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November 24, 2014

Via Email

California Energy Commission
Dockets Office, MS-4
Re: Docket No. 14-BSTD-01
1516 Ninth Street
Sacramento, CA 95814-5512
docket@energy.ca.gov

Re: 2016 Code Change Proposal re Flexible Ducts: Docket # 2014-BSTD-01

Dear Docket Office:

I am writing on behalf of the Joint Committee on Energy and Environmental Policy ("JCEEP") to respectfully request that the California Energy Commission adopt the following amendments to restrict the allowable length of flexible air ducts (including flexible air connectors) to no more than five feet.

As discussed in detail below, there is substantial evidence that longer lengths of flexible duct are not readily capable of being installed in the field in a manner that would prevent significant pressure loss. Surveys have demonstrated that it is entirely unrealistic to expect flexible ducts of any significant length to be installed in full compliance with installation instructions. When residential and commercial installations of flexible duct were reviewed, not a single installation was found to be in compliance with installation requirements.[1] Moreover, enforcement of installation requirements is unreliable because improperly installed flexible duct

[1] ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333, Final Report (March 2011) at p. 10.

can be difficult to detect, since compression is hard to see or measure when installed.[2]

A 2011 ASHRAE study on flexible duct pressure loss measurements found that flexible duct performs adequately only when stretched *on a flat surface* at less than four percent compression *without any bends or turns*. Flexible duct manufacturer's instructions, however, do not require verification that flexible duct has been installed on a perfectly flat surface with less than four percent compression or prohibit any bends or turns. Accordingly, even if flexible duct could be reliably installed in full compliance with installation instructions (which has never been shown to be true), flexible duct installations of any significant length would still result in substantial energy loss. Simply put, the performance of flexible duct in ideal laboratory conditions and in strict compliance with manufacturer instructions has not come close to being replicated in the field.

If the commission is going to achieve its zero net energy building goals, it needs to follow the lead of numerous other authorities and jurisdictions that have already limited the allowable length of flexible duct.

I. JOINT COMMITTEE ON ENERGY AND ENVIRONMENTAL POLICY

JCEEP is made up of the California sheet metal workers' local unions and more than 25,000 technicians working for over 600 contractors throughout California. The mission of the Joint Committee on Energy and Environmental Policy is to promote responsible environmental, indoor air quality, and energy policy as it pertains to and impacts the HVAC industry.

II. PROPOSED CODE LANGUAGE

A. Add new subdivision (g) to Section 120.4:

<u>(g) Flexible air ducts and connectors shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of ridged elbows or fittings.</u>

[2] ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333 (March 2011) at p.44.

B. Amend Section 150.0(m)(10):

10. ~~Porous Inner Core Flex Duct~~ Flexible Duct and Connectors. Flexible air ducts and connectors shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of ridged elbows or fittings. Flexible ducts and connectors having porous inner cores shall not be used.

III. JUSTIFICATION

A. In Real World Applications, Longer Lengths of Flexible Ducts Create Pressure Drops and Result In Significant Energy Efficiency Reductions

Because of its spiral wire helix construction, flexible duct has a much higher friction loss than sheet metal duct or fiberglass duct board. The inner core of flex changes shape with compression and bending, which increases turbulence and friction loss.[3]

At ideal (i.e., fully stretched, straight and horizontal") test conditions, flex the pressure drop is approximately the same as rigid galvanized sheet metal duct. [4] However, at even just the minimum 4% compression, the pressure drop will increase approximately two times what would occur in duct conditions.[5] At a moderate compression of 15%, the pressure drop increases approximately four times

[3] Chris Van Rite, M&M Manufacturing Co., *Airflow Is Critical To HVAC System Performance*, https://www.energyvortex.com/files/Airflow_is_Critical.pdf.
[4] Abushakra, et al, Lawrence Berkeley National Laboratory, *Compression Effects on Pressure Loss in Flexible HVAC Ducts* (2002) http://www.escholarship.org/uc/item/0d76400v.
[5] Chris Van Rite, M&M Manufacturing Co., *Airflow Is Critical To HVAC System Performance*, https://www.energyvortex.com/files/Airflow_is_Critical.pdf; Abushakra, et al, Lawrence Berkeley National Laboratory, *Compression Effects on Pressure Loss in Flexible HVAC Ducts* (2002); see also ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333, Final Report (March 2011). http://www.escholarship.org/uc/item/0d76400v.

