



BPFK
JAKARTA



TALKSHOW AND WORKSHOP
HOSPITAL HVAC SYSTEM
DURING ENDEMIC COVID-19

Pengujian dan Pemantauan Sistem Tata Udara Di berbagai Ruangan Rumah Sakit

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Kepala Instalasi Lembaga Inspeksi Sarana Prasarana BPFK Jakarta

Indonesian Association of Hospital Engineering
Jakarta, December 4 2021

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Pendidikan :

1. Magister Teknik : Teknik Mesin Universitas Indonesia
2. Sarjana Teknik: Teknik Fisika : Institut Teknologi Sepuluh Nopember Surabaya

Profesi :

1. Balai Pengamanan Fasilitas Kesehatan Jakarta
 - Kepala Instalasi Lembaga Inspeksi (2018 – Sekarang)
 - Staf Lembaga Inspeksi (2011-2017)
 - Staf Laboratorium Kalibrasi Alkes (2008-2011)

A photograph of a modern hospital corridor with glass railings, showing medical equipment and staff in green scrubs. The word 'OUTLINE' is overlaid in large blue letters.

OUTLINE

01 LEMBAGA INSPEKSI BPFK JAKARTA

02 RUANG ISOLASI

03 RUANGAN OPERASI

04 PARAMETER UJI

05 TESTING AND COMMISIONING

06 PELAPORAN

07 KESIMPULAN

1

Lembaga Inspeksi BPFK Jakarta

1. Sejarah Layanan Inspeksi
2. Jenis Layanan Inspeksi

Perkembangan Lembaga Inspeksi BPFK Jakarta

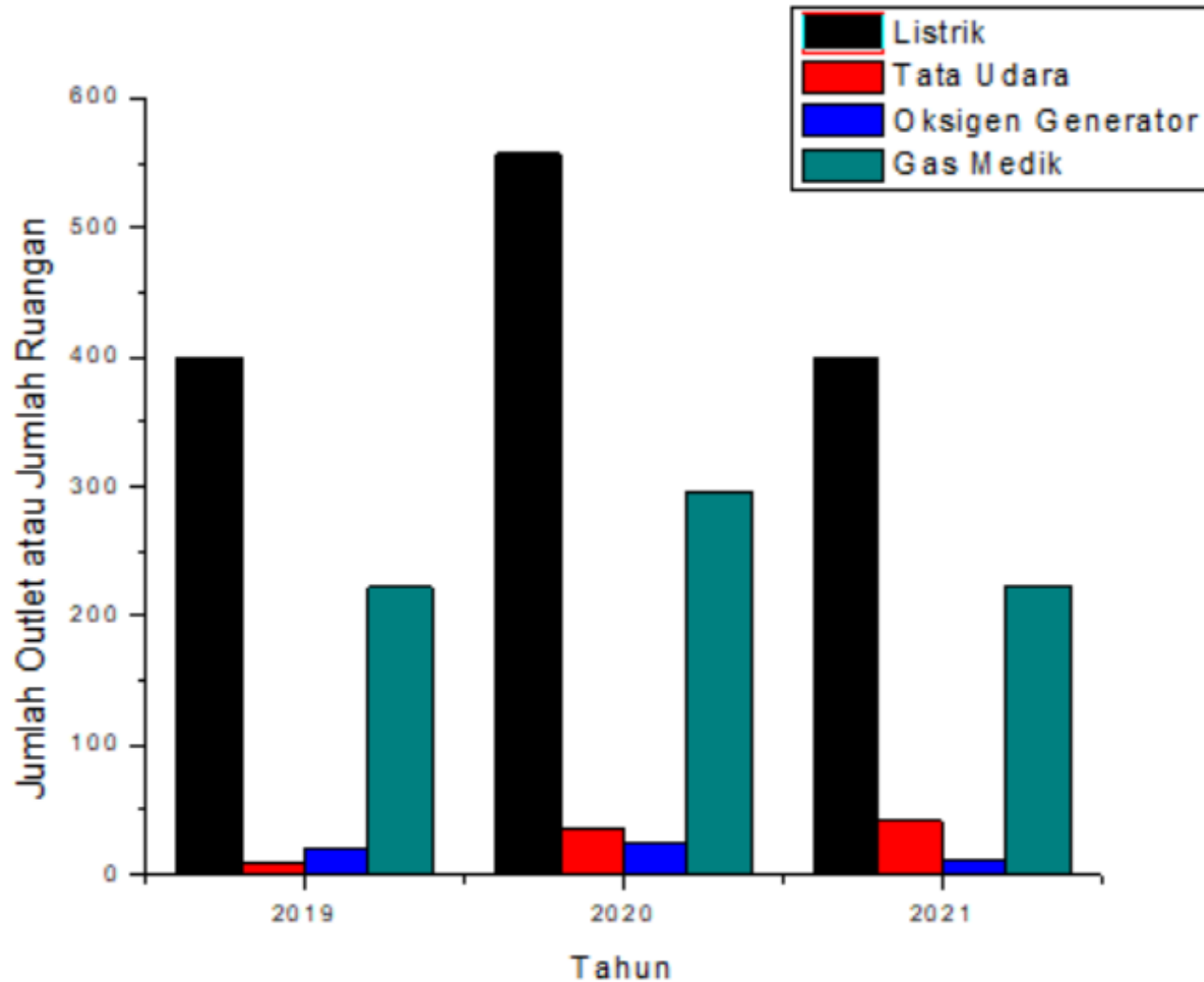
1. Tahun 2011 Awal Pembentukan Lembaga Inspeksi Sarana Prasarana
2. Sumber Daya Manusia sampai tahun 2018 terdiri 4 orang (PNS) dan 2 orang honorer / non PNS :
 - S2 Teknik Mesin , S1 Teknik Instrumentasi ,
 - S1 Teknik Elektro , S1 Teknik Fisika, D3 Teknik Elektro

Roadmap Lembaga Inspeksi Sarana Prasarana

Ruang Lingkup Akreditasi KAN



KURVA LAYANAN LEMBAGA INSPEKSI BPFK JAKARTA (per September 2021)



Tahun	Listrik Outlet	Tata Udara Ruangan	Oksigen G Outlet	Gas Medik Outlet
2019	400	8	20	222
2020	557	35	25	296
2021	399	41	11	223

Data Outlet Gas Medik

158	4	17	44
O2	N2O	UTM	Vac

2

Ruang Isolasi

1. Lay Out Ruang Isolasi
2. Standar Ruang Isolasi di beberapa negara

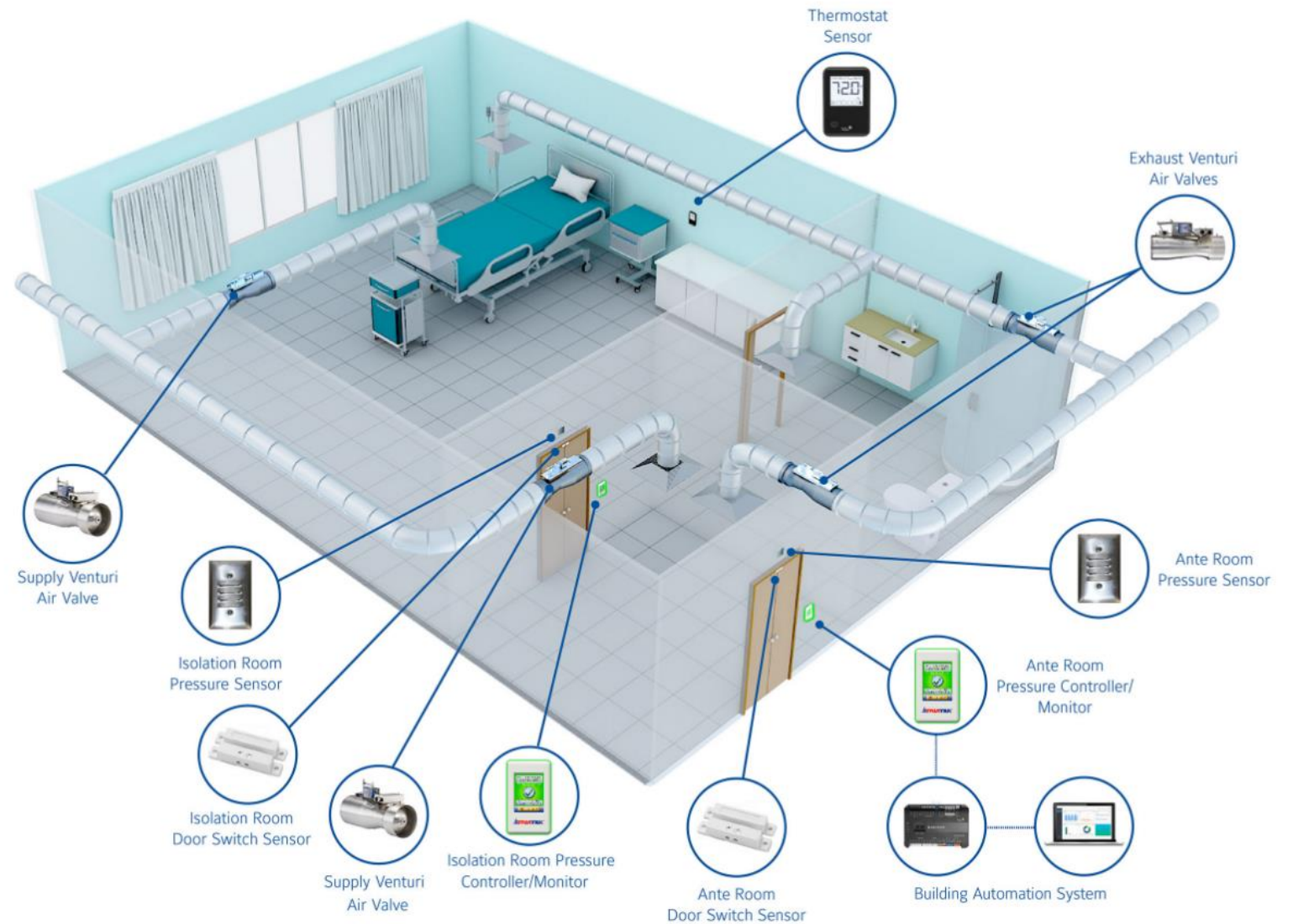
LayOut Ruang Isolasi

/www.triatek.com/wp-content/uploads/2020/03/Artboard-1@2x.jpg

Secara Umum Terdiri :

