Wireless CO2 Monitoring Devices

Additional submitted attachment is included below.

During the most recent workshop the Energy Commission verbally invited manufactures of wireless CO2 sensors to share product data and reasoning as to why wireless CO2 monitors should be considered in the program.

In the revised Program Guidelines Section C: Carbon Dioxide Monitoring, sub paragraph 1.a states "*The monitor is hard-wired or plugged-in and mounted to the wall…*" Our interpretation of this description of work is that a physical piece of wire / cable is to be routing above ceilings and down internal wall chases, connecting to the CO2 monitoring device using screw terminals, wire nuts or a plug-in jack similar to an RJ-11 or an Ethernet RJ 45. The other end of this cable is then connected to a higher level of hardware or network.

Wireless technology eliminates the need for this physical connection and potentially challenging problematic installation in an existing classroom. In this application, existing K12 classrooms, using physical wire / cable has multiple potential challenges:

1. Wired installation can be labor intensive.
2. The design indicated mounting location may not be ideal in practice, leading to sensor relocation. Again, this process is labor intensive and often performed by cable splicing, introducing another variable that is vulnerable to failure; difficult to execute, costly to troubleshoot and or repair.
3. Wired sensors typically do not have alternate communication pathways if the hosting Facilities Automation System experiences a primary communication link disruption.

Wireless technology eliminates all these limitations of a hard-wired system. The following items pertain to wireless technology that you may want review as part of your process of evaluating a wireless option for CO2 monitoring:

1. **Reliable:** 200 feet indoor design range for communications, Self-Healing Wireless Mesh.
2. **Flexibility:** Wireless allows for convenient relocation or affordable addition of sensor technologies, including Temperature, Relative Humidity, Occupancy or CO2, if needed for classroom reconfigurations i.e., social distancing requirements and future improvements in facility control.
3. **Performance:** Equivalent application performance as wired CO2 monitors. Monitor reporting provided based on Change of Value and Heartbeat.
4. **Battery Life:** *15+ Year*, Off-the-shelf AA Batteries. Battery condition available at BAS/EMS User Interface. Low Battery Alarm dispatched multiple days in advance of battery failure.
5. **Proven Coexistence**: IEEE 802.15.4 Radios designed for coexistence with other wireless technologies such as Wi-Fi (802.11).

Wired or Wireless: At Trane Technologies our systems are designed to leverage the best technical option for our clients based on their application. We appropriately apply wired or wireless solutions and urge the Energy Commission to afford this choice the participating LEAs. We have attached data sheets and industry white papers for your consideration and review.

Tim Sisson, LEED AP
Trane Technologies

White Paper
Trane® Air-Fi® Wireless Security

Air-Fi® Wireless Network Security

Air-Fi® Wireless is secured using Advanced Encryption Standard AES-128 (FIPS Pub 197) and HMAC (FIPS Pub 198). The Trane WCI operating as a Trust Center will create a randomly generated 128-bit network security key for each ZigBee®[1] network. This network security key is required to decrypt communications from the network. In order to join the secured Air-Fi network, the network must first be "opened" or set to allow devices to join. A device requesting to join the network is given a transport key which must be decrypted by the joining device before it can communicate on the Air-Fi network. The Air-Fi® network will automatically close or prevent new devices from joining the network one hour after it was opened.

Isolation from Intellectual Property or Business Systems

Air-Fi® Wireless is either a stand-alone network or it is connected to a Trane Tracer® SC. Tracer® SC can be connected to a building IP LAN to provide remote information to building operators. Many security options are available at the IP network level and IP security policies are implemented and enforced by the customer's IT department. Many customers will put Tracer® SC on their building LAN and secure access to their IP network using a VPN (Virtual Private Network). Other customers will setup a VLAN (Virtual Local Area Network) for Tracer® SC or use a

separate IP network infrastructure from their building IP network.

