Respiratory Tract Safe Sampling and Quarantine Cabinet Development and Application Results

Solunum Yolu Güvenli Numune Alma ve Karantina Kabini Geliştirilmesi ve Uygulama Sonuçları

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ABSTRACT

The Safe Sampling Cabinet will be used to safely take the respiratory tract samples of patients who have the possibility of being infected due to Covid19 Pandemic or similar reasons; to take samples from a cabinet in positive pressure by filtering and ventilating in the operating theater hygiene class without transmitting the infection to health care professionals and to keep the areas with potential patients in the negative pressure and prevent infection. By filtering and discharging the air exhausted from the negative pressure division where the patient is present; it is aimed to prevent infection in open or closed areas. Furthermore, the units in the form of mobile cabinets have been designed and implemented to keep / quarantine the patients; who have positive test results or those waiting for the test results in crowded areas such as airports, shopping malls; in clean cabinets with negative atmospheric pressure.

Key Words: COVID19, Respiratory Tract Infection, Quarantine, Patient, Sample, Cabinet

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ÖZET

Güvenli Numune Alma Kabini Covid19 Pandemisi veya benzer nedenler ile, enfekte olma ihtimali bulunan hastaların solunum yolu test numunelerinin güvenli biçimde alınması; enfeksiyonu sağlık çalışanlarına bulaştırmadan, ameliyathane temizlik sınıfında filtrelendirilip, havalandırılarak, pozitif basınçtaki bir kabinden, numune alınması ve potansiyel hastaların bulunduğu alanları ise negatif basınçta tutarak bulaşı engellemek için kullanılacaktır. Hastanın bulunduğu Negatif basınçtaki bölümünden egzost edilen hayayı da filtre ederek tahliye etmek sureti ile, açık veya kapalı alanlarda bulaşı engellemek amaçlanmıştır. Ayrıca; Havaalanları, AVM'ler vb. insanların kalabalık olduğu alanlarda, test sonucu bekleyen veya testi pozitif çıkan hastaların, Negatif atmosfer basınçlı temiz kabinlerde bekletilmesi / karantinaya alınması için mobil kabinler biçimindeki ünitelerin tasarımı ve uygulaması yapılmıştır.

Anahtar Sözcükler: COVİD19, Solunum Yolu Enfeksiyonu, Karantina, Hasta, Numune, Kabin

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INTRODUCTION

Way of spread of viruses and bacteria in the air and prevention methods

As a result of conducted researches; it was found that a person with regular clothing spreads 1.000.000 particles per minute; a person doing sports spreads above 15-30.000.000 and a person standing stable spreads 100.000 (d>0.3 µm) particles and at least 10% of those particles contain the bacteria and microorganisms that can reproduce(1).

Since the viruses and bacteria between 10nm - 200 µm sizes which are normally motionless are relatively weightless, they cannot fly in the air on their own; they adhere to bigger particles such as dust, moisture due to gravity effect and form structures called as CFP (Colony Forming Particles), BCP (Bacteria Carrying Particles), Airborne Particles and similar names and become flyable in the air(2).

In researches conducted between 1960-1975; it was observed that when the clean room / operating theater air is first passed through the rough synthetic filter and then through the miniplate bag filter and then blowed to the operating theater through HEPA (High Efficiency Particulate Air Filter) filters; infections decreased by 63% when it was blowed to revolve once per hour; they decreased by 86% when it was blowed to revolve twice per hour and they decreased by 99% when it was blowed 10 times(3,4).

After these developments, filter standards such as Eurovent 4/5 , DIN 24185 and many other standards that determine the locus particle class, environment and design conditions such as US 209 D, DIN 1946, HTM 2025, GMP (Good Manufacturing Practices).

Atmospheric conditions, air flow profile and pressure values have been determined at HTM 2025, HTM 03-01, DIN 1946 and GMP standards. The purpose is to keep both the mechanical and electronical air control equipments and the air flow profile between areas, pressure balances and the proper flow of the air, which means the particles, in the clean room under control.

The Covid19 particle size is 120–160 nm in diameter. It is stable at 4 ° C. It can survive 14 days and it is not resistant to temperature. It lives for 5 minutes at 70 °C; 30 minutes at 56 °C and 2 days at 37 °C, it is not resistant to alcohol.