1. Ruang Pasien
2. Ruang Anteroom
3. Ruang Toilet / Kamar Mandi

DISA
DIUPL



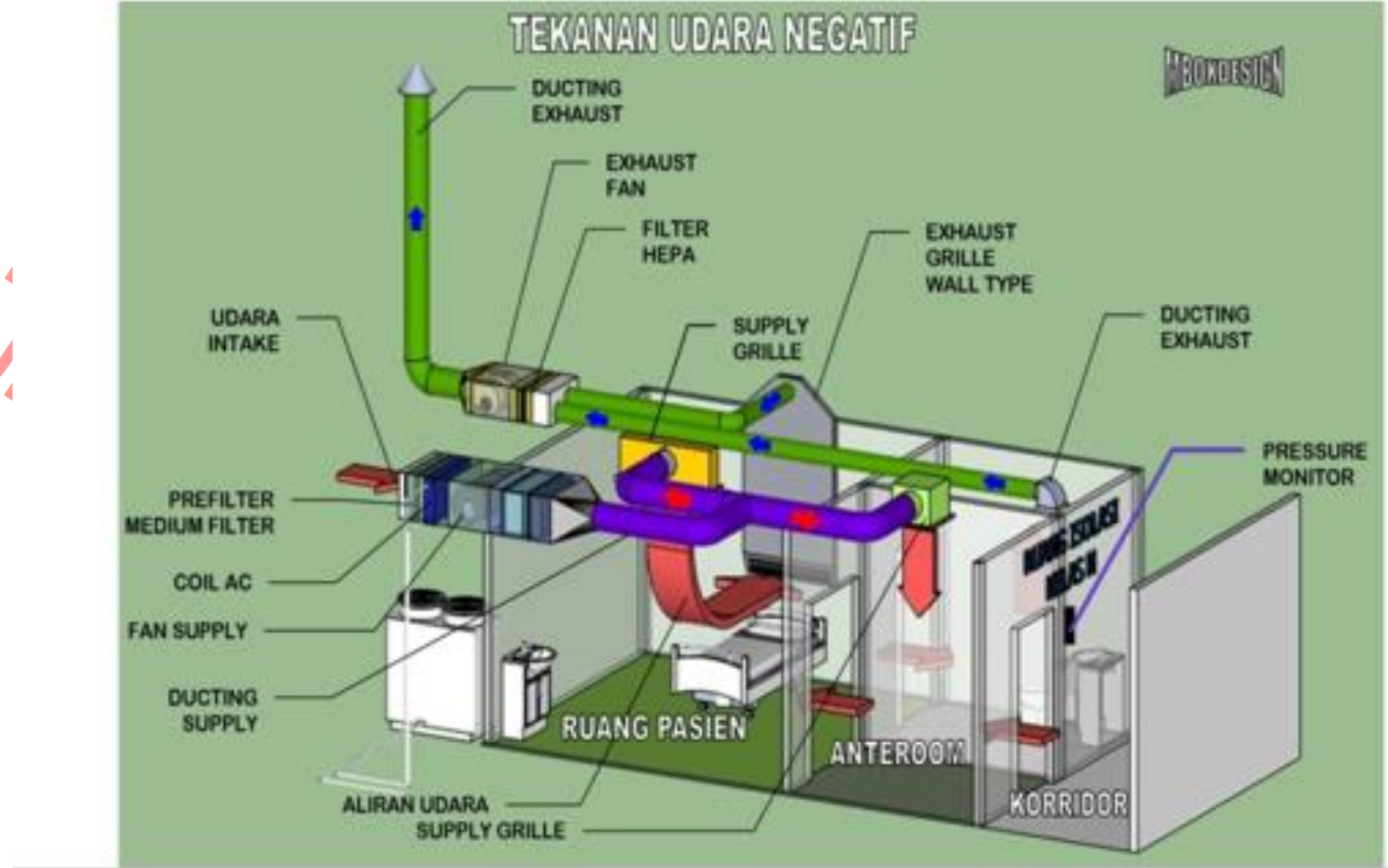
LayOut Ruang Isolasi

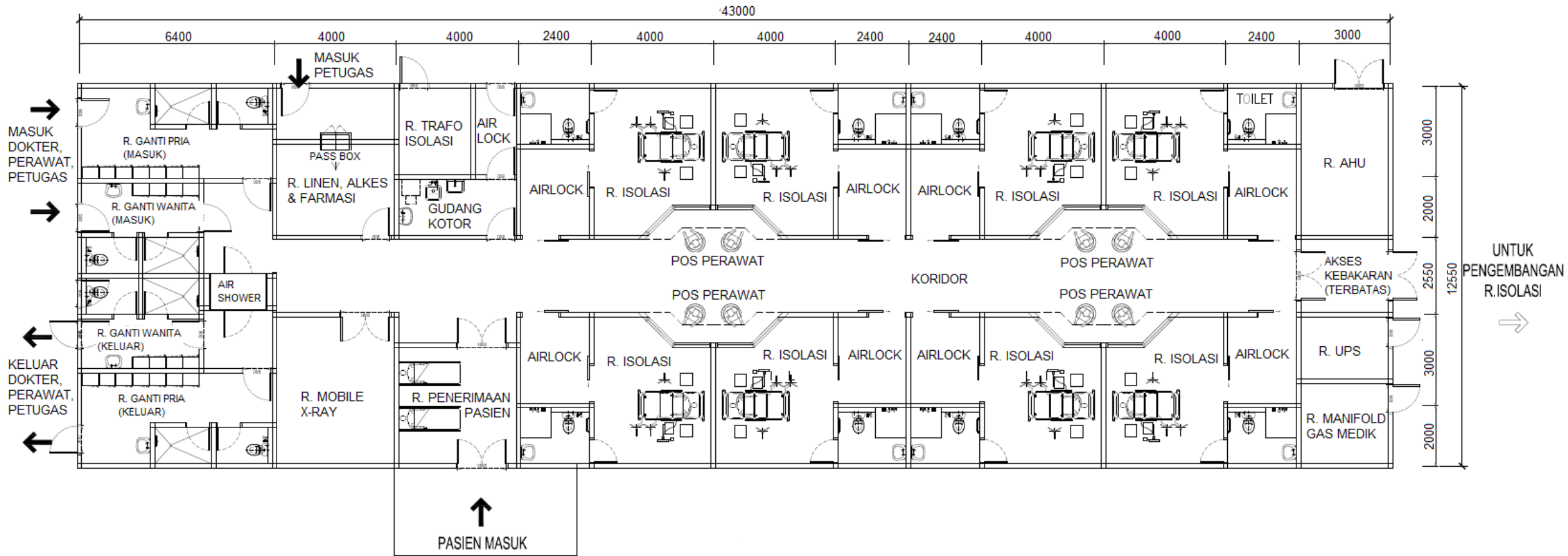
○ Isolasi Untuk Transmisi Airborne

Secara Umum Terdiri :

1. Ruang Pasien
2. Ruang Anteroom
3. Ruang Toilet / Kamar Mandi

DIU





“ONLINE”

Perbandingan Standar yang dipakai di beberapa negara

Airborne infection isolation room design standards in various contries					
	Organization	Air Change rate (ACH)	Pressure Differential	Recirculation	Anteroom
USA	Centers for Disease Control and Prevention	More than 12	More than 2.5 Pa	Yes (w/HEPA Filter)	Recommend
Canada	Public Health Agency	More than 9	-	Yes (w/HEPA Filter)	Recommend
UK	Department of Health	More than 10	More than 5 Pa	No	Recommend
Norway	Folkehelseinstitutt	More than 12	More than 5 Pa	No	Mandatory
Australia	Department of Health And Human Services	More than 15	More than 15 Pa	No	Mandatory
Hong Kong	Infection Control Committee Department of Health	More than 12	More than 2.5 Pa	Yes (w/HEPA Filter)	-
South Korea	Centers for Disease Control and Prevention	More 12	More than 2.5 Pa	Yes (w/HEPA Filter)	Mandatory

(source: ASHRAE Journal)

Table 4 Airborne isolation facilities

Applications: isolation rooms category 2 & 3, Infectious disease units, Containment level 3 rooms		
Area/zone	Reason for ventilation	Typical design factors
Category 2 isolation room Category 3 isolation room	Protection of staff and all other building occupants from airborne organisms dispersed by a patient with an infectious disease. See Health Building Note 04-01 Supplement 1	Extract only in patient's room and en-suite. Supply air from corridor passing into room via door undercut, transfer grille or pressure stabiliser. Alternatively the patient's room may have a supply and extract provided they are interlocked to ensure that the room is always at -ve pressure with regard to the corridor. Design parameters: Air change: ≥ 10 per hour Pressure regime: -5 Pa to general area Noise level: 35 d(B)A Temp range: 20 to 25°C BMS control Humidity: Floating; max 60%RH Air quality: BS EN 16798 – SUP2
Positive pressure ventilated lobby (PPVL) isolation room Universal isolation facility	Protection of building occupants from patients who may be infected and protection of patients who may be immunocompromised and protection for patients with both conditions. See Health Building Note 04-01 Supplement 1	Supply in lobby flowing through a pressure stabiliser to patient's room and on via a door undercut or transfer grille to an extract in the en-suite. Design parameters: Bedroom air change: ≥ 10 per hour Lobby pressure: +10 Pa to corridor Bedroom pressure: Neutral En-suite pressure: -ve Comfort parameters as above Air quality: BS EN 16798 – SUP2 With facility to fit BS EN 1822 – EPA12
Containment level 3 laboratory	Protection of occupants in adjoining spaces from airborne bio-hazards	For design details see the Medical Research Council's "Standards for containment level 3 facilities"
Category 4 facility	Design advice will be provided by the client	

See also Health Building 04-01 – 'Adult in-patient facilities' and Health Building 04-02 – 'Critical care units'.

