

**SULIT**



**KEMENTERIAN PENDIDIKAN TINGGI  
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI**

**BAHAGIAN PEPERIKSAAN DAN PENILAIAN  
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI  
KEMENTERIAN PENDIDIKAN TINGGI**

**JABATAN KEJURUTERAAN AWAM**

**PEPERIKSAAN AKHIR**

**SESI II : 2022/2023**

**DCB40153: AIR CONDITIONING SYSTEM TECHNOLOGY**

**TARIKH : 14 JUN 2023**

**MASA : 8.30 PG – 10.30 PG (2 JAM)**

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Kertas ini mengandungi **SEPULUH (10)** halaman bercetak.

Bahagian A: Subjektif (2 soalan)

Bahagian B: Subjektif (4 soalan)

Dokumen sokongan yang disertakan : Formula, Lampiran 1-5.

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**JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN**

(CLO yang tertera hanya sebagai rujukan)

**SULIT**

**SECTION A: 50 MARKS****BAHAGIAN A: 50 MARKAH****INSTRUCTION:**

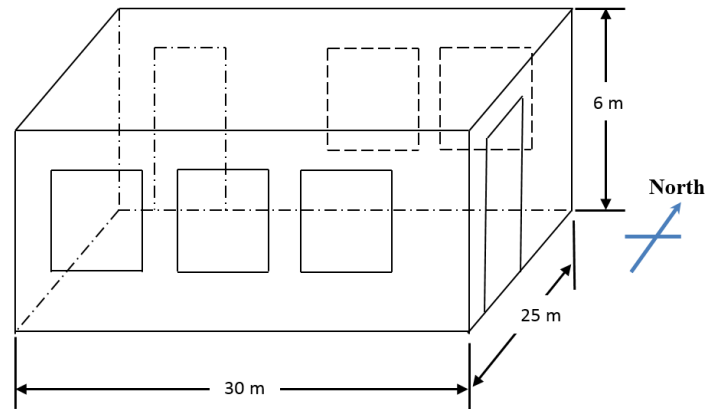
This section consists of **TWO (2)** subjective questions. Answer **ALL** questions.

**ARAHAN:**

*Bahagian ini mengandungi **DUA (2)** soalan subjektif. Jawab **semua** soalan.*

**QUESTION 1****SOALAN 1**

- CLO2 (a) Describe **TWO (2)** sources of cooling load in a building.  
*Jelaskan **DUA (2)** sumber beban penyejukan di dalam bangunan.*  
[5 marks]  
[5 markah]
- CLO2 (b) Sketch by labelling the summer air conditioning system.  
*Lakarkan berserta label sistem pendingin hawa musim panas.*  
[10 marks]  
[10 markah]
- CLO2 (c) An office measuring 30 m x 25 m x 6 m has walls constructed from brick, complete with glass windows and doors as shown in **Figure A1**. The internal temperature is 24°C while external temperature is 38°C. If the internal load is 40 kW, calculate the total cooling load of the office.  
*Sebuah pejabat berukuran 30 m x 25 m x 6 m dibina dengan bata dan lengkap dengan tingkap kaca dan pintu seperti yang ditunjukkan dalam **Rajah A1**. Suhu dalaman adalah 24°C manakala suhu dalam adalah 38°C. Jika beban dalaman adalah 40 kW, kirakan jumlah beban penyejukan pejabat tersebut.*

Figure A1/ *Rajah A1*Building details/ perincian bangunan

Window size: 1.2 m x 1.8 m / *saiz tingkap: 1.2 m x 1.8 m*

Door size : 1.2 m x 2.5 m / *saiz pintu 1.2 m x 2.5 m*

U-value / nilai-u

wall =  $2.61 \text{ W/m}^2\text{K}$  / *dinding =  $2.61 \text{ W/m}^2\text{K}$*

ceiling =  $3.4 \text{ W/m}^2\text{K}$  / *siling =  $3.4 \text{ W/m}^2\text{K}$*

floor =  $3.5 \text{ W/m}^2\text{K}$  / *lantai =  $3.5 \text{ W/m}^2\text{K}$*

glass window =  $3.2 \text{ W/m}^2\text{K}$  / *tingkap kaca =  $3.2 \text{ W/m}^2\text{K}$*

door =  $1.5 \text{ W/m}^2\text{K}$  / *pintu =  $1.5 \text{ W/m}^2\text{K}$*

[10 marks]

[10 markah]