Spread of the virus:

The disease is mainly transmitted through droplets:

- Coughing,
- Sneezing,
- Loudly speaking
- Liquid particles in different diameters containing viruses that come from respiratory tracts (droplet) are the main sources.

The droplet cloud coming out of the mouth during sneezing is shown in Figure 1.

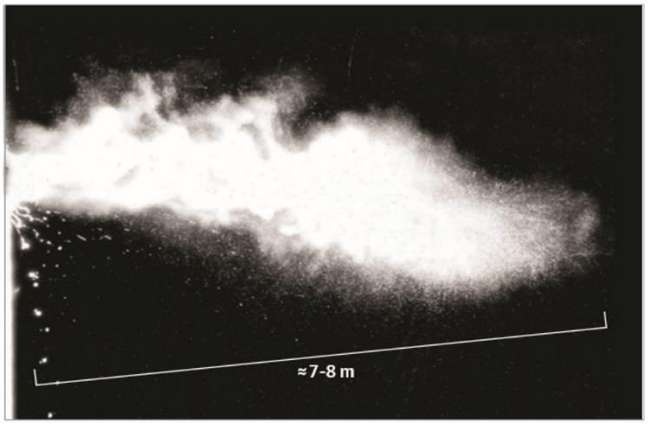

Figure 1 The Droplet coming out of the mouth during sneezing

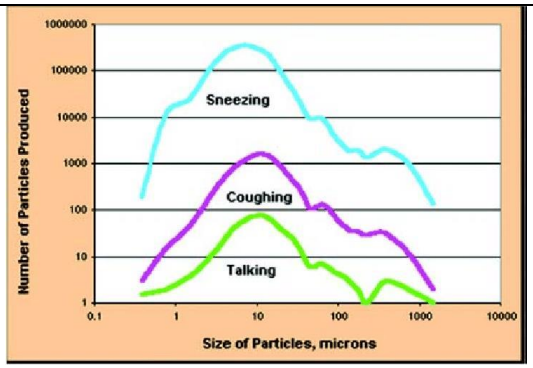

Figure 2 The Peak Particle Size

As shown in Figure 2, the peak particle size is at the level of 10 microns.If the droplet diameter is bigger than 10 microns, it is defined as the big particle. They fall to the ground within a few meters since they are heavy. If the droplet diameter is smaller than 5 microns, it is defined as the small droplet and may hang in the air and is transported through air flows. The Nuclei is formed when the small particles are vaporized and dry. Its diameter depends on the vaporization and drying process. They are formed in a very short time and are very long-lasting. This is the dimension that must be taken into account in the design. The approximate relation between the hanging duration and diameter is given in the Figure 3.

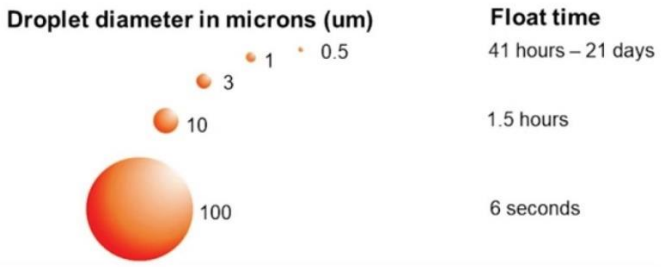

Figure 3 The Approximate Relation Between The Hanging Duration and Diameter

H14 HEPA filters can efficiently catch % 99,995 of particles flying in the air which are ≥ 0.5 µm in size; while U15 ULPA filters can efficiently catch % 99,9995 of particles ≥0.5 µm in size.(5,6,7,8,9,10)

The criteria used in the design of "Respiratory Tract Safe Sampling Cabinet" for Potential Patients and test results

The cabinet shown in the Figure 4 consists of a 1.8 x 2 x 2.1 m. positive pressure and two 1 x 1 x 2.1 m negative pressure chambers in which the Medical personnel will stand, and the medical personnel intervene the patient from inside through stable leak proof gloves between these areas.