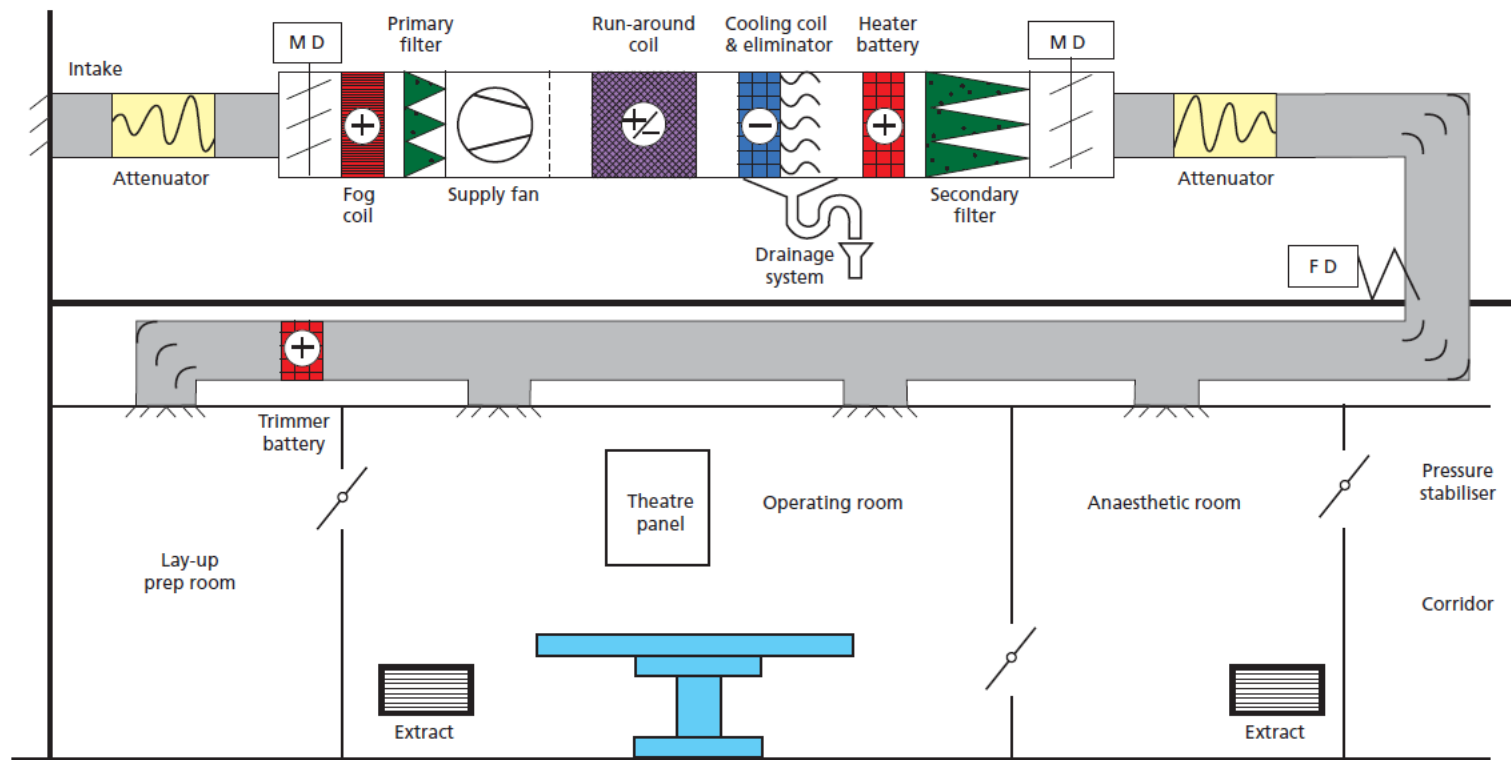
3

Ruang Operasi

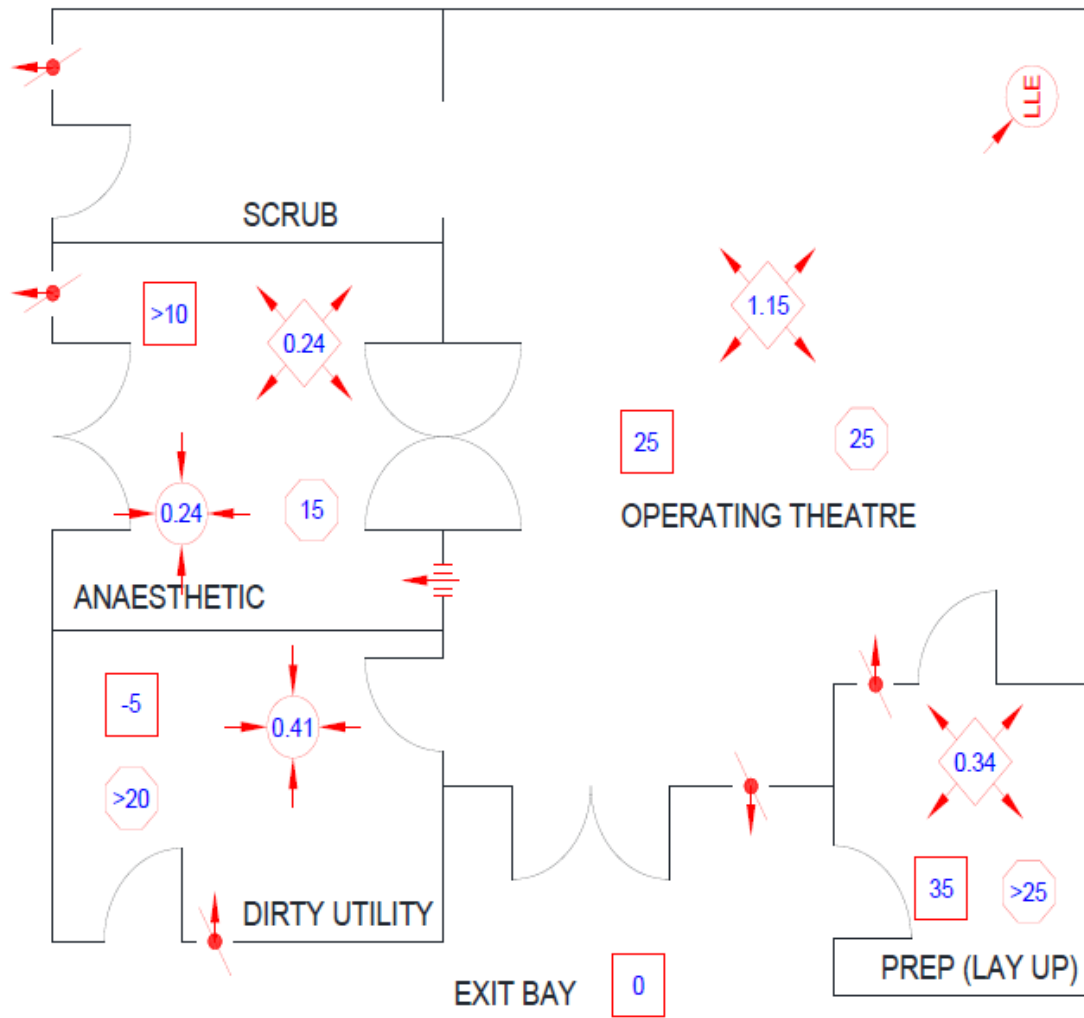
1. Lay Out Ruang Operasi
2. Standar Ruang Isolasi di beberapa negara

Lay Out Ruang Operasi

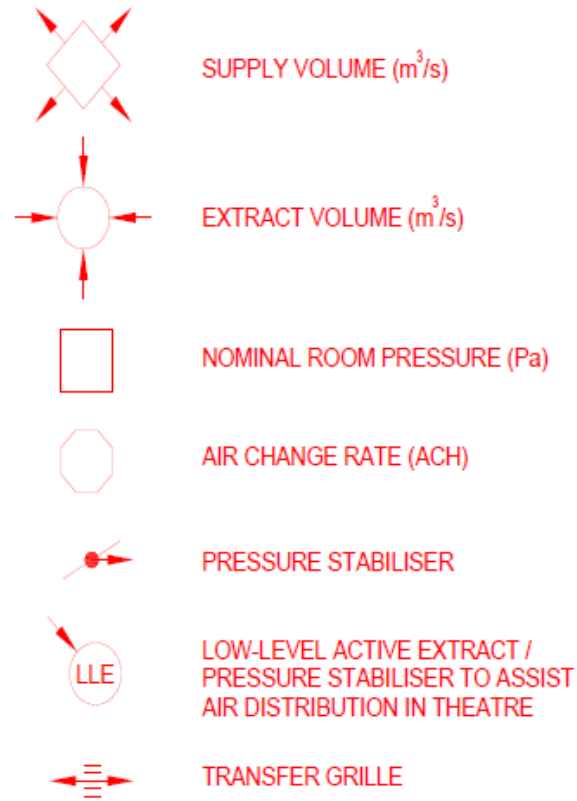
Figure A1 Schematic of typical operating suite AHU with energy recovery by run-around coil from a remote extract fan unit



Health Technical Memorandum 03-01 Specialised ventilation for healthcare premises Part A



LEGEND



> adequate air supply
 > air movement :
 from clean to less clean areas

TYPICAL CONVENTIONAL THEATRE (EXAMPLE 1) (HTM 03-01)

AHU formed plantroom (external)

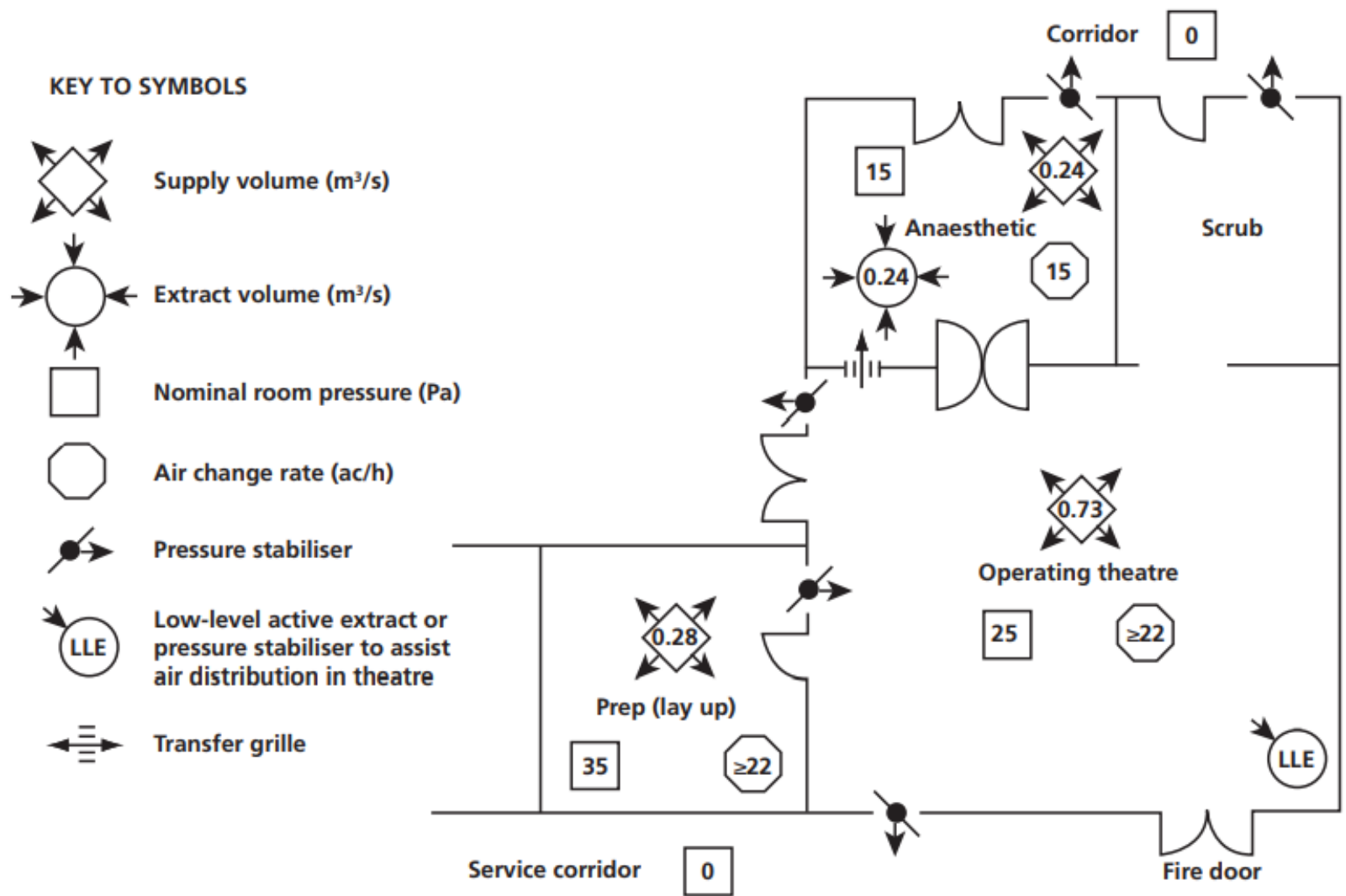


Bagian Luar Air Handling Unit tipe Planroom

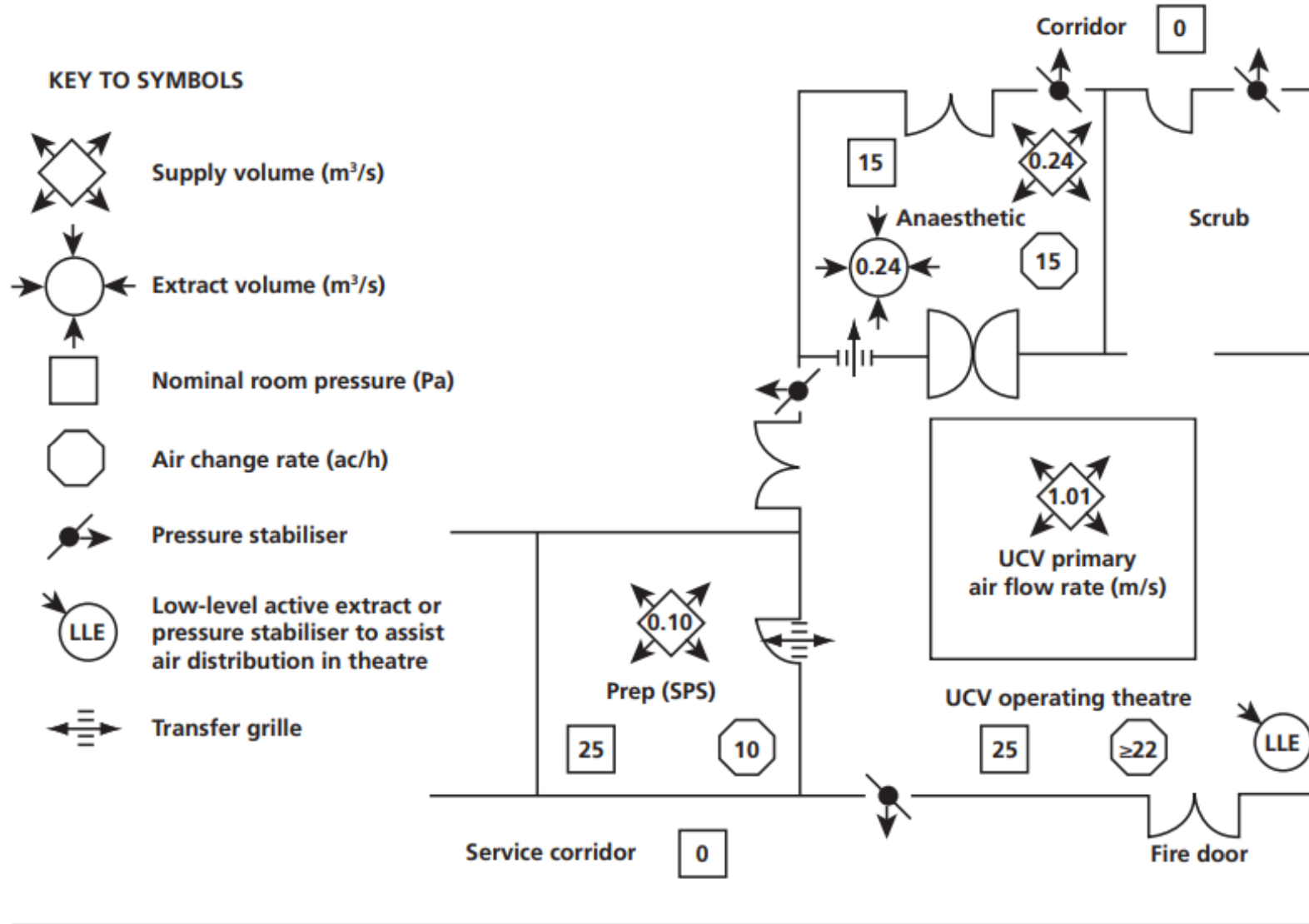
AHU plantroom (internal)