**QUESTION 2****SOALAN 2**

CLO 2

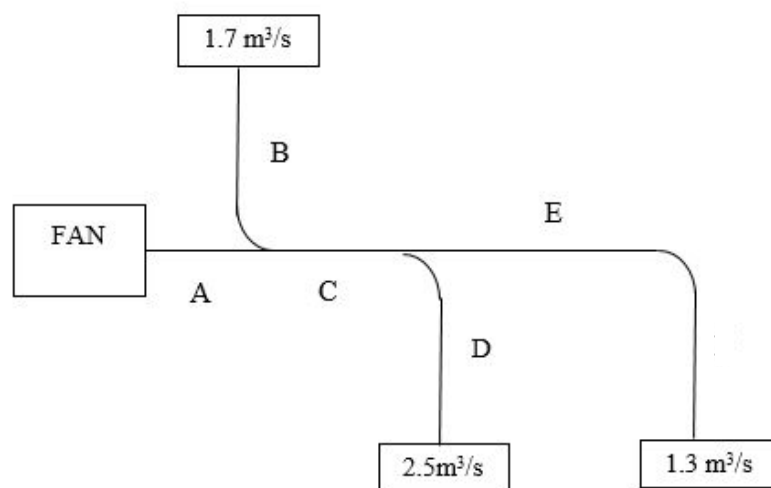
(a) Explain **THREE (3)** purposes of ventilation.*Terangkan **TIGA (3)** tujuan pengudaraan.*

[5 marks]

[5 markah]

- CLO2 (b) **Figure A2** shows the supply air duct system for a space. Based on **chart 4.33 (Appendix 1)**, by using equal friction method, determine the duct size for duct section A, B, D and E, Assume the air velocity at duct AB is 7 m/s.

*Rajah A2 menunjukkan sistem sesalur bekalan udara bagi sebuah ruang. Berdasarkan kepada carta 4.33 (Lampiran 1), dengan menggunakan kaedah geseran sama, tentukan saiz sesalur untuk sesalur bahagian AB, BC, CD, DE, BH dan CF. Diberi halaju udara di dalam sesalur AB ialah 7 m/s.*



**Figure A2/ Rajah A2**

[10 marks]

[10 markah]

- CLO2 (c) Barkoba restaurant' dining room is being upgraded to be air-conditioned. Usually this shop operates from 7.00 am to 7.00 pm and can accommodate 50 customers at a time. The cumulative external heat load is 3500 watts. The internal heat load consists of lighting load (1800 watts), desktop computer load (100 watts), Wi-Fi router load (10 watts) and P.A system load (30 watts). Given the sensible heat and latent heat for each customer are 72 watts and 45 watts respectively. By referring to the catalogue in **Table A2 (Appendix 2)**, select the preferable air conditioner unit for the Barkoba restaurant.

*Kedai makan Barkoba sedang dinaiktaraf untuk menjadikan ruang makan dalam kedainya berhawa dingin. Kebiasaannya kedai ini beroperasi bermula dari pukul 7.00 pagi hingga 7.00 petang dan boleh memuatkan 50 orang pelanggan pada satu-satu masa. Beban haba luaran terkumpul adalah 3500 watt. Beban haba dalaman pula terdiri daripada beban pencahayaan (1800 watt), beban komputer meja (100 watt), beban penghala Wi-Fi (10 watt), beban projektor (150 watt) dan beban sistem P.A (30 watt). Diberi haba deria dan haba pendam bagi setiap pelanggan masing-masing adalah 72-watt dan 45 watt. Dengan merujuk kepada katalog pada **Jadual A2 (Lampiran 2)**, pilih unit penyamanan udara yang sesuai bagi kedai makan Barkoba.*

[10 marks]

[10 markah]

**SECTION B : 50 MARKS****BAHAGIAN B : 50 MARKAH****INSTRUCTION:**

This section consists of **FOUR (4)** subjective questions. Answer **ALL** questions.

