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Button Up Concept – A Need for Community Disaster Preparedness

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***Abstract*: In the volatile world of today, particularly after the recent pandemic of corona, the people in most countries have realized that the concepts like Lock Down, Button UP, Close Door Isolation are no more the myths but these are the realities of life which can be forced upon us any time in future. The present study explains the concept of Button Up Period and presents the solutions to ensure a safe and workable living environment under emergency and crisis situations. It presents the concepts of Emergency Homes, Dual Home/Multiple Home, Composite Homes and Work from Home (Normal & Emergency) which are based on Button Up Concept and are essential to safeguard the health and life of the people both during normal and emergency periods. The Indoor Air Quality Management System invented by BUNKERMAN [1, 8, 9] and presented in this study, performed well during the tests in Button Up Mode. The CO2 level was automatically maintained in the room by the Facility management System (FMS) between 600 ppm and 800 ppm as per the settings selected by the users, While the ventilation system was off, the value of CO2 inside the closed room was found to be continuously increasing and the moment it touched the maximum value of 800 ppm set by the user, the CO2 Removal System started automatically. At this time, the CO2 level initially increased slightly beyond 800 ppm but it soon started reducing and it never went beyond 1000 ppm as prescribed by the codes and technical manuals on the subject. The TVOC levels were also increasing along with the CO2 when the ventilation system was off but it soon came down as the ventilation system started automatically and the inside air started to be filtered and circulated in the room by the Indoor Air Quality Management System. Similarly, the oxygen level in the room was always kept within the selected range of 17% to 21% by the user.**

***Keywords*: Button up, CO2 removal, Emergency homes, Indoor air quality, Odour removal, Oxygen replenishment, Positive pressure, TVOC.**

1. Introduction

In today's world, government agencies and civil organizations are expected to ensure an adequate flow of services without disruption and under any circumstances. Organizations are required to continue functioning without major disruption during any crisis situation and quickly recover after the crisis, natural or manmade disasters.

Post 9/11 trauma and increasing threats by terrorist activities world over, created alarm in the minds of not only Govt agencies but in Business Houses and Private individuals too, for some increasing demand for highly protected facilities for few years. But, as the time passed, the simplistic "low cost" model took over this approach again. Now the recent trauma created by COVID-19, has again shaken the minds of public world over to understand the importance of the desired safety and protection in case of such disasters whether natural or man-made. People in most countries have now realized that the concepts like Lock Down, Button UP, Close Door Isolation are no more the myths but these are the realities of life which can be forced upon us any time in future due to the changing environment world over and as recently experienced by them so practically in their own personal life.

2. Proposals and Findings

A. Emergency Homes: Evolution of a New Concept

People in many countries (mostly rich and big businessmen) are now ready to spend a part of their money on strengthening/hardening of their existing houses/bungalows against such disasters and even to construct a separate hardened emergency home or a shelter for them where they can easily shift with their families in case of any such emergencies.

Some companies like BunkerMan [1, 8, 9], have come up to provide their expert services for such construction of Private Houses, Bungalows, Farm Houses, Flats, Basement Houses, Deep Under Ground Houses etc; and they even modify/upgrade the existing ones which can be safe and protected for use in any such emergencies. Following Specialised Services are generally provided in such houses/facilities:

a) To protect the house against any biological/chemical threat in the environment outside, the house is sealed with air/gas tight doors and windows from all around, so that no air from outside can enter the house during the Button Up Period of 7 days, 10 days, 15 days or even upto 30 days in some cases as per requirements of the clients.
b) A Button Up Period is defined as the period during which no outside air is taken for human inhalation (being contaminated or suspected to be contaminated) and the occupant's safety and survival are ensured by maintaining the indoor air quality in the house as per the international standards and guidelines prescribed under such crisis

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situations.

