z9.7 Recirculation

Requires a Hazard Evaluation to be conducted, ala Appendix B of the OSHA Hazard Communication Standard
Z9.7 Recirculation

- Carcinogens

- Do you really want to ??
Z9.7 Recirculation

- If you can’t remove it from the air stream, don’t recirculate.
Z9.7 Recirculation
Z9.7 Recirculation

Continuous Monitoring Device

- An air sampling instrument, usually fixed in one location, designed to continuously or repeatedly sample the air for a specific contaminant
Z9.7 Recirculation
Z9.7 Recirculation

The location of the in-plant discharge from a recirculating exhaust system shall be arranged so as to minimize build-up of contaminant concentration, moisture, unwanted heat, and unwanted drafts.
ANSI/AIHA Z9.9 - Portable Ventilation Systems

Neil McManus, CIH, ROH, CSP

NorthWest Occupational Health & Safety
Vancouver, BC
Does Your Portable Ventilation Equipment Look Like This?
Do Your Portable Ventilation Installations Look Like This?
Or This?
When They Could Look Like This
Or This
Benefits From a Standard...

- better product design
- consistency in product testing
- consistency in system design
- more effective use of equipment
- better performance from equipment
- improved product and personnel safety
What a Standard Must Consider...
Equipment Covered... Airmovers
Equipment Covered... Airmovers
Equipment Covered… Airmovers
Equipment Covered... Components
Equipment Covered... Components
Equipment Covered... Duct and Hose
Equipment Covered… Fittings
Equipment Covered… Integrated Units
Topic Areas....

- design, construction, performance testing, labelling, and servicing and maintenance of portable ventilation equipment

- design, application, management, operation, and performance validation of portable ventilation systems
Design Considerations:

- equipment and system design principles
- machine design for service and maintenance
- electrical safety
- requirements for hazardous location equipment
- control of static electricity
- heat and fire resistance of materials
- contamination and decontamination issues
- incompatibility between materials of construction and substances transported and in the surroundings
Operational Considerations

- ventilation outcome to be achieved
- interaction between source(s) and worker(s) during work activity
- impact of ventilation discharge into the surroundings
- function and capability, and strengths and limitations of ventilation system components
- safety issues
- failure mode(s)
- contamination and decontamination
- training in equipment operation
- optimizing and verifying performance
Maintenance Considerations

- contamination issues and decontamination strategies
- procedures for disassembly and repair and maintenance
- performance criteria for bench testing of components
- maintaining safety features during reassembly
- incompatibility between materials of construction and substances transported and in the surroundings
- end of service life indicators
Major Issues....

- need for uniform labeling
- need for uniform performance testing and reporting
- testing and classification of nonelectrical components for use in ignitable atmospheres
- control of static electricity in nonelectrical components
- maintenance and service
Outcomes... Labeling

- uniform labeling system proposed for airmovers, components and duct
- label will report:
  - performance
  - applications
  - restrictions
  - precautions
Outcomes… Performance Testing

- adopt relevant current AMCA standards for airmover performance testing
- provide performance curve for all airmovers
- provide loss data for components and duct
- provide noise data
for all equipment and components intended for use in ignitable atmospheres (hazardous locations):
  – test and classify using criteria in NFPA 70 (Article 500)
  – determine and report maximum surface temperature
  – assign Class, Division, Group
Outcomes... Static Electricity

- for all equipment and components intended for use in ignitable atmospheres (hazardous locations):
  - meet requirements of NFPA 70 (Article 250) for bonding and grounding
  - test and classify performance according to standards devised by the Electrostatic Discharge Association
  - design to minimize electrostatic accumulation
  - design to minimize spark discharge
Outcomes... Critical Operations

- additional requirements for equipment intended for use in critical operations (asbestos, mold, lead, nuclear applications, life-support situations)

- operation-critical situations demand reliability:
  - redundancy of components
  - documented performance of entrapping devices (filters, sorbents)
  - surveillance to warn about failure
  - design to prevent escape of contaminants during changeout of entrapping devices
Outcomes... Maintenance

- diagnostic and service procedures
- test protocols
- decontamination procedures
- end of service life indicators
- training for maintenance personnel
In Conclusion...

- portable ventilation systems, while superficially, seeming unsophisticated, are used in wide-ranging, sometimes hazardous environments, often under minimal informed supervision
- a consensus standard will benefit all stakeholders from designers and manufacturers, to end-users