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J Occup Environ Hyg. Author manuscript; available in PMC 2016 July 01.

Published in final edited form as:

J Occup Environ Hyg. 2016 July ; 13(7): D111–D117. doi:10.1080/15459624.2016.1163710.

Workplace air quality: International consensus standards

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Keywords

Air quality; ASTM International; Comité Européen de Normalisation (CEN); consensus standards; International Organization for Standardization (ISO); workplace atmospheres

Introduction

Standardization is essential to fostering the use of harmonized methods for exposure assessment in occupational hygiene nationally and internationally. A standardized method for sampling and analysis provides data of known quality and reliability through the assurance of acceptable accuracy or uncertainty, which can then be compared to results collected at other times or in other places. Consensus standards can be used by regulatory agencies or advisory bodies to determine compliance with occupational exposure limit values. In addition, harmonized methods can be employed to generate high-quality databases of exposure results that can be used for other purposes such as epidemiological studies. Efforts have been made to promulgate consensus standards to maximize such benefits for professionals in the occupational hygiene field throughout the world. Consensus is reached through input from many stakeholders, occupational hygienists, industrial hygiene chemists, manufacturers, national authorities, and government representatives, along with many other professionals in private industry, academia, and nonprofit organizations.

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Supplemental data for this article can be accessed at tandfonline.com/uoeh. AIHA and ACGIH members may also access supplementary material at http://oeh.tandfonline.com/.

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With regard to workplace air quality, there are three primary relevant consensus standards organizations: ASTM International (formerly the American Society for Testing and Materials) Subcommittee (SC) D22.04 on Workplace Air Quality (under Committee D22 on Air Quality); Comité Européen de Normalisation (CEN; European Standards Organization), Technical Committee (TC) 137 on Assessment of Workplace Exposure to Chemical and Biological Agents; and International Organization for Standardization (ISO), SC 2 on Workplace Atmospheres (under TC 146 on Air Quality).[1] These consensus standards bodies, with respect to air quality, generally represent North America, Europe, and the world, respectively. Each organization produces its own standard methods, practices, guides, technical specifications (TS), and/or technical reports (TR), based on its needs. This commentary reports the most recent updates concerning each organization's mission, structure, status of standards (published or under development), and other relevant information. It also introduces harmonized standards that have been promulgated among these voluntary consensus standards organizations.

ASTM International, Committee D22 (Air Quality), Subcommittee D22.04 (Workplace Air Quality)

The scope of work of Committee D22 on Air Quality of the ASTM International is "the promotion of knowledge, the development of test methods, practices, guides, and terminology pertaining to sampling and analysis of atmospheres, interpretation of data, the standardization of recognized and practiced methods for measurement of atmospheric quality, and sponsoring of discussions among those active in the study of air quality." Committee D22, formed in 1951, is composed of eight technical SCs and lists over 500 members from around the globe. Each SC addresses a specific subject; D22.04 is a technical SC covering workplace air quality issues (excluding the establishment of occupational exposure limit values) as well as related workplace exposure issues such as surface and dermal exposures.[2] D22.04 generates standard test methods, practices, or guides, depending on the purpose of draft standards, which are balloted at the SC and main committee stages by volunteer members presented in Table 1. ASTM International ensures a balance in official voting status among producers and other voting interests. The number of published standards under D22.04 is 47, and currently four standards on various chemical agents are under development or revision.

Table 2 lists harmonized consensus standards that have been promulgated (or are under development or revision) among the three standards organizations (i.e., ASTM International, CEN and ISO). Note that the bold and italic text indicates those under development or revision. (The full names of the standards are listed in a supplementary file.) Standards developed by D22.04 are published in Volume 11.07 of the *Annual Book of ASTM Standards* in hard copy, online, or CD format. Published standards require review, followed by reapproval or revision, at least every 5 years. Other SCs relevant to D22.04 are D22.01 (Quality Control), D22.05 (Indoor Air), and D22.07 (Sampling and Analysis of Asbestos), and standards developed in these other SCs can be useful in workplace situations. In addition, D22 is a mirror committee of ISO/TC 146 on Air Quality, and D22.09 (ISO Technical Advisory Group [TAG] for ISO TC146) advises the U.S. national standards body

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(i.e., the American National Standards Institute [ANSI]) on ISO activities, by providing technical comments.