c) The proper Heating, Ventilation and Air Conditioning (HVAC) system is designed and provided in the house.
d) In addition to the HVAC System, other custom made systems like CO2 removal system, oxygen replenishment system, compressed air system, odour removal system, filtration system, communication and control system, Environment Monitoring System (EMS), Building Management System (BMS) and other such important systems are designed and integrated with the HVAC System of the House so that a safe, comfortable and working environment is ensured inside the house during desired button up period, thereafter during filtration mode and finally once the biological/chemical threat is over and the house is switched over to normal mode. All this is done as per laid down international standards and norms for such important facilities to remain safe and functional before, during and after such disasters.
e) A positive overpressure is maintained inside the house during Button Up period and also during Filtration Mode so that no outside contaminated air can enter the living area through any possible leakages.
f) Adequate supplies like food, water, oxygen, compressed air, consumables, spares, medicines, first aid kits, protective masks and suits, stand by power supply are also designed and provided as per customer's requirements.
g) Special attention is paid to arrangements of waste disposal, sewage disposal, waste water disposal, cleaning, hygiene and sanitation inside the facility particularly during button up and filtration modes.
h) Education and Training on following the Standard Operating Procedures (SOP) and operation and maintenance of the facility in automatic, semi-automatic and manual modes are also provided.
i) Any addition facility or service as felt necessary and as per client's requirement.

More details of these are available at www.bunkerman.in/EmergencyHomes.php

B. Dual Home/Multiple Home Concept

Dual Home and Multiple Home Concept are though not the new concepts but it has caught the attention of the public for its importance during the recent COVID-19 crisis. It was not only the daily wagers and migrated labourers who rushed from big cities to their native villages in COVID-19, but many rich and well to do families (both service and business class) also shifted to their alternate family homes to feel more safe and secure and to help each other in the case of any further crisis. In countries like India, many joint families which got defragmented into number of smaller individual based families over the years (due compulsion of seeking employment in various cities), were again found vacating their individual accommodations and shifting to their joint family houses during this crisis.

It is for consideration of such joint families that they must think of providing the emergency facilities in at least one of their such primary or secondary homes which can come handy to their entire joint family in case of such disasters.

C. Composite Homes

Most rich and well to do people have big and luxury houses comprising of 4 or more bed rooms. In cases where such houses are generally occupied only by few members (2 to 4), it is easier and economical to convert such houses into composite homes. In a composite home, while in the normal case, the entire house is occupied by its occupants for their normal use, but the house is so designed that in the case of any emergency, only the minimum essential area of the house is provided with the emergency facilities and services to make only one or two bed rooms with connected wash room(s) and kitchenette functional during the button up period.

D. Work From Home (Normal & Emergency)

Work from Home is a fairly new concept which was initially forced upon the people and corporates by the calamity of COVID-19. But after going through this concept once (though by compulsion only), many people and corporates are finding it to be more practical and economical now. While the individuals are viewing that this concept is more convenient and productive for them, the corporates find it equally productive yet more economical since it cuts down the unnecessary extra cost of creation/hiring and maintenance of their office premises.

Therefore, the requirement is even felt for the homes used for Work from Home (whether small or big), to be designed in such a way that they remain functional both during normal and emergency periods. No corporate will desire that its employees who work from home are not available to them or they get cut off from them during emergencies like natural or man-made disasters. Similarly, no employee will like to lose his/her job due to being cut off from his/her employer due to disruption of certain services/facilities to them due to such disasters. They will certainly like firstly, to be safe and protected and secondly, to continuously remain in communication with their employers and discharge their duties even in such disasters. In fact, the employer-employee relationship becomes more essential and crucial during such crisis situations and continuity of the same must be ensured at any cost to effectively fight out the disaster and come out of it as soon as possible.

E. Indoor Air Quality Management During Button Up Period

It is a well-known fact that normal atmospheric air generally contains 79.03% Nitrogen, 20.94% Oxygen and 0.03% Carbon dioxide by volume. Nitrogen is not absorbed by lungs and in human respiration it goes into lungs and comes out as it was inhaled as part of the air. Exhaled air, however, contains a higher percentage of Carbon Dioxide (an average of 4.38%) as compared to the percentage of CO2 in inhaled air. During inhalation, a small percentage of Oxygen is permanently consumed by lungs and it goes into the blood cells inside the human body [11]-[14].