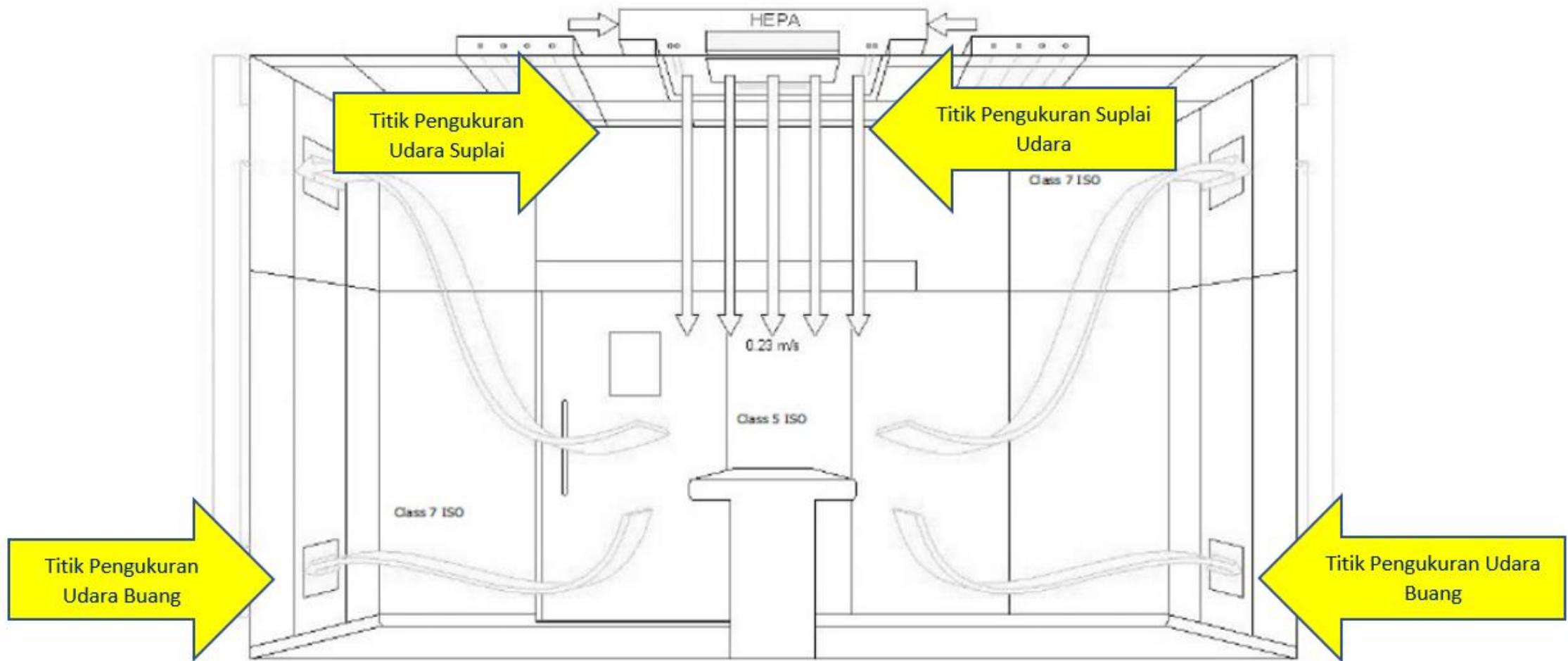


Bagian Dalam Tipe Air Handling Unit PlantRoom



“LIVE”





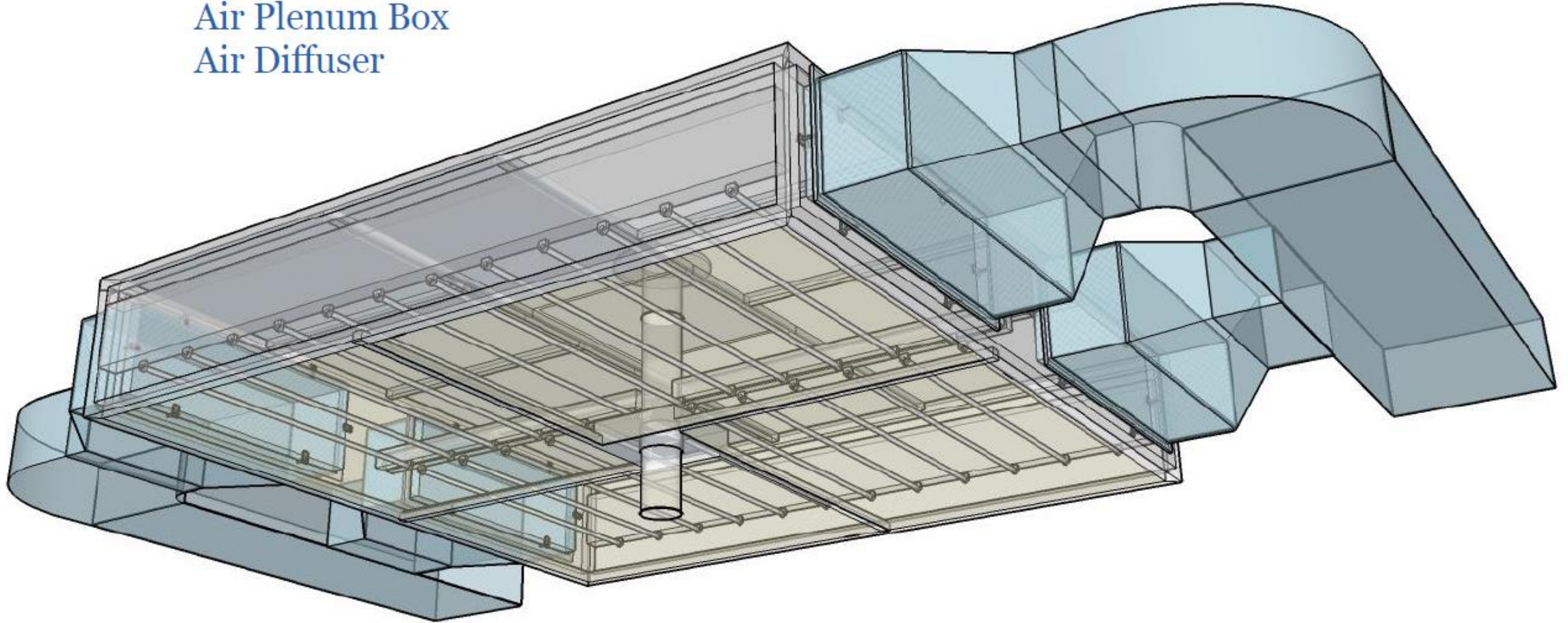
Laminar Air Flow Ceiling

Consisting of:

Filter Chamber

Air Plenum Box

Air Diffuser



[https://www.orphf.gov.hk/files/seminar/4-Seminar 21 Feb - Specialised Ventilation Systems for Hospitals.pdf](https://www.orphf.gov.hk/files/seminar/4-Seminar%2021%20Feb-Specialised%20Ventilation%20Systems%20for%20Hospitals.pdf)



4

Parameter Uji

1. Ruang Operasi
2. Ruang Isolasi

Performa Sistem Tata Udara

Ruangan ICU Isolasi Tekanan Negatif

1. Pertukaran Udara Perjam Ruang Pasien
2. Pertukaran Udara Perjam Ruang Anteroom
3. Tekanan Udara
4. Temperatur Udara
5. Kelembaban Relatif Udara
6. Posisi Penempatan Diffuser Udara Suplai
7. Posisi Penempatan Grill Udara Buang
8. Kelengkapan Filter Udara Suplai
9. Kelengkapan Filter Udara Buangan
10. Kelengkapan Sistem Interlock Pintu

Ruangan Operasi

1. Temperatur = 22° C – 24° C
2. Kelembaban Relatif Udara (RH) : 45% – 60%
3. Pergantian Udara perjam / Air Change per Hour (ACH) = minimal 20 kali
4. Positive Pressure Air = 1,5 Pascal terhadap ruangan sebelah
5. Kelas Udara Bersih Klas 7-8 ISO 14644
6. Luasan HEPA Filter di ruangan (5%-15% dari Luasan Ruang Operasi)
7. Kebisingan : < 50 dbA

Parameter
Kelaikan
Ruang Isolasi
Tekanan Negatif

No	Klausul Persyaratan Kelaikan	Ambang Batas
1	Pergantian Udara Per Jam Ruang Isolasi Pasien	12 kali per jam
2	Pergantian Udara Per Jam Ruang Anteroom	6-10 kali per jam
3	Temperatur Ruang Perawatan	24-26 ° Celcius
4	Kelembaban Relatif Udara Ruang Pasien	Maksimal 60% RH
5	Tekanan Udara Ruang Perawatan Pasien terhadap Koridor	Minimal (-15 Pascal)
6	Penempatan Diffuser Suplai Udara di Ruang Isolasi Perawatan Pasien	Di langit-langit area kaki pasien
7	Penempatan Grill Udara Buang di Ruang Isolasi Perawatan Pasien	Di dinding samping Kiri dan kanan tempat tidur pasien
8	Kelengkapan Sistem Filtrasi Suplai Udara	Filter Medium dan Filter Pre
9	Kelengkapan Sistem Filtrasi Udara Buangan	Minimal HEPA Filter terpasang
10	Sistem Interlock Pintu Ruang Isolasi	Dapat berfungsi Interlock dan bisa juga dibypass jika dibutuhkan

Sumber :
**Pedoman Teknis
Penyakit Infeksius
Emergency,
Fasyankes 2020**

TABLE 1 Design standards for AIIR to prevent airborne contamination.¹¹

	ORGANIZATION	AIR CHANGE RATE (ACH)		PRESSURE DIFFERENTIAL	RECIRCULATION	ANTEROOM
USA	Centers for Disease Control and Prevention	Existing	New/Remodeling	More than 2.5 Pa	Yes (w/HEPA Filter)	Recommend
		More than 6	More than 12			
Canada	Public Health Agency of Canada	Existing	New/Remodeling	-	Yes (w/HEPA Filter)	Recommend
		More than 6	More than 9			
UK	Department of Health	More than 10		More than 5 Pa	No	Recommend
Norway	Folkehelseinstitutt	More than 12		More than 5 Pa	No	Mandatory
Australia	Department of Health And Human Services	Mandatory	Recommend	More than 15 Pa	No	Mandatory
		More than 12	More than 15			
Hong Kong	Infection Control Committee Department of Health	Existing	New/Remodeling	More than 2.5 Pa	Yes (w/HEPA Filter)	-
		More than 6	More than 12			
South Korea	Centers for Disease Control and Prevention	Mandatory	Recommend	More than 2.5 Pa	Yes (w/HEPA Filter)	Mandatory
		More than 6	More than 12			



Parameter Kelaikan Ruang Operasi

TABLE I Summary of ASHRAE Standard 170-2017*

1. Ceiling height between 9 and 12 ft (2.7 and 3.6 m)
2. Nonaspirating diffuser ceiling air supply grid
3. Diffuser array face velocity of 25-35 feet per minute
4. 99.97% efficient HEPA filters upstream of or part of the ceiling grid†
5. Ceiling grid size between 6 × 8 ft (1.8 × 2.4 m) and 8 × 8 ft (2.4 × 2.4 m) centered over OR table
6. Up to 30% of ceiling grid can be devoted to nonairflow delivery (i.e., OR lights)
7. Ceiling grid must extend a minimum of 12 in (30 cm) beyond the OR table
8. At least 2 wall-mounted return grilles mounted at least 8 in (20 cm) above the floor in either corner of the room
9. Twenty ACH with at least 4 ACH from outdoor air‡
10. Room pressurized to 0.01-in wc (2.5 Pa) positive relative to adjacent spaces
11. Temperature 68°-75°F (20°-24°C) and relative humidity 20%-60%

*Compiled from ANSI/ASHRAE/ASHE standard 170-2017: Ventilation of Health Care Facilities³⁸. †HEPA = high-efficiency particulate air. ‡ACH = air changes per hour.