compared to the stretched conditions.[6] At 30% compression, the pressure drop increases approximately ten times.[7]

In real world applications, flexible duct installations are almost never installed at 4% compression because the only way to ensure 4% compression is to pull the ends of the flexible duct much farther apart than is realistically possible in the field for long lengths of flexible duct. Indeed, when housing and industrial installations of flexible duct were reviewed, *not a single installation was found to be in compliance* with installation requirements. Rather, installed compression ratios were observed to vary from 10% compression to over 50% compression.[8]

Moreover, enforcement of installation requirements is almost impossible because improperly installed flexible duct is difficult to detect or verify after installation.[9] Even if reliable detection methods were available, inspectors do not have the resources or time to measure the compression of all flexible duct runs after installation or to observe and measure the radius of all bends.

In addition, these pressure-drop-loss numbers for moderately compressed flexible duct are based upon tests where flexible duct is on a flat surface with no bends, scenarios that are highly unlikely to occur in the real world and which are not required by flexible duct installation standards.[10] The number of bends, the number or degrees in each bend and the amount of sag allowed between support joists will result in substantial additional reductions in efficiency and system performance due to the increased resistance each introduces.[11]

When flexible duct is hung, even minimum sag will result in an additional 60% increase in pressure loss at 15% compression and a 75% increase in loss at 30%

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[6] *Id.*
[7] *Id.*
[8] ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333, Final Report (March 2011) at p. 10.
[9] ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333, Final Report (March 2011) at p.44.
[10] Chris Van Rite, M&M Manufacturing Co., *Airflow Is Critical To HVAC System Performance*, https://www.energyvortex.com/files/Airflow_is_Critical.pdf; Abushakra, et al, Lawrence Berkeley National Laboratory, *Compression Effects on Pressure Loss in Flexible HVAC Ducts* (2002); see also ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333, Final Report (March 2011). http://www.escholarship.org/uc/item/0d76400v.
[11] *Id.*

compression.[12] Where inadequate supports create more sag, this additional pressure loss increases accordingly.[13] This does not even take into account additional pressure losses from air leaks that result when flexible air ducts are spliced to allow for long-length runs.

Accordingly, even calculations based upon an assumption of just 4% compression with no sag or turns substantially underestimate the pressure losses incurred in real world installations. Because most installation guides allow up to 15% compression and all permit bends and non-flat, horizontal conditions, even installations that comply with code and installation instructions (whether 4% or 15% compression) result in significant energy loss.[14]

Moreover, "flexible duct is almost never installed correctly" in either existing buildings or new construction.[15] The most common problems encountered with flex are:[16]

- Kinks and sharp turns.
- Duct runs that are long and not supported well.
- Radial systems with too many ducts coming off the plenum and the takeoffs too close together.
- Extra duct length that should have been cut off.
- Poorly fastened and sealed connections.
- Butt joints that are just taped together.

These installation errors further exacerbate the energy waste resulting from the use of flexible ducts. Additional fan power, as well as energy consumption for

[12] ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333, Final Report (March 2011) at p. 24.
[13] ASHRAE, *HVAC Flexible Duct Pressure Loss Measurements*, ASHRAE RP-1333, Final Report (March 2011) at p. 24.
[14] Abushakra, et al, Lawrence Berkeley National Laboratory, *Compression Effects on Pressure Loss in Flexible HVAC Ducts* (2002) http://www.escholarship.org/uc/item/0d76400v; Chris Van Rite, M&M Manufacturing Co., *Airflow Is Critical To HVAC System Performance*, http://www.energyvortex.com/files/Airflow is Critical.pdf.
[15] Allison A. Bailes III, Ph.D., *Green Building Advisor, Should flexible duct Be Banned?* (Nov. 28, 2012), http://www.greenbuildingadvisor.com/book/export/html/26079; Chris Van Rite, M&M Manufacturing Co., *Airflow Is Critical To HVAC System Performance*, https://www.energyvortex.com/files/Airflow_is_Critical.pdf.
[16] *Id.*

additional heating and cooling of the replacement air will be required to compensate for the pressure drops due to crimps, sags, turns and coils in the installed flexible duct.[17]

B. Flexible ducts Are Less Durable, Harder to Clean and Increase Health and Safety Risks to Occupants

In addition to increased energy waste, flexible duct are also less durable, have lower puncture and impact resistance, and are easily chocked or disconnected. Pinching or tears during construction can occur when pipes, conduit, bracing, etc, are installed adjacent to the duct by other workers. Flex is also susceptible to rodents chewing through the flex. Because there is no static pressure limit on flexible duct, the energy loss gets compounded when higher pressure duct becomes damaged, punctured, or disconnected.