Key Facts Regarding Air-Fi® Wireless Security

Encryption requirements are similar to Wi-Fi

- All wireless traffic is encrypted!
- The Coordinator creates a randomly-generated 128-bit security key

The network needs to be open to allow new devices to join

- Devices must first be allowed into the network to obtain the encrypted network key
- The network will only stay open to allow new devices to join for 60 minutes

Requires an IEEE 802.15.4 radio

- Not commonly available like Wi-Fi or Bluetooth®

The WCI will only allow BACnet®/ZigBee® communications

- Cannot be used to communicate to business systems

---

[1] ZigBee is a registered trademark of the ZigBee Alliance.

Facts About Trane Air-Fi® Wireless Technology

What is Trane Air-Fi Wireless technology?	Trane® Air-Fi® wireless technology replaces the need for wired building controls, allowing installations to be completed quickly and with less disruption to building occupants.
Features	**Self-repairing mesh technology and extended range** Air-Fi has self-repairing mesh technology that features redundant signal paths to help prevent communication failures. It immediately reroutes disrupted signals around obstacles to ensure that wireless communication is maintained. With a typical 200-foot indoor signal range and four times the number of potential paths, Air-Fi extends up to a half-mile when unobstructed for even greater levels of signal reliability. Challenges that interfere with other systems — including obstructions and wall damage — won't impact Air-Fi because it is built on an IEEE standard (802.15.4). **Lifetime battery*** Trane Air-Fi has a battery life three times that of competitive products which eliminates time and money replacing batteries and can last for the life of the system in most installations. **Built on BACnet Standards** Air-Fi® wireless uses BACnet/ZigBee® wireless mesh. This allows customers to integrate devices in the future when the building expands or changes. Adding unit controllers, zone sensors and other devices down the road can be easy and affordable, which increases options and flexibility as technology and building needs evolve. **System security** Air-Fi secures building automation networks by the use of AES 128 encryption, keys and device authentication. **Factory programmed and tested** The Air-Fi interface is available factory-installed and pre-addressed. This expedites installation time and reduces labor and upfront costs. It also ensures system consistency and is easily repeatable in controlled factory environments. *Based on typical indoor operating conditions.

Benefits	• Self-repairing mesh eliminates the risks of conventional wired systems, which fail when wires are cut or disconnected or fail intermittently when damaged.
	• In most installations, the battery will last the life of the system, eliminating the time and money spent replacing batteries.
	• Pre-programmed controls provide consistency, reliability and optimized system operation, resulting in better building performance and less on-site trouble shooting.
	• Because there is no need to pull or run wire in the facility, installations can be completed more quickly, with less disruption to building occupants.
	• Wireless sensors are easy to move or replace, as needed, to resolve occupant comfort, sensing accuracy, aesthetic issues or reconfigured spaces.
	• The easy-to-install wireless control system offers affordable advantages on time project schedule completion.
Key Markets	Trane Air-Fi wireless technology can help optimize any building's performance, including commercial real estate, education, healthcare, religious and hospitality applications.

Trane – by Trane Technologies (NYSE: TT), a global climate innovator – creates comfortable, energy efficient indoor environments through a broad portfolio of heating, ventilating and air conditioning systems and controls, services, parts and supply. For more information, please visit *trane.com* or *tranetechnologies.com*.

All trademarks referenced in this document are the trademarks of their respective owners.   © 2020 Trane. All Rights Reserved.

Product Data Sheet

Air-Fi® Wireless Communication Sensors

(WCS-SB, WCS-SD, WCS-SO, WCS-SCO2, WCS-RH, WCS-SB/R)

⚠ SAFETY WARNING

Only qualified personnel should install and service the equipment. The installation, starting up, and servicing of heating, ventilating, and air-conditioning equipment can be hazardous and requires specific knowledge and training. Improperly installed, adjusted or altered equipment by an unqualified person could result in death or serious injury. When working on the equipment, observe all precautions in the literature and on the tags, stickers, and labels that are attached to the equipment.

TRANE TECHNOLOGIES

Introduction

Trane Air-Fi® wireless systems provide significant advantages to better meet customer requirements by providing:

- A lower initial cost
- Ease of installation for reduced risk
- Increased reliability and flexibility for easier problem solving

Air-Fi® components with industry-leading technology and performance have fewer maintenance issues for worry-free operation and cost savings over the life of the system.