The ASTM International air quality committee, D22, has biannual meetings (one in April and the other in October) in the United States and Canada. Future ASTM International meetings are scheduled for Orlando, Florida (October 2016); Toronto, Ontario, Canada (April 2017); and New Orleans, Louisiana (October 2017). In addition, D22 sponsors or cosponsors a number of symposia and workshops relevant to D22 SC activities. Table 3 lists symposia and workshops since year 2000. A symposium consists of a 1- or 2-day meeting, normally held in conjunction with D22 committee and its SC meetings during the biannual ASTM committee week. Occasionally, a week-long conference on air quality issues is held separately (typically in summer or winter). Future workshops and conferences are also listed in Table 3.

Comité Européen de Normalisation (CEN), Technical Committee (TC) 137 (Assessment of Workplace Exposure to Chemical and Biological Agents)

The main work of CEN/TC 137, equivalent to ASTM D22.04, is “standardization in the field of assessment of exposure to chemical and biological agents at the workplace, also taking into account the dermal exposure. This includes the planning and performing of measurements but excludes the establishment of limit values.” The members of this committee represent manufacturers, trade unions and governmental delegates. Furthermore, the European Commission (EC) and the European Free Trade Association (EFTA) has entrusted TC 137 (under the overall responsibility of TC 352 on nanotechnologies) with the elaboration of deliverables dedicated to specific aspects of nanotechnologies and nanomaterials (Mandate M/461, see below). To participate in the TC activities, experts can become members only via their own country’s national standards organizations. Currently, Germany (Deutsches Institut für Normung e.V., or DIN) holds the secretariat of TC 137. There are six working groups (WGs) under the CEN/TC 137, and currently all except WG 4 (Definitions) and WG 5 (Measurement of biological agents) are active (Table 1).

The number of standards published under TC 137 is 32, and currently seven standards are under development (Table 2). All reports, including European standards (EN), Technical Specifications (TS), and Technical Reports (TR), are prepared in English, and then at a later stage (such as a Draft European Standard and/or approval for CEN/TS or CEN/TR), they are translated into French and German. A few highlighted projects under WG 3 (Particulate Matter), mandated by the EC and EFTA, are three EN standards under development: (1) characterization of ultrafine aerosols/nanoaerosols (prEN 16897:2015, WI-00137052), (2) provision of metrics for measurements of exposure to inhaled nanoparticles (prEN 16966:2016, WI-00137056), and (3) assessment of inhalation exposure to nano-objects and their agglomerates and aggregates (WI-00137053). WG 6 (Dermal Exposure) is developing a TS for assessing dermal exposure to nano-objects and their aggregates and agglomerates (WI-00137054, Joint ISO/CEN work item with CEN lead), in conjunction with the EU Mandate M/461 on nanotechnologies and nanomaterials. These are expected to be completed between 2016 and 2018.

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The CEN/TC 137 usually has a plenary meeting every 2 years, and it strongly recommends all WGs meet concurrently with the main committee. Most WGs meet in conjunction with the TC and also separately in the interim. In 2016, no TC meeting will take place but various WG meetings are planned. In 2017, the CEN/TC 137 meeting and other WG meetings are scheduled for mid-May in Helsinki, Finland.

To avoid duplication of effort, CEN/TC 137 is closely working with other committees and SCs, including CEN/TC 264 on Air Quality, CEN/TC 352 on Nanotechnology, ISO/TC 146/SC 2 on Workplace Atmospheres, ISO/TC 229 on Nanotechnology, and ASTM D22.04 on Workplace Air Quality. For instance, four EN ISO standards were recently developed in collaboration with ISO/TC 146/SC 2 under the Vienna Agreement:[1] EN ISO 13137:2013, Personal Sampling Pump Standard; EN ISO 17621:2015, Requirements and Test Methods for Detector Tubes; EN ISO 13138:2012, Sampling Conventions for Airborne Particle Deposition; and EN ISO 28439:2011, Characterization of Ultrafine Aerosols/Nanoaerosols Using Differential Electrical Mobility Analyzing Systems.