Therefore, when a facility goes into a Button Up Mode in Closed Up Conditions, the following things happen inside the facility almost simultaneously or in some sequential manner:

a) Oxygen level keeps on depleting with time.
b) CO_2 level keeps on increasing with time.
c) Overall volume of air keeps on reducing with time

(since some oxygen is permanently absorbed by lungs).

d) This fact theoretically and practically creates a negative pressure in the closed chamber.

e) Above changes take place inside the facility almost every second as the occupant's inhale & exhale the air.

The rate of change in overall composition of air is not a simple phenomenon but it is quite complex in nature and it depends on following factors:

a) Number and Nature of occupants.

b) Density and distribution pattern of persons in different areas inside the facility.

c) Movement and working pattern of occupants inside the facility.

And hence to monitor and control this highly complex phenomenon, there is always a requirement of having a computerized fully automated Indoor Air Quality Management and Control System comprising of the following sub systems duly integrated with one another:

a) CO_2 Removal System.

b) Odour/TVOC Removal System

c) Oxygen Replenishment System

d) NBC Filtration System

e) Compressed Air System

f) Facility Management System

All these six systems are required to operate not independently but in coordination with one another so as to always maintain the desired CO_2, Oxygen and pressure levels in the facility for human inhalation and not to allow any inward leakage of contaminated air from outside environment by maintaining a positive pressure inside the facility.

1) CO_2 Removal System

The shelter design should consider carbon dioxide levels when determining the shelter size, and take into account the desired sheltering time and number of people occupying the shelter. Carbon dioxide is present in atmospheric air at about 0.03 percent by volume and acts on the human nervous system to maintain involuntary respiration. At levels in excess of 1 percent it begins to cause hyperventilation, increased oxygen consumption, and increased respiratory carbon dioxide production; concentrations higher than 4 percent are toxic. The recommended levels of carbon dioxide for safe sheltering from various standards are provided below:

a) *OSHA:* The Occupational Safety and Health Administration (OSHA) has set the carbon dioxide permissible exposure limit (PEL) 5000 ppm for an 8-hour period and a short term exposure limit (STEL) of 30000 ppm for 15-minute period.

b) *NIOSH:* The National Institute for Occupational Safety and Health (NIOSH) has recommended that carbon dioxide does not exceed 10000 ppm for up to a 10- hour period and a ceiling concentration of 30000 ppm not to exceed a 10-minute period.

c) *TM5-858-7:* As per this technical manual for designing facilities to resist nuclear weapon effects, the maximum carbon dioxide content of the room exhaust air should not exceed 1 percent and the corresponding concentration in return air should be less than 0.08 percent.

Two types of CO_2 Removal Systems, one Non-Regenerative Type and the other Regenerative Type were developed in the present invention. In the first phase, the Bunkerman Brand CO_2 absorbents, adsorbents and molecular sieves were indigenously developed by conducting several tests and trials on commercially available materials in the Indian market. In the second phase, Bunkerman Filters for CO_2 and TVOC removal from the air were developed and optimised. In the third phase, the complete CO_2 Removal System was developed by integrating the CO_2 Removal Filters, TVOC Removal Filters and other equipment, accessories like valves, vacuum pumps, fans, heating and cooling systems etc. The optimisation has been achieved in the filters and the systems by making use of the following materials and principles:

a) CO_2 Absorbents which absorb CO_2 from the air by way of their chemical reaction.

b) CO_2 adsorbents which adsorb CO_2 from the air by way of not only their chemical reactions but also or only by way of their molecular structure and other properties.

c) Molecular Sieves based on adsorbent materials which are Sodium based, Potassium based, Lithium based and/or Zeolite based. Optimisation in shapes and sizes of the molecular sieves and their granules has also been successfully achieved, while designing these filters.

d) Use of moisture absorbing materials has been made in these filters so as to maximise the CO_2 absorption and adsorption capacity of the filters.

e) An effective use of membrane type filters has been made to achieve the optimum efficiency in the filters.

f) An effective use of special filter material like activated carbon impregnated with one or more of the items shown at Paras 8 (a) to (e) above, has been made with a view to absorb/adsorb the odour and TVOC in addition to CO_2. Therefore, the system does not only work as a CO_2 Removal System but it works as a CO_2 and Odour Removal System.

g) The presented CO_2 Removal System, therefore, does not depend only on one type of absorbent/adsorbent material but it makes use of the latest technology making an optimum use of the properties of various absorbents, adsorbents, molecular Sieves, Moisture absorbing, Odour Removing, TVOC removing and other useful materials to suit the requirement of ensuring the desired indoor air quality in a facility designed to work in Button Up Mode.