Features and Benefits

Feature		Benefit
Reduced project labor and complexity		Reduces installation time and risks for on-time project completion while increasing return on investment.
Reliable and secure		Based on the IEEE 802.15.4 standard. The Institute of Electrical and Electronics Engineers (IEEE) is an international non-profit, professional organization, in which coexistence is a fundamental requirement and includes methods for network key establishment, network key transport, frame protection, and device management.
Lifetime batteries		Batteries will outlast the typical sensor life in typical applications.
Life-cycle savings		By avoiding (re)wiring, savings are incurred both for the initial installation and whenever the spaces are reconfigured or expanded.
Wireless communications sensor (WCS)	Digital display (WCS-SD)	Easy-to-use interface for clear and simple monitoring and control. Can be configured for any Trane system or to meet the customer's preference.
	Base model (WCS-SB)	Measures temperature and optional humidity (with WCS-SH) for use in public spaces where no local user interface is preferred.
	2% relative humidity (RH) sensor module (WCS-SH)	The optional RH sensor module plugs in to any WCS model, further simplifying installation by eliminating the needed for additional wiring.
	Remote temperature (WCS-SB/R)	Wireless monitoring of refrigerators and freezers to reduce food and medication waste and risks using external 10K type 2 thermistors (by others). The sensor shall be applied on stable temperature applications only, similar to refrigerator and freezer applications. Rapid temperature changes will reduce battery life.
Occupancy sensor	WCS-SO	Measures temperature and optional humidity (with WCS-SH) as well as occupancy. All sensing values are displayed on an internal LED display, which prevents public viewing.
CO_2 / Occupancy sensor	WCS-SCO$_2$	Measures temperature, optional humidity (with optional WCS-SH), CO_2 levels in parts per million, and occupancy. All sensing values are displayed in an internal facing LCD display, which prevents public viewing. This sensor is typically used on demand - control ventilation applications. An LED indicates when movement is observed for proper sensor positioning during installation.

Air-Fi Wireless Device Part Numbers

| Air-Fi® Wireless model			Part number	BAYSENS	Global part
Wireless communications sensor—Digital display (WCS-SD)	Universal	Field, factory, or service	X13790955010	N/A	SEN02362
	FC BC UV		X13790955040	N/A	N/A
	RTU WSHP		X13790955050	BAYSENS202*	SEN02263
	Universal—BAA[a]		X13790968010	BAYSENS212*	SEN02265
Wireless communications sensor—Base model (WCS-SB)	Universal		X13790956010	BAYSENS203*	SEN02264
	Universal—BAA[a]		X13790969010	BAYSENS213*	SEN02266
Wireless communications sensor accessory—2% relative humidity (RH) sensor module (WCS-SH)			X13790973030	BAYSENS230*	SEN02638
Wireless communications sensor—with Occupancy sensor (WCS-SO)	Universal—BAA[a]		X13790986001	BAYSENS154*	SEN2502
Wireless communication sensor—with CO_2 and Occupancy sensors (WCS-SCO$_2$)	Universal—BAA[a]		X13790987001	BAYCO2K200*	SEN2503
Wireless communications sensor—remote temperature (WCS-SB/R)	Universal—BAA[a]		X13791004001	N/A	SEN02773

(a) Conforms to Buy America Act guidelines.