**ARAHAN:**

*Bahagian ini mengandungi **EMPAT (4)** soalan subjektif. Jawab **semua** soalan.*

**QUESTION 1****SOALAN 1**

- |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CLO1 | <p>(a) Describe the psychometric properties of the dry bulb temperature and relative humidity.</p> <p><i>Jelaskan sifat-sifat psikometrik bagi suhu bebuli kering dan kelembapan relatif.</i></p> <p style="text-align: right;">[5 marks]<br/>[5 markah]</p>                                                                                                                                                                                                                                                                                                  |
| CLO1 | <p>(b) Illustrate the winter air conditioning system.</p> <p><i>Gambarkan sistem penyamanan udara musim sejuk.</i></p> <p style="text-align: right;">[10 marks]<br/>[10 markah]</p>                                                                                                                                                                                                                                                                                                                                                                           |
| CLO1 | <p>(c) Purnama Holding is building a medium-scale office with a capacity of 30 people at Hornet Hill Residence. The office will be equipped with a summer air conditioning system based on CIBSE standard. The conditions outside the office are 34°C DBT and 27°C WBT while the conditions inside the office are 24°C DBT and 50% RH. The air volume that needs to be supplied into this office is 0.4 m<sup>3</sup>/min/person. By using the <b>psychometric chart (Appendix 3)</b>, calculate the sensible heat, SH that needs to be removed from air.</p> |

*Purnama Holding akan membina sebuah pejabat berskala sederhana dengan kapasiti 30 orang di Bukit Hournet Residence. Pejabat tersebut akan disediakan sekali dengan sistem penyamanan udara musim panas berdasarkan piawai CIBSE. Keadaan luar pejabat adalah 34°C DBT dan 27°C WBT manakala keadaan dalam pejabat adalah 24°C DBT dan 50% RH. Isipadu udara yang perlu dibekalkan ke dalam pejabat ini adalah 0.4 m<sup>3</sup>/min/orang. Dengan menggunakan **carta psikometrik (Lampiran 3)**, kirakan haba deria, SH yang perlu dikeluarkan dari udara.*

[10 marks]

[10 markah]

**QUESTION 2****SOALAN 2**

- CLO1 (a) Describe **FIVE (5)** ways to reduce solar radiation from getting into building.  
*Jelaskan **LIMA (5)** cara untuk mengurangkan solar radiasi daripada memasuki dalam bangunan.*
- [5 marks]  
[5 markah]
- CLO1 (b) Explain **FIVE (5)** factors that affect heat loads in a room.  
*Terangkan **LIMA (5)** faktor yang mempengaruhi beban haba dalam bangunan.*
- [10 marks]  
[10 markah]
- CLO1 (c) A room measuring 40 m x 32 m x 5 m has walls constructed from brick, complete with glass windows and doors as shown in **Figure B2**. Given the internal temperature is 21°C and external temperature is 38°C. By referring to **Table B2**, calculate the heat gain accumulated from the wall, ceiling, floor, glass window and door.

Sebuah bilik berukuran  $40\text{ m} \times 32\text{ m} \times 5\text{ m}$  mempunyai binaan dinding daripada bata dan lengkap dengan tingkap kaca dan pintu seperti yang ditunjukkan dalam **Rajah B2**. Diberi suhu dalaman adalah  $21^\circ\text{C}$  dan suhu luaran ialah  $38^\circ\text{C}$ . Dengan merujuk kepada **Jadual B2**, kirakan pengumpulan beban haba daripada dinding, siling, lantai, tingkap kaca dan pintu.