International Organization for Standardization (ISO), Technical Committee (TC) 146 (Air Quality), SC 2 (Workplace Atmospheres)

ISO is a leading worldwide organization supported by a Central Secretariat based in Geneva, Switzerland. The scope of the work of ISO/TC 146, created in 1971, is the “standardization of tools for air quality characterization of emissions, workplace air, ambient air, indoor air, in particular measurement methods for air pollutants (particles, gases, odors, micro-organisms) and for meteorological parameters, measurement planning, procedures for Quality Assurance/Quality Control (QA/QC) and methods for the evaluation of results including the determination of uncertainty.” The SC 2 on Workplace Atmospheres of TC 146 considers standardization related to workplace atmospheres, excluding the establishment of occupational limit values.

As of February 2016, ISO/TC 146/SC 2 has 24 participating (P)-member countries and 16 observing (O)-member countries in all regions of the world (Table 1). Only the P-member countries can vote (that is, one vote for each country) for ballots at various stages. For example, the national standards body in the United States, ANSI, utilizes Technical Assistance Groups to provide recommendations and technical comments on ISO ballot items; for ISO/TC 146, ASTM SC D22.09 serves this role. The O-member countries can participate in developing ISO standards, TSs or TRs, but have no voting authority. Currently, the United States (ANSI) is the secretariat of SC 2.

ISO/TC 146/SC 2 is divided into nine WGs; all are active except for WG 9 on Sampling Pump Performance (dormant), as indicated in Table 1. WG3 has developed a joint working

[1]The agreement on technical cooperation between ISO and CEN (Vienna Agreement) is an agreement on technical cooperation between ISO and the European Committee for Standardization (CEN). Formally approved on June 27, 1991 in Vienna by the CEN Administrative Board following its approval by the ISO Executive Board at its meeting on May 16 and 17, 1991 in Geneva, it replaced the Agreement on exchange of technical information between ISO and CEN (Lisbon Agreement) concluded in 1989. The “codified” Vienna Agreement was approved by ISO Council and the CEN Administrative Board in 2001.” (See http://isotc.iso.org/livelink/livelink?func=ll&objId=4230458&objAction=browse&sort=subtype, accessed on January 8, 2016).

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group with the International Electrochemical Commission (IEC) to harmonize standards for direct-reading gas and vapor instruments from the US, Canada, Europe and Asia. Developing or revising a standard takes 3–4 years, with votes at up to five different stages: new work item proposal, working draft, committee draft (optional to skip), draft international standard, and final draft international standard (optional to skip). It usually takes less time to develop a TS or a TR. The number of published standards under the ISO/TC 146/SC 2 is 40, and currently seven standards are in development or under revision. All reports are prepared in English, but when publication nears, they are translated into French and German. Once each standard, TS, or TR is developed, a systematic review occurs after 3 years and then every 5 years after that.

The ISO/TC 146 has a plenary meeting every 2 years, and it strongly recommends that SCs and their WGs meet concurrently with the main committee. ISO/TC 146/SC 2 has a plenary meeting every year and most WGs meet in conjunction with the SC 2 and also separately in the interim. In 2016, the ISO/TC 146/SC 2 annual meeting and other WG meetings are scheduled for September 25–30 in Burlington, Vermont, along with the plenary meeting of ISO/TC 146.

Conclusion

This commentary has described current activities of the voluntary consensus standards organizations related to workplace atmospheres and has provided information about each committee's and subcommittee's scope, structure, and status of standards (published or under development). Numerous standards were developed on the basis of methods published by the National Institute for Occupational Safety and Health (NIOSH) (www.cdc.gov/niosh/nmam) and the Occupational Safety and Health Association (OSHA) (www.osha.gov/dts/sltc/methods), and governmental organizations in other countries (e.g., Germany, France, Great Britain).[3] Currently, key personnel in ISO/TC 146/SC 2 are also actively involved in activities of ASTM D22.04 or CEN/TC137, which will lead to harmonization of consensus standards. The continuous activities in developing harmonized standards have been marked by collaboration among the three main organizations.

To learn more about the consensus standards committees/subcommittees on workplace atmospheres, contact Mike Brisson (mike.brisson@srs.gov, SC 2 Chair and ASTM D22 Chair), Eun Gyung (Emily) Lee (dtq5@cdc.gov, SC 2 Secretary), or Martin Harper (zzg7@cdc.gov, previous SC 2 Chair) for information on ISO/TC 146/SC 2; Kevin Ashley (kea0@cdc.gov, D22.04 Chair) for information on ASTM D22.04; and Dietmar Breuer (dietmar.breuer@dguv.de, TC 137 Chair) or Christian Thom (christian.thom@din.de, TC 137 Secretary) for information on CEN/TC 137.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding

This work was funded internally by the National Institute for Occupational Safety and Health.

