



UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2010 SESSION

SUBJECT CODE : FCB 20101
SUBJECT TITLE : VIBRATION
LEVEL : BACHELOR
TIME / DURATION : 9.00am – 11.00am
(2 HOURS)
DATE : 27 APRIL 2010

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper **CAREFULLY**.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This questions paper consists of **THREE (3)** questions. Answer **ALL** questions.
6. Answer **ALL** questions in English.
7. Formula is appended.

THERE ARE 2 PAGES OF QUESTIONS AND 11 PAGES OF APPENDIX, EXCLUDING THIS PAGE.

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1

Define the following concept:

- a) Natural Frequency
- b) Transmissibility

(5 marks)

Question 2

Referring to figure Q2. A motor weighting 40kg is supported by **four springs**, each having a spring stiffness of 20 kN/m. The unbalanced force of the rotor is equivalent to a weight of 50g located at 100 mm from the axis of rotation.

Calculate:

- a) the motor speed in rpm at which the resonance occurs
- b) the amplitude of the vibration of the motor at a speed of 1000rpm

(7 marks)

(8 marks)

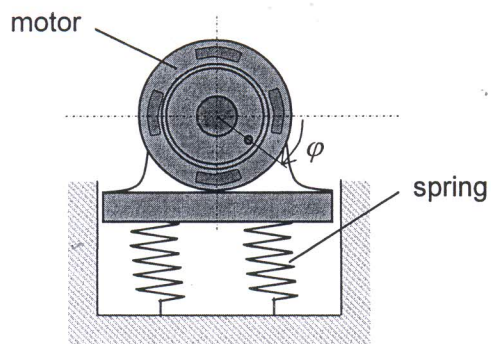


Figure Q2: Fan motor and 4 springs

Question 3

Referring to figure Q3, the following are the Air Handling Unit (AHU) specifications:

Power supply	= 240V-1 ϕ -50Hz
$\eta_{\text{mechanical}}$	= 80%
weight of Fan Motor	= 50 kg
weight of Fan Blower	= 15 kg
weight of Frame	= 16 kg

(Note: Let 20% as Safety Factor (S.F) for the final weight calculation)

For all springs at corner A,B,C and D:

- a) Calculate spring static deflection δ_{st} in (mm) and spring stiffness k in (N/m) (20 marks)
- b) Refer to Appendix attached, select the closest suitable spring for each corner (10 marks)

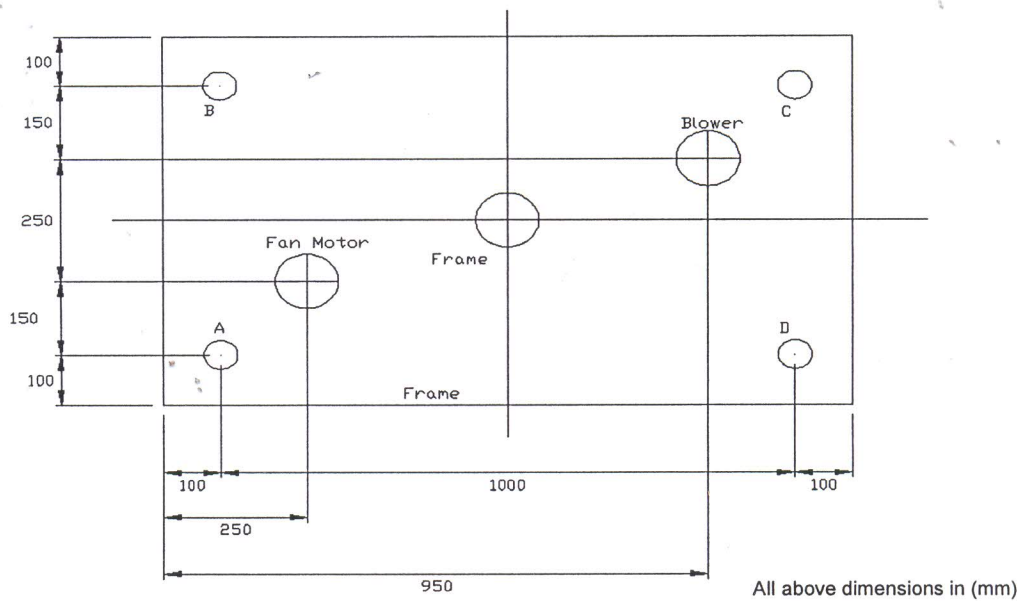
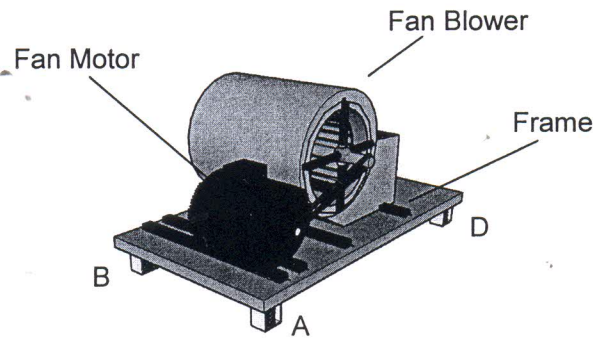