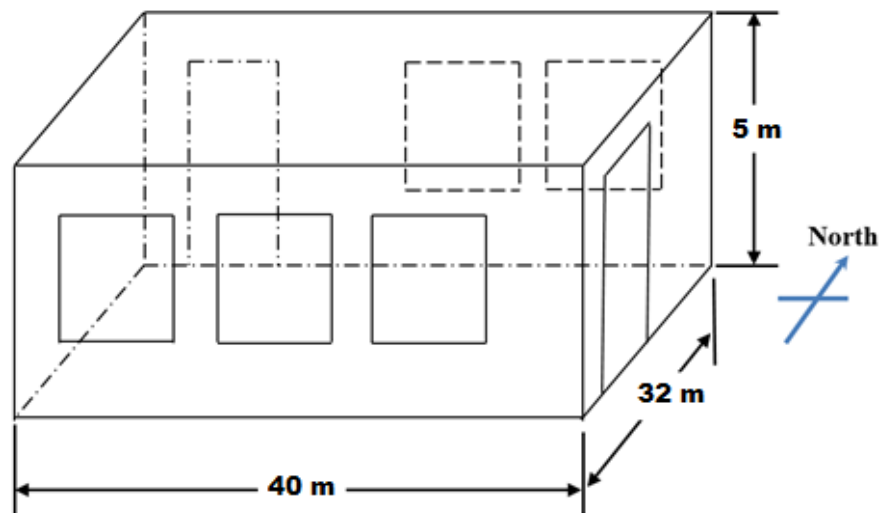


Figure B2/ *Rajah B2*

Table B2/ *Jadual B2*

|                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Building details/<br/>perincian<br/>bangunan</b> | Window size: $1.2\text{ m} \times 1.8\text{ m}$ / <i>saiz tingkap: <math>1.2\text{ m} \times 1.8\text{ m}</math></i><br>Door size : $1.2\text{ m} \times 2.5\text{ m}$ / <i>saiz pintu : <math>1.2\text{ m} \times 2.5\text{ m}</math></i>                                                                                                                                                                                                                                                        |
| <b>U-value/ nilai-U</b>                             | wall = $2.61\text{ W/m}^2\text{K}$ / <i>dinding = <math>2.61\text{ W/m}^2\text{K}</math></i><br>ceiling = $3.4\text{ W/m}^2\text{K}$ / <i>siling = <math>3.4\text{ W/m}^2\text{K}</math></i><br>floor = $3.5\text{ W/m}^2\text{K}$ / <i>lantai = <math>3.5\text{ W/m}^2\text{K}</math></i><br>glass window = $3.2\text{ W/m}^2\text{K}$ / <i>tingkap kaca = <math>3.2\text{ W/m}^2\text{K}</math></i><br>door = $1.5\text{ W/m}^2\text{K}$ / <i>pintu = <math>1.5\text{ W/m}^2\text{K}</math></i> |

[10 marks]

[10 markah]

**QUESTION 3****SOALAN 3**

- CLO1 (a) Explain the features of duct shapes from the economical perspective.

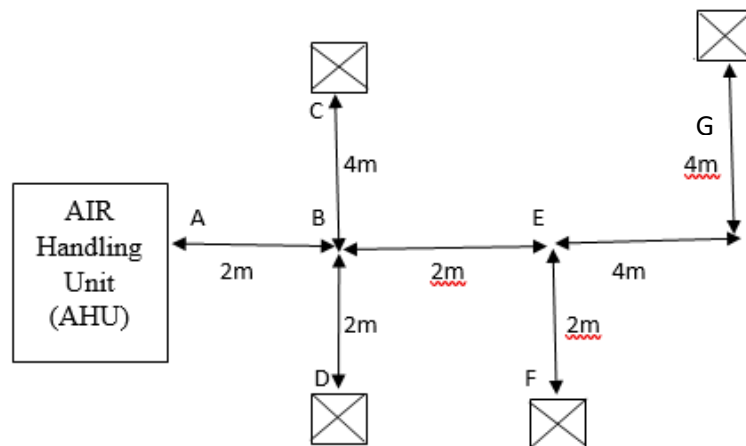
*Terangkan ciri-ciri bentuk sesalur udara dari perspektif ekonomi.*

[5 marks]

[5 markah]

- CLO1 (b) According to **Figure B3** and **chart 4.33 (Appendix 4)**, determine air volume and circular duct size for duct AB, BC, BD, BE, EF and EG by using equal friction method. Given air volume at each outlet is  $0.45 \text{ m}^3/\text{s}$ . Assume the air velocity at duct AB is  $7 \text{ m/s}$ .

*Berdasarkan kepada **Rajah B3** dan **carta 4.33 (Lampiran 4)**, tentukan isipadu udara dan saiz sesalur bulat bagi salur AB, BC, BD, BE, EF dan EG dengan menggunakan kaedah geseran sama. Diberi isipadu udara disetiap keluaran adalah  $0.45 \text{ m}^3/\text{s}$ . Anggapkan bahawa halaju udara pada sesalur AB adalah  $7 \text{ m/s}$ .*



**Figure B3/ Rajah B3**

[10 marks]

[10 markah]

- CLO1 (c) By referring to **QB3(b)** and **Chart 4.19 (Appendix 5)**, estimate the rectangular duct size for duct AB, BC, BD, BE, EF and EG. Given the duct dimension ratio is 2:1.

*Dengan merujuk kepada QB3(b) dan Carta 4.19 (Lampiran 5), anggarkan saiz sesalur segiempat bagi salur AB, BC, BD, BE, EF dan EG. Diberi nisbah dimensi sesalur ialah 2:1.*

[10 marks]

[10 markah]

#### QUESTION 4

#### SOALAN 4

- CLO1 (a) Describe the meaning of supply air duct and return air duct.  
*Jelaskan maksud sesalur udara bekal dan sesalur udara balikkan.*

[5 marks]

[5 markah]

- CLO1 (b) Illustrate the vane axial fan.  
*Gambarkan kipas aliran paksi berbilah.*

[ 10 marks]

[10 markah]

- CLO1 (c) A fan delivers 6500 m<sup>3</sup>/min at a static pressure of 500 Pa when operating at a speed of 1500 RPM and requires an input of 7.5 hp. Estimate the speed, static pressure and power that will be obtained if the fan is added with 650 m<sup>3</sup>/min of air flow rate.