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Table 1

International standards on workplace air quality.

	ASTM D22/D22.04	CEN TC 137	ISO TC 146/SC 2
Type of Standards or Reports	Standard Test Method Standard Practice Standard Guide	European Standard CEN Technical Specification CEN Technical Report	International Standard Technical Specification Technical Report
Members involved	Instrument/product manufacturers, trade unions, national authorities and government representatives, academia, and non-profit organizations	Instrument/product manufacturers, trade unions, national authorities and government representatives, and European Commission	• 24 Participating (P) countries: Australia, Austria, Belgium, Canada, China, Finland, France, Germany, India, Italy, Japan, Kenya, Republic of Korea, Malaysia, Netherlands, Norway, Poland, Russian Federation, South Africa, Spain, Sweden, Turkey, United Kingdom, and United States • 16 Observing (O) countries: Chile, Czech Republic, Denmark, Hungary, Iceland, Mongolia, New Zealand, Portugal, Romania, Saudi Arabia, Serbia, Slovakia, Sri Lanka, Switzerland, United Republic of Tanzania, and Ukraine
Voting	Individual members, one vote per voting interest	One vote per national standards body ("weighted vote" for EN or TS approval)[a]	One vote per P-member
Subcommittee (SC) or working groups (WG)	• Relevant SCs to D22.04 SC – D22.01 Quality control – D22.05 Indoor Air – D22.07 Sampling and analysis of asbestos – D22.09 ISO TAG for ISO/TC 146	• WG 1 Monitoring strategy • WG 2 General requirements for measuring procedures • WG 3 Particulate matter • WG 4 Definitions (dormant) • WG 5 Measurement of biological agents (dormant) • WG 6 Dermal Exposure	• WG 1 Particle size-selective sampling and analysis • WG 2 Inorganic particulate matter • WG 3 Gases • WG 4 Organic vapors • WG 5 Inorganic vapors • WG 7 Silica • WG 8 Assessment of contamination of skin & surfaces from airborne chemicals • WG 9 Sampling pump performance (dormant) • WG 10 Terminology and quality control in workplace air
Languages	English	English, French, and German	English, French, and German
Secretariat	–	Germany - Deutsches Institut für Normung e.V. (DIN)	United States — American National Standards Institute (ANSI)
No. of published standards[b]	47	32	40

	ASTM D22/D22.04	CEN TC 137	ISO TC 146/SC 2
No. of standards under development or revision[c]	4	7	7

[a]"Weighted vote" means that the votes casted by the CEN national standards body organizations are weighted according to the population of the CEN member country

[b]Number of published standards as of November, 2015

[c]Number of standards under development or revision as of November, 2015

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Table 2

Harmonized international/national voluntary consensus reports (Note that the bold and italic texts indicate projects under process and see the supplement for the full name of standards).