Figure Q3: AHU System

END OF QUESTION

APPENDICES

VIBRATION:VIBRATION:

$$F = k\delta$$

$$f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}} = \frac{15.8}{\sqrt{\delta_{ST}}} \text{ where } \delta_{ST} \text{ in mm}$$

$$\tau = \frac{x_m}{\delta_{ST}} = \frac{1}{1 - \left(\frac{f_d}{f_n}\right)^2} \text{ where } \tau = \text{transmissibility}$$

$$\tau = \frac{x_m}{\delta_{ST}} = \frac{1 + \left(2\varepsilon \frac{f_d}{f_n}\right)^2}{\sqrt{\left[1 - \left(\frac{f_d}{f_n}\right)^2\right]^2 + \left[2\varepsilon \frac{f_d}{f_n}\right]^2}} \text{ where}$$

$$\varepsilon = \frac{c}{c_0}, c_0 = \text{critical damping}$$

$$x_m = \frac{\delta_m}{1 - (f_d/f_n)^2}$$

$$\tan \varphi = \frac{c \times f_d}{k - mf_d^2} = \frac{2(c/c_0)(f_d/f_n)}{1 - (f_d/f_n)^2}$$

$$v_m = x_m f_n, a_m = x_m f_n^2$$

$$\text{velocity: } v = \omega r, \text{ where } \omega = 2\pi (\text{in radian}), \text{ Note: } 2\pi (\text{rad}) = 360^\circ = 1 \text{ rev}$$

$$a_t = \alpha r = \dot{\theta} r$$

$$a_n = \omega^2 r$$

$$\text{Centrifugal Force} = F_n$$

$$F_n = \frac{mv^2}{r}; F_n = m\omega^2 r$$

$$A = 1 - \tau \text{ where } A = \text{Attenuation (Vibration Isolation efficiency)}$$

$$N (\text{rpm}) = \frac{(2 \times \text{Freq}) \times 60 \text{ sec/min} \times \eta_m}{\text{Poles}}$$

VIBRATION ISOLATOR SELECTION PROCEDURE

1. DETERMINE THE SUGGESTED ISOLATION EFFICIENCY.

REFER TABLE AV 01

2. DETERMINE THE STATIC DEFLECTION CAUSED BY THE VIBRATION.

REFER TABLE AV 02

3. SELECT THE TYPE OF VIBRATION ISOLATOR

REFER TABLE AV 02 OR CATALOGUE

4. CHECK THE ISOLATION SELECTION

REFER TABLE AV 03

5. DETERMINE THE MINIMUM DEFLECTION REQUIRED.

REFER TABLE AV 04

SEMESTER :

DATE :

DURATION :