Specifications

General Specifications	
Operating temperature	WCS-SB, SD, SO, SCO$_2$: 32 to 122°F (0 to 50°C) WCS-SB/R: -58 to 122°F (-50 to 50°C)
Storage temperature	-40 to 158°F (-40 to 85°C)
Storage and operating humidity range	5% to 95% relative humidity (RH), non-condensing
Housing material	Polycarbonate/ABS (suitable for plenum mounting), UV protected, UL 94: 5 VA flammability rating
Range[a]	Open range: 2,500 ft (762 m) with packet error rate of 2%. Indoor: Typical range is 200 ft (61 m); actual range is dependent on the environment. See BAS-SVX55* for more detail.
Output power	100 mW
Radio frequency	2.4 GHz (IEEE Std 802.15.4-2003 compliant) (2405–2480 MHz, 5 MHz spacing)
Radio channels	16
Wireless Communications Sensor (WCS) Specifications	
Accuracy (integrated temperature)	0.5°F for a range of 55 to 85°F (12.8 to 29.4°C)
Accuracy (remote temperature)	(See Table 1, p. 4)
Resolution	+0.125°F over a range of 60°F to 80°F (15.56°C to 26.67°C)/±0.25°F outside this range
Setpoint functional range	45°F to 95°F (7.22°C to 35°C)
Sensor battery	Two (2) AA lithium 1.5 V batteries, 2800 mAh with an expected life of 15 years under typical operating conditions
Address range	001 to 999
Maximum time between transmissions	15 minutes
Minimum time between transmissions	10 seconds. Time between transmissions can be shorter during user interaction.
Mounting	Fits a standard 2 in. by 4 in. junction box (vertical mount only). Mounting holes are spaced 3.2 in. (83 mm) apart on vertical center line. Includes mounting screws for junction box and wall anchors for sheet-rock walls. Overall dimensions: 2.9 in (74 mm) by 4.7 in. (119 mm)
WCS-SO Sensor Specifications	
Coverage Patterns	(See Figure 1, p. 4.)
Occupied Timeout Delay	Average 10 minutes after motion is detected (not adjustable)
Maximum Detection Range	32 feet (10 m)
WCS-SCO$_2$ Sensor Specifications	
CO$_2$ range	0 — 10,000 ppm CO$_2$
Accuracy at 25°C	±40 ppm CO2 + 3% of reading (includes repeatability)
Pressure dependence of output	Built-in pressure sensor eliminates inaccuracy due to altitude
Recommended calibration interval	None (auto-calibrated)
Response resolution	50 ppm change or 15 minute heartbeat
Life expectancy	15 years
Operating temperature	From 32°F to 122°F (0°C to 50°C)
Storage temperature	From —40°F to 158°F (-40°C to 70°C)
Humidity range	20% to 60% RH
Warm-up time	1 min @ full spec? 15 min
Housing material	Polycarbonate/ABS blend (wall)
2% Relative Humidity (RH) Sensor Module	
Accuracy	±1.8% (typical)
Hysteresis	±1% (typical)
Response time	8 seconds
Long-term drift	<0.5% RH/year

(a) Range values are estimated transmission distances for satisfactory operation. Actual distance is job specific and must be determined during site evaluation. Placement of the WCI is critical to proper system operation. In most general office space installations, distance is not the limiting factor for proper signal quality. Signal quality is more greatly affected by walls, barriers, and general clutter. Note that sheetrock walls and ceiling tiles offer little restriction to the propagation of the radio signal throughout the building as opposed to concrete or metal barriers. More details information, including wiring schematics, are available at http://www.trane.com.

Figure 1. WCS-SO Sensor coverage patterns
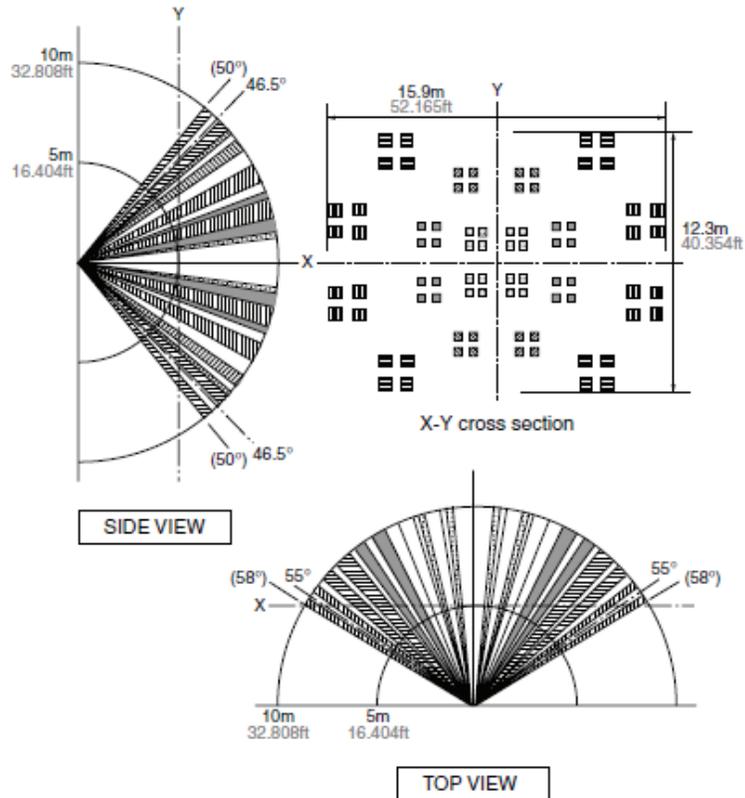
Note: This sensor coverage pattern also applies when occupancy sensing is activated on WCS-SCO$_2$ applications.