2) Control by Sensors

The CO_2 Removal System is designed to maintain the permissible exposure limit of CO_2 for its occupants not greater than 1000 ppm (0.1%) for the desired Button Up Period as specified by Bhabha Atomic Research Center (BARC) Mumbai. Activation of CO_2 Removal System shall be based on the signal from the CO_2 sensor located in the return air duct of the air handling units serving the buildings. The threshold value of CO_2 to start the CO_2 Removal System has been kept at 800

ppm (0.08%), as per recommendations given in TM 5-858-7: Designing Facilities to Resist Nuclear Weapon Effects. As soon as the CO_2 content in the indoor air exceeds 800 ppm, the sensor sends the signal to the inbuilt Facility Management System of the CO_2 Removal Unit to start filtering the air for CO_2 removal and returns it back to the facility through the Air Handling Unit. This way, the contents of CO_2 are automatically lowered in the facility. To economise on the use of electricity and filters, the CO_2 Removal System automatically stops once the CO_2 level comes below 400 ppm or any other value in the facility as desired by users. Therefore, the CO_2 level in the facility is always maintained between 400 ppm (or any other such value set by users) and 1000 ppm by the automation system.

3) Odour/TVOC Removal System

In addition to CO_2 removal, the Bunkerman Indoor Air Quality management System is also designed to remove TVOC contents from the air (such as body odour, food/drinks smell, toilet odour etc). For this purpose, the composition of filters is suitably designed to include the absorbents/adsorbents which can remove TVOC from the air in addition to the CO_2 removal.

4) CO_2 and Odour Removal System for Toilet Blocks

For toilet blocks, though the duration and strength of occupancy by personnel is much lesser than the other accommodation but the problem of CO_2 removal becomes more complex due to requirement of removal of odour and foul gases from the air (which are more predominant) in addition to removal of CO_2. This problem has been resolved in the present system firstly, by installing the ozone generators in the toilet blocks which helps in decomposing the foul gases; and secondly, by designing a combined system for removal of CO_2 and the TVOC together. Specially designed filters have been used in the system to achieve this purpose.

The functioning of the CO_2 and Odour removal System in places like toilet blocks, are generally governed by monitoring the TVOC contents due to its predominance rather that the CO_2. Both types of sensors i.e., CO_2 and TVOC are, therefore, essential to be integrated with these systems in toilet blocks.

5) Oxygen Replenishment System

Even though oxygen depletion is a lesser threat than carbon dioxide, most occupants will not be aware of this and may become overly concerned and anxious about the level of oxygen in the shelter. For prolonged Button Up period it becomes mandatory to supply additional oxygen to the occupants after oxygen level drops below 17%.

Oxygen is supplied from pressurized tanks, stored inside the facility. This oxygen is piped to the air handling units and released continuously or in batches by a computerized system that senses the percentage of oxygen in the return air. Periodic checking of the oxygen concentration and manual adjustments of flow rate can also be made. A two-stage pressure regulating valve shall be used to set the flow. The variation of oxygen content between 17% and 21% is acceptable as per TM5-858-7 "Designing facilities to resist Nuclear weapon effect". The permissible oxygen concentration within the underground facility is provided as under:

The oxygen concentration for the underground facility should preferably be maintained at 21% for heavy work activity and shall not drop below 20% for activity involving light work. However, considering the desired activities of personnel during the Button Up period it should be acceptable to maintain the oxygen levels in the facility between 21% and 17%. Therefore, the Oxygen Replenishment has been designed to consist of the following:

a) Manifold cylinders containing pressurized oxygen,
b) Oxygen Sensor,
c) Control System.