Persyaratan Minimum Ruang Operasi (Ashrae Standard 170-2017)

AD "DO"

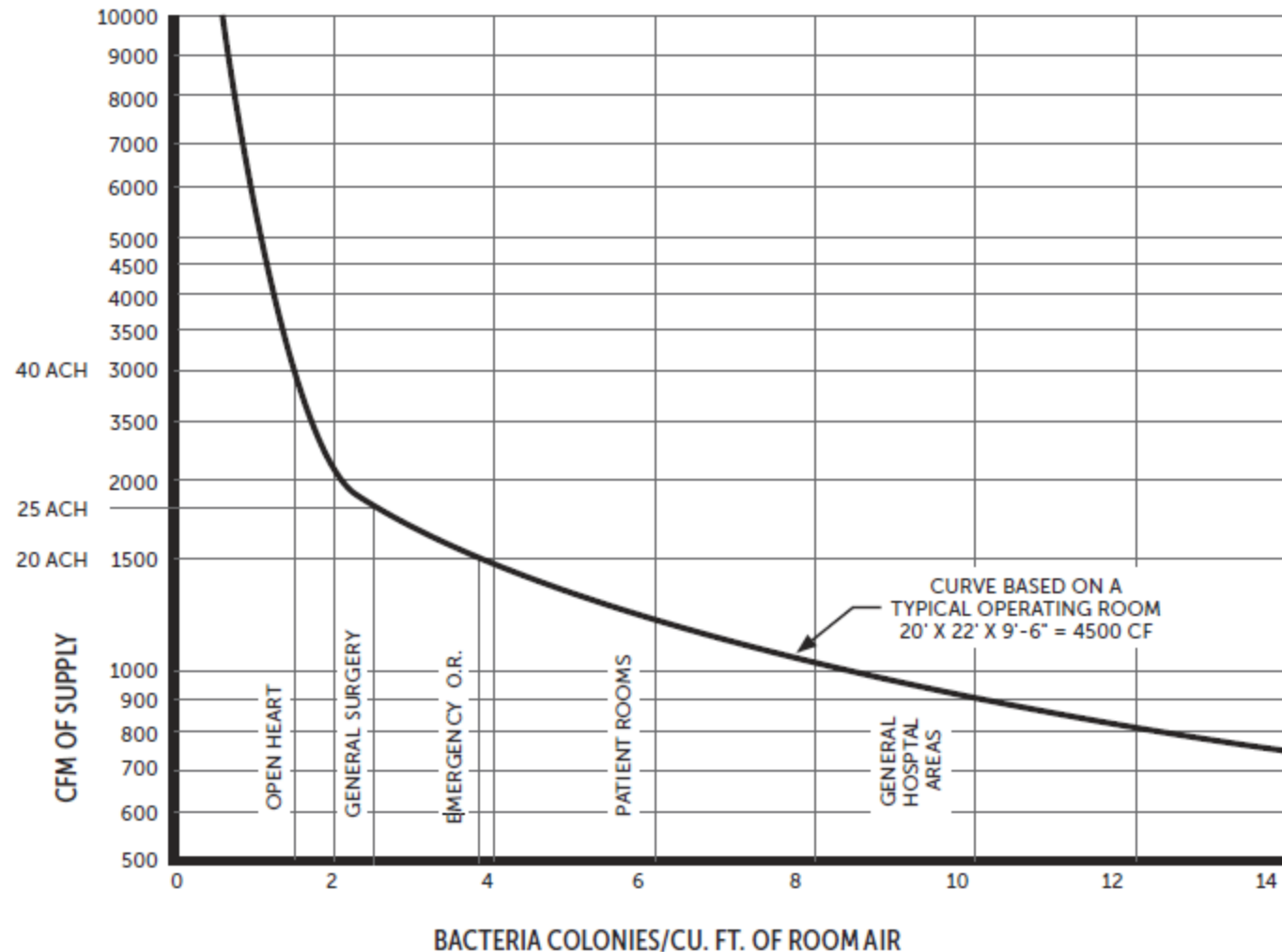
TABLE 1 Minimum requirements for OR ventilation according to Standard 170-2017.²

MINIMUM REQUIREMENT	LEGACY	CEILING EXHAUST	DISTRIBUTED SUPPLY
Total Air Change Rate (ACH): 20	23	23	23
Pressure Relationship to Adjacent Areas: Positive	Positive	Positive	Positive
Design Temperature: 68 to 75°F (20 to 24°C)	70°F (21°C)	70°F (21°C)	70°F (21°C)
Airflow: Unidirectional, Downward	Unidirectional, Downward	Unidirectional, Downward	Unidirectional, Downward
Airflow: Average Discharge Velocity 25 to 35 cfm/ft ² (127 to 178 L/s·m ²)	30 cfm/ft ² (153 L/s·m ²)	30 cfm/ft ² (153 L/s·m ²)	22.5 cfm/ft ² (114 L/s·m ²)
The Room Shall be Provided With at Least Two Low Sidewall Return or Exhaust Grilles Spaced at Opposite Corners or as Far Apart as Possible*	Two Low Sidewall Returns	Six Ceiling Returns*	Two Low Sidewall Returns

*In addition to the required low return (or exhaust) air grilles, such grilles may be placed high on the walls.

"LINE"

Grafik Air Change perHour (CFM Supply) vs Room Type



Application	Ventilation	Air-change rate (ac/h)	Pressure (Pascal – Pa)	Supply filter grade (BS EN 16798)	Noise (dB(A))	Temp (°C)	Comments (for further information see Chapter 8)
General ward (level 0 and 1 care)	S/N	6	–	SUP2	35	18–28	
Communal ward toilet	E	6	–ve	–	45	–	
Single room	S/E/N	6	0 or –ve	SUP2	35	18–28	
Single room WC	E	3	–ve	–	45	–	
Clean utility	S	6	+ve	SUP3	45	18–22	
Dirty utility	E	6	–ve	–	45	–	
Ward isolation room (PPVL)	S	10	Lobby +10 Room 0	SUP2	35	–	See Health Building Note 04-01 (Supplement 1)
Infectious diseases isolation room	E	10	–5	SUP2	35	–	See Table 4
Neutropaenic patient ward	S	10	+10	H12	35	–	See Table 3
Critical care areas (Level 2 and 3 care)	S	10	+10	SUP1	35	–	Isolation room may be –ve pressure or PPVL. See Table 3
Birthing room	S & E	10	0	SUP2	45	20–25	See Table 5
NICU/SCBU	S & E	10	+ve	SUP1	35	20–28	Isolation room may be –ve pressure
For general and UCV operating suites and associated rooms, see specific guidance in Chapter 8 and typical design solutions in Appendix 7							
Operating department recovery room	S & E	15	0	SUP2	45	18–25	Provide clean airflow path
Catheterisation room	S & E	10	+ve	SUP2	45	18–22	

Type	Pressure difference (Pa)							
	5	10	15	20	25	30	35	40
Single door	0.03	0.05	0.06	0.06	0.07	0.08	0.09	0.10
Single door + half	0.04	0.06	0.07	0.08	0.09	0.10	0.11	0.12
Double door	0.05	0.08	0.10	0.11	0.12	0.13	0.14	0.15

Designers' notes:

The door gaps assumed are 4 mm along the bottom, 3 mm at the top and sides, and 2 mm between double leaves.

If doors are fitted with cold smoke seals, these will significantly reduce the door leakage rate when new and undamaged. It is therefore recommended that provision for the design leakage be factored into the size of the appropriate transfer grille or pressure stabiliser. Failure to do this will result in air-gap whistles and doors being held partially open by air pressure.

Factory-assembled door-sets with a steel frame and pre-hung leaves are becoming common. There is effectively no leakage across these doors when closed. Therefore, when this type of door assembly is fitted, the door leakage can be ignored and the design airflow into the room reduced accordingly. The design airflow would then become that required either (i) for open door protection (Appendix 5), or (ii) to achieve the specified air-change rate – whichever is the greater.

Sumber Informasi : NHS

Health Technical Memorandum 03-01 Specialised ventilation for healthcare premises Part A:
The concept, design, specification, installation and acceptance testing of healthcare ventilation systems

TABLE II ISO Standards for Clean Rooms*

ISO Class	Maximal Acceptable Concentrations of Particles of the Sizes Listed Below (<i>particles/m³</i>)					
	≥0.1 μm	≥0.2 μm	≥0.3 μm	≥0.5 μm	≥1 μm	≥5 μm
ISO 1	10	2.37	1.02	0.35	0.083	0.0029
ISO 2	100	23.7	10.2	3.5	0.83	0.029
ISO 3	1,000	237	102	35	8.3	0.29
ISO 4	10,000	2,370	1,020	352	83	2.9
ISO 5	100,000	23,700	10,200	3,520	832	29.3
ISO 6	1 × 10 ⁶	237,000	102,000	35,200	8,320	293
ISO 7	1 × 10 ⁷	2.37 × 10 ⁶	1.02 × 10 ⁶	352,000	83,200	2,930
ISO 8	1 × 10 ⁸	2.37 × 10 ⁷	1.02 × 10 ⁷	3.52 × 10 ⁶	832,000	29,300
ISO 9	1 × 10 ⁹	2.37 × 10 ⁸	1.02 × 10 ⁸	3.52 × 10 ⁷	8.32 × 10 ⁶	293,000

*ISO (International Organization for Standardization) 1 represents the “cleanest” clean room, while ISO 9 is the “dirtiest” clean room. Orthopaedic and transplant ORs are recommended to be ISO class 6, while general surgery may be ISO class 7, and minor ORs and endoscopy suites may be ISO class 8. (©ISO. This material is reproduced from ISO 14644-1:2015 with permission of the American National Standards Institute [ANSI] on behalf of the International Organization for Standardization. The complete standard can be purchased from ANSI at <https://webstore.ansi.org>. All rights reserved.)