PAGE : 3/11

GENERAL SUMMARY

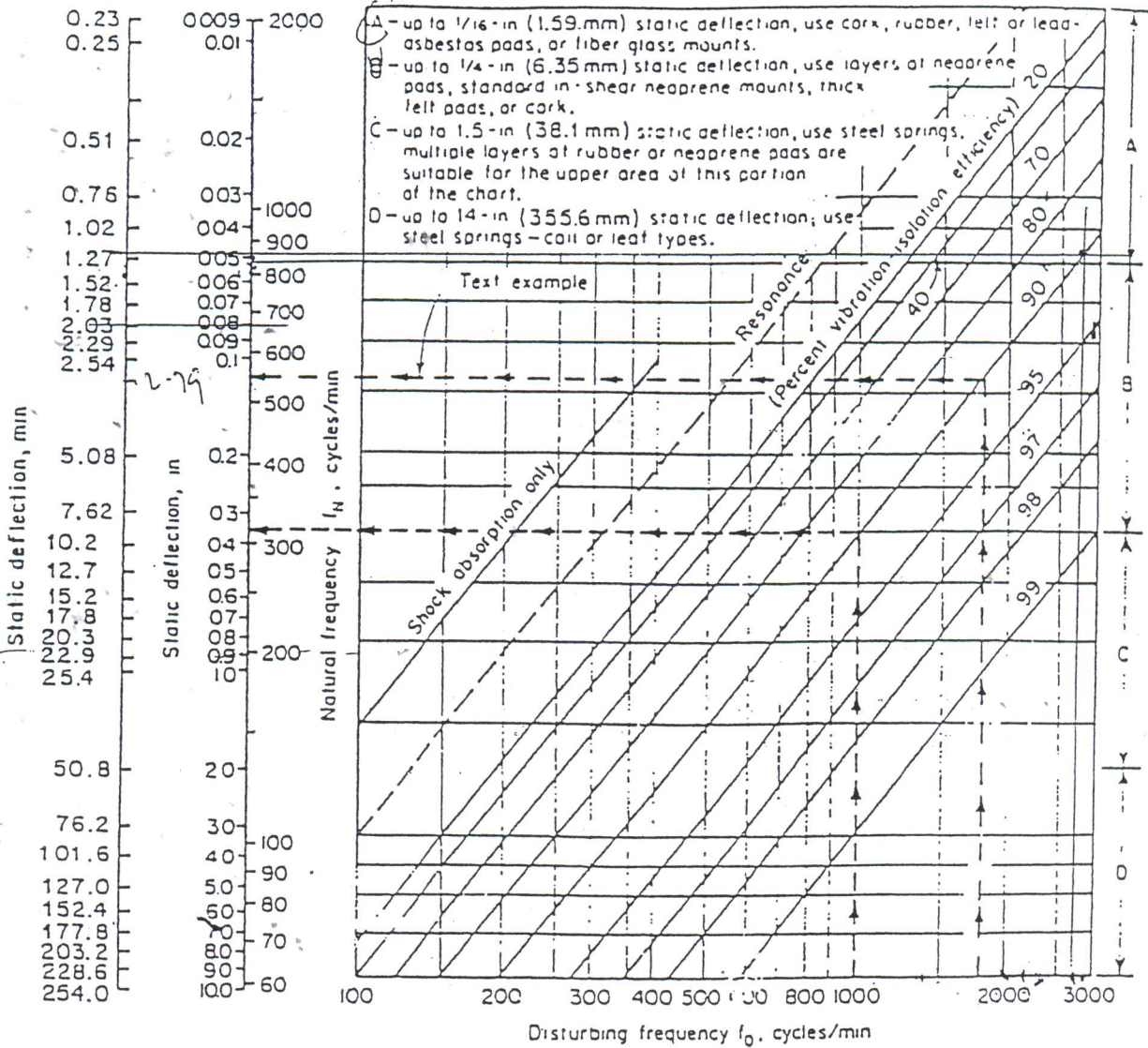
TABLE AV 01
SUGGESTED ISOLATION EFFICIENCIES IN HVAC