6) Compressed Air System

In addition to the above two systems, the third system i.e. Compressed Air System is also integrated so as to always maintain a desired positive pressure in the facility. This is done so that no contaminated air from outside leaks into the facility and the desired level of Indoor Air Quality is always ensured in the facility as per the standards laid down in the Indian and International Codes of Practice.

7) NBC Filtration System

Bunkerman also provides suitably designed NBC filtration system for the facilities which are required to be functional under such emergency conditions. Due to security reasons, more details of NBC Filtration System are excluded from the scope of this document.

8) Facility Management System (FMS)

All the above systems are integrated together with the help of a suitably designed Facility Management System (FMS) by Bunkerman. The Bunkerman FMS includes specially designed hardware and software components assembled and integrated together so as to control and manage the entire Indoor Air Quality Management System automatically with least human intervention. The entire system, therefore, works as an intelligent system based on the concept of fix and forget type.

The schematic diagram of the indoor air quality management system is given in Fig. 1 below.

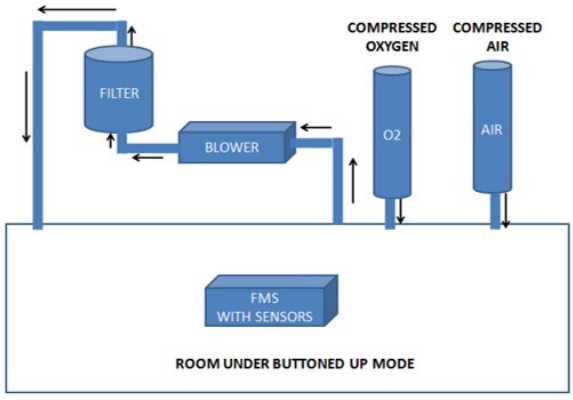

Fig. 1. Schematic diagram of indoor air quality management system

3. Test Results

The tests on materials, filters and equipment's were conducted in the following sequential manner:

a) Tests on materials (Bunkerman absorbents, Bunkerman Adsorbents, Bunkerman Molecular Sieves etc.) developed buy BUNKERMAN for absorption and adsorption of CO_2.

b) Tests on Bunkerman brand Filters (CO_2 Scrubbers) both Regenerative and Non-Regenerative Type.
c) Tests on complete system under simulated button up conditions.
d) Tests on complete system under real button up conditions.

The test results for testing of materials for Bunkerman Absorbents and Adsorbents can be found in other references [1, 8, 9].

The test results of the complete CO_2 Removal System tested on 15 Sep 22 and 05 Nov 22 under Real Button Up Mode, are given in other reference [11]. The latest test results of the complete CO_2 Removal System tested on 15 Feb 23 and 16 Feb 23 under Real Button Up Mode, are given in Table 1 to 3.

Table 1
Test results of system in button up mode conducted on 15 Feb. 23

BUNKERMAN
PlotNo.20,HIMUDA,BhatoliKalan,BaddiIndustrialArea,Solan,HimachalPradesh-173205
RECORD/CERTIFICATEOFTESTING
CORE MOVALSYSTEM
NON-REGENERATIVETYPE

DateofTesting:15*February.2023 — Absorbents used in each
CartridgeNo. ofPersonsinButtonUp Mode:-8 Persons — BunkermanAbsorbentType-1:-
9KgNo.ofCO_2Cartridgesused:-6Nos. — Bunkerman Absorbent Type-2: - 3
KgTotalQty. ofAbsorbent-13x6 =78 Kg — BunkermanAbsorbentType-3 :-1 Kg
Total:-13KgEach