Poor air flow from flexible duct runs also create ventilation hazards that reduces the IEQ (Indoor Environmental Quality) for the building occupants and increase the risk of airborne disease transmission.[18] Moreover, because of its relative fragility, the Air Diffusion Council's (ADC) *Flexible Duct Performance and Installation Standards* states that flexible ducts should not be cleaned. If flexible ducts need cleaning because they are contaminated, moldy or excessively dusty, the ADC recommends replacing the duct instead.[19] This increases the overall lifecycle costs of flexible ducts to building owners and is largely impractical if the duct is in a non-accessible area.

C. Numerous Studies and Guidelines Recommend Limiting the Length of Flexible Duct and Numerous Jurisdictions and AHJs Limit the Length of Flexible Duct

Due to the inability to ensure quality installation and the energy loss even in systems that comply with installation standards, ASHRAE and numerous other experts have concluded that flexible duct should be limited to "relatively short runs

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[17] *Id.*
[18] See U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, *Guidelines for Environmental Infection Control in Health-Care Facilities Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)*, (2003) at pp. 13-21, http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_HCF_03.pdf.
[19] Air Diffusion Council, *Flexible Duct Performance and Installation Standards* (5th Edition).

in a trunk-and-branch system, not entire air distribution systems."[20] ASHRAE's Advanced Energy Design Guides for *"Small Office Buildings"*, "*Retail Buildings"* and "*K-12 School Buildings"* recommend that flexible ducts should be:

- Limited to connections between duct branch and diffusers.
- Limited to connections between duct branch and VAV terminal units.
- Limited to 5 ft (fully stretched length) or less.
- Installed without any kinks.
- Installed with a durable elbow support when used as an elbow.
- Installed with no more that 15% compression from fully stretched length.

The 2009 ASHRAE Fundamentals Books states that for commercial systems, flexible ducts should be no more than 5 feet in length, full stretched.[21] The 2013 ASHRAE Fundamentals Books maintains the recommendation to limit the length of flexible duct, but increases the recommended limit to 6 feet.[22] Energy Design Resources, in a study funded by the four investor owned utilities in California, recommends that flexible duct runs be limited to six feet or less, as well as supported at five foot intervals and with a bend radius of greater than one times the duct diameter.[23] The PDHonline Course, HVAC Ducting - Principles and Fundamentals, states that flexible duct runs should be limited to six feet or less.[24] The 2013 ASHRAE HVAC Design Manual for Hospitals and Clinics recommends limiting flexible duct lengths to 5 or 6 feet "because of its higher pressure losses,

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[20] Allison A. Bailes III, Ph.D., *Green Building Advisor, Should flexible duct Be Banned?* (Nov. 28, 2012), http://www.greenbuildingadvisor.com/book/export/html/26079; ASHRAE, *HVAC Design Manual for Hospitals and Clinics* (2013 2nd ed.) at p. 71, § 3.5.1 (http://wtgzik.pairserver.com/Transfer/ASHRAE_HVAC-HospitalBook_WHOLE-BOOK_PRF_2-12-13-wg.pdf); Chris Van Rite, M&M Manufacturing Co., *Airflow Is Critical To HVAC System Performance*, https://www.energyvortex.com/files/Airflow_is_Critical.pdf (citing Air Diffusion Council's recommendation to not only install duct fully extended, but to also avoid using excess lengths).

[21] ASHRAE, *Fundamentals Handbook* (2009) at p. 21.7 (http://www.slideshare.net/virginiavenus/2009-ashrae-handbookfundamentalsinchpoundeditionashrae2009).

[22] ASHRAE, *Fundamentals Handbook* (2013), ch. 21.

[23] Energy Design Resources, *Design Brief, Integrated Design for Small Commercial HVAC* at p. 11.