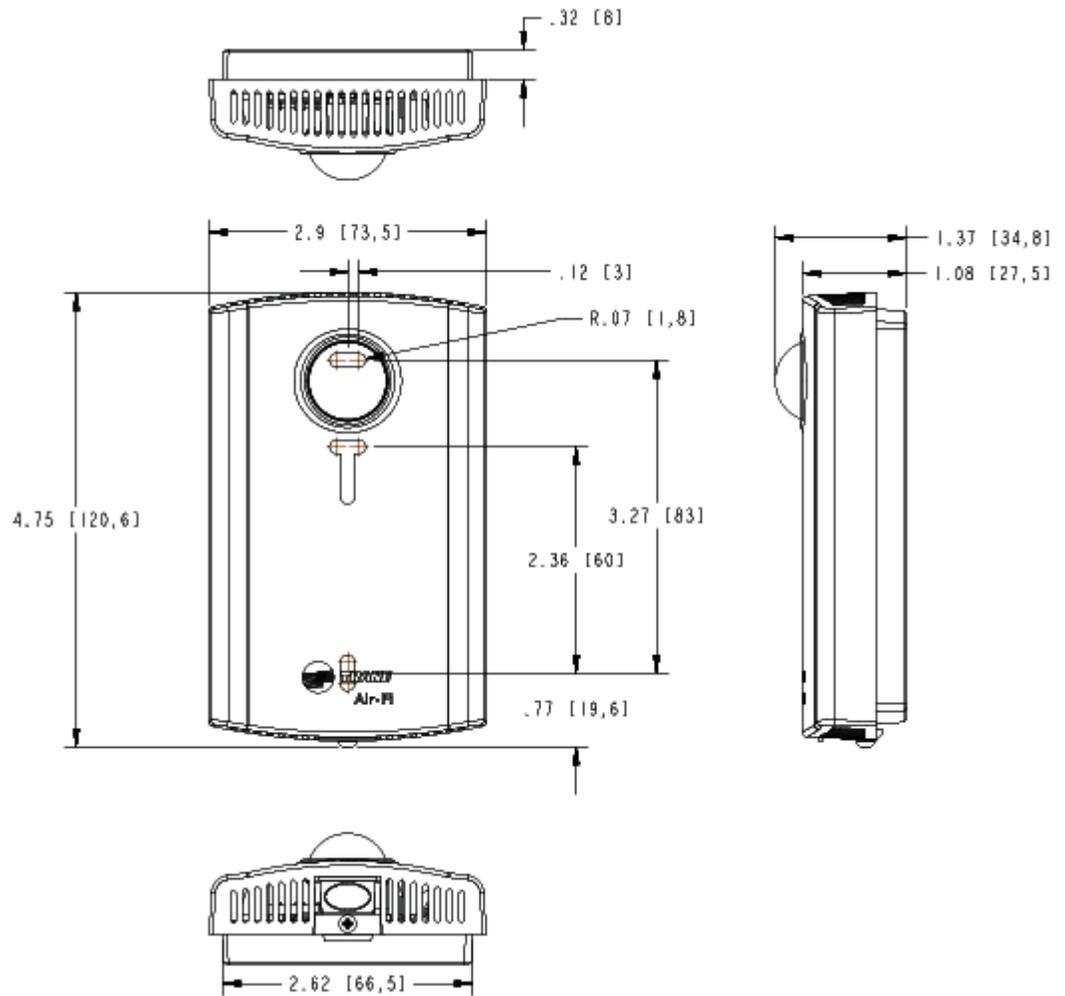**Table 1. Remote sensor input resolution**