Timeto Start Button UpMode:-

Time	AHUO N/OFF	CO_2 (ppm)	TVOC (ppb)	O_2(%)	Pressure (pascal)	Remarks
3:00	OFF	560	14	19.61	95471.99	
3:05	OFF	610	13	19.58	95479.21	
3:10	OFF	645	13	19.53	95484.89	
3:15	OFF	690	16	19.60	95483.01	
3:20	OFF	740	19	19.58	95483.30	
3:24	ON	800	23	19.48	95480.11	
3:29	ON	840	25	19.61	95481.16	
3:30	ON	820	25	19.60	95473.37	
3:35	ON	760	21	19.61	95473.01	
3:40	ON	700	19	19.57	95461.72	
3:45	ON	640	18	19.50	95466.01	
3:49	OFF	600	19	19.51	95447.84	
3:55	OFF	560	19	19.56	95481.21	
4:00	OFF	595	23	19.55	95481.07	
4:05	OFF	640	25	19.51	95465.34	
4:10	OFF	680	27	19.52	95470.63	
4:15	OFF	715	27	19.58	95463.04	
4:20	OFF	760	29	19.58	95473.11	
4:25	OFF	790	29	19.56	95476.37	
4:27	ON	800	30	19.66	95477.39	
4:30	ON	830	38	19.57	95475.31	
4:35	ON	755	32	19.61	95483.33	
4:40	ON	685	23	19.53	95483.92	
4:43	ON	630	13	19.64	95484.31	
4:48	OFF	600	13	19.61	95493.16	
4:50	OFF	604	14	19.56	95508.36	

Representative: Bunkerman — Representative: SPEA EntradePvt.Ltd.
Representative:DRDE Gwalior — Representative:DEBEL Bangalore — Representative:CCE (R&D) North, New Delhi

4. Discussion

It is observed from the test results that the Indoor Air Quality Management System invented by BUNKERMAN performs well during Button Up Period. The CO_2 level was automatically maintained in the room by the FMS between 600 ppm and 800 ppm as per the settings selected by the users, While the ventilation system is off, the value of CO_2 inside the closed room was found to be continuously increasing and the moment it touched the maximum value of 800 ppm set by the user, the CO_2 Removal System started automatically At this time the CO_2 level initially increased slightly beyond 800 ppm but it soon started reducing and it never went beyond 1000 ppm as prescribed by the codes and technical manuals on the subject [2 to 7].

Table 2
Test results of system in button up mode conducted on 16 Feb. 23

BUNKERMAN
PlotNo.20,HIMUDA,BhatoliKalan,BaddiIndustrialArea,Solan,HimachalPradesh-173205
RECORD/CERTIFICATEOFTESTINGCORE
MOVALSYSTEM
NON-REGENERATIVETYPE

DateofTesting:16*February.2023 — Absorbents used in each
CartridgeNo. ofPersonsinButtonUp Mode:-6 Persons — BunkermanAbsorbentType-1:-
9KgNo.ofCO_2Cartridgesused:-6Nos. — Bunkerman Absorbent Type-2: - 3
KgTotalQty. ofAbsorbent-13x6 =78 Kg — BunkermanAbsorbentType-3 :-1 Kg
Total:-13KgEach

Timeto Start Button UpMode:-

Time	AHUO N/OFF	CO_2 (ppm)	TVOC (ppb)	O_2(%)	Pressure (pascal)	Remarks
9:15	OFF	500	0	19.57	96034.29	
9:20	OFF	564	1	19.52	96033.79	
9:25	OFF	600	3	19.47	96043.44	
9:30	OFF	635	5	19.53	96036.40	
9:35	OFF	675	8	19.50	96040.99	
9:40	OFF	710	11	19.54	96037.35	
9:45	OFF	740	13	19.48	96048.35	
9:50	OFF	780	20	19.52	96043.04	
9:51	ON	800	25	19.52	96040.94	
9:55	ON	805	33	19.49	96047.17	
10:00	ON	755	35	19.53	96049.13	
10:05	ON	665	31	19.38	96051.60	
10:10	ON	620	26	19.34	96047.23	
10:11	OFF	600	25	19.34	96047.73	
10:15	OFF	570	21	19.33	96040.99	
10:20	OFF	565	20	19.31	96052.99	
10:25	OFF	604	21	19.32	96069.90	
10:30	OFF	645	21	19.32	96079.33	
10:35	OFF	690	24	19.49	96081.70	
10:40	OFF	715	25	19.53	96078.31	
10:43	OFF	735	26	19.47	96073.94	
10:50	ON	805	29	19.46	96066.67	
10:53	ON	815	28	19.52	96068.33	
10:55	ON	794	26	19.53	96067.29	
11:00	ON	735	24	19.47	96072.76	
11:05	ON	685	20	19.49	96062.42	
11:10	ON	640	15	19.52	96056.17	