*Sebuah kipas menghasilkan 6500 m<sup>3</sup>/min pada tekanan statik 500 Pa apabila beroperasi pada kelajuan 1500 RPM dan memerlukan kemasukkan 7.5 hp. Anggarkan kelajuan, tekanan statik dan kuasa yang boleh didapati jika kadar alir udara kipas ini di tambah sebanyak 650 m<sup>3</sup>/min.*

[ 10 marks]

[10 markah]

#### SOALAN TAMAT

## FORMULA

$$Q = \frac{\text{nos} \times \text{power} \times \text{hours}}{24}$$

$$Q_p = \frac{\text{no of people} \times (SH + LH) \times \text{hours}}{24 \text{ hours}}$$

$$Q_{LH} = 0.8 N V (m_{so} - m_{sr})$$

$$SH = m_a (h_3 - h_2)$$

$$LH = m_a (h_1 - h_3)$$

$$SHF = \frac{SH}{SH+LH}$$

$$\frac{m_1}{m_2} = \frac{h_3 - h_2}{h_1 - h_3}$$

$$m_a = \frac{Q_a}{V_s}$$

$$Q = \frac{V \times ACH}{3600}$$

$$\text{Supply Air Rate} = \frac{\text{Volume Flow Rate}}{\text{Room volume}}$$

$$Q = \frac{\text{mass flow rate} \left( \frac{kg}{s} \right)}{\text{density of air} \left( \frac{kg}{m^3} \right)}$$