	ASTM D22.04	CEN/TC 137	ISO/TC 146/SC 2
General – Air sampling strategies	E1370-14	EN 689:1995; ***prEN 689 revision***	
General – Requirements for the performance of procedures		EN 482:2012+A1:2015	***ISO DIS 20581***
General – Choice of procedures for the measurement of chemical agents		***WI = 00137065***	
General –Personal sampling pumps	D5337-11		
		EN ISO 13137:2013	ISO 13137:2013
General - Terminology	D1356-15b	EN 1540:2011	***ISO 18158 (under publication)***
Diffusive Samplers – Performance evaluation	D6246-08(2013)e1	EN 838:2010	ISO 16107:2007
Detector tube – Requirements and test methods		EN ISO 17621:2015	ISO 17621:2015
Dermal – Measurement or strategy for the evaluation of dermal exposure	D7822-13	CEN/TS 15279:2006 CEN/TR 15278:2006	TR 14294:2011
		WI = 00137054	*a*
Particles – Guidance for sampling of aerosol fractions	D6062-07(2012)	CEN/TR 15230:2005	
Particles - Calculation of the health-related aerosol fraction concentration		CEN/TR 15547:2007	
Particles - Particle size fraction definitions		EN 481:1993	ISO 7708:1995; ***PWI 7708 revision***
Particles - Sampling conventions for airborne particle deposition		EN ISO 13138:2012	ISO 13138:2012
Particles - Assessment of sampler performance for measuring airborne particle concentrations		EN 13205–1:2014 EN 13205–2:2014 CEN/TR 13205–3:2014 EN 13205–4:2014 EN 13205–5:2014 EN 13205–6:2014	
Particles – Monitoring using direct reading Instruments		CEN/TR 16013–1:2010 CEN/TR 16013–2:2010 CEN/TR 16013–3:2012	
Particles – Weighing procedures for the collected aerosol	D6552-06 (2011)		ISO 15767:2009
Particles – Respirable dust	D4532-10(2015) D6061-01(2012)e1		
Particles - Ultrafine, nanoparticle and/or nano-structured aerosols[b]		EN ISO 28439:2011 ***prEN 16897:2015*** ***prEN 16966:2016*** ***WI = 00137053***	TR 27628:2007 ISO 28439:2011
Particles – Diesel particulate matter	D6877-13e1	EN 145302004	
Particles – Respirable crystalline silica			ISO 16258–1:2015 ISO 16258–2:2015 ISO 24095:2009; ***NP 24095 revision***
Fiber – Asbestos	D7948-14 D7200-12-(**WK34196**) D7201-06 (2011)		***ISO CD 19087***

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	ASTM D22.04	CEN/TC 137	ISO/TC 146/SC 2
Fiber – Crystal ceramic	D6056-96 (2011) D6057-96 (2011) D6058-96 (2011) D6059-96 (2011)		ISO 8672:2014
Metals – Requirements and test methods		EN 13890:2009	
Metals – Metals and/or metalloids	D4185-06 (2011) D7035-10-(**WK50741**)		ISO 15202–1:2012 ISO 15202–2:2012 ISO 15202–3:2004
	D7439-14		ISO 30011:2010
Metals – Lead and/or lead compounds			ISO 8518:2001
	D6785-13		
Metals – Cadmium and cadmium compounds			ISO 11174:1996
Metals – Beryllium	D7202-15 D7441-08(2013)		
Metalloid – Arsenic			ISO 11041:1996
Metal working fluid aerosol	D7049-04(2010)		
Bioaerosols	*c*	EN 14583:2004 EN 13098:2000 EN 14031:2003	
Benzene	D4600-95(2010) D6494-99 (2015)		
Carbon monoxide			ISO 8760:1990 and 8760:1990/Cor 1:2009
Ethylene oxide	D5578-04(2015) -Replaced D4413		
Fluorides	D4765-13		
Toxic gases or vapors	D4490-96(2011) D4599-14 D4597-10 (2015)		
Gases – Monitoring using direct reading instruments			***ISO CD 20435-1/IEC 62990-1***[d]
Hexavalent chromium	D6832-13e1		ISO 16740:2005
Hydrofluoric acid and particulate fluorides	***WK38734***		ISO 21438–3:2010
Hydrogen sulfide by direct reading, length of stain, visual chemical detectors	D4913-00(2011)		
Isocyanates	D5836-08 (2013) D5932-08(2013) e1 D6561-06 (2011)		ISO 14382:2012
	D6562-12		ISO 17734–1:2013 ISO 17734–2:2013 ISO 17735:2009 ISO 17736:2010 ISO 16702:2007 TR17737:2012
Lithium hydroxide, sodium hydroxide, potassium hydroxide and calcium dihydroxide			ISO 17091:2013
Mercury and inorganic mercury compounds			ISO 17733:2015
Mercury vapor			ISO 20552:2007
Mixture of airborne particles and vapor		EN 13936:2014	
Nitrogen dioxide			ISO 8761:1989 and 8761:1989/Cor 1:2009

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	ASTM D22.04	CEN/TC 137	ISO/TC 146/SC 2
Organic vapors	D3686-13 D3687-07 (2012)	EN 1076:2009	ISO 9486:1991 ISO 16200-1:2001 ISO 16200-2:2000 ISO 9487:1991
Sulfuric acid and/or phosphoric acid	D4856-11		ISO 21438-1:2007
Vinyl chloride	D4766-98 (2014)		
Volatile inorganic acids (HCl, HBr, and HNO_3)	D7773-12		ISO 21438-2:2009
Surface sampling	D6966-13 D7659-10 (2015) D7144-05a(2011) D7296-12 D7707-11 ***WK46215***		
Measurement of the dustiness of bulk materials		EN 15051-1: 2013 EN 15051-2:2013-(***WI = 00137069***) EN 15051-3:2013	