Temperature Input Range	Resolution[a]
-10 ºF to 80 ºF	≤ 0.2 ºF
-11 ºF to -30 ºF and 81 ºF to 100 ºF	≤ 0.3 ºF
-31 ºF to -40 ºF and 101 ºF to 122 ºF	≤ 0.4 ºF
-41 ºF to -58 ºF	≥ 0.4 ºF

(a) Resolution does not include field supplied 10K Type 2 thermistor tolerance.

WCS Dimensions

The following dimensions are typical for WCS-SB, WCS-SB/R, WCS-SD, WCS-SO, and WCS-SC0$_2$.

Figure 2. **Dimensions**

Agency Compliance

United States	UL listed: UL 94, 5 VA flammability rating and UL916. Energy Management Equipment FCC CFR47, Sec. 15.247 & subpart E, Digital Modulation Transmission with no SAR (FCC ID: TPF-251701). This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications not expressly approved by the manufacturer for compliance could void the user's authority to operate the equipment. **Note:** This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: • Reorient or relocate the receiving antenna. • Increase the separation between the equipment and receiver. • Connect the equipment into an outlet on a circuit different from that to which the receiver is connected. • Consult the dealer or an experienced radio/TV technician for help.
Canada	CSA-C22.2 No. 205-M1983 Signal Equipment Industry Canada (IC: 6178A-251701) Cet appareil est conforme à la partie 15 du règlement du FCC. Son fonctionnement fait l'objet des deux conditions suivantes: (1) Cet appareil ne produit pas de brouillages nuisibles, et (2) cet appareil doit pouvoir recevoir n'importe quel type d'interférence, y compris les brouillages pouvant occasionner un fonctionnement non désiré. Les changements et les modifications n'ayant pas été approuvés expressément par le fabricant comme étant conformes, pourraient rendre nulle le droit de l'utilisateur à faire fonctionner cet équipement. **Remarque:** Cet équipement a été testé et reconnu comme étant conforme aux limites des appareils numériques de classe B, tel qu'indiqué dans la partie 15 du règlement du FCC. Ces limites ont été établies afin de fournir un niveau de protection raisonnable contre le brouillage nuisible dans les installations résidentielles. Cet appareil produit, utilise, et peut aussi émettre des fréquences radioélectriques. Si celui-ci n'est pas installé et utilisé conformément aux instructions, il peut provoquer des brouillages nuisibles dans les communications radioélectriques. L'absence d'interférence n'est cependant pas garantie dans toutes les installations. Si cet équipement provoque des brouillages nuisibles dans la réception des communications radioélectriques ou de télévision (ceci pouvant être déterminé en allumant et en éteignant l'équipement), l'utilisateur est encouragé à essayer de corriger l'interférence en utilisant un ou plusieurs des moyens suivants : • Réorienter ou changer l'emplacement de l'antenne réceptrice. • Éloigner l'équipement et le récepteur l'un de l'autre. • Brancher l'équipement à une prise de courant se trouvant sur un circuit différent de celui sur lequel le récepteur est branché. • Faire appel aux services du fournisseur ou d'un technicien radio/TV qualifié.
IEEE/radio frequency range	IEEE 802.15.4-2003, IEEE Standard for Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements, Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (LR-WPANs)

Trane - by Trane Technologies (NYSE: TT), a global climate innovator - creates comfortable, energy efficient indoor environments for commercial and residential applications. For more information, please visit trane.com or tranetechnologies.com.