Equipment	Installed efficiency, %
Absorption units	95
Steam generators	95
Centrifugal compressors	98
Reciprocating compressors:	
Up to 15 hp (11.2 kW)	85
20-60 hp (14.9-44.8 kW)	90
75-150 hp (56.0-111.9 kW)	95
Packaged air conditioners	90
Centrifugal fans:	
80 r/min and above; all diameters	90-95
350-800 r/min; all diameters	70-90
200-350 r/min; 48-in (121.9-cm) diameter or smaller	
200-350 r/min; 54-in (137.2-cm) diameter or larger	70-80
Centrifugal pumps	95
Cooling towers	85
Condensers	80
Fan coil units	80
Piping	95

GENERAL SUMMARY

TABLE AV 02

DEFLECTION FOR VARIOUS DISTURBING FREQUENCIES



GENERAL SUMMARY

TABLE AV 03
THEORETICAL VIBRATION-ISOLATION EFFICIENCIES

Isolation material	Average static deflection, in (mm)	Average natural frequency	Efficiencies, percent											
			350 r/min	500 r/min	600 r/min	800 r/min	1000 r/min	1200 r/min	1500 r/min	1800 r/min	3000 r/min	3600 r/min		
2-in (50.8-mm) thick standard-density cork	0.08 (2.03)	By test 1420	...	...	...	...	...	...	...	...	...	...	72	82
Type W waffle pad	Curvature (0.89) corrected, 0.035	1000	...	...	...	...	...	...	...	...	20	55	87	92
Two layers of W waffle pad	Curvature (1.78) corrected, 0.070	710	...	...	...	...	...	...	46	71	82	82	93	96
Single-deflection rubber mountings	0.20 (5.08)	420	...	...	...	62	79	86	93	91	94	98	98	99
Double-deflection rubber mountings	0.40 (10.16)	300	...	44	67	84	90	93	96	97	97	99	99	Almost perfect
Standard spring mountings	1.00 (25.4)	188	70	85	89	94	96	97	98	99	99	99	Almost perfect	Almost perfect
Double-deflection rubber and spring mountings	1.40 (35.6)	160	75	89	93	96	97	98	99	99	Almost perfect	Almost perfect	Almost perfect	Almost perfect

SEMESTER:

DATE:

DURATION

PAGE: 6/11

GENERAL SUMMARY

TABLE AV 04
MINIMUM MOUNTING DEFLECTIONS

Operating speed, r/min	Basement—negligible floor deflection, in (mm)	Rigid concrete floor, in (mm)	Upper story—light-concrete floor, in (mm)	Wood floor, in (mm)
300	1.50 (38.1)	3.00 (76.2)	3.50 (88.9)	4.00 (101.6)
500	0.63 (16.0)	1.25 (31.8)	1.65 (41.9)	1.95 (49.5)
800	0.25 (6.35)	0.60 (15.2)	1.00 (25.4)	1.25 (31.6)
1200	0.20 (5.08)	0.45 (11.4)	0.80 (20.3)	1.00 (25.4)
1800	0.10 (2.54)	0.35 (8.9)	0.80 (20.3)	1.00 (25.4)
3600	0.03 (0.76)	0.20 (5.08)	0.80 (20.3)	1.00 (25.4)
7200	0.03 (0.76)	0.20 (5.08)	0.80 (20.3)	1.00 (25.4)