Area of zone [m2]	ISO 14644-1:1999	ISO 14644-1:2015
2	2	1
4	2	2
6	3	3
8	3	4
10	4	5
24	5	6
28	6	7
32	6	8
36	6	9
52	8	10
56	8	11
64	8	12
68	9	13
72	9	14
76	9	15
104	11	16
108	11	17
116	11	18
148	13	19
156	13	20
192	14	21
232	16	22
276	17	23
352	19	24
436	21	25
636	24	26
1000	32	27
>1000	n/a	See Formula A. 1

Untuk ruangan lebih dari 1000 m2 menggunakan formula :

$$N_L = 27x \left(\frac{A \text{ m}^2}{1000} \right) \text{ (A.1)}$$

“DOKUMEN INI BUKAN MILIK PTPI DAN BOLEH DI LUASKAN ATAU DICARA ONLINE”

5

Testing and Commisioning

1. Testing Activity
2. Kegiatan Testing Ruang Isolasi dan Ruang Operasi

Whats Inspection



“AU
ONLINE”

Kegiatan Inspeksi Sistem Tata Udara

- **Pengecekan Kelengkapan Dokumen**
 - Blok Diagram / Single Line Diagram
 - Sertifikat Pelatihan untuk Petugas Teknik RS
 - Dokumen Perawatan Sistem Tata Udara
- Pengamatan Visual terhadap obyek inspeksi
- Pengujian Performa Sistem Tata Udara RS
- Kompetensi SDM untuk Bidang Teknik Elektro, Teknik Fisika, Teknik Mesin, Teknik Sipil

Pengukuran Performa Sistem Tata Udara

1. Temperature and Temperature Distribution
2. Relative Humidity of Air
3. Class of Cleanroom Air / Kandungan Partikel di Udara
4. Air Change per Hour (ACH) / Pergantian Udara per jam
5. Positive / Negative Pressure Air / Tekanan Udara Ruangan

Kegiatan Rapat Awal Pra Inspeksi



RSUP dr Ario Wirawan, Salatiga, Jawa Tengah

“IVE”

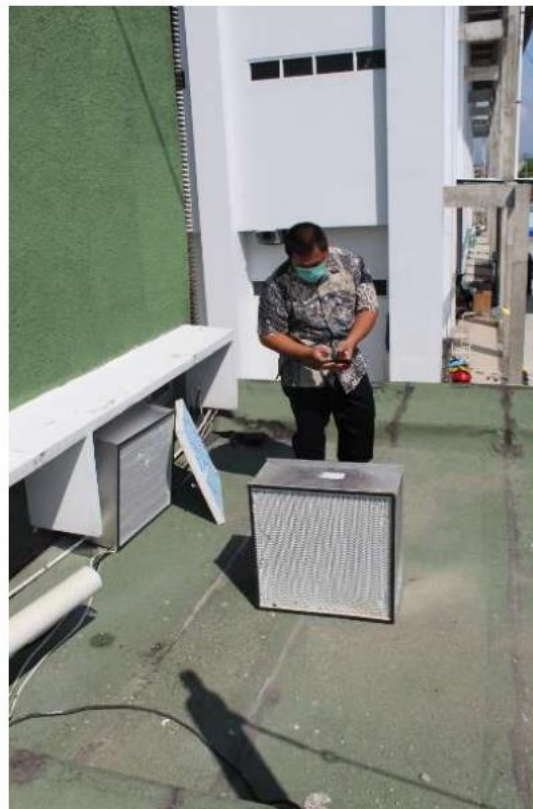
Tabel Review Dokumen Teknis

No	Mata Uji	Proses Pengujian	Satuan (hasil Keluar)	Referensi
1	Gambar Teknik Sistem Tata Udara	Dokumen teknis diteliti kesesuaiannya dengan system tata udara yang dipakai.	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak Sesuai	Gambar teknis rancangan instalasi sistem tata udara
2	Spesifikasi material	Spesifikasi material diteliti disesuaikan dengan spesifikasi penggunaannya.	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak Sesuai	Ashrae Standard 52.1-1992
3	Sertifikat kalibrasi Thermometer	Diteliti masa berlaku sertifikat Kalibrasi	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	Sertifikat
4	Sertifikat kalibrasi Hygrometer	Diteliti masa berlaku sertifikat Kalibrasi	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	Sertifikat
5	Sertifikat kalibrasi Manometer / Magnehelic	Diteliti masa berlaku sertifikat hasil uji pabrikan	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	Sertifikat hasil uji pabrikan
6	Sertifikat / Dokumen HEPA/ULPA Filter	Diteliti sertifikat yang disertakan dari pabrik	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	UJI DOP/MERV
7	Nama refrigeran	Spesifikasi diteliti disesuaikan dengan spesifikasi penggunaannya.	<input type="checkbox"/> <input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	Gambar teknis rancangan instalasi sistem tata udara
8	Kapasitas Pendinginan	Spesifikasi diteliti disesuaikan dengan spesifikasi penggunaannya.	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	Gambar teknis rancangan instalasi sistem tata udara
9	Jenis Mesin Refrigerator / Chiller yang dipakai	Spesifikasi diteliti disesuaikan dengan spesifikasi penggunaannya.	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	Gambar teknis rancangan instalasi sistem tata udara
10	SOP Operasional & Perawatan (STU)	Diteliti masa berlaku Jenis SOP	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	SOP
11	Log Book kegiatan Perawatan	Diteliti Jenis kegiatan yang dilakukan secara berkala	<input type="checkbox"/> Sesuai <input type="checkbox"/> Tidak tersedia	Log Book Perawatan

Kegiatan Inspeksi SISTEM Tata Udara

Inspeksi Ruang Isolasi Tekanan Negatif

Lokasi : RS dr Soeradji Klaten Jawa Tengah



Proses Pengujian Ruang Isolasi

Nama Peralatan yang dibutuhkan

No	Nama Alat	Merk	Model	Nomor Seri
1	Particle Counter	Lasair	Lasair III 350L	
2	Balometer atau Capture Hood	Shortridge	ADM-860c	
3	Thermo anemometer	Kimo	MCT	
4	Thermohygrometer	Gresinger	GTFB 200	
5	Laser Distance meter	Extech	DT 300	
6	Meteran	Oni	5 m	
7	Smoke Generator	Peasoap	-	
8	Kamera Digital	Canon	EOS1200D	

Peralatan Uji



Thermoanemometer dengan Capture Hood



Particle Counter untuk Udara Kelas Clean Room



Particle Counter with HEPA Filter Efficiency Analyzer



Laser Distance Meter



Thermohygrometer

Parameter 1

Pergantian Udara Per Jam (Air Change per Hour) Ruang Pasien

- Pengukuran Debit / Flowrate Udara Exhaust / Udara Buangan
- Pengukuran Debit / Flowrate Udara Suplai

Tujuannya memastikan flowrate exhaust / flowrate udara buangan lebih besar dibandingkan Flowrate udara suplai



Parameter 2

Pergantian Udara per jam Ruang Anteroom minimal = 6 – 10 kali pergantian udara perjam

- a. Pengukuran Flowrate Udara Suplai
- b. Pengukuran Flowrate Udara Exhaust

- Pengukuran Debit / Flowrate Udara Exhaust / Udara Buangan
- Pengukuran Debit / Flowrate Udara Suplai

Tujuannya memastikan flowrate exhaust / flowrate udara buangan lebih besar dibandingkan Flowrate udara suplai



Parameter 3

Temperatur Ruang Perawatan Pasien
Penentuan jumlah titik ukur merujuk standard
cleanroom air class

Parameter 4

Kelembaban Udara Relatif
Penentuan jumlah titik ukur merujuk
standard cleanroom air class



Parameter 5

Perbedaan Tekanan Udara antara Ruang Perawatan dan Ruang Koridor



DOKUMEN INI
MILIK



Contoh Hasil Pengukuran Differensial Pressure

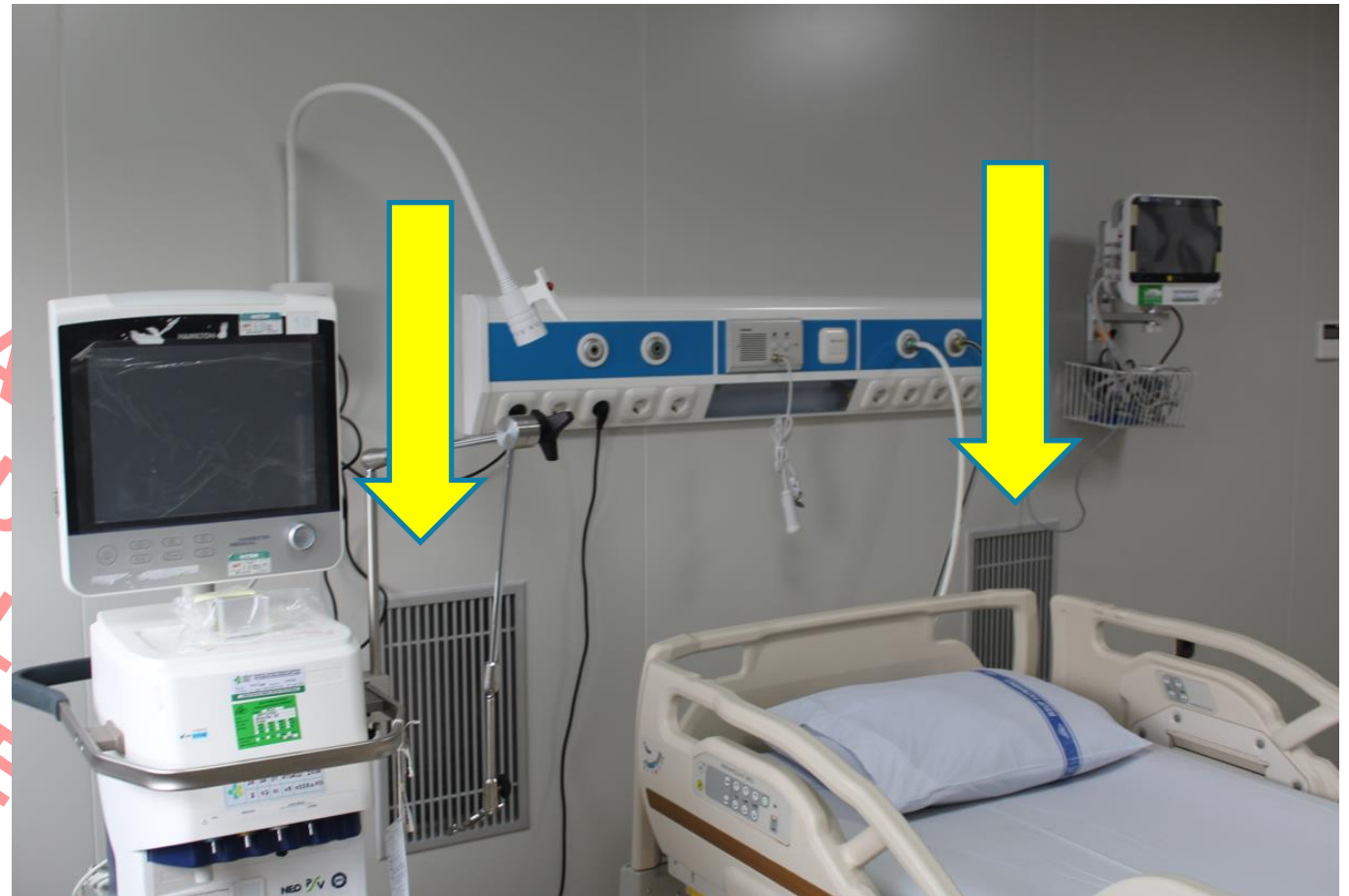
Nama Ruangan	Ruang Pasien – Ruang Anteroom	Ruang Pasien – Ruang Kamar Mandi	Ruang Anteroom- Ruang Koridor	Ruang Pasien – Ruang Koridor
	(Pascal)	(Pascal)	(Pascal)	(Pascal)
Pasien 1	-1,8	-5,8	-22,1	-24,9
Pasien 2	-20,4	-12,5	-1,5	-21,9
Pasien 3	-14,7	9,0	-9,0	-23,7
Pasien 4	-20,2	7,9	0,0	-20,2

ADALAH DOKUMEN INI
 TIDAK BOLEH
 DIUPLUASKAN ATAU
 SECARA ONLINE”

Parameter 7

Posisi Penempatan Return Air Grill di Ruang Perawatan Pasien

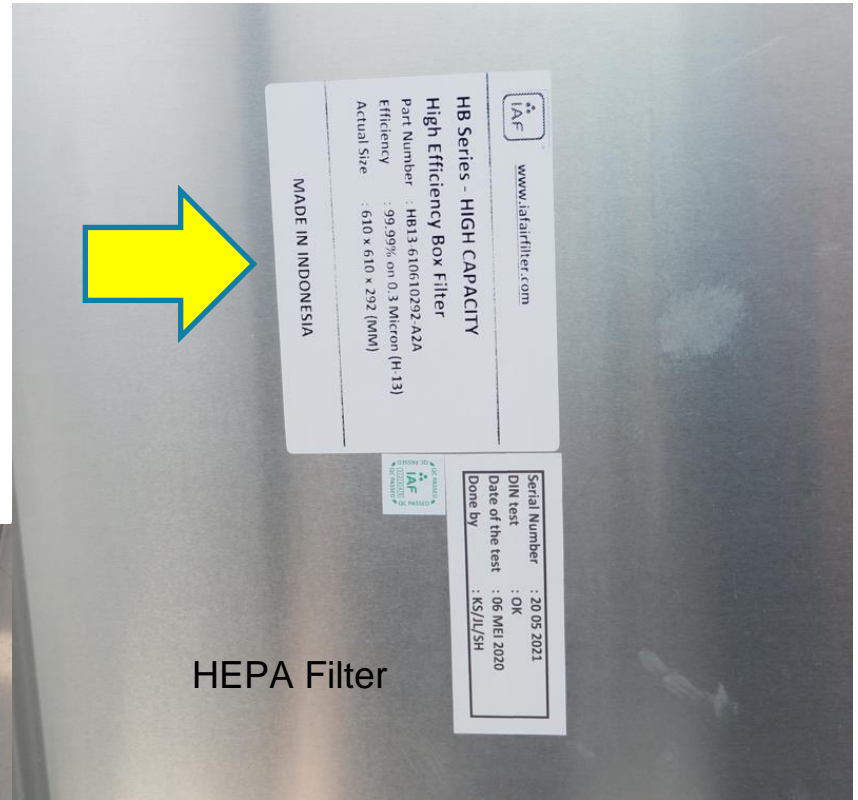
Diharapkan udara yang keluar dari pernapasan pasien langsung terhisap oleh grill udara buang