Figure 4 Covid Mobile Test Unit

Positive Clean room air is provided with fresh air passed through the U15 ULPA filter 70 times per hour. As it can be seen in the attached test report, the area is constantly kept at ≥ +14 Pascal positive pressure and the difference is followed by a pressure manometer. Despite the performed test is at ISO 7 / Class 10.000, in the consequence of the test; 8.602.982 particles which were ≥0.5 in size in the outside air of Ankara during the test were reduced to the level of 40 pieces of ≥0.5 µm in the positive test chamber as a result of filtration; which is quite lower than the ISO 5 / Class 100 value that applies for operating theaters and the amount of particles in the outside air was reduced by 8.602.982 / 800 = 10.753 times. In the tests, it was measured that the unit could reduce the air to the desired hygiene class within 5 minutes.

Table 1 ISO Standards of Particle Numbers

ISO	US 209E	0,3µm/m3	0,3µm/ft3	0,5µm/m3	0,5µm/ft3
Class-5	Class-100	10.600	300	**3.530**	100
Class-6	Class-1000	105,900	3.000	35.300	1.000
Class-7	Class-10000	1.059.000	30.000	353,000	10.000
Class-8	Class-100000	10.590.000	300,000	3.530.000	100,000

Air of the negative chambers in which the patients are present receives the atmospheric fresh air and is replaced 220 times per hour and is exhausted by passing through the U15 ULPA filter. As it can be seen in the attached test report, the area is constantly kept at ≥ 20 Pascal negative pressure and the difference is followed by a pressure manometer.

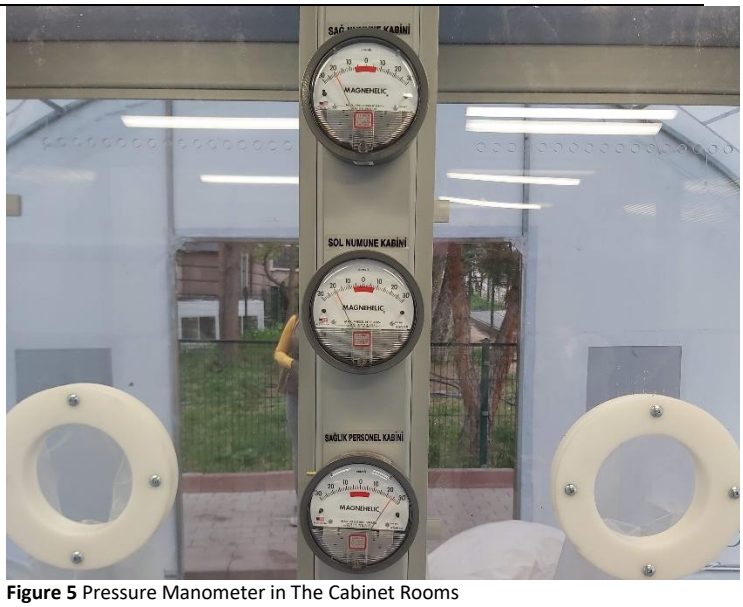

Figure 5 Pressure Manometer in The Cabinet Rooms

After each patient, the negative sampling division is disinfected by the pressurised pulverized alcohol vapour since it vaporizes very quickly and does not damage the filters and surfaces of gloves that remain in the negative contaminated area are cleaned with alcohol.

The alcohol vapor formed constantly also disinfects the exhaust filters with the flow of the indoor air, which changes every 15 seconds shown in Figure 6.

Figure 6 Representation of The Sanitizing The Cabinet

Use of Respiratory Tract Safe Sampling Cabinets in the Field

10 pieces of Infected Patient Respiratory Tract Safe Sampling Cabinets have been produced and they are installed in Ankara and Eskişehir provinces with the guidances of Provincial Directorates of Health.