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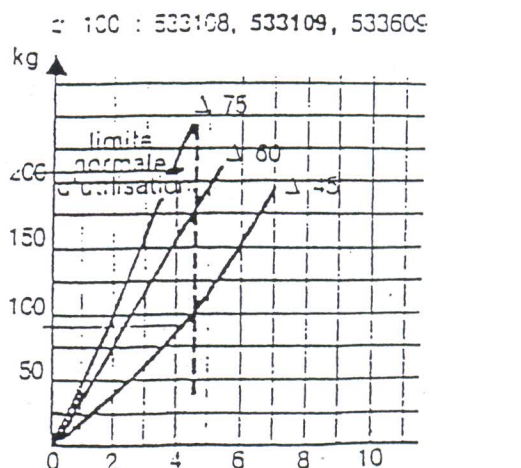
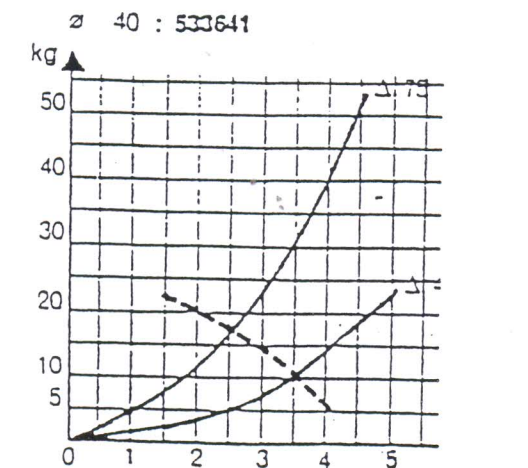
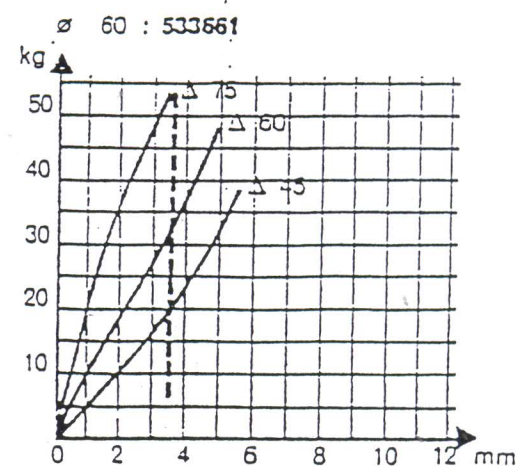
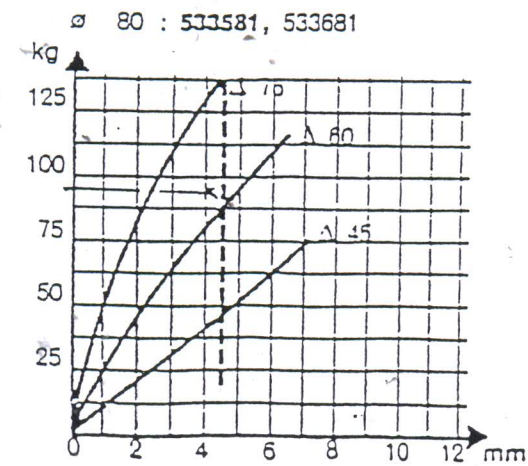
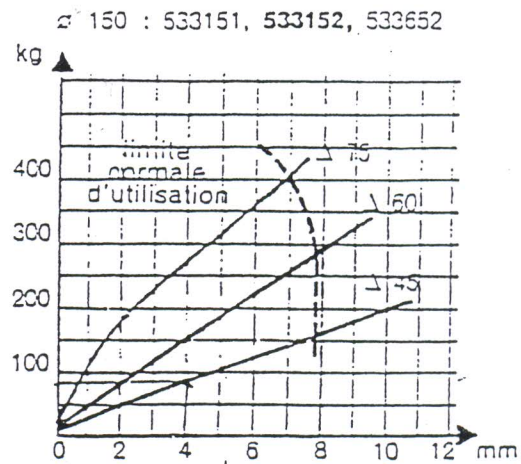
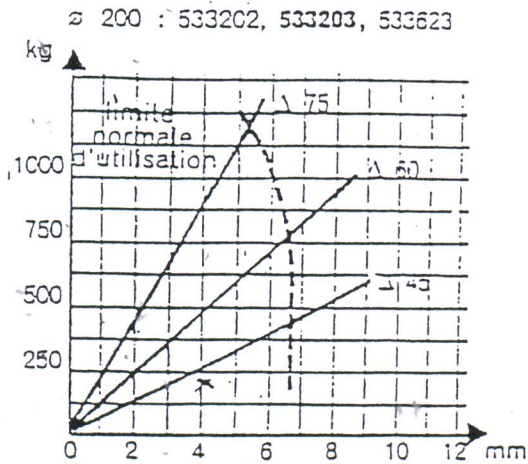
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DURATION:

PAGE: 2/11

GENERAL SUMMARY

HARDNESS SELECTION TABLES



Vibration Isolation

Table 2: For Concrete Floor Slab In Less Critical Application

Recommended Isolation Efficiencies (150mm (6inch) Concrete Floor Slab)

Less Critical Areas		Transmissibility %	Isolation Efficiency %
Centrifugal compressors		6	94
Centrifugal fans	greater than 25HP	10	90
Reciprocating compressors	greater than 50HP		
Pumps	greater than 5HP		
Unit air conditioners	supported		
Fan coil units	supported		
Axial flow fans	greater than 50HP	20	80
Centrifugal fans	5 to 25HP		
Reciprocating compressors	10 to 50HP		
Pumps	3 to 5HP		
Air handling units			
Unit air conditioners	hung		
Fan coil units	hung		
Axial flow fans	10 to 50HP	25	75
Axial flow fans	up to 10HP	30	70
Centrifugal fans	up to 10HP		
Reciprocating compressors	up to 10HP		
Pumps	up to 3HP		
Pipes	hung		
Gas fired boilers (more than 100 000BThU, 25kW)		12 to 20Hz	
Oil fired boilers (more than 60 000BThU, 15kW)		12 to 20Hz	

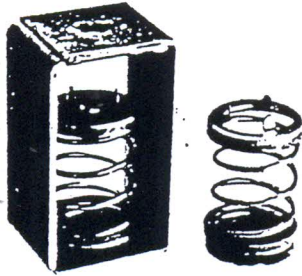
SEMESTER : 2

DATE :

DURATION :

PAGE : 9/11

VIBRATION ISOLATORS SPRING MOUNTS



FEATURES

An easily-installed, all-purpose spring mount in which the spring can be quickly interchanged to give a wide range of load-deflection characteristics, provides effective isolation of noise and vibration.

We have only featured the spring mounts most commonly used with the equipment shown in this catalogue.

Types XSB and XL only

- heavy-duty steel spring.
- colour-coded for easy identification of the load range.
- built-in levelling bolt with locking capscrew, capable of compensating for full static deflection.
- separate top and bottom location cups.
- rubber-isolated bolt hole in base.
- moulded noise-absorbing rubber base cup with non-skid surface (XL only).
- noise-absorbing non-skid rubber pad bonded to the base cup (XSB only).

Types SHS only

- heavy-duty steel spring.
- colour-coded for easy identification of the load range.
- heavy-duty steel cage.
- rod hole in spring compression plate, fully rubber-isolated.
- large diameter lower rod clearance hole in the cage.
- fully weatherproofed.

If features or ratings are required beyond that shown, please contact Fantech.

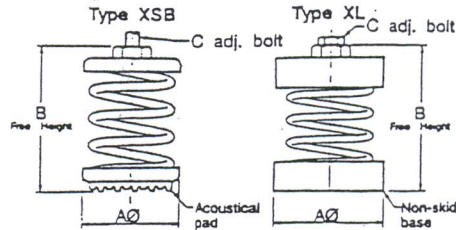
HOW TO ORDER

When selecting vibration isolators, divide the weight of the unit being isolated by the number of mounts being used to determine the kg/mount required. Then select the mount with the next highest weight loading and deflection required. Vibration isolators are generally used in sets of four.