Parameter 8

Kelengkapan Sistem Udara Buangan Ruang Isolasi Tekanan Negatif

- 1. Pre Filter (25-30%) / MERV 7
- 2. Medium Filter (90-95%) / MERV 13/14
- 3. HEPA Filter(99,97% - 99,999%)/ MERV 17-20
- 4. Differensial Pressure Meter (Monitoring kemampuan filter)



HEPA Filter

Parameter 9

Kelengkapan Sistem Tata Udara
Suplai Udara Masuk

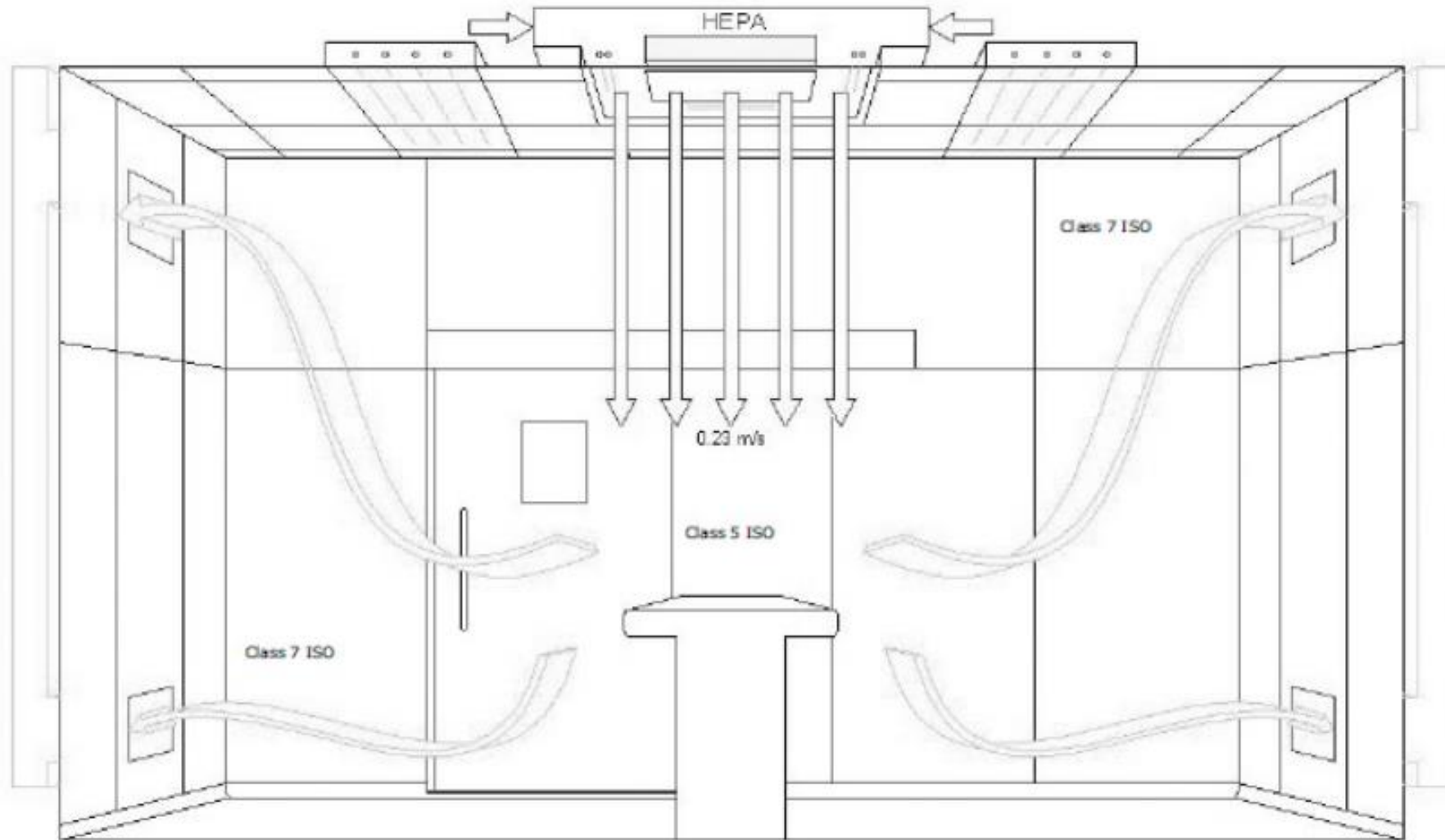
Minimal Filter Terpasang :

1. Medium Filter (MERV 14 / 16)
2. Pre Filter (35% efisiensi / MERV 7)



MERV Rating	Will trap particle size .3 to 1.0 microns	Will trap particle size 1.0 - 3.0 microns	Will trap particle size 3 to 10 microns	Filter Type [Will remove these particles]
MERV 1	< 20%	< 20%	< 20%	Fiberglass & aluminum mesh filters [Pollen, dust mites, spray paint, carpet fibers]
MERV 2	< 20%	< 20%	< 20%	
MERV 3	< 20%	< 20%	< 20%	
MERV 4	< 20%	< 20%	< 20%	
MERV 5	< 20%	< 20%	20% - 34%	Cheap disposable filters [Mold spores, cooking dusts, hair spray, furniture polish]
MERV 6	< 20%	< 20%	35% - 49%	
MERV 7	< 20%	< 20%	50% - 69%	
MERV 8	< 20%	< 20%	70% - 85%	Better home box filters [Lead dust, flour, auto fumes, welding fumes]
MERV 9	< 20%	Less than 50%	85% or better	
MERV 10	< 20%	50% - 64%	85% or better	
MERV 11	< 20%	65% - 79%	85% or better	Superior commercial filters [Bacteria, smoke, sneezes]
MERV 12	< 20%	80% - 90%	90% or better	
MERV 13	Less than 75%	90% or better	90% or better	
MERV 14	75% - 84%	90% or better	90% or better	
MERV 15	85% - 94%	90% or better	90% or better	HEPA & ULPA filters [Viruses, carbon dust, <.30pm]
MERV 16	95% or better	95% or better	90% or better	
MERV 17	99.97%	99% or better	99% or better	
MERV 18	99.997%	99% or better	99% or better	
MERV 19	99.9997%	99% or better	99% or better	
MERV 20	99.99997%	99% or better	99% or better	

Proses Pengujian Ruang Operasi



Proses Pengukuran Flowrate Udara Suplai



No	Nama Ruangan	Panjang	Lebar	Tinggi	Volume	No	Nama Ruangan	Panjang	Lebar	Tinggi	Volume
		m	m	m	m ³			m	m	m	m ³
1						14					
2						15					
3						16					
4						17					
5						18					
6						19					
7						20					
8						21					
9						22					
10						23					
11						24					

“DOKUMEN”
“LAH MI”

FORM PENGAMBILAN DATA RUANGAN

NO	NAMA	Diffuser (m/detik)					Exhaust 1					Exhaust 2					Debit Aliran Udara				Debit Aliran Udara				Pergantian Udara per Jam	Temp. Ruangan (°C)	RH Ruangan (%)	Intensitas cahaya (Lux)						
		P	L	A	T	RH	P	L	A	T (°C)	RH (%)	P	L	A	T (°C)	RH (%)	Diffuser 1	Diffuser 2	Diffuser 2	Diffuser 2	Diffuser 1	Diffuser 2	Exha 1	Exha 2										
		m	m	m ²	(°C)	(%)	m	m	m ²	(°C)	(%)	m	m	m ²	(°C)	(%)	Liter / detik				Liter / detik								Kali/jam					
1																																		
2																																		
3																																		
4																																		
5																																		
6																																		

Contoh Checklist Monitoring

FORMULIR PEMANTAUAN

CHECK LIST SUHU, KELEMBABAN DAN TEKANAN RUANGAN

BULAN: Maret RUANGAN: OP-1

SUHU (°C)	TANGGAL																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
25																																
24																																
23																																
22																																
21																																
20																																
19																																
18																																
17	17.1	17.3	17.6	16.0	16.2	16.5				16.5			17.1	17.3	17.6	17.2	17.2	17.7	17.9	18.2	18.2	18.5	18.7	18.7	18.8	18.8	18.8	18.8	18.8	18.8	18.8	
16																																
15																																

KELEMBABAN (35-75%)	TANGGAL																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	55.4	54.4	57.4	67.7	60.3	68.9		52.8	61.3	60.6		52.7	54.1	53.3	57.9	56.5	54.1	55.7	57.3	57.3	61.5	52.4	63.7	59.9	60.0		62.0				

TEKANAN	TANGGAL																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
POSITIVE	0	0	0	0	0	0		0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NEGATIVE																																
Inisial Petugas	M	M	M	M	M	M		M	M	M		M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	

Keterangan :

- Berikan tulisan "positif" pada kolom positif dan tulisan "negatif" pada kolom negatif
- Petugas menulis inisial nama pada kolom inisial
- Untuk Tekanan dan Kelembaban dituliskan dalam bentuk angka
- Jika terjadi perubahan Suhu, Kelembaban, dan Tekanan tidak sesuai standar, segera lapor ke Bagian Teknik

Penanggung Jawab
(.....)

054/rev00/SLU/PHC/2013

Titik Pengukuran Kandungan Partikel dan Temperatur

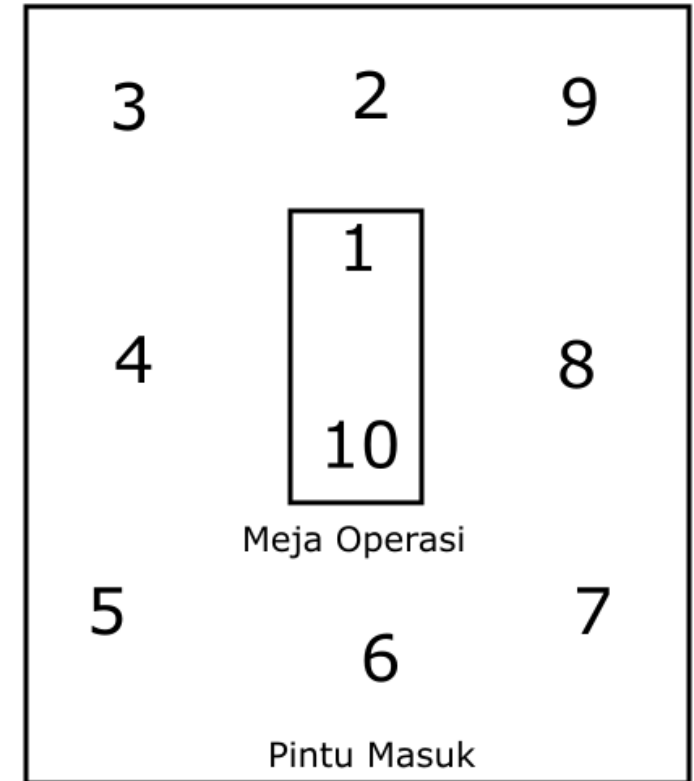
Titik Pengukuran merujuk ISO 14644-1:2015 dan posisi alat ukur terhadap lantai minimal : 80 cm dari lantai.