Table 2 Infected Patient Respiratory Tract Safe Sampling Cabinets Installed Hospitals

Name of the Installed Hospital
Dr. Nafiz Körez Sincan State Hospital
SBÜ Ankara Training and Research Hospital
Ankara Gazi Mustafa Kemal State Hospital
Eskişehir Yunus Emre State Hospital
Ankara University Medical Faculty İbn-I Sina Hospital Ankara University Medical Faculty Cebeci Research Hospital
SBÜ Ankara Numune Training and Research Hospital
SBÜ Ankara Keçiören Training and Research Hospital
Beytepe Murat Erdi Eker State Hospital

In Dr. Nafiz Körez Sincan State Hospital, which is the first of our hospitals which have been installed in an order since April 2020, 200-250 samples are taken in one shift on an average. Our other hospitals can also reach this value per shift depending on their population.

Figure 7 Representation of Giving Sample

Criteria used in the design of Waiting / QUARANTINE Cabinets for Potentially Infected Patients

Waiting/ QUARANTINE Cabinets for Potentially Infected Patients have been designed in several sizes in the form of mobile cabinets to keep / quarantine the patients waiting for test results or have positive test results in crowded areas such as airports, shopping malls etc. in negative pressure clean cabinets. The quarantine chambers manufactured in 1.1 x 1.1 x 2.1 m. sizes for a single patient and in 1.8 x 2 x 2.1 sizes for groups are different from negative sampling chambers. The air of these negative chambers in which the patients wait receives the fresh air in closed areas such as airports etc. after the ambient air of the area is passed through the H14 HEPA filter and is changed minimum 70 times per hour, it is passed through the U15 ULPA filter and exhausted to the area; it is constantly kept at ≥ -20 Pascal negative pressure and the difference is followed through the pressure manometer. When they are deployed in the open atmospheric air, an additional hygienic heating and cooling unit is added on them. After the patient is released, these units are manually disinfected with the above mentioned method; automatic disinfection system can also be integrated if desired.

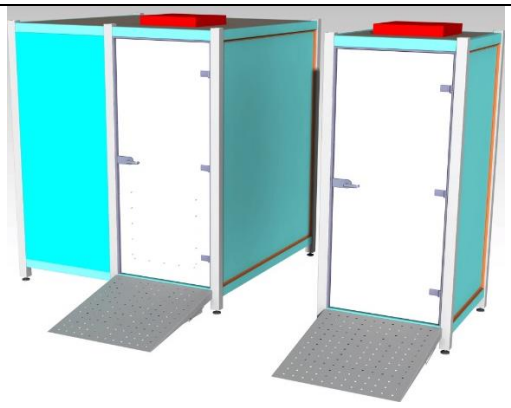

Figure 8 Innovative Design of The Covid Mobile Test Unit

CONCLUSION

Covid 19 Pandemic has shown that not only the population but also the health care professionals can be frequently infected. Infection of health care professionals facilitates the spread of the disease within the population and it causes loss of labour and prevents the fight against the disease. In addition, health care professionals working in safer environments will undoubtedly perform their duties more efficiently. In addition, is also another public health precaution to use the developed cabinet not only during sampling but also as a quarantine cabinet in places such as airports, shopping malls etc. where people stand collectively.

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Federal Standard 209D Class Limits

Class	Particles /ft3				
Size	>= 0.1 µm	>= 0.2 µm	>= 0.3 µm	>= 0.5 µm	>= 5.0 µm
1	35	39.209	3	1	NA
10	350	75	30	10	NA
100	NA	750	300	100	NA
1.000	NA	NA	NA	1.000	7
10.000	NA	NA	NA	10.000	70
100.000	NA	NA	NA	100.000	700

ISO Standard 14644-1 Class Limits

ISO Classification Number	Maximum concentration limits(Particles/m3 of air) for particles equal to and larger than the considered sizes shown below					
	>= 0.1µm	>= 0.2m	>= 0.3µm	>= 0.5µm	>= 1µm	>= 5.0µm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1.000	237	102	35	8	
ISO Class 4	10.000	2.370	1.020	352	83	
ISO Class 5	100.000	23.700	10.200	3.520	832	29
ISO Class 6	1.000.000	237.000	102.000	35.200	8.320	293
ISO Class 7				352.000	83.200	2.930
ISO Class 8				3.520.000	832.000	29.300
ISO Class 9				35.200.000	8.320.000	293.000

EN779 ve EN1822 Filtrede Verimlilik %	
H13	99,95
H14	99,995
U15	99,9995
U16	99,99995
U17	99,999995