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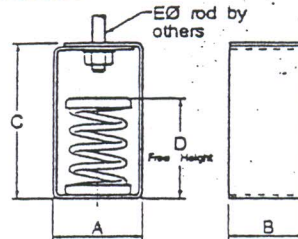
DIMENSIONS & SELECTION TABLES

Spring Mounts



Model No.	Colour	Max. Load kg/mt	Static Defl. mm	Dimensions, mm		
				AØ	B	C
XSB-9	Yellow	10	33			
XSB-10	Brown	15	33			
XSB-11	Blue	30	33			
XSB-12	Black	50	28	55	100	M12
XSB-13	Red	75	25			
XSB-14	Green	125	25			
XSB-16	Grey	175	20			
XSB-17	Orange	200	15			
XL-89	White	10	40			
XL-90	Violet	20	38			
XL-91	Vio/Bla	35	35			
XL-92	Yellow	50	33	83	130	M10
XL-93	Brown	100	33			
XL-94	Blue	150	30			
XL-95	Black	200	30			

Hanger Mounts



Model No.	Colour	Max. Load kg	Static Defl. mm	Dimensions, mm				
				A	B	C	D	EØ
SHS-9	Yellow	10	33					
SHS-10	Brown	15	33					
SHS-11	Blue	30	33					
SHS-12	Black	50	28	75	65	130	86	13
SHS-13	Red	75	25					
SHS-14	Green	125	25					
SHS-16	Grey	175	20					
SHS-17	Orange	200	15					

VIBRATION ISOLATORS

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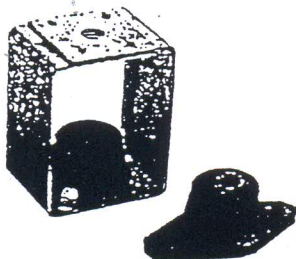
DATE :

DURATION :

PAGE :

10/11

VIBRATION ISOLATORS
RUBBER-IN-SHEAR



FEATURES

These mounts provide effective isolation of noise and vibration from equipment speeds of 15 r/s (6-pole) upwards.

Types R and RD only

- threaded insert in the top for equipment fastening.
- rated static deflection from 5-12mm.
- non-skid ribbed base; bolting down not normally required.
- moulded in oil-resistant materials. colour-coded for easy identification of the load range.
- corrosion-proof element; metal parts embedded in the elastomer.

Types RH and RHD only

- rated static deflection from 5-12mm.
- moulded in oil-resistant materials
- colour-coded for easy identification of the load range.
- corrosion-proof element; metal parts embedded in the elastomer
- heavy-duty steel cage.
- if mechanical or fire damage occurs, the metal plates in the hanger element interlock so that complete loss of support is unlikely.
- fully weatherproofed.

If features or ratings are required beyond that shown, please contact Fantech.

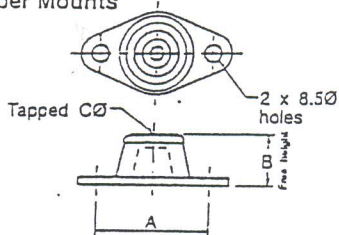
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VIBRATION ISOLATORS

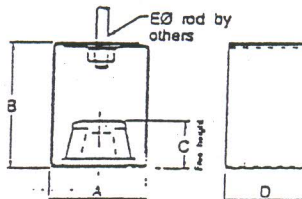
DIMENSIONS & SELECTION TABLES

Rubber Mounts



Model No.	Colour	Max. Load kg/mt	Static Defl. mm	Dimensions, mm		
				A	B	CØ
Single deflection						
R-1	Blue	15	5	60	28	M8
	Black	25	5			
	Red	40	5			
R-2	Blue	60	6	76	32	M10
	Black	75	6			
Double deflection						
RD-1	Blue	15	10	60	35	M8
	Black	25	10			
	Red	40	10			
RD-2	Blue	60	12	76	44	M10
	Black	75	12			

Hanger Mounts



Model No.	Colour	Max. Load kg	Static Defl. mm	Dimensions, mm				
				A	B	C	D	EØ
Single deflection								
RH-1	Blue	15	5	60	75	31	50	10
	Black	25	5					
	Red	40	5					
RH-2	Black	75	6	75	130	41	65	16
Double deflection								
RHD-1	Blue	15	10	60	75	38	50	10
	Black	25	10					
	Red	40	10					
RHD-2	Black	75	12	75	130	54	65	16