$$p_f = \frac{fL}{m} \left( \frac{v}{4.04} \right)^2$$

$$Q = AV$$

$$m = \frac{A}{p}$$

$$P = \pi D$$

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$$

$$\frac{P_1}{P_2} = \left[ \frac{N_1}{N_2} \right]^2$$

$$\frac{KW_1}{KW_2} = \left[ \frac{N_1}{N_2} \right]^3$$

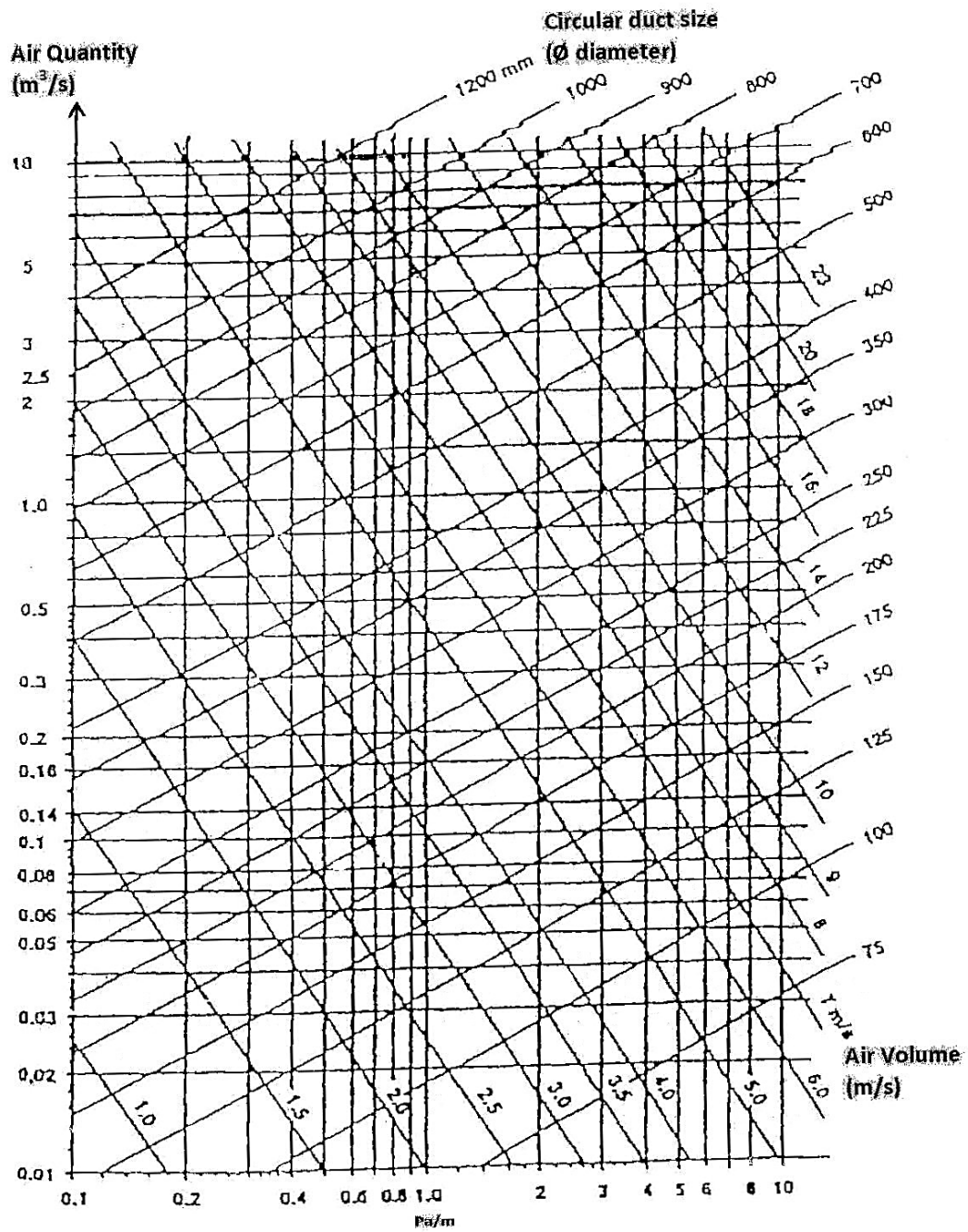
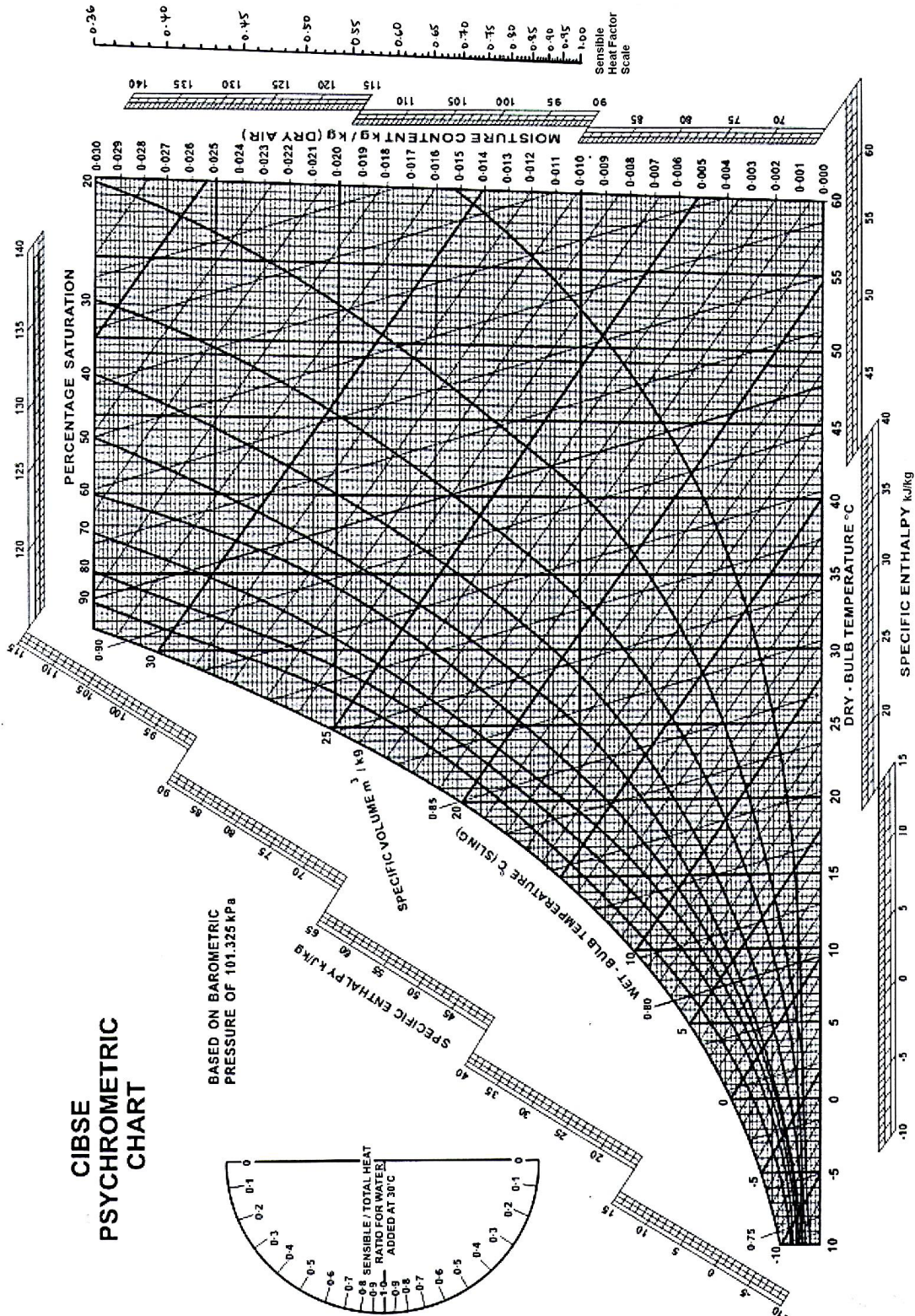