[24] PDHonline Course, M246 (4PDH) *HVAC Ducting - Principles and Fundamentals* (2012) at p. 6 (http://www.pdhcenter.com/courses/m246/m246content.pdf).

particularly when crimped or coiled, and its greater susceptibility to abuse or damage."[25]

In addition, numerous AHJs and municipalities have adopted enforceable limits on the length of flexible duct ranging from 18 inches to 10 feet. The U.S. Department of Defense limits flexible duct lengths to no more than 6 feet in its *United Facilities Criteria*.[26] New Hampshire limits flexible duct runs to no more than 6 feet.[27] Northern Arizona University limits flexible duct to 18 inches on high pressure systems and 48 inches on low pressure systems.[28] The University of Illinois limits flexible duct to six feet in length and prohibits flexible duct in medium and high pressure duct systems.[29] The City of Fort Worth includes limiting flexible ducts to 5 feet as a one of the options for recognition as a Fort Worth Energy Sustainability Program building.[30] The California Mechanical Code section 602.3.1 provides that flexible ducts may only be used in OSHPD 1, 2, 3 & 4 occupancies if they are not more than 10 feet in length and are used to connect supply, return or exhaust-air terminal devices to rigid duct systems.[31]

Accordingly, a restriction of five feet is well within the range of restrictions that have been recommended in national guidelines and adopted by authorities having jurisdiction across the country.

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[25] ASHRAE, *HVAC Design Manual for Hospitals and Clinics* (2013 2nd ed.) at p. 71, § 3.5.1 (http://wtgzik.pairserver.com/Transfer/ASHRAE_HVAC-HospitalBook_WHOLE-BOOK_PRF_2-12-13-wg.pdf).
[26] See Dept. of Defense, *United Facilities Criteria (2-4.1.14),* UFC-3-400-10N (July 2006) at p. 11.
[27] New Hampshire, Bureau of Public Works Design & Construction, *Design Guidelines*, § 700(C)(3) (June 2013) at p. 7.2.
(http://www.admin.state.nh.us/purchasing/publicworks/NH%20BPW%20Design%20Guidelines.pdf.)
[28] Northern Arizona University Technical Standards Division, *Design Guidelines*, Division 23, § 23-31-13 (2014) at p. 34
(http://nau.edu/uploadedFiles/Administrative/Finance_and_Administration/Facility_Services/Documents/Tech_Standards/Current/Division%2023%20050114.pdf.)
[29] University of Illinois, *Facilities Standards*, Division 23, Section 23-31-00, subd. 2.2(A)(8) (2013) at p. 5. (http://www.fs.illinois.edu/docs/default-source/facility-standards/technical-sections/division-23---heating-ventilating-and-air-conditioning-(hvac)/23-31-00---hvac-ducts30BDB69C738C.pdf?sfvrsn=2.)
[30] City of Fort Worth, Municipal Code, Section 7-42
(http://www.amlegal.com/nxt/gateway.dll/Texas/fortworth_tx/cityoffortworthtexascodeofordinances?f=templates$fn=default.htm$3.0$vid=amlegal:fortworth_tx)
[31] Cal. Code Regs., tit. 24, Part 4, § 602.3.1.

D. Restrictions on Flexible Duct Length Should Also Be Applied to Flexible Connectors

The same issues with flexible duct also apply to the use of flexible connectors. Flexible connectors are an inferior subset of flexible ducts and thus are subject to the same performance, reliability and safety issues as flexible ducts. The UL 181 Standard for Factory-Made Air Ducts and Air Connectors defines two categories of flexible duct: flexible air ducts and flexible air connectors. Both the flexible air duct and flexible air connector must comply with the requirements of UL 181 for Class 0 or Class 1.

The only difference between the two products under this standard is that flexible air connectors are not required to pass the flame penetration, puncture, or impact tests. This difference in testing is what determines the markings on the material and whether or not it is classified as a flexible air duct or a flexible air connector.[32] Accordingly, the energy efficiency and performance issues from the use of flexible air ducts also apply to flexible air connectors. Flexible connectors should thus also be restricted to no more than five feet in length.

IV. CONCLUSION

For the above stated reasons, JCEEP respectfully requests that the Energy Commission propose the requested amendments for adoption in the 2016 Code.

Sincerely,

Thomas A. Enslow

TAE:ljl

[32] UL 181 Standard for Factory-Made Air Ducts and Air Connectors; see also See Fetters, Technical Bulletin TT-03, *The Difference Between Flexible Air Ducts and Flexible Air Connectors* (2002) (http://www.flexibleduct.org/ADC_FAQs.asp.); see also Inspectors Journal, Construction Code Communicator, *Flexible Air Ducts and Flexible Air Connectors* at p. 8 (http://www.inspectorsjournal.com/forum/uploads/Darren/20124126215_Ducts.pdf).