Abbreviation: CD = Committee Draft, Cor = Corrigendum, DIS = Draft International Standard, NP = New Work Item Proposal, prEN = Draft EN standard, PWI = Preliminary Work Item, TR =Technical Report, TS =Technical Specification, WK or WI =Work Item

[a]ISO/TC 146/SC 2 recently finished a ballot to develop a TS for assessment of dermal exposure to nano-objects and their aggregates and agglomerates with CEN/TC 137/WG 6 (WI = 00137054) under Vienna Agreement (with CEN lead) and is waiting for a TS number from ISO Central Secretariat.

[b]Although separate TC/SC covering nano-related materials are present under three organizations (ASTM, CEN, and ISO), a few standards, TR and TS are developed or in development process under these particular TC or SC.

[c]Bioaerosols are covered under ASTM D22.08 on Sampling and Analysis of Mold

[d]This is a joint project by JWG developed between WG 3 and the International Electrochemical Commission.

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Table 3

Symposia sponsored or cosponsored by ASTM Committee D22 (since Year 2000).

Symposia Date	Title
10/26–27, 2000	Isocyanates
07/21–25, 2002	Johnson Conference
04/22–23, 2004	Symposium on Silica: Sampling and Analysis
07/25–30, 2004	D22 Boulder Conference on Mold: Detection Health, and Physical Effects, and Remediation
10/04–05, 2004	Workshop on Emission Testing
04/21–22, 2005	Symposium on Beryllium: Sampling and Analysis
07/18–22, 2005	Johnson Conference on Asbestos
07/24–28, 2006	Boulder Conference on Mold
10/23, 2006	Workshop on Calibration Standards for Indoor Material/Product Emissions Assessment
04/16–17, 2007	Workshop on Improving the Reliability of Indoor Material/Product Emission Measurements
07/16–20, 2007	Johnson Conference: Workplace Aerosol Sampling to Meet ISO Size-Selective Criteria
04/10–11, 2008	Symposium on Airliner Cabin Environment: Recent Progress in Characterization and Improvement
07/14–18, 2000	2008 Johnson Conference – Critical Issues in Monitoring Asbestos
07/13–16, 2009	2009 ASTM Johnson Conference: Standardization of Mold Response Procedures
01/28–29, 2010	Michael E. Beard Asbestos Conference 2010: Laboratory Issues
04/19, 2010	Workshop on Reference Material Development for Product Emissions Testing
10/14–15, 2010	Symposium on Surface and Dermal Sampling
07/24–29, 2011	Johnson Conference 2011 on Asbestos
10/31, 2011	Workshop on Spray Polyurethane Foam Insulation Emission Testing
10/25–26, 2012	Second Symposium on Silica & Associated Respirable Mineral Particles
01/31–02/01, 2013	Michael E. Beard Conference Asbestos Laboratory Issues
10/24, 2013	Workshop on State of Science and Best Practice in Mold Assessment, Sampling and Analysis
04/07, 2014	Workshop on Advancements in VOC Diffusive Air Sampling for Indoor Air and Workplace Environments
07/21–25, 2014	ASTM Johnson Conference on Asbestos, Almost Asbestos, and Asbestos Progeny: New Challenges
04/30, 2015	Symposium on Developing Consensus Standards for Measuring Chemical Emission from Spray Polyurethane Foam (SPF) Insulation
04/30–05/01,2015	Symposium on Natural Occurrences of Asbestos (NOA)
01/27, 2016	Workshop on Air Quality Issues with Hydraulic Fracturing
01/28–29, 2016	ASTM Michael E. Beard Conference: Asbestos and Fibrous Mineral Analysis and Research
04/14, 2016	Workshop on Co-Sampling of Aerosols and Gases/Vapors of Semi-Volatile Substances
08/29–31, 2016	Conference on Detection Limits[a]
2017 (Oates TBD)	ASTM Johnson Conference on Asbestos[a]

[a]These are future symposia or workshops planned in 2016–2017.