Nama Alat Ukur : Airborne Particle Counter

Contoh : Lighthouse Solair Portable 3100 Airborne Particle

Untuk Luasan 56 m² dibutuhkan 10 titik pengukuran

No	Kode Ruang	Nama Ruangan	Luas (m ²)	Jumlah Titik	Jumlah Partikel / m ³	
					0.5 mikron < 3520	5 mikron < 29



Ruang Operating Theatre 1

Table 6.4 Minimum Filter Efficiencies

Space Designation (According to Function)	Filter Bank No. 1 (MERV)^a	Filter Bank No. 2 (MERV)^a
Operating rooms (ORs); inpatient and ambulatory diagnostic and therapeutic radiology; inpatient delivery and recovery spaces	7	14
Inpatient care, treatment, and diagnosis, and those spaces providing direct service or clean supplies and clean processing (except as noted below); AII (rooms)	7	14
Protective environment (PE) rooms	7	HEPA ^{c,d}
Laboratory work areas, procedure rooms, and associated semirestricted spaces	13 ^b	NR
Administrative; bulk storage; soiled holding spaces; food preparation spaces; and laundries	7	NR
All other outpatient spaces	7	NR
Nursing facilities	13	NR
Psychiatric hospitals	7	NR
Resident care, treatment, and support areas in inpatient hospice facilities	13	NR
Resident care, treatment, and support areas in assisted living facilities	7	NR

NR = not required

a. *Informative Note:* The minimum efficiency reporting value (MERV) is based on the method of testing described in ANSI/ASHRAE Standard 52.2 (ASHRAE [2017a]).

b. Additional prefilters may be used to reduce maintenance for filters with efficiencies higher than MERV 7.

c. As an alternative, MERV-14 rated filters may be used in Filter Bank No. 2 if a tertiary terminal HEPA filter is provided for these spaces.

d. *Informative Note:* High-efficiency particulate air (HEPA) filters are those filters that remove at least 99.97% of 0.3 micron-sized particles at the rated flow in accordance with the testing methods of IEST RP-CC001.6 (IEST [2016]).

6

Reporting (Pelaporan)

1. Ruang Isolasi
2. Ruang Operasi

1. LAPORAN HASIL INSPEKSI RUANG ISOLASI

No	Nama Ruangan	Flowrate (Laju aliran) Grill 1	Flowrate (Laju aliran) Grill 2	Total Laju Aliran	Total Laju Aliran Udara per jam	Volume Ruangan	Pergantian Udara perjam	Minimal Pergantian Udara
		m ³ /detik	m ³ /detik	m ³ /detik	m ³ /jam	m ³	x perjam	perjam
1	401	-	-	-	-	69.65	-	12 kali Perjam
2	402	-	-	-	-	67.69	-	
3	403	-	-	-	-	69.52	-	
4	404	0.22		0.22	781.20	67.69	11.54	
5	405	-	-	-	-	0.00	-	

Tabel 2 terlihat hanya Ruang perawatan 404 yang mempunyai nilai pergantian udara perjam 11,54 kali per jam. Karena Ruang 404 terpasang diffuser udara suplai dan grill udara buang.

Tabel 5 Data Nilai Tekanan Ruang Pasien terhadap Ruang koridor

No	Nama Ruangan	Delta Pressure Ruang Pasien – Ruang Koridor
		Pascal
Zona 3	501	-2.4
	502	-6
	503	0
	504	-4.3
	505	0
	506	-5.9
	507	-1.6
	508	-5.8
	509	-3.2
Zona 1	510	2
	511	-20
	512	-1.4
	513	-18.1
	514	-1.8
	515	-2.3
	516	0.1
	517	5.1
	518	-2.4
	519	2.4
	520a	-2.7
	520b	-2.7
	521a	0.0
	521b	0.0
	522	-0.9
	523	-0.5
524	0.0	
525	-2.9	

2. LAPORAN HASIL INSPEKSI RUANG OPERASI

Tabel 1. Data Aliran Laju Udara Ruangan OK 7

No	Zona	Nama Ruangan	Volume ruangan m ³	Diffuser Udara <u>Suplai Ceiling</u>			Return/Exhaust Grill Ruang Pasien		<u>Laju Aliran Udara Suplai</u> m ³ /jam	<u>Laju Aliran Udara Return</u> m ³ /jam	Total Air Change per Hour kali / jam
				Diffuser ke	<u>Luasan Diffuser</u> m ²	<u>Laju Aliran Udara</u> liter/detik	<u>Luasan Return</u> m ²	<u>Laju Aliran Udara</u> liter/detik			
1	<u>Ruang Operasi</u>	OK 7	126,9	1	0,756	228	0,097	-242	820,8	-871,2	
				2	0,756	209	0,097	-218	752,4	-218,0	
				3	0,756	229	0,097	-110	824,4	-110,0	
				4	0,756	230	0,097	-182	828,0	-182,0	
Total <u>Laju Aliran Udara Suplai</u>									3225,6		
Total Udara Return										2707,2	
Total Air Change per Hour											25,4





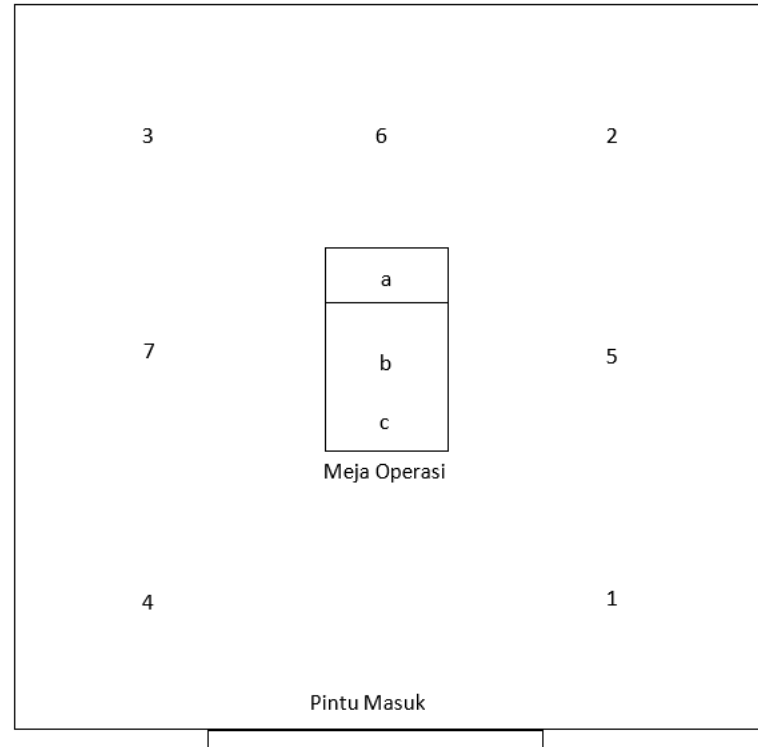
Tabel 2. Data Luasan Diffuser Udara Suplai (HEPA Filter Diffuser)

No	Zona	Nama Ruangan	Luas Ruangan (m ²)	Diffuser HEPA Filter Ruang OK			
				Filter ke	Panjang m	Lebar m	Luas m ²
1	OK	7	42,185	1	0,630	1,200	0,756
				2	0,630	1,200	0,756
				3	0,630	1,200	0,756
				4	0,630	1,200	0,756
						<u>Total Luasan Diffuser</u>	3,024 m²
				<u>Persentase Luasan Filter terhadap Luasan Ruangan</u>			= 7,2 %



POSISI PENGUKURAN PARTICLE

7.1. Denah Pengambilan Sampel Particle Counter



1. Pada area di dalam meja ruang operasi OK 7

a. Tabel 7.2.1. Data Hasil Pengukuran

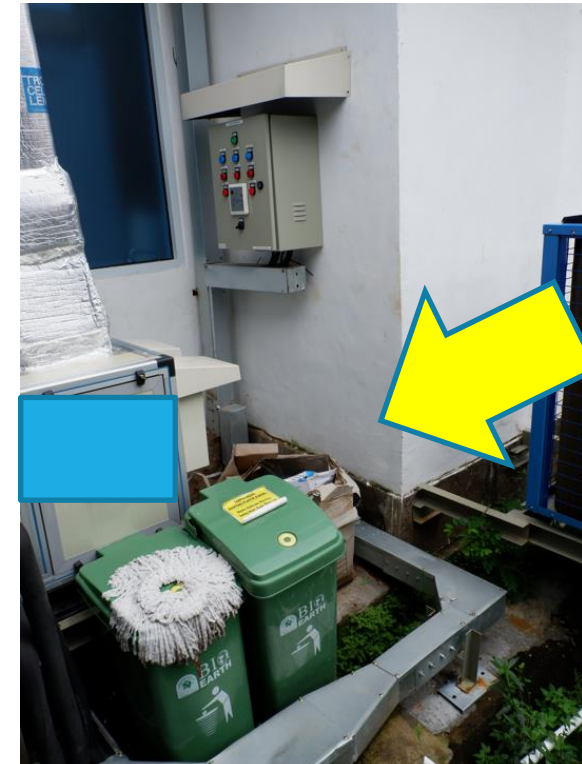
Partikel (μm)	UCL 95% (N/m^3)
0,3	37626
0,5	3110
1,0	879
5,0	120

Tabel 7.2.2. Standard Clean Room ISO 14644 : 2015

ISO Class	Jumlah Maximum Partikel di Udara (partikel dalam setiap meter kubik sama dengan atau lebih besar dari spesifikasi ukuran)					
	Ukuran Partikel					
	$\geq 0,1 \mu\text{m}$	$\geq 0,2 \mu\text{m}$	$\geq 0,3 \mu\text{m}$	$\geq 0,5 \mu\text{m}$	$\geq 1 \mu\text{m}$	$\geq 5 \mu\text{m}$
Class 2	100	24	10	4		
Class 3	1000	237	102	35	8	
Class 4	10.000	2.370	1.020	352	83	
Class 5	100.000	23.700	10.200	3.520	832	29
Class 6	1.000.000	237.000	102.000	35.200	8.320	293
Class 7				352.000	83.200	2.930
Class 8				3.520.000	832.000	29.300
Class 9				35.200.000	8.320.000	293.000

Temuan Ketidaksesuaian yang sering dijumpai

1. Kesalahan Penempatan Diffuser Suplai Udara (diffuser di area kepala pasien)
2. Penempatan return air grill atau lubang exhaust (di belakang bed terhalang bed pasien)
3. Air Handling Unit → Sistem Filter dijumpai ditumpuk dengan barang bekas
4. Ruangan anteroom yang digabung dgn ruangan koridor
5. Penempatan Filter Udara Buangan di atas ruangan pasien (menyulitkan penggantian filter)



Temuan Positif

Sistem Kelistrikan yang sesuai PUIL 2011 sangat mendukung kesiapan operasional sistem Ruang Isolasi Tekanan Negatif :

1. Papan Hubung Bagi sudah sesuai PUIL
2. Alat Monitor : Arus, Tegangan, Cos Phi
3. Pengaman Bagian Konduktif Terbuka
4. Penyama Potensial
5. Putaran Phasa (RST / Clock Wise)



KESIMPULAN

- * Penggunaan Material Dinding, Langit-langit (Sandwich Panel) dapat mengurangi potensi pressure losses di dalam ruang pasien
- * Kelaikan ruangan isolasi / ruangan operasi sangat dipengaruhi oleh kesesuaian system HVAC, bahan lantai, dinding, jendela yang dipakai terhadap peraturan / standar
- * Pengukuran temperature, kelembaban relatif, tekanan udara , pergantian udara perjam dilakukan dalam waktu yang singkat. Sehingga hasil pengukuran yang didapatkan hanya mewakili nilai sesaat performa sistem HVAC pada rentang waktu tertentu.
- * Kualitas Pelaporan Hasil Testing dan Commisioning sistem tata udara harus mampu menggambarkan / menampilkan performa sistem tata udara yang diuji



TALKSHOW AND WORKSHOP
HOSPITAL HVAC SYSTEM
DURING ENDEMIC COVID-19

Thank You

“DOKUMEN
ADALAH MILIK
TIDAK BOLEH
DISEBARLUASKAN
DUPLOKASI SECARA
ONLINE”