Representative: Bunkerman — Representative: SPEA EntradePvt.Ltd.
Representative:DRDE Gwalior — Representative:DEBEL Bangalore — Representative:CCE (R&D) North, New Delhi

Table 3
Test results of system in button up mode conducted on 16 Feb. 23

BUNKERMAN
PlotNo.20,HIMUDA,BhatoliKalan,BaddiIndustrialArea,Solan,HimachalPradesh-173205
RECORD/CERTIFICATEOFTESTINGCORE
MOVALSYSTEM
NON-REGENERATIVETYPE

DateofTesting:16*February.2023 — Absorbents used in each
CartridgeNo. ofPersonsinButtonUp Mode:-6 Persons — BunkermanAbsorbentType-1:-
9KgNo.ofCO_2Cartridgesused:-6Nos. — Bunkerman Absorbent Type-2: - 3
KgTotalQty. ofAbsorbent-13x6 =78 Kg — BunkermanAbsorbentType-3 :-1 Kg
Total:-13KgEach

Timeto Start Button UpMode:-

Time	AHUO N/OFF	CO_2 (ppm)	TVOC (ppb)	O_2(%)	Pressure (pascal)	Remarks
11:20	OFF	390	11	19.50	96033.98	
11:23	OFF	380	10	19.53	96036.77	
11:25	OFF	610	11	19.54	96023.99	
11:30	OFF	650	11	19.53	96024.46	
11:35	OFF	695	13	19.60	96026.42	
11:40	OFF	735	18	19.48	96029.33	
11:45	OFF	775	19	19.49	96031.92	
11:48	ON	800	20	19.50	96017.49	
11:50	ON	810	21	19.56	96020.92	
11:55	ON	790	20	19.47	96021.01	
12:00	ON	730	19	19.46	96023.78	
12:05	ON	680	15	19.50	96008.37	
12:10	ON	640	13	19.57	96007.40	
12:15	ON	610	11	19.48	95999.87	
12:16	OFF	600	10	19.50	95998.83	
12:20	OFF	570	9	19.61	95995.29	
12:25	OFF	594	10	19.63	95999.04	
12:30	OFF	660	11	19.53	95995.43	
12:35	OFF	720	14	19.53	95984.39	
12:40	OFF	740	17	19.51	95987.72	
12:45	OFF	765	19	19.60	95971.82	
12:48	ON	800	20	19.49	95973.11	
12:50	ON	825	19	19.47	95969.01	
12:55	ON	795	14	19.57	95952.99	
1:00	ON	750	9	19.59	95948.32	
1:05	ON	700	5	19.55	95933.31	
1:10	ON	685	1	19.47	95929.39	
1:15	ON	635	0	19.51	95912.29	
1:20	OFF	600	0	19.55	95904.39	

Representative: Bunkerman — Representative: SPEA EntradePvt.Ltd.
Representative:DRDE Gwalior — Representative:DEBEL Bangalore — Representative:CCE (R&D) North, New Delhi

The TVOC levels were also increasing along with the CO_2 when the ventilation system was off but it soon came down as the ventilation system started automatically and the inside air started to be filtered and circulated in the room by the indoor air quality management system.

Similarly, the oxygen level in the room was always kept

within the selected range of 17% to 21% by the user.

5. Conclusions

Based on the above results and discussion, the following important conclusions are made:

a) The concepts of emergency homes, dual home /multiple home, composite homes and work from home (normal & emergency) are the need of the present-day world and button Up Concept is essential to safeguard the health and life of the people both during normal and emergency periods.

b) The Indoor Air Quality Management System invented by BUNKERMAN and presented in this study, ensures the desired levels of CO_2, oxygen and positive pressure inside the facility during button up mode. In the present case, the CO_2 level was maintained between 600 ppm and 800 ppm as per the setting selected by the users. The TVOC levels was maintained below 50 ppb. The oxygen level was also maintained by the system within selected range of 17 to 21%.

References

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