Chart 4.33: Determination of Air Duct Sizing

## Appendix 2/ Lampiran 2

**Table A2/ Jadual A2**

| SPECIFICATIONS   |                  |                                | Cooling [ ]: Outdoor Unit      |                                |  |
|------------------|------------------|--------------------------------|--------------------------------|--------------------------------|--|
| MODEL            | (50Hz)           | CS-VU10UKH-1<br>[CU-VU10UKH-1] | CS-VU13UKH-1<br>[CU-VU13UKH-1] | CS-VU18UKH-1<br>[CU-VU18UKH-1] |  |
| Cooling Capacity | (min-max) kW     | 2.80 [0.84-3.28]               | 3.66 (0.92-420)                | 5.20 (1.10-5.80)               |  |
|                  | (min-max) Btu/h  | 9,550 (2,860-11,200)           | 12,500 (3,140-14,300)          | 17,700 (3,750-19,800)          |  |
| EER              | (min-max) Btu/hW | 13.64 (12.71-12.44)            | 13.59 (12.08-12.43)            | 12.21 (12.93-11.86)            |  |
|                  | (min-max) W/W    | 4.00 (3.73-3.64)               | 3.98 (3.54-3.65)               | 3.59 (3.79-3.47)               |  |
| CSPF             | Wh/Wh            | 5.59                           | 5.40                           | 5.24                           |  |
|                  | Voltage V        | 230                            | 230                            | 230                            |  |



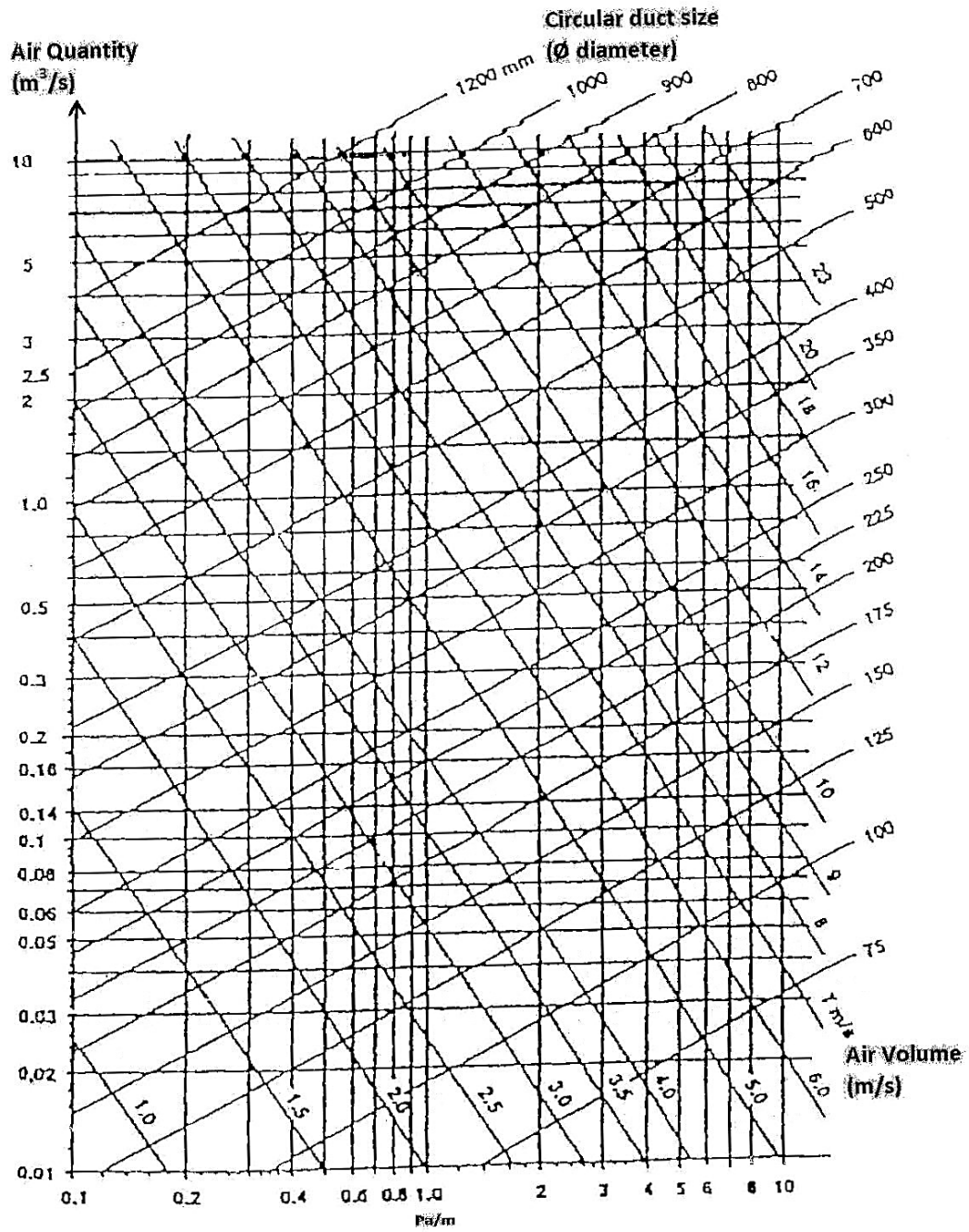


Chart 4.33: Determination of Air Duct Sizing

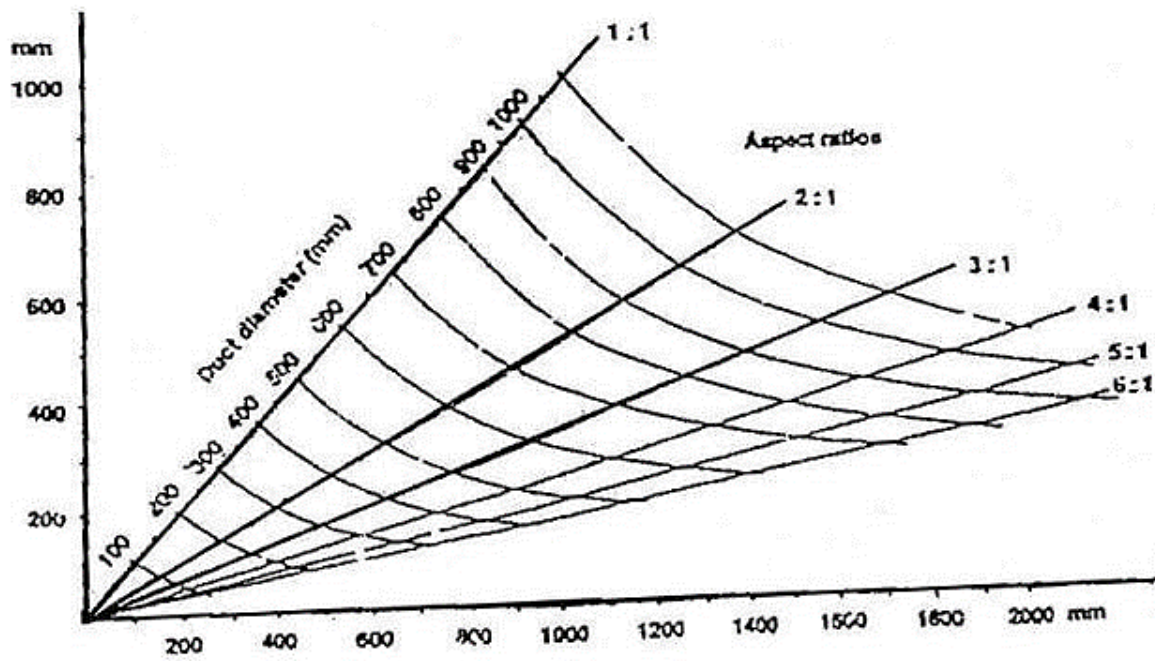


Chart 4.19: Circular to Rectangular Ductwork